Quantitative Effectiveness Monitoring of Bank Stabilization and Riparian Vegetation Restoration: A Field Evaluation of Protocols

Prepared for:

California Department of Fish and Game
Grant Agreement No. P0310538

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March 2007

EXECUTIVE SUMMARY

Over the past two decades, State and Federal grant programs have funded numerous projects to improve stream habitat, reduce delivery of sediment and other water quality contaminants, and provide stewardship education to public and private land managers in an effort to conserve and enhance habitat functions and maintain or recover species that are dependent upon those functions.

The California Department of Fish and Game (CDFG) administers a substantial number of stream and watershed restoration project funds within the state. Realizing the need for a systematic and consistent means of assessing project effectiveness, they contracted Richard Harris, Forest Ecology Specialist at the University of California Berkeley, and team members to develop standard qualitative and quantitative protocols for implementation and effectiveness monitoring of stream restoration projects. Harris and team presented those protocols to CDFG in 2005 (Kocher and Harris 2005, Harris et al. 2005, respectively).

During the 2005 summer field season, we, the University of California Cooperative Extension (UCCE), field tested the Harris et al. qualitative implementation and effectiveness monitoring protocols (Nossaman et al. 2006). During the 2006 summer field season, we field tested the quantitative effectiveness monitoring protocols outlined in *Monitoring the Effectiveness of Bank Stabilization Restoration* (Gerstein and Harris 2005) and five of the seven protocols outlined in *Monitoring the Effectiveness of Riparian Vegetation Restoration* (Harris et al. 2005) for usability and efficacy. The purpose of this monitoring effort was two-fold: 1) to collect data for verification of projects funded through CDFG's Fisheries Restoration Grant Program (FRGP), and 2) to field-test the protocols and provide recommended modifications and suggestions for their continued use. Field work was structured as follows:

- Quantitative monitoring protocols were applied at a total of 30 recent and current restoration treatment sites in Marin, Sonoma and Mendocino Counties.
- Specific protocols employed at each site were selected based on project objectives.
- Bank Stabilization Restoration Field Method 1, Line Intercept Transects Along Banks and Method 2, Cross Section Surveys, were applied at all bank stabilization treatment sites.
- Riparian Vegetation Restoration Field Method 1was applied at all riparian planting sites where treatments were intended to change conditions at bankfull.
- At least one of Field Methods 2-4 (various Line Intercept Transects surveys) was applied at all riparian plantings sites, usually in addition to Method 1. Methods were selected based on site layout and project objectives.
- Field Method 7, Intercepted Sunlight Due to Riparian Canopy, was employed at each site where plantings were intended to impact canopy cover over the channel.
- A census was conducted at all post-treatment planting sites to document survivorship in lieu of Method 5, Planted Tree Survival Assessment, which was attempted unsuccessfully at one site.

The comments and recommendations that arose as a result of this monitoring effort are outlined in this report and are intended to increase efficiency and reduce potential inconsistencies and ambiguities in the survey process. Some of the key points are as follows:

- We found all protocols to be useful in their current forms, though several questions arose during their application, ranging from broad, programmatic issues to specific field application procedures.
- We recommend that quantitative and qualitative monitoring efforts be coordinated in order to offer a holistic overview of restoration project outcomes, eliminate duplicative work, insure that overlapping details are addressed in a consistent manner and, most importantly, to allow for a study of how quantitative monitoring data corresponds with qualitative ratings.
- Project feature identification procedures must be standardized for all monitoring programs.
- We recommend that the timing of effectiveness monitoring visits for both qualitative and quantitative efforts be standardized based on project type, depending on the expected amount of time required for the treatment to experience stressing events and meet project objectives.
- We suggest that three of the riparian vegetation restoration Line Intercept Transect survey methods (Methods 2, 3, and 4) be merged in order to simplify protocol application.
- We recommend that all protocols be included in the manual in their *revised* forms, with the possible exceptions of Riparian Vegetation Restoration Field Method 5, Planted Tree Survival Assessment, and Method 7, Intercepted Sunlight Due to Riparian Canopy.
- We recommend prioritizing the development of a more suitable protocol for assessing planted tree survival at common riparian vegetation restoration project sites on coastal streams.

The reader will notice some redundancy between the body of the report and the appendices. This is deliberate and is intended to generate the tools needed to facilitate revisions to the protocols. Appendix A, a summarized list of all recommendations, is a check list to insure that each recommendation is addressed. These points compliment the editorial revisions made directly to the text of the Harris et al. documents found in Appendix B (Gerstein and Harris 2005) and Appendix C (Harris et al. 2005). Changes and inserted comments are highlighted in these appendices to insure that the recommended revisions are made in the correct locations within the respective documents. A list of required field equipment, which we recommend for inclusion in the instructions for all methods, can be found in Appendix D. We also recommend certain basic additions to the general survey forms used in both qualitative and quantitative monitoring, including the On-site Navigation, Photo Description and Site Access and Location Data Forms. See Appendix E for information on those additions and revisions to all data forms used in our monitoring effort.

We organized our data electronically and calculated summary statistics. Data output includes graphs of vegetation cover by monitoring protocol applied and project age, bank stability by project age, quantitative and qualitative results of bank stabilization treatments, and a comparison of different methods of canopy density assessment.

We hope that the information we have provided will be used by CDFG to revise these protocols before their inclusion into the statewide monitoring manual. If the details outlined in this report are addressed, we feel that CDFG's monitoring program can effectively meet the needs of their federal funders, act as a model for systematic statewide monitoring and provide critical data to guide research and development within the science of fisheries habitat restoration.

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Acknowledgements: We want to recognize the comprehensive accomplishment of Richard Harris and team in creating the effectiveness monitoring protocols. We would like to thank Dr. Harris, Susie Kocher and Jared Gerstein for taking the time to discuss these protocols with us and during our review. Completing the fieldwork would not have been possible without the faithful help of UC Cooperative Extension Technician Miguel Huerta and the ongoing access offered by all of our landowner cooperators. Special thanks to Brooke Budnick, Senior Fish Technician for the California Department of Fish & Game, for patiently answering our many questions.

INTRODUCTION

Ecological restoration is a strategic component of natural resource management in its effort to conserve and enhance habitat functions and maintain or recover species that are dependent upon those functions. Resources to implement this component have included State and Federal funding of grant programs. On-the-ground organizations have actively participated in these programs over two decades to improve stream habitat, reduce delivery of sediment and other water quality contaminants, and provide stewardship education to public and private land managers. This body of work presents an opportunity to learn about the intended and unintended outcomes of individual restoration projects as feedback to policy decisions regarding implementation of ecological restoration programs. Systematic and consistent collection of useful restoration project information and data depends upon the development and application of proven and repeatable monitoring protocols. For that purpose, Richard Harris, Forest Ecology Specialist at the University of California Berkeley, and team members presented qualitative (Kocher and Harris 2005) and quantitative (Harris et al. 2005) protocols for effectiveness monitoring of restoration projects to the California Department of Fish and Game (CDFG) in 2005.

During the 2005 summer field season, the University of California Cooperative Extension (UCCE) field tested the Harris et al. 2005 *qualitative* implementation and effectiveness monitoring protocols outlined in *Qualitative Monitoring of Fisheries Habitat Restoration* (Nossaman et al. 2006). During the 2006 summer field season, UCCE conducted *quantitative* effectiveness monitoring of several riparian planting and streambank stabilization project sites using the Harris et al. (2005) monitoring protocols outlined in *Monitoring the Effectiveness of Riparian Vegetation Restoration* and *Monitoring the Effectiveness of Bank Stabilization Restoration*. The purpose of this monitoring effort was two-fold: 1) to collect data for verification of projects funded through CDFG's Fisheries Restoration Grant Program (FRGP), and 2) to field-test the protocols and provide recommended modifications and suggestions for their continued use.

This report synthesizes the results of the quantitative monitoring effort and provides a summary of our findings for both restoration project verification and protocol field testing. It is intended to guide refinement of specific protocols and discuss programmatic monitoring opportunities and challenges. This report is organized to begin at a broad programmatic scale, with subsequent sections devoted to specific details regarding each method. Appendices include our recommended revisions to field data forms which can be utilized by CDFG directly as digital files.

The comments and recommendations included in this report were drafted from the perspective of the user. The Harris et al. monitoring protocols assume users will be "agency staff or professional consultants with expertise in project design, implementation and contracting" and training in monitoring methods (Kocher and Harris 2005). The UCCE evaluation team members who field-tested these methods have experience consistent with the users for which these protocols were intended.

Before proceeding, we would like to say that the task of creating a straightforward and effective systematic monitoring protocol for use on a variety of project types, each with numerous indicators of performance, is tremendously challenging. Perfecting field methods that accurately reflect the wide array of variables encountered at each individual project feature could involve several years of testing and refinement. With that in mind, we would like to acknowledge the exceptional work done by Harris and team. It is only because our focus was limited to the quantitative protocols pertaining to bank stabilization and riparian vegetation restoration that we were able to address the finer details that arose during their application—a task that was probably not possible for the Harris team considering the magnitude of their assignment. We hope that our efforts will compliment their work and build upon the excellent foundation they have created.

FIELD WORK OVERVIEW

The seven effectiveness monitoring protocols utilized in this effort were selected by CDFG and UCCE based on their apparent suitability for evaluating the objectives of projects most commonly funded through the FRGP. UCCE staff identified appropriate sites based on project type, age and description. Priority was given to FRGP-funded sites. All surveyed sites were located in Marin, Sonoma and Mendocino Counties and most were in the Russian River watershed, with one site in the Salmon Creek watershed and one in the Estero de San Antonio watershed. Site Access & Location and Onsite Navigation forms were completed for all sites and photomonitoring was conducted at all bank stabilization sites and all FRGP-funded riparian planting sites.

Bank Stabilization Restoration Field Method 1, Line Intercept Transects Along Banks, was employed at 16 individual restoration treatment sites (Table 1). All sites were surveyed post-treatment and two sites were also surveyed prior to treatment. Bank Stabilization Restoration Field Method 2, Cross Section Surveys, was attempted at 15 treatment sites and employed successfully at 12 sites (Table 1). Eleven of these sites were surveyed post-treatment, two sites were surveyed before and after treatment, and one possible future restoration site was surveyed prior to treatment. Bank stabilization restoration sites sampled were implemented between 2000 and 2006, with an average age of 4 years old.

Table 1. UCCE 2006 Quantitative Monitoring - Bank Stabilization Restoration Sites

PROJECT SITE ID	TREATMENT	METHODS USED	TREATMENT PHASE	IMPLEMENT. YEAR
Dutcher Ck Pool Enhanc. & Bank Stab. PF#5	Boulder deflector	1 & 2	Post-treatment	2000
Forsythe CreekWillow Wall	Willow wall	1	Post-treatment	2002
Gird Creek Bioengineering PF#1	Willow mattress	1 & 2	Post-treatment	2000
Gird Creek Bioengineering PF#2	Willow baffles (3)	1 & 2	Post-treatment	2000
Green Valley Creek Coho Enhancement II	Willow mattress	1 & 2	Pre- & Post-treatment	2004
Mark West Creek Willow Mattress	Willow mattress	1	Post-treatment	2001
Mark West Creek Willow Wall	Willow wall	1 & 2	Post-treatment	2001
Mill Creek 3 Streams Ranch Eroded Bank	Possible treatment site	2	Pre-treatment	n/a
MIll Creek Bank Stab. & Reveg. PF#2	Willow mattress	1	Post-treatment	2002
MIll Creek Bank Stab. & Reveg. PF#3	Boulder/log deflector	1 & 2	Post-treatment	2002
Muscat Creek Willow Mattress	Willow mattress	1	Post-treatment	2003
Parsons Creek Weirs & J-Hooks PF#2	Boulder J-hooks (5)	1 & 2	Post-treatment	2000
Parsons Creek Willow Wall	Willow wall	1 & 2	Post-treatment	2003
Pena Creek Bioengineering PF#1	Willow deflectors (4)	1 & 2	Post-treatment	2001
Pena Creek Bioengineering PF#2	Willow wall	1 & 2	Post-treatment	2001
Robinson Creek Riparian Restoration Project	Armor & will. baffles	1 & 2	Pre- & Post-treatment	2006
Salmon Creek Mache II Project	Willow mattress	1	Post-treatment	2005

Various Riparian Vegetation Restoration Line Intercept Transect Methods, including Field Method 1, Line Intercept Transects Along Banks; Field Method 3, Line Intercept Transects Across Floodplains; and Field Method 4, Line Intercept Transects Through Delineated Treatment Areas, were employed at a total of 14 individual restoration treatment sites (Table 2). All sites were surveyed post-treatment and four sites were surveyed prior to planting. All sites surveyed consisted of basic riparian planting projects, with the exception of the four Giant Reed Removal and Revegetation Project sites, which also include a vegetation control component. For this project, the sites listed as pre-treatment are those where *Arundo* biomass has been removed but native tree planting has not yet occurred. Field Method 7, Intercepted Sunlight Due to Riparian Canopy, was employed at a total of six sites. Each time Method 7 was employed, using a Solar Pathfinder to measure solar availability, Densiometer readings were also taken to allow for a comparison of the two methods. In addition, Riparian Vegetation Restoration Method 5, Planted Tree Survival Assessment, was attempted unsuccessfully at one site. A census (direct count) was conducted at all post-treatment revegetation sites (except for HREC Section 8, where individual plantings could not be identified) to document survivorship in lieu of Method 5.

Table 2. UCCE 2006 Quantitative Monitoring - Riparian Vegetation Restoration Sites

PROJECT SITE ID	METHODS USED	TREATMENT PHASE	YEAR PLANTED
Copeland Creek Sweet Lane Planting	1, 3, 4 & 7	Post-treatment	2005
Duncan Creek Sedge Planting (PF#2)	1 & 4	Post-treatment	2002
Giant Reed Removal & Reveg. Asti Seasonal Trib. Stand 1	4	Pre-treatment	n/a
Giant Reed Removal & Reveg. Asti Seasonal Trib. Stand 2	4	Pre-treatment	n/a
Giant Reed Removal & Reveg. Asti Upstream Portion	4	Pre-treatment	n/a
Giant Reed Removal & Reveg. Rodney Strong	4	Post-treatment	2005 & 2006
Green Valley Creek Riparian Planting	4	Post-treatment	2004
HREC Parsons Creek Planting Section 12	1, 4 & 7	Post-treatment	2002
HREC Parsons Creek Planting Section 3	1, 3, 4 & 7	Post-treatment	2002
HREC Parsons Creek Planting Section 8	1 & 7	Post-treatment	2002
Parsons Creek Willow Wall (native grass seeding)	4 - modified	Post-treatment	2003
Robinson Creek Riparian Restoration	1 & 4	Pre- & Post-treatment	2006
Salmon Creek Mache II Planting	1, 4 & 7	Post-treatment	2005
Stemple Creek Murphy Planting	1, 3, 4 & 7	Post-treatment	2001 & 2004

We employed every riparian vegetation method at the first three riparian planting sites surveyed, regardless of suitability. This allowed us to become familiar with each protocol. Subsequent sites were surveyed using the most appropriate methods, determined by evaluating project objectives and site layout. For example, if a planting project was intended to increase native vegetation cover in a narrow strip along the upper bank, that site was surveyed using Method 4, Line Intercept Transects Through Delineated Treatment Areas, as there was no need to sample several transects through the floodplain (Method 3). All riparian planting treatments that were intended to improve conditions at bankfull were surveyed using Method 1, Line Intercept Transects Along Banks, in addition to any other suitable methods. Likewise, Method 7, Intercepted Sunlight Due to Riparian Canopy, was employed at all sites where plantings were intended to increase canopy cover over the stream channel.

The average age of riparian planting sites sampled was 2.5 years old. These projects were implemented between 2001 and 2006, and were selected to correlate with the age of the projects most likely to be implemented through the FRGP.

DATA ANALYSIS AND RESULTS

We were interested in offering a holistic assessment of the field methods so we organized our data electronically and calculated summary statistics in order to evaluate data output. We conducted the data entry and method evaluation simultaneously, which allowed us to consider specifics related to how the raw data would be summarized and time dedicated to this task. We visited the FIREMON website (http://www.fire.org/index.php?option=com_content&task=category&sectionid=5&id=18&Itemid=42), as recommended by Harris et al. (2005), for advice on data organization tools.

The project feature was our fundamental sample unit. In many cases, we utilized multiple field methods per project feature and these were all entered as separate rows in Excel. We created separate spreadsheets in Excel for line intercept transects (LITs), direct plant counts, stream shade, cross sections and project implementation information. For LIT surveys, we entered percent vegetation cover for each height class by project feature by method by site, which allowed for tracking specific project features over time but did not allow for easy calculations of total cover across all height classes.

