TFW Effectiveness Monitoring and Evaluation Program

Riparian Stand Survey

Final Draft

by

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1. Introduction

The Riparian Stand Survey is a sampling method developed to monitor riparian stand conditions and stream channel characteristics on a site scale. It can be used to evaluate the effectiveness of riparian forest practices in providing large woody debris to stream channels. This can be accomplished by monitoring trends in stand conditions over time or by using data on current stand conditions in a model that will estimate LWD abundance over time. The Riparian Stand Survey can also be used to quantify rates and processes related to LWD recruitment and function in order to improve the interpretation of monitoring results and LWD modeling efforts. This requires tagging individual trees and sampling permanently-located monitoring sites regularly over time. The procedures are described below, including sections for equipment needed, site selection, sampling strategy, sampling plots, standing trees, down wood, stand regeneration, stand height and age, and channel characteristics.

2. Equipment Needed

The following equipment will be needed for the Riparian Stand Survey:

- two 30-m or 50-m fiberglass tapes
- 50-m or 100-m survey chain (optional)
- hip chain or range finder (optional)
- metric diameter tape
- two clinometers
- slope correction table
- two azimuth compasses with sighting mirrors and declination adjustment
- set of 11 chaining pins
- flagging and survey stakes
- railroad chalk or numbered aluminum tags and small hammer
- fence posts or rebar, tree paint, and a small hatchet
- aerial photographs, topographic maps, and a waterproof map case
- field identification guide for trees
- loppers, small saw, machete, and/or safety goggles
- field forms, notebook, and pencils
- field vests, waders, and rain gear

Additional equipment for channel measurements:

- laser level or hand level
- stadia rod
- spherical densiometer
- log calipers

3. Site Selection

Riparian survey reaches should be selected to meet the needs of the monitoring project study design (see the LWD Recruitment Study Design Guidelines (Smith and Schuett-Hames [1998]) for more information). Survey reaches can be delineated with one of two methods, depending on the objectives of the monitoring project. To evaluate the effectiveness of specific forest practices, sampling will take place within survey reaches defined by the harvest boundaries at each site. To assess specific stand or channel types, sampling will occur in survey reaches defined by the riparian stand and stream channel characteristics of interest. These reaches can be identified with remote sensing methods, but it will be necessary to verify the exact location of reach boundaries in the field.

Landowners should be contacted to get permission for access to monitoring sites and to ensure that harvests in riparian stands will not interfere with the objectives of the monitoring project. For example, salvage logging of windthrown trees could be a significant confounding factor for projects monitoring rates of windthrow. Landowners should also be consulted to identify the type of permanent marking (rebar, flagging, etc.) to use for trees and sampling plots.

4. Sampling Strategy

For this survey, riparian stand and stream channel parameters are measured in 30-m sampling plots placed at 120-m intervals throughout the riparian survey reach, which will yield a sampling rate of approximately 25% of the lineal distance of the reach. This approach is based on the results of a field project designed to determine the optimal plot size and sampling rate needed to accurately and precisely estimate stand density in Riparian Management Zones (RMZs) that have been left adjacent to streams after timber harvest (Smith and Conrad, Northwest Indian Fisheries Commission, unpublished data). This project involved measuring every tree in contiguous 30-m plots placed throughout two RMZs located near Olympia, Washington. A total lineal distance of 1,460 m was surveyed. These data were then used in a computer program to simulate sampling designs using plots of various sizes (30-m, 60-m, 90-m, etc.) with several sampling intensities (percent of lineal distance in RMZ) and both random and systematic sampling. Density estimates from each simulated sampling design were compared to the known density for the entire RMZ and the precision of the estimates calculated. The optimal plot size was found to be 30-m, and a 25% sampling rate using this plot size produced density estimates that were within ±20% of the true RMZ density 80% of the time and had a mean coefficient of variation of 15% or less. Although there was little difference in accuracy and precision between random and systematic sampling when 30-m plots were sampled at a 25% rate, the systematic design was recommended because of trends in density that were observed in the RMZs.

