Eastside Type F Riparian Assessment Project
Phase 1 Study Plan

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1.0 INTRODUCTION

The Scientific Advisory Group for the Eastside (SAGE) is charged with validating Type S/F Riparian prescriptions on lands managed in eastern WA under the State's Forest and Fish Rules (FFR). This study plan will be the basis for implementing Phase I of SAGE's preferred strategy for conducting the Eastside Type F Riparian Assessment Project. In advance of Phase II (full study implementation), Phase I is designed to test field methods, estimate variability in the sample population, refine statistical and analytical approaches, and to assess the ability of the study to meet SAGE's defined objectives. As outlined in the June 2004 SAGE Scoping Document (SAGE 2004), five specific objectives frame the work to be conducted by SAGE:

- Objective 1: Determine range and distribution of current riparian stand conditions.
- Objective 2: Determine the relationship between site characteristics and riparian stand attributions.
- Objective 3: Determine the effect of proximity to the stream on the characteristics of eastside riparian stands.
- Objective 4: Determine the frequency and distribution of mortality and insect and disease effects in eastern Washington riparian stands.
- Objective 5: Document management practices and other disturbance factors that affect eastern Washington riparian stands.

As developed in the aforementioned scoping document, the following are the primary objectives, related key questions, and major data requirements envisioned by SAGE that have led to this study.

Objective 1: Determine range and distribution of current riparian stand conditions.

Key Questions:

- What are the current characteristics of riparian stands in eastern Washington?
- What is the frequency distribution of forest stand attributes?
- Are there regional patterns or differences in riparian stand characteristics across eastern Washington?
- To what extent do current riparian stands meet the size and basal area thresholds for timber harvest across the regulatory habitat types (elevation bands)?
- What forest series and plant association groups are represented in riparian stands?
- Is the current riparian timber habitat type classification system valid?

Data Requirements:

- Live tree/snag diameter, height; species; distance from stream, basal area, trees.

- Per acre; tree age (cores for growth basal area), percent canopy closure in stand and above stream; live crown ratio, canopy class, decay class, downed wood volume.
- Seedling and sapling regeneration data, snags and decay class, stocking rates.

Objective 2: Determine the relationship between site characteristics and riparian stand attributions.

Key Questions:

- How do the characteristics of the study sites (e.g. physiography, geology, climate, and channel or valley morphology) affect the distribution and characteristics of riparian stands?
- What, if any, significant relationships exist between site characteristics and riparian stand attributes?
- How do site characteristics influence the distribution and characteristics of eastside riparian stands?
- Are there differences in riparian characteristics in different eco-regions?

Data Requirements:

- Elevation, aspect, stream direction, valley confinement, precipitation class, slope, landform, geology/geomorphology.

Objective 3: Determine the effect of proximity to the stream on the characteristics of eastside riparian stands.

Key Questions:

- How does proximity to stream influence the characteristics of eastside stands?
- Are there differences in the forest series and plant association groups (PAG) between stands in close proximity to the stream and those more distant?
- Are there differences in other stand characteristics associated with distance to the stream?

Data Requirements:

- Forest Zone and Vegetation Association Group. Distance from stream of individual trees, PAGs, undergrowth species cover and composition.

Objective 4: Determine the frequency and distribution of mortality and insect and disease effects in eastern Washington riparian stands.

Key Questions:

- What is the extent of tree mortality, breakage and other physical disturbances in riparian stands in eastern Washington?
- How widespread are insect and disease effects in East side riparian zones?
- What are the characteristics of snags and diseased or damaged trees?
- Is there evidence of a relationship between stand characteristics, physiographic, climatic factors, management activities and tree mortality?

Data Requirements:

- Volume of downed wood and standing dead trees; species; distance from stream; decay class; percent mortality, causal agent (insects, disease, wind throw, ice, top breakage).
- Elevation; aspect; stream direction; valley confinement and precipitation class.
- Locations of down trees relative to the channel (i.e., into channel, over channel, away from channel).

Objective 5: Document management practices and other disturbance factors that affect eastern Washington riparian stands.

Key Questions:

- What are the primary factors influencing riparian stands in eastern Washington?
- How do past or current management activities (e.g. fire suppression, harvest, grazing, road construction, timber harvest) influence current riparian stand conditions?
- What other processes (e.g. beaver, fire, noxious weeds) influence current riparian stand conditions?

Data Requirements:

- Evidence of grazing by livestock; past and current timber harvest practices.
- Buffer zones; fire scares; noxious weeds; fire and fire suppression; and beaver activity past and present.

Discussions with SAGE in June 2005 around an early draft of this plan brought forward the following additional guidelines/goals for the eastside riparian assessment:

1. Data collected in the study should make it possible to evaluate not only the current FFR rules for the east side, but possible modifications to the rules.

2. Data collected and estimates made in the study should not be restricted to the current FFR regulatory zones, which might be defined by the edge of the regulatory Channel Migration Zone (CMZ), but to vegetation in riparian stands in general, i.e., vegetation along the streams.

This Study Plan is for Phase I of the Riparian Assessment Project. This Phase will test the ability of the design to meet the above objectives, and identify the types of refinements in field and analytical approaches that may be necessary for Phase II.

An important task prior to implementation of Phase 1 will be development of a field manual. The Phase 1 Field Manual will be a step-by-step guide for field staff containing data collection methods and protocols, data sheets, project contacts, and additional details such as condition codes and decay classes used for riparian data collection. The manual will be revised as needed following completion of an initial 20-site subset, as described in Section 8 of this document.

2.0 CHARACTERISTICS OF EASTSIDE FORESTS

This study will take place on forested lands in eastern Washington subject to Forest and Fish Rules (FFR Lands). These lands, encompassing approximately 3 million acres across eastern WA, contain riparian stands with regulatory buffers for the protection of fish-bearing streams (Type F). Characterization of riparian stands is the focus of the current study.

2.1 DISTRIBUTION OF FFR LANDS BY VEGETATION ZONES

Among FFR Lands are a number of relatively distinct vegetation zones, as defined by Franklin and Dyrness (1973), and more recently by Henderson et al., 1992, and Henderson (2005 [manuscript in prep.]). The latter classification is a product of a USFS-based model of riparian and upland stands using a number of physical and abiotic determinants, such as elevation, air temperature, soils, and cold air drainage. These zones extend in elevation from Steppe to Subalpine fir. In total, there are 11 Henderson Vegetation Zones within the population of interest:

- Steppe
- Ponderosa Pine
- Oregon White Oak
- Douglas-fir Zone
- Grand Fir Zone
- Western Hemlock Zone
- Pacific Silver Fir Zone
- Mountain Hemlock Zone
- Subalpine Fir Zone
- Parkland Zone
- Alpine Zone

Analysis of FFR lands in eastern WA indicates that 99% are distributed among six vegetation zones; the majority (47%) is within the Douglas-fir zone (Figure 2.1-1). Zones with less than 1 percent of FFR lands are mainly in higher elevation areas of NE WA, and along the western-most boundary of eastern WA (Figure 2.1-2).

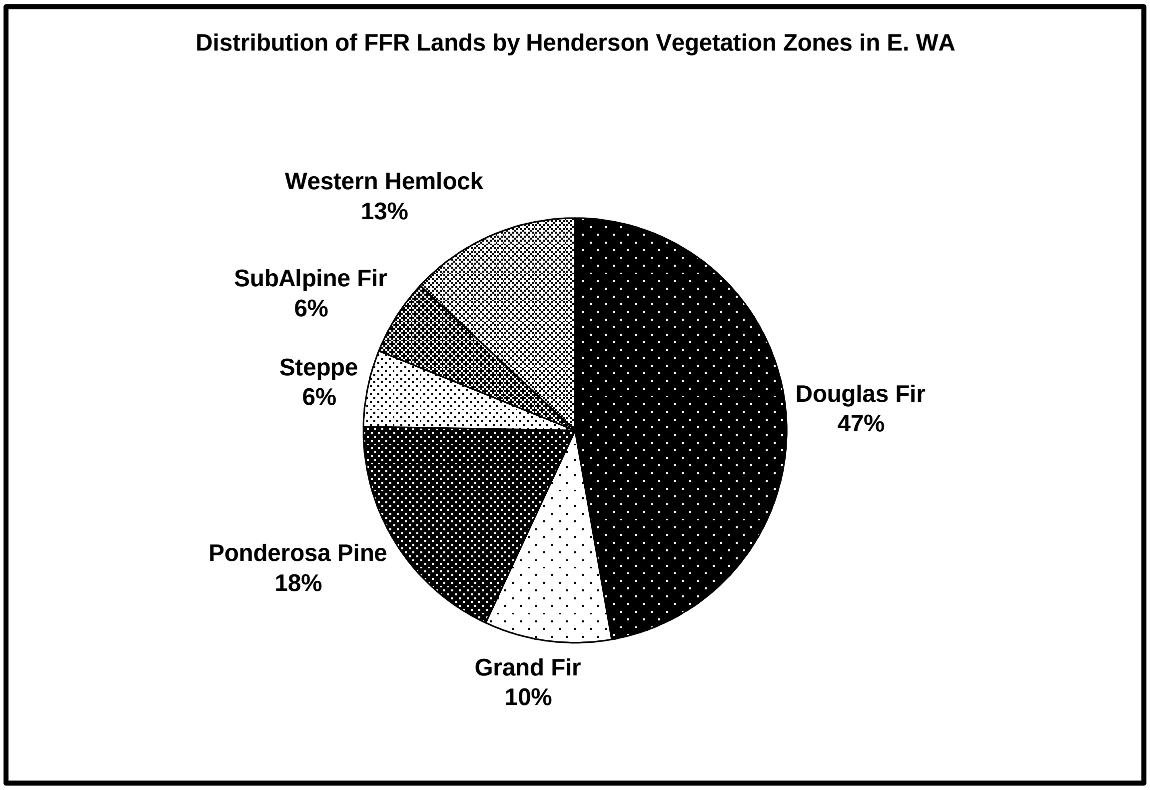

Figure 2.1-1. Distribution of FFR lands by Henderson vegetation zones (from Henderson 2005, unpublished).

Vegetation zones developed by Henderson and others are useful ecological tools in terms of characterizing major stand types and associated shrub and understory plant species since they are representative of the complete array of climatic influences. However, they have no regulatory significance. More importantly, and of direct relevance to the current study, the composition of riparian zones in Eastern WA may not reflect the composition of uplands, which may differ substantially in terms of both species composition and complexity of tree and shrub communities.

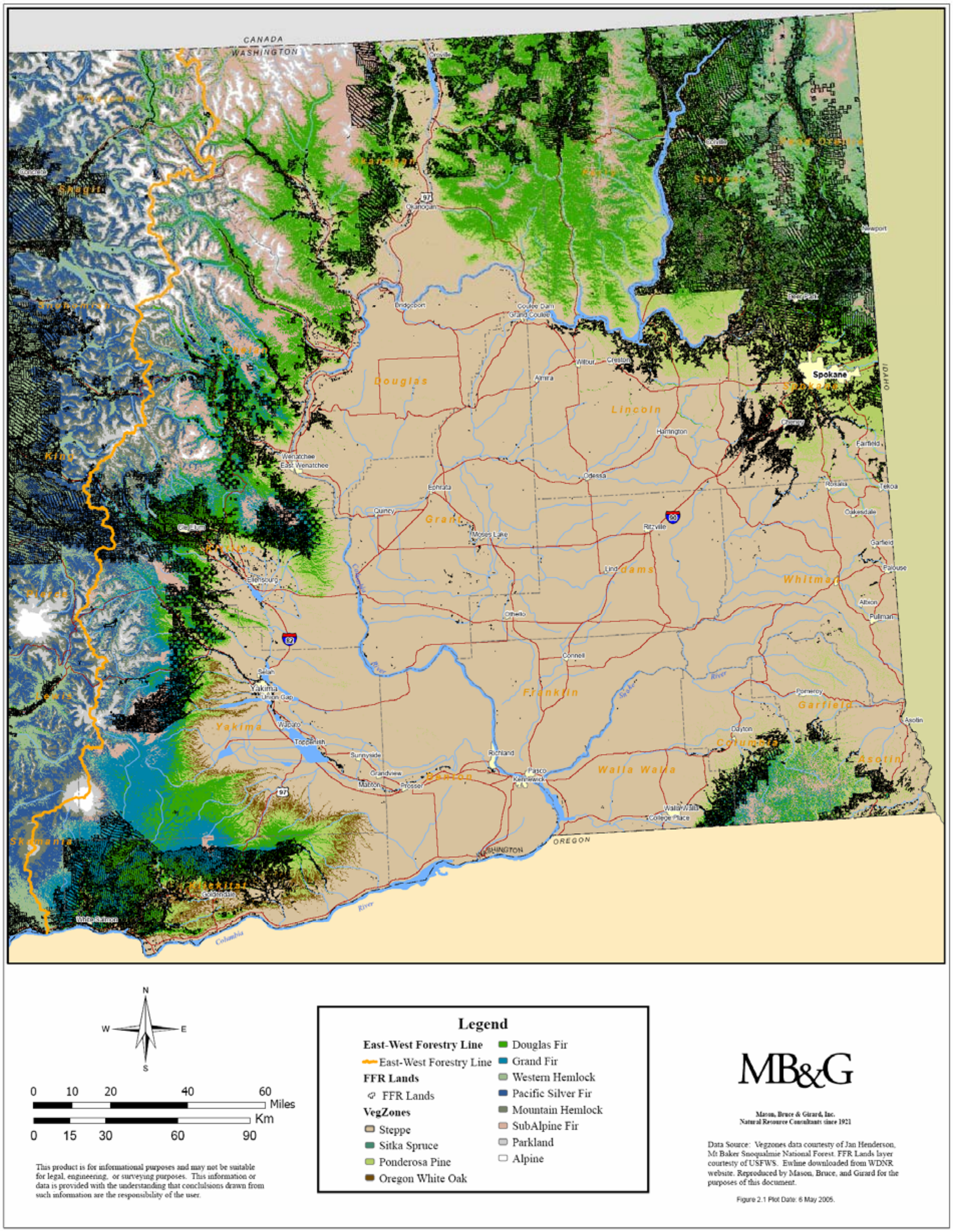

Figure 2.1-2. FFR lands (shown in black) and Henderson vegetation zones in eastern WA. Data courtesy of Jan Henderson, USFS, and Steve Dilley, USFWS.

