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Publication 8363 / May 2009

Developing a Monitoring Program for Riparian Revegetation Projects

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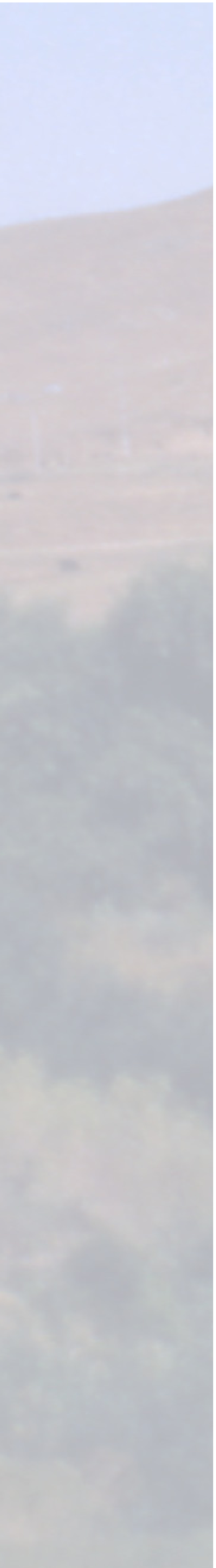
INTRODUCTION

Increasing native vegetation along the banks of streams and rivers is one of the principal stewardship tools land use managers have to conserve, restore, and protect soil and water resources (Roni 2005). Referred to as "riparian revegetation," these projects are carried out by a partnership of private landowners, restoration professionals, and resource agency staff. They are generally implemented by removing pressure on existing vegetation or replanting tree, shrub, and herbaceous plants, or both (fig. 1). Funding for such projects is usually provided through a combination of federal, state, and local grant sources in conjunction with private landowner cost-share contributions.

Figure 1. Riparian revegetation project including exclusionary fencing, tree or shrub planting, and irrigation system to reestablish native woody species. Photo: Courtesy Marin Resource Conservation District.



All parties involved, from grantor to practitioner to land manager, are vested in the outcomes of these projects and therefore benefit from feedback on project successes and failures. This feedback is critical in expanding our collective knowledge of the relatively young science of stream and watershed restoration, fine tuning techniques, and enhancing maintenance regimes. Also, by directing the maintenance of existing projects and improving the design of future projects, this evaluation may increase the credibility of restoration efforts in the eyes of participating landowners. More formally, grant administrators are requiring an increased level of accountability from grantees, including documentation that financial resources were used for the purposes requested and that the activities produced the desired results (Reeve et al. 2006).

The need for project feedback to improve project results and meet contractual requirements of financial accountability supports the essential role of riparian revegetation project monitoring. This sentiment is expressed well by Thayer et al. (2005) when defining the more global term "restoration monitoring" as "the systematic collection and analysis of data that provides information useful for measuring project performance at a variety of scales (locally, regionally and nationally), determining when modification of efforts is necessary, and building long-term public support for habitat protection and restoration."

Monitoring vegetation change at multiple scales is a well-established discipline, complete with time-tested methods and protocols (see Harris et al. 2005; Herrick et al. 2005; Coulloudon et al. 1999). If correctly selected and adapted, these methods are appropriate and effective for monitoring revegetation projects. We have developed this publication to assist you in developing a riparian restoration monitoring program that addresses both planted vegetation and the resulting ecological functions. Our recommendations are applicable at either the initial stage of project design, after project implementation or, ideally, at both stages and into the future to document project result trajectories.

The approach outlined here is designed for site- or reach-level riparian vegetation restoration project monitoring. We do not cover broad-scale assessments of watershed conditions (see Shilling et al. 2005). Scientific research projects comparing outcomes from a number of sites often require a more specialized set of criteria, such as a statistically valid sample size and sampling of control sites or reference reaches. For those looking to implement a study design of this scope, we recommend evaluating additional references such as Griggs and Golet (2002), Opperman and Merenlender (2004), Gardali et al. (2006), and Lennox et al. (2009).

This publication serves as a planning tool and is intended to be used in conjunction with your riparian project documents, including maps, design plans, and contracts. The monitoring plan worksheet, instructions, and example provided in appendix A guide you through a series of questions that form the foundation of a riparian restoration monitoring program. Following our proposed process will assist you in developing a monitoring program complete with specific objectives and corresponding methods, which are referenced for your retrieval.

