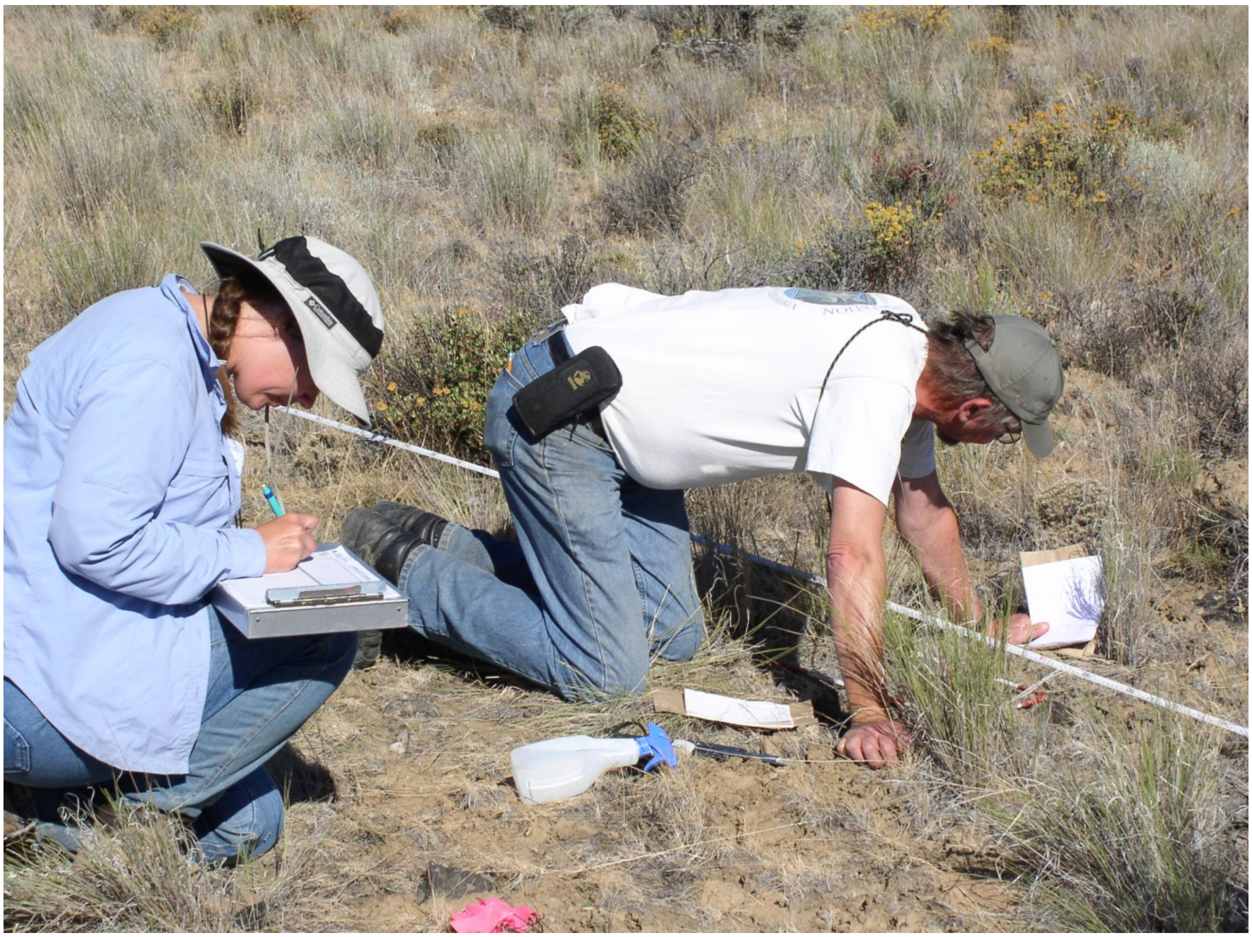
ECOLOGICAL INTEGRITY ASSESSMENTS: MONITORING AND EVALUATION OF WILDLIFE AREAS IN WASHINGTON



Michael A. Schroeder, Rex C. Crawford, F. Joseph Rocchio, D. John Pierce, and Matt Vander Haegen (this is just a draft list)

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INTRODUCTION

The Washington Department of Fish and Wildlife (WDFW) serves Washington's citizens by protecting, restoring, and enhancing fish and wildlife on private and public lands, such as those support by the Bonneville Power Administration (BPA). In order to make informed management decisions aimed at maintaining or protecting ecological integrity, credible data on how human activities affect the chemical, physical, and biological integrity of ecological systems needs to be collected (USEPA 2002). Indicator-based (ecological endpoints) approaches to assessing and reporting on ecological integrity (Harwell et al. 1999, Young and Sanzone 2002, USEPA 2002) are now being used by numerous organizations to assist with regulatory decisions (Mack 2004, USACE 2003, 2005, 2006), to set mitigation performance standards (Mack 2004, Faber-Langendoen et al. 2006, 2008), and to set conservation priorities (Faber-Langendoen et al. 2009*a*).

Assessing the current ecological condition of an ecosystem requires developing indicators of the structure, composition, and function of an ecosystem as compared to reference or benchmark examples of those ecosystems operating within the bounds of natural or historic disturbance regimes (Lindenmayer and Franklin 2002, Young and Sanzone 2002). Given the complexity of ecological systems, concerns over cost-effectiveness and statistical rigor, and the loss of adequate reference sites, the selection and development of indicators can be challenging (Brewer and Menzel 2009). There is a need for a method which provides guidance on the range of options for assessing ecological integrity, scaled both in terms of the scale of ecosystem type that is being assessed, and the level of information required to conduct the assessment. NatureServe and the Natural Heritage Network have recently developed such an approach called the Ecological Integrity Assessment (Faber-Langendoen et al. 2006, 2008, 2009*a*, 2009*b*) and are now implementing it for a variety of small- and large-scale projects (Lemly and Rocchio 2009, Faber-Langendoen et al. 2009*b*, Tierney et al. 2009).

The Ecological Integrity Assessment (EIA) method aims to measure the current ecological integrity of a site through a standardized and repeatable assessment of current ecological conditions associated with the structure, composition, and ecological processes of a particular ecological system. These conditions are then compared to those associated with sites operating within the bounds of their natural range of variation. Ratings or scores for individual metrics and overall ecological integrity are presented in a clear and transparent scorecard matrix. The purpose of assigning an index of ecological integrity is to provide a succinct assessment of the current status of the composition, structure and function of occurrences of a particular ecosystem type and to give a general sense of conservation value, management effects, and restoration success. As such, the EIA will address a number of objectives including: (1) assessment of ecological integrity on a fixed, objective scale; (2) comparison of ecological integrity of various occurrences of the same ecological systems; (3) determination of, and support for, conservation priorities; (4) improved decisions on monitoring individual ecological attributes; and (5) provision of an aggregated index of integrity to interpret monitoring data.

The general framework of the EIA will be tailored by regional and local ecologist to more specifically address the complexity of individual ecosystem types using the following approach: (1) develop a conceptual model with key ecological attributes and associated indicators; (2) apply a three-level approach to identify a suite of metrics, including Level 1 (remote sensing), Level 2 (rapid ground-based), and Level 3 (intensive ground-based) metrics (USEPA 2006); (3) identify ratings and thresholds for each metric based on deviation from the ‘natural range of variation’ benchmarks for each metric relative to each type; and (4) provide a scorecard matrix by which the metrics are rated and integrated into an overall assessment of ecological integrity. The EIA aims to standardize expert opinion and existing data up front so that a single, qualified ecologist could apply the EIA in a rapid manner to get an estimate of a site’s ecological integrity. The EIA can improve an understanding of current ecological conditions which can lead to more effective and efficient use of available resources for ecosystem protection, management, and restoration efforts. The flexibility in scale, detail, and level of effort associated with the three-level approach around which the EIA is developed provides a foundation upon which a multi-scaled approach to monitoring and assessment can be systematically implemented.

Recognizing that EIAs are essential tools for monitoring and evaluating these resources, the WDFW contracted with the Washington Natural Heritage Program to adapt the EIA method (Faber-Langendoen et al. 2009*a*) as an approach for developing standards and a monitoring protocol for measuring desired ecological conditions on State Wildlife Areas. This document presents a framework in which the EIA can be used to achieve those objectives. This document (1) describes the EIA method; (2) provides an overview of how the EIA will be used within the context of a multi-scaled monitoring program; and (3) describes how the EIA approach will be applied to wildlife areas in Washington.

Development of a comprehensive monitoring and evaluation strategy has been a long process and this document borrows heavily from earlier documents on the subject (Ashley 2007, Schroeder et al. 2009, Rocchio and Crawford 2009*b*) which provided much of the foundation for this effort. It is also likely that this report will be a stage in the process, rather than the ‘final word’. Because of the complexity of the topic, numerous acronyms and abbreviations (Appendix A) are used, as well as common names for species (Appendix B).

OVERVIEW OF ECOLOGICAL INTEGRITY ASSESSMENTS

The EIA is a multi-metric index designed to document degradation of key biotic and abiotic attributes along a continuum from reference to degraded. The EIA approach to assessing ecological integrity is similar to the Index of Biotic Integrity (IBI) approach. The original IBI interpreted stream integrity from twelve metrics that reflected the health, reproduction, composition and abundance of fish species (Karr and Chu 1999). Each metric was rated by comparing measured values with values expected under relatively unimpaired (reference standard) conditions, and the ratings were aggregated into a total score. The EIA builds upon this foundation and assesses the integrity of ecosystems by developing suites of indicators or metrics comprising key biological, physical and functional attributes of those ecosystems (Harwell et al. 1999, Andreasen et al. 2001, Parrish et al. 2003). The EIA uses a scorecard matrix to communicate the results of the assessment. A rating or score for individual metrics, as well as an overall index of ecological integrity are presented in the scorecard.

Ecological Integrity Assessments are developed using the following steps:

1) Outline a general conceptual model that identifies the major ecological attributes, provide a narrative description of declining integrity levels based on changes to those ecological attributes, and introduce the metrics-based approach to measure those attributes and assess their levels of degradation.
2) Use ecological classifications at multiple classification scales to guide the development of the conceptual models, allowing improved refinement of assessing attributes, as needed.
3) Use a three level assessment approach to guide development of metrics: (1) remote sensing; (2) rapid ground-based; and (3) intensive ground-based metrics. The 3-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.
4) Identify ratings and thresholds for each metric based on ‘normal’ or ‘natural range of variation’ benchmarks.
5) Provide a scorecard matrix by which the metrics are rated and integrated into an overall index of ecological integrity.

This section describes each of these components associated with EIA development. Most of this discussion is summarized and adapted from Faber-Langendoen et al. (2009*a*). For additional background and details concerning EIA development, please consult that document as well as Faber-Langendoen et al. (2006, 2008). A general note of caution: ecosystems are far too complex to be fully represented by a suite of key ecological attributes, indicators, and metrics. As such, our efforts to assess ecological integrity are approximations of our current understanding of any ecosystem which means the metrics, indices and scorecards presented in this report must be flexible enough to allow change over time as our knowledge grows.

DEFINITIONS

Ecological Integrity

The concept of ecological integrity, as used within the context of the EIA method, builds on the related concepts of biological integrity and ecological health, and is a broad and useful endpoint for ecological assessment and reporting (Harwell et al. 1999). Ecological integrity, as used for the EIA, is defined as “an assessment of the structure, composition, and function of an ecosystem as compared to reference ecosystems operating within the bounds of natural or historic disturbance regimes” (adapted from Karr and Dudley 1981, Lindenmayer and Franklin 2002, Young and Sanzone 2002, Parrish et al. 2003). To have ecological integrity, an ecosystem should be relatively unimpaired across a range of ecological attributes and spatial and temporal scales (De Leo and Levin 1997, Karr 1994). Impairment is defined as deviation from the natural range of variation as described by the ecological condition of reference or benchmark sites. The notion of naturalness (or its inverse, impairment) depends on an understanding of how the presence and impact of human activity relates to natural ecological patterns and processes (Kapos et al. 2002). Identification of reference or benchmark conditions based on natural or historic ranges of variation, although challenging, can provide a basis for interpretation of ecological integrity (Swetnam et al. 1999). These concepts require greater specificity to become a useful guide for conducting ecological integrity assessments.

Ecological Condition

Ecological condition represents the current state of a resource compared to reference standards or benchmarks for physical, chemical, and biological characteristics.

Desired Ecological Condition

Management objectives, societal values, and other factors determine the desired ecological conditions of any particular site or ecosystem. Specifically, desired ecological conditions can be defined as the detailed, measureable descriptions of what a resource will look like after social, economic, and ecological management goals have been achieved (IEMTF 1995). Desired ecological conditions are the long-term goals a natural resource manager is targeting and can be used as performance standards or measures of success for management actions (USNPS 2009). For this approach, desired ecological conditions for each of the Ecological Systems will be addressed. Thus, any metric, key ecological attribute, or overall ecological integrity rating meeting the specified criteria would be considered to be within desired ecological conditions. Correspondingly, anything outside specified criteria for desired conditions would require management action to reverse conditions.

Best Attainable Condition

Best attainable condition is a subset of both ecological integrity and desired ecological conditions. In other words, the ecological potential or best attainable condition of any given site can vary depending on factors outside the control of the manager setting desired ecological conditions. For example, best attainable condition may be constrained by the landscape an ecological system is embedded within or by past land use which has occurred and left lasting impacts. A specific example might be a riparian ecological system that occurs immediately downstream of a dam. Unless managers of the dam are willing to conduct flood releases that would mimic the natural timing, duration, and frequency of flooding associated with that riparian type, achieving desired ecological conditions may not be feasible for that particular occurrence. Given those constraints, the particular ecological conditions that are possible at this site are referred to as best attainable condition. Best attainable conditions are determined on a case-by-case basis through an integrated assessment of both site- and landscape scale ecological conditions and stressors. This can be accomplished using and EIA approach.

Management Assessment Points

Management assessment points, also known as 'triggers', are points along a continuum of values associated with a metric or attribute where managers are encouraged to initiate closer examination of current management and ecological conditions in order to avoid crossing an undesirable threshold (Bennetts et al. 2007, Carter and Bennetts 2007). Within the context of the EIA framework presented here, triggers or management assessment points will be most applicable when using a Level 2 EIA since these are rapid assessments designed to provide a snapshot of current ecological condition. If a trigger point is detected by the Level 2 EIA, then a more detail assessment (e.g. Level 3 EIA) is warranted in order to provide a more accurate assessment of status and trends as well as the type of preventive management actions that need to be taken to avoid crossing an ecological threshold into an undesirable state of ecological condition.

IMPORTANCE OF ECOLOGICAL CLASSIFICATION

Classification and Natural Range of Variation

Classification is a necessary component to both using and developing an EIA as it constrains natural variability and thus helps clarify whether differences in ecological condition are due to natural or anthropogenic causes. To successfully develop indicators of ecological integrity, an understanding of the structure, composition, and processes that govern the wide variety of ecosystem types is needed. Ecological classifications help ecologists to better cope with natural variability within and among types so that differences between occurrences with good integrity and poor integrity can be more clearly recognized. In other words, classification helps us differentiate signals (indicators of degradation) from noise (natural variability). Classifications are also important in establishing 'ecological equivalency' which is especially important for establishing restoration targets and benchmarks. There are a variety of classification schemes and ecoregional frameworks for structuring ecological integrity assessments. The EIA presented here are based on the International Vegetation Classification and Ecological Systems classification.

National Vegetation Classification Standard

The International Vegetation Classification (IVC) covers all vegetation from around the world. In the United States, its national application is the U.S. National Vegetation Classification Standard (NVCS), supported by the Federal Geographic Data Committee (FGDC 2008), NatureServe (Faber-Langendoen et al. 2009*c*), and the Ecological Society of America (Jennings et al. 2009), with other partners. The IVC and NVCS were developed to classify both wetlands and uplands, and identify types based on vegetation composition and structure and associated ecological factors.

1) The NVCS meets several important needs for conservation and resource management. It provides the following:
2) Multi-level, ecologically based framework that allow users to address conservation and management concerns at scales relevant to their work.
3) Characterization of ecosystem patterns across the entire landscape or watershed, both upland and wetland.
4) Information on the relative rarity of types. Each association has been assessed for conservation status (extinction risk).
5) Relationships to other classification systems are explicitly linked to the NVCS types
6) Federal standard for all federal agencies, facilitating sharing of information on ecosystem types (FGDC 2008).

A related classification approach, the Ecological Systems classification (Comer et al. 2003), can be used in conjunction with the IVC and NVCS. Ecological systems provide a spatial-ecologic perspective on the relation of associations and alliances (fine-scale NVCS types), integrating vegetation with natural dynamics, soils, hydrology, landscape setting, and other ecological processes. They can also provide a mapping application of the NVCS, much as soil associations help portray the spatial-ecologic relations among soil series in a soil taxonomic hierarchy. Ecological systems types facilitate mapping at meso-scales (1:24,000 – 1:100,000; Comer and Schulz 2007) and a comprehensive ecological systems map exists for Washington State (www.landscope.org). Ecological systems are somewhat comparable to the Group level of the revised NVCS hierarchy, and can be linked to higher levels of the NVCS hierarchy, including macrogroups and formations. Ecological systems meet several important needs for conservation, management and restoration, because they provide the following:

1) Integrated biotic and abiotic approach that is effective at constraining both biotic and abiotic variability within one classification unit.
2) Comprehensive maps of all ecological system types are becoming available.
3) Explicit links to the US NVCS, facilitating crosswalks of both mapping and classifications.

Both the NVCS and Ecological Systems classifications can be used in conjunction to sort out the ecological variability that may affect ecological integrity. For this project, Ecological Systems are used as the foundation from which EIAs will be developed. It is recommended that the Draft Field Guide to Washington's Ecological Systems (Rocchio and Crawford 2008) be used to identify the ecological system in question to ensure that the correct EIA is used. However, if finer-scale classification units are needed for WDFW's monitoring objectives, NVCS types are recommended.

Integration of NVCS and Ecological Integrity Assessment

The purpose of intersecting the various classifications approaches with that of the EIA methods is that as the level of assessment intensifies we may find (but not always) that a greater (or lesser) level of ecosystem classification detail is needed. Finer classes allow for greater specificity in developing conceptual models of the natural variability and stressors of an ecological system and the thresholds that relate to impacts of stressors. On the other hand, coarser classes allow the development of metrics that are more likely to be applicable across classes since the specificity of these metrics is limited by scale. Because the Ecological Systems classification remains comparable to coarser or finer-scale levels of the NVCS, the flexibility to tailor EIAs to NVCS types remains an option if WDFW finds a need for monitoring such types in the future. However, there are some metrics which are broadly applicable across any classification scale. For example, the percent cover of native species is a metric that is likely useful for any classification type, whether coarse or fine-scale. Likewise, some metrics are very specific regardless of scale, such as the Floristic Quality Index which requires detailed knowledge of the floristics of any classification unit. Thus, consideration of both the level of metric resolution and the scale of classification that is desired is taken into account in order to accurately develop the metric. In summary, the EIA is both practical and flexible for a range of assessment types spanning broad to local scale and from extensive to intensive detail and effort.

CONCEPTUAL ECOLOGICAL MODELS

A conceptual model helps guide the selection of indicators, organized across a standard set of ecological attributes and factors (e.g., Harwell et al. 1999, Young and Sanzone 2002, Parrish et al. 2003). With a specific Ecological System type in mind, a conceptual model describing linkages between key ecosystem attributes and known stressors is developed and used for identifying and interpreting metrics with high ecological and management relevance (Noon 2003, Faber-Langendoen et al. 2009*a*). The first component to the conceptual model is identifying the key ecological attributes associated with the overall structure, composition and ecological processes which are considered primary drivers or have a very important functional role in maintaining the integrity of the ecological system. In other words, the conceptual models identify the key ecological drivers that are most valuable to measure for assessing ecological integrity. The models can be narrative or a graph. Next, the primary stressors impacting the ecological system are identified and incorporated into the conceptual model. With stressors incorporated, the conceptual model is then used to describe the predicted relationships between ecological components and their potential stressors.

ECOLOGICAL INDICATORS AND METRICS

Use of Indicators and Metrics in This Report

The conceptual model provides guidance as to which specific indicators and metrics will be useful for distinguishing a highly impacted, degraded or depauperate state from a relatively unimpaired, intact and functioning state. The difference between indicators and metrics is subtle yet important to distinguish. Indicators provide the specificity needed to assess the key ecological attributes. Example indicators for vegetation include structure, composition, diversity, life history, tolerance, alien taxa and examples for hydrology include water depth or flooding duration. Metrics are measureable expressions of an indicator. For example, metrics for the alien plant taxa indicator might include percent alien species richness, relative alien cover, or number of invasive alien species.

For this report, metrics are the focus. Any use of indicators is for conceptual organization of metrics but indicators are not included in the EIA Scorecards and thus are not ranked or scored in the EIA method. However, if this would be useful for monitoring, indicators could be added into the framework.

Selecting Metrics

The selection of metrics is focused on those that can detect changes in a key ecological attributes due to a response that can be attributed to stressors. In other words, not all measures of various characteristics in an ecosystem are useful for measuring ecological integrity. Metrics that can be used to measure a key ecological attribute and are sensitive to changes from stressors are referred to here as ‘condition metrics.’ Stressors themselves can also be measured, but information from these metrics provides only an indirect measure of ecological condition – we will need to infer that changes in the stressor correspond to changes in the condition of the system. Such metrics are referred to as ‘stressor metrics.’ It is preferable to use condition metrics separate from stressors metrics, in order to independently assess the effects of stressors on condition at a site to guide interpretation and possible correlations between ecological integrity and stressors (e.g. stressor checklists). However, when measuring condition is challenging or not cost-effective a stressor metric may be substituted. However, if a stressor index is used to test, verify, or validate the EIA model then it is important to remove stressor metrics from the analysis.

Metrics relate to the key ecological attributes identified in the conceptual ecological model, which are themselves organized by rank factors (Table 1). Stressor checklists are also shown within the context of this model. Metrics are identified using a variety of expert-driven processes and through a series of data-driven calibration tests. The scientific literature is searched to identify existing and vetted metrics that could be useful for measuring ecological integrity. Some of the metrics presented in this report were derived from a national effort to select metrics for rapid assessment and monitoring of ecological integrity of wetlands (Faber-Langendoen et al. 2006, 2008). Many of these metrics are also applicable to some upland ecological systems. A variety of existing rapid assessment and monitoring materials, particularly the California Rapid Assessment Manual (Collins et al. 2006, 2007), the Ohio Rapid Assessment Manual (Mack 2001), indicators of rangeland health (Pellant et al. 2005), Natural Resources Conservation Service ecological site descriptions, etc., were referenced for suitable metrics. From these resources, as well metrics identified by the Washington Natural Heritage Program, a list of potential metrics was compiled then filtered through the following criteria to determine which would be most useful for use in the EIA (Andreasen et al. 2001, Kapos et al. 2002, Kurtz et al. 2001).

1) Useful at multiple spatial scales.
2) Inclusive across ecological attributes of composition, structure and function.
3) Grounded in natural history and ecologically relevant.
4) Practically relevant to managers, decision-makers, and the public, not just scientists.
5) Criteria must be flexible to implement and measure.
6) Target or threshold settings should be relevant.
7) Responsive to changes, including changes due to stressors.

Table 1. Conceptual Ecological Model for a wetland. Stressors are described using checklists.

Rank Factor	Key Ecological Attribute	Metric
Landscape Context	Landscape Structure	Landscape Connectivity
		Buffer Index
		Surrounding Land Use Index
	Landscape Stressors	Landscape Stressors Checklist
	Patch size	Patch Size Condition
		Patch Size
Condition	Vegetation	Vegetation Structure
		Organic Matter Accumulation
		Vegetation Composition
		Relative Cover of Native Species
	Vegetation Stressors	Vegetation Stressors Checklist
	Soils/Physiochemical	Physical Patch Types
		Water Quality
		Soil Surface Condition
	Soil Stressors	Soil Stressors Checklist
	Hydrology	Water Source
		Hydroperiod
		Hydrologic Connectivity
	Hydrology Stressors	Hydrology Stressors Checklist

THREE LEVEL APPROACH TO METRIC DEVELOPMENT

The selection of metrics to assess ecological integrity can be done at three levels of intensity depending on the purpose and design of the data collection effort (Brooks et al. 2004, Tiner 2004, USEPA 2006). This 'three-level approach' to assessments, summarized in Table 2, allows the flexibility to develop data for many sites that cannot readily be visited or intensively studied, permits more widespread assessment, while still allowing for detailed monitoring data at selected sites. 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.

Table 2. Summary of 'three-level' approach to conducting ecological integrity assessments (adapted from Brooks et al. 2004, USEPA 2006).

Level 1 – Remote assessment	Level 2 – Rapid assessment	Level 3 - Intensive assessment
General description: Landscape condition assessment	**General description:** Rapid site condition assessment	**General description:** Detailed site condition assessment
Evaluates: Condition of individual areas/occurrences using remote sensing indicators	**Evaluates:** Condition of individual areas/occurrences using relatively simple field indicators	**Evaluates:** Condition of individual areas/occurrences using relatively detailed quantitative field indicators
Based on: GIS and remote sensing data Layers typically include: Land cover / use Other ecological types	**Can be based on:** Stressor metrics (e.g., ditching, road crossings, and pollutant inputs); and Condition metrics (e.g., hydrologic regime, species composition)	**Can be based on:** Indicators that have been calibrated to measure responses of the ecological system to disturbances (e.g., indices of biotic or ecological integrity)
Potential uses: Identifies priority sites Identifies status and trends of patches across the landscape Identifies condition of ecological types across the landscape Informs targeted restoration and monitoring	**Potential uses:** Promotes integrated scorecard reporting Informs monitoring for implementation of restoration or management projects Supports landscape / watershed planning Support s general conservation and management planning	**Potential uses:** Promotes integrated scorecard reporting Identifies status and trends of specific occurrences or indicators Informs monitoring for restoration, mitigation, and management projects
Example metrics: Landscape Development Index Land Use Map Road Density Impervious Surface	**Example metrics:** Landscape Connectivity Vegetation Structure Invasive Exotic Plant Species Forest Floor Condition	**Example metrics:** Landscape Connectivity Structural Stage Index Invasive Exotic Plant Species Floristic Quality Index (mean C) Vegetation Index of Biotic Integrity Soil Calcium:Aluminum Ratio

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 Remote 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 (Mack 2006, USEPA 2006, Faber-

Langendoen et al. 2009*a*). Level 1 metrics are usually developed from readily available, processed imagery or existing GIS coverages. Limited ground-truthing may be a component of some assessments. Although remote sensing metrics are usually thought of as ‘coarser’ or less accurate than field-based rapid or intensive metrics, this is not always the case. Some information available from imagery may be very accurate and more intensive than can be gathered in the field. Remote sensing information may also be more time-demanding and expensive.

Level 2 Rapid 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 (Fennessy et al. 2007).

Level 3 Intensive Assessments require more rigorous, intensive field-based methods and metrics that provide higher-resolution information on the integrity of occurrences within a site. They often use quantitative, plot-based protocols coupled with a sampling design to provide data for detailed metrics (Barbour et al. 1996, Blocksom et al. 2002). Often indices of biological condition such as the Floristic Quality Index or Vegetation Index of Biotic Integrity (Rocchio 2007*a*, 2007*b*, DeKeyser et al. 2003, Mack 2004, Miller et al. 2006) are solely used as the Level 3 assessment since vegetation has been found to be an effective integrator of condition of many ecological attributes (Mack 2004). However, quantitative metrics for soils, hydrology, birds, fish, amphibians, invertebrates, and other major ecological attributes can be used. These attributes are typically more time-consuming and costly to measure, but their response may differ enough from that of the vegetation that they provide additional valuable information on ecological integrity.

Although the three levels are integrated, 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. It is also possible to use the three levels together. One might first assign a Level 1 rating or rank to all occurrences, then choose or prioritize among them to conduct a Level 2 EIA, and finally, focus on a few of those with a Level 3 assessment. The process should lead to an increasing accuracy of assessment. Where information is available for all three levels across multiple sites, it is desirable to calibrate the levels, to ensure that there is an increase in accuracy of the assessment as one goes from Level 1 to 3. To ensure that the three-level approach is consistent in how ecological integrity is assessed, a standard framework or conceptual model for choosing metrics is used (Table 2). Using this model, a similar set of metrics are chosen across the three levels, organized by the standard set of ecological attributes and factors (landscape context, size, and condition, and vegetation, hydrology, and soils). This approach facilitates working between levels for a specific assessment. For example, if the goal is simply to estimate ecological integrity as accurately as possible, given limitation of time and resources, it maybe that landscape context and size are measured using level 1 metrics, soils and hydrology using level 2 metrics, and vegetation using level 3 metrics.

DEFINITIONS OF THE ECOLOGICAL INTEGRITY RANKING SCALE

Ecological integrity can be defined as the natural range of variability associated with the structure, composition, and function of an ecosystem exposed to minimal human-induced impacts. Impairment is defined as deviation from the natural range of variation as described by the ecological condition of reference or benchmark sites. A critical aspect of linking ecological integrity to reference sites is to distinguish natural ranges of variation from variation caused by a variety of negative anthropogenic impacts i.e., those impacts that directly or indirectly degrade occurrences of an ecosystem. In other words, an understanding of how the presence and impact of human activity relates to natural ecological patterns and processes is needed to define ratings of individual metrics according to their deviation from the natural range of variation (Kapos et al. 2002). Ideally, measurements of each metric are collected from sites exposed to various degrees of human-induced disturbance ranging from those possessing minimal impact to those highly degraded by human activity, providing an ecological dose-response curve from which to assess the relationship between each metric and human disturbance. This process allows each metric to be quantitatively described along a continuum of human disturbance and provides a means of assessing the deviation of condition from its natural range of variation (Karr and Chu 1999). Each metric is then individually scored on a comparable scale then combined to produce an overall index score.

Regardless of which metric is being measured, a standard ecological integrity ranking scale is used to score each measurement. A report-card style scale is used and metrics, key ecological attributes, or overall ecological integrity is ranked from ‘excellent’ to ‘degraded’ or ‘A’, ‘B’, ‘C’ or ‘D’ (Table 3). In order to make such rankings operational, the general ranking definitions are specifically described. A suite of attributes that are assumed to be important to assessing various grades of ecological integrity are used to describe, in more detail, the overall condition each of these rankings are intended to reflect (Table 3). These descriptions provide guidance when developing specific metric rankings. The helps ensure that all metrics, regardless of the actual unit of measurement of the field value, is ranked or scored on a comparable scale.

Table 3. Ecological Integrity Rank definitions (Faber-Langendoen et al. 2009a).

Ecological Integrity Rank	Description
A (Excellent)	Occurrence is believed to be, on a global or range-wide scale, among the highest quality examples with respect to major ecological attributes functioning within the bounds of natural disturbance regimes. Characteristics include: the landscape context contains natural habitats that are essentially unfragmented (reflective of intact ecological processes) and with little to no stressors; the size is very large or much larger than the minimum dynamic area ; vegetation structure and composition, soil status, and hydrological function are well within natural ranges of variation, exotics (non-natives) are essentially absent or have negligible negative impact; and, a comprehensive set of key plant and animal indicators are present.
B (Good)	Occurrence is not among the highest quality examples, but nevertheless exhibits favorable characteristics with respect to major ecological attributes functioning within the bounds of natural disturbance regimes. Characteristics include: the landscape context contains largely natural habitats that are minimally fragmented with few stressors; the size is large or above the minimum dynamic area, the vegetation structure and composition, soils, and hydrology are functioning within natural ranges of variation; invasives and exotics (non-natives) are present in only minor amounts, or have or minor negative impact; and many key plant and animal indicators are present.
C (Fair)	Occurrence has a number of unfavorable characteristics with respect to the major ecological attributes, natural disturbance regimes. Characteristics include: the landscape context contains natural habitat that is moderately fragmented, with several stressors; the size is small or below, but near the minimum dynamic area; the vegetation structure and composition, soils, and hydrology are altered somewhat outside their natural range of variation; invasives and exotics (non-natives) may be a sizeable minority of the species abundance, or have moderately negative impacts; and many key plant and animal indicators are absent. Some management is needed to maintain or restore these major ecological attributes. Ecological restoration is: "the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed. Restoration attempts to return an ecosystem to its historic trajectory" (SER 2004).
D (Poor)	Occurrence has severely altered characteristics (but still meets minimum criteria for the type), with respect to the major ecological attributes. Characteristics include: the landscape context contains little natural habitat and is very fragmented; size is very small or well below the minimum dynamic area; the vegetation structure and composition, soils, and hydrology are severely altered well beyond their natural range of variation; invasives or exotics (non-natives) exert a strong negative impact, and most, if not all, key plant and animal indicators are absent. There may be little long-term conservation value without restoration, and such restoration may be difficult or uncertain. D-ranked types present a number of challenges. First, with respect to classification, a degraded type may bear little resemblance to examples in better condition. Whether a degraded type has 'crossed the line' ('transformed' in the words of SER 2004) into a semi-natural or cultural type is a matter of classification criteria. These criteria specify whether sufficient diagnostic criteria of a type remain, bases on composition, structure, and habitat.

NATURAL RANGE OF VARIATION AND REFERENCE CONDITIONS

Ecological Integrity Rankings in the EIA are based or benchmarked in the concept of natural range of variability (NRV). In other words, the NRV provides a baseline from which biotic or abiotic variables can be assessed to determine whether ecological integrity has been degraded at a site. Thus, defining and describing the NRV for each ecological system is extremely important to maintaining consistency in how each metric is ranked within and among ecological systems. The conceptual ecological models associated with each ecological system in Section 4.0 essentially summarize the key ecological factors associated with how the system functions within the bounds of the NRV. The specific values or description of the NRV for each of the key ecological attributes are represented by the 'A' ranks for each metric.

The concept of the NRV is based on the temporal and spatial range of climatic, edaphic, topographic, and biogeographic conditions under which contemporary ecosystems evolved (Morgan et al. 1994, Quigley and Arbelbide 1997). Whitlock (1992) suggested that modern vegetation patterns in the Pacific Northwest began about 5,000 – 1,500 years before present although notes that climate and vegetation response is constantly shifting. Thus, the NRV is not considered to be static for any given variable but rather a range of responses to climatic fluctuations which have occurred over the past few thousand years.

Another consideration for describing the NRV is the degree to which anthropogenic impacts have altered natural ecosystems. There is disagreement over whether disturbances resulting from Native Americans' interaction with the landscape occurred over spatial and temporal scales in which native flora and fauna were able to adapt (see Vale 1998 and Denevan 1992). The hypothesis offered by Vale (1998), which notes that Native American impacts were not ubiquitous across the landscape, is accepted for this project. Furthermore, where Native American impacts did occur (i.e. intentional burning of ecosystems), it is accepted here that they occurred over spatial and temporal scales in which native biota were able to adapt and thus are included within the NRV (Quigley and Arbelbide 1997, Wilhelm and Masters 1996). European settlement is presumed to have introduced a myriad of land uses and impacts that, because of their intensity, frequency, and duration were novel changes to the ecological template upon which most contemporary ecosystems evolved.

The description of the NRV is based on historical evidence and current status of natural variation. The current status of NRV is best measured by collecting data from sites with minimal human-induced stress. These conditions, also referred to as the reference standard condition, represent one end of a continuum ranging from sites with minimal or no exposure to human-induced disturbance to those in a highly degraded condition due to such impacts (Stoddard et al. 2006). This continuum is also called the reference condition and characterizes the full range of common circumstances – from seemingly 'pristine' or benchmark sites to highly degraded sites – so that metrics may be developed and applied that adequately characterize that full range of conditions on the landscape. Sampling ecological conditions associated with the entire spectrum of human-induced stress allows the construction of multi-metric indices as well as a framework for interpreting changes in ecological condition (Davies and Jackson 2006). This requires collection of data from sites exposed to varying types and intensities of human disturbance in order to characterize how metrics respond to increasing human-induced stress. Historical information can also be used to define what ecological conditions were like prior to major human alterations. Only through such sampling and incorporation of historical information can the full range of metric values be sufficiently analyzed and interpreted to provide for rigorous and repeatable ecological integrity assessment ranks.

DEVELOPMENT OF METRIC RANKINGS

Each metric is rated according to deviation from its natural range of variability based on an understanding of how each metric responds to increasing human disturbance. The further a metric deviates from its natural range of variability the lower rating (the same applies to the overall index of ecological integrity). The EIA uses four rating categories to describe the status of each metric relative to its natural variability. There are two important thresholds associated with these ranks. The B-C threshold indicates the level below which conditions are not considered acceptable for sustaining ecological integrity. This threshold is also the basis for defining Desired Ecological Conditions for this project. The C-D threshold indicates a level below which system integrity has been drastically compromised and restoration is very difficult and/or very costly.

What is natural or historical may be difficult to define for many cases, given our inability to document this range of variation over sufficient spatial and temporal scales and the relative extent of human disturbance over time. However, through reflections on historical data, and analysis of data gathered from the full range of reference sites, we can often distinguish the effects of intensive human uses and begin to describe an expected natural range of variation for ecological attributes that maintain the occurrence over the long-term.

For this project, existing information (e.g. literature, existing data sets, best professional judgment, etc.) was used to make some initial hypotheses about specific semi-quantitative values as they relate to the standardized metric rating descriptions developed by NatureServe. Minimally, this process incorporates expert opinion and existing data into a standardized format so that a qualified ecologist could apply the EIA in a rapid and standardized manner to get an estimate of a site’s ecological integrity. Ideally, the next phase in EIA development would be to field test and validate these initial hypotheses by determining their ability to discriminate between sites exposed to varying degrees of human-induced stress through collection of field data.

STRESSOR CHECKLIST

As noted above, the measurement of stressors independently from that of ecological condition provides a means for assessing the possible correlations between ecological integrity and specific stressors. Such correlations might help in guiding management recommendations, restoration actions, and conservation measures at a variety of spatial scales. NatureServe has developed a simple method for documenting the type, scope, and severity of stressors associated with each Rank Factor (Faber-Langendoen et al. 2009*a*, Master et al. 2009). The use of stressor checklists, along with EIA Scorecards (Appendix C), is recommended when using the EIA Framework.

PROTOCOL FOR EIA METRICS

Metrics relate to the key ecological attributes identified in conceptual ecological models. They are designed to be useful at multiple spatial scales, relavent across ecosystems, grounded in natural history, relevant to management, and flexible. The metrics are divided into landscape context, vegetation condition, physicochemical and hydrology, and natural disturbance regime.

LANDSCAPE CONTEXT

Buffer and Edge Length, Width, and Condition

Buffer and edge length, width, and condition are measures of the outer edge of an ecosystem and the area immediately surrounding it. Condition specifically addresses the intensity of human dominated land uses within a specified landscape area. The intensity and types of land uses around the assessment area can affect ecological integrity. There is abundant evidence on the value of buffers for wetlands (Environmental Law Institute 2008) and uplands (Forman 1995). Buffer and edge metrics are measured using field-based, rapid protocols. GIS can be used to prior or after field visit to aid in determining buffer or edge length, width, and condition of non-native vegetation (Collins et al. 2006). We assumed a 200m width would capture effects for most vegetation or habitat units (Table 4 for Level 1 EIAs).The edge width may also vary based on the ecosystem being assessed (Table 5 for Level 2 and 3 EIAs).

Table 4. Level 1 Ecological Integrity Assessment applicable to all natural ecosystems (adapted from Faber-Langendoen et al. 2009a).

General ecological attribute	Metric and/or ecosystem	Rank			
		A (5 points)	**B (4 points)**	**C (3 points)**	**D (1 point)**
Landscape Context	Edge/buffer length	Buffer ≥75% of occurrence perimeter	Buffer ≥50–75% of occurrence perimeter	Buffer ≥25–50% of occurrence perimeter	Buffer <25% of occurrence perimeter
	Edge/buffer width[a]	Average buffer width of occurrence is >200m	Average buffer width ≥100–200m	Average buffer width ≥50–100m	Average buffer width <50m
	Landscape condition model	Landscape condition model 1.0–0.9	Landscape condition model 0.89–0.75	Landscape condition model 0.75–0.5	Landscape condition model <0.5
	Connectivity	Intact: Embedded in 90-100% natural habitat; connectivity expected to be high	Variegated: Embedded in 60-90% natural habitat; connectivity generally high, but lower for species sensitive to habitat modification	Fragmented: Embedded in 20-60% natural habitat; connectivity generally low, but varies with species mobility	Relictual: Embedded in <20% natural habitat; connectivity essentially absent
	Relative patch size	Minimally reduced from natural extent (>95% remains)	Modestly reduced from natural extent (80–95% remains)	Substantially reduced from natural extent (50–80% remains)	Severely reduced from natural extent (<50% remains)
	Absolute patch size (ha) and length (km)	Matrix: >5,000ha	500–5,000ha	50–500ha	<50ha
		Large Patch: >500ha	50–500ha	5–50ha	<5ha
		Small Patch: >10ha	2–10ha	0.5–2ha	0.5ha
		Linear: >5km	1–5km	0.1–1km	<0.1km
Vegetation condition	Forest ecosystems	Vegetation cover >80%, woody cover >40%; crown size diversity large or ≥20 tree stems >50cm DBH/ha	Vegetation cover >80%, woody cover >10%, crown size diversity moderate, or ≥10 tree stems >50cm DBH/ha	Vegetation cover >50%, woody cover >10%, crown Size diversity low or ≥5 tree stems >50cm DBH/ha	Vegetation cover <50%, woody cover <10%, crown diversity low or <5 tree sems >50cm DBH/ha
	Woodland ecosystems	Vegetation cover >80%, woody cover >25%	Vegetation cover >80%, woody cover >10%	Vegetation cover >50%, woody cover >10%	Vegetation cover <50%, woody cover <10%

	Naturally closed shrubland ecosystems	Shrub cover ≥40%, diversity of patch types and woody cover ≤5%.		Shrub cover 25-39%, little patch diversity both spatially and vertically (<5%)	Shrub cover <25%, weedy herbaceous cover may be > shrub cover
	Naturally open shrubland ecosystems	Shrub cover ≥15% and ≤35%, if shrub cover >35% then it is usually invaded by aggressive woody species or it is a misidentified naturally closed shrubland ecosystem		Shrub cover ≥10% and <15%	Shrub cover <10%
	Grassland and meadow ecosystems	Cover >80% or near reference conditions; diversity of patch types and woody cover <10%; if herbaceous cover dominated by annual vegetation, species are native	Cover >80% or near reference conditions; woody cover <10%; diversity of patch types may be diminished; if herbaceous cover dominated by annual vegetation, species are native	Cover >50%; little patch diversity spatially and vertically; woody cover <10%	Cover <50%, woody cover >10%
	Shrubsteppe ecosystems	Grass cover ≥80%; shrubs well spaced, generally 5–25% cover	Grass cover >50–80%; increaser shrubs (e.g. *Artemisia tridentata*) may be denser than pre-disturbance, but still <35%	Grass cover ≥30%, but ≤50%; shrub cover approaching <5%, or >25%	Grass cover <50%; shrub cover may be >40%
	Tree savanna ecosystems	Cover between trees enough to carry frequent surface fires; tree density <30/ha, but may be up to 200/ha on small rocky inclusions	Cover between trees enough to carry frequent surface fires; tree density <40/ha, but may be up to 600/ha on small rocky inclusions	Cover between trees too sparse to carry frequent surface fires; tree density <40/ha, but may be up to 600/ha on small rocky inclusions	Cover between trees nearly absent; tree density >800/ha on deep as well as rocky sites
Hydrology condition	Non-riparian wetland ecosystems	No alterations such as dikes, diversions, ditches, flow additions, pugging, fill, or wells that restricts, redirects, or lowers flow or water table	Low intensity alterations such as roads at/near grade, pugging, small diversions or ditches (<30cm deep), small flow additions, or few wells	Moderate alterations such as 2-lane roads, low dikes, pugging, roads with culverts, medium diversions or ditches (30–90cm deep), moderate flow additions or wells	High alterations such as 4-lane roads, large dikes, diversions, ditches (>90 cm deep), large amounts of fill, flow additions, groundwater and well pumping
	Riparian ecosystems (floodplains)	Floodplain within natural range of variability; no geomorphic modifications (e.g., incised channel, dikes, levees, riprap, bridges, road beds)	Floodplain slightly disrupted due to the presence of few geomorphic modifications; <20% of area affected	Floodplain highly disrupted due to multiple geomorphic modifications; 20–50% of area affected	Complete geomorphic modification along floodplain; channel steep, incised gulley due to anthropogenic impacts on >50% of area
	Riparian ecosystems (upstream surface water)	<5% of basin drains to surface water storage facilities	>5–20% of basin drains to surface water storage facilities	>20–50% of basin drains to surface water storage facilities	>50% of basin drains to surface water storage facilities
	Riparian ecosystems (upstream diversions)	No upstream, onsite, or downstream water diversions present	Few diversions present and their impacts are minor relative to watershed size; onsite and downstream diversions, if present, have minor impact on local hydrology	Many diversions present and impacts moderate relative to watershed size; onsite and downstream diversions, if present, appear to have major impact on local hydrology	Water diversions numerous and impacts are high relative to watershed size; onsite and downstream diversions, if present, have major impact on local hydrology
Natural disturbance regime	Fire condition in upland ecosystems	No departure from historic fire regime	Slight departure from historic fire regime	Moderate departure from historic fire regime	Severe departure from historic fire regime
Physicochemical condition	On site land use	Land use index score 1.0–0.95	Land use index score 0.95–0.80	Land use index score 0.80–0.40	Land use index score <0.40

[a]Buffer widths and edges should be adjusted upward to compensate for slope. A multiplier of 1.3 should be used for slopes of 5-14%, 1.4 for slopes of 15-40%, and 1.5 for slopes >40%.

Table 5. Level 2 and 3 Ecological Integrity Assessment scorecard for buffer and edge length, width, and condition by ecosystem type (Appendix C) on wildlife areas in Washington.

Ecosystem type	Rank			
	A (5 points)	**B (4 points)**	**C (3 points)**	**D (1 point)**
Buffer and edge length				
All ecosystems	≥75% of edge bordered by natural communities	≥50–75% of edge bordered by natural communities	≥25–50% of edge bordered by natural communities	<25% of edge bordered by natural communities
Buffer and edge width				
Columbia Basin Foothill Canyon Dry Grassland Columbia Basin Palouse Prairie Columbia Basin Steppe and Grassland Columbia Plateau Scabland Shrubland Intermountain Basins Semidesert shrubsteppe Intermountain Basins Montane Big Sagebrush Steppe Intermountain Basins Big Sagebrush Steppe Intermountain Basins Semidesert Grassland Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland and Rocky Mountain Subalpine Mesic-Wet Spruce-Fir Forest and Woodland Rocky Mountain Lodgepole Pine Forest East Cascades Mesic Montane Mixed-Conifer Forest and Woodland East Cascades Oak-Ponderosa Pine Forest and Woodland Northern Rocky Mountain Subalpine Woodland and Parkland Northern Rocky Mountain Mesic Montane Mixed Conifer Forest Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest Northern Rocky Mountain Subalpine-Upper Montane Grassland Northern Rocky Mountain Subalpine Deciduous Shrubland Northern Rocky Mountain Lower Montane, Foothill and Valley Grassland	Average width of edge ≥100m	Average width of edge ≥75–100m	Average width of edge ≥25–75m	Average width of edge <25m
Columbia Plateau Low Sagebrush Steppe Intermountain Basins Cliff and Canyon Intermountain Basins Active Stable Dunes Rocky Mountain Cliff, Canyon and Massive Bedrock Rocky Mountain Aspen Forest and Woodland Northern Rocky Mountain Western Larch Woodland and Savanna Northern Rocky Mountain Ponderosa Pine Woodland and Savanna Northern Rocky Mountain Foothill Conifer Wooded Steppe Northern Rocky Mountain Montane-Foothill Deciduous Shrubland Rocky Mountain Subalpine-Montane Riparian Woodland Rocky Mountain Subalpine-Montane Riparian Shrubland Rocky Mountain Subalpine-Montane Mesic Meadow Rocky Mountain Alpine-Montane Wet Meadow Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland North American Arid Freshwater Emergent Marsh Intermountain Basins Greasewood Flat Intermountain Basins Alkali Closed Depression and Playa Columbia Plateau Vernal Pool Columbia Basin Foothill Riparian Woodland and Shrubland	Average width of edge ≥200m	Average width of edge ≥100–200m	Average width of edge ≥50–100m	Average width of edge <50m
Buffer and edge condition				
All ecosystems	>95% native vegetation cover; <5% non-native cover; intact soils	75–95% cover native vegetation; 5–25% cover of non-native plants; intact or moderately disrupted soils	25–50% cover non-native plants; moderate or extensive soil disruption	>50% cover non-native plants; barren ground; highly compacted or otherwise disrupted soils

Connectivity

Landscape connectivity can be defined as "a measure of the percent of unaltered (natural) habitat within a specified landscape area (non-riverine), or degree to which the riverine corridor above and below a floodplain area exhibits connectivity with adjacent natural riverine systems" (McIntyre and Hobbs 1999, Collins et al. 2007). Habitat loss and fragmentation have synergistic cumulative impacts upon remaining natural areas. As more habitat is altered, remaining fragments become more important to remaining wildlife populations. These remaining fragments are also more likely to be isolated and have disruptions to structure, biotic composition, ecosystem functions, and natural disturbance regimes, such as grazing or fires. The percentage of anthropogenic (altered) patches provides an estimate of connectivity among natural ecological systems.

McIntyre and Hobbs (1999) reviewed the full continuum of landscape alteration, and summarized the changes into four landscape states: (1) intact; (2) variegated; (3) fragmented; and (4) relictual. This metric primarily accounts for outright conversion of natural habitat to other habitats; it does not directly address the degree of "habitat modification" or condition of the remaining natural habitat (McIntyre and Hobbs 1999). It is also primarily a gross assessment of landscape alteration, and individual species may respond differently to these four states.

Typically, the specification of landscape area varies depending on the spatial scale of the system under study. For matrix types, a 10,000 ha area can be used to reference a large large landscape. Alternatively, a smaller area of 4,000 ha can also be justified. Large patch types could use a 1000 ha to reference a small landscape and 100 ha to reference a local landscape. Small patch communities could use the local landscape definition of 100 ha. But when a Level 1 assessment is applied to broadly classified types (e.g. deciduous forest, evergreen shrubland, perennial grassland), it is hard to know the ideal scale of the landscape area.

In non-riverine ecosystems the metric is fairly simple, treating the landscape in a binary fashion (either natural or non-natural), and for a Level 1 metric this may be sufficient. But a more sophisticated metric should accommodate the idea that landscape types have varying degrees of connectivity, depending on the variety of natural and non-natural ecosystem types.

In riverine ecosystems corridors should allow uninterrupted movement of animals to up- and down-stream portions of the riparian zone as well as access to adjacent uplands (Gregory et al. 1991). Riverine areas were historically comprised of a continuous corridor of intact natural vegetation along the stream channel and floodplain (Smith 2000). These corridors also allow for unimpeded movement of surface and overbank flow, which are critical for the distribution of sediments and nutrients as well as recharging local alluvial aquifers. Fragmentation of the riverine corridor can occur as a result of human alterations such as roads, power and pipeline corridors, agriculture activities, and urban/industrial development (Smith 2000, Collins et al. (2007).

This metric is measured by estimating the amount of natural habitat in a pre-defined landscape area surrounding the stand or polygon and dividing that by the total area (Table 4 for Level 1 EIAs and Table 6 for Level 2 and 3 EIAs). Natural habitat includes both natural and semi-natural habitat, but excludes cultural habitat, namely agriculture and developed (urban, suburban) habitats. This measure can be completed in the office using aerial photographs or GIS, then, if possible or desirable, verifying the natural cover in the field (Collins et al. 2007).

Table 6. Level 2 and 3 Ecological Integrity Assessment scorecard for landscape connectivity by ecosystem type (Appendix C) on wildlife areas in Washington.

Ecosystem type	**Rank**			
	A (5 points)	**B (4 points)**	**C (3 points)**	**D (1 point)**
Columbia Basin Foothill Canyon Dry Grassland Columbia Basin Palouse Prairie Columbia Basin Steppe and Grassland Columbia Plateau Scabland Shrubland Columbia Plateau Low Sagebrush Steppe Intermountain Basins Semidesert shrubsteppe Intermountain Basins Montane Big Sagebrush Steppe Intermountain Basins Big Sagebrush Steppe Intermountain Basins Semidesert Grassland Intermountain Basins Cliff and Canyon Intermountain Basins Active Stable Dunes Rocky Mountain Cliff, Canyon and Massive Bedrock Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland and Rocky Mountain Subalpine Mesic-Wet Spruce-Fir Forest and Woodland Rocky Mountain Lodgepole Pine Forest Rocky Mountain Aspen Forest and Woodland East Cascades Mesic Montane Mixed-Conifer Forest and Woodland East Cascades Oak-Ponderosa Pine Forest and Woodland Northern Rocky Mountain Western Larch Woodland and Savanna Northern Rocky Mountain Subalpine Woodland and Parkland Northern Rocky Mountain Ponderosa Pine Woodland and Savanna Northern Rocky Mountain Mesic Montane Mixed Conifer Forest Northern Rocky Mountain Foothill Conifer Wooded Steppe Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest Northern Rocky Mountain Subalpine-Upper Montane Grassland Northern Rocky Mountain Subalpine Deciduous Shrubland Northern Rocky Mountain Montane-Foothill Deciduous Shrubland Northern Rocky Mountain Lower Montane, Foothill and Valley Grassland Rocky Mountain Subalpine-Montane Mesic Meadow Rocky Mountain Alpine-Montane Wet Meadow Intermountain Basins Greasewood Flat Intermountain Basins Alkali Closed Depression and Playa Columbia Plateau Vernal Pool North American Arid Freshwater Emergent Marsh	Intact: Embedded in 90–100% natural habitat; connectivity expected to be high	Variegated: Embedded in 60–90% natural habitat; connectivity generally high, but lower for species sensitive to habitat modification; mosaic with both gradients and abrupt boundaries	Fragmented: Embedded in 20–60% natural habitat; connectivity generally low, but varies with species mobility and arrangement on landscape; gradients shortened	Relictual: Embedded in <20% natural habitat; connectivity essentially absent; remaining habitat uniform
Rocky Mountain Subalpine-Montane Riparian Woodland Rocky Mountain Subalpine-Montane Riparian Shrubland Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland Columbia Basin Foothill Riparian Woodland and Shrubland	Watershed primarily natural; no connectivity barriers/dams; <5% urban and agriculture; no recent clearcuts	Landscape primarily natural; connectivity mostly retained; 5-20% urban or agriculture; <30% clearcut	20-50% urban or agriculture; limited connectivity; <50% in clearcuts	>50% urban or agriculture; connectivity largely disrupted (dams)

The categorical ratings are based principally on McIntyre and Hobb's (1999) review of the literature showing that organisms are largely unaffected by landscapes with at least 60% habitat retention, whereas below 10% there appears to be a dramatic difference in bird composition on landscapes and fragmentation effects are severe (Andrén 1994). We use 20% as a more precautionary cutoff. Heinz Center (2002) used >90% forest as a measure of unaltered or unfragmented habitat (core = 100%, interior=90-99%), and 60-90% as "connected" forest. Heinz Center is also investigating the use of a fragmentation index that takes into account roads that occur within the neighborhood area (Cavender-Bares pers. comm. 2005). It is assumed that landscape connectivity operates similarly in other vegetation types.

Landscape Condition

Landscape condition addresses the intensity of human-dominated land uses within a specified landscape area. The Landscape Integrity Model incorporates multiple stressors, their varying individual intensities, the combined and cumulative effect of those stressors, and if possible, some measure of distance away from each stressor where negative effects remain likely (Comer and Hak 2009).

The Landscape Integrity Model is a GIS-based algorithm which plugs various land use GIS layers (roads, land cover, water diversions, groundwater wells, dams, mines, etc.) weighted according to their perceived impact on ecological integrity, into a distance-based, decay function to determine what effect these stressors have on landscape integrity. Land uses may have different impacts on ecological patterns and processes. Some land uses have minimal impact, such as simply altering the integrity of native vegetation (e.g., recreation and grazing), while other activities (e.g., production of hay and other crops) may replace native vegetation with nonnative or cultural vegetation, yet still provide potential cover for species movement. Intensive land uses (i.e., urban development, roads, mining, energy development) may completely destroy vegetation and drastically alter ecological processes. Coefficients in the model were assigned according to best scientific judgment regarding each land use's potential impact (Table 7). The product of the model is a map depicting areas according to their potential integrity. The index is segmented into rank classes from slightly impacted to highly impacted (Table 8 for Level 2 and 3 EIAs).

Table 7. Level 2 and 3 Ecological Integrity Assessment scorecard for landscape condition by ecosystem type (Appendix C) on wildlife areas in Washington.

Current Land Use	Model coefficient
Paved roads/parking lots/domestic or commercially developed buildings	0.0
Mining (gravel pit, quarry, open pit, strip mining)	0.0
Unpaved Roads (e.g., driveway, tractor trail)	0.1
Abandoned mines	0.1
Agriculture (tilled crop production)	0.2
Intensively developed vegetation (golf courses, lawns, etc.)	0.2
Vegetation conversion (chaining, cabling, rotochopping, clearcut)	0.3
Heavy grazing on rangeland or pastures	0.3
Heavy logging or tree removal with 50-75% of trees >30 cm DBH removed	0.4
Intense recreation (ATV use/camping/sport fields/popular fishing spot, etc.)	0.4
Military training areas (armor, mechanized)	0.4
Agriculture - permanent crop (vineyards, orchards, nurseries, berry production, introduced hay field and pastures, etc)	0.4
Commercial tree plantations and Christmas tree farms	0.5
Dam sites and flood disturbed shorelines around water storage reservoirs	0.5

Recent old fields and other disturbed fallow lands dominated by ruderal and exotic species	0.5
Moderate grazing on rangeland	0.6
Moderate recreation (high-use trail)	0.7
Mature old fields and other fallow lands with natural composition	0.7
Selective logging or tree removal with <50% of trees >30 cm DBH removed	0.8
Light grazing and light recreation (low-use trail)	0.9
Haying of native grassland	0.9
Natural area (land managed for native vegetation)	1.0

Table 8. Level 2 and 3 Ecological Integrity Assessment scorecard for landscape condition by ecosystem type (Appendix C) on wildlife areas in Washington.

Ecosystem type	**Rank**		
	A and B combined (5 points)	**C (3 points)**	**D (1 point)**
All ecosystems	Landscape Integrity Model >0.8	Landscape Integrity Model 0.8–0.65	Landscape Integrity Model <0.65

Relative and Absolute Size

Relative size can be defined as the current size of an ecosystem patch divided by the historic size (within most recent period of intensive settlement or 200 years), multiplied by 100. Absolute size is the current size (ha) of the ecosystem patch compared to reference stands of the type throughout its range. These metrics were adapted from Faber-Langendoen et al. (2009*a*). The relative size metric is adapted from Rondeau (2001) and the absolute size metric is adapted from NatureServe's Ecological Integrity Assessment Working Group.

Patch size (relative or absolute) is an indication of the amount of the change caused by human-induced disturbances. It provides information that allows the user to calibrate the current size to the historic patch size for the ecosystem. It also provides information about the potential occupancy of the patch by animal and plant species. Larger patches also tend to have more microhabitat features and they are more resistant to stressors such as invasion by exotics. Thus patch size can serve as a readily measured proxy for ecological processes and the diversity of interdependent assemblages of plants and animals.

Relative and absolute patch size can be measured using field-based, rapid protocols with GIS support in Level 1 (Table 6). Field calibration of size may be required since it can be difficult to discern the historic area from remote sensing data. Size can also be estimated in the field using aerial photographs, orthophoto quads, 7.5 minute topographic quads, USNPS Vegetation Mapping maps, National Wetland Inventory maps, or a global positioning system. The definition of the historic timeframe will vary by region, but generally refers to the intensive Euro-American settlement and influence on ecological processes in the mid-1800s. If the historic time frame is unclear, use a 200-year time period, long enough to ensure that the ecosystem effects are well-established. Size ranges of reference stands can be derived from National Wetland Inventory maps, other previous mapping efforts, and estimates from expert-based efforts such as Ecoregional Assessments or Natural Heritage Program efforts. Scaling criteria are based on

Rondeau (2001), Faber-Langendoen et al. (2008), and best scientific judgment. Level 2 and 3 EIAs are summarized by percent category for relative and absolute patch size (Table 4 for Level 1 EIAs and Table 9 for Level 2 and 3 EIAs).

Table 9. Level 2 and 3 Ecological Integrity Assessment scorecard for relative and absolute patch size by ecosystem type on wildlife areas (Appendix C) in Washington.

Ecosystem type	**Rank**			
	A (5 points)	**B (4 points)**	**C (3 points)**	**D (1 point)**
Relative Patch Size				
All ecosystems	Site at or minimally reduced from natural extent (≥95% remains)	Occurrence modestly reduced from original natural extent (≥80-95% remains)	Occurrence substantially reduced from original natural extent (≥50–80% remains)	Occurrence severely reduced from original natural extent (<50% remains)
Absolute Patch Size				
Columbia Basin Foothill Canyon Dry Grassland	>100ha	>50–100ha	10–50ha	<10ha[a]
Columbia Basin Palouse Prairie	>1000ha	>500–1000ha	10–500ha	<10ha[a]
Columbia Basin Steppe and Grassland	>100ha	>50–100ha	10–50ha	<10ha[a]
Columbia Plateau Scabland Shrubland	>250ha	>25–250ha	2.5–25ha	<2.5ha
Columbia Plateau Low Sagebrush Steppe	>250ha	>25–250ha	2.5–25ha	<2.5ha
Intermountain Basins Semidesert shrubsteppe	>2000ha	>200–2000ha	20–200ha	<20ha[b]
Intermountain Basins Montane Big Sagebrush Steppe	>400ha	>200–400ha	120–200ha	<120ha[c]
Intermountain Basins Big Sagebrush Steppe	>1000ha	>500–1000ha	16–500ha	<16ha[d]
Intermountain Basins Semidesert Grassland	>1000ha	>500–1000ha	10–500ha	<10ha[a]
Intermountain Basins Cliff and Canyon	Large cliffs (>20m)	Medium cliffs (10-20m)	Small cliffs (5-10 m)	Cliffs <5m
Intermountain Basins Active Stable Dunes	>800ha	>400–800ha	160–400ha	<160ha
Rocky Mountain Cliff, Canyon and Massive Bedrock	Large cliffs (>20m)	Medium cliffs (10-20m)	Small cliffs (5-10 m)	Cliffs <5m
Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland and Rocky Mountain Subalpine Mesic-Wet Spruce-Fir Forest and Woodland	>10000ha	>1000–10000ha	100–1000ha	<100ha
Rocky Mountain Lodgepole Pine Forest	>10000ha	>1000–10000ha	100–1000ha	<100ha
Rocky Mountain Aspen Forest and Woodland	>25ha	>10–25ha	2.5–10ha	<2.5ha
East Cascades Mesic Montane Mixed-Conifer Forest and Woodland	>8000ha	>4000–8000ha	2000–4000ha	<2000ha
East Cascades Oak-Ponderosa Pine Forest and Woodland	>7500ha	>500–7500ha	50–500ha	<50ha
Northern Rocky Mountain Western Larch Woodland and Savanna	>7500ha	>500–7500ha	50–500ha	<50ha
Northern Rocky Mountain Subalpine Woodland and Parkland	>450ha	>45–450ha	4.5–45ha	<4.5ha
Northern Rocky Mountain Ponderosa Pine Woodland and Savanna	>7500ha	>500–7500ha	50–500ha	<50ha
Northern Rocky Mountain Mesic Montane Mixed Conifer Forest	>8000ha	>4000–8000ha	2000–4000ha	<2000ha
Northern Rocky Mountain Foothill Conifer Wooded Steppe	>1000ha	>500–1000ha	10–500ha	<10ha
Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest	>5000ha	>500–5000ha	50–500ha	<50ha
Northern Rocky Mountain Subalpine-Upper Montane Grassland	>225ha	>20–225ha	10–20ha	<10ha[e]
Northern Rocky Mountain Subalpine Deciduous Shrubland	>4000ha	>400–4000ha	40–400ha	<40ha
Northern Rocky Mountain Montane-Foothill Deciduous Shrubland	>1000ha	>500–1000ha	1–500ha	<1ha
Northern Rocky Mountain Lower Montane, Foothill and Valley Grassland	>1000ha	>500–1000ha	10–500ha	<10ha[a]
Rocky Mountain Subalpine-Montane Riparian Woodland	>25 meander wavelengths or >50 point bars	>10–25 meander wavelengths or >20-50 point bars	4–10 meander wavelengths or 8-20 point bars	<4 meander wavelengths or <8 point bars
Rocky Mountain Subalpine-Montane Riparian Shrubland	>25 meander wavelengths or >50 point bars	>10–25 meander wavelengths or >20-50 point bars	4–10 meander wavelengths or 8-20 point bars	<4 meander wavelengths or <8 point bars
Rocky Mountain Subalpine-Montane Mesic Meadow	>120ha	>12–120ha	1–12ha	<1ha
Rocky Mountain Alpine-Montane Wet Meadow	>30ha	>8–30ha	0.5–8ha	<0.5ha
Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland	>8 linear km or >25 meander wavelengths or >50 point bars	>5-8 linear km or >10–25 meander wavelengths or >20-50 point bars	1.5-5 linear km or 4–10 meander wavelengths or 8-20 point bars	<1.5 linear km or <4 meander wavelengths or <8 point bars
North American Arid Freshwater Emergent Marsh	>80ha	>30–80ha	2–30ha	<2ha

Intermountain Basins Greasewood Flat	>4000ha	>400–4000ha	20–400ha	<20ha
Intermountain Basins Alkali Closed Depression and Playa	>8ha	>4–8ha	1–4ha	<1ha
Columbia Plateau Vernal Pool	>0.02ha	0.001–0.02ha		<0.001ha
Columbia Basin Foothill Riparian Woodland and Shrubland	>25 meander wavelengths or >50 point bars	>10–25 meander wavelengths or >20-50 point bars	4–10 meander wavelengths or 8-20 point bars	<4 meander wavelengths or <8 point bars

[a]Based on grasshopper sparrow conservation minimum (Paczek 2004).
[b]Based on home range size for the black-tailed jackrabbit.
[c]Based on occupancy data for sage sparrow.
[d]Based on home range size for sage sparrow.
[e]Based on viable populations of grassland birds.

Patch Diversity

Ecological diversity of a site is correlated with biotic/abiotic patch richness (Collins et al. 2006, Faber-Langendoen 2009*a*). Unimpacted sites have an expected range of biotic/abiotic patches. Increasing physical complexity tends to increase ecological functions, beneficial uses, as well as overall condition of an ecosystem. Human-induced alterations can decrease patch richness by homogenizing microtopography, altering channel characteristics, etc. The metric is adapted from Rocchio (2006) and is not a measure of the spatial arrangement of each patch.

This metric is measured by determining the number of biotic/abiotic patches present at a site and dividing by the total number of possible patches for the specific ecosystem type. This percentage is then used to rate the metric in the scorecard. Although the scaling criteria are based on Collins et al. (2006), scientific judgment also was used (Table 4 for Level 1 EIAs and Table 10 for Level 2 and 3 EIAs).

Table 10. Level 2 and 3 Ecological Integrity Assessment scorecard for patch diversity by ecosystem type (Appendix C) on wildlife areas in Washington.

Ecosystem type	**Rank**			
	A (5 points)	**B (4 points)**	**C (3 points)**	**D (1 point)**
Intermountain Basins Cliff and Canyon Rocky Mountain Cliff, Canyon and Massive Bedrock	No or little change in patch types due to human stressors	<50% change in expected patch types due to human stressors	>50% change in expected patch types due to human stressors	All or most patch types changed due to human stressors
Rocky Mountain Lodgepole Pine Forest	>90% of patches result from natural processes	75-90% of patches result from natural processes	50-75% of patches result from natural processes	<50% of patches result from natural processes
East Cascades Mesic Montane Mixed-Conifer Forest and Woodland East Cascades Oak-Ponderosa Pine Forest and Woodland	Diverse mosaic approximating 65% late, 25% mid-, and 10% early seral stages	Diverse mosaic, with <65% late seral stages; mosaic may be simplified due to fire suppression	Cohort diversity low with most being early to mid-seral; interspersion simplified	
Northern Rocky Mountain Western Larch Woodland and Savanna Northern Rocky Mountain Ponderosa Pine Woodland and Savanna Northern Rocky Mountain Foothill Conifer Wooded Steppe	>75% of area dominated by widely-spaced large, old trees with shrub or herbaceous understory; remaining 25% post-fire shrublands or closed canopy of young trees	50-75% of area dominated by widely-spaced large, old trees with shrub or herbaceous understory	25-50% of area dominated by widely-spaced large, old trees with shrub or herbaceous understory	<25% of area dominated by widely-spaced large, old trees with shrub or herbaceous understory
Northern Rocky Mountain Mesic Montane Mixed Conifer Forest	Diverse assemblage of seral patches; 45-50% late seral, 35-45% mid-seral, 10-15% early seral	Diversity remains, but late seral patches reduced due to logging or fire suppression	Cohort diversity low; most mid-seral; interspersion simplified	Single cohort present

Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest	Diverse assemblage of seral patches; 40-60% old grouse in mosaic with dense regeneration	Diversity remains, but mid seral are reduced while eaerly and late seral patches are higher	Cohort diversity low; most mid and early seral; interspersion simplified	Single cohort present
Rocky Mountain Subalpine-Montane Riparian Woodland Rocky Mountain Subalpine-Montane Riparian Shrubland Columbia Basin Foothill Riparian Woodland and Shrubland	Connectivity within riparian reach unfragmented; heterogenous mix of connected patch types; mixed species and seral stages	Connectivity of confined reaches may be fragmented; connectivity and diversity present between patches	Connectivity of confined reaches moderately fragmented; connectivity and diversity restricted between patches; some patches isolated	Confined reaches severely fragmented; homogenous patch types; fragmentation prevalent
Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland	Heterogenous mix of well connected patch types; mixed mature species along with early seral stands	Expected patch diversity present but connectivity between patches becoming fragmented or less diverse than expected	Patch diversity low and becoming homogenous; few if any mature stands of trees; many patches isolated due to fragmentation	Mostly dominated by one patch type; fragmentation with the system

VEGETATION CONDITION

Cover of Native Species (Understory Plants)

Cover of Native Species or Native Understory Species refers to the percent cover of all plant species native to the region on the assessed area, not counting tree species. Native species provide a measure of the degree to which plant communities have been altered by human disturbance. With increasing human disturbance, non-native species invade and can dominate the site. This metric has been developed by the NatureServe's Ecological Integrity Assessment Working Group, building on a variety of related metrics that assess relative species richness of exotic species (Miller et al. 2006).

The protocol is an ocular evaluation of cover of non-tree native species. A field form should be used that describes species composition using either strata or growth forms (Jennings et al. 2009). For the strata method: (1) list all major strata such as tree, shrub, field, non-vascular, floating, submerged; (2) estimate strata cover and cover of exotic species. For the growth form approach: (1) list major growth forms such as tree (subdivided into overstory and regeneration), shrub (subdivided by tall and medium/low), forb, nonvascular, floating, submerged, epiphyte, and liana; (2) estimate strata cover and cover of exotic species. The field survey method for estimating structure may be: (1) semiquantitative Site Survey method where the observer walks the entire assessment area and makes notes on vegetation strata, its cover, and the cover of exotics or (2) quantitative Plot Data where a fixed area is surveyed using either plots or transects. The plot or transect is typically a 'rapid' plot, but a single intensive plot can also be taken. The metric is calculated by first estimating the total cover of the vegetation (preferably by tree, shrub, herb, and non-vascular layer). Because the layers are individually tallied, the total cover could easily exceed 100%. For the understory species metric, exclude tree layer value. The criteria are based on extrapolated thresholds from ecological site descriptions from Cooper (1990), Windell et al. (1986), and CNHP (2005*a*), and best scientific judgment (Table 11 for Level 2 and 3 EIAs). These criteria need further validation. Scaling of this metric using exotic species richness rather than cover is an alternative approach (Miller et al. 2006).

Table 11. Level 2 and 3 Ecological Integrity Assessment scorecard for Cover of native species by ecosystem type on wildlife areas (Appendix C) in Washington.

Ecosystem type	Rank			
	A (5 points)	B (4 points)	C (3 points)	D (1 point)
All ecosystems[a]	Cover of native plants ≥95%	Cover of native plants 80–95%	Cover of native plants 50–80%	Cover of native plants <50%

[a]In forest ecosystems native plants refer to the non-tree (understory) plants only.

Cover of Native Bunchgrass

Native bunchgrasses dominate native shrubsteppe and related grasslands. High density or narrow distance among bunches provides community resistance to invasion (Pellant 1996; Pyke et al. 2009). Native bunchgrass abundance varies by site type and climatic regime so cover measurements need to be evaluated by sites (See NRCS functional/structural types for historic reference conditions). The Level 2 metric is adapted from Washington Natural Heritage element occurrence rankings that were based on cover values in Daubenmire (1970) and field experience. Native bunchgrass cover varies by site type and climatic regime so measurements need to be standardized by sites (See NRCS functional/structural types for historic reference conditions). The Level 3 metric is adapted from Pellant (1996).

The Level 2 metric is measured using field-based, rapid protocols which may be either: (1) semiquantitative Site Survey method where the observer walks the entire assessment area and makes notes on vegetation strata, its cover, and the cover of exotics or (2) quantitative Plot Data where a fixed area is surveyed using either plots or transects. The plot or transect is typically a 'rapid' plot, but a single intensive plot can also be taken. The Level 3 metric would apply the same metric but use more standardized and consistent methods such as line-intercept (Pellent et al. 2000). The criteria are based on best scientific judgment based on values found in the literature cited above (Table 12 for Level 2 and 3 EIAs).

Table 12. Level 2 and 3 Ecological Integrity Assessment scorecard for cover of native bunchgrass by ecosystem type (Appendix C) on wildlife areas in Washington.

Ecosystem type	Rank			
	A (5 points)	B (4 points)	C (3 points)	D (1 point)
Columbia Basin Foothill Canyon Dry Grassland Columbia Basin Palouse Prairie Columbia Basin Steppe and Grassland Columbia Plateau Low Sagebrush Steppe Intermountain Basins Semidesert shrubsteppe Intermountain Basins Montane Big Sagebrush Steppe Intermountain Basins Big Sagebrush Steppe Intermountain Basins Semidesert Grassland Intermountain Basins Cliff and Canyon Northern Rocky Mountain Subalpine-Upper Montane Grassland Northern Rocky Mountain Lower Montane, Foothill and Valley Grassland	Perennial bunchgrass cover >80% or near site potential	Perennial bunchgrass cover 50–80% or reduced from site potential	Perennial bunchgrass cover 30–50% or reduced from site potential	Perennial bunchgrass cover <30% and much reduced from site potential
Columbia Plateau Scabland Shrubland	Perennial short bunchgrasses dominate cover near site potential	Perennial short bunchgrasses dominate cover, but slightly reduced from site potential by stressors	Perennial short bunchgrass domate cover, but cover clearly reduced from site potential by stressors	Perennial short bunchgrass dominate cover, but cover much reduced from site potential by stressors

Rocky Mountain Aspen Forest and Woodland Northern Rocky Mountain Ponderosa Pine Woodland and Savanna	Perennial bunchgrass cover >75% or near site potential	Perennial bunchgrass cover 50–75% or reduced from site potential	Perennial bunchgrass cover 25–50% or reduced from site potential	Perennial bunchgrass cover <25% and much reduced from site potential

Cover of Invasive Species

Cover of invasive species refers to the percent cover of a selected set of plant species that are considered invasive (new to the system) with human stressors. When invasive plants become established in habitats, they can inflict a suite of ecological damage to native species including loss of habitat, loss of biodiversity, decreased nutrition for herbivores, competitive dominance, overgrowth, struggling, and shading, resource depletion, alteration of biomass, energy cycling, productivity, and nutrient cycling (Dukes and Mooney 1999). Invasive plant species can also affect hydrologic function and balance, making water scarce for native species. Native species may become invasive when a process has been altered, such as fire suppression or changed in duration or intensity as with introduced novel grazing regimes. Exotic invasive species with characteristic novel to a system or introduce new system responses to natural processes, such as, the fire-cheatgrass cycle, are targeted.

This metric has been drafted by NatureServe's Ecological Integrity Assessment Working Group, based in part on work by Tierney et al. (2009), Miller et al. (2006), and Pellent et al. (2000). This metric consists of an ocular evaluation of the relative proportion of vegetation comprised of exotic species. A field form should be used that describes exotic species composition using either strata or growth forms (FGDC 2008). For the strata method: (1) list all major strata such as tree, shrub, field, non-vascular, floating, submerged; (2) estimate strata cover and cover of exotic species. For the growth form approach: (1) list major growth forms such as tree (subdivided into overstory and regeneration), shrub (subdivided by tall and medium/low), forb, nonvascular, floating, submerged, epiphyte, and liana; (2) estimate strata cover and cover of exotic species. The field survey method for estimating structure may be: (1) semiquantitative Site Survey method where the observer walks the entire assessment area and makes notes on vegetation strata, its cover, and the cover of exotics or (2) quantitative Plot Data where a fixed area is surveyed using either plots or transects. The plot or transect is typically a 'rapid' plot, but a single intensive plot can also be taken. The grading criteria are based on scientific judgment (Table 4 for Level 1 EIAs and Table 13 for Level 2 and 3 EIAs).

Table 13. Level 2 and 3 Ecological Integrity Assessment scorecard for relative cover of invasive species by ecosystem type (Appendix C) on wildlife areas in Washington.

Ecosystem type	Rank			
	A (5 points)	B (4 points)	C (3 points)	D (1 point)
Columbia Basin Foothill Canyon Dry Grassland Columbia Basin Palouse Prairie Columbia Basin Steppe and Grassland Columbia Plateau Scabland Shrubland Columbia Plateau Low Sagebrush Steppe Intermountain Basins Semidesert shrubsteppe Intermountain Basins Montane Big Sagebrush Steppe Intermountain Basins Big Sagebrush Steppe Intermountain Basins Semidesert Grassland Intermountain Basins Cliff and Canyon Intermountain Basins Active Stable Dunes Rocky Mountain Cliff, Canyon and Massive Bedrock Rocky Mountain Aspen Forest and Woodland Northern Rocky Mountain Subalpine Woodland and Parkland Northern Rocky Mountain Ponderosa Pine Woodland and Savanna Northern Rocky Mountain Foothill Conifer Wooded Steppe Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest Northern Rocky Mountain Subalpine-Upper Montane Grassland Northern Rocky Mountain Montane-Foothill Deciduous Shrubland Northern Rocky Mountain Lower Montane, Foothill and Valley Grassland Rocky Mountain Subalpine-Montane Riparian Woodland Rocky Mountain Subalpine-Montane Riparian Shrubland Rocky Mountain Subalpine-Montane Mesic Meadow Rocky Mountain Alpine-Montane Wet Meadow Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland North American Arid Freshwater Emergent Marsh[a] Intermountain Basins Greasewood Flat Intermountain Basins Alkali Closed Depression and Playa Columbia Plateau Vernal Pool[b] Columbia Basin Foothill Riparian Woodland and Shrubland	None present	Invasive species present, but sporadic (<3% cover)	Invasive species prevalent (3–10% cover)	Invasive species abundant (>10% cover)
East Cascades Oak-Ponderosa Pine Forest and Woodland	None or minimal present (<1%)	Invasive species present, but sporadic (1-5% cover)	Invasive species prevalent (5–30% cover)	Invasive species abundant (>30% cover)

[a]Invasive species include *Typha*, *Phalaris*, and *Phragmites*.
[b]Invasive species include *Cirsium avense*, *Elytrigia repens*, and *Taeniatherum caputmedusae*).

Cover of Native Increasers

Cover of native increasers refers to the percent cover of a selected set of plant species that increase in abundance with human stressors in the system that is being assessed. Human stressors include artificially drained wetlands (Cooper 1990, Johnson 1996) or livestock grazing (Dyksterhuis 1949). Although increasers are native, they can be indicative of disturbance if they dominate areas previously occupied by reference sites dominants. This metric is adapted from Faber-Langendoen et al. (2008).