2.2 Distribution of FFR Lands by Elevation Bands

Washington Forest Practices (WAC 222-16-010) define major forest types by elevation, and these forest or habitat types in turn dictate leave tree requirements following harvest:

> Harvest within the inner zone must retain a minimum number of leave trees, and leave tree requirements vary by timber habitat type. Three timber habitat types are recognized: 1) ponderosa pine, 2) mixed conifer and 3) high elevation. The ponderosa pine timber habitat type is 2,500 feet or lower in elevation, the mixed conifer timber habitat type is 2,501 to 5,000 feet in elevation and the high elevation timber habitat type is above 5,000 feet.

With respect to elevation, the majority of FFR lands in eastern WA (54 percent) are within the mixed conifer timber habitat type, between 2,501 and 5000 feet above mean sea level (amsl) (Table 2.2-1). A small percentage of FFR lands is above 5,000 feet. This is in sharp contrast to Western WA, where the majority of FFR lands are below 2,500 feet.

Table 2.2-1. Breakdown of FFR lands in Eastern WA by Henderson vegetation zone and elevation band. *Vegetation zone data courtesy of Jan Henderson (USFS); FFR coverages from Steve Dilley (USFWS).*

			Elevation (feet amsl)					
			0 – 2500		2501 – 5000		>5000	
Vegetation Zone	**ACRES**	**% FFR Land**	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**
Alpine	191	0.0						
Douglas Fir	1,411,527	46.6	528,303	17.4%	875,888	28.9%	7,310	0.2%
Grand Fir	298,800	9.9	116,605	3.8%	178,474	5.9%	3,708	0.1%
Mountain Hemlock	2,441	0.1						
Oregon White Oak	13,391	0.4						
Pacific Silver Fir	10,001	0.3						
Parkland	6,391	0.2						
Ponderosa Pine	548,569	18.1	395,585	13.1%	152,986	5.0%	1	0.0%
Steppe	169,468	5.6	142,555	4.7%	26,910	0.9%	4	0.0%
Sub Alpine Fir	173,520	5.7	2,282	0.1%	96,284	3.2%	74,956	2.5%
Western Hemlock	395,222	13.0	91,543	3.0%	300,647	9.9%	2,890	0.1%
SUM	**3,029,520**	**100.0**	**1,276,874**	**42.0%**	**1,631,190**	**54.0%**	**88,868**	**3.0%**

In summary, there are approximately 3 million acres of FFR lands in eastern WA, distributed primarily among Douglas fir, ponderosa pine, western hemlock, and grand fir vegetation zones. Approximately 42 percent are below 2,500 feet in elevation, and 54 percent between 2,501 and 5,000 feet. Less than 5 percent of FFR lands are above 5,000 feet in elevation.

3.0 INVENTORY DESIGN

3.1 OVERVIEW

Phase 1 of the Eastside Type F Riparian Assessment is essentially a sample-based vegetation inventory effort, which includes both data collection and analysis, intended to satisfy the following objectives:

- Objective 1: Determine range and distribution of current riparian stand conditions.
- Objective 2: Determine the relationship between site characteristics and riparian stand attributions.
- Objective 3: Determine the effect of proximity to the stream on the characteristics of eastside riparian stands.
- Objective 4: Determine the frequency and distribution of mortality and insect and disease effects in eastern Washington riparian stands.
- Objective 5: Document management practices and other disturbance factors that affect eastern Washington riparian stands.

In addition, the data and analyses in Phase I must facilitate the following:

1) Determine whether the plot configuration and field protocols for sampling riparian vegetation are sufficient for use in the larger study (Phase 1).
2) Determine variability in the data and thus the number of plots needed in Phase 2 to satisfy precision and accuracy requirements desired by SAGE.
3) Determine the value, if any, of stratifying the FFR riparian lands by vegetation zone, elevation band, or other parameter of interest in Phase 2.

The "population of interest" in the project might be described as all riparian stands on FFR lands in eastern Washington, but that is not strictly correct because the sample units are not stands, but randomly located sample locations that might span several stands. This is an important point, because if the sample unit was a stand, then all stands in the population of interest would have to be delineated and identified in order to affect a random sample of stands. This would require a large amount of work before any field work could begin. This point was discussed and clarified with SAGE at a meeting in Chelan on June 14, 2005.

Instead, the population of interest should be thought of as *the vegetation* in riparian stands on FFR lands in eastern Washington. The sample frame consists of an infinite number of points on the ground where the vegetation can be characterized, and the sample will consist of a randomly selected subset of these points.

Other discussions at the SAGE meeting in June 2005 listed the following additional guidelines/goals for the eastside riparian assessment:

- Data collected in the study should make it possible to evaluate not only the current FFR rules for the east side, but possible modifications to the rules.

This means that the data must be compatible with existing growth and yield models, so that future conditions can be predicted.

- Data collected and estimates made in the study should not be restricted to the current FFR regulatory zones, which might be defined by the edge of the regulatory Channel Migration Zone (CMZ), but to vegetation in riparian stands in general, i.e., vegetation along the streams.

The data to be collected and the sample site selection methods will allow limited hypothesis testing, but it should be clear that Phase I of this study is not an experimental design project, e.g., with clearly defined hypotheses and appropriate approaches for testing them. However, Section 7 of this plan contains hypotheses and example analyses that the current study will be able to test. Section 7 also addresses potential stratification of the data during Phase 2 of this project.

3.2 Required Number of Sites

In most sampling exercises, determination of the sample size, i.e.., the number of sample units to measure, requires an up-front declaration of how sure the investigator wants to be that the population attribute of interest will be estimated to within some specified tolerance, or allowable error. For example, if in this case the attribute of interest was average basal area per acre within 100' of the stream, the declaration of the precision and accuracy requirements might be to provide an estimate of average basal area that is within plus or minus 5% of the true average, with a confidence level of 90%. Assuming simple random sampling (i.e., no stratification), where every possible site location in the area of interest has an equal chance of being drawn, the number of sites to sample (n) can be estimated using Equation 1:

$$n = t^2 * CV^2 / AE^2, \qquad (1)$$

Where t is estimated from the Students-T distribution,

CV is the coefficient of variation for basal area,

And AE is the allowable error.

If we assume a CV of 60%, an allowable error of 5%, and a confidence level of 90% (such that t can be approximated with 1.7), the estimate of the sample size becomes:

$$n = 1.7^2 * .60^2 / .05^2 = 417 \text{ sites.}$$

Obviously the calculation of the sample size depends on the accuracy and precision requirements specified by the investigator. In this example, if the precision requirement (allowable error) was reduced to 10%, the number sites decreases to 104.

In the current study SAGE did not specify accuracy or precision requirements. In addition, there are many attributes of interest in the study, so picking one particular attribute to key on for purposes of sample size estimation would be problematic. Therefore, a different approach is needed to develop a reasonable sample size for Phase I.

The number of sites to be visited during Phase I will be a function of the total budget (or time) available for field work. At the same time, enough sites have to be visited to meet the objectives listed in Sections 1.0 and 3.1. Of those, the objective to determine the value of stratification in Phase II provides the most guidance with regard to developing a sample size for Phase I, i.e., enough sites will have to be visited in Phase I to support an analysis of the value of stratification.

Assuming that sites in Phase 1 are to be distributed at random across the range of FFR riparian lands, we can also assume that their resulting allocation by any stratum of interest will be proportional to the relative size of that stratum in the population. In other words, a stratum that occupies 20% of the FFR lands will probably get about 20% of the sample size in Phase I.

Most parametric tests to evaluate variability within strata and differences between strata will not benefit by more than about 30 observations in a stratum. At the same time, most sample-based estimation exercises see little gain in precision (in the estimation of population parameters) with more than 6 or 7 strata (Cochran 1963; page 134). The combination of 6 or 7 strata and 30 observations in a stratum suggest that an overall sample size of about 200 sites (180 to 210) would be reasonable for Phase I. Section 7.0 provides some example stratified sampling estimates to illustrate the value of stratification.

Would 200 sample sites fit within a typical field season? In eastern Washington, depending on elevation and the amount of snow, a typical field season for this kind of work would last about 15 weeks. Working 5 days per week, a 2- person field crew will probably get about 4 to 5 sites done per week, so in 15 weeks the crew will finish 60 to 75 sites. This would suggest the need for 3 to 4 crews for the field season to get 200 sites done in total.

3.3 Site Selection

The sample design for Phase 1 will utilize probability sampling (Overton 1990), the same approach developed for the U.S. EPA Ecological Monitoring and Assessment Program (EMAP); and for other projects now in development by CMER (e.g., Ehinger et al., 2005). Sites will be randomly located along Type F streams, and will span the geographic extent of FFR lands.

GPS coordinates and a map showing selected sites will be provided by CMER/SAGE. Using this information, field crews will navigate to the center of the randomly drawn stream reach closest to the assigned coordinates. A coin flip will then determine whether the transect begins on the left or right bank. Field crews will record the GPS coordinates (if possible) and the bearing and distance of the final starting point from the original coordinates provided by CMER/SAGE. Crews will also monument the starting location so that it is easily re-located in the field.

3.4 FIELD CREW SIZE

A single field crew should consist of two people working together on each site. This is for reasons of safety as well as efficiency in plot layout and measurements. An additional person (on a project-wide basis) should be employed to do quality control work. His/her job would be to train the field crews, ensure consistency in fieldwork between crews, and visit established plots to monitor the quality of fieldwork. An assumption in this plan is that one 2-person crew will take about 10 hours to travel to a site, lay out the plot design, collect the data, and travel back. The crew is expected to complete 4-5 sites per week.

4.0 RIPARIAN DATA COLLECTION

Riparian vegetation surveys will be conducted using the plot configurations illustrated here, which have been designed to be efficient in terms of fieldwork, and to satisfy the information needs of the project.

The basic plot configuration is to use horizontal line sampling for snags and trees >= 3.0" dbh, fixed area plots for smaller trees, seedlings, and shrub cover estimates, and line intercept sampling for down woody material. The basic plot layout is shown in Figure 4.1-1. Sampling methods and related data for vegetation components of the riparian survey are summarized below (Table 4.0-1).

Table 4.0-1. Vegetation components and methods for riparian inventories.

Component	Method	Data Produced
Canopy closure	Spherical densiometer reading at 20' intervals along the plot central axis.	Percent canopy closure at various distances from the edge of the bankfull width.
Downed wood	Line intercept sampling using randomly oriented 20' line transects located at 20' intervals along the plot central axis.	Number of pieces and cubic foot volume per acre of downed wood, decay class, and size class, and trends with distance from stream.
Snags	Tallied with horizontal line sampling with a BAF of 20, along the plot central axis, down to minimum dbh of 3.0" and minimum height of 10 feet. Record distance from edge of bankfull width.	Number of snags per acre by species, decay class[1], and size class, and trends with distance from stream.
Live trees	Tallied with horizontal line sampling with a BAF of 20, along the plot central axis, down to 3.0" dbh; record species, dbh, distance from edge of bankfull width, total height, crown ratio, direction of lean, damage agents.	Stand and stock tables, including trends with distance from stream. [Crown ratio will be critical if growth modeling might be applied in later analyses.]
Tree seedlings and saplings	1' tall to 2.9" dbh, tallied on 10'x10' subplots along the plot central axis.	Number of seedlings and saplings per acre by species, including trends with distance from stream.
Shrub cover	Record percent area occupancy by species in each 10'x10' subplot along the plot central axis.	Presence/absence and average percent cover by species, and trends with distance from stream.