DEVELOPING A MONITORING PROGRAM

Revegetation Project Goals and Objectives

Monitoring objectives are directly connected to the goals and objectives of the revegetation project, and the two should be integrated starting from the project design stage (Kondolf and Micheli 1995). This is why Dahm et al. (1995) explained that "ecological success in a restoration project cannot be declared in the absence of clear project objectives from the start and subsequent evaluation of their achievement." Understanding this connection and integration of the project's expected outcomes with monitoring will increase your ability to use monitoring effectively as a management tool.

The clarity and direction of project and site goals and objectives can be improved by ensuring that they are specific, measurable, achievable, relevant, and time-based (Lutes et al. 2006). This can be done by identifying an attribute of riparian revegetation, such as plant species composition, and setting a target, such as greater than 90 percent native species (English Nature 2002). This is similar to identifying the structural and functional components of the site that the revegetation project is expected to change and posing a hypothesis of the direction and degree of that change (Thayer et al. 2005). Examples of structural components of riparian habitat include bank cover, canopy, and channel width-to-depth ratio (fig. 2). Examples of riparian functions include nutrient cycling, habitat complexity, stream temperature, and sediment

Figure 2. Sampling width-to-depth ratio during project effectiveness monitoring. Photo: M. Lennox.

retention, among others (Kocher and Harris 2007). The expectation is that these components would improve from their preproject conditions at acceptable rates after restoration activities.

Project goals and objectives should clearly state desired outcomes that are measurable through monitoring. These anticipated outcomes provide the rationale for monitoring components such as improvements to habitat or water quality. They also direct the selection of metrics or attributes to measure, such as tree and shrub abundance, canopy cover, streambank stability, stream channel shape, and utilization of the project area by wildlife. Therefore, project goals and objectives determine monitoring goals and objectives. When scrutinizing project objectives in order to determine which attributes to monitor, you may discover that project objectives are too general or do not identify clear, measurable targets. This is a good time to reevaluate and, if necessary, clarify or redraft project goals and objectives. Preproject data may be used to set reasonable goals and measurement targets in conjunction with results from local reference sites or restored sites (Lennox 2007; Lennox et al. 2007; Gardali et al. 2006; Griggs and Golet 2002). The definition and further discussion of reference sites is provided in the section "Control and Reference Site". When seeking information about reference sites to use in setting targets, seek out knowledgeable and experienced local practitioners and professionals. Also, research reports and documents describing conditions at both reference and restored sites in the area are useful to this end.

Revegetation Project Funding and Resources

Confirming the amount and duration of funding needed or available to implement your monitoring effort is a critical and practical step in setting monitoring objectives that are realistic and achievable. Many grantors mandate that some level of funding be included in the project budget to ensure that monitoring is implemented. To plan a monitoring budget prior to submitting a project proposal, we urge you to review suitable methods and estimate the cost of staff time, training, and materials needed to monitor each site for each desired stage of monitoring (i.e., pretreatment, postimplementation, and effectiveness). The percentage of your budget dedicated to monitoring must coincide with the unique terms outlined by the grantor to which you intend to submit your proposal.

You will also need to consider the duration of your contract with the grantor and how this relates to your ideal monitoring timeframe. Remember that all funds used for monitoring need to be expended before the contract termination date. Most contract periods allow for a minimum of one preimplementation and one postimplementation monitoring visit to each site. We recommend conducting at least one effectiveness monitoring survey of each site before the close of contract whenever possible. Grantors with longer contract periods may support repeat monitoring visits over multiple years. These longer-term monitoring programs generally yield the most definitive confirmation of project outcomes. If the trained staff, volunteer resources, and multiple grants are available to support monitoring, we recommend repeating effectiveness monitoring at your project sites after the close of the initial contract. See the section "Monitoring Timeframe and Documenting Trajectory" for a more thorough discussion of timing considerations as they pertain to monitoring.

Understanding and Selecting Types of Monitoring

It is important to have a good understanding of monitoring types as they relate to restoration and vegetation monitoring (Harris et al. 2005; Mulder et al. 1999) before you develop and implement a monitoring program. Types of monitoring include preproject, implementation, effectiveness, and validation. Determining which of four principal questions you want to answer will provide direction to help you identify the types of monitoring to be used in a monitoring program (table 1). It is often the case that multiple questions and monitoring types are of interest.