The protocol is an ocular evaluation of cover of native species that increase with disturbance. A field form should be used that describes species composition using either strata or growth forms (FGDC 2008). For the strata method: (1) list all major strata such as tree, shrub, field, non-vascular, floating, submerged; (2) estimate strata cover and cover of exotic species. For the growth form approach: (1) list major growth forms such as tree (subdivided into overstory and regeneration), shrub (subdivided by tall and medium/low), forb, nonvascular, floating, submerged, epiphyte, and liana; (2) estimate strata cover and cover of exotic species. Species may increase or decrease with human stressors depending on the system being assessed. Shrubsteppe and grassland vegetation guides and NRCS documents often have species listed by response to disturbance. Either develope a list of indicator species prior to the field survey or evaluate a more complete species list and determine species behavior later (longer process). The field survey method for estimating structure may be: (1) semiquantitative Site Survey method where the observer walks the entire assessment area and makes notes on vegetation strata, its cover, and the cover of exotics or (2) quantitative Plot Data where a fixed area is surveyed using either plots or transects. The plot or transect is typically a 'rapid' plot, but a single intensive plot can also be taken for calibration. The grading criteria are based on scientific judgment (Table 14 for Level 2 and 3 EIAs).

Table 14. Level 2 and 3 Ecological Integrity Assessment scorecard for cover of native increasers by ecosystem type (Appendix C) on wildlife areas in Washington.

Ecosystem type	**Rank**			
	A (5 points)	**B (4 points)**	**C (3 points)**	**D (1 point)**
Columbia Basin Foothill Canyon Dry Grassland Columbia Basin Palouse Prairie Columbia Basin Steppe and Grassland Columbia Plateau Low Sagebrush Steppe Intermountain Basins Semidesert shrubsteppe Intermountain Basins Montane Big Sagebrush Steppe Intermountain Basins Big Sagebrush Steppe Intermountain Basins Semidesert Grassland Intermountain Basins Cliff and Canyon Intermountain Basins Active Stable Dunes Rocky Mountain Cliff, Canyon and Massive Bedrock Rocky Mountain Aspen Forest and Woodland[a] East Cascades Oak-Ponderosa Pine Forest and Woodland[a] Northern Rocky Mountain Subalpine Woodland and Parkland Northern Rocky Mountain Ponderosa Pine Woodland and Savanna Northern Rocky Mountain Foothill Conifer Wooded Steppe[a] Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest[a] Northern Rocky Mountain Subalpine-Upper Montane Grassland Northern Rocky Mountain Montane-Foothill Deciduous Shrubland Northern Rocky Mountain Lower Montane, Foothill and Valley Grassland Rocky Mountain Subalpine-Montane Riparian Woodland Rocky Mountain Subalpine-Montane Riparian Shrubland Rocky Mountain Subalpine-Montane Mesic Meadow Rocky Mountain Alpine-Montane Wet Meadow Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland North American Arid Freshwater Emergent Marsh Intermountain Basins Greasewood Flat Intermountain Basins Alkali Closed Depression and Playa Columbia Plateau Vernal Pool Columbia Basin Foothill Riparian Woodland and Shrubland	Absent or incidental	<10% cover	10-20% cover	>20% cover
Columbia Plateau Vernal Pool	Absent or incidental	*Apera interrupta*, *Hypericum perforatum*, *Lactuca serriola*, *Poa bulbosa*, *Sisymbrium altissimum*, and *Taeniatherum caputmedusae* present, but sporadic (<50% cover); litter thatch <65%	Prevalent (50-75% cover); litter that 65-80%	Abundant (>75% cover); litter thatch >80%

[a]Focused on understory plants only.

Species Composition

Species composition refers to the overall species composition and diversity by layer, including evidence of specific species' diseases or mortality. The overall composition of native species can shift when exposed to stressors. Trees, shrubs, forbs, and grasses play an important role in providing wildlife habitat, and they are the most readily surveyed aspect of biodiversity. Vegetation is the single largest component of net primary productivity. More detailed assessments can be derived from a composition list, such as, functional/structural indictors in Rangeland Health Indicators guides (Pellant et al. 2000) appropriate for Level 3 assessments. This metric has been drafted by NatureServe's Ecological Integrity Assessment Working Group.

The protocol for this metric is an ocular evaluation of overall species composition. These metrics require the ability to recognize the major-dominant plants species of each layer or stratum. When a field team lacks the necessary botanical expertise, voucher specimens will need to be collected using standard plant presses and site documentation. This can greatly increase the time required to complete an assessment. A field form should be used that describes composition using either strata or growth forms (FGDC 2008). For the strata method: (1) list all major strata such as tree, shrub, field, non-vascular, floating, submerged; (2) estimate strata cover and cover of exotic species. For the growth form approach: (1) list major growth forms such as tree (subdivided into overstory and regeneration), shrub (subdivided by tall and medium/low), forb, nonvascular, floating, submerged, epiphyte, and liana; (2) estimate strata cover and cover of exotic species. The field survey method for estimating structure may be: (1) semiquantitative Site Survey method where the observer walks the entire assessment area and makes notes on vegetation strata, its cover, and the cover of exotics or (2) quantitative Plot Data where a fixed area is surveyed using either plots or transects. The plot or transect is typically a 'rapid' plot, but a single intensive plot can also be taken. The metric is scaled based on the similarity between the dominant species composition of the vegetation and what is expected based on reference condition (Table 4 for Level 1 EIAs and Table 15 for Level 2 and 3 EIAs). Reference conditions reflect the accumulated experience of field ecologists, studies from sites where natural processes are intact, regional surveys and historic sources (Collins et al. 2006).

Table 15. Level 2 and 3 Ecological Integrity Assessment scorecard for species composition by ecosystem type on wildlife areas (Appendix C) in Washington.

Ecosystem type	**Rank**			
	A (5 points)	**B (4 points)**	**C (3 points)**	**D (1 point)**
All ecosystems	Diversity/abundance at or near reference standards; native species negative to anthropogenic degradation are present, species positive to anthropogenic degradation are absent to minor; full range of indicator species present	Diversity/abundance close to reference standards; native species reflective of anthropogenic degradation; some indicator species absent	Diversity/abundance differs from reference standards, but largely composed of native species; may include ruderal species; many indicator species absent	Vegetation severely altered from reference standards; dominated by ruderal species or comprised of planted stands of non-characteristic species or unnaturally dominated by single species; most indicator species absent

Shrub Cover

Fire-sensitive shrubs are deep-rooted, non-sprouting shrubs (*Artemisia tridentata* vars. *tridentata*, *wyomingensis* and *xericensis*, *Purshia tridentata*) that respond negatively to fire. Natural fire regimes promote patchy low cover big sagebrush or bitterbrush cover and consequently on herbaceous cover. The metric is adapted from NRCS (2004) functional/structural groups historic cover range and information in Perryman et al. (2001) and Davies et al. (2004). The Level 2 metric is adapted from Washington Natural Heritage element occurrence ranking that were based cover values in Daubenmire (1970) and field experience.

The Level 2 field survey protocol for measuring shrubs is a (1) semiquantitative Site Survey method where the observer walks the entire assessment area and makes notes on vegetation strata, its cover, and the cover of exotics or (2) quantitative Plot Data where a fixed area is surveyed using either plots or transects. The plot or transect is typically 'rapid', but a single intensive plot can also be conducted. Level 3 assessments are best accomplish using line-intercept transects (Pellant et al. 2005). The criteria are based on best scientific judgment based on values found in the literature cited above (Table 4 for Level 1 EIAs and Table 16 for Level 2 and 3 EIAs).

Table 16. Level 2 and 3 Ecological Integrity Assessment scorecard for shrub cover by ecosystem type (Appendix C) on wildlife areas in Washington.

Ecosystem type	**Rank**			
	A (5 points)	**B (4 points)**	**C (3 points)**	**D (1 point)**
Columbia Plateau Scabland Shrubland	Fire-sensitive shrubs mature and recovered from past fires	Fire-sensitive shrubs common, not fully recovered from past fires	Fire-sensitive shrubs present, recovering from past fires	Fire-sensitive shrubs rare due to past fires
Columbia Plateau Low Sagebrush Steppe	Fire-sensitive shrubs mature and recovered from past fires; generally <25% cover	Fire-sensitive shrubs common, not fully recovered from past fires	Fire-sensitive shrubs present, recovering from past fires	Fire-sensitive shrubs absent or rare due to past fires
Intermountain Basins Semidesert shrubsteppe Intermountain Basins Big Sagebrush Steppe	Fire-sensitive shrubs mature and recovered from past fires; generally 3–10% cover	Fire-sensitive shrubs not fully recovered from past fires, mostly seedlings shorter than bunchgrasses; generally <20% cover	Fire-sensitive shrubs generally >20% cover; beginning to affect bunchgrass layer	Fire-sensitive shrubs clearly >20% cover; reducing bunchgrass layer
Intermountain Basins Montane Big Sagebrush Steppe	Fire-sensitive shrubs mature and recovered from past fires; generally 3–20% cover	Fire-sensitive shrubs not fully recovered from past fires, mostly seedlings shorter than bunchgrasses; generally <50% cover	Fire-sensitive shrubs generally >50% cover; beginning to affect bunchgrass layer	Fire-sensitive shrubs clearly >50% cover; reducing bunchgrass layer
Northern Rocky Mountain Subalpine Deciduous Shrubland	Shrub cover ≥95%	Shrub cover ≥80-95%	Shrub cover ≥50-80%	Shrub cover <50%

Canopy Cover and Condition

Tree size and age are important structural attributes of a functioning forest, with its natural range of variability (Franklin et al. 2008, Agee 2003, Hessburg et al. 2005). Late seral trees are target of most timber harvesting and their structure is lost to forest functions. Canopy cover and condition refers to the dominant tree layer, including the density, stem size, and canopy cover relative to reference conditions. Intact areas have a diversity of age classes. Canopy structure is an important reflection of ecosystem dynamics. The distribution of total cover, crown diversity, and stem size reflects natural disturbance regimes across the landscape and affects the maintenance of biological diversity, particularly of species dependent upon specific stages. This metric is adapted from Agee (2003), Hessburg et al. (2005), Faber-Langendoen et al. (2008, 2009*a*), and Franklin et al. (2008).

This metric consists of an evaluation of the density, stem size, and canopy cover of the dominant layer relative to a reference (Table 4 for Level 1 EIAs and Table 17 for Level 2 and 3 EIAs). Level 1 and 2 assessments can be conducted remotely if accurate aerial photographs are available. The metric requires an evaluation of the canopy cover of the observable tree layer. Often, ground verification will be very helpful in interpreting the remote sensing signature. The field survey method for estimating structure may be either a: (1) semiquantitative Site Survey method where the observer walks the entire assessment area and records notes on vegetation strata and their cover or (2) quantitative Plot Data where a fixed area is surveyed using either standard plots, transects, or plotless methods. The plots are typically 'rapid', but a single intensive plot can also be taken. Scaling is based on professional judgment. For forests, we consulted old growth patterns (Tyrrell et al 1998) across many forest types. However, note that high montane and boreal forests may not have as many large stems typical of many lower elevation temperate forests. Conversely, stands in the Pacific coast rain forests may require a higher number of stems per size class or a change in size class limits (e.g. number of stems that exceed 100cm DBH). Addition reference studies from sites where natural processes are intact include Franklin et al. (2008), Agee (2003), and Hessburg et al (2005).

Table 17. Level 2 and 3 Ecological Integrity Assessment scorecard for tree canopy cover by ecosystem type (Appendix C) and seral stage on wildlife areas in Washington.

Ecosystem type	**Rank**			
	A (5 points)	**B (4 points)**	**C (3 points)**	**D (1 point)**
Mid-seral Forest				
East Cascades Mesic Montane Mixed-Conifer Forest and Woodland Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest	<10% of old trees harvested	10-30% of trees harvested	30-75% of trees harvested	>75% trees harvested
Late-seral Forest				
Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland and Rocky Mountain Subalpine Mesic-Wet Spruce-Fir Forest and Woodland	Majority of old trees not harvested; few stumps; large trees >150 years old; >25 old trees/ha (>38cm DBH)	10-30% old trees harvested; 10-25 old trees/ha (>38cm DBH)	>50% of old trees harvested; 5-10 old trees/ha (>38cm DBH)	Most, if not all, old trees harvested; <5 old trees/ha (>38cm DBH)
Rocky Mountain Lodgepole Pine Forest	Lodgepole pine dominates canopy; shade tolerant species in subcanopy only; no stumps	Lodgepole pine dominates canopy; 10-30% shade tolerant species in canopy only; some stumps	Lodgepole pine co-dominates canopy; 30-50% shade tolerant species in canopy; some stumps	Lodgepole pine co-dominates canopy; >50% shade tolerant species in canopy; some stumps
East Cascades Oak-Ponderosa Pine Forest and Woodland	>50% oak cover, 25-50% conifer cover; little harvest of old trees, >7 38cm DBH trees	40-50% oak cover, 25-50% conifer cover; <30% harvest of old trees, 7 38cm DBH trees	20-40% oak cover, 15-25% or 50-60% conifer cover; 30-75% harvest of old trees, 1-6 38cm DBH trees	<20% oak cover, <15% or >60% conifer cover; >75% harvest of old trees, 38cm DBH trees absent
Rocky Mountain Subalpine-Montane Riparian Woodland	Cover generally >50%; Mixed canopy of sufficient size to provide future large woody debris		Somewhat homogenous in density and age or <50% canopy cover	Extremely homogenous, sparse, or absent (<10% cover)
Northern Rocky Mountain Western Larch Woodland and Savanna Northern Rocky Mountain Ponderosa Pine Woodland and Savanna	<10% of old larch harvested; 25-75 >53cm DBH trees/ha; 5-15 >78cm DBH trees/ha	10-30% of old (>150 years) larch harvested	30-75% of old (>150 years) trees harvested	>75% of old (>150 years) trees harvested
East Cascades Mesic Montane Mixed-Conifer Forest and Woodland Northern Rocky Mountain Mesic Montane Mixed Conifer Forest Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest	<10% of old trees harvested; >25 old trees/ha (>150 years old, DBH >53cm)	10-30% old trees harvested; few stumps; 10-25 old trees/ha (>150 years old, DBH >53cm)	30-75% old trees harvested; 5-10 old trees/ha (>150 years old, DBH >53cm)	>75% old trees harvested; <5 old trees/ha (>150 years old, DBH >53cm)

Northern Rocky Mountain Subalpine Woodland and Parkland	<10% of old trees harvested	10-30% of old trees harvested	30-75% of old trees harvested	>75% of old trees harvested
Northern Rocky Mountain Subalpine Deciduous Shrubland Northern Rocky Mountain Montane-Foothill Deciduous Shrubland	Trees are absent	Trees shorter than shrubs and <10% cover	Trees pole-sized or smaller; susceptible to fire mortality; <10% cover	Trees larger than pole-sized, not susceptible to fire; <10% cover
Northern Rocky Mountain Foothill Conifer Wooded Steppe	<10% of old (>150 years) trees harvested	10-30% of old (>150 years) trees harvested	30-75% of old (>150 years) trees harvested	>75% of old (>150 years) trees harvested

Regeneration of Woody Species

The amount and spatial distribution of regeneration of woody species is important to maintaining historical structure and is an indication of integrity of disturbance regimes (Franklin et al. 2008, Agee 2003, Hessburg, et al. 2005). Intensive grazing by domestic livestock and/or alteration of natural flow regime can reduce or eliminate regeneration by native woody plants in riparian areas (Elmore and Kauffman 1994). Species such as willows depend on flooding to create new bare surfaces suitable for germination of willow seedlings (Woods 2001). In addition, base flows following flooding need to be high enough to maintain soil water content in these areas at or above 15% through July and August in order for these seedlings to survive long enough to establish a deep root system (Woods 2001). Beaver dams also create bare areas suitable for regeneration of woody species, especially as they accumulate silt and/or there is a breach in the dam. Lack of regeneration is indicative of altered ecological processes and has adverse impacts to the biotic integrity of the riparian area. This metric estimates the amount of regeneration of native woody plants (Table 4 for Level 1 EIAs and Table 18 for Level 2 and 3 EIAs). The metric is adapted from Rocchio (2006) and Faber-Langendoen et al. (2009*a*).

Table 18. Level 2 and 3 Ecological Integrity Assessment scorecard for regeneration of woody species (trees and shrubs) by ecosystem type (Appendix C) on wildlife areas in Washington.

Ecosystem type	**Rank**			
	A (5 points)	**B (4 points)**	**C (3 points)**	**D (1 point)**
Rocky Mountain Aspen Forest and Woodland	'Stable' condition characterized by multiple size trees, regeneration, and little aspen mortality	'Successional to conifers' characterized by conifers replacing aspen; aspen regeneration may be present, but not abundant		'Decadent' characterized by little to no regeneration and aspen mortality; conifers may be present
Rocky Mountain Subalpine-Montane Riparian Woodland Rocky Mountain Subalpine-Montane Riparian Shrubland Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland Columbia Basin Foothill Riparian Woodland and Shrubland	Saplings/seedlings of native woody species present in expected amount	Saplings/seedlings of native woody species present, but less than expected	Saplings/seedlings of native woody species present, but in low abundance	No reproduction of native woody species
Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest	Regeneration limited and occurs in natural gaps within older stands	Regeneration occurring outside natural gaps (10-25% of site); <300 >2.5cm DBH trees/ha	Regeneration occurring outside natural gaps (25-50% of site); 300-750 >2.5cm DBH trees/ha	Small and medium sized trees in multiple layered canopies throughout; density >750 >2.5cm DBH trees/ha

This metric is measured by determining the distribution and abundance of each species' regeneration in the assessment area. This is completed in the field and ocular estimates are used to match regeneration with categorical ratings in the scorecard. Level 2 estimates are either: (1) semiquantitative Site Survey method where the observers walks the entire assessment area or (2) quantitative Plot Data where a fixed area is surveyed, using either plots or transects. The plot is typically a ‘rapid’ plot, but a single intensive plot can also be taken. More intensive Level 3 assessments are typically fixed radius 0.04ha plots arranged along transects or placed to sample the variation in canopy structure. The criteria are based on best scientific judgment.

Course Woody Debris

Woody debris refers to accumulated dead woody material including downed logs and snags >10cm in diameter. Accumulation of coarse woody debris can be minimal in some forests due to recurring fire and too much debris can increase risk from fire. The metric is adapted from Franklin et al. (2008).

This metric is measured using field-based, rapid protocols for a Level 2 assessment (Table 19 for Level 2 and 3 EIAs). The field survey method for estimating structure may be: (1) Semiquantitative Site Survey (semiquantitative) where the observer walks the entire assessment area and records the size, distribution, and abundance of woody debris or (2) Quantitative Plot Data where a fixed area is surveyed using standard plot or transect methods. The plots are typically ‘rapid’, but a single intensive plot can also be taken. Level 3 assessments (Table 21) are more intensive and follow standard protocols developed by the USFS (1993) and Brown (1974). Scaling of woody debris measurements are based on similarity between observed coarse woody debris and what is expected based on reference conditions. Reference conditions reflect the accumulated experience of field ecologists, studies from sites where natural processes are intact, regional surveys, and historic sources.

Table 19. Level 2 and 3 Ecological Integrity Assessment scorecard for woody debris by ecosystem (Appendix C) type on wildlife areas in Washington.

Ecosystem type	Rank			
	A (5 points)	**B (4 points)**	**C (3 points)**	**D (1 point)**
Course Woody Debris				
Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland and Rocky Mountain Subalpine Mesic-Wet Spruce-Fir Forest and Woodland East Cascades Oak-Ponderosa Pine Forest and Woodland Northern Rocky Mountain Western Larch Woodland and Savanna Northern Rocky Mountain Foothill Conifer Wooded Steppe	Within old forests, few large (>2m high and 30cm DBH) snags and downed logs	Snags and down logs 10-30cm DBH or <2m high may be abundant		Snags and downed logs 10-30cm DBH or <2 m high very abundant
East Cascades Mesic Montane Mixed-Conifer Forest and Woodland Northern Rocky Mountain Mesic Montane Mixed Conifer Forest	Large snags frequent; unless in natural, late stem exclusion stage; wide variety of downed log sizes with large variation in stages of decay	Large snags occasionally present; moderately wide variety of downed log sizes with some variation in levels of decay		Large snags absent; low variety of downed log sizes with most logs in early stages of decay
Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest	Within old forests, few large (>2m high and 30cm DBH) snags and downed logs	Snags and down logs 10-30cm DBH or <2m high may be abundant	Snags and downed logs 10-30cm DBH or <2 m high very abundant	
East Cascades Oak-Ponderosa Pine Forest and Woodland	>7 38cm DBH trees and snags/ha	7 38cm DBH trees and snags/ha	<7 38cm DBH trees and snags/ha	38cm DBH trees and snags absent
Rocky Mountain Lodgepole Pine Forest	Snags and downed woody debris abundant in early-seral stages	Snags and downed woody debris moderately abundant in early-seral stages		Snags and downed woody debris sparse in early-seral stages
Columbia Basin Foothill Riparian Woodland and Shrubland	Characterized by wide size class diversity of downed coarse woody debris (logs) and standing snags	Moderately wide size class diversity of downed coarse woody debris (logs) and snags		Low size class diversity of downed coarse woody debris (logs) and snags

Woody debris <3m			
Rocky Mountain Subalpine-Montane Riparian Woodland	>28 pieces/100m channel length	15-28 pieces/100m channel length	<15 pieces/100m channel length
Woody debris 3-30m			
Rocky Mountain Subalpine-Montane Riparian Woodland	>56 pieces/100m channel length	25-56 pieces/100m channel length	<25 pieces/100m channel length
Woody debris 30-50m			
Rocky Mountain Subalpine-Montane Riparian Woodland	>63 pieces/100m channel length	22-63 pieces/100m channel length	<22 pieces/100m channel length
Woody debris <6m			
Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland	>29 pieces/100m channel length	5-29 pieces/100m channel length	<5 pieces/100m channel length
Woody debris 6-30m			
Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland	>35 pieces/100m channel length	5-35 pieces/100m channel length	<5 pieces/100m channel length

Organic Matter Accumulation

The accumulation of organic material and an intact litter layer are integral to a variety of wetland functions, such as surface water storage, percolation and recharge, nutrient cycling, and support of wetland plants (Collins et al. 2006). Intact litter layers provide areas for primary production and decomposition that are important to maintaining functioning food chains. They nurture fungi essential to the growth of rooted wetland plants. They support soil microbes and other detritivores that comprise the base of the food web in many wetlands. The abundance of organic debris and coarse litter on the substrate surface can significantly influence overall species diversity and food web structure. Fallen debris serves as cover for macroinvertebrates, amphibians, rodents, and even small birds. Litter is the precursor to detritus, which is a dominant source of energy for most wetland ecosystems. However, organic matter accumulation can be a problem in vernal pools and playas because it encourages biological invasions and can lead to deleterious algal blooms.

This metric consists of evaluating the organic matter accumulation The protocol is an evaluation in overall organic including size and number of standing snags, downed logs and their decay, and amount of fine litter accumulation including litter layers, duff layers, and leaf piles in pools. A field form should be used that describes the organic matter accumulation. Collins et al. (2006) recommend that for estuarine habitats the metric should be assessed in areas that would typically support sedimentation of fine-grained, organic-rich substrates, such as back bays, off-channel basins, or on the surface of the main salt marsh plain. Areas that are hydro-dynamically active should not be used to evaluate this metric. Field survey method for estimating organic matter accumulation may be either a: (1) semiquantitative Site Survey method where the observer walks the entire assessment area and make notes on organic matter accumulation or (2) quantitative Plot Data where a fixed area is surveyed, using either plots or transects. The plot or transect is typically a ‘rapid’ plot, but a single intensive plot can also be taken. The metric scale is based on the similarity between the observed organic matter accumulation and what is expected based on a reference condition (Table 20). Reference conditions reflect experience, studies from sites where natural processes are intact, regional surveys, and historic sources (Collins et al. 2006).

Table 20. Level 2 and 3 Ecological Integrity Assessment scorecard for organic matter by ecosystem type (Appendix C) on wildlife areas in Washington.

Ecosystem type	Rank			
	A (5 points)	B (4 points)	C (3 points)	D (1 point)
Rocky Mountain Alpine-Montane Wet Meadow North American Arid Freshwater Emergent Marsh	Characterized by moderate amount of fine organic matter; new materials more prevalent than old materials; litter layers and leaf piles in pools are thin	Ssmall amounts of coarse organic debris; little evidence of organic matter	Essentially no significant amounts of coarse plant debris; little fine debris (or too much)	Characterized by moderate amount of fine organic matter; new materials more prevalent than old materials; litter layers and leaf piles in pools are thin

Biological Soil Crust

There is abundant evidence that biological crust occupy most of the vascular plant interspaces where natural site characteristics are not limiting, i.e. steep unstable slopes, south aspects, sandy soil or heavy vascular plant cover. Biological crust provides resistance to erosion, soil stabilization, and enhanced soil water retention. Livestock trampling and other physical site disturbances break-up biological crust and its cover is an indicator of site disturbance (Belnap et al. 2001). Susceptibility to mechanical disturbance varies by dominant morphological group of biological crusts.

Level 2 estimates are either a: (1) semiquantitative Site Survey where the observer walks the assessment area and make notes of biological crust abundance and distribution or (2) quantitative Plot Data where a fixed areas are surveyed, using either plots or transects. The plot is typically a 'rapid' plot, but several intensive plots can also be taken. More intensive Level 3 assessments are standardized monitoring methods (Belnap et al. 2001). The criteria for scoring are based on scientific judgment (Table 21).

Table 21. Level 2 and 3 Ecological Integrity Assessment scorecard for biological soil crust by ecosystem type (Appendix C) on wildlife areas in Washington.

Ecosystem type	Rank			
	A (5 points)	B (4 points)	C (3 points)	D (1 point)
Columbia Basin Foothill Canyon Dry Grassland Columbia Basin Palouse Prairie Columbia Basin Steppe and Grassland Columbia Plateau Scabland Shrubland Intermountain Basins Semidesert shrubsteppe Intermountain Basins Montane Big Sagebrush Steppe Intermountain Basins Big Sagebrush Steppe Intermountain Basins Semidesert Grassland Northern Rocky Mountain Lower Montane, Foothill and Valley Grassland	Biological soil crust nearly matches site capacity where site characteristics not limiting (i.e. steep unstable, south aspect, or dense grass)	Biological soil crust evident, but its continuity is broken	Biological soil crust present in protected areas and with minor component elsewhere	Biological soil crust, if present, only in protected areas

PHYSICOCHEMICAL AND HYDROLOGY

Soil Surface Condition

Bare ground is exposed mineral or organic soil that is susceptible to erosion. The amount and distribution of bare ground is important to site stability and is a direct indicator of site susceptibility to accelerated wind or water erosion. Large patches of exposed soil are less stable than where bare soil is distributed in small patches (Pellant et al. 2005). This metric is partly based on a metric developed by Mack (2001) and the NatureServe Ecological Integrity Working Group. Shrubsteppe reflects Pellant et al. (2005).

Bare ground is soil surface not covered by vegetation (basal and canopy, litter, standing dead plants, gravel/rock, and biological crust. Level 2 estimates are either a: (1) semiquantitative Site Survey where the observer walks the assessment area and make notes of bareground abundance, distributions, and origin or (2) quantitative Plot Data where fixed areas are surveyed using either plots or transects (Table 22). Percentages of bare soil due to human disturbance are adapted from Adamus (2006).

Table 22. Level 2 and 3 Ecological Integrity Assessment scorecard for soil surface condition by ecosystem type (Appendix C) on wildlife areas in Washington.

Ecosystem type	**Rank**			
	A (5 points)	**B (4 points)**	**C (3 points)**	**D (1 point)**
Columbia Basin Foothill Canyon Dry Grassland Columbia Basin Palouse Prairie Columbia Basin Steppe and Grassland Columbia Plateau Scabland Shrubland Columbia Plateau Low Sagebrush Steppe Intermountain Basins Semidesert shrubsteppe Intermountain Basins Montane Big Sagebrush Steppe Intermountain Basins Big Sagebrush Steppe Intermountain Basins Semidesert Grassland Intermountain Basins Cliff and Canyon East Cascades Mesic Montane Mixed-Conifer Forest and Woodland East Cascades Oak-Ponderosa Pine Forest and Woodland Northern Rocky Mountain Western Larch Woodland and Savanna Northern Rocky Mountain Subalpine Woodland and Parkland Northern Rocky Mountain Ponderosa Pine Woodland and Savanna Northern Rocky Mountain Mesic Montane Mixed Conifer Forest Northern Rocky Mountain Foothill Conifer Wooded Steppe Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest Northern Rocky Mountain Montane-Foothill Deciduous Shrubland Northern Rocky Mountain Lower Montane, Foothill and Valley Grassland Rocky Mountain Subalpine-Montane Riparian Woodland Rocky Mountain Subalpine-Montane Riparian Shrubland Rocky Mountain Subalpine-Montane Mesic Meadow Rocky Mountain Alpine-Montane Wet Meadow Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland North American Arid Freshwater Emergent Marsh Columbia Basin Foothill Riparian Woodland and Shrubland	Bare soil areas limited to naturally caused disturbances such as burrowing animals or game trails	Bare soil due to human causes, but extent and impact minimal; depth of disturbance limited to ~5cm	Bare soil due to human causes are common; compaction to ~15cm; machinery may have left shallow ruts	Bare soil areas substantial and they contribute to long-lasting impacts; deep ruts from machinery present or livestock trails widespread
Intermountain Basins Active Stable Dunes Rocky Mountain Cliff, Canyon and Massive Bedrock	Bare soil areas limited to naturally caused disturbances such as burrowing animals or game trails	Bare soil due to human causes, but extent and impact minimal; depth of disturbance limited to ~5cm		Bare soil due to human causes are common; compaction to ~15cm; machinery may have left shallow ruts
Northern Rocky Mountain Subalpine-Upper Montane Grassland Northern Rocky Mountain Subalpine Deciduous Shrubland Intermountain Basins Greasewood Flat	Bare soil areas limited to naturally caused disturbances such as burrowing animals or game trails	Bare soil due to humans and livestock, but extent and impact aniimal		Bare soil areas substantial and they contribute to long-lasting impacts; deep ruts from machinery present or livestock trails widespread

Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland and Rocky Mountain Subalpine Mesic-Wet Spruce-Fir Forest and Woodland Rocky Mountain Lodgepole Pine Forest Rocky Mountain Aspen Forest and Woodland	Soil disturbance class 0 (undisturbed) – No evidence of equipment, wheel tracks, soil disturbance, compaction, and erosion, and management-created platy soils	Soil disturbance class 1 – Minimal evidence of equipment, wheel tracks, soil disturbance, compaction (0–12cm), and erosion; soil burn from fires low	Soil disturbance class 2 – Clear evidence of equipment, wheel tracks, soil disturbance (missing layers), compaction (≤30cm), and erosion; soil burn from fires moderate	Soil disturbance class 3 – Substantial evidence of equipment, wheel tracks, soil disturbance (missing layers), compaction (>30cm), and erosion; soil burn from fires high
Intermountain Basins Alkali Closed Depression and Playa	Bare soil areas limited to naturally caused disturbances such as burrowing animals or game trails and flood deposition; salt crust often present and intact	Bare soil due to human causes, but extent and impact minimal; depth of disturbance <10cm and no evidence of ponding or channeling water; salt crust mostly intact	Bare soil due to human causes are common; machinery may have left shallow ruts; depth of disturbance 10-20cm; may be pugging due to livestock; salt crust minimally represented	Bare soil areas substantial and they contribute to long-lasting impacts; deep ruts from machinery present or livestock trails widespread;soil disturbance >20cm; water channeled or ponded; salt crust mostly absent or current year
Columbia Plateau Vernal Pool	No evidence of alteration by anthropogenic sources	Minor soil disturbance; confined in intensity (livestock hoof marks) or area (<25% of vernal pool complex)	Moderate degree of disturbance, either in intensity or area (25-50% of vernal pool complex)	High degree of disturbance in intensity and area (>50% of vernal pool complex)

Water Quality

Water quality is believed to reflect levels of pollution, nutrients, and sediment loads. All are likely indications of stressors. This metric was developed by the NatureServe Ecological Integrity Assessment Working Group in Faber-Langendoen et al. (2009*a*). Some of the data on water quality available from rivers an lakes could be very relevant to riverine and lakeshore wetland types, but this metric has not been fully developed (Table 23).

Table 23. Ecological Integrity Assessment scorecard for water quality by ecosystem type on wildlife areas in Washington.

Ecosystem type	**Rank**			
	A (5 points)	**B (4 points)**	**C (3 points)**	**D (1 point)**
Rocky Mountain Subalpine-Montane Riparian Woodland Rocky Mountain Subalpine-Montane Riparian Shrubland Rocky Mountain Alpine-Montane Wet Meadow Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland North American Arid Freshwater Emergent Marsh Intermountain Basins Alkali Closed Depression and Playa Columbia Basin Foothill Riparian Woodland and Shrubland	No evidence of degraded water quality; water is clear	Water may have minimal greenish tint or cloudiness; negative features limited in area or intensity	Water may have minimal greenish tint, cloudiness, or sheen; negative indicators illustrate response to nutrients	Many negative indicators (algae mats, tint, sheen, turbidity); bottom difficult to see

Water Source

Collins et al. (2006) stated the following. “Wetlands, by definition, depend on constant or recurrent, shallow inundation or saturation at or near the surface of the substrate (National Research Council 2001). Consistent, natural inflows of water to a wetland are important to their ability to perform and maintain most of their intrinsic ecological, hydrological, and societal functions. The flow of water into a wetland also affects sediment processes and the physical structure/geometry of the wetland. Sudol and Ambrose (2002) found that one of the greatest causes of failed wetland mitigation or restoration projects is inadequate, or inappropriate hydrology.” Water Sources encompass the forms, or places, of direct inputs of water to the assessment area as well as any unnatural diversions of water from that area. Diversions are considered a water source because they affect the ability of the assessment area to function as a source of water for other habitats while also directly affecting the hydrology of that area (Collins et al. 2006, Faber-Langendoen 2009*a*).

The first procedure for this metric is the use of detailed aerial photographs or satellite imagery to identify unnatural sources or water diversions that directly affect the assessment area. “Permanent or semipermanent features that affect water source at the overall watershed or regional level should not be considered in the evaluation of this metric” (Collins et al. 2006). Indicators of unnatural water sources “include adjacent intensive development or irrigated agriculture, nearby wastewater treatment plants, and nearby reservoirs”. Natural sources of water include rainfall, groundwater, and rivers and streams. The metric ratings are from Collins et al. (2006, Table 24).

Table 24. Level 2 and 3 Ecological Integrity Assessment scorecard for water source by ecosystem type (Appendix C) on wildlife areas in Washington.

Ecosystem type	Rank			
	A (5 points)	B (4 points)	C (3 points)	D (1 point)
Rocky Mountain Subalpine-Montane Riparian Woodland Rocky Mountain Subalpine-Montane Riparian Shrubland Rocky Mountain Alpine-Montane Wet Meadow Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland North American Arid Freshwater Emergent Marsh Intermountain Basins Greasewood Flat Intermountain Basins Alkali Closed Depression and Playa Columbia Plateau Vernal Pool Columbia Basin Foothill Riparian Woodland and Shrubland	Source is natural; no indication of direct artificial water sources	Source is mostly natural, but site directly receives small amounts of inflow from anthropogenic sources	Source is primarily urban runoff, direct irrigation, pumped water, or impounded water	Water flow substantially diminished by human activity

Channel and Streambank Stability

Collins et al. (2006) stated the following: “A basic understanding of the natural hydrology or channel dynamics of the type wetland being evaluated is needed to apply this metric. For instance high gradient riparian areas in mountainous areas have very different dynamics from those in flat coastal plains, especially in terms of aggradation or degradation. “For riverine systems, the patterns of increasing and decreasing flows that are associated with storms, releases of water from dams, seasonal variations in rainfall, or longer term trends in peak flow, base flow, and average flow are more important that hydroperiod. The patterns of flow, in conjunction with the kinds and amounts of sediment with which the flow interacts, largely determine the form of riverine systems, including their floodplains, and thus also control their ecological functions. Under natural conditions, the opposing tendencies for sediment to stop moving and for flow to move the sediment tend toward a dynamic equilibrium, such that the form of the channel that contains the sediment and the flow remains relatively constant over time (Leopold 1994). Large and persistent changes in either the flow regime or the sediment regime tend to destabilize the channel and cause it to change form. Such regime changes are associated with upstream land use changes, alterations of the drainage network of which the channel of interest is a part, and climatic changes. A riverine channel is an almost infinitely adjustable complex of interrelations between flow, width, depth, bed resistance, sediment transport, and riparian vegetation. Change in any one will be countered by adjustments in the others. The degree of channel stability can be assessed based on field indicators. Every stable riverine channel tends to have a particular form in cross section, profile, and plan view that is in dynamic equilibrium with the inputs of water and sediment. If these supplies change enough, the channel will tend to adjust toward a new equilibrium form. For example, an increase in the supply of sediment, relative to the supply of water, can cause a channel to aggrade (i.e., the elevation of the channel bed increases), which might cause simple increases in the duration of inundation for existing wetlands, or complex changes in channel location and morphology through braiding, avulsion, burial of wetlands, creation of new wetlands, spray and fan development, etc. An increase in water relative to sediment might cause a channel to incise (i.e., the bed elevation decreases), leading to bank erosion, headward erosion of the channel bed, floodplain abandonment, and dewatering of riparian habitats. For most riverine systems, chronic incision (i.e., bed degradation) is generally regarded as more deleterious than aggradation because it is more likely to cause significant decreases in the extent of riverine wetland and riparian habitats (Kondolf 1996). There are many well-known field indicators of equilibrium conditions, or deviations from equilibrium, that can be used to assess the existing mode of behavior of a channel and hence the degree to which its hydroperiod can sustain wetland and riparian habitats."

The protocol for this metric focuses on field indicators of aggradation and degradation in the assessment area. The observed should determine whether the assessment area is in equilibrium, aggrading, or degrading and then determine a rating score (Collins et al. 2006, Table 25).

Table 25. Level 2 and 3 Ecological Integrity Assessment scorecard for channel and streambank stability by ecosystem type (Appendix C) on wildlife areas in Washington.

Ecosystem type	**Rank**			
	A (5 points)	**B (4 points)**	**C (3 points)**	**D (1 point)**
Channel Stability				
Rocky Mountain Subalpine-Montane Riparian Woodland Rocky Mountain Subalpine-Montane Riparian Shrubland Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland Columbia Basin Foothill Riparian Woodland and Shrubland	Natural channel; no evidence of aggradation or degradation	Most of the channel has aggradation or degradation, none of which is severe	Evidence of severe degradation of most of the channel	Concrete, or artificially hardened channels through the site
Streambank Stability				
Rocky Mountain Subalpine-Montane Riparian Woodland Rocky Mountain Subalpine-Montane Riparian Shrubland Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland Columbia Basin Foothill Riparian Woodland and Shrubland	Stable: perennial vegetation to waterline; no raw or undercut banks; no recently exposed roots	Slightly stable: perennial vegetation to waterline in most places; minor erosion	Moderately unstable: perennial vegetation to waterline sparse (scoured or removed by erosion); bank held in place by trees and bolders; extensive erosion	Completely unstable: no perennial vegetation to waterline; banks only held in place by roots and bolders; severe erosion

Water Table

A wetland's hydrologic regime is the most important ecological processes given its affect on the wetland's soils and flora and fauna communities (Mitsch and Gosselink 2000). The natural variability of water level fluctuations (e.g., hydroperiod) has a strong impact on the floristic composition, nutrient dynamics, and fauna distributions in a wetland. Thus, alterations to the hydroperiod can have negative impacts to ecological processes, including a shift in species composition and an alteration of biogeochemical cycling. This metric is one aspect of the condition of specific occurrences of wetland or terrestrial ecological systems.

To measure a change in the hydroperiod, a "flashiness" index, developed by Fennessey et al. (2004) for Ohio wetlands is used. The Flashiness Index is calculated by averaging the absolute value of the differences between ground water measurements from the measurement just preceding it. Thus, long-term well or staff-gauge data are needed to calculate the metric. Staff gauges should be placed in deep open water areas whereas shallow groundwater monitoring wells should be placed in less deep water.

If quantitative vegetation data are being collected, monitoring wells should be located within these plots to allow correlations with vegetation data. For example, if using the 20 x 50 m plots described by Peet et al. (1998), wells would be located within each of the intensive modules. Monitoring wells are set vertically in the ground to intercept the groundwater passively (USACE 2000); 3.8 cm PVC pipe is perforated from just below the ground surface to the bottom of the pipe, a hole is dug with a soil auger to ≥40cm, sand is placed in the bottom of the well, the pipe is placed in the hole which is then backfilled with the excavated soil, and bentonite clay is used to seal the opening of the hole and to ensure surface water does not infiltrated freely into the hole. Water levels inside the pipe result from the integrated water pressures along the entire length of perforations. Water levels can be read with a steel measuring tape marked with a water-soluble marker. The only equipment needed is the tape, marker, and a rag to wipe the tape dry after each reading. The height of the well above the ground surface should be noted every time the instrument is read because pipes are known to move (USACE 2000). Another simple measuring tool for measuring water levels is that described in Henszey (1991). This instrument is attached to a meter tape, lowered into the well, and beeps when it contacts water, at which point a measurement is taken from the tape and subtracted from the height of the well above the soil surface to give the depth of the water table.

Water levels should be checked weekly during the summer months. Automatic recording devices record water levels with down-well transducers or capacitance-based sensors are efficient for season-long monitoring but these cost much more than manually read instruments (USACE 2000). However, automatic recorders may be less expensive than total travel costs and salaries. In addition, the credibility of monitoring data is enhanced by automatic wells (USACE 2000). Automatic water-level recorders should be periodically checked and recalibrated as necessary (USACE 2000).

Consideration of annual precipitation (or more specifically, annual snowpack) and its deviation from long-term averages from the closest weather station are needed to assess the reliability of this metric. During years of average precipitation (e.g. average snowpack) this metric is a reliable rapid metric of the integrity of groundwater levels in the marsh. Long-term monitoring of ground water in the wetland coupled with an analysis of climatic variation during that timeframe will provide the most reliable information. Water table averages should be calculated for each month and hydrographs should be constructed to visually inspect trends.

Data are not available to distinguish between Excellent and Good; thus, they are lumped into one category. These criteria are tentative hypotheses as they have not been validated with quantitative data throughout the range of this type. The scaling is based on best scientific judgment and on Fennessey et al. (2004) who found that Ohio wetlands with very strong depressional hydrology (vertical hydrologic pathway driven by precipitation and evapotranspiration) had flashiness scores of 1.0 to ~2.0 while riverine marshes had scores of between 2 and 3. Wetland with small to moderate stormwater inputs were also found to have scores between 2-3 while Scores greater than 3 were indicative of high stormwater inputs disrupting the natural hydroperiod. Scaling criteria are only provided for non-riverine marshes. Additional research needs to be conducted for riverine marshes. This metric could also be used to monitor site-specific changes if long-term baseline, as well as post-impact, data are available (Table 26).

Table 26. Level 2 and 3 Ecological Integrity Assessment scorecard for water table by ecosystem type (Appendix C) on wildlife areas in Washington.

Ecosystem type	Rank			
	A (5 points)	B (4 points)	C (3 points)	D (1 point)
Rocky Mountain Alpine-Montane Wet Meadow	Soils saturated for long durations; hydric soils present; water table <5m of soil surface; surface soil horizons gleyed or have a chroma value of ≤2 in mottled soils or ≤1 in unmottled soils; depth to mottles <40cm		No redoximorphic features present <40cm; soil chromo >2; hydric soils not present; indicators of remnant hydric conditions may be present (distinct boundaries between mottles and matrix)	

Hydrological Alteration

Ecological processes of riparian areas are driven to a large degree by the magnitude and frequency of peak flows and the duration and volume of base flows (Poff et al. 1997). The biotic and physical integrity of riparian areas are dependent on the natural variation associated with these flow characteristics (Gregory et al. 1991, Poff et al. 1997). The amount of water retained in upstream facilities has a direct effect on these flows and subsequent effects on the continued biotic and physical integrity of the riparian area (Poff et al. 1997). For example, retention of surface water can decrease or eliminate episodic, high intensity flooding, decrease seasonal high flows (e.g., spring snowmelt) and increase base flows during seasonal dry periods causing a shift in channel morphology and altering the dispersal capabilities, germination, and survival of many plant species dependent on those flows (Poff et al. 1997, Patten 1998). The metric is modified from Smith (2000) and developed by Rocchio (2006).

This metric can be measured by calculating the total number of water diversions occurring in the upstream contributing watershed as well as those onsite. The number of diversions relative to the size of the contributing basin is considered and then compared to the scorecard to determine the rating. Examples of water diversions include ditch, well, reservoir, spring, mine, pipeline, pump, power plant. For stream reaches that receive water from local ground water (i.e. gaining reaches), the degree to which water tables are affected by area water wells must be considered. Since the riparian area may occur on a variety of stream orders and since the corresponding upstream or contributing watershed differs in area, it is difficult to set standard guidelines. Thus, the user must use their best scientific judgment regarding the number of diversions and their impact relative to the size of the contributing watershed. If available, attributes such as capacity (cubic feet/second) of each diversion can be considered in the assessment. The scaling is based on best scientific judgment. Additional research is needed and may suggest changes to the scaling criteria.

These calculations can be conducted using GIS themes of surface water retention facilities, USGS 7.5 minute topographic maps, and/or Digital Elevation Models. The contributing watershed can be calculated or digitized using Digital Elevation Models in a GIS. The percentage of the contributing watershed upstream of surface water retention facilities is simply 'cut' from the original contributing watershed layer and its area is then calculated then compared to the total area. The scaling is based on Smith (2000) and best scientific judgment. Additional research may suggest changes to the scaling criteria (Table 4 for Level 1 EIAs and Table 27 for Level 2 and 3 EIAs).

Table 27. Level 2 and 3 Ecological Integrity Assessment scorecard for hydrological alteration by ecosystem type (Appendix C) on wildlife areas in Washington.

Ecosystem type	**Rank**			
	A (5 points)	**B (4 points)**	**C (3 points)**	**D (1 point)**
Intermountain Basins Alkali Closed Depression and Playa Columbia Plateau Vernal Pool	No alterations such as dykes, diversions, ditches, and/or flow additions	Low intensity alterations such as dykes, diversions, ditches, and/or flow additions	Moderate intensity alterations such as dykes, diversions, ditches, roads, and/or flow additions	High intensity alterations such as roads, dykes, diversions, ditches, and/or flow additions

Hydroperiod

Collins et al. (2006) state the following: "For all wetlands except riverine wetlands, hydroperiod is the dominant aspect of hydrology. The pattern and balance of inflows and outflows is a major determinant of wetland functions Mitch and Gosselink (1993). The patterns of import, storage, and export of sediment and other water-borne materials are functions of the hydroperiod. In most wetlands, plant recruitment and maintenance are dependent on hydroperiod. The interactions of hydroperiod and topography are major determinants of the distribution and abundance of native wetland plants and animals. Natural hydroperiods are key attributes of successful wetland projects. For riverine systems, the patterns of increasing and decreasing flows that are associated with storms, releases of water from dams, seasonal variations in rainfall, or longer term trends in peak flow, base flow, and average flow are more important that hydroperiod. The patterns of flow, in conjunction with the kinds and amounts of sediment with which the flow interacts, largely determine the form of riverine systems, including their floodplains, and thus also control their ecological functions. Under natural conditions, the opposing tendencies for sediment to stop moving and for flow to move the sediment tend toward a dynamic equilibrium, such that the form of the channel that contains the sediment and the flow remains relatively constant over time (Leopold 1994). Large and persistent changes in either the flow regime or the sediment regime tend to destabilize the channel and cause it to change form. Such regime changes are associated with upstream land use changes, alterations of the drainage network of which the channel of interest is a part, and climatic changes. A riverine channel is an almost infinitely adjustable complex of interrelations between flow, width, depth, bed resistance, sediment transport, and riparian vegetation. Change in any one will be countered by adjustments in the others. The degree of channel stability can be assessed based on field indicators."

Collins et al. (2006) stated the following: "This metric evaluates recent changes in the hydroperiod, flow regime, or sediment regime of a wetland and the degree to which these changes affect the structure and composition of the wetland plant community or, in the case of riverine wetlands, the stability of the riverine channel. Common indicators are presented for the different wetland classes. This metric focuses on changes that have occurred in the last 2-3 years." Metric ratings are taken from Collins et al. (2006, Table 28).

Table 28. Level 2 and 3 Ecological Integrity Assessment scorecard for hydroperiod function by ecosystem type (Appendix C) on wildlife areas in Washington.

Ecosystem type	Rank			
	A (5 points)	B (4 points)	C (3 points)	D (1 point)
Rocky Mountain Alpine-Montane Wet Meadow North American Arid Freshwater Emergent Marsh Intermountain Basins Greasewood Flat Intermountain Basins Alkali Closed Depression and Playa Columbia Plateau Vernal Pool	Characterized by stable saturated hydrology or by naturally damped cycles of saturation and partial drying	Experiences minor altered inflows or drawdown/drying as compared to more natural wetlands	Somewhat altered by increased inflow from runoff or experiences moderate drawdown or drying	Altered by increased inflow from runoff or experiences large drawdown or drying

Hydrological Connectivity

Collins et al. (2006) stated the following: "Hydrologic connectivity between wetlands and adjacent uplands supports ecologic function by promoting exchange of water, sediment, nutrients, and organic carbon. Inputs of organic carbon are of great importance to ecosystem function. Litter and allochthonous input from adjacent uplands provides energy that subsidizes the aquatic food web (Roth et al. 1996). Connection with adjacent water bodies promotes the import and export of water-borne materials, including nutrients. Surface and subsurface hydrologic connections, including connections with shallow aquifers and hyporheic zones, influence most wetland functions. Plant and animal communities are affected by these hydrologic connections. Plant diversity tends to be positively correlated with connectivity between wetlands and natural uplands and negatively correlated with increasing inter-wetland distances (Lopez 2002). Diversity of amphibian communities is directly correlated with connectivity between streams and their floodplains (Amoros and Bornette 2002). Linkages between aquatic and terrestrial habitats allow wetland-dependent species to move between habitats to complete life cycle requirements."

Collins et al. (2006) stated the following: "Scoring of this metric is based solely on field indicators (Table 29). No office work is required. For riverine wetlands and riparian habitats, hydrologic connectivity is assessed based on the degree of channel entrenchment (Leopold et al. 1964, Rosgen 1996, Montgomery and MacDonald 2002). Entrenchment is a field measurement calculated as the flood-prone width divided by the bankfull width. Bankfull width is the channel width at the height of bankfull flow. The flood-prone channel width is measured at the elevation of twice the maximum bankfull depth.

Table 29. Level 2 and 3 Ecological Integrity Assessment scorecard for hydrological connectivity by ecosystem type (Appendix C) on wildlife areas in Washington.

Ecosystem type	**Rank**			
	A (5 points)	**B (4 points)**	**C (3 points)**	**D (1 point)**
Hydrologic connectivity (level 2)				
Rocky Mountain Subalpine-Montane Riparian Woodland Rocky Mountain Subalpine-Montane Riparian Shrubland Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland Columbia Basin Foothill Riparian Woodland and Shrubland	Completely connected to floodplain (backwater sloughs and channels)	Minimally disconnected from floodplain by dikes and elevated culverts	Moderately disconnected from floodplain by dikes and elevated culverts	Extensively disconnected from floodplain by dikes and elevated culverts
Hydrologic connectivity (level 3)				
Rocky Mountain Subalpine-Montane Riparian Woodland Rocky Mountain Subalpine-Montane Riparian Shrubland Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland Columbia Basin Foothill Riparian Woodland and Shrubland	Unconfined entrenchment ratio >4.0; confined entrenchment ratio >1.4	Unconfined entrenchment ratio 1.4-2.2; confined entrenchment ratio 1.0-1.4	Unconfined entrenchment ratio <1.4; confined entrenchment ratio <1.0	
Hydrologic connectivity (non-riverine)				
North American Arid Freshwater Emergent Marsh	Rising water has unrestricted access to adjacent upland; without levees, high banks, artificial barriers, or other obstructions	Lateral movement of water partially restricted by unnatural features; <50% of site restricted by barriers to drainage	Lateral movement of water partially restricted by unnatural features; 50-90% of site restricted by barriers to drainage	Lateral movement of water largely restricted by unnatural features; >90% of site restricted by barriers to drainage

The process for estimating entrenchment in outlined in the following steps below. Entrenchment varies naturally with channel confinement. Channels in steep canyons naturally tend to be confined, and tend to have small entrenchment ratios indicating less hydrologic connectivity. Assessments of hydrologic connectivity based on entrenchment must therefore be adjusted for channel confinement, according to the following worksheets". The protocol for examining the bankfull contour includes the following (Collins et al. 2006):

Step 1: Identify bankfull contour. This is a critical step requiring experience. If the stream is entrenched, the height of bankfull flow is identified as a scour line, narrow bench, or the top of active point bars well below the top of apparent channel banks. If the stream is not entrenched, bankfull stage can correspond to the elevation of a broader floodplain with indicative riparian vegetation.

Step 2: Estimate maximum bankfull depth. Once the bankfull contour is identified, estimate its height above the nearest point along the channel bottom.

Step 3 Estimate flood prone height. Double the estimate of maximum bankfull depth from Step 2, and note the location of the new height on the channel bank.

Step 4: Estimate flood prone width. Estimate the width of the channel at the flood prone height.

Step 5: Calculate entrenchment ratio. Divide the flood prone width (results of Step 4) by the maximum bankfull depth Result of Step 2)

The protocol for examining the bankfull width includes the following (Collins et al. 2006):

Step 1: Estimate bankfull width of assessment area. Estimate channel width at bankfull based on the Step 1 of the entrenchment worksheet immediately above.

Step 2: Estimate effective valley width for AA Estimate the maximum distance from the top of either bank to the adjacent land that is ≥3 meters higher than the bank top.

Step 3: Determine confinement of assessment area Channel is confined if valley width (Step 2) is less than twice bankfull width (Step 1).

Sand Dynamics

Sand dynamics is an important feature of sand-dominated ecosystems. Native and/or stabilized sand substrates are generally ranked higher while exotic and/or migrating sand substrates are ranked lowest. The recording for this metric is general (Tabel 30).

Table 30. Ecological Integrity Assessment scorecard for sand dynamics by ecosystem type on wildlife areas in Washington.

Ecosystem type	Rank			
	A (5 points)	**B (4 points)**	**C (3 points)**	**D (1 point)**
Intermountain Basins Active Stable Dunes	Sparsely vegetated open/migrating, native, anchored and stabilized stages	Open/migrating and native anchored stages dominate; exotic-stabilized stages on <50% of area (areas stabilized by raised ground water may contribute here)	Open/migrating and native anchored stages less common; exotic-stabilized stages on >50% of area (areas stabilized by raised ground water may contribute here)	Open/migrating and native anchored stages absent; exotic-stabilized stages on >50% of area (areas stabilized by raised ground water may contribute here)

NATURAL DISTURBANCE REGIME

Forest Pathogens

Forest Pathogens are an important feature of forest ecosystems. Native and/or non-native pathogens can dramatically affect forest structure, native pathogens are usually present in naturally functioning ecosystems. The primary difference between a ‘heathy’ ecosystem and one that has been altered is the relative impact of exotic pathogens on the observed range of variability in the ecosystem. The recording for this metric is general (Table 4 for Level 1 EIAs and Table 31 for Level 2 and 3 EIAs).

Table 31. Level 2 and 3 Ecological Integrity Assessment scorecard for forest pathogens by ecosystem type (Appendix C) on wildlife areas in Washington.

Ecosystem type	Rank			
	A (5 points)	**B (4 points)**	**C (3 points)**	**D (1 point)**
Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland and Rocky Mountain Subalpine Mesic-Wet Spruce-Fir Forest and Woodland Rocky Mountain Lodgepole Pine Forest East Cascades Mesic Montane Mixed-Conifer Forest and Woodland Northern Rocky Mountain Western Larch Woodland and Savanna Northern Rocky Mountain Subalpine Woodland and Parkland Northern Rocky Mountain Mesic Montane Mixed Conifer Forest Northern Rocky Mountain Foothill Conifer Wooded Steppe Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest	Pathogens all native species within natural range of variability	Native pathogens significantly affect forest structure beyond natural range of variability	Exotic and native pathogens significantly affect forest structure beyond natural range of variability	Exotic and native pathogens significantly affect forest structure well beyond natural range of variability

Fire Condition Class

Frequent, low severity fire (~10-50 years; Fire Regime Classes I and III) is vital to maintaining ecological integrity. Fire suppression (prolonging fire return interval and/or its severity) alters forest composition, structure and fire effects (Franklin et al. 2008, Agee 2003, Hessburg, et al. 2005). The metric is synthesized from Franklin et al. (2008), Agee (2003) and Hessburg et al. (2005).

Level 1 estimates are based on LANDFIRE data (www.landfire.gov). Level 2 estimates are either a: (1) semiquantitative Site Survey where the observer walks the entire assessment area and make notes of tree species diameter-classes, height-classes, canopy vertical structure, snags, downed logs, and evidence of fire (charcoal, fire scars) or (2) quantitative Data where a fixed areas are surveyed, using either plots or transects. The 'rapid' assessment may include determination of tree age with an increment corer. Van Pelt (2008) provides a field guide to identifying old trees and forest. These forests often occur in large areas (hundreds to thousands of hectares) that, due to fire and insect disturbances, often contained mosaics of older, larger trees and smaller trees. This addresses the condition at a stand level (Table 32).

Table 32. Ecological Integrity Assessment scorecard for fire condition class by ecosystem type on wildlife areas in Washington.

<table>
<tr><th rowspan="2">Ecosystem type</th><th colspan="3">Rank</th></tr>
<tr><th>A (5 points)</th><th>B and C (3.5 points)</th><th>D (1 point)</th></tr>
<tr><td>Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland and Rocky Mountain Subalpine Mesic-Wet Spruce-Fir Forest and Woodland
Rocky Mountain Aspen Forest and Woodland
East Cascades Mesic Montane Mixed-Conifer Forest and Woodland
East Cascades Oak-Ponderosa Pine Forest and Woodland
Northern Rocky Mountain Western Larch Woodland and Savanna
Northern Rocky Mountain Subalpine Woodland and Parkland
Northern Rocky Mountain Ponderosa Pine Woodland and Savanna
Northern Rocky Mountain Mesic Montane Mixed Conifer Forest
Northern Rocky Mountain Foothill Conifer Wooded Steppe
Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest
Northern Rocky Mountain Subalpine Deciduous Shrubland
Northern Rocky Mountain Montane-Foothill Deciduous Shrubland
Rocky Mountain Subalpine-Montane Riparian Woodland
Rocky Mountain Subalpine-Montane Riparian Shrubland
Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland
Intermountain Basins Greasewood Flat</td><td>Fire Regime Condition Class 1 – No departure from historic regime</td><td>Fire Regime Condition Class 2 – Slight to moderate departure from historic fire regime</td><td>Fire Regime Condition Class 3 – Severe departure from historic fire regime; fire suppression evident</td></tr>
</table>

On Site Land Use

The intensity of human activity in the wetland often has a proportionate impact on the ecological processes occurring onsite. Each land use type is assigned a coefficient ranging from 0.0 to 1.0 indicating its relative impact to the wetland (Hauer et al. 2002).

This metric is measured by documenting land use(s) within the wetland. This should be completed in the field then verified in the office using aerial photographs or GIS. However, with access to current aerial photography and/or GIS data a rough calculation of Land Use can be made in the office. Ideally, both field data as well as remote sensing tools are used to identify an accurate % of each land use. To calculate a Total Land Use Score estimate the % of the wetland area under each Land Use type and then plug the corresponding coefficient (Table 33) with some manipulation to account for regional application. The coefficients were assigned according to best scientific judgment regarding each land use's potential impact (Hauer et al. 2002). Land uses have differing degrees of potential impact. Some land uses have minimal impact, such as simply altering the integrity of native vegetation (e.g., recreation and grazing), while other activities (e.g., hay production and agriculture) may replace native vegetation with nonnative or cultural vegetation yet still provide potential cover for species movement. Intensive land uses (i.e., urban development, roads, mining, etc.) may completely destroy vegetation and drastically alter hydrological processes.

Table 33. Current Land Use and Corresponding Land Use Coefficients (based on Table 21 in Hauer ete al. (2002).

Current Land Use	Land use coefficients
Paved roads/parking lots/buildings	0.00
Gravel pit operation	0.00
Unpaved Roads (e.g., driveway, tractor trail)	0.10
Mining	0.10
Agriculture (tilled crop production)	0.20
Heavy grazing by livestock	0.30
Intense recreation (ATV use/camping/popular fishing spot, etc.)	0.30
Logging or tree removal with 50-75% of trees >50 cm DBH removed	0.40
Hayed	0.50
Moderate grazing	0.60
Moderate recreation (high-use trail)	0.70
Selective logging with <50% of trees >50cm DBH removed	0.80
Light grazing	0.90
Light recreation (low-use trail)	0.90
Fallow with no history of grazing or other human use in past 10 years	0.95
Natural area (land managed for native vegetation)	1.00

Complete the following equation for each land use, then sum the Sub-Land Use Score(s) to arrive at a Total Land Score. For example, if 30% of the wetland was under moderate grazing (0.3 * 0.6 = 0.18), 10% composed of unpaved roads (0.1 * 0.1 = 0.01), and 40% was a natural area (e.g. no human land use) (1.0 * 0.4 = 0.4), the Total Land Use Score would = 0.59 (0.18 + 0.01 + 0.40).

Sub-land use score = Σ LU x PC/100

where: LU = Land Use Score for Land Use Type; PC = % of adjacent area in Land Use Type

GENERAL APPLICATION OF EIA

A monitoring framework designed to track the status and trends of ecological systems across a large spatial scale (e.g. a large or multiple State Wildlife Areas) will be organized around a hierarchical, multi-scale approach to monitoring and assessment. Because the EIA is scalable in terms of its applicability to multi-scaled classification systems and the scale and intensity of application, it is suited to serve as a foundation for a monitoring framework designed to accommodate site-scale and landscape objectives. For example, a Level 1 EIA will be used as a means of prioritizing sites for field visits where a Level 2 or Level 3 assessment would be completed (metrics for each ecosystem type in Appendix C). Prioritization could be based on which sites may be at risk of moving away from desired ecological conditions (as determined by Level 1 metric rankings). Level 2 could serve a similar purpose but with increased accuracy and detail about sites in need of a Level 3 EIA.

DEVELOPMENT OF THE EIA MODEL

The development of an ecological assessment tool can be categorized into three major phases: initial development, field testing, and validation (Wakeley and Smith 2001, Collins et al. 2008).

Initial Development

The overall framework or model of the assessment is designed to describe the overall purpose and method of the assessment. Conceptual models are used to identify the key ecological attributes and metrics useful for measuring ecological integrity. Natural variability and the response of each metric to human-induced disturbance is described and used to establish ranking thresholds. These tasks are accomplished through an intensive literature review, expert consultation, and use of best professional judgment. A protocol for rating each of the attributes or sites is developed.

The process of EIA development described thus far in this report is focused on initial development. Although these initial models could be immediately applied toward a monitoring framework, it is recommended that EIA development continue with field testing and validation. This allows for increased confidence in the sensitivity, accuracy, and precision of the EIA to measure ecological integrity.

Field Testing

Field testing determines whether the ecological attributes and metrics identified during initial development adequately describe ecological integrity. In addition, this exercise may reveal other useful attributes and metrics which hadn’t been previously identified. The sensitivity of the metrics to changes in ecological condition is checked as well as the repeatability of metric scores in wetlands of similar condition. The consistency of metric scores between different users is also assessed. Details concerning EIA instructions and field forms are informed by field testing. All necessary changes are made to ensure the assessment adequately describes and discerns different states of ecological condition and that the results of the assessment are repeatable among different users.

Field testing is accomplished by sampling sites across a human disturbance gradient (from relatively intact to highly impacted) for each ecological system. These sample sites are referred to as reference sites (or reference set) and represent the range of variability that occurs in an ecological system as a result of natural processes as well as anthropogenic alterations. Data collected from reference sites establish a basis for defining what constitutes the natural range of variability and how each metric responds to human-induced stress. Reference standard sites are the subset of reference sites that are the least altered (or minimally disturbed) in the least altered landscapes (Stoddard et al. 2006). In other words, these are the sites currently functioning with their NRV and would typically have 'A' (excellent) ratings for individual metrics and categories. In order to determine the level of anthropogenic alteration and thus ensure that the entire range of reference sites is sample, the level of human disturbance at each site can be rated using NatureServe's stressor checklist (Master et al. 2009), a human disturbance index (Rocchio 2007*a*), and/or a Landscape Stressor Model (Comer and Hak 2009).

Validation

To conduct validation, an independent measure of ecological integrity must be collected at each of the reference sites. The accuracy or reliability of the EIA is tested by comparing it to the independent measure (e.g., vegetation index of biotic integrity). The EIA Scorecards are recalibrated to ensure that the best possible fit is achieved with the independent measure. This may include reassessing the metrics included in the EIAs, altering metric rating criteria, or simply changing the weights associated with each metric to more accurately reflect their influence on the overall scores.

The three-level approach to EIA development also lends itself to the validation phase. For example, sites where a Level 3 index of vegetation or ecological integrity had been measured could be used to calibrate a Level 1 remote-sensing assessment (Mack 2006, Mita et al. 2007, Lemly and Rocchio 2009). Level 3 could also be used in a similar manner to validate a Level 2 EIA. This process of validation results in relatively consistent information about ecological integrity being provided at the three levels of assessment, with improved interpretations as the level of intensity goes up.

GENERAL APPLICATION OF THE EIA FOR MONITORING AND ASSESSMENT

Below are general guidelines as to how a Level 2 or 3 EIA would be implemented (adapted from Collins et al. 2006). A comprehensive field operating manual has not yet been produced but additional details regarding the steps below can be found in Collins et al. (2006), Rocchio (2007*a*, 2007*b*), Faber-Langendoen et al. (2009*a*).

1) Assemble background information about the management and history of the site.
2) Classify the site using Draft Field Guide to Washington's Ecological Systems (Rocchio and Crawford 2008) to ensure that the correct EIA is used.
3) Determine the extent and size of the ecological system.
4) Determine the boundary and estimate the size of the assessment area (if different than the area of the ecological system) and allocate observation points or plots, if needed.
5) Establish the landscape context boundary for the occurrence.
6) Verify the appropriate season and other timing aspects of field assessment.

7) Consult metric protocols to ensure they are measured systematically (Appendix C).
8) Conduct the office assessment of stressors, landscape context and on-site conditions of the assessment area.
9) Conduct the field assessment of stressors and on-site conditions of the assessment area.
10) Complete assessment scores.
11) Upload results into BIOTICS Database or other regional and statewide information systems.

Communication and Reporting: The EIA Scorecard

Andreasen et al. (2001) outlined six characteristics that a practical index of ecological integrity should be composed of and we added a seventh characteristic:

1) Multi-scaled
2) Grounded in natural history
3) Relevant and helpful (to the public and decision-makers, not just scientists)
4) Flexible
5) Measurable
6) Comprehensive (for composition, structure and function)
7) Repeatable (important component of reliability)

The EIA is scalable, both in terms of its applicability to multi-scaled classification systems as well as the three-level approach used for the EIA assessment. Metric rankings are firmly anchored in the natural history of ecosystem types and using the conceptual model as a framework ensures that the metrics are comprehensive and helpful to a wide audience. The EIA uses a transparent and simple tabular format to report scores or ranks from the various hierarchical scales of the assessment depending on which best meets the user's objectives. For example, the user may not wish to roll-up metric ranks into aggregated ranks of integrity. Or, 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) Size; and (3) Condition. These rank factor rankings can then be combined into an Overall Ecological Integrity Rank. All of these characteristics make the EIA a practical, transparent, and easily communicable approach to assessing ecological integrity.

The metrics are integrated into a rank factor ranking by plugging each metric score into a simple, weight-based algorithm. These algorithms are constructed based on expert scientific judgment regarding the interaction and corresponding influence of these metrics on ecological integrity (e.g., as done by NatureServe 2002, Parrish et al. 2003).

There are a number of approaches that could be used to aggregate the metric ranks into aggregate rankings. The approach used in this report is a simple non-interaction point-based approach (Table 34). Each metric within a rank factor is assigned a weight, based on its perceived importance. Rankings for each metric are converted to a point value for that rank (A = 5 points, B = 4, C=3, D=1). The points are then multiplied by the weight to get a score for the metric. The scores (weighted points) for all metrics within a rank factor are summed and divided by the sum of the weights to get a rank factor score. The rank factor scores are summed and divided by the total number of factors to get an overall score, which is converted to an Index of Ecological Integrity.

Table 34. Ecological Integrity Assessment Scorecard Example for an assessment.

Key ecological attribute (KEA) / Metric	Metric Rating[a]	Metric Points	Weight (W)	Metric Score (M)	KEA Score (M/W)	KEA Rank[a]	EIS[b]	EIR[c]
Landscape context								
Buffer length	A	5	1	5				
Buffer width	B	4	1	4				
Buffer condition	B	4	1	4				
Connectivity	B	4	1	4				
Relative patch size	A	5	0.5	2.5				
Absolute patch size	B	4	1	4				
Summary			∑=5.5	∑=23.5	4.3	B		
Vegetation (biota)								
Cover of native plants	C	3	1	3				
Cover of invasive species	C	3	0.5	1.5				
Cover of native increasers	B	4	1	4				
Species composition	B	4	1	4				
Woody species regeneration	C	3	1	3				
Canopy structure	C	3	1	3				
Organic matter accumulation	B	4	0.5	2				
Summary			∑=6	∑=20.5	3.4	C		
Hydrology								
Water Source	C	3	1	3				
Channel Stability	B	4	1	4				
Hydrologic Connectivity	A	5	1	5				
Summary			∑=3	∑=12	4.0	B		
Soils (physioco-chemistry)								
Physical Patch Types	B	4	0.5	2				
Water Quality	B	4	1	4				
Soil Surface Condition	B	4	1	4				
Summary			∑=2.5	∑=10	4.0	B		
Overall summary							∑=20	4

[a]Rating: A=4.5-5.0, B = 3.5-4.4, C=2.5-3.4, D=1.0-2.4.

[b]EIS refers to Ecological Integrity score.

[c]EIR refers to Ecological Integrity rank.

Desired Ecological Conditions

The WDFW has identified a portion of the ecological integrity ranking scale, specifically the A and B integrity rankings, as comprising desired ecological conditions for each of the ecological systems that are addressed in this report. Thus, any metric, key ecological attribute, or overall ecological integrity rating that has an A or B rating would be considered to be within desired ecological conditions. Correspondingly, C and D ratings would indicate that a variable is outside desired conditions and that management action is required to reverse these results.

Whether or not a metric, key ecological attribute or site is functioning within desired ecological condition will guide how the EIA Monitoring Framework is implemented. To make this more operational, additional concepts such as triggers and best attainable condition are also incorporated. Collectively, desired ecological condition, best attainable condition, and triggers provide guidance toward decision making within the context of the monitoring framework. This is further described below within the context of each EIA Level.

Level 1 Assessment

A Level 1 EIA is a comprehensive generic approach that is applicable to all natural ecosystems and is based primarily on metrics derived from remote sensing imagery. A Level 1 EIA could be used as a means of prioritizing sites for field visits, where a Level 2 or Level 3 assessment is completed. Level 1 EIAs can also be used as a measure of integrity whenever a field visit cannot be completed. Because the objective of all three EIA levels is the same (i.e. 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.

A very basic Level 1 EIA might include an overall assessment of landscape integrity using a Landscape Condition Model (LCM; Comer and Hak 2009). The LCM is similar to the Landscape Development Intensity Index (Brown and Vivas 2005), human footprint model (Leu et al. 2008), and anthropogenic stress model (Danz et al. 2007) all which have been used for similar purposes elsewhere. The LCM integrates various GIS land use layers (roads, land cover, water diversions, groundwater wells, dams, mines, etc.) at a 30-90 m or 1 km pixel scale. These layers are the basis for various stressor-based metrics. The metrics are weighted according to their perceived impact on ecological integrity, into a distance-based, decay function to determine what effect these stressors have on landscape integrity. The result is that each grid-cell (30 m or more) is assigned a stressor 'score'. The product is a landscape or watershed map depicting areas according to their potential 'integrity.' We can segment the index into four rank classes, from Excellent (slightly impacted) to Poor (highly impacted). This landscape model is valuable in its own right for landscape scale planning, site selection, etc.

An example of methodology for implementing a Level 1 assessment is as follows. Locations are chosen within State Wildlife Areas. These locations may be a subset or all examples of an ecosystem type that is of interest identified to specified level of ecosystem classification. Points or polygons are established for each of these locations, and these are overlain on the Landscape Condition Model. A landscape context area is defined around the occurrence. The landscape condition model provides the data for the 'landscape condition model' metric, based on the average score of the pixels within the landscape context. Connectivity and Size can be readily assessed as well. Together these metrics provide a simple means of characterizing the ecological integrity of an occurrence of any ecological system. These metrics also can be integrated into a system of triggers and potential actions (Table 35).

Table 35. Triggers for Level 1 Ecological Integrity Assessment (EIA).

Key Ecological Attribute	Trigger	Action
Any hydrology metric	C rank OR within desired ecological conditions but showing a negative trend OR effects of management must be monitored with greater precision	Conduct Level 2 OR 3 assessment; ensure current management does not result in further degradation
Vegetation Structure	C rank OR within desired ecological conditions but showing a negative trend OR effects of management must be monitored with greater precision	Conduct Level 2 OR 3 assessment; ensure current management does not result in further degradation
Physicochemical	C rank OR within desired ecological conditions but showing a negative trend OR effects of management must be monitored with greater precision	Conduct Level 2 OR 3 assessment; ensure current management does not result in further degradation
Natural Disturbance Regimes	C rank OR within desired ecological conditions but showing a negative trend OR effects of management must be monitored with greater precision	Conduct Level 2 OR 3 assessment; ensure current management does not result in further degradation

The results from this analysis can be used in multiple ways:

1) To provide a cost efficient way of estimating ecological integrity of every ecosystem which occurs on State Wildlife Areas. This alone could be used for guiding management decisions.
2) To prioritize where Level 2 or 3 EIA should be conducted. The ecological integrity rank of each occurrence, relative to desired ecological conditions, best attainable conditions or triggers, could be used as the criteria for needing to conducting Level 2/3 assessments
3) To integrate the status and trends of extent and condition of an ecological system to monitor long-term changes of ecological systems on State Wildlife Areas.

A Level 1 assessment can also help determine best attainable conditions of any particular occurrence or site. For example, the best attainable condition of occurrence embedded in a landscape or part of an occurrence with poor integrity might be constrained to an ecological state outside desired ecological conditions. In other words, due to the surrounding landscape, it might not be possible for WDFW to restore or manage the site toward desired ecological conditions. For such a scenario, best attainable condition would describe (using ecological integrity ranks) the ecological conditions that could be feasibly managed for.

Level 2 Assessment

Level 2 EIAs are used for relatively rapid (~2 hours per small patch up to full day for matrix types) site assessments. The Level 2 EIA can be considered the 'workhorse' within the context of a hierarchical monitoring framework as it provides a compromise between efficiency of application and assessment accuracy. Although it would be more costly and time consuming to apply the Level 2 EIA to each ecological system occurrence on State Wildlife Areas, the Level 2 assessment could be a very useful method for implementing a probability-based approach to monitoring. Probability-based monitoring designs such as the Generalized Random Tessellation Stratified (GRTS) survey design create a spatially balanced random sample of points (Stevens and Olsen 1999). Using a Level 2 EIA to determine ecological integrity of these sites results in a rigorous estimate of overall ecological integrity for the targeted ecological systems. This information can be used to determine if, on average, a particular ecological system is functioning within or outside desired ecological conditions as it appears on State Wildlife Areas. Those systems functioning near or outside the threshold of desired ecological conditions (Appendix C) would require Level 3 assessments to obtain more detailed information about current ecological conditions.

Of course, Level 2 EIA could also be used at any particular site to determine its current ecological integrity and, thus, determine whether it is functioning within desired ecological conditions. If the site is near (i.e. a trigger has occurred) or outside the desired ecological conditions then a Level 3 assessment would be warranted for that specific location.

A probability-based Level 2 assessment could also be useful for identifying sensitive or vulnerable ecological systems on State Wildlife Areas through the development of ecological system 'profiles'. These profiles would include: (1) total extent on and off a particular State Wildlife Area; (2) changes in extent with time; and (3) overall ecological integrity of a system throughout extent of the profile. The current and historical extent would be determined using comprehensive maps such as NatureServe's Ecological Systems map. The profile could then be used to prioritize management actions for ecological systems on State Wildlife Areas. For example, depending on the type, abundance, and overall ecological integrity of each ecological system, they can be categorized into 'action' categories, thereby providing a systematic means of prioritizing protection, restoration, and enhancement actions.

Finally, the Level 2 assessment should be used to test and calibrate a Level 1 EIA. This is accomplished by correlating Level 1 with Level 2 ecological integrity ranks from multiple occurrences, ideally spanning the full range of ecological conditions.

Level 3 Assessment

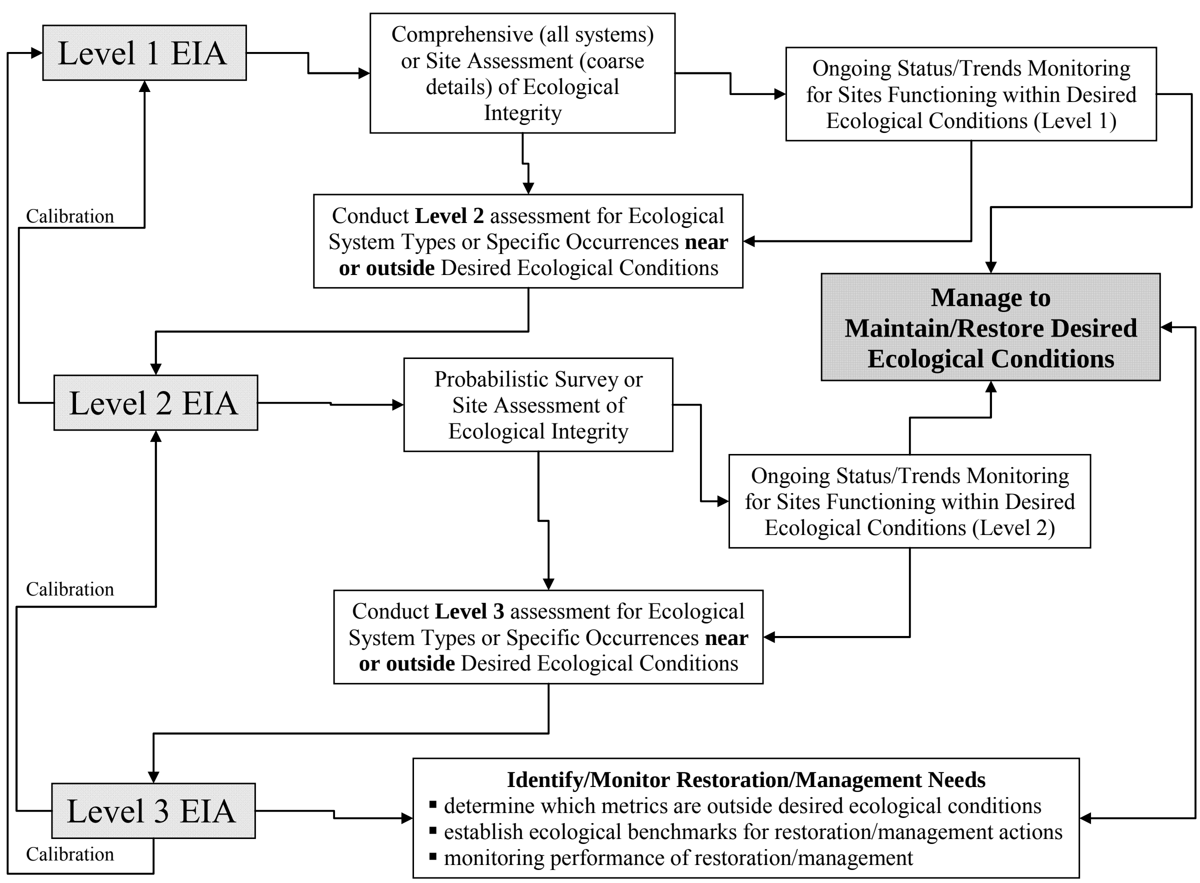
Level 3 assessments are intended for more intensive sampling objectives such as detailed assessment of ecological integrity or quantitative site-scale monitoring. Level 3 assessments are also time-consuming, costly and may required extended commitments. They are most valuable where it is important to assess in detail the status and trends of a particularly important site. The Level 3 assessment is essentially an intensification of the metrics collected for Level 2 EIAs through use of a more rigorous sampling design to collective quantitative data.

Within a multi-scaled monitoring framework, Level 3 assessments may typically be used when a Level 2 assessment has indicated that a specific ecological system type or occurrences is near (i.e. a trigger has occurred) or outside desired ecological conditions. The Level 3 assessment may confirm the results of the Level 2 assessment and provide additional detail about specific conditions for each key ecological attribute. Level 3 assessments will also be used to test and calibrate a Level 2 (or Level 1) EIA using the same approach described above. Finally, the Level 3 EIA will be used to set and monitor attainment of specific performance measures (specific thresholds for each ecosystem type in Appendix C) for restoration or management actions. An example of this is the use of habitat evaluation procedures (see description below).

Integrated Monitoring Framework

Level 1, 2, and 3 EIAs can be integrated into a multi-scale monitoring framework (Fig. 1). Ecological triggers for a Level 1 EIA or conditions under which management activities need to be reassessed are shown in Table 35. Because a Level 1 EIA is a coarse measure of ecological integrity, most of the component metrics are applicable across all ecological system types (Table 4). Minor variations are noted in metric ratings.

Fig. 1. Generalized Schematic of Integrated Monitoring Framework.



The integrated EIA can include many characteristics including: (1) edge/buffer length and width (important to biotic and abiotic processes); (2) landscape condition model (intensity and land use in surrounding landscape can affect ecological integrity); (3) connectivity (intact areas have continuous corridor of natural vegetation); (4) relative patch size (indicates proportion lost due to stressors); (5) absolute patch size (size important for buffering impacts in surrounding landscape); (6) vegetation condition (reflects natural disturbance regimes across the landscape and affects the maintenance of biological diversity); (7) hydrologic alterations (dams and diversions); (8) hydrological condition (important aspect of ecological processes); (9) natural disturbance regime (degree of departure from historic conditions); and (10) Physicochemical condition (intensity of land use has a proportionate impact on ecological processes). The advantage of an integrated EIA is that the advantages of the different levels of assessments (time, accuracy, precision, etc.) can brought into a single assessment.

SPECIFIC APPLICATION OF THE EIA FOR MONITORING AND ASSESSMENT

Specific Ecosystems

Metrics and thresholds have been developed to conduct EIAs. These include identified stressors that are associated with the loss and degradation of ecological integrity. Stressors are the cause of the system shifting away from its natural range of variability. In other words, type, intensity, and duration of stressors are what moves a system's ecological integrity rank away from the expected, natural condition toward degraded integrity ranks. 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.

Many different metrics are used in EIA, including metrics that deal with landscape context, vegetation condition, hydrology condition, natural disturbance regime, physic-chemical condition. 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 a 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 1 assessments are the same for all ecosystem types (Table 6).

In contrast to Level 1 EIAs, 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. A Habitat Evaluation Procedure is an example of a Level 3

EIA method (Appendix D). Thresholds for Level 2 and 3 EIAs can vary by ecosystem type due to subtle differences in biotic and abiotic responses to natural and anthropogenic stressors (Appendix C).

Specific Wildlife Areas

A monitoring and assessment EIA strategy will be developed for all wildlife areas in Washington (description of BPA-funded wildlife areas in Schroeder et al. 2009). This strategy will be implemented by first developing an EIA strategy on a small number of wildlife areas, as a pilot project. The pilot effort will help refine the overall procedure. The following ordered steps provide insight into an integrated EIA for each Washington wildlife area.

1) Assemble background information about the management and history of the wildlife area. This information will be essential for provide the 'boundaries' for the assessment area as well as development and interpretation of desired ecological conditions.
2) Develop available GIS imagery for the wildlife area. Although these maps are currently available, they have not been ground truthed, especially for uncommon (e.g., riparian) ecosystems. Care must be taken to include ecosystems adjacent to the wildlife area to insure an accurate assessment of patch characteristics and off-area influences on system function.
3) Classify the ecosystems using the Draft Field Guide to Washington's Ecological Systems (Rocchio and Crawford 2008). This classification will help ensure that the ecosystems are correctly identified and that the correct EIAs (Appendix C) are used. It will also provide inside into additional mapping needs (see below).
4) Modify maps to correct for obvious errors. For example, riparian areas are frequently under represented and this oversight should be corrected.
5) Determine the extent, size, and boundaries of the assessment area and for each ecological system.
6) Conduct a level 1 EIA (Table 4) for each ecosystem and metric that can be conducted remotely. The level 1 EIA will serve as a benchmark for future efforts, as well as providing insight into areas requiring more detailed assessment.
7) Apply available data (such as previously collected HEP data; Appendix D and Schroeder et al. 2009) to supplement the level 1 EIA. Although some HEP data was collected with the aid of transects that crossed ecosystems, most of the data is adequate to provide ground truthing support at the very least.
8) Allocate addition observation points or plots, if needed, for each assessment area. The purpose of this effort is to supplement the remote level 1 EIA with ground truthing and level 2 EIAs (Appendix C).
9) Conduct an office assessment of stressors, landscape context, and on-site conditions of the assessment area.
10) Consult metric protocols to ensure they are measured systematically, regardless of the assessment level (Appendix C).

11) Use the ground truthing data to refine GIS images. This is efficient because many of the same characteristics that are looked for when identifying ecosystem type (Appendix C) are also used in the level 1 EIA (Table 4). The image produced at this stage will be the basemap that provides a reference point for future monitoring and assessment efforts.

12) Conduct level 2 EIAs (Appendix C) to provide data needed to assess ecosystems when a level 1 EIA (Table 4) is insufficient. It is projected that level 2 EIAs will be relatively quick to conduct, often requiring a general "walk through" of the area. This is the stage where the observer can conduct a field assessment of stressors and on-site conditions of the assessment area. As with level 1 EIAs, available data (such as previously collected HEP data; Appendix D and Schroeder et al. 2009) can be used to supplement this effort. Although some HEP data was collected with the aid of transects that crossed ecosystems, most of the data is adequate to provide solid ground-based information. Level 2 assessments will serve the pupose of providing detailed information on critical sites, sites that are difficult to monitor remotely, and validation (ground truthing) for level 1 assessments.

13) Design and conduct level 3 EIAs (Appendix C) in situations where detailed information is essential. It is unlikely that a level 3 EIA will be needed in most situations early in this process. This is especially true on BPA-funded wildlife areas, where HEP data is available for most of the ecosystems. Level 3 assessments will serve the pupose of providing detailed information on critical sites, sites that are difficult to monitor remotely, and validation (ground truthing) for level 1 and 2 assessments.

14) Complete assessment scores for each ecosystem and each wildlife area. This EIA will form the baseline for each wildlife area and will provide the foundation for future monitoring and evaluation efforts.

15) Use wildlife area plans and discussions with managers to develop desired ecological conditions for each ecosystem and each wildlife area. The desired ecological conditions will be based on management objectives for each wildlife area and goals for ecosystems. Examination of these goals will be an essential step in developing a long-term monitoring plan for each wildlife area.

16) Use desired ecological conditions and logistical considerations to develop a monitoring and evaluation plan that encorporates an integrated EIA. The logistical considerations include the following.

    a) Available manpower can determine how much area can be monitored and evaluated.

    b) The number of wildlife areas, number of ecosystems, and size of area needing to be monitored can determine how much can be monitored in one field season.

    c) The EIA needs can influence how often an area needs to be assessed. For example, a level 1 EIA might be possible every year, but it is unlikely that the data collected in such a borad-scale effort would be useful. In contrast, an assessment every 5 years may be more than sufficient.

    d) The budget can influence all other considerations.

17) Develop a rotational schedule that incorporates an integrated EIA for each wildlife area on a rotational basis. This schedule might include an EIA for each wildlife area once

every 5 years. The plan should include an evaluation of the manpower and other tools needed to conduct the assessments.

18) Develop a plan to conduct EIAs for specialized purposes on specific wildlife areas, such as an evaluation of livestock impacts.

19) Additional types of monitoring and evaluation (e.g., birds, mammals, etc.) can be integrated into the overall effort. The purpose of these additional strategies needs to be clearly addressed in the plans, but will likely only be supplemental to the overall monitoring and evaluation strategy.

20) Incorporate citizen science into the long-term monitoring efforts on wildlife areas. Citizen scientists can collect accurate data in a cost-effective way. This effort can be focused in numerous different directions including the following.

    a) Photo plots can be developed as a way to photographically monitor features of the landscape (Hall 2002). Photos would be available online by wildlife area and location within each wildlife area and citizen scientists would be able to contribute to the effort remotely. Photo plots would provide a significant technique for addressing ecosystems at the level 1 and 2 EIA.

    b) Breeding bird surveys can be used to evaluate the effectiveness of management strategies on wildlife areas. These surveys would likely only be supplemental to the overall monitoring and evaluation strategy. Citizen scientists have a long history of conducting surveys of breeding birds that are both accurate and useful (e.g., USGS breeding bird surveys and Audubon Christmas Bird Counts).

    c) Involve grade schools in the collection of data relevant to their education as well as to wildlife areas in the region. This type of technique has been very effective in certain situations.

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APPENDIX A: ACRONYMS AND ABBREVIATIONS

ACWA – Asotin Creek Wildlife Area

AS – Asotin Subbasin

BLM – U.S. Bureau of Land Management

BBS – USGS Breeding Bird Survey

BPA – Bonneville Power Administration

CBC – National Audubon Society Christmas Bird Count

CCS – Crab Creek Subbasin

CCT – Colville Confederated Tribes

CNHP – Colorado Natural Heritage Program

CRAP – California Rapid Assessment Method

CRP – Federal Conservation Reserve Program

CTUIR – Confederated Tribes of the Umatilla Indian Reservation

DBH – Diameter at breast height for trees

DOD – Department of Defense

DOE – U.S. Department of Energy

DWA – Desert Wildlife Area

EIA – Ecological Integrity Assessment

FCCD – Foster Creek Conservation District

FEIS – Fire Effects Information System

FGDC – Federal Geographic Data Committee

FRCC – Fire Regime Condition Class

ESA – Endangered Species Act

GIS – Geographical Information Systems

GMU – Game Management Unit

GPS – Global Positioning System

GRTS – Generalized Random Tessellation Stratified

HEP – Habitat Evaluation Procedures

HSI – Habitat Suitability Index

HU – Habitat Unit

IBI – Index of Biotic Integrity

IBIS – Interactive Biological Information Systems

IETMF – Interagency Ecosystem Management Task Force

IVC – International Vegetation Classification

LANDFIRE – Landscape Fire and Resource Management Planning Tools Project

LCM – Landscape condition model

LCTS – Lower Columbia Tributaries Subbasin

LTMWA – L. T. Murray Wildlife Area

NPPC – Northwest Power Planning Council

NRCS – National Resource Conservation Service

NRV – Natural range of variability

NVCS – National Vegetation Classification Standard

OCWA – Oak Creek Wildlife Area

OKS – Okanogan Subbasin

PIF – Partners in Flight

PUD – Public Utilities District

RMEF – Rocky Mountain Elk Foundation

SCWA – Scotch Creek Wildlife Area

SER – Society for Ecological Restoration

SFWA – Sagebrush Flat Wildlife Area

SLWA – Swanson Lakes Wildlife Area

SPWA – Shillapoo Wildlife Area

SSWA – Sunnyside Wildlife Area

TNC – The Nature Conservancy

UCS – Upper Columbia Subbasin

UMMS – Upper Middle Mainstem Subbasin

USFS – U.S. Forest Service

USACE – United States Army Corps of Engineers

USEPA – Environmental Protection Agency

USFWS – U.S. Fish and Wildlife Service

USGS – U.S. Geological Survey

USNPS – U.S. National Park Service

UTM – Universal Transverse Mercator projection

VOR – Visual Obstruction Reading (Robel et al. 1970)

WDFW – Washington Department of Fish and Wildlife

WDNR – Washington Department of Natural Resources

WDOT – Washington Department of Transportation

WSU – Washington State University

WWA – Wenas Wildlife Area

WWS – Walla Walla Subbasin

YIN – Yakima Indian Nation

YS – Yakima Subbasin

APPENDIX B: SCIENTIFIC NAMES

PLANTS

Table B1. Scientific names for plants on wildlife areas and/or discussed in this report.

Trees	
Abies grandis (grand fir)	*Pinus albicaulis* (white bark pine)
Abies lasiocarpa (subalpine fir)	*Pinus contorta* (lodgepole pine)
Abies procera (noble fir)	*Pinus flexilis* (limber pine)
Acer macrophyllum (bigleaf maple)	*Pinus monticola* (western white pine)
Alnus rubra (red alder)	*Pinus ponderosa* (Ponderosa pine)
Alnus sinuata (Sitka alder)	*Populus balsamifera* (balsam poplar)
Betula occidentalis (water birch)	*Populus tremuloides* (quaking aspen)
Betula papyrifera (paper birch)	*Populus trichocarpa* (black cottonwood)
Larix lyallii (subalpine larch)	*Pseudotsuga menziesii* (Douglas fir)
Larix occidentalis (western larch)	*Quercus garryana* (Oregon white oak)
Malus diversifolia (Oregon crab apple)	*Acer glabrum* (Rocky Mountains maple)
Arbutus menziesii (Pacific madrone)	*Thuja plicata* (western red cedar)
Picea engelmannii (Engelmann spruce)	*Tsuga heterophylla* (western hemlock)
Picea glauca (white spruce)	*Tsuga mertensiana* (mountain hemlock)
Picea sitchensis (Sitka spruce)	
Small trees/large shrubs	
Acer glabrum (Rocky Mountain maple)	*Oplopanax horridus* (Devil's club)
Alnus incana (speckled alder)	*Prunus* spp. (cherry)
Alnus tenuifolia (thinleaf alder)	*Rhamnus purshiana* (Cascara buckthorn)
Amelanchier alnifolia (serviceberry)	*Rhus* spp. (sumac)
Cornus nuttallii (Pacific dogwood)	*Salix* spp. (willow)
Cornus sericea (red-osier dogwood)	*Sambucus* spp. (elderberry)
Shrubs	
Artemisia rigida (stiff sagebrush)	*Ribes cereum* (squaw currant)
Artemisia tridentata (big sagebrush)	*Rosa woodsii* (woods rose)
Artemisia tripartita (threetip sagebrush)	*Salvia dori* (gray ball sage)
Chrysothamnus nauseosus (common rabbit-brush)	*Sambucus cerulea* (blue elderberry)
Chrysothamnus viscidiflorus (green rabbit-brush)	*Sarcobatus vermiculatus* (black greasewood)
Grayia spinosa (spiny hopsage)	*Shepherdia* spp. (buffalo berry)
Juniperus communis (common juniper)	*Spiraea betulifolia* (white spiraea)
Philadelphus lewisii (mockorange)	*Symphoricarpos albus* (snowberry)
Physocarpus malvaceus (ninebark)	*Tetradymia canescens* (gray horse-brush)
Purshia tridentata (antelope bitterbrush)	*Vaccinium membranaceum* (thinleaf huckleberry)
Ribes aureum (golden currant)	
Small shrubs	
Arenaria congesta (dense-lowered sandwort)	*Eriogonum sphaerocephalum* (rock buckwheat)
Arenaria franklinii (Franklin's sandwort)	*Eriogonum strictum* (strict buckwheat)
Erigeron linearis (desert yellow daisy)	*Eriogonum thymoides* (thyme-leaf buckwheat)
Eriogonum compositum (northern buckwheat)	*Eurotia lanata* (winterfat)
Eriogonum douglasii (Douglas' buckwheat)	*Haplopappus stenophyllus* (narrow-leaf goldenweed)
Eriogonum heracleoides (parsnip-flowered buckwheat)	*Leptodactylon pungens* (leptodactylon)
Eriogonum microthecum (slenderbush buckwheat)	*Phlox hoodii* (Hood's phlox)
Eriogonum niveum (snow buckwheat)	*Phlox longifolia* (Longleaf phlox)
Grasses	
Achnatherium thurberiana	*Oryzopsis hymenoides*
Agropyron cristatum	*Poa ampla*
Agropyron intermedium	*Poa bulbosa*

Bromus commutatus	*Poa cusickii*
Bromus tectorum	*Poa pratensis*
Calamagrostis rubescens	*Poa secunda*
Carex douglasii	*Pseudoreogneria spicata*
Carex filifolia	*Schoenoplectus* spp.
Distichlis stricta	*Scirpus* spp.
Eleocharis spp.	*Sitanion hystrix*
Elymus cinereus	*Stipa occidentalis*
Festuca idahoensis	*Taeniatherum caput-medusae*
Festuca washingtonica	*Vulpia bromoides*
Hesperostipa comata	*Vulpia microstachys*
Juncus spp.	*Vulpia octoflora*
Koeleria macrantha	
Forbs	
Achillea millefolium	*Brasenia* spp.
Acroptilon repens	*Brodiaea douglasii*
Agoseris heterophylla	*Calochortus macrocarpus*
Amsinckia lycopsoides	*Castilleja thompsonii*
Antennaria dimorpha	*Centaurea diffusa*
Arabis cusickii	*Centaurea maculosa*
Arabis glabra	*Ceratocephala testiculata*
Arabis holboellii	*Chaenactis douglasii*
Astragalus lentiginosus	*Chorispora tenella*
Astragalus purshii	*Cicuta* spp.
Astragalus reventiformis	*Cirsium undulatum*
Astragalus spaldingii	*Cirsium vulgare*
Astragalus speirocarpus	*Clematis ligusticifolia*
Athyrium filix-femina	*Collinsia grandiflora*
Balsamorhiza careyana	*Collinsia parviflora*
Balsamorhiza hookeri	*Collomia linearis*
Balsamorhiza sagittata	*Commandra umbellata*
Bidens spp.	*Conyza Canadensis*
Crepis acuminata	*Lupinus sulphureus*
Crepis atribarba	*Lupinus wyethii*
Crocidium multicaule	*Machaeranthera canescens*
Cymopterus terebinthinus	*Medicago sativa*
Cynoglossum officinale	*Mertensia longiflora*
Delphinium nutallianum	*Mertensia oblongifolia*
Descurainia pinnata	*Microseris troximoides*
Dodecatheon conjugens	*Nuphar* spp.
Draba verna	*Oenothera andina*
Epilobium brachycarpum	*Oenothera pallida*
Epilobium minutum	*Opuntia polyacantha*
Erigeron corymbosus	*Orthocarpus tenuifolius*
Erigeron filifolius	*Pectocarya linearis*
Erigeron poliospermus	*Penstemon gairdneri*
Erigeron pumilis	*Perideridia gairdneri*
Eriogonum elatum	*Phacelia hastata*
Erodium cicutarium	*Phacelia linearis*
Fritillaria pudica	*Phalaris* spp.
Gymnocarpium dryopteris	*Phlox caespitosa*
Heuchera cylindrical	*Phoenicaulis cheiranthoides*
Holosteum umbellatum	*Plantago patagonica*
Hydrocotyle spp.	*Plectritis macrocera*
Hydrophyllum capitatum	*Polemonium micranthum*
Lactuca serriola	*Polygonum aviculare*

Lemna spp.	*Potamogeton* spp.
Lepidium latifolium	*Ranunculus glaberrimus*
Lepidium perfoliatum	*Rorippa* spp.
Lewisia rediviva	*Sagittaria* spp.
Linaria dalmatica	*Salsola kali*
Linum perenne	*Saxifraga occidentalis*
Lithophragma glabrum	*Sedum lanceolatum*
Lithospermum ruderale	*Senecio intergerrimus*
Lomatium ambiguum	*Silene douglasii*
Lomatium canbyi	*Sisymbrium altissimum*
Lomatium dissectum	*Sparganium* spp.
Lomatium geyeri	*Sphaeralcea munroana*
Lomatium gormanii	*Taraxacum officinale*
Lomatium grayi	*Townsendia florifera*
Lomatium macrocarpum	*Tragopogon dubius*
Lomatium triternatum	*Trifolium macrocephalum*
Lupinus lepidus	*Verbascum thapsus*
Lupinus leucophyllus	*Viola trinervata*
Lupinus sericeus	*Zigadenus paniculatus*

MAMMALS

Table B2. Scientific names for mammals identified on wildlife areas and/or discussed in this report.

Common name	Scientific name
Beaver	*Castor canadensis*
Badger	*Taxidea taxus*
Bighorn sheep	*Ovis canadensis*
Black-tailed jackrabbit	*Lepus californicus*
Canada lynx	*Lynx canadensis*
Columbian ground squirrel	*Spermophilus columbianus*
Coyote	*Canus latrans*
Deer mouse	*Peromyscus maniculatus*
Elk	*Cervus elaphus*
Fisher	*Martes pennanti*
Fox squirrel	*Sciurus niger*
Golden-mantled squirrel	*Spermophilus saturatus*
Gray wolf	*Canus lupins*
Great Basin pocket mouse	*Perognathus parvus*
Grizzly bear	*Ursus arctos horribilis*
Least chipmunk	*Eutamias minimus*
Long-tailed vole	*Microtus longicaudus*
Marten	*Martes americana*
Masked shrew	*Sorex cinereus*
Meadow vole	*Microtus pennsylvanicus*
Merriam's shrew	*Sorex merriami*
Mink	*Mustela vison*
Montane vole	*Microtus montanus*

Mountain cottontail	*Sylvilagus nuttalli*
Mule deer	*Odocoileus hemionus*
Muskrat	*Ondatra zibethica*
Northern pocket gopher	*Thomomys talpoides*
Porcupine	*Erethizon dorsatum*
Pygmy rabbit	*Sylvilagus idahoensis*
Racoon	*Procyon lotor*
Red squirrel	*Tamiasciurus hudsonicus*
River otter	*Lutra canadensis*
Sagebrush vole	*Lagurus curtatus*
Townsend’s ground squirrel	*Spermophilus townsendi*
Townsend's big-eared bat	*Plecotus townsendi*
Vagrant shrew	*Sorex vagrans*
Washington ground squirrel	*Spermophilus washingtoni*
Western gray squirrel	*Sciurus griseus*
Western harvest mouse	*Reithrodontomys megalotis*
White-tailed deer	*Odocoileus virginianus*
White-tailed jackrabbit	*Lepus townsendi*
Yellow pine chipmunk	*Eutamias amoenus*
Yellow-bellied marmot	*Marmota flaviventris*

BIRDS

Table B3. Scientific names for birds identified on the Wildlife Areas and/or discussed in this report.

Common name	Scientific name
American avocet	*Recurvirostra americana*
American bittern	*Botaurus lentiginosus*
American coot	*Fulica americana*
American crow	*Corvus brachyrhynchos*
American dipper	*Cinclus mexicanus*
American goldfinch	*Carduelis tristis*
American green-winged teal	*Anas crecca*
American kestrel	*Falco sparverius*
American pipit	*Anthus rubescens*
American robin	*Turdus migratorius*
American tree sparrow	*Spizella arborea*
American white pelican	*Pelecanus erythrorhynchos*
American wigeon	*Anas Americana*
Bald eagle	*Haliaeetus leucocephalus*
Band-tailed pigeon	*Columba fasciata*
Bank swallow	*Riparia riparia*
Barn owl	*Tyto alba*
Barn swallow	*Hirundo rustica*
Barred owl	*Strix varia*

Barrow's goldeneye	*Bucephala islandica*
Belted kingfisher	*Ceryle torquata*
Bewick's wren	*Thryomanes bewickii*
Black tern	*Chlidonias niger*
Black-billed magpie	*Pica pica*
Black-capped chickadee	*Parus atricapillus*
Black-chinned hummingbird	*Archilochus alexandri*
Black-crowned night-heron	*Nycticorax nycticorax*
Black-headed grosbeak	*Pheucticus melanocephalus*
Black-necked stilt	*Himantopus mexicanus*
Black-throated gray warbler	*Dendroica nigrescens*
Blue (dusky) grouse	*Dendragapus obscurus*
Blue jay	*Cyanocitta cristata*
Blue-winged teal	*Anas discors*
Bobolink	*Dolichonyx oryzivorus*
Bohemian waxwing	*Bombycilla garrulus*
Brewer's blackbird	*Euphagus cyanocephalus*
Brewer's sparrow	*Spizella breweri*
Brown creeper	*Certhia Americana*
Brown-headed cowbird	*Molothrus ater*
Bufflehead	*Bucephala albeola*
Bullock's oriole	*Icterus bullockii*
Burrowing owl	*Aegolius funereus*
California gull	*Larus californicus*
California quail	*Callipepla californica*
Calliope hummingbird	*Stellula calliope*
Canada goose	*Branta canadensis*
Canvasback	*Aythya valisineria*
Canyon wren	*Catherpes mexicanus*
Caspian tern	*Sterna caspia*
Cassin's finch	*Carpodacus cassinii*
Cattle egret	*Bubulcus ibis*
Cedar waxwing	*Bombycilla cedrorum*
Chestnut-backed chickadee	*Poecile rufescens*
Chipping sparrow	*Spizella passerina*
Chukar	*Alectoris chukar*
Cinnamon teal	*Anas cyanoptera*
Clark's nutcracker	*Nucifraga columbiana*
Clay-colored sparrow	*Spizella pallida*
Cliff swallow	*Hirundo pyrrhonota*
Common goldeneye	*Bucephala clangula*
Common loon	*Gavia immer*
Common merganser	*Mergus merganser*
Common nighthawk	*Chordeiles minor*
Common poorwill	*Phalaenoptilus nuttallii*
Common raven	*Corvus corax*

Common redpoll	*Carduelis flammea*
Common yellowthroat	*Geothlypis trichas*
Cooper's hawk	*Accipiter cooperii*
Cordilleran flycatcher	*Empidonax occidentalis*
Dark-eyed junco	*Junco hyemalis*
Double-crested cormorant	*Phalacrocorax auritus*
Downy woodpecker	*Picoides pubescens*
Dusky flycatcher	*Empidonax oberholseri*
Eared grebe	*Podiceps nigricollis*
Eastern kingbird	*Tyrannus tyrannus*
Eastern meadowlark	*Sturnella magna*
Eurasian wigeon	*Ana Penelope*
European starling	*Sturnus vulgaris*
Evening grosbeak	*Coccothraustes vespertinus*
Ferruginous hawk	*Buteo regalis*
Flammulated owl	*Otus flammeolus*
Fox sparrow	*Passerella iliaca*
Gadwall	*Anas strepera*
Canada goose	*Branta canadensis*
Glaucous-winged gull	*Larus glaucescens*
Golden eagle	*Aquila chrysaetos*
Golden-crowned kinglet	*Regulus satrapa*
Grasshopper sparrow	*Ammodramus savannarum*
Gray catbird	*Dumetella carolinensis*
Gray flycatcher	*Empidonax wrightii*
Gray partridge	*Perdix perdix*
Gray-crowned rosy-finch	*Leucosticte tephrocotis*
Great blue heron	*Ardea herodias*
Great horned owl	*Bubo virginianus*
Greater sage-grouse	*Centrocercus urophasianus*
Greater scaup	*Aythya marila*
Greater white-fronted goose	*Anser albifrons*
Green-winged teal	*Anas crecca*
Gyrfalcon	*Falco rusticolus*
Hairy woodpecker	*Picoides villosus*
Hammond's flycatcher	*Empidonax hammondii*
Harris' sparrow	*Zonotrichia querula*
Hermit thrush	*Catharus guttatus*
Herring gull	*Larus argentatus*
Hooded merganser	*Lophodytes cucullatus*
Horned grebe	*Podiceps auritus*
Horned lark	*Eremophila alpestris*
House finch	*Carpodacus mexicanus*
House sparrow	*Passer domesticus*
House wren	*Troglodytes aedon*
Killdeer	*Charadrius vociferus*

Lark sparrow	*Chondestes grammacus*
Lazuli bunting	*Passerina amoena*
Least flycatcher	*Empidonax minimus*
Least sandpiper	*Calidris minutilla*
Lesser scaup	*Aythya affinis*
Lewis' woodpecker	*Melanerpes lewis*
Lincoln's sparrow	*Melospiza lincolnii*
Loggerhead shrike	*Lanius ludovicianus*
Long-billed curlew	*Numenius tahitiensis*
Long-eared owl	*Asio otus*
Long-tailed duck	*Clangula hyemalis*
MacGillivray's warbler	*Oporornis tolmiei*
Mallard	*Anas platyrhynchos*
Marsh wren	*Cistothorus palustris*
Merlin	*Falco columbarius*
Mountain bluebird	*Sialia currucoides*
Mountain chickadee	*Parus gambeli*
Mountain quail	*Oreotyx pictus*
Mourning dove	*Zenaida macroura*
Nashville warbler	*Vermivora ruficapilla*
Northern flicker	*Colaptes auratus*
Northern goshawk	*Accipiter gentilis*
Northern harrier	*Circus cyaneus*
Northern oriole	*Icterus galbula*
Northern pintail	*Anas acuta*
Northern pygmy-owl	*Glaucidium gnoma*
Northern rough-winged swallow	*Stelgidopteryx serripennis*
Northern saw-whet owl	*Aegolius acadicus*
Northern shoveler	*Anas clypeata*
Northern shrike	*Lanius excubitor*
Northern waterthrush	*Seiurus noveboracensis*
Northwestern crow	*Corvus caurinus*
Olive-sided flycatcher	*Contopus borealis*
Orange-crowned warbler	*Vermivora peregrina*
Osprey	*Pandion haliaetus*
Pacific loon	*Gavia pacifica*
Pacific-slope flycatcher	*Empidonax difficilis*
Peregrine falcon	*Falco peregrinus*
Pied-billed grebe	*Podilymbus podiceps*
Pileated woodpecker	*Dryocopus pileatus*
Pine grosbeak	*Pinicola enucleator*
Pine siskin	*Carduelis pinus*
Plumbeous vireo	*Vireo plumbeus*
Prairie falcon	*Falco mexicanus*
Purple finch	*Carpodacus purpureus*
Pygmy nuthatch	*Sitta pygmaea*

Red crossbill	*Loxia curvirostra*
Red-breasted nuthatch	*Sitta Canadensis*
Red-eyed vireo	*Vireo olivaceus*
Redhead	*Aythya americana*
Red-naped sapsucker	*Sphyrapicus varius*
Red-necked grebe	*Podiceps grisegena*
Red-tailed hawk	*Buteo jamaicensis*
Red-winged blackbird	*Agelaius phoeniceus*
Ring-billed gull	*Larus delawarensis*
Ring-necked duck	*Aythya collaris*
Ring-necked pheasant	*Phasianus colchicus*
Rock pigeon	*Columba livia*
Rock wren	*Salpinctes obsoletus*
Ross' goose	*Chen rossii*
Rough-legged hawk	*Buteo lagopus*
Ruby-crowned kinglet	*Regulus calendula*
Ruddy duck	*Oxyura jamaicensis*
Ruffed grouse	*Bonasa umbellus*
Rufous hummingbird	*Selasphorus rufus*
Sage sparrow	*Amphispiza belli*
Sage thrasher	*Oreoscoptes montanus*
Sandhill crane	*Grus Canadensis*
Savannah sparrow	*Passerculus sandwichensis*
Say's phoebe	*Sayornis saya*
Sharp-shinned hawk	*Accipiter striatus*
Sharp-tailed grouse	*Tympanuchus phasianellus*
Short-eared owl	*Asio flammeus*
Snow bunting	*Plectrophenax nivalis*
Snow goose	*Chen caerulescens*
Solitary vireo	*Vireo solitarius*
Song sparrow	*Melospiza melodia*
Sora	*Porzana carolina*
Spotted owl	*Strix occidentalis*
Spotted sandpiper	*Actitis macularia*
Spotted towhee	*Pipilo erythrophthalmus*
Steller's jay	*Cyanocitta stelleri*
Surf scoter	*Melanitta perspicillata*
Swainson's hawk	*Buteo swainsoni*
Swainson's thrush	*Catharus ustulatus*
Thayer's gull	*Larus thayeri*
Townsend's solitaire	*Myadestes townsendi*
Townsend's warbler	*Dendroica townsendi*
Tree swallow	*Tachycineta bicolor*
Trumpeter swan	*Cygnus buccinator*
Tundra swan	*Cygnus columbianus*
Turkey vulture	*Cathartes aura*

Varied thrush	*Ixoreus naevius*
Vaux's swift	*Chaetura vauxi*
Veery	*Catharus fuscescens*
Vesper sparrow	*Pooecetes gramineus*
Violet-green swallow	*Tachycineta thalassina*
Virginia rail	*Rallus limicola*
Warbling vireo	*Vireo gilvus*
Western bluebird	*Sialia mexicana*
Western grebe	*Aechmophorus occidentalis*
Western gull	*Larus occidentalis*
Western kingbird	*Tyrannus verticalis*
Western meadowlark	*Sturnella neglecta*
Western tanager	*Piranga ludoviciana*
Western wood-pewee	*Contopus sordidulus*
White-breasted nuthatch	*Sitta carolinensis*
White-crowned sparrow	*Zonotrichia leucophrys*
White-headed woodpecker	*Picoides albolarvatus*
White-throated sparrow	*Zonotrichia albicollis*
White-throated swift	*Aeronautes saxatalis*
White-winged scoter	*Melanitta fusca*
Wild turkey	*Meleagris gallopavo*
Williamson’s sapsucker	*Sphyrapicus thyroideus*
Willow flycatcher	*Empidonax traillii*
Wilson's phalarope	*Phalaropus tricolor*
Wilson's snipe	*Gallinago gallinago*
Wilson's warbler	*Wilsonia pusilla*
Winter wren	*Troglodytes troglodytes*
Wood duck	*Aix sponsa*
Yellow warbler	*Dendroica petechia*
Yellow-billed loon	*Gavia adamsii*
Yellow-breasted chat	*Icteria virens*
Yellow-headed blackbird	*Xanthocephalus xanthocephalus*
Yellow-rumped warbler	*Dendroica coronata*

REPTILES AND AMPBIBIANS

Table B4. Scientific names for reptiles and amphibians identified on the wildlife areas and/or discussed in this report.

Common name	Scientific name
Gopher snake	*Pituophis catenifer*
Great Basin spadefoot toad	*Scaphiopus intermontanus*
Larch Mountain salamander	*Plethodon larselli*
Long-toed salamander	*Ambystoma macrodactylum*
Night snake	*Hypsiglena torquata*
Oregon spotted frog	*Rana pretiosa*

Racer	*Coluber constrictor*
Short-horned lizard	*Phrynosoma douglassii*
Tiger salamander	*Ambystoma tigrinum*
Western fence lizard	*Sceloporus occidentalis*
Western ground snake	*Sonora semiannulata*
Western pond turtle	*Clemmys marmorata*
Western rattlesnake	*Crotalus viridis*
Western skink	*Eumeces skiltonianus*
Western terrestrial garter snake	*Thamnophis elegans*
Western toad	*Bufo boreas*

APPENDIX C: DESCRIPTIONS AND ECOLOGICAL INTEGRITY ASSESSMENTS FOR SPECIFIC ECOSYSTEMS

COLUMBIA BASIN FOOTHILL CANYON DRY GRASSLAND

General Description

The Columbia Basin Foothill and Canyon Dry Grassland ecological systems occur on steep open slopes, from 90 to 1520 meters elevation in the canyons and valleys of the Columbia Basin, particularly along the Snake River canyon and large tributaries. These grasslands were originally described by Tisdale (1986) along the lower foothill slopes of the Blue Mountains in Oregon, and along the main stem of the Columbia River. They typically occur at and well below lower treeline. They are floristically similar to the Columbia Basin Palouse Prairie but are distinguished by landform, soil, and process characteristics. When Intermountain Basins Big Sagebrush Steppe ecological systems on steep slopes have *Artemisia tridentata* and/or *Purshia tridentata* eliminated because of fire, they are categorized as Columbia Basin Steppe and Grassland ecological systems rather than this canyon system. The Northern Rocky Mountain Lower Montane, Foothill and Valley Grassland ecological system merges with the canyon and foothill dry grassland system and generally is associated with moister areas, higher elevations near and above lower tree line, and closed fescue-dominated grasslands. Valley bottom and toe slope, droughty, gravelly, and sandy sites in low precipitation areas in are the Intermountain Basins Semi-desert Grassland ecological system.

Landform settings of this grassland are primarily long, steep slopes of 100 m to well over 400 m in length, with colluvial soils derived from residuum and having patchy, thin, wind-blown surface deposits. Slope failures and soil creep are common processes. Saturated soil layers over frozen soil are related to most soil slips (Tisdale 1986). Perennial bunchgrasses and forbs dominate these grasslands, usually >25% cover. Bare ground, gravel and rock between bunches are common features due to soil movement and sun exposure. Biological soil crust cover is usually present but generally decreases with increasing vascular plant cover, elevation, loose surface rock, and coarseness of soil (Belnap et al. 2001). Dry occurrences of this grassland are open with spaces between mid-tall deep-rooted bunchgrass (*Pseudoroegneria spicata* or *Aristida purpurea* var. *longiseta*) along with *Poa secunda*, *Lupinus* spp., *Balsamorhiza sagittata*, *Phlox colubrina*, *Erigeron pumilus*, and *Opuntia polyacantha*. These species are joined by other mid-tall deep-rooted bunchgrasses (*Festuca idahoensis* and *Koeleria macrantha*) on moister sites (north aspects or higher elevations) often with a heavy litter cover. Burrowing animals and their predators likely played important roles in creating small-scale patch patterns. Annual precipitation is low (12-25 cm) and occurs mostly in winter, primarily as rain. Fire frequency is presumed to be less than 20 years; the return interval may have been as low as 5-10 years (LANDFIRE 2007). Elk, deer, and bighorn sheep are native large grazers who used this ecosystem, particularly in winter and spring (Tisdale 1986).

Stressors

The primary stressors of this system are livestock practices, annual exotic species invasion, fire regime alteration, direct soil surface disturbance, and fragmentation. Excessive grazing stresses the system through soil disturbance, diminishing or eliminating the biological soil crust, altering the composition of perennial species, and increasing the establishment and expansion of native increasers and exotic annual grasses, particularly *Bromus tectorum*. There are strong links between foliose lichens and ecosystem health (Rosentreter and Eldridge 2002). Severe trampling breaks lichen into fragments that are too small to reestablish, thus leading to their elimination (Rosentreter and Eldridge 2002). Persistent grazing further diminishes perennial cover, exposes bare ground, and increase exotic annuals. When bare ground is approximately ≤15% in fescue grasslands, there is reduced infiltration and increased runoff (Darambazar 2007, Johnston 1962). Fire further stresses livestock-altered vegetation by increasing exposure of bare ground, increasing exotic annuals, and decreasing perennial bunchgrass. Due to steepness of terrain grazing effects are usually concentrated in less steep slopes, although grazing does create contour trail networks that can lead to additional slope failures.

In more mesics areas, fire suppression leads to increases of deciduous shrubs (*Symphoricarpos* spp., *Physocarpus malvaceus*, *Holodiscus discolor*, and *Ribes* spp.) and in some areas trees (*Pinus ponderosa* or *Pseudotsuga menziesii*). Additional disturbances, such as vehicle tracks and chaining of shrubs, will increase the probability of alteration of vegetation structure and composition. Invasive perennial exotics such as *Centaurea solstitialis*, *Hypericum perfoliatum*, *Poa pratensis*, and *Prunus cerasifera* are major site stressors. Davies et al. (2009) concluded that sites with heavy litter accumulation (e.g., ungrazed *Artemisia tridentata* ssp. *wyomingensis/Festuca idahoensis – Achnatherium thurberiana* community) are more susceptible to exotic annual invasion following fire than those with less litter accumulation. They noted that introduced species and changes in climate may change ecosystem response to natural disturbance regimes. Canyon grasslands are "highly stable, with boundaries that are unlikely to change without a sizeable shift in climate" and "grassland community changes caused by heavy grazing do not appear to have altered their pattern of distribution" (Tisdale 1986).

Ecological Integrity Assessment

The following table (Table C-1) displays metrics chosen to measure most of the key ecological attributes in the conceptual ecological model. Unless otherwise noted, metric ratings apply to both Level 2 and Level 3 EIAs. The difference is that a Level 3 EIA will use more intensive and precise methods to determine metric ratings such as: (1) quantitative measurements of range health indicators (Pellant et al. 2005); (2) biological soil crust stability index (Rosentreter and Eldridge 2002); and (3) biological soil crust species composition and abundance (Eldridge and Rosentreter 1999).

Table C-1. Columbia Basin Foothill and Dry Canyon Grassland Ecological Integrity Assessment Scorecard.

Metric	Justification	Rank			
		A (5 points)	B (4 points)	C (3 points)	D (1 point)
Key ecological attribute – Landscape context					
Edge length	Intactness of edge can be biotically and abiotically important	≥75% of edge bordered by natural communities	≥50–75% of edge bordered by natural communities	≥25–50% of edge bordered by natural communities	<25% of edge bordered by natural communities
Edge width		Average width of edge ≥100m	Average width of edge ≥75–100m	Average width of edge ≥25–75m	Average width of edge <25m

Edge condition		>95% native vegetation cover; <5% non-native cover; intact soils	75–95% cover native vegetation; 5–25% cover of non-native plants; intact or moderately disrupted soils	25–50% cover non-native plants; moderate or extensive soil disruption	>50% cover non-native plants; barren ground; highly compacted or otherwise disrupted soils
Connectivity	Intact areas have continuous corridor of natural or semi-natural vegetation	Intact: Embedded in 90–100% natural habitat; connectivity expected to be high	Variegated: Embedded in 60–90% natural habitat; connectivity generally high, but lower for species sensitive to habitat modification	Fragmented: Embedded in 20–60% natural habitat; connectivity generally low, but varies with species mobility and arrangement on landscape	Relictual: Embedded in <20% natural habitat; connectivity essentially absent
Landscape condition	Intensity and type of surrounding land use can affect ecological integrity	Landscape Condition Model Index >0.8		Landscape Condition Model Index 0.8–0.65	Landscape Condition Model Index <0.65
Relative patch size	Indicates proportion lost due to stressors	Site at or minimally reduced from natural extent (≥95% remains)	Occurrence modestly reduced from original natural extent (≥80-95% remains)	Occurrence substantially reduced from original natural extent (≥50–80% remains)	Occurrence severely reduced from original natural extent (<50% remains)
Absolute patch size	Based on steppe obligate grasshopper sparrow conservation minimum ≥10ha and 40ha landscape patch (Paczek 2004)	>100ha	50–100ha	10–50ha	<10ha
Key ecological attribute – Vegetation condition					
Cover of native species	Non-native species increase with human impacts	Cover of native plants ≥95%	Cover of native plants 80–95%	Cover of native plants 50–80%	Cover of native plants <50%
Cover of native bunchgrass	High cover of native bunchgrasses related to resistance to invasion	Perennial bunchgrass cover >80% or near site potential	Perennial bunchgrass cover 50–80% or reduced from site potential	Perennial bunchgrass cover 30–50% or reduced from site potential	Perennial bunchgrass cover <30% and much reduced from site potential
Cover of invasive species	Invasive species inflict wide range of impacts.	None present	Invasive species present, but sporadic (<3% cover)	Invasive species prevalent (3–10% cover)	Invasive species abundant (>10% cover)
Cover of native increasers	Stressors such as grazing can shift or homogenize species composition	Absent or incidental	<10% cover	10-20% cover	>20% cover
Species composition	Composition of native species can shift when exposed to stressors	Diversity/abundance at or near reference standards; native species negative to anthropogenic degradation are present, species positive to anthropogenic degradation are absent to minor; full range of indicator species present	Diversity/abundance close to reference standards; native species reflective of anthropogenic degradation; some indicator species absent	Diversity/abundance differs from reference standards, but largely composed of native species; may include ruderal species; many indicator species absent	Vegetation severely altered from reference standards; dominated by ruderal species or comprised of planted stands of non-characteristic species or unnaturally dominated by single species; most indicator species absent
Biological soil crust	Crust cover and diversity greatest where not impacted by trampling or other disturbance	Biological soil crust nearly matches site capacity where site characteristics not limiting (i.e. steep unstable, south aspect, or dense grass)	Biological soil crust evident, but its continuity is broken	Biological soil crust present in protected areas and with minor component elsewhere	Biological soil crust, if present , only in protected areas
Key ecological attribute: Physicochemical and hydrology					
Soil surface condition	Disturbance result in erosion with negative affects on ecological processes	Bare soil areas limited to naturally caused disturbances such as burrowing animals or game trails	Bare soil due to human causes, but extent and impact minimal; depth of disturbance limited to ~5cm	Bare soil due to human causes are common; compaction to ~15cm; machinery may have left shallow ruts	Bare soil areas substantial and they contribute to long-lasting impacts; deep ruts from machinery present or livestock trails widespread

COLUMBIA BASIN PALOUSE PRAIRIE

General Description

The Columbia Basin Palouse Prairie ecological system was once an extensive grassland system in southeast Washington and adjacent Idaho and Oregon. It was characterized by dense bunchgrass cover on a dune-like topography composed of loess hills and plains over basalt informally called the Palouse loess (Busacca et al. 1992). The Palouse Prairie system is part of the Pacific Northwest Bunchgrass (Tisdale 1983, Lichthardt and Moseley 1997) associated with deep soils on rolling loess hills with 3 to 30 meter long slopes centered in southeast Washington and adjacent Idaho and Oregon. The system appears between the Columbia Plateau Steppe and Grassland and the Intermountain Basins Big Sagebrush Steppe systems to the east and the Northern Rocky Mountain Ponderosa Pine and Northern Rocky Mountain Dry-Mesic Forest ecological systems north and eastward. In the southern portion, the Palouse is dissected by the floristically similar Columbia Basin Canyon Dry Grasslands that is associated with steep, long slopes with soil derived from colluvial material and loess. The Northern Rocky Mountain Lower Montane, Foothill and Valley Grassland system, also floristically similar, occurs at higher elevation at and within the lower forest zones on broad ridgetops, plateaus, or in wide valleys. Once a matrix system, today the Palouse is a large patch system due to widespread conversion to cropland (Black et al. 1998). Remnant prairies are typically associated with small, steep and rocky sites or small, isolated sites within an agricultural landscape.

The associated climate of the Palouse Prairie is generally warm to hot, dry summers and cool, wet winters. Annual precipitation is relatively high, 38-76 cm. The soils were typically deep, well-developed, and old. A frequent, non-lethal fire regime (Morgan et al. 1996), along with soil drought and herbivory, retards invasion by woody species and can result in a patchy distribution of shrubs and trees. The most droughty sites are relatively unproductive with discontinuous fuel and likely have much longer fire return rates. Isolation of grassland patches by fragmentation may also limit seed dispersal of native shrubs leading to persistence of the grassland. Elk and deer are native grazers that use the Palouse, particularly in spring.

Characteristic species are *Festuca idahoensis* and *Pseudoroegneria spicata* (typically ssp. *inerme*) with *Hesperostipa comata*, *Koeleria macrantha*, *Leymus cinereus*, or *Poa secunda*. Shrubs commonly found include *Rosa* spp., *Symphoricarpos albus*, *Prunus virginiana*, *Eriogonum heraceloides*, *Amelanchier alnifolia*, and *Crataegus douglasii*. Past land use, excessive grazing, and invasion by introduced annual species have resulted in a broad conversion to agriculture or steppe with shrubs and annual grasslands dominated by *Artemisia* spp., *Ericameria nauseosa*, *Chrysothamnus viscidiflorus*, and *Bromus tectorum*, *Ventenata dubia*, *Poa bulbosa*.

Stressors

The primary stressors of this system are agricultural and livestock practices, establishment and expansion of exotic species, alteration of fire regimes, disturbance of the soil surface, and fragmentation of the landscape. Excessive grazing stresses the system through soil disturbance, thus increasing the probability of establishment and expansion of native increasers and exotic annual grasses, particularly annual bromes (*Bromus commutatus*, *B. japonicus*, *B. mollis*, *B.*

tectorum, Ventenata dubia) on more xeric sites and exotic perennial grasses (*Arrhenatherum elatius*, *Bromus inermis*, *Phleum pratense*, *Poa pratensis)* on more mesic sites. Other exotic species threatening this ecological system through invasion and expansion include *Hypericum perfoliatum*, *Potentilla recta*, *Euphorbia esula*, and knapweeds, especially *Centaurea biebersteinii* (= *Centaurea maculosa*). Persistent grazing will further diminish native perennial cover, expose bare ground, and increase the prevalence of exotic species (Johnson and Swanson 2005). When bare ground is approximately ≤15% in fescue grasslands, there is reduced infiltration and increased runoff (Darambazar 2007, Johnston 1962). Fire further stresses livestock-altered vegetation by increasing exposure of bare ground, increasing prevalence of exotic annuals, and decreasing perennial bunchgrass. Grazing effects are usually concentrated in less steep slopes although grazing does create contour trail networks that can lead to additional slope failures. Fire suppression leads to increases in deciduous shrubs (*Symphoricarpos* spp., *Physocarpus malvaceus*, *Holodiscus discolor*, *Ribes* spp.) or trees (*Pinus ponderosa, Pseudotsuga menziesii*) in some areas.

Davies et al. (2009) concluded that sites with heavy litter accumulation, (e.g., an ungrazed *Artemisia tridentata* ssp. *wyomingensis/Festuca idahoensis – Achnatherium thurberiana* community) are more susceptible to exotic annual invasion following fire than those with less litter accumulation. They note that introduced species and changes in climate can change ecosystem response to natural disturbance regimes. *Festuca idahoensis* may decrease following fire but following a flush of annuals sites regain pre-fire cover of *Festuca* after a few years (Johnson and Swanson 2005).

Ecological Integrity Assessment

The following table (Table C-2) displays metrics chosen to measure most of the key ecological attributes in the conceptual ecological model. Unless otherwise noted, metric ratings apply to both Level 2 and Level 3 EIAs. The difference is that a Level 3 EIA will use more intensive and precise methods to determine metric ratings.

Table C-2. Columbia Basin Palouse Prairie Ecological Integrity Assessment Scorecard.

Metric	Justification	Rank			
		A (5 points)	**B (4 points)**	**C (3 points)**	**D (1 point)**
Key ecological attribute – Landscape context					
Edge length	Intactness of edge can be biotically and abiotically important	≥75% of edge bordered by natural communities	≥50–75% of edge bordered by natural communities	≥25–50% of edge bordered by natural communities	<25% of edge bordered by natural communities
Edge width		Average width of edge ≥100m	Average width of edge ≥75–100m	Average width of edge ≥25–75m	Average width of edge <25m
Edge condition		>95% native vegetation cover; <5% non-native cover; intact soils	75–95% cover native vegetation; 5–25% cover of non-native plants; intact or moderately disrupted soils	25–50% cover non-native plants; moderate or extensive soil disruption	>50% cover non-native plants; barren ground; highly compacted or otherwise disrupted soils
Connectivity	Intact areas have continuous corridor of natural or semi-natural vegetation	Intact: Embedded in 90–100% natural habitat; connectivity expected to be high	Variegated: Embedded in 60–90% natural habitat; connectivity generally high, but lower for species sensitive to habitat modification	Fragmented: Embedded in 20–60% natural habitat; connectivity generally low, but varies with species mobility and arrangement on landscape	Relictual: Embedded in <20% natural habitat; connectivity essentially absent

Landscape condition	Intensity and types of land uses in surrounding landscape can affect ecological integrity	Landscape Condition Model Index >0.8		Landscape Condition Model Index 0.8–0.65	Landscape Condition Model Index <0.65
Relative patch size	Indicates proportion lost due to stressors	Site at or minimally reduced from natural extent (≥95% remains)	Occurrence modestly reduced from original natural extent (≥80-95% remains)	Occurrence substantially reduced from original natural extent (≥50–80% remains)	Occurrence severely reduced from original natural extent (<50% remains)
Absolute patch size	Based on steppe obligate grasshopper sparrow conservation minimum ≥10ha and 40ha landscape patch (Paczek 2004)	>1000ha	500–1000ha	10–500ha	<10ha
Key ecological attribute – Vegetation condition					
Cover of native species	Native species dominate ecosystem; non-natives increase with human impacts	Cover of native plants ≥95%	Cover of native plants 80–95%	Cover of native plants 50–80%	Cover of native plants <50%
Cover of native bunchgrass	Native bunchgrasses dominate; high cover related to resistance to invasion	Perennial bunchgrass cover >80% or near site potential	Perennial bunchgrass cover 50–80% or reduced from site potential	Perennial bunchgrass cover 30–50% or reduced from site potential	Perennial bunchgrass cover <30% and much reduced from site potential
Cover of invasive species	Invasive species inflict wide range of impacts; early detection critical	None present	Invasive species present, but sporadic (<3% cover)	Invasive species prevalent (3–10% cover)	Invasive species abundant (>10% cover)
Cover of native increasers	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	Composition of native species can shift when exposed to stressors.	Diversity/abundance at or near reference standards; native species negative to anthropogenic degradation are present, species positive to anthropogenic degradation are absent to minor; full range of indicator species present	Diversity/abundance close to reference standards; native species reflective of anthropogenic degradation; some indicator species absent	Diversity/abundance differs from reference standards, but largely composed of native species; may include ruderal species; many indicator species absent	Vegetation severely altered from reference standards; dominated by ruderal species or comprised of planted stands of non-characteristic species or unnaturally dominated by single species; most indicator species absent
Shrub cover	Shrubs can indicate past disturbance such as grazing or fire suppression	<5% cover	5–10% cover	10–25% cover	>25% cover
Biological soil crust	Crust cover and diversity greatest where not impacted by trampling or other disturbance	Biological soil crust nearly matches site capacity where site characteristics not limiting (i.e. steep unstable, south aspect, or dense grass)	Biological soil crust evident, but its continuity is broken	Biological soil crust present in protected areas and with minor component elsewhere	Biological soil crust, if present , only in protected areas
Key ecological attribute: Physicochemical and hydrology					
Soil surface condition	Disturbance can result in erosion with negative affects on ecological processes; bareground amount varies naturally with site type	Bare soil areas limited to naturally caused disturbances such as burrowing animals or game trails	Bare soil due to human causes, but extent and impact minimal; depth of disturbance limited to ~5cm	Bare soil due to human causes are common; compaction to ~15cm; machinery may have left shallow ruts	Bare soil areas substantial and they contribute to long-lasting impacts; deep ruts from machinery present or livestock trails widespread

COLUMBIA BASIN STEPPE AND GRASSLAND

General Description

This steppe system occurs over large areas, occasionally entire landforms. This system is an alternative state of the Intermountain Basins Big Sagebrush Steppe ecological system type where a frequent fire (< 20 years) or fire severity results in the general absence or scarsity of deep-rooted, fire intolerant shrubs (Laycock 1991). *Artemisia tridentata*, *A. tripartita* and *Purshia tridentata* are absent and are unlikely to re-establish due to lack of seed sources. This system can be distinguished from shrubless patches within the Big Sagebrush Steppe or Semi-desert shrubsteppe ecological systems by the absence of shrubsteppe indicator shrubs in relatively homogeneous environments of ≥20ha, often including whole landforms. Columbia Steppe and Grassland is dominated by perennial bunchgrasses and forbs (>25% cover), and can have little exposed ground due to mosses and lichens carpeting the area between plants. Associated graminoids include *Achnatherum hymenoides*, *Elymus elymoides*, *Elymus lanceolatus* ssp. *lanceolatus*, *Hesperostipa comata*, *Festuca idahoensis*, *Koeleria macrantha*, *Poa secunda*, and *Pseudoroegneria spicata*. Common forbs are *Phlox hoodii*, *Arenaria* spp., and *Astragalus* spp. Areas with deeper soils are rare because of conversion to other land uses. Shrubs such as *Chrysothamnus viscidiflorus*, *Ericameria nauseosa*, or *Tetradymia* spp. may be present in burned or grazed stands. Biological soil crust is very important in this ecological system. Soils are variable, ranging from relatively deep, fine-textured, often with coarse fragments, to stony volcanic-derived clays, to alluvial sands. Burrowing animals and their predators likely played important roles in creating small-scale patch patterns.

Precipitation and soil depth and texture largely drive the distribution of shrubsteppe and associated systems in the Columbia Basin in Washington. Geographically, this steppe system is associated with the Intermountain Basins Big Sagebrush Steppe system, it rings the driest portion of the Basin that supports the Big Sagebrush Shrubland and the Semi-desert Shrub Steppe systems, and is bounded by montane woodlands and the Palouse prairie. By comparison, the Northern Rocky Mountain Foothill and Valley Grasslands are more productive. Deep canyons (Snake River) dissecting the southeastern corner of the basin, support Dry Canyon grasslands that are distinguished by primarily colluvial soils derived from basalt and loess and by periodic slope failures and slumping. Shallow soils (lithic or deep, gravel flood deposits) occur in Pleistocene flood channels that fan across the basin and support the Columbia Scabland system. Columbia Steppe and Grassland soils are deep to shallow (≥2.5cm) and non-saline, often with a biological soil crust. Greater crust cover occurs on north- and east-facing slopes at mid elevations with stable, silt-loam or calcareous soils where not disturbed (Tyler 2006) or where vascular cover and litter are not limiting. Tyler (2006) found that shrubsteppe plots were generally correlated with biological soil crust variables, while grass-steppe plots were generally aligned with *Bromus tectorum* and *Salsola*. He stated that pattern reflected that grass-steppe habitats on Yakima Training Center mostly resulted from the conversion of shrubsteppe habitats by past wildfire.

Fire return interval for productive shrubsteppe is 12-15 years (fire regime I) and 50-100 years (fire regime II) in less productive areas (Miller and Eddleman 2001); alternatively Baker (2006) concludes that Wyoming sagebrush fire rotations are 100-240 years (fire regime V). Grassland or steppe fire intervals are 1-23 years (Perryman et al. 2001). The Columbia Basin Steppe and

Grassland system exists because fire frequency has allowed for ashift to a native grassland condition maintained without significant shrub invasion over a 50 to 70 year interval. Perryman et al. (2001) calculated a mean recruitment interval of 2.3 (±0.7) years for sagebrush stands in Wyoming. Shrubs produce large quantities of small seeds beginning at 3 to 4 years of age. FEIS summarizes that approximately 90% of big sagebrush seed is dispersed within 9 meters of the parent and few seeds are carried more than 30 meters (http://www.fs.fed.us/database/feis/plants/shrub/arttrit).

Large native ungulate grazing in the Columbia Basin differed from that in the Great Plains grasslands in duration, seasonality, and severity (Mack and Thompson 1982, Burkhart 1995). In general, grazing was dispersed during the winter and spring when forage was available. Davies et al. (2009) conclude that sites with heavy litter accumulation, (e.g., ungrazed *Artemisia tridentata* ssp. *wyomingensis/Festuca idahoensis – Achnatherium thurberiana* community) are more susceptible to exotic annual invasion following fire than those with less litter accumulation. They note that introduced species and changes in climate can change ecosystem response to natural disturbance regimes.

Stressors

The primary stressors of this system are livestock practices, annual exotic species, fire regime alteration, direct soil surface disturbance, and fragmentation. Excessive grazing stresses the system through soil disturbance, trampling, displacement of the biological soil crust, alteration of the composition of perennial species, and establishment and expansion of native increasers and exotic annual grasses, particularly *Bromus tectorum*. Persistent grazing can further diminish perennial cover, expose bare ground, and increase exotic annuals. Fire further stresses livestock-altered vegetation by increasing exposure of bare ground, increasing exotic annuals, and decreasing perennial bunchgrass. In more mesic steppe, fire is not as important in maintenance of perennial grasses and forbs. Any disturbances to soil and bunchgrass layers, such as vehicle tracks and chaining shrubs, will increase the probability of alteration of vegetation structure and composition. Davies et al. (2009) concluded that sites with heavy litter accumulation, (e.g., ungrazed *Artemisia tridentata* ssp. *wyomingensis / Festuca idahoensis – Achnatherium thurberiana* community) are more susceptible to exotic annual invasion following fire than those with less litter accumulation. They noted that introduced species and changes in climate can change ecosystem response to natural disturbance regimes. *Festuca idahoensis* decreases following fire, but following a flush of annuals these sites regain pre-fire cover after a few years (Johnson and Swanson 2005).

Fragmentation of shrubsteppe by agriculture increases cover of annual grass, total annual/biennial forbs, and bare ground and decreases cover of perennial forbs, biological soil crusts, and obligate insects (Quinn 2004), birds, and small mammals (Vander Haegen et al 2005). These fragmentation responses are similarly expected in steppe vegetation.

Ecological Integrity Assessment

The following table (Table C-3) displays metrics chosen to measure most of the key ecological attributes in the conceptual ecological model. Unless otherwise noted, metric ratings apply to both Level 2 and Level 3 EIAs. The difference is that a Level 3 EIA will use more intensive and

precise methods to determine metric ratings such as: (1) quantitative measurements of range health indicators (Pellant et al. 2005); (2) biological soil crust stability index (Rosentreter and Eldridge 2002); and (3) biological soil crust species composition and abundance (Eldridge and Rosentreter 1999).

Table C-3. Columbia Basin Steppe and Grassland Ecological Integrity Assessment Scorecard.

Metric	Justification	Rank			
		A (5 points)	**B (4 points)**	**C (3 points)**	**D (1 point)**
Key ecological attribute – Landscape context					
Edge length	Intactness of edge can be biotically and abiotically important	≥75% of edge bordered by natural communities	≥50–75% of edge bordered by natural communities	≥25–50% of edge bordered by natural communities	<25% of edge bordered by natural communities
Edge width		Average width of edge ≥100m	Average width of edge ≥75–100m	Average width of edge ≥25–75m	Average width of edge <25m
Edge condition		>95% native vegetation cover; <5% non-native cover; intact soils	75–95% cover native vegetation; 5–25% cover of non-native plants; intact or moderately disrupted soils	25–50% cover non-native plants; moderate or extensive soil disruption	>50% cover non-native plants; barren ground; highly compacted or otherwise disrupted soils
Connectivity	Intact areas have continuous corridor of natural or semi-natural vegetation	Intact: Embedded in 90–100% natural habitat; connectivity expected to be high	Variegated: Embedded in 60–90% natural habitat; connectivity generally high, but lower for species sensitive to habitat modification	Fragmented: Embedded in 20–60% natural habitat; connectivity generally low, but varies with species mobility and arrangement on landscape	Relictual: Embedded in <20% natural habitat; connectivity essentially absent
Landscape condition	Intensity and types of land uses in surrounding landscape can affect ecological integrity	Landscape Condition Model Index >0.8		Landscape Condition Model Index 0.8–0.65	Landscape Condition Model Index <0.65
Relative patch size	Indicates proportion lost due to stressors	Site at or minimally reduced from natural extent (≥95% remains)	Occurrence modestly reduced from original natural extent (≥80-95% remains)	Occurrence substantially reduced from original natural extent (≥50–80% remains)	Occurrence severely reduced from original natural extent (<50% remains)
Absolute patch size	Based on steppe obligate grasshopper sparrow conservation minimum ≥10ha and 40ha landscape patch (Paczek 2004)	>100ha	50–100ha	10–50ha	<10ha
Key ecological attribute – Vegetation condition					
Cover of native species	Native species dominate ecosystem; non-natives increase with human impacts	Cover of native plants ≥95%	Cover of native plants 80–95%	Cover of native plants 50–80%	Cover of native plants <50%
Cover of native bunchgrass	Native bunchgrasses dominate; high cover related to resistance to invasion	Perennial bunchgrass cover >80% or near site potential	Perennial bunchgrass cover 50–80% or reduced from site potential	Perennial bunchgrass cover 30–50% or reduced from site potential	Perennial bunchgrass cover <30% and much reduced from site potential
Cover of invasive species	Invasive species inflict wide range of impacts; early detection critical	None present	Invasive species present, but sporadic (<3% cover)	Invasive species prevalent (3–10% cover)	Invasive species abundant (>10% cover)
Cover of native increasers	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	Composition of native species can shift when exposed to stressors.	Diversity/abundance at or near reference standards; native species negative to anthropogenic degradation are present, species positive to anthropogenic degradation are absent to minor; full range of indicator species present	Diversity/abundance close to reference standards; native species reflective of anthropogenic degradation; some indicator species absent	Diversity/abundance differs from reference standards, but largely composed of native species; may include ruderal species; many indicator species absent	Vegetation severely altered from reference standards; dominated by ruderal species or comprised of planted stands of non-characteristic species or unnaturally dominated by single species; most indicator species absent
Biological soil crust	Crust cover and diversity greatest where not impacted by trampling or other disturbance	Biological soil crust nearly matches site capacity where site characteristics not limiting (i.e. steep unstable, south aspect, or dense grass)	Biological soil crust evident, but its continuity is broken	Biological soil crust present in protected areas and with minor component elsewhere	Biological soil crust, if present , only in protected areas
Key ecological attribute: Physicochemical and hydrology					
Soil surface condition	Disturbance can result in erosion with negative affects on ecological processes; bareground amount varies naturally with site type	Bare soil areas limited to naturally caused disturbances such as burrowing animals or game trails	Bare soil due to human causes, but extent and impact minimal; depth of disturbance limited to ~5cm	Bare soil due to human causes are common; compaction to ~15cm; machinery may have left shallow ruts	Bare soil areas substantial and they contribute to long-lasting impacts; deep ruts from machinery present or livestock trails widespread

COLUMBIA PLATEAU SCABLAND SHRUBLAND

General Description

The large to small patch Columbia Plateau Scabland Shrubland ecological system occurs on the Columbia Plateau in eastern Washington, eastern Oregon, southern Idaho, and extreme northern Nevada. It is a xeric, low (e.g. < 0.5 m tall) open shrubland with short grasses that occurs on sites with little soil development and extensive areas of exposed rock, gravel, or compacted soil. It is found across a wide range of elevations from 150 to 1,500 meters and is characterized with flats, plateaus, and gentle to steep slopes with rock. Bare ground and rock usually account for >60% of ground cover. Shallow (10-23 cm) lithic soil occurs over fractured basalt or rarely deep gravel that has limited water-holding capacity and is a major environmental driver. Due to poor drainage through basalt, winter precipitation can saturate soils from fall to spring but typically dry out completely to bedrock by spring to midsummer. Precipitation ranges from 20 to 40 cm.

Total vegetation cover is typically low, generally less than 50% and often much less. The open dwarf-shrub canopy is usually dominated by *Artemisia rigida* along with other dwarf-shrub species, particularly *Eriogonum* spp. (*compositum*, *douglasii*, *sphaerocephalum*, *strictum* or *thymoides*). Some sites are dominated by grasses and semi-woody forbs, such as *Stenotus stenophyllus*. More than a presence of other *Artemisia* species besides *Artemisia rigida* indicates a different ecological system. Other characteristics of scabland sites include low cover of perennial short bunchgrasses, primarily *Poa secunda*, with scattered forbs such as *Allium*, *Antennaria*, *Balsamorhiza*, *Lomatium*, *Phlox*, and *Sedum*. Other short bunchgrasses, *Danthonia unispicata* and *Elymus elymoides* can characterize sites. Annuals may be seasonally abundant, and cover of moss and lichen is often high in natural areas (e.g. 1-60% cover). Biological soil crust cover in Columbia Plateau Scabland Shrublands is considered to be high (Belnap et al 2001). Tyler (2006) found that tall moss (*Tortula*) is positively correlated with dwarf shrubsteppe in Yakima County, Washington. Hardman (2007) concluded from a study in the Blue Mountains that *Artemisia rigida* steppe and thin soil grasslands are sensitive habitats greatly impacted by soil disturbance and that they host rare lichen and bryophyte species, such as *Grimmia ovalis*, *Dermatocarpon bachmannii*, and *Cladonia imbricarica*. Johnson and Swanson (2005) found little difference in biological soil crust cover in grazed areas although they stated overgrazing will destroy crusts. Freezing of saturated soils results in frost-heaving that churns the soil and is a major disturbance factor in determining vegetation patterns. Native ungulates utilize this ecological system in early spring and contribute to disturbance of the soil surface. Severely grazed *Artemisia rigida* bushes are browsed to compact mats (Johnson and Swanson 2005). Vegetation cover is too low to carry fires and scablands rarely burn (Agee 1994). Sites with co-dominance of *Artemisia rigida* and *Artemisia tridentata* or *Purshia tirdentata* are included as part of the matrix Intermountain Basins Big Sagebrush Steppe system. These are rocky sites with fine texture soils and have intermediate characteristics of scablands and shrubsteppe.

Stressors

Land uses in this system are few and stressors to natural processes are primarily confined to livestock use and exotic species invasion. This system provides little forage and consequently is used marginally by livestock. However, heavy disturbance by livestock or vehicles, particularly after the sites have dried, disrupts the moss/lichen layer and increases exposed rock and bare ground, thus increasing the potential for invasion by non-native plants. Grazing also reduces the cover of bunchgrasses and increases the abundance of forbs such as *Achillea millefolium*, *Phlox* sp., *Trifolium macrocephalum*, *Balsamorhiza serrata*, *Sitanion hystrix*, and annual bromes. All dwarf-shrub species are intolerant of fire and do not sprout. Consequently, redevelopment of dwarf shrubsteppe habitat is slow following fire or any disturbance that removes shrubs. Wind and industrial solar panel farms have been developed on scabland causing conversion and fragmentation.

Ecological Integrity Assessment

The following table (Table C-4) displays metrics chosen to measure most of the key ecological attributes in the conceptual ecological model. Unless otherwise noted, metric ratings apply to both Level 2 and Level 3 EIAs. The difference is that a Level 3 EIA will use more intensive and precise methods to determine metric ratings such as: (1) quantitative measurements of range health indicators (Pellant et al. 2005); (2) biological soil crust stability index (Rosentreter and Eldridge 2002); and (3) biological soil crust species composition and abundance (Eldridge and Rosentreter 1999).

Table C-4. Columbia Plateau Scabland Shrubland.

Metric	Justification	Rank			
		A (5 points)	B (4 points)	C (3 points)	D (1 point)
Key ecological attribute – Landscape context					
Edge length	Intactness of edge can be biotically and abiotically important	≥75% of edge bordered by natural communities	≥50–75% of edge bordered by natural communities	≥25–50% of edge bordered by natural communities	<25% of edge bordered by natural communities
Edge width		Average width of edge ≥200m	Average width of edge ≥100–200m	Average width of edge ≥50–100m	Average width of edge <50m
Edge condition		>95% native vegetation cover; <5% non-native cover; intact soils and no refuse	75–95% cover native vegetation; 5–25% cover of non-native plants; intact or moderately disrupted soils and little refuse	25–50% cover non-native plants; moderate or extensive soil disruption and refuse	>50% cover non-native plants; barren ground; highly compacted or otherwise disrupted soils and refuse

Connectivity	Intact areas have continuous corridor of natural or semi-natural vegetation	Intact: Embedded in 90–100% natural habitat; connectivity expected to be high	Variegated: Embedded in 60–90% natural habitat; connectivity generally high, but lower for species sensitive to habitat modification	Fragmented: Embedded in 20–60% natural habitat; connectivity generally low, but varies with species mobility and arrangement on landscape	Relictual: Embedded in <20% natural habitat; connectivity essentially absent
Landscape condition	Intensity and types of land uses in surrounding landscape can affect ecological integrity	Landscape Condition Model Index >0.8		Landscape Condition Model Index 0.8–0.65	Landscape Condition Model Index <0.65
Relative patch size	Indicates proportion lost due to stressors	Site at or minimally reduced from natural extent (≥95% remains)	Occurrence modestly reduced from original natural extent (≥80-95% remains)	Occurrence substantially reduced from original natural extent (≥50–80% remains)	Occurrence severely reduced from original natural extent (<50% remains)
Absolute patch size	Determined by soil depth; naturally small	>250ha	25–250ha	2.5–25ha	<2.5ha
Key ecological attribute – Vegetation condition					
Cover of native species	Native species dominate ecosystem; non-natives increase with human impacts	Cover of native plants ≥95%	Cover of native plants 80–95%	Cover of native plants 50–80%	Cover of native plants <50%
Cover of native bunchgrass	Native bunchgrasses dominate vascular layers	Perennial short bunchgrasses dominate cover near site potential	Perennial short bunchgrasses dominate cover, but slightly reduced from site potential by stressors	Perennial short bunchgrass domate cover, but cover clearly reduced from site potential by stressors	Perennial short bunchgrass dominate cover, but cover much reduced from site potential by stressors
Cover of invasive species	Invasive species inflict wide range of impacts; early detection critical	None present	Invasive species present, but sporadic (<3% cover)	Invasive species prevalent (3–10% cover)	Invasive species abundant (>10% cover)
Species composition	Composition of native species can shift when exposed to stressors.	Diversity/abundance at or near reference standards; native species negative to anthropogenic degradation are present, species positive to anthropogenic degradation are absent to minor; full range of indicator species present	Diversity/abundance close to reference standards; native species reflective of anthropogenic degradation; some indicator species absent	Diversity/abundance differs from reference standards, but largely composed of native species; may include ruderal species; many indicator species absent	Vegetation severely altered from reference standards; dominated by ruderal species or comprised of planted stands of non-characteristic species or unnaturally dominated by single species; most indicator species absent
Shrub cover (fire-sensitive species)	Fire, naturally rare, eliminates or reduces *Artemisia rigida* or woody *Eriogonum* cover	Fire-sensitive shrubs mature and recovered from past fires	Fire-sensitive shrubs common, not fully recovered from past fires	Fire-sensitive shrubs present, recovering from past fires	Fire-sensitive shrubs rare due to past fires
Biological soil crust	Crust cover and diversity greatest where not impacted by trampling or other disturbance	Biological soil crust nearly matches site capacity where site characteristics not limiting (i.e. steep unstable, south aspect, or dense grass)	Biological soil crust evident, but its continuity is broken	Biological soil crust present in protected areas and with minor component elsewhere	Biological soil crust, if present , only in protected areas
Key ecological attribute: Physicochemical and hydrology					
Soil surface condition	Disturbance can result in erosion with negative affects on ecological processes; bareground amount varies naturally with site type	Bare soil areas limited to naturally caused disturbances such as burrowing animals or game trails	Bare soil due to human causes, but extent and impact minimal; depth of disturbance limited to ~5cm	Bare soil due to human causes are common; compaction to ~15cm; machinery may have left shallow ruts	Bare soil areas substantial and they contribute to long-lasting impacts; deep ruts from machinery present or livestock trails widespread

COLUMBIA PLATEAU LOW SAGEBRUSH STEPPE

General Description

The matrix or large patch Columbia Plateau Low Sagebrush Steppe ecological system occurs in a variety of shallow-soil habitats throughout eastern Oregon, northern Nevada, southern Idaho and eastern Washington. Rangewide, this system is dominated by *Artemisia arbuscula*. Of the four subspecies of *A. arbuscula* only subspecies *arbuscula* is in Washington. It occurs on isolated ridges near or above lower treeline in Chelan, Kittitas and Yakima counties and is not particularly commonly. In Washington, it forms stands on mountain ridges, flanks, and terraces, ranging from 1000 to 1400 meters elevation surrounded by *Pseudotsuga menziesii* and *Pinus ponderosa* forests. Substrates are shallow, fine-textured soils, poorly drained clays, and almost always very stony, characterized by recent rhyolite or basalt. In Washington, the habitat is characterized by *Artemisia rigida* and *Artemisia tridentata* ssp. *wyomingensis* or *vaseyana* with an understory of *Festuca idahoensis*, *Poa secunda*, *Pseudoroegneria spicata*, and *Koeleria macrantha*. Other shrubs and dwarf-shrubs present may include *Purshia tridentata* and *Eriogonum* spp. Many forbs also occur and may dominate the herbaceous vegetation, especially at higher elevations. The space between vascular plants may support a biological crust that has low cover even without disturbance. Biological crust cover generally decreases with increasing disturbance of soil surface, vascular plant cover, elevation, loose surface rock, and coarseness of soil so that its presence and diversity indicate high integrity relative to anthropogenic disturbance. Johnson and Swanson (2005) indicate that bare ground, even in least disturbed sites, is 0-25% cover.

In general, fire increases the abundance of herbaceous perennials and decreases the abundance of woody plants. The fire interval for this system is about 110 years (LANDFIRE 2007). Anecdotal observations indicate that these patches often are not burned during forest fires in adjacent ecosystems. However, recovery of this system after fire may take 325–450 years (Baker 2006). Low sagebrush steppe in Washington can be confused remotely with the mountain sagebrush steppe and must be determine on-the-ground.

Stressors

The primary stressors of this system are livestock practices, annual exotic species invasion, fire regime alteration, direct soil surface disturbance, and fragmentation. *Artemisia arbuscula* is considered a valuable browse plant during the spring, fall, and winter months and often is grazed by native ungulates (elk and mule deer) and domestic livestock. Prolonged livestock use can cause a decrease in the abundance of native bunch grasses and increase in the cover of shrubs and non-native grass species, such as *Poa bulbosa* and *Bromus tectorum*.

Ecological Integrity Assessment

The following table (Table C-5) displays metrics chosen to measure most of the key ecological attributes in the conceptual ecological model. Unless otherwise noted, metric ratings apply to both Level 2 and Level 3 EIAs. The difference is that a Level 3 EIA will use more intensive and precise methods to determine metric ratings such as: (1) quantitative measurements of range health indicators (Pellant et al. 2005) and (2) biological soil crust species composition and abundance (Eldridge and Rosentreter 1999).

Table C-5. Columbia Plateau Low Sagebrush Steppe Ecological Integrity Assessment Scorecard.

Metric	Justification	Rank			
		A (5 points)	B (4 points)	C (3 points)	D (1 point)
Key ecological attribute – Landscape context					
Edge length	Intactness of edge can be biotically and abiotically important	≥75% of edge bordered by natural communities	≥50–75% of edge bordered by natural communities	≥25–50% of edge bordered by natural communities	<25% of edge bordered by natural communities
Edge width		Average width of edge ≥200m	Average width of edge ≥100–200m	Average width of edge ≥50–100m	Average width of edge <50m
Edge condition		>95% native vegetation cover; <5% non-native cover; intact soils and no refuse	75–95% cover native vegetation; 5–25% cover of non-native plants; intact or moderately disrupted soils and little refuse	25–50% cover non-native plants; moderate or extensive soil disruption and refuse	>50% cover non-native plants; barren ground; highly compacted or otherwise disrupted soils and refuse
Connectivity	Intact areas have continuous corridor of natural or semi-natural vegetation	Intact: Embedded in 90–100% natural habitat; connectivity expected to be high; mosaic with gradients	Variegated: Embedded in 60–90% natural habitat; connectivity generally high, but lower for species sensitive to habitat modification; mosaic with both gradients and abrupt boundaries	Fragmented: Embedded in 10–60% natural habitat; connectivity generally low, but varies with species mobility and arrangement on landscape; gradients shortened	Relictual: Embedded in <10% natural habitat; connectivity essentially absent; remaining habitat uniform
Landscape condition	Intensity and types of land uses in surrounding landscape can affect ecological integrity	Landscape Condition Model Index >0.8		Landscape Condition Model Index 0.8–0.65	Landscape Condition Model Index <0.65
Relative patch size	Indicates proportion lost due to stressors	Site at or minimally reduced from natural extent (≥95% remains)	Occurrence modestly reduced from original natural extent (≥80-95% remains)	Occurrence substantially reduced from original natural extent (≥50–80% remains)	Occurrence severely reduced from original natural extent (<50% remains)
Absolute patch size	Determined by soil depth; naturally small	>250ha	25–250ha	2.5–25ha	<2.5ha
Key ecological attribute – Vegetation condition					
Cover of native species	Native species dominate ecosystem; non-natives increase with human impacts	Cover of native plants ≥95%	Cover of native plants 80–95%	Cover of native plants 50–80%	Cover of native plants <50%
Cover of native bunchgrass	Native bunchgrasses dominate; high cover related to resistance to invasion	Perennial bunchgrass cover >80% or near site potential	Perennial bunchgrass cover 50–80% or reduced from site potential	Perennial bunchgrass cover 30–50% or reduced from site potential	Perennial bunchgrass cover <30% and much reduced from site potential
Cover of invasive species	Invasive species inflict wide range of impacts; early detection critical	None present	Invasive species present, but sporadic (<3% cover)	Invasive species prevalent (3–10% cover)	Invasive species abundant (>10% cover)
Cover of native increasers	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	Composition of native species can shift when exposed to stressors.	Diversity/abundance at or near reference standards; native species negative to anthropogenic degradation are present, species positive to anthropogenic degradation are absent to minor; full range of indicator species present	Diversity/abundance close to reference standards; native species reflective of anthropogenic degradation; some indicator species absent	Diversity/abundance differs from reference standards, but largely composed of native species; may include ruderal species; many indicator species absent	Vegetation severely altered from reference standards; dominated by ruderal species or comprised of planted stands of non-characteristic species or unnaturally dominated by single species; most indicator species absent
Shrub cover (fire-sensitive species)	Shrubs part of historic range of variation	Fire-sensitive shrubs mature and recovered from past fires; generally <25% cover	Fire-sensitive shrubs common, not fully recovered from past fires	Fire-sensitive shrubs present, recovering from past fires	Fire-sensitive shrubs absent or rare due to past fires
Key ecological attribute: Physicochemical and hydrology					
Soil surface condition	Disturbance can result in erosion with negative affects on ecological processes; bareground amount varies naturally with site type	Bare soil areas limited to naturally caused disturbances such as burrowing animals or game trails	Bare soil due to human causes, but extent and impact minimal; depth of disturbance limited to ~5cm	Bare soil due to human causes are common; compaction to ~15cm; machinery may have left shallow ruts	Bare soil areas substantial and they contribute to long-lasting impacts; deep ruts from machinery present or livestock trails widespread

INTERMOUNTAIN BASINS SEMIDESERT SHRUBSTEPPE

General Description

The widespread matrix-forming Intermountain Basins Semidesert Shrubsteppe ecological system occurs throughout much of the Intermountain West, most commonly in the southern portions. In Washington, it occurs as large to small patches in the hottest, driest (<20cm precipitation/year) portions of the Columbia Basin (Pasco, Quincy, Umatilla, and lower Yakima basins). Soil depth and texture and precipitation largely drives the distribution of shrubsteppe and associated systems in the Columbia Basin of Washington. This rare system is surrounded upslope by the Big Sagebrush Shrub Steppe system (mostly Wyoming big sagebrush/bluebunch wheatgrass and related associations) on deeper soils and the Columbia Basin Scabland system on shallow soils (lithic or deep, gravel flood deposits). In the valley bottoms associated with rivers, this system can occur in a landscape pattern with Intermountain Basins Greasewood Flat on wetter, alkaline to saline sites and Intermountain Basins Active and Stabilized Dune systems. Soils are deep to shallow, well-drained, non-saline, often calcareous, and typically with a biological soil crust. They apparently are associated with the Ringold Formation on slopes.

The woody layer is often a mixture of shrubs and dwarf-shrubs, although it may be dominated by a single shrub species. Characteristic species include *Grayia spinosa*, *Krascheninnikovia lanata*, and *Ericameria nauseosa*. *Artemisia tridentata* may be present, particular in disturbed sites, but it typically does not dominate. On stonier sites, *Salvia dorrii* can be present to common. In Washington, the *Artemisia tridentata-Poa secunda* association can occur in this system when in association with semi-desert vegetation. This semi-arid shrubsteppe typically has an open to dense shrub layer and a strong graminoid layer (>25% cover but rarely closed). Characteristic grasses include *Achnatherum hymenoides*, *A. thurberiana*, *Elymus elymoides*, *Poa secunda*, *Sporobolus airoides*, and *Hesperostipa comata*. The most widespread species are *Poa secunda* and *Pseudoroegneria spicata* (not dominant). Annual grasses, especially *Bromus tectorum*, may be present to abundant. Forbs are generally of low importance and are highly variable across the range. but may be diverse in some occurrences (e.g. *Helianthus cusickii* and *Sphaeralcea* *munroana*). In Washington, this ecological system has a limited area and overlaps the similar Intermountain Mixed Salt Desert Scrub ecological system. The latter system apparently occurs on the White Bluffs in Grant and Franklin Counties with the above shrub species plus *Atriplex nuttallii* and several rare and endemic species (Deborah Salstrom, personal communication).

Disturbance may be important in maintaining the woody component of this ecosystem. Greater biological soil crust cover occurs on undisturbed north- and east-facing slopes at mid elevations with stable, silt-loam or calcareous soils (Tyler 2006) or where vascular cover and litter are not limiting. The natural fire regime of this ecological system is assumed to be similar to the Big Sagebrush Steppe Ecological Systems although both *Grayia spinosa* and *Krascheninnikovia lanata* are capable of sprouting following fire. In general, fire increases the abundance of herbaceous perennials and decreases woody plants. Fire return interval for productive shrubsteppe is 12-15 years and 50-100 years in less productive areas (Miller and Eddleman 2001). Fire maintains a patchy distribution of shrubs, so the general appearance of the vegetation is that of grassland. Where fire frequency has allowed shifts to a native grassland condition, maintained without significant shrub invasion over a 50- to 70-year interval, the area would be considered Intermountain Basins Semi-Desert Grassland. Large native ungulate grazing in the Columbia Basin differed from that of the Great Plains grasslands in duration, seasonality, and severity (Mack and Thompson 1982, Burkhart 1996). In general, grazing was dispersed during winter and spring when forage was available. Growing season is typically around six-weeks (Burkhart 1996).

Stressors

The primary stressors of this system are livestock practices, invasion by exotic annual species, alteration of the fire regime, disturbance of the soil surface, and fragmentation. Excessive grazing stresses the system through soil disturbance, diminishing or eliminating the biological soil crust, altering the composition of perennial species, and increasing the prevalence of native increasers and exotic annual grasses, particularly *Bromus tectorum*. Persistent grazing further diminishes perennial grass cover, thus exposing bare ground and increasing exotic annuals, potentially leading to dense stands of *Artemisia tridentata*. Fire further stresses livestock-altered vegetation by increasing exposure of bare ground, increaseing exotic annuals, and decreasing perennial bunchgrasses such as *Krascheninnikovia lanata*. Native communities dominated by *Krascheninnikovia lanata* produce little fine fuel whereas the introduction of *Bromus tectorum* into these communities has increased fuel loads and fuel distribution. Fire drastically alters the community composition because salt-desert shrubs are not adapted to periodic fire. Loss of shrub density and degradation of the bunchgrass layer decreases obligate shrubsteppe birds (Vander Haegen et al. 2000). Fragmentation of shrubsteppe by agriculture increases cover of annual grass, annual/biennial forbs, and bare ground and decreases abundance of perennial forbs, biological soil crusts, obligate insects (Quinn 2004), and obligate birds and small mammals (Vander Haegen et al. 2005).

Ecological Integrity Assessment

The following table (Table C-6) displays metrics chosen to measure most of the key ecological attributes in the conceptual ecological model. Unless otherwise noted, metric ratings apply to both Level 2 and Level 3 EIAs. The difference is that a Level 3 EIA will use more intensive and

precise methods to determine metric ratings such as: (1) quantitative measurements of range health indicators (Pellant et al. 2005) and (2) biological soil crust species composition and abundance (Eldridge and Rosentreter 1999).

Table C-6. Intermountain Basins Semidesert Shrubsteppe Ecological Integrity Assessment Scorecard.

Metric	Justification	Rank			
		A (5 points)	B (4 points)	C (3 points)	D (1 point)
Key ecological attribute – Landscape context					
Edge length	Intactness of edge can be biotically and abiotically important	≥75% of edge bordered by natural communities	≥50–75% of edge bordered by natural communities	≥25–50% of edge bordered by natural communities	<25% of edge bordered by natural communities
Edge width		Average width of edge ≥100m	Average width of edge ≥75–100m	Average width of edge ≥25–75m	Average width of edge <25m
Edge condition		>95% native vegetation cover; <5% non-native cover; intact soils	75–95% cover native vegetation; 5–25% cover of non-native plants; intact or moderately disrupted soils	25–50% cover non-native plants; moderate or extensive soil disruption	>50% cover non-native plants; barren ground; highly compacted or otherwise disrupted soils
Connectivity	Intact areas have continuous corridor of natural or semi-natural vegetation	Intact: Embedded in 90–100% natural habitat; connectivity expected to be high	Variegated: Embedded in 60–90% natural habitat; connectivity generally high, but lower for species sensitive to habitat modification	Fragmented: Embedded in 20–60% natural habitat; connectivity generally low, but varies with species mobility and arrangement on landscape	Relictual: Embedded in <20% natural habitat; connectivity essentially absent
Landscape condition	Intensity and types of land uses in surrounding landscape can affect ecological integrity	Landscape Condition Model Index >0.8		Landscape Condition Model Index 0.8–0.65	Landscape Condition Model Index <0.65
Relative patch size	Indicates proportion lost due to stressors	Site at or minimally reduced from natural extent (≥95% remains)	Occurrence modestly reduced from original natural extent (≥80-95% remains)	Occurrence substantially reduced from original natural extent (≥50–80% remains)	Occurrence severely reduced from original natural extent (<50% remains)
Absolute patch size	Based on obligate black-tailed jackrabbit home range size	>2000ha	200–2000ha	20–200ha	<20ha
Key ecological attribute – Vegetation condition					
Cover of native species	Native species dominate ecosystem; non-natives increase with human impacts	Cover of native plants ≥95%	Cover of native plants 80–95%	Cover of native plants 50–80%	Cover of native plants <50%
Cover of native bunchgrass	Native bunchgrasses dominate; high cover related to resistance to invasion	Perennial bunchgrass cover >80% or near site potential	Perennial bunchgrass cover 50–80% or reduced from site potential	Perennial bunchgrass cover 30–50% or reduced from site potential	Perennial bunchgrass cover <30% and much reduced from site potential
Cover of invasive species	Invasive species inflict wide range of impacts; early detection critical	None present	Invasive species present, but sporadic (<3% cover)	Invasive species prevalent (3–10% cover)	Invasive species abundant (>10% cover)
Cover of native increasers	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	Composition of native species can shift when exposed to stressors.	Diversity/abundance at or near reference standards; native species negative to anthropogenic degradation are present, species positive to anthropogenic degradation are absent to minor; full range of indicator species present	Diversity/abundance close to reference standards; native species reflective of anthropogenic degradation; some indicator species absent	Diversity/abundance differs from reference standards, but largely composed of native species; may include ruderal species; many indicator species absent	Vegetation severely altered from reference standards; dominated by ruderal species or comprised of planted stands of non-characteristic species or unnaturally dominated by single species; most indicator species absent
Shrub cover (fire-sensitive species)	Natural fire regime promotes patchy low shrub cover	Fire-sensitive shrubs mature and recovered from past fires; generally 3–10% cover	Fire-sensitive shrubs not fully recovered from past fires, mostly seedlings shorter than bunchgrasses; generally <20% cover	Fire-sensitive shrubs generally >20% cover; beginning to affect bunchgrass layer	Fire-sensitive shrubs clearly >20% cover; reducing bunchgrass layer
Biological soil crust	Crust cover and diversity greatest where not impacted by trampling or other disturbance	Biological soil crust nearly matches site capacity where site characteristics not limiting (i.e. steep unstable, south aspect, or dense grass)	Biological soil crust evident, but its continuity is broken	Biological soil crust present in protected areas and with minor component elsewhere	Biological soil crust, if present , only in protected areas
Key ecological attribute: Physicochemical and hydrology					
Soil surface condition	Disturbance can result in erosion with negative affects on ecological processes; bareground amount varies naturally with site type	Bare soil areas limited to naturally caused disturbances such as burrowing animals or game trails	Bare soil due to human causes, but extent and impact minimal; depth of disturbance limited to ~5cm	Bare soil due to human causes are common; compaction to ~15cm; machinery may have left shallow ruts	Bare soil areas substantial and they contribute to long-lasting impacts; deep ruts from machinery present or livestock trails widespread

INTERMOUNTAIN BASINS MONTANE BIG SAGEBRUSH STEPPE

General Description

The widespread large to small patch Intermountain Montane Big Sagebrush Steppe ecological system occurs throughout much of the northern Intermountain West. This ecological system includes sagebrush communities occurring in foothills to montane and subalpine elevations from 1000 meters in eastern Oregon and Washington to over 3000 meters in the southern Rockies (NatureServe 2007). This includes sagebrush communities in forest landscapes in the east Cascades and western Okanogan Highlands in Washington. This system primarily occurs on deep-soiled to stony flats, ridges, nearly flat ridgetops, and mountain slopes. In general, this system shows an affinity for mild topography, fine soils with some source of subsurface moisture, zones of higher precipitation, and areas of snow accumulation (NatureServe 2007). Across its range of distribution, this system is a compositionally diverse system. It is composed primarily of *Artemisia tridentata* ssp. *vaseyana*, and related taxa such as *Artemisia tridentata* ssp. *spiciformis* (= *Artemisia spiciformis*). *Purshia tridentata* may co-dominate some stands. Other common shrubs include *Symphoricarpos* spp., *Amelanchier* spp., *Ericameria nauseosa*, *Ribes cereum*, and *Chrysothamnus viscidiflorus*. Most stands have an abundant perennial herbaceous layer (>25% cover, in many cases >50% cover). Common graminoids include *Festuca idahoensis*, *Hesperostipa comata*, *Poa fendleriana*, *Elymus trachycaulus*, *Bromus carinatus*, *Poa secunda*, *Calamagrostis rubescens*, and *Pseudoroegneria spicata*. Species of *Achnatherum* are common, including *Achnatherum nelsonii* ssp. *dorei*, *Achnatherum nelsonii* ssp. *nelsonii*, and *Achnatherum hymenoides*. In many areas, wildfires create an open herbaceous-rich steppe condition, although shrub cover can be >40%, with moisture providing equally high grass and forb cover.

The space between vascular plants may support a biological soil crust that is low cover even without disturbance. Biological soil crust cover generally decreases with increasing natural disturbance of soil surface, vascular plant cover, elevation, loose surface rock, and coarseness of soil. Johnson and Swanson (2005) indicate that bare ground, even in naturally undisturbed sites, is 3-25% cover. In general, fire increases abundance of herbaceous perennials and decreases woody plants. Fire return interval is 40-75 years or fire regime II (LANDFIRE 2007) although the FRIS database cites 15-20 years at lower treeline locations in Idaho. In stark contrast, Baker (2006) concluded that *Artemisia tridentata* spp. *vaseyana* steppe fire rotations are 325-450 years (fire regime V). Anecdotal observations suggest that these patches often are not burned during surrounding forest fires.

This system is found in the montane or subalpine (typically >2000 m elevations) zone while the similar Intermountain Basins Big Sagebrush Steppe system occurs at lower elevations. The Montane Big Sagebrush Steppe can be confused remotely with the Northern Rocky Mountain Lower Montane, Foothill and Valley grassland. It overlaps with Low Sagebrush Steppe system in Washington. If *Purshia tridentata* is used as indicator, Montane Sagebrush Steppe also overlaps with *Artemisia tripartita* along foothills if the east Cascades. These determinations must be made on-the-ground.

Stressors

The primary stressors of this system are livestock practices, exotic species, direct soil surface disturbance, and fragmentation. Healthy sagebrush shrublands are very productive and as such are often grazed by native ungulates and domestic livestock and can be strongly preferred sites during the growing season (Johnson and Swanson 2005). Prolonged livestock use can cause a decrease in the abundance of native bunch grasses and an increase in the cover of shrubs and non-native grass species, such as *Poa pratensis*. Conversely, fire in the fall may decrease shrub abundance. *Artemisia tridentata* ssp. *vaseyana* is generally killed by fire and may take >10 years to recover.

Ecological Integrity Assessment

The following table (Table C-7) displays metrics chosen to measure most of the key ecological attributes in the conceptual ecological model. Unless otherwise noted, metric ratings apply to both Level 2 and Level 3 EIAs. The difference is that a Level 3 EIA will use more intensive and precise methods to determine metric ratings such as: (1) quantitative measurements of range health indicators (Pellant et al. 2005) and (2) biological soil crust species composition and abundance (Eldridge and Rosentreter 1999).

Table C-7. Intermountain Basins Montane Big Sagebrush Steppe Ecological Integrity Assessment Scorecard.

Metric	Justification	Rank			
		A (5 points)	B (4 points)	C (3 points)	D (1 point)
Key ecological attribute – Landscape context					
Edge length	Intactness of edge can be biotically and abiotically important	≥75% of edge bordered by natural communities	≥50–75% of edge bordered by natural communities	≥25–50% of edge bordered by natural communities	<25% of edge bordered by natural communities
Edge width		Average width of edge ≥100m	Average width of edge ≥75–100m	Average width of edge ≥25–75m	Average width of edge <25m

Edge condition		>95% native vegetation cover; <5% non-native cover; intact soils	75–95% cover native vegetation; 5–25% cover of non-native plants; intact or moderately disrupted soils	25–50% cover non-native plants; moderate or extensive soil disruption	>50% cover non-native plants; barren ground; highly compacted or otherwise disrupted soils
Connectivity	Intact areas have continuous corridor of natural or semi-natural vegetation	Intact: Embedded in 90–100% natural habitat; connectivity expected to be high	Variegated: Embedded in 60–90% natural habitat; connectivity generally high, but lower for species sensitive to habitat modification	Fragmented: Embedded in 20–60% natural habitat; connectivity generally low, but varies with species mobility and arrangement on landscape	Relictual: Embedded in <20% natural habitat; connectivity essentially absent
Landscape condition	Intensity and types of land uses in surrounding landscape affect ecological integrity	Landscape Condition Model Index >0.8		Landscape Condition Model Index 0.8–0.65	Landscape Condition Model Index <0.65
Relative patch size	Indicates proportion lost due to stressors	Site at or minimally reduced from natural extent (≥95% remains)	Occurrence modestly reduced from original natural extent (≥80-95% remains)	Occurrence substantially reduced from original natural extent (≥50–80% remains)	Occurrence severely reduced from original natural extent (<50% remains)
Absolute patch size	Based on obligate sage sparrow occupancy data	>400ha	200–400ha	120–200ha	<120ha
Key ecological attribute – Vegetation condition					
Cover of native species	Non-native species increase with human impacts	Cover of native plants ≥95%	Cover of native plants ≥80–95%	Cover of native plants ≥50–80%	Cover of native plants <50%
Cover of native bunchgrass	Native bunchgrasses dominate; high cover related to resistance to invasion	Perennial bunchgrass cover >80% or near site potential	Perennial bunchgrass cover ≥50–80% or reduced from site potential	Perennial bunchgrass cover ≥30–50% or reduced from site potential	Perennial bunchgrass cover <30% and much reduced from site potential
Cover of invasive species	Invasive species inflict wide range of impacts; early detection critical	None present	Invasive species present, but sporadic (<3% cover)	Invasive species prevalent (3–10% cover)	Invasive species abundant (>10% cover)
Cover of native increasers	Stressors such as grazing can shift or homogenize native composition	Absent or incidental	<10% cover	10-20% cover	>20% cover
Species composition	Composition of native species can shift when exposed to stressors.	Diversity/abundance at or near reference standards; native species negative to anthropogenic degradation are present, species positive to anthropogenic degradation are absent to minor; full range of indicator species present	Diversity/abundance close to reference standards; native species reflective of anthropogenic degradation; some indicator species absent	Diversity/abundance differs from reference standards, but largely composed of native species; may include ruderal species; many indicator species absent	Vegetation severely altered from reference standards; dominated by ruderal species or comprised of planted stands of non-characteristic species or unnaturally dominated by single species; most indicator species absent
Shrub cover (fire-sensitive species)	Natural fire regime promotes patchy low shrub cover	Fire-sensitive shrubs mature and recovered from past fires; generally 3–20% cover	Fire-sensitive shrubs not fully recovered from past fires, mostly seedlings shorter than bunchgrasses; generally <50% cover	Fire-sensitive shrubs generally >50% cover; beginning to affect bunchgrass layer	Fire-sensitive shrubs clearly >50% cover; reducing bunchgrass layer
Biological soil crust	Crust cover and diversity greatest where not impacted by trampling or other disturbance	Biological soil crust nearly matches site capacity where site characteristics not limiting (i.e. steep unstable, south aspect, or dense grass)	Biological soil crust evident, but its continuity is broken	Biological soil crust present in protected areas and with minor component elsewhere	Biological soil crust, if present , only in protected areas
Key ecological attribute: Physicochemical and hydrology					
Soil surface condition	Disturbance can result in erosion with negative affects on ecological processes; bareground amount varies naturally with site type	Bare soil areas limited to naturally caused disturbances such as burrowing animals or game trails	Bare soil due to human causes, but extent and impact minimal; depth of disturbance limited to ~5cm	Bare soil due to human causes are common; compaction to ~15cm; machinery may have left shallow ruts	Bare soil areas substantial and they contribute to long-lasting impacts; deep ruts from machinery present or livestock trails widespread

INTERMOUNTAIN BASINS BIG SAGEBRUSH STEPPE

General Description

The widespread matrix-forming Intermountain Basins Big Sagebrush Steppe ecological system occurs throughout much of the northern intermountain west (West and Young 2000). Within the Columbia Basin in Washington, soil depth and texture and precipitation largely drive the distribution of shrubsteppe-associated systems. This system is bound by montane woodlands and the Palouse prairie (Northern Rocky Mountain Foothill and Valley Grasslands) and rings the driest portion of the Basin that supports the Semi-Desert Grassland and the Semi-Desert Shrub Steppe systems. The distribution of shrubsteppe appears in a landscape mosaic reflecting topography and/or soils' texture and depth. Deep canyons (Snake River) dissecting the southeastern corner of the basin support Dry Canyon grasslands distinguished by colluvial soils derived from basalt and loess and periodic slope failures and slumping. Shallow soils (lithic or deep, gravel flood deposits) are concentrated in Pleistocene flood channels that fan across the Basin and support the Columbia Basin Scabland system.

Landforms that support shrubsteppe are a mosaic of patch types or plant associations that reflect differences in site (soil/precipitation zone) and fire effects. Soils are deep (>15cm) to shallow and non-saline. The space between vascular plants usually supports a biological soil crust that can cover up to 90% without disturbance. Biological soil crust cover generally decreases with vascular plant cover, elevation, increasing disturbance of soil surface, loose surface rock, and coarseness of soil so that its presence and diversity better indicates integrity. Greater biological crust cover occurs on north- and east-facing slopes at mid elevations with stable, silt-loam or calcareous soils where not disturbed (Tyler 2006) or where vascular cover and litter are not limiting. Tyler (2006) found that shrubsteppe plots were generally associated with biological soil crust variables while grass-steppe plots were generally associated with *Bromus tectorum* and *Salsola kali*. That pattern reflected the conversion of shrubsteppe habitats by past wildfire to grass-steppe habitats on Yakima Training Center (Tyler 2006).

This ecological system is dominated by perennial bunchgrasses and forbs (>25% cover) with *Artemisia tridentata* (ssp. *tridentata*, *xericensis*, and *wyomingensis*), *Artemisia tripartita*, and/or *Purshia tridentata* shrubs in an open to moderately dense (5-30% cover) shrub layer. Associated graminoids may include *Pseudoroegneria spicata*, *Poa secunda*, *Poa cusickii*, *Koeleria macrantha*, *Hesperostipa comata*, and *Achnatherum thurberiana*. Moister areas support closed to nearly closed grasslands with *Festuca idahoensis* or *F. washingtonica*., higher forb diversity (perhaps even the rhizomatous *Carex filifolia*), and the shrubs *Artemisia tripartita* ssp. *tripartita*, *Artemisia tridentata* ssp. *tridentata*, *Artemisia tridentata* ssp. *xericensis*, and/or *Purshia tridentata*. They have fewer species that are similar to the southern Great Basin than they would on sites with lower precipitation and shallow, more skeletal soils. The latter areas typically have more *Bromus tectorum* in all seres. When sagebrush cover reaches 5-7%, herbaceous biomass production begins to decline and when cover is 12-15%, herbaceous density begins to decline (Perryman et al. 2001).

The natural fire regime of this ecological system maintains a patchy distribution of shrubs, so the general aspect of the vegetation is that of grassland. In general, fire increases abundance of herbaceous perennials and decreases woody plants. Fire return interval for productive shrubsteppe is 12-15 years (fire regime I) and 50-100 years (fire regime II) in less productive areas (Miller and Eddleman 2001). Alternatively, Baker (2006) concludes that *Artemisia tridentata* spp. *wyomingensis* steppe fire rotations are 100-240 years (fire regime V). Grassland or steppe fire intervals are 1-23 years (Perryman et al. 2001). Where fire frequency has allowed for a shift to a native grassland condition maintained without significant shrub invasion over a 50 to 70 year interval, the area should be considered Columbia Basin Steppe and Grassland system. Rocky sites have longer fire return rates, higher shrub cover, and lower bunchgrass cover than sites with finer textured soils. Pre-settlement large native ungulate grazing in the Columbia Basin differed from that in the Great Plains grasslands in duration, seasonality, and severity (Mack and Thompson 1982, Burkhart 1996). In general, pre-settlement grazing was dispersed during the winter and spring when forage was available. Growing season is typically around six-weeks (Burkhart 1996). Davies et al. (2009) concluded that sites with heavy litter accumulation (ungrazed *Artemisia tridentata* ssp. *wyomingensis/Festuca idahoensis – Achnatherium thurberiana* community) are more susceptible to exotic annual invasion following fire than those with less litter accumulation. They noted that introduced species and changes in climate can change ecosystem response to natural disturbance regimes.

Stressors

The primary stressors of this system are livestock practices, annual exotic species, fire regime alteration, direct soil surface disturbance, and fragmentation. Excessive grazing stresses the system through soil disturbance, diminishing or eliminating the biological soil crust, altering the composition of perennial species, and increasing prevalence of native increasers and exotic annual grasses, particularly *Bromus tectorum*. If soil moisture is present and sagebrush seeds are available, grassing can result in increased shrub density. There are strong links between foliose lichens and ecosystem health (Rosentreter and Eldridge 2002). Severe trampling breaks lichens into fragments too small to become reestablished, eventually leading to their elimination (Rosentreter and Eldridge 2002). Fire further stresses livestock-altered vegetation by increasing exposure of bare ground and consequently increasing exotic annuals and decreasing perennial bunchgrasses and sagebrush. Fire suppression, even in the absence of livestock grazing, can increase shrub density that in turn reduces bunchgrass cover or results in increased grass litter and fire fuel. Both conditions increase the probability of fire and vegetation responses that subsequently lead to increased annual grass abundance (Davies et al. 2009). Any soil and bunchgrass layer disturbances, such as vehicle tracks or shrub removal (i.e., by chainging), will increase the probability of vegetation structure and composition alteration. Loss of shrub density and degradation of the bunchgrass layer's native diversity, decreases obligate shrubsteppe birds (Vander Haegen et al. 2000). Fragmentation of shrubsteppe by agriculture increases cover of annual grass, total annual/biennial forbs, and bare ground and decreases cover of perennial forbs, biological soil crusts, obligate insects (Quinn 2004), and obligate birds and small mammals (Vander Haegen et al. 2005).

Ecological Integrity Assessment

The following table (Table C-8) displays metrics chosen to measure most of the key ecological attributes in the conceptual ecological model. Unless otherwise noted, metric ratings apply to both Level 2 and Level 3 EIAs. The difference is that a Level 3 EIA will use more intensive and precise methods to determine metric ratings such as: (1) quantitative measurements of range health indicators (Pellant et al. 2005) and (2) biological soil crust species composition and abundance (Eldridge and Rosentreter 1999).

Table C-8. Intermountain Basins Big Sagebrush Steppe Ecological Integrity Assessment Scorecard.

Metric	Justification	Rank			
		A (5 points)	**B (4 points)**	**C (3 points)**	**D (1 point)**
Key ecological attribute – Landscape context					
Edge length		≥75% of edge bordered by natural communities	≥50–75% of edge bordered by natural communities	≥25–50% of edge bordered by natural communities	<25% of edge bordered by natural communities
Edge width	Intactness of edge can be biotically and abiotically important	Average width of edge ≥100m	Average width of edge ≥75–100m	Average width of edge ≥25–75m	Average width of edge <25m
Edge condition		>95% native vegetation cover; <5% non-native cover; intact soils	75–95% cover native vegetation; 5–25% cover of non-native plants; intact or moderately disrupted soils	25–50% cover non-native plants; moderate or extensive soil disruption	>50% cover non-native plants; barren ground; highly compacted or otherwise disrupted soils
Connectivity	Intact areas have continuous corridor of natural or semi-natural vegetation	Intact: Embedded in 90–100% natural habitat; connectivity expected to be high	Variegated: Embedded in 60–90% natural habitat; connectivity generally high, but lower for species sensitive to habitat modification	Fragmented: Embedded in 20–60% natural habitat; connectivity generally low, but varies with species mobility and arrangement on landscape	Relictual: Embedded in <20% natural habitat; connectivity essentially absent
Landscape condition	Intensity and types of land uses in surrounding landscape can affect ecological integrity	Landscape Condition Model Index >0.8		Landscape Condition Model Index 0.8–0.65	Landscape Condition Model Index <0.65
Relative patch size	Indicates proportion lost due to stressors	Site at or minimally reduced from natural extent (≥95% remains)	Occurrence modestly reduced from original natural extent (≥80-95% remains)	Occurrence substantially reduced from original natural extent (≥50–80% remains)	Occurrence severely reduced from original natural extent (<50% remains)
Absolute patch size	Based on obligate sage sparrow home range size	>1000ha	500–1000ha	16–500ha	<16ha
Key ecological attribute – Vegetation condition					
Cover of native species	Native species dominate ecosystem; non-natives increase with human impacts	Cover of native plants ≥95%	Cover of native plants ≥80–95%	Cover of native plants ≥50–80%	Cover of native plants <50%
Cover of native bunchgrass	Native bunchgrasses dominate; high cover related to resistance to invasion	Perennial bunchgrass cover >80% or near site potential	Perennial bunchgrass cover ≥50–80% or reduced from site potential	Perennial bunchgrass cover ≥30–50% or reduced from site potential	Perennial bunchgrass cover <30% and much reduced from site potential
Cover of invasive species	Invasive species inflict wide range of impacts; early detection critical	None present	Invasive species present, but sporadic (<3% cover)	Invasive species prevalent (3–10% cover)	Invasive species abundant (>10% cover)
Cover of native increasers	Stressors such as grazing can shift or homogenize native composition	Absent or incidental	<10% cover	10-20% cover	>20% cover
Species composition	Composition of native species can shift when exposed to stressors.	Diversity/abundance at or near reference standards; native species negative to anthropogenic degradation are present, species positive to anthropogenic degradation are absent to minor; full range of indicator species present	Diversity/abundance close to reference standards; native species reflective of anthropogenic degradation; some indicator species absent	Diversity/abundance differs from reference standards, but largely composed of native species; may include ruderal species; many indicator species absent	Vegetation severely altered from reference standards; dominated by ruderal species or comprised of planted stands of non-characteristic species or unnaturally dominated by single species; most indicator species absent

Shrub cover (fire-sensitive species)	Natural fire regime promotes patchy low shrub cover	Fire-sensitive shrubs mature and recovered from past fires; generally 3–10% cover	Fire-sensitive shrubs not fully recovered from past fires, mostly seedlings shorter than bunchgrasses; generally <20% cover	Fire-sensitive shrubs generally >20% cover; beginning to affect bunchgrass layer	Fire-sensitive shrubs clearly >20% cover; reducing bunchgrass layer
Biological soil crust	Crust cover and diversity greatest where not impacted by trampling or other disturbance	Biological soil crust nearly matches site capacity where site characteristics not limiting (i.e. steep unstable, south aspect, or dense grass)	Biological soil crust evident, but its continuity is broken	Biological soil crust present in protected areas and with minor component elsewhere	Biological soil crust, if present , only in protected areas
Key ecological attribute: Physicochemical and hydrology					
Soil surface condition	Disturbance can result in erosion with negative affects on ecological processes; bareground amount varies naturally with site type	Bare soil areas limited to naturally caused disturbances such as burrowing animals or game trails	Bare soil due to human causes, but extent and impact minimal; depth of disturbance limited to ~5cm	Bare soil due to human causes are common; compaction to ~15cm; machinery may have left shallow ruts	Bare soil areas substantial and they contribute to long-lasting impacts; deep ruts from machinery present or livestock trails widespread

INTERMOUNTAIN BASINS SEMI-DESERT GRASSLAND

General Description

This widespread ecological system includes the driest grasslands throughout the intermountain region. It occurs on xeric sites in an elevation range of approximately 1450 to 2320 meters on a variety of landforms, including swales, mesas, alluvial flats, and plains (NatureServe 2007). In the Columbia Basin in Washington and adjacent Oregon, soil depth and texture and precipitation largely drive the distribution of shrubsteppe and associated systems. The Semi-Desert Grassland ecological system is associated with the hotter, drier (<25cm/year) portions of the Columbia Basin, and with extensive sand deposits centered in the Pasco, Quincy, Umatilla, and lower Yakima basins. In Washington, this system is associated with the Intermountain Semi-Desert Shrub Steppe, Columbia Basin Steppe and Grassland, and the Big Sagebrush Shrub Steppe ecological systems. The Intermountain Basins Semi-Desert Grassland and Columbia Basin Foothill and Canyon Dry Grassland share many dominant species and soil characteristics and are primarily distinguished by geographic location and steepness of slopes. The Columbia Basin Foothill and Canyon Dry Grasslands occur in the canyons and valleys on steep open slopes, from 90 to 1520 meters elevation along the Snake River canyon and large tributaries. Semi-Desert Grassland soils are deep to shallow, well-drained, typically sandy or gravelly with a biological soil crust, and not on long steep slopes.

These grasslands are floristically similar to part of the Intermountain Basins Semi-Desert Steppe but are distinguished by a more frequent fire regime and the absence or low cover of shrubs. These are extensive grasslands, not grass-dominated patches within the shrubsteppe ecological system (NatureServe 2007). The dominant perennial bunchgrasses and shrubs within this system are drought-resistant plants including *Achnatherum hymenoides*, *Aristida purpurea* var. *longiseta*, *Elymus lanceolatus* ssp. *lanceolatus*, and primarily *Hesperostipa comata*. All of these have been reported to increase with grazing. Sites may include scattered shrubs and dwarf-shrubs of species *Artemisia* spp., *Purshia tridentata*, *Grayia spinosa*, *Gutierrezia*, or *Krascheninnikovia lanata*. Shrubs such as *Chrysothamnus viscidiflorus* and *Ericameria nauseosa* also may be present.

This steppe system can occur over large areas, occasionally entire landforms. It resembles the Intermountain Basins Semi-Desert Shrub Steppe ecological system except with more frequent or severe fire (< 20 years) resulting in a sparcity of deep-rooted, fire intolerant shrubs. *Artemisia tridentata*, *Grayia spinosa* and *Purshia tridentata* are generally absent and are unlikely to reestablish due to lack of seed sources. This represents a grassland state transition in State-Transition Models (Laycock, 1991). Distinguishing this steppe system from shrub-less bunchgrass-dominated patches within a shrubsteppe ecological system is an on-the-ground determination based on occurrence of shrubs in areas separated by landscape barriers such as rivers, canyons, and important soil changes.

Tyler (2006) found that plots with shrubsteppe were generally associated with biological soil crust variables, while fire created grass-steppe plots were generally associated with *Bromus tectorum* and *Salsola kali*. He stated that grass-steppe habitats on the Yakima Training Center mostly resulted from the conversion of shrubsteppe habitats by past wildfire. Perryman et al. (2001) calculated a mean recruitment interval of 2.3 (±0.7) years for sagebrush stands in Wyoming. Shrubs produce large quantities of small seeds beginning at 3 to 4 years of age. Approximately 90% of big sagebrush seed is dispersed <9 meters of the parent and few seeds are carried >30 meters (http://www.fs.fed.us/database/feis/plants/shrub/arttrit). We estimate that sagebrush will invade semi-desert grasslands at a rate of approximately 10 ha in 50 years. Thus, 20 ha is a reasonable estimate for a minimum persistent patch of bunchgrass steppe.

Stressors

The primary stressors of this system are livestock practices, annual exotic species, fire regime alteration, direct soil surface disturbance, and fragmentation. Excessive grazing stresses the system through soil disturbance, reducing the biological soil crust and perennial herbaceous layers, and enabling establishment of native increasers and exotic annual grasses, particularly *Bromus tectorum*. Fire further stresses livestock-altered vegetation by decreasing perennial bunchgrasses and increasing bare ground and exotic annuals. Any disturbance to soil and bunchgrass layers, such as vehicle tracks and shrub removal (chaining), will increase the probability of alteration of vegetation structure and composition. Fragmentation of shrubsteppe by agriculture increases cover of annual grass, total annual/biennial forbs, and bare ground and decreases perennial forbs, biological soil crusts, obligate insects (Quinn 2004), and obligate birds and small mammals (Vander Haegen et al 2005). Similar responses are expected in steppe vegetation.

Ecological Integrity Assessment

The following table (Table C-9) displays metrics chosen to measure most of the key ecological attributes in the conceptual ecological model. Unless otherwise noted, metric ratings apply to both Level 2 and Level 3 EIAs. The difference is that a Level 3 EIA will use more intensive and precise methods to determine metric, for example: (1) quantitative measurements of range health indicators (Pellant et al. 2005) and (2) biological soil crust species composition and abundance (Eldridge and Rosentreter 1999).

Table C-9. Intermountain Basins Semi-Desert Grassland Ecological Integrity Assessment Scorecard.

Metric	Justification	Rank			
		A (5 points)	B (4 points)	C (3 points)	D (1 point)
Key ecological attribute – Landscape context					
Edge length	Intactness of edge can be biotically and abiotically important	≥75% of edge bordered by natural communities	≥50–75% of edge bordered by natural communities	≥25–50% of edge bordered by natural communities	<25% of edge bordered by natural communities
Edge width		Average width of edge ≥100m	Average width of edge ≥75–100m	Average width of edge ≥25–75m	Average width of edge <25m
Edge condition		>95% native vegetation cover; <5% non-native cover; intact soils	75–95% cover native vegetation; 5–25% cover of non-native plants; intact or moderately disrupted soils	25–50% cover non-native plants; moderate or extensive soil disruption	>50% cover non-native plants; barren ground; highly compacted or otherwise disrupted soils
Connectivity	Intact areas have continuous corridor of natural or semi-natural vegetation	Intact: Embedded in 90–100% natural habitat; connectivity expected to be high	Variegated: Embedded in 60–90% natural habitat; connectivity generally high, but lower for species sensitive to habitat modification	Fragmented: Embedded in 20–60% natural habitat; connectivity generally low, but varies with species mobility and arrangement on landscape	Relictual: Embedded in <20% natural habitat; connectivity essentially absent
Landscape condition	Intensity and types of land uses in surrounding landscape can affect ecological integrity	Landscape Condition Model Index >0.8		Landscape Condition Model Index 0.8–0.65	Landscape Condition Model Index <0.65
Relative patch size	Indicates proportion lost due to stressors	Site at or minimally reduced from natural extent (≥95% remains)	Occurrence modestly reduced from original natural extent (≥80-95% remains)	Occurrence substantially reduced from original natural extent (≥50–80% remains)	Occurrence severely reduced from original natural extent (<50% remains)
Absolute patch size	Based on obligate grasshopper sparrow conservation size (Paczek 2004)	>1000ha	500–1000ha	10–500ha	<10ha
Key ecological attribute – Vegetation condition					
Cover of native species	Native species dominate ecosystem; non-natives increase with human impacts	Cover of native plants ≥95%	Cover of native plants ≥80–95%	Cover of native plants ≥50–80%	Cover of native plants <50%
Cover of native bunchgrass	Native bunchgrasses dominate; high cover related to resistance to invasion	Perennial bunchgrass cover >80% or near site potential	Perennial bunchgrass cover ≥50–80% or reduced from site potential	Perennial bunchgrass cover ≥30–50% or reduced from site potential	Perennial bunchgrass cover <30% and much reduced from site potential
Cover of invasive species	Invasive species inflict wide range of impacts; early detection critical	None present	Invasive species present, but sporadic (<3% cover)	Invasive species prevalent (3–10% cover)	Invasive species abundant (>10% cover)
Cover of native increasers	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	Composition of native species can shift when exposed to stressors.	Diversity/abundance at or near reference standards; native species negative to anthropogenic degradation are present, species positive to anthropogenic degradation are absent to minor; full range of indicator species present	Diversity/abundance close to reference standards; native species reflective of anthropogenic degradation; some indicator species absent	Diversity/abundance differs from reference standards, but largely composed of native species; may include ruderal species; many indicator species absent	Vegetation severely altered from reference standards; dominated by ruderal species or comprised of planted stands of non-characteristic species or unnaturally dominated by single species; most indicator species absent
Biological soil crust	Crust cover and diversity greatest where not impacted by trampling or other disturbance	Biological soil crust nearly matches site capacity where site characteristics not limiting (i.e. steep unstable, south aspect, or dense grass)	Biological soil crust evident, but its continuity is broken	Biological soil crust present in protected areas and with minor component elsewhere	Biological soil crust, if present , only in protected areas
Key ecological attribute: Physicochemical and hydrology					
Soil surface condition	Disturbance can result in erosion with negative affects on ecological processes; bareground amount varies naturally with site type	Bare soil areas limited to naturally caused disturbances such as burrowing animals or game trails	Bare soil due to human causes, but extent and impact minimal; depth of disturbance limited to ~5cm	Bare soil due to human causes are common; compaction to ~15cm; machinery may have left shallow ruts	Bare soil areas substantial and they contribute to long-lasting impacts; deep ruts from machinery present or livestock trails widespread

INTERMOUNTAIN BASINS CLIFF AND CANYON

General Description

The Intermountain Basins Cliff and Canyon ecological system is found from lowland to lower montane 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 and Pleistocene flood deposits of large, lithic material (NatureServe 2007). Basalt is the dominant parent material in the Columbia Basin in Washington for this system. Other cliff and canyon parent material includes metamorphic volcanic and marine sedimentary rocks associated with the surrounding mountains, Pliocene sedimentary rocks, and Pleistocene sedimentary rocks. This system is found on steep open slopes in the canyons and valleys of the Columbia Basin, particularly along the Columbia and Snake River canyons and their tributaries. It is very common within the Scabland Channel topography (Bretz 1959).

Vegetation occurs in small patches or widely scattered trees and shrubs that generally cover less than 10% of total area. Common woody plants include *Pinus ponderosa*, *Pseudotsuga menziesii* var. *glauca*, *Amelanchier alnifolia*, *Celtis occidentalis* ssp. *reticulata*, *Holodiscus discolor*, *Philadelphus lewisii*, *Rhus glabra*, *Ribes* spp. and other species often common in adjacent plant communities, such as, *Artemisia tridentata*, *Cercocarpus ledifolius*, *Eriogonum compositum*, *E. niveum*, and *Purshia tridentata*. These are often restricted to shelves, cracks and crevices in the rock, or other areas where soil accumulation allows growth. Small patches of grassland can occur among rocks where soil accumulates. Common species include *Pseudoroegneria spicata*, *Poa spp*., *Lupinus* spp., *Festuca idahoensis*, and *Koeleria macrantha*.

In Colorado, species richness of cliff communities appeared to be controlled by aspect, microsite size, and cliff surface roughness (Graham and Knight 2004). Diversity increases when cliff microhabitats are compressed into a small area. There are three basic parts of a cliff habitat: (1) relatively level plateau on top of the cliff of on benchs above and below a cliff face; (2) steep cliff face; and (3) the debris and talus at the bottom of the cliff (Larson et al. 2000). "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). Unfractured cliffs with no rooting space for vascular plants provide habitat for lichens. Ledges that accumulate organic matter, minerals and water can support grasses, sedges or small trees (Larson et al. 2000). Cliffs, in general, support high endemism of plants; they can provide refugia for old trees (Larson et al. 2000). In general, cliffs provide habitat for roosting or nesting birds and bats (Johnson and O'Neil 2001). 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).

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 be less important than the cliff micro-topography and therefore, larger cliff areas would not necessarily contain a greater number of species. Influences on the cliff environment include precipitation, temperature, chemistry, and gravity (Larson et al. 2000).

Stressors

This system usually occurs in inaccessible locations and thus is protected from much disturbance resulting from human activities. Direct stressors remove or modify cliff topography (localized quarry or borrow pit operations) and vegetation patches (recreational activities such as climbing, firearms practice, and vehicular use). Agricultural and residential development adjacent or above cliffs and talus modifies cliff microsites through changes in water surface and sub-surface flow or accelerating deposition of fine-textured soils that increase or change vegetation cover from perennials to annuals.

Ecological Integrity Assessment

The following table (Table C-10) displays metrics chosen to measure most of the key ecological attributes in the conceptual ecological model. Unless otherwise noted, metric ratings apply to both Level 2 and Level 3 EIAs. The difference is that a Level 3 EIA will use more intensive and precise methods to determine metric ratings, for example composition of lichen and other species (Eldridge and Rosentreter 1999).

Table C-10. Intermountain Basins Cliff and Canyon Ecological Integrity Assessment Scorecard.

Metric	Justification	Rank			
		A (5 points)	B (4 points)	C (3 points)	D (1 point)
Key ecological attribute – Landscape context					
Edge length	Intactness of edge can be biotically and abiotically important	≥75% of edge bordered by natural communities	≥50–75% of edge bordered by natural communities	≥25–50% of edge bordered by natural communities	<25% of edge bordered by natural communities
Edge width		Average width of edge ≥200m	Average width of edge ≥100–200m	Average width of edge ≥50–100m	Average width of edge <25m
Edge condition		>95% native vegetation cover; <5% non-native cover; intact soils and no refuse	75–95% cover native vegetation; 5–25% cover of non-native plants; intact or moderately disrupted soils and little refuse	25–50% cover non-native plants; moderate or extensive soil disruption and refuse	>50% cover non-native plants; barren ground; highly compacted or otherwise disrupted soils and refuse
Connectivity	Intact areas have continuous corridor of natural or semi-natural vegetation	Intact: Embedded in 90–100% natural habitat; connectivity expected to be high	Variegated: Embedded in 60–90% natural habitat; connectivity generally high, but lower for species sensitive to habitat modification	Fragmented: Embedded in 20–60% natural habitat; connectivity generally low, but varies with species mobility and arrangement on landscape	Relictual: Embedded in <20% natural habitat; connectivity essentially absent
Landscape condition	Intensity and types of land uses in surrounding landscape can affect ecological integrity	Landscape Condition Model Index >0.8		Landscape Condition Model Index 0.8–0.65	Landscape Condition Model Index <0.65
Relative patch size	Indicates proportion lost due to stressors	Site at or minimally reduced from natural extent (≥95% remains)	Occurrence modestly reduced from original natural extent (≥80-95% remains)	Occurrence substantially reduced from original natural extent (≥50–80% remains)	Occurrence severely reduced from original natural extent (<50% remains)
Absolute patch size	Plant species lists were least similar between large and small cliff faces	Large cliffs (>20m high)	Medium cliffs (10-20m high)	Small cliffs (5-10m high)	Cliffs <5m high
Patch diversity	Spatial heterogeneity of microhabitats influences abundance and distribution of species; human induced stressors play a role	No or little change in patch types due to human stressors	<50% change in expected patch types due to human stressors	>50% change in expected patch types due to human stressors	All or most patch types changed due to human stressors
Key ecological attribute – Vegetation condition					
Cover of native species	Native species dominate ecosystem; non-natives increase with human impacts	Cover of native plants ≥95%	Cover of native plants ≥80–95%	Cover of native plants ≥50–80%	Cover of native plants <50%
Cover of native bunchgrass	Native bunchgrasses dominate; high cover related to resistance to invasion	Perennial bunchgrass cover >80% or near site potential	Perennial bunchgrass cover ≥50–80% or reduced from site potential	Perennial bunchgrass cover ≥30–50% or reduced from site potential	Perennial bunchgrass cover <30% and much reduced from site potential
Cover of invasive species	Invasive species inflict wide range of impacts; early detection critical	None present	Invasive species present, but sporadic (<3% cover)	Invasive species prevalent (3–10% cover)	Invasive species abundant (>10% cover)
Cover of native increasers	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	Composition of native species can shift when exposed to stressors.	Diversity/abundance at or near reference standards; native species negative to anthropogenic degradation are present, species positive to anthropogenic degradation are absent to minor; full range of indicator species present	Diversity/abundance close to reference standards; native species reflective of anthropogenic degradation; some indicator species absent	Diversity/abundance differs from reference standards, but largely composed of native species; may include ruderal species; many indicator species absent	Vegetation severely altered from reference standards; dominated by ruderal species or comprised of planted stands of non-characteristic species or unnaturally dominated by single species; most indicator species absent
Key ecological attribute: Physicochemical and hydrology					
Soil surface condition	Disturbance can result in erosion with negative affects on ecological processes; bareground amount varies naturally with site type	Bare soil areas limited to naturally caused disturbances such as burrowing animals or game trails	Bare soil due to human causes, but extent and impact minimal; depth of disturbance limited to ~5cm	Bare soil due to human causes are common; compaction to ~15cm; machinery may have left shallow ruts	Bare soil areas substantial and they contribute to long-lasting impacts; deep ruts from machinery present or livestock trails widespread

INTERMOUNTAIN BASINS ACTIVE STABLE DUNES

General Description

This system is characterized by active or stabilized dunes and sandsheets and has patchy or sparse vegetation. Four simple dune types have been observed in Washington: (1) Longitudinal dunes, which form when there is a small to moderate supply of sand, much wind, and little vegetation; (2) Transverse dunes, which form when there is a copious sand supply, little to moderate wind, and little vegetation; (3) Parabolic or U-shaped dunes, which form when there is a moderate supply of sand, wind, and vegetation; and (4) Climbing dunes, which climb the windward side of hills as sand sheets. This system is composed of unvegetated to moderately vegetated (<10-30% plant cover), active and stabilized dunes and sandsheets. Vegetation cover is related to the amount of annual rainfall and rate of evapo-transpiration. Species occupying these environments are often adapted to shifting, coarse-textured substrates (usually quartz sand) and form patchy or open grasslands, shrublands or steppe, and occasionally woodlands.

In Washington, this ecological system occurs in localized locations across the Columbia Plateau. This system includes multiple plant associations that represent a range of conditions from sparse (<20%) to moderate (> 60%) vegetation cover and are often found together in fine scale spatial mosaics. Plant species composition often relates to the degree of sand stabilization / vegetation cover and position on a particular dune. *Psoralidium lanceolatum*, a forb, and *Achnatherum hymenoides*, a bunchgrass, typically dominate the initial stages of stabilization and are also commonly found on dunes with a wide range of vegetation. Prior to stabilization shrubs tended to be sparse while *Elymus lanceolatus*, a rhizomatous grass, and forbs *Corispermum* spp., *Rumex venosus* and *Phacelia hastata* are common. With increased sand stabilization, shrubs *Ericameria nauseosa*, *Chrysothamnus viscidiflorus*, *Purshia tridentata*, and *Artemisia tridentata* ssp. *wyomingensis* are often present to dominant. *Eriogonum niveum* is common when gravel is present. Forbs *Oenothera pallida*, *Penstemon acuminatus*, *Phacelia hastata*, *Balsamorhiza careyana*, *Pteryxia terebinthina*, *Hymenopappus filifolius*, *Erigeron filifolius* and grasses *Koeleria macrantha* may also be present, but contribute little to total vegetation cover. *Pinus ponderosa* or *Juniperus occidentalis* trees can be members of dune vegetation. Exotic annuals, *Bromus tectorum*, *Salsola kali* and *Sisymbrium altissimum* are common and at times abundant.

Where dunes have overridden or partially covered “normal” soil, *Pseudoroegneria spicata*, *Poa secunda* or other shrubsteppe species are often present.

Stressors

The total extent of Washington inland sand dune systems has declined approximately 76% from the early 1970s, primarily due to agricultural conversion, reservoir flooding and dune stabilization. Currently, the major threats to the sand dune ecological system in Washington are stabilization by invasive species, agricultural conversion including effects from adjacent irrigation, off-road vehicle use, intentional sand dune stabilization, conversion to residential lots, mining activities, and livestock grazing (Hallock et al. 2007).

Ecological Integrity Assessment

The following table (Table C-11) displays metrics chosen to measure most of the key ecological attributes in the conceptual ecological model. Unless otherwise noted, metric ratings apply to both Level 2 and Level 3 EIAs. The difference is that a Level 3 EIA will use more intensive and precise methods to determine metric ratings.

Table C-11. Intermountain Basins Active Stable Dunes Ecological Integrity Assessment Scorecard.

Metric	Justification	Rank			
		A (5 points)	**B (4 points)**	**C (3 points)**	**D (1 point)**
Key ecological attribute – Landscape context					
Edge length	Intactness of edge can be biotically and abiotically important	≥75% of edge bordered by natural communities	≥50–75% of edge bordered by natural communities	≥25–50% of edge bordered by natural communities	<25% of edge bordered by natural communities
Edge width		Average width of edge ≥200m	Average width of edge ≥100–200m	Average width of edge ≥50–100m	Average width of edge <25m
Edge condition		>95% native vegetation cover; <5% non-native cover; intact soils and no refuse	75–95% cover native vegetation; 5–25% cover of non-native plants; intact or moderately disrupted soils and little refuse	25–50% cover non-native plants; moderate or extensive soil disruption and refuse	>50% cover non-native plants; barren ground; highly compacted or otherwise disrupted soils and refuse
Connectivity	Intact areas have continuous corridor of natural or semi-natural vegetation	Intact: Embedded in 90–100% natural habitat; connectivity expected to be high	Variegated: Embedded in 60–90% natural habitat; connectivity generally high, but lower for species sensitive to habitat modification	Fragmented: Embedded in 20–60% natural habitat; connectivity generally low, but varies with species mobility and arrangement on landscape	Relictual: Embedded in <20% natural habitat; connectivity essentially absent
Landscape condition	Intensity and types of land uses in surrounding landscape can affect ecological integrity	Landscape Condition Model Index >0.8		Landscape Condition Model Index 0.8–0.65	Landscape Condition Model Index <0.65
Relative patch size	Indicates proportion lost due to stressors	Site at or minimally reduced from natural extent (≥95% remains)	Occurrence modestly reduced from original natural extent (≥80-95% remains)	Occurrence substantially reduced from original natural extent (≥50–80% remains)	Occurrence severely reduced from original natural extent (<50% remains)
Absolute patch size	Lage mosaics capture biophysical gradients and natural disturbance	Very large (>800ha)	Large (400-800ha)	Medium (160-400ha)	Small (<160ha)

Key ecological attribute – Vegetation condition					
Cover of native species	Native species dominate ecosystem; non-natives increase with human impacts	Cover of native plants ≥95%	Cover of native plants ≥80–95%	Cover of native plants ≥50–80%	Cover of native plants <50%
Cover of invasive species	Invasive species inflict wide range of impacts; early detection critical	None present	Invasive species present, but sporadic (<3% cover)	Invasive species prevalent (3–10% cover)	Invasive species abundant (>10% cover)
Cover of native increasers	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	Composition of native species can shift when exposed to stressors.	Diversity/abundance at or near reference standards; native species negative to anthropogenic degradation are present, species positive to anthropogenic degradation are absent to minor; full range of indicator species present	Diversity/abundance close to reference standards; native species reflective of anthropogenic degradation; some indicator species absent	Diversity/abundance differs from reference standards, but largely composed of native species; may include ruderal species; many indicator species absent	Vegetation severely altered from reference standards; dominated by ruderal species or comprised of planted stands of non-characteristic species or unnaturally dominated by single species; most indicator species absent
Key ecological attribute: Physicochemical and hydrology					
Soil surface condition	Disturbance can result in erosion with negative affects on ecological processes; bareground amount varies naturally with site type	Bare soil areas limited to naturally caused disturbances such as burrowing animals or game trails	Bare soil due to human causes, but extent and impact minimal; depth of disturbance limited to ~5cm		Bare soil due to human causes are common; compaction to ~15cm; machinery may have left shallow ruts
Sand dynamics	Dependent on mosaic of non-vegetated shifting sands and sparsely vegetated sand dunes	Sparsely vegetated open/migrating, native, anchored and stabilized stages	Open/migrating and native anchored stages dominate; exotic-stabilized stages on <50% of area (areas stabilized by raised ground water may contribute here)	Open/migrating and native anchored stages less common; exotic-stabilized stages on >50% of area (areas stabilized by raised ground water may contribute here)	Open/migrating and native anchored stages absent; exotic-stabilized stages on >50% of area (areas stabilized by raised ground water may contribute here)

ROCKY MOUNTAIN CLIFF, CANYON AND MASSIVE BEDROCK

General Description

The Rocky Mountain Cliff, Canyon and Massive Bedrock ecological system is large patch system located throughout the Rocky Mountains including the isolated island ranges of central Montana, northeastern Cascade Range, and northeastern Olympic Mountains. The North Pacific Montane Massive Bedrock, Cliff and Talus, a similar system, includes sites in the Cascades and west, except the northeastern Olympics, where the Rocky Mountain Cliff, Canyon and Massive Bedrock system occurs in rain shadows. The Rocky Mountain system differs from the Intermountain Basins Cliff and Canyon in that the latter system usually occurs at lower elevations (< 1800 m) and thus has a slightly different flora associated with it. 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 in small dense patches of shrubs or forbs. Characteristic trees include species from the surrounding landscape, such as *Pseudotsuga menziesii*, *Pinus ponderosa*, *Populus tremuloides*, *Abies lasiocarpa*, or *Juniperus occidentalis* at lower elevations. There may be scattered shrubs present, such as *Amelanchier alnifolia*, *Juniperus communis*, or species of *Holodiscus*, *Ribes*, *Penstemon*, *Physocarpus*, *Rosa*, and *Mahonia*. Herbaceous cover is limited and typically patchy. Mosses and lichens can be very common.

Cliffs generally 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 were once more common in the surrounding landscapes 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 vegetation, although this lack of fire influence creates an environment for fire refugia (Graham and Knight 2004, Camp et al. 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 provides 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). 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. In Colorado, species richness of cliff communities appeared to be controlled by aspect, microsite size, and cliff surface roughness (Graham and Knight 2004). Diversity increases when cliff microhabitats are compressed into a small area. There are three basic parts of a cliff habitat: (1) relatively level plateau on top of the cliff of on benchs above and below a cliff face; (2) steep cliff face; and (3) the debris and talus at the bottom of the cliff (Larson et al. 2000). "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). Unfractured cliffs with no rooting space for vascular plants provide habitat for lichens. Ledges that accumulate organic matter, minerals and water can support grasses, sedges or small trees (Larson et al. 2000). Influences on the cliff environment include precipitation, temperature, chemistry, and gravity (Larson et al. 2000).

Stressors

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).

Ecological Integrity Assessment

The following table (Table C-12) displays metrics chosen to measure most of the key ecological attributes in the conceptual ecological model. Unless otherwise noted, metric ratings apply to both Level 2 and Level 3 EIAs. The difference is that a Level 3 EIA will use more intensive and precise methods to determine metric ratings such as lichen and moss species composition and abundance (Eldridge and Rosentreter 1999).

Table C-12. Rocky Mountain Cliff, Canyon and Massive Bedrock Ecological Integrity Assessment Scorecard.

Metric	Justification	Rank			
		A (5 points)	B (4 points)	C (3 points)	D (1 point)
Key ecological attribute – Landscape context					
Edge length	Intactness of edge can be biotically and abiotically important	≥75% of edge bordered by natural communities	≥50–75% of edge bordered by natural communities	≥25–50% of edge bordered by natural communities	<25% of edge bordered by natural communities
Edge width		Average width of edge ≥200m	Average width of edge ≥100–200m	Average width of edge ≥50–100m	Average width of edge <25m
Edge condition		>95% native vegetation cover; <5% non-native cover; intact soils and no refuse	75–95% cover native vegetation; 5–25% cover of non-native plants; intact or moderately disrupted soils and little refuse	25–50% cover non-native plants; moderate or extensive soil disruption and refuse	>50% cover non-native plants; barren ground; highly compacted or otherwise disrupted soils and refuse
Connectivity	Intact areas have continuous corridor of natural or semi-natural vegetation	Intact: Embedded in 90–100% natural habitat; connectivity expected to be high	Variegated: Embedded in 60–90% natural habitat; connectivity generally high, but lower for species sensitive to habitat modification	Fragmented: Embedded in 20–60% natural habitat; connectivity generally low, but varies with species mobility and arrangement on landscape	Relictual: Embedded in <20% natural habitat; connectivity essentially absent
Landscape condition	Intensity and types of land uses in surrounding landscape can affect ecological integrity	Landscape Condition Model Index >0.8		Landscape Condition Model Index 0.8–0.65	Landscape Condition Model Index <0.65
Relative patch size	Indicates proportion lost due to stressors	Site at or minimally reduced from natural extent (≥95% remains)	Occurrence modestly reduced from original natural extent (≥80-95% remains)	Occurrence substantially reduced from original natural extent (≥50–80% remains)	Occurrence severely reduced from original natural extent (<50% remains)
Absolute patch size	Plant species lists were least similar between large and small cliff faces	Large cliffs (>20m high)	Medium cliffs (10-20m hight)	Small cliffs (5-10m high)	Cliffs <5m high

Patch diversity	Spatial heterogeneity of microhabitats influences abundance and distribution of species; human induced stressors play a role	No or little change in patch types due to human stressors	<50% change in expected patch types due to human stressors	>50% change in expected patch types due to human stressors	All or most patch types changed due to human stressors
Key ecological attribute – Vegetation condition					
Cover of native species	Native species dominate ecosystem; non-natives increase with human impacts	Cover of native plants ≥95%	Cover of native plants ≥80–95%	Cover of native plants ≥50–80%	Cover of native plants <50%
Cover of invasive species	Invasive species inflict wide range of impacts; early detection critical	None present	Invasive species present, but sporadic (<3% cover)	Invasive species prevalent (3–10% cover)	Invasive species abundant (>10% cover)
Cover of native increasers	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	Composition of native species can shift when exposed to stressors.	Diversity/abundance at or near reference standards; native species negative to anthropogenic degradation are present, species positive to anthropogenic degradation are absent to minor; full range of indicator species present	Diversity/abundance close to reference standards; native species reflective of anthropogenic degradation; some indicator species absent	Diversity/abundance differs from reference standards, but largely composed of native species; may include ruderal species; many indicator species absent	Vegetation severely altered from reference standards; dominated by ruderal species or comprised of planted stands of non-characteristic species or unnaturally dominated by single species; most indicator species absent
Key ecological attribute: Physicochemical and hydrology					
Soil surface condition	Disturbance can result in erosion with negative affects on ecological processes; bareground amount varies naturally with site type	Bare soil areas limited to naturally caused disturbances such as burrowing animals or game trails	Bare soil due to human causes, but extent and impact minimal		Bare soil due to human causes are common

ROCKY MOUNTAIN SUBALPINE DRY-MESIC SPRUCE-FIR FOREST AND WOODLAND AND ROCKY MOUNTAIN SUBALPINE MESIC-WET SPRUCE-FIR FOREST AND WOODLAND

General Description

The spruce – fir (*Picea engelmannii - Abies lasiocarpa*) subalpine forest and woodlands of the Rocky Mountains and in northeast Cascade Mountains are composed of two ecological systems recognized at high-elevations. The Dry-Mesic Subalpine Spruce Fir and the Mesic-Wet Spruce Fir Forest and Woodland ecological systems usually co-occur on the landscape separated by aspect and topographic position. The Mesic-Wet system extends to lower elevations in cold air drainages or frost pockets and is more common in wetter, deeper snowpack climates. In Washington, the Mesic-Wet system is more common than the Dry-Mesic system which is more common in the Rocky Mountains. They are combined here, although differences will be emphasized when appropriate.

In Washington, these systems generally appear at mid-elevation to near upper treeline (1200 to 2000 m) in northeastern Washington, east Cascades, Blue Mountains, Mount Baker, Mount Rainier, and the high rain shadow in the northeast Olympic Mountains. These are in cold, moist environments with a snow-dominated climate. Winters are long and cold creating a short growing season. Snowpack depth (0.6-3.7 m), late snow melting, and spring moisture are important to success of tree regeneration. Forests are closed to open and usually dominated by *Picea engelmannii* and/or *Abies lasiocarpa*. *Pinus contorta* is a common canopy member in Rocky Mountain and northeast Cascade sites. Large *Pinus contorta* var. *latifolia* stands are recognized as the Rocky Mountain Lodgepole Pine Forest system. A portion of the Mesic-Wet system includes *Tsuga mertensiana* in the Northern Rockies and in the drier portions of the Cascades (areas typically without *Abies amabilis* or *Cupressus nootkatensis*). The Mesic-Wet Subalpine Spruce Fir system is usually associated with Northern Rocky Mountain or East Cascades Montane Mesic systems. *Pseudotsuga menziesii*, *Pinus contorta*, or *Larix occidentalis* may persist in occurrences of the Dry-Mesic system for long periods without regeneration. Mixed conifer/*Populus tremuloides* stands may be encountered in the Dry-Mesic Subalpine Spruce Fir system.

Upper elevation examples may have more woodland physiognomy and *Pinus albicaulis* can be a seral component. The understory is variable where shrubs can be absent to dominant. The highest elevation sites that are in transition to subalpine parkland or woodland systems typically contain the short shrubs *Phyllodoce empetriformis* and *Empetrum nigrum* and the herbaceous species *Luzula glabrata* var. *hitchcockii* or *Lupinus arcticus* ssp. *subalpinus*. Mesic-Wet Subalpine Spruce Fir system understory species includes taller shrubs *Menziesia ferruginea*, *Vaccinium membranaceum*, *Rhododendron albiflorum*, *Rubus parviflorus*, *Rubus pedatus*, *Ledum glandulosum* and herbaceous species *Actaea rubra*, *Clintonia uniflora*, *Cornus canadensis*, *Gymnocarpium dryopteris*, *Tiarella trifoliata*, and *Valeriana sitchensis*. Species typically associated with the Dry-Mesic Subalpine Spruce Fir system include *Vaccinium scoparium*, *Shepherdia canadensis*, *Amelanchier alnifolia*, *Juniperus communis*, *Linnaea borealis*, *Mahonia repens* and herbaceous species *Arnica cordifolia*, *Calamagrostis canadensis*, and *Carex geyeri*. More mesic shrub species, such as *Menziesia ferruginea*, *Rhododendron albiflorum*, and *Vaccinium membranaceum* may be present in the Dry-Mesic Subalpine Spruce Fir system as shorter stature less abundant members of the understory.

A high-severity/low frequency fire regime typically characterizes spruce-fir forests (Agee 1993). This results from the subalpine environment that influences flammability and fire spread and in combination with weather that limits fires risk to only a few weeks in late summer (Jenkins et al 2008). Fire frequency in spruce-fir forests consequently is low. Trees with dense crowns and low branches are often covered with lichens and typically have a sparse understory with compact litter. This reduces low-intensity surface fires and creates conditions for crown fire (Jenkins et al 2008). LANDFIRE (2007) lists fire regime III for both Wet-Mesic and Dry-Mesic subalpine spruce-fir systems that include 35-100+ year frequency of mixed severity and 35-400+ year frequency of high severity fires. Lightning strikes are frequent, but will often result in small, patchy spot fires. Other natural disturbances include occasional windthrow and insect outbreaks (30-50 years) that create canopy gaps. Actions of defoliator and bark beetles can influence stand development, species composition and stand density. Large scale insect infestations may create large patches of early seral conditions and/or create conditions that lead to large, stand-replacement fires.

The historic range of variability of these systems is high. Fire history (sensitivity, intensity, return rate) are important in initial stand conditions for both *Picea engelmannii* and *Abies lasiocarpa*. In general, infrequent fires can lead to dominance of *Picea engelmannii* and/or *Abies lasiocarpa* with little or no *Pinus contorta*, *Larix occidentalis*, or *Pseudotsuga menziesii* because of severe site conditions. When severe fires occur, shrubland or grassland areas can persist for long periods. These are often part of the Mesic-Wet Subalpine Spruce Fir system with high severity fire regimes. Persistent treeless areas may be classified as the Northern Rocky Mountain Subalpine Deciduous Shrubland or Northern Rocky Mountain Subalpine-Upper Montane Grassland systems. Tree establishment is slow and stands remain open even into old-growth (Agee 1989). These aging mixed conifer stands become more susceptible to spruce beetle, root diseases (*Phellinus*, *Armillaria*), and to windthrow with time. Stands with over 65% *Picea engelmannii* >40 cm DBH are most susceptible to spruce beetle attack. The patchy nature of these forests is similar to forests with a mixed severity fire regime although the stands are primarily uneven age. The Dry-Mesic Subalpine Spruce Fir system typically has mixed conifer forests with more fire-adapted tree species, *Pinus contorta*, *Larix occidentalis* or *Pseudotsuga menziesii*. These may include small even-aged stands of a single species. Bark beetle infestations of *Pinus contorta* can create gaps and move these stands to high severity regimes dominated by *Picea engelmannii* and/or *Abies lasiocarpa*. Quigley et al. (1997) estimated that, historically, late-seral patches occupied approximately 25%, mid-seral 52%, and early-seral 23% in the east Cascades of Washington. LANDFIRE (2007) modeled 30-35% of these systems as late seral (75% closed canopy), 50-60% mid-seral (40% closed canopy), and 5-20% early seral.

Stressors

Since European settlement, timber harvest, introduced diseases (e.g., balsam woolly adelgids [*Adelges piceae*] on subalpine fir), road building, development, tree plantations, and climate change have all impacted natural disturbance regimes, forest structure, composition, landscape patch diversity, and tree regeneration. Fire exclusion generally has had little to no effect on fuels or forest structure in forests characterized by high-severity fire regimes (Noss et al 2006). Road development has fragmented many forests creating fire breaks. Quigley et al. (1997) estimated that mid-seral forest structure is currently 10% more abundant, late-seral forests 75% less abundant, and early-seral forest abundance 57% more abundant than historically in the east Cascades of Washington.

Ecological Integrity Assessment

The following table (Table C-13) displays metrics chosen to measure most of the key ecological attributes in the conceptual ecological model. Unless otherwise noted, metric ratings apply to both Level 2 and Level 3 EIAs. The difference is that a Level 3 EIA will use more intensive and precise methods to determine metric ratings such as: (1) stand structure and composition measurements (Franklin et al. 2002); (2) impact of introduced forest pathogens, particularly white pine blister rust on Pinus albicaulis and adelgid aphid on forest structure; (3) weighted Old Growth Habitat Index (Franklin et al. 2005); and (4) fire Regime Condition Class standard landscape worksheet method (FRCC 2010).

Table C-13. Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland and Rocky Mountain Subalpine Mesic-Wet Spruce-Fir Forest and Woodland Ecological Integrity Assessment Scorecard.

Metric	Justification	Rank			
		A (5 points)	**B (4 points)**	**C (3 points)**	**D (1 point)**
Key ecological attribute – Landscape context					
Edge length	Intactness of edge can be biotically and abiotically important	≥75% of edge bordered by natural communities	≥50–75% of edge bordered by natural communities	≥25–50% of edge bordered by natural communities	<25% of edge bordered by natural communities
Edge width		Average width of edge ≥100m	Average width of edge ≥75–100m	Average width of edge ≥25–75m	Average width of edge <25m
Edge condition		>95% native vegetation cover; <5% non-native cover; intact soils	75–95% cover native vegetation; 5–25% cover of non-native plants; intact or moderately disrupted soils	25–50% cover non-native plants; moderate or extensive soil disruption	>50% cover non-native plants; barren ground; highly compacted or otherwise disrupted soils
Connectivity	Intact areas have continuous corridor of natural or semi-natural vegetation	Intact: Embedded in 90–100% natural habitat; connectivity expected to be high	Variegated: Embedded in 60–90% natural habitat; connectivity generally high, but lower for species sensitive to habitat modification	Fragmented: Embedded in 20–60% natural habitat; connectivity generally low, but varies with species mobility and arrangement on landscape	Relictual: Embedded in <20% natural habitat; connectivity essentially absent
Landscape condition	Intensity and types of land uses in surrounding landscape can affect ecological integrity	Landscape Condition Model Index >0.8		Landscape Condition Model Index 0.8–0.65	Landscape Condition Model Index <0.65
Relative patch size	Indicates proportion lost due to stressors	Site at or minimally reduced from natural extent (≥95% remains)	Occurrence modestly reduced from original natural extent (≥80-95% remains)	Occurrence substantially reduced from original natural extent (≥50–80% remains)	Occurrence severely reduced from original natural extent (<50% remains)
Absolute patch size	Important for buffering surrounding impacts	>10000ha	1000–10000ha	100–1000ha	<100ha
Key ecological attribute – Vegetation condition					
Cover of native species (understory plants)	Native species dominate understory; non-natives increase with human impacts	Cover of native plants ≥95%	Cover of native plants ≥80–95%	Cover of native plants ≥50–80%	Cover of native plants <50%
Species composition	Composition of native species can shift when exposed to stressors.	Diversity/abundance at or near reference standards; native species negative to anthropogenic degradation are present, species positive to anthropogenic degradation are absent to minor; full range of indicator species present	Diversity/abundance close to reference standards; native species reflective of anthropogenic degradation; some indicator species absent	Diversity/abundance differs from reference standards, but largely composed of native species; may include ruderal species; many indicator species absent	Vegetation severely altered from reference standards; dominated by ruderal species or comprised of planted stands of non-characteristic species or unnaturally dominated by single species; most indicator species absent
Canopy cover and condition (late seral patches)	Late seral patches are closed to open; multilayered shade tolerant and intolerant trees	Majority of old trees not harvested; few stumps; large trees >150 years old; >25 old trees/ha (>38cm DBH)	10-30% old trees harvested; 10-25 old trees/ha (>38cm DBH)	>50% of old trees harvested; 5-10 old trees/ha (>38cm DBH)	Most, if not all, old trees harvested; <5 old trees/ha (>38cm DBH)
Coarse woody debris	Debris is indicator of disturbance regime and fire severity	Wide variety of downed log sizes with large variation in stages of decay	Moderately wide variety of downed log sizes with some variation in levels of decay		Low variety of downed log sizes with most logs in early stages of decay

Key ecological attribute: Physicochemical and hydrology					
Soil surface condition	Disturbance can result in erosion and compaction, thereby affecting ecological processes	Soil disturbance class 0 (undisturbed) – No evidence of equipment, wheel tracks, soil disturbance, compaction, and erosion, and management-created platy soils	Soil disturbance class 1 – Minimal evidence of equipment, wheel tracks, soil disturbance, compaction (0–12cm), and erosion; soil burn from fires low	Soil disturbance class 2 – Clear evidence of equipment, wheel tracks, soil disturbance (missing layers), compaction (≤30cm), and erosion; soil burn from fires moderate	Soil disturbance class 3 – Substantial evidence of equipment, wheel tracks, soil disturbance (missing layers), compaction (>30cm), and erosion; soil burn from fires high
Key ecological attribute: Natural disturbance regimes					
Forest pathogens	Pathogens are sources of mortality that influence fire and forest structure	Pathogens all native species within natural range of variability (NRV)	Native pathogens significantly affect forest structure beyond NRV	Exotic and native pathogens significantly affect forest structure beyond NRV	Exotic and native pathogens significantly affect forest structure well beyond NRV
Fire condition class	Mixed to high severity fire vital for maintaining ecological integrity	Fire Regime Condition Class 1 – No departure from historic regime	Fire Regime Condition Class 2 – Slight to moderate departure from historic fire regime		Fire Regime Condition Class 3 – Severe departure from historic fire regime; fire suppression evident

ROCKY MOUNTAIN LODGEPOLE PINE FOREST

General Description

The Rocky Mountain Lodgepole Pine Forest ecological system is composed of subalpine and upper montane forests with *Pinus contorta* (primarily var. *latifolia*) dominance that is related to fire history, not to topo-edaphic conditions. This Rocky Mountain Lodgepole Pine Forest type is a widespread, large patch to matrix-forming system in upper montane to subalpine elevations of the Rocky Mountains, Intermountain West region, north into the Canadian Rockies, east into mountain islands of north-central Montana and into the northeast Cascades in Washington. *Pinus contorta* stands south in the Cascades in Oregon are either Rocky Mountain Poor-Site Lodgepole Pine Forest (pumice zone) or Sierra Nevada Subalpine Lodgepole Pine Forest and Woodland (*Pinus contorta* var. *murrayana*). As described here, the Rocky Mountain Lodgepole Pine Forest system includes fire-maintained *Pinus contorta* forests in the subalpine spruce-fir and Montane spruce zones in Washington (Meidinger and Pojar 1991). The similar Rocky Mountain Poor-Site Lodgepole Pine Forest differs in that they are related to topo-edaphic conditions and nutrient-poor soils, such as excessively well-drained pumice deposits, glacial till and alluvium on valley floors where there is cold-air accumulation, warm and droughty shallow soils over fractured quartzite bedrock, and shallow moisture-deficient soils with a significant component of volcanic ash.

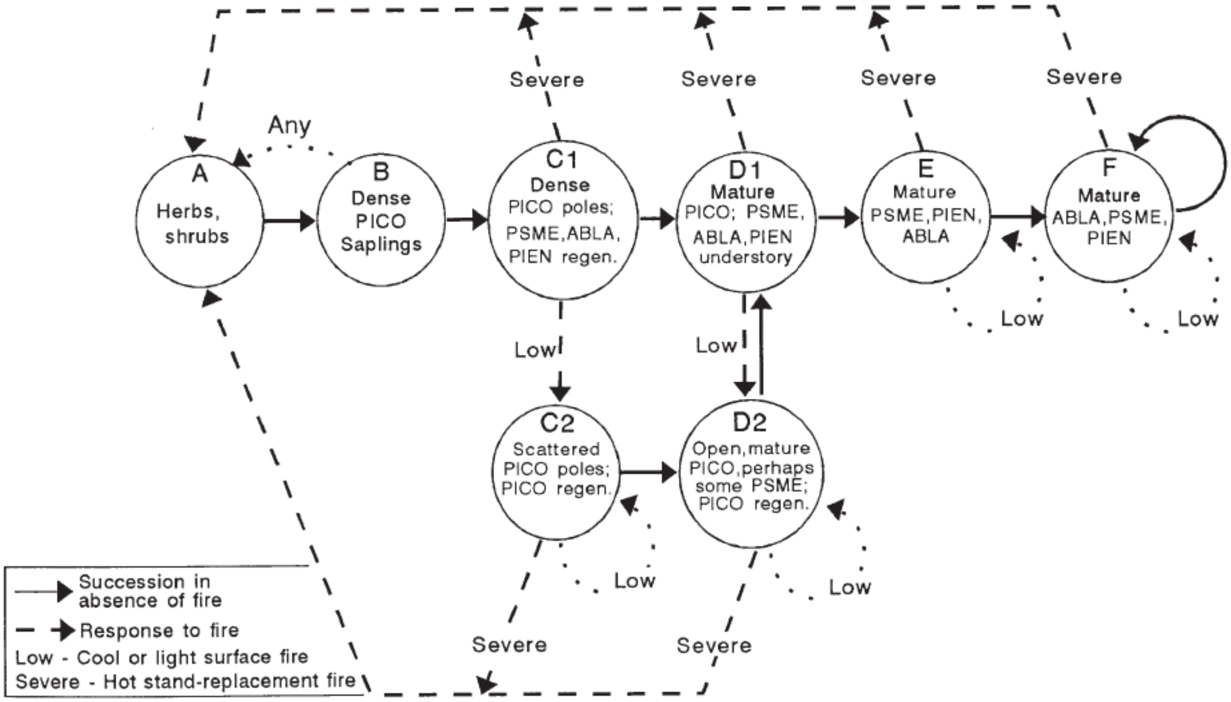
Rocky Mountain Lodgepole Pine Forest system is found mostly at mid- to higher elevations in typically cold and relatively dry areas, usually with a persistent winter snowpack. Most stands occur as early- to mid-successional forests which developed following fires associated with the Dry-Mesic Subalpine Spruce Fir and Mesic-Wet Subalpine Spruce Fir ecological systems. Soils supporting these forests are typically well-drained, gravelly, coarse-textured, acidic, and rarely formed from calcareous parent materials.

Pinus contorta possesses cone serotiny which is an important factor in its regeneration after fire. It typically is nonserotinous (open) cones until 20 to 30 years old and afterwards trees produce more serotinous (closed) cones (Smith and Fischer 1997). The serotinous cones on older trees open after exposure to heat during forest fire and allow the stands regenerate quickly (Smith and

Fischer 1997). Typically, *Pinus contorta* establishes within 10-20 years after fire and then declines after 100-200 years (Lilybridge et al. 1995). While these forests usually persist for over 100 years, they may eventually be replaced by mixed montane coniferous forests. Potential for high severity fires are in the dense regeneration phases and overmature late seral stage when fuels accumulate (Smith and Fischer 1997). Without fire and insects, stands become more closed with sparse undergrowth and prone to stagnation, snow breakage, and windthrow. Because *Pinus contorta* rarely reproduces under a canopy, old unburned stands are replaced by shade-tolerant conifers. Several distinct undergrowth types develop under the tree layer: 1) evergreen or deciduous medium-tall shrubs, 2) evergreen low shrub, or 3) graminoids with few shrubs. The tree layer is dominated by *Pinus contorta* var. *latifolia* and may be associated with other montane conifers (*Abies grandis*, *Larix occidentalis*, *Pinus monticola*, *P. ponderosa*, *Pseudotsuga menziesii*). Tall deciduous shrubs include *Acer glabrum*, *Amelanchier alnifolia*, *Holodiscus discolor*, or *Salix scouleriana*. These tall shrubs often occur over a layer of mid-height deciduous shrubs such as *Rosa gymnocarpa*, *Shepherdia canadensis*, *Spiraea betulifolia*, and *Symphoricarpos albus*. At higher elevations, *Vaccinium membranaceum* can be locally important, particularly following fire. Mid-tall evergreen shrubs can be abundant in some stands, for example, *Mahonia repens*, *Ceanothus velutinus*, and *Paxistima myrsinites*. Colder and drier sites support low-growing evergreen shrubs, such as *Arctostaphylos uva-ursi* or *A. nevadensis*. *Vaccinium scoparium* and *Xerophyllum tenax* are consistent evergreen low shrub dominants in the subalpine part of this habitat. Some undergrowth is dominated by graminoids with few shrubs. *Calamagrostis rubescens* and/or *Carex geyeri* can appear with *Vaccinium scoparium* in the subalpine zone. The forb component of this habitat is diverse and varies with environmental conditions.

In general, fire-free intervals less than the life span of *Pinus contorta* favor its dominance while greater intervals and the loss of standing dead trees with closed cones, favor dominance by other trees (Smith and Fischer 1997). Mean fire interval of replacement fires (80% of all fires) is 115 years and described as 35-100+ year frequency (Fire regime IV, LANDFIRE 2007). Woody fuels accumulate on the forest floor from insect (*Dendroctonus ponderosae* mountain pine beetle) and disease outbreaks and residual wood from past fires or logging activities. High-severity crown fires are likely in young stands, when the tree crowns are near deadwood on the ground. Because of fire sensitivity of both *Pinus contorta* and most invading conifers seedlings during stand development (*Abies lasiocarpa* and *Picea engelmannii*), the majority of trees are killed. LANDFIRE (2007) modeled the natural composition of the Lodgepole Pine Forest system and concluded that 25% were the early, closed canopy sapling stage, 45% were the mid-seral, closed canopy <25cm DBH stage, and 30% were late-seral, closed canopy 25-53 cm DBH stage. This system is model as stages B, C, and D in the graphic below (Fig. C-1).

Fig. C-1. Hypothetical fire-related succession for fire group four stands where lodgepole pine is the major seral species.



Stressors

Fire suppression has left many single-canopy *Pinus contorta* sites unburned resulting in more multilayered stands. Mountain pine beetle can infest and kill *Pinus contorta* trees when they reach large trunk sizes and at low levels of infestation can create openings for new tree recruitment. As most trees reach large sizes (>25 cm DBH) with phloem thick enough to support large beetle populations, pine beetle epidemics can occur and kill many trees and increase the potential for severe fires (Smith and Fischer 1997). These forests have been fragmented by roads, timber harvest, and influenced by periodic livestock grazing and altered fire regimes. Grasses compete with *Pinus contorta* seedlings, and use of non-native species causes long-term changes in community composition (Smith and Fischer 1997). *Poa pratensis* and *Elymus elymoides* can be locally abundant where livestock grazing has persisted. Increases in cattle use results in increases in trampling damage to regenerating *Pinus contorta* seedlings (Pitt et al. 1998).

Ecological Integrity Assessment

The following table (Table C-14) displays metrics chosen to measure most of the key ecological attributes in the conceptual ecological model. Unless otherwise noted, metric ratings apply to both Level 2 and Level 3 EIAs. The difference is that a Level 3 EIA will use more intensive and precise methods to determine metric ratings such as: (1) stand structure and composition measurements (Franklin et al. 2002); (2) impact of introduced forest pathogens, particularly white pine blister rust on Pinus albicaulis and adelgid aphid on forest structure; and (3) fire Regime Condition Class standard landscape worksheet method (FRCC 2010).

Table C-14. Rocky Mountain Lodgepole Pine Forest Ecological Integrity Assessment Scorecard.

Metric	Justification	Rank			
		A (5 points)	**B (4 points)**	**C (3 points)**	**D (1 point)**
Key ecological attribute – Landscape context					
Edge length	Intactness of edge can be biotically and abiotically important	≥75% of edge bordered by natural communities	≥50–75% of edge bordered by natural communities	≥25–50% of edge bordered by natural communities	<25% of edge bordered by natural communities
Edge width		Average width of edge ≥100m	Average width of edge ≥75–100m	Average width of edge ≥25–75m	Average width of edge <25m
Edge condition		>95% native vegetation cover; <5% non-native cover; intact soils	75–95% cover native vegetation; 5–25% cover of non-native plants; intact or moderately disrupted soils	25–50% cover non-native plants; moderate or extensive soil disruption	>50% cover non-native plants; barren ground; highly compacted or otherwise disrupted soils
Connectivity	Intact areas have continuous corridor of natural or semi-natural vegetation	Intact: Embedded in 90–100% natural habitat; connectivity expected to be high	Variegated: Embedded in 60–90% natural habitat; connectivity generally high, but lower for species sensitive to habitat modification	Fragmented: Embedded in 20–60% natural habitat; connectivity generally low, but varies with species mobility and arrangement on landscape	Relictual: Embedded in <20% natural habitat; connectivity essentially absent
Landscape condition	Intensity and types of land uses in surrounding landscape can affect ecological integrity	Landscape Condition Model Index >0.8		Landscape Condition Model Index 0.8–0.65	Landscape Condition Model Index <0.65
Relative patch size	Indicates proportion lost due to stressors	Site at or minimally reduced from natural extent (≥95% remains)	Occurrence modestly reduced from original natural extent (≥80-95% remains)	Occurrence substantially reduced from original natural extent (≥50–80% remains)	Occurrence severely reduced from original natural extent (<50% remains)
Absolute patch size	Important for buffering surrounding impacts	>10000ha	1000–10000ha	100–1000ha	<100ha
Patch diversity	Diversity reflects natural fire regime dynamics	>90% of patches result from natural processes	75-90% of patches result from natural processes	50-75% of patches result from natural processes	<50% of patches result from natural processes
Key ecological attribute – Vegetation condition					
Cover of native species (understory plants)	Native species dominate understory; non-natives increase with human impacts	Cover of native plants ≥95%	Cover of native plants ≥80–95%	Cover of native plants ≥50–80%	Cover of native plants <50%
Species composition	Composition of native species can shift when exposed to stressors.	Diversity/abundance at or near reference standards; native species negative to anthropogenic degradation are present, species positive to anthropogenic degradation are absent to minor; full range of indicator species present	Diversity/abundance close to reference standards; native species reflective of anthropogenic degradation; some indicator species absent	Diversity/abundance differs from reference standards, but largely composed of native species; may include ruderal species; many indicator species absent	Vegetation severely altered from reference standards; dominated by ruderal species or comprised of planted stands of non-characteristic species or unnaturally dominated by single species; most indicator species absent
Canopy cover and condition (late seral patches)	Late seral patches (>80 years old) are closed and typically homogenous	Lodgepole pine dominates canopy; shade tolerant species in subcanopy only; no stumps	Lodgepole pine dominates canopy; 10-30% shade tolerant species in canopy only; some stumps	Lodgepole pine co-dominates canopy; 30-50% shade tolerant species in canopy; some stumps	Lodgepole pine co-dominates canopy; >50% shade tolerant species in canopy; some stumps
Course woody debris	Downed woody debris abundant in early (<20 years old) patches	Snags and downed woody debris abundant in early-seral stages	Snags and downed woody debris moderately abundant in early-seral stages		Snags and downed woody debris sparse in early-seral stages

Key ecological attribute: Physicochemical and hydrology					
Soil surface condition	Disturbance can result in erosion and compaction, thereby affecting ecological processes	Soil disturbance class 0 (undisturbed) – No evidence of equipment, wheel tracks, soil disturbance, compaction, and erosion, and management-created platy soils	Soil disturbance class 1 – Minimal evidence of equipment, wheel tracks, soil disturbance, compaction (0–12cm), and erosion; soil burn from fires low	Soil disturbance class 2 – Clear evidence of equipment, wheel tracks, soil disturbance (missing layers), compaction (≤30cm), and erosion; soil burn from fires moderate	Soil disturbance class 3 – Substantial evidence of equipment, wheel tracks, soil disturbance (missing layers), compaction (>30cm), and erosion; soil burn from fires high
Key ecological attribute: Natural disturbance regimes					
Forest pathogens	Pathogens are sources of mortality that influence fire and forest structure	Pathogens all native species within natural range of variability (NRV)	Native pathogens significantly affect forest structure beyond NRV	Exotic and native pathogens significantly affect forest structure beyond NRV	Exotic and native pathogens significantly affect forest structure well beyond NRV
Fire condition class	Mixed to high severity fire vital for maintaining ecological integrity	Fire Regime Condition Class 1 – No departure from historic regime	Fire Regime Condition Class 2 – Slight to moderate departure from historic fire regime		Fire Regime Condition Class 3 – Severe departure from historic fire regime; fire suppression evident

ROCKY MOUNTAIN ASPEN FOREST AND WOODLAND

General Description

The Rocky Mountain Aspen Forest and Woodland system is a widespread, large patch system found throughout much of the western U.S. and Canada. It is most common in the southern and central Rocky Mountains. In Washington, Populus tremuloides forests and woodlands are a minor, small patch type found east of the Cascades, most common in the north and in the Okanogan Highlands. *Populus tremuloides* probably makes up less than one percent of the trees on the Okanogan and Wenatchee National Forests (Hadfield and Magelssen 2004). Although *Populus tremuloides* can be associated with streams, ponds, or wetlands, the Rocky Mountain Aspen Forests and Woodland system consists of upland aspen stands found from low to moderate elevation as patches or stands primarily within Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest systems. Rockfalls, talus, or stony north slopes are often typical sites and the aspen system may occur in Intermountain Basin big sagebrush landscapes on such moist microsites. *Populus tremuloides* stands are small patches in Washington with more than half of surveyed stands covering <0.8 ha (Hadfield and Magelssen 2004, 2006).

This system is characterized by dominance of *Populus tremuloides* in forests or woodlands with less than 25% total tree canopy cover by conifers. The tree canopy is typically closed and essentially all *Populus tremuloides* regeneration results from asexual vegetative production of sprouts from roots following disturbances (Hadfield and Magelssen 2004, 2006). Populus tremuloides is the sole dominant in many stands although scattered *Abies grandis*, *Pinus ponderosa*, *Pinus contorta* or *Pseudotsuga menziesii* trees are common in Washington stands (Hadfield and Magelssen 2004, 2006). *Symphoricarpos oreophilus* and *S. albus* are the most common shrubs. Tall shrubs, such as *Acer glabrum*, *Salix scouleriana* and *Amelanchier alnifolia* may be abundant. In some stands, *Calamagrostis rubescens* may dominate the ground cover without shrubs. Other common grasses are *Festuca idahoensis*, *Bromus carinatus*, or *Elymus glaucus*. Characteristic tall forbs include *Agastache* spp., *Aster* spp., *Senecio* spp., *Rudbeckia* spp. Low forbs include *Thalictrum* spp., *Galium* spp., *Osmorhiza* spp., and *Lupinus* spp.

Occurrences of this system originate and are maintained by stand-replacing disturbances such as crown fire, insect outbreak, disease, and windthrow within the matrix of conifer forests. *Populus tremuloides* will colonize sites after fire or other stand disturbances through root sprouting. The stems of these thin-barked, clonal trees are easily killed by ground fires, but they can quickly and vigorously resprout in densities of up to 30,000 stems per hectare (CNHP 2005*b*). With adequate disturbance a clone may live many centuries or millennia. The stems are relatively short-lived (100-150 years), and stands will succeed to longer-lived conifer forest if left undisturbed. Natural fire return interval may be as frequent as 7-10 years although LANDFIRE (2007) modeling cites 35-100 year frequency of mixed severity fires as fire regime III (LANDFIRE modeling of this system in the central Rockies assumes fire regime I). Ungulate browsing plays a variable role in aspen habitat by slowing tree regeneration by eating *Populus tremuloides* sprouts on some sites. Wolf predation plays a role in reducing elk browse effects and thus structure of *Populus tremuloides* stands in Yellowstone (Halofsky et al 2008). Although *Populus tremuloides* produces abundant seeds, seedling survival is rare because the long moist conditions required to establish them are rare in these habitats (Romme et al. 1997). Grazing reduces the fine fuels thereby reducing the risk of fires spreading into the stands; grazing also can kill aspen stems and small conifers (Hadfield and Magelssen 2004, 2006).

Stressors

Heavy livestock browsing can adversely impact *Populus tremuloides* growth and regeneration. Cattle and elk commonly graze on grasses and forbs in *Populus tremuloides* stands allowing conifers to become established (Hadfield and Magelssen 2004, 2006). With fire suppression and alteration of fine fuels, fire rejuvenation of aspen habitat has been greatly reduced since about 1900. Conifers now dominate many seral *Populus tremuloides* stands and extensive stands of young *Populus tremuloides* are uncommon. Many stands surveyed on the Okanogan and Wenatchee National Forests are successional to conifers and shrinking in size. Hadfield and Magelssen (2004, 2006) conclude that *Populus tremuloides* occupied a considerably larger area in Washington in the past than now. Major factors contributing to this condition are browsing by wild and domestic ungulates and exclusion of fires. Grazing also increases invasion by exotic species such as *Poa pratensis* and *Cirsium* spp.

Ecological Integrity Assessment

The following table (Table C-15) displays metrics chosen to measure most of the key ecological attributes in the conceptual ecological model. Unless otherwise noted, metric ratings apply to both Level 2 and Level 3 EIAs. The difference is that a Level 3 EIA will use more intensive and precise methods to determine metric ratings such as: (1) size distribution of stems: “seedling” (<1.0” DBH), “sapling” (1.0” – 4.9” DBH), “pole” (5.0” – 9.9”), and “mature” (10.0” and larger DBH); (2) roots, butt (lowest 2’), stem, and foliage examined for damage-causing agents (Hadfield and Magelssen 2004, 2006); and (3) fire Regime Condition Class standard landscape worksheet method (FRCC 2010).

Table C-15. Rocky Mountain Aspen Forest and Woodland Ecological Integrity Assessment Scorecard.

Metric	Justification	Rank			
		A (5 points)	B (4 points)	C (3 points)	D (1 point)
Key ecological attribute – Landscape context					
Edge length	Intactness of edge can be biotically and abiotically important	≥75% of edge bordered by natural communities	≥50–75% of edge bordered by natural communities	≥25–50% of edge bordered by natural communities	<25% of edge bordered by natural communities
Edge width		Average width of edge ≥200m	Average width of edge ≥100–200m	Average width of edge ≥50–100m	Average width of edge <50m
Edge condition		>95% native vegetation cover; <5% non-native cover; intact soils and no refuse	75–95% cover native vegetation; 5–25% cover of non-native plants; intact or moderately disrupted soils and little refuse	25–50% cover non-native plants; moderate or extensive soil disruption and refuse	>50% cover non-native plants; barren ground; highly compacted or otherwise disrupted soils and refuse
Connectivity	Intact areas have continuous corridor of natural or semi-natural vegetation	Intact: Embedded in 90–100% natural habitat; connectivity expected to be high; mosaic with gradients	Variegated: Embedded in 60–90% natural habitat; connectivity generally high, but lower for species sensitive to habitat modification; mosaic with both gradients and abrupt boundaries	Fragmented: Embedded in 20–60% natural habitat; connectivity generally low, but varies with species mobility and arrangement on landscape; gradients shortened	Relictual: Embedded in <20% natural habitat; connectivity essentially absent; remaining habitat uniform
Landscape condition	Intensity and types of land uses in surrounding landscape can affect ecological integrity	Landscape Condition Model Index >0.8		Landscape Condition Model Index 0.8–0.65	Landscape Condition Model Index <0.65
Relative patch size	Indicates proportion lost due to stressors	Site at or minimally reduced from natural extent (≥95% remains)	Occurrence modestly reduced from original natural extent (≥80-95% remains)	Occurrence substantially reduced from original natural extent (≥50–80% remains)	Occurrence severely reduced from original natural extent (<50% remains)
Absolute patch size	Important for buffering surrounding impacts	>25ha	10–25ha	2.5–10ha	<2.5ha
Key ecological attribute – Vegetation condition					
Cover of native species (understory plants)	Native species dominate understory; non-natives increase with human impacts	Cover of native plants ≥95%	Cover of native plants ≥80–95%	Cover of native plants ≥50–80%	Cover of native plants <50%
Cover of native bunchgrass	Native bunchgrasses dominate; high cover related to resistance to invasion	Perennial bunchgrass cover >75% or near site potential	Perennial bunchgrass cover 50–75% or reduced from site potential	Perennial bunchgrass cover 25–50% or reduced from site potential	Perennial bunchgrass cover <25% and much reduced from site potential
Cover of invasive species	Invasive species inflict wide range of impacts; early detection critical	None present	Invasive species present, but sporadic (<3% cover)	Invasive species prevalent (3–10% cover)	Invasive species abundant (>10% cover)
Cover of native increasers (understory)	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	Composition of native species can shift when exposed to stressors.	Diversity/abundance at or near reference standards; native species negative to anthropogenic degradation are present, species positive to anthropogenic degradation are absent to minor; full range of indicator species present	Diversity/abundance close to reference standards; native species reflective of anthropogenic degradation; some indicator species absent	Diversity/abundance differs from reference standards, but largely composed of native species; may include ruderal species; many indicator species absent	Vegetation severely altered from reference standards; dominated by ruderal species or comprised of planted stands of non-characteristic species or unnaturally dominated by single species; most indicator species absent

Canopy cover and condition (aspen)	Aspen stands assigned to a condition class	'Stable' condition characterized by multiple size trees, regeneration, and little aspen mortality	'Successional to conifers' characterized by conifers replacing aspen; aspen regeneration may be present, but not abundant		'Decadent' characterized by little to no regeneration and aspen mortality; conifers may be present
Key ecological attribute: Physicochemical and hydrology					
Soil surface condition	Disturbance can result in erosion and compaction, thereby affecting ecological processes	Soil disturbance class 0 (undisturbed) – No evidence of equipment, wheel tracks, soil disturbance, compaction, and erosion, and management-created platy soils	Soil disturbance class 1 – Minimal evidence of equipment, wheel tracks, soil disturbance, compaction (0–12cm), and erosion; soil burn from fires low	Soil disturbance class 2 – Clear evidence of equipment, wheel tracks, soil disturbance (missing layers), compaction (≤30cm), and erosion; soil burn from fires moderate	Soil disturbance class 3 – Substantial evidence of equipment, wheel tracks, soil disturbance (missing layers), compaction (>30cm), and erosion; soil burn from fires high
Key ecological attribute: Natural disturbance regime					
Fire condition class	Mixed to high severity fire vital for maintaining ecological integrity	Fire Regime Condition Class 1 – No departure from historic regime	Fire Regime Condition Class 2 – Slight to moderate departure from historic fire regime		Fire Regime Condition Class 3 – Severe departure from historic fire regime; fire suppression evident

EAST CASCADES MESIC MONTANE MIXED-CONIFER FOREST AND WOODLAND

General Description

The East Cascades Mesic Montane Mixed-Conifer Forest and Woodland ecological system is composed of highly variable montane coniferous forests in Chelan, Kittitas, Yakima, and Klickitat counties in Washington and in adjacent Oregon. This large patch to matrix system lies between and intertwined with the higher elevation North Pacific Mountain Hemlock Forest, North Pacific Mesic Western Hemlock-Silver Fir Forest, or Rocky Mountain Subalpine Mesic-Wet Spruce-Fir Forest and Woodland and the lower elevation Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest. Westward in the Columbia River Gorge, this system merges with North Pacific Maritime Dry-Mesic Douglas-fir-Western Hemlock Forest. Elevations range from 610 to 1520 meters. The system is associated with a mesic climate regime with annual precipitation ranging from 100 to 200 cm and winter snowpack that typically melts off in early spring at lower elevations.

Dominant canopy trees include a mix of *Pseudotsuga menziesii* var. *menziesii* with *Abies grandis*, *Thuja plicata* and/or *Tsuga heterophylla*. The latter trees have at least 10% cover. Several other conifers can dominate or codominate, including *Pinus contorta*, *Pinus monticola*, *Pinus ponderosa* and *Larix occidentalis*. Common shrubs include *Mahonia nervosa*, *Linnaea borealis*, *Paxistima myrsinites*, *Acer circinatum*, *Spiraea betulifolia*, *Symphoricarpos hesperius*, *Cornus nuttallii*, *Rubus parviflorus*, and *Vaccinium membranaceum*. This system is similar to the Northern Rocky Mountain Mesic Montane Mixed Conifer Forest system except with distinct Cascadian floristic elements, such as *Acer circinatum*, *Acer macrophyllum* and *Mahonia nervosa*. Herbaceous species the reflects local climate and degree of canopy closure and include species restricted to the Cascades, for example, *Achlys triphylla*, *Anemone deltoidea*, and *Vancouveria hexandra*.

Stand-replacement, fire-return intervals are typically 150-500 years, with moderate-severity fire intervals of 50-100 years (Fire Regime Group III or IV, LANDFIRE 2007). Wright and Agee (2004) calculated a mean fire return interval of 23.9 years for the 'wet grand fir' plant association group in the Teanaway Drainage. Hessburg et al. (2007) found that mixed severity fires occurred on 53% of the cool/moist forest landscape of the east Cascades and the rest were low (21%) and high severity (26%) fires. Timing of mixed severity fires is irregular and fires are often overlapping (Brown and Smith 2000). These mixed fire regimes and topography result in a varied landscape of stand development and composition. Noss et al. (2006) concluded that knowledge of the mixed-severity fire regime is lacking on its influence on stand structure and development and that assumptions that fire exclusion will result in high tree density or shade-tolerant trees abundance may be incorrect. This complexity results in five general seral or developmental types recognizable in the similar Northern Rocky Mountain Mesic Mixed Conifer system (Shiplett and Neuenschwander 1994):

1) *Tsuga heterophylla – Thuja plicata* stands that initiate following disturbance

2) Mixed conifer stands that initiate from various disturbances

3) Shrubfields that develop from multiple burns

4) Scattered large *Larix occidentalis* surviving fires, and

5) *Pinus contorta* on less productive sites and relatively frequent burns.

The East Cascades Mesic Montane Mixed-Conifer Forest system is primarily composed of the first two types. Shrubfields (type 3 above) composed of *Acer circinatum* and *A. glabrum*, *Amelanchier alnifolia*, *Ceanothus* spp., *Salix scouleriana*, *Ribes* spp., and/or *Vaccinium membranaceum* typically develop following stand-replacing fires. Tree regeneration usually accompanies shrubs and the shrubfields become young forests within a few decades and are included in this system. (Shrubfields where trees are persistently absent to rare should be included in the Northern Rocky Mountain Lower Montane and Foothill Deciduous Shrubland system). Most stands following fire retain some trees and other biological legacies from the previous forest stand. Trees or whole sites that escape a fire or two may reach sizes more resistant to fire, thus resulting in the clustering of old trees and stands across the landscape. Thus, old growth forests (type 1 above) develop in fire refugia such as headwalls, riparian stringers, and along benches (Camp et al. 1997). The less fire resistant and shade tolerant *Abies grandis*, *Taxus brevifolia*, *Thuja plicata*, and *Tsuga heterophylla* are more common in older forests. The mid-seral, mixed conifer (100-200 year old) stands (type 2 above) are usually canopies composed of *Pseudotsuga menziesii* var. *menziesii*, *Picea engelmannii*, *Pinus monticola*, and *Larix occidentalis* with *Abies grandis* and maybe *Thuja plicata* on moist, cool sites (Lillybridge et al 1995). Type 4 (above) is recognized as a separate small to large patch within the Western Larch Savanna and Woodland ecological system and type 5 is the Rocky Mountain Lodgepole Pine ecological system. Less productive sites may be susceptible to insects or disease. Douglas-fir bark beetle will affect *Pseudotsuga menziesii* var. *menziesii* and *Abies grandis*. Root rots, butt rots, and stem decay can affect *Abies grandis*, *Thuja plicata*, whereas *Tsuga heterophylla* is less susceptible. *Pinus monticola* has been impacted by white pine blister rust and its abundance reduced in affected stands. Park et al. (2005) concluded that due to climate, limited settlement history, low seed sources, and closed canopy forests, the mountain ecoregions of the Northwest have fewer non-native invasive plants than other regions of the United States. Quigley et al. (1997) estimated that late-seral forest structure (stands with upper canopy of primarily shade-intolerant trees) historically occupied about one-third of the landscape, mid-seral forest occupied 40% of the landscape, and early-seral forest occupied 20% of the landscape. LANDFIRE (2007) modeled 65% of this system as late seral (50% open), 25% as mid-seral (20% closed), and 10% as early seral.

Stressors

Since European settlement, fire suppression, timber harvest, introduced diseases, road building, development, livestock grazing, and plantation establishments have all impacted natural disturbance regimes, forest structure, composition, landscape patch diversity, and tree regeneration (Franklin et al. 2008). Timber harvest has focused on the large shade-intolerant, fire-resistant species in mid- and late-seral forests thereby eliminating many old forest attributes from stands (Franklin et al. 2008). Fire suppression has allowed less fire-resistant, shade-tolerant trees to become established in the understory (and sometimes dominant in the canopy) creating more dense and multi-layered forests than what historically occurred on the landscape. Road development has fragmented many forests creating fire breaks. Under present conditions the fire regime is mixed severity and more variable, with stand-replacing fires more common and the forests more homogeneous. With vigorous fire suppression, fire-return intervals are longer, and multi-layered stands provide fuel ladders, making these forests more susceptible to high-intensity, stand-replacing fires. Quigley et al. (1997) estimated that mid-seral forest structure is currently over 40% more abundant, late-seral forests 90% less abundant, and early-seral forests 20% less abundant than historically.

Ecological Integrity Assessment

The following table (Table C-16) displays metrics chosen to measure most of the key ecological attributes in the conceptual ecological model. Unless otherwise noted, metric ratings apply to both Level 2 and Level 3 EIAs. The difference is that a Level 3 EIA will use more intensive and precise methods to determine metric ratings such as: (1) stand structure and composition measurements (Franklin et al. 2002); (2) impact of introduced forest pathogens, particularly white pine blister rust and adelgid aphid on forest structure; (3) weighted Old Growth Habitat Index (Franklin et al. 2005); and (4) Fire Regime Condition Class standard landscape worksheet method (FRCC 2010).

Table C-16. East Cascades Mesic Montane Mixed-Conifer Forest and Woodland Ecological Integrity Assessment Scorecard.

Metric	Justification	Rank			
		A (5 points)	B (4 points)	C (3 points)	D (1 point)
Key ecological attribute – Landscape context					
Edge length	Intactness of edge can be biotically and abiotically important	≥75% of edge bordered by natural communities	≥50–75% of edge bordered by natural communities	≥25–50% of edge bordered by natural communities	<25% of edge bordered by natural communities
Edge width		Average width of edge ≥100m	Average width of edge ≥75–100m	Average width of edge ≥25–75m	Average width of edge <25m
Edge condition		>95% native vegetation cover; <5% non-native cover; intact soils	75–95% cover native vegetation; 5–25% cover of non-native plants; intact or moderately disrupted soils	25–50% cover non-native plants; moderate or extensive soil disruption	>50% cover non-native plants; barren ground; highly compacted or otherwise disrupted soils

Connectivity	Intact areas have continuous corridor of natural or semi-natural vegetation	Intact: Embedded in 90–100% natural habitat; connectivity expected to be high; mosaic with gradients	Variegated: Embedded in 60–90% natural habitat; connectivity generally high, but lower for species sensitive to habitat modification; mosaic with both gradients and abrupt boundaries	Fragmented: Embedded in 20–60% natural habitat; connectivity generally low, but varies with species mobility and arrangement on landscape; gradients shortened	Relictual: Embedded in <20% natural habitat; connectivity essentially absent; remaining habitat uniform
Landscape condition	Intensity and types of land uses in surrounding landscape can affect ecological integrity	Landscape Condition Model Index >0.8		Landscape Condition Model Index 0.8–0.65	Landscape Condition Model Index <0.65
Relative patch size	Indicates proportion lost due to stressors	Site at or minimally reduced from natural extent (≥95% remains)	Occurrence modestly reduced from original natural extent (≥80-95% remains)	Occurrence substantially reduced from original natural extent (≥50–80% remains)	Occurrence severely reduced from original natural extent (<50% remains)
Absolute patch size	Important for buffering surrounding impacts	>8000ha	4000–8000ha	2000–4000ha	<2000ha
Patch diversity	Diversity and interspersion of seral patches indicative of disturbance regimes	Diverse mosaic approximating 65% late, 25% mid-, and 10% early seral stages	Diverse mosaic, with <65% late seral stages; mosaic may be simplified due to fire suppression	Cohort diversity low with most being early to mid-seral; interspersion simplified	
Key ecological attribute – Vegetation condition					
Cover of native species (understory plants)	Native species dominate understory; non-natives increase with human impacts	Cover of native plants ≥95%	Cover of native plants ≥80–95%	Cover of native plants ≥50–80%	Cover of native plants <50%
Species composition	Composition of native species can shift when exposed to stressors.	Diversity/abundance at or near reference standards; native species negative to anthropogenic degradation are present, species positive to anthropogenic degradation are absent to minor; full range of indicator species present	Diversity/abundance close to reference standards; native species reflective of anthropogenic degradation; some indicator species absent	Diversity/abundance differs from reference standards, but largely composed of native species; may include ruderal species; many indicator species absent	Vegetation severely altered from reference standards; dominated by ruderal species or comprised of planted stands of non-characteristic species or unnaturally dominated by single species; most indicator species absent
Canopy cover and condition (late seral patches)	Late seral patches closed to open, typically multilayered	<10% of old trees harvested; >25 old trees/ha (>150 years old, DBH >53cm)	10-30% old trees harvested; few stumps; 10-25 old trees/ha (>150 years old, DBH >53cm)	30-75% old trees harvested; 5-10 old trees/ha (>150 years old, DBH >53cm)	>75% old trees harvested; <5 old trees/ha (>150 years old, DBH >53cm)
Canopy cover and condition (mid-seral patches)	Mid-seral patches typically closed; often multilayered	<10% of old trees harvested	10-30% of trees harvested	30-75% of trees harvested	>75% trees harvested
Coarse woody debris	Large snags are vital part of forest and debris is indicator of disturbance regime and fire severity	Large snags frequent; unless in natural, late stem exclusion stage; wide variety of downed log sizes with large variation in stages of decay	Large snags occasionally present; moderately wide variety of downed log sizes with some variation in levels of decay		Large snags absent; low variety of downed log sizes with most logs in early stages of decay
Key ecological attribute: Physicochemical and hydrology					
Soil surface condition	Disturbance can result in erosion and compaction, thereby affecting ecological processes	Soil disturbance class 0 (undisturbed) – No evidence of equipment, wheel tracks, soil disturbance, compaction, and erosion, and management-created platy soils	Soil disturbance class 1 – Minimal evidence of equipment, wheel tracks, soil disturbance, compaction (0–12cm), and erosion; soil burn from fires low	Soil disturbance class 2 – Clear evidence of equipment, wheel tracks, soil disturbance (missing layers), compaction (≤30cm), and erosion; soil burn from fires moderate	Soil disturbance class 3 – Substantial evidence of equipment, wheel tracks, soil disturbance (missing layers), compaction (>30cm), and erosion; soil burn from fires high

Key ecological attribute: Natural disturbance regimes					
Forest pathogens	Pathogens are sources of mortality that influence fire and forest structure	Pathogens all native species within natural range of variability (NRV)	Native pathogens significantly affect forest structure beyond NRV	Exotic and native pathogens significantly affect forest structure beyond NRV	Exotic and native pathogens significantly affect forest structure well beyond NRV
Fire condition class	Mixed to high severity fire vital for maintaining ecological integrity	Fire Regime Condition Class 1 – No departure from historic regime	Fire Regime Condition Class 2 – Slight to moderate departure from historic fire regime		Fire Regime Condition Class 3 – Severe departure from historic fire regime; fire suppression evident

EAST CASCADES OAK-PONDEROSA PINE FOREST AND WOODLAND

General Description

The East Cascades Oak-Ponderosa Pine Forest and Woodland ecological system is narrowly restricted appearing at or near lower treeline in foothills of the eastern Cascades in Washington and Oregon within 65 km of the Columbia River Gorge. Disjunct occurrences in Klamath and Siskiyou counties, Oregon, have more sagebrush and bitterbrush in the understory, along with other shrubs. This system dominates in areas between shrubsteppe at lower elevations and conifer-dominated woodlands or forest above. Elevations range from 460 to 1920 m. They occur in slopes ranging from steep, lower slopes to more moderate slopes on dry benches. Substrates are usually very gravelly, stony coarse loams derived from basalt colluvium. Oak types associated with wetlands or riparian areas are not included here. They are associated with the Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland or Columbia Basin Foothill Riparian Woodland and Shrubland ecological systems.

Most occurrences of this system are dominated by a mix of *Quercus garryana* and *Pinus ponderosa* or *Pseudotsuga menziesii*. Scattered *Pinus ponderosa* or *Pseudotsuga menziesii* can comprise the upper canopy over *Quercus garryana* trees, but they only occur in favorable microsites and do not regenerate well. Clonal *Quercus garryana* can create dense patches across a grassy landscape or dominate open woodlands and savannas. The understory may include dense stands of shrubs or, more often, grasses, sedges, or forbs. Shrubsteppe shrubs may be prominent in some stands and create a distinct tree-shrub-sparse grassland habitat, including *Purshia tridentata*, *Artemisia tridentata*, *Artemisia nova* (not in Washington), and *Chrysothamnus viscidiflorus*. Understories are generally dominated by herbaceous species, especially graminoids. Mesic sites have an open to closed sodgrass understory dominated by *Calamagrostis rubescens*, *Carex geyeri*, *Carex rossii*, *Carex inops*, or *Elymus glaucus*. Drier savanna and woodland understories typically contain bunchgrass steppe species such as *Festuca idahoensis* or *Pseudoroegneria spicata*. Common exotic grasses that often appear in high abundance are *Bromus tectorum*, *Cynosurus echinata*, and *Poa bulbosa*. These woodlands occur at the lower treeline ecotone between *Artemisia* spp. or *Purshia tridentata* steppe or shrubland and *Pinus ponderosa* and/or *Pseudotsuga menziesii* forests or woodlands. In the Columbia River Gorge, this system appears as small to large patches in transitional areas in the Little White Salmon and White Salmon river drainages in Washington and Hood River, Rock Creek, Mosier Creek, Mill Creek, Three-mile Creek, Fifteen Mile Creek, and White River drainages in Oregon. *Quercus garryana* can create dense patches often associated with grassland or shrubland balds within a closed *Pseudotsuga menziesii* forest landscape. Commonly the understory is shrubby and composed of *Ceanothus integerrimus*, *Holodiscus discolor*, *Symphoricarpos albus*, and *Toxicodendron diversilobum* and similar to the North Pacific Oak Woodland ecological system.

East Cascades Oak-Pine Forest and Woodland is characterized by frequent (5-30 year fire return interval) low intensity ground fires that maintain the open savanna structure characteristic of most of this system (LANDFIRE 2007 fire regime I). Fire severity increases with density of understory shrubs and canopy trees. Soil drought plays a role, maintaining an open tree canopy in part of this dry woodland habitat. Increasing timber harvest or altered fire regime can result in lower densities of large live trees, thus increasing dominance of smaller size classes and sprouting clumps which results in denser stands. In Klickitat County, dense stands of stunted oak indicate effects of fire exclusion in this community type (M. Vander Haegen, WDFW, pers. comm.). Decades of fire suppression have led to invasion by *Pinus ponderosa* in favorable sites along lower treeline and by *Pseudotsuga menziesii* in the gorge and other oak patches on xeric sites in the east Cascade foothills. Where this system occurs on river terraces and other more mesic sites, fuel loads are increased and a mixed severity fire regime prevails, with return intervals of 50-60 years (Clausnitzer and Crawford 2008). Thus, canopy cover can both increase or decrease outside the historic range of variability due to altered fire regime, timber harvest, and grazing.

The Little White Salmon drainage near Augspurger Mountain is the transition area between North Pacific Oak Woodland and this system (Dog Mountain is the westernmost in Washington). East Cascade oak-pine differs from westside oak in that easterly sites respond more positively (in terms of growth) to minimum temperatures in the spring and in the fall than other Oregon white oaks west of the Cascade Mountains; Westside stands have the opposite relationship (Maertens 2008).

Stressors

Conversion to agricultural and range lands, urban development, past homesteading, and fuelwood cutting are the most significant sources of oak-pine decline. With fire suppression, many oak-pine woodlands have been invaded by a greater density and cover of oak and conifer trees. Fire suppression has also increased shrub cover in many oak woodlands leading to the development of fuel ladders. Fire sensitive species have also become more common due to fire suppression. Some areas have been lost to urban or agriculture development. Ongoing threats include residential development, increase and spread of exotic species, and fire suppression effects. Conifer encroachment can occur in wetter sites, such as the White Salmon River drainage, but for the most part is not a significant stressor in this system. Improper grazing can result in the replacement of native bunchgrasses with nonnative species such as *Bromus tectorum*, *Poa bulbosa*, or *Cynosurus echinatus*. Some stands have been harvested for firewood and fenceposts. Logging and grazing have created scrub-like stands of oak, which are more susceptible to stand-replacement fires.

Ecological Integrity Assessment

The following table (Table C-17) displays metrics chosen to measure most of the key ecological attributes in the conceptual ecological model. Unless otherwise noted, metric ratings apply to both Level 2 and Level 3 EIAs. The difference is that a Level 3 EIA will use more intensive and

precise methods to determine metric ratings such as: (1) presence/absence of wildlife species such as woodpeckers, Flammulated Owl, Western Gray Squirrel; (2) presence/absence of woodpeckers, and neotropical migrant birds (Hanna and Dunn 1996); (3) species composition of lichens and bryophytes on oak trees; and (4) Fire Regime Condition Class standard landscape worksheet method (FRCC 2010).

Table C-17. East Cascades Oak-Ponderosa Pine Forest and Woodland Ecological Integrity Assessment Scorecard.

Metric	**Justification**	**Rank**			
		A (5 points)	**B (4 points)**	**C (3 points)**	**D (1 point)**
Key ecological attribute – Landscape context					
Edge length	Intactness of edge can be biotically and abiotically important	≥75% of edge bordered by natural communities	≥50–75% of edge bordered by natural communities	≥25–50% of edge bordered by natural communities	<25% of edge bordered by natural communities
Edge width		Average width of edge ≥100m	Average width of edge ≥75–100m	Average width of edge ≥25–75m	Average width of edge <25m
Edge condition		>95% native vegetation cover; <5% non-native cover; intact soils	75–95% cover native vegetation; 5–25% cover of non-native plants; intact or moderately disrupted soils	25–50% cover non-native plants; moderate or extensive soil disruption	>50% cover non-native plants; barren ground; highly compacted or otherwise disrupted soils
Connectivity	Intact areas have continuous corridor of natural or semi-natural vegetation	Intact: Embedded in 90–100% natural habitat; connectivity expected to be high	Variegated: Embedded in 60–90% natural habitat; connectivity generally high, but lower for species sensitive to habitat modification	Fragmented: Embedded in 20–60% natural habitat; connectivity generally low, but varies with species mobility and arrangement on landscape	Relictual: Embedded in <20% natural habitat; connectivity essentially absent
Landscape condition	Intensity and types of land uses in surrounding landscape can affect ecological integrity	Landscape Condition Model Index >0.8		Landscape Condition Model Index 0.8–0.65	Landscape Condition Model Index <0.65
Relative patch size	Indicates proportion lost due to stressors such as fire suppression	Site at or minimally reduced from natural extent (≥95% remains)	Occurrence modestly reduced from original natural extent (≥80-95% remains)	Occurrence substantially reduced from original natural extent (≥50–80% remains)	Occurrence severely reduced from original natural extent (<50% remains)
Absolute patch size	Important for buffering surrounding impacts	>7500ha	500–7500ha	50–500ha	<50ha
Patch diversity	Diversity and interspersion of seral patches indicative of disturbance regimes	Diverse mosaic approximating 65% late, 25% mid-, and 10% early seral stages	Diverse mosaic, with <65% late seral stages; mosaic may be simplified due to fire suppression	Cohort diversity low with most being early to mid-seral; interspersion simplified	
Key ecological attribute – Vegetation condition					
Cover of native species	Natives in shrub and herbaceous layers; non-natives increase with human impacts	Cover of native plants in all layers ≥95%	Cover of native plants in shrub and herbaceous layers ≥80–95%	Cover of native plants in shrub and herbaceous layers ≥50–80%	Cover of native plants in shrub and herbaceous layers <50%
Cover of invasive species	Invasive species inflict wide range of impacts; early detection critical	None or minimal present (<1%)	Invasive species present, but sporadic (1-5% cover)	Invasive species prevalent (5–30% cover)	Invasive species abundant (>30% cover)

Cover of native increasers (understory plants)	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	Composition of native species can shift when exposed to stressors.	Diversity/abundance at or near reference standards; native species negative to anthropogenic degradation are present, species positive to anthropogenic degradation are absent to minor; full range of indicator species present	Diversity/abundance close to reference standards; native species reflective of anthropogenic degradation; some indicator species absent	Diversity/abundance differs from reference standards, but largely composed of native species; may include ruderal species; many indicator species absent	Vegetation severely altered from reference standards; dominated by ruderal species or comprised of planted stands of non-characteristic species or unnaturally dominated by single species; most indicator species absent
Canopy cover and condition (oak)	Important aspect of ecosystem structure	>50% oak cover, 25-50% conifer cover	40-50% oak cover, 25-50% conifer cover	20-40% oak cover, 15-25% or 50-60% conifer cover	<20% oak cover, <15% or >60% conifer cover
Canopy cover and condition (age and size class)	Presence of trees of various ages important aspect of vegetation structure	Large open-grown trees common; multiple age and size classes present; little harvest	Dense even-aged regeneration; ≤30% harvest of large old trees	Dense even-aged regeneration; most trees <100 years old or 30-75% old trees harvested	Single age class of trees present; all <100 years old or >75% old trees harvested
Canopy cover and condition (>38cm DBH oaks and conifers and snags)	Large trees and snags are vital part of forest structure	>7 large trees and snags/ha	7 large trees and snags/ha	<7 large trees and snags/ha	Large trees and snags absent
Coarse woody debris	Debris is indicator of disturbance regime and fire severity	Wid variety of downed log sizes with large variation in stages of decay	Moderately wide variety of downed log sizes with some variation in levels of decay		Low variety of downed log sizes with most logs in early stages of decay
Key ecological attribute: Physicochemical and hydrology					
Soil surface condition	Disturbance can result in erosion and compaction, thereby affecting ecological processes	Soil disturbance class 0 (undisturbed) – No evidence of equipment, wheel tracks, soil disturbance, compaction, and erosion, and management-created platy soils	Soil disturbance class 1 – Minimal evidence of equipment, wheel tracks, soil disturbance, compaction (0–12cm), and erosion; soil burn from fires low	Soil disturbance class 2 – Clear evidence of equipment, wheel tracks, soil disturbance (missing layers), compaction (≤30cm), and erosion; soil burn from fires moderate	Soil disturbance class 3 – Substantial evidence of equipment, wheel tracks, soil disturbance (missing layers), compaction (>30cm), and erosion; soil burn from fires high
Key ecological attribute: Natural disturbance regime					
Fire condition class	Low to mixed severity fire vital for maintaining ecological integrity	Fire Regime Condition Class 1 – No departure from historic regime	Fire Regime Condition Class 2 – Slight to moderate departure from historic fire regime		Fire Regime Condition Class 3 – Severe departure from historic fire regime; fire suppression evident

NORTHERN ROCKY MOUNTAIN WESTERN LARCH WOODLAND AND SAVANNA

General Description

The Northern Rocky Mountain Western Larch Savanna system is a large patch type restricted to the interior montane zones of the Pacific Northwest in northern Idaho, adjacent Montana, Washington, Oregon, and southeastern interior British Columbia. In Washington, it appears in the Okanogan Highlands, East Cascades and possibly in the Blue Mountains. *Larix occidentalis* appears between elevations of 680 to 2190 meters. Open stands of *Larix occidentalis* and other conifers on talus or bedrock are included in Northern Rocky Mountain Foothill Conifer Wooded Steppe or Rocky Mountain Cliff, Canyon and Massive Bedrock ecological systems.

Larix occidentalis dominates although stands may be co-dominated by *Pseudotsuga menziesii* or *Pinus contorta*. The shade-tolerant, more fire sensitive trees *Abies lasiocarpa*, *Picea engelmannii*, or *Abies grandis* are slow to establish on these sites, grow slowly and, given the fire-return intervals, rarely gain canopy dominance but can be common in the sub-canopy. Undergrowth is dominated by low-growing *Arctostaphylos uva-ursi*, *Calamagrostis rubescens*, *Linnaea borealis*, *Spiraea betulifolia*, *Vaccinium caespitosum*, or *Xerophyllum tenax*. Less frequent fire allows mixed-dominant stands to develop often with shrubby undergrowth of *Acer glabrum*, *Ceanothus velutinus*, *Shepherdia canadensis*, *Physocarpus malvaceus*, *Rubus parviflorus*, or *Vaccinium membranaceum*. *Larix occidentalis* is a long-lived species (400-900 years old; Van Pelt 2008), and thus stands fitting this concept are themselves long-persisting. However, the *Larix*-dominated stands probably rarely exceed 250 years due to various mortality factors and competition by shade-tolerant species.

Many *Larix occidentalis* stands and mixed conifer stands with *Larix* are early to mid-seral components of the mixed to high severity fire systems - East Cascades Mesic Montane Mixed Conifer Forest, Northern Rocky Mountain Mesic Montane Mixed Conifer Forest and Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest systems. Those stands initiate following crown fires in areas with stand-replacing fire frequencies greater than 150 years. This contrasts with the high-frequency, mixed to low-severity fires that maintain the characteristic open-canopied savanna or woodland of the Northern Rocky Mountain Western Larch Savanna system. Canopy coverage typically ranges from 10-60%. These sites may be maintained in a mid-seral, single-layer status for hundreds of years by low or mixed intensity, high frequency fires. LANDFIRE (2007) describes this system as variant of the Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest system with a mixed severity fire regime (III), mean fire return interval of approximately 40 years, rare replacement fires, and occasional small, patchy surface fires. Older stands typically include multiple size and age cohorts and are maintained by frequent surface and mixed-severity fires. Closed canopy or dense stands were also minor part of the historical range of stand variability. However, such vertical structure is increasing in abundance due to fire suppression. Fire suppression has created conditions that increase the likelihood of stand replacement fire as well mistletoe infestations of *Larix* stands. LANDFIRE (2007) estimated 30% of the system was open late-seral, 20% closed late-seral, 40% open and closed mid-seral, and 10% early seral.

Stressors

Since European settlement, fire suppression, tree harvesting, introduced diseases, road building, development, and plantation establishments have all impacted natural disturbance regimes, forest structure, composition, landscape patch diversity, and tree regeneration (Franklin et al. 2008). Timber harvesting has focused on the large, older trees in mid- and late-seral forests thereby eliminating many old forest attributes from stands (Franklin et al. 2008). Fire suppression has resulted in increased tree regeneration and thus a denser understory composed of young trees. Fire suppression has also allowed less fire-resistant, shade-tolerant trees to become established in the understory (and sometimes to dominate the canopy) of moist or protected sites creating more dense and multi-layered forests than what historically occurred on the landscape. Road development has fragmented many forests creating fire breaks. Under present conditions the fire regime tends to be higher severity and variable, with stand-replacing fires more common, and the forests more homogeneous. The resultant stands at all seral stages tend to lack snags, have high tree density, and are composed of smaller and more shade-tolerant trees. The introduced forest pest, larch casebearer (*Coleophora laricella*) defoliates trees and eventually kills trees.

Ecological Integrity Assessment

The following table (Table C-18) displays metrics chosen to measure most of the key ecological attributes in the conceptual ecological model. Unless otherwise noted, metric ratings apply to both Level 2 and Level 3 EIAs. The difference is that a Level 3 EIA will use more intensive and precise methods to determine metric ratings such as Fire Regime Condition Class standard landscape worksheet method (FRCC 2010).

Table C-18. Northern Rocky Mountain Western Larch Woodland and Savanna Ecological Integrity Assessment Scorecard.

Metric	**Justification**	**Rank**			
		A (5 points)	**B (4 points)**	**C (3 points)**	**D (1 point)**
Key ecological attribute – Landscape context					
Edge length	Intactness of edge can be biotically and abiotically important	≥75% of edge bordered by natural communities	≥50–75% of edge bordered by natural communities	≥25–50% of edge bordered by natural communities	<25% of edge bordered by natural communities
Edge width		Average width of edge ≥200m	Average width of edge ≥100–200m	Average width of edge ≥50–100m	Average width of edge <50m
Edge condition		>95% native vegetation cover; <5% non-native cover; intact soils and no refuse	75–95% cover native vegetation; 5–25% cover of non-native plants; intact or moderately disrupted soils and little refuse	25–50% cover non-native plants; moderate or extensive soil disruption and refuse	>50% cover non-native plants; barren ground; highly compacted or otherwise disrupted soils and refuse
Connectivity	Intact areas have continuous corridor of natural or semi-natural vegetation	Intact: Embedded in 90–100% natural habitat; connectivity expected to be high; mosaic with gradients	Variegated: Embedded in 60–90% natural habitat; connectivity generally high, but lower for species sensitive to habitat modification; mosaic with both gradients and abrupt boundaries	Fragmented: Embedded in 20–60% natural habitat; connectivity generally low, but varies with species mobility and arrangement on landscape; gradients shortened	Relictual: Embedded in <20% natural habitat; connectivity essentially absent; remaining habitat uniform
Landscape condition	Intensity and types of land uses in surrounding landscape can affect ecological integrity	Landscape Condition Model Index >0.8		Landscape Condition Model Index 0.8–0.65	Landscape Condition Model Index <0.65
Relative patch size	Indicates proportion lost due to stressors such as fire suppression	Site at or minimally reduced from natural extent (≥95% remains)	Occurrence modestly reduced from original natural extent (≥80-95% remains)	Occurrence substantially reduced from original natural extent (≥50–80% remains)	Occurrence severely reduced from original natural extent (<50% remains)
Absolute patch size	Important for buffering surrounding impacts	>7500ha	500–7500ha	50–500ha	<50ha
Patch diversity	Spatial heterogeneity of seral patches indicative of intact disturbance regimes	>75% of area dominated by widely-spaced large, old trees with shrub or herbaceous understory; remaining 25% post-fire shrublands or closed canopy of young trees	50-75% of area dominated by widely-spaced large, old trees with shrub or herbaceous understory	25-50% of area dominated by widely-spaced large, old trees with shrub or herbaceous understory	<25% of area dominated by widely-spaced large, old trees with shrub or herbaceous understory

Key ecological attribute – Vegetation condition					
Cover of native species (understory plants)	Natives in shrub and herbaceous layers; non-natives increase with human impacts	Cover of native plants ≥95%	Cover of native plants ≥80–95%	Cover of native plants ≥50–80%	Cover of native plants <50%
Species composition	Composition of native species can shift when exposed to stressors.	Diversity/abundance at or near reference standards; native species negative to anthropogenic degradation are present, species positive to anthropogenic degradation are absent to minor; full range of indicator species present	Diversity/abundance close to reference standards; native species reflective of anthropogenic degradation; some indicator species absent	Diversity/abundance differs from reference standards, but largely composed of native species; may include ruderal species; many indicator species absent	Vegetation severely altered from reference standards; dominated by ruderal species or comprised of planted stands of non-characteristic species or unnaturally dominated by single species; most indicator species absent
Canopy cover and condition (larch)	Old, large-diameter trees provide ecosystem structure	<10% of old larch harvested; 25-75 >53cm DBH trees/ha; 5-15 >78cm DBH trees/ha	10-30% of old (>150 years) larch harvested	30-75% of old (>150 years) larch harvested	>75% of old (>150 years) larch harvested
Coarse woody debris	Debris is indicator of disturbance regime and fire severity	Within old forests, few large (>2m high and 30cm DBH) snags and downed logs	Snags and down logs 10-30cm DBH or <2m high may be abundant	Snags and downed logs 10-30cm DBH or <2 m high very abundant	
Key ecological attribute: Physicochemical and hydrology					
Soil surface condition	Disturbance can result in erosion and compaction, thereby affecting ecological processes	Soil disturbance class 0 (undisturbed) – No evidence of equipment, wheel tracks, soil disturbance, compaction, and erosion, and management-created platy soils	Soil disturbance class 1 – Minimal evidence of equipment, wheel tracks, soil disturbance, compaction (0–12cm), and erosion; soil burn from fires low	Soil disturbance class 2 – Clear evidence of equipment, wheel tracks, soil disturbance (missing layers), compaction (≤30cm), and erosion; soil burn from fires moderate	Soil disturbance class 3 – Substantial evidence of equipment, wheel tracks, soil disturbance (missing layers), compaction (>30cm), and erosion; soil burn from fires high
Key ecological attribute: Natural disturbance regimes					
Forest pathogens	Pathogens are sources of mortality that influence fire and forest structure	Pathogens all native species within natural range of variability (NRV)	Native pathogens significantly affect forest structure beyond NRV	Exotic and native pathogens significantly affect forest structure beyond NRV	Exotic and native pathogens significantly affect forest structure well beyond NRV
Fire condition class	Mixed to high severity fire vital for maintaining ecological integrity	Fire Regime Condition Class 1 – No departure from historic regime	Fire Regime Condition Class 2 – Slight to moderate departure from historic fire regime		Fire Regime Condition Class 3 – Severe departure from historic fire regime; fire suppression evident

NORTHERN ROCKY MOUNTAIN SUBALPINE WOODLAND AND PARKLAND

General Description

The Northern Rocky Mountain Subalpine Woodland and Parkland system consists of a high-elevation mosaic of stunted tree clumps, open woodlands, and forb- or dwarf-shrub-dominated openings. It appears between closed subalpine forest ecosystems and alpine communities. This large patch system occurs in the northern Rocky Mountains, west into the Cascade Mountains and northeastern Olympic Mountains, and east into the mountain islands of central Montana. The elevation range of the system varies from 1710 to 1980 meters in southwestern Montana. It is typically either a woodland of scattered trees or an open landscape with clumps of trees. Stands can be dominated by *Pinus albicaulis*, *Abies lasiocarpa*, and/or *Larix lyallii* occasionally with *Picea engelmannii*.

Northern Rocky Mountain Subalpine Woodland and Parkland sites occur in a climate that is typically very cold in winter and dry in summer. In the Cascades and Olympic Mountains, the climate is more Maritime, not as extreme, with heavier snow and wind desiccation. Landforms include ridgetops, mountain slopes, glacial trough walls and moraines, talus slopes, landslides and rockslides, and cirque headwalls and basins. Some sites have little snow accumulation because of high winds and sublimation. *Larix lyallii* stands generally occur at or near upper treeline on north-facing cirques or slopes where snowfields persist until June or July. *Pinus albicaulis* typically occurs on drier sites. On the eastside of the Cascade Mountains and northeastern Olympic Mountains, the tree clump landscape pattern is a common feature, although woodlands with an open canopy are frequent. Woodlands without the tree clump pattern are more common in the Northern Rockies. Trees are often stunted and flagged from damage associated with wind and blowing snow and ice crystals, especially at upper elevations.

Woodlands are common with *Pinus albicaulis* and *Larix lyallii*. In the Cascades and Olympics, *Abies lasiocarpa* sometimes dominates the tree layer without *Pinus albicaulis* and without more mesic site trees *Tsuga mertensiana* and *Abies amabilis*. As with most subalpine habitats, plant diversity is more related to site differences than with successional development. The undergrowth can be somewhat depauperate on harsh sites while some stands support a dense sward of heath plants, such as *Phyllodoce glanduliflora*, *Phyllodoce empetriformis*, *Empetrum nigrum*, and *Cassiope mertensiana*. Stands can include a slightly taller more open shrub layer of *Vaccinium myrtillus* or *Vaccinium scoparium*. The herbaceous layer is sparse under dense shrub canopies but may be dense where the shrub canopy is open or absent. *Festuca viridula*, *Vahlodea atropurpurea*, *Luzula glabrata* var. *hitchcockii*, and *Juncus parryii* are the most commonly associated graminoids. The lowest elevation dries sites in Washington support *Pinus albicaulis* with a grass ground cover of *Calamagrostis rubescens* and *Carex geyeri* with an occasional *Paxistima mrysinites*, *Vaccinium myrtillus*, or *Vaccinium scoparium* short shrub layer. These sites are the some of the highest species richness parts of the system (Lilybridge et al 1995).

This woodland and parkland system exists on harsh sites were component trees are not in competition during stand development. Major disturbances there are windthrows and snow avalanches. The system also exists were fire plays a role in removing competing trees and keeping stands in open stages of development. The fire regime is highly variable and difficult to document. Lightning strikes are common on the ridges but discontinuous fuels created by rocky terrain effect fire spread that results in high variability in fire severity (LANDFIRE 2007). Ignitions may be common but typically do not spread beyond the initial patch. Infrequent severe crown fires in adjacent spruce-fir forests can spread into this system (LANDFIRE 2007). A 300 year replacement interval is estimated although most fires are mixed severity with an 80-year return interval (Fire regime III, LANDFIRE 2007). Fire suppression has contributed to change in habitat structure and functions. Blister rust (*Cornartium ribicola*), an introduced pathogen, is increasing *Pinus albicaulis* mortality in these woodlands (Kendall and Keane 2001) and changing fire regime and successional relationship that accelerates changes in this system.

Mean patch size for this system historically is estimated to be 43.5 ha and currently is 30 ha (Morgan and Murray 2001). Logging can have prolonged effects because of slow invasion rates of trees and other high elevation species on the disturbed sites. This is particularly important on drier sites and in *Larix lyallii* stands. During wet cycles, fire suppression can lead to tree islands coalescing and the conversion of parklands into a more closed forest habitat. Parkland conditions can displace alpine conditions through tree invasions (Montana Field Guide 2011). Livestock use and heavy horse or foot traffic can lead to trampling and soil compaction. Slow growth in this habitat prevents rapid recovery.

Stressors

The primary stressors of this system are establishment and expansion of exotic species, direct soil surface disturbance, timber management, livestock practices, and fragmentation. The introduced pathogen blister rust (*Cornartium ribicola*) increases *Pinus albicaulis* mortality in these woodlands (Kendall and Keane 2001) and changes fire regime and mountain pine beetle effects successional relationships. Exotic species threatening this ecological system through invasion and potential replacement of native species include *Poa pratensis*. Excessive grazing stresses the system through soil disturbance and inproved conditions for native increasers (*Lupinus* spp., *Juncus parryi*, *Achillea millifolium*; Johnson 2004). Persistent grazing will further diminish native perennial cover; expose bare ground, and increase erosion and exotics (Johnson and Swanson 2005). Grazing effects are usually concentrated in less steep slopes although grazing does create contour trail networks that can lead to addition slope failures. Cattle and heavy use by elk can reduce fescue cover and lead to erosion during summer storms (Johnson and Swanson 2005). Introduction of exotic ungulates can have noticeable impacts (e.g., mountain goats in the Olympic Mountains and domestic sheep grazing in the bunchgrass habitats east of the Cascades). Historical domestic sheep grazing may have occurred in these systems but its cumulative effects are unknown (LANDFIRE 2007). Locally trampling and associated recreational impact can affect sites for decades or longer (Lilybridge et al 1995). Sites are naturally low in timber productivity and in stocking rate such that remove of trees can have very long-lasting influence on ecological processes (Lilybridge et al 1995).

Ecological Integrity Assessment

The following table (Table C-19) displays metrics chosen to measure most of the key ecological attributes in the conceptual ecological model. Unless otherwise noted, metric ratings apply to both Level 2 and Level 3 EIAs. The difference is that a Level 3 EIA will use more intensive and precise methods to determine metric ratings such as quantitative measurements of range health indicators (Pellant et al. 2005) and Fire Regime Condition Class standard landscape worksheet method (FRCC 2010).

Table C-19. Northern Rocky Mountain Subalpine Woodland and Parkland Ecological Integrity Assessment Scorecard.

Metric	Justification	Rank			
		A (5 points)	B (4 points)	C (3 points)	D (1 point)
Key ecological attribute – Landscape context					
Edge length	Intactness of edge can be biotically and abiotically important	≥75% of edge bordered by natural communities	≥50–75% of edge bordered by natural communities	≥25–50% of edge bordered by natural communities	<25% of edge bordered by natural communities
Edge width		Average width of edge ≥100m	Average width of edge ≥75–100m	Average width of edge ≥25–75m	Average width of edge <25m
Edge condition		>95% native vegetation cover; <5% non-native cover; intact soils	75–95% cover native vegetation; 5–25% cover of non-native plants; intact or moderately disrupted soils	25–50% cover non-native plants; moderate or extensive soil disruption	>50% cover non-native plants; barren ground; highly compacted or otherwise disrupted soils

Connectivity	Intact areas have continuous corridor of natural or semi-natural vegetation	Intact: Embedded in 90–100% natural habitat; connectivity expected to be high	Variegated: Embedded in 60–90% natural habitat; connectivity generally high, but lower for species sensitive to habitat modification	Fragmented: Embedded in 20–60% natural habitat; connectivity generally low, but varies with species mobility and arrangement on landscape	Relictual: Embedded in <20% natural habitat; connectivity essentially absent
Landscape condition	Intensity and types of land uses in surrounding landscape can affect ecological integrity	Landscape Condition Model Index >0.8		Landscape Condition Model Index 0.8–0.65	Landscape Condition Model Index <0.65
Relative patch size	Indicates proportion lost due to stressors	Site at or minimally reduced from natural extent (≥95% remains)	Occurrence modestly reduced from original natural extent (≥80-95% remains)	Occurrence substantially reduced from original natural extent (≥50–80% remains)	Occurrence severely reduced from original natural extent (<50% remains)
Absolute patch size	Important for buffering surrounding impacts and supporting a mosaic of plant associations	>450ha	45–450ha	4.5–45ha	<4.5ha
Key ecological attribute – Vegetation condition					
Cover of native species	Non-natives increase with human impacts	Cover of native plants ≥95%	Cover of native plants ≥80–95%	Cover of native plants ≥50–80%	Cover of native plants <50%
Cover of invasive species	Invasive species inflict wide range of impacts; early detection critical	None present	Invasive species present, but sporadic (<3% cover)	Invasive species prevalent (3–10% cover)	Invasive species abundant (>10% cover)
Cover of native increasers	Stressors such as grazing can shift or homogenize native composition	Absent or incidental	<10% cover	10-20% cover	>20% cover
Species composition	Composition of native species can shift when exposed to stressors.	Diversity/abundance at or near reference standards; native species negative to anthropogenic degradation are present, species positive to anthropogenic degradation are absent to minor; full range of indicator species present	Diversity/abundance close to reference standards; native species reflective of anthropogenic degradation; some indicator species absent	Diversity/abundance differs from reference standards, but largely composed of native species; may include ruderal species; many indicator species absent	Vegetation severely altered from reference standards; dominated by ruderal species or comprised of planted stands of non-characteristic species or unnaturally dominated by single species; most indicator species absent
Canopy cover and condition (age)	Mixed fire regimes leave trees, snags, and large woody debris	<10% of old trees harvested	10-30% of old trees harvested	30-75% of old trees harvested	>75% of old trees harvested
Key ecological attribute: Physicochemical and hydrology					
Soil surface condition	Disturbance can result in erosion and compaction, thereby affecting ecological processes	Soil disturbance class 0 (undisturbed) – No evidence of equipment, wheel tracks, soil disturbance, compaction, and erosion, and management-created platy soils	Soil disturbance class 1 – Minimal evidence of equipment, wheel tracks, soil disturbance, compaction (0–12cm), and erosion; soil burn from fires low	Soil disturbance class 2 – Clear evidence of equipment, wheel tracks, soil disturbance (missing layers), compaction (≤30cm), and erosion; soil burn from fires moderate	Soil disturbance class 3 – Substantial evidence of equipment, wheel tracks, soil disturbance (missing layers), compaction (>30cm), and erosion; soil burn from fires high
Key ecological attribute: Natural disturbance regimes					
Forest pathogens	Pathogens are sources of mortality that influence fire and forest structure	Pathogens all native species within natural range of variability (NRV)	Native pathogens significantly affect forest structure beyond NRV	Exotic and native pathogens significantly affect forest structure beyond NRV	Exotic and native pathogens significantly affect forest structure well beyond NRV
Fire condition class	Mixed severity fire vital for maintaining ecological integrity	Fire Regime Condition Class 1 – No departure from historic regime	Fire Regime Condition Class 2 – Slight to moderate departure from historic fire regime		Fire Regime Condition Class 3 – Severe departure from historic fire regime; fire suppression evident

NORTHERN ROCKY MOUNTAIN PONDEROSA PINE WOODLAND AND SAVANNA

General Description

The Northern Rocky Mountain Ponderosa Pine Woodland and Savanna is the predominant ponderosa pine system of eastern Washington and occurs on the driest sites supporting conifers in the Pacific Northwest. This matrix system occurs in the foothills along the eastern Cascades, the Blue Mountains, the Okanogan Highlands, and in the Columbia Basin in northeastern Washington. Precipitation varies from 36-76 cm with most occurring as snowfall. These woodlands occur on warm, dry, exposed sites on all slopes and aspects; however, moderately steep to very steep slopes or ridgetops are most common. They are generally found on glacial till, glacio-fluvial sand, gravel, dunes, basaltic rubble, colluvium, deep loess, and volcanic ash-derived soils. They are characterized by good aeration and drainage, coarse textures, circumneutral to slightly acidic pH, an abundance of mineral material, rockiness, and periods of drought during the growing season.

These woodlands and savannas are, or at least historically were, fire-maintained and occurring at the lower treeline/ecotone between grasslands or shrublands and more mesic coniferous forests at higher elevations. Canopy coverage typically ranges from 10-60%. Summer drought and frequent low-severity fires create woodlands composed of widely spaced, large trees with small scattered clumps of dense, even-aged stands which regenerated in forest gaps or were protected from fire due to higher soil moisture or topographic protection. Closed canopy or dense stands were also part of the historical range of stand variability but were a minor component of that landscape. However, such structure is increasing in abundance due to fire suppression. Older stands typically include multiple size and age cohorts and are maintained by frequent surface and mixed-severity fires. Native Americans and lightning were sources of ignition during presettlement era. Historically, many of these woodlands and savannas lacked the shrub component as a result of low severity but high frequency fires (2-10 year fire-return intervals). Mixed-severity fires had a return interval of 25-75 years while stand-replacing fire occurred at an interval of >100 year. The latter two intervals only occur on 20-25% of stands within the landscape while surface fires were the dominant fire regime on over 75% of stands (LANDFIRE Models; www.landfire.gov). Western pine beetle is another significant disturbance and especially affects larger trees. Mistletoe can cause tree mortality in young trees. Fires and insect outbreaks resulted in a landscape consisting of a mosaic of open forests of large trees (most abundant patch), small denser patches of trees, and openings (Franklin et al. 2008).

Fire suppression has created conditions that increase the likelihood of all these disturbances. Most areas that may have been savanna in the past are now more nearly closed-canopy woodlands/forests. These true, fire-maintained savannas are included with this woodland system, rather than with the climatically-edaphically controlled Northern Rocky Mountain Foothill Conifer Wooded Steppe system (NatureServe 2007). Hot, dry Douglas-fir types with grass are included here as well. *Pinus ponderosa* var. *ponderosa* is the predominant conifer; *Pseudotsuga menziesii* (primarily var. *glauca*) may be present in the tree canopy but is usually absent. *Populus tremuloides* may be present, but is generally <25% of tree canopy. The understory can be shrubby, with *Artemisia tridentata*, *Arctostaphylos uva-ursi*, *Ceanothus velutinus*, *Physocarpus malvaceus*, *Purshia tridentata*, *Symphoricarpos albus*, *Prunus virginiana*, *Amelanchier alnifolia*, and *Rosa* spp. being common. Understory vegetation in the true savanna is predominantly fire-resistant grasses and forbs that resprout following surface fires and shrubs, understory trees and downed logs are uncommon in these areas. Open stands support grasses such as *Pseudoroegneria spicata*, *Hesperostipa* spp., *Achnatherum* spp., *Festuca idahoensis*, or *Festuca campestris*. The more mesic portions of this system may include *Calamagrostis rubescens* or *Carex geyeri*, species more typical of Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest.

Stressors

Before 1900, this system was mostly open and park-like with relatively few understory trees. Currently, much of this system has a younger tree cohort, often more shade-tolerant species, resulting in a more closed, multilayered canopy. Fire suppression has lead to a buildup of fuels that in turn increase the likelihood of stand-replacing fires. Heavy grazing, in contrast to fire, removes the grass cover and tends to favor shrub and conifer species. Fire suppression combined with grazing creates conditions that support invasion by conifers. Large late-seral *Pinus ponderosa* and *Pseudotsuga menziesii* are harvested in much of this habitat. Under most management regimes, typical tree size decreases and tree density increases in this habitat.

Since European settlement, fire suppression, timber harvest, livestock grazing, introduced diseases, road building, development, and plantation establishments have all impacted natural disturbance regimes, forest structure, composition, landscape patch diversity, and tree regeneration (Franklin et al. 2008). Timber harvesting has focused on the large, older trees in mid- and late-seral forests thereby eliminating many old forest attributes from stands (Franklin et al. 2008). Fire suppression has resulted in increased tree regeneration and thus a denser understory composed of young trees. Fire suppression has also allowed less fire-resistant, shade-tolerant trees to become established in the understory (and sometimes dominate the canopy) of moist or protected sites creating more dense and multi-layered forests than what historically occurred on the landscape. Overgrazing may have contributed to the contemporary dense stands by eliminating grasses in some areas thereby creating suitable spots for tree regeneration as well as reducing the abundance and distribution of flashy fuels that are important for carrying surface fires (Franklin et al. 2008, Hessburg et al. 2005). Road development has fragmented many forests creating fire breaks. Under present conditions the fire regime is mixed severity and more variable, with stand-replacing fires more common and the forests more homogeneous. With vigorous fire suppression, longer fire-return intervals are now the rule, and multi-layered stands of *Pinus ponderosa* and/or *Pseudotsuga menziesii* provide fuel ladders making these forests more susceptible to high-intensity, stand-replacing fires. The resultant stands at all seral stages tend to lack snags, have high tree density, and are composed of smaller and more shade-tolerant trees. Mid-seral forest structure is currently 70% more abundant than in historical, native systems. Late-seral forests of shade-intolerant species are now essentially absent. Early-seral forest abundance is similar to that found historically but lacks snags and other legacy features.

Ecological Integrity Assessment

The following table (Table C-20) displays metrics chosen to measure most of the key ecological attributes in the conceptual ecological model. Unless otherwise noted, metric ratings apply to both Level 2 and Level 3 EIAs. The difference is that a Level 3 EIA will use more intensive and

precise methods to determine metric ratings such as Fire Regime Condition Class standard landscape worksheet method (FRCC 2010).

Table C-20. Northern Rocky Mountain Ponderosa Pine Woodland and Savanna Ecological Integrity Assessment Scorecard.

Metric	Justification	Rank			
		A (5 points)	**B (4 points)**	**C (3 points)**	**D (1 point)**
Key ecological attribute – Landscape context					
Edge length	Intactness of edge can be biotically and abiotically important	≥75% of edge bordered by natural communities	≥50–75% of edge bordered by natural communities	≥25–50% of edge bordered by natural communities	<25% of edge bordered by natural communities
Edge width		Average width of edge ≥200m	Average width of edge ≥100–200m	Average width of edge ≥50–100m	Average width of edge <50m
Edge condition		>95% native vegetation cover; <5% non-native cover; intact soils and no refuse	75–95% cover native vegetation; 5–25% cover of non-native plants; intact or moderately disrupted soils and little refuse	25–50% cover non-native plants; moderate or extensive soil disruption and refuse	>50% cover non-native plants; barren ground; highly compacted or otherwise disrupted soils and refuse
Connectivity	Intact areas have continuous corridor of natural or semi-natural vegetation	Intact: Embedded in 90–100% natural habitat; connectivity expected to be high; mosaic with gradients	Variegated: Embedded in 60–90% natural habitat; connectivity generally high, but lower for species sensitive to habitat modification; mosaic with both gradients and abrupt boundaries	Fragmented: Embedded in 20–60% natural habitat; connectivity generally low, but varies with species mobility and arrangement on landscape; gradients shortened	Relictual: Embedded in <20% natural habitat; connectivity essentially absent; remaining habitat uniform
Landscape condition	Intensity and types of surrounding land uses can affect ecological integrity	Landscape Condition Model Index >0.8		Landscape Condition Model Index 0.8–0.65	Landscape Condition Model Index <0.65
Relative patch size	Indicates proportion lost due to stressors	Site at or minimally reduced from natural extent (≥95% remains)	Occurrence modestly reduced from original natural extent (≥80-95% remains)	Occurrence substantially reduced from original natural extent (≥50–80% remains)	Occurrence severely reduced from original natural extent (<50% remains)
Absolute patch size	Important for buffering surrounding impacts	>7500ha	500–7500ha	50–500ha	<50ha
Patch diversity	Diversity and interspersion of seral patches indicative of disturbance regimes	>75% of area dominated by widely-spaced large, old trees with shrub or herbaceous understory; remaining 25% post-fire shrublands or closed canopy of young trees	50-75% of area dominated by widely-spaced large, old trees with shrub or herbaceous understory	25-50% of area dominated by widely-spaced large, old trees with shrub or herbaceous understory	<25% of area dominated by widely-spaced large, old trees with shrub or herbaceous understory
Key ecological attribute – Vegetation condition					
Cover of native species (understory plants)	Natives dominate understory; non-natives increase with human impacts	Cover of native understory plants ≥95%	Cover of native understory plants ≥80–95%	Cover of native understory plants ≥50–80%	Cover of native understory plants <50%
Cover of native bunchgrass	Native bunchgrasses dominate; high cover related to resistance to invasion	Perennial bunchgrass cover >75% or near site potential	Perennial bunchgrass cover 50–75% or reduced from site potential	Perennial bunchgrass cover 25–50% or reduced from site potential	Perennial bunchgrass cover <25% and much reduced from site potential
Cover of invasive species	Invasive species inflict wide range of impacts	None present	Invasive species present, but sporadic (<3% cover)	Invasive species prevalent (3–10% cover)	Invasive species abundant (>10% cover)

Cover of native increasers	Stressors such as grazing can shift or homogenize native composition	Absent or incidental	<10% cover	10-20% cover	>20% cover
Species composition	Composition of native species can shift when exposed to stressors	Diversity/abundance at or near reference standards; native species negative to anthropogenic degradation are present, species positive to anthropogenic degradation are absent to minor; full range of indicator species present	Diversity/abundance close to reference standards; native species reflective of anthropogenic degradation; some indicator species absent	Diversity/abundance differs from reference standards, but largely composed of native species; may include ruderal species; many indicator species absent	Vegetation severely altered from reference standards; dominated by ruderal species or comprised of planted stands of non-characteristic species or unnaturally dominated by single species; most indicator species absent
Canopy cover and condition (late seral patches)	Stands with late seral trees provide strutural attributes found in functioning forests	<10% of old trees harvested; 25-75 >53cm DBH trees/ha; 5-15 >78cm DBH trees/ha	10-30% of old (>150 years) trees harvested	30-75% of old (>150 years) trees harvested	>75% of old (>150 years) trees harvested
Key ecological attribute: Physicochemical and hydrology					
Soil surface condition	Disturbance can result in erosion and compaction, thereby affecting ecological processes	Soil disturbance class 0 (undisturbed) – No evidence of equipment, wheel tracks, soil disturbance, compaction, and erosion, and management-created platy soils	Soil disturbance class 1 – Minimal evidence of equipment, wheel tracks, soil disturbance, compaction (0–12cm), and erosion; soil burn from fires low	Soil disturbance class 2 – Clear evidence of equipment, wheel tracks, soil disturbance (missing layers), compaction (≤30cm), and erosion; soil burn from fires moderate	Soil disturbance class 3 – Substantial evidence of equipment, wheel tracks, soil disturbance (missing layers), compaction (>30cm), and erosion; soil burn from fires high
Key ecological attribute: Natural disturbance regime					
Fire condition class	Mixed to high severity fire vital for maintaining ecological integrity	Fire Regime Condition Class 1 – No departure from historic regime	Fire Regime Condition Class 2 – Slight to moderate departure from historic fire regime		Fire Regime Condition Class 3 – Severe departure from historic fire regime; fire suppression evident

NORTHERN ROCKY MOUNTAIN MESIC MONTANE MIXED CONIFER FOREST

General Description

The interior Pacific Northwest Northern Rocky Mountain Mesic Montane Mixed Conifer Forest ecological system is composed of the highly variable montane coniferous forests in the Rocky Mountains in southeastern British Columbia, eastern Washington, northern Idaho, western Montana, and northeastern Oregon. This system, locally referred to as cedar-hemlock, is associated with a submesic climate regime in areas influenced by incursions of mild, wet, Pacific maritime air masses producing an annual precipitation ranging from 75 to 150 cm, with a maximum in winter or late spring. Winter snowpacks typically melt off in early spring at lower elevations. Elevations range from 760 to 1800 meters. At the periphery of its distribution (such as northeastern Washington), this system is more confined to moist canyons and cooler, moister aspects. Forest canopies are typically closed although higher elevation or colder sites may be open. In the northeast and southeast corners of Washington, *Tsuga heterophylla*, *Thuja plicata* and /or *Abies grandis* commonly share the tree canopy with *Pseudotsuga menziesii* var. *glauca*, although the former species can be sole canopy dominants. *Picea engelmannii*, *Pinus monticola*, *Pinus contorta*, *Taxus brevifolia* and *Larix occidentalis* are major canopy associates. *Abies lasiocarpa* may be present but only on the colder sites. *Linnaea borealis*, *Paxistima myrsinites*, *Alnus incana*, *Acer glabrum*, *Spiraea betulifolia*, *Cornus canadensis*, *Rubus parviflorus*, *Menziesia ferruginea*, and *Vaccinium membranaceum* are common shrub or sub-shrub species. The composition of the herbaceous layer reflects local climate and degree of canopy closure but is typically very diverse in all but closed-canopy conditions. Important mesic-site forbs and ferns include *Actaea rubra*, *Adiantum pedatum*, *Anemone piperi*, *Aralia nudicaulis*, *Asarum caudatum*, *Clintonia uniflora*, *Gymnocarpium dryopteris*, *Polystichum munitum*, *Rubus pedatus*, *Thalictrum occidentale*, *Tiarella trifoliata*, *Trientalis borealis*, *Trillium ovatum*, *Viola glabella* and *Xerophyllum tenax*.

In the northeast and southeast corners of Washington, this system is associated with the highest lightning strike area in the state (Van Pelt 2008). Stand-replacement, fire-return intervals are typically 150-500 years, with moderate-severity fire intervals of 50-100 years (Williams et al 1995) and within Fire Regime Group III or V (LANDFIRE 2007). Most forest areas composing this system are limited more by light competition than water (McDonald et al. 2000). Transitional areas between this system and the more water-limited Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest system are influenced by Armillaria root diseases and defoliators. These forests are within a mixed severity fire regime that experience little to no underburning and produce a landscape composed of small patches (200-2000 ha) (Brown and Smith 2000; McDonald et al 2000). The more moist portions of the system (higher precipitation and valley bottoms) are more likely to experience high severity fires that result in larger, older patches (500-50,000 ha; McDonald et al. 2000). Timing of fires is irregular and fires are often overlapping (Brown and Smith 2000). These mixed fire regimes and diverse topography result in a varied landscape of stand development and composition. This complexity results in five general seral or developmental types recognizable in this system (Shiplett and Neuenschwander 1994):

1) *Tsuga heterophylla* – Thuja plicata stands that initiate following disturbance

2) Mixed conifer stands that initiate from various disturbances

3) Shrubfields that develop from multiple burns

4) Scattered large Larix occidentalis surviving fires, and

5) *Pinus contorta* on less productive sites and relatively frequent burns.

This system is primarily composed of the first two types. Shrubfields (type 3 above) composed of *Acer glabrum*, *Amelanchier alnifolia*, *Ceanothus* spp., *Salix scouleriana*, *Shephardia canadensis*, and/or *Vaccinium membranaceum* typically develop following stand-replacing fire. Tree regeneration usually accompanies shrubs and the shrubfields become young forests within a few decades and are included in this system. Shrubfields where trees are persistently absent to rare are better included in the Northern Rocky Mountain Lower Montane and Foothill Deciduous Shrubland system. Most stands following fire retain some trees and other biological legacies from the previous forest stand. Tree individuals or whole sites that escape a fire or two allow trees to reach more resistant fire sizes that results in the clustering of old trees and stands across the landscape. Thus, old growth forests (type 1 above) develop in less fire prone areas, such as in riparian stringers and along benches in lower precipitation areas (Williams et al 1995). The old growth version of this system occupied 20-50% of the pre-settlement landscape (Lesica 1996).

The less fire resistant and shade tolerant *Abies grandis*, *Taxus brevifolia*, *Thuja plicata*, and *Tsuga heterophylla* are more common in older forests. The mid-seral, mixed conifer (100-200 year old) stands (type 2 above) are usually canopies composed of *Pseudotsuga menziesii*, *Picea engelmannii*, *Pinus monticola*, and *Larix occidentalis* with *Abies grandis* and maybe *Thuja plicata* on moist, cool sites (Williams et al 1995). Type 4 is recognized as a separate small to large patch ecological system (Western Larch Savanna and Woodland) and type 5 is the Rocky Mountain Lodgepole Pine ecological system. Part of the natural range of variability of this and related systems is currently rare to absent – *Pinus monticola* stands. McDonald et al. (2000) recognize it as a keystone species prior to introduction of western white pine blister rust. *Pinus monticola* forests likely are an extirpated ecological system that is now represented as stands or by individuals in the variation of the current Northern Rocky Mountain Mesic Montane Mixed Conifer Forest system. Quigley et al. (1997) estimated that late-seral forest structure (stands with an upper canopy of comprised of more shade-intolerant than shade tolerant trees) historically occupied around one-third of the landscape, mid-seral forest occupied 40-50% of the landscape, and early-seral forest occupied 20-30% of the landscape. LANDFIRE (2007) modeled 45-50% of this system as late seral (40% closed), 35-45% mid-seral (30-40% closed), and 10-15% early seral.

Stressors

Since European settlement, fire suppression, timber harvest, introduced diseases, road building, development, and plantation establishments have all impacted natural disturbance regimes, forest structure, composition, landscape patch diversity, and tree regeneration (Franklin et al. 2008). Timber harvesting has focused on the large shade-intolerant, fire-resistant species in mid- and late-seral forests thereby eliminating many old forest attributes from stands (Franklin et al. 2008). Fire suppression has allowed less fire-resistant, shade-tolerant trees to become established in the understory (and sometimes dominate the canopy) creating more dense and multi-layered forests than what historically occurred on the landscape. Road development has fragmented many forests creating fire breaks. Under present conditions the fire regime is mixed severity and more variable, with stand-replacing fires more common and forests more homogeneous. With vigorous fire suppression, fire-return intervals are longer, and multi-layered stands provide fuel ladders, making these forests more susceptible to high-intensity, stand-replacing fires. Quigley et al. (1997) estimated that mid-seral forest structure is currently over 40% more abundant than historically, late-seral forests are diminished by 90% and early-seral forests by 20% (lacks snags and other legacy features). Park et al. (2005) concluded that due to climate, limited settlement history, low seed source and closed canopy forest the mountain ecoregions of the Northwest have fewer non-native invasive plants than other regions of the United States.

Ecological Integrity Assessment

The following table (Table C-21) displays metrics chosen to measure most of the key ecological attributes in the conceptual ecological model. Unless otherwise noted, metric ratings apply to both Level 2 and Level 3 EIAs. The difference is that a Level 3 EIA will use more intensive and precise methods to determine metric ratings such as: (1) stand structure and composition measurements (Green et al. 1994, Franklin et al. 2002); (2) impact of introduced forest pathogens, particularly white pine blister rust and adelgid aphid on forest structure and composition; (3) weighted Old Growth Habitat Index (Franklin et al. 2005); and (4) Fire Regime Condition Class standard landscape worksheet method (FRCC 2010).

Table C-21. Northern Rocky Mountain Mesic Montane Mixed Conifer Forest Ecological Integrity Assessment Scorecard.

Metric	Justification	Rank			
		A (5 points)	B (4 points)	C (3 points)	D (1 point)
Key ecological attribute – Landscape context					
Edge length	Intactness of edge can be biotically and abiotically important	≥75% of edge bordered by natural communities	≥50–75% of edge bordered by natural communities	≥25–50% of edge bordered by natural communities	<25% of edge bordered by natural communities
Edge width		Average width of edge ≥100m	Average width of edge ≥75–100m	Average width of edge ≥25–75m	Average width of edge <25m
Edge condition		>95% native vegetation cover; <5% non-native cover; intact soils	75–95% cover native vegetation; 5–25% cover of non-native plants; intact or moderately disrupted soils	25–50% cover non-native plants; moderate or extensive soil disruption	>50% cover non-native plants; barren ground; highly compacted or otherwise disrupted soils
Connectivity	Intact areas have continuous corridor of natural or semi-natural vegetation	Intact: Embedded in 90–100% natural habitat; connectivity expected to be high	Variegated: Embedded in 60–90% natural habitat; connectivity generally high, but lower for species sensitive to habitat modification	Fragmented: Embedded in 20–60% natural habitat; connectivity generally low, but varies with species mobility and arrangement on landscape	Relictual: Embedded in <20% natural habitat; connectivity essentially absent
Landscape condition	Intensity and types of land uses in surrounding landscape can affect ecological integrity	Landscape Condition Model Index >0.8		Landscape Condition Model Index 0.8–0.65	Landscape Condition Model Index <0.65
Relative patch size	Indicates proportion lost due to stressors	Site at or minimally reduced from natural extent (≥95% remains)	Occurrence modestly reduced from original natural extent (≥80-95% remains)	Occurrence substantially reduced from original natural extent (≥50–80% remains)	Occurrence severely reduced from original natural extent (<50% remains)
Absolute patch size	Important for buffering surrounding impacts	>8000ha	4000–8000ha	2000–4000ha	<2000ha
Patch diversity	Diversity and interspersion of seral patches indicative of disturbance regimes	Diverse assemblage of seral patches; 45-50% late seral, 35-45% mid-seral, 10-15% early seral	Diversity remains, but late seral patches reduced due to logging or fire suppression	Cohort diversity low; most mid-seral; interspersion simplified	Single cohort present
Key ecological attribute – Vegetation condition					
Cover of native species (understory plants)	Natives dominate understory; non-natives increase with human impacts	Cover of native understory plants ≥95%	Cover of native understory plants ≥80–95%	Cover of native understory plants ≥50–80%	Cover of native understory plants <50%
Species composition	Composition of native species can shift when exposed to stressors.	Diversity/abundance at or near reference standards; native species negative to anthropogenic degradation are present, species positive to anthropogenic degradation are absent to minor; full range of indicator species present	Diversity/abundance close to reference standards; native species reflective of anthropogenic degradation; some indicator species absent	Diversity/abundance differs from reference standards, but largely composed of native species; may include ruderal species; many indicator species absent	Vegetation severely altered from reference standards; dominated by ruderal species or comprised of planted stands of non-characteristic species or unnaturally dominated by single species; most indicator species absent
Canopy cover and condition (late seral patches)	Stands with late seral trees provide strutural attributes found in functioning forests	<10% of old (>150 years) trees harvested; >25 >53cm DBH trees/ha	10-30% of old (>150 years) trees harvested; 10-25 >53cm DBH trees/ha	30-75% of old (>150 years) trees harvested; 5-10 >53cm DBH trees/ha	>75% of old (>150 years) trees harvested; <5 >53cm DBH trees/ha

Canopy cover and condition (mid-seral patches)	Mid-seral typically closed canopy and indicative of disturbance	<10% of old trees harvested	10-30% trees harvested	30-75% trees harvested	>75% trees harvested
Coarse woody debris	Large snags are vital part of forest and debris is indicator of disturbance regime and fire severity	Large snags frequent; unless in natural, late stem exclusion stage; wide variety of downed log sizes with large variation in stages of decay	Large snags occasionally present; moderately wide variety of downed log sizes with some variation in levels of decay		Large snags absent; low variety of downed log sizes with most logs in early stages of decay
Key ecological attribute: Physicochemical and hydrology					
Soil surface condition	Disturbance can result in erosion and compaction, thereby affecting ecological processes	Soil disturbance class 0 (undisturbed) – No evidence of equipment, wheel tracks, soil disturbance, compaction, and erosion, and management-created platy soils	Soil disturbance class 1 – Minimal evidence of equipment, wheel tracks, soil disturbance, compaction (0–12cm), and erosion; soil burn from fires low	Soil disturbance class 2 – Clear evidence of equipment, wheel tracks, soil disturbance (missing layers), compaction (≤30cm), and erosion; soil burn from fires moderate	Soil disturbance class 3 – Substantial evidence of equipment, wheel tracks, soil disturbance (missing layers), compaction (>30cm), and erosion; soil burn from fires high
Key ecological attribute: Natural disturbance regimes					
Forest pathogens	Pathogens are sources of mortality that influence fire and forest structure	Pathogens all native species within natural range of variability (NRV)	Native pathogens significantly affect forest structure beyond NRV	Exotic and native pathogens significantly affect forest structure beyond NRV	Exotic and native pathogens significantly affect forest structure well beyond NRV
Fire condition class	Mixed to high severity fire vital for maintaining ecological integrity	Fire Regime Condition Class 1 – No departure from historic regime	Fire Regime Condition Class 2 – Slight to moderate departure from historic fire regime		Fire Regime Condition Class 3 – Severe departure from historic fire regime; fire suppression evident

NORTHERN ROCKY MOUNTAIN FOOTHILL CONIFER WOODED STEPPE

General Description

The Northern Rocky Mountain Foothill Conifer Wooded Steppe ecological system is a large patch type that occurs in the foothills of the northern Rocky Mountains into southern interior British Columbia, the Columbia Plateau region, and along the foothills of the Modoc Plateau and eastern Cascades. The Northern Rocky Mountain Foothill Conifer Wooded Steppe typically occurs at the ecotone between lower treeline and grasslands or shrublands, on warm, dry, exposed sites too droughty to support a closed tree canopy (NatureServe 2007). It occurs in large patches on edaphically dry sites although occasionally it is a small patch on rimrock or exposed sites. It is found on all slopes and aspects but most commonly on moderately steep to very steep slopes. Parent material varies although they have characteristic features of good aeration and drainage, coarse textures, an abundance of mineral material, rockiness, and periods of drought during the growing season. The system also can occur on sand dunes, scablands, and pumice where edaphic conditions limit tree abundance.

Tree growth is likely episodic, with regeneration episodes during years with available moisture. In Washington, *Pinus ponderosa* (var. *ponderosa*) and *Pseudotsuga menziesii* are the predominant conifers (not always together) and rarely with *Juniperus occidentalis* at lower or *Larix occidentalis* at higher elevations. In transition areas with big sagebrush steppe systems, *Purshia tridentata*, *Artemisia tridentata* ssp. *wyomingensis*, *Artemisia tridentata* ssp. *tridentata*, and *Artemisia tripartita* may be common in fire-protected sites such as rocky areas. Deciduous shrubs, such as *Physocarpus malvaceus*, *Symphoricarpos albus*, or *Spiraea betulifolia*, can be abundant in more northerly sites or moister climates. Important grass species include *Pseudoroegneria spicata*, *Poa secunda*, *Hesperostipa* spp., *Achnatherum* spp., *Elymus elymoides*, *Festuca idahoensis*, or *Festuca campestris* (NatureServe 2007).

This is not a fire-maintained savanna system; its scattered tree character results from a climate-edaphic interaction that results in xeric soil conditions which limits tree establishment. The tree canopy rarely reaches woodland density even with long periods without fire. This system burns occasionally, but the vegetation is sparse enough that fires are typically not carried through the stand or into canopies. This type usually has little surface fuel and replacement fires would be a function of extreme conditions. However, surface fuels are dense enough to carry relatively frequent fire that is speculated to be 30-50 year return intervals representing fire regime III (LANDFIRE 2007). In some instances, a century of anthropogenic disturbance and fire suppression has resulted in a higher density of conifers and species composition such as understories of more shade-tolerant species (LANDFIRE 2007).

Western pine beetle is a significant disturbance and especially affects larger trees. Mistletoe can cause tree mortality in young trees. Fires and insect outbreaks resulted in a landscape consisting of a mosaic of open forests of large trees (most abundant patch) and small denser patches of trees, and openings (Franklin et al. 2008).

Stressors

The primary stressors of this system are livestock practices, tree removal, exotic species, fire regime alteration, direct soil surface disturbance, and fragmentation. Excessive grazing stresses the system through soil disturbance, opening the perennial layers to the establishment of native increasers and annual grasses. Any soil and bunchgrass layer disturbances, such as vehicle tracks and shrub removal (chaining), will increase fire risk and the probability of alteration of vegetation structure and composition. Harvesting of tree species alters the structural characteristics of this system and given the harsh environment typically reestablishment of the trees occurs very slowly. Fire suppression has resulted in increased tree regeneration and thus a denser understory with young trees. Road development has fragmented many forests creating fire breaks.

Ecological Integrity Assessment

The following table (Table C-22) displays metrics chosen to measure most of the key ecological attributes in the conceptual ecological model. Unless otherwise noted, metric ratings apply to both Level 2 and Level 3 EIAs. The difference is that a Level 3 EIA will use more intensive and precise methods to determine metric ratings such as Fire Regime Condition Class standard landscape worksheet method (FRCC 2010).

Table C-22. Northern Rocky Mountain Foothill Conifer Wooded Steppe Ecological Integrity Assessment Scorecard.

Metric	Justification	Rank			
		A (5 points)	B (4 points)	C (3 points)	D (1 point)
Key ecological attribute – Landscape context					

Edge length	Intactness of edge can be biotically and abiotically important	≥75% of edge bordered by natural communities	≥50–75% of edge bordered by natural communities	≥25–50% of edge bordered by natural communities	<25% of edge bordered by natural communities
Edge width		Average width of edge ≥200m	Average width of edge ≥100–200m	Average width of edge ≥50–100m	Average width of edge <50m
Edge condition		>95% native vegetation cover; <5% non-native cover; intact soils and no refuse	75–95% cover native vegetation; 5–25% cover of non-native plants; intact or moderately disrupted soils and little refuse	25–50% cover non-native plants; moderate or extensive soil disruption and refuse	>50% cover non-native plants; barren ground; highly compacted or otherwise disrupted soils and refuse
Connectivity	Intact areas have continuous corridor of natural or semi-natural vegetation	Intact: Embedded in 90–100% natural habitat; connectivity expected to be high	Variegated: Embedded in 60–90% natural habitat; connectivity generally high, but lower for species sensitive to habitat modification	Fragmented: Embedded in 20–60% natural habitat; connectivity generally low, but varies with species mobility and arrangement on landscape	Relictual: Embedded in <20% natural habitat; connectivity essentially absent
Landscape condition	Intensity and types of land uses in surrounding landscape can affect ecological integrity	Landscape Condition Model Index >0.8		Landscape Condition Model Index 0.8–0.65	Landscape Condition Model Index <0.65
Relative patch size	Indicates proportion lost due to stressors	Site at or minimally reduced from natural extent (≥95% remains)	Occurrence modestly reduced from original natural extent (≥80-95% remains)	Occurrence substantially reduced from original natural extent (≥50–80% remains)	Occurrence severely reduced from original natural extent (<50% remains)
Absolute patch size	Important for buffering surrounding impacts	>1000ha	100–1000ha	10–100ha	<10ha
Patch diversity	Diversity and interspersion of seral patches indicative of disturbance regimes	>75% of area dominated by widely-spaced large, old trees with shrub or herbaceous understory; remaining 25% post-fire shrublands or closed canopy of young trees	50-75% of area dominated by widely-spaced large, old trees with shrub or herbaceous understory	25-50% of area dominated by widely-spaced large, old trees with shrub or herbaceous understory	<25% of area dominated by widely-spaced large, old trees with shrub or herbaceous understory
Key ecological attribute – Vegetation condition					
Cover of native species (understory plants)	Natives dominate understory; non-natives increase with human impacts	Cover of native understory plants ≥95%	Cover of native understory plants ≥80–95%	Cover of native understory plants ≥50–80%	Cover of native understory plants <50%
Cover of invasive species	Invasive species inflict wide range of impacts; early detection critical	None present	Invasive species present, but sporadic (<3% cover)	Invasive species prevalent (3–10% cover)	Invasive species abundant (>10% cover)
Cover of native increasers (understory plants)	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	Composition of native species can shift when exposed to stressors.	Diversity/abundance at or near reference standards; native species negative to anthropogenic degradation are present, species positive to anthropogenic degradation are absent to minor; full range of indicator species present	Diversity/abundance close to reference standards; native species reflective of anthropogenic degradation; some indicator species absent	Diversity/abundance differs from reference standards, but largely composed of native species; may include ruderal species; many indicator species absent	Vegetation severely altered from reference standards; dominated by ruderal species or comprised of planted stands of non-characteristic species or unnaturally dominated by single species; most indicator species absent
Canopy cover and condition (late seral patches)	Stands with late seral trees provide strutural attributes found in functioning forests	<10% of old (>150 years) trees harvested	10-30% of old (>150 years) trees harvested	30-75% of old (>150 years) trees harvested	>75% of old (>150 years) trees harvested

Coarse woody debris	Debris is indicator of disturbance regime and fire severity	Within old forests, few large (>2m high and 30cm DBH) snags and downed logs	Snags and down logs 10-30cm DBH or <2m high may be abundant	Snags and downed logs 10-30cm DBH or <2 m high very abundant	
Key ecological attribute: Physicochemical and hydrology					
Soil surface condition	Disturbance can result in erosion and compaction, thereby affecting ecological processes	Soil disturbance class 0 (undisturbed) – No evidence of equipment, wheel tracks, soil disturbance, compaction, and erosion, and management-created platy soils	Soil disturbance class 1 – Minimal evidence of equipment, wheel tracks, soil disturbance, compaction (0–12cm), and erosion; soil burn from fires low	Soil disturbance class 2 – Clear evidence of equipment, wheel tracks, soil disturbance (missing layers), compaction (≤30cm), and erosion; soil burn from fires moderate	Soil disturbance class 3 – Substantial evidence of equipment, wheel tracks, soil disturbance (missing layers), compaction (>30cm), and erosion; soil burn from fires high
Key ecological attribute: Natural disturbance regimes					
Forest pathogens	Pathogens are sources of mortality that influence fire and forest structure	Pathogens all native species within natural range of variability (NRV)	Native pathogens significantly affect forest structure beyond NRV	Exotic and native pathogens significantly affect forest structure beyond NRV	Exotic and native pathogens significantly affect forest structure well beyond NRV
Fire condition class	Mixed to high severity fire vital for maintaining ecological integrity	Fire Regime Condition Class 1 – No departure from historic regime	Fire Regime Condition Class 2 – Slight to moderate departure from historic fire regime		Fire Regime Condition Class 3 – Severe departure from historic fire regime; fire suppression evident

NORTHERN ROCKY MOUNTAIN DRY-MESIC MONTANE MIXED CONIFER FOREST

General Description

The Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest ecological system is composed of highly variable montane coniferous forests found in the interior Pacific Northwest, from southernmost interior British Columbia, eastern Washington, eastern Oregon, northern Idaho, western and north-central Montana, and south along the east slope of the Cascades in Washington and Oregon. This system is associated with a submesic climate regime with annual precipitation ranging from 50 to 100 cm, with a maximum in winter or late spring. Winter snowpack typically melts off in early spring at lower elevations. Elevations range from 460 to 1920 m. Most occurrences of this system are dominated by a mix of *Pseudotsuga menziesii* and *Pinus ponderosa* (but there can be one without the other) and other typically seral species, including *Pinus contorta*, *Pinus monticola*, and *Larix occidentalis*. *Pinus ponderosa* overstory is typical in frequent, low-severity, fire-maintained stands. Lack of wildfire results in an increase of *Pinus ponderosa*, *Pseudotsuga menziesii* and *Abies grandis* in the understory. *Larix occidentalis* can be locally important.

Presettlement fire regimes may have been characterized by frequent, low-intensity ground fires that maintained relatively open stands of a mix of fire-resistant species (Fire regime I in LANDFIRE 2007). Much more infrequent mixed-severity and stand replacement wildfire occurred and tended to generate mosaics of older, larger trees and younger regeneration. Low and mixed severity fires favored relatively low tree density, clumped tree distribution, light and patchy fuel loads, simple canopy layering, and fire-tolerant tree and associated species compositions (Agee 2003, Hessburg et al. 2005). Low severity fires supported open, widely spaced, clusters of large *Pinus ponderosa* and *Pseudotsuga menziesii*. The understory varied depending on the fire interval and soil moisture. In dry sites, frequent fires results in an understory dominated by *Calamagrostis rubescens*, *Carex geyeri*, *Pseudoroegneria spicata*, *Carex rossii*, or *Arctostaphylos uva-ursi*. Moister sites or sites which may have missed a fire or two, such as north slopes, have a higher cover of shrubs such as *Acer glabrum*, *Juniperus communis*, *Physocarpus malvaceus*, *Symphoricarpos albus*, *Spiraea betulifolia*, and/or *Vaccinium membranaceum*. Regeneration of tree species occurs between fires but most of these seedlings and saplings are killed during the next fire. However, some tree individuals or sites escape a fire or two allowing individuals to reach an age where they are able to resist future fires resulting in the clustering of old trees and regeneration occurring across the landscape. This process of fire selection produces a forest with relatively low tree density (70-100 trees/ha), patchy distribution of young cohorts, and very little coarse woody debris and snags (Agee 2003). Many of the herbaceous and shrub species are sprouters or rhizomatous making them resilient to fire and able to quickly regrow following fire events. Stands of large mature trees become susceptible to bark beetle mortality and occasionally root disease, subsequent fires burn snags and woody debris creating natural gaps where regeneration patches initiate. Collectively, fire, insect, and disease disturbance created a landscape mosaic of differing age classes and thereby spatially isolated patches where mixed or high severity fires would occur. Thus, snags and coarse woody debris were clustered across the landscape with their location shifting with beetle outbreaks and consumption by fire (Agee 2003). Under current conditions, the landscape mosaic is more homogenous with the predominant patch type being stands with a dense understory of shrubs and/or young trees. These stands are susceptible to mixed or high severity fires and thus have eliminated the historically patchy distribution of stands with low, mid, and high severity fire regimes. Endemic bark beetles produced patch mortality and rarely caused larger-scale overstory mortality thereby releasing understory trees. Defoliator outbreaks also cause fir mortality in some areas. Spruce budworm outbreaks are now more widespread than under historical conditions. Root diseases may play a significant role in late seral forests.

Stressors

Since European settlement, fire suppression, timber harvest, livestock grazing, introduced diseases, road building, development, and plantation establishments have all impacted natural disturbance regimes, forest structure, composition, landscape patch diversity, and tree regeneration (Franklin et al. 2008). Timber harvesting has focused on the large shade-intolerant, fire-resistant species in mid- and late-seral forests thereby eliminating many old forest attributes from stands (Franklin et al. 2008). Fire suppression has allowed less fire-resistant, shade-tolerant trees to become established in the understory (and sometimes dominate the canopy) creating more dense and multi-layered forests than what historically occurred on the landscape. Overgrazing may have contributed to the contemporary dense stands by eliminating grasses in some areas thereby creating suitable spots for tree regeneration as well as reducing the abundance and distribution of flashy fuels that are important for carrying surface fires (Franklin et al. 2008; Hessburg et al. 2005). Road development has fragmented many forests creating fire breaks. Under present conditions the fire regime is mixed severity and more variable, with stand-replacing fires more common and the forests more homogeneous. With vigorous fire suppression, longer fire-return intervals are now the rule, and multi-layered stands of *Pseudotsuga menziesii*, *Pinus ponderosa*, and/or *Abies grandis* provide fuel ladders, making these forests more susceptible to high-intensity, stand-replacing fires. The resultant stands at all seral stages tend to lack snags, have high tree density, and are composed of smaller and more shade-tolerant trees. Mid-seral forest structure is currently 70% more abundant than in historical, native systems. Late-seral forests of shade-intolerant species are now essentially absent. Early-seral forest abundance is similar to that found historically, but lacks snags and other legacy features.

Ecological Integrity Assessment

The following table (Table C-23) displays metrics chosen to measure most of the key ecological attributes in the conceptual ecological model. Unless otherwise noted, metric ratings apply to both Level 2 and Level 3 EIAs. The difference is that a Level 3 EIA will use more intensive and precise methods to determine metric ratings such as: (1) stand structure and composition measurements (Green et al. 1994, Franklin et al. 2002); (2) impact of introduced forest pathogens on forest structure and composition; and (3) Fire Regime Condition Class standard landscape worksheet method (FRCC 2010).

Table C-23. Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest Ecological Integrity Assessment Scorecard.

Metric	Justification	Rank			
		A (5 points)	**B (4 points)**	**C (3 points)**	**D (1 point)**
Key ecological attribute – Landscape context					
Edge length	Intactness of edge can be biotically and abiotically important	≥75% of edge bordered by natural communities	≥50–75% of edge bordered by natural communities	≥25–50% of edge bordered by natural communities	<25% of edge bordered by natural communities
Edge width		Average width of edge ≥100m	Average width of edge ≥75–100m	Average width of edge ≥25–75m	Average width of edge <25m
Edge condition		>95% native vegetation cover; <5% non-native cover; intact soils	75–95% cover native vegetation; 5–25% cover of non-native plants; intact or moderately disrupted soils	25–50% cover non-native plants; moderate or extensive soil disruption	>50% cover non-native plants; barren ground; highly compacted or otherwise disrupted soils
Connectivity	Intact areas have continuous corridor of natural or semi-natural vegetation	Intact: Embedded in 90–100% natural habitat; connectivity expected to be high	Variegated: Embedded in 60–90% natural habitat; connectivity generally high, but lower for species sensitive to habitat modification	Fragmented: Embedded in 20–60% natural habitat; connectivity generally low, but varies with species mobility and arrangement on landscape	Relictual: Embedded in <20% natural habitat; connectivity essentially absent
Landscape condition	Intensity and types of land uses in surrounding landscape can affect ecological integrity	Landscape Condition Model Index >0.8		Landscape Condition Model Index 0.8–0.65	Landscape Condition Model Index <0.65
Relative patch size	Indicates proportion lost due to stressors	Site at or minimally reduced from natural extent (≥95% remains)	Occurrence modestly reduced from original natural extent (≥80-95% remains)	Occurrence substantially reduced from original natural extent (≥50–80% remains)	Occurrence severely reduced from original natural extent (<50% remains)
Absolute patch size	Important for buffering surrounding impacts	>5000ha	500–5000ha	50–500ha	<50ha
Patch diversity	Diversity and interspersion of seral patches indicative of disturbance regimes	Diverse assemblage of seral patches; 40-60% old grouse in mosaic with dense regeneration	Diversity remains, but mid seral are reduced while eaerly and late seral patches are higher	Cohort diversity low; most mid and early seral; interspersion simplified	Single cohort present
Key ecological attribute – Vegetation condition					
Cover of native species (understory plants)	Natives dominate understory; non-natives increase with human impacts	Cover of native understory plants ≥95%	Cover of native understory plants ≥80–95%	Cover of native understory plants ≥50–80%	Cover of native understory plants <50%

Cover of invasive species	Invasive species inflict wide range of impacts; early detection critical	None present	Invasive species present, but sporadic (<3% cover)	Invasive species prevalent (3–10% cover)	Invasive species abundant (>10% cover)
Cover of native increasers (understory plants)	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	Composition of native species can shift when exposed to stressors.	Diversity/abundance at or near reference standards; native species negative to anthropogenic degradation are present, species positive to anthropogenic degradation are absent to minor; full range of indicator species present	Diversity/abundance close to reference standards; native species reflective of anthropogenic degradation; some indicator species absent	Diversity/abundance differs from reference standards, but largely composed of native species; may include ruderal species; many indicator species absent	Vegetation severely altered from reference standards; dominated by ruderal species or comprised of planted stands of non-characteristic species or unnaturally dominated by single species; most indicator species absent
Canopy cover and condition (late seral patches)	Stands with late seral trees provide strutural attributes found in functioning forests	Vast majority of old (>150 years) trees not harvested; >20 >53cm DBH trees/ha	10-30% of old (>150 years) trees harvested; 10-20 >53cm DBH trees/ha	30-75% of old (>150 years) trees harvested; 5-10 >53cm DBH trees/ha	>75% of old (>150 years) trees harvested; <5 >53cm DBH trees/ha
Regeneration of woody species	Amount and distribution of regeneration important for maintaining system integrity	Regeneration limited and occurs in natural gaps within older stands	Regeneration occurring outside natural gaps (10-25% of site); <300 >2.5cm trees/ha	Regeneration occurring outside natural gaps (25-50% of site); 300-750 >2.5cm trees/ha	Small and medium sized trees in multiple layered canopies throughout; density >750 >2.5cm trees/ha
Coarse woody debris	Debris is indicator of disturbance regime and fire severity	Within old forests, few large (>2m high and 30cm DBH) snags and downed logs	Snags and down logs 10-30cm DBH or <2m high may be abundant	Snags and downed logs 10-30cm DBH or <2 m high very abundant	
Key ecological attribute: Physicochemical and hydrology					
Soil surface condition	Disturbance can result in erosion and compaction, thereby affecting ecological processes	Soil disturbance class 0 (undisturbed) – No evidence of equipment, wheel tracks, soil disturbance, compaction, and erosion, and management-created platy soils	Soil disturbance class 1 – Minimal evidence of equipment, wheel tracks, soil disturbance, compaction (0–12cm), and erosion; soil burn from fires low	Soil disturbance class 2 – Clear evidence of equipment, wheel tracks, soil disturbance (missing layers), compaction (≤30cm), and erosion; soil burn from fires moderate	Soil disturbance class 3 – Substantial evidence of equipment, wheel tracks, soil disturbance (missing layers), compaction (>30cm), and erosion; soil burn from fires high
Key ecological attribute: Natural disturbance regimes					
Forest pathogens	Pathogens are sources of mortality that influence fire and forest structure	Pathogens all native species within natural range of variability (NRV)	Native pathogens significantly affect forest structure beyond NRV	Exotic and native pathogens significantly affect forest structure beyond NRV	Exotic and native pathogens significantly affect forest structure well beyond NRV
Fire condition class	Low to mixed severity fire vital for maintaining ecological integrity	Fire Regime Condition Class 1 – No departure from historic regime	Fire Regime Condition Class 2 – Slight to moderate departure from historic fire regime		Fire Regime Condition Class 3 – Severe departure from historic fire regime; fire suppression evident

NORTHERN ROCKY MOUNTAIN SUBALPINE-UPPER MONTANE GRASSLAND

General Description

The Northern Rocky Mountain Subalpine-Upper Montane Grassland ecological system is found at upper montane into subalpine elevations in the mountains of western Montana, west through Idaho into eastern Oregon and Washington, and north into the Okanagan and Fraser plateaus of British Columbia and the Canadian Rockies. They are lush grasslands dominated by perennial grasses and forbs on dry sites, particularly south-facing slopes. They also occur as small meadows to large open parks surrounded by conifer trees but lack tree cover within them.

Northern Rocky Mountain Subalpine-Upper Montane Grassland is a large to small patch system within mid- to high-elevation forests and is most extensive in the Canadian Rockies portion of the Rocky Mountain cordillera. Soil textures are generally much finer and soils often deeper under these grasslands than in the neighboring forests. Disturbance such as fire and big game browsing also play a role in maintaining these open grassy areas. Generally sites are too droughty or otherwise severe to support trees. In Washington, this ecological system occurs at elevations above 1650 meters ranging from small meadows to open parks surrounded by conifers in the upper montane grasslands below the upper tree line.

Although composed primarily of tussock-forming species, a dense sod can be present which makes root penetration difficult for trees. Typical dominant species include *Festuca campestris*, *Festuca idahoensis*, *Festuca viridula* (a characteristic species in Washington), *Elymus trachycaulus*, *Leymus innovatus* (= *Elymus innovatus*), *Koeleria macrantha*, *Achnatherum occidentale* (= *Stipa occidentalis*), *Achnatherum richardsonii* (= *Stipa richardsonii*), *Bromus inermis* ssp. *pumpellianus* (= *Bromus pumpellianus*), *Elymus trachycaulus*, *Phleum alpinum*, *Trisetum spicatum*, and a variety of carices, such as *Carex hoodii*, *Carex obtusata*, and *Carex scirpoidea*. Important forbs include *Lupinus argenteus* var. *laxiflorus*, *Potentilla diversifolia*, *Potentilla flabellifolia*, *Fragaria virginiana*, and *Chamerion angustifolium* (= *Epilobium angustifolium*). *Festuca viridula* sites in undisturbed condition form closed sods with little exposed soils or microphytic crusts and little forb cover (Johnson and Swanson 2005). *Festuca idahoensis* communities are typically associated with more open bunchgrass cover typically with mosses or gravel/bareground (Johnson and Swanson 2005).

This system is similar to the Northern Rocky Mountain Lower Montane, Foothill and Valley Grassland with few or any subalpine taxa. Occurrences of the upper montane system are often more forb-rich than Southern Rocky Mountain Montane-Subalpine Grassland (Rydberg 1915). The upper montane system lies within the Northern Rocky Mountain Montane Mesic Forest and Rocky Mountain Subalpine mesic-wet and dry-mesic Forest ecological systems. It can be confused with the lower elevation Northern Rocky Mountain Lower Montane, Foothill and Valley Grassland and Intermountain Basins Montane Big Sagebrush Steppe systems and the higher elevation Northern Rocky Mountain Subalpine Woodland and Parkland, Rocky Mountain Alpine Turf and North Pacific Alpine and Subalpine Dry Grassland systems.

Late season fires may damage *Festuca viridula* plants (LANDFIRE 2007). It is possible that lack of fire has promoted invasion by *Abies lasiocarpa* and *Pinus albicaulis* (Johnson and Claustnitzer 1992). Average fire return interval is estimated to be over 200 years (1000 years in LANDFIRE 2007), although this type lacks fire history data. Over-grazing can cause soil erosion and an increase in forbs and other grasslike species such as *Lupinus* species, *Juncus parryi*, *Carex* spp., *Achnatherum occidentale* and *Penstemon* spp. (LANDFIRE 2007).

Stressors

Major impacts include trampling and associated recreational impacts (e.g., tent sites) and livestock grazing. Resistance and resilience of vegetation to impacts varies by life form.

Domestic sheep grazing has also had dramatic impacts, and large expanses of grasslands are currently used for livestock ranching.

The primary stressors of this system are livestock practices, exotic species, direct soil surface disturbance, and fragmentation. Excessive grazing stresses the system through soil disturbance and perennial layers to the establishment of native increasers (*Lupinus* spp., *Achnatherium* spp., *Carex rossii*, *Rudbeckia occidentalis*; Johnson 2004). Exotic species threatening this ecological system through invasion and potential replacement of native species include *Poa pratensis*. In Montana in subalpine grassland drier sites, *Potentilla recta*, *Euphorbia esula*, *Centaurea* spp., *Hypericum perforatum*, and *Cardaria* draba are problematic species while mesic sites include *Hieracium pratense*, *H. floribundum*, *H. piloselliodes*, *Hieracium aurantiacum*, *Leucanthemum vulgare*, *Ranunculus acris*, and *Cirsium arvense*, *Poa pratensis*, *Phleum pratense*, and *Bromus inermis* can be threats (Montana Field Guide 2010*b*). Persistent grazing will further diminish native perennial cover; expose bare ground, and increase erosion and exotics (Johnson and Swanson 2005). Grazing effects are usually concentrated in less steep slopes although grazing does create contour trail networks that can lead to addition slope failures. Cattle and heavy use by elk can reduce fescue cover and lead to erosion during summer storms (Johnson and Swanson 2005).

Ecological Integrity Assessment

The following table (Table C-24) displays metrics chosen to measure most of the key ecological attributes in the conceptual ecological model. Unless otherwise noted, metric ratings apply to both Level 2 and Level 3 EIAs. The difference is that a Level 3 EIA will use more intensive and precise methods to determine metric ratings such as quantitative measurements of range health indicators (Pellant et al. 2005) and microphytic species composition and abundance (Eldridge and Rosentreter 1999).

Table C-24. Northern Rocky Mountain Subalpine-Upper Montane Grassland Ecological Integrity Assessment Scorecard.

Metric	Justification	Rank			
		A (5 points)	B (4 points)	C (3 points)	D (1 point)
Key ecological attribute – Landscape context					
Edge length	Intactness of edge can be biotically and abiotically important	≥75% of edge bordered by natural communities	≥50–75% of edge bordered by natural communities	≥25–50% of edge bordered by natural communities	<25% of edge bordered by natural communities
Edge width		Average width of edge ≥100m	Average width of edge ≥75–100m	Average width of edge ≥25–75m	Average width of edge <25m
Edge condition		>95% native vegetation cover; <5% non-native cover; intact soils	75–95% cover native vegetation; 5–25% cover of non-native plants; intact or moderately disrupted soils	25–50% cover non-native plants; moderate or extensive soil disruption	>50% cover non-native plants; barren ground; highly compacted or otherwise disrupted soils
Connectivity	Intact areas have continuous corridor of natural or semi-natural vegetation	Intact: Embedded in 90–100% natural habitat; connectivity expected to be high	Variegated: Embedded in 60–90% natural habitat; connectivity generally high, but lower for species sensitive to habitat modification	Fragmented: Embedded in 20–60% natural habitat; connectivity generally low, but varies with species mobility and arrangement on landscape	Relictual: Embedded in <20% natural habitat; connectivity essentially absent

Landscape condition	Intensity and types of land uses in surrounding landscape can affect ecological integrity	Landscape Condition Model Index >0.8		Landscape Condition Model Index 0.8–0.65	Landscape Condition Model Index <0.65
Relative patch size	Indicates proportion lost due to stressors	Site at or minimally reduced from natural extent (≥95% remains)	Occurrence modestly reduced from original natural extent (≥80-95% remains)	Occurrence substantially reduced from original natural extent (≥50–80% remains)	Occurrence severely reduced from original natural extent (<50% remains)
Absolute patch size	Important for buffering surrounding impacts and supporting viable populations of grassland birds	>225ha	20–225ha	10–20ha	<10ha
Key ecological attribute – Vegetation condition					
Cover of native species	Natives dominate system; non-natives increase with human impacts	Cover of native plants ≥95%	Cover of native plants ≥80–95%	Cover of native plants ≥50–80%	Cover of native plants <50%
Cover of native bunchgrass	Native perennial bunchgrass related to resistance to invasion	Perennial bunchgrass ≥80% cover	Perennial bunchgrass ≥50-80% cover	Perennial bunchgrass ≥30-50% cover	Perennial bunchgrass <30% cover
Cover of invasive species	Invasive species inflict wide range of impacts; early detection critical	None present	Invasive species present, but sporadic (<3% cover)	Invasive species prevalent (3–10% cover)	Invasive species abundant (>10% cover)
Cover of native increasers	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	Composition of native species can shift when exposed to stressors.	Diversity/abundance at or near reference standards; native species negative to anthropogenic degradation are present, species positive to anthropogenic degradation are absent to minor; full range of indicator species present	Diversity/abundance close to reference standards; native species reflective of anthropogenic degradation; some indicator species absent	Diversity/abundance differs from reference standards, but largely composed of native species; may include ruderal species; many indicator species absent	Vegetation severely altered from reference standards; dominated by ruderal species or comprised of planted stands of non-characteristic species or unnaturally dominated by single species; most indicator species absent
Key ecological attribute: Physicochemical and hydrology					
Soil surface condition	Disturbance can result in erosion with negative affects on ecological processes; bareground amount varies naturally with site type	Bare soil areas limited to naturally caused disturbances such as burrowing animals or game trails	Bare soil due to humans and livestock, but extent and impact aniimal		Bare soil areas substantial and they contribute to long-lasting impacts; deep ruts from machinery present or livestock trails widespread

NORTHERN ROCKY MOUNTAIN SUBALPINE DECIDUOUS SHRUBLAND

General Description

The Northern Rocky Mountain Subalpine Deciduous Shrubland ecological system occurs on upland sites within the zone of continuous forest (not avalanche chutes) at upper montane into subalpine elevations in the Northern Rocky Mountains of northeastern Washington, Idaho, western Montana, eastern Oregon and north into British Columbia's Canadian Rockies. These shrublands or shrubfields are a typically seral stage to coniferous forest and their persistence depends on periodic fires. The shrub species in this system are often vigorous stump sprouting species and provide important browse and cover species for wildlife as well as berries for people.

Vaccinium membranaceum is the most common member of this mixed deciduous shrubland vegetation. *Menziesia ferruginea*, *Rhamnus alnifolia*, *Ribes lacustre*, *Rubus parviflorus*, *Alnus viridis*, *Rhododendron albiflorum*, *Sorbus scopulina*, *Sorbus sitchensis*, *Vaccinium myrtillus*, and *Vaccinium scoparium* are the other common dominant shrubs that can occur alone or in various combinations. The evergreen shrub *Paxistima myrsinites* often occurs under dense tall shrubs. Other shrubs can include *Shepherdia canadensis* and *Ceanothus velutinus* which never occur as dominants in this system but occur more abundantly in the Northern Rocky Mountain Montane-Foothill Deciduous Shrubland ecological system. Herbaceous cover and litter accumulation are often low (Smith and Fisher 1997). The evergreen, woody-based "forb" *Xerophyllum tenax* can be dominant in some areas often with *Vaccinium membranaceum*. Important forbs include *Chamerion angustifolium* and *Pteridium aquilinum*, reflecting the mesic nature of many of these shrublands.

These shrublands appear as large and small patches lacking significant tall tree cover while surrounded by conifer. Shrublands vary in height from <0.3 meters in drier environments to >3 meters in mild moist areas. The shrubfields occur on all aspects and soils although they are more prevalent on south and west-facing slopes that have periodically burned (Smith and Fisher 1997). They are generally associated with well-drained sites that are moist to wet. Northern Rocky Mountain Subalpine Deciduous Shrubland is maintained by recurring disturbances, including fire and downslope movement of soil, water, snow and rock. Stands are typically initiated by fires persist on sites for long periods because of repeated burns and changes in the presence of volatile oils in the soil which impedes tree regeneration (LANDFIRE 2007). Fire frequencies in these shrubfields are relatively short intervals as compared to the surrounding vegetation with longer fire return intervals. Fire frequencies will be highly dependent on surrounding vegetation, but typically range from 50 to 75years (LANDFIRE 2007). Smith and Fisher (1997) cite factors contributing to the persistence of seral shrubfields including repeated shrubfield fires that: (1) reduce conifer seed sources, (2) increase soil temperature and soil drought, 3) increase soil erosion, (3) reduce soil wood that limits nitrogen fixation, micorrhizae inoculum, and microsites for tree establishment; and (4) may increase soil pH. While fire influences these shrubfields many can persist on sites for up to 500 years (Montana Field Guide 2010*a*). By killing or weakening adjacent forests, insects and diseases often play an indirect role in the development or maintenance of these shrublands (Montana Field Guide 2010*a*). Fire was used by native people to expand or rejuvenate shrubfields for berries and/or beargrass (Richards and Alexander 2006, Boyd 1999, Fisher 1996) so shrubfields are at least partially anthropongenic in extent.

This system is floristically similar to Northern Rocky Mountain Avalanche Chute Shrubland, but the avalanche chutes originate from very different processes, tend to be more diverse within stands, and are wetter, being driven ecologically by snow-loading and concomitant snowmelt. Seral shrub fields of comparable composition that typically will develop into a seral stage with trees (over 10% tree cover within 50 years) are excluded from this shrub system and are included in their appropriate forest system.

Stressors

Maintenance and expansion of seral shrubfields have been reduced due to fire exclusion and fuel management may have reduced their reburning (Wellner 1970). In response to fire suppression, trees may invade these shrublands. With heavy livestock grazing, shrubs are browsed, broken, and trampled, which eventually creates a more open shrubland with a more abundant herbaceous layer. Fisher (1996) states that some berry gathering areas were historically cleared and farmed by Euro-Americans, or grazed, especially by sheep. Minore (1979) concluded that sheep grazing did not damage huckleberry production in a controlled experiment. Invasive species are generally not as problematic at higher elevations and in closed forests as lower elevation disturbed forests and riparian areas. There is some concern about invasive species threatening subalpine and alpine environments (Parks et al. 2005).

Ecological Integrity Assessment

The following table (Table C-25) displays metrics chosen to measure most of the key ecological attributes in the conceptual ecological model. Unless otherwise noted, metric ratings apply to both Level 2 and Level 3 EIAs. The difference is that a Level 3 EIA will use more intensive and precise methods to determine metric ratings such as: (1) quantitative measurements of range health indicators (Pellant et al. 2005); (2) microphytic species composition and abundance (Eldridge and Rosentreter 1999); and Fire Regime Condition Class standard landscape worksheet method (FRCC 2010).

Table C-25. Northern Rocky Mountain Subalpine Deciduous Shrubland Ecological Integrity Assessment Scorecard.

Metric	Justification	Rank			
		A (5 points)	**B (4 points)**	**C (3 points)**	**D (1 point)**
Key ecological attribute – Landscape context					
Edge length	Intactness of edge can be biotically and abiotically important	≥75% of edge bordered by natural communities	≥50–75% of edge bordered by natural communities	≥25–50% of edge bordered by natural communities	<25% of edge bordered by natural communities
Edge width		Average width of edge ≥100m	Average width of edge ≥75–100m	Average width of edge ≥25–75m	Average width of edge <25m
Edge condition		>95% native vegetation cover; <5% non-native cover; intact soils	75–95% cover native vegetation; 5–25% cover of non-native plants; intact or moderately disrupted soils	25–50% cover non-native plants; moderate or extensive soil disruption	>50% cover non-native plants; barren ground; highly compacted or otherwise disrupted soils
Connectivity	Intact areas have continuous corridor of natural or semi-natural vegetation	Intact: Embedded in 90–100% natural habitat; connectivity expected to be high	Variegated: Embedded in 60–90% natural habitat; connectivity generally high, but lower for species sensitive to habitat modification	Fragmented: Embedded in 20–60% natural habitat; connectivity generally low, but varies with species mobility and arrangement on landscape	Relictual: Embedded in <20% natural habitat; connectivity essentially absent
Landscape condition	Intensity and types of surrounding land use can affect ecological integrity	Landscape Condition Model Index >0.8		Landscape Condition Model Index 0.8–0.65	Landscape Condition Model Index <0.65
Relative patch size	Indicates proportion lost due to stressors	Site at or minimally reduced from natural extent (≥95% remains)	Occurrence modestly reduced from original natural extent (≥80-95% remains)	Occurrence substantially reduced from original natural extent (≥50–80% remains)	Occurrence severely reduced from original natural extent (<50% remains)
Absolute patch size	Important for buffering surrounding impacts	>4000ha	400–4000ha	40–400ha	<40ha
Key ecological attribute – Vegetation condition					

Cover of native species	Non-natives increase with human impacts	Cover of native plants ≥95%	Cover of native plants ≥80–95%	Cover of native plants ≥50–80%	Cover of native plants <50%
Species composition	Composition of native species can shift when exposed to stressors.	Diversity/abundance at or near reference standards; native species negative to anthropogenic degradation are present, species positive to anthropogenic degradation are absent to minor; full range of indicator species present	Diversity/abundance close to reference standards; native species reflective of anthropogenic degradation; some indicator species absent	Diversity/abundance differs from reference standards, but largely composed of native species; may include ruderal species; many indicator species absent	Vegetation severely altered from reference standards; dominated by ruderal species or comprised of planted stands of non-characteristic species or unnaturally dominated by single species; most indicator species absent
Shrub cover	Shrub cover indicator for site integrity	Cover of shrubs ≥95%	Cover of shrubs ≥80-95%	Cover of shrubs ≥50-80%	Cover of shrubs <50%
Canopy cover and condition	Tree abundance and distribution indicator of site integrity and disturbance regimes	Trees are absent	Trees shorter than shrubs and <10% cover	Trees pole-sized or smaller; susceptible to fire mortality; <10% cover	Trees larger than pole-sized, not susceptible to fire; <10% cover
Key ecological attribute: Physicochemical and hydrology					
Soil surface condition	Disturbance can result in erosion with negative affects on ecological processes; bareground amount varies naturally with site type	Bare soil areas limited to naturally caused disturbances such as burrowing animals or game trails	Bare soil due to humans and livestock, but extent and impact aniimal		Bare soil areas substantial and they contribute to long-lasting impacts; deep ruts from machinery present or livestock trails apparent
Key ecological attribute: Natural disturbance regime					
Fire condition class	Mixed to high severity fire vital for maintaining ecological integrity	Fire Regime Condition Class 1 – No departure from historic regime	Fire Regime Condition Class 2 – Slight to moderate departure from historic fire regime		Fire Regime Condition Class 3 – Severe departure from historic fire regime; fire suppression evident

NORTHERN ROCKY MOUNTAIN MONTANE-FOOTHILL DECIDUOUS SHRUBLAND

General Description

The Northern Rocky Mountain Montane-Foothill Deciduous Shrubland is a small to large patch ecological system found in the lower montane and foothill regions around the Columbia Basin and north and east into the northern Rockies. These shrublands typically occur at and below lower treeline, within the matrix of surrounding low-elevation grasslands and sagebrush steppe. They also occur in the ponderosa pine and Douglas-fir zones, but rarely up into the subalpine zone (on dry sites). The Northern Rocky Mountain Montane-Foothill Deciduous shrublands are usually found on steep slopes of canyons and in areas with some soil development, either loess deposits or volcanic clays and they occur on all aspects. This system develops near talus slopes as garlands, at the heads of dry drainages, and toe slopes in the moist shrubsteppe and steppe zones. Fire, flooding and erosion all impact this system, but the shrublands will typically persist on sites for long periods. *Physocarpus malvaceus*, *Prunus emarginata*, *Prunus virginiana*, *Rosa* spp., *Rhus glabra*, *Acer glabrum*, *Amelanchier alnifolia*, *Symphoricarpos albus*, *Symphoricarpos oreophilus*, and *Holodiscus discolor* are the most dominant shrubs, occurring alone or in any combination. *Rubus parviflorus*, *Ceanothus velutinus* and *Artemisia tridentata* var. *vaseyana* can be important shrubs in this system, being more common in montane occurrences. *Crataegus douglasii* may be common in lowland moist areas. *Festuca idahoensis*, *Festuca campestris*, *Calamagrostis rubescens*, *Carex geyeri*, *Koeleria macrantha*, *Pseudoroegneria spicata*, and *Poa* *secunda* are the most important grasses. *Achnatherum thurberianum* and *Leymus cinereus* can be locally important. *Poa pratensis* and *Phleum pratense* are common introduced perennial grasses. *Geum triflorum*, *Potentilla gracilis*, *Lomatium triternatum*, *Balsamorhiza sagittata*, and species of *Eriogonum*, *Phlox*, and *Erigeron* are important forbs. Shrubs *Shepherdia canadensis*, *Spiraea betulifolia* and *Vaccinium membranaceum*, can be abundant in some cases. These three shrub species also occur in the Northern Rocky Mountain Subalpine Deciduous Shrubland system in which *Vaccinium membranaceum* is a dominant indicator.

Fire is an important disturbance in the Northern Rocky Mountain Montane-Foothill Deciduous Shrubland system. Most dominant species resprout after fire or regenerate from the buried seed and quickly re-establish (Williams et al. 1995). Although the precise fire frequency is unknown, fire return interval in the adjacent bunchgrass and savanna slopes is low as 5 to 10 years and likely defines shrub patches. LANDFIRE (2007) modeled the ecosystem as fire regime II. Defoliating insects, ungulate browsing, slope movement, and erosion are other disturbance factors. Soil creep on these steep slopes makes rapid slope movements possible, especially after fire.

Shrub fields within lower montane forests (primarily associated with the Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest system) are maintained by factors that inhibit or slow tree invasion: fire intensity, increased fire frequency, or site drought. Seral shrub fields with trees that could develop into a seral forest stage (within 50 years) are excluded from this shrub system and are included in an appropriate forest system.

Stressors

The primary stressors of this system are fire regime alteration, livestock practices, exotic species invasion, timber harvesting, and fragmentation. In response to fire suppression, shrub thickets on northerly aspects near and above lower treeline tend to increase in patch size and height and are invaded by tree species. Fire suppression increases tree (*Pinus ponderosa* or *Pseudotsuga menziesii*) invasion by allowing smaller trees that would be killed in fire to survive. Due to steepness of terrain grazing effects are usually concentrated in less steep slopes, although grazing does create contour trail networks that can lead to additional slope failures. With heavy livestock grazing, shrubs are browsed, broken, and trampled, which eventually creates a more open shrubland with a more abundant herbaceous layer, often with invasive species. Invasive perennial exotics such as *Centaurea solstitialis*, *Hypericum perfoliatum*, *Poa pratensis*, and *Prunus cerasifera* are major stressors.

Ecological Integrity Assessment

The following table (Table C-26) displays metrics chosen to measure most of the key ecological attributes in the conceptual ecological model. Unless otherwise noted, metric ratings apply to both Level 2 and Level 3 EIAs. The difference is that a Level 3 EIA will use more intensive and precise methods to determine metric ratings such as quantitative measurements of range health indicators (Pellant et al. 2005).

Table C-26. Northern Rocky Mountain Montane-Foothill Deciduous Shrubland Ecological Integrity Assessment Scorecard.

Metric	Justification	Rank			
		A (5 points)	B (4 points)	C (3 points)	D (1 point)
Key ecological attribute – Landscape context					
Edge length	Intactness of edge can be biotically and abiotically important	≥75% of edge bordered by natural communities	≥50–75% of edge bordered by natural communities	≥25–50% of edge bordered by natural communities	<25% of edge bordered by natural communities
Edge width		Average width of edge ≥200m	Average width of edge ≥100–200m	Average width of edge ≥50–100m	Average width of edge <50m
Edge condition		>95% native vegetation cover; <5% non-native cover; intact soils and no refuse	75–95% cover native vegetation; 5–25% cover of non-native plants; intact or moderately disrupted soils and little refuse	25–50% cover non-native plants; moderate or extensive soil disruption and refuse	>50% cover non-native plants; barren ground; highly compacted or otherwise disrupted soils and refuse
Connectivity	Intact areas have continuous corridor of natural or semi-natural vegetation	Intact: Embedded in 90–100% natural habitat; connectivity expected to be high	Variegated: Embedded in 60–90% natural habitat; connectivity generally high, but lower for species sensitive to habitat modification	Fragmented: Embedded in 20–60% natural habitat; connectivity generally low, but varies with species mobility and arrangement on landscape	Relictual: Embedded in <20% natural habitat; connectivity essentially absent
Landscape condition	Intensity and types of land uses in surrounding landscape can affect ecological integrity	Landscape Condition Model Index >0.8		Landscape Condition Model Index 0.8–0.65	Landscape Condition Model Index <0.65
Relative patch size	Indicates proportion lost due to stressors	Site at or minimally reduced from natural extent (≥95% remains)	Occurrence modestly reduced from original natural extent (≥80-95% remains)	Occurrence substantially reduced from original natural extent (≥50–80% remains)	Occurrence severely reduced from original natural extent (<50% remains)
Absolute patch size	Important for buffering surrounding impacts	>1000ha	500–1000ha	1–500ha	<1ha
Key ecological attribute – Vegetation condition					
Cover of native species	Natives dominate system; non-natives increase with human impacts	Cover of native plants ≥95%	Cover of native plants ≥80–95%	Cover of native plants ≥50–80%	Cover of native plants <50%
Cover of invasive species	Invasive species inflict wide range of impacts; early detection critical	None present	Invasive species present, but sporadic (<3% cover)	Invasive species prevalent (3–10% cover)	Invasive species abundant (>10% cover)
Cover of native increasers	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	Composition of native species can shift when exposed to stressors.	Diversity/abundance at or near reference standards; native species negative to anthropogenic degradation are present, species positive to anthropogenic degradation are absent to minor; full range of indicator species present	Diversity/abundance close to reference standards; native species reflective of anthropogenic degradation; some indicator species absent	Diversity/abundance differs from reference standards, but largely composed of native species; may include ruderal species; many indicator species absent	Vegetation severely altered from reference standards; dominated by ruderal species or comprised of planted stands of non-characteristic species or unnaturally dominated by single species; most indicator species absent
Canopy cover and condition	Tree abundance and distribution indicator of site integrity and disturbance regimes	Trees are absent	Trees shorter than shrubs and <10% cover	Trees pole-sized or smaller; susceptible to fire mortality; <10% cover	Trees larger than pole-sized, not susceptible to fire; <10% cover
Key ecological attribute: Physicochemical and hydrology					

Soil surface condition	Disturbance can result in erosion with negative affects on ecological processes; bareground amount varies naturally with site type	Bare soil areas limited to naturally caused disturbances such as burrowing animals or game trails	Bare soil due to human causes, but extent and impact minimal	Bare soil due to human causes are common; machinery may have left shallow ruts	Bare soil areas substantial and they contribute to long-lasting impacts; deep ruts from machinery present or livestock trails widespread
Key ecological attribute: Natural disturbance regime					
Fire condition class	Mixed to high severity fire vital for maintaining ecological integrity	Fire Regime Condition Class 1 – No departure from historic regime	Fire Regime Condition Class 2 – Slight to moderate departure from historic fire regime		Fire Regime Condition Class 3 – Severe departure from historic fire regime; fire suppression evident

NORTHERN ROCKY MOUNTAIN LOWER MONTANE, FOOTHILL AND VALLEY GRASSLAND

General Description

The Northern Rocky Mountain Lower Montane, Foothill and Valley Grassland ecological system occurs at lower montane to foothill elevations in the mountains and large valleys of northeastern Wyoming and western Montana, west through Idaho into the Blue Mountains of Oregon, and north into the Okanagan and Fraser plateaus of British Columbia and the Canadian Rockies. In Washington, this ecological system occurs at elevations from 500 to 1650 meters. It range from small meadows to open parks surrounded by conifers within lower montane forests in the mountains surrounding the Columbia Basin to foothill and valley grasslands below the lower tree line. The system lies above the Intermountain Basins Big Sagebrush Steppe and below or within Northern Rocky Mountain Ponderosa Pine and Northern Rocky Mountain Dry-Mesic Forest ecological systems. It can be confused with the higher elevation Columbia Basin Canyon Dry Grasslands, remnants of the Columbia Basin Palouse Prairie, Intermountain Basins Montane Big Sagebrush Steppe, and the Northern Rocky Mountain Subalpine-Upper Montane Grassland systems.

In Washington, this system typically receives 50-75 cm annual precipitation, much as snow and spring rains. Non-saline soils are relatively deep to shallow, often with coarse fragments. Soils dry by mid-summer and limit tree and shrub invasion. Unvegetated mineral soil is commonly found between clumps of grass and occasionally a moss/lichen cover, particularly on rocky sites. Steep slopes, shallow skeletal soils, and sites with heavy native ungulate use that reduce foliar and litter cover have more exposed soil and apparently support more soil moss/lichens (Johnson and Swanson 2005). Greater crust cover occurs on north- and east-facing slopes at mid elevations with stable, silt-loam or calcareous soils where not disturbed (Tyler 2006) or where vascular cover and litter are not limiting soil moss/lichens.

The most important species are cool-season, perennial bunchgrasses and forbs (>25% cover), sometimes with a sparse (<10% cover) shrub layer. Mid-tall bunchgrasses, such as *Pseudoroegneria spicata*, *Festuca campestris*, *Festuca idahoensis* or *Koeleria macrantha*, commonly dominate sites on level to moderate slopes and on steep slopes not associated with canyons. *Danthonia unispicata* and *Poa secunda* are important shorter bunchgrasses. Other possible graminoids include *Achnatherum occidentale* (= *Stipa occidentalis*), *Achnatherum richardsonii*, *Bromus inermis*, *Calamagrostis rubescens*, *Carex geyeri*, *Carex pensylvanica*, *Elymus trachycaulus*, *Festuca washingtonica*, *Hesperostipa comata*, *Hesperostipa curtiseta*, *Leymus cinereus*, and *Pascopyrum smithii*. Grassland shrub species include *Artemisia frigida*, and *Selaginella densa*. Shrub species may be scattered, including *Eriogonum heracleoides*, *Amelanchier alnifolia*, *Rosa* spp., *Symphoricarpos* spp., *Juniperus communis*, *Artemisia tridentata*, and *Artemisia tripartita*. Common associated forbs include *Geum triflorum*, *Galium boreale*, *Campanula rotundifolia*, *Antennaria* spp., *Geranium viscosissimum*, and *Potentilla gracilis*.

A high-frequency fire regime (presumed to be less than 35 years (Johnson and Swanson 2005), along with soil drought and herbivory, retards shrub and tree invasion resulting in a patchy distribution of shrubs and trees when present. The most droughty sites and discontinuous fuel source likely results in a much longer fire regimes. Isolation of grassland patches by fragmentation may also limits seed dispersal of native shrubs leading to persistence of the grassland. Elk, deer and bighorn sheep are native large grazers in the canyon who use the areas, particularly in spring.

Stressors

The primary stressors of this system are livestock practices, exotic species, fire regime alteration, direct soil surface disturbance, and fragmentation. Excessive grazing stresses the system through soil disturbance, increasing the probability of establishment of native increasers and exotic annual grasses, particularly *Bromus commutatus*, *B. japonicus*, *B. mollis*, *B. tectorum*, and *Ventenata dubia* on more xeric sites and exotic perennial grasses *Bromus inermis*, *Phleum pratense*, and *Poa pratensis* on more mesic sites. Other exotic species threatening this ecological system through invasion and potential replacement include *Hypericum perfoliatum*, *Potentilla recta*, *Euphorbia esula*, and knapweeds, especially *Centaurea biebersteinii* (= *Centaurea maculosa*). When bare ground is approximately 15%, reduced infiltration and increased runoff occurs in *Festuca* grassland ecosystems (Johnston 1962). Fire further stresses livestock altered vegetation by increasing exposure of bare ground, decreasing bungrasses, and increasing exotic annuals. Grazing effects are usually concentrated in less steep slopes, although grazing does create contour trail networks that can lead to addition slope failures. Fire suppression leads to increases in deciduous shrubs, *Symphoricarpos* spp., *Physocarpus malvaceus*, *Holodiscus discolor*, and *Ribes* spp. and in some areas trees (*Pseudotsuga menziesii*).

Davies et al. (2009) concluded that sites with heavy litter accumulation, (e.g., an ungrazed *Artemisia tridentata* ssp. *wyomingensis/Festuca idahoensis – Achnatherium thurberiana community*) are more susceptible to exotic annual invasion following fire than those with less litter accumulation. They note that introduced species and changes in climate can alter ecosystem response to natural disturbance regimes. Johnson and Swanson (2005) note that *Festuca idahoensis* decreases following fire but following a flush of annuals sites regain pre-fire cover of *Festuca* after a few years.

Ecological Integrity Assessment

The following table (Table C-27) displays metrics chosen to measure most of the key ecological attributes in the conceptual ecological model. Unless otherwise noted, metric ratings apply to both Level 2 and Level 3 EIAs. The difference is that a Level 3 EIA will use more intensive and

precise methods to determine metric ratings such as: (1) quantitative measurements of range health indicators (Pellant et al. 2005); (2) biological Soil Crust Stability Index (Rosentreter and Eldridge 2002); and (3) microphytic species composition and abundance (Eldridge and Rosentreter 1999).

Table C-27. Northern Rocky Mountain Lower Montane, Foothill and Valley Grassland Ecological Integrity Assessment Scorecard.

Metric	Justification	Rank			
		A (5 points)	**B (4 points)**	**C (3 points)**	**D (1 point)**
Key ecological attribute – Landscape context					
Edge length	Intactness of edge can be biotically and abiotically important	≥75% of edge bordered by natural communities	≥50–75% of edge bordered by natural communities	≥25–50% of edge bordered by natural communities	<25% of edge bordered by natural communities
Edge width		Average width of edge ≥100m	Average width of edge ≥75–100m	Average width of edge ≥25–75m	Average width of edge <25m
Edge condition		>95% native vegetation cover; <5% non-native cover; intact soils	75–95% cover native vegetation; 5–25% cover of non-native plants; intact or moderately disrupted soils	25–50% cover non-native plants; moderate or extensive soil disruption	>50% cover non-native plants; barren ground; highly compacted or otherwise disrupted soils
Connectivity	Intact areas have continuous corridor of natural or semi-natural vegetation	Intact: Embedded in 90–100% natural habitat; connectivity expected to be high	Variegated: Embedded in 60–90% natural habitat; connectivity generally high, but lower for species sensitive to habitat modification	Fragmented: Embedded in 20–60% natural habitat; connectivity generally low, but varies with species mobility and arrangement on landscape	Relictual: Embedded in <20% natural habitat; connectivity essentially absent
Landscape condition	Intensity and types of land uses in surrounding landscape can affect ecological integrity	Landscape Condition Model Index >0.8		Landscape Condition Model Index 0.8–0.65	Landscape Condition Model Index <0.65
Relative patch size	Indicates proportion lost due to stressors	Site at or minimally reduced from natural extent (≥95% remains)	Occurrence modestly reduced from original natural extent (≥80-95% remains)	Occurrence substantially reduced from original natural extent (≥50–80% remains)	Occurrence severely reduced from original natural extent (<50% remains)
Absolute patch size	Important for buffering surrounding impacts and supporting steppe obligate grasshopper sparrow (Paczek 2004)	>1000ha	500–1000ha	10–500ha	<10ha
Key ecological attribute – Vegetation condition					
Cover of native species	Natives dominate system; non-natives increase with human impacts	Cover of native plants ≥95%	Cover of native plants ≥80–95%	Cover of native plants ≥50–80%	Cover of native plants <50%
Cover of bunchgrass	Native bunchgrass related to resistance to invasion	Native bunchgrass ≥80% cover	Native bunchgrass ≥50-80% cover	Native bunchgrass ≥30-50% cover	Native bunchgrass <30% cover
Cover of invasive species	Invasive species inflict wide range of impacts; early detection critical	None present	Invasive species present, but sporadic (<3% cover)	Invasive species prevalent (3–10% cover)	Invasive species abundant (>10% cover)
Cover of native increasers	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	Composition of native species can shift when exposed to stressors.	Diversity/abundance at or near reference standards; native species negative to anthropogenic degradation are present, species positive to anthropogenic degradation are absent to minor; full range of indicator species present	Diversity/abundance close to reference standards; native species reflective of anthropogenic degradation; some indicator species absent	Diversity/abundance differs from reference standards, but largely composed of native species; may include ruderal species; many indicator species absent	Vegetation severely altered from reference standards; dominated by ruderal species or comprised of planted stands of non-characteristic species or unnaturally dominated by single species; most indicator species absent
Biological soil crust	Crust cover and diversity greatest where not impacted by trampling or other disturbance	Biological soil crust nearly matches site capacity where site characteristics not limiting (i.e. steep unstable, south aspect, or dense grass)	Biological soil crust evident, but its continuity is broken	Biological soil crust present in protected areas and with minor component elsewhere	Biological soil crust, if present , only in protected areas
Key ecological attribute: Physicochemical and hydrology					
Soil surface condition	Disturbance can result in erosion with negative affects on ecological processes; bareground amount varies naturally with site type	Bare soil areas limited to naturally caused disturbances such as burrowing animals or game trails	Bare soil due to human causes, but extent and impact minimal	Bare soil due to human causes are common; machinery may have left shallow ruts	Bare soil areas substantial and they contribute to long-lasting impacts; deep ruts from machinery present or livestock trails widespread

ROCKY MOUNTAIN SUBALPINE-MONTANE RIPARIAN WOODLAND

General Description

The Rocky Mountain Subalpine-Montane Riparian Woodland system is comprised of seasonally flooded forests and woodlands found at montane to subalpine elevations of the Rocky Mountain cordillera, from southern New Mexico north into Montana, and west into the Intermountain region and the Colorado Plateau. It occurs throughout the interior of British Columbia and the eastern slopes of the Cascade Mountains. In Washington, the system occurs at high elevations within dry and cold portions of the east Cascades, throughout the Okanogan Highlands, and in the Northern Rocky Mountains. Snowmelt moisture may create shallow water tables or seeps for a portion of the growing season. In Washington, stands typically occur at elevations between 610 and 2130 meters (Kovalchik and Clausnitzer 2004). This system most commonly occurs in V-shaped, narrow valleys and canyons (where there is cold-air drainage). Less frequently, occurrences are found in moderate-wide valley bottoms on large floodplains along broad, meandering rivers, and on pond or lake margins.

Riparian woodland development is driven mostly by the magnitude and frequency of flooding, valley type, and stand replacing disturbances such as crown-fire, disease, windthrow, or clearcutting by humans or beaver. Valley type may be the most important variable, as riparian woodlands are mostly found in V-shaped, steep valleys with many large boulders and coarse soils. The forest vegetation in these environments is often very similar to the adjacent uplands (Baker 1987, Kovalchik and Clausnitzer 2004). Disturbances may create gaps in the canopy and allow pioneer species, such as aspen, or shrubs to establish. Less steep and wider valleys can lead to shrubland or woodland development. Flooding inundates vegetation, dislodges seedlings and saplings, and alters channel morphology through erosion and deposition of sediment. Infrequent, high-powered floods determine large geomorphic patterns that persist on the landscape for hundreds to thousands of years (Hubert 2004). Floods of intermediate frequency and power produce floodplain landforms which persist for tens to hundreds of years as well as reset succession to early seral vegetation types (LANDIRE 2005, Hubert 2004). High frequency low-powered floods which occur nearly annually determine short-term patterns such as seed germination and seedling survival (Hubert 2004).

Narrow and steep (i.e. confined) occurrences have minimal to no floodplain development whereas less steep and wider valley bottoms (i.e., unconfined) occurrences are often associated with substantial floodplain development (LANDFIRE 2005, Gregory et al. 1991). Floodplains associated with the latter are comprised of a complexity of geomorphic surfaces which support a diverse array of vegetation communities and are able to store and release water slowly throughout the growing season (Hubert 2004). Confined streams typically have shallow soils with minimal alluvium and transport water downstream rapidly through step-pool channels armored by boulders, bedrock, and large woody debris (LANDFIRE 2005, Hubert 2004).

Beaver, are of minimal significance in confined riparian woodlands as the steep nature of the latter system and often lack of deciduous trees typically precludes beaver activity. However, beaver activity but can have an impact on hydrology and vegetation in unconfined occurrences and especially in those areas dominated by aspen (*Populus tremuloides*).

Conifer and aspen woodlands dominate the canopy of this system. In Washington, confined occurrences (mostly along Rosgen A and B channels) are dominated by *Abies lasiocarpa* and/or *Picea engelmannii* (Kovalchik and Clausnitzer 2004). In older stands, *Picea engelmannii* may dominate the canopy while *Abies lasiocarpa* forms multi-aged canopies in the understory (Kovalchik and Clausnitzer 2004). Both *Abies lasiocarpa* and/or *Picea engelmannii* may be reproducing in the understory. *Pinus contorta*, *Pseudotsuga menziesii*, and *Larix occidentalis* are common early seral species. Common understory shrubs in confined woodlands include *Alnus viridis* ssp. *sinuata*, *Lonicera involucrata*, *Oplopanax horridus*, *Rosa gymnocarpa*, *Rubus parviflorus*, *Cornus canadensis*, *Ledum glandulosum*, *Vaccinium scoparium*, and *V. cespitosum*. *Arnica latifolia*, *Clintonia uniflora*, *Galium trifidum*, *Polemonium pulcherrimum*, *Senecio triangularis*, *Maianthemum stellatum*, *Streptopus amplexifolius*, *Athyrium filix-femina*, and *Gymnocarpium dryopteris* are common herbaceous species (Kovalchik and Clausnitzer 2004). Unconfined occurrences (mostly Rosgen C and E channels) are most often dominated by a canopy of *Picea engelmannii* while *Populus tremuloides*, *Betula papyrifera*, and occasionally *Pinus contorta* occur as early seral species. Common shrubs include *Cornus sericea*, *Symphoricarpos albus*, *Cornus canadensis*, *Lonicera involucrata*, *Rubus parviflorus*, *Pachistima myrsinites*, *Salix* ssp. *Alnus incana*, *A. viridis* ssp. *sinuata*, and *Ribes lacustre*. Herbaceous species often found in unconfined occurrences include *Carex scopulorum* var. *prionophylla*, *C. disperma*, *Elymus glaucus*, *Aralia nudicaulis*, *Streptopus amplexifolius*, *Gymnocarpium dryopteris*, and *Equisetum* ssp. Riparian woodlands dominated by *Populus tremuloides* are less common than coniferous dominated sites, however they can be found along riparian zones along low to moderate gradient channels (mostly Rosgen C and B channels) and ephemeral draws or depressions (Kovalchik and Clausnitzer 2004). Moderately large *Populus tremuloides* individuals are found in mature stands. *Betula papyrifera* and *Pinus contorta* are occasionally found in these stands. Regenerating *Populus tremuloides* and occasionally *Betula papyrifera*, *Pseudotsuga menziesii*, or *Picea engelmannii* can be found in the understory. Shrub diversity can be high and include *Cornus sericea*, *Symphoricarpos albus*, *Alnus incana*, *Acer glabrum* var. *douglasii*, *Amelanchier alnifolia*, *Ribes lacustre*, *Rosa gymnocarpa*, *Rubus parviflorus*, and *Salix* ssp. Herbaceous species are sparse in stands with high shrub cover. However, species such as

Carex pellita, *Calamagrostis canadensis*, *Deschampsia cespitosa*, *Angelica arguta*, *Fragaria virginiana* var. *platypetala*, *Petasites sagittatus*, *Maianthemum stellatum*, and *Equisetum arvense* are often found in these woodlands (Kovalchik and Clausnitzer 2004). Some stands in northeastern Washington are dominated by *Thuja plicata* and/or *Tsuga heterophylla* and represent an inland version of the North Pacific Lowland Riparian Forest and Shrubland system. Either the EIA associated with the latter or this system should be applicable to these riparian forests. *Thuja plicata* and *Tsuga heterophylla* also occur along with *Oplopanax horridus* and *Lysichiton americanus* on saturated soils in depressions or seeps. Such sites would be classified as the Northern Rocky Mountain Conifer Swamp.

The moisture associated with riparian areas promotes lower fire frequency compared with adjacent uplands. Stand replacement fires are rare but may occur when replacement fires occur in adjacent uplands (Fire regime III, average fire frequency of 100 years; LANDFIRE 2005). More frequent surface fires (~ every 50 years) can affect shrub patches through a combination of replacement fire from uplands and occasional native burning (LANDFIRE 2005). Following stand replacement fires deciduous woody species (e.g., *Populus tremuloides*, *Salix* spp., etc.) can be top-killed but generally resprout within a short period. Post-fire establishment of conifers occurs from seed. Wet meadows seldom burn and when they do, they typically recover within a single growing season (LANDFIRE 2005).

Stressors

Historic and contemporary land use practices have impacted hydrologic, geomorphic, and biotic structure and function of riparian areas in eastern Washington. Human land uses both within the riparian area as well as in adjacent and upland areas have fragmented many riparian reaches, which has reduced connectivity between riparian patches and riparian and upland areas. This can adversely affect the movement of surface water, groundwater, and nutrients and dispersal of plants and animals. Roads, bridges, and development can also fragment both riparian and upland areas. Intensive grazing and recreation can also create barriers to ecological processes.

Reservoirs, water diversions, ditches, roads, and human land uses in the contributing watershed can have a substantial impact on the hydrology as well as biotic integrity of riparian woodlands (Woods 2001; Kattelmann and Embury 1996; Poff et al. 1997; Baker 1987). All these stressors can induce downstream erosion and channelization, reduce changes in channel morphology, reduce base and/or peak flows, lower water tables in floodplains, and reduce sediment deposition in the floodplain (Poff et al. 1997). Vegetation responds to these changes by shifting from wetland and riparian dependent species to more mesic and xeric species typical of adjacent uplands (typical of herbaceous species) and/or encroaching into the stream channel. Although already narrow, floodplain width and the abundance and spatial distribution of various patch types also typically decline.

Livestock grazing is not a significant threat in confined riparian woodlands. However, in unconfined reaches, excessive livestock or native ungulate use can impact riparian woodlands by altering nutrient concentrations and cycles, changing surface and subsurface water movement and infiltration, shifting species composition, and reducing regeneration of woody species (Kauffman and Krueger 1984; Elmore and Kauffman 1994; Weixelman et al. 1997; Flenniken et al. 2001; Kauffman et al. 2004).

Management effects on woody riparian vegetation can be obvious (e.g., removal of vegetation by dam construction, roads, logging) or subtle (e.g., removal of beavers or large woody debris, construction of a weir dam for fish habitat). Non-native plants or animals, which can have wide-ranging impacts, also tend to increase with these stressors.

All of these stressors have resulted in many riparian areas being incised, supporting altered riparian plant communities, as well as numerous non-native species. This system has also decreased in extent due to agricultural development, roads, dams and other flood-control activities.

Ecological Integrity Assessment

The following table (Table C-28) displays metrics chosen to measure most of the key ecological attributes in the conceptual ecological model. Unless otherwise noted, metric ratings apply to both Level 2 and Level 3 EIAs. The difference is that a Level 3 EIA will use more intensive and precise methods to determine metric ratings such as: (1) benthic invertebrate Index of Biotic Integrity (BIBI; WADOE 2003, statewide data maintained by WADOE at http://www.ecy.wa.gov/apps/watersheds/streambio/regions/state.asp?symtype=1); (2) Index of Hydrological Alteration (Richter et al. 1997); (3) specific water quality measures (e.g., temperature, dissolved oxygen, pH, conductivity, and turbidity of stream water); (4) Pool Quality Index (May 2002, may need modification for Eastside riparian systems); and (5) Riffle Quality Index (May 2002, may need modification for Eastside riparian systems).

Table C-28. Rocky Mountain Subalpine-Montane Riparian Woodland Ecological Integrity Assessment Scorecard.

Metric	Justification	Rank			
		A (5 points)	B (4 points)	C (3 points)	D (1 point)
Key ecological attribute – Landscape context					
Edge length	Intactness of edge can be biotically and abiotically important	≥75% of edge bordered by natural communities	≥50–75% of edge bordered by natural communities	≥25–50% of edge bordered by natural communities	<25% of edge bordered by natural communities
Edge width		Average width of edge ≥200m	Average width of edge ≥100–200m	Average width of edge ≥50–100m	Average width of edge <50m
Edge condition		>95% native vegetation cover; <5% non-native cover; intact soils and no refuse	75–95% cover native vegetation; 5–25% cover of non-native plants; intact or moderately disrupted soils and little refuse	25–50% cover non-native plants; moderate or extensive soil disruption and refuse	>50% cover non-native plants; barren ground; highly compacted or otherwise disrupted soils and refuse
Connectivity	Land cover/uses in watershed have significant effects on ecological processes	Watershed primarily natural; no connectivity barriers/dams; <5% urban and agriculture; no recent clearcuts	Landscape primarily natural; connectivity mostly retained; 5-20% urban or agriculture; <30% clearcut	20-50% urban or agriculture; limited connectivity; <50% in clearcuts	>50% urban or agriculture; connectivity largely disrupted (dams)
Landscape condition	Intensity and types of land uses in surrounding landscape can affect ecological integrity	Landscape Condition Model Index >0.8		Landscape Condition Model Index 0.8–0.65	Landscape Condition Model Index <0.65
Relative patch size	Indicates proportion lost due to stressors	Site at or minimally reduced from natural extent (≥95% remains)	Occurrence modestly reduced from original natural extent (≥80-95% remains)	Occurrence substantially reduced from original natural extent (≥50–80% remains)	Occurrence severely reduced from original natural extent (<50% remains)
Absolute patch size	Important for buffering impacts along steams with limited floodplains	>8 linear km	5-8 linear km	1.5-5.0 lenear km	<1.5 linear km

	Important for buffering impacts along meandering streams with well-developed floodplains	>25 meander wavelengths or >50 point bars	10-25 meander wavelengths or 20-50 point bars	4-10 meander wavelengths or 8-20 point bars	<4 meander wavelengths or <8 point bars
Patch diversity	Good hydrological processes help produce diverse seral patches and connectivity without anthropogenic effects	Connectivity within riparian reach unfragmented; heterogenous mix of connected patch types; mixed species and seral stages	Connectivity of confined reaches may be fragmented; connectivity and diversity present between patches	Connectivity of confined reaches moderately fragmented; connectivity and diversity restricted between patches; some patches isolated	Confined reaches severely fragmented; homogenous patch types; fragmentation prevalent
Key ecological attribute – Vegetation condition					
Cover of native species	Natives dominate system; non-natives increase with human impacts	Cover of native plants ≥95%	Cover of native plants ≥80–95%	Cover of native plants ≥50–80%	Cover of native plants <50%
Cover of invasive species	Invasive species inflict wide range of impacts; early detection critical	None present	Invasive species present, but sporadic (<3% cover)	Invasive species prevalent (3–10% cover)	Invasive species abundant (>10% cover)
Cover of native increasers	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	Composition of native species can shift when exposed to stressors.	Diversity/abundance at or near reference standards; native species negative to anthropogenic degradation are present, species positive to anthropogenic degradation are absent to minor; full range of indicator species present	Diversity/abundance close to reference standards; native species reflective of anthropogenic degradation; some indicator species absent	Diversity/abundance differs from reference standards, but largely composed of native species; may include ruderal species; many indicator species absent	Vegetation severely altered from reference standards; dominated by ruderal species or comprised of planted stands of non-characteristic species or unnaturally dominated by single species; most indicator species absent
Canopy cover and condition	Diversity of age classes indicator of integrity	Cover generally >50%; Mixed canopy of sufficient size to provide future large woody debris		Somewhat homogenous in density and age or <50% canopy cover	Extremely homogenous, sparse, or absent (<10% cover)
Regeneration of woody species	Amount and distribution of regeneration important for maintaining system integrity	Saplings/seedlings of native woody species present in expected amount	Saplings/seedlings of native woody species present, but less than expected	Saplings/seedlings of native woody species present, but in low abundance	No reproduction of native woody species
Course woody debris (<3m)	Large woody debris in stream channel important for channel formation and hydrological processes (piece=10cm diameter and 2m in length	>28 pieces/100m channel length		15-28 pieces/100m channel length	<15 pieces/100m channel length
Course woody debris (3-30m)		>56 pieces/100m channel length		25-56 pieces/100m channel length	<25 pieces/100m channel length
Course woody debris (30-50m)		>63 pieces/100m channel length		22-63 pieces/100m channel length	<22 pieces/100m channel length
Key ecological attribute: Physicochemical and hydrology					
Soil surface condition	Disturbance can result in erosion with negative affects on ecological processes; bareground amount varies naturally with site type	Bare soil areas limited to naturally caused disturbances such as burrowing animals or game trails	Bare soil due to human causes, but extent and impact minimal	Bare soil due to human causes are common; machinery may have left shallow ruts	Bare soil areas substantial and they contribute to long-lasting impacts; deep ruts from machinery present or livestock trails widespread

Water quality	Excess nutrients and sediments have an adverse affect on water quality	No evidence of degraded water quality; water is clear	Water may have minimal greenish tint or cloudiness; negative features limited in area or intensity	Water may have minimal greenish tint, cloudiness, or sheen; negative indicators illustrate response to nutrients	Many negative indicators (algae mats, tint, sheen, turbidity); bottom difficult to see
Water source	Anthropogenic sources of water have detrimental effects on hydrological regime	Source is natural; no indication of direct artificial water sources	Source is mostly natural, but site directly receives small amounts of inflow from anthropogenic sources	Source is primarily urban runoff, direct irrigation, pumped water, or impounded water	Water flow substantially diminished by human activity
Channel stability	Alteration in hydrology or sediment loads or some onsite stressors can degrade channel stability	Natural channel; no evidence of aggradation or degradation	Most of the channel has aggradation or degradation, none of which is severe	Evidence of severe degradation of most of the channel	Concrete, or artificially hardened channels through the site
Streambank stability	Stable streambanks indicative of intact hydrological and sediment regimes	Stable: perennial vegetation to waterline; no raw or undercut banks; no recently exposed roots	Slightly stable: perennial vegetation to waterline in most places; minor erosion	Moderately unstable: perennial vegetation to waterline sparse (scoured or removed by erosion); bank held in place by trees and bolders; extensive erosion	Completely unstable: no perennial vegetation to waterline; banks only held in place by roots and bolders; severe erosion
Hydrological connectivity (level 2)	Floodwater should have access to floodplain; stressors resulting in entrenchment affect hydrological connectivity	Completely connected to floodplain (backwater sloughs and channels)	Minimally disconnected from floodplain by dikes and elevated culverts	Moderately disconnected from floodplain by dikes and elevated culverts	Extensively disconnected from floodplain by dikes and elevated culverts
Hydrological connectivity (level 3)		Unconfined entrenchment ratio >4.0; confined entrenchment ratio >1.4	Unconfined entrenchment ratio 1.4-2.2; confined entrenchment ratio 1.0-1.4	Unconfined entrenchment ratio <1.4; confined entrenchment ratio <1.0	
Key ecological attribute: Natural disturbance regime					
Fire condition class	Mixed severity fires can be out of range of natural variability	Fire Regime Condition Class 1 – No departure from historic regime	Fire Regime Condition Class 2 – Slight to moderate departure from historic fire regime		Fire Regime Condition Class 3 – Severe departure from historic fire regime; fire suppression evident

ROCKY MOUNTAIN SUBALPINE-MONTANE RIPARIAN SHRUBLAND

General Description

The Rocky Mountain Subalpine-Montane Riparian Shrubland system is comprised of montane to subalpine riparian shrublands occurring as narrow bands or large expanses of shrubs lining streambanks and alluvial terraces in narrow to wide, low-gradient valley bottoms and floodplains with sinuous stream channels. The system is found along the Rocky Mountain cordillera, from southern New Mexico north into Montana and Idaho, and west into the Intermountain region and the Colorado Plateau. It occurs throughout the interior of British Columbia and the eastern slopes of the Cascade Mountains. In Washington, the system occurs at high elevations within dry and cold portions of the east Cascades, throughout the Okanogan Highlands, and in the Northern Rocky Mountains. Snowmelt moisture may create shallow water tables or seeps for a portion of the growing season. In Washington, stands typically occur at elevations between approximately 610 and 2290 meters (Kovalchik and Clausnitzer 2004). This system most commonly occurs in drainages, stream terraces, semi-riparian flats and spring or seep-fed slopes. Soils vary but are typically well-developed, fine-textured, poorly drained, and often have histic epipedons. Sites can be quite wet, with saturated soils and standing water occasionally present. Sites with true organic soils (i.e. > 40 cm of organic soil) would be classified as Rocky Mountain Subalpine-Montane Fen Ecological System.

Riparian shrubland development is driven by the magnitude and frequency of flooding, valley and substrate type, and beaver activity. Infrequent, high-powered floods determine large geomorphic patterns that persist on the landscape for hundreds to thousands of years (Hubert 2004). Floods of intermediate frequency and power produce floodplain landforms which persist for tens to hundreds of years as well as reset succession to early seral vegetation types (LANDIRE 2005, Hubert 2004). Seasonal and episodic flooding erode and/or deposit sediment resulting in complex patterns of soil development which subsequently have a strong influence on the distribution of riparian vegetation (Gregory et al. 1991, Poff et al. 1997). Bare alluvium also provides suitable substrate for the germination of willow seedlings and is thus a critical patch type for continued regeneration of some riparian shrublands (Poff et al. 1997, Hubert 2004). Other types of willows can propagate through rooting of broken stems or roots, branch layering, and in a few species sprouting from subsurface runners (Kovalchik and Clausnitzer 2004). Narrow and steep (i.e. confined) occurrences have minimal to no floodplain development whereas less steep and wider valley bottoms (i.e., unconfined) occurrences are often associated with substantial floodplain development (LANDFIRE 2005, Gregory et al. 1991). Floodplains associated with the latter are comprised of a complexity of geomorphic surfaces which support a diverse array of vegetation communities and are able to store and release water slowly throughout the growing season (Hubert 2004). Confined streams typically have shallow soils with minimal alluvium and transport water downstream rapidly through step-pool channels armored by boulders, bedrock, and large woody debris (LANDFIRE 2005, Hubert 2004).

Beaver are an important hydrogeomorphic driver of Rocky Mountain Subalpine-Montane Riparian Shrublands, especially along unconfined reaches. The presence of beaver creates a heterogeneous complex of wet meadows, marshes and riparian shrublands and increases species richness on the landscape. Naiman et al. (1986) note that beaver-influenced streams are very different from those not impacted by beaver activity by having numerous zones of open water and vegetation, large accumulations of detritus and nutrients, more wetland areas, having more anaerobic biogeochemical cycles, and in general are more resistance to disturbance.

Typically, this system occurs as a mosaic of shrub and herbaceous-dominated communities and includes snowmelt-fed headwater basins above-treeline that is willow-dominated. The dominant shrubs reflect the wide elevational and stream gradients and include *Alnus incana, A. sinuata, Betula glandulosa, Betula occidentalis, Cornus sericea, Salix bebbiana, S. boothii, S. brachycarpa, S. drummondiana, S. geyeriana,* and *S. planifolia*. Valley geomorphology and substrate dictate the types of riparian shrublands which typically develop.

In Washington, *Alnus sinuata* and *Cornus sericea* are common dominant shrubs along confined (mostly along Rosgen A and B channels), steep and/or gravelly streams (Kovalchik and Clausnitzer 2004). Occasionally, trees such as *Picea engelmannii*, *Abies lasiocarpa*, *Populus balsamifera* ssp. *trichocarpa*, and *Thuja plicata* can occur in the shrublands. Along these steep reaches, the understory can be depauperate but species such as *Hydrophyllum fendleri*, *Senecio triangularis*, *Athyrium filix-femina*, and *Gymnocarpium dryopteris* are often present (Kovalchik and Clausnitzer 2004). A variety of willows (*Salix* sp.) and mountain alder (*Alnus incana*) are common dominant shrubs along unconfined, gently sloped streams with finer sediment. Tall willow species (e.g., *Salix bebbiana*, *S. boothii*, *S. drummondiana*, *S. geyeriana*, *S. lasiandra*, etc.) are dominant at low to moderate elevations while short willow species (e.g., *S. cascadensis*, *S. commutata*, *S. planifolia*, *S. nivalis*, *S. farriae*, etc.) are dominant in subalpine and alpine shrublands. Understory species are highly variable. Graminoids (*Carex utriculata*, *C. scopulorum*, *C. spectabilis*, *C. disperma, Eleocharis* spp., *Calamagrostis canadensis*, *Glyceria elata*) typically dominate the understory of willow types and composition varies according to elevation and site type (Kovalchik and Clausnitzer 2004). *Equisetum* ssp. and forbs can be abundant in some willow sites (Kovalchik and Clausnitzer 2004). *Alnus incana* shrublands often support other shrubs such as *Cornus sericea*, *Symphoricarpos albus*, *Spiraea douglasii*, and *Rosa* spp. (Kovalchik and Clausnitzer 2004). Cover of understory species generally has an inverse relationship with the cover of *Alnus incana*. Typical species include *Carex utriculata*, *C. disperma*, *Calamagrostis canadensis*, *Glyceria elata*, *Equisetum* spp. *Athyrium filix-femina, Maianthemum stellatum*, *Viola spp.*, *Senecio triangularis*, *Pyrola secunda*, and a variety of other forbs (Kovalchik and Clausnitzer 2004).

The moisture associated with riparian areas promotes lower fire frequency compared with adjacent uplands. Stand replacement fires are rare but may occur when replacement fires occur in adjacent uplands (Fire regime III, average fire frequency of 100 years; LANDFIRE 2005). More frequent surface fires (~ every 50 years) can affect shrub patches through a combination of replacement fire from uplands and occasional native burning (LANDFIRE 2005). Wet meadows seldom burn and when they do, they typically recover within a single growing season (LANDFIRE 2005).

Stressors

Historic and contemporary and land use practices have impacted hydrologic, geomorphic, and biotic structure and function of riparian areas in eastern Washington. Human land uses both within the riparian area as well as in adjacent and upland areas have fragmented many riparian reaches which has reduced connectivity between riparian patches and riparian and upland areas. This can adversely affect the movement of surface/groundwater, nutrients, and dispersal of plants and animals. Roads, bridges, and development can also fragment both riparian and upland areas. Intensive grazing and recreation can also create barriers to ecological processes.

Reservoirs, water diversions, ditches, roads, and human land uses in the contributing watershed can have a substantial impact on the hydrology as well as biotic integrity of riparian shrublands (Woods 2001, Kattelmann and Embury 1996, Poff et al. 1997, Baker 1987). All these stressors can induce downstream erosion and channelization, reduce changes in channel morphology, reduce base and/or peak flows, lower water tables in floodplains, and reduce sediment deposition in the floodplain (Poff et al. 1997). Vegetation responds to these changes by shifting from wetland and riparian dependent species to more mesic and xeric species typical of adjacent uplands (typical of herbaceous species) and/or encroaching into the stream channel. Floodplain width and the abundance and spatial distribution of various patch types also typically decline.

Livestock grazing is a significant threat in confined riparian shrublands. Excessive livestock or native ungulate use can impact riparian shrublands by altering nutrient concentrations and cycles, changing surface and subsurface water movement and infiltration, shifting species composition, and reducing regeneration of woody species (Kauffman and Krueger 1984; Elmore and Kauffman 1994; Weixelman et al. 1997; Flenniken et al. 2001; Kauffman et al. 2004). Management effects on woody riparian vegetation can be obvious, e.g., removal of vegetation by dam construction, roads, logging, or they can be subtle, e.g., removing beavers from a watershed, removing large woody debris, or construction of a weir dam for fish habitat. Non-native plants or animals, which can have wide-ranging impacts, also tend to increase with these stressors. Reed canarygrass (Phalaris arundinacea) can be a major invasive in these shrublands.

All of these stressors have resulted in many riparian areas being incised, supporting altered riparian plant communities, as well as numerous non-native species. This system has also decreased in extent due to agricultural development, roads, dams and other flood-control activities.

Ecological Integrity Assessment

The following table (Table C-29) displays metrics chosen to measure most of the key ecological attributes in the conceptual ecological model. Unless otherwise noted, metric ratings apply to both Level 2 and Level 3 EIAs. The difference is that a Level 3 EIA will use more intensive and precise methods to determine metric ratings such as: (1) benthic invertebrate Index of Biotic Integrity (BIBI; WADOE 2003, statewide data maintained by WADOE at http://www.ecy.wa.gov/apps/watersheds/streambio/regions/state.asp?symtype=1); (2) Index of Hydrological Alteration (Richter et al. 1997); (3) specific water quality measures (e.g., temperature, dissolved oxygen, pH, conductivity, and turbidity of stream water); (4) Pool Quality Index (May 2002, may need modification for Eastside riparian systems); and (5) Riffle Quality Index (May 2002, may need modification for Eastside riparian systems).

Table C-29. Rocky Mountain Subalpine-Montane Riparian Shrubland Ecological Integrity Assessment Scorecard.

<table>
<tr><th rowspan="2">Metric</th><th rowspan="2">Justification</th><th colspan="4">Rank</th></tr>
<tr><th>A (5 points)</th><th>B (4 points)</th><th>C (3 points)</th><th>D (1 point)</th></tr>
<tr><th colspan="6">Key ecological attribute – Landscape context</th></tr>
<tr><td>Edge length</td><td rowspan="3">Intactness of edge can be biotically and abiotically important</td><td>≥75% of edge bordered by natural communities</td><td>≥50–75% of edge bordered by natural communities</td><td>≥25–50% of edge bordered by natural communities</td><td><25% of edge bordered by natural communities</td></tr>
<tr><td>Edge width</td><td>Average width of edge ≥200m</td><td>Average width of edge ≥100–200m</td><td>Average width of edge ≥50–100m</td><td>Average width of edge <50m</td></tr>
<tr><td>Edge condition</td><td>>95% native vegetation cover; <5% non-native cover; intact soils and no refuse</td><td>75–95% cover native vegetation; 5–25% cover of non-native plants; intact or moderately disrupted soils and little refuse</td><td>25–50% cover non-native plants; moderate or extensive soil disruption and refuse</td><td>>50% cover non-native plants; barren ground; highly compacted or otherwise disrupted soils and refuse</td></tr>
<tr><td>Connectivity</td><td>Land cover/uses in watershed have significant effects on ecological processes</td><td>Watershed primarily natural; no connectivity barriers/dams; <5% urban and agriculture; no recent clearcuts</td><td>Landscape primarily natural; connectivity mostly retained; 5-20% urban or agriculture; <30% clearcut</td><td>20-50% urban or agriculture; limited connectivity; <50% in clearcuts</td><td>>50% urban or agriculture; connectivity largely disrupted (dams)</td></tr>
<tr><td>Landscape condition</td><td>Intensity and types of land uses in surrounding landscape can affect ecological integrity</td><td colspan="2">Landscape Condition Model Index >0.8</td><td>Landscape Condition Model Index 0.8–0.65</td><td>Landscape Condition Model Index <0.65</td></tr>
<tr><td>Relative patch size</td><td>Indicates proportion lost due to stressors</td><td>Site at or minimally reduced from natural extent (≥95% remains)</td><td>Occurrence modestly reduced from original natural extent (≥80-95% remains)</td><td>Occurrence substantially reduced from original natural extent (≥50–80% remains)</td><td>Occurrence severely reduced from original natural extent (<50% remains)</td></tr>
</table>

Absolute patch size	Important for buffering impacts along steams with limited floodplains	>4 linear km	2.5-4 linear km	1.5-2.5 lenear km	<1.5 linear km
	Important for buffering impacts along meandering streams with well-developed floodplains	>25 meander wavelengths or >50 point bars	10-25 meander wavelengths or 20-50 point bars	4-10 meander wavelengths or 8-20 point bars	<4 meander wavelengths or <8 point bars
Patch diversity	Good hydrological processes help produce diverse seral patches and connectivity without anthropogenic effects	Connectivity within riparian reach unfragmented; heterogenous mix of connected patch types; mixed species and seral stages	Connectivity of confined reaches may be fragmented; connectivity and diversity present between patches	Connectivity of confined reaches moderately fragmented; connectivity and diversity restricted between patches; some patches isolated	Confined reaches severely fragmented; homogenous patch types; fragmentation prevalent
Key ecological attribute – Vegetation condition					
Cover of native species	Natives dominate system; non-natives increase with human impacts	Cover of native plants ≥95%	Cover of native plants ≥80–95%	Cover of native plants ≥50–80%	Cover of native plants <50%
Cover of invasive species	Invasive species inflict wide range of impacts; early detection critical	None present	Invasive species present, but sporadic (<3% cover)	Invasive species prevalent (3–10% cover)	Invasive species abundant (>10% cover)
Cover of native increasers	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	Composition of native species can shift when exposed to stressors.	Diversity/abundance at or near reference standards; native species negative to anthropogenic degradation are present, species positive to anthropogenic degradation are absent to minor; full range of indicator species present	Diversity/abundance close to reference standards; native species reflective of anthropogenic degradation; some indicator species absent	Diversity/abundance differs from reference standards, but largely composed of native species; may include ruderal species; many indicator species absent	Vegetation severely altered from reference standards; dominated by ruderal species or comprised of planted stands of non-characteristic species or unnaturally dominated by single species; most indicator species absent
Regeneration of woody species	Amount and distribution of regeneration important for maintaining system integrity	Saplings/seedlings of native woody species present in expected amount	Saplings/seedlings of native woody species present, but less than expected	Saplings/seedlings of native woody species present, but in low abundance	No reproduction of native woody species
Key ecological attribute: Physicochemical and hydrology					
Soil surface condition	Disturbance can result in erosion with negative affects on ecological processes; bareground amount varies naturally with site type	Bare soil areas limited to naturally caused disturbances such as burrowing animals or game trails	Bare soil due to human causes, but extent and impact minimal; no evidence of ponding or channeling water	Bare soil due to human causes are common; machinery may have left shallow ruts; may be pugging due to livestock	Bare soil areas substantial and they contribute to long-lasting impacts; deep ruts from machinery present or livestock trails widespread; water channeled or ponded
Water quality	Excess nutrients and sediments have an adverse affect on water quality	No evidence of degraded water quality; water is clear	Water may have minimal greenish tint or cloudiness; negative features limited in area or intensity	Water may have minimal greenish tint, cloudiness, or sheen; negative indicators illustrate response to nutrients	Many negative indicators (algae mats, tint, sheen, turbidity); bottom difficult to see

Water source	Anthropogenic sources of water have detrimental effects on hydrological regime	Source is natural; no indication of direct artificial water sources	Source is mostly natural, but site directly receives small amounts of inflow from anthropogenic sources	Source is primarily urban runoff, direct irrigation, pumped water, or impounded water	Water flow substantially diminished by human activity
Channel stability	Alteration in hydrology or sediment loads or some onsite stressors can degrade channel stability	Natural channel; no evidence of aggradation or degradation	Most of the channel has aggradation or degradation, none of which is severe	Evidence of severe degradation of most of the channel	Concrete, or artificially hardened channels through the site
Streambank stability	Stable streambanks indicative of intact hydrological and sediment regimes	Stable: perennial vegetation to waterline; no raw or undercut banks; no recently exposed roots	Slightly stable: perennial vegetation to waterline in most places; minor erosion	Moderately unstable: perennial vegetation to waterline sparse (scoured or removed by erosion); bank held in place by trees and bolders; extensive erosion	Completely unstable: no perennial vegetation to waterline; banks only held in place by roots and bolders; severe erosion
Hydrological connectivity (level 2)	Floodwater should have access to floodplain; stressors resulting in entrenchment affect hydrological connectivity	Completely connected to floodplain (backwater sloughs and channels)	Minimally disconnected from floodplain by dikes and elevated culverts	Moderately disconnected from floodplain by dikes and elevated culverts	Extensively disconnected from floodplain by dikes and elevated culverts
Hydrological connectivity (level 3)		Unconfined entrenchment ratio >4.0; confined entrenchment ratio >1.4	Unconfined entrenchment ratio 1.4-2.2; confined entrenchment ratio 1.0-1.4	Unconfined entrenchment ratio <1.4; confined entrenchment ratio <1.0	
Key ecological attribute: Natural disturbance regime					
Fire condition class	Mixed severity fires can be out of range of natural variability	Fire Regime Condition Class 1 – No departure from historic regime	Fire Regime Condition Class 2 – Slight to moderate departure from historic fire regime		Fire Regime Condition Class 3 – Severe departure from historic fire regime; fire suppression evident

ROCKY MOUNTAIN SUBALPINE-MONTANE MESIC MEADOW

General Description

Subalpine Rocky Mountain Subalpine-Montane Mesic Meadow ecological systems are subalpine-montane herbaceous meadows typically dominated or co-dominated by perennial forbs. This is a small to large patch system that occurs throughout the Rocky Mountains restricted to lower montane to subalpine sites where finely textured soils, snow deposition, or windswept dry conditions limit tree establishment. Sites are gentle to moderate-gradient slopes and relatively moist. Soils typically are seasonally moist to saturated in the spring and dry later in the growing season. At montane elevations, soils have an A-horizon over 10 cm are usually clays or silt loams, and some occurrences may have inclusions of hydric soils in low, depressional areas (Luna and Vance 2010). At subalpine elevations, soils are derived a variety of parent materials, and are usually rocky or gravelly with good aeration and drainage, but with a well developed organic layer (Luna and Vance 2010). Many occurrences are small patches found in mosaics with woodlands, dense shrublands, or just below alpine communities. Elevations range from 610 to 2010 meters in the northern Rocky Mountains (Luna and Vance 2010).

Vegetation is typically forb-rich, with forbs often contributing more to overall herbaceous cover than graminoids. Tall forb-dominated mesic meadows are typically composed of a wide diversity of genera. Important forb taxa include *Erigeron* spp., Asteraceae spp., *Mertensia* spp., *Penstemon* spp., *Campanula* spp., *Lupinus* spp., *Solidago* spp., *Ligusticum* spp., *Thalictrum* *occidentale, Valeriana sitchensis, Rudbeckia occidentalis, Balsamorhiza sagittata*, and *Wyethia* spp. Some stands are comprised of dense grasslands, these often being taxa with relatively broad and soft blades *Luzula* and *Bromus*. Important grasses include *Deschampsia caespitosa, Koeleria macrantha*, perennial *Bromus* spp., and a number of *Carex* species. *Dasiphora fruticosa* ssp. *floribunda* and *Symphoricarpos* spp. are occasional shrubs that are never abundant. In Montana, some occurrences are more dominated by grasses (Luna and Vance 2010). Northern Rocky Mountain montane elevations can have *Allium schoenoprasum*, *Arnica chamissonis*, *Camassia quamash*, *Erigeron speciosus*, *Eucephalus* and *Symphyotrichum* species, *Mertensia* spp., *Chamerion angustifolium*, *Hackelia* spp, *Penstemon procerus, Geum macrophyllum*, *Campanula rotundifolia*, *Solidago canadensis*, *Zigadenus elegans*, *Thalictrum occidentale*, *Senecio hydrophiloides* and *Senecio serra* are important flowering forbs (Luna and Vance 2010). *Camassia quamash* dominates some mesic meadows that were important food gathering sites and were intensively managed for food production by indigenous people. At more subalpine elevations, *Senecio triangularis*, *Erigeron peregrinus*, *Erythronium grandiflorum*, *Ligusticum* species, *Veratrum viride* and *Valeriana* species become more important forbs (Luna and Vance 2010).

Natural burrowing mammal disturbance regimes at montane elevations can increase forb diversity. Early successional stages may be dominated by *Agastache urticifolia*, *Fragaria virginiana*, *Urtica dioica*, *Achillea millefolium*, and other forbs, and small amounts of mesic grasses such as *Bromus carinatus* and *Deschamspia cespitosa*. Most fires are replacement occurring around 40 years (Fire regime II LANDFIRE 2007). Mixed severity fires with a mean return interval of 75years influence late development of meadows by removing shrubs (LANDFIRE 2007). Fire starts where likely native peoples or from adjacent shrub or tree-dominated sites (LANDFIRE 2007). Patch size is 4 to 120 ha (LANDFIRE 2007).

LANDFIRE (2007) concluded that there is little information about this type. As described, the system appears to be mostly the dry end lower elevation of the Alpine-Montane Wet Meadow system and the forb-rich, wet end of the Northern Rocky Mountain Subalpine-Upper Montane Grassland system. It appears to be a map unit with a mix of local citations/descriptions. Dominance of forbs distinguishes this type from other montane upland herbaceous systems such as the Northern Rocky Mountain Subalpine - Upper Montane Grassland and Northern Rocky Mountain Lower Montane, Foothill and Valley Grassland systems dominated by perennial graminoids. Sites are not as wet as those found in Rocky Mountain Alpine-Montane Wet Meadow system.

Stressors

This system is tolerant of moderate-intensity ground fires and late-season livestock grazing (Kovalchik 1987). Most appear to be relatively stable types, although in some areas these may be impacted by intensive livestock grazing. Herbaceous mesic meadows that have experienced e intensive grazing are often susceptible to invasive non-native vegetation. Typically, disturbed meadows contain *Poa pratensis, Bromus inermis* and *Phleum pratense* at lower to montane elevations. *Taraxacum officinale* can replace native forb diversity in continuously disturbed areas. Highly invasive noxious species such as *Hieracium caespitosum*, *Hieracium auranticum*, *Ranunculus acris*, and *Leucanthemum vulgare* are and pose a real threat to the structure and diversity of these meadows (Luna and Vance 2010). Livestock use and heavy horse or foot traffic can lead to trampling and soil compaction. Slow growth in this habitat prevents rapid recovery.

Ecological Integrity Assessment

The following table (Table C-30) displays metrics chosen to measure most of the key ecological attributes in the conceptual ecological model. Unless otherwise noted, metric ratings apply to both Level 2 and Level 3 EIAs. The difference is that a Level 3 EIA will use more intensive and precise methods to determine metric ratings such as soil Bulk density (can reduce the soil’s water holding capacity, infiltration rate, water movement through the soil, and limit plant growth by physically restricting root growth).

Table C-30. Rocky Mountain Subalpine-Montane Mesic Meadow Ecological Integrity Assessment Scorecard.

Metric	Justification	Rank			
		A (5 points)	**B (4 points)**	**C (3 points)**	**D (1 point)**
Key ecological attribute – Landscape context					
Edge length	Intactness of edge can be biotically and abiotically important	≥75% of edge bordered by natural communities	≥50–75% of edge bordered by natural communities	≥25–50% of edge bordered by natural communities	<25% of edge bordered by natural communities
Edge width		Average width of edge ≥200m	Average width of edge ≥100–200m	Average width of edge ≥50–100m	Average width of edge <50m
Edge condition		>95% native vegetation cover; <5% non-native cover; intact soils and no refuse	75–95% cover native vegetation; 5–25% cover of non-native plants; intact or moderately disrupted soils and little refuse	25–50% cover non-native plants; moderate or extensive soil disruption and refuse	>50% cover non-native plants; barren ground; highly compacted or otherwise disrupted soils and refuse
Connectivity	Intact areas have continuous corridor of natural or semi-natural vegetation	Intact: Embedded in 90–100% natural habitat; connectivity expected to be high	Variegated: Embedded in 60–90% natural habitat; connectivity generally high, but lower for species sensitive to habitat modification	Fragmented: Embedded in 20–60% natural habitat; connectivity generally low, but varies with species mobility and arrangement on landscape	Relictual: Embedded in <20% natural habitat; connectivity essentially absent
Landscape condition	Intensity and types of land uses in surrounding landscape can affect ecological integrity	Landscape Condition Model Index >0.8		Landscape Condition Model Index 0.8–0.65	Landscape Condition Model Index <0.65
Relative patch size	Indicates proportion lost due to stressors	Site at or minimally reduced from natural extent (≥95% remains)	Occurrence modestly reduced from original natural extent (≥80-95% remains)	Occurrence substantially reduced from original natural extent (≥50–80% remains)	Occurrence severely reduced from original natural extent (<50% remains)
Absolute patch size	Important for buffering surrounding impacts	>120ha	12–120ha	1–12ha	<1ha
Key ecological attribute – Vegetation condition					
Cover of native species	Natives dominate system; non-natives increase with human impacts	Cover of native plants ≥95%	Cover of native plants ≥80–95%	Cover of native plants ≥50–80%	Cover of native plants <50%
Cover of invasive species	Invasive species inflict wide range of impacts; early detection critical	None present	Invasive species present, but sporadic (<3% cover)	Invasive species prevalent (3–10% cover)	Invasive species abundant (>10% cover)
Cover of native increasers	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	Composition of native species can shift when exposed to stressors.	Diversity/abundance at or near reference standards; native species negative to anthropogenic degradation are present, species positive to anthropogenic degradation are absent to minor; full range of indicator species present	Diversity/abundance close to reference standards; native species reflective of anthropogenic degradation; some indicator species absent	Diversity/abundance differs from reference standards, but largely composed of native species; may include ruderal species; many indicator species absent	Vegetation severely altered from reference standards; dominated by ruderal species or comprised of planted stands of non-characteristic species or unnaturally dominated by single species; most indicator species absent
Key ecological attribute: Physicochemical and hydrology					
Soil surface condition	Disturbance can result in erosion with negative affects on ecological processes; bareground amount varies naturally with site type	Bare soil areas limited to naturally caused disturbances such as burrowing animals or game trails	Bare soil due to human causes, but extent and impact minimal; no evidence of ponding or channeling water	Bare soil due to human causes are common; machinery may have left shallow ruts; may be pugging due to livestock	Bare soil areas substantial and they contribute to long-lasting impacts; deep ruts from machinery present or livestock trails widespread; water channeled or ponded

ROCKY MOUNTAIN ALPINE-MONTANE WET MEADOW

General Description

The Rocky Mountain Alpine-Montane Wet Meadow ecological system is a small patch system found throughout the high elevations of Rocky Mountains and Intermountain regions. Wet meadows are dominated by herbaceous species with very low velocity surface and subsurface water flows. They appear in elevations from montane to alpine (1000 to 3600 m). These types occur as large meadows in montane or subalpine valleys associated with groundwater discharge or seasonally high water tables such as narrow strips bordering ponds, lakes, and streams, and along toe slope seeps. They are typically found on flat areas or gentle slopes, but may also occur on sub-irrigated sites with slopes up to 10%. In alpine regions, sites typically are small depressions located below late-melting snow patches or on snowbeds tightly associated with snowmelt and typically not subjected to high disturbance events such as flooding, however montane wet meadows may be seasonally flooded. Soils of this system are mineral and may have large amount of organic matter but less than 40 cm thick. Soils show typical hydric soil characteristics, including high organic content and/or low chroma and redoximorphic features. This system often occurs as a mosaic of several plant associations, often dominated by graminoids. Wet site species such as *Calamagrostis stricta*, *Caltha leptosepala, Cardamine cordifolia, Carex illota, C. microptera, C. nigricans, C. scopulorum, C. utriculata, C. vernacular, Deschampsia cespitosa, Eleocharis quinqueflora, Juncus drummondii, Phippsia algida, Rorippa alpina, Senecio triangularis,* and *Trifolium parryi* are common. Often alpine dwarf-shrublands, especially those dominated by *Salix* spp., are immediately adjacent to the wet meadows.

This system is characterized as montane to alpine wet meadows that are typically dominated by graminoids and occasionally forbs and soils do **not** have > 40 cm of organic matter. Sites with soils with > 40 cm of organic matter would be classified as Rocky Mountain Subalpine-Montane Fens. Similar systems include the Temperate Pacific Subalpine-Montane Wet Meadow and Boreal Wet Meadow. Floristics of these three systems is somewhat similar with differences related to biogeographic affinities of the species composing the vegetation.

Stressors

Historic and contemporary land use practices have impacted hydrologic, geomorphic, and biotic structure and function of wetlands in Washington. Reservoirs, water diversions, ditches, roads, and human land uses in the contributing watershed can induce lower water tables and contribute excess nutrients and sediment. Increased nutrients can alter species composition by allowing aggressive, invasive species to displace native. Human land uses in adjacent and upland areas can fragment the landscape and thereby reduce connectivity between wet meadow patches and between wetland and upland areas. The intensity and types of land use within and near wet meadows can have a significant effect on plant community composition (Rocchio 2005). Direct alteration of hydrology (i.e., channeling, draining, damming) or indirect alteration (i.e., roading or removing vegetation on adjacent slopes) results in changes in amount and pattern of herbaceous wetland habitat. Livestock management can impact wet meadows by compacting soil, pugging (creation of pedestals by hooves) on the soil surface, altering nutrient concentrations and cycles, changing surface and subsurface water movement and infiltration, and shifting species composition. In general, excessive livestock or native ungulate use leads to a shift in plant species composition. Non-native plants or animals, which can have wide-ranging impacts, also tend to increase with these stressors. Although most wetlands some receive regulatory protection at the national, state, and county level, many wetlands have been and continued to be filled, drained, and grazed in the Washington. Montane wetlands are less altered than lowland wetlands even though they have undergone modification as well. Non-native species can displace native species, alter hydrology, alter structure, and affect food web dynamics by changing the quantity, type, and accessibility to food for fauna. Wetland dominated by non-native, invasive species typically support fewer native animals. Wet meadows are susceptible to invasion by many non-native species, especially pasture grasses such as *Poa pratensis* and *Phleum pratense* as well as exotics species common to other wetland types such as *Cirsium arvense* and *Taraxacum officinale*. *Phalaris arundinacea* is also common exotics in wet meadows. Native increasers such as *Juncus arcticus*, *Iris missouriensis*, *Argentea anserina*, and *Dasiphora floribunda* often increase with overgrazing and or changes in the water table.

Ecological Integrity Assessment

The following table (Table C-31) displays metrics chosen to measure most of the key ecological attributes in the conceptual ecological model. Unless otherwise noted, metric ratings apply to both Level 2 and Level 3 EIAs. The difference is that a Level 3 EIA will use more intensive and precise methods to determine metric ratings such as: (1) soil Bulk density (can reduce the soil's water holding capacity, infiltration rate, water movement through the soil, and limit plant growth by physically restricting root growth); (2) soil organic carbon (strong metric of soil quality due to its sensitivity to environmental disturbance); and (3) nutrient enrichment (C:P and C:N ratios).

Table C-31. Rocky Mountain Alpine-Montane Wet Meadow Ecological Integrity Assessment Scorecard.

Metric	Justification	Rank			
		A (5 points)	B (4 points)	C (3 points)	D (1 point)
Key ecological attribute – Landscape context					
Edge length	Intactness of edge can be biotically and abiotically important	≥75% of edge bordered by natural communities	≥50–75% of edge bordered by natural communities	≥25–50% of edge bordered by natural communities	<25% of edge bordered by natural communities

Edge width		Average width of edge ≥200m	Average width of edge ≥100–200m	Average width of edge ≥50–100m	Average width of edge <50m
Edge condition		>95% native vegetation cover; <5% non-native cover; intact soils and no refuse	75–95% cover native vegetation; 5–25% cover of non-native plants; intact or moderately disrupted soils and little refuse	25–50% cover non-native plants; moderate or extensive soil disruption and refuse	>50% cover non-native plants; barren ground; highly compacted or otherwise disrupted soils and refuse
Connectivity	Intact areas have continuous corridor of natural or semi-natural vegetation	Intact: Embedded in 90–100% natural habitat; connectivity expected to be high	Variegated: Embedded in 60–90% natural habitat; connectivity generally high, but lower for species sensitive to habitat modification	Fragmented: Embedded in 20–60% natural habitat; connectivity generally low, but varies with species mobility and arrangement on landscape	Relictual: Embedded in <20% natural habitat; connectivity essentially absent
Landscape condition	Intensity and types of land uses in surrounding landscape can affect ecological integrity	Landscape Condition Model Index >0.8		Landscape Condition Model Index 0.8–0.65	Landscape Condition Model Index <0.65
Relative patch size	Indicates proportion lost due to stressors	Site at or minimally reduced from natural extent (≥95% remains)	Occurrence modestly reduced from original natural extent (≥80-95% remains)	Occurrence substantially reduced from original natural extent (≥50–80% remains)	Occurrence severely reduced from original natural extent (<50% remains)
Absolute patch size	Important for buffering surrounding impacts	>30ha	8–30ha	0.5–8ha	<0.5ha
Key ecological attribute – Vegetation condition					
Cover of native species	Natives dominate system; non-natives increase with human impacts	Cover of native plants ≥95%	Cover of native plants ≥80–95%	Cover of native plants ≥50–80%	Cover of native plants <50%
Cover of invasive species	Invasive species inflict wide range of impacts; early detection critical	None present	Invasive species present, but sporadic (<3% cover)	Invasive species prevalent (3–10% cover)	Invasive species abundant (>10% cover)
Cover of native increasers	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	Composition of native species can shift when exposed to stressors.	Diversity/abundance at or near reference standards; native species negative to anthropogenic degradation are present, species positive to anthropogenic degradation are absent to minor; full range of indicator species present	Diversity/abundance close to reference standards; native species reflective of anthropogenic degradation; some indicator species absent	Diversity/abundance differs from reference standards, but largely composed of native species; may include ruderal species; many indicator species absent	Vegetation severely altered from reference standards; dominated by ruderal species or comprised of planted stands of non-characteristic species or unnaturally dominated by single species; most indicator species absent
Organic matter accumulation	Accumulation of coarse and fine debris is integral to ecological processes	Characterized by moderate amount of fine organic matter; new materials more prevalent than old materials; litter layers and leaf piles in pools are thin		Ssmall amounts of coarse organic debris; little evidence of organic matter	Essentially no significant amounts of coarse plant debris; little fine debris (or too much)
Key ecological attribute: Physicochemical and hydrology					
Soil surface condition	Disturbance can result in erosion with negative affects on ecological processes; bareground amount varies naturally with site type	Bare soil areas limited to naturally caused disturbances such as burrowing animals or game trails	Bare soil due to human causes, but extent and impact minimal; no evidence of ponding or channeling water	Bare soil due to human causes are common; machinery may have left shallow ruts; may be pugging due to livestock	Bare soil areas substantial and they contribute to long-lasting impacts; deep ruts from machinery present or livestock trails widespread; water channeled or ponded

Water quality	Excess nutrients and sediments have an adverse affect on water quality	No evidence of degraded water quality; water is clear	Water may have minimal greenish tint or cloudiness; negative features limited in area or intensity	Water may have minimal greenish tint, cloudiness, or sheen; negative indicators illustrate response to nutrients	Many negative indicators (algae mats, tint, sheen, turbidity); bottom difficult to see
Water source	Anthropogenic sources of water have detrimental effects on hydrological regime	Source is natural; no indication of direct artificial water sources	Source is mostly natural, but site directly receives small amounts of inflow from anthropogenic sources	Source is primarily urban runoff, direct irrigation, pumped water, or impounded water	Water flow substantially diminished by human activity
Water table	Water table is an important component of hydrology function	Soils saturated for long durations; hydric soils present; water table <5m of soil surface; surface soil horizons gleyed or have a chroma value of ≤2 in mottled soils or ≤1 in unmottled soils; depth to mottles <40cm		No redoximorphic features present <40cm; soil chromo >2; hydric soils not present; indicators of remnant hydric conditions may be present (distinct boundaries between mottles and matrix)	
Hydroperiod	Alteration in hydrology or sediment loads can degrade channel stability	Characterized by stable saturated hydrology or by naturally damped cycles of saturation and partial drying	Experiences minor altered inflows or drawdown/drying as compared to more natural wetlands	Somewhat altered by increased inflow from runoff or experiences moderate drawdown or drying	Altered by increased inflow from runoff or experiences large drawdown or drying

NORTHERN ROCKY MOUNTAIN LOWER MONTANE RIPARIAN WOODLAND AND SHRUBLAND

General Description

The Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland system includes riparian woodland and shrubland consisting of deciduous, coniferous, and mixed conifer-deciduous trees and shrubs that occur on streambanks and river floodplains in the lower montane and foothill zones of the Northern Rocky Mountains. In Washington, this linear system occurs on streambanks and river floodplains of the lower montane and foothill zones in the northern Rocky Mountains, the Okanogan Highlands, the Blue Mountains, and sporadically on the slopes of the northeast Cascades. In the Okanogan, this is defined as all the cottonwood-dominated or codominated riparian systems below subalpine and above the Ponderosa pine zone. Complex geomorphic and biotic components and processes maintain the long-term integrity of this system (Gregory et al. 1991). Annual flooding is a key ecological process which results in a diversity of patch types such as woodlands, shrublands, wet meadows, and marshes. Beaver activity is an important driver of hydrological change. Woodlands are often dominated by *Populus balsamifera* ssp. *trichocarpa* which is the key indicator species. Several other tree species can be mixed in the canopy, including *Populus tremuloides*, *Betula papyrifera*, and *Betula occidentalis*. Shrub understory components include *Cornus sericea*, *Acer glabrum*, *Alnus incana*, *Betula papyrifera*, *Oplopanax horridus* and *Symphoricarpos albus*. Ferns and forbs of mesic sites are commonly present in many occurrences, including such species as *Athyrium filix-femina*, *Gymnocarpium dryopteris*, and *Senecio triangularis*.

The moisture associated with riparian areas promotes lower fire frequency compared with adjacent uplands. Stand replacement fires are rare but may occur when replacement fires occur in adjacent uplands (Fire regime III, average fire frequency of 100 years; LANDFIRE 2007). More frequent surface fires (~ every 50 years) can affect shrub patches through a combination of replacement fire from uplands and occasional native burning (LANDFIRE 2007). Following stand replacement fires deciduous woody species (e.g., *Populus tremuloides*, *Salix* spp., etc.) can be top-killed but generally resprout within a short period. Post-fire establishment of conifers occurs from seed. Wet meadows seldom burn and when they do, they typically recover within a single growing season (LANDFIRE 2007).

Stressors

Historic and contemporary land use practices have impacted hydrologic, geomorphic, and biotic structure and function of riparian areas in eastern Washington. Human land uses both within the riparian area as well as in adjacent and upland areas have fragmented many riparian reaches which has reduced connectivity between riparian patches and riparian and upland areas. Adjacent and upstream land uses also have the potential to contribute excess nutrients into riparian areas Reservoirs, water diversions, ditches, roads, and human land uses in the contributing watershed can have a substantial impact on the hydrology regime. Management effects on woody riparian vegetation can be obvious, e.g., removal of vegetation by dam construction, roads, logging, or they can be subtle, e.g., removing beavers from a watershed, removing large woody debris, or construction of a weir dam for fish habitat. In general, excessive livestock or native ungulate use leads to less woody cover and an increase in sod-forming grasses particularly on fine-textured soils. Undesirable forb species, such as *Urtica diocia* and *Equisetum* spp., increase with livestock use. Non-native plants or animals, which can have wide-ranging impacts, also tend to increase with these stressors. All of these stressors have resulted in many riparian areas being incised, supporting altered riparian plant communities, as well as numerous non-native species. This system has also decreased in extent due to agricultural development, roads, dams and other flood-control activities.

Ecological Integrity Assessment

The following table (Table C-32) displays metrics chosen to measure most of the key ecological attributes in the conceptual ecological model. Unless otherwise noted, metric ratings apply to both Level 2 and Level 3 EIAs. The difference is that a Level 3 EIA will use more intensive and precise methods to determine metric ratings such as: (1) benthic invertebrate Index of Biotic Integrity (BIBI; WADOE 2003, statewide data maintained by WADOE at http://www.ecy.wa.gov/apps/watersheds/streambio/regions/state.asp?symtype=1); (2) Index of Hydrological Alteration (Richter et al. 1997); (3) specific water quality measures (e.g., temperature, dissolved oxygen, pH, conductivity, and turbidity of stream water); (4) Pool Quality Index (May 2002, may need modification for Eastside riparian systems); and (5) Riffle Quality Index (May 2002, may need modification for Eastside riparian systems).

Table C-32. Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland Ecological Integrity Assessment Scorecard.

Metric	Justification	Rank			
		A (5 points)	B (4 points)	C (3 points)	D (1 point)
Key ecological attribute – Landscape context					
Edge length	Intactness of edge can be biotically and abiotically important	≥75% of edge bordered by natural communities	≥50–75% of edge bordered by natural communities	≥25–50% of edge bordered by natural communities	<25% of edge bordered by natural communities
Edge width		Average width of edge ≥200m	Average width of edge ≥100–200m	Average width of edge ≥50–100m	Average width of edge <50m

Edge condition		>95% native vegetation cover; <5% non-native cover; intact soils and no refuse	75–95% cover native vegetation; 5–25% cover of non-native plants; intact or moderately disrupted soils and little refuse	25–50% cover non-native plants; moderate or extensive soil disruption and refuse	>50% cover non-native plants; barren ground; highly compacted or otherwise disrupted soils and refuse
Connectivity	Land cover/uses in watershed have significant effects on ecological processes	Watershed primarily natural; no connectivity barriers/dams; <5% urban and agriculture; no recent clearcuts	Landscape primarily natural; connectivity mostly retained; 5-20% urban or agriculture; <30% clearcut	20-50% urban or agriculture; limited connectivity; <50% in clearcuts	>50% urban or agriculture; connectivity largely disrupted (dams)
Landscape condition	Intensity and types of land uses in surrounding landscape can affect ecological integrity	Landscape Condition Model Index >0.8		Landscape Condition Model Index 0.8–0.65	Landscape Condition Model Index <0.65
Relative patch size	Indicates proportion lost due to stressors	Site at or minimally reduced from natural extent (≥95% remains)	Occurrence modestly reduced from original natural extent (≥80-95% remains)	Occurrence substantially reduced from original natural extent (≥50–80% remains)	Occurrence severely reduced from original natural extent (<50% remains)
Absolute patch size	Important for buffering impacts along steams with limited floodplains	>8 linear km	5-8 linear km	1.5-5.0 lenear km	<1.5 linear km
	Important for buffering impacts along meandering streams with well-developed floodplains	>25 meander wavelengths or >50 point bars	10-25 meander wavelengths or 20-50 point bars	4-10 meander wavelengths or 8-20 point bars	<4 meander wavelengths or <8 point bars
Patch diversity	Good hydrological processes help produce diverse seral patches and connectivity without anthropogenic effects	Heterogenous mix of well connected patch types; mixed mature species along with early seral stands	Expected patch diversity present but connectivity between patches becoming fragmented or less diverse than expected	Patch diversity low and becoming homogenous; few if any mature stands of trees; many patches isolated due to fragmentation	Mostly dominated by one patch type; fragmentation with the system
Key ecological attribute – Vegetation condition					
Cover of native species	Natives dominate system; non-natives increase with human impacts	Cover of native plants ≥95%	Cover of native plants ≥80–95%	Cover of native plants ≥50–80%	Cover of native plants <50%
Cover of invasive species	Invasive species inflict wide range of impacts; early detection critical	None present	Invasive species present, but sporadic (<3% cover)	Invasive species prevalent (3–10% cover)	Invasive species abundant (>10% cover)
Cover of native increasers	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	Composition of native species can shift when exposed to stressors.	Diversity/abundance at or near reference standards; native species negative to anthropogenic degradation are present, species positive to anthropogenic degradation are absent to minor; full range of indicator species present	Diversity/abundance close to reference standards; native species reflective of anthropogenic degradation; some indicator species absent	Diversity/abundance differs from reference standards, but largely composed of native species; may include ruderal species; many indicator species absent	Vegetation severely altered from reference standards; dominated by ruderal species or comprised of planted stands of non-characteristic species or unnaturally dominated by single species; most indicator species absent
Fire condition class	Mixed severity fires can be out of range of natural variability	Fire Regime Condition Class 1 – No departure from historic regime	Fire Regime Condition Class 2 – Slight to moderate departure from historic fire regime		Fire Regime Condition Class 3 – Severe departure from historic fire regime; fire suppression evident

Canopy cover and condition	Diversity of age classes indicator of integrity	Cover generally >25%; Mixed aged canopy of sufficient size to provide future large woody debris		Somewhat homogenous in density and age or <25% or >90% canopy cover	Extremely homogenous, sparse, or absent (<10% cover)
Regeneration of woody species	Amount and distribution of regeneration important for maintaining system integrity	Saplings/seedlings of native woody species present in expected amount	Saplings/seedlings of native woody species present, but less than expected	Saplings/seedlings of native woody species present, but in low abundance	No reproduction of native woody species
Course woody debris (<6m)	Large woody debris in stream channel important for channel formation and hydrological processes (piece=10cm diameter and 2m in length	>29 pieces/100m channel length		5-29 pieces/100m channel length	<5 pieces/100m channel length
Course woody debris (6-30m)		>35 pieces/100m channel length		5-35 pieces/100m channel length	<5 pieces/100m channel length
Key ecological attribute: Physicochemical and hydrology					
Soil surface condition	Disturbance can result in erosion with negative affects on ecological processes; bareground amount varies naturally with site type	Bare soil areas limited to naturally caused disturbances such as burrowing animals or game trails	Bare soil due to human causes, but extent and impact minimal; no evidence of ponding or channeling water	Bare soil due to human causes are common; machinery may have left shallow ruts; may be pugging due to livestock	Bare soil areas substantial and they contribute to long-lasting impacts; deep ruts from machinery present or livestock trails widespread; water channeled or ponded
Water quality	Excess nutrients and sediments have an adverse affect on water quality	No evidence of degraded water quality; water is clear	Water may have minimal greenish tint or cloudiness; negative features limited in area or intensity	Water may have minimal greenish tint, cloudiness, or sheen; negative indicators illustrate response to nutrients	Many negative indicators (algae mats, tint, sheen, turbidity); bottom difficult to see
Water source	Anthropogenic sources of water have detrimental effects on hydrological regime	Source is natural; no indication of direct artificial water sources	Source is mostly natural, but site directly receives small amounts of inflow from anthropogenic sources	Source is primarily urban runoff, direct irrigation, pumped water, or impounded water	Water flow substantially diminished by human activity
Channel stability	Alteration in hydrology or sediment loads or some onsite stressors can degrade channel stability	Natural channel; no evidence of aggradation or degradation	Most of the channel has aggradation or degradation, none of which is severe	Evidence of severe degradation of most of the channel	Concrete, or artificially hardened channels through the site
Streambank stability	Stable streambanks indicative of intact hydrological and sediment regimes	Stable: perennial vegetation to waterline; no raw or undercut banks; no recently exposed roots	Slightly stable: perennial vegetation to waterline in most places; minor erosion	Moderately unstable: perennial vegetation to waterline sparse (scoured or removed by erosion); bank held in place by trees and bolders; extensive erosion	Completely unstable: no perennial vegetation to waterline; banks only held in place by roots and bolders; severe erosion
Hydrological connectivity (level 2)	Floodwater should have access to floodplain; stressors resulting in entrenchment affect hydrological connectivity	Completely connected to floodplain (backwater sloughs and channels)	Minimally disconnected from floodplain by dikes and elevated culverts	Moderately disconnected from floodplain by dikes and elevated culverts	Extensively disconnected from floodplain by dikes and elevated culverts
Hydrological connectivity (level 3)		Unconfined entrenchment ratio >4.0; confined entrenchment ratio >1.4	Unconfined entrenchment ratio 1.4-2.2; confined entrenchment ratio 1.0-1.4	Unconfined entrenchment ratio <1.4; confined entrenchment ratio <1.0	

NORTH AMERICAN ARID FRESHWATER EMERGENT MARSH

General Description

The North American Arid Freshwater Emergent Marsh ecological system occurs throughout much of the arid and semi-arid regions of western North America. It occurs throughout eastern Washington below lower treeline where semi-permanently flooded habitats are found as small patches in the matrix of a relatively dry landscape. The system is typically surrounded by savanna, shrubsteppe, steppe, or semi-desert vegetation. Natural marshes may occur in depressions in the landscape (ponds, kettle ponds), as fringes around lakes, and along slow-flowing streams and rivers (such riparian marshes are also referred to as sloughs). Marshes are frequently or continually inundated, with water depths up to 2 meters. Water levels may be stable, or may fluctuate 1 m or more over the course of the growing season. Water chemistry may be alkaline or semi-alkaline, but the alkalinity is highly variable even within the same complex of wetlands. Marsh development along riparian areas is driven by the magnitude and frequency of flooding, valley and substrate type, and beaver activity. Seasonal and episodic flooding scour depressions in the floodplain, create side channels and floodplain sloughs, and force channel migration which can result in oxbows. Marsh vegetation establish in these landforms if there is semi-permanent to permanent water contained within them. Marshes also occur near the fringes of lakes and ponds where their development is dictated by the shoreline gradient and fluctuation of lake or pond levels. Relatively flat or gently sloping shorelines support a much larger marsh system than a steep sloping shoreline. Water is at or above the surface for most of the growing season but in some areas can water levels fluctuate with dramatic drawdowns exposing bare soil by later summer. The frequency and magnitude of water level fluctuations determine the extent of each marsh zone (floating, submerged, emergent, etc.). Water level fluctuations also support the development of different marsh zones (floating, submergent, emergent, etc.) which vary according to the degree of inundation. Soils have characteristics that result from long periods of anaerobic conditions in the soils (e.g., gleyed soils, high organic content, redoximorphic features) and can be mineral or organic. Hydrophytic vegetation dominates these wetlands. Common emergent and floating vegetation includes species of *Scirpus* and/or *Schoenoplectus, Typha, Juncus, Potamogeton, Polygonum, Nuphar*, and *Phalaris*. This ecological system may also include areas of relatively deep water with floating-leaved plants (*Lemna, Potamogeton*, and *Brasenia*) and submergent and floating plants (*Myriophyllum, Ceratophyllum*, and *Elodea*).

Stressors

Historic and contemporary land use practices have impacted hydrologic, geomorphic, and biotic structure and function of marshes in eastern Washington. Reservoirs, water diversions, ditches, roads, and human land uses in the contributing watershed can have a substantial impact on the hydrological regime. Direct alteration of hydrology (i.e., channeling, draining, damming) or indirect alteration (i.e., roading or removing vegetation on adjacent slopes) results in changes in amount and pattern of herbaceous wetland habitat. If the alteration is long term, wetland systems may reestablish to reflect new hydrology, e.g., cattail is an aggressive invader. Human land uses both within the marshes as well as in adjacent upland areas have reduced connectivity between wetland patches and upland areas. Land uses in contributing the watershed have the potential to contribute excess nutrients into to the system which could lead to the establishment of non-native species and/or dominance of native increasing species. In general, excessive livestock or native ungulate use leads to a shift in plant species composition. Non-native plants or animals, which can have wide-ranging impacts, also tend to increase with these stressors. Although most wetlands receive regulatory protection at the national, state, and county level, many wetlands have been and continued to be filled, drained, grazed, and farmed extensively. A keystone species, the beaver, has been trapped to near extirpation in parts of the Pacific Northwest and its population has been regulated in others. Herbaceous wetlands (including freshwater emergent marsh) have decreased along with the diminished influence of beavers on the landscape. However, in the Columbia Basin of eastern Washington, the abundance of marshes has increased in many areas due to the amount of irrigation water being used across the landscape. This 'wastewater' emerges in various locations to form herbaceous marshes and wet meadows.

Direct alteration of hydrology (i.e., channeling, draining, damming) or indirect alteration (i.e., roading or removing vegetation on adjacent slopes) results in changes in species composition and wetland extent. If the alteration is long term, wetland systems may reestablish to reflect new hydrology, e.g., cattail is an aggressive invader in roadside ditches. Severe livestock grazing and trampling can decrease the abundance of native sedge and grass species, increase the abundance of nonnative and native, weedy species. As mentioned above, irrigation wastewater has also played a role in altering the natural range of variation of many marshes in the basin. This wastewater has created new wetlands in some areas and increased flow volume in others, which could lead to corresponding changes in species composition.

Ecological Integrity Assessment

The following table (Table C-33) displays metrics chosen to measure most of the key ecological attributes in the conceptual ecological model. Unless otherwise noted, metric ratings apply to both Level 2 and Level 3 EIAs. The difference is that a Level 3 EIA will use more intensive and precise methods to determine metric ratings such as: (1) nitrogen enrichment (C:N); (2) phosphorous enrichment (C:P); (3) soil organic carbon; (4) soil bulk density; and (5) water table depth.

Table C-33. North American Arid Freshwater Emergent Marsh Ecological Integrity Assessment Scorecard.

Metric	**Justification**	**Rank**			
		A (5 points)	**B (4 points)**	**C (3 points)**	**D (1 point)**
Key ecological attribute – Landscape context					
Edge length	Intactness of edge can be biotically and abiotically important	≥75% of edge bordered by natural communities	≥50–75% of edge bordered by natural communities	≥25–50% of edge bordered by natural communities	<25% of edge bordered by natural communities
Edge width		Average width of edge ≥200m	Average width of edge ≥100–200m	Average width of edge ≥50–100m	Average width of edge <50m
Edge condition		>95% native vegetation cover; <5% non-native cover; intact soils and no refuse	75–95% cover native vegetation; 5–25% cover of non-native plants; intact or moderately disrupted soils and little refuse	25–50% cover non-native plants; moderate or extensive soil disruption and refuse	>50% cover non-native plants; barren ground; highly compacted or otherwise disrupted soils and refuse

Connectivity	Intact areas have continuous corridor of natural or semi-natural vegetation	Intact: Embedded in 90–100% natural habitat; connectivity expected to be high	Variegated: Embedded in 60–90% natural habitat; connectivity generally high, but lower for species sensitive to habitat modification	Fragmented: Embedded in 20–60% natural habitat; connectivity generally low, but varies with species mobility and arrangement on landscape	Relictual: Embedded in <20% natural habitat; connectivity essentially absent
Landscape condition	Intensity and types of land uses in surrounding landscape can affect ecological integrity	Landscape Condition Model Index >0.8		Landscape Condition Model Index 0.8–0.65	Landscape Condition Model Index <0.65
Relative patch size	Indicates proportion lost due to stressors	Site at or minimally reduced from natural extent (≥95% remains)	Occurrence modestly reduced from original natural extent (≥80-95% remains)	Occurrence substantially reduced from original natural extent (≥50–80% remains)	Occurrence severely reduced from original natural extent (<50% remains)
Absolute patch size	Important for buffering surrounding impacts	>80ha	30–80ha	2–30ha	<2ha
Key ecological attribute – Vegetation condition					
Cover of native species	Natives dominate system; non-natives increase with human impacts	Cover of native plants ≥95%	Cover of native plants ≥80–95%	Cover of native plants ≥50–80%	Cover of native plants <50%
Cover of invasive species	Invasive species inflict wide range of impacts; early detection critical	None present	Invasive species present (*Typha*, *Phalaris*, *Phragmites*), but sporadic (<3% cover)	Invasive species (*Typha*, *Phalaris*, *Phragmites*) prevalent (3–10% cover)	Invasive species (*Typha*, *Phalaris*, *Phragmites*) abundant (>10% cover)
Cover of native increasers	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	Composition of native species can shift when exposed to stressors.	Diversity/abundance at or near reference standards; native species negative to anthropogenic degradation are present, species positive to anthropogenic degradation are absent to minor; full range of indicator species present	Diversity/abundance close to reference standards; native species reflective of anthropogenic degradation; some indicator species absent	Diversity/abundance differs from reference standards, but largely composed of native species; may include ruderal species; many indicator species absent	Vegetation severely altered from reference standards; dominated by ruderal species or comprised of planted stands of non-characteristic species or unnaturally dominated by single species; most indicator species absent
Organic matter accumulation	Accumulation of coarse and fine debris is integral to ecological processes	Characterized by moderate amount of fine organic matter; new materials more prevalent than old materials; litter layers and leaf piles in pools are thin		Ssmall amounts of coarse organic debris; little evidence of organic matter	Essentially no significant amounts of coarse plant debris; little fine debris (or too much)
Key ecological attribute: Physicochemical and hydrology					
Soil surface condition	Disturbance can result in erosion with negative affects on ecological processes; bareground amount varies naturally with site type	Bare soil areas limited to naturally caused disturbances such as burrowing animals or game trails	Bare soil due to human causes, but extent and impact minimal; no evidence of ponding or channeling water	Bare soil due to human causes are common; machinery may have left shallow ruts; may be pugging due to livestock	Bare soil areas substantial and they contribute to long-lasting impacts; deep ruts from machinery present or livestock trails widespread; water channeled or ponded
Water quality	Excess nutrients and sediments have an adverse affect on water quality	No evidence of degraded water quality; water is clear	Water may have minimal greenish tint or cloudiness; negative features limited in area or intensity	Water may have minimal greenish tint, cloudiness, or sheen; negative indicators illustrate response to nutrients	Many negative indicators (algae mats, tint, sheen, turbidity); bottom difficult to see

Water source	Anthropogenic sources of water have detrimental effects on hydrological regime	Source is natural; no indication of direct artificial water sources	Source is mostly natural, but site directly receives small amounts of inflow from anthropogenic sources	Source is primarily urban runoff, direct irrigation, pumped water, or impounded water	Water flow substantially diminished by human activity
Hydroperiod	Alteration in hydrology or sediment loads can degrade channel stability	Characterized by stable saturated hydrology or by naturally damped cycles of saturation and partial drying	Experiences minor altered inflows or drawdown/drying as compared to more natural wetlands	Somewhat altered by increased inflow from runoff or experiences moderate drawdown or drying	Altered by increased inflow from runoff or experiences large drawdown or drying
Hydrological connectivity (non-riverine)	Floodwater should have access to floodplain; stressors resulting in entrenchment affect hydrological connectivity	Rising water has unrestricted access to adjacent upland; without levees, high banks, artificial barriers, or other obstructions	Lateral movement of water partially restricted by unnatural features; <50% of site restricted by barriers to drainage	Lateral movement of water partially restricted by unnatural features; 50-90% of site restricted by barriers to drainage	Lateral movement of water largely restricted by unnatural features; >90% of site restricted by barriers to drainage

INTERMOUNTAIN BASINS GREASEWOOD FLAT

General Description

The Intermountain Basins Greasewood Flat ecological system is a widespread, large patch system that occurs sporadically throughout much of the western North American Intermountain Basins and east into the western Great Plains. In Washington, it occurs in the Columbia Basin and Okanogan Valley. Occurrences are often surrounded by Intermountain Basins Semi-Desert Shrub Steppe or Big Sagebrush Steppe systems and are associated with Playa or Alkali Depression systems. This system typically occurs near drainages on stream terraces and flats or may form rings around more sparsely vegetated playas. Seasonally high water tables and intermittent flooding is expected, however most sites remain dry at the soil surface through most growing seasons. Soils are typically saline and bare ground is a common feature. The water table remains high enough to maintain vegetation, despite salt accumulations. Wetland vegetation may concentrate near seeps/springs or in drainages where standing water is perennial. Saline soils and dominance by *Sarcobatus vermiculatus* distinguish this type from other ecological systems. The primary ecological process maintaining greasewood flat systems is an elevated groundwater table.

This system appears as an open to moderately dense shrubland dominated or codominated by *Sarcobatus vermiculatus*. It usually occurs as a mosaic of multiple plant associations. There may be interspersed patches of *Distichlis spicata* throughout the site. Other shrubs that may be present to co-dominant, listed in order of decreasing tolerance of a high water table or high salinity, are *Krascheninnikovia lanata*, *Grayia spinosa, Ericameria nauseosa*, and *Artemisia tridentata* ssp. *tridentata*. The herbaceous layer, when present, is usually dominated by graminoids, in order of decreasing tolerance of a high water table or high salinity, such as *Distichlis spicata, Puccinellia* spp., *Eleocharis palustris*, *Leymus cinereus*, and *Pascopyrum smithii.*

Sarcobatus vermiculatus and *Ericameria nauseosa* are intolerant of periodic inundation and waterlogged soils and typically increase with water table drawdown (Cooper et al. 2006). *Sarcobatus vermiculatus* is an obligate phreatophyte and is able to tap into groundwater at great depth (>10 meters). Severe fires can kill *Sarcobatus vermiculatus* although it commonly sprouts after low- to moderate-severity fire (Anderson 2004). Fire regime for associated greasewood flat plant communities is generally less than 100 year return interval (Anderson 2004) although LANDFIRE (2007) applied fire regime V (200 + years) and assumed fire to be a minor driver within this system. Grazing and other disturbances can lead to biomass increases in the spring associated with an increase in *Bromus tectorum* and other fine fuel annuals which influence fire regime (Brown and Smith 2000). *Sarcobatus vermiculatus* is noted to be important winter browse for domestic sheep, cattle, big game animals, as well, as jackrabbits (Anderson 2004). It provides quality forage throughout the growing season although it contains soluble sodium and potassium oxalates that may cause poisoning and death in domestic sheep and cattle (Anderson 2004). Livestock grazing is reported to decrease small mammal numbers in *Sarcobatus vermiculatus / Distichlis stricta* (=*Distichlis spicata)* vegetation in Nevada and adjacent California (Page et al. 1978). *Distichlis spicata* is considered a grazing increaser. Grazing early when the upper part of the soil may be wet can sometimes cause compaction.

Stressors

The primary stressors of this system are alteration of hydrology, livestock practices, annual exotic species invasion, fire regime alteration, and fragmentation. Any activity resulting in hydrological alterations, sedimentation, nutrient inputs, and/or physical disturbance may negatively shift species composition and allow for non-native species establishment. Declining water tables create perennially dry soils, stop surface salt accumulation, and allow salts to leach deeper that create a drier, less saline soil resulting in a change in vegetation composition and pattern (Cooper et al. 2006). The tall perennial pepperwood (*Lepidium latifolium*), a nonnative invasive species decreases the abundance of shorter native grasses and forbs. The introduction of *Bromus tectorum* into these communities has altered fuel loads and fuel distribution. Fire drastically alters the community composition because salt-desert shrubs are not adapted to periodic fire.

Ecological Integrity Assessment

The following table (Table C-34) displays metrics chosen to measure most of the key ecological attributes in the conceptual ecological model. Unless otherwise noted, metric ratings apply to both Level 2 and Level 3 EIAs. The difference is that a Level 3 EIA will use more intensive and precise methods to determine metric ratings such as: (1) nitrogen enrichment (C:N); (2) phosphorous enrichment (C:P); (3) soil organic carbon; (4) soil salinity; (5) soil bulk density; and (6) water table depth/fluctuation.

Table C-34. Intermountain Basins Greasewood Flat Ecological Integrity Assessment Scorecard.

Metric	Justification	Rank			
		A (5 points)	B (4 points)	C (3 points)	D (1 point)
Key ecological attribute – Landscape context					
Edge length	Intactness of edge can be biotically and abiotically important	≥75% of edge bordered by natural communities	≥50–75% of edge bordered by natural communities	≥25–50% of edge bordered by natural communities	<25% of edge bordered by natural communities
Edge width		Average width of edge ≥200m	Average width of edge ≥100–200m	Average width of edge ≥50–100m	Average width of edge <50m

Edge condition		>95% native vegetation cover; <5% non-native cover; intact soils and no refuse	75–95% cover native vegetation; 5–25% cover of non-native plants; intact or moderately disrupted soils and little refuse	25–50% cover non-native plants; moderate or extensive soil disruption and refuse	>50% cover non-native plants; barren ground; highly compacted or otherwise disrupted soils and refuse
Connectivity	Intact areas have continuous corridor of natural or semi-natural vegetation	Intact: Embedded in 90–100% natural habitat; connectivity expected to be high; mosaic with gradients	Variegated: Embedded in 60–90% natural habitat; connectivity generally high, but lower for species sensitive to habitat modification; mosaic with both gradients and abrupt boundaries	Fragmented: Embedded in 20–60% natural habitat; connectivity generally low, but varies with species mobility and arrangement on landscape; gradients shortened	Relictual: Embedded in <20% natural habitat; connectivity essentially absent; remaining habitat uniform
Landscape condition	Intensity and types of land uses in surrounding landscape can affect ecological integrity	Landscape Condition Model Index >0.8		Landscape Condition Model Index 0.8–0.65	Landscape Condition Model Index <0.65
Relative patch size	Indicates proportion lost due to stressors	Site at or minimally reduced from natural extent (≥95% remains)	Occurrence modestly reduced from original natural extent (≥80-95% remains)	Occurrence substantially reduced from original natural extent (≥50–80% remains)	Occurrence severely reduced from original natural extent (<50% remains)
Absolute patch size	Important for buffering surrounding impacts and supporting wide range of plant associations	>4000ha	400–4000ha	20–400ha	<20ha
Key ecological attribute – Vegetation condition					
Cover of native species	Natives dominate system; non-natives increase with human impacts	Cover of native plants ≥95%	Cover of native plants ≥80–95%	Cover of native plants ≥50–80%	Cover of native plants <50%
Cover of invasive species	Invasive species inflict wide range of impacts; early detection critical	None present	Invasive species present, but sporadic (<3% cover)	Invasive species prevalent (3–10% cover)	Invasive species abundant (>10% cover)
Cover of native increasers	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	Composition of native species can shift when exposed to stressors.	Diversity/abundance at or near reference standards; native species negative to anthropogenic degradation are present, species positive to anthropogenic degradation are absent to minor; full range of indicator species present	Diversity/abundance close to reference standards; native species reflective of anthropogenic degradation; some indicator species absent	Diversity/abundance differs from reference standards, but largely composed of native species; may include ruderal species; many indicator species absent	Vegetation severely altered from reference standards; dominated by ruderal species or comprised of planted stands of non-characteristic species or unnaturally dominated by single species; most indicator species absent
Key ecological attribute: Physicochemical and hydrology					
Soil surface condition	Disturbance can result in erosion with negative affects on ecological processes; bareground amount varies naturally with site type	Bare soil areas limited to naturally caused disturbances such as burrowing animals or game trails	Bare soil due to humans and livestock, but extent and impact aniimal		Bare soil areas substantial and they contribute to long-lasting impacts; deep ruts from machinery present or livestock trails apparent

Water source	Anthropogenic sources of water have detrimental effects on hydrological regime	Source is natural; no indication of direct artificial water sources	Source is mostly natural, but site directly receives small amounts of inflow from anthropogenic sources	Source is primarily urban runoff, direct irrigation, pumped water, or impounded water	Water flow substantially diminished by human activity
Hydroperiod	Alteration in hydrology or sediment loads can degrade channel stability	Characterized by stable saturated hydrology or by naturally damped cycles of saturation and partial drying	Experiences minor altered inflows or drawdown/drying as compared to more natural wetlands	Somewhat altered by increased inflow from runoff or experiences moderate drawdown or drying	Altered by increased inflow from runoff or experiences large drawdown or drying
Key ecological attribute: Natural disturbance regime					
Fire condition class	Mixed severity fires can be out of range of natural variability	Fire Regime Condition Class 1 – No departure from historic regime	Fire Regime Condition Class 2 – Slight to moderate departure from historic fire regime		Fire Regime Condition Class 3 – Severe departure from historic fire regime; fire suppression evident

INTERMOUNTAIN BASINS ALKALI CLOSED DEPRESSION AND PLAYA

General Description

The Intermountain Basins Playa and the Intermountain Basins Alkali Closed Depression ecological systems occur throughout much of the cool arid and semi-arid regions of the Columbia Plateau and Great Basin either as a large or small patch type. They almost always appear within a shrubsteppe or semi-desert landscape. Biogeography separates these from the similar Warm Desert Playa and Western Great Plains Closed Depression Wetland ecological systems.

The Intermountain Basins Playa and the Intermountain Basins Alkali Closed Depression ecological systems are found in closed depressions or in terminal basins and differ by: 1) vegetation cover (Playa is typically sparse to patchily vegetated, generally <10% plant cover while Alkali Closed Depression is moderately to densely covered by herbaceous plants), 2) soil chemistry (playas are considered more saline than alkaline closed depressions), and 3) hydrological regime (playas are more intermittently flooded; closed depressions are more seasonally to semi-permanently flooded).

Precipitation and runoff characteristics in contributing basins are important to system function. During high precipitation years Intermountain Basins Playa systems may have water for 3 to 4 months and during dry years not retain any standing water. Water usually does not percolate because of an impermeable layer. Water loss is primarily through evaporation that results in a high concentration of salts in the upper soil profile. Some playas are influenced by groundwater and have minor surface flooding (Rocchio 2006). Those playas have open water early in the season and as the water evaporates salt crust is left on the soil surface from the salts dissolved in the water. This environment supports a flora adapted to seasonal soil saturation and saline conditions. Species composition varies with soil salinity and moisture and usually displays vegetation zones (Rocchio 2006). The Intermountain Basins Playa system almost always has an unvegetated or sparsely vegetated center at its lowest elevation. Mud flats may appear with the salt flats. A few plants such as *Salicornia* spp. can appear on salt flats but they mostly lack vegetation. *Schoenoplectus acutus,* typically without *Typha latifolia* due to its lower salt tolerance, can establish where flooding occurs 3 or more months. *Eleocharis palustris* can occur in areas inundated for 1 to 3 months. *Amphiscirpus nevadensis* and *Juncus balticus* can grow in areas of high water tables and saline soils. Saline wet meadow plants such as *Distichlis spicata* and *Juncus balticus* are found in seasonally saturated soils (Rocchio 2006).

NatureServe (2007) defines the Intermountain Basins Alkali Closed Depression ecological system as occurring in seasonally to semi-permanently flooded depressions that usually retain water into the growing season and dry completely only during droughts. They are located in basins with internal drainage and many are associated with groundwater (springs). Soils are alkaline to saline clays with hardpans. Seasonal drying exposes mudflats which are often colonized by pioneering species, such as *Hordeum jubatum*. Salt crust may sporadically occur on the soil surface. Species that typify this system are halophytic species such as *Distichlis spicata, Puccinellia lemmonii, Poa secunda, Muhlenbergia* spp., *Leymus triticoides (= Elymus triticoides), Schoenoplectus maritimus, Schoenoplectus americanus, Triglochin maritima*, and *Salicornia* spp. This system often occurs along the margins of perennial lakes with extremely low-gradient shorelines. This system is very similar to Western Great Plains Closed Depression Wetland (NatureServe 2007). In Washington, the Intermountain Basins Playa and the Intermountain Basins Alkali Closed Depression broadly overlap (Rocchio and Crawford 2009a), are difficult to distinguish and are therefore lumped here for the EIA applications.

Stressors

Historic and contemporary land use practices have impacted hydrologic, geomorphic, and biotic structure and function of playas on the Columbia Basin. Reservoirs, water diversions, ditches, roads, and human land uses in the contributing watershed can also have a substantial impact on the hydrological regime. Direct alteration of hydrology (i.e., channeling, draining, damming) or indirect alteration (i.e., roads or removing vegetation on adjacent slopes) results in changes in the amount and pattern of herbaceous wetland habitat. In general, excessive livestock use leads to a shift in plant species composition. Native species, such as *Juncus balticus*, increase with excessive livestock use. Non-native plants or animals, which can have wide-ranging impacts, also tend to increase with these stressors. Several exotic species invade playas including *Cardaria* spp., *Chenopodium glaucum, C. rubra*, (*Salsola* spp.), *Bassia hyssopifolia*, and *Kochia scoparia*. Although most wetlands receive regulatory protection at the national, state, and county level, many wetlands have been and continued to be filled, drained, grazed, and farmed extensively. In addition, recent Supreme Court decisions exclude many, if not most occurrences of this system, from protection under the Clean Water Act (Haukos and Smith 2003). Minor changes in the water table depth or duration of inundation can have profound effects on soil salinity, and consequently, wetland vegetation (Cooper and Severn 1992). Wetland animals, such as waterbirds, amphibians, or invertebrates are affected changes in hydrology.

Ecological Integrity Assessment

The following table (Table C-35) displays metrics chosen to measure most of the key ecological attributes in the conceptual ecological model. Unless otherwise noted, metric ratings apply to both Level 2 and Level 3 EIAs. The difference is that a Level 3 EIA will use more intensive and precise methods to determine metric ratings such as: (1) nitrogen enrichment (C:N); (2) phosphorous enrichment (C:P); (3) soil organic carbon; (4) soil bulk density; and (5) water table depth.

Table C-35. Intermountain Basins Alkali Closed Depression and Playa Ecological Integrity Assessment Scorecard.

Metric	Justification	Rank			
		A (5 points)	B (4 points)	C (3 points)	D (1 point)
Key ecological attribute – Landscape context					
Edge length	Intactness of edge can be biotically and abiotically important	≥75% of edge bordered by natural communities	≥50–75% of edge bordered by natural communities	≥25–50% of edge bordered by natural communities	<25% of edge bordered by natural communities
Edge width		Average width of edge ≥200m	Average width of edge ≥100–200m	Average width of edge ≥50–100m	Average width of edge <50m
Edge condition		>95% native vegetation cover; <5% non-native cover; intact soils and no refuse	75–95% cover native vegetation; 5–25% cover of non-native plants; intact or moderately disrupted soils and little refuse	25–50% cover non-native plants; moderate or extensive soil disruption and refuse	>50% cover non-native plants; barren ground; highly compacted or otherwise disrupted soils and refuse
Connectivity	Intact areas have continuous corridor of natural or semi-natural vegetation	Intact: Embedded in 90–100% natural habitat; connectivity expected to be high; mosaic with gradients	Variegated: Embedded in 60–90% natural habitat; connectivity generally high, but lower for species sensitive to habitat modification; mosaic with both gradients and abrupt boundaries	Fragmented: Embedded in 20–60% natural habitat; connectivity generally low, but varies with species mobility and arrangement on landscape; gradients shortened	Relictual: Embedded in <20% natural habitat; connectivity essentially absent; remaining habitat uniform
Landscape condition	Intensity and types of land uses in surrounding landscape can affect ecological integrity	Landscape Condition Model Index >0.8		Landscape Condition Model Index 0.8–0.65	Landscape Condition Model Index <0.65
Relative patch size	Indicates proportion lost due to stressors	Site at or minimally reduced from natural extent (≥95% remains)	Occurrence modestly reduced from original natural extent (≥80-95% remains)	Occurrence substantially reduced from original natural extent (≥50–80% remains)	Occurrence severely reduced from original natural extent (<50% remains)
Absolute patch size	Important for buffering surrounding impacts	>8ha	4–8ha	1–4ha	<1ha
Key ecological attribute – Vegetation condition					
Cover of native species	Natives dominate system; non-natives increase with human impacts	Cover of native plants ≥95%	Cover of native plants ≥80–95%	Cover of native plants ≥50–80%	Cover of native plants <50%
Cover of invasive species	Invasive species inflict wide range of impacts; early detection critical	None present	Invasive species present, but sporadic (<3% cover)	Invasive species prevalent (3–10% cover)	Invasive species abundant (>10% cover)
Cover of native increasers	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	Composition of native species can shift when exposed to stressors.	Diversity/abundance at or near reference standards; native species negative to anthropogenic degradation are present, species positive to anthropogenic degradation are absent to minor; full range of indicator species present	Diversity/abundance close to reference standards; native species reflective of anthropogenic degradation; some indicator species absent	Diversity/abundance differs from reference standards, but largely composed of native species; may include ruderal species; many indicator species absent	Vegetation severely altered from reference standards; dominated by ruderal species or comprised of planted stands of non-characteristic species or unnaturally dominated by single species; most indicator species absent

Key ecological attribute: Physicochemical and hydrology					
Soil surface condition	Disturbance can result in erosion with negative affects on ecological processes; bareground amount varies naturally with site type	Bare soil areas limited to naturally caused disturbances such as burrowing animals or game trails and flood deposition; salt crust often present and intact	Bare soil due to human causes, but extent and impact minimal; depth of disturbance <10cm and no evidence of ponding or channeling water; salt crust mostly intact	Bare soil due to human causes are common; machinery may have left shallow ruts; depth of disturbance 10-20cm; may be pugging due to livestock; salt crust minimally represented	Bare soil areas substantial and they contribute to long-lasting impacts; deep ruts from machinery present or livestock trails widespread;soil disturbance >20cm; water channeled or ponded; salt crust mostly absent or current year
Water quality	Excess nutrients and sediments have an adverse affect on water quality	No evidence of degraded water quality; water is clear	Water may have minimal greenish tint or cloudiness; negative features limited in area or intensity	Water may have minimal greenish tint, cloudiness, or sheen; negative indicators illustrate response to nutrients	Many negative indicators (algae mats, tint, sheen, turbidity); bottom difficult to see
Water source	Anthropogenic sources of water have detrimental effects on hydrological regime	Source is natural; no indication of direct artificial water sources	Source is mostly natural, but site directly receives small amounts of inflow from anthropogenic sources	Source is primarily urban runoff, direct irrigation, pumped water, or impounded water	Water flow substantially diminished by human activity
Hydroperiod	Alteration in hydrology or sediment loads can degrade channel stability	Characterized by stable saturated hydrology or by naturally damped cycles of saturation and partial drying	Experiences minor altered inflows or drawdown/drying as compared to more natural wetlands	Somewhat altered by increased inflow from runoff or experiences moderate drawdown or drying	Altered by increased inflow from runoff or experiences large drawdown or drying
Hydrological alteration	Degree to which adjacent land use alters the hydrological processes	No alterations such as dykes, diversions, ditches, and/or flow additions	Low intensity alterations such as dykes, diversions, ditches, and/or flow additions	Moderate intensity alterations such as dykes, diversions, ditches, roads, and/or flow additions	High intensity alterations such as roads, dykes, diversions, ditches, and/or flow additions

COLUMBIA PLATEAU VERNAL POOL

General Description

The Columbia Plateau Vernal Pool small patch system occurs throughout the exposed volcanic scablands on the Columbia Plateau in Washington, Oregon, and northern Nevada. Washington occurrences are concentrated in the Channeled Scablands and glaciated areas in Spokane, Lincoln, Douglas, southern Okanogan, Grant, Whitman and Adams counties. They are often found within a mounded or biscuit-swale topography within *Artemisia* shrubsteppe, bunchgrass steppe or rarely *Pinus ponderosa* savanna. They are characterized by freshwater inundation for much of the winter and spring, followed by dramatic lowering of the water table at the approach of summer, such that soils are dry in the summer. They are found in isolated small depressions with no inflow or outflow and a restrictive subsurface soil layer (clay or bedrock). Vegetation is dominated primarily by annual forbs. This EIA also applies to the Modoc Basalt Flow Vernal Pool ecological system found on exposed basalt along the Columbia River Gorge in Klickitat County, Washington.

The Columbia Plateau Vernal Pool system occurs as shallow ephemeral wetlands in very small (3 m^2) to rarely large depressions (260 ha). Bjork and Dunwiddie (2004) measured 242 vernal pools in Washington to be between 3 m^2 and 4,610 m^2 with a 1,590 m^2 average. Vernal pools mostly are located on massive basalt flows exposed by Pleistocene floods but also occur on andesite or rhyodacite caprock. Often perched above the surrounding landscape, vernal pools are generally not subject to runoff from major stream systems. Climatically, the system is defined by wet winters (November through January) and severe summer drought (July-September), although May or June can be wet. Pool inundation primarily results from direct precipitation and varies yearly and seasonally, and with the size of the small upland watershed associated with a vernal pool or in some cases, surface runoff from adjacent pools or wetlands (Environmental Science Associates 2007). Inundation is highly irregular, sometimes not occurring for several years. Depressions usually (but not always) fill with water during winter and spring and generally dry well within 9 months. In exceptional times they can remain inundated for two consecutive years. Soil texture is typically silty clay, sometimes with sandy margins.

The periodic inundation and drying leads to development of concentric zones of different plants as the pools dries (Crowe et al. 1994). Characteristic plants species of this system are predominantly annual and diverse. Floristically this system is akin to the California vernal pool flora (approximately one-third); however, many of the most abundant species are not reported in Californian pools (Bjork and Dunwiddie 2004). Characteristic species include *Callitriche marginata, Camissonia tanacetifolia, Elatine* spp., *Epilobium densiflorum (= Boisduvalia densiflora), Eryngium vaseyi, Juncus uncialis, Myosurus X clavicaulis, Plagiobothrys* spp., *Polygonum polygaloides* ssp. *confertiflorum, Polygonum polygaloides* ssp. *polygaloides, Psilocarphus brevissimus, Psilocarphus elatior, Psilocarphus oregonus*, and *Trifolium cyathiferum* (Bjork 1997; Bjork and Dunwiddie 2004). *Artemisia ludoviciana* ssp. *ludoviciana* can occur on better developed soils. When full, the pool's water column and saturated substrates support assemblages of macroinvertebrates as well as habitat for mobile invertebrates adapted to ephemeral wetlands (Environmental Science Associates 2007). Fairy shrimps (Anostraca) are found in vernal pools along with birds and amphibians (Environmental Science Associates 2007). Pools provide water storage and support nitrogen transformation (Environmental Science Associates 2007).

Biogeographic differences separate this system from the Modoc Basalt Flow Vernal Pool and geography and soil type/parent material from the North Pacific Hardpan Vernal Pool. Annual plant dominance and lack of surface salt deposits distinguish the Columbia Plateau Vernal Pool from the Intermountain Basin Alkaline Closed Depression.

Stressors

Historic and contemporary land use practices have impacted hydrologic, geomorphic, and biotic structure and function of vernal pools on the Columbia Basin. Reservoirs, water diversions, ditches, roads, and human land uses in the contributing watershed can also have a substantial impact on the hydrological regime. Direct alteration of hydrology (i.e., channeling, draining, damming) or indirect alteration (i.e., roading or removing vegetation on adjacent slopes) results in changes in amount and pattern of herbaceous wetland habitat. In general, excessive livestock use leads to a shift in plant species composition. Several exotic species can invade this habitat with grazing or other soil disturbance. Native species, such as *Juncus bufonis* and *Polygonum aviculare* increase with excessive livestock use and *Eleocharis* spp. decrease (Brown 2001). Vernal pool invasibility depends on multiple biotic and physical factors including hydrologic regime, soil nutrient properties, the native plant community, site disturbance history and climatic variability (Environmental Science Associates 2007). Southern Oregon vernal pools showed a pattern noted in California vernal pools of non-native plant species occurring in higher abundance in the outer edge or "flank" zone of pools (Environmental Science Associates 2007).

Invasion likely occurs as an indirect result of the prevalence of non-native upland plants in the surrounding uplands (Environmental Science Associates 2007). Zedler (1987) stated that "moderate cattle or horse grazing does not seem to pose much of a threat to the persistence of vernal pool plants despite the disruptive effect of trampling". Brown (2001) following a 2-year study in eastern Washington found a significantly greater cover of weedy species in grazed vernal pools. Grazing livestock has been experimentally correlated with a significantly longer duration of vernal pool hydrology during dry-down stage, in comparison to ungrazed pools (Environmental Science Associates 2007).

Non-native plants or animals, which can have wide-ranging impacts, also tend to increase with these stressors. Several exotic species invade vernal pools particularly upper zones: *Centaurea spp., Cirsium arvense, Descurainia sophia, Elytrigia repens, Phalaris arundinacea, Poa compressa, Poa pratensis,* and *Sisymbrium altissimum* (Bjork and Dunwiddie 2004). Although most wetlands receive regulatory protection at the national, state, and county level, many wetlands have been and continued to be filled, drained, grazed, and farmed extensively. Even minor changes in the water table depth or duration of inundation can have profound effects on soil salinity, and consequently, wetland vegetation (Cooper and Severn 1992). Wetland animals, such as waterbirds, amphibians, or invertebrates are affected changes in hydrology.

Ecological Integrity Assessment

The following table (Table C-36) displays metrics chosen to measure most of the key ecological attributes in the conceptual ecological model. Unless otherwise noted, metric ratings apply to both Level 2 and Level 3 EIAs. The difference is that a Level 3 EIA will use more intensive and precise methods to determine metric ratings such as: (1) presence of vernal pool fairy shrimp (Environmental Science Associates 2007); (2) average maximum depth of pool (Environmental Science Associates 2007); (3) percent of watershed containing wetlands (Environmental Science Associates 2007); and (4) gopher mounds abundance (Environmental Science Associates 2007).

Table C-36. Columbia Plateau Vernal Pool Ecological Integrity Assessment Scorecard.

Metric	Justification	Rank			
		A (5 points)	B (4 points)	C (3 points)	D (1 point)
Key ecological attribute – Landscape context					
Edge length	Intactness of edge can be biotically and abiotically important	≥75% of edge bordered by natural communities	≥50–75% of edge bordered by natural communities	≥25–50% of edge bordered by natural communities	<25% of edge bordered by natural communities
Edge width		Average width of edge ≥200m	Average width of edge ≥100–200m	Average width of edge ≥50–100m	Average width of edge <50m
Edge condition		>95% native vegetation cover; <5% non-native cover; intact soils and no refuse	75–95% cover native vegetation; 5–25% cover of non-native plants; intact or moderately disrupted soils and little refuse	25–50% cover non-native plants; moderate or extensive soil disruption and refuse	>50% cover non-native plants; barren ground; highly compacted or otherwise disrupted soils and refuse
Connectivity	Intact areas have continuous corridor of natural or semi-natural vegetation	Intact: Embedded in 90–100% natural habitat; connectivity expected to be high; mosaic with gradients	Variegated: Embedded in 60–90% natural habitat; connectivity generally high, but lower for species sensitive to habitat modification; mosaic with both gradients and abrupt boundaries	Fragmented: Embedded in 20–60% natural habitat; connectivity generally low, but varies with species mobility and arrangement on landscape; gradients shortened	Relictual: Embedded in <20% natural habitat; connectivity essentially absent; remaining habitat uniform

Landscape condition	Intensity and types of land uses in surrounding landscape can affect ecological integrity	Landscape Condition Model Index >0.8		Landscape Condition Model Index 0.8–0.65	Landscape Condition Model Index <0.65
Relative patch size	Indicates proportion lost due to stressors	Site at or minimally reduced from natural extent (≥95% remains)	Occurrence modestly reduced from original natural extent (≥80-95% remains)	Occurrence substantially reduced from original natural extent (≥50–80% remains)	Occurrence severely reduced from original natural extent (<50% remains)
Absolute patch size	Important for buffering surrounding impacts	>0.02ha	0.001–0.02ha		<0.001ha
Key ecological attribute – Vegetation condition					
Cover of native species	Natives dominate system; non-natives increase with human impacts	Cover of native plants ≥95%	Cover of native plants ≥80–95%	Cover of native plants ≥50–80%	Cover of native plants <50%
Cover of invasive species	Invasive species inflict wide range of impacts; early detection critical	None present	Invasives (*Cirsium arvense*, *Elytrigia repens* and *Taeniatherum caputmedusae*) present, but sporadic (<3% cover)	Invasive species prevalent (3–10% cover)	Invasive species abundant (>10% cover)
Cover of native increasers	Stressors such as grazing can shift or homogenize native composition toward species tolerant of stressors.	Absent or incidental	Invasives (*Apera interrupta*, *Hypericum perforatum*, *Lactuca serriola*, *Poa bulbosa*, *Sisymbrium altissimum*, and *Taeniatherum caputmedusae*) present, but sporadic (<50% cover); litter thatch <65%	Invasives prevalent (50-75% cover); litter that 65-80%	Invasives abundant (>75% cover); litter thatch >80%
Species composition	Composition of native species can shift when exposed to stressors.	Diversity/abundance at or near reference standards; native species negative to anthropogenic degradation are present, species positive to anthropogenic degradation are absent to minor; full range of indicator species present	Diversity/abundance close to reference standards; native species reflective of anthropogenic degradation; some indicator species absent	Diversity/abundance differs from reference standards, but largely composed of native species; may include ruderal species; many indicator species absent	Vegetation severely altered from reference standards; dominated by ruderal species or comprised of planted stands of non-characteristic species or unnaturally dominated by single species; most indicator species absent
Key ecological attribute: Physicochemical and hydrology					
Soil surface condition	Disturbance can result in erosion with negative affects on ecological processes; bareground amount varies naturally with site type	No evidence of alteration by anthropogenic sources	Minor soil disturbance; confined in intensity (livestock hoof marks) or area (<25% of vernal pool complex)	Moderate degree of disturbance, either in intensity or area (25-50% of vernal pool complex)	High degree of disturbance in intensity and area (>50% of vernal pool complex)
Water source	Anthropogenic sources of water have detrimental effects on hydrological regime	Source is natural; no indication of direct artificial water sources	Source is mostly natural, but site directly receives small amounts of inflow from anthropogenic sources	Source is primarily urban runoff, direct irrigation, pumped water, or impounded water	Water flow substantially diminished by human activity
Hydroperiod	Alteration in hydrology or sediment loads can degrade channel stability	Characterized by stable saturated hydrology or by naturally damped cycles of saturation and partial drying	Experiences minor altered inflows or drawdown/drying as compared to more natural wetlands	Somewhat altered by increased inflow from runoff or experiences moderate drawdown or drying	Altered by increased inflow from runoff or experiences large drawdown or drying
Hydrologic alteration	Degree to which adjacent land use alters the hydrological processes	No alterations such as dykes, diversions, ditches, and/or flow additions	Low intensity alterations such as dykes, diversions, ditches, and/or flow additions	Moderate intensity alterations such as dykes, diversions, ditches, roads, and/or flow additions	High intensity alterations such as roads, dykes, diversions, ditches, and/or flow additions

COLUMBIA BASIN FOOTHILL RIPARIAN WOODLAND AND SHRUBLAND

General Description

This is a low-elevation riparian system found in the Columbia River Basin at and below lower tree line and associated with the main stem of the Columbia River and associated tributaries including those on the periphery of the surrounding mountains. This system is found in low-elevation canyons and draws, on floodplains, steep-sided canyons, or narrow V-shaped valleys with rocky substrates. This includes both perennial and intermittent streams. Sites are typically subject to temporary flooding during spring or late winter runoff. Overbank flooding and some gravel areas are required for regeneration of these riparian forests and woodlands, especially for cottonwoods. Large bottomlands may have large occurrences, but most have been cut over or cleared for agriculture. Beavers crop younger cottonwood and willows and frequently dam side channels. Important and diagnostic trees include *Populus balsamifera* ssp. *trichocarpa, Alnus rhombifolia, Populus tremuloides, Celtis laevigata* var. *reticulata, Betula occidentalis*, or *Pinus ponderosa*. Important shrubs associated with smaller streams include *Crataegus douglasii, Philadelphus lewisii, Cornus sericea, Salix lucida* ssp. *lasiandra, Salix eriocephala, Rosa nutkana, Rosa woodsii, Amelanchier alnifolia, Prunus virginiana*, and *Symphoricarpos albus* (Crawford 2001).

Stressors

Historic and contemporary land use practices have impacted hydrologic, geomorphic, and biotic structure and function of riparian areas in eastern Washington. Human land uses both within the riparian area as well as in adjacent and upland areas have fragmented many riparian reaches which has reduced connectivity between riparian patches and riparian and upland areas. Adjacent and upstream land uses also have the potential to contribute excess nutrients into riparian areas. Reservoirs, water diversions, ditches, roads, and human land uses in the contributing watershed can have a substantial impact on the hydrology regime. Management effects on woody riparian vegetation can be obvious, e.g., removal of vegetation by dam construction, roads, logging, or they can be subtle, e.g., removing beavers from a watershed, removing large woody debris, or construction of a weir dam for fish habitat. Grazing is a major influence in altering structure, composition, and function of the system (Kaffman et al 2004). In general, excessive livestock or native ungulate use leads to less woody cover and an increase in sod-forming grasses particularly on fine-textured soils. Undesirable forb species, such as *Urtica* and *Equisetum*, increase with livestock use. Non-native plants or animals, which can have wide-ranging impacts, also tend to increase with these stressors. All of these stressors have resulted in many riparian areas being incised, supporting altered riparian plant communities, as well as numerous non-native species. This system has also decreased in extent due to agricultural development, roads, dams and other flood-control activities.

Ecological Integrity Assessment

The following table (Table C-37) displays metrics chosen to measure most of the key ecological attributes in the conceptual ecological model. Unless otherwise noted, metric ratings apply to both Level 2 and Level 3 EIAs. The difference is that a Level 3 EIA will use more intensive and precise methods to determine metric ratings such as: (1) Benthic invertebrate Index of Biotic

Integrity (BIBI; WADOE 2003, statewide data are maintained by WADOE at http://www.ecy.wa.gov/apps/watersheds/streambio/regions/state.asp?symtype=1); (2) Index of Hydrological Alteration (Richter et al. 1997); (3) specific water quality measures (e.g., the temperature, dissolved oxygen, pH, conductivity, and turbidity of stream water; (4) Pool Quality Index (May 2002, may need modification for Eastside riparian systems); and (5) Riffle Quality Index (May 2002, may need modification for Eastside riparian systems).

Table C-37. Columbia Basin Foothill Riparian Woodland and Shrubland Ecological Integrity Assessment Scorecard.

Metric	**Justification**	**Rank**			
		A (5 points)	**B (4 points)**	**C (3 points)**	**D (1 point)**
Key ecological attribute – Landscape context					
Edge length	Intactness of edge can be biotically and abiotically important	≥75% of edge bordered by natural communities	≥50–75% of edge bordered by natural communities	≥25–50% of edge bordered by natural communities	<25% of edge bordered by natural communities
Edge width		Average width of edge ≥200m	Average width of edge ≥100–200m	Average width of edge ≥50–100m	Average width of edge <50m
Edge condition		>95% native vegetation cover; <5% non-native cover; intact soils and no refuse	75–95% cover native vegetation; 5–25% cover of non-native plants; intact or moderately disrupted soils and little refuse	25–50% cover non-native plants; moderate or extensive soil disruption and refuse	>50% cover non-native plants; barren ground; highly compacted or otherwise disrupted soils and refuse
Connectivity	Land cover/uses in watershed have significant effects on ecological processes	Watershed primarily natural; no connectivity barriers/dams; <5% urban and agriculture; no recent clearcuts	Landscape primarily natural; connectivity mostly retained; 5-20% urban or agriculture; <30% clearcut	20-50% urban or agriculture; limited connectivity; <50% in clearcuts	>50% urban or agriculture; connectivity largely disrupted (dams)
Landscape condition	Intensity and types of land uses in surrounding landscape can affect ecological integrity	Landscape Condition Model Index >0.8		Landscape Condition Model Index 0.8–0.65	Landscape Condition Model Index <0.65
Relative patch size	Indicates proportion lost due to stressors	Site at or minimally reduced from natural extent (≥95% remains)	Occurrence modestly reduced from original natural extent (≥80-95% remains)	Occurrence substantially reduced from original natural extent (≥50–80% remains)	Occurrence severely reduced from original natural extent (<50% remains)
Absolute patch size	Important for buffering impacts along steams with limited floodplains	>8 linear km	5-8 linear km	1.5-5.0 lenear km	<1.5 linear km
	Important for buffering impacts along meandering streams with well-developed floodplains	>25 meander wavelengths or >50 point bars	10-25 meander wavelengths or 20-50 point bars	4-10 meander wavelengths or 8-20 point bars	<4 meander wavelengths or <8 point bars
Patch diversity	Good hydrological processes help produce diverse seral patches and connectivity without anthropogenic effects	Connectivity within riparian reach unfragmented; heterogenous mix of connected patch types; mixed species and seral stages	Connectivity of confined reaches may be fragmented; connectivity and diversity present between patches	Connectivity of confined reaches moderately fragmented; connectivity and diversity restricted between patches; some patches isolated	Confined reaches severely fragmented; homogenous patch types; fragmentation prevalent
Key ecological attribute – Vegetation condition					
Cover of native species	Natives dominate system; non-natives increase with human impacts	Cover of native plants ≥95%	Cover of native plants ≥80–95%	Cover of native plants ≥50–80%	Cover of native plants <50%
Cover of invasive species	Invasive species inflict wide range of impacts; early detection critical	None present	Invasive species present, but sporadic (<3% cover)	Invasive species prevalent (3–10% cover)	Invasive species abundant (>10% cover)

Cover of native increasers	Stressors such as grazing can shift or homogenize native composition	Absent or incidental	<10% cover	10-20% cover	>20% cover
Species composition	Composition of native species can shift when exposed to stressors.	Diversity/abundance at or near reference standards; native species negative to anthropogenic degradation are present, species positive to anthropogenic degradation are absent to minor; full range of indicator species present	Diversity/abundance close to reference standards; native species reflective of anthropogenic degradation; some indicator species absent	Diversity/abundance differs from reference standards, but largely composed of native species; may include ruderal species; many indicator species absent	Vegetation severely altered from reference standards; dominated by ruderal species or comprised of planted stands of non-characteristic species or unnaturally dominated by single species; most indicator species absent
Canopy cover and condition	Diversity of age classes indicator of integrity	Cover generally >50%; Mixed canopy of sufficient size to provide future large woody debris		Somewhat homogenous in density and age or <50% canopy cover	Extremely homogenous, sparse, or absent (<10% cover)
Regeneration of woody species	Amount and distribution of regeneration important for system integrity	Saplings/seedlings of native woody species present in expected amount	Saplings/seedlings of native woody species present, but less than expected	Saplings/seedlings of native woody species present, but in low abundance	No reproduction of native woody species
Organic matter accumulation	Accumulation of coarse and fine debris is integral to ecological processes	Characterized by wide size class diversity of downed coarse woody debris (logs) and standing snags		Moderately wide size class diversity of downed coarse woody debris (logs) and snags	Low size class diversity of downed coarse woody debris (logs) and snags
Key ecological attribute: Physicochemical and hydrology					
Soil surface condition	Disturbance can result in erosion with negative affects on ecological processes; bareground amount varies naturally with site type	Bare soil areas limited to naturally caused disturbances such as burrowing animals or game trails	Bare soil due to human causes, but extent and impact minimal; no evidence of ponding or channeling water	Bare soil due to human causes are common; machinery may have left shallow ruts; may be pugging due to livestock	Bare soil areas substantial and they contribute to long-lasting impacts; deep ruts from machinery present or livestock trails widespread; water channeled or ponded
Water quality	Excess nutrients and sediments have an adverse affect on water quality	No evidence of degraded water quality; water is clear	Water may have minimal greenish tint or cloudiness; negative features limited in area or intensity	Water may have minimal greenish tint, cloudiness, or sheen; negative indicators illustrate response to nutrients	Many negative indicators (algae mats, tint, sheen, turbidity); bottom difficult to see
Water source	Anthropogenic sources of water have detrimental effects on hydrological regime	Source is natural; no indication of direct artificial water sources	Source is mostly natural, but site directly receives small amounts of inflow from anthropogenic sources	Source is primarily urban runoff, direct irrigation, pumped water, or impounded water	Water flow substantially diminished by human activity
Channel stability	Alteration in hydrology or sediment loads or some onsite stressors can degrade channel stability	Natural channel; no evidence of aggradation or degradation	Most of the channel has aggradation or degradation, none of which is severe	Evidence of severe degradation of most of the channel	Concrete, or artificially hardened channels through the site
Streambank stability	Stable streambanks indicative of intact hydrological and sediment regimes	Stable: perennial vegetation to waterline; no raw or undercut banks; no recently exposed roots	Slightly stable: perennial vegetation to waterline in most places; minor erosion	Moderately unstable: perennial vegetation to waterline sparse (scoured or removed by erosion); bank held in place by trees and bolders; extensive erosion	Completely unstable: no perennial vegetation to waterline; banks only held in place by roots and bolders; severe erosion
Hydrological connectivity (level 2)	Floodwater should have access to floodplain; stressors resulting in entrenchment affect hydrological connectivity	Completely connected to floodplain (backwater sloughs and channels)	Minimally disconnected from floodplain by dikes and elevated culverts	Moderately disconnected from floodplain by dikes and elevated culverts	Extensively disconnected from floodplain by dikes and elevated culverts
Hydrological connectivity (level 3)		Unconfined entrenchment ratio >4.0; confined entrenchment ratio >1.4	Unconfined entrenchment ratio 1.4-2.2; confined entrenchment ratio 1.0-1.4	Unconfined entrenchment ratio <1.4; confined entrenchment ratio <1.0	

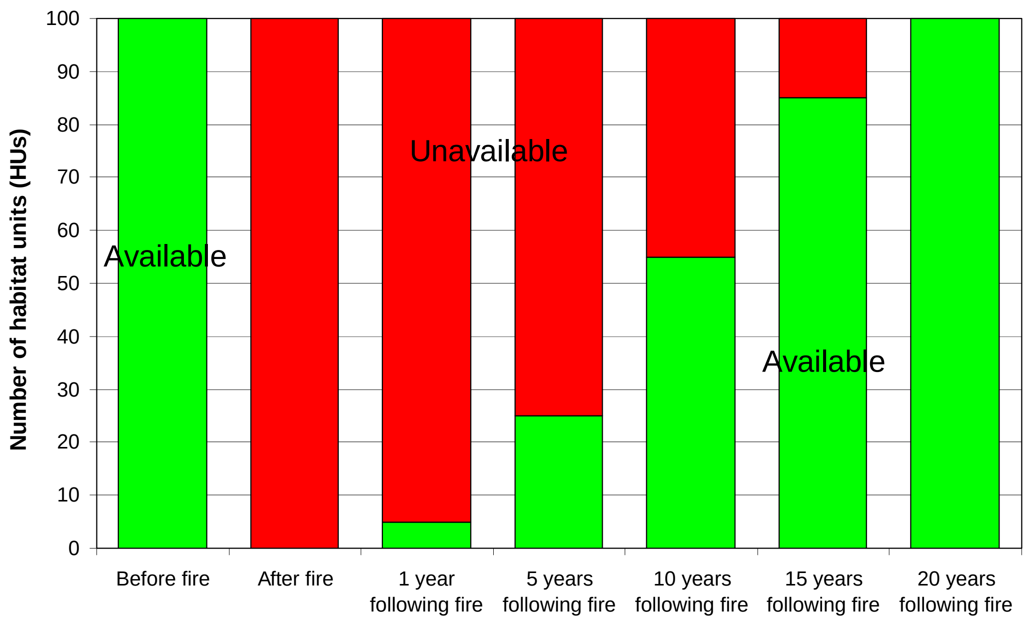
APPENDIX D: HABITAT EVALUATION PROCEDURES

GENERAL DESCRIPTION

Habitat Evaluation Procedures (HEPs) were developed by the US Fish and Wildlife Service (USFWS) to quantify the quality and abundance of available habitat for selected wildlife species. HEPs have provided the majority of information on habitat condition and trend on wildlife areas, and consequently this report will focus on the methods used to collect this data up to this date (originally compiled by Ashley 2007). HEPs provide information for two general types of wildlife habitat comparisons: 1) the relative value of different habitats at the same point in time; and 2) the relative value of the same area at different points in time. By combining the two types of comparisons, the impact of actual, proposed, or anticipated land and water use changes on diverse wildlife habitats can be quantified.

HEPs are based on ecological principles and the assumption that habitat for selected wildlife species can be described as a numerical value known as a Habitat Suitability Index (HSI). This value is derived from an evaluation of the ability of key habitat components to supply the resource needs of focal species of fish and wildlife. The HSI values (ranging from 0.0 for no value to a maximum of 1.0) are multiplied by the area of available habitat to obtain Habitat Units (HUs), which are for mitigation purposes, the "currency" used to measure/compare habitat losses and gains. For example, when an event such as the fire occurs, wildlife habitat and associated HUs may become unavailable to wildlife (Fig. D-1). The unavailable habitat units are gained incrementally each year until mitigation objectives are met. In this example, it will take 15 to 20 years for the 100 HUs in the burned area to reach conditions similar to those found prior to the fire. If the habitat recovered in one year, then the entire 100 HUs would be realized and mitigation would be complete.

Fig. D-1. Theoretical change in the number of available HUs before and after a fire.



HSI-values typically vary by cover type. A cover type refers to an area of land or water with similar physical, chemical, and biological characteristics that meet a specified standard of homogeneity. For example, current monitoring and evaluation procedures tend to focus on relatively general categories such as grassland (areas comprised of grasses and forbs having less than 5% shrub canopy closure) and shrubsteppe (areas comprised of grasses and forbs having at least 5% shrub canopy closure). Homogeneity is a relative term and is affected by our ability to: 1) map specific habitat types; 2) develop understandable, testable, and defendable HSIs; and 3) understand complex wildlife-habitat relationships. As a consequence of these considerations, the cover types used in current HEPs tend to be relatively simple. HEP transects should be distributed to monitor focal habitats and change. Effective monitoring necessitates the placement of some transects in habitats not directly effected by enhancements or maintenance activities (about 25% of transects). These transects essentially serve as a 'control' in subsequent evaluations of management. Replication of HEP transects every 5 years is recommended. Subsequent HEPs should be conducted about the same general time of year, to avoid differences in plant phenology.

In general, the methods for monitoring and evaluating habitat in Washington are focused more on frequency of occurrence rather than specific coverage, particularly for herbaceous vegetation. Percent frequency was selected as the primary monitoring technique because it is appropriate for any plant species' growth form. For example, it is appropriate for monitoring some annual species, whose density may vary year-to-year, but whose spatial arrangement of germination remains fairly stable. Rhizomatous species, especially grasses, are often measured by frequency because there is no need to define a sampling unit such as percent cover or density. Frequency is also a good measure for monitoring invasions of undesirable species as well as increases or decreases in desirable species. Another advantage of frequency methods is that there is a longer time window for sampling. Once plants have germinated, frequency measurements are fairly stable throughout the growing season, as compared to cover measurements, which can change considerably from week to week as plants grow. The biggest advantage of frequency methods, however, is that the only decision required by the observer is whether or not a species occurs within the plot. Technicians can be easily taught to measure frequency with minimal training on methodology and species identification. If the species is easy to recognize, frequency plots can be evaluated quickly.

Methods for monitoring and evaluating habitat have evolved throughout the course of HEP work in the state of Washington. Consequently, it is not possible to describe a single set of methods that is applicable to all HEP work. Nevertheless, the following document will provide some background for most of the techniques used, even if consistency between years and areas is not always possible.

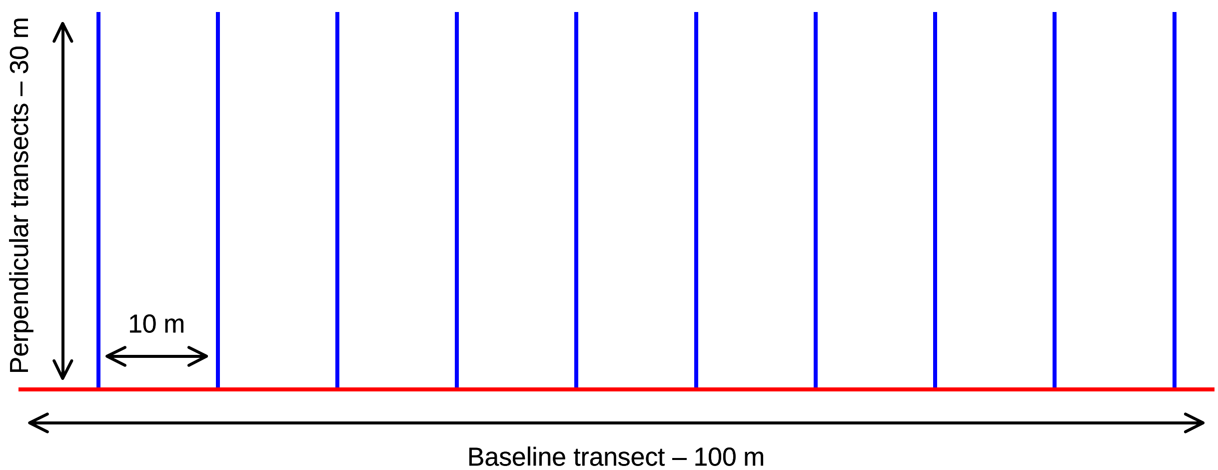
Transects have been the fundament tool used to measure habitat characteristics needed in HEPs. A minimum of two transects have been, or should be, established for each cover type on each wildlife area unit. Transects should be randomly placed within defined open cover types (i.e., grassland, shrubsteppe, and Conservation Reserve Program (CRP) so that transects are stratified by geographic area, at least 100 meters from the edge of the cover type (unless the cover type is restricted in size and configuration), and away from roads and other anthropogenic factors (unless the disturbed area is the target for the evaluation).

Transects should be regularly repeated in all cover types, but especially where the habitat is being enhanced. The interval should be about 5-years or less depending on the rapidity of habitat change. For example, weed-control projects should be monitored at two-year intervals. Monitoring can also be expanded to address specific management efforts such as alteration in the grazing regime or fire frequency.

METHODS FOR OPEN HABITATS

Two types of transects configurations are used in open habitats. In one technique, 100-meter baseline transects are oriented along a random azimuth. An alternate azimuth (random or varied by 45 degrees from first azimuth) is used if the first baseline transect exits the cover type. Ten 30-meter transects are anchored on the baseline transect and oriented at a 90 degree angle (perpendicular) to the baseline transect. The location of the first perpendicular transect is selected at random location between 0-10 meters from the start point on the baseline transect. The following perpendicular transects are placed systematically at ten-meter intervals on the baseline transect. For example, if the first perpendicular transect is positioned at the 5-meter mark, the second transect is placed at the 15-meter mark, the third at the 25-meter, and so on until 10 perpendicular transects are established (Fig. D-2).

Fig. D-2. Layout of baseline and perpendicular transects for HEP work.

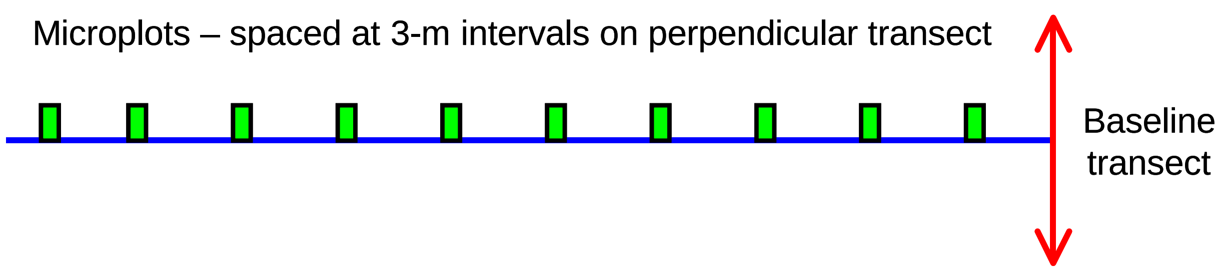


In the second type of transect configuration, the baseline transect is used as the primary data-collection transect with no perpendicular transects. The techniques are generally similar, except that the baseline transect is longer in the second technique and the distances between data collection points varies. In addition, with the second technique, the transect direction is altered every 100 meters (or 300 feet depending on the type of tape measure used), or if the cover type changes. In situations where a new azimuth is needed, either a random direction is chosen, or a 45-degree turn is used and the ‘right or left’ decision is determined with the flip of a coin. Regardless of the transect configuration used, transect start, end, and turn points are permanently marked with a 36-cm long 0.6-cm rebar stakes painted fluorescent orange or red.

Start, end, and turn points on the baseline transects are determined with GPS equipment. Other relevant information, including observers, date, and azimuths (controlled for declination) are also be recorded. At least one photo is taken at the start point on each baseline transect. The camera is positioned one meter above the ground (use 1-m cover board or similar device for camera rest). The photo includes a 1.5-meter cover board (1.5 m X 0.1 m rectangle with alternating white and red bands at 1-dm intervals) 10-meters in front of the camera, as well as the transect photo board (relevant information for transect identification). The photo is taken from the start point of the baseline transect and facing the transect direction. The camera type, aperture, distance and azimuth to cover board, cover board dimensions, date, time of day, transect/location identification, GPS coordinates, and photographer are recorded. Additional photos are used to document the habitat, but basic information such as date, location, and direction is critical.

Herbaceous vegetation (forbs, grasses, and noxious weeds), biological crusts, bare ground, and rock are measured with the aid of microplots. Microplots are positioned systematically at 3-meter intervals along each perpendicular transect from a random start point (Fig. D-3) or at intervals of 6.10 meters (20 feet) or 7.62 meters (25 feet) on the baseline transect. The placement of microplots on the perpendicular transects is determined by selecting a random number between 0 and 3 (the first data collection point for the perpendicular transect). Starting at the first data collection point, place the microplots at 3-meter intervals along the perpendicular transect until 10 microplot measurements are taken. For example, if the first data point is located at 2 meters on the perpendicular transect, the second data point is at 5 meters, the third is at 8 meters, and so forth. The long axis of the microplot (if there is a long axis) is placed perpendicular to the transect azimuth with the microplot edge on the line and the corner at the appropriate transect point (Fig. D-3).

Fig. D-3. Layout of microplots on perpendicular transects for HEP work.



Herbaceous vegetation frequency, abundance, and density are collected using the microplots. Microplots vary in size; 0.04-meters^2 (20 cm X 20 cm), 0.1-meters^2 (31.6 cm X 31.6 cm), 0.16-meters^2 (40 cm X 40 cm), and 0.5-meters^2 (50 cm X 100 cm). Regardless of the type of microplot used, it is critical that its dimensions and characteristics be recorded, since the frequency of occurrence of many species will be affected by the size of the microplot. In general, species have a greater frequency of occurrence in larger microplots. The 0.5-meter^2 microplot is usually used in shrublands and is divided into equal 0.1-meter^2 rectangles (10 cm X 50 cm rectangles) to facilitate collection of abundance and percent cover data (Fig. D-4). The 0.16-meter^2 microplot is nested within a small 10 cm X 10 cm area (0.01-m^2) and a medium sized 20 cm X 20 cm area (0.04-m^2) that includes the previous small 0.01-meter^2 area. The 0.1-meter^2 microplot is usually used in grasslands and is nested within five 0.01-meter^2 rectangles and a larger 0.05-meter^2 rectangle (Fig. D-5).

Fig. D-4. The following 0.5-m2 microplot shows an example where the target species has an abundance of 3 (rooted in 3 subplots) and a density of 2 (6-10 individuals).

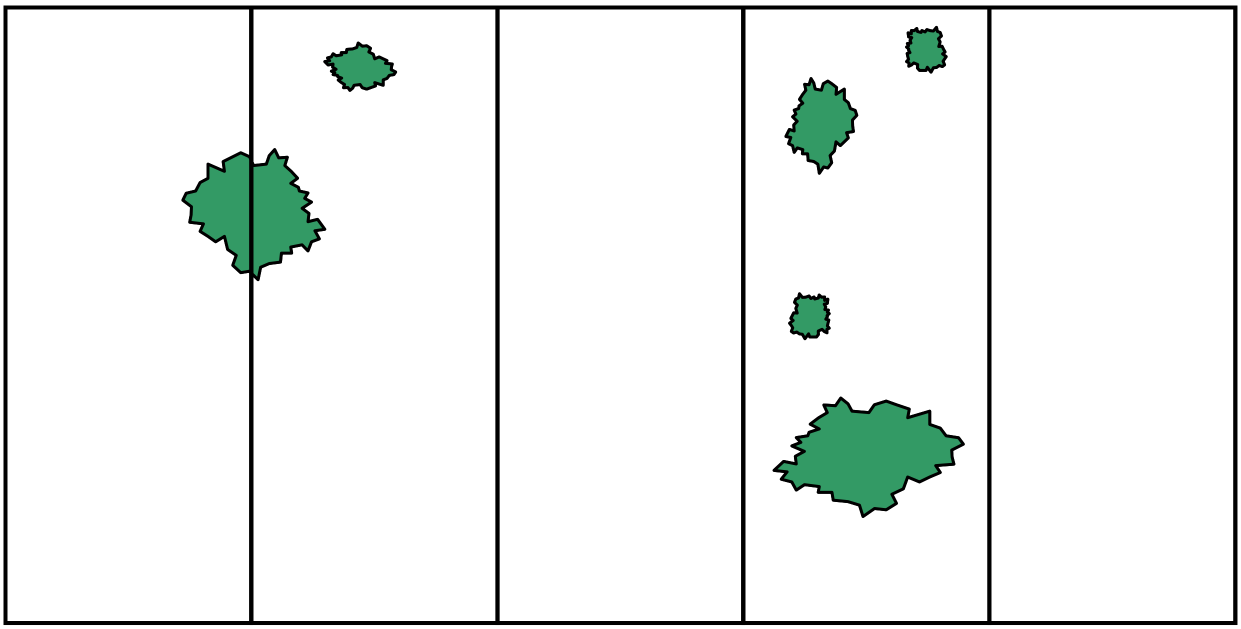
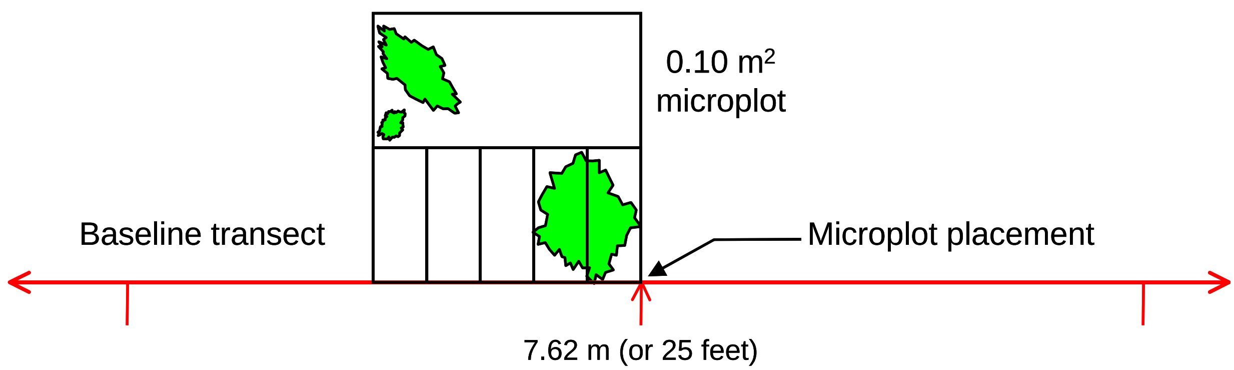


Fig. D-5. The following 0.1-m2 microplot shows an example where the target species has an estimated coverage of 20%.



Vegetation is always measured on the right side of the transect and observers should walk on the left side to avoid trampling vegetation. Whether measuring frequency, abundance, or density, plants that are partially rooted both in and outside of the microplot are counted in and out alternately along the boundary (i.e., count every other plant).

Plant frequency is determined by noting whether or not a given species is rooted within the overall microplot. For example, if 100 microplots are laid out and species 'A' occurs in 25 of the plots, frequency is 25%. Abundance, ranging from one to five, is the number of subplots within a microplot in which a species is rooted (Fig. D-4). Density, in contrast, is the number of individuals of a given species rooted within the entire microplot. Density is divided into 5 classes: Class 1) 1-5 individuals; Class 2) 6-10 individuals; Class 3) 11-15 individuals; Class 4) 16-20 individuals; and Class 5) >20 individuals. Classes are adjusted based on target species growth form (i.e., if the plant species of interest is very small, 20 individuals may not be significant). Density measurements are most sensitive to changes caused by mortality or recruitment. Plant community inventories are conducted on at least one transect per cover type in conjunction with the microplot surveys, if time is available. In addition to frequency, abundance, and density information, plant inventory data includes species composition, height, and percent cover for each microplot.

Herbaceous height is measured for each microplot to the nearest 10th of a foot (approximately 3-cm intervals). Only leaf material is measured, not the inflorescences of grasses. The height measurement is either an average height (3 or 4 measurements) or the height of vegetation at the interval point where the corner of the microplot is placed.

Visual obstruction reading (VOR) is a standard technique requiring a 3-cm diameter Robel pole to quantify horizontal herbaceous cover (Robel et al. 1970). Four measurements are recorded at pre-determined intervals; 10 meters on the perpendicular transects or 6.10 meters (20 feet), 7.62 meters (25 feet), or 15.24 meters (50 feet) on the baseline transect. A minimum of 12 measurements is required for each transect; more in structurally diverse cover types. The Robel pole is placed on the transect line at the appropriate interval and four observations are taken from a distance of four meters from the Robel pole and at a height of 1 meter. Observers record how much of the Robel pole is totally obscured from the ground up (Fig. D-6). Measurements are reported in 0.25-decimeter (rarely) or 0.5-decimeter (usually) increments. Two measurements are taken on the transect line on opposite sides of the Robel pole and two measurements are taken perpendicular to the transect line for a total of four readings per point (Fig D-7).

Fig. D-6. The following diagram illustrates the use of a Robel pole in a situation with an estimated VOR of 1.5 dm (the lowest visible 0.5-dm band is 1.5-2.0 dm in height). The illustrated pole has colored graduations every 0.5 decimeters (5 cm), but graduations every 1 decimeter is also common.

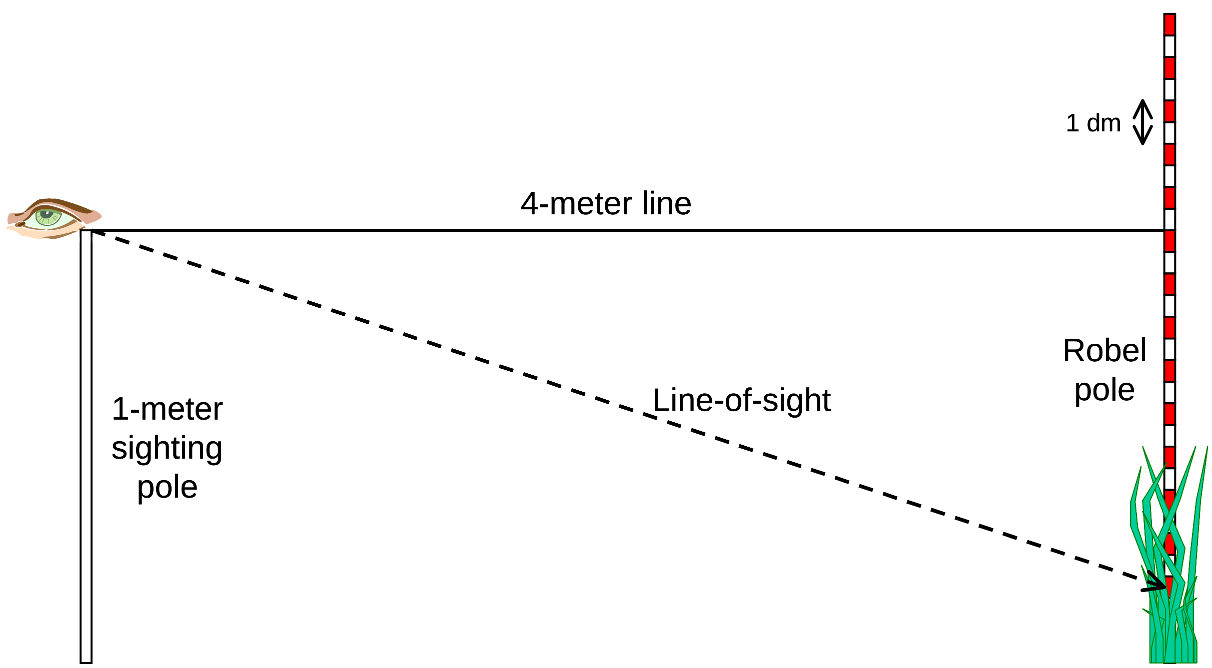
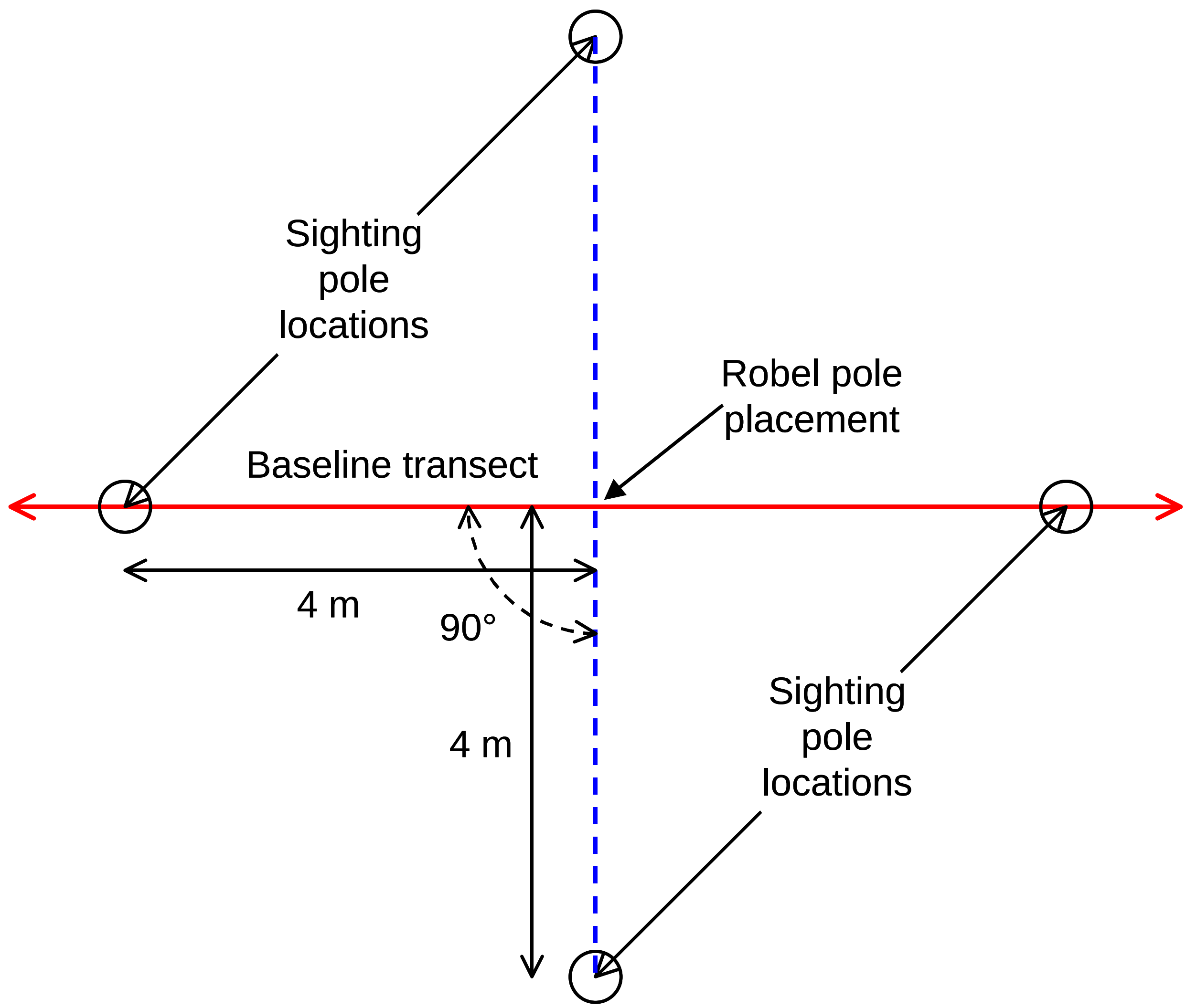


Fig. D-7. The following illustrates the 'bird's-eye' view of the layout of four Robel pole readings at a pre-determined point on the transect.



Each perpendicular transect or the baseline transect is used to collect data on shrub cover and frequency. Shrubs are defined as woody vegetation including trees <5 meters in height unless otherwise defined in HEP models. Line-intercept data is collected when shrub cover is estimated to be <5% and point-intercept data is collected when shrub cover is estimated to be ≥5%. The line-intercept method measures the amount of cover by species that intercepts the transect line (Fig. D-8). Measurements are to the nearest 10th of a foot (approximately 3 cm). Gaps in vegetation <12 cm are ignored. The amount of transect covered by shrubs is added together to determine shrub coverage for the entire transect. Shrub height is measured to the nearest 10th of a foot (approximately 3 cm) at the highest point for each uninterrupted line-intercept segment (Fig. D-9). Shrub age classes are broken down into 6 categories: 1) seedling; 2) young or non-flowering/non-seed bearing shrub; 3) mature or flowering/seed bearing shrub with <25% of the shrub dead; 4) decadent shrub with 25-50% of the shrub dead; 5) very decadent shrub with >50% of the shrub dead, but the shrub as a whole is still alive; and 6) dead shrub with no living material remaining on the shrub.

Fig. D-8. The following illustrates the measurement technique for shrubs in the line intercept method.

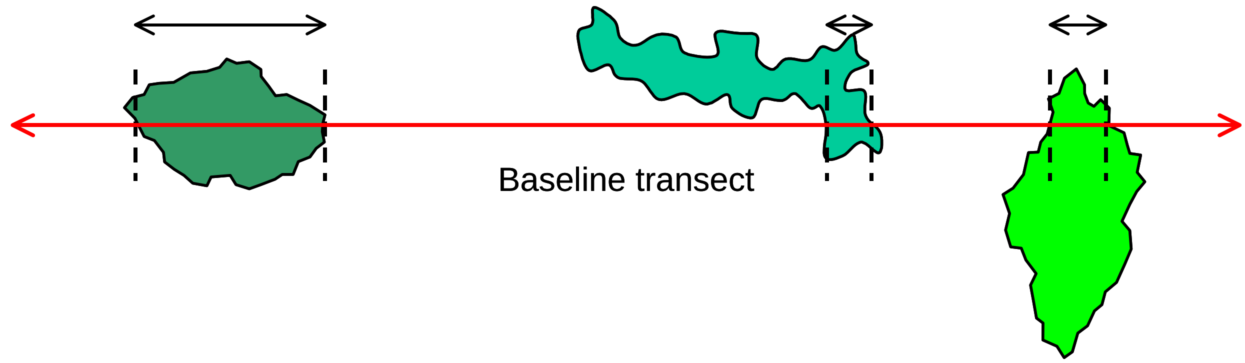
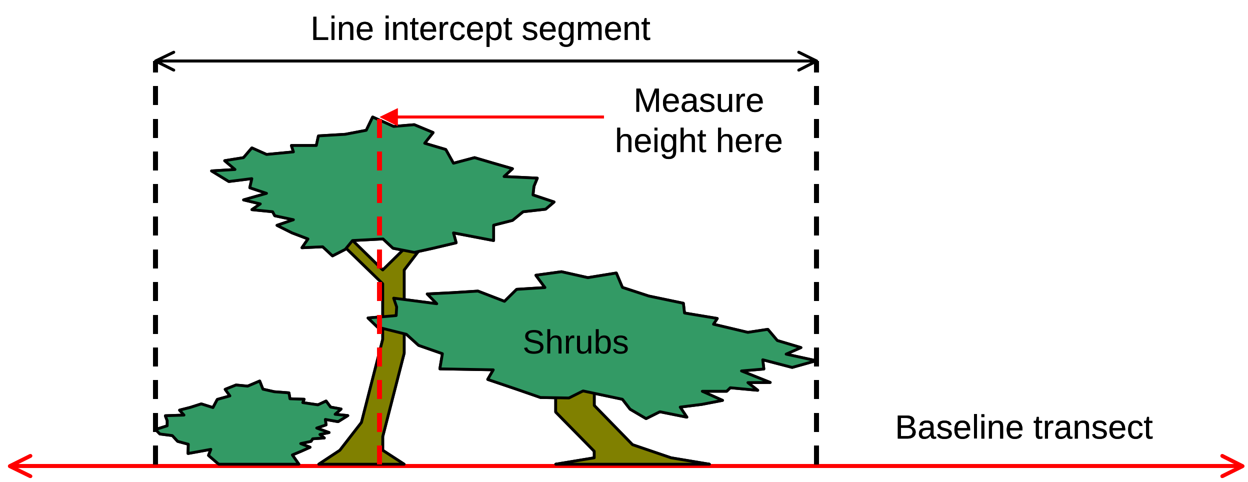


Fig. D-9. The following illustrates a horizontal view of a transect and the location to measure shrub height when conducting the line intercept method.



Point intercept data for shrubs is collected by recording the number of 'hits' at specific intervals along a transect line. To be counted as a 'hit', a portion of the shrub must cross the pre-determined point on the transect tape. If a portion of the shrub does not break the point (either above or below the line), it is reported as a miss. Data for every point is recorded as a 'miss' or the species of shrub 'hit', its height to the nearest 10th of a foot (approximately 3-cm intervals, Fig. D-10) at the transect point, and its age category. Shrub age classes are the same as for line intercept data; seedling, young, mature, decadent, very decadent, and dead. With approximately 5% to 20% shrub cover, point data is collected at 0.61-meter intervals (2 feet). If shrub cover is initially estimated to be >20%, point data is collected at 1.52-meter intervals (5 feet). On rare occasions when shrub cover appears to exceed 50%, 3.05-meter intervals (10 feet) are used. When 30-meter perpendicular transects are used, a standard interval of 2 meters is typically used (Fig. D-11). The larger intervals are generally applied to shrub monocultures, or areas with few shrub species that exhibit relatively homogenous distribution and density.

Fig. D-10. Height measurements for shrubs in the point intercept method.

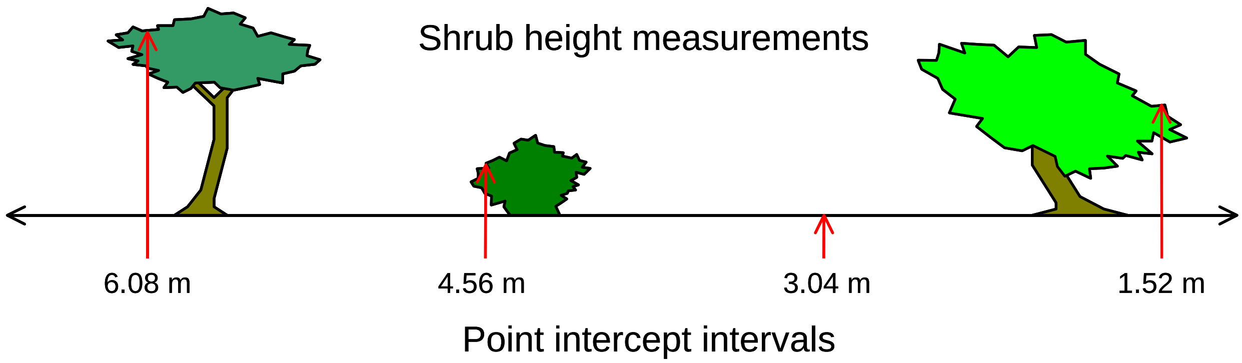
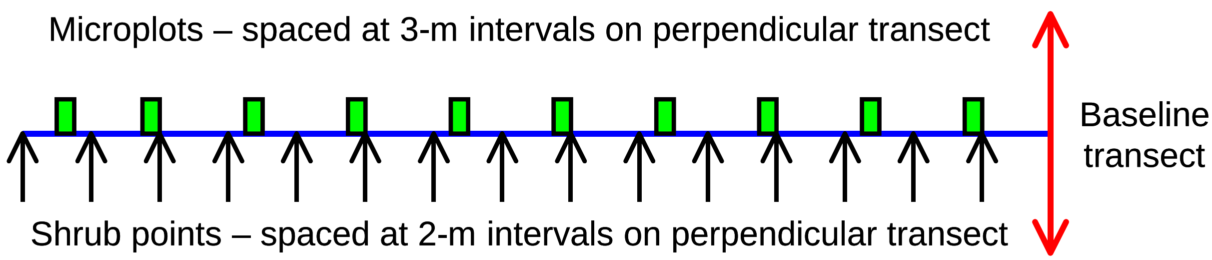
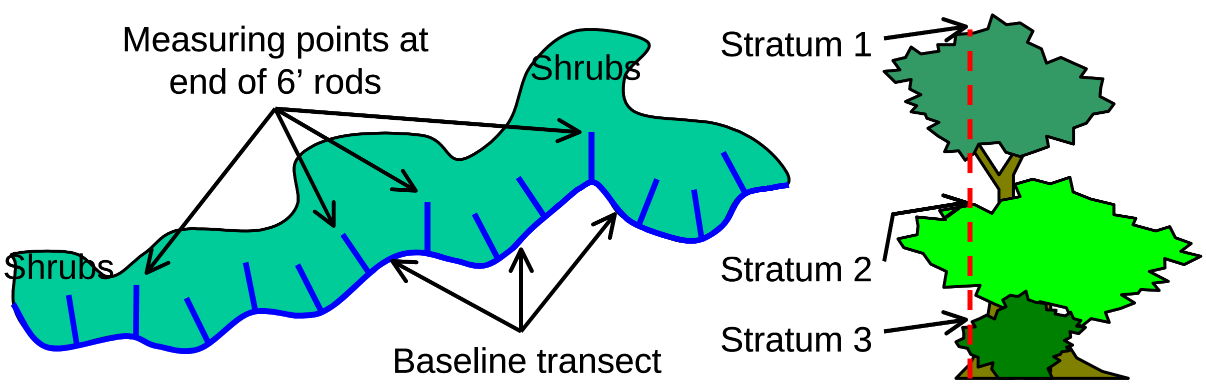


Fig. D-11. Layout of point intercepts on perpendicular transects in relation to the layout of microplots.



A modified point method is used when shrub cover is impenetrable or otherwise inaccessible. A baseline transect is established along the edge of the shrub cover (Fig. D-12). A six-foot (1.83 m) measuring rod is then inserted into the shrub cover at right angles to the baseline tape at appropriate strata heights (first stratum is the highest). Observers estimate shrub 'hits', species information, and height data for each stratum where the end of the six-foot measuring rod intercepts the shrub cover (Fig. D-12). As with the previous point intercept method, intervals along the baseline transect may vary (e.g., 0.61 m, 1.52 m, 3.05 m).

Fig. D-12. Modified point-intercept method for estimated shrub composition, height, and strata when shrub cover is impenetrable and/or inaccessible. A measuring rod is inserted horizontally into the shrub cover at the height of each stratum to estimate shrub composition and height.



Shrubs can also be partitioned by type depending on preference. For example, preferred shrubs for deer do not include rabbitbrush whereas hydrophytic shrubs for yellow warblers include quaking aspen, cottonwood, water birch, willow, woods rose, red osier dogwood, and chokecherry.

METHODS FOR FOREST AND RIPARIAN HABITATS

Baseline transects are about 300 meters in length, partitioned into 30-meter sampling units. Each baseline transect is oriented along a random azimuth when possible, but in riparian areas, the transects, by definition, follow the course of the riparian area. The size of the sample area strongly influences transect length. In small cover types, data from several short (100-m) transects may be 'pooled' in order to obtain adequate data. Transect start, end and turn points are permanently marked with a 36-cm long 0.6-cm rebar stakes painted fluorescent orange or red.

Each transect is documented with photos from the start point. One photograph is taken along the baseline transect facing the transect direction. The camera is positioned one meter above the ground for the photo or photos (use one meter cover board or similar device for camera rest). For each photo use a 1.5-meter cover board (1.5 m X 0.1 m rectangle with alternating white and red bands at 0.1-m intervals) 10-meters in front of the camera as well as the transect photo board (relevant information for transect identification). If vegetation is too dense, a photograph is taken from a point along side or perpendicular to the transect. The camera type, aperture, distance and azimuth to cover board, cover board dimensions, date, time of day, transect/location identification, GPS coordinates, and photographer should be recorded.

Two different configurations are used to sample snag and/or tree basal area information. In one, information is collected from within 0.04 ha circular plots (radius of 11.3 m) located at 30-meter intervals along the baseline transect (Fig. D-13). In the other configuration, information is collected from within areas of the same size (0.04 ha), but configured as rectangular belts (100' X 44' or 30.48 m X 13.41 m). The rectangular belts configured end-to-end and centered on the baseline transect with the long axis paralleling the transect (Fig. D-14).

Fig. D-13. Design of one type of transects in forest and riparian cover types. The circles represent 0.04 ha areas (11.3 m radius from the center point) used for estimation of tree and snag density and tree basal cover. Other characteristics such as shrub and tree composition and herbaceous cover are measured along the baseline at standardized intervals.

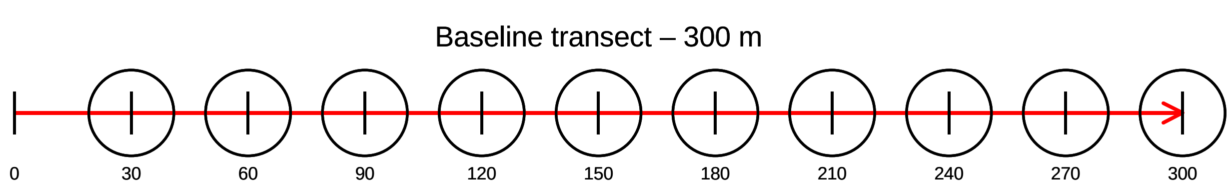
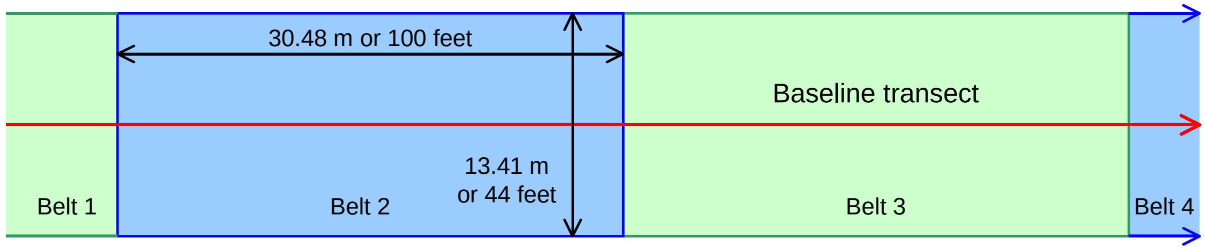


Fig. D-14. Design of belt transects in forest and riparian cover types for estimation of tree and snag density and tree basal cover. Other characteristics such as shrub and tree composition and herbaceous cover are measured along the baseline at standardized intervals.



The information collected within these circular plots or belts includes the number of snags (dead trees), trees recorded by species, and the DBH (diameter at breast height, 1.5 m above the ground) of both snags and trees. The DBH categories include: ≤ 10 cm, > 10 cm – 15 cm, > 15 cm – 25 cm, > 25 cm – 50 cm, and > 50 cm. The data is subsequently converted to basal area, or meters^2 of tree at 1.5-meters height per hectare. Alternatively, tree basal area is collected at pre-determined intervals with the aid of a 'factor 10' prism (see below).

Tree species (generally > 5-m in height) is recorded at either 1.52-meter or 3.05-meter intervals (5- or 10-foot interval) along the baseline transect with the aid of a densitometer; DBH of the dominant tree nearest the point is also recorded by category (≤ 10 cm, > 10 cm – 15 cm, > 15 cm – 25 cm, > 25 cm – 50 cm, and > 50 cm). Measurement intervals are determined by visually estimating tree canopy closure prior to initiating the survey. If estimated canopy closure is < 20% or estimated transect length is ≤ 200 meters (approximately 600'), measurements are recorded at 1.52-meter intervals; if estimated canopy closure is > 20% and estimated transect length is > 200 meters, 3-meter intervals are used. Tree height is estimated with a clinometer at the 30.48-meter (100') points (starting at zero), or the point between adjacent belts (Fig. D-14) or center of the circular plots (Fig. D-13) used for estimating basal cover. Data for basal area also can be collect at the same intervals (30.48 m or 100') with the aid of a 'factor 10' prism. Each 30.48 m interval is considered an independent sample.

Information on shrubs (generally < 5-m in height) also is collected along the baseline transect at standardized intervals. Shrub frequency and cover is determined using point intercept data at 0.67 m intervals (450 points per 300-m transect [recorded at 2-foot intervals on 900-foot transect]). Shrub data includes species, height, and age. Shrub height is measured at the highest vertical projection directly above the data point (Fig. D-9). Shrub age classes are the same as for line intercept data in open habitats; seedling, young, mature, decadent, very decadent, and dead. In some cases, multiple layers of different shrub species are recorded. Herbaceous vegetation is recorded at 7.62-meter or 15.24-meter intervals with a 0.5-meter^2 microplot (40/transect). The information recorded includes the dominant grass, forb, and weed species, frequency, abundance, density, percent cover of different categories of vegetation. This information enables additional examinations of palatability for species such as deer. A visual obstruction reading, similar to that obtained in open habitats (Fig. D-6 and D-7), is also recorded, except that the sighting distance is 15 meters instead of 4 meters, and the estimated number the obscured centimeters on a 1-meter pole is recorded rather than the lowest visible mark.

APPLICATION OF HEP DATA TO WILDLIFE

HEP data can be used to document the suitability, using a Habitat Suitability Index (HSI), of a particular habitat to support a particular species of wildlife. Because HSI information is designed to attribute a habitat with a numerical value, between 0 (completely unsuitable) and 1 (completely suitable), HSIs can be effectively applied with HEP data (assuming the appropriate data was collected). When an HSI is applied to an area, a Habitat Unit value is estimated. When an HSI is applied to an area of habitat change, the amount of improvement or decline can be estimated, by recording the change in HUs; an increase in HU value indicates habitat improvement, while a decreased HU value indicates declining habitat quality. These measured changes are a fundamental component of the BPA's mitigation plans for the Columbia Basin.

HSIs are available for many species in the Columbia Basin (Table D-1) and species vary dramatically in their responses to habitat (Table D-2). However, the effectiveness of these models in accurately predicting species response in the Columbia Basin has rarely been tested and many of the models were developed in other regions. Nevertheless, the models have been applied with actual HEP data and results appear to offer a promising technique for monitoring and evaluating habitat change (see WDFW 2001, for example). It is critical that the HEPs consider the type of data needed in the HSI procedures, and in some cases to anticipate the type of data that "might" be needed as models are improved and developed. It also is critical that the HEP data be collected strictly following the established sampling procedures; otherwise, the analysis could be flawed, with no way of knowing where errors have been made.

Table D-1. List of some of the habitat suitability indices (H.S.I.) considered for species in the Columbia Basin.

Species	H.S.I. status	Reference
Canada goose	Report	Martin et al. 1987
Wood duck	Publication	Sousa and Farmer 1983
Mallard	Report	Martin et al. 1987
Redhead	Publication	Howard and Kantrud 1983
Blue-winged teal	Publication	Sousa 1985
Bald eagle	Report	Martin et al. 1987
Osprey	Publication	Vana-Miller 1987
Ferruginous hawk	Publication	Jasikoff 1982
Sandhill crane	Publication	Armbruster 1987
Great blue heron	Publication	Short and Cooper 1985
Spotted sandpiper	Report	Ashley 2006*c*
Greater sage-grouse	Report	Ashley 2006*a*
Sharp-tailed grouse	Report	Ashley 2006*b*
Ruffed grouse	Publication	Cade and Sousa 1985
Blue (dusky) grouse	Publication	Schroeder 1984
California quail	Report	Ashley 2006*c*
Spotted owl	Publication	Layman et al. 1985
Belted kingfisher	Publication	Prose 1985
Hairy woodpecker	Publication	Sousa 1987
Downy woodpecker	Publication	Schroeder 1982*a*

Lewis' woodpecker	Publication	Sousa 1982
Williamson's sapsucker	Publication	Sousa 1983
Pileated woodpecker	Publication	Schroeder 1982*b*
Black-capped chickadee	Publication	Schroeder 1983
Marsh wren	Publication	Gutzwiller and Anderson 1987
Yellow warbler	Publication	Schroeder 1982*d*
Brewer's sparrow	Publication	Short 1984
Western meadowlark	Publication	Schroeder and Sousa 1982
Red-winged blackbird	Publication	Short 1985
Yellow-headed blackbird	Publication	Schroeder 1982*c*
Beaver	Publication	Allen 1983*a*
Muskrat	Publication	Allen and Hoffman 1984
Fox squirrel	Publication	Allen 1982*a*
Snowshoe hare	Publication	Carreker 1985
Fisher	Publication	Allen 1983*b*
Mink	Publication	Allen 1984
Marten	Publication	Allen 1982*b*
Mule deer	Report	Ashley and Berger 1999
White-tailed deer	Report	Martin et al. 1987

Table D-2. Sample of focal species and the habitats and habitat features with which they are associated (adapted from Ashley and Stovall 2004a,b). A focal species and/or habitat in one subbasin was not necessarily considered in other subbasins, even if the species and/or habitat was present. In addition, focal species associated with habitats that were not substantially present on the Wildlife Areas were not considered here.

Species	Habitat Type	Key Feature	Indicator
Elk	Ponderosa Pine	Canopy > 70% and height > 12 m	Healthy forest canopy intermixed with openings for foraging
		Sagebrush height > 50 cm	
		Herbaceous cover > 10%	
Mule deer	Shrubsteppe	Preferred shrub cover 30-60%	Healthy and diverse shrub layer
		Preferred shrubs 1-1.5 m	
		At least 3 preferred shrub species	
Bighorn sheep	Grassland	Steep grassy areas close to escape cover such as rocky outcrops	Grass/forb cover intermixed with steep rocky escape cover
Western gray squirrel	Ponderosa Pine	Prefers mixed stands of Ponderosa pine and oak; large pines essential	Healthy mix of pine mixed with oak
Pygmy rabbit	Shrubsteppe	Sagebrush cover > 20% and > 1 m in height in deep soils	Healthy shrubsteppe habitat in deep soils
Beaver	Riparian Wetlands	Tree/shrub canopy 40-60%	Healthy regenerating aspen stands and an important habitat manipulator
		Trees < 15 cm diamert	
		Shrub height > 2 m	
		Stream channel gradient < 6%	

Great blue heron	Riparian Wetland	Tree grove > 0.4 ha < 250 m from water	Light human disturbance in vertebrate-rich shallow water
		Disturbance-free zone > 250 m on land and > 150 m on water	
Mallard	Riparian Wetland	Ratio of emergent vegetation to open water 40:60 to 60:40	Wetland habitat near riparian or grassland
Sharp-tailed grouse	Shrubsteppe	Visual obstruction reading > 15 cm	Healthy shrubsteppe and steppe habitat with imbedded riparian wetlands dominated with deciduous shrubs
		Grass cover > 40%	
		Forb cover > 30%	
		Introduced cover < 10%	
		Optimum nest habitat > 50% of area and < 0.25 km from winter habitat	
	Riparian Wetlands[a]	Deciduous shrub/tree cover > 75%	
		Optimum winter habitat > 10% of area	
Greater sage-grouse	Shrubsteppe	Sagebrush cover 10-30%	Heathy shrubsteppe habitat across the broad landscape
		Forb cover > 10%	
		Open ground cover > 10%	
		Non-native herbaceous cover < 10%	
Flammulated owl	Ponderosa Pine	> 0.25 snags > 30 cm diameter and > 1.8 m tall/ha	Healthy landscape mosaic in Ponderosa pine/Douglas fir forest
		> 20 trees > 50 cm diameter/ha	
		Brushy thickets and grassy openings	
Lewis' woodpecker	Ponderosa Pine and Riparian Wetlands	> 2 tree > 50 cm diameter/ha	Riparian wetlands with old cottonwoods and mature Ponderosa pine
		Tree cover 10-40%	
		Shrub cover 30-80%	
White-headed woodpecker	Ponderosa Pine	> 25 trees > 50 cm diameter/ha	Large patches of healthy old-growth Ponderosa pine forest
		> 5 trees > 75 cm diameter/ha	
		10-50% canopy closure	
		> 4 snags > 20 cm diameter/ha	
Gray flycatcher	Ponderosa Pine	Nest tree > 45 cm in diameter	Healthy fire-maintained Ponderosa pine forest.
		Tree height > 16 m	
Willow flycatcher	Riparian Wetlands	Native shrubs mixed with openings	Healthy riparian wetlands dominated with deciduous shrubs
		Shrub layer cover 40-80%	
		Shrub layer height > 1 m	
		Tree cover < 30%	
Yellow warbler	Riparian Wetlands	60-80% deciduous shrub cover	Riparian shrub habitat adjacent to wetlands
		Shrub height > 1 m	
Red-eyed vireo	Riparian Wetlands	Canopy cover > 60%	Riverine cottonwood gallery forests with healthy recruitment
		Mature deciduous trees > 75 m	
		Shrub layer > 10% cottonwoods	
Pygmy	Ponderosa	> 25 trees > 50 cm diameter/ha	Old-growth

nuthatch	Pine	> 5 trees > 75 cm diameter/ha	Ponderosa pine forests with abundant snags
		> 3 snags > 20 cm diameter/ha	
		> 1 snag > 60 cm diameter/ha	
Sage thrasher	Shrubsteppe	Sagebrush cover 5-20%	Healthy, tall sagebrush-dominated habitat
		Sagebrush height > 80 cm	
		Herbaceous cover 5-20%	
		Non-native herbaceous cover < 10%	
Yellow-breasted chat	Riparian Wetlands	Shrub layer 1-4 m tall	Healthy shrub-dominated riparian habitats
		Shrub cover 30-80%	
		Tree cover < 20%	
Grasshopper sparrow	Shrubsteppe	Native bunchgrass cover > 15% and > 60% of total grass cover	Healthy grassland dominated by native bunchgrasses
		Shrub cover < 10%	
		Bunchgrass height > 25 cm	
Brewer's sparrow	Shrubsteppe	Sagebrush cover 10-30%	Healthy sagebrush-dominated habitat intermixed with herbaceous cover
		Sagebrush height > 60 cm	
		Open ground > 20 %	
		Non-native herbaceous cover < 10%	
Sage sparrow	Shrubsteppe	10-25% cover sagebrush	Large patches of shrubsteppe with relatively high cover of sagebrush
		Sagebrush height > 50cm	
		Grass cover > 10%	
		Non-native herbaceous cover < 10%	
		Occupied patches > 160 ha in size	
Red-winged blackbird	Herbaceous Wetlands	Herbaceous cover > 50% and height > 1 m	Riparian shrub communities

[a]Sharp-tailed grouse are not considered a focal species in Riparian Wetland.