We calculated percent cover by species by height class given total LIT length sampled. Our response variables were total percent native tree cover and total bank stability. The statistical software utilized was JMP 5.1 (SAS Institute 2003) for calculating mean and standard error values. For all project types, mean early seral tree cover was 8.7 (±2.5 SE), 15.1 (±3.1 SE), and 11.2 (±3.8 SE) percent native tree cover for 0-3 foot, 3-15 foot, and 15+ foot height classes, respectively. Mean late seral tree cover was 0.2 (±0.08 SE), 0.5 (±0.2 SE), and 2.3 (±0.9 SE) percent native tree cover for 0-3 foot, 3-15 foot, and 15+ foot height classes, respectively. Dominant early seral tree species were willow, cottonwood, and alder while late seral species were predominantly oak, box elder, maple, bay, and buckeye. We summarized the mean native tree cover results for each LIT method utilized (Figure 1). Riparian Vegetation Restoration Method 3 produced the most variability. This most likely results because it is the only protocol in which transects are sampled perpendicular to the channel, across multiple project features in most cases.

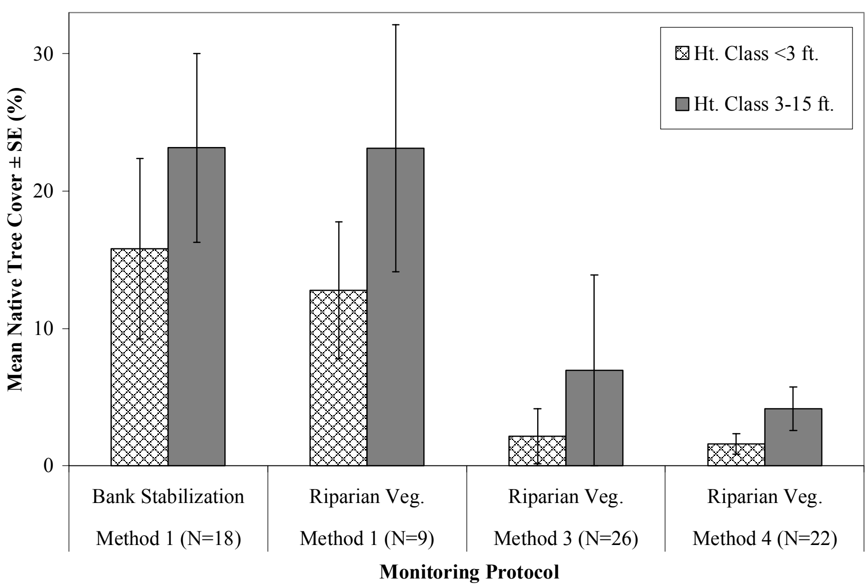

Figure 1. Mean native tree cover by height class, project type, and field method utilized.

Mean early seral tree species richness (number of species) across all project types and methods was 0.8 species per project feature (±0.19 SE), ranging from 0 to 3 and mean late seral tree species richness was 3.1 species per project feature (±0.39 SE), ranging from 0 to 6. Mean shrub species richness was 1.0 species per project feature (±0.48 SE), ranging from 0 to 7. The dominant shrub species were elderberry, rose, toyon, coffeeberry and dogwood.

At the riparian vegetation project sites we surveyed, the planting density by project feature of early seral tree species was 255 per acre (±85 SE) with a range from 0 to 1275; late seral density was 76.7 per acre (±34 SE) with a range from 0 to 677; and shrub density was 19.2 per acre (±9.7 SE) with a range from 0 to 137. Willow species were planted as sprigs from local populations and the other species were planted from nursery grown container stock.

We analyzed pre- and post-implementation data by comparing the pre-treatment sites we surveyed to the post-treatment sites. Because this monitoring project was essentially retrospective in design (we did not have baseline data), we were only able to sample two bank stabilization treatment sites and one riparian planting site prior to project implementation. Thus, we are analyzing different sites by project age group and *not comparing site change over time*.

We attempted to assess direct increases in bank stability as a result of the treatment by comparing the estimated percent stable bank prior to treatment to the stability data collected during our LIT surveys. The documented percent stable bank prior to treatment was a visual estimate of streambank stability across the entire site from toe to top of bank, or 20 feet upslope. We found too much error in this attempt because the two methods were not comparable. For example, visually one may observe that the entire bank appears to be 70 percent stable. However, the LIT method assesses bank stability class from toe to top of bank to the nearest 0.5 foot along a transect placed at bankfull. If each 0.5-foot section along that bank is 70 percent stable, it would result in each section being classified as stable, which would equal 100 percent stability along bank length. Despite apparent similarities, these two methods of estimating bank stability offer varying results.

One fundamental assumption of the LIT method is that the resulting data represents overall treatment site conditions. The Harris (2005) et al. riparian vegetation restoration document states that the data collected along transects is intended to represent total vegetation cover, species composition, or other parameter sampled as a proportion of total sampled area. However, the proportionate relationship is unknown and we not did discover a direct relationship during our data analysis. We expect a positive relationship between the total length of transects sampled at each site and the amount of cover observed. Unfortunately, our sample size was not sufficient to build a confident correlation. Thus, we cannot verify the accuracy of this method in obtaining estimates of overall conditions within a treatment area, or changes in those conditions prior to and after treatment. However, we can state that the LIT method is suitable for accurately detecting relatively large changes at an established location over time, which is a priority for CDFG.

GENERAL COMMENTS ON THE MONITORING PROGRAM

The following comments are primarily intended to encourage more efficient monitoring techniques and consistent and accurate data results. A condensed list of our recommendations is presented in Appendix A and discussed in depth in this section of the report.

Though this report is fairly comprehensive, some of the information relative to smaller details was omitted from the body of the report, in order to avoid confusion, and incorporated directly into the text of the original Gerstein and Harris (2005) and Harris et al. (2005) documents. The modified versions of those documents, which also contain many of the comments found in this report, can be found in Appendices B and C. We recommend that remarks be reviewed within the context of those documents.

We also recommend that the instructions for all methods include a list of equipment needed to perform the survey. This will help insure that surveyors are well prepared for field visits. See Appendix D for a table of required equipment for all methods, which CDFG can incorporate into the instructions at their discretion.

We recommend certain basic additions to the general survey forms used in both qualitative and quantitative monitoring, including the On-site Navigation, Photo Description and Site Access and Location Data Forms. See Appendix E for information on those additions and revisions to additional data forms.

Usability of Protocols in their Current Forms

All of the protocols we reviewed are useable in their current forms. All of the protocols, with the possible exception of Method 5 (for reasons discussed in the section devoted to that method), are suitable for evaluating attributes of bank stabilization and riparian vegetation restoration projects commonly funded through the FRGP, as a means of determining whether projects have met their stated objectives. However, several questions arose during their application, ranging from broad, programmatic issues to specific field application procedures. We are concerned that individuals who apply these protocols, as they are written, will encounter the same questions that we did and answer them independently, leading to inconsistencies in protocol application and resulting data. We spent a great deal of time deliberating over ambiguous aspects of specific field procedures. We also noticed that our approach to undefined points within the protocols tended to evolve over time, leading to inconsistencies in data collection methods through time even among the same set of surveyors. If these points can be clarified before the protocols are incorporated into the monitoring manual it will lead to greater efficiency and consistency in protocol application.

It is our hope that CDFG and all future users of the protocols will use the information contained in this report to fine-tuning their monitoring programs.

Coordinating Quantitative and Qualitative Monitoring Efforts

In order to offer useful and realistic feedback to CDFG, we are assessing the broad framework under which the protocols will be utilized. One fundamental question is how to integrate the qualitative and quantitative effectiveness monitoring protocols. Qualitative monitoring provides a descriptive summary of the treatment plan, implementation details and effectiveness outcomes for each project while quantitative monitoring provides objective information about site conditions before and after treatment.

We recommend that quantitative and qualitative monitoring efforts be coordinated because the two methods function in a complimentary manner to offer a holistic overview of restoration project outcomes. Coordinating these monitoring efforts would also help to insure that project features were numbered in the same manner at each site. More importantly, employing both types of monitoring at the same treatment sites would allow for a study of how they agree and disagree in their documentation of project results. Perhaps, over time, clear correlations between the two could be drawn. We expect that the quantitative results could support the qualitative ratings and help to refine the protocols. For example, bank stabilization sites with a rating of “good” might consistently show increases of 70-80 percent in the length of stabilized bank, indicating that quantitative outcomes could dictate qualitative ratings. If quantitative sampling does indeed validate qualitative ratings, then it could be used to improve the qualitative rating system or, over time, the two types of monitoring might even be meshed into one quasi-quantitative protocol.

To pursue our interest in correlations between the qualitative and quantitative effectiveness monitoring results, we revisited a number of bank stabilization project sites that we sampled qualitatively during the summer of 2005. We assessed mean bank stability given the qualitative rating category (failed, poor, fair, good, or excellent) that the site received (Figure 2). Even given our low sample size, a clear trend exists with significantly greater bank stability at sites with “fair”, “good”, and “excellent” effectiveness ratings. The relationship between qualitative rating and native tree cover is more variable and less clear for bank stability treatment sites because tree cover is a secondary objective of those types of projects.

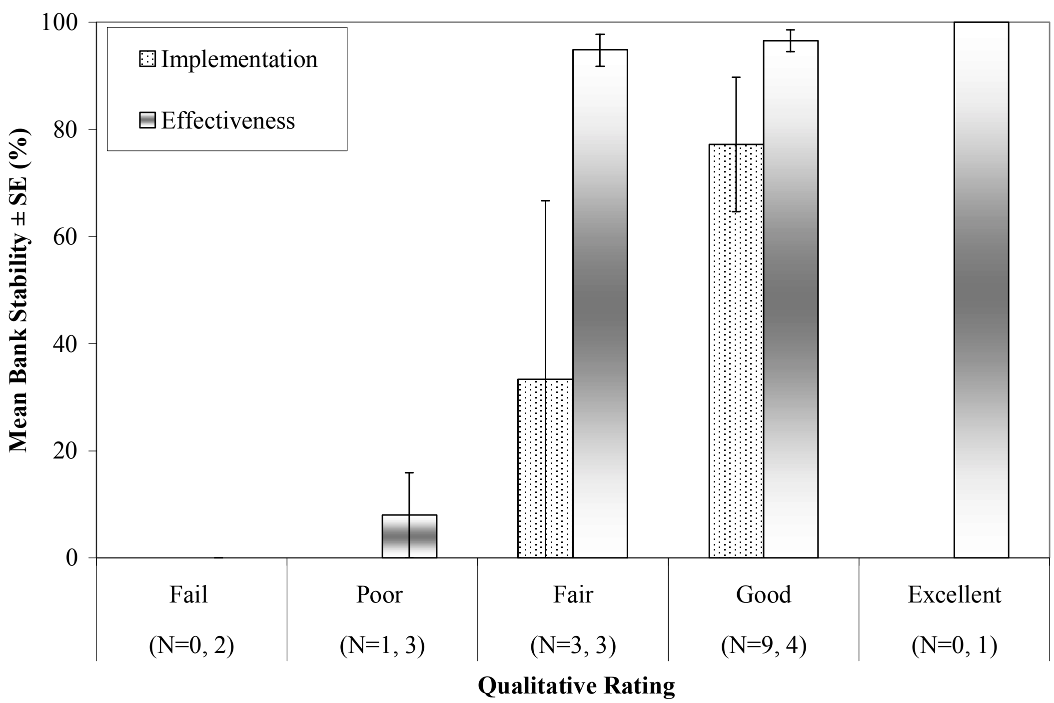

Figure 2. Mean bank stability by qualitative implementation and effectiveness rating.

Ideally, qualitative surveys would be done prior to, or at the same time as, the quantitative so that both surveys could utilize the information contained in the qualitative project summary, which includes a verbal description of the project plan, some implementation details and effectiveness outcomes and answers many questions that are useful when conducting quantitative surveys. The quantitative monitoring includes no similar summary. In the absence of this information, quantitative surveyors would be obliged to invest additional time to obtain and evaluate information identical to that evaluated by qualitative surveyors, while having no standard format in which to document it. For example, when conducting a quantitative bank stabilization treatment survey, evaluators would need to know the length of bank *intended* to be stabilized before determining the length of the treatment area. If qualitative monitoring had been conducted, surveyors could consult the implementation checklist for a direct answer to this question, rather than requesting additional copies of project documentation from CDFG contract managers. Furthermore, if qualitative surveys were conducted prior to the quantitative, those treatments with a qualitative rating of "failed" could be eliminated from the quantitative effort, saving time and resources for sites where viable data could be collected. Therefore, **we recommend that qualitative and quantitative monitoring efforts be coordinated and that qualitative surveys be performed prior to quantitative surveys at each site. We also recommend that the resulting data be analyzed for correlations between the two survey methods as part of a long-term effort to improve the monitoring program.**[1]

Identifying Project Features

The task of isolating project features and assigning project feature numbers during pre-treatment surveys at sites where multiple types of treatments are proposed to be implemented presents serious complications for surveyors in the field. It is imperative that project feature numbers assigned during the pre-treatment survey are consistent with those assigned during the post-treatment survey but it is difficult to systematically number project features, which are generally identified subjectively depending on site layout and treatment types. Inconsistent numbering of project features is a logistical problem that creates a significant weak point in the monitoring program by making it difficult to accurately compare data collected from the same treatment area during different project phases (i.e., pre-treatment, implementation or post-treatment) or different monitoring efforts (i.e., qualitative or quantitative). The need for guidance on how to assign project feature numbers based on structure type, function and location and how to determine the area affected by each one was outlined in our report on the qualitative methods (Nossaman et al. 2006). We feel that this issue must be addressed to insure consistency and accuracy in the monitoring program

Creating a standardized method for project feature delineation will be difficult. In some cases it will not be feasible to assign a single project feature number to a survey site. Take, for example, an eroded bank where boulder armor, willow baffles and sprigging are proposed for installation. What is the best way to divide that one bank into three project features when each of the three proposed treatments is intended to impact the entire bank? Since it is impossible to determine precisely what portion of the bank will be affected by each treatment (even if it were possible, it would be very difficult to divide the bank accordingly), the bank could be assessed as one feature or divided into thirds horizontally or vertically. With any of these options, it is highly unlikely that pre-treatment project feature numbers will correlate with post-treatment feature numbers, where features will be identified based on treatment type (i.e., armor, baffles and sprigs). It is also unlikely that feature numbers assigned during qualitative monitoring will match those assigned during quantitative monitoring, unless those efforts are closely linked. Perhaps in such cases a single project feature number could be assigned to a site during the pre-treatment survey, to be broken down into multiple feature numbers after project implementation. That, of course, presents the problem of how to compare pre- and post-treatment conditions when the same project feature is

[1] Bold, italic type denotes specific recommendations. These are repeated in the list in Appendix A.

numbered inconsistently. This inconvenience becomes critical during database management. **We recommend that the difficulties associated with inconsistent project feature numbering throughout all project phases and monitoring efforts be investigated further and that standardized solutions be drafted for inclusion in the final CDFG monitoring manual.**

Furthermore, we recommend that all project features be assigned a short name in addition to being numbered. In most cases, this name would be a structure name (e.g., PF#1 log deflector) or, in the case of riparian vegetation restoration, a name indicating the location of plantings being sampled (e.g., PF#2 right bank floodplain plantings, PF#3 upper left bank plantings). Whereas project feature numbers are unique, project feature names would not need to be unique but would simply function as a means of identifying different features within the database to enable more efficient queries. For example, at some point in the future after monitoring data has been amassed and centralized, researchers studying the difference between the survivorship of floodplain and upslope plantings could use the database to query project features by planting location, eliminating the work involved in obtaining and evaluating site sketches and navigation forms from project monitoring files. Therefore, **we recommend that names and numbers be assigned to all project features sampled during qualitative and quantitative monitoring efforts.** Our revised data forms (Appendix E) and correlating instructions (Appendices B and C) have been modified accordingly.

Standard Survey Timing

In our 2006 report on the qualitative methods, we expressed concern over timing of surveys in relation to project implementation (Nossaman et al. 2006). We are reiterating that point here due to its relevance during our recent quantitative efforts. The dynamic nature of stream systems and restoration projects can lead to extreme variability in the outcome of monitoring surveys which could be reduced by standardizing sampling intervals. A systematic approach to survey timing for quantitative riparian vegetation and bank stabilization project monitoring would significantly improve program efficiency.

The protocols laid out by Harris et al. (2005) in *Monitoring the Effectiveness of Riparian Vegetation Restoration* are designed to answer a variety of questions relative to the success of riparian plantings and the effect of revegetation practices on habitat trajectory. Because resources allocated to monitoring are limited at this time, we believe that CDFG would benefit from designating specific protocols to be used at explicit temporal intervals, based on their prioritized effectiveness criteria for different project types. For example, for the majority of riparian planting projects CDFG will likely be most interested in assessing planted tree survival two to three years after project implementation and changes in native vegetative cover and canopy closure five or ten years later. For exotic species removal projects, monitoring may focus on assessments of relative cover by species prior to and immediately after project implementation, with follow-up monitoring five and ten years after project implementation (not to be confused with the visual monitoring required by the contractor and/or project manager to assess maintenance needs). **We recommend that CDFG prioritize effectiveness criteria for different project types specific to their needs through the FRGP, and standardize time frames for assessing the correlating project parameters.**

The same concept applies to bank stabilization restoration projects, and bioengineering bank stabilization treatments in particular, which can have a greater variability of results based on specific survey timing. For example, a willow wall that we surveyed on Parsons Creek thrived for the first year after implementation. During the second year irrigation problems occurred but it survived with some growth.

By the third year it was almost completely dead. Accordingly, quantitative results would have gone from an estimated 90 percent cover down to 10 percent cover over the first three years. If the ideal program of repeat monitoring were employed, these changes would be reflected over time. However, given the limitations of monitoring program resources in conjunction with the tremendous workload presented by the number of past and current projects that require sampling, **the initial effectiveness survey should be strategically timed to reflect conditions after stressing events have been experienced and project efficacy can be reasonably ascertained.**

For most bioengineering streambank stabilization projects, willow cuttings are irrigated for the first two years after implementation. Thus, monitoring data collected after the third year will probably reflect the health and vigor of planted vegetation more accurately than data collected earlier, before environmental stresses have occurred. Structural integrity is also a concern for any type of bank stabilization structure. For example, a boulder deflector site surveyed one year after implementation may not have experienced the stresses associated with high stream flows. Furthermore, it will likely not have had adequate time to meet the objective of re-building the target stream bank through sediment deposition. Baseline data should be collected before and after treatment implementation, but three years post-implementation may be the preferred timing for the initial quantitative effectiveness survey, with a subsequent survey occurring six to eight years post-implementation. Survey intervals of three to five years may also provide answers to questions of expected structure longevity within different stream systems. The test of time on restoration structures has been shown to be especially challenging in alluvial reaches (Frissel and Nawa 1992).

We recommend that the timing of effectiveness monitoring visits for both qualitative and quantitative efforts be standardized based on project type, depending on the expected amount of time required to reasonably ascertain whether objectives have been met. If general guidelines are not established to address this component, monitoring results may not accurately reflect the effectiveness of projects.

To pursue our interest in how project site conditions changed over time, we analyzed data by project age group. For LIT surveys, we compared tree cover to

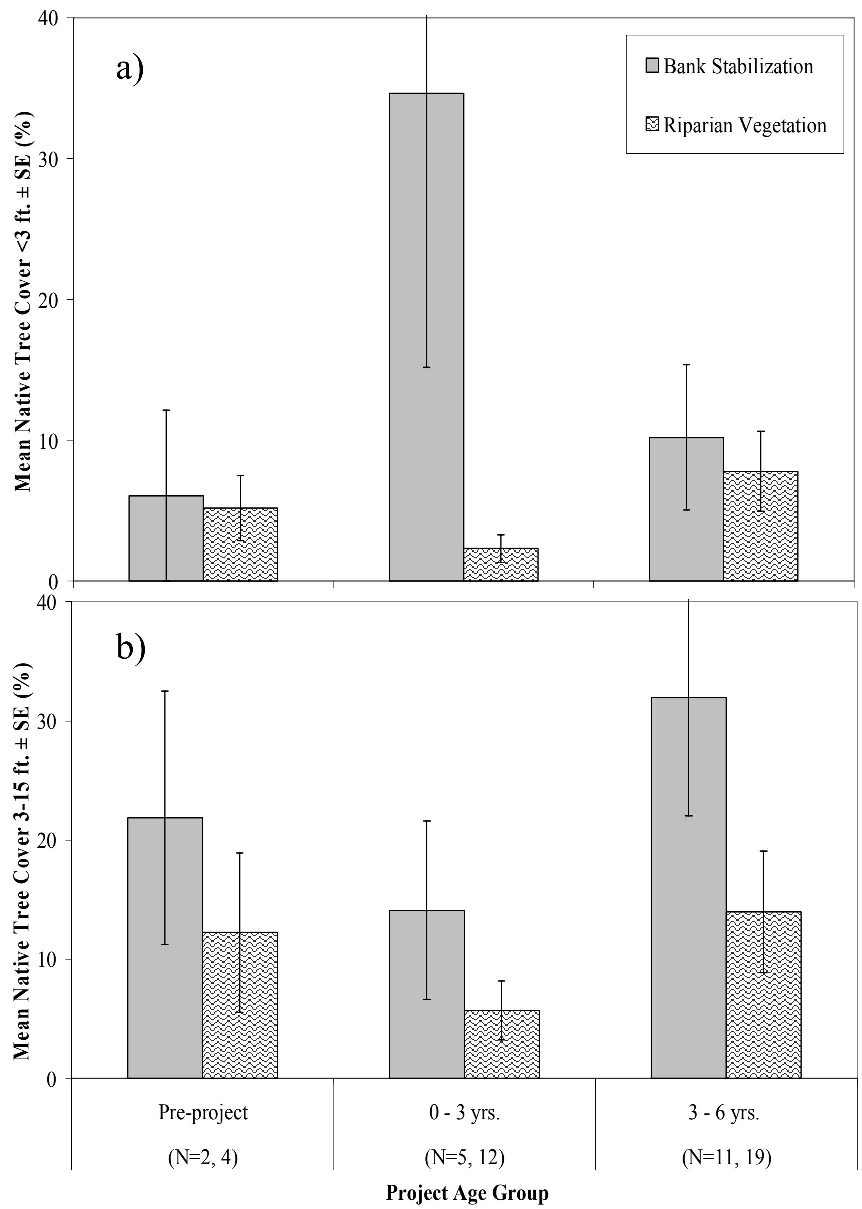

Figure 3. Mean native tree cover by project type and age group for a) 0-3 foot height class; and b) 3-15 foot height class

project age group and type (Figure 3). The expectation is that older sites will have more native tree cover than younger sites. This was the case in the 3-15 foot height class. In the 0-3 foot height class, there was a significant increase in cover for riparian vegetation sites which were dominated by slow growing species. However, at bank stabilization project sites, there was a decrease in native tree cover in the 0-3 foot height class at the older project sites. This may result from fast growing species, planted in high densities at bioengineering sites, which quickly grew into the 3-15 foot height class. Again, these results represent pre- and post-implementation conditions from *different* sites. We were not able to assess actual changes in conditions over time at the *same* sites, as our survey effort was limited to one year. Despite this limitation, we found significantly greater cover by native trees at the bank stabilization project sites, though it varied by age group and height class. This indicates the usefulness of LIT data for documenting trends over time and the effects of various restoration practices.

We also compared our results from bank stabilization sites for correlations to project age group given qualitative effectiveness rating (Figure 4). Results indicate a clearer trend of improving bank stability at older project sites when we excluded the sites which received qualitative effectiveness ratings of "poor" and "failed".

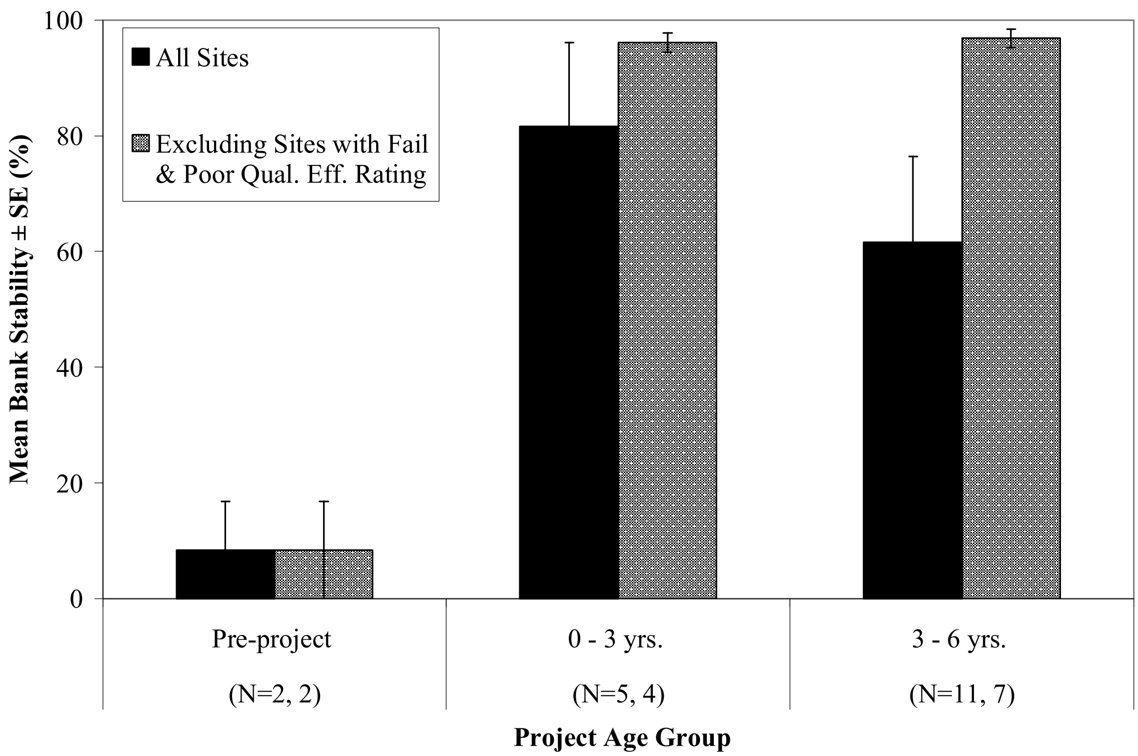

Figure 4. Mean bank stability by age group.

BACI Design

The general study design recommended by Gerstein and Harris (2005) for all Bank Stabilization and Riparian Vegetation Restoration monitoring protocols, aside from Method 5, Planted Tree Survival Assessment, is a before-after-control-impact (BACI) approach in which sampling of the control and the impact area is conducted before and after treatment for all parameters. There is no doubt that this scientifically valid approach is ideal from an academic standpoint and is particularly useful for research studies which assess causation. Nevertheless, it may not be practical, from a programmatic perspective, for CDFG to require that control sites be sampled in conjunction with each restoration treatment. Identifying, accessing and sampling control sites could easily require as much time as it takes to sample restoration project sites, which would reduce the total number of project sites that could be sampled given the limited resources allocated to the current monitoring effort. Control sites that are directly comparable to restoration sites are difficult to locate, which further reduces the feasibility of implementing the BACI design at a programmatic scale. Unless CDFG intends to compare restoration project results with the findings at control sites, the BACI approach may not be the most efficient study design.

We are not suggesting that the BACI design be disregarded. Control sites are fundamental in accounting for all factors that drive site response and are a necessity for isolating causes of change. The only way to state definitively whether changes in site conditions are a result of restoration treatments (e.g., tree planting) or natural occurrence (e.g., native plant colonization) is through comparing restored sites to control sites. However, it is our understanding that CDFG is primarily interested in ascertaining whether or not projects funded through FRGP have met their objectives and we do not find it necessary to compare restoration project outcomes to control sites in order to determine whether project objectives have been met on a site-by-site basis.

In the case of most bank stabilization restoration treatments, objective achievement could be ascertained simply by comparing the length of unstable streambank before and after treatment (over time). In the case of riparian vegetation restoration this could be determined by assessing target attributes (e.g., vegetation cover, canopy, species composition) before and after treatment within the treatment area. These programmatic restoration objectives are sufficiently correlated by surveying a broad subsample of all project types for multiple generations. The test of time in disturbance-dependent ecosystems is a challenging test in and of itself (Frissel and Nawa 1992, Lennox et al. 2007). **We recommend that the BACI approach remain in the monitoring manual to be used for research studies where it is feasible and appropriate, but not be required as a mandatory component of the CDFG monitoring program to document achievement of project objectives as stated in the statement of work.** Clearly, this recommendation should be re-evaluated if CDFG has the necessary resources and intends to compare restoration treatment sites to control sites as part of their data analysis effort. For non-CDFG monitoring efforts, we suggest that instructions and stipulations for project study designs be drafted according to individual program needs.

COMMENTS ON SPECIFIC PROTOCOLS

This section of the report focuses on our assessment of the quantitative monitoring protocols outlined in *Monitoring the Effectiveness of Bank Stabilization Restoration* (Gerstein and Harris 2005) and *Monitoring the Effectiveness of Riparian Vegetation Restoration* (Harris et al. 2005). The following methods were designed to accommodate the various site specific approaches restoration practitioners utilize to meet bank stabilization and riparian vegetation restoration project objectives.

Line Intercept Transect Surveys (General)

The comments in this section apply to Bank Stabilization Restoration Method 1 and Riparian Vegetation Restoration Methods 1 through 4, which are all variations of line intercept transect (LIT) surveys. Additional comments, specific to each method, can be found in the following sections later in this report: *Bank Stabilization Restoration Field Method 1: Line Intercept Transects Along Banks, Riparian*

Vegetation Restoration Field Method 1: Line Intercept Transects Along Banks and *Riparian Vegetation Restoration Field Methods 2-4: LIT Variations*.

Field Methods

For LIT surveys, the ability to replicate transects in successive re-measurement years is critical, as it is the only way to insure accurate comparisons of pre-treatment, post-treatment and long-term monitoring data. As a measure to insure replication of transects, **we recommend documenting locations of end points, in addition to start points, and recording the bearing of the line in every case. The location and layout of transects should also be photographed and added to the site sketch.** Depending on the size of the treatment area, documenting transect location can frequently take as long as conducting the survey.

We recommend collecting more specific information on willow species identification. All willows are currently recorded as "*Salix*" for both bank stabilization and riparian revegetation surveys. Differentiating between species when possible will enable comparisons of growth and survival rates between different functional groups within the willow genus (Lennox et al. 2007). Plus, many ranch managers and flood control engineers prefer the tree forms over the smaller shrub varieties; however, the shrub forms may be the most suitable for bioengineering. Identifying different species of tree willows can be difficult, time consuming, and dependent on spring blooms so a realistic objective is needed for taxonomic purposes. **We recommend recording full species codes for sandbar and arroyo willow, recording tree willow species as "*Salix*", and updating CDFG's plant species code list accordingly.**

The Harris et al. (2005) instructions state that LIT surveys should record interception along the transect line to the nearest 0.5 foot. Though this may seem straightforward, we discovered variability of interpretation by surveyors. For example, if a plant intercepts the line from 0-1.7 feet, should it be recorded as 1.5 feet or 2 feet? Some staff assumed a presence-absence approach and recorded a 0-2 foot cover interval, but this was not correct. Instead, a 0-1.5 foot interval should be recorded. **We recommend that instructions for measuring cover interception along the transect be clarified in order to reduce the margin of error between surveyors and the possible misrepresentation of site conditions.** However, **we also recommend surveying vegetation cover to the nearest 0.1 foot in order to capture the variability of plant species at young planting sites where it is common for only 0.1-0.2 foot of foliar cover to intercept the line.** If measuring to the nearest 0.5 foot, it would take several years for certain species to be large enough to record, if they did intercept the line. During field testing, we actually found measuring to 0.1 foot to be easier in many cases since it eliminated deliberation. However, in cases where transects are greater than 500 feet, accuracy to this level will likely not be necessary and surveyors can return to measuring to the nearest 0.5 foot. It is always possible to round numbers down during data entry but the precision of the data cannot be increased if it is not built in to the survey process. **To maintain survey efficiency, we recommend that bank stability class and cover types other than vegetation (e.g., barren soil, rock, litter) be recorded to the nearest 0.5 foot, defined so that < 0.25 foot is recorded as zero and > 0.25 foot is recorded as 0.5 foot.**

We experienced some deliberation about the level of detail necessary for classifying rock and barren soil. At what point does barren soil become rock? Should gravel and small cobble cover be estimated separately or combined in a rock or soil category? If one surveyor classified gravel along the line as "barren soil" and another surveyor three years later recorded that same substrate as "rock" it would appear that site conditions had changed. **To decrease ambiguity and insure a more efficient survey and accurate representation of site conditions, we recommend adding alluvium (ALLV) as a cover type**

for classifying cobble, gravel and sand. Rock would be defined as boulders, bedrock or concrete and silt would be classified as barren soil.

We also recommend adding roots (ROOT) as a cover type used to classify exposed, woody tree roots, which have been documented to increase significantly over time (Lennox et al. 2007). **Wood (WOOD) should be specifically defined as dead wood in order to avoid confusion with trunks or roots**.

Written Instructions

The instructions for all LIT methods focus on establishing transects only for the initial LIT survey of a site. Procedures for establishing transects at sites that have previously been surveyed should outline how to replicate the initial transect location and layout. **We recommend the inclusion of specific instructions for conducting surveys on follow-up visits since the method used to relocate and sample a previously established transect is different than that used to establish a new one**.

The current instructions could offer more specific guidance on how to conduct the LIT survey. **We recommend enhancing the instructions to include the following**:

> "Any portion of a plant that falls directly on, below or above the line qualifies as intercepting the line. Plants even a short distance off of the line should not be recorded. For taller plants, a vertical stadia rod can be helpful in determining where plants intercept the line…Use CDFG's plant species code list (see CDFG manual or http://plants.usda.gov/index.html) to determine the appropriate code for each tree and shrub."

It would also be helpful for instructions to specify how to assess plant height class. **We recommend enhancing the instructions to include the following**:

> "The height class recorded should be the height of the plant intercepted by the line, not the total actual height of the plant. If multiple height classes of one plant intercept the line, record that species in each relative height class. For example, if the line intercepts a willow tree that has a maximum height of 18 feet, but crosses only the trunk and branches up to 13 feet above the ground, that species should be recorded in the 0-3 foot and 3-15 foot height class columns. Some type of cover should always be recorded in the 0-3 foot height class column. If no vegetation of this size is present, record one of the other cover options from the data sheet (rock, litter, etc.)."

Photographing and sketching treatment sites are critical aspects of the survey, but are not mentioned in the instructions for any LIT surveys (though this information is covered in the *Project Location Documentation* section in the Harris manual, 2005). These components are invaluable tools in documenting the location of transects to insure accurate replication in successive re-measurement years. **We recommend adding the following statement directly to the instructions for all LIT protocols:**

> "Photograph transects and document the location and layout of transects on the site sketch. A site sketch should be completed at each site and should include landmarks, treatment area boundaries, photopoints and other features of importance."

All of the above changes to field methods and instructions were incorporated into our recommended revisions to the Gerstein and Harris (2005) protocols in Appendices B and C. See Appendix E for the revised line intercept transect data forms.

Bank Stabilization Restoration General Comments

If CDFG is interested in streamlining protocol text, we recommend revising the chapter on *Monitoring the Effectiveness of Bank Stabilization Restoration* (Gerstein and Harris 2005) to include only a concise introduction, guidance on protocol use, instructions and data sheets. The background information on erosion and streambank restoration is interesting, but could be eliminated. People reading this document should be familiar enough with stream processes and streambank restoration so as to not require this background information. The more concise and simple the document is, the more likely people are to read it thoroughly. See Appendix B for detailed recommended edits to this chapter.

We recommend that the table on page 5 of *Monitoring the Effectiveness of Bank Stabilization Restoration* (Gerstein and Harris 2005) be restructured to direct surveyors to the most appropriate protocol to use based on project objectives rather than monitoring questions. The questions are definitely interesting and worthy of programmatic considerations; however, most CDFG monitoring will focus on whether projects did or did not meet stated objectives.

Based on our field experience, **we recommend inserting the following paragraph after the table on page 5 of the Gerstein and Harris (2005) document to help standardize method selection:**

> "Whenever feasible, both Bank Stabilization Restoration Field Methods 1 and 2 should be used at each treatment site. Even if parameters for the primary project objective of increasing bank stability can be adequately assessed using Method 1, Method 2 provides an additional, visual documentation of change in bank angle, which reflects stability."

Bank Stabilization Restoration Field Method 1: Line Intercept Transects Along Banks

Please refer to the previous section *Line Intercept Transect Surveys (General)* for additional comments on field methods and written instructions applicable to this and other LIT protocols.

Field Methods

LIT surveys are a standard method which we found useful in assessing both bank stability and vegetative cover, two critical attributes at bank stabilization restoration treatment sites. This method provides definitive, quantitative information on changes to both bank stability and native tree cover, through comparisons of the percent of stable and vegetated bank before and after treatment. It should be noted, however, that the work involved in the installation of bank stabilization structures (e.g., heavy equipment access, extensive foot-traffic, vegetation clearing) can temporarily reduce the amount of vegetative cover at treatment sites. Our short-term post-treatment monitoring documented a reduction in native tree cover at one site, though long-term effectiveness monitoring of that site may point to an increase in cover over time. We measured greater stability at all project sites surveyed. **Given the variability of results, we recommend that data collected prior to and following treatment be interpreted with care to determine whether vegetative cover changed as a result of treatment implementation.**

Another complicating factor arises when target streambanks have been re-shaped or relocated. **CDFG and associated surveyors should be aware of the inherent difficulties of accurately replicating transects before and after treatments where extensive bank alterations have occurred.** Pre-treatment and post-treatment transects may be several feet apart and reflect very different conditions. For example, a LIT survey was conducted on Robinson Creek immediately prior to and shortly following implementation of a bank stabilization treatment that included extensive bank re-shaping. The pre-treatment transect was located along the original bank where over-hanging vegetation was abundant. The post-treatment transect was located along the new bank, more than 30 feet away, where there was no over-hanging vegetation at all. Along the LIT at bankfull, we estimated 12.1, 32.5, and 14.6 percent native tree cover during our pre-project survey and 8.0, 4.0, and 3.0 percent native tree cover during our post-project survey for the 0-3 foot, 3-15 foot, and 15+ foot height classes, respectively. Along the LIT at mid-bank, we estimated 11.1, 28.2, and 16.8 percent native tree cover during our pre-project survey and 0.5, 5.4, and 0 percent during our post-project survey for the 0-3 foot, 3-15 foot, and 15+ foot height classes, respectively.

Evaluating the resulting data could lead to the conclusion that, though the treatment increased bank stability, it dramatically decreased vegetation at the site. In cases like this, it is more efficient to use post-implementation (rather than pre-treatment) data as “baseline” data for monitoring changes in vegetative cover over time. If this limitation is clearly understood, we feel the proposed LIT surveys are an effective method of documenting changes in bank stability and vegetative cover as part of a long-term monitoring regime.

In regards to delineation of study areas, Harris et al. (2005) state that, “Until further data are available to refine the area of potential effects, the study area should extend 10-20 bankfull channel widths above and below treated areas”. Reach-level surveys will likely include this distance up and downstream. However, for site-specific monitoring, surveying up to 600 feet downstream in a relatively small channel with a bankfull width of 30 feet is probably unnecessary. It is time consuming (which may limit monitoring feasibility) and very likely too far from the treatment site to capture off-site effects. Surveying too large of an area also includes the risk of attributing unrelated detrimental effects to a given treatment.

At most sites we surveyed with channel bankfull widths in the realm of 30 feet, it was difficult to identify possible effects of a treatment (e.g., opposite bank erosion) occurring even as far downstream as 300 feet. Various features within that distance (e.g., additional structures, bank and bed geology, bends, vegetation in or near the channel) usually make it impossible to isolate streambank treatments as the cause of downstream conditions. It is also hard to imagine any reasonable bank treatment on streams of this size having *upstream* impacts for 300-600 feet. Yet, including the “10-20 bankfull widths” rule will cause dedicated surveyors to undertake the additional work of surveying points at that distance, possibly even causing them to overlook impacts closer to the site. The distance and location along the channel where significant effects can be expected will vary depending on project type. For example, baffles and deflectors may indeed have measurable upstream impacts, whereas treatments like willow walls and mattresses are unlikely to.

We recommend that the question of how far the study area (i.e., area to be monitored) should extend above and below treatment sites be further explored. Until this is defined, there is no certainty that all potential project impacts are being documented. This is also critical information for correlating instream benefits to restoration efforts implemented on the stream bank, which is a realistic objective over time (Lennox et al. 2007). **We recommend that the requirement to survey 10-20 bankfull widths upstream and downstream of treated sites be tested and a standard method for recording length of the study area be developed, based not only on channel size, but also project type.** This effort may not be conclusive, considering Harris et al.'s (2005) statement alluding to a lack of data "available to refine the area of potential effects". Nevertheless, some realistic standards must be adopted by CDFG for use in the monitoring program.

We encountered similar difficulties on a smaller scale when defining treatment areas. How should the specific treatment area (which, in turn, determines the length of the LIT survey) be delineated for a deflector or baffle that is intended to affect some distance above and below the structure itself? If the treatment area is limited to the structure location in such cases, it will probably not allow for the documentation of intended changes (e.g., sediment deposition downstream of structure). **We recommend that the question of how to delineate treatment areas be examined and a standard method for recording the length of the treatment area be developed, particularly for cases where impacts of the treatment extend beyond the immediate structure site.** This information should then be incorporated into all applicable monitoring protocols.

We also recommend that Method 1 include guidance on how to determine bank stability class when treatment effects are not limited to the structure installation site. For example, when conducting LIT bank stability surveys, should banks between baffles or immediately downstream of weirs be classified as "treatment area" or "no treatment"? **For pre-treatment surveys, we recommend classifying banks within proposed treatment areas as "no treatment" until project implementation is complete.** In general, there is too much ambiguity around the exact lengths and areas of proposed treatment sites until post-implementation, making it difficult to record treatment location accurately during pre-treatment surveys. **The instructions should also note that any location where a treatment was previously implemented should be considered a "treatment area", regardless of whether restoration structures still exist**.

Another detail is the categorical options available to determine bank stability. Footnotes to the Gerstein and Harris (2005) protocol note that limiting bank stability categories to two, rather than five, reduces observer error. However, we found that in several cases it was difficult to classify banks as simply "stable" or "unstable". Additional bank classification categories like "moderately unstable", if clearly defined, would allow for a more accurate depiction of site conditions. If a bank is experiencing some erosion that does not mean it is unstable, but it would be misleading to include it in the same category as the most stable bank. We repeatedly wished for the ability to classify banks using "moderately" or "extremely" stable. **We recommend that CDFG examine whether expanding this classification to include additional categories would increase their ability to accurately document changes in bank stability over time.**

Written Instructions

Surveyors using Method 1 are directed to "establish the line intercept transect through the permanent riparian vegetation closest to the channel bankfull line (this is a modified version of the "green line" method...) (Gerstein and Harris 2005)." However, most bank stabilization restoration sites do not have permanent riparian vegetation in the vicinity of the bankfull line, as they have experienced erosion and subsequent modification. Furthermore, the bankfull line is dynamic by nature (Rosgen 1996), often difficult to identify (particularly at modified sites), and somewhat subjective among surveyors. Because of these things, we do not recommend that transects be established along the "green line" as a rule. The most important thing is that the line intercept is well-documented and can be repeated, not that it is precisely at bankfull. Another important factor to consider is the location of transects in relation to restoration treatments, which are usually installed at or near bankfull. During our surveys, we generally established the LIT on the lower part of the bank at or near the bankfull elevation within the treatment area after a visual evaluation of the site. **We recommend modifying the instructions to read:**

> "…establish the line intercept transect approximately following the bankfull elevation. In many cases, the line will be placed over the top of restoration structures at approximate bankfull or through the permanent riparian vegetation closest to the channel bankfull line. If no vegetation or restoration structure is present in the vicinity of bankfull, the transect should follow the bankfull elevation as precisely as possible."

Surveyors will likely know the best location for the LIT after consideration of project objectives and a visual evaluation of the site. The most important thing is that the line intercept is well-documented and can be repeated, not that it is precisely at bankfull. **We recommend that specific transect location be defined and noted by surveyors at each site. We also recommend further enhancing the instructions to include the following:**

> "Record the vertical distance of the transect from stationary features or landmarks (where possible), and run the line at that elevation as consistently as possible. In the case of a willow mattress, for example, it may be most efficient to record the distance of the line above the toe boulders. When establishing a transect along bankfull in a braided channel with multiple bankfull lines, be sure to record which line the transect follows (e.g., bankfull line along outer right bank). The ability to replicate the transect location in successive re-measurement years is imperative. Record the bearing of your line from start to endpoint in the comments section of the data sheet."

The instructions on page 8 of *Monitoring the Effectiveness of Bank Stabilization Restoration* (Gerstein and Harris 2005) refer users to *Monitoring the Effectiveness of Riparian Vegetation Restoration* (Harris et al. 2005) for information on how to conduct a LIT survey. **We recommend including Figures 2-5 on pages 8-10 of that reference, along with all associated text, in the instructions for Field Method 1.** These figures and instructions provide valuable guidance on how to conduct LIT surveys and including them would make Bank Stabilization Method 1 a "stand alone" protocol, which surveyors could apply without having to bring instructions for riparian vegetation surveys into the field.

The current instructions direct users to assess bank stability from toe to top. When target stream banks are excessively tall visibility can be limited and different conditions at the toe and upper bank can make an accurate classification difficult. **We recommend including a height limit of 20 feet for the bank area to be assessed when determining bank stability class on banks taller than 20 feet.** We enhanced the instructions to read, "…record the stability class of the bank, as inferred from observing the bank from toe to top, or to 20 feet upslope for banks taller than 20 feet". This identifies the precise area to evaluate when taller banks limit the feasibility of an accurate assessment. This correlates with CDFG's method of assessing percentage of bank vegetated, as described in the Habitat Inventory Methods section of the *California Salmonid Stream Habitat Restoration Manual* (Flosi et al. 1998).

See Appendix B for all of the above and additional recommended revisions to the instructions for Method 1, including guidance on survey direction, page numbering, stability class, species codes and more. The instructions on pages 10 and 11 have been modified to accompany the revised Bank Stability Line Intercept Data Form in Appendix E.

Bank Stabilization Restoration Field Method 2: Cross Section Surveys

Field Methods

Cross section surveys are a standard, widely-accepted and effective way of documenting changes in channel geometry over time. **When considering cross section surveys as a long-term monitoring tool, however, surveyors and managers should be aware that certain site conditions can make the survey difficult, or even impossible, to perform.** We were unable to conduct this survey at three of fifteen treatment sites (20percent) due to lack of visibility through dense vegetation and/or site topography. Though pruning branches is a common part of performing these surveys, the amount of pruning required to facilitate the surveys at two of these sites was not feasible. At the third site, the topography was such that we could not set-up the laser level at the appropriate elevation to obtain an unobstructed view of the site.

Even at sites where cross section surveys can be performed without such complications in the early years after treatment, the feasibility of conducting surveys may be reduced over time, particularly if the project is successful and vegetation growth is vigorous. Eventually, vegetation is likely to cover the treatment site completely, obscuring visibility and creating a stable and functioning ecosystem that is difficult, or impossible, to survey in this manner without causing significant damage. Cross-section surveys will likely be an appropriate survey tool for most bank stabilization treatment sites if surveyors are prepared to be creative and do some vegetation pruning. However, **when choosing long-term monitoring sites, we recommend that surveyors carefully assess site topography and vegetation to ensure that survey instruments can be set-up above streambanks and benchmarks, with an unobstructed view of the laser detector.**

We recommend offering more specific guidance on the number and location of cross sections required at an individual treatment site, based on treatment area size, project objectives and possible off-site impacts. The current instructions state that, “In cases of small treatments (<75 feet long), one cross section may be sufficient to detect changes. For larger treatment areas, it is recommended that at least three cross sections, placed at the downstream and upstream ends and middle of the treated area, be used (Gerstein and Harris 2005)”. At what point (or treatment area size) should a survey include more than three cross sections? If one cross section is sufficient for treatment areas <75 feet long, should that be located in the middle of the treatment area?

During our field surveys, we placed cross sections at stratified locations across each treatment site to the best of our ability. In general, when working around existing vegetation and channel morphology, surveyors will tend to place transects in the easiest, most visible location. Nonetheless, **we recommend including some general guidance on cross section location, or at least a description of what attributes to look for when determining cross section location, to help reduce surveyor subjectivity and the amount of deliberation required at each treatment site.** This could be satisfied by adding the following statement to the instructions: “Look for cross section locations that are typical of the channel in the treatment area, with relatively clear views of geomorphic features”.

According to the current instructions, two benchmarks are required on the downstream end of the survey site and one at the upstream end. Locating even one solid benchmark in the field, let alone three, can be challenging, as permanent features are often not present in the vicinity of the treatment area. Locating, monumenting and describing benchmarks is generally quite time consuming. Harrelson et al. (1994) only asks surveyors to use one benchmark. We believe that two benchmarks would suffice in cases where three are not available. We also believe that benchmarks should not be limited by location upstream or downstream of the treatment area, as this can cause undue difficulty and unnecessary time expenditures in the field. If CDFG determines that three benchmarks *are* necessary, **we recommend asking surveyors to locate three permanent benchmarks, without specifying the number upstream or downstream. We also recommend including the definition of a benchmark and the rationale for needing more than one.**

The current instructions say to monument benchmarks in a "method suitable for the survey tools in use" and that cement monuments should be constructed for total stations (Gerstein and Harris 2005). **We recommend that the method in which benchmarks are monumented be determined based on resources allocated to surveying a particular site and what is acceptable to landowners, rather than on survey tools used.** If long-term monitoring at regular intervals is scheduled to occur at a given site, the cement monument described in Gerstein and Harris (2005) would be ideal (provided there is no recreational or livestock use of the site). As for CDFG's use of these protocols, it seems likely that, at least initially, sites will be monitored once within the first three years and hopefully once or twice in the future. If so, then boulder monuments or tree tags should suffice. If CDFG concurs, than this portion of the instructions should be modified. **We also recommend directing protocol users to the Harrelson et al. (1994) reference for additional information on how to establish benchmarks.**

Is it necessary to record water elevation during cross section surveys? We did not do this on our surveys, but it would be interesting to have data available to study how water depth correlates to climatic conditions, withdrawals and geomorphic factors. It is more labor-intensive, but **if CDFG supports collecting data on surface water elevation, it should be emphasized in the instructions and the code for water surface (WS) should be added to the data form.**

Written Instructions

We recommend including a simple cross section diagram on page 13 of the instructions for Method 2. This could be taken from page 26 of Harrelson et al. (1994).

We recommend including a modified version the Harrelson et al. (1994) method of establishing permanent cross section endpoints, for use in the field where feasible and acceptable to landowners. That is, drive a two to four foot piece of ½ inch rebar into each bank, leaving ½ inch above the surface. Attach colored plastic caps to the top of the rebar (these are available at survey supply houses). In most cases, drive a second, shorter piece of rebar as close as possible to the first, leaving 6-12 inches above the surface to attach the tape to. We support this as an effective and unobtrusive method of establishing permanent endpoints where it will not interfere with livestock or recreational uses of sites.

Though surveyors are directed to useful references for additional guidance on cross section survey techniques, the current instructions on how to perform the measurement portion of the cross-section are limited. Surveyors are assumed to be familiar with fundamental transit operations, as current instructions state only that users should, "Conduct the cross section survey by measuring elevations at each station…using standard differential leveling techniques (Gerstein and Harris 2005)". **We recommend adding elevation measurement instructions and associated diagrams (adapted from Harrelson et al. 1994) to the instructions for Method 2.** This would lengthen the instructions by a page or so but would make this a "stand alone" protocol with specific standards. Surveyors with experience in basic surveying techniques could conduct cross-section transects without having to consult additional references.

We recommend that the instructions emphasize site sketches as an effective means of documenting the locations of benchmarks and cross sections. These can be done on the back of the cross section data form.

We recommend enhancing the instructions to include better definitions of backsight, foresight, instrument height and elevation, as follows:

- "Back Sight is a rod reading taken on a point of known (or assumed) elevation, typically a benchmark. It is the actual vertical distance from the point to a horizontal line projected by the instrument. There is only one backsight measurement for each setup of the instrument."

- "Height of Instrument is the elevation of the line of sight projected by the instrument. This is calculated by adding the rod reading from the backsight to the known (or assumed) elevation at that point, typically a benchmark. For example, if the assumed elevation at the benchmark is 100 and the line of site of the instrument is 5.12 feet above the benchmark, then BS = 5.12 and HI = 105.12."

- "Foresight is a rod reading taken on any point to determine its elevation. All measurements across the channel are recorded in the FS column. The FS is subtracted from the HI to find the ground elevation of the point in question."

- Elevation refers to "the actual elevation of the point in question, calculated from HI, BS, or FS readings. If the elevation at your starting point (typically a benchmark) is not known, use an arbitrary elevation of 100 feet."

See Appendix B for the above and additional recommended revisions to the instructions for Method 2, including enhanced guidance on how to locate cross sections, document benchmarks, and perform the survey. The instructions on pages 19 and 20 of have been modified to accompany the revised Cross Section Data Form in Appendix E.

Riparian Vegetation Restoration General Comments

One of the primary problems encountered when sampling riparian planting sites is that it is often difficult to identify planted trees and shrubs among naturally-recruited vegetation, and even treatment area boundaries in some cases. Conditions become particularly obscured along the edge of channels where alders, willow and cottonwoods may be planted in high densities with no protective hardware. As early as one year after project implementation, many of these trees may have washed out, been buried by flood deposits, and/or natural colonization of these species may have occurred among the planted trees within the treated area. This problem may be alleviated by thorough documentation of site conditions and by surveying sites soon after project implementation and at consistent intervals thereafter. Whenever possible, repeat monitoring of a treatment area should be conducted by the same surveyors because every detail can not be recorded and interactions between watershed stability and site recovery are dynamic. There may be no absolute way to avoid this problem altogether, but **we recommend that CDFG explore options (both at the implementation and the monitoring levels) to increase the likelihood of locating planted vegetation on subsequent surveys, such as tagging trees.** Tagging trees is an effective means of tracking planted vegetation, but can be inefficient at larger sites. For sites where planted trees will not be marked and are likely to become obscured by the effects of natural regeneration over time or relict populations near the project site, the BACI approach may be a useful means of assessing changes in site conditions as a result of the treatment. However, the BACI approach is not useful for assessing survival of planted vegetation.

At any given riparian planting site, plant survival and the underlying causes tend to vary greatly across geomorphic features (i.e., channel, floodplain, upper bank, upslope) so it is common to experience different levels of plant success within a given treatment area. For example, floodplain plantings frequently wash out while upslope plantings may have a higher survival rate if irrigated. Sampling survivorship in all treated areas as one project feature leads to an overall survival rate that indicates very little about how plantings fared based on soil, available water and disturbance. Alternately, classifying project features according to the landform they occupy and assessing survival by species at the project feature level provides a more accurate and realistic representation of pertinent site conditions and project success. Likewise, breaking riparian planting sites into separate project features insures that the multiple data sets needed to compare changes over time are obtained. We have provided this feedback to encourage the development of guidelines on how to identify project features and assign project feature numbers. **We recommend that riparian vegetation restoration treatment areas be broken into multiple project features to be classified by landforms (e.g., channel margin, floodplain, upper bank) which are formed by past and current hydrologic regimes** (Harris 1987 and 1999). **We also recommend that project feature identification information specific to planting projects be summarized in the riparian vegetation restoration chapter in the monitoring manual.**

Vegetation surveys conducted after deciduous trees have lost their leaves can yield results that are drastically different from those obtained during the summer months. Variable seasonal conditions can affect canopy density, vegetation cover and plant identification feasibility. Though this basic fact will hopefully be understood intuitively by most protocol users, **we recommend that the timing of all riparian vegetation surveys be standardized, by season, around foliage presence and abundance on deciduous trees.**

We recommend that the table on page 4 in the introductory section of *Monitoring the Effectiveness of Riparian Vegetation Restoration* (Harris et al. 2005) be restructured to direct surveyors to the most appropriate protocol to use based on project objectives rather than monitoring questions. The questions are definitely interesting and worthy of programmatic considerations; however, most CDFG monitoring will focus on whether projects did or did not meet their objectives.

Based on our field experience, we recommend inserting the following paragraph after the table on page 4 of the Harris et al. (2005) document to standardize method selection:

> "In general, Riparian Vegetation Restoration Field Method 1 should be applied at all sites where treatments are intended to change conditions in the vicinity of bankfull, even if other Line Intercept Transect methods will be used in the rest of the treatment area. Either Method 2, 3 or 4 should be employed at all riparian planting sites, depending on which is most suitable for site layout and project objectives. Planted Tree Survival should be assessed at all planting sites and Method 7 should be employed at all sites where treatments are intended to impact canopy cover over the stream channel."

Riparian Vegetation Restoration Field Method 1: Line Intercept Transects Along Banks

Please refer to the previous section *Line Intercept Transect Surveys (General)* for additional comments on field methods and written instructions applicable to this and other LIT protocols.

Field Methods

Line intercept transect (LIT) surveys are a standard method which we found useful in assessing vegetative cover by species and height class at riparian vegetation restoration treatment sites. The different vegetation height classes are useful for differentiating between colonizing and established populations, as well as effectively representing mature tree populations.

Method 1 should be used, by itself or in conjunction with additional methods, at all riparian vegetation restoration sites where streambank or floodplain plantings are intended to increase vegetation cover along, or canopy cover over, the channel. If the treatment area extends beyond the edge of the channel, then Method 1 should be employed in conjunction with additional methods for a thorough assessment of the entire treated area. If the treatment is not intended to impact the channel at bankfull, then Method 1 need not be used at all.

We experienced some confusion about how to apply Method 1 on subsequent surveys at sites where bankfull location had changed since the initial survey; a point which is not directly addressed in the current protocol text. Richard Harris (personal communication, 2007) explained that, though theoretically the location of bankfull discharge does not change, in alluvial channels with unstable beds and banks it may shift in response to localized scouring or deposition. He said that at the initial measurement best efforts should be made to locate the bankfull discharge stage. Subsequent measurements can either replicate the original survey line or re-establish the bankfull line and survey along it, even if it has shifted slightly, as there should not be extreme differences between the two results unless the channel has actually changed location. **We recommend that this information be included in the instructions. We also recommend that CDFG identify the location at which to conduct the Method 1 survey—along the original survey line or the newly created bankfull line—in the event that bankfull location shifts *drastically* as a result of stochastic events.** This will help insure consistency in method application.

Written Instructions

The standardized location of the LIT for Method 1 is at, or near, the bankfull line for the target stream bank. As with Bank Stabilization Method 1, surveyors using this method are directed to "establish the line intercept transect through the permanent riparian vegetation closest to the channel bankfull line (this is a modified version of the "green line" method...)" (Harris et al. 2005). The bankfull line is dynamic by nature (Rosgen 1996), often difficult to identify and somewhat subjective among surveyors. Furthermore, many restoration sites do not have permanent riparian vegetation in the vicinity of the bankfull line. As a result, we do not recommend that transects be established along the "green line" as a rule, though we did find it to be useful where bankfull was ambiguous at one site with a braided channel. **We recommend modifying the instructions to read:**

> "…establish the line intercept transect along the bank approximately following the bankfull elevation. Start on the left bank if both banks are within the treatment area. In many cases, the line will run along the base of the permanent riparian vegetation closest to the channel bankfull line. If

no vegetation is present in the vicinity of bankfull, the transect should follow the bankfull elevation as precisely as possible."

Surveyors will likely know the best location for the LIT on the initial survey after a consideration of project objectives and a visual evaluation of the site. The most important thing is that the transect is well-documented and can be repeated, not that it is precisely at bankfull. **We recommend that specific transect location be defined and noted by surveyors at each site.** This is helpful for repeating the LIT in a dynamic landscape and for documenting changes to the site from reach-scale process such as incision or aggradation. **We recommend enhancing the instructions to include the following:**

> "Record the vertical distance of the transect from stationary features or landmarks (where possible), and run the line at that elevation as consistently as possible. When establishing the transect along bankfull in a braided channel with multiple bankfull lines, be sure to record which line the transect follows (e.g., bankfull line along outer right bank). The ability to repeat the line transect in successive re-measurement years is imperative. Record the bearing of your transect from start to endpoint in the comments section of the data sheet."

See Appendix C for the above and additional recommended revisions to the instructions for Method 1. The instructions on pages 14 and 15 have been modified to accompany the revised Riparian Line Intercept Data Form in Appendix E.

Riparian Vegetation Restoration Field Methods 2-4: LIT Variations

Please refer to the previous section *Line Intercept Transect Surveys (General)* for additional comments on field methods and written instructions applicable to this and other LIT protocols.

We were interested in assessing the relationship between vegetation cover captured during LIT surveys and the actual total cover by planted vegetation over the entire project feature. We estimated the cover of each planted individual during our direct counts and calculated the total percent cover for each project feature given its total area. The positive relationship between actual planted vegetation cover and LIT native tree cover was significant for both 0-3 foot and 3-15 foot height classes (R^2=0.42, p=0.001; and R^2=0.16, p=0.048, respectively). The stronger relationship for the shorter size class was expected, given that we were not able to accurately assess individual tree cover using our adapted census cover method in dense, established willow thickets.

Field Methods

The LIT sampling method is standardized, widely-accepted and useful. Our experience with this protocol indicates that it is effective at capturing changes in conditions over time at a defined location. The results can be utilized to show general trends in trajectory by region when multiple sites are pooled together for assessing program effectiveness. Despite the problems identified in this section, LIT surveys offer a practical tool for quantifying revegetation project effectiveness. Surveyors can utilize the following recommendations to be confident that baseline monitoring efforts will be efficient and productive in the long run.

Riparian Vegetation Restoration Field Methods 1-4 are different variations of LIT surveys. Method 1, Line Intercept Transects Along Banks, serves the specific purpose of assessing changes at or near the bankfull boundaries of the stream channel. Methods 2-4, however, are essentially the same method with different transect layouts—across channels, across floodplains and through delineated treatment areas, respectively—depending on treatment objectives and the size and shape of the treatment area. We believe it would be most efficient to combine methods 2-4 into one protocol named Line Intercept Transects Through Delineated Treatment Areas (currently Method 4). This would eliminate unnecessary and repetitive text and simplify the survey process. This combined method would be suitable for any treatment area, regardless of project objectives or site parameters. Surveyors would simply determine transect layout for each project feature based on the size and shape of the area, eliminating the need to review each method and deliberate which to use for every single treatment. **Users should be reminded that Method 1 must also be used, in conjunction with Line Intercept Transects Through Delineated Treatment Areas, at all riparian vegetation restoration sites where streambank or floodplain plantings are intended to increase vegetation cover along, or canopy cover over, the channel.**

Adopting this combined method, and making the necessary revisions, would also eliminate certain problems within the current protocols. For example, the statement on page 15 which explains that Method 3, Line Intercept Transects Across Floodplains, is "intended for monitoring changes within a zone extending 50 feet out from the channel", yet proceeds to say that Method 3 is not suitable for sites where the riparian zone is less than 50 feet wide (Harris et al. 2005). This is confusing. It also states that, in such cases, Method 1 should be adapted for use instead, despite the fact that Method 1 is not a sufficient means of surveying upper bank plantings more than ten or twenty feet away from the channel. **We recommend that Field Methods 2-4 be combined into one protocol and that the instructions be edited and enhanced at that time.** Revisions would include, but not necessarily be limited to, those recommend in the Line Intercept Transect Surveys section of this report and those detailed below.

The current protocols for Methods 2-4 contain minimal guidance on how to determine the number of transects to be sampled at a given treatment area, or how to ascertain whether a sufficient number of transects has been sampled to capture the variability of the attribute of interest (e.g., cover, species composition). The instructions for Method 4 state that, "Normally, multiple transects will be used," and that, "…the number to sample should be estimated based on vegetation variability. A minimum of four transects is recommended (Harris et al. 2005)." Unfortunately, there are no instructions describing how to estimate transect numbers based on vegetation variability, leaving the exact number of transects to sample at each site undefined. Furthermore, the recommended minimum of four transects is questionable. While a minimum of four transects seems appropriate in a 50-foot wide by 150-foot long treatment area, would it really be necessary in a 20-foot wide by 1000-foot long treatment area where two long transects should capture sufficient data? **We recommend that, if possible, the number of transects to be sampled at a given treatment area be standardized since data collected from the same site could produce drastically different results depending on the number and locations of transects surveyed.** The question is: How can this be done and effectively applied to treatment areas of different sizes, planting densities and species diversity?

The primary reference cited by Harris et al. (2005), confirms that, "The amount of variation in plant species composition and distribution determines the number and length of transects required for sampling (FIREMON 2003)." They recommend sampling five transects but stipulate that there are situations where more transects should be sampled. Users are referred to another chapter in the FIREMON document, *How to Determine Sample Size*, which explains a statistical method of determining whether a sufficient number of transects has been sampled by plotting graphs of mean values for varying sample sizes. This exercise is time-intensive since it requires evaluators to manually calculate data results and plot graphs accordingly, (usually) sample additional transects and then repeat the exercise until the unknown target number of transects has been achieved. If evaluators choose to use a program like Excel to expedite the process, then they will likely need to return to the office (unless they have a powered laptop for field use) to calculate data results, then again to the field if the sufficient number of transects was not surveyed during the first visit. This could be repeated multiple times until the sufficient number of transects was determined and sampled—an incredibly time-consuming process.

Alternatively, the plot sample methods proposed by Harris and team, Methods 5 and 6, consider a sample size of two percent of the vegetation restoration project area to be sufficient in general (Harris et al. 2005). It seemed likely to us that sampling a set percentage of the treatment area would also be sufficient for LIT methods. We used several project site maps to test this theory, assigning varying sample sizes as a proportion of the total treatment area (broken down by project feature), and found that a sample size of two percent resulted in an average spacing of five feet between transects. This spacing proved to be closer than we desired, often capturing the same relict tree cover multiple times and leading to an unnecessary amount of work. We found a sample of one percent of the total treatment area to be preferable for LIT surveys, as it consistently resulted in what seems to be an adequate number and spacing (an average of ten feet apart) of transects. This approach was easy to apply in the field and appeared to capture sufficient data to reflect site conditions.

We conducted the following exercise to calculate survey specifications for our proposed "One Percent Stratified Sampling Method":

LIT survey results are calculated as the sum of all transects sampled (not an average of multiple transects) so we found the most relevant metric to be *total length of transects* sampled, rather than the number of individual transects. The width of the transect line along the measuring tape is roughly 0.1 foot, so we assigned this value to all transect widths in order to obtain a square foot measurement based on transect length. We used the approximate area (square feet) of the project feature (average length X average width) to determine the total length of transects to be sampled; equal to one percent of the project feature area. Then, we divided the total length of transects to be sampled by the average length of the project feature to determine the number of transects to be sampled. Finally, the width of the project feature was divided by the number of transects to determine the distance at which transects should be spaced apart.

For example, a project feature that is 848 feet long by 50 feet wide will have a total area of 42,400 ft.^{2}. One percent of that area is 424 ft.^{2}. Assuming the width of each transect sampled is 0.1 foot, then ten feet of transect is equal to one square foot. So, multiply 424 by ten to obtain the necessary footage of transect to be sampled (e.g., 4,240 feet). The total footage to be sampled is then divided by the length of the project feature to determine the number of transects to be sampled (e.g., 4,240/848 = 5). The number of transects sampled is then divided into the average width of the project feature to determine transect spacing (e.g., 50/5 = 10 feet apart).