Qualitative and Quantitative Methods

Monitoring can be conducted in a qualitative or a quantitative manner. Both have their place and purpose, and they can be complimentary to each other.

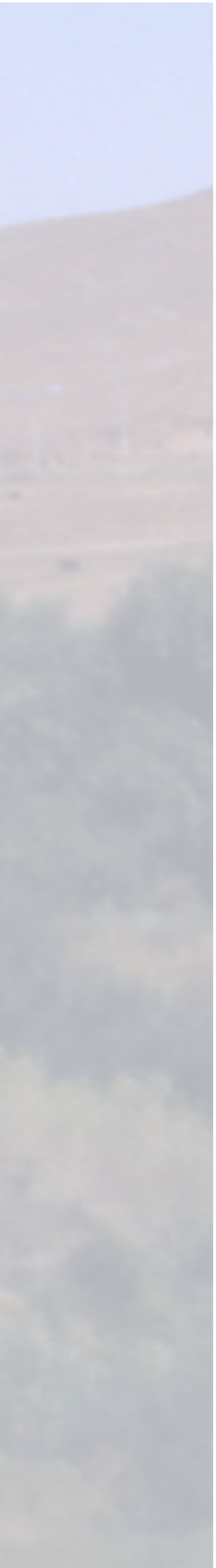
Qualitative monitoring provides subjective observations of implementation, effectiveness, and validation outcomes. These subjective observations may include a broad assessment of project site conditions with questions pertaining to multiple common riparian vegetation project objectives. Though qualitative monitoring can include some quantitative measurements, it is generally not necessary to identify specific attributes when conducting a qualitative evaluation. Photopoint monitoring is a very useful qualitative technique, achieved through a series of photographs taken to document site conditions before and after project implementation and over time as changes in vegetation occur at the site.

Quantitative monitoring is data-driven and assesses changes in project site characteristics as a means of objectively measuring project outcomes. For example, measurements of tree height or species composition generate quantitative results of vegetation growth and change.

Table 1. Fundamental monitoring types with principal questions that riparian revegetation project monitoring can answer

Principal monitoring question	Type of monitoring
1. What are the existing site conditions and the reasons for implementing a project at the site?	**PREPROJECT ASSESSMENT:** Documentation of current site conditions and how they support project selection and design.
2. Was the project installed according to design specifications, permits, and landowner agreements?	**IMPLEMENTATION:** Monitoring to confirm that the project was implemented according to the approved designs, plans, and permits. In other words, determining whether the agreed upon work was completed as planned. This is also a critical moment to identify any potential threats to project success so they can be addressed.
3. Did attributes and components at the project site change in magnitude as expected over the appropriate time frame?	**EFFECTIVENESS:** Monitoring to assess postproject site conditions and to document changes resulting from the implemented project. This is done through comparison with preproject conditions to establish trends in the condition of resources at the site. Accordingly, effectiveness monitoring needs to occur over a sufficient period of time to allow conditions to change as a result of the vegetation treatment. Also, similar to implementation monitoring, effectiveness monitoring is a critical moment in the project timeline to identify and address threats to project success.
4. Did fish, wildlife, or water quality respond to the changes in physical or biological attributes or components brought about by the revegetation project?	**VALIDATION:** Monitoring to confirm the cause and effect relationship between the project and biotic (wildlife) or physical (water quality) response. For example, this includes the change in use, presence, or abundance of desired salmon and steelhead trout or migratory songbirds at the project site. Similar to effectiveness monitoring, validation monitoring needs to occur over a sufficient period of time for wildlife use to change as a result of the vegetation treatment. This is predicated on the availability and proximity of targeted wildlife to the project site.

Source: Adapted from Roni 2005.



Your choice to use qualitative methods, quantitative methods, or both will depend on the availability and duration of funding as well as the level of detail required to meet your needs for feedback on project outcomes. Which principal questions you wish to answer through monitoring and your choice to use qualitative or quantitative methods will influence the time, effort, and resources required to conduct monitoring. It may not be realistic in all cases, but, where resources allow, we recommend that qualitative monitoring be conducted in conjunction with quantitative monitoring. Qualitative monitoring is able to identify a broad range of concerns that might not be detected by a more narrowly focused quantitative approach. On the other hand, quantitative monitoring provides objective data that is less subject to varying interpretations of project outcomes.