[1] See Figure 4.4-2 for a list of decay classifications.

Component	Method	Data Produced
Plant series	Use keys provided in Kovalchik and Clausnitzer (2004) to determine the plant series at 3 points along the plot central axis; these points will be at 40’, 120’, and 200’ from the starting point.	Observations of plant series at 3 fixed locations at each sample site.

Additional attributes of the riparian stands will be noted, as shown below (Table 4.0-2):

Table 4.0-2. Additional attributes to be noted for riparian stands.

Site Attribute	Method	Data Produced
Site Index	Record total height and total age at breast height of at least 3 suitable site index trees per sample site. A suitable tree is of the predominant species, a dominant or co-dominant in crown position, near 50 years old, and judged to have been free to grow during its lifetime. Record distance of site tree from bankfull edge.	Estimate of site index.
Elevation	Collected by altimeter at the edge of the bankfull width (altimeters to be calibrated daily).	Feet above sea level.
Geomorphic Features	Montgomery-Buffington channel type (See Section 5); channel width.	Montgomery-Buffington classification for each sample site. Classification of channel width.
Disturbance Factors (natural, anthropogenic)	See Section 6; fire, insect, grazing, road presence; landslide/avalanche evidence.	Qualitative assessment of disturbance factors potentially influencing riparian stands.
“Notes of interest”	Observations in or near the riparian zone made by field crew not readily handled with preset codes, but of probable interest to analysts.	Narrative observation in the database.

Note that the methodology presented here not only characterizes the current resource, but will produce data that can be used as input to tree growth and yield models, so that future stand attributes can be modeled.

4.1 GENERAL PLOT CONFIGURATION AND SETUP

The general sample plot configuration is illustrated in Figure 4.1-1. The major components of the plot configuration and setup are as follows:

a. Establishment of the Start Point on the edge of the bankfull width. This location should be monumented with a stake or other permanent marker so that the QA/QC person or subsequent field crews can check the original measurements. Tags on witness trees should be used to document the location in the event the stake is lost.

b. Establishment of the Central Axis of the plot, which originates at the Start Point and extends perpendicular to the tangent of the bankfull edge at that point.

c. Demarcation on the ground of 10’ intervals along the Central Axis, for a total length (i.e., horizontal distance from the Start Point) of 240’.

d. At the 0’ (Start Point), 20’, 40’, …, 240’ marks, establishment of (1) an overstory canopy densiometer reading, and (2) the center of a randomly oriented line transect to sample down wood.

e. At the 0’, 10’, 20’, …., 230’ marks, establishment of a 10’x10’ plot, centered on the Central Axis, to tally seedling and saplings up to 2.9” dbh and at least 1’ tall, and an ocular estimate of shrub cover by species.

f. Continuous tally of any snag or live tree at least 3.0” dbh that is “in” on a BAF 20 horizontal line sample along the length of the Central Axis. In addition to the usual attributes of species, dbh, total height, and crown ratio, the distance between the tree and the closest point on the bankfull edge will be recorded as well. This distance will usually be equal to the distance of the observer from the Start Point, so the observer must take care to have his/her line of sight to the tree or snag be “perpendicular” to the Central Axis.

g. Notation on a sketch map of the locations of skid trails, roads, springs, seeps, braided channels, terrace/flood plain breaks, and other local topographic features as they intersect the Central Axis of the plot. Also note the edge of the regulatory CMZ if it differs from the edge of the bankfull width.

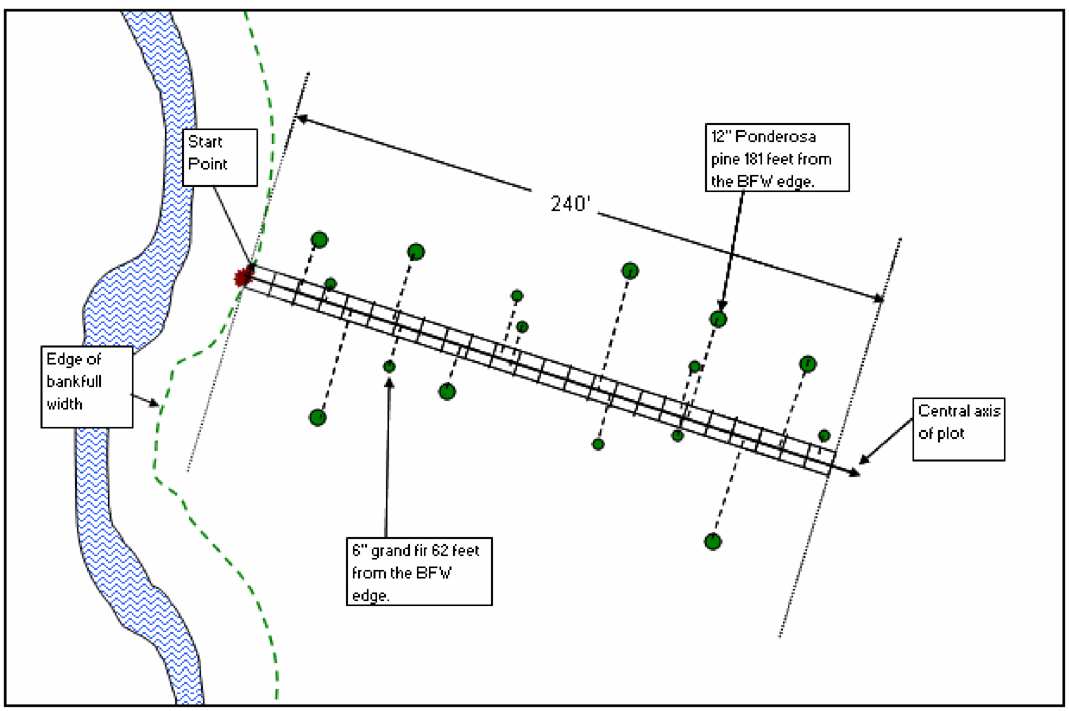

Figure 4.1-1. General sample plot layout showing start point, central axis, 24 subplots each 10’x10’, and trees and snags tallied using horizontal line sampling.

Figure 4.1-2 shows the general plot layout with the addition of the 20' line transects for dead and down material.

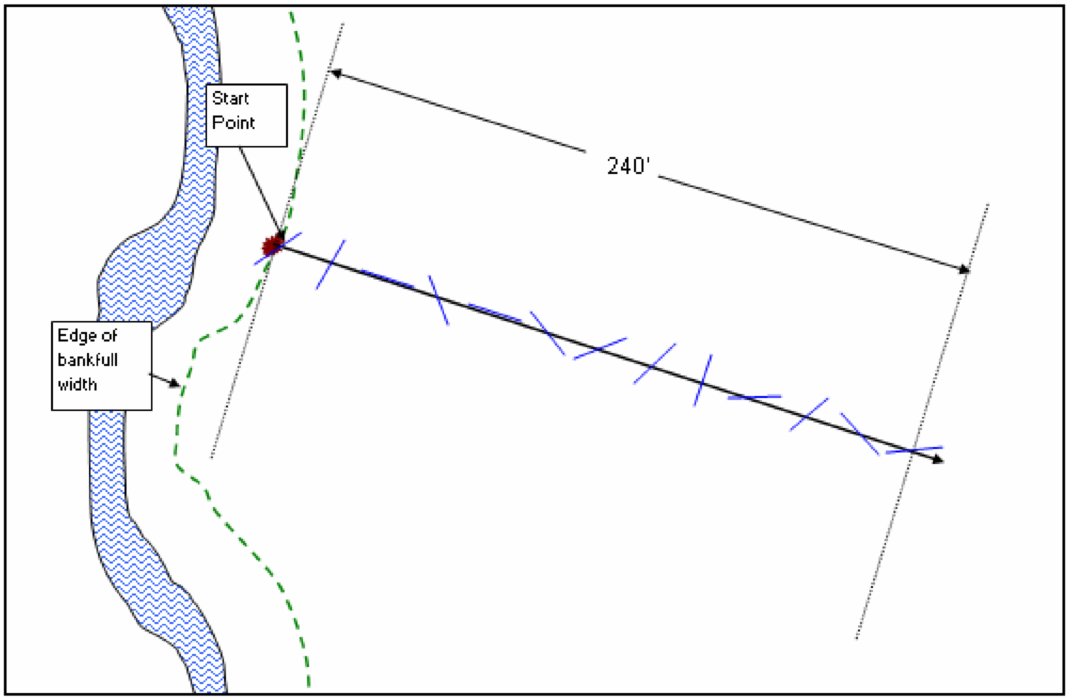

Figure 4.1-2. General sample plot layout for vegetation components; 20' line transects for tallying downed wood are shown at 20' intervals along the central axis of the plot.

4.2 HORIZONTAL LINE SAMPLING (HLS) FOR TREES AND SNAGS

Sampling for trees and snags will be conducted using horizontal point sampling, also referred to as prism sampling, variable radius sampling, and Bitterlich sampling. Horizontal point sampling requires that the field person stand at a point, swing the prism (or relascope) around the point, and tally trees that are "in". The probability of a tree being tallied is proportional to its basal area, and the number of trees per acre it represents is equal to the basal area factor of the prism divided by the basal area of the tree. This is a very efficient field method for tallying larger trees, and the computations result in unbiased estimates of trees per acre, basal area per acre, volume per acre, etc.

Horizontal line sampling (HLS) also makes use of a prism or relascope, but the sample plot geometry is no longer a point on the ground, but a line of known length. The field person walks the line and looks in both directions, perpendicular from the line, for trees that are "in". The calculation of trees per acre for each tallied tree is, again, a function of the basal area factor of the prism or relascope, and the dbh of the tree, as well as the length of the line. HLS has been described by Husch, Miller, and Beers (1972; page 276), Grosenbaugh (1958), and more recently by Ducey et al (2002).

One of the advantages of using the relascope for determining "in" trees is that on steep ground, the relascope automatically adjusts for slope. Using the relascope in the HLS application eliminates the need for the field crew to try to lay out plots of a certain fixed dimension on sloping ground, which will save time.

Implementation of HLS in the pilot project will proceed as follows:

- The crew must establish the Start Point and the Central Axis. Establishment of the Central Axis should include the demarcation of 10' intervals, such that at any point along the Central Axis the crew can accurately estimate the distance from the Start Point to the nearest foot.
- One crew member will walk the Central Axis line with a relascope while the other crew member helps to determine "in" trees and measures dbh on those trees. A BAF 20 will be used for both snags and live trees (>= 3.0" dbh).[2] Trees on both sides of the Central Axis must be tallied.
- When a tree is tallied on the HLS, the observer should be on the Central Axis with a line of sight to the tally tree that is perpendicular to the Central Axis. At this point the distance along the Central Axis can be used to approximate the distance of the tree from the edge of the bankfull width.
- In most cases the distance of the observer from the Start Point when a tree is sighted will be equal to the distance of the tree from the edge of the bankfull width, but meanders in the stream may require extra steps be taken to accurately record the distance of the tree from the bankfull edge. In these cases, the crew will have to flag the bankfull edge for some distance on both sides of the Start Point, such that the distance to the nearest point on the edge can be measured from each subject tree.

4.3 Fixed Area Sub Plots for Saplings, Seedlings, and Shrub Cover

Small 10'x10' square plots will be established along the Central Axis to characterize saplings, seedlings, and shrub cover. The plots are small enough that laying them out on steep ground (and correcting for slope) should not be problematic.

It should be sufficient to record the number of seedlings and saplings by 1" dbh class, by species. Dbh classes should be 0" to .99", 1.0" to 1.99", and 2.0" to 2.99". Average total height should be recorded by species and dbh class.

Ocular estimates of percent cover of shrubs and invasive species will also be made on each subplot. Estimates to the nearest 5% will be sufficient.

4.4 Line Transect Sampling for Downed Wood

Line transects 20' long located along the Central Axis will be used to tally downed wood. To qualify for tally, a piece must be at least 6' long and 4" in diameter at the large end. A piece will only be tallied if the line transect intersects the central axis of the piece (Figure 4.4-1). The diameter of the piece at the point of intersection, as well as the species, length, decay class, and whether or not any part of the piece is in the channel, will be

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[2] This basal area factor should be sufficient for Phase 1. Based on the results of Phase 1, it may be adjusted for the larger study, or different basal areas may be used for snags and live trees.

recorded. Also noted will be the probable origin of downed wood (e.g., logging, wind throw, bank failure/erosion).

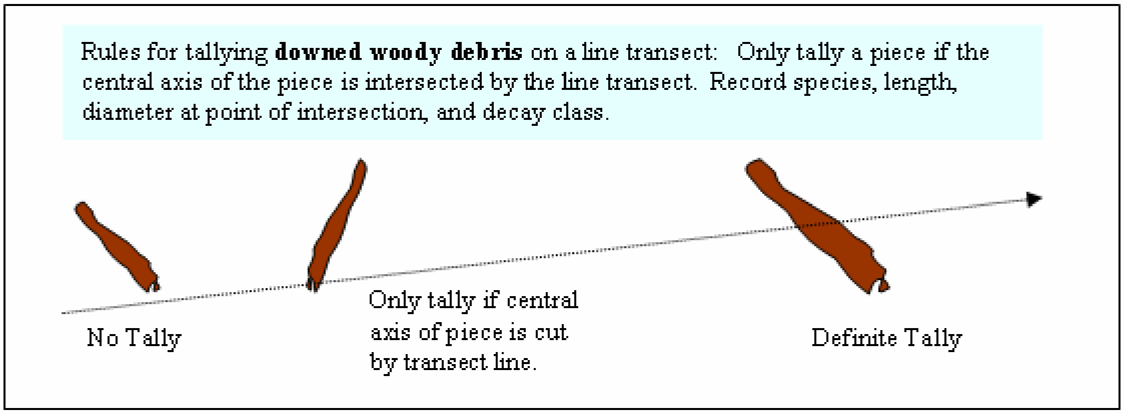


Figure 4.4-1. Rules for tallying downed woody debris on a line transect.

The following decay class codes and guidelines (Smith, 1998) will be used for characterizing the downed wood.

Table 4.4-1. Guidelines for classifying stages of decay in downed wood and snags

Decay Class	**Bark**	**Twigs (<3 cm)**	**Wood Texture LWD**	**Wood Texture Snag/Stump**	**Shape**	**Wood Color LWD**	**Wood Color Snag/Stump**
0	Use decay class 0 for fresh, recently fallen downed wood with green leaves or needles.						
1	Intact	Present	Intact	Intact	Round	Original color	Original color
2	Intact	Absent	Intact	Intact to softening	Round	Original color	Original color
3	Trace	Absent	Smooth; some surface abrasion	Hard, large pieces	Round	Original to darkening color	Original to faded color
4	Absent	Absent	Abrasion; some holes and openings	Small, soft blocky pieces	Round to oval	Dark	Light brown to reddish brown
5	Absent	Absent	Vesicular; many holes and openings	Disintegrating	Irregular	Dark	dark reddish brown

5.0 PHYSICAL/GEOMORPHIC CHARACTERISTICS

This primary focus of this Study Plan is to characterize riparian vegetation in Eastern WA. However, a secondary goal, as stated in SAGE's June 2004 Scoping Document, is to explore relationships between stand conditions, riparian functions and in-channel habitat conditions. Detailed measurement of instream physical/geomorphological variables is beyond the scope of this study; however, a classification of stream channels will be made using the Montgomery-Buffington system (Montgomery 1997) to provide linkages between the riparian data and key geomorphic characteristics of adjacent stream reaches. Stream channels will be "types" for each study reach to help characterize or predict riparian conditions and attributes, and to provide possible correlates with biological data. The Montgomery-Buffington stream classification system to be used during Phase 1 is summarized below.

5.1 MONTGOMERY-BUFFINGTON STREAM TYPE

The Montgomery-Buffington Stream Classification methodology (Montgomery 1997) has become a widely accepted approach for channel classification. This system utilizes systematic variations in stream bed morphology as the basis for classifying stream channels on a local scale, utilizing easily discernable field and map-based attributes. The seven channel types used in this methodology include:

***Cascade Channels*—**Channels generally occurring on steep slopes that are narrowly confined by valley walls and are characterized by disorganized bed material consisting of cobbles and boulders. These channels contain streams in which there is a nearly continuous, highly turbulent flow over and around large grained materials (clasts).

***Step-Pool Channels*—**Channels characterized by longitudinal steps formed by large clasts organized into discrete channel-spanning accumulations that separate pools containing finer material. The stepped morphology of the beds in these channels results in alternating turbulent flow over steps and tranquil flow through pools.

***Plane-Bed Channels*—**Channels with a nearly uniform flow that are characterized by long stretches of relatively featureless bed. Plane-bed channels have a low width to depth ratio and occur at moderate to high slopes in relatively straight channels.

***Pool-Riffle Channels*—**Pool-riffle channels are defined as channels with undulating beds comprising a sequence of bars, pools, and riffles. Bars are exposed creating a sinuous watercourse, with water flowing turbulently through riffles and more tranquilly through pools.

***Dune-Ripple Channels*—**Low-gradient, sand-bed channels.

***Colluvial Channels*—**These channels typify small headwater streams at the tips of a channel network that flow over a colluvial valley fill and exhibit weak or ephemeral fluvial transport.

Bedrock Channels—Bedrock channels lack a continuous alluvial bed and are generally confined by valley walls.

In addition to classification of the study reach, the presence of any tributary or side channel reach within or near the study area will be noted. If present, tributaries will also be classified.

For purposes of this project, the Montgomery-Buffington stream type will be determined based on limited field observations (e.g., estimated bed material composition (sand, gravels, cobble, etc.), field photographs (upstream and downstream at mid-channel if possible), and the information contained below (Table 5.2-1). Diagrams of Montgomery-Buffington stream types (from Montgomery 1997) will be provided in the Phase 1 Field Manual.

Table 5.2-1 Montgomery-Buffington Diagnostic Features of Channel Types (from Montgomery 1997).

	Dune ripple	Pool riffle	Plane bed	Step pool	Cascade	Bedrock	Colluvial
Typical bed material	Sand	Gravel	Gravel-cobble	Cobble-boulder	Boulder	Rock	Variable
Bedform pattern	Multilayered	Laterally oscillatory	Featureless	Vertically oscillatory	Random	Irregular	Variable
Dominant roughness elements	Sinuosity, bedforms (dunes, ripples, bars) grains, banks	Bedforms (bars, pools), grains, sinuosity, banks	Grains, banks	Bedforms (steps, pools), grains, banks	Grains, banks	Boundaries (bed and banks)	Grains
Dominant sediment sources	Fluvial, bank failure	Fluvial, bank failure	Fluvial, bank failure, debris flows	Fluvial, hillslope, debris flows	Fluvial, hillslope, debris flows	Fluvial, hillslope, debris flows	Hillslope, debris flows
Sediment storage elements	Overbank, bedforms	Overbank, bedforms	Overbank	Bedforms	Lee and stoss sides of flow obstructions	Pockets	Bed
Typical confinement	Unconfined	Unconfined	Variable	Confined	Confined	Confined	Confined
Typical pool spacing (channel widths)	5 to 7	5 to 7	None	1 to 4	<1	Variable	Unknown

The Phase 1 Field Manual will also contain photographs of the seven channel types noted above, as well as more detailed explanations of the various determinants of channel type, as per Montgomery (1997).

6.0 RIPARIAN DISTURBANCE

CMER/SAGE has recently completed a literature review project entitled "A Review and Synthesis of Available Information on Riparian Disturbance Regimes in Eastern Washington" (SAGE 2004). A key finding of this review was that much of the scientific literature describing Eastern Washington disturbance regimes and forest responses is at the forest series or plant association group level, and does not distinguish between riparian and upslope communities. The composition of riparian stands is clearly influenced by recent and ongoing disturbance, thus readily identifiable sources of both anthropogenic and natural disturbance will be noted in the field and/or office.

6.1 ANTHROPOGENIC DISTURBANCE

Identification of site-specific riparian disturbances will be identified if evident during field data collection. Anthropogenic disturbance regimes may include:

<u>Recent timber harvest</u>

- Are harvested trees (stumps) evident within the RMZ? (Assign Prevalent, Few, or None). Note the type of harvest, and decay class of the stumps.

<u>Road influence</u>

- Do roads or impervious surfaces occur within the RMZ? (if yes describe location, intersection with central axis of plot). This includes paved and unpaved roads, skid trails, and landings.

<u>Grazing influence</u>

- Is there recent evidence of cattle within the RMZ? (grazed stubble, trampling, bank sloughing/erosion).

<u>Invasive plant species</u>

- (note presence and percent cover of noxious weed species [photo key to be provided to field crew]).

6.2 NATURAL DISTURBANCE

Riparian forest structure, composition, and patch heterogeneity within riverine systems are often driven by major disturbance processes (Fetherston et al. 1995). All channels have been affected by disturbance of some kind, whether historic or recent. Therefore, the characterization of riparian areas from a single survey provides a temporal “snap-shot,” documenting a single point in the patterns of fluctuation. Riparian trees recover at different rates following disturbance, dictated by disturbance frequency, species characteristics, and site growth potential.

Natural disturbances found in riparian areas of Washington State include fire, wind throw, insect infestations, drought, disease, animal impacts, ice storms, floods, debris flows, bank erosions, landslides, and snow avalanches. Field and/or electronic data sheets will require that evidence of any of these be noted in the field for both small scale, e.g., on an individual tree, and large scale, e.g., evidence of a fire-induced return to an earlier seral stage over a large portion of the study area.

Fire, insects, and disease are natural disturbance factors most likely to exert influence over riparian vegetation at selected sites. Field crews will utilize condition factor codes to describe evidence of these factors based on those in use by the USFS and/or WDNR (e.g., Figure 6.2-1).

6.2.1 Forest Health

The Eastside Type F Riparian Assessment project is focused on describing and quantifying riparian vegetation on FFR-managed lands throughout eastern Washington. Assessment of the condition and health of vegetation is not a principal objective. However, SAGE recognizes that this study presents an important opportunity to augment on-going efforts to monitor forest health by state and federal agencies, e.g., the annual aerial "sketchmap" surveys conducted by WDNR and the U.S. Forest Service that provide statewide assessments of a number of insect and disease related threats to forest health. Highlights of the 2005 survey are shown below (Figure 6.2-1).

Field crews will utilize photos/diagrams and associated condition codes to indicate presence or absence of many of the priority concerns of forest health specialists in the Pacific Northwest. These data will be collected for each "in tree" as defined in Section 4. Presence or absence of the following insects and disease will be noted:

Insects:

- Western Spruce Budworm (and associated budworms)
- Douglas-fir Tussock Moth
- Mountain/Western/Pine Bark/Fir Engraver Beetle
- Asian long-horned beetle
- Balsam Woolly Adelgid
- Hemlock Looper
- Spruce Aphid.

Disease:

- Root Rot
- White Pine Blister Rust
- Dwarf Mistletoe.

Additional codes may be added based on discussion with agency staff. If a tree appears to be defoliated but the cause is unknown, field crews will indicate "unknown defoliant". The percent of affected trees will thus be available in the project data, regardless of whether the cause of the damage is known.

6.2.2 Fire and Wind-Throw

If possible, fire history will be obtained via fire history maps, discussion with landowners and Washington DNR staff, and tree ring or whirl counts during field observations. The severity of these disturbances (i.e., understory burns, partial burns, stand replacement) will also be noted in the field.

Wind-throw will be noted on both standing trees and downed wood. This will enable wind-throw assessments within the RMZ, as well as establishing relationships with distance from the stream. Decay classifications (see Table 4.4.1) will also be used for wind thrown trees.

Indications that tree mortality is due to wind-throw rather than other causes will be 1) the presence of intact branches, leaves/needles, 2) no evidence of mortality due to root, fungal, insects, animals, or other forms of disturbance. This may be difficult to ascertain in some instances, particularly if the downed wood has decayed or has since been infested with insects, fungus, or other factors that make causes of mortality unclear. In these instances, downed wood will receive an "unknown" source of mortality in the field forms.

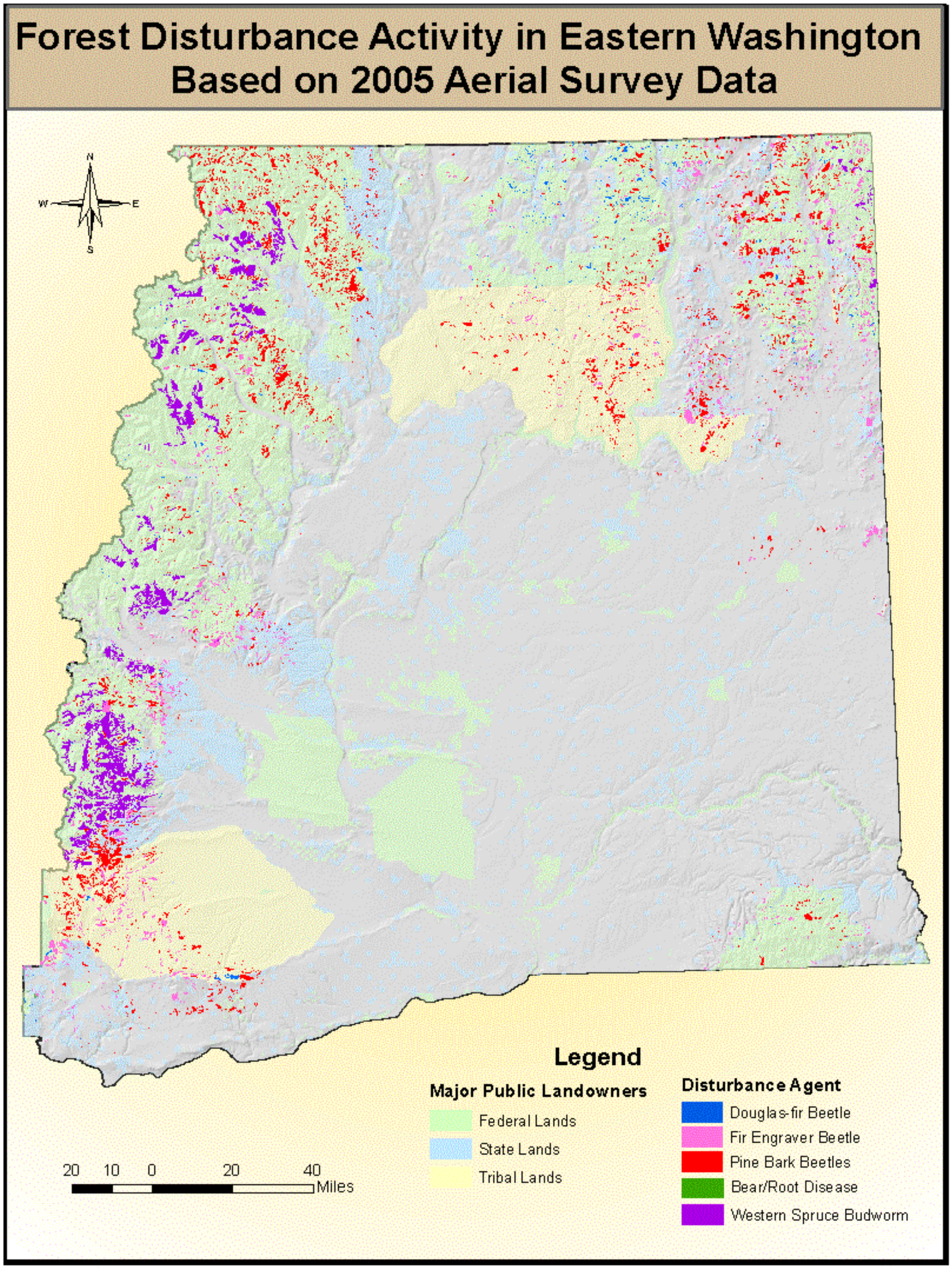


Figure 6.2-1. Summary of 2005 WDNR and USFS aerial survey data for forest health – Eastern Washington (WDNR 2006).

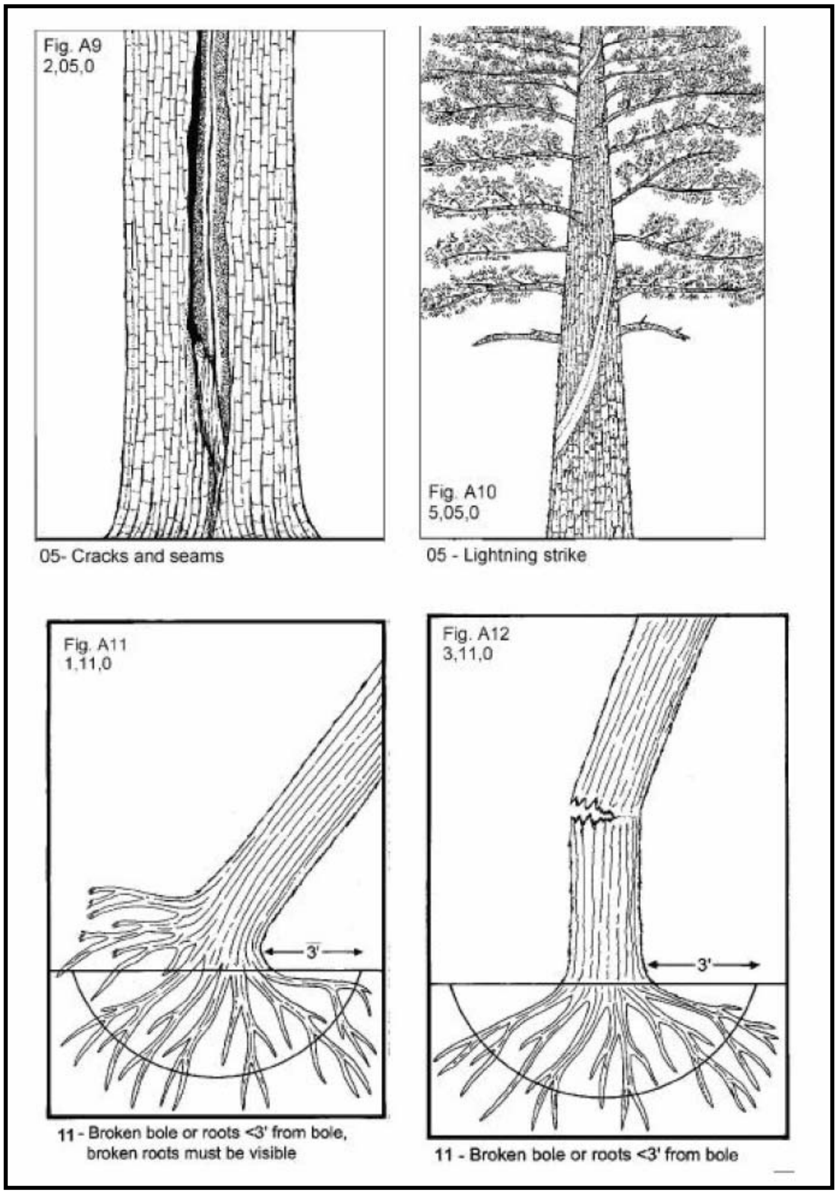


Figure 6.2-2. Example of diagram for use in assessing damage to trees in riparian zones (from USFS West Coast Forest Inventory and Analysis – National Core Field Guide (2005).

7.0 DATA MANAGEMENT AND ANALYSIS

In addition to field data collection, Phase I project activities will require data management and analysis to address three primary study goals, as described previously in Section 3:

- Determine whether the plot configuration and field protocols for sampling riparian vegetation are sufficient for use in the larger study (Phase 1).
- Determine variability in the data and thus the number of plots needed in Phase 2 to satisfy precision and accuracy requirements desired by SAGE.

- Determine the value, if any, of stratifying the FFR riparian lands by vegetation zone, elevation band, or other parameter of interest in Phase 2.

Data management activities required to address these goals are discussed below (Section 7.1). Example analyses to address key questions (presented in Section 1), are presented in Section 7.2.

7.1 Data Management

Data collected in the field in Phase 1 will be entered into an electronic data recorder by the field crews. The data entry application in the data recorder will feature user-friendly screens with prompts and menus, as well as error checking. Data collected will be backed up on CD-ROM at the end of the day.

Field data in the data recorder will then be transferred and stored in an Access database, an example of which is shown in Figures 7.1-1 through 7.1-6. Data fields in each table will be clearly documented (Figures 7.1-2 and 7.1-3), and tables will be designed such that data redundancy is minimized. During the data transfer process additional error checking will be done to ensure data integrity.

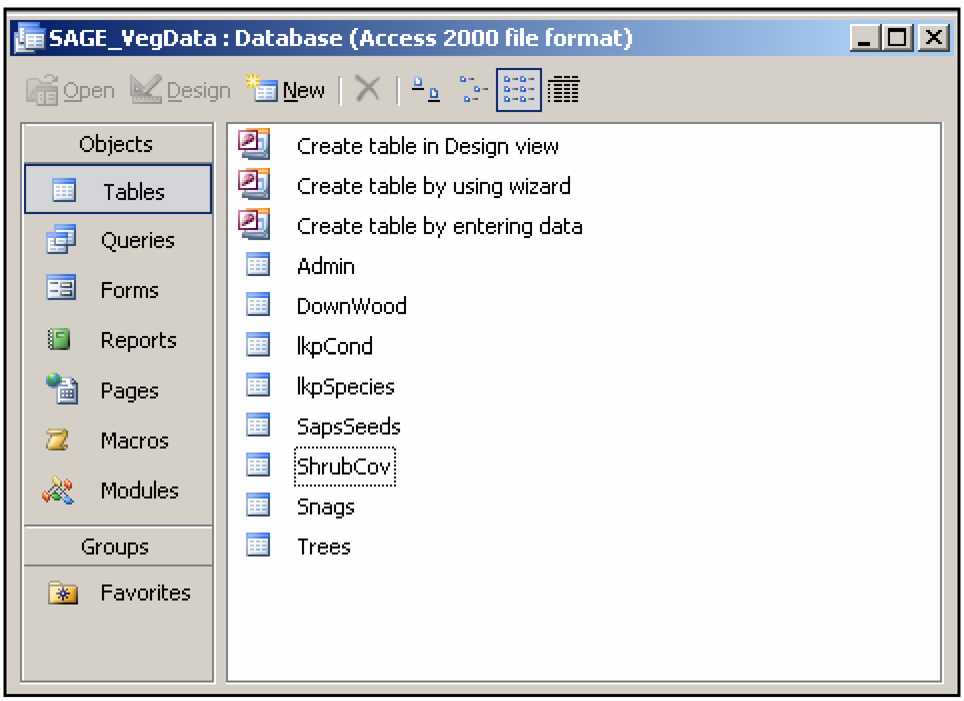


Figure 7.1-1. Example database for storing SAGE riparian data.

The following figures illustrate documentation of data fields in an example database.

Admin : Table

Field Name	Data Type	Description
ReachID	Text	Unique identification code for stream reach
SiteNumber	Text	Unique identification code for sample site within the reach
MsmtDate	Date/Time	Date of field data collection - mm/dd/yy
CheckDate	Date/Time	Date of QA/QC field check - mm/dd/yy
Crew	Text	Field crew leader initials
Checker	Text	QA/QC initials
Landowner	Text	Name of landowner
OwnerType	Text	Type of landowner - agency, NIPF, industrial, etc.
Fire	Yes/No	Evidence of past fire?
FireYear	Number	Year that fire occurred
FireSev	Text	Fire severity - S=severe, M=moderate, L=Light
Mgmt	AutoNumber	Evidence of past harvesting?
MgmtYear	Number	Year of past harvesting
MgmtType	Text	Harvest type - C = clearcut, S = shelterwood, T = thin, O = overstory removal, X = seed tree
StreamWidth	Number	Width of stream in feet
StreamGradient	Number	Slope in percent
Rosgen	Text	Rosgen classification

Figure 7.1-2. Table structure for Admin Table.

Trees : Table

Field Name	Data Type	Description
ReachID	Text	Unique Identification Code for stream reach
SiteNumber	Text	Unique identification code for sample site within the reach
Distance	Number	Distance between bankfull edge and tree location, in feet
TreeNum	Text	Unique tree identification number at this site
Species	Text	USFS 3-digit code for tree species
DBH	Number	Tree diameter at breast height to nearest tenth inch
TotHt	Number	Tree total height to nearest foot
CR	Number	Ocular estimate of live crown ratio to nearest 5%
Pos	Text	Tree position in the canopy - D=Dominant, C=Codominant, I=Intermediate, S=Suppressed
Site	Yes/No	Is this tree suitable for site index estimation?
BHAge	Number	Tree age at breast height
Cond1	Text	First field to record tree condition, from lkpCond table; primary condition
Cond2	Text	Second field to record tree condition, from lkpCond table; secondary condition

Figure 7.1-3. Table structure for Trees table.

The "lkp" tables are lookup tables, holding codes and definitions. The lkpSpecies table is illustrated in Figure 7.1-4.

lkpSpecies : Table

SpCode	SpName	GenSp
119	Western white pine	Pinus monticola
122	Ponderosa pine	Pinus ponderosa
17	Grand fir	Abies grandis
202	Douglas-fir	Pseudotsuga menziesii
263	Western hemlock	Tsuga heterophylla
351	Red alder	Alnus rubra
746	Quaking aspen	Populus tremuloides

Figure 7.1-4. Lookup Table for Species Codes.

Figure 7.1-5 and 7.1-6 illustrate some example data entries in portions of the ADMIN and LargeTrees tables.

Admin : Table

ReachID	SiteNumber	MsmtDate	CheckDate	Crew	Checker	Landowner	OwnerType	Fire	FireYear	FireSev
215	1	6/4/2006		RJW		WDNR	Agency	☐	0	
215	2	6/5/2006	6/7/2006	RJW	TLB	Smith	NIPF	☑	1978	M
215	3	6/7/2006		TRE		WDNR	Agency	☐	0	

Figure 7.1-5. Example data in the Admin table.

Trees : Table

ReachID	SiteNumber	Distance	TreeNum	Species	DBH	TotHt	CR	Pos	Site	BHAge	Cond1	Cond2
215	2	12	1	202	12.5	60	35	I	☐	0	00	00
215	2	14	2	263	10	70	45	C	☐	0	00	00
215	2	23	3	263	8.8	65	45	C	☐	0	BT	00
215	2	27	4	351	15.2	100	50	D	☐	0	00	00

Figure 7.1-6. Example data in the Trees table.

The data in the Access database will be related to stream reach and sample site locations on a GIS layer, enabling some limited spatial analyses.

7.2 EXAMPLE ANALYSES

This section presents examples of statistical tests and analyses that can be supported by data collected during the Phase 1 Study. Keeping the data in the Access database will allow the use of database queries, spreadsheet tools, and statistical packages for data analysis. <u>This section does not include all possible analyses, only some examples to illustrate some basic calculations and provide guidance for future analyses.</u> Examples have been arranged to relate to the project objectives and key questions listed in Section 1.0, and additional project goals listed in 3.1. Section 7.2.1 discusses analyses focused on the Key Questions underlying this study. Section 7.2.2 suggests alternative exploratory tests that may help illustrate patterns in the data, and the variables most important in determining them.

7.2.1 Directed Analyses

Suggested approaches for addressing the Key Questions for Phase 1 are presented in this subsection. In contrast to "exploratory analyses" discussed in Section 7.2.2, analyses described in this section are directed specifically at the Key Questions. Underlying several of these is the issue of the potential need for stratification of the data for Phase 2. Stratification in this context refers to a non-random apportionment or weighting of sample locations based on *a priori* understanding (or assumption) of the role of certain key variables in explaining variance in the non-stratified data. Sites to be sampled in Phase 1 have been chosen randomly and are not stratified. Most of the examples below will inform a decision regarding this question, in particular Key Questions 1(c), 1(d), and 2(d).

Key Question 1a. What are the current characteristics of riparian stands in eastern Washington?

Example – Find the average basal area in live trees >= 8.0" dbh within 45' of the edge of the bankfull width.

Data in the Trees table would be used to answer this question. The first step would be to calculate the number of trees per acre represented by each tree tallied on the horizontal line sample within 45' of the bankfull edge for each sample site. The equation is:

TPA = (43,560*k)/(11*D*45/66) Eq. 1
Where TPA = trees per acre represented by a tree tallied on the horizontal line sample ,
k = a factor dependent on the BAF; in this case, when BAF = 20, k = .0428;
D = dbh of the tree,
and 45/66 = proportion of the length of the base line as a function of the length of a chain (66').

For example, a 12.3" dbh tree tallied in the first 45' of the HLS with a BAF of 20 would represent 20.21 trees per acre, as shown:

TPA = (43,560*.0428)/(11*12.3*45/66) = 20.21 .

In this example we'll use the data stored in the Trees table, calculate the trees per acre expansion factor for each tree tallied on the horizontal line plot, and multiply by the basal area of the tree to arrive at basal area per acre for the tree (Figure 7.2-1). We'll then sum the basal areas per acre for each site, sum the basal area figures over all sites, and divide by the number of sites in the sample to get the average basal area per acre (Figure 7.2-2).

Tree Tally on Horizontal Line Sample - from the Trees table

Reach ID	Site ID	Distance	Species	DBH	Height	TPA	BA/a
215	2	2	202	12.5	60	19.88659	16.94742
215	2	3	263	5.0	70	49.71648	6.778966
215	2	10	263	8.8	65	28.248	11.93098
215	2	14	351	15.2	100	16.35411	20.60806
215	2	22	351	3.7	45	67.18443	5.016435
215	2	22	351	8.9	54	27.93061	12.06656
215	2	25	351	15.0	92	16.57216	20.3369
215	2	35	202	12.5	71	19.88659	16.94742
215	2	44	263	9.3	66	26.72929	12.60888
215	2	46	351	9.5	68	26.16657	12.88004
215	2	58	122	9.5	65	26.16657	12.88004
215	2	90	202	16.3	110	15.25045	22.09943
215	2	91	351	21.1	121	11.78116	28.60724

Figure 7.2-1. Portion of data from the Trees table for a single site. Shaded data correspond to trees >= 8.0" dbh within 45' of the edge of the bankfull width. For this site the basal area is 111.4 square feet per acre.

Obs #	Reach ID	Site ID	BA/a
1	215	2	111.4
2	221	1	92.5
3	276	1	97.1
4	348	2	172.3
.	.	.	.
.	.	.	.
.	.	.	.
200	931	1	46.2

Average over 200 sites => 94.2 sq ft/a

Figure 7.2-2. Determination of average basal area per acre in trees >= 8.0" within 45 feet of the bankfull edge, using a sample size of 200 sites. The basal area result for Observation #1 is from Figure 7.2-1.

Example – Find the 95% confidence interval for the average basal area of trees >= 8.0" within 45' of the bankfull edge.

Calculations for this estimate would use the data pictured in Figure 7.2-2. In that example, the average basal area per acre on 200 sites was 94.2 square feet. If the standard deviation of the 200 observations was 35.2, the standard error would be $35.2/(200)^{0.5}$, or 2.489. The 95% confidence interval would be 94.2 $\pm$ 1.96(2.489), or 94.2 $\pm$ 4.9 square feet per acre.

Key Question 1b. What is the frequency distribution of forest stand attributes?

Example – How frequently does ponderosa pine over 12" dbh occur within 100 feet of the edge of the bankfull width?

This type of question can be answered easily using the data in the Trees table.

The approach would be to count the number of sites on which ponderosa pine greater than 12" dbh was tallied within 100' of the Start Point, and then divide the count by the total number of sample sites. If there were 200 sample sites, and at least one tree meeting the specifications was tallied on 77 of those sites, the estimated frequency would be 77/200, or 38.5%.

In this particular calculation, it is important to note that it is not how many times the tree with the specified characteristics occurred at a sample site; but whether it was or was not there. Therefore, trees per acre expansion factors associated with each tree are inconsequential for this particular calculation.

Key Question 1c. Are there regional patterns or differences in riparian stand characteristics across eastern Washington?

Example – Is there a statistically significant difference in the average basal area per acre of Douglas-fir within 50 feet of the bankfull width between small streams and large streams in eastern Washington?

This question can be answered in a hypothesis testing framework using an unpaired t-test. We would use the data to estimate the difference in average basal area per acre for the two stream sizes, and to find the pooled standard error for the difference. The resulting test statistic would be compared to the proper Student's t value to decide if the null hypothesis of zero difference should be rejected.

In the following example, the total sample of 200 sites has been post-stratified by stream size. A difference of 11.4 square feet in basal area per acre is found to be a statistically significant difference.

Results - Doug-fir BA/acre Within 50' of BFW

	Small Streams	Large Streams
Number of sites	67	133
Average BA/a	23.4	34.8
Standard Dev.	19.4	28.2
Variance of the Mean	5.62	5.98

Difference between means = -11.4
Pooled Standard Error = 3.405372
Value of Test Statistic = -3.34765

Reject the null hypothesis of no difference between small streams and large streams, at alpha=.05.

Figure 7.2-3. Unpaired t-test results for testing null hypothesis of zero difference in basal area per acre of Doug-fir between two stream size classes.

Key Question 1d. To what extent do current riparian stands meet the size and basal area thresholds for timber harvest across the regulatory habitat types (elevation bands)?

Example – In the mixed conifer timber habitat type (2,501 to 5,000 feet), what percentage of the sites meets the threshold requirements?

Suppose that 120 of the 200 sites fell in the given elevation band. If 40 of these sites met the threshold requirements, the estimated percentage would be 40/120, or 33%. A confidence interval could also be constructed around this point estimate.

Key Question 1e. What forest plant series are represented in riparian stands?

This question could be easily answered by referring to the database and listing the plant series noted at each site. In the example database in Section 7.1, this information would be stored in the Admin table, at the site level.

Key Question 1f. Is the current riparian timber habitat type classification system valid?

Example – In the ponderosa pine timber habitat type (0 to 2,500 feet), what percentage of the sites are dominated by Ponderosa pine?

A point and interval estimate of the percentage of sites in the given elevation band can be constructed using the Phase I data. Suppose 120 of the 200 sites fell in the elevation band from 0 to 2,500 feet. If 50 percent of the Ponderosa pine at those sites had a total basal area of 85, then point and interval estimates of the true percentage of sites dominated by Ponderosa pine would be:

$p = 85/120 = 70.8\%$; and, (point estimate of the percentage)

$70.8\% \pm 1.96*[(70.8*29.2)/120]^{0.5} = 70.8\% \pm 4.2\%$ (95% confidence interval).

Key Question 2a. How do the characteristics of the study sites (e.g., physiography, geology, climate, and channel or valley morphology) affect the distribution and characteristics of riparian stands?

Note: Phase I will not be able to determine cause and affect – but the data will be useful for finding relationships between site characteristics and the distribution and characteristics of riparian stands.

Example – Is there a statistically significant difference in the average basal area per acre within 100' of the BFW between streams with less than a 5% gradient, and those at 5% or greater?

Answering this type of question will require controlling for other influences on basal area per acre, in order to isolate the impact of stream gradient as clearly as possible. But, suppose there were 23 sites with less than 5% gradient, and 34 sites greater than 5%, all similar in terms of aspect, elevation, fire history, etc. An unpaired t-test would be appropriate, just as was done for Key Question 1c.

Key Question 2b. What, if any, significant relationships exist between site characteristics and riparian stand attributes?

Example – In the 0 – 2,500 foot elevation band, is there a statistically significant relationship between slope and dominant tree height at a given age?

A confounding factor in this analysis would be aspect, so the question would have to be refined to control for aspect, as well as for species, treatment history, dbh, age, etc. One way to approach the question would be through regression analysis. The dependent variable would be average dominant tree height, and the independent variables would include slope percent. The null hypothesis would be that the coefficient on slope in the regression is zero. If the null hypothesis can be rejected, it would show that there is a statistically significant relationship between slope and dominant tree height.

Another way to approach the same question would be to recognize "dominant tree height at a given age" as the classic definition of site index. Since site index is being determined for every study site, site index could serve as the dependent variable in a regression analysis.

Key Question 2c. How do site characteristics influence the distribution and characteristics of eastside riparian stands?

Example – How does the average tree size differ within 50' of bankfull width between step pool and plane bed reach morphologies (Montgomery and Buffington,1997)?

After controlling for other variables such as treatment history, an unpaired t-test might be appropriate, just as was done for Key Question 1c.

Key Question 2d. Are there differences in riparian stand characteristics in different eco-regions? ***Note: This example illustrates how Phase 1 data may be used to determine whether stratification would help explain variation in the data, using Eco-Regions as an example.***

Example – On sites with the same site index, does the height/dbh relationship in Douglas-fir differ between the Columbia Plateau and Northern Rockies (EPA) ecoregions?

Individual tree data from the two different ecoregions could be used to develop a graph shown below (Figure 7.2-4).

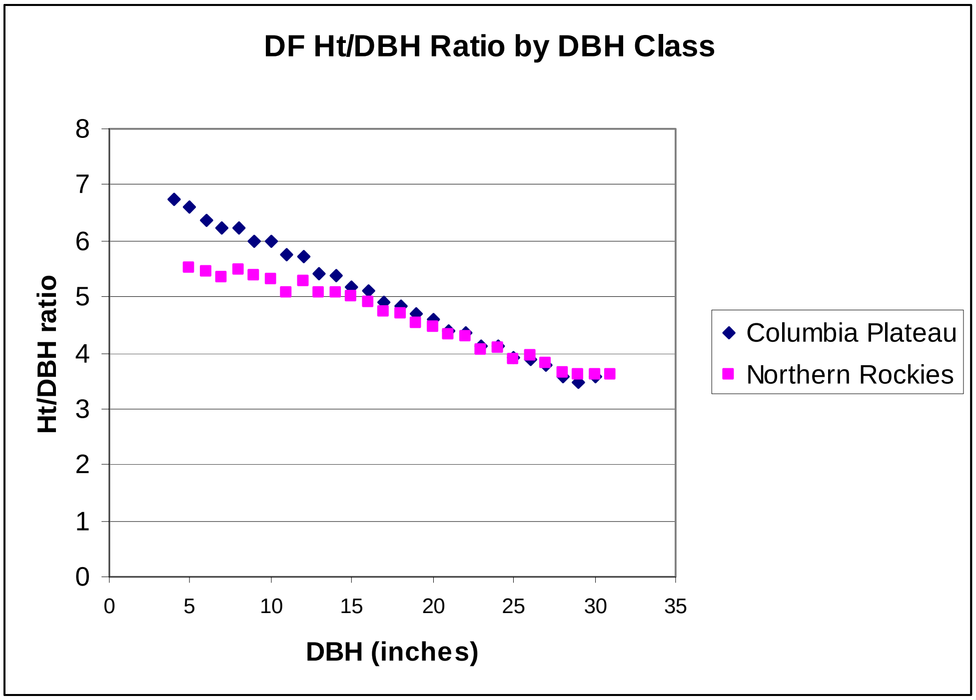


Figure 7.2-4. Exploratory test of dbh against tree height for two ecoregions.

The linear relationship between dbh and tree height confirms that the intercept and slope coefficients of the two regressions could then be used to test for a difference between regions (Figure 7.2-5).

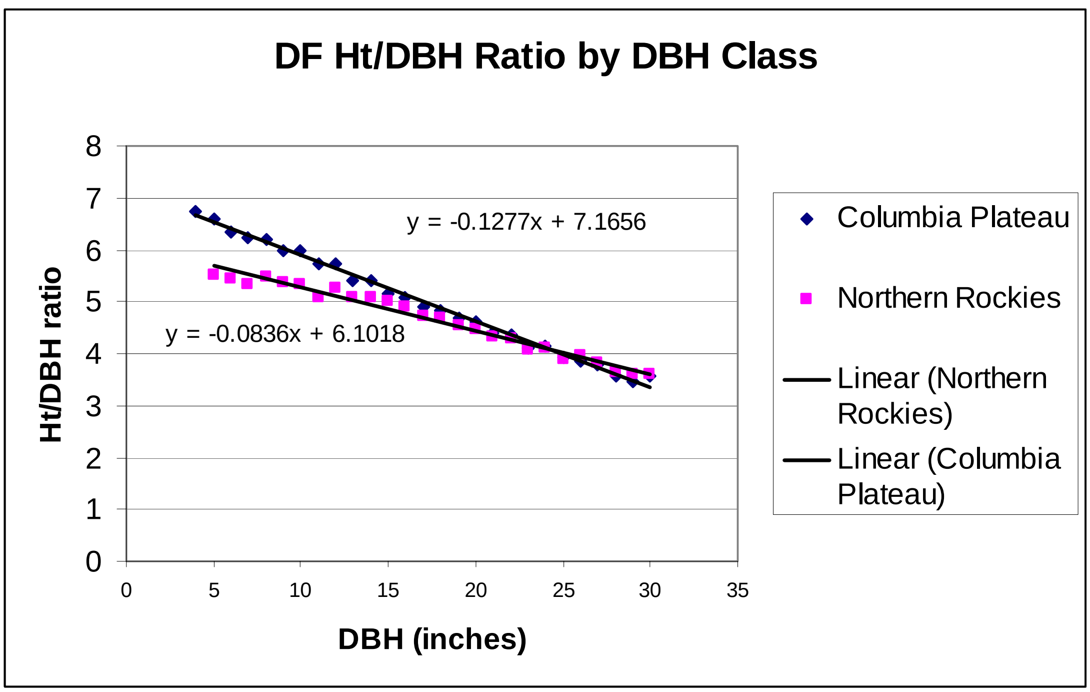


Figure 7.2-5. Example linear regression of dbh against tree height to test for differences among ecoregions.

The standard errors for the slope coefficients (in the ANOVAs below) can be used to test for a significant difference between slopes. The test statistic would be:

$$T = [-.128 - (-.084)]/[.002^2 + .003^2]^{.5} = -.044/.0036 = 12.2 .$$

A value of 12.2 would be significant at the .05 level, indicating that there is a statistical difference in dbh between ecoregions. Based on this hypothetical example, stratification by ecoregion in Phase 2, or *a priori* site selection to ensure proportional representation of ecoregions, may be beneficial.

SUMMARY OUTPUT **Columbia Plateau**

ANOVA

	df	*SS*	*MS*	*F*
Regression	1	26.71340148	26.7134015	4138.753
Residual	25	0.161361433	0.00645446	
Total	26	26.87476291		

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	7.166	0.037	193.042	0.000
X Variable 1	-0.128	0.002	-64.333	0.000

SUMMARY OUTPUT **Northern Rockies**

ANOVA

	df	*SS*	*MS*	*F*
Regression	1	10.21698475	10.2169848	981.9934
Residual	24	0.249703943	0.01040433	
Total	25	10.4666887		

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	6.102	0.051	120.157	0.000
X Variable 1	-0.084	0.003	-31.337	0.000

Key Question 3a. How does proximity to the stream influence the characteristics of eastside stands?

Example – Develop a regression to model the relationship between percent shrub cover and distance from bankfull width.

Regression modeling, using either linear or nonlinear model forms, may be useful for quantifying trends in the vegetation with distance from the edge of the bankfull width.

In the following example (Figure 7.2-4), a nonlinear model is fit to describe the relationship between percent shrub cover (for some particular species) and distance from the bankfull width. The regression data set includes the reach and site identification numbers, the distance from the Start Point to the middle of the 10’ x 10’ square subplot used to characterize shrub cover, and the observation of percent shrub cover for that subplot. There would be 24 observations associated with each sample site.

In this example, the observations are graphed, and a simple logistic function is used to develop a nonlinear model to predict percent cover as a function of distance from the CMZ. Any of various statistical software packages could be used to fit different model forms and prepare goodness-of-fit statistics.

Reach ID	Site ID	MidPt Dist. (ft)	% Cover
233	2	5.0	40
233	2	10.0	15
233	2	15.0	20
233	2	20.0	20
233	2	25.0	15
233	2	30.0	25
233	2	35.0	0
233	2	40.0	10
233	2	45.0	10
233	2	50.0	0
233	2	55.0	5
233	2	60.0	10
233	2	65.0	10
233	2	70.0	0
233	2	75.0	5
233	2	80.0	0
233	2	85.0	0
233	2	90.0	5
233	2	95.0	5
233	2	100.0	0
233	2	105.0	0
233	2	110.0	0
233	2	115.0	0
233	2	120.0	0

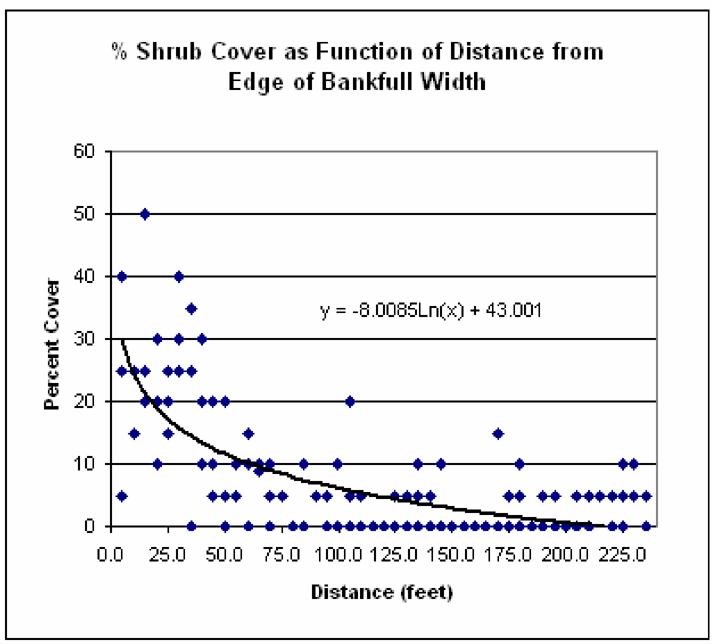


Figure 7.2-6. Example analysis to model the relationship between shrub cover and distance from the edge of the bankfull width.

Key Question 3b. Are there differences in the forest series and plant association groups (PAG) <u>between stands</u> in close proximity to the stream and those more distant?

If we temporarily ignore a strict interpretation of the "between stands" clause, the following question relative to plant series could be addressed with the field protocols described in this plan:

Example – Is there any statistically significant difference in the prevalence (percent occurrence) of the Mountain Hemlock series within 80' of the BFW and greater than 160' from the BFW?

The sampling protocol resulted in three observations at each sample site, made along the Central Axis at 40', 120', and 200' from the Starting Point. We will make use of the observations made at the 40' and 200' points to answer this question.

Suppose that of 200 sample sites visited, the TSME series was observed 23 times at the 40' mark, and 48 times at the 200' mark. The proportions would be 11.5% and 24% respectively. These are sample-based estimates of the proportions. The null hypothesis might be that the difference between the true proportions in the population is zero; if the null hypothesis can be rejected, we would conclude that there is a difference in the percent occurrence of the TSME series close to the stream as opposed to farther from the stream.

The appropriate test would be an unpaired t-test for proportions. The test statistic T would be:

$T = (p_1 – p_2)/[(p_1q_1/n_1) + (p_2q_2/n_2)]^{0.5} = (.115–.24)/[(.115)(.885)/200) + (.24)(.76)/200)]^{0.5}=$
$T = -.125/.0376 = -3.324.$

Is a difference of 12.5% between the two marks a significant difference? The probability of seeing a value of T smaller than -3.324, given the sample size, if the true difference was zero, is less than 0.005, so the null hypothesis of zero difference would be rejected.

Note that a strict interpretation of Key Question 3b suggests a direct hypothesis about differences between *types* of stands, where one type of stand is close to the stream and the other type of stand is farther from the stream. In the Phase I study, supplying data to answer this type of question would require that stand polygons be delineated at each randomly selected sample site, and that observations made on the site be tagged according to which stand the observation was made in. The Phase I plan outlined in this document does not specifically address this question (see the comments about defining the population of interest in Section 3.1), which would require aerial photography or another type of remote sensing approach to delineate stands at each randomly selected sample site. Stands are traditionally defined as contiguous areas on the ground differentiated by their species mix, density, and size of vegetation, and are usually subject to some minimum size requirement, such as 5 acres.

Once this work was complete, the stand boundaries could be overlaid on the Central Axis of the plot, so it was clear at any time which trees, downed wood, shrub, and crown closure observations occurred in which stand.

At that point, the following example could be investigated –

Example – Is there any statistically significant difference in average crown closure between those stands within a) 100 feet , and b) 150 feet of the bankfull width?

Suppose 12 sample sites had stands that met the criteria for the question. Because of the low sample size, a nonparametric Wilcoxon sign test might be appropriate for testing the hypothesis of zero difference in average crown closure between the types of stands. Consider the data –

Site Number	Crown Closure by Type of Stand		Positive or Negative difference in crown closure?
	Near	Far	
1	42	41	+
2	47	49	-
3	66	62	+
4	70	69	+
5	67	68	-
6	45	44	+
7	57	57	0
8	60	58	+
9	74	69	+
10	49	47	+
11	61	60	+
12	52	49	+

In the data there were 9 positive differences and 2 negative differences, and a resulting sample size of 11 sites (due to the zero difference at site 7). The null hypothesis would be zero difference in crown closure due to proximity to the stream, and the alternate hypothesis would be the crown closure on near sites is greater than that on far sites. From the statistical table for the Sign Test, the probability of seeing only two negative differences in a sample of size 11 if the null hypothesis was true is .033, leading to a rejection of the null hypothesis of zero difference, and a conclusion that the average crown closure is higher in the near stands than in the far stands.

Key Question 3c. Are there differences in other stand characteristics associated with distance to the stream?

Example – How does the average basal area per acre by species, for trees >= 3.0” dbh, vary as a function of distance from the edge of the bankfull width.

This analysis will require the use of the horizontal line sample data in the Trees table. The tree expansion formula (Eq. 1) will be used again, but in an effort to get a finer resolution, multiple horizontal line sample segments along the Central Axis will be used. For example, we could use 24 line segments, each 10’ in length. Using a BAF of 20, a 12.3” dbh tree tallied in any 10’ segment of the HLS would represent 90.94 trees per acre, as shown:

$$TPA = (43{,}560*.0428)/(11*12.3*10/66) = 90.94 .$$

Figure 7.2-7 shows the estimates of trees per acre using multiple 10’ segments for one site. These calculations would be repeated for each of the 200 sites, and the results would be averaged by segment and species.

Site 233

	Cutoff:	10	20	30	40	50	60
	Length:	10	10	10	10	10	10

Tree	Species	DBH	Dist from Start Point	TPA_1	TPA_2	TPA_3	TPA_4	TPA_5	TPA_6
1	RA	11.1	10	100.78					
2	RA	12.3	21			90.94			
3	DF	6.0	25			186.44			
4	RA	12.5	33				89.49		
5	WI	10.4	34				107.56		
6	WI	7.9	39				141.60		
7	DF	6.0	40				186.44		
8	RA	5.4	47					207.15	
9	DF	18.4	180						
10	DF	12.8	207						
11	PP	3.0	220						
12	PP	20.1	231						

	TPA_1	TPA_2	TPA_3	TPA_4	TPA_5	TPA_6
Total Trees per acre in segment:	100.78	0.00	277.38	525.08	207.15	0.00
RA tpa:	100.78	0.00	90.94	89.49	207.15	0.00
DF tpa:	0.00	0.00	186.44	186.44	0.00	0.00
WI tpa:	0.00	0.00	0.00	249.16	0.00	0.00
PP tpa:	0.00	0.00	0.00	0.00	0.00	0.00

Figure 7.2-7. Estimation of trees per acre by species in 10’ segments for one particular site. (There are actually 24 segments, each 10’ in length; not all segments are shown.)

After converting the trees per acre estimates to basal area per acre, and after repeating the calculations for all 200 sample sites, the average basal area per acre by species can be found for each 10’ interval moving away from the stream. At that point graphs similar to that shown in Figures 7.2-8 and 7.2-9 could be created.

Reach ID	Site ID	MidPt Dist. (ft)	% Cover
233	2	5.0	40
233	2	10.0	15
233	2	15.0	20
233	2	20.0	20
233	2	25.0	15
233	2	30.0	25
233	2	35.0	0
233	2	40.0	10
233	2	45.0	10
233	2	50.0	0
233	2	55.0	5
233	2	60.0	10
233	2	65.0	10
233	2	70.0	0
233	2	75.0	5
233	2	80.0	0
233	2	85.0	0
233	2	90.0	5
233	2	95.0	5
233	2	100.0	0
233	2	105.0	0
233	2	110.0	0
233	2	115.0	0
233	2	120.0	0

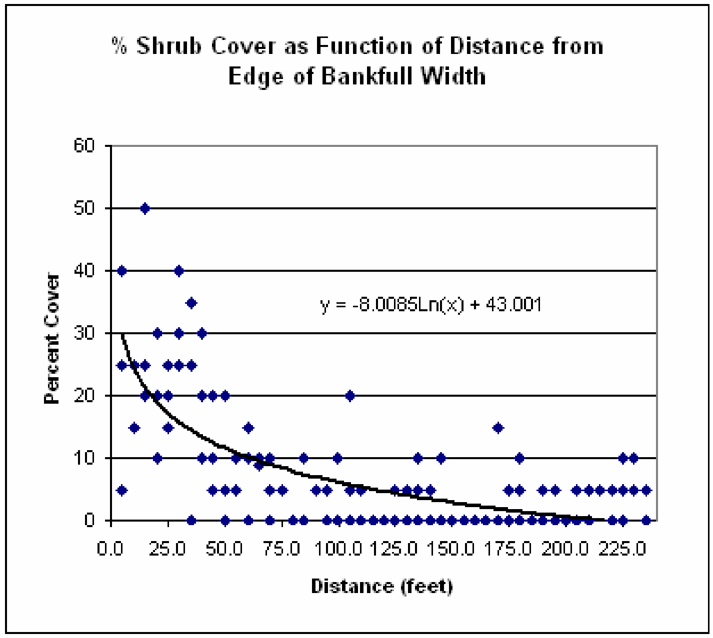


Figure 7.2-8. Example analysis to model the relationship between shrub cover and distance from the edge of the bankfull width.

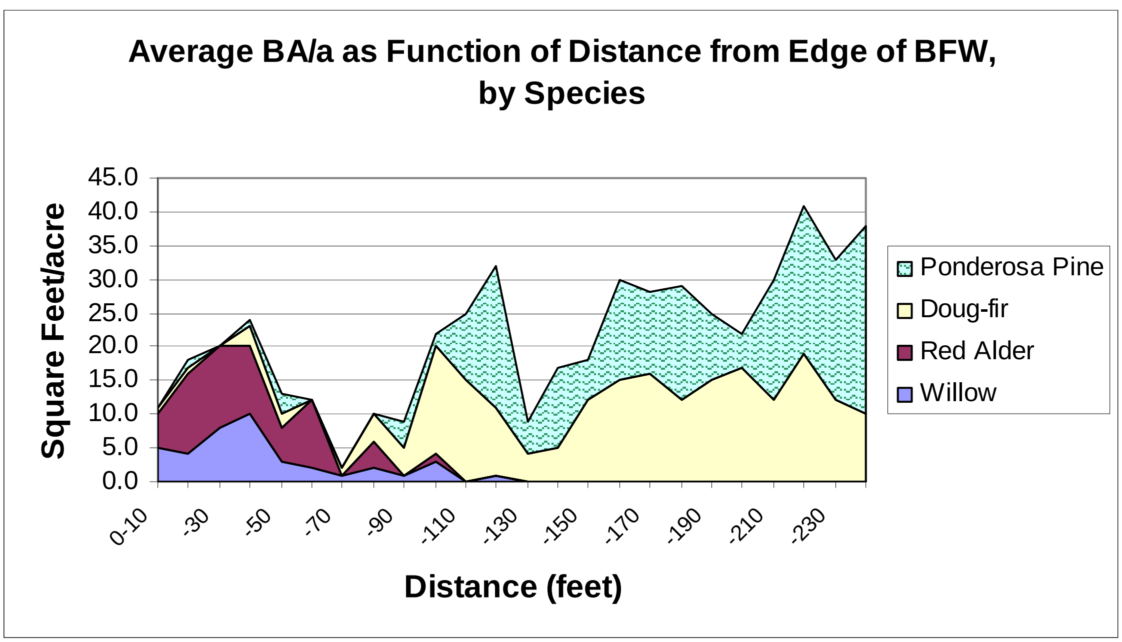


Figure 7.2-9. Example display of change in species composition with distance from the edge of the bankfull width.

Key Question 4a. What is the extent of tree mortality, breakage, and other physical disturbances in riparian stands in eastern Washington?

Example – What is the average number of recently dead (decay class 0) standing trees per acre, by species and dbh class, by type of landowner?

This analysis will require calculation of the number of recently dead trees per acre at each sample site, by species and dbh class. The calculations will be similar to those used in the example for Key Question 1a. Because every site will be assigned to a landowner type, it will be possible to develop "stand tables" (i.e., number of trees per acre by species and dbh class) for every type of landowner, or for any other stratum of interest.

Key Question 4b. How widespread are insect and disease effects in East side riparian zones?

Example – Estimate the proportion of riparian stands on FFR lands on the East side where the mountain pine beetle is present.

If the beetle was present on 37 of 200 sample sites, the 95% confidence interval for the proportion of riparian stands where the beetle is present would be:

$$p \pm t[pq/n]^{0.5},$$

$$= .185 \pm 1.96[(.185)(.815)/200]^{0.5} = .185 \pm .054 = 18.5\% \pm 5.4\%.$$

Key Question 4c. What are the characteristics of snags and diseased or damaged trees?

Example – Estimate the diameter distribution of snags in riparian zones in the lower elevation band (<2,500') within 45' of the BFW.

In Phase I, snags >= 3.0" will be tallied on the horizontal line sample plot, just as live trees will be tallied. This will allow estimation of the number of snags per acre by size class and/or by any stratum of interest. In this case, the stratum of interest is the lower elevation band, within 45' of the bankfull width. The first step would be to calculate the number of snags per acre represented by each snag tallied on the horizontal line sample within 45' of the bankfull edge for each sample site. The calculations would be identical to those used in the example for Key Question 1a, except that every snag would also be assigned to a dbh class, and results would be presented by dbh class.

Key Question 4d. Is there evidence of a relationship between stand characteristics, physiographic factors, climatic factors, management activities and tree mortality?

Example – Is there a difference in the amount of mortality within 100' of the BFW between stream gradients < 4% and stream gradients >=4%?

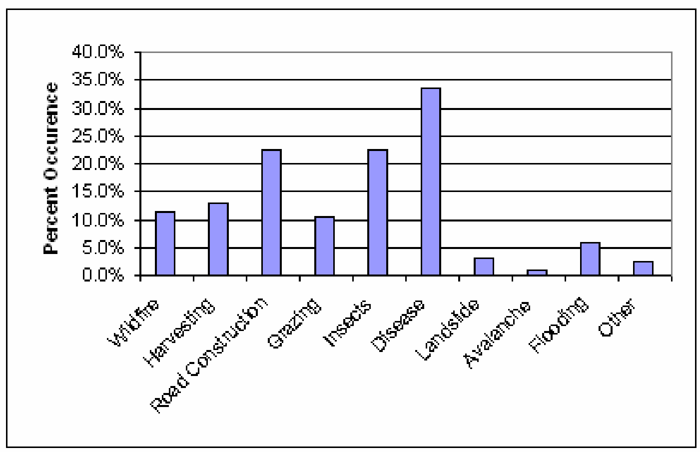
If we use estimates of basal area per acre in snags as a way to quantify tree mortality, we could compare estimates between the two stream gradient classes to see if the estimates are statistically significantly different. The calculation of basal area per acre would be similar to that used in Key Question 1a. An unpaired t-test would be appropriate for testing the null hypothesis of no difference between gradient classes, as was done for Key Question 1c.

Key Question 5a. What are the key (disturbance) factors influencing riparian stands in eastern Washington?

Example – Develop a histogram to illustrate the relative importance of various disturbance factors in riparian stands.

Since disturbance factors will be noted for every sample site (see Table 4.0-2), it will be easy to determine the percentage of the sites that each disturbance factor was noted on. More that one disturbance factor may be present on a site, so the sum of the counts may add to more than the total sample size (in this example, 200).

Disturbance Factor	Count	%
Wildfire	23	11.5%
Harvesting	26	13.0%
Road Construction	45	22.5%
Grazing	21	10.5%
Insects	45	22.5%
Disease	67	33.5%
Landslide	6	3.0%
Avalanche	2	1.0%
Flooding	12	6.0%
Other	5	2.5%



Key Question 5b. How do past or current management activities (e.g., fire suppression, harvest, grazing, road construction, timber harvest) influence current riparian stand conditions?

Example – Is there a difference in species composition between stands that were grazed in the past, and those that were not grazed?

After controlling for other factors that may influence species composition, this question could be addressed with a Chi-square Goodness-of-Fit test. The null hypothesis would be that the distribution of plant series, for example, is the same between grazed and ungrazed stands. Suppose for a given slope class, aspect, elevation, site index, etc., we have the following observations:

Plant Series	Actual Count of Grazed Sites	Actual Count of Ungrazed Sites
TSME	5	15
ABAM	2	5
TSHE	12	56
THPL	2	7
	21	83

Is there a difference in the distribution by plant series attributable to grazing? If the distribution of grazed sites by plant series was the same as that for ungrazed sites, the expected number of grazed sites would be as shown:

Plant Series	Actual Count of Grazed Sites	Actual Count of Ungrazed Sites	Expected Count of Grazed Sites
TSME	5	15	4
ABAM	2	5	1
TSHE	12	56	14
THPL	2	7	2
	21	83	21

The value of the Chi-square test statistic in this case is 1.17, with 3 degrees of freedom. The critical value from the Chi-square table at alpha=.05 is 7.81, so in this case we would have to conclude no significant difference in the distribution of grazed and ungrazed sites by plant series.

7.2.2 Exploratory Multivariate Analyses

The statistical tests described above are, in general, framed by the key questions described earlier in this Study Plan. A more exploratory approach is often used in ecological data analysis to assess patterns as a result of biotic or abiotic factors, and the variables most responsible for determining them. It is the expectation of CMER and SAGE that application of exploratory multivariate analyses such as Discriminant Analysis (DA), Principal Components Analysis (PCA) and Factor Analysis (FA) will be conducted in order to address the Phase 1 questions regarding potential stratification of sample sites for Phase 2. Tests will be applied assuming required assumptions are met and that such tests will improve understanding of relationships that may not otherwise be apparent in the Phase 1 data.

Exploratory Multivariate Analyses can be powerful tools in helping to identify and rank key sources of variance. PCA and FA are looking for hypothetical variables (components) that account for as much of the variance in the data as possible. The components can be viewed as axes along which the data are aligned in multi-dimensional space; they define which variables are most closely correlated with one another, and which are largely independent of other subsets of variables. For example, tree species composition may be most closely correlated with elevation, but also by distance from the stream, precipitation, soil type and possibly other factors such as degree or type of disturbance regime. PCA will successively remove variance, in the order in which it is exerted, thus generating a series of successively weaker linear combinations.

Discriminant Analysis (DA) is another multivariate exploratory technique used to predict group membership (or outliers) from a set of potential predictors. DA consists of finding the maximum ratio of difference between a pair of group multivariate means to the multivariate variance within the two groups (Davis 1986). The user tests the validity of groups, e.g., dominant tree species composition by elevation band, ecoregion, or distance from the stream, based upon actual data; thus DA may be considered a multivariate version of ANOVA.

It is beyond the scope of this Study Plan to prescribe specific multivariate tests or to present specific examples and hypothetical results. Nonetheless, CMER/SAGE anticipates that these tests will be important and useful analyses in planning Phase 2 of the Eastern WA Type F Riparian Assessment project.

8.0 PHASE 1 PROJECT MANAGEMENT

Phase 1 of the eastside riparian assessment project is intended to test procedures to be used in Phase 2. Still, even as a pilot project, Phase 1 is quite large, entailing the measurement of approximately 200 plots.

Phase 1 should be conducted in three stages. The first stage should consist of the measurement of about 20 plots according to the procedures outlined in this plan. The second stage will be conducted in the office, reviewing field data and methods following completion of the first approximately 20 sites to decide whether corrections need to be made in the field procedures. Basic data analyses would be conducted during this period to make sure that information needs will be met with the current field data collection protocols. The third stage of Phase 1 will commence once any corrections have been made, and will complete the remainder of the 200 plots.

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