To implement the strategy on a riparian survey reach, first document its location in field notes and mark the exact boundaries of the reach on topographic maps or aerial photographs. Calculate the length of the survey reach by measuring the linear distance between the two boundaries on aerial photographs or with a hip chain or range finder in the field. This length should be measured straight along the general direction of the stream, ignoring meanders in the channel.

For survey reaches that are 240 m or greater in length, locate the first plot randomly in the first 120 m section along the stream channel, by dividing the first 120-m section into four 30-m units and randomly selecting one of those units. Successive plots should be placed 120 m apart, measured from the center of each plot. If this systematic placement causes a plot to cross a boundary of the survey reach, then a shorter sampling plot can be used to ensure only trees actually in the reach are sampled. In any case, plots smaller than 15 m should not be sampled. For survey reaches that are less than 240 m in length, two plots should be randomly located within the reach. If curvature in the channel would cause any portion of a plot to overlap with a previous plot, then skip an additional 30 m between the two plots, but be sure to preserve the original spacing when moving to the next plot location. If the 30-m adjustment does not prevent the plots from overlapping, then skip to the next plot location.

For most purposes, sampling plots should include both sides of the stream. Substantial time can be saved, however, by only surveying one side of the stream. If this is desirable, then set up the plot on the side with the harvest or a randomly chosen side if the harvest includes both sides of the stream. The decision to follow the less intensive approach should be based on the objectives of the monitoring project. Record which side of the stream is surveyed, how it was selected, and field notes about the opposite side (include comments about stand characteristics, harvest history, and topography). For all survey reaches, sketch a plan-view map that includes the stream, relevant landmarks, the exact location of each sampling plot, and a side-view illustration that documents the valley confinement and important topographic features at the site.

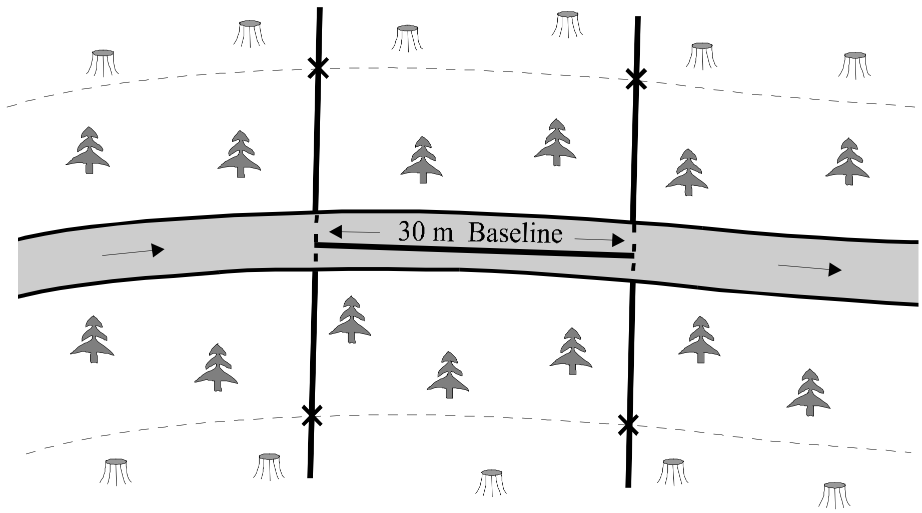
5. Sampling Plots

In addition to delineating the sampling area, sampling plots provide the following information:

- Stream channel orientation
- Valley confinement
- Lanform and distance from stream for individual trees
- RMZ width in meters
- Plot area in square meters

To establish individual sampling plots, begin by using a compass, clinometer, tape or survey chain, and survey stakes to run a straight 30-m baseline that follows the general direction of the stream (Figure 1). Use a slope correction table to measure the baseline in horizontal distance and correct all compass bearings to true using the regional declination for the site. Record the azimuth of the baseline to indicate the orientation of the stream channel. At each end of the baseline, use a compass to extend plot boundary lines perpendicular to the baseline, starting from the bankfull channel on each side of the stream. The location of the bankfull channel should be identified using the procedure described in the TFW Reference Point Survey (Pleus and Schuett-Hames 1998).

Figure 1. Graphic representation of a riparian sampling plot



Use a compass to run a tape or survey chain along each boundary line of the sampling plot, starting at the edge of the bankfull channel and making sure it is anchored at bankfull height so elevation above the channel can be calculated. Try to keep the tape within 1 m of the ground along its length by using chaining pins to hold it in place at slope breaks. Use a clinometer and the tape to measure the slope and distance between slope breaks, ignoring slope irregularities that are smaller than 2 m long. This information will be used to determine valley confinement and to estimate the distance from stream and landform category for each tree in the sampling plot (described in the next section).

For streams that have a recent clearcut within a site-potential tree height (horizontal distance) of the bankfull channel, the boundary lines should extend to the first slope break upslope of the harvest edge. A clearcut is a harvest unit that removes most of the standing trees (≥10 cm dbh). The sampling area will only include trees left standing, so record the tape reading along each boundary line at the harvest edge, defined as half the distance from standing trees to the nearest stumps in the clearcut. These measurements (converted to horizontal) will indicate the width of the RMZ and will be used with the fixed baseline length to calculate the area of the plot. For streams that are not bordered by a recent clearcut, the boundary lines should extend a site-potential tree height from the bankfull channel. The sampling area will include all the standing trees within that distance and site-potential tree height will be used with the fixed baseline length to calculate the area of the plot. For streams that have had a channel migration zone (CMZ) delineated as part of a Watershed Analysis (Washington Forest Practices Board 1995), record the tape reading along each boundary line at the CMZ edge.

Place flagging at regular intervals to clearly mark the location of each boundary line. This flagging can be left in place (with approval from the landowner) to help relocate the plot. Additionally, permanently monument the four outside corners (marked with "X"s in Figure 1) of the plot with survey stakes, rebar, or fence posts. To help relocate each corner, select two nearby "witness" trees that are visible from the stream and are likely to remain standing. Blaze each witness tree with a hatchet, paint it with brightly colored, permanent paint, and attach a tag indicating the distance and true azimuth from the tree to the corner. A GPS unit can also be used to document the location of the corners. Record in field notes any additional information that may facilitate relocating the sampling plot.

If the survey only includes one side of the stream, then the plot only needs to be established on that side of the stream. However, the downstream boundary line for each plot still needs to be extended on both sides of the stream in order to collect information on valley confinement. Record estimates of species composition, density, and average tree diameter for the unsurveyed side of the stream using the categories defined in the Watershed Analysis Riparian Function Assessment (Washington Forest Practices Board 1995). For one-sided plots, it may be easier to place the baseline in the clearcut and extend the boundary lines to the bankfull channel, as long as the baseline is a straight line that is parallel with the general direction of the stream.

6. Standing Trees

In each sampling plot, collect the following information for all live trees (≥10 cm dbh), dead trees (≥10 cm dbh, ≥2 m tall, with weight still supported by root structure), and harvested stumps (≥10 cm diameter):

- Species
- Diameter at breast height (dbh) in centimeters for live trees, dead trees, and tall stumps
- Diameter at harvest height in centimeters for stumps cut below breast height
- Condition (Live, Broken, Stressed, Dead)
- Decay class for dead trees (1-5)
- Mortality agent for dead trees (flooding, suppression mortality, sun scald, hit by another tree, lightning, ice/snow damage, insect/disease, animal damage, logging damage, timber harvest, unknown)
- Horizontal distance from bankfull channel in meters
- Landform (floodplain, low terrace, high terrace, and hillslope)

Species, condition, decay class, and mortality agent for dead trees are all determined with a visual assessment. See Appendix A for species codes and instructions for measuring dbh. Stressed trees are identified as those that have smaller than average crowns, crowns thinned from wind damage or obvious dieback, boles damaged by sun scald, or are otherwise obviously unhealthy. Specific stressors should be recorded in the field notes column. Decay class codes are described in Table 1. Mortality agents refer to the process that killed the tree. In the absence of clear evidence as to the cause, record unknown as the mortality agent. The distance from bankfull channel should be measured to the downslope side of the tree. For leaning trees, the distance should be measured to the breast height location on the tree. Distance can be estimated from boundary line tapes using a compass and later corrected to horizontal using the slope information taken along the nearest boundary line. Alternatively, slope distance and slope can be measured for each tree individually as long as slope measurements are taken from the elevation of the bankfull channel.

Table 1. Decay class codes for snags, stumps, and woody debris (adapted from Robison and Beschta [1991] and Washington State Department of Natural Resources [1996])

Decay Class	Bark	Twigs (<3 cm)	Wood Texture LWD	Wood Texture Snag/Stump	Shape	Wood Color LWD	Wood Color Snag/Stump
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	Smoth; 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

Landform units can be determined quantitatively for each tree using the height above the bankfull channel (Table 2). This height is measured from the bankfull height to the base of the tree on the downslope side. It can be calculated from the slope information associated with each distance measurement or extrapolated from the boundary line tape. The heights above channel identified for the landform classes in Table 2 are only appropriate for channels with a bankfull width of 25 m or less.

Table 2. Landform features based on height above the bankfull channel (source: Rot [1995])

Landform	Height Above Channel
Floodplain	< 1 m
Low terrace	≥ 1 m – 3 m
High terrace	≥ 3 m
Hillslope	≥ 20% slope for at least 15 m (slope distance)

For long-term studies that are designed to monitor trends or quantify rates of change, attach numbered aluminum tags to each tree near the base and at breast height on the upslope side. Be sure to leave room for tree growth when attaching tags. Place the breast height tags just above where the dbh measurement was taken. This will produce more precise information on how conditions change in riparian stands over time. Tags could also be nailed into down wood in the riparian stand and into each piece of in-channel LWD. If tags are not used, trees should be marked with railroad chalk when they are measured to avoid double sampling.

7. Down Wood

In each sampling plot, collect information for each piece of down wood (dead trees or pieces ≥10 cm in diameter, ≥2 m long, with weight not supported by root structure). The procedure is described below for two categories of down wood: trees with attached rootwads and individual broken pieces.

7.1.1 Trees with attached rootwads

Down trees with attached rootwads are included if more than 50% of the rootwad is in the plot, the length from the base of the tree to the top is at least 2 m, and it is ≥10 cm dbh. Collect the following information for each qualifying piece:

- Species
- Dbh in centimeters
- True azimuth of fall direction taken from the base of the tree
- Horizontal distance from base to bankfull channel (shortest distance to stream, not necessarily along fall direction)
- Decay class (1-5)
- Recruitment class (upland, bankfull, suspended, or spanning)
- Mortality agent (windthrow, bank erosion, suppression mortality, sun scald, hit by another tree, mass wasting, snow avalanche, debris torrent, lightning, ice/snow damage, insect/disease, animal damage, logging damage, timber harvest)
- Is the tree broken? (Y/N)

Species, dbh, distance from bankfull channel, and decay class are determined as for standing trees. Measure the true azimuth of fall direction along the bole from the base of the tree using a compass, and note if the tree has broken into several pieces. These additional pieces will also need to be recorded individually as described in the next section. Recruitment class categories describe the interaction of the tree with the bankfull channel, and are described in Table 3. It is not necessary to include upland down trees that have a decay class of 4 or 5. Mortality agents refer to the process that caused the tree to fall down. In the absence of clear evidence, record windthrow as the default mortality agent.

Table 3. Description of recruitment class categories for down wood

Recruitment class	Description
Upland	No part of the tree enters the bankfull channel
Bankfull	Some part of the tree enters the bankfull channel
Suspended	The tree is suspended above the bankfull channel
Spanning	The tree is supported above the bankfull channel by banks on both sides of the stream

7.1.2 Individual broken pieces

Individual broken pieces of trees are included if the midpoint of the piece is in the plot (or if the piece broke off from a tree in the plot), the length of the piece is at least 2 m, and the diameter is ≥10 cm for at least 2 m of the length. Collect the following information for each qualifying piece:

- Species
- Diameter at midpoint in centimeters
- Number of source tree (standing or down), if identifiable and the number is known
- Midpoint inside or outside the plot? (I/O)
- Horizontal distance from midpoint to bankfull channel (shortest distance to stream, not necessarily along fall direction)
- Decay class (1-5)
- Recruitment class (upland, bankfull, suspended, or spanning)
- Mortality agent (windthrow, bank erosion, suppression mortality, sun scald, hit by another tree, mass wasting, snow avalanche, debris torrent, lightning, ice/snow damage, insect/disease, animal damage, logging damage, timber harvest)

It is not necessary to include upland pieces of down wood that have a decay class of 4 or 5.

8. Stand Regeneration

Collect the following information on seedlings (≥ 15 cm and < 2.5 cm dbh) and saplings (≥ 2.5 cm dbh and < 10 cm dbh) of woody vegetation:

- species
- horizontal distance from bankfull channel in 10-meter bands
- substrate (log, stump, ground)

Sample seedlings in a 1-m wide belt transect established perpendicular to the stream in each sampling plot. These transects should be set up along with the downstream plot boundary line using a tape measure or stadia rod to ensure that the belt transect is 1-m wide. For each 10-m length (horizontal distance) along the boundary line tape, tally seedlings by species and substrate. Sample saplings in a 5-m wide belt transect established perpendicular to the stream in each sampling plot. This transect should also be set up along with the downstream plot boundary line. For each 10-m length (horizontal distance) along the boundary line tape, tally saplings by species and substrate.

9. Stand Characteristics

In order to determine average height, average age, growth increment, and site index of the riparian stand, measure the following parameters on one out of five randomly selected live trees (≥ 10 cm dbh) in each plot:

- Total height in meters
- Breast height age in years
- 5- and 10-year diameter growth in centimeters
- Site tree? (Y/N)

The procedure for measuring tree height is described in Appendix A. Breast height age can be found by using an increment borer to extract a core from the tree at breast height and counting tree rings from the inside of the bark to the center of the tree. 5- and 10-year diameter growth can be determined by using an engineers scale to measure the length of the core for the most recent 5 and 10 years of growth. Detailed procedures for boring trees are described in the field procedures manual for the Washington Forest Resource Inventory System (Washington State Department of Natural Resources 1996). After collecting height, age, and growth information for each tree, record whether or not it is a site tree. Site trees are defined as overstory trees that are not broken, forked, stressed, or heavily leaning. Overstory trees have medium-sized or larger crowns that form the average level of crown cover or extend above it, and receive full light from above and sometimes also from the sides. Data from site trees will be used to calculate the site index for the dominant species at the site (Avery and Burkhart 1994). Data from all the trees will be used to calculate mean height and age for the riparian stand.

10. Channel Characteristics

Measure the following channel characteristics for each riparian survey reach:

- stream reach length
- bankfull width
- canopy cover
- dominant substrate
- channel gradient
- in-channel LWD volume and piece count

Measure the stream reach length, average bankfull width, and canopy cover with the TFW Reference Point Survey (Pleus and Schuett-Hames 1998). The downstream boundary lines of the riparian sampling plots can be treated as reference points for the purpose of collecting these parameters. Record the dominant and subdominant substrate composition at each downstream boundary line using the size classes in Table 4. Measure channel gradient throughout the survey reach with the use of a laser level or hand level and stadia rod. Measure in-channel large woody debris with the TFW Large Woody Debris Survey (Schuett-Hames et al. 1994) throughout the survey reach. For long-term studies that are designed to monitor trends or quantify rates of change, attach numbered aluminum tags on at least two sides of each piece of LWD. This will produce more precise information on how in-channel LWD loading changes over time.

Table 4. Size classes used for determining dominant and subdominant substrate

Size Class	Size Range (mm)
Sand	< 2
Gravel	2-64
Cobble	64-256
Boulder	≥ 256
Bedrock	N/A

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Appendix A

Conifer Species

Tree	Code	Tree	Code
Alaska yellow-cedar	YC	Rocky Mountain juniper	RJ
Douglas-fir	DF	Scotch pine	SP
Engelmann spruce	ES	Sequoia	SQ
Grand fir	GF	Sitka spruce	SS
Lodgepole pine	LP	Subalpine fir	AF
Mountain hemlock	MH	Western hemlock	WH
Noble fir	NF	Western larch	WL
Pacific silver fir	SF	Western redcedar	RC
Pacific yew	PY	Western white pine	WP
Ponderosa pine	PP	Whitebark pine	WB
Port Orford cedar	OC	*Unknown Conifer*	UC

Deciduous Species

Tree	Code	Tree	Code
Aspen	AS	Oregon oak	OO
Bigleaf maple	MA	Pacific madrone	MD
Black cottonwood	BC	Paper birch	BR
Cascara	CA	Red alder	RA
Cherry	CH	White alder	WA
Crabapple	AC	Willow	WO
Dogwood	DG		
Hawthorn	HW	*Unknown Deciduous*	UD
Oregon ash	OA	*Unknown*	UK

Measuring Tree Diameter

Diameter at breast height (DBH) should be measured 1.37 m (4.5 ft) from the ground on the upslope side of the tree. This distance should be measured along the bole if the tree is leaning. Diameter tapes should be extended around the tree perpendicular to the bole.

When the tree has an abnormality (such as a limb, bulge, or buttresses) at breast height, the diameter should be measured above it to obtain the diameter the tree would have had without the abnormality. Diameter tapes should be rounded out over scars or cat faces.

If a tree forks or is grown together at or above breast height, measure the diameter for the single tree below the abnormality caused by the fork. If a tree forks below breast height, measure each stem as an individual tree 1.07 m (3.5 ft) above the fork.

Measuring Tree Height

To measure tree height with a tape and clinometer, a location must be selected away from the tree where the top is visible and the angle to it can be measured with a clinometer. Accuracy is best if height is measured one half to a whole tree length away from the tree in a direction that is perpendicular to the lean of the tree. It is generally easier to sight to the top of the tree from upslope, but other locations may be chosen if necessary.

Once a location is selected, slope distance and slope measurements need to be taken to determine the horizontal distance from the tree. Then, the angles to the top and the base of the tree should be measured, taking care to keep track of the sign (+/-). It is important to measure to the very top of the tree. For trees that are forked above breast height, measure the height of the taller fork. If the base of the tree is not visible, sight to a spot above the base that can be measured from the ground with a stadia rod or tape and add this offset to the height calculation. The total angle to the tree is equal to the angle to the top *minus* the angle to the base. If these angles are measured with percent units, then the height is equal to the horizontal distance from the tree *times* the total angle to the tree.

If the tree has a significant lean (> 45%), measurements should be taken to the top of the tree and then to a location defined by an imaginary plum line dropped from the tree tip. Then the angle of tree lean needs to be recorded and used to correct the height calculation.

Height should be calculated in the field using a height calculation table to help catch errors in measurement.

Appendix B

Field Forms 5H, 5.1, 5.2A, 5.2B, 5.3, 5.4, 5.5