MONITORING METHODS

Qualitative Methods

For information on implementing qualitative monitoring, refer to the California Department of Fish and Game's (DFG) Coastal Monitoring and Evaluation Program qualitative monitoring forms and instructions (Collins 2007; Kocher and Harris 2005). These protocols were developed in an effort to standardize stream restoration project monitoring statewide and are currently being used to assess projects funded through the DFG Fisheries Restoration Grant Program. Specific checklists that may apply to your revegetation project include "Revegetation Treatments (RT)," "Vegetation Control and Removal (VC)," "Instream Habitat and Bank Restoration (IN)," and "Land Use Treatments and Exclusion Fencing (LU)." These forms and instructions are available online (see Collins 2007). Note that "Revegetation Treatments" checklists should be completed in conjunction with "Instream Habitat and Bank Restoration" checklists for bioengineering bank stabilization projects.

Quantitative Attributes and Monitoring Methods

In order to conduct quantitative monitoring you will need to determine, on a site-by-site basis, which attributes are appropriate indicators of change in site conditions as a result of your revegetation treatments. First and foremost, the selection of attributes to be sampled and the determination of the timing and frequency of sampling should be driven by project goals and objectives. If the primary goal of a project is to increase native woody cover on the target streambank, then the parameters to be sampled would be native tree and shrub cover and species composition. Selecting those attributes will direct you to the Line Intercept Transect protocol (see Harris et al. 2005; Coulloudon et al. 1999). Table 2 contains a list of common attributes that could be expected to change over time as a result of riparian revegetation treatments and the preferred methods for monitoring change in those attributes.

Keep in mind that the identified protocols may be modified to suit your unique project needs. However, using standardized methods rather than customized ones allows direct comparisons and analyses with other restoration projects. This offers the ability to quantify the performance of multiple projects within a region and evaluate the effectiveness of restoration methods. For this reason we recommend using the standardized methods listed in table 2.

While it is crucial that the selection of attributes and methods be guided by specific revegetation project objectives, additional factors such as desired woody vegetation stature or height and monitoring program duration also influence the appropriateness of attributes. For example, changes in cover are anticipated to occur over decades as trees and shrubs increase in size. In contrast, responses in the composition or survival of planted trees and shrubs occur in a few years.

Another factor to consider when developing a monitoring plan is the level of expertise and resources available (Roni 2005; Herrick et al. 2005). We have selected the methods referenced in table 2 because they can be implemented on a project-specific basis and most can be learned through guidance documents and basic field training.

The exception to this is habitat use or population estimate monitoring. These fall under the category of validation monitoring and include the response of migratory songbirds to changes in riparian vegetation (Ralph et al. 1993) and change in steelhead trout and salmon populations as a result of change in stream morphology and complexity (Duffy 2005; Dolloff et al. 1993). Other aquatic and terrestrial wildlife, including amphibians and insects, can be monitored similarly. These methods generally require species identification skills as well as expertise in monitoring program design. They are also likely to require special agency permits for

Table 2. Recommended monitoring methods based on attributes sampled

Attribute monitored	Quantitative method	References	Time*	Skill†
survival and establishment	direct count	See the section "Assessing Survival of Planted Vegetation"	—	—
	plot method	See the section "Assessing Survival of Planted Vegetation"	—	—
tree or shrub cover	line intercept transects	Harris et al. 2005[‡] Coulloudon et al. 1996	L	L
tree or shrub composition	line intercept transects	Harris et al. 2005[‡] Coulloudon et al. 1996	L	M
	floodplain forest composition plots	Harris et al. 2005[‡]	M	H
herbaceous cover; herbaceous composition	gap intercept	Herrick et al. 2005 vol. 1	L	L
	line-point intercept	Herrick et al. 2005 vol. 1	M	M–H
	step-point method	Coulloudon et al. 1996		
canopy cover; solar radiation	spherical densiometer	Flosi et al. 1998	L	L
	solar pathfinder	Harris et al. 2005[‡]	M	M
stream channel morphology	bankfull width-to-depth ratio	Rosgen 1996	L	M
	cross section	Harrelson et al. 1994	M	M
	longitudinal profile	Gerstein 2005 Harrelson et al. 1994	M	M
bank stability	line intercept transects	Gerstein and Harris 2005[‡]	L	L
	cross section	Harrelson et al. 1994	H	M
woody debris	woody debris survey	Gerstein 2005 Flosi et al. 1998	L	M
maximum or mean pool depth	residual pool depth	Lisle 1987	L	M
	longitudinal profile	Gerstein 2005 Harrelson et al. 1994	M	H
water quantity	stream flow	SWRCB 2001 Tate 1995a, b	M	H
	groundwater elevation	Nielsen 1991 Freeze and Cherry 1979	H	H
habitat use or population estimates	birds	Ralph et al. 1993	M	H
	benthic macroinvertebrates	Barbour et al. 1999	M	H
	salmon or steelhead	Duffy 2005 Dolloff et al. 1993	H	H

Notes:

*Time required: L = in general a few hours per site per year; M = a full day to multiple days per site per year; H = more than a week per site per year.

†Skill level required: L = little to no experience needed; M = some experience applying terminology to field measurements; H = considerable experience and or M.S.-level training in discipline and methods.

‡If you are interested in using the Gerstein and Harris and Harris et al. protocols, consult Nossaman et al. (2007) for recommendations following additional field testing.

handling wildlife. This is particularly true if working with species listed as threatened or endangered under the Federal or State Endangered Species Act. Please contact the California Department of Fish and Game for information on permitting needs if you intend to conduct validation monitoring.

Assessing the Survival of Planted Vegetation

A universal objective for planting riparian vegetation is plant survival. To this end, numerous methods have been developed for documenting survivorship and vegetation establishment. We recommend a direct count as the primary method of assessing survivorship, as it results in the most accurate site-scale information. A direct count, or census, assesses each individual tree or shrub planted and is commonly used at small sites or sites that can be broken into smaller sections for monitoring purposes (Nossaman et al. 2007). We also recommend collecting information on plant vigor, cover estimates, and any other factors applicable to your project's objectives during the census.

At large sites where counting individual plantings is inefficient, it is often necessary to subsample the project area so more detailed information can be collected within a reasonable timeframe (Harris et al. 2005). Plot-based subsampling methods are generally developed or adapted according to individual project objectives and physical site parameters. For example, Griggs and Golet (2002) adapted plot subsampling to assess valley oak *(Quercus lobata)* survival and establishment given site conditions on large floodplain sites along the Sacramento River.

Because of the variability of plot sampling methods, we do not direct users to a definitive protocol; however, we recommend exploring multiple methods and adapting the selected method as necessary to suit the needs of your project. If your revegetation site is greater than 148 feet wide, you may find the Planted Tree Survival Assessment protocol outlined in Harris et al. (2005) to be suitable (see Nossaman et al. 2007). FIREMON's Integrated Sampling Strategy Guide (Lutes et al. 2006) contains detailed information on developing a plot sampling strategy and includes a discussion of appropriate statistical approach, number and location of plots, and sampling procedures.

Water Quality

A common goal for watershed restoration projects is to improve water quality by reducing the delivery of sediment, nutrients, pathogens, and other pollutants to a stream. One potential objective is to promote vegetation that will prevent erosion, reduce runoff, and remove potential contaminants in water before they enter a stream. Similarly, projects that increase canopy cover have the objective to reduce solar radiation and stream temperature.

Confirming whether stream turbidity or another pollutant parameter is reduced as a result of the project can be an intensive undertaking, depending on the constituent targeted. This is in part because the factors that drive water quality parameters often operate at a scale that is larger than the project site.

A typical revegetation project is only a few hundred yards in length, compared to many miles of upstream channel above the project site. Various upstream conditions will likely hinder the ability of a monitoring program to detect a difference in stream sediment or temperature above and below a particular project site as a result of the restoration treatment. Keeping this effect of scale in mind, methods and sources of more information do exist for water quality monitoring (see MacDonald et al. 1991; Tate et al. 2005a and b; USGS 2003–2007). We recommend a strategic approach to validating water quality improvements if projects are implemented at a large scale or numerous projects connect over time.

Scale of Attributes

Our focus in this document and in table 2 is on site-scale, or reach-scale, revegetation monitoring; however, remote sensing options such as geographic information systems with aerial photography (see Wehren et al. 2002) and infrared imagery can be applied to effectiveness monitoring. Information collected from such a broad scale can be used to help interpret the variability of data collected at a finer scale (Opperman et al. 2005). For further information on specific methods, refer to Roni (2005).

ADDITIONAL CONSIDERATIONS

Project Location Documentation and Photographic Monitoring

All qualitative and quantitative monitoring should occur in conjunction with proper documentation of the project location, as outlined in Gerstein et al. (2005) and Collins (2007). Also, we recommend that photopoint monitoring (Gerstein and Kocher 2005) be conducted at all riparian vegetation restoration sites, regardless of the monitoring type employed.

As the saying goes, pictures are worth a thousand words and are particularly valuable when sharing your project results with the public. It is important to locate photopoints so that they allow for repeated unobstructed photos once trees become well established. Detailed notes on the precise location and direction of photo points are also critical.

Monitoring Timeframe and Documenting Trajectory

Baseline data should be collected shortly before the project begins or immediately following its completion. Implementation monitoring should occur as soon as possible within the first year after project implementation.

Ideally, the duration of effectiveness monitoring should depend on the expected amount of time required to reasonably ascertain whether project objectives have been met. In other words, the monitoring timeframe should reflect the time necessary for identified attributes to change as a result of the revegetation project. For example, planted tree survival may be accurately assessed 3 years after project implementation, while significant changes in canopy closure may take 10 years or more to manifest (Lennox et al. 2007; Lennox et al. 2009).

Depending on the attribute, monitoring project sites for 10 years or more may be desirable (Lennox 2007; Lennox et al. 2007). However, this is generally longer than funding for most projects will allow (Reeve et al. 2006). Many restoration funding contracts last 3 to 5 years, with monitoring conducted during that time. Site conditions 3 to 5 years after implementation may be reasonable indicators of whether the riparian vegetation treatment is likely to have the desired effects, even if the duration of monitoring is insufficient to ascertain a direct response and thorough achievement of project objectives. Ideally, subsequent visits at a minimum of 3- to 5-year intervals are recommended to document ongoing changes in site response and trends in trajectory (Reeve et al. 2006).

Environmental stressors, project maintenance, and seasonal factors should also be considered when planning the timing of effectiveness monitoring because of their potential to influence monitoring survey results. For example, planted trees and shrubs are often irrigated for the first 2 years after installation. Thus, monitoring data collected after the third year, following a dry season without irrigation, will more accurately reflect the health and vigor of planted vegetation. Structural integrity is a concern for any type of bioengineered bank stabilization structure (Gerstein and Harris 2005; Wehren et al. 2002). Ideally, streambank structures and floodplain plantings should be assessed after high flow events to determine the project's ability to maintain its integrity following extreme physical conditions.

Monitoring should not be confused with maintenance. Ideally, a visual evaluation of the project site should be conducted annually by the contractor, project manager, or landowner to assess maintenance needs. It may be most efficient to do this before the onset of the dry season, when irrigation lines need to be checked and replaced, depending on the vigor and establishment of desired plant species.

Control and Reference Sites

A control site is a stream reach in the vicinity of a project site that is similar to the project site with regards to disturbance and impact but has not been restored. A reference site is an unimpacted site that serves as an example of ideal restored conditions (e.g., undisturbed native riparian forest). When chosen carefully, control and reference sites can provide a useful context for interpreting project success and evaluating how soon the trajectory of each attribute will reach the "predisturbance condition."

Control sites illustrate changes that occur naturally as a result of climatic and site conditions versus those that occur as a result of the revegetation treatment. A control site is generally an unrestored stream reach or bank with similar conditions and scale as the project site prior to treatment (i.e., location in the watershed, microclimate, stream channel type, seed source proximity, vegetation cover, composition, structure, and distribution). An alternative form of a control site, useful for documenting the effect of specific restoration techniques, is a site with similar conditions that was treated with a different restoration method. For example, fenced stream reaches with tree planting can be compared with fenced reaches that are not planted. This type of control site allows for the evaluation of restoration technique effectiveness, such as whether revegetation occurs more rapidly with planting than through natural regeneration.

Monitoring appropriate control sites in conjunction with restored sites provides useful information and can more definitively document whether changes in site conditions are a result of restoration treatments (e.g., tree planting) or natural occurrence (e.g., native plant colonization). Parties that have the necessary resources to locate and sample control sites may find that they are valuable in ascertaining trends and isolating beneficial impacts of their projects in the long run. However, control sites that are directly comparable to restoration sites are often difficult to locate and access. For these reasons and the increased time commitment required, it is usually unrealistic to expect most parties involved in project monitoring to sample control sites in conjunction with each restoration treatment site.

Reference sites illustrate ecological features of a predisturbance state and have been useful for both planning revegetation projects (e.g., selecting species to be planted) and establishing quantifiable project objectives. Such sites are, however, elusive and difficult to find (Harrelson et al. 1994). In many cases, watershed-scale impacts such as stream channelization or aggradation have precluded the ability of any stream reach to represent reference conditions for all attributes. In other instances the debate and lack of agreement as to what predisturbance conditions are hinder reference site selection. Because of this difficulty, we do not recommend that a monitoring program expend resources to identify and monitor such sites beyond gathering input for project design.

Identifying Planted Vegetation

One of the primary problems encountered when monitoring riparian planting sites is that it is often difficult to identify planted trees and shrubs among naturally colonizing vegetation. Conditions become particularly obscured along the edge of channels where alder (*Alnus* spp.), willow (*Salix* spp.), and cottonwood (*Populus* spp.) are planted in high densities with no protective hardware or marking. As early as 1 year after project implementation, many of these trees may have been washed out or buried by flood deposits, or natural colonization of these species may have occurred among the planted trees.

When selecting a monitoring method, consider whether you would like to evaluate only installed plants or all vegetation at the site. Selecting a method such as line intercept transects allows you to sample cover and composition for all vegetation and eliminates the need to identify specific plantings where natural recruitment of the same species is occurring. This method may also be adapted to include comments on planted versus colonized plants. If installed plants will be assessed individually, take care to mark or tag trees to ensure they can be identified as the site changes in the future. Keep in mind that for species that propagate vegetatively, such as arroyo willow *(Salix lasiolepis)*, interpreting the origin of low-sprouting regrowth becomes impractical 10 to 20 years after project implementation. Specific project objectives should either target success of plantings (i.e., 80 percent planted tree survival within the first 3 to 10 years of the project), overall site conditions (i.e., 400 percent increase in native woody cover) or both, and monitoring should be carried out accordingly.

CONCLUSION

Documenting changes in site conditions before and after restoration project implementation is critical to determining whether a project has achieved its objectives. Planning a monitoring program in conjunction with your revegetation project facilitates developing realistic, measurable project goals and objectives and using suitable protocols to assess project outcomes. In addition to documenting intended beneficial effects, consistent and systematic monitoring may also highlight inadvertent effects of vegetation restoration on target ecosystems. The information obtained through monitoring provides critical feedback to project participants and grantors. Furthermore, qualitative and quantitative monitoring outcomes can help restoration professionals decipher the reasons behind project successes and failures and apply those lessons to their practice. When project outcomes and the resulting lessons are presented and shared, they help increase the overall knowledge of riparian ecosystems and shape the growing science of stream and watershed restoration. Even projects that fail to meet their stated objectives can contribute valuable information to this process. As stated in Palmer et al. (2005), "assessment is a critical component of all restoration projects but achieving stated goals is not a prerequisite to a valuable project. Indeed, well-documented projects that fall short of initial objectives may contribute more to the future health of our waterways than projects that fulfill predictions." To that end, we encourage the communication of project outcomes and monitoring results beyond project partners to restoration practitioners, permitting agencies, scientists, landowners, and other stakeholders.

APPENDIX A
MONITORING PLAN WORKSHEET, INSTRUCTIONS, AND EXAMPLE
Monitoring Plan Worksheet

Project Name: **Implementation Date:**

Project Goals and Objectives

1. Project goals and objectives:

2. Attribute(s):

3. Targets (Include expected recovery timeline or number of years needed to achieve target):

Project Funding and Resources

1. Contract termination date:
2. Length of contract:
3. Monitoring required by contract? ☐ Yes ☐ No
4. Contractually required monitoring duration:
5. Duration of monitoring desired for attribute and trajectory:
6. Monitoring funds included in grant? ☐ Yes ☐ No Amount:
7. Monitoring funds from other sources? ☐ Yes ☐ No Source and amount:
8. Total monitoring funds available:

Monitoring Types

____Preproject Comments:
____Implementation ____Qualitative ____Quantitative
____Effectiveness ____Qualitative ____Quantitative
____Validation ____Qualitative ____Quantitative

Monitoring Objective(s)

Monitoring Methods

1. Method(s) and reference(s):
2. Method documents obtained and reviewed? ☐ Yes ☐ No
3. Estimated time required at each site:
4. Estimated equipment costs, if any:
5. Control site employed: ☐ Yes ☐ No
6. Reference site employed: ☐ Yes ☐ No

Monitoring Plan Worksheet Instructions

The Monitoring Plan Worksheet is intended to guide you in developing a monitoring program based on revegetation project goals and available monitoring resources. You may modify this worksheet as needed to suit your particular program needs.

Project Goals and Objectives

1. Review your original project documents and record the overall project goals and site-specific restoration project objectives (e.g., increase native woody vegetation on streambank, or increase over channel canopy cover to 80 percent). These should be stated in the contract or project description. In some cases it may prove beneficial to redraft the original project goals and objectives into a more useful and definitive format. See the section "Revegetation Project Goals and Objectives" for more information on developing objectives.
2. List all attributes or habitat components of interest relating to specific project objectives (e.g., native and non-native vegetation cover, canopy cover).
3. List quantitative target values for these attributes as a result of the revegetation project. Target metrics may be stated in the contract or project description (e.g., 70 percent native woody cover on streambank, or 80 percent over-channel canopy cover). It is important at this step to also indicate the timeline or number of years required to achieve the intended target.

Project Funding and Resources

1. Enter the contract termination date.
2. Enter the length of contract from start date to termination date. If the contract has already started, enter the time remaining to termination date.
3. Enter yes or no.
4. Enter the duration of monitoring required, if specified in contract.
5. Enter the duration of monitoring needed to match the timeline or number of years needed to achieve the identified attribute target.
6. Check yes or no and, if yes, the amount.
7. Check yes or no. If yes, enter the source(s) and amount of funds.
8. Enter the total monitoring funds available.

Types of Monitoring

Check the box next to the type(s) of monitoring you would like to conduct in your program. Preproject monitoring must be conducted in conjunction with all qualitative and quantitative effectiveness monitoring to ensure valid results. Record any pertinent comments. This may include intervals and overall timeframe for monitoring visits. Note whether qualitative or quantitative methods will be used for each monitoring type by checking the appropriate box.

Monitoring Objective(s)

State the monitoring objective(s), incorporating the project target and attributes. These are determined by your project goals and objectives. Be sure to include the number of years until the attribute targets are expected to be achieved. See the section "Revegetation Project Goals and Objectives" for more information on developing objectives.

Monitoring Methods

1. List the method(s) you intend to use and give references (see the reference list in this publication) for each selected method(s).
2. Enter yes or no. Methods should be reviewed prior to committing to any specific one to ensure that they can meet your monitoring objectives. Question three cannot be answered prior to protocol review.
3. Estimate the time required to sample each site, based on your review of the protocols, complexity of the project site(s), and your best professional opinion.
4. Make a list of the equipment needed to conduct field surveys. You will probably already have many of the common items. Consider borrowing expensive items such as survey equipment whenever possible to keep costs reasonable. Determine what additional equipment must be procured and estimate costs.
5. Indicate whether a control site or sites will be employed.
6. Indicate whether a reference site or sites will be employed.

COMPLETED WORKSHEET FOR EXAMPLE SITE

Project Name: Parsons Creek Willow Wall **Implementation Date:** 10/2003

Project Goals and Objectives

1. Project goals and objectives:
   a) stabilize eroding streambank to reduce fine sediment in channel
   b) increase woody vegetative cover on bank
   c) increase canopy cover over channel
2. Attribute(s):
   a) stability
   b) woody species cover
   c) canopy cover
3. Targets (Include expected recovery timeline or number of years needed to achieve target):
   a) stability ≥ 90% (after 3 years)
   b) establish woody veