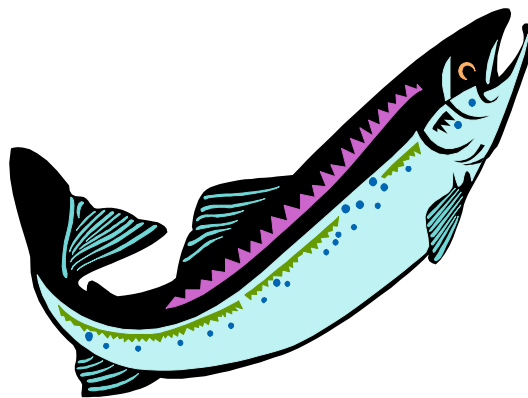


# Monitoring the Effectiveness of Riparian Vegetation Restoration

Final Report



*Prepared for:*

**California Department of Fish and Game  
Salmon and Steelhead Trout Restoration Account Agreement No. P0210566**

*Prepared by:*

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## INTRODUCTION

Riparian vegetation plays important roles in maintaining suitable habitat for anadromous fish. It provides shade and cover, promotes bank stability, enhances physical channel features, provides large wood recruitment, filters sediment, and serves as a major source of nutrients to support instream fauna and flora. Most riparian restoration projects are intended to improve one or more of these functions.



The time period over which riparian vegetation responds to restoration varies with the plant community type (herbaceous, shrub or tree) and the functions targeted for restoration. In the initial phases of monitoring (1-2 years after implementation), it may only be possible to assess whether or not vegetation was successfully established on a site. Subsequent effectiveness monitoring will focus on the development of community characteristics such as canopy cover or species diversity. Over the long term, the focus may shift to other conditions such as stream temperature, instream wood or instream habitat. As the emphasis changes from the vegetation to the functions of the vegetation, the methods used for monitoring will also change. During the initial phases, simple plant counts may be adequate. Later, more complex sampling designs may be necessary to obtain statistically valid measurements of community characteristics. Monitoring functions such as stream temperature or wood recruitment may not require any vegetation measurements at all.

This report includes recommendations for study design and methods for data collection. It is assumed that this report will be used as a guide for preparing monitoring study plans. The field methods presented here are for monitoring the effectiveness of riparian restoration during the initial and intermediate stages of establishment and community development at the site and stream reach scales. The stipulated period is 10 years, which is the time that access to treated sites is allowed under FRGP contracts. The methods focus on tree and shrub vegetation. Other methods will be appropriate for monitoring functions either in locations where riparian vegetation already exists and is being protected (e.g., through a conservation easement), for projects involving herbaceous wetland restoration or for long-term studies of stream response to riparian restoration. For example, studies of large wood recruitment to streams should be



conducted using the field methods in *Monitoring the Effectiveness of Instream Habitat Restoration*.

Use of this report presupposes a working knowledge of basic plant ecology, forest and vegetation sampling and plant identification. References provided at the end of this report provide details on the field methods presented.

## RESTORATION OBJECTIVES

This report applies to the following restoration project types:

- Riparian Planting: Planting in the immediate vicinity of the channel or in patches along a stream reach.
- Vegetation Control: Removal of exotic or other vegetation in or near the channel or floodplain.
- Land Use Control: Fencing, grazing management, and/or conservation easements.



The primary objectives for these projects are:



- Improving bank and floodplain stability, usually by increasing vegetation cover and root mass.
- Reducing stream temperature by increasing interception of sunlight by riparian canopy.
- Reducing cover and biomass of exotic plant species.
- Enhancing long-term recruitment of large woody debris especially of coniferous species.

The special case of using bioengineered structures for bank or floodplain stabilization is treated elsewhere (*see Monitoring the Effectiveness of Bank Stabilization Restoration*).

## EFFECTIVENESS MONITORING QUESTIONS AND STUDY DESIGN

It is expected that questions regarding the effectiveness of riparian restoration practices will generally be centered on either the effectiveness of alternative practices (e.g., planting versus riparian exclosures as a means of achieving increased riparian cover) or on the effects of environmental conditions on practices (e.g., effects of soil conditions or regional climate on plantation survival). It is further anticipated that studies addressing these topics will be conducted by sampling multiple sites over time. The following is a list of potential questions that might be addressed:

- Did planted vegetation survive at an acceptable rate?
- Did the restoration practice increase the cover of native riparian vegetation?
- Did the restoration practice increase the amount of shade canopy on the channel?
- Did the restoration practice reduce the abundance of exotic species in the riparian community?
- Did the restoration practice reduce encroachment of vegetation into the active channel?
- Did the restoration practice increase the abundance of coniferous trees in the riparian community?
- Did the restoration practice increase the connectivity and/or area of native riparian vegetation?



The general study design recommended is a before-after-control-impact approach (BACI). Other designs, such as retrospective studies and Bayesian approaches, have been used or might be used for assessing success of riparian restoration projects, but the BACI approach has features that make it superior (Smith 1998, Stewart-Oaten et al. 1986, Crawford and Johnson 2003). Sampling of the control and the impact area is conducted before and after treatment. Unique attributes of sampling related to the BACI design are discussed below in the field methods description.

Table 1 indicates what parameters, effectiveness criteria and field methods would be used to address each of the questions posed above. Field method numbering corresponds to their description in the next section of this report. Specific effectiveness criteria (e.g., targets such as survival rates, desired cover increases, etc.) should be defined in project contracts and/or within study plans for riparian effectiveness monitoring.

**Table 1.** Monitoring Questions, Parameters, Effectiveness Criteria and Field Methods.

<b>Monitoring Question</b>	<b>Parameters</b>	<b>Effectiveness Criteria</b>	<b>Field Methods</b>
Did planted vegetation survive at an acceptable rate?	Number of surviving plants. Cover of surviving vegetation.	Survival equals or exceeds contract specifications after 3 years e.g., 50 percent survival.	Planted tree survival assessment (field method 5). Line intercept transects for most other vegetation (field methods 1, 3 and 4).
Did the restoration practice increase the cover of native riparian vegetation 1) on streambanks 2) on the floodplain?	Percent cover in one or more canopy height classes (ground cover, shrub cover, tree cover).	Percent cover equals or exceeds contract specifications within 10 years (or more for conifer plantings) e.g., cover increases by 50 percent.	Line intercept transects 1) along banks (field method 1) 2) within 50 feet of channel (field method 3).
Did the restoration practice increase shade canopy on the channel?	Percentage of solar radiation intercepted by riparian canopy.	Shade produced by riparian canopy equals or exceeds contract specifications within 10 years (or more for conifer plantings) e.g., measured canopy interception > 75 percent.	Measurements of percentage of solar radiation intercepted by riparian canopy (field method 7).
Did the restoration practice reduce the abundance of exotic species in the riparian community?	Relative cover or relative frequency of exotic species targeted for control.	Relative cover or relative frequency of targeted species is equal to or less than contract specifications and remains so for at least 3 years e.g., cover of exotic vegetation <20 percent.	Line intercept transects 1) along banks (field method 1) 2) within 50 feet of channel or further (field method 3) 3) through delineated treatment areas (field method 4).
Did the restoration practice reduce encroachment of vegetation into the active channel?	Percent vegetation cover within the bankful channel.	Vegetation cover within the bankful channel is equal to or less than contract specifications and remains so for at least 3 years e.g., instream cover <10 percent.	Line intercept transects across the channel (field method 2).
Did the restoration practice increase the abundance of coniferous trees in the riparian community?	Relative frequency of coniferous trees.	Relative frequency of coniferous trees equals or exceeds contract specifications within 10 years of treatment e.g., relative frequency of conifers >50 percent.	Floodplain forest composition plots (field method 6).
Did the restoration practice increase the 1) connectivity and/or 2) area of native riparian vegetation	Connectivity (i.e., absence of gaps) or length of riparian corridor. Width or area of riparian vegetation.	Connectivity or area of riparian vegetation equals or exceeds contract specifications within 10 years e.g., barren streambank <10 percent of reach length.	Line intercept transects 1) along banks (field method 1) 2) within 50 feet of channel or further (field method 3).

The first question is not an effectiveness issue per se, but is important since initial survival rate may influence later performance. Survival assessments should be done immediately after treatment and after one or more stressful periods (summer drought and/or winter floods). Sampling at control sites is not necessary unless it is desirable to control for or study the effects of natural recruitment.





For other questions, data should be collected before treatment, immediately after treatment and at one or more future dates, depending on how long it takes for a response in both treated and control areas. For example, to determine if the abundance of exotic species was permanently reduced by a treatment, initial measurements should quantify the existing abundance of the species targeted for control. Then, monitoring should occur immediately after treatment and perhaps one to three years later. As another illustration, to determine if shade canopy has increased, it is necessary to wait long enough for the treated area to develop sufficient canopy cover and height. This may require sampling several years after treatment.

Goals for detecting differences due to treatments should be based on the restoration objectives typical for the treatments being evaluated. Generally, most riparian restoration practices are expected to make big changes in conditions, e.g., convert barren streambanks to fully vegetated streambanks, totally eliminate stands of exotic vegetation, etc. Since most practices will be assessed at the stream reach level, however, changes may only represent a relatively small proportion of the total community.



## DATA QUALITY

This report and field methods are intended for use by agency staff, experienced consultants or practitioners who are trained in riparian sampling methods. There are data quality objectives inherent to the field methods presented here. Additional data quality objectives should be described within specific study designs. Generally, a goal of between-observer variability of plus or minus 10 percent in measurements is desirable. Bias will be minimized through the use of standards and training. Quality control will be achieved through a combination of: 1) initial training, 2) repeat surveys by independent surveyors, and 3) follow-up training.

## FIELD METHODS

### Delineation of Study Areas

Study areas may be discrete areas (*see below*) or stream reaches. Stream reach study area locations are documented according to the location method. Generally, stream reach study areas should begin and end with the limits of proposed treatments, even if the treatments are not continuous. For example, if a stream reach has 11 defined sites for riparian planting, the study area boundaries would begin with the most upstream treatment site and end with the most downstream treatment site.

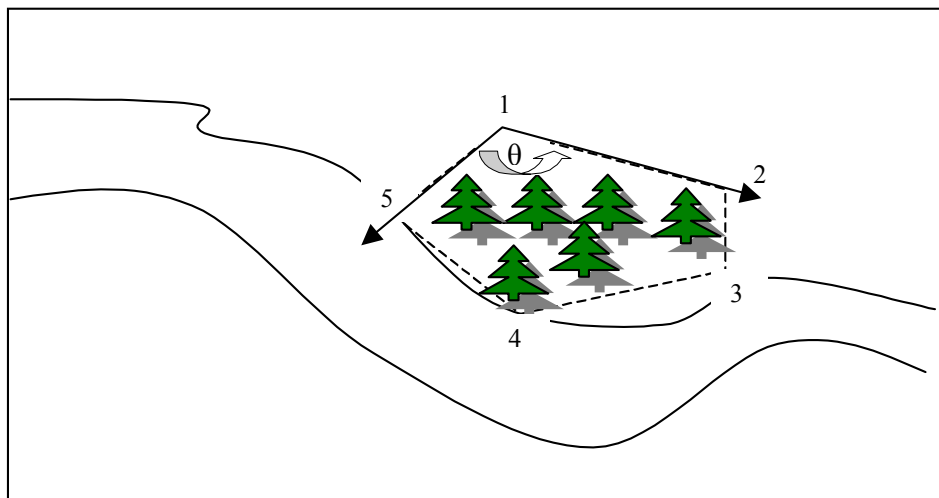
Control (untreated) stream reaches, if possible, should be located upstream of the treated area, or at least in their vicinity. Control reaches should be environmentally and ecologically comparable to the reaches that will be treated.

In some cases, riparian restoration treatments are applied to relatively large, independent areas such as grazing exclusions, plantings on eroded sites, exotic plant eradications, etc. In such cases, it is necessary to establish the boundaries of the area proposed for treatment so that it may be properly sampled and relocated in the future (Figure 1):

- Establish the location of one corner of the area relative to a known reference point. Flag the perimeter of the area to be treated.
- At each polygon corner, record the bearing between the corners.
- Using a hip chain or tape, record the length of each side of the polygon.
- Sketch the polygon onto field form.

In Figure 1, points 1, 2, 3, 4, and 5 are corners of the treatment polygon. Record the length of each side (e.g., the distance between points one and two). Record the bearings between all corners. The angle theta at point one is the difference in degrees between the bearing on line 1 to 2 and the bearing on line 1 to 5.

For more guidance on this procedure refer to *Documenting Salmonid Habitat Restoration Project Locations*.



**Figure 1.** Delineating the Treatment Area.

## Field Method 1: Line Intercept Transects Along Banks

These transects are used to assess changes in bank cover, riparian connectivity, vegetation structure and species composition at or near the bankfull boundaries of the channel. They are used where one or both sides of the stream will be treated as a whole or where there are multiple treatments located along one or both banks. In either case, effectiveness will be assessed at the reach scale. Data recorded are cover by tree and shrub species (or genus) by height class. These data allow calculation of percent vegetation cover on each bank by species or percent cover of barren ground or other features, such as restoration structures.



Data on herbaceous cover are not analyzed for two reasons: 1) herbaceous cover tends to vary on a seasonal basis; and 2) coastal restoration projects rarely involve the use of herbaceous vegetation. If it is desirable to collect herbaceous data for analysis purposes, other methods should be used. A text or paper on range sampling should be consulted for guidance (e.g., Winward 2000).

It should be noted that this field procedure is essentially the same as the field procedure for assessing effectiveness of bank stability (*see Monitoring the Effectiveness of Bank Stabilization Restoration*). The principal difference is that this field procedure does not require collection of data on bank conditions.

### *Determination of Sample Size*

The entire length of stream that is treated or control is measured. In a study assessing effectiveness of practices across many sites or regions, each transect would be a sample and an estimate of the mean difference in condition before and after treatment on treated and control sites can be made. A paired single-sided *t*-test will be used for statistical comparison.

Sample size will be determined by the specified level of change detection i.e., the quantified effectiveness criteria, and the number of locations that are treated (and their corresponding

control areas). The measurement of difference methodology is statistically powerful such that a relatively small sample will be sufficient to detect differences. Also, the changes due to restoration will generally be large (e.g., cover increases of 50 percent or greater). A pilot study may be used to obtain estimates of variance in cover and to then compute required sample sizes. The use of paired observations tends to reduce the variance thereby reducing the required sample needed to detect differences (Dixon and Massey 1969).

### *Field Method*

- Describe and/or monument the starting point for the transect. Multiple monuments may be needed to ensure relocating the point in the future. Distance from a bridge, road, parking lot, or other landscape feature is useful in referencing the starting point. Tie this point into other monitoring activities if possible. It is essential that the starting point be identifiable in the future
- From the monumented starting point, establish the line intercept transect along the left bank of the channel (if both sides of reach are to be treated, or either bank if only one side is to be treated) with a tape measure (Figure 2). The line should intercept the permanent riparian vegetation closest to the channel bankfull line (i.e., the “green line” according to Winward [2000]). The line intercept may be at, below or above bankfull depending on the location of permanent vegetation at that particular site. If no vegetation is present, the transect should follow the bankfull elevation.
- Walk along the channel bank and record interception of the line (in feet and/or inches, to the nearest 0.5 foot) by each shrub or tree species (or genus if species is not identifiable) within three height class categories (less than 3 feet, 3 to 15 feet, and over 15 feet). Record interception by herbaceous cover (if >10 percent; barren otherwise), litter, rock, or restoration structures where vegetation is not present (see Figures 1 through 4 for guidance on how to record intercept data). It may be necessary to repeat the line more than once to accurately measure vegetation in each height class.
- Repeat for the right bank if both sides of the reach are to be treated.

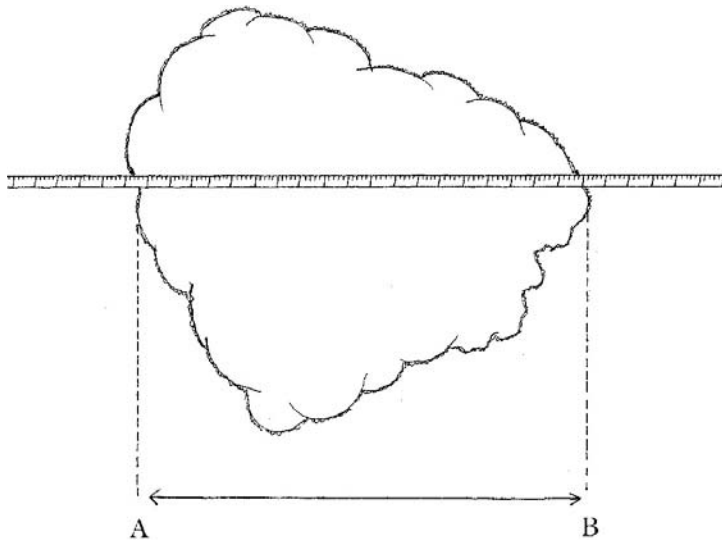
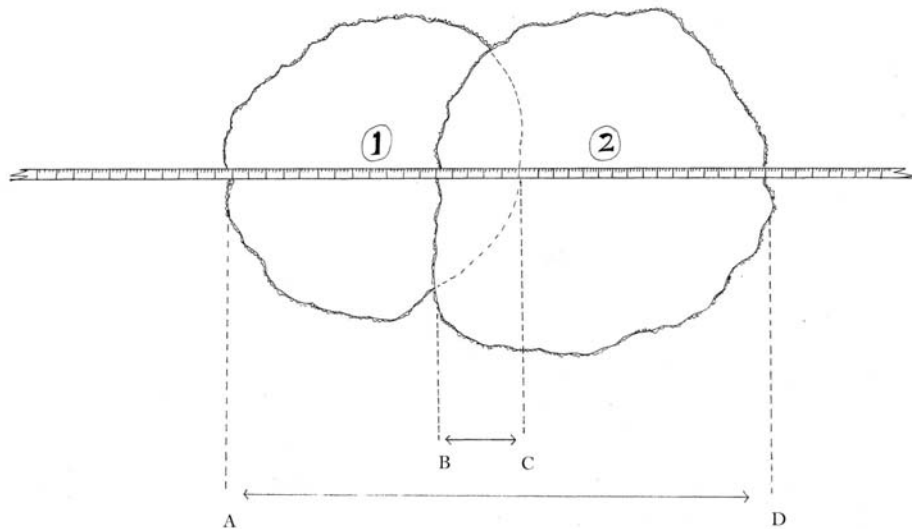


Figure 2 demonstrates the method for measuring canopy cover intercept along the measuring tape. Record the start of the plant intercept (A) in the Start field and the end intercept (B) in End field in feet.

**Figure 2.** Method for Measuring Canopy Intercept.  
*Source:* FIREMON 2003.



Figure 3 demonstrates the method for measuring canopy overlap. Overlap, (points B to C) is not measured if the canopy of two or more plants of the same species overlap. For example, if shrubs 1 and 2 are the same species, then the canopy intercept is measured from points A to D. If shrubs 1 and 2 are different species, then canopy intercept is measured from points A to C for shrub species 1 and from points B to D for shrub species 2. Overlap of different species is subtracted to obtain total cover estimates but is retained to estimate relative cover by species.



**Figure 3.** Method for Measuring Canopy Overlap.  
*Source:* FIREMON 2003.

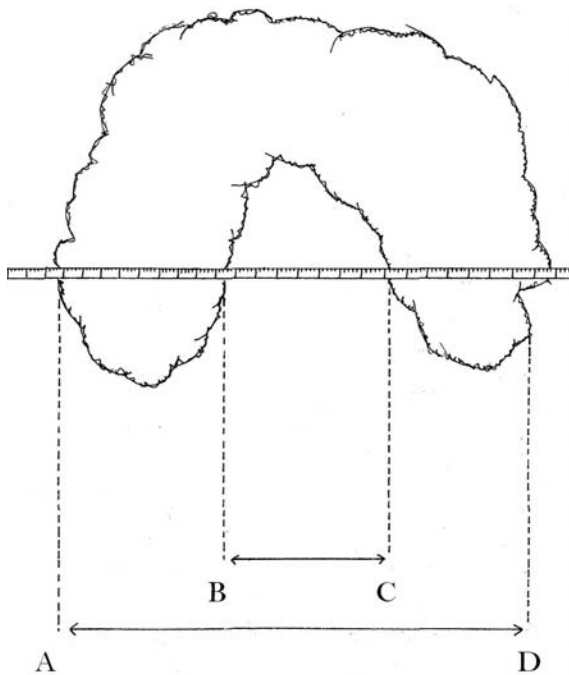
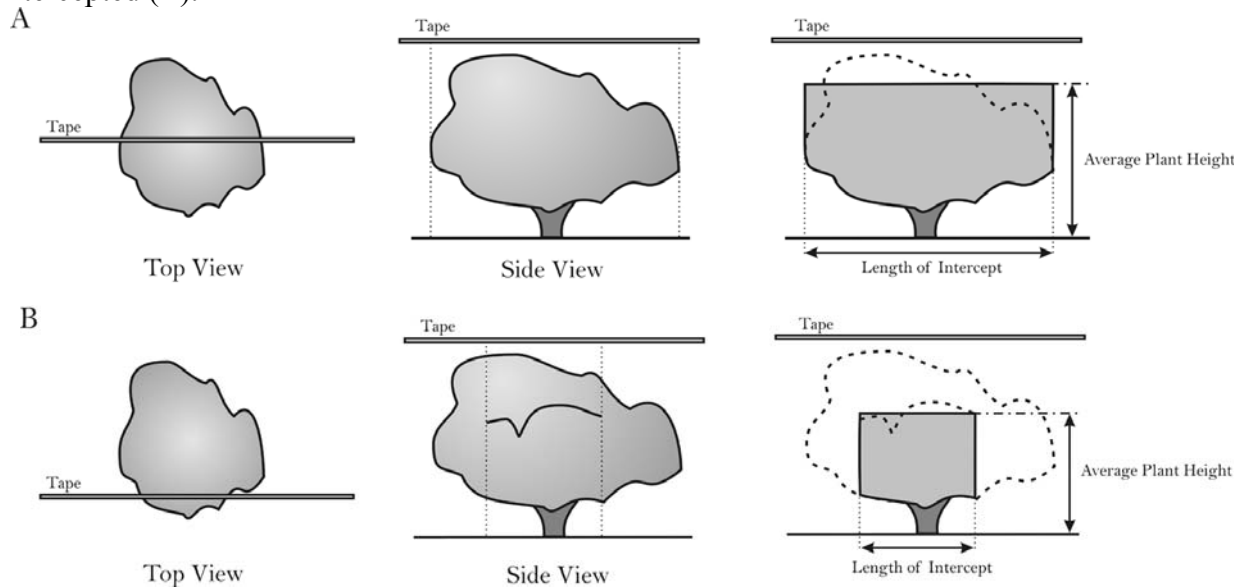


Figure 4 illustrates the method for measuring gaps in the canopy. Gaps (points B to C) greater than 6 inches (5 cm) are not measured. The canopy intercept for this shrub is measured from point A to D if the distance from B to C is less than or equal to 6 inches or measured from points A to B and points C to D if the gap is greater than 6 inches.

**Figure 4.** Method for Measuring Canopy Gaps.  
*Source:* FIREMON 2003.



Estimate the average plant height only for the portion of the plant intercepted by the tape (Figure 5). If the tape crosses the entire plant then average the height for the entire plant (A). If the tape only crosses a portion of the plant, estimate the average height for only the part that is intercepted (B).



**Figure 5.** Method for Estimating Tree Height.

#### Data Analysis

In a study of effectiveness, at least three parameters may be of interest: 1) total length of vegetated bank as a proportion of total bank length, 2) percent cover of one or more species targeted for restoration (or removal), 3) relative cover of one or more species targeted for restoration (or removal). As shown below, the analysis can be done for each of the height classes and then combined to produce total cover measurements. They would be calculated in the same way as shown below for these three parameters.

Total length of vegetated bank as a proportion of total bank length is calculated as follows:

$$\frac{\text{Total length of sampled line with vegetation cover in height class A, B or C}}{\text{Total length of sampled line}} * 100 = \text{Percentage of reach with vegetated banks in height class A, B or C}$$

In cases where canopy overlap by different species occurs, it should be subtracted so that the maximum cover in any one layer cannot exceed 100 percent. As indicated, cover should be calculated separately for each height class. It may be expressed for one or both banks, as desired. Adding together the estimates for each canopy layer will produce a total cover measurement that may be up to 300 percent. Which data will be most important for analysis will depend on the objectives of the restoration (e.g., increase bank cover, increase shade canopy, etc.) and study design.

Percent cover for each species (or for other cover elements) is calculated as follows:

$$\frac{\text{Length of sampled line with species (X)}}{\text{Total length of sampled line}} * 100 = \text{Percent cover of species (X)}$$

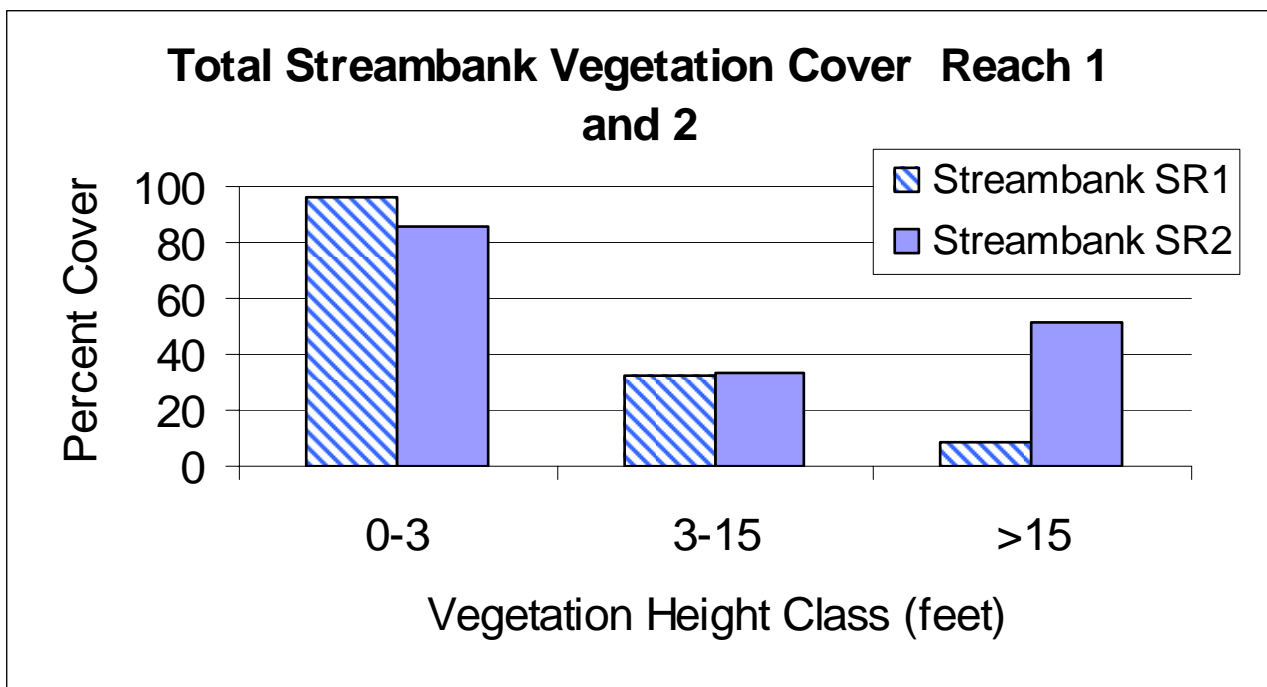
These data should initially be provided for each of three canopy layers. The total maximum cover for all three layers may exceed 100 percent in cases where a species occurs in more than one canopy class.

Relative cover is defined as the cover of one species relative to the cover of all species combined. It is a measure of dominance that can be directly related to restoration project effectiveness. It is calculated as follows:

$$\frac{\text{Length of sampled line with species (X)}}{\text{Total length of sampled line with vegetation cover}} * 100 = \text{Relative cover of species (X)}$$

Again, data may be provided for each of the three canopy layers or for all layers combined.

For each variable of interest the test of statistical significance, to see if treatment resulted in achieving target levels, will be a paired *t*-test.



**Figure 6.** Cover Values for Transects Along Banks on Wilson Creek.

Figure 6 is an example of the results obtained from use of this method. The figure shows the total percent cover of riparian vegetation along banks on stream reaches 1 and 2, Lower Wilson Creek, CA. Vegetation data were collected using a line transect approximately following the bankfull channel elevation. Data are from the right bank on reach 1 and the left bank on reach 2.

## Instructions for Completing the Line Intercept Transects Field Data Collection Form

### General Information- section 1

- 1) **Page \_\_\_ of \_\_\_**—Number the page. For example, if this is page 2 out of 3 total pages, enter: Page 2 of 3.
- 2) **Contract #**—Enter in the contract number assigned to this project by the Department of Fish and Game.
- 3) **Contract Name** – Enter the name of the contract.
- 4) **Stream/Road Name**—Enter in the name of the stream or road. If unnamed, use named stream or road to which it is tributary.
- 5) **Date**—Enter the date: *mm/dd/yy*
- 6) **Crew**—Enter the names of the crew members collecting the data using the following format: *last name, first initial*.
- 7) **Drainage Name**—Enter the name of the main drainage basin that the stream is a tributary to.
- 8) **Transect #-** Enter the number of the transect for which data is being recorded.
- 9) **Transect Length-** Enter the total length of the completed transect.
- 10) **Start Point-** Describe the location at which the survey began, using permanent reference points.
- 11) **Streambank-** Circle the stream bank being surveyed, if applicable.
- 12) **Survey Direction-** Circle the direction of travel taken by surveyors during data collection, if applicable.

### Line Intercept Vegetation Data – section 2

- 13) **<3 Foot Height Class Start Distance** - Enter the distance displayed on the tape at the location where the vegetation begins.
- 14) **<3 Foot Height Class End Distance** - Enter the distance displayed on the tape at the location where the vegetation ends.
- 15) **Species** - Enter the species found at that section of the line. Or, if unvegetated, enter barren soil, wood, rock, restoration structure or other structure according to codes listed on the data sheet.
- 16) **3-15 Foot Height Class Start Distance** - Enter the distance displayed on the tape at the location where the vegetation begins.
- 17) **3-15 Foot Height Class End Distance** - Enter the distance displayed on the tape at the location where the vegetation ends
- 18) **Species-** Enter the species found at that section of the line.
- 19) **>15 Foot Height Class Start Distance** - Enter the distance displayed on the tape at the location where the vegetation begins.
- 20) **>15 Foot Height Class End Distance** - Enter the distance displayed on the tape at the location where the vegetation ends
- 21) **Species** – Enter the species found at that section of the line. If litter, rock, or restoration structures are found on that section, enter the appropriate code. Add codes as needed for objects encountered on the line.
- 22) **Comments** – Record relevant comments, including the location at which any associated monitoring transects or plots are taken.



## Field Method 2: Line Intercept Across Channels

Transects across channels are used to assess changes in vegetation cover within the bankfull channel. They are applied primarily to restoration projects that intend to reduce vegetation cover within the channel, i.e., encroachment. However, they may be used to study increases in bank or canopy cover overhanging the channel. They begin and end at the bankfull limits of the main channel.



### *Determination of Sample Size*

The recommended procedure is to place multiple transects perpendicular to the stream spanning the bankfull channel within the reach to be treated. As in Field Method 1, the summed transect length represents the sample. This will provide an estimate of weighted average cover that is not affected by stream size.

The number of cross channel transects to be used to obtain an adequate sample will depend on the length and variability of treated and control reaches. Generally, evaluation of effectiveness in reducing or increasing cover within the bankfull channel should only be done on a reach scale. Quantitative evaluation of individual treatment sites such as specific fluvial deposits is not recommended. For reach-scale evaluations, the rule-of-thumb of Kaufmann et al. (1999) should be followed. They recommend installing cross sections approximately four channel widths apart with a minimum of 11 per treated or control reach. This procedure may be varied, i.e., more or less transects may be used, depending on the variability in the reach.

### *Field Method*

- Establish the first transect in a random location. The location of each transect should be recorded in relation to a defined reference point.
- Conduct line intercept sampling, as previously described.

### *Data Analysis*

It is assumed that generally, this method will be used to assess effectiveness of instream vegetation control projects. Consequently, the parameter of greatest interest will be vegetation cover as a proportion of total transect length. This will be equivalent to percent vegetation cover within the bankfull channel. This can be calculated in the same way as previously shown for Field Method 1.

The statistical comparison approach will be the same as in Field Method 1. Within each treatment area, the transects will constitute a single measurement such that the difference



between before treatment and control will be paired with the difference between after treatment and control.

### **Instructions for Completing the Line Intercept Data Form**

The Line Intercept Data Form should be completed in the same manner as described for Field Method 1 (*see page 12*).

### **Field Method 3: Line Intercept Transects Across Floodplains**

Line intercept transects across floodplains are intended for monitoring changes in vegetation within a zone extending 50 feet out from the channel on either or both sides of a stream proposed for treatment. Most benefits of riparian restoration (enhanced bank stability, increased stream shading, improved instream shelter and recruitment of large woody debris) are expected to occur within this 50-foot zone. In special cases, transects may be longer, for example, to measure changes in the absolute width of the riparian zone, or to measure changes across broad floodplains with multiple channels. In cases where the riparian zone is generally less than 50 feet wide, this method should not be used. Instead, field method 1 should suffice.



#### *Determination of Sample Size*

Multiple transects will be used following the guideline of Kaufmann et al. (1999), as described for Field Method 2. Transects will be 50 feet long and may be located on either or both sides of the stream, depending on specific conditions. They will begin at the bankfull point and proceed away from the stream. Transects will be equidistantly spaced. The total length of all transects will be combined to provide estimates of vegetation cover.

For situations in which measurements of the lateral extent of the riparian community are desired, transects may extend beyond the 50-foot zone. The width of the riparian zone can then be estimated as the average transect length for either or both sides of the stream. In cases where total width is to be estimated, transects on both sides of the stream should be paired at the same locations so that total width can be calculated as the sum of the pair. The bankfull channel width is not included in the total riparian zone width. Average width can then be calculated from the paired transects.

#### *Field Method*

- Establish the location of the starting transect in a random location. The location of each transect should be recorded in relation to a defined reference point, as previously described.
- Position each 50-foot transect with a tape from the bankfull edge out into the floodplain perpendicular to the channel. Run the tape over or under vegetation (Figure 7).

- Collect line intercept data starting at bankfull edge (beginning of the tape). Identify and record the linear extent of vegetation by species or genus for each of three height classes along the transect.
- As required, relocate the tape to the opposite bank and repeat the data collection process.

Figure 7 illustrates the method for locating the transect tape across the floodplain. The measuring tape is laid down to complete a line intercept transect measurement across the floodplain.



**Figure 7.** Measuring Line Intercept Across the Floodplain.  
Source: FIREMON 2003.

**LINE INTERCEPT TRANSECTS FIELD DATA COLLECTION FORM**

**Contract #:** 0197642 **Date (mm/dd/yy):** 08/12/03 **Implementation (mm/yy):** 05/01

**Stream:** Parson's Creek **Drainage:** Russian River

**Crew:** Gerson, J.; Kocher, S. **Transect #:** 2 **Transect length:** 50 feet

**Start Time:** 1:50 PM **Start Point:** Bridge at vineyard entrance

**Streambank:** *(Left or Right)* **Direction:** *(Upstream or Downstream)* **Page 2 of 6**

0-3 ft height class			3-15 ft. height class			>15 ft. height class			Comments (Record location of other transects/plots)
Start	End	Species	Start	End	Species	Start	End	Species	
Dist	Dist		Dist	Dist		Dist	Dist		
0	3	REST	4	14	SALX	13	34	QUAG	Began transect at 44 on transect of
4	11	LITT				28	50	PSME	of line intercept along banks
14	50	GRSS							

**Species** LITT = Litter REST = Restoration Structure GRSS = Grass SALX = Willow PSME = Pseudotsuga menzeseii

**Figure 8.** Sample Data Collected During a Line Intercept Across the Floodplain.

*Data Analysis*

Analogous to bank vegetation restoration, the parameters of interest in a study of the effectiveness of floodplain riparian restoration are: 1) total vegetation cover as a proportion of total sampled floodplain; 2) percent cover of one or more species targeted for restoration (or removal); 3) relative cover of one or more species targeted for restoration (or removal). Other cover measurements may also be of interest. For example, there may be an interest in the relative

cover of shrub versus tree vegetation, relative cover of deciduous versus coniferous trees, etc. These would be calculated in the same way as for any cover estimates.

Total vegetation cover as a proportion of total (sampled) floodplain is calculated as follows:

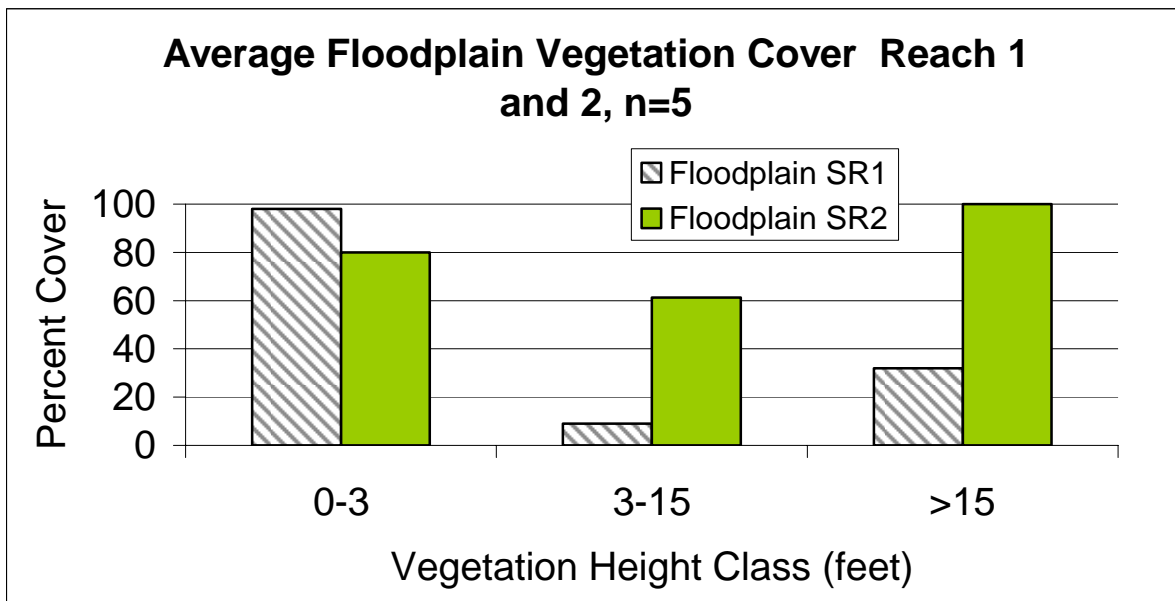
$$\text{Total length of sampled line with vegetation cover in height class A, B or C} / \text{Total length of sampled line} * 100 = \text{Percent vegetation cover on the floodplain in height class A, B or C}$$

Evaluation by canopy layer may be of interest in cases where restoration is aimed at changing an herbaceous or shrub community to a tree community. These data may also be aggregated to provide measures of total vegetation cover. Overlap of different species within a single canopy class should be subtracted so that total cover per layer does not exceed 100 percent.

Percent cover for each species (or for other cover elements) and relative cover values would be calculated as shown previously for Field Method 1.

The statistical comparison approach will be the same as in Field Method 1. Within each treatment area the transects will be combined as a single measurement such that the difference between before treatment and control will be paired with the difference between after treatment and control.

Figure 9 shows the values for the average of absolute cover values for transects extending across the floodplain adjacent to Reach 1 and 2 on Lower Wilson Creek, CA. Five transects were measured in each stream reach. Values represent combined percent cover of all species in each height class.



**Figure 9.** Cover Values for Floodplain Transects on Wilson Creek.

### Instructions for Completing the Line Intercept Data Form

The Line Intercept Data Form should be completed in the same manner as described for Field Method 1 (*see page 12*).

#### **Field Method 4: Line Intercept Transects Through Delineated Treatment Areas**

Line intercept can be used to measure changes in cover by species by height class within designated treatment areas that are relatively large and contiguous. An example of such a treatment area would be a grazing enclosure on a higher floodplain or terrace surface. Another example would be a planting project on a terrace. A third example would be a large instream deposit such as a gravel bar. The same data are obtained as for any line intercept sampling.



##### *Determination of Sample Size*

Normally, multiple transects will be used. If it is more efficient and convenient to use one continuous transect (e.g., in a narrow, elongated treatment area), Field Method 1 may be adapted for use. For multiple transects, the number to sample should be estimated based on vegetation variability. A minimum of four transects is recommended. All transects will extend entirely across delineated treatment areas. Transects will normally be equidistantly spaced. The total lengths of all transects will be combined to provide estimates of vegetation cover. The sample size is the number of treatment areas and their controls. A paired single-sided *t*-test will be used for statistical comparison.

##### *Field Method*

- It is assumed that the treatment and control areas will have been delineated according to the method described in this report. Depending on its size, the sampling layout may be one continuous transect through the treatment area or a series of parallel transects.
- Establish the location of the starting transect (or the beginning of the one continuous transect) at one boundary of the treatment area in a random location. The location of each transect should be recorded in relation to a defined reference point, as previously described.
- Conduct line intercept sampling as previously described.

##### *Data Analysis*

Delineated treatment areas are analogous to floodplain areas and the measures and calculation procedures are the same.

The statistical comparison approach will be the same as in Field Method 1. Within each treatment area the transects will be combined as a single measurement such that the difference between before treatment and control will be paired with the difference between after treatment and control.



## Instructions for Completing the Line Intercept Data Form

The Line Intercept Data Form should be completed in the same manner as described for Field Method 1 (*see page 12*).

### Field Method 5: Planted Tree Survival Assessment

Survey techniques for evaluating the survival of planted trees are well established (Stein 1992). The method recommended here is appropriate for evaluating treatment areas with a relatively uniform distribution of single stem seedlings. This method is not appropriate for projects where seedlings are planted in single lines, randomly or in clumps. For those projects, it would be necessary to flag or otherwise identify planted seedlings in order to track survival. This method is also appropriate for evaluating survival of herbaceous plantings, willow baffles, willow mattresses, or similar projects.



Control sites are not required for assessments of planting survival unless there is a desire to evaluate the effects of natural recruitment or of extreme events (floods or droughts) on plantations. If it desirable to separate planted from naturally recruited individuals of the same species, planted stock must be flagged or otherwise identified.

For evaluating survival of shrub and/or herbaceous plantings, other methods are required. Line intercept, as previously described, is recommended to evaluate survival of vegetative clumps or shrubs within delineated treatment areas, within 50 feet of the channel or along banks. For plantings involving grasses or other small, individual plants, point intercept methods may be more appropriate. Texts on rangeland sampling should be consulted in the event that these kinds of projects must be assessed for survival.

#### *Determination of Sample Size*

Determine the extent and location of the project area(s) using polygon traverses, as outlined above or other information. Using GIS, planimeter, or dot grid determine the area(s) of the polygon(s) to be planted in acres.

Once the area has been determined for each polygon, the required number of 1/100-acre sample plots is determined as follows. If the polygon is less than 30 acres, two percent of the area should be sampled. If the area of the polygon is greater than 30 acres, one percent of the area should be sampled. In any event, a minimum of 5 sample plots should be surveyed. If the polygon is less than 0.25 acre, all seedlings should be counted.

#### *Field Method*

- Determine locations of sample plots within the project area polygon(s). The plots need to be equally distributed. First, divide the number of acres in the project area by the number of



plots that will be surveyed. This will give the portion of an acre that each plot represents. Multiply this number times the square feet in one acre: 43,560. Then calculate the square root of the result to provide a value in lineal feet. This will be the distance between lines and between plots on the line.

- After the distance between plots and lines has been determined, these lines and plot locations are drawn onto the appropriately scaled map. All lines must be parallel to each other and the first line should be inset from the polygon boundary by one half the calculated distance between plots and lines ( $147.5/2 = 73.8$  feet). After drawing the grid on the map, determine the distance and bearing to the first plot from a recognizable reference point (e.g., bridge, tributary junction, large snag, etc.)
- Locate the reference point on a map or air-photo. Navigate to the first plot location using the bearing and distance calculated from the map or air-photo. After recording data for the first plot, navigate to all successive plots with a compass set to the bearing of the lines drawn on the map or air-photo. All distances between plots must be slope corrected.
- After locating the plot center, measure out a distance of 11.4 feet due north. Search the plot in a clockwise direction for seedlings until arriving back at the due north starting point of your search. For every seedling within 11.4 feet of plot center record *species* and *vigor class* (live, dead, or dying). Record any observations regarding obvious causes of death (browsing, desiccation, competition, etc.) or other relevant observations in the comments section for the plot, not for each seedling.

**PLANTED TREE SURVIVAL ASSESSMENT DATA COLLECTION FORM**

**Contract #:** 0197642 **Date (mm/dd/yy):** 08/12/03 **Implementation (mm/yy):** 05/01

**Stream:** Parson's Creek **Drainage:** Russian River

**Crew:** Gerson, J.; Kocher, S. **Polygon #:** 2 **Location:** NE of unit

**Start Time:** 11:00 AM **Start Point:** Large boulder by structure #2

**Streambank:** (Left or Right) **Direction:** (Upstream or Downstream) **Page 1 of 4**

Plot #	Species	Vigor	Tally	Comments	
1	PSME	Live	15	From boulder, pace 75 feet at 95 degrees	
	PSME	Poor health	8		
	PSME	Dead	5		
	ALRU	Live	10		
	ALRU	Dead	2		
2	PSME	Live	10	From plot 1, pace 75 feet at 95 degrees	
	PSME	Poor health	10		
	PSME	Dead	15		Poor survival appears to be due to dessication
	ALRU	Live	5		
	ALRU	Dead	18		

**Species Codes** Vigor Class = Live, Dead, Poor health

PSME = Doug-fir		
ALRU = alder		

**Figure 10.** Example of Collected Tree Survival Data.

*Data Analysis*

These data may be used to calculate: average number of trees per acre by species across all plots, percent of live versus dead seedlings observed and percent of plots with at least one live seedling. A confidence interval of survival rate at each site can be computed (if the treated area is less than 0.25 acres then the survival rate is known).

## Instructions for Completing the Planted Tree Survival Assessment Data Form

### General Information- section 1

- 1) **Page \_\_\_ of \_\_\_**—Number the page. For example, if this is page 2 out of 3 total pages, enter: Page 2 of 3.
- 2) **Contract #**—Enter in the contract number assigned to this project by the Department of Fish and Game.
- 3) **Contract Name** – Enter the name of the contract.
- 4) **Stream Name**—Enter in the name of the stream or road. If unnamed, use named stream or road to which it is tributary.
- 5) **Date**—Enter the date: *mm/dd/yy*
- 6) **Crew**—Enter the names of the crew members collecting the data using the following format: *last name, first initial*.
- 7) **Drainage Name**—Enter the name of the main drainage basin that the stream is a tributary to.
- 8) **Polygon #/Location**- Enter the number of the treatment polygon and locational information.
- 9) **Start Point**- Describe the location at which the survey began, using permanent reference points.
- 10) **Streambank**- Circle the stream bank being surveyed, if applicable.
- 11) **Survey Direction**- Circle the direction of travel taken by surveyors during data collection, if applicable.

### Seedling Survey Data – section 2

- 13) **Plot #**- Enter the number of the plot where the data is collected.
- 14) **Species**- Enter the species of the seedlings found on the plot.
- 15) **Vigor**- Enter all possible vigor classes for seedlings of each species, live, poor health and dead.
- 16) **Tally**- For each species and vigor class, enter the number of seedlings found on that plot as a dot tally.
- 17) **Comments**- Enter any pertinent comments on the seedlings found in that plot.



## Field Method 6: Floodplain Forest Composition Plots

In some cases, restoration activities will be aimed at changing the composition of existing vegetation types to other types that have superior value to anadromous fish. The method presented below is intended primarily for evaluating practices aimed at increasing the relative abundance of conifers in hardwood- or shrub-dominated stands. These may include thinning and/or planting projects.

The measure used for evaluating compositional changes is relative frequency. This can be applied to either planting or thinning projects. It is suitable for evaluating effectiveness within a 10-year time frame after treatment. For long-term studies of changes in composition, especially shifts in dominance, data on tree size may be collected. Standard texts on forest mensuration should be consulted for planning such studies (Husch et al. 2003).



Line intercept methods previously described can be used to assess structural changes (from herbaceous to shrub, from shrub to tree) because data are collected for three different canopy layers. These data may also be analyzed at the species level to determine changes in composition (e.g., changes in relative cover by species).

### *Determination of Sample Size*

- Determine the extent and location of the project area(s) using polygon traverses, as outlined above or other sources of information, e.g., maps of treatment areas in proposals. Using GIS, planimeter, or dot grid determine the area(s) of the polygon(s) to be planted in acres.
- Once the area has been determined for each polygon, the required number of 1/10-acre sample plots to survey in each polygon is calculated. A sample of two percent of the project area should be sufficient if stands are relatively uniform, more samples may be required for heterogeneous stands. A minimum of 5 sample plots should be surveyed.

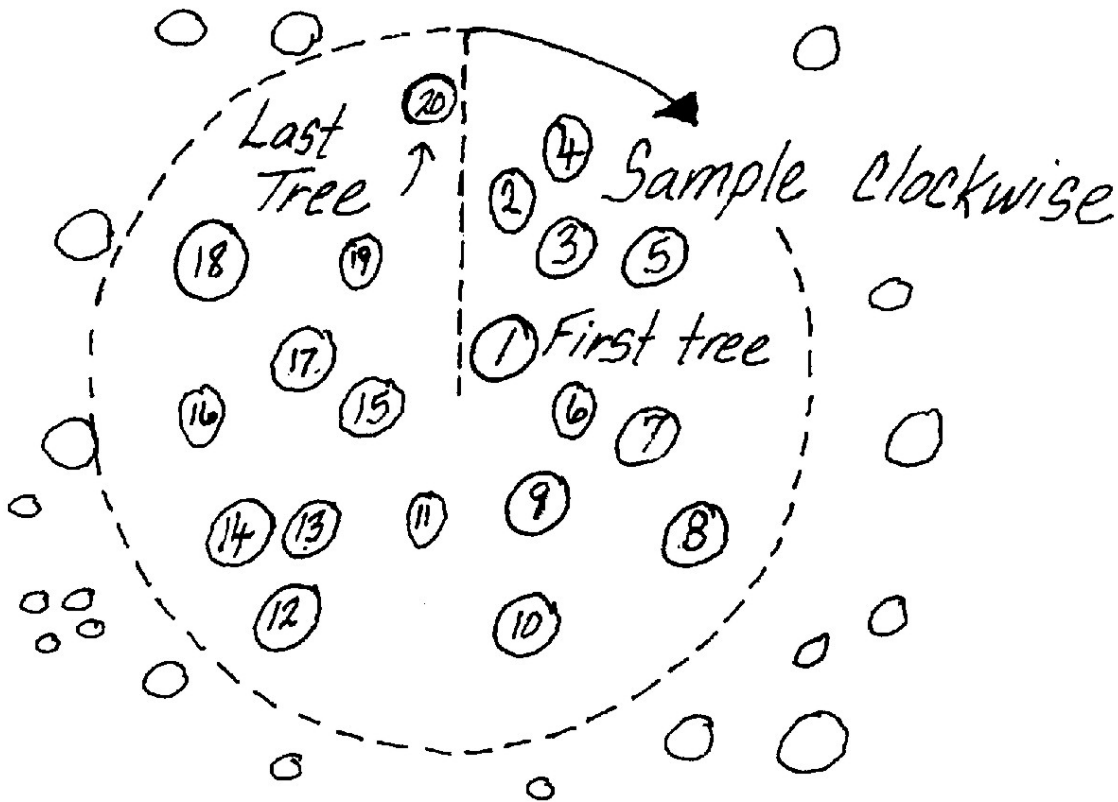
### *Field Method*

- Determine locations of sample plots within the project area polygon(s). The plots need to be equally distributed throughout the project area. Assuming that a long, narrow riparian

corridor is treated, only one 1/10<sup>th</sup> acre plot may fit within the width of the corridor (1/10<sup>th</sup> acre plots are 75 feet in diameter and most projects will probably occur within 100-150 feet of the channel). Thus, plots will be placed down the centerline of the riparian corridor at equal distances throughout the treated area. If there is a desire to evaluate compositional changes within some set distance from the channel (e.g., 0-75 feet from the bankful channel) then plot positions should be adjusted accordingly.

- Following the calculated spacing guidelines, proceed through the project area and locate the first plot, measure it and proceed to the next plot. The first plot should be located 100 feet in from the end of the treated area.
- Measure out a distance of 37.2 feet due north from the plot center (plot radii must be slope corrected using a correction table). Tally all trees by species on the plot greater than 4.5 feet tall, proceed in a clockwise direction until arriving back at the due north starting point (Figure 11). A dot tally may be used for data collection (Figure 12). (Note: this method may be modified if the number of trees to be counted is excessive. For example, only trees over a specified diameter may be counted.) Additional data e.g., tree heights, vigor etc. may be collected if desired.

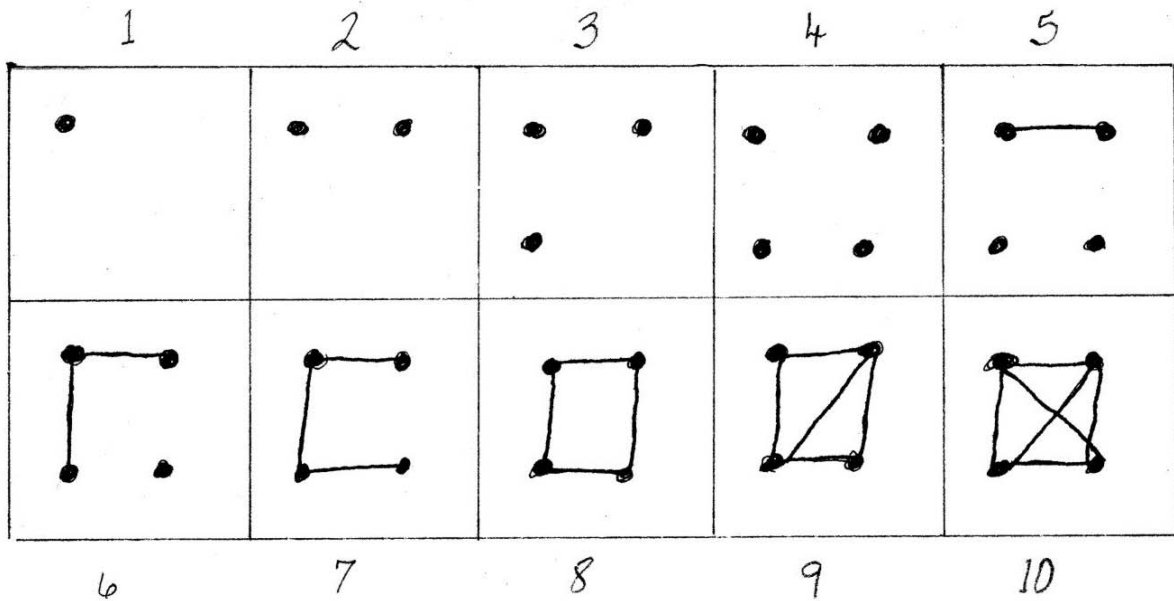
Figure 11 illustrates the measurement direction for circular plots. Tally all trees on the plot greater than 4.5 feet tall. Number trees as you proceed in a clockwise direction from plot center until arriving back at the due north starting point.



**Figure 11.** Measurement Direction for Circular Plots.  
*Source:* FIREMON 2003.



Figure 12 illustrates use of the dot tally when trees. Use the dot tally method to make counts quickly with little chance of error.



**Figure 12.** Use of the Dot Tally.  
*Source:* FIREMON 2003.

*Data Analysis*

In the context of restoration effectiveness, the most important data provided will be relative frequency of trees by species. This is calculated as follows:

$$\frac{\text{Total count of species (X)}}{\text{Total count of all trees}} * 100 = \text{Percent frequency of species (X)}$$

In long-term studies of forest composition and dominance, e.g., in studies evaluating shifts from deciduous hardwood to conifer-dominated riparian zones, other metrics should be used such as importance value.

## **Instructions for Completing the Floodplain Forest Composition Data Form**

### **General Information- section 1**

- 12) Page \_\_\_ of \_\_\_**—Number the page. For example, if this is page 2 out of 3 total pages, enter: Page 2 of 3.
- 13) Contract #**—Enter in the contract number assigned to this project by the Department of Fish and Game.
- 14) Contract Name** – Enter the name of the contract.
- 15) Stream Name**—Enter in the name of the stream or road. If unnamed, use named stream or road to which it is tributary.
- 16) Date**—Enter the date: *mm/dd/yy*
- 17) Crew**—Enter the names of the crew members collecting the data using the following format: *last name, first initial*.
- 18) Drainage Name**—Enter the name of the main drainage basin that the stream is a tributary to.
- 19) Start Point**- Describe the point at which the forest plot transect is started. This should be described in reference to permanent reference points if any.
- 20) Streambank**- Circle the stream bank being surveyed, if applicable.
- 21) Survey Direction**- Circle the direction of travel taken by surveyors during data collection, if applicable.

### **1/10<sup>th</sup> Acre Plot Data – Section 2**

- 22) Plot #** - Enter the number of the plot where the data is collected.
- 23) Location**- Enter identifying information on the specific plot location, typically distance and bearing from previous plot or fixed reference point.
- 24) Species** - Enter the species of each tree found in the plot
- 25) Tally**- Count the number of individual stems of each species found in the plot and tally the total in the box provided.

**FLOODPLAIN FOREST COMPOSITION FORM**

Page \_\_\_ of \_\_\_

Contract #: \_\_\_\_\_ Contract name: \_\_\_\_\_

Stream: \_\_\_\_\_ Date: \_\_\_\_\_ Evaluation crew: \_\_\_\_\_

Drainage: \_\_\_\_\_ Start Point: \_\_\_\_\_

**Streambank:** (*Left or Right*) **Direction:** (*Upstream or Downstream*)

1/10th acre plot #: \_\_\_\_\_ Location: \_\_\_\_\_

Species	Tally

1/10th acre plot #: \_\_\_\_\_ Location: \_\_\_\_\_

Species	Tally

1/10th acre plot #: \_\_\_\_\_ Location: \_\_\_\_\_

Species	Tally

Species Codes


## Field Method 7: Intercepted Sunlight Due to Riparian Canopy

The percentage of sunlight intercepted by riparian canopy along a stream has an effect on stream water temperature. Water temperature is a limiting factor in salmonid habitat quality during periods of high air temperature and low stream flow, generally, late summer. The solar pathfinder, in its usual configuration, allows one to determine the percentage of solar radiation (or energy) available or shaded, and is weighted heavily for vegetation that blocks solar radiation during midday hours.

A major goal of many riparian restoration projects is to increase stream shading so that summertime water temperatures may be reduced, thereby improving rearing habitat. Since the amount of sunlight intercepted is a function of riparian canopy cover and tree height, it may take several years for measurable changes in it to occur. Summers (1982) determined that 8 to 20 years were required for clearcut and burned riparian zones to recover to 75 percent cover on Oregon streams. The rate of recovery was faster on coastal streams than on streams in the Cascades. Larger streams requiring taller conifers to provide shade will require a longer time to exhibit effects.

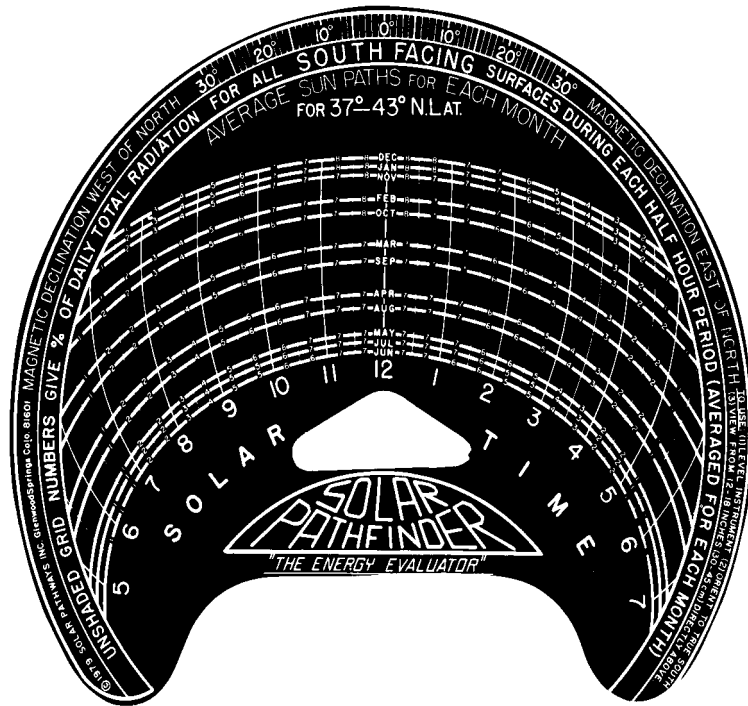


Figure 13. Dial Face on Solar Pathfinder.

### *Determination of Sample Size*

The minimum spacing between measurement points should be 66 feet and the maximum 132 feet, with 100 feet as a commonly used distance (Peter Cafferata, personal communication). There is no rule for the minimum number of sample points but an estimate of variance can be obtained through preliminary sampling and the sample size can then be calculated, given a specified level of confidence and quantified effectiveness criteria. Spatial autocorrelation should be avoided i.e., measurement points should not be spaced too closely. They should be spaced at distances determined by dividing the total reach length by the number of samples.

### *Field Method*

Locate the first data point at the upstream end of the reach by choosing a random number between 1-10 and commencing that many feet from the terminus of the study reach. The solar pathfinder is used as follows. This field method was provided by Peter Cafferata, California Department of Forestry and Fire Protection (Cafferata 2000).

- A latitude-appropriate insert is placed below the reflecting dome (usually use the one labeled 37° to 43° N Latitude).
- The device is set up on a mini-tripod in the center of the stream if possible (or edge if not) at the stream, oriented to the south, and leveled. A built-in declination adjustment must be set to allow orientation to true south.
- All the vegetation and topography shading the instrument are reflected instantly and clearly on the instrument's transparent plastic dome. Pick a month to record shading (usually July or August).
- Try to make the readings early in the day or late in the afternoon. If the sun is shining and is reflected in the dome, the operator may stand in any position around the dome using his or her shadow to cover the dome so as not to stare at the sun's reflected image on the dome surface—**this can be harmful to the eyes and should be avoided!** If the observer's shadow falls across the area to be measured, this area can be profiled by changing the observer's position and, if needed, shading the sun spot area with a hand.
- Viewing the dome from 12 to 18 inches above the dome and within 10 to 15 degrees of vertical centerline provides acceptable accuracy.
- The boundary between the unobstructed sky and all intercepting objects that appear on the horizon is either: 1) traced in white grease pencil on the diagram chart (for a permanent record), or 2) simply observed without making a recording.
- The average percentage of monthly total solar radiation that will fall on the selected area is taken directly from the diagram (the small white numbers on the monthly curves).
- The solar radiation received at the site is estimated by adding the unshaded half-hour numbers across the arc of the selected month, or by subtracting shaded numbers from 100 percent. Half-hour values can be split into any value that is appropriate based on the shading observed.
- Repeat sampling at specified intervals until the end of the study reach.

### *Data Analysis*

The data collected will be percent of sunlight subject to interception by canopy or topography during the chosen month. Normally, the month chosen for analysis will be the one when streamflow and air temperatures combine to create the most stressful water temperatures for fish (usually late summer—often August). These should be summed and averaged for study reaches and appropriate statistics calculated.



These data may be used in conjunction with temperature modeling or monitoring data to determine restoration practice effectiveness (Cafferata 1990).

The statistical comparison approach will be based upon a BACI design. Within each treatment area the averaged measurements will constitute a sample such that the difference between before treatment and control will be paired with the difference between after treatment and control.



## Instructions for Completing the Effective Shade Data Form

### General Information- section 1

- 26) **Page \_\_\_ of \_\_\_**—Number the page. For example, if this is page 2 out of 3 total pages, enter: Page 2 of 3.
- 27) **Contract #**—Enter in the contract number assigned to this project by the Department of Fish and Game.
- 28) **Contract Name** – Enter the name of the contract.
- 29) **Stream Name**—Enter in the name of the stream or road. If unnamed, use named stream or road to which it is tributary.
- 30) **Date**—Enter the date: *mm/dd/yy*
- 31) **Crew**—Enter the names of the crew members collecting the data using the following format: *last name, first initial*.
- 32) **Drainage Name**—Enter the name of the main drainage basin that the stream is a tributary to.
- 33) **Start Point**- Describe the location at which the survey began, using permanent reference points.

### Temperature Data- section 2

- 34) **Water Temperature**- Record the temperature of the water within a foot of stream surface on transects # 1, 10, 20 and 30 only. Take the temperature reading at the stream thalweg along the solar pathfinder transect. If this point occurs within a stagnant area of stream, take the temperature reading within a section of the stream where water is flowing and mixing instead.
- 35) **Air Temperature**- Record the temperature of the air within a foot of stream surface on transects # 1, 10, 20 and 30 only. Take the temperature reading at the stream thalweg along the solar pathfinder transect. If this point occurs within a stagnant area of stream, take the temperature reading within a section of the stream where water is flowing and mixing instead.

### Effective Shade Data – section 3

- 36) **Stream Distance** – Enter the distance of the data point from the monitoring starting point (#8 above).
- 12) **Solar Availability/July** – Enter the amount of solar radiation received despite vegetation and topography in the month of July. Add the unshaded half-hour numbers across the July arc or subtract the shaded numbers from 100 percent to yield the solar radiation received at the site.
- 13) **Solar Availability/August** – Enter the amount of solar radiation received despite vegetation and topography in the month of August. Add the unshaded half-hour numbers across the August arc or subtract the shaded numbers from 100 percent to yield the solar radiation received at the site.
- 14) **Percent Deciduous**– Estimate the percent of vegetation blocking radiation to the solar pathfinder which is deciduous (e.g., if the vegetation is all willow and alder, enter 100%).
- 15) **Percent Evergreen**- Estimate the percent of vegetation blocking radiation to the solar pathfinder which is evergreen (e.g., if the vegetation is all conifers, enter 100%).
- 16) **Comments**- Enter any information pertinent to understanding the data collected at this transect.

## EFFECTIVE SHADE FORM

Page \_\_\_ of \_\_\_

Contract #: \_\_\_\_\_ Contract name: \_\_\_\_\_

Stream: \_\_\_\_\_ Date: \_\_\_\_\_ Evaluation crew: \_\_\_\_\_

Drainage: \_\_\_\_\_ Start Point: \_\_\_\_\_

Water Temperature, Point: 1 \_\_\_\_\_ 10 \_\_\_\_\_ 20 \_\_\_\_\_ 30 \_\_\_\_\_

Air Temperature, Point: 1 \_\_\_\_\_ 10 \_\_\_\_\_ 20 \_\_\_\_\_ 30 \_\_\_\_\_

Point #	Stream Distance	Solar Availability		Percent		Comments
		July	August	Deciduous	Evergreen	
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
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## HISTORY OF REPORT DEVELOPMENT AND REVISION

This report was initially developed in November 2002 after some preliminary field testing. It was published in an interim manual of monitoring methods in early 2003 (Collins, B.W. (editor). 2003. *Interim restoration effectiveness and validation monitoring protocols*. California Coastal Salmonid Restoration Monitoring and Evaluation Program, March 2003, p. 320. California Department of Fish and Game, Fortuna, CA.). Further field-testing of this report was conducted in the summer and fall of 2003. The draft report was subsequently revised in June 2004 and subjected to peer review. The final report reflects changes made in response to peer reviewers.

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Websites:

[http://www.fire.org/firemon/LIv3\\_Methods.pdf](http://www.fire.org/firemon/LIv3_Methods.pdf)

<http://ifasstat.ufl.edu/nrs/LIC.htm>

### On Use of Solar Pathfinder

California Department of Fish and Game (DFG). 1997. *Instream Monitoring Handbook: A Guide For Project Development, Implementation, And Assessment*. Final Report submitted to the Calif. Dept. of Forestry and Fire Protection under Interagency Agreement No. 8CA95070. Sacramento, CA. 153 p.

McGurk, B. J. 1989. *Predicting Stream Temperature After Riparian Vegetation Removal*. USDA Forest Service, General Technical Report PSW-110. Pages 157-164.

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### How the Pathfinder Works

<http://www.solarpathfinder.com/spf/works.html>

### On Stream Temperature Monitoring:

[http://www.nwifc.wa.gov/TFW/onlinedocs/manuals/TFW\\_Stream\\_Temperature\\_Survey.pdf](http://www.nwifc.wa.gov/TFW/onlinedocs/manuals/TFW_Stream_Temperature_Survey.pdf).