PROTOCOL FOR MONITORING EFFECTIVENESS OF RIPARIAN PLANTING PROJECTS

MC-3

Washington Salmon Recovery Funding Board

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ORGANIZATION

Riparian habitat improvement projects are popular habitat restoration techniques. They have accounted for 5% of all SRFB projects and are often a subsidiary activity for other categories of projects as well. They have the potential to create improvements in bank stability, streamside shading, erosion, and other benefits within a moderate amount of time (5-20 years).

This document details the monitoring design, procedures, and quality assurance steps necessary to document and report the effectiveness of riparian plantings. This document is in compliance with the Washington Comprehensive Monitoring Strategy (Crawford et al. 2002).

The goal of riparian planting projects is to restore natural streamside vegetation to the stream bank and riparian corridor. The assumption is that riparian vegetation increases shading of the stream, leading to cooler temperatures more desirable for salmon rearing. Vegetative cover also reduces sedimentation and erosion, which can impact egg survival, food organisms, and the ability of salmon to find food.

MONITORING GOAL

Determine whether riparian plantings are effective at restoring riparian vegetation and stream bank stability and reducing sedimentation.

QUESTIONS TO BE ANSWERED

Have at least 50% of the riparian plantings survived for the first three years after planting?

Has the cover of woody riparian plants reached 80% by year 10?

Has the riparian shading been improved by year 10?

Has the riparian vegetative structure been improved by year 10?

Has bank erosion been significantly reduced by year 10?

NULL HYPOTHESIS

Planting of vegetation in the riparian corridor has had no effect upon:

- Increasing the cover of woody riparian plant species
- Increasing the amount of shading
- Increasing the complexity of canopy layers of streamside riparian cover
- Reducing the proportion of actively eroding streambanks

OBJECTIVES

BEFORE PROJECT (YEAR 0)

Determine the proportion of the three layers of riparian vegetation present within the project impact and control areas.

Determine the proportion of shading within the project impact and control areas.

Determine the proportion of actively eroding stream banks within the project impact and control areas.

Determine percentage of pool tail fines.

AFTER PROJECT (YEARS 1 AND 3)

Determine the survival of the species of planted riparian vegetation.

Determine the percent woody cover provided by riparian vegetation.

Determine the proportion of the three layers of riparian vegetation present within the project impact and control areas.

Determine the proportion of shading within the project impact and control areas.

Determine the proportion of actively eroding stream banks within the project impact and control areas.

Determine percentage of pool tail fines.

AFTER PROJECT (YEARS 5 AND 10)

Determine the percent woody cover provided by riparian vegetation.

Determine the proportion of the three layers of riparian vegetation present within the project impact and control areas.

Determine the proportion of shading within the project impact and control areas.

Determine the proportion of actively eroding stream banks within the project impact and control areas.

Determine percentage of pool tail fines.

RESPONSE INDICATORS

Level 1- Number of trees and shrubs planted and the cover provided by planted trees and shrubs. The Level 1 indicator tracks how many of the original plantings remain alive in Years 1 and 3 to help measure the effectiveness of initial planting and the influence of supplemental water. Determining the survival of planted species becomes increasingly difficult after three years due to natural recruitment of shrub and tree seedlings, which can be difficult to tell apart from planted individuals. Additionally, these volunteer seedlings are often from the initial plantings, and serve the same function as the original plantings. Thus, percent cover of riparian species is a better indicator of project effectiveness in years 5 and 10, and will be used to make the success determination in those sample years.

The percent cover of woody plants is an indicator of whether woody riparian vegetation is being restored to the stream bank and riparian corridor. Estimates of percent woody cover will include cover provided by naturally recruited shrub and tree seedlings as well as that provided by planted seedlings.

Riparian plantings variable

Indicator Abbreviation	Description
PLANTINGS	The number of planted plants remaining in the impact area
PLANTCOV	Mean percent cover of woody species as measured in permanent riparian planting plots
RIPAREA	The area planted with riparian vegetation in the project in acres

Level 2- Riparian Vegetation. Using EMAP protocols (Peck et al. Unpubl.), the percent shading is calculated using a densitometer. Additionally, the riparian species diversity, understory ground cover, and canopy can be determined in a consistent manner. One would expect the percent shading and the species diversity to change over time as the plantings grow. The proportion of actively eroding streambanks is an indicator of sedimentation and erosion into the stream. If riparian plantings are effective in creating riparian cover, then bank erosion should decline.

Riparian vegetation variables

Indicator Abbreviation	Description
XCDENBK	Mean percent shading at the bank (using a densiometer)
XPCMG	Proportion of the reach containing all 3 layers of riparian vegetation, canopy cover, understory, and ground cover
BANK	Proportion of the reach containing actively eroding stream banks
STRMLGTH	Affected stream length includes meander length affected by the project
CREACHLGTH	The length of the stream control reach actually sampled
CREACHWIDTH	The average stream width of the control reach actually sampled
IREACHLGTH	The length of the stream Impact reach actually sampled
IREACHWIDTH	The average stream width of the Impact reach actually sampled

MONITORING DESIGN

Due to the inter-annual variance in habitat parameters, it is anticipated that at least 10 projects should be sampled in order to provide adequate statistical power to detect change. Approximately 10 riparian planting projects are funded by the SRFB each year. The SRFB intends to monitor 10 projects selected randomly over two consecutive years.

The Board will employ a Before and After Control Impact (BACI) experimental design to test for changes associated with riparian plantings (Stewart-Oaten et al.1986). A BACI design samples the control and impact simultaneously at both locations at designated times before and after the impact has occurred. For this type of restoration, riparian plantings would be the impact and a similar location upstream of the riparian project would represent the control.

For riparian plantings, the BACI design tests for changes in shading, the proportion of the reach with all three layers of vegetation (canopy, under-story, and ground cover), and bank erosion of the riparian plantings *relative to* the these same parameters observed at control sites upstream. This type of design is required when external factors (e.g., rainfall and species composition) affect the riparian areas at the control sites. The object is to see whether the difference between impact and control shade, cover levels, and bank erosion have changed as a result of the riparian planting projects. The presence of multiple projects with control and impact locations will address the concerns detailed by Underwood (1994) regarding pseudoreplications. It is also not considered cost effective to employ multiple control locations for each passage project as recommended by Underwood. Although the ideal BACI would have multiple years of before data as well as after data, this was not possible with locally sponsored projects where there was a need and desire to complete their project as soon as possible.

The plan is to compare the most recent time period of sampling with Year 0 (before project implementation) conditions. A paired *t*-test will be used to test for differences between control (downstream) and impact (upstream) sites during the most recent impact year and Year 0. In other words, we first compute the difference between the control and impact and use those values in a paired *t*-test. This test assumes that differences between the control and impact sites are only affected by riparian plantings and that external influences affect vegetation in the same way at both the control and impact sites. The paired sample *t*-test does not have the same assumptions for normality and equality of variances of the two-sample *t*-test but only requires that the differences be approximately normally distributed. In fact, the paired-sample test is really equivalent to a one-sample *t*-test for a difference from a specified mean value.

To implement the design, we will monitor 10 riparian projects funded in 2003-2004 as part of Round 4 and 5. The number of projects is based upon the calculated sample size needed to obtain statistically significant information in the shortest amount of time.

The variance associated with Impact and control areas will not be known until sampling has occurred in Year 0 of both impact and control areas. After Year 0, a better estimate of the true sample size needed to detect change will be available. Cost estimates and sampling replicates may need to be adjusted at that time.

At the end of the effectiveness monitoring testing, there will be one year of “before” impact information for all projects for both control and impact areas, and multiple years of “after” impact information for the same control and impact areas for each of the projects.

Depending upon circumstances, the results may also be tested for significance, using a linear regression model of the data points for each of the years sampled and for each of the indicators tested.

Testing for significant trends can begin as early as Year 1. Final sampling may be completed in 2016.

DECISION CRITERIA

Effective if at least 50% of the riparian plantings in the planting area survived to Year 3.

Effective if percent cover of woody riparian species, as measured in riparian planting plots, is at least 80% in Year 10.

Effective if a change of 20% or more is detected by Year 10 at the Alpha=0.10 level for measures of the mean percent canopy density and the mean proportion of the three layers of riparian vegetation presence for the calculated difference between the paired Impact and control areas.

Table 1. Decision criteria for riparian plantings

Habitat	Indicators	Metric	Test Type	Decision Criteria
Plantings	The number of planted plants remaining in the impact area (PLANTINGS)	#	None. Count of live plantings	≥ 50% of plantings are living by Year 3
	Mean percent cover of woody species in the riparian planting area is at least 80% (PLANTCOV)	%	None. Mean percent woody cover measured in riparian planting plots.	≥ 80% cover of woody riparian species by Year 10
Riparian Condition	Mean percent canopy density at the bank densiometer Reading (XCDENBK)	1-17 score	Linear Regression or Paired *t*-test	Alpha = 0.10 for one-sided test. Detect a minimum 20% change between impact and control by Year 10
	3-layer riparian vegetation presence (proportion of reach) (XPCMG)	%	Linear Regression or Paired *t*-test	Alpha = 0.10 for one-sided test. Detect a minimum 20% change between impact and control by Year 10
	Actively eroding banks (BANK)	%	Linear Regression or Paired *t*-test	Alpha = 0.10 for one-sided test. Detect a minimum 20% change between impact and control by Year 10

SAMPLING

SELECTING SAMPLING REACHES

Impact Reach

Riparian plantings are often not very large and an impact reach should be sampled according to the methods detailed on pages 11-14.

Control Reach

A control reach of equal size and habitat type, located upstream of the project site, should be selected and designed in the same manner as the impact reach.

BEFORE PROJECT SAMPLING

All riparian planting projects identified for long-term monitoring by the SRFB must have completed pre-project Year 0 monitoring prior to beginning the project. Year 0 monitoring will consist of the following:

- Determining the acreage and linear distance of stream bank in kilometers to the nearest tenth to be planted with riparian species.
- Visually estimating the riparian vegetation structure for the project impact and control reaches. These estimations are for three vegetation layers: canopy layer (>5m high), understory (0.5 to 5m high), and ground cover (<0.5m high).
- Measuring canopy cover density at the banks and in the center of the channel using a densiometer.
- Measuring the proportion of the streambanks in the sample reaches that are actively eroding.

AFTER PROJECT SAMPLING

Upon completion of the project, Years 1, 3, 5, and 10 monitoring will consist of:

- Enumerating surviving planted trees and shrubs (Year 1 and 3) and measuring woody cover in riparian planting areas (Year 1, 3, 5, and 10). The goal of the project is to increase the cover of trees and shrubs in the riparian zone. Therefore, post-project sampling will consist of evaluating survival and cover of planted trees and shrubs within the project area. Estimates of percent cover will include natural recruitment of woody riparian species. Naturally recruited woody individuals are often difficult to differentiate from planted individuals and including naturally recruited individuals is a more relevant measure of success as these individuals add to the functions provided by the original plantings. If additional plantings occur after the beginning of the project, these should be noted and included in the analysis.
- Visually estimating the riparian vegetation structure for the project impact and control reaches. These estimations are for three vegetation layers: canopy layer (>5m high), understory (0.5 to 5m high), and ground cover (<0.5m high).
- Measuring canopy cover density at the banks and in the center of the channel using a densiometer.
- Measuring the proportion of the streambanks in the sample reaches that are actively eroding.

METHOD FOR QUANTIFYING RIPARIAN PLANTINGS

Protocol adapted from: *New Zealand National Vegetation Survey (2004); Greening Australia Federation (2004); Wishnie et al. (1999)*

PURPOSE

This protocol is to be implemented after a habitat restoration project funded by the SRFB has placed vegetative plantings along the riparian corridor. The intent is to trace the survival, condition, growth, and cover provided by the riparian plantings. Riparian restoration plantings may be a mixture of evergreen and deciduous tree and shrub species tolerant to riparian areas. In reforestation areas, tree densities of 400-700 trees per acre are commonly used at the time of planting. It is normally anticipated that tree loss will occur and that after 3-5 years 50% or more will have succumbed to competition, browsing or some other effect. Normal timberlands in the Pacific Northwest thinned for wood production will contain 30 trees/acre for Douglas fir and up to 60 trees per acre for planted hemlock and alder. For the purposes of testing effectiveness over a relatively short period of ten years, there could be expected to be approximately 200 trees per acre at the end of the study.

EQUIPMENT

Orthophoto if available, handheld GPS device, 50 m tape measure, 2 ft. steel rebar stakes, 8 ft. ½ inch pvc pole, engineer flagging tape, appropriate waterproof field forms, aluminum numbered tags, small gauge wire (for attaching tags), wire cutter, plastic rebar caps, Vernier caliper, DBH tape, and metal detector

SITE SELECTION

The sample reaches are those laid out according to the methods on pages 15-17.

SAMPLING DURATION

Sampling should occur during June -August when vegetation is at its maximum growth, or when feasible at each project site.

PROCEDURE

Step 1 (Year 0): Determine the overall area (acres) of riparian plantings by marking the boundaries using a GPS device, and by using a metric tape measure or calibrated ortho-photo. Mark the beginning of the baseline Transect, which will be used to locate sample plots (see Step 2) with a 2-foot steel rebar stake driven solidly into the ground. Cover the stake with a plastic cap and mark it with a numbered tag. The starting point could be a corner of the planting area or other recognizable landmark (e.g., large tree).

Step 2 (Year 0): The field crew should select 10 random points throughout the plantings and construct a 201ft^2 circular plot using an 8' plot rope held at the center point. Plots should be located by running a baseline Transect in a randomly chosen direction heading into or along the boundary of the planted area from the starting point established in Step 1. Sample points should then be established at random distances along, and perpendicular to, the baseline Transect (e.g., plot 1 would be established X feet along the baseline Transect and then X feet out). For the center point of each plot, a 2 ft. piece of rebar should be driven into the ground and flagged with engineer tape and its location recorded using GPS. If the center point is located next to a planting, record the species.

Step 3: (Year 1 and 3):

Stand at the stake at the center of the randomly selected point and walk in a circle holding the end of the plot rope. As you turn, count the plantings, making sure to only count tree and shrub individuals that were planted during the initial planting effort, which fall under the rope. Calculate the average number of plantings per plot and multiply that figure by 216.65 to give the average number of plantings per acre.

Average Θ = (s1 + s2 + s3 + s4….+s10)/10

Variance = [(s1- Θ) 2 + (s2 – Θ) 2 +…(s10 – Θ)2]/10-1

Density (acres) = Average s X 216.65 = trees/acre

Step 4 (Year 1 and 3): For each planting sampled within a permanent plot, the following steps should be performed and recorded on the Riparian Planting Field Form (Figure 1):

a. Record the project site, plot number (1-10), and date.
b. Assign a sequential number to each planting.
c. Record the species using the appropriate USFS species code.
d. Measure the height of each planting in feet from the highest point to the ground. If the planting is leaning to one side, measure from the highest point down to a point level with the base of the stem, not along the stem itself and record into the data sheet.
e. Tag the planting (plantings only need to be tagged in Year 1 unless tags are missing in subsequent years). Tagging will be accomplished using an aluminum numbered tag or similar metal tag attached bar locked loosely to the stem above the first whorl.
f. Using a Vernier caliper or DBH tape, determine the DBH class for each planting. DBH classes are as follows:
    1) 0.0” - 2.5” = 1
    2) 2.6” – 5.0” = 2
    3) 5.1” – 10.0” = 3
    4) 10.1” – 15.0” =4
    5) 15.1” – 20.0” = 5
    6) 20.1” – 25.0” = 6
    7) 25.1” – 30.0” = 7
    8) >30.1” = 8
g. Determine brush competition using the appropriate brush competition code for each planting (Table 2).
h. Classify groundcover competition using the appropriate groundcover code (Table 2).
i. Classify browse damage using the appropriate browse classification code (Table 2).
j. Record whether the planting is alive (A) or dead (D).

Step 5 (Year 1, 3, 5, and 10):

a. Record the project site, plot number (1-10), and date on the Riparian Planting Field Form.
b. Stand at the stake at the center of the randomly selected point and walk in a circle holding the end of the 8’ plot rope. Estimate the overall aerial percent cover of woody plant species in the 201 ft^2 circular plot and record on the datasheet.

Table 2. Seedling condition codes

Category	Points	Description
Brush Competition		
	0	No brush shading or within 2 ft.
	1	Brush within 2 ft. and shading <25%
	2	Brush within 2 ft. and shading 25-50%
	3	Brush within 2 ft. and shading > 50%
Groundcover Competition		
	0	No sod within 2 ft.
	1	Sod within 12 in.
	2	Sod within 6 in.
	3	Sod to stem
Browse damage		
	0	No browse damage
	1	Terminal leader not browsed, less than 1/3 lateral branches browsed
	2	Terminal leader not browsed, 1/3-2/3 lateral branches browsed
	3	Terminal leader not browsed, > 2/3 lateral branches browsed
	4	Only terminal leader browsed
	5	Terminal leader browsed, less than 1/3 lateral branches browsed
	6	Terminal leader browsed, 1/3-2/3 lateral branches browsed
	7	Terminal leader browsed, > 2/3 lateral branches browsed
	8	Girdled and/or cut off stems

RIPARIAN PLANTING FIELD FORM								
Project #:					**Plot #:**			
Worksite:					**Longitude:**			
Date:		**Surveyors:**			**Latitude:**			
	Species Code	**Tag#**	**Height (cm)**	**DBH (class code)**	**Brush Code**	**Grass Code**	**Browse Code**	**Dead/Alive (D/A)**
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
Percent cover of woody species:				**Notes:**				

Figure 1. Riparian planting field form

METHOD FOR LAYING OUT CONTROL AND IMPACT STREAM REACHES FOR WADEABLE STREAMS

Protocol taken from: ***Peck et al. (2003), pp. 63-65, Table 4-4; Mebane et al. (2003)***

EQUIPMENT

Metric tape measure, surveyor stadia rod, handheld GPS device, 3 - 2 ft. pieces of rebar, orange and blue spray paint or plastic rebar caps, engineer flagging tape, waterproof markers

SAMPLING CONCEPT

The concept of EMAP sampling is that randomly selected reaches located on a stream can be used to measure changes in the status and trends of habitat, water quality, and biota over time if taken in a scientifically rigorous manner per specific protocols. We have applied the EMAP field sampling protocols for measuring effectiveness of restoration and acquisition projects. Instead of a randomly selected stream reach, the stream reach impacted by the project is sampled. These “impact” reaches have been matched with “control” reaches of the same length and size on the same stream whenever possible.

Within each sampled project reach a series of Transects A-K are taken across the stream and riparian zone as points of reference for measuring characteristics of the stream and riparian areas (see Figure 2). The Transects are then averaged to obtain an average representation of the stream reach.

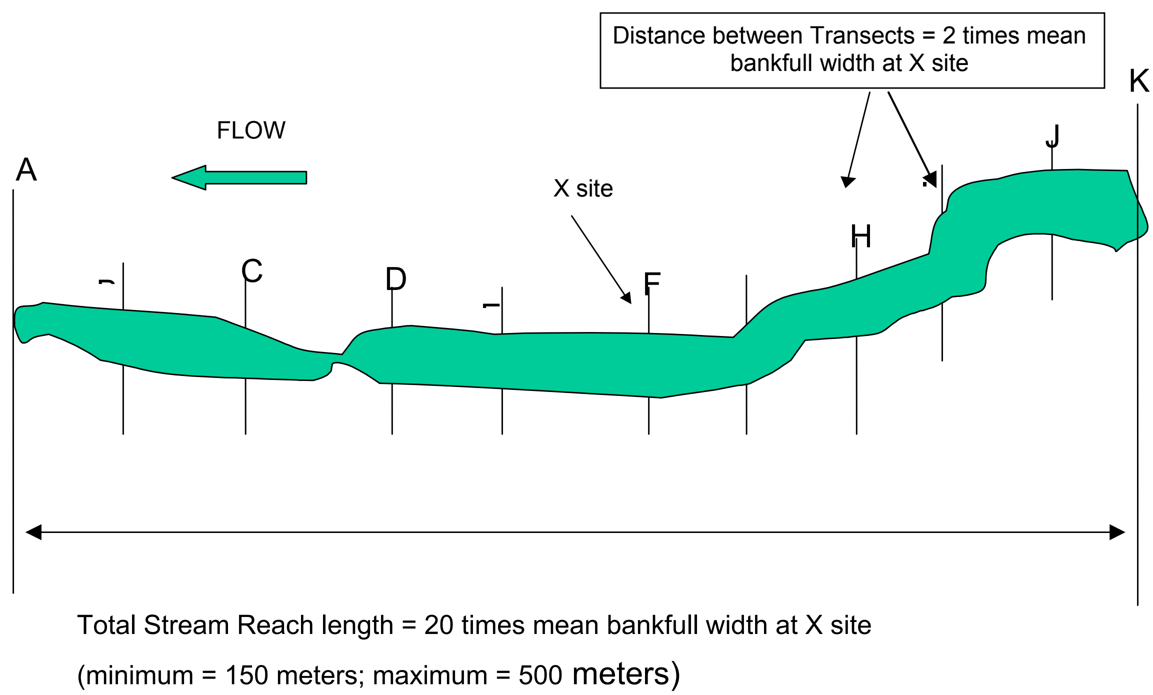

Figure 2. Sampled project reach

LAYING OUT THE TREATMENT AND CONTROL STREAM REACHES

Step 1: Using a handheld GPS device, determine the location of the X site and record latitude and longitude on the stream verification form. The X site should be considered the center of the impact or control study reach. The impact reach X site must fall within the project affected area. The location of the control X site should be determined based upon the length of the impact reach. It will be located in the center of the control reach, which will measure the same as the length of the impact reach whenever possible. Mark the X site on the bank above the high water mark with one of the rebar stakes and a colored plastic cap so that the X site can be found in future years. Use a surveyor's rod or tape measure to determine the bankfull width of the channel at five places considered to be of "typical" width within approximately five channel widths distance upstream and downstream of the X site location. Average those five bankfull widths, then multiply that average bankfull width by 20 to determine the reach length. For streams less than 7.5 m in average bankfull width, the reach length should be at minimum 150 m, and for streams greater than 25 m in width, the maximum reach length shall be 500 m. If the impact reach is less than 150 m, measure and include the entire impact area in the sampling reach. Determine the impact reach length based upon the above, and set the control site reach length equal to the impact reach length.

Step 2: Check the condition of the stream upstream and downstream of the X site by having one team member go upstream and one downstream. Each person proceeds until they can see the stream to a distance of 10 times the bankfull width (equal to one half the sampling reach length) determined in Step 1.

For example, if the reach length is determined to be 150 meters, each person would proceed 75 m from the X site to lay out the reach boundaries.

NOTE: *For restoration projects less than 20 times bankfull width, the entire project's length should be sampled and a control reach of similar size should likewise be developed within the treatment stream either upstream or downstream as appropriate.*

Step 3: Determine if the reach needs to be adjusted around the X site due to confluences with lower order streams, lakes, reservoirs, waterfalls, or ponds. Also adjust the boundaries to end and begin with the beginning of a pool or riffle, but not in the center of the pool or riffle. Hankin and Reeves (1988) have shown that measures of the variance of juvenile fish populations is decreased by using whole pool/riffles in the sample area. To adjust the stream reach, simply add or subtract additional length to Transects A or K, as appropriate (i.e. do not shift the entire reach upstream or downstream to encompass an entire pool). In the case where the treatment site is dry in Year 0, reach lengths should still be based upon 20 times the bankfull width.

Step 4: Starting back at the X site, measure a distance of 10 average bankfull widths down one side of the stream using a tape measure. Be careful not to cut corners. Enter the channel to make measurements only when necessary to avoid disturbing the stream channel prior to sampling activities. This endpoint is the downstream end of the reach and is flagged as Transect "A".

Step 5: Using the tape, measure 1/10th (2 average bankfull widths in big streams or 15 m in small streams) of the reach length upstream from the start point (Transect A). Flag this spot as the next cross section or Transect (Transect B).

For example, if the reach length is determined to be 200 meters, a Transect will be located every 20 meters, which is equivalent to 1/10th the total reach length.

Step 6: Proceed upstream with the tape measure and flag the positions of nine additional Transects (labeled “C” through “K” as you move upstream) at intervals equal to 1/10th of the reach length. At the reach end points (Transects A and K) and the middle of the reach (X site or Transect F),, install a rebar stake as described in Step 1.

METHOD FOR CHARACTERIZING RIPARIAN VEGETATION STRUCTURE

Protocol taken from: *Peck et al. (2003), Table 7-10; Kauffman et al. (1999)*

PURPOSE

This protocol is designed to determine the changes in riparian vegetation due to a restoration project where riparian vegetation has been planted.

EQUIPMENT

Convex spherical densiometer, field waterproof forms, hip boots or waders

SITE SELECTION

The sample reaches are those laid out according to the methods on pages 15-17.

SAMPLING DURATION

Sampling should occur during June -August when vegetation is at its maximum growth, or when feasible at each project site.

PROCEDURES FOR MEASURING RIPARIAN VEGETATION AND STRUCTURE

Following are taken from Table 7-10 of EMAP protocols:

Step 1: Standing in mid-channel at a Transect (A-K), estimate a 5m distance upstream and downstream (10m length total).

Step 2: Facing the left bank (left as you face downstream), estimate a distance of 10m back into the riparian vegetation or until an exclosure is encountered. On steeply sloping channel margins, estimate the distance into the riparian zone as if it were projected down from an aerial view.

Step 3: Within this 10 m X 10 m area, conceptually divide the riparian vegetation into three layers: a canopy layer (>5 m [16ft] high), an understory (0.5 to 5 m [20 inches to 16ft.] high), and a ground cover layer (<0.5 m high).

Step 4: Within this 10 m X 10 m area, determine the dominant vegetation type for the canopy layer as Deciduous, Coniferous, Broadleaf Evergreen, Mixed, or None. Consider the layer mixed if more than 10% of the aerial coverage is made up of the alternate vegetation type. Indicate the appropriate vegetation type in the “Visual Riparian Estimates” section of the Channel/Riparian Cross Section Form (Figure 7).

Step 5: Determine separately the aerial cover class of large trees (>0.3 m [1ft] diameter breast height [DBH]) and small trees (<0.3m DBH) within the canopy layer. Estimate aerial cover as the amount of shadow that would be cast by a particular layer alone if the sun were directly overhead. Record the appropriate cover class on the field data form (“0”= absent: zero cover, “1”= sparse: <10%, “2”= moderate: 10-40%, “3”=heavy: 40-75%, or “4”= very heavy: >75%).

Step 6: Look at the understory layer. Determine the dominant vegetation type for the understory layer as described in Step 4.

Step 7: Determine the aerial cover class for woody shrubs and saplings separately from non-woody vegetation within the understory, as described in Step 5 for large trees.

Step 8: Look at the ground cover layer. Determine the aerial cover class for woody shrubs and seedlings, non-woody vegetation as described in Step 5 for large canopy trees, and the amount of bare ground present. Note that Reed's canary grass often meets the height requirements for the understory layer, but should always be counted as ground cover.

Step 9: Repeat steps 1 through 8 for the right bank.

Step 10: Repeat steps 1 through 9 for all Transects, using a separate field data form for each Transect. Once vegetation has been accounted for in a layer, it should not be included in subsequent layers as they are evaluated.

Riparian Vegetation Cover	Left Bank					Right bank					Flag
	Canopy (> 5m high)										
Vegetation type	**D**	**C**	**E**	**M**	**N**	**D**	**C**	**E**	**M**	**N**	
Big trees (trunk > 0.3m DBH) XCL	**0**	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**	
Small trees (trunk ,0.3m DBH) XCS	**0**	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**	
	Understory (0.5 to 5m high)										
Vegetation type	**D**	**C**	**E**	**M**	**N**	**D**	**C**	**E**	**M**	**N**	
Woody shrubs and saplings XMW	**0**	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**	
Non-woody herbs grasses and forbs XMH	**0**	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**	
	Ground Cover (0.5m high)										
Woody shrubs & saplings XGW	**0**	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**	
Non-woody herbs grasses and forbs XGH	**0**	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**	
Barren dirt or duff XGB	**0**	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**	

Figure 3. Form for recording visual riparian estimates

Note: Use one form for each Transect (A – K)

The following table taken from Kauffman et al. (1999) details the parameter codes and precision metrics of EMAP procedures conducted in Oregon (Table 3). Parameters in bold type are the most precise. This table is provided for information purposes only.

Table 3. Parameter codes and precision metrics of EMAP procedures conducted in Oregon.

Code	Variable name and description	RMSE = σ_{rep}	CV = σ_{rep} / ”(%)	S/N = $\sigma^2_{st(yr)}$ / σ^2_{rep}
XCL	Large diameter tree canopy cover (proportion of riparian)	0.057	38	4.6
XCS	Small diameter tree canopy cover (proportion of riparian)	0.12	55	1.4
XC	**Tree canopy cover (proportion of riparian)**	**0.12**	**33**	**2.4**
XPCAN	**Tree canopy presence (proportion of riparian)**	**0.08**	**8.7**	**10**
XMW	Mid-layer woody vegetation cover (proportion of riparian)	0.12	41	0.9
XMH	Mid-layer herbaceous vegetation cover (proportion of riparian)	0.13	100	0.9
XM	**Mid-layer vegetation cover (proportion of riparian)**	**0.19**	**44**	**0.6**
XPMID	**Mid-layer vegetation presence (proportion of riparian)**	**0.03**	**3.5**	**2.1**
XGW	Ground layer woody vegetation cover (proportion of riparian)	0.17	77	0.1
XGH	Ground layer herbaceous vegetation cover (proportion of riparian)	0.16	40	1.1
XGB	Ground layer barren or duff cover (proportion of riparian)	0.07	47	2.0
XG	Ground layer vegetation cover (proportion of riparian)	0.22	36	0
PCAN_C	Conifer riparian canopy (proportion of riparian)	0.11	58	8.5
PCAN_D	Broadleaf deciduous riparian canopy (proportion of riparian)	0.13	31	7.4
PCAN_M	Mixed conifer-broadleaf canopy (proportion of riparian)	0.16	65	2.9
PMID_C	Conifer riparian mid-layer (proportion of riparian)	0.02	55	37
PMID_D	Broadleaf deciduous riparian mid-layer (proportion of riparian)	0.33	58	0.7
PMID_M	Mixed conifer-broadleaf canopy (proportion of riparian)	0.32	87	0.6

PROCEDURES FOR MEASURING CANOPY COVER

Canopy cover is determined for the stream reach in the treatment and control areas at each of the 11 cross-section Transects. A convex spherical densiometer (Model B) is used. Six measurements are obtained at each cross section Transect at mid-channel

Step 1: At each cross-section Transect, stand in the stream at mid-channel and face upstream.

Step 2: Hold the densiometer 0.3 m (1 ft.) above the stream. Hold the densiometer level using the bubble level. Move the densiometer in front of you so that your face is just below the apex of the taped “V”.

Step 3: Count the number of grid intersection points within the "V" that are covered by either a tree, a leaf, a high branch, or other shade providing feature (Reed's canary grass, bridge or other fixed structure, stream bank, etc.). Record the value (0-17) in the CENUP field of the canopy cover measurement section of the form.

Step 4: Face toward the left bank (left as you face downstream). Repeat steps 2 and 3, recording the value in CENL field of the data form.

Step 5: Repeat steps 2 and 3 facing downstream, and again while facing the right bank (right as you look downstream). Record the values in the CENDWN and CENR fields of the field data form.

Step 6: Repeat steps 2 and 3 again, this time facing the bank while standing first at the left bank, then the right bank, while holding the densiometer approximately 0.3 m (1 ft.) above the water surface and at the wetted edge. Record the value in the LFT and RGT fields of the data form.

Step 7: Repeat steps 1-6 for each cross-section Transect (A-K). Record data for each Transect on a separate data form.

Step 8: If for some reason a measure cannot be taken, indicate in the "Flag" column. This situation would occur if there is no access to one side of the channel, or if the channel is too wide or deep to cross, so middle measurements cannot be taken. If measurements cannot be taken they will not be estimated.

Location	1-17	Flag
CENUP		
CENL		
CENDWN		
CENR		
LFT		
RGT		

Figure 4. Form for tallying canopy density

Each of the measures taken at the center of the stream are summed for all 11 Transects and converted to a percentage based upon a maximum score of 17 per Transect. The results are then averaged to produce a mean % canopy density at mid-stream (XCDENMID).

Each of the measures taken at the banks of the stream are summed for all 11 Transects and converted to a percentage based upon a maximum score of 17 per Transect. The results are then averaged to produce a mean % canopy density at the stream bank (XCDENBK).

Each of the measures are totaled and averaged to produce the following table of riparian vegetative cover.

Table 4. The shaded composite variables are considered the most important in terms of their precision and are the ones that will be used to determine effectiveness of riparian plantings.
RMSE = σ_{rep} is the root mean square error. The lower the value, the more precise the measurement.
CV σ_{rep} / ”(%) is the coefficient of variation. The lower the number, the more precise the measurement.
S/N = $\sigma^2_{st(yr)}$ / σ^2_{rep} is the signal to noise ratio. The higher the number, the more that metric is able to discern trends or changes in habitat in a single or multiple sites. This table is provided to demonstrate the best indicators for testing significance.

Variable	Description	RMSE = σ_{rep}	CV = σ_{rep} / ”(%)	S/N = $\sigma^2_{st(yr)}$ / σ^2_{rep}
XCDENBK	Mean % canopy density at bank (Densiometer reading)	3.9	4.4	17
XC DENMID	**Mean % canopy density mid-stream (densiometer reading)**	**5.8**	**8.1**	**15**
XCM	Mean riparian canopy + mean mid-layer cover	0.22	33	1.4
XPCM	Riparian canopy and mid-layer presence (proportion of reach)	0.08	9.8	7.9
XPCMG	**3-layer riparian vegetation presence (proportion of reach)**	**0.08**	**9.8**	**8.0**

METHOD FOR MEASURING POOL TAIL FINES

Protocol taken from: ***Heitke et al (2010), pp. 49-50.***

PURPOSE

This protocol is designed to determine the percentage of fine sediments on the pool tail surface of plunge pools and scour pools.

EQUIPMENT

Grid (14”x14”, with 49 evenly distributed intersections), measuring stick, electrical tape, field forms, waders

SITE SELECTION

The sample reaches are those laid out according to the methods on pages 15-17.

SAMPLING DURATION

Sampling should occur during summer low flow levels, or when feasible at each project site.

PROCEDURES FOR MEASURING POOL TAIL FINES

For the purposes of this method, the following criteria must be met for a feature to be considered a pool:

- Pools are depressions in the streambed that are concave in profile, laterally and longitudinally.
- Pools are bound by a ‘head’ crest (upstream break in streambed slope) and a ‘tail’ crest (downstream break in streambed slope).
- Only consider main channel pools where the thalweg runs through the pool, and not backwater pools.
- Pools span at least 50% of the wetted channel width at any location within the pool. So a pool that spans 50% of the wetted channel width at one point, but spans <50% elsewhere is a qualifying pool.
- When islands are present only consider pools in the main channel; don’t measure pools in side channels.
- If a side channel is present, the pool must span at least 50% of the main channel’s wetted width; disregard side channels width when making this determination.
- Maximum pool depth is at least 1.5 times the pool tail depth.

Step 1: Collect measurements in the first ten scour and plunge pools of each reach beginning at the downstream end (Transect A). Exclude dam pools (and beaver pools). If there are fewer than 10 pools within the reach, sample all pools that meet the criteria listed above.

- Sample within the wetted area of the channel.
- Take measurements at 25, 50, and 75% of the distance across the wetted channel, following the shape of the pool tail.

- Take measurements upstream from the pool tail crest a distance equal to 10% of the pool's length or one meter, whichever is less.

For example, if the pool length is 7 meters, measurements would be taken 0.7 meters upstream of the pool tail crest, which is 10% of the pool length.

If the pool length is 12 meters, measurements would be taken at 1 meter upstream from the pool tail crest because it is less than 10% of the pool's length, which would be 1.2 meters.

- Locations are estimated visually.

Step 2: Assess surface fines using a 14 x 14 inch grid with 49 evenly distributed intersections. Include the top right corner of the grid and there are a total of 50 intersections.

Step 3: Using the grid, take measurements in each pool by completing the following steps:

1. Place the bottom edge of the grid upstream from the pool tail crest a distance equal to 10% of the pool's length or one meter, whichever is less (Figure 5).

2. Place the center of the grid at 25% of the distance across the wetted channel, making sure the grid is parallel to and following the shape of the pool tail crest.

3. If a portion of the fines grid lands on substrate 512 mm (approx. 20 inches) or larger in size (b-axis), record the intersections affected as non-measurable intersections (Figure 6).

Step 4: Record the number of intersections that are underlain with fine sediment < 2 mm in diameter at the b-axis in the Pool Tail Fines Form (Figure 7). Place a 2 mm wide piece of electrical tape on the grid and use this to assess the particle size at each intersection.

Step 5: Record the number of intersections that are underlain with fine sediment < 6 mm in diameter at the b-axis in the Pool Tail Fines Form (Figure 7). Place a 6 mm wide piece of electrical tape on the grid and use this to assess the particle size at each intersection.

Step 6: Aquatic vegetation, organic debris, roots, or wood may be covering the substrate. First attempt to identify the particle size under each intersection. If this is not possible due to debris, then record the number of non-measurable intersections. Do not attempt to move the obstructing debris

Notes:

- Your number of fines < 2mm cannot exceed the number of fines < 6mm.
- In small streams you can have grid placements overlap.

Step 7: Repeat steps 2 – 6 at 50% and 75% of the distance across the wetted channel, for a total of three measurements per pool

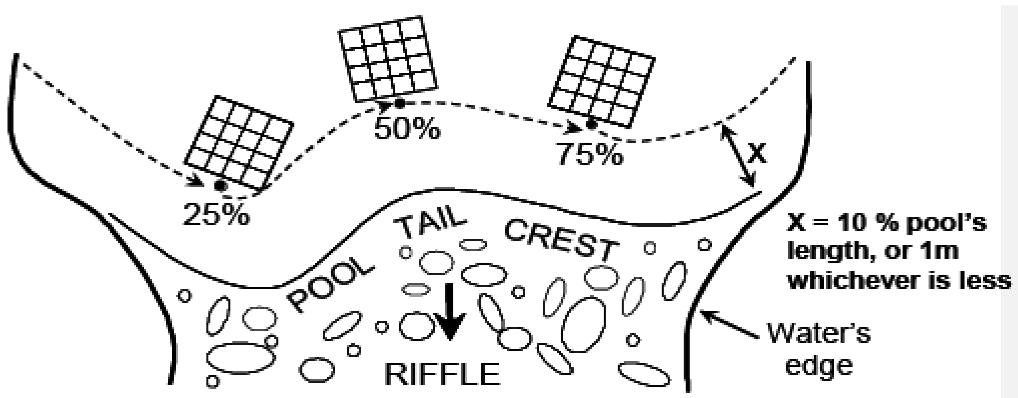

Figure 5. Orientation and location of grid placement (from Heitke et al (2010)).

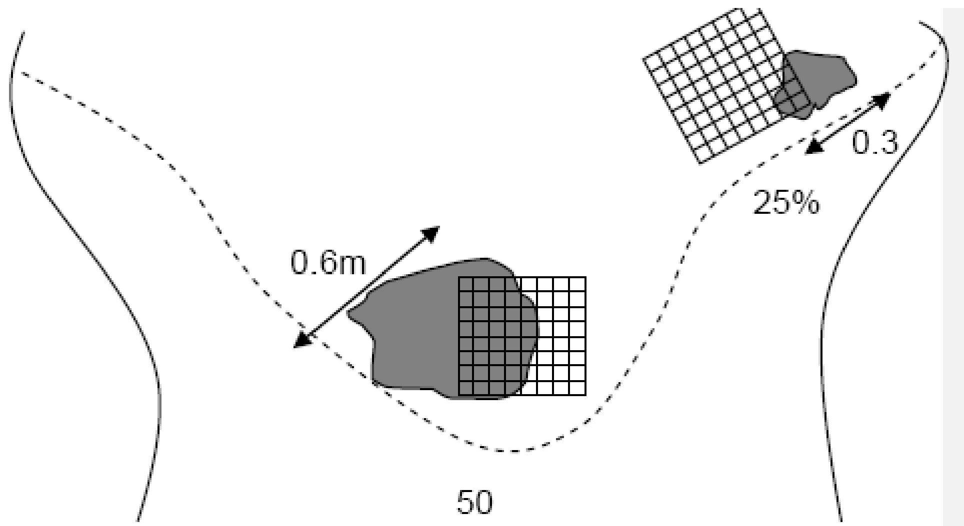

Figure 6. This figure illustrates non-measureable substrate at the 50% placement (from Heitke et al (2010)).

Pool Tail Fines Data Sheet										
Site: ________		Reach: Control Impact					Surveyors: ________			
Date: ________		Visit #: ________								
Transect (A-B, B-C, etc.)	**Pool #** (1-10)*	**# Intersections with Fine Sediment** (out of 50 at each location)								
		25%			***50%***			***75%***		
		<2mm	***<6mm***	***Non-measurable***	***<2mm***	***<6mm***	***Non-measurable***	***<2mm***	***<6mm***	***Non-measurable***
Comments:										
*Pools should be numbered from 1-10 sequentially beginning at downstream end of reach. Note: The number of intersections listed as < 2 mm can not exceed the number that is listed as < 6 mm										

Figure 7. Pool Tail Fines Form

METHOD FOR MEASURING ACTIVELY ERODING STREAMBANKS

Protocol taken from: ***Moore et al. (1998)***

PURPOSE

This protocol will allow us to determine if the stream banks within the habitat restoration area have improved and thereby reduced siltation and erosion by reducing the percentage of the streambank that is actively eroding.

EQUIPMENT

Appropriate waterproof sampling form, waders or hip boots.

SITE SELECTION

The sample reaches are those laid out according to the methods on pages 15-17.

SAMPLING DURATION

Sampling should occur during summer low flow levels, or when feasible at each project site.

PROCEDURE

Step 1: Estimate the percent of the lineal distance between each Transect (A – B, B – C, etc.) that is actively eroding at the active channel height. Active erosion is defined as recently actively eroding or collapsing banks and may have the following characteristics: exposed soils and inorganic material, evidence of tension cracks, active sloughing, or superficial vegetation that does not contribute to bank stability.

Step 2: Record estimated percent on the bank erosion form (Figure 8)

Transect	Left Bank	Right Bank
A-B		
B-C		
C-D		
D-E		
E-F		
F-G		
G-H		
H-I		
I-J		
J-K		
Total (sum left & right bank)		
Mean Percent erosion (total/20)		
Variance		

Figure 8. Bank erosion form (percent erosion)

SUMMARY STATISTICS

After field data collection, the data are uploaded into an MS Access® database which then computes summary statistics to reflect habitat conditions at the reach scale. These summary statistics were generally developed as part of the EPA EMAP and were selected for this program based on their high signal to noise ratios as compared to other potential summary variables. The following variables are reported for Riparian Planting Projects.

Pre-Monitoring Data Collection – From Project Sponsor or Application

Area Planted
This is simply a measurement of the riparian area planted for the project.

Stream Length
This is the length of stream affected by the project, or the linear distance in km along the stream bank where new plantings are installed.

Project Site Verification Measurements

GPS Coordinates
The GPS coordinates are taken at Transect A, Transect F (also known as the X-site), and Transect K in each reach, impact and control. These response variables are the GPS coordinates in Degrees, Minutes, Seconds, which are entered into the stream verification form on-site.

Reach Length
Reach length is measured on-site as the distance between the start and end of a reach, or calculated as twenty times the average bankfull width of the stream. The reach length is determined for both the impact and control reaches, as described in the Method For Laying Out Control And Impact Stream Reaches For Wadeable Streams (pages 15-17). In general, the impact reach length is scaled to the reach width and the control reach length is set to match the impact reach length unless that is not feasible. The Reach Length variable is simply reported as this measurement or calculated distance in meters.

Reach Width
Reach width is calculated as the average wetted width of the reach. A measurement of wetted with (in meters) is taken at each Transect, and wetted width and bar width are measured at station 5 or 7, the midpoint between each Transect. Each of the 11 wetted width measurements from the major transects and the 10 measurements of wetted width from midpoints, or inter-transects, (the width used from the intermediate transects is defined as the wetted width minus the bar width) are summed and divided by the number of measurements to come up with the average wetted width, which is the Reach Width, in meters.

In- Channel Data Collection

Canopy Cover
This is the mean percent canopy density at the bank, based on densiometer readings at the left and right banks. We collect a measurement from a densiometer at locations near the right and left banks of each transect in the reach. The reading is a value between 0 and 17, with 0 indicating no canopy density whatsoever and 17 reading 100 percent canopy density. The final variable takes the measurements read from each transect, both left and right, and calculates the mean.

Riparian Vegetation Structure
Riparian Vegetation Structure is the proportion of the reach containing all 3 layers of riparian vegetation: canopy cover, understory and ground cover. Each of the three layers of riparian vegetation is defined by two constituent layers, and we count a layer as containing riparian vegetation if either of its two constituents are present. The constituents for canopy cover are small trees and big trees. Understory is

broken into woody understory and non-woody understory, and ground cover is broken into woody ground cover and non-woody ground cover. At each transect a value is recorded for all six constituents at each bank. For instance a value is recorded for big trees on the left bank and big trees on the right bank at each transect. The values are integers from 0 to 4, representing percentage ranges. A 0 means no presence whatsoever, 1 means less than 10 percent, 2 means 10-40 percent, 3 is 40-75 percent, and 4 is greater than 75 percent.

The calculation is the percentage of the 22 possible locations in the reach that have each of the three layers of riparian vegetation present. We treat the right and left banks separately to come up with the 22 possible locations (the right and left banks for each of the 11 transects.) Since presence of a layer is shown if either of its constituents are present, we start the calculation by looking at the canopy cover, and if the value for big trees OR the value for small trees is 1 or greater, then we count that location to have canopy cover present. In a similar way we judge understory and ground cover and if the location has all 3 layers present we contribute that location to the percentage of the full 22 locations in the reach.

Bank Erosion
Bank erosion is a measure of the proportion of the reach containing actively eroding stream banks. At each transect we collect an estimation in percent (0-100) along the left and right banks. The variable Bank Erosion is the mean of all the measurements, right and left banks combined.

Average Pool Tail Fines
The Average Pool Tail Fines is an average of the pool tail fines measured through the Method for Measuring Pool Tail Fines and recorded on the Pool Tail Fines Form. The average pool tail fines are reported for fines <2mm and fines <6mm as a percentage. This is calculated by averaging all pool tail fines across the reach for <2mm and dividing by 50 (number of intersections in the grid). The same procedure is followed for fines <6mm across the reach.

Riparian Planting Area Data Collection

Number of Plantings
This number is collected during Year 1, right after plantings have been installed. It is used to calculate the average number of plants per acre (using the 1/10 acre plots established) and the total number of plants installed as part of the project (by multiplying the average density per acre by the number of acres planted.

Percent of Plants Living
This is the percent of the original number of planted trees and shrubs that are still alive during monitoring in Year 3. This statistic is calculated by counting and recording the number of live trees and shrubs in each of the ten permanent circular plots established in the impact reach. The total number of live trees and shrubs in all plots combined is divided by the total number of trees and shrubs originally planted in the riparian planting area, as determined in Year 1. Only trees and shrubs that were planted during the original riparian planting effort are used in calculating the percent of plants living. This percentage is only calculated in Year 3 to measure the two-year survival of the original planting efforts. After Year 3, due to the difficulty in determining whether an individual is an original planting or is a volunteer, Percent Cover of Woody Vegetation in the Riparian Planting Area is measured instead of Percent of Plants Living.

Percent Cover of Woody Vegetation within the Riparian Planting Area
This is the average aerial percent cover of woody species in the riparian planting area. This statistic is calculated by estimating aerial cover of woody species present in ten 201 ft^2 circular riparian planting plots. The variable Percent Woody Cover is the mean of the estimates from the 10 plots.

TESTING FOR SIGNIFICANCE

We can create a table resembling the following from the data collected for each of the indicators for number of riparian plantings, canopy cover, understory, ground cover, and canopy.

Table 5. Example - Data table for hypothetical presence of riparian plantings

	Year 0 # AIS installed	Year 1	Year 3	Year 5	Year 10
	Impact	**Impact**	**Impact**	**Impact**	**Impact**
Proj. 1	**0**	**200**	**190**	**170**	**160**
Proj. 2	**0**	**50**	**44**	**36**	**22**
Proj. 3	**0**	**1000**	**882**	**796**	**600**
Proj. 4	**0**	**250**	**249**	**233**	**120**
Proj. 5	**0**	**90**	**44**	**23**	**7**
Proj. 6	**0**	**450**	**428**	**401**	**336**
Proj. 7	**0**	**2000**	**1884**	**1588**	**1109**
Proj. 8	**0**	**100**	**91**	**72**	**55**
Proj. 9	**0**	**200**	**187**	**152**	**109**
Proj.10	**0**	**1500**	**1443**	**1103**	**932**
Total	**0**	**5840**	**5442**	**4574**	**3450**
Percent Remaining	**0**	**100**	**93**	**78**	**59**

Table 6. Mean % canopy density at bank (Densiometer reading)

	Year 0 2003		Year 1 2005		Year 3 2006		Year 5 2008		Year 10 2014	
	Impact	**Cntrl**	**Impact**	**Cntrl**	**Impact**	**Cntrl**	**Impact**	**Cntrl**	**Impact**	**Cntrl**
Proj. 1										
Proj. 2										
Proj. 3										
Proj. 4										
Proj. 5										
Proj. 6										
Proj. 7										
Proj 8										
Proj 9										
Proj 10										
Sum										
Mean										
Var.										
% Change										

Among all of the measures taken in the riparian area under EMAP sampling protocols, two measures demonstrate the greatest precision and signal to noise ratio (see Table 7). These are the mean percent canopy density at bank (densiometer reading) and the 3-layer riparian vegetation presence (proportion of reach). We wish to test whether the percentage of the area with 3-layer riparian vegetation presence has increased significantly post impact.

We also wish to test whether the mean percent canopy density at bank has increased significantly in the treated area post impact.

Table 7. Composite variable exhibiting the best all-around precision and signal to noise ratios. RMSE = σ_{rep} is the root mean square error. The lower the value, the more precise the measurement. CV σ_{rep} / ”(%) is the coefficient of variation. The lower the number, the more precise the measurement. S/N = $\sigma^2_{st(yr)}$ / σ^2_{rep} is the signal to noise ratio. The higher the number, the more that metric is able to discern trends or changes in habitat in a single or multiple sites. Table provided for information purposes only.

Variable	Description	RMSE = σ_{rep}	CV = σ_{rep} / ”(%)	S/N = $\sigma^2_{st(yr)}$ / σ^2_{rep}
XCDENBK	**Mean % canopy density at bank (densiometer reading)**	**3.9**	**4.4**	**17**
XC DENMID	Mean % canopy density midstream (densiometer reading)	5.8	8.1	15
XCM	Mean riparian canopy + mean mid layer cover	0.22	33	1.4
XPCM	Riparian canopy and mid layer presence (proportion of reach)	0.08	9.8	7.9
XPCMG	**3-layer riparian vegetation presence (proportion of reach)**	**0.08**	**9.8**	**8.0**

Table 8. 3-layer riparian vegetation presence (proportion of reach)

	Year 0 2003		Year 1 2005		Year 3 2006		Year 5 2008		Year 10 2014	
	Impact	**Cntrl**	**Impact**	**Cntrl**	**Impact**	**Cntrl**	**Impact**	**Cntrl**	**Impact**	**Cntrl**
Proj. 1										
Proj. 2										
Proj. 3										
Proj. 4										
Proj. 5										
Proj. 6										
Proj. 7										
Proj 8										
Proj 9										
Proj 10										
Sum										
Mean										
Var.										
% Change										

The data will be tested using a paired *t*-test. The paired *t*-test is a very powerful test for detecting change because it eliminates the variability associated with individual sites by comparing each stream to itself, that is, at impact and control locations within the same stream. The impact reach and control reach for each stream are affected by the same local environmental factors and local characteristics in the flora and fauna in contrast with other stream systems with their own unique environmental conditions. In other words, the two observations of the pair are related to each other.

Because the paired *t*-test is such a powerful test for detecting differences, very small differences may be statistically significant but not biologically meaningful. For this reason, biological significance will be defined as a 20% increase in shading and vegetation at the Impact sites. The statistical test will be one-sided for an Alpha=0.10. We use a one-sided test because a significant decrease in salmon abundance after the impact of the project would not be considered significant, that is, the project would not be considered effective. In other words, we are not interested in testing for that outcome. The test will be conducted in Years 1, 3, 5, and 10. If the results are significant in any of those years, the riparian projects will be considered effective.

Our conclusions are, therefore, based upon the differences of the paired scores for the 10 sampled riparian projects. Though somewhat confusing, it may be helpful to think of the statistic as the “difference of the differences”. A one-tailed paired-sample *t*-test would test the hypothesis:

H_0 *:* The mean difference is less than or equal to zero.
H_A *:* The mean difference is greater than zero.

The test statistic is calculated as:

$$t_{n-1} = \frac{\bar{d} - 0}{s_{\bar{d}}}$$

where
$\bar{d}$ = mean of the differences for Year 0 and a subsequent year
s_d = variance of the differences
$s_{\bar{d}} = {}^{s_d}\!/\!_{\sqrt{n}}$ = variance mean
n = number of sites (or site pairs).

DATA MANAGEMENT PROCEDURES

Data will be collected in the field using various hand-held data entry devices. Raw data will be kept on file by the project monitoring entity. A copy of all raw data will be provided to the SRFB at the end of the project. Summarized data from the project will be entered into the PRISM database after each sampling season. The PRISM database contains data fields for the following parameters associated with these objectives.

Table 9. Riparian Plantings Project Level PRISM Data

Indicator	Metric	Pre Impact Year 0	Post Impact Year 1	Post Impact Year 3	Post Impact Year 5	Post Impact Year 10
Stream Distance affected by plantings	miles	√				
Total area affected	acres	√				
Plantings present	#	√	√	√		
Percent Woody Cover	%		√	√	√	√
Riparian Canopy Covers Impact	Mean % canopy density at the bank	√	√	√	√	√
Riparian Canopy Covers Control	Mean % canopy density at the bank	√	√	√	√	√
Statistically significant	Yes/No			√	√	√
Riparian Cover Impact	Proportion of Impact reaches where 3 vegetation layers are present	√	√	√	√	√
Riparian Cover Control	Proportion of control reaches where 3 vegetation layers are present	√	√	√	√	√
Statistically significant	Yes/No		√	√	√	√
Bank Stability Impact	Mean % of stream bank	√	√	√	√	√
Bank Stability Control	Mean % of stream bank	√	√	√	√	√
Statistically significant	Yes/No		√	√	√	√

REPORTS

PROGRESS REPORT

A progress report will be presented to the SRFB in writing by the monitoring entity after the sampling season for Years 1 and 5.

FINAL REPORT

A final report will be presented to the SRFB in writing by the monitoring entity after the sampling season for Year 10. It shall include:

- Estimates of precision and variance.
- Confidence limits for data.
- Summarized data required for PRISM database.
- Determination whether project met decision criteria for effectiveness.
- Analysis of completeness of data, sources of bias.

Results will be reported to the SRFB during a regular meeting after 1, 3, 5, and 10 years post project. Results will be entered in the PRISM database and will be reported and available on the Interagency Committee for Outdoor Recreation website and the Natural Resources Data Portal.

ESTIMATED COST

It is estimated that 33 man-hours will be needed to complete each project site (control and impact). Cost estimate using 2004 rates are $2,500 - $3,500 per site.

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APPENDIX A

Stream Measurement and Densiometer Reading Locations

TRANSECT MEASUREMENTS AND DENSIOMETER READING LOCATIONS

Figure 1

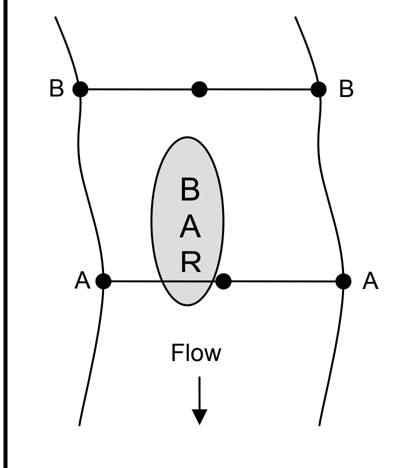


Figure 2

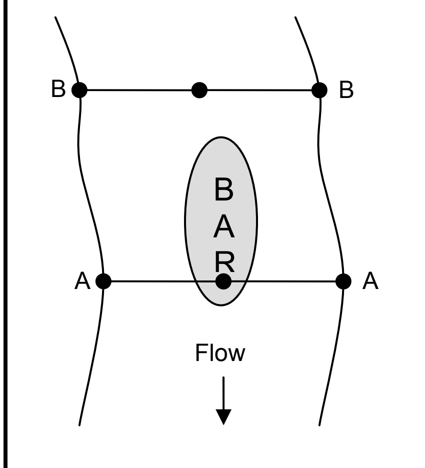


Figure 3

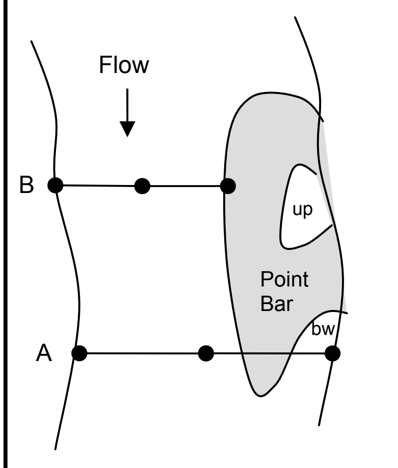


Figure 4

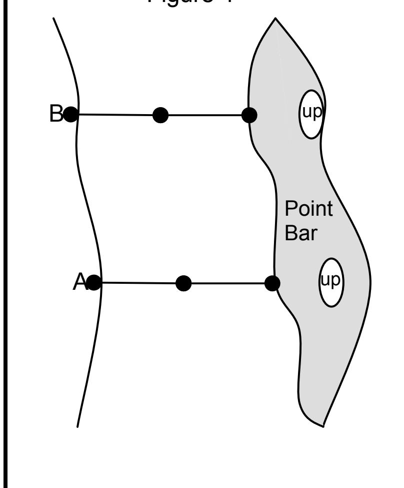


Figure 5

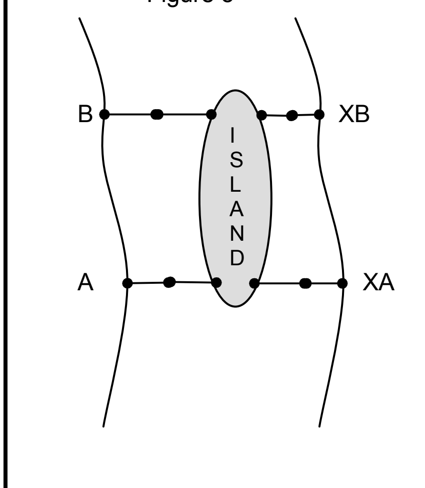


Figure 6

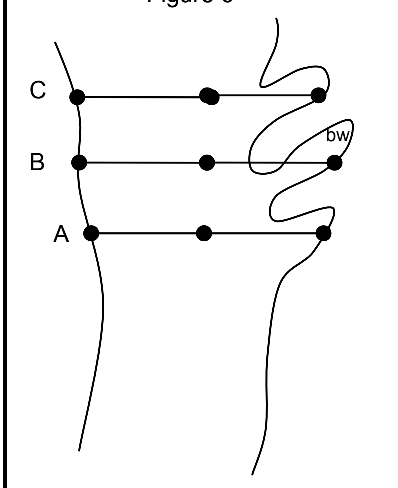


Figure 7

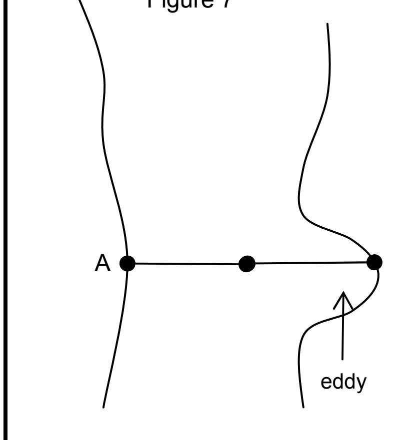


Figure 8

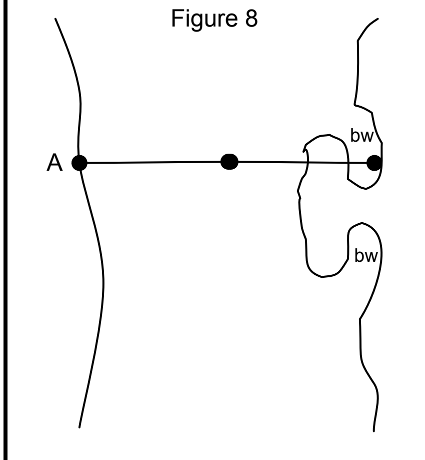
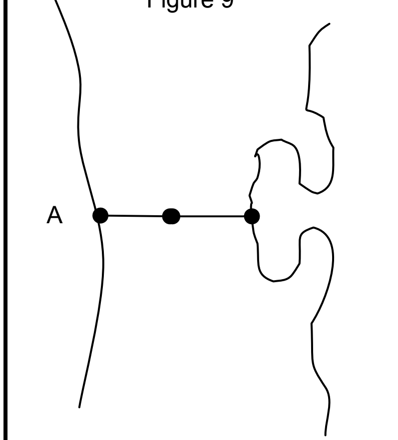


Figure 9



Notes:

- up = unconnected puddle; bw = backwater
- In all figures, flow is from the top of the figure to the bottom of the figure.
- In all figures, each line across the channel represents a Transect and the dots represent the locations of densiometer measurements.
- Measurement locations within the reach are determined based on the conditions present at the time of the survey.
- Substrate measurements (not illustrated in the figures) are made at five equal distance locations across each Transect and each secondary/mid-Transect (e.g., between Transect A and B).
- Right bank is on the right side of the stream when facing downstream; left bank is on the left side of the stream when facing downstream.
- Regardless if a bar is present, densiometer readings occur at the right bank, in the center of the channel, and at the left bank (Figures 1 and 2).
- Wetted width is measured across bars from the right edge of water to the left edge of water (Figures 1 and 2). The bar width is also measured and is independent of the wetted width measurement.
- If a point bar is present (e.g., gray areas in Figures 3 and 4), the edge of water is where the point bar and water meet (i.e., the bank). In Figures 3 and 4, the left bank measurements occur where the point bar and water meet (i.e., the left edge of the water). However, in the case of Transect A, in Figure 3, backwater is present and, therefore, the left edge of water (i.e., the left bank) would be on the left bank of the backwater. Unconnected puddles are never included in any measurements.
- Bars are mid-channel features below the bankfull flow mark that are dry during baseflow conditions. Islands are mid-channel features that are dry even when the stream is experiencing a bankfull flow. Both bars and islands cause the stream to split into side channels. When a mid-channel bar is encountered along the thalweg profile, it is noted on the field form and the active channel is considered to include the bar. Therefore, the wetted width is measured as the distance between the wetted left and right banks. It is measured across and over mid-channel bars and boulders. If mid-channel bars are present, record the bar width in the space provided in the form.
- If a mid-channel feature is as high as the surrounding flood plain, it is considered an island (Figure 5). Treat side channels resulting from islands different from mid-channel bars. Manage the ensuing side channel based on visual estimates of the percent of total flow within the side channel as follows:

  Flow less than 15% - Indicate the presence of a side channel on the thalweg field data form.

  Flow 16 to 49% - Indicate the presence of a side channel on the thalweg field data form.

  Establish a secondary Transect across the side channel (Figure 5) designated as “X” plus the primary Transect letter; (e.g., XA), by creating a new record in the physical habitat form and selecting “X” and the appropriate Transect letter (e.g., A through K) in the new record on the field data form. Complete the physical habitat and riparian cross-section measurements for the side channel on this form. No thalweg measurements are made in the side channel. When doing width measurements within a side channel separated by an island, include only the width measurements of the main channel in main channel form, and then measure the side channel width separately, recording these width measurements in the physical habitat side channel form. Refer to Peck et al. (2003) for detailed instructions on side channel measurements.
- When multiple backwaters and eddies are encountered (Figure 6), measurements are made across the entire channel, over depositional areas (e.g., Figure 6, Transect B) to the edge of water.
- When eddies are encountered (Figure 7), measurements are still made from the right bank to the left bank.

- In instances where a depositional area has become a peninsula and the Transect falls in a location where backwater is present (Figure 8), measure from the right bank across the depositional area to the left bank (e.g., Figure 8, Transect A). When the Transect falls in a location where backwater is not present (e.g., Figure 9, Transect A), only measure to where the water meets the edge of the depositional area/peninsula.