Using this method, transects will be spaced an average of ten feet apart (approximately eight to twelve feet). In general, the number of transects to be sampled should be rounded to the nearest whole number, rounding up for values of 0.5 feet. In all cases, the first transect will be inset from the boundary of the project feature at a random distance between one and five feet (1/2 of the average ten-foot transect spacing) to be determined using a random number table. Subsequent transects will be evenly stratified across the project feature. In most cases, transects will be established parallel to the stream channel because of the linear riparian corridor landscape position of most coastal streams; however, if surveyors need to establish transects perpendicular to the channel due to site layout or location of plantings the number and spacing of transects can be determined using the same exercise explained above using average project feature width in place of length (e.g., 4,240 feet to be sampled/50 feet average width = 85 transects, spaced 10 feet apart). LIT surveys conducted perpendicular to the channel often extend across multiple project features, as they tend to move from the edge of channel, through the floodplain and onto the upper bank. We recommend choosing LIT locations which represent single project feature units. The "One Percent Stratified Sampling Method" can be adapted as needed, particularly when working with irregular project feature polygons or at locations where project attributes can clearly be captured using fewer transects (e.g., limited species diversity, fast-growing species, etc.).

We are *not* suggesting that this method is an equally valid replacement for the statistical method of determining sample size presented in FIREMON (2003). However, we do not feel that conducting that exercise for every project feature at each treatment area is a reasonable expectation within the context of CDFG's monitoring program. The Harris LIT protocols (Harris et al. 2005) offer no definitive information on how to determine sample size, yet without this information is it virtually impossible to apply the methods in a consistent manner. A standard and applicable means of determining number and locations of transects to sample is a critical component of the LIT protocols. Due to this overt need, we are offering the "One Percent Stratified Sampling Method" as one possible solution for standardizing sample size based on treatment area size. It is intended to be used as a rule of thumb to reduce subjectivity in the survey process. It will require further field testing to determine whether one percent is indeed a sufficient sample size for capturing changes over time; we were not able to test this as we had no baseline data for the sites we sampled. **Thus, we recommend that the "One Percent Stratified Sampling Method" be considered as a possible standard method of determining number and location of transects to be sampled. We also recommend that it be field tested at variable project sites and statistically analyzed for sufficiency in capturing the desired project attributes (e.g., vegetation cover, species variability, etc.).**

If the one percent sampling method is not considered as an option, and no other viable solution is introduced, determining the number of transects to be sampled subjectively in the field will lead to inconsistencies. **If no alternative method for determining sample size is adopted, then the steps for plotting graphs of mean values for varying sample sizes or, at the very least, a reference to additional information on this topic should be included with the written instructions. Furthermore, if Methods 2-4 will be adopted in their current forms, we recommend that laptop or handheld PCs be utilized so data can be entered directly and species-area curves may be graphed in the field.** This will be much more efficient than processing and plotting data manually, but will still take a substantial amount of time.

Another critical component of LIT surveys that presents a concern is the location of transects sampled at sites where plantings are not uniformly distributed. According to the current protocol, random transect locations are established within project polygons through the use of a random number table or similar number-generating tool. It is common for transects to be placed along open paths, particularly in the early years following planting when foliar cover may only extend one or two square feet around seedling stems and more frequently where irrigation lines are installed. We experienced several cases where transects fell entirely on bare ground, capturing zero percent cover along the line. If this occurs during the initial survey of a site should the transect be abandoned and a new line established or should it be sampled during the initial and subsequent surveys? Technically, selecting a transect location different than that dictated by the random number table introduces bias and subjectivity into the survey process. Nevertheless, documenting the location of, and repeatedly sampling barren transects could be construed as an inefficient use of time (documenting transect location is particularly time-consuming).

If the *One Percent Stratified Sampling Method* (or other standard method) is adopted, it will resolve this problem, simply by mandating the number and location of transects to be sampled, regardless of data captured at each location. As the protocol is written now, with the exact number of transects undefined, there is a tendency to feel as though sampling barren lines is frustratingly futile and one should compensate for it by sampling additional transects. If the one percent method is not adopted and it is determined that sampling transects along barren lines is futile, techniques should be established to govern how these situations should be addressed. It is possible that certain practices could help alleviate these problems; things like surveying sites at an angle so that open pathways and densely planted rows are more likely to be avoided, or simply waiting until vegetation growth is substantial before conducting LIT surveys. These points must be considered and practical solutions to the common problems associated with transect number and location must be developed.

It is possible that LIT surveys would represent conditions more accurately at older planting sites where substantial canopy cover would reduce bare areas and create more balanced cover conditions. Unfortunately, we cannot comment on the effectiveness of Methods 2-4 in assessing older sites since we did not sample any sites older than five years using these methods; our sites were selected to correlate with the age of the sites most likely to be sampled through the FRGP—an average of three years after implementation. However, it appears that the problem of barren transects may simply be a function of planted vegetation age; one that would be eliminated once successful vegetation has grown sufficiently to reduce the size of gaps between plantings. Conducting LIT surveys at planting sites younger than, perhaps, ten years old may be a poor allocation of limited monitoring resources, as data may not reflect significant changes before that time. Willows and other fast-growing species may increase cover and effectively close gaps in a shorter period of time, but these species will likely be captured in Method 1 surveys, which assess conditions at bankfull.

Furthermore, it may not be a viable expenditure of time to employ Methods 2-4 at riparian planting sites within the first few years after project implementation, since the abundance of established trees may not differ significantly from that collected prior to implementation. We were interested in how the cover of established trees changed over time so we assessed the 3-15 foot height class and found a 5.7 percent (± 1.3 SE) mean cover in the zero to three year old project age group and 14.0 percent (± 5.1 SE) mean cover at the three to six year old riparian planting sites (Figure 3). The post-treatment percent cover at the two project sites sampled before and after implementation was not significantly different than pre-treatment mean cover (12.2 percent ± 6.6 SE). Is it worth the effort involved in surveying each treatment site multiple times within the first five years post-treatment to capture slight incremental increases in cover? More to the point, what is a viable measurement frequency for follow-up surveys? **We recommend that baseline LIT data be collected prior to riparian planting treatments, with post-implementation monitoring conducted five or ten years after implementation, at which time plant growth should be a definitive indicator of project success.**

We also recommend that additional field testing be done to quantify the relationship between cover estimates obtained during census (direct count) and LIT surveys for each species and each landform (e.g., channel, floodplain, upslope). It might be determined that there is a general age (of plantings) at which the two surveys will yield corresponding data.

There was some discrepancy as to how exactly to define the perimeter of the project feature area. Should the boundary be drawn at the base (trunk) of the furthest planting on each side or extend five feet or more beyond the base to capture future plant growth? Since the extent of future foliar growth beyond the base of an individual planting is difficult to predict, **we recommend using the edge of plantings (foliar**

cover) on the initial post-treatment visit to define the project feature area boundary. Transect length could be extended in the future, if desired, to capture additional growth. Also, roughly rectangular areas are much easier to work with than irregularly shaped polygons, so evaluators should attempt to draw rectangular boundaries where possible; i.e., if it does not cause large patches of untreated areas to be captured, misrepresenting project conditions. Where this was not feasible during our surveys, we used average lengths and widths to estimate total project feature area.

Written Instructions

Though comprehensive revisions were not made to the instructions for Methods 2-4, several comments on the sections prior to the instructions for each protocol are included in Appendix C. Any additional revisions to these sections or the instructions should be made after the methods are combined, if CDFG approves of the combination. At that time, step-by-step instructions, including specific instructions for the revised Riparian Line Intercept Data Forms in Appendix E, can be copied from the chapter on Riparian Vegetation Restoration Field Method 1 and modified as needed.

Riparian Vegetation Restoration Field Method 5: Planted Tree Survival Assessment

Field Methods

As stated in the Harris et al. (2005) protocol, Field Method 5 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." The majority of riparian planting projects with which we are familiar contain single and multiple stem seedlings planted randomly or in clumps, and not in the uniformly distributed manner which is a fundamental assumption of the sampling design. The planting distribution for which this method appears to be devised is more common to timber reforestation projects. Clumped plantings tend to be preferable within the riparian corridor, due to the variety of landforms in the vicinity of stream channels and the autecology specific to each plant species in terms of sunlight, water and disturbance.

In our attempts to field test Method 5, we were unable to locate any planting sites with the appropriate plant distribution or the necessary treatment area width. In order for this protocol to function as designed, project features must be at least 148 feet wide. Though this fact is not stated directly in the protocol instructions, when we attempted to apply the protocol at treatment areas less than 147.5 feet wide, we found that the number of sample plots increased in a manner inconsistent with the equations contained in the protocol, making it impossible to apply. It appears that Method 5 may be suitable for large-scale reforestation projects like those commonly being implemented at abandoned floodplain orchards along the Sacramento River, rather than the riparian plantings with which we are familiar with on coastal streams.

Therefore, instead of using Method 5 to assess planted tree survival, we conducted a census (i.e., direct count) at each of the planting sites that we surveyed, which included cover estimates for individual plants (width and length to the nearest 0.5 foot). The mean survival at the planting sites we surveyed was 59.2 (± 6.7 SE) percent ranging from 1.7 to 98.3 percent. We also assessed the relationship between survival and cover using our estimated cover from the direct count census survey. We found a significant linear relationship for late seral tree species (R^2=0.47, p=0.0003) and a trend of a linear relationship for early seral tree species (R^2=0.13, p=0.060). The dynamic nature of the floodplain habitat for the early seral pioneer species may explain the weaker relationship between survival and cover that we observed.

It is clear that CDFG needs a protocol for planted tree survival that can be effectively applied at the majority of riparian planting sites. **We recommend a census by project feature as the primary method of assessing survivorship.** The technique is straight-forward, accurate, and easy to apply at smaller sites. **We also recommend collecting information on plant vigor and cover estimates during the census, wherever resources allow it.**

The fundamental question is: At what scale does it become too laborious to conduct a direct count? This is a function of treatment area size and planting density. The instructions for Method 5 state that all seedlings should be counted if the project polygon is less than 0.25 acre. We found it efficient (in terms of time expended) to conduct a census at sites up to 1.5 acres. It is likely that it would be efficient for even larger areas, though we did not survey larger sites using this technique. If one reads between the lines, the requirement of a minimum of 5 sample plots when using Method 5 could be interpreted to mean that sites should be at least 2.5 acres for that method to be employed in place of a direct count (a minimum treatment area of 2.5 acres is necessary to obtain 5 or more plots using equations included in the protocol). **We recommend that this issue be examined further and propose a minimum treatment area of 2.5 acres as a basis for using a plot sample method in place of a census (to be increased or decreased as individual site conditions dictate).** CDFG and CCC personnel, restoration contractors and researchers with experience in monitoring survivorship should also have some viable input on this topic.

We recommend that Method 5 be field tested at large, uniformly planted project sites typical of the Central Valley to determine whether it is suitable for assessing those types of riparian planting sites. We also recommend that a standard protocol for assessing planted tree survival at riparian planting sites with random and clumped plantings be developed, field tested, and included in the monitoring manual for use where a census is not an efficient option. Alternative plot sample methods, including Method 6, should be examined for suitability in assessing survivorship at riparian planting sites commonly implemented through FRGP. Though we did not test Field Method 6, Floodplain Forest Composition Plots, as per our agreement with Barry Collins, our initial review of that protocol suggests that it may be useful for assessing planted tree survival in treatment areas larger than 75 feet wide.

We also recommend that, for the time being, Method 5 remain in the monitoring manual for use where appropriate, such as the large-scale floodplain planting sites found in the Central Valley and other large riverine systems throughout the state. If a new plot sample method is developed and found to be useful at all sites, regardless of plant distribution, it could ultimately replace Method 5. **In the meantime, certain caveats about the limitations of this method, particularly in terms of plant distribution and treatment area width, should be emphasized and the name should be changed accordingly** (e.g., Planted Tree Survival Assessment for Large, Uniform Sites).

Furthermore, certain aspects of Method 5 could be simplified. According to our calculations (using the provided equations) the number of sample plots and the distance between lines and plots on the line are relatively consistent figures, suggesting that it may not be necessary for surveyors to perform the equations outlined in the first two paragraphs of the instructions. We found no exceptions to the rule that the number of plots required for sites less than 30 acres in area will be equal to twice the number of acres (two plots per acre). We also found that the distance between lines and plots on the line for treatment areas less than 30 acres will consistently equal 147.5 feet, with an inset of 73.8 feet from the project polygon boundary. We did not test this for sites greater than 30 acres, but we expect the results to be similarly consistent. **We recommend that this information be verified by CDFG to their satisfaction and that the equations from Method 5 be replaced with the resulting numbers in order to reduce the amount of work required and potential for user error when applying this protocol.**

We also recommend that Method 5 be modified to include more vigor classes. Currently, vigor class is limited to "live", "dead" or "poor health". Adding a class such as "vigorous growth" would insure that it is duly noted when trees are thriving in their environment. This information could prove valuable in a future research study of causal mechanisms for planting project success and failure. **We also recommend that the term "vigor" and each vigor classification be defined in the instructions.**

Written Instructions

See Appendix C for all recommended revisions to the current instructions for Method 5. The instructions on pages 24 of that section have been modified to accompany the revised Plantation Survival Data Form in Appendix E.

Riparian Vegetation Restoration Field Method 6: Floodplain Forest Composition Plots

Though we did not test Method 6, as per our agreement with Barry Collins, our initial review of this protocol suggests that it may be useful for assessing planted tree survival in treatment areas larger than 75 feet wide. Nevertheless, we would like to state that **we recommend census (direct count) surveys as the most effective method of assessing species composition in treatment areas up to 2.5 acres in size, or the area (greater or smaller than 2.5 acres) at which a census becomes inefficient based on site layout and planting density.**

Riparian Vegetation Restoration Field Method 7: Intercepted Sunlight Due to Riparian Canopy

We measured solar availability using a Solar Pathfinder, as recommended by Harris et al. (2005) in Method 7, at all project sites where treatments were intended to increase shade due to riparian canopy. We also estimated shade as canopy density using a Densiometer. The correlation of the results obtained using each method was highly significant (Figure 5).

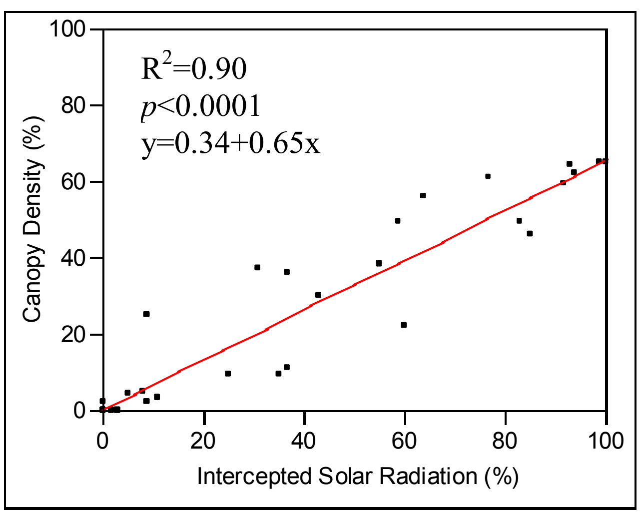

Figure 5. Correlation between intercepted solar radiation (Solar Pathfinder) and canopy density (Densiometer).

Our results agree with other research done to compare the two methods (Lennox et al. 2007). The Solar Pathfinder method measures slightly more shade compared to the Densiometer method. Though the

Densiometer method appears to produce data with slightly greater variability, the data may represent riparian vegetation to a greater degree than the Solar Pathfinder method. This is because the Pathfinder captures greater amounts of shade from topography and vegetation further toward the horizon than the Densiometer. As a result, restoration project monitoring programs should utilize the method that is most convenient and consistent with previous data collected.

Field Methods

Because data obtained using a Solar Pathfinder is so similar to that obtained using a Spherical Densiometer, one could question the need for assessing available or intercepted solar radiation in this manner during *quantitative* surveys while Densiometers are currently being used to assess canopy density during *qualitative* surveys. Solar Pathfinders are precise and useful instruments that provide accurate measurements of shade and available sunlight. When used with the optional paper diagram chart, they also offer a visual record of changes in canopy cover over time. In addition, the Pathfinder protocol requires the collection of air and water temperature data, which is not currently collected during qualitative monitoring surveys.

Nevertheless, because the Spherical Densiometer has always been the standard method of assessing canopy for CDFG stream habitat assessment and improvement programs it is consistent with previous data collected. Also, acquiring Solar Pathfinders and performing the associated surveys will require additional resources. **We recommend that the Spherical Densiometer be specifically utilized for canopy density assessments for CDFG monitoring purposes.** Because canopy density is currently being assessed during *qualitative* surveys, **we recommend not duplicating those efforts during *quantitative* surveys.** If CDFG decides to use the Solar Pathfinder, **we recommend that surveyors complete the "optional" diagram charts in order to provide a visual record of changes in canopy cover over time.**

We also recommend adding air and water temperature data collection to the relevant qualitative monitoring protocols, to be conducted at least once at each treatment site. In regards to collecting temperatures for reach scale surveys, the instructions for Method 7 ask surveyors to record air and water temperatures on "transects # 1, 10, 20 and 30 only" (Harris et al. 2005). The wording implies that 30 or more transects will always be sampled (an average of 3000 feet of stream), which is not the case. Many reaches will contain ten or fewer transects (shorter than 660-1000 feet). It may be preferable to adopt current CDFG methods that dictate the distance along the stream at which air and water temperatures are collected. Regardless of whether CDFG decides to include Method 7 in the monitoring manual or remove it in favor of the Densiometer assessments conducted during the qualitative monitoring, **for reach-scale canopy assessment surveys we recommend that protocols for air and water temperature collection be standardized to the instream methods currently utilized by CDFG.**

Because it is unlikely that canopy data collected prior to project implementation will differ significantly from that collected shortly after implementation, **we recommend that baseline canopy data be collected prior to treatment. We recommend that follow-up monitoring occur again in five to ten years, depending on the species planted (e.g., fast-growing riparian species, slow-growing hardwoods),** as significant changes in canopy generally require several years to manifest.

Written Instructions

The instructions for Method 7 contain multiple contradictions on how to collect data using the Solar Pathfinder. The protocol title, Intercepted Sunlight Due to Riparian Canopy, implies that this method is intended to measure intercepted, rather than available, sunlight. This is also stated in the Data Analysis section on page 34 of that protocol (Harris et al. 2005): "The data collected will be percent of sunlight subject to interception by canopy or topography during the chosen month". By contrast, the field method on that same page and the instructions on page 36 direct users to estimate solar radiation received at the site and to record that data on the Effective Shade Form as "solar availability" (Harris et al. 2005). There appears to be some confusion as to whether solar availability or intercepted sunlight should be assessed. **This must be reconciled if this protocol is to be included in the monitoring manual. We recommend using the Solar Pathfinder to collect data on intercepted sunlight, rather than solar radiation, because canopy cover and density are usually considered in terms of shade and because data will be closer to that produced by the Densiometer.**

For Densiometer use, we recommend that the difference between canopy closure and canopy density be explained in the instructions. This can be taken directly from CDFG's *California Salmonid Stream Habitat Restoration Manual* (Flosi et al. 1998, p. M-5):

> "Vegetation canopy closure is the area of the sky over the selected stream channel that is bracketed by vegetation (regardless of density). Canopy density is the amount of sky blocked within the closure by vegetation. [When using the Densiometer], the number of points (line grid intersects) that are covered by vegetation are counted when measuring canopy density. The number of points surrounded by vegetation are counted when measuring canopy closure."

Though it should be fairly common knowledge, specifying the need to assess canopy *density*, as opposed to *cover* (unless otherwise dictated by study design), provides an extra level of clarity since the two terms are often used interchangeably.

Because canopy cover can change drastically by season, **we recommend that the instructions state that data be collected during the summer months, before deciduous leaf-fall occurs.** Though surveys are generally conducted during the summer season, they can extend into November in the absence of early rain.

See Appendix C for recommended minor revisions to the instructions for Method 7. The instructions on pages 35 and 36 have been modified to accompany the revised Effective Shade Data Form in Appendix E.

CONCLUSION

During the summer of 2006, we field tested the quantitative effectiveness monitoring protocols outlined in *Monitoring the Effectiveness of Bank Stabilization Restoration* (Gerstein and Harris 2005) for usability and efficacy. We also field tested five of the seven protocols outlined in *Monitoring the Effectiveness of Riparian Vegetation Restoration* (Harris et al. 2005). We applied these protocols at a total of 30 recent and current restoration sites in Marin, Sonoma and Mendocino Counties. Clearly, this effort would not have been possible without the high quality work completed by the Harris team in 2005.

At a programmatic level, we suggest that quantitative and qualitative monitoring efforts be coordinated because the two methods function in a complimentary manner to offer a holistic overview of restoration project outcomes. Employing both types of monitoring at the same treatment sites would also eliminate duplicative work, insure that details like project feature numbers are addressed in a consistent manner and, most importantly, allow for and understanding of how quantitative monitoring data corresponds with qualitative ratings. Other key points that must be addressed and standardized for both qualitative and quantitative monitoring programs include timing of monitoring surveys and project feature identification.

We found all of the protocols to be useful in their current forms, though several questions arose during their application, ranging from broad, programmatic issues to specific field application procedures. Our resulting comments and recommendations focus primarily on increasing efficiency and reducing potential inconsistencies and ambiguities in the survey process.

We recommend that all protocols be included in the manual in their *revised* forms, with the possible exceptions of Riparian Vegetation Restoration Field Method 5, Planted Tree Survival Assessment, and Method 7, Intercepted Sunlight Due to Riparian Canopy. Method 5 does not appear to be a suitable method of assessing survivorship at many riparian planting sites common to coastal California due to treatment area size and plant distribution specifications. We recommend prioritizing the development of a more suitable protocol for assessing planted tree survival that will enable CDFG to determine whether survival rates are acceptable at large riparian vegetation restoration project sites. Method 7, using a Solar Pathfinder to measure available solar radiation, is an effective and well-written protocol but may not be necessary, as canopy density is currently being assessed using Spherical Densiometers during qualitative monitoring of restoration project sites. Furthermore, since the Densiometer has historically been the standard instrument for measuring canopy density in CDFG fish habitat assessment and restoration efforts, it is consistent with previous data collected.

We suggest that three of the riparian vegetation restoration LIT survey methods (Methods 2, 3, and 4) be merged in order to simplify protocol application. We outline how these methods could be combined into one standardized method that is adaptable to any treatment area. We also propose a systematic means of determining how to establish and locate transects given project feature area. This *One Percent Stratified Sampling Method* might ultimately prove useful in resolving the problem of sample size for Methods 2-4, though it will require additional field-testing and data analysis before its viability can be confirmed.

We hope that the information we have provided will be used by CDFG to revise these protocols. Appendices A, B and C are intended to act as tools to facilitate such revisions. Appendix A, a summarized list of all recommendations, is a check list to insure that each recommendation is addressed. Appendix B (Gerstein and Harris 2005) and Appendix C (Harris et al. 2005), modified versions of the Harris et al. documents, highlight our recommended changes and comments within the context of the original protocol text to insure that revisions are made in the correct locations within the respective documents. If the points outlined in this report can be resolved, we feel that CDFG's monitoring program can effectively meet the needs of their federal funders, act as a model for systematic statewide monitoring and provide critical data to guide research and development within the science of fisheries habitat restoration. Years of field testing and refinement may be necessary in order to perfect a set of protocols that accurately reflect the wide array of variables encountered at restoration treatment sites across the state. We believe that the monitoring protocol development effort should be viewed as an ongoing process, subject to improvements and revisions even after protocols have been officially adopted for use. Surveyors utilizing the protocols should keep notes on key issues and intermittent updates should be considered as new needs and limitations are discovered.

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APPENDIX A. SUMMARIZED LIST OF RECOMMENDATIONS

*Please see page numbers following each recommendation for additional information.

MONITORING PROTOCOL REVIEW AND RECOMMENDATIONS

1. We recommend that the instructions for all methods include a list of equipment needed to perform the survey (p. 11).

2. We recommend that qualitative and quantitative monitoring efforts be coordinated and that qualitative surveys be performed prior to quantitative surveys at each site (p. 13).

    a. We recommend that the resulting data be analyzed for correlations between the two survey methods as part of a long-term effort to improve the monitoring program (p. 13).

3. In regards to project feature identification, we recommend that:

    a. the difficulties associated with inconsistent project feature numbering throughout all project phases and monitoring efforts be investigated further and that standardized solutions be drafted for inclusion in the final CDFG monitoring manual (p. 13).

    b. names and numbers be assigned to all project features sampled during qualitative and quantitative monitoring efforts (p. 14).

4. In regards to survey timing, we recommend that:

    a. CDFG prioritize effectiveness criteria for different project types specific to their needs through the FRGP and standardize time frames for assessing the correlating project parameters (p. 14).

    b. the initial effectiveness survey be strategically timed to reflect conditions after stressing events have been experienced and project efficacy can be reasonably ascertained (p. 15).

    c. the timing of effectiveness monitoring visits for both qualitative and quantitative efforts be standardized based on project type and the expected amount of time required to reasonably ascertain whether objectives have been met (p. 15).

5. We recommend that the BACI approach remain in the monitoring manual to be used for research studies where it is feasible and appropriate, but not be required as a mandatory component of the CDFG monitoring program to document achievement of project objectives as stated in the statement of work (p. 17).

COMMENTS ON SPECIFIC PROTOCOLS

Line Intercept Transect Surveys

Field Methods

6. We recommend documenting locations of end points, in addition to start points, and recording the bearing of the line in every case as a measure to insure replication of transects (p. 18).
    a. We also recommend that the location and layout of transects be photographed and added to the site sketch (p. 18).
7. We recommend recording full species codes for sandbar and arroyo willow, recording tree willow species as "*Salix*", and updating CDFG's plant species code list accordingly (p. 18).
8. We recommend that instructions for measuring cover interception along the transect be clarified in order to reduce the margin of error between surveyors and the possible misrepresentation of site conditions (p. 18).
9. We recommend surveying vegetation cover to the nearest 0.1 foot in order to capture the variability of plant species at young planting sites where it is common for only 0.1-0.2 foot of foliar cover to intercept the line (p. 18).
10. We recommend that bank stability class and cover types other than vegetation (e.g., barren soil, rock, litter) be recorded to the nearest 0.5 foot, defined so that < 0.25 foot is recorded as zero and > 0.25 foot is recorded as 0.5 foot (p. 18).
11. In regards to cover type classification, we recommend:
    a. adding alluvium (ALLV) as a cover type for classifying cobble, gravel and sand (p. 18).
    b. defining rock as boulders, bedrock or concrete and classifying silt as barren soil (p. 18).
    c. adding roots (ROOT) as a cover type used to classify exposed, woody tree roots (p. 19).
    d. defining wood (WOOD) as dead wood in order to avoid confusion with trunks or roots (p. 19).

Written Instructions

12. We recommend that specific instructions for conducting surveys on follow-up visits be included since the method used to relocate and sample a previously established transect is different than that used to establish a new one (p. 19).
13. We recommend enhancing the instructions, specifically as stated on page 19, to offer more specific guidance on how to conduct the LIT survey.
14. We recommend enhancing the instructions, specifically as stated on page 19, to include guidance on how to assess plant height class.

15. We recommend directing surveyors to photograph transects and document transect locations on the site sketch for all LIT protocols (p. 19).

Bank Stabilization Restoration General Comments

16. If CDFG is interested in streamlining protocol text, we recommend revising the chapter on *Monitoring the Effectiveness of Bank Stabilization Restoration* (Gerstein and Harris 2005) to include only a concise introduction, guidance on protocol use, instructions and data sheets (p. 20).

17. We recommend that the table on page 5 of *Monitoring the Effectiveness of Bank Stabilization Restoration* (Gerstein and Harris 2005) be restructured to direct surveyors to the most appropriate protocol to use based on project objectives rather than monitoring questions (p. 20).

18. We recommend inserting a paragraph, specifically as written on page 20, after the table on page 5 of the Gerstein and Harris (2005) document to help standardize method selection.

Bank Stabilization Restoration Field Method 1: Line Intercept Transects Along Banks

Field Methods

19. Given the variability of results, we recommend that LIT data collected prior to and following treatment be interpreted with care to determine whether vegetative cover changed as a result of treatment implementation (p. 20).

20. CDFG and associated surveyors should be aware of the inherent difficulties of accurately replicating transects before and after treatments where extensive bank alterations have occurred (p. 20).

21. We recommend that the question of how far the study area should extend above and below treatment sites be further explored (p. 21).

    a. We recommend that the requirement to survey 10-20 bankfull widths upstream and downstream of treated sites be tested and a standard method for recording length of the study area be developed, based not only on channel size, but also project type (p. 21).

22. We recommend that the question of how to delineate treatment areas be examined and a standard method for recording the length of the treatment area be developed, particularly for cases where impacts of the treatment extend beyond the immediate structure site (p. 22).

23. We recommend that Method 1 include guidance on how to determine bank stability class when treatment effects are not limited to the structure installation site (p. 22).

24. In regards to bank stability class, we recommend:

    a. classifying banks within proposed treatment areas as “no treatment” until project implementation is complete (p. 22).

    b. that any location where a treatment was previously implemented be considered a “treatment area”, regardless of whether restoration structures still exist (p. 22).

25. We recommend that CDFG consider expanding bank stability class to include additional categories such as “moderately” or “extremely” stable or unstable (p. 22).

Written Instructions

26. We recommend modifying the instructions for establishing transects at or near bankfull, specifically as stated on page 23.

27. In regards to transect location documentation, we recommend:

    a. that specific transect location be defined and noted by surveyors at each site (p. 23).

    b. enhancing the instructions for recording transect location, specifically as stated on page 23.

28. We recommend including Figures 2-5 on pages 8-10 of *Monitoring the Effectiveness of Riparian Vegetation Restoration* (Harris et al. 2005), along with all associated text, in the instructions for Field Method 1 (p. 23).

29. We recommend including a height limit of 20 feet for the bank area to be assessed when determining bank stability class on banks taller than 20 feet (p. 23).

Bank Stabilization Restoration Field Method 2: Cross Section Surveys

Field Methods

30. We recommend that surveyors and managers considering cross section surveys as a long-term monitoring tool be aware that certain site conditions can make the survey difficult, or even impossible, to perform (p. 24).

    a. When choosing long-term monitoring sites, we recommend that surveyors carefully assess site topography and vegetation to ensure that survey instruments can be set-up above streambanks and benchmarks, with an unobstructed view of the laser detector (p. 24).

31. We recommend offering more specific guidance on the number and location of cross sections required at an individual treatment site, based on treatment area size, project objectives and possible off-site impacts (p. 24).

32. We recommend including some general guidance on cross section location, or at least a description of what attributes to look for when determining cross section location, to help reduce surveyor subjectivity and the amount of deliberation required at each treatment site (p. 24).

33. We recommend asking surveyors to locate three permanent benchmarks for cross section surveys, without specifying the number upstream or downstream (p. 25).

    a. We recommend including the definition of a benchmark and the rationale for needing more than one (p. 25).

34. We recommend that the method in which benchmarks are monumented be determined based on resources allocated to surveying a particular site and what is acceptable to landowners, rather than on survey tools used (p. 25).

35. We recommend directing protocol users to the Harrelson et al. (1994) reference for additional information on how to establish benchmarks (p. 25).

36. If CDFG supports collecting data on surface water elevation, we recommend emphasizing that point in the instructions and adding the code for water surface (WS) to the data form (p. 25).

Written Instructions

37. We recommend including a simple cross section survey diagram, like that found on page 26 of Harrelson et al. (1994), on page 13 of the instructions for Method 2 (p. 25).

38. We recommend including a modified version the Harrelson et al. (1994) method of establishing permanent cross section endpoints, for use in the field where feasible and acceptable to landowners (p. 25).

39. We recommend adding elevation measurement instructions and associated diagrams (adapted from Harrelson et al.) to the instructions for Method 2 (p. 25).

40. We recommend that the instructions emphasize site sketches as an effective means of documenting the locations of benchmarks and cross sections (p. 26).

41. We recommend enhancing the instructions to include better definitions of backsight, foresight, instrument height and elevation, specifically as stated on page 26.

Riparian Vegetation Restoration General Comments

42. We recommend that CDFG explore options (both at the implementation and the monitoring levels) to increase the likelihood of locating planted vegetation on subsequent surveys, such as tagging trees. (p. 26).

43. We recommend that riparian vegetation restoration treatment areas be broken into multiple project features to be classified by landforms (e.g., channel margin, floodplain, upper bank) which are formed by past and current hydrologic regimes (p. 27).

    a. We recommend that project feature identification information specific to planting projects be summarized in the riparian vegetation restoration chapter in the monitoring manual (p. 27).

44. We recommend the timing of all riparian vegetation surveys be standardized by season around foliage presence and abundance on deciduous trees (p. 27).

45. We recommend that the table on page 4 in the introductory section of *Monitoring the Effectiveness of Riparian Vegetation Restoration* (Harris et al. 2005) be restructured to direct surveyors to the most appropriate protocol to use based on project objectives rather than monitoring questions (p. 27).

46. We recommend inserting a paragraph, specifically as written on page 27, after the table on page 4 of the Harris et al. 2005 document to standardize method selection.

Riparian Vegetation Restoration Field Method 1: Line Intercept Transects Along Banks

Field Methods

47. We recommend that the instructions include guidance on how to apply Method 1 on subsequent surveys at sites where the bankfull location has changed slightly since the initial survey (p. 28).

48. We recommend that CDFG identify the location at which to conduct the Method 1 survey—along the original survey line or the newly created bankfull line—in the event that bankfull location shifts *drastically* as a result of stochastic events (p. 28).

Written Instructions

49. We recommend modifying the instructions for establishing transects at or near bankfull, specifically as stated on page 28.

50. In regards to transect location documentation, we recommend:

    a. that specific transect location be defined and noted by surveyors at each site (p. 29).

    b. enhancing the instructions for recording transect location, specifically as stated on page 29.

Riparian Vegetation Restoration Field Methods 2-4: LIT Variations

Field Methods

51. We recommend that instructions remind users to employ Method 1, in conjunction with Line Intercept Transects Through Delineated Treatment Areas, at all riparian vegetation restoration sites where streambank or floodplain plantings are intended to increase vegetation cover along, or canopy cover over, the channel (p. 30).

52. We recommend that Field Methods 2-4 be combined into one protocol and that the instructions be edited and enhanced at that time (p. 30).

53. We recommend that, if possible, the number of transects to be sampled at a given treatment area be standardized since data collected from the same site could produce drastically different results depending on the number and locations of transects surveyed (p. 30).

54. We recommend that our proposed *One Percent Stratified Sampling Method* be considered as a possible solution to standardizing the number of transects to be sampled, and that it be field tested further at variable project sites and statistically analyzed for sufficiency in capturing the desired project attributes (e.g., vegetation cover, species variability, etc.) (p. 32).

55. If no standard method of determining the number of transects to sample at each site is adopted, we recommend:

a. that the steps for plotting graphs of mean values for varying sample sizes or, at the very least, a reference to additional information on this topic be included with the written instructions (p. 32).

b. that laptop or handheld PCs be utilized so data can be entered directly and species-area curves may be graphed in the field (p. 32).

56. We recommend that baseline LIT data be collected prior to riparian planting treatments, with post-implementation monitoring conducted five or ten years after implementation, at which time plant growth should be a definitive indicator of project success (p. 33).

57. We recommend that additional field testing be done to quantify the relationship between cover estimates obtained during census (direct count) and LIT surveys for each species and each landform (e.g., channel, floodplain, upslope) (p. 33).

58. We recommend using the edge of plantings (foliar cover) on the initial post-treatment visit to define the project feature area boundary (p. 33).

Riparian Vegetation Restoration Field Method 5: Planted Tree Survival Assessment

Field Methods

59. We recommend a census by project feature as the primary method of assessing survivorship (p. 35).

    a. We recommend collecting information on plant vigor and cover estimates during the census, wherever resources allow it (p. 35).

60. We recommend that the question, "At what scale does it become too laborious to conduct a direct count?" be examined further and propose a minimum treatment area of 2.5 acres as a basis for using a plot sample method in place of a census (to be increased or decreased as individual site conditions dictate) (p. 35).

61. We recommend that Method 5 be field tested at large, uniformly planted project sites typical of the Central Valley to determine whether it is suitable for assessing those types of riparian planting sites (p. 35).

62. We also recommend that a standard protocol for assessing planted tree survival at riparian planting sites with random and clumped plantings be developed, field tested, and included in the monitoring manual for use where a census is not an efficient option (p. 35).

63. We recommend that, for the time being, Method 5 remain in the monitoring manual for use where appropriate, under the following conditions:

    a. that caveats about the limitations of this method, particularly in terms of plant distribution and treatment area width, be emphasized and the name be changed accordingly (e.g., Planted Tree Survival Assessment for Large, Uniform Sites) (p. 35).

64. We recommend that the consistency of the results for the equations in Method 5 be verified by CDFG and that the resulting numbers replace the equations in order to reduce the amount of work required and potential for user error when applying this protocol (p. 35).

65. We recommend that Method 5 be modified to include more vigor classes (p. 36).

66. We recommend that the term "vigor" and each vigor classification be defined in the instructions (p. 35).

Riparian Vegetation Restoration Method 6: Floodplain Forest Composition Plots

67. We recommend census (direct count) surveys as the most effective method of assessing species composition in treatment areas up to 2.5 acres in size, or the area (greater or smaller than 2.5 acres) at which a census becomes inefficient based on site layout and planting density (p. 36).

Riparian Vegetation Restoration Method 7: Intercepted Sunlight Due to Riparian Canopy

Field Methods

68. We recommend that the Spherical Densiometer be specifically utilized for canopy density assessments for CDFG monitoring purposes (p. 37).

69. Because canopy density is currently being assessed during *qualitative* surveys, we recommend not duplicating those efforts during *quantitative* surveys (p. 37).

70. If CDFG decides to use the Solar Pathfinder, we recommend that surveyors complete the "optional" diagram charts in order to provide a visual record of changes in canopy cover over time (p. 38).

71. We recommend adding air and water temperature data collection to the relevant qualitative monitoring protocols, to be conducted at least once at each treatment site (p. 38).

72. For reach-scale canopy assessment surveys, we recommend that protocols for air and water temperature collection be standardized to the instream methods currently utilized by CDFG (p. 38).

73. We recommend that baseline canopy data be collected prior to treatment and that follow-up monitoring occur again in five to ten years, depending on the species planted (e.g., fast-growing riparian species, slow-growing hardwoods) (p. 38).

Written Instructions

74. We recommend using the Solar Pathfinder to collect intercepted sunlight data, rather than solar radiation data, because canopy cover and density are usually considered in terms of shade and because data will be closer to that produced by the Densiometer (p. 38).

    a. References to the type of data collected must be standardized throughout the current protocol document (p. 38).

75. For Densiometer use, we recommend that the difference between canopy closure and canopy density be explained in the instructions (p. 38).

76. We recommend that the instructions state that canopy data be collected during the summer months, before deciduous leaf-fall occurs (p. 39).

APPENDIX B. REVISIONS TO *MONITORING THE EFFECTIVENESS OF BANK STABILIZATION RESTORATION*

(Gerstein and Harris 2005)

This Appendix includes comments on and edits to the original Gerstein and Harris (2005) document. It was not incorporated into the digital copy of the report in order to reduce document size and is contained in a separate digital file. All comments and changes within the document were highlighted using Microsoft Word's "track changes" function. Please note that we did not adjust the document formatting; that should be done, in conjunction with proofreading, during final document revision.

APPENDIX C. REVISIONS TO *MONITORING THE EFFECTIVENESS OF RIPARIAN VEGETATION RESTORATION*

(Harris et al. 2005)

This Appendix includes comments on and edits to the original Gerstein and Harris (2005) document. It was not incorporated into the digital copy of the report in order to reduce document size and is contained in a separate digital file. All comments and changes within the document were highlighted using Microsoft Word's "track changes" function. Please note that we did not adjust the document formatting; that should be done, in conjunction with proofreading, during final document revision.

APPENDIX D. FIELD EQUIPMENT LIST

The following chart lists required field gear for all Bank Stabilization and Riparian Vegetation Restoration survey methods. Line Intercept Transect Surveys include Bank Stabilization Restoration Field Method 1 and Riparian Vegetation Restoration Field Methods 1-4. A string box should be added for all surveys that require extensive foot travel from vehicle or reference points to sampling points.

Required Equipment	Line Intercept Transect Surveys	Bank Method 2: Cross Section Survey	Vegetation Method 5: Planted Tree Survival Assessment	Vegetation Method 6: Flood-plain Forest Composition Plots	Vegetation Method 7: Riparian Canopy Survey
Calculator	X	X	X	X	X
Camera with film	X	X	X	X	X
Clipboard	X	X	X	X	X
Compass	X	X	X	X	X
Data forms	X	X	X	X	X
Flagging tape or aluminum tags	X	X	X	X	X
GPS unit, spare batteries	X	X	X	X	X
Hammer and rebar stakes (end caps if permanent endpoints will be established)	X	X			
Indelible ink pen (e.g., Sharpie)	X	X	X	X	X
Lead pencils with lead refills	X	X	X	X	X
Maps, directions and project description documentation	X	X	X	X	X
Marking flags (wire stake landscape flags)			X	X	
Random number table or similar tool	X				X
Solar Pathfinder instrument and tripod					X
Solar Pathfinder diagram chart and wax pencil (optional)					X
Stadia Rod	X	X			
Survey equipment: total station or auto level with tripod and laser detector, spare batteries		X			
Tape 100 ft or longer, marked in 0.1 units	X	X(2)	X	X	X
Thermometer					X

APPENDIX E. REVISIONS TO DATA FORMS

It is our understanding that DFG does not currently have modifiable digital copies of the quantitative effectiveness data forms, as the copies included in the Harris documents are in jpeg format (i.e., not able to be modified). We re-created the data forms and included our recommended changes. All additions are highlighted in blue text for easy viewing. The Bank Stability Line Intercept Data Form is for Bank Stabilization Restoration Field Method 1, and the Cross Section Data Form is for Field Method 2. The Riparian Line Intercept Data Form is for Riparian Vegetation Restoration Field Methods 1-4, the Plantation Survival Form for Field Method 5 and the Effective Shade Data Form for Field Method 7. The following entries were added to all data forms in this appendix and **are also recommended for inclusion on Site Access and Location, Onsite Navigation and Photo Description Forms**:

- Site Name: This is an informal name created by the contractor or evaluator that generally includes the stream name and structure type. Often times the contract name does not refer to the treatment being evaluated. Furthermore, multiple treatments may be included in the same contract. Site name allows one to determine at a glance whether the data refers to, for example, the boulder deflectors or the neighboring willow wall. The *site* name for this example might be "Green Valley Creek Boulder Deflectors", while the *contract* name could be as illusive as "Russian River Tributary Restoration & Landowner Outreach". This entry need only be used when Site Name differs significantly from Contract Name.

- Implementation Month/Year: It is helpful to be able to see this information at a glance when evaluating treatments**.** Implementation date is particularly relevant when considering vegetation growth and structure condition. Year will suffice if month is not known.

- Project Feature #/Name: We recommend that all project features be assigned a short name in addition to being numbered. In most cases, this name would be a structure name (e.g., PF#1 log deflector) or, in the case of riparian vegetation restoration, a name indicating the location of plantings being sampled (e.g., PF#2 floodplain plantings). Whereas project feature numbers are unique, project feature names would not need to be unique, but would simply function as a means of identifying different treatment types within the database to enable more thorough queries (see report body, p. 14). Project features should be identified on forms and *documented in site sketches*. This is particularly important when large planting sites are broken into several project features by location to facilitate monitoring.

- Project Phase (*Pre-treatment* or *Post-treatment*): This clearly states the project phase during which data was collected. It is particularly helpful with navigation and location information, especially when re-visiting a site to conduct post-treatment monitoring with the pre-treatment form in hand when site alterations due to project implementation can cause confusion. This may not be entirely necessary if project implementation date is known and entered (which is not always the case), but can be considered a backup measure in case the survey or implementation date is recorded incorrectly.

- Additional Comments: This encourages comments on site conditions not reflected by the data collected. For example, one bank at a cross section survey site may currently be experiencing erosion due to LWD that became trapped in the center of the channel during high flows and not due to the bank stabilization treatment on the opposite bank. This should be noted under

Additional Comments. Or, if surveyors noted that the trees planted at a riparian vegetation restoration site were experiencing stunted growth due to inadequate irrigation, it would be clear that the vegetative cover along the LIT was not increasing significantly due to lack of growth, not inadequate planting density.

We also suggest that the following additions be made to the associated monitoring field forms indicated below (if Brooke has not already done so):

- Access Forms: Add an entry for site street address. Instructions for this entry should stipulate that site address need only be used where it is relevant, in which case it can be very helpful. However, site address should not be noted in many remote locations where it is not relevant or misrepresents site location. This will likely be most helpful in urban and suburban areas.

- Access *and* Navigation Forms: Add an entry for additional monitoring dates at the top of each form for dates to be added as monitoring occurs in subsequent years. This will make it clear that new access forms do not need to be completed for each visit unless information has changed (a subject of some confusion) and make it easier to locate data from different dates; because the Access and Location Form is generally the first page in the stack of field forms for a given site, it can be misleading to only record the date on which the access form was originally filled out when associated data forms may be from subsequent survey dates. We also recommend that DFG determine whether this would be an appropriate addition to the Qualitative Project Summary Forms for use where conditions remain static on subsequent visits.

- Photo Description Form: Add a large spot for site sketches on a separate sheet or on the back side of the Photo Description Form (a title and border around the entire page would suffice) and instruct surveyors to sketch the site and label project features, photo points, transect locations, benchmarks and other important features.

- Qualitative Pre-Treatment and Effectiveness Checklists: Add an entry for bankfull width for instream and streambank stabilization projects.

BANK STABILITY LINE INTERCEPT DATA FORM

Contract #:______________ Contract Name:_______________________________________ Implementation Mo/Yr:_______
Site Name:____ Stream/Drainage:_____________________________
Evaluators:____________________ Date:_________ Project Feature #/Name:_________________________ Transect #:____
Transect Length:_______ Start Point:____

Streambank: (*Left* or *Right*) **Direction:** (*Upstream* or *Downstream*) **Project Phase:** (*Pre-treatment* or *Post-treatment*)

Bank Class			0-3' Height Class			3-15' Height Class			>15' Height Class			Comments
Start Distance	End Distance	Stability Class	Start Distance	End Distance	Species	Start Distance	End Distance	Species	Start Distance	End Distance	Species	(location & bearing of transect, total # transects)

Species Codes

				BRRS = Barren Soil
				ALLV = Cobble, gravel and/or sand
				ROCK = Boulders, bedrock, concrete
				LITT = Leaf litter
				HERB = Herbaceous
				ROOT = Woody roots
				WOOD = Dead wood
				REST = Restoration Structure
				OTST = Other Structure

Bank Stability Codes

STNT = stable bank, no treatment	STPT = stable, treatment area	UNPT = unstable, treatment area	UNNT = Unstable bank, no treatment

LB = Left Bank, **RB** = Right Bank, **UPS** = Upstream, **DNS** = Downstream, ‖ = Parallel, ⊥ = Perpendicular

Additional Comments:

RIPARIAN LINE INTERCEPT DATA FORM

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Contract #:______________ Contract Name:____________________________________ Implementation Mo/Yr:_________
Site Name:____ Stream/Drainage:____________________________
Evaluators:________________________ Date:________ Project Feature #/Name:_____________________ Method #:____
Transect #:_____ Length:_______ Start Point:____

Streambank: (*Left* or *Right*) **Direction:** (*Upstream* or *Downstream*) **Project Phase:** (*Pre-treatment* or *Post-treatment*)

0-3' Height Class			**3-15' Height Class**			**>15' Height Class**			**Comments**
Start Distance	End Distance	Species	Start Distance	End Distance	Species	Start Distance	End Distance	Species	(location & bearing of transect, total # transects)

Species Codes

			BRRS = Barren Soil
			ALLV = Cobble, gravel and/or sand
			ROCK = Boulders, bedrock, concrete
			LITT = Leaf litter
			HERB = Herbaceous
			ROOT = Woody roots
			WOOD = Dead wood
			REST = Restoration Structure
			OTST = Other Structure

LB = Left Bank, **RB** = Right Bank, **UPS** = Upstream, **DNS** = Downstream, ‖ = Parallel, ⊥ = Perpendicular

Additional Comments:

CROSS SECTION DATA FORM

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Contract #: **Contract Name:** **Implementation Mo/Yr:**

Site Name: **Stream/Drainage:**

Date: **Phase:** (*Pre-treatment* or *Post-treatment*) **Project Feature #/Name:** **XS #:**

Crew: **Level** **Stadia Rod** **Recorder**

Description of Survey (include BM & XP locations)**:**

Total Survey Length (ft & tenths)**:**

Station	(+) BS	HI	(-) FS	Elevation	Comments (record geomorphic features, substrate, vegetation and other factors of interest at each station)

Codes: **BM** = Benchmark, **HI** = Height of Instrument, **FS** = Foresight, **BS** = Backsight, **XP** = Cross Section Endpoint, **LB** = Left Bank, **RB** = Right Bank, **UPS** = Upstream, **DNS** = Downstream, **FP** = Floodplain, **LT/MT/HT** = Low/Middle/High Terrace, **LEW/REW** = Left/Right Edge Water, **BKF** = Bankfull, **PB** = Point Bar, **TP** = Turning Point, ∥ = Parallel, ⊥ = Perpendicular

Additional Comments:

PLANTATION SURVIVAL DATA FORM

Contract #:______________ Contract Name:____________________________________ Implementation Mo/Yr:_________
Site Name:____ Stream/Drainage:____________________________
Evaluators:________________________ Date:________ Project Feature #/Name:_____________________ Polygon #:____
Location:____________________ Start Point:____

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

Plot #	Species	Vigor	Tally	Comments

Vigor Class = **L**ive, **D**ead, **P**oor Health, **V**igorous Growth

Species Codes

Additional Comments:

EFFECTIVE SHADE DATA FORM

Contract #:______________ Contract Name:_____________________________________ Implementation Mo/Yr:_________
Site Name:____ Stream/Drainage:_____________________________
Evaluators:___________________________________ Date:__________ Project Phase: (*Pre-treatment* or *Post-treatment*)
Project Feature #/Name:__________________ Start Point:____

Water Temperature, Point: 1______________ 10 ______________ 20 ______________ 30 ______________
Air Temperature, Point: 1______________ 10 ______________ 20 ______________ 30 ______________

Point #	Stream Distance	Intercepted Sunlight		Percent		Comments
		July	August	Deciduous	Evergreen	
1						
2						
3						
4						
5						
6						
7						
8						
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Additional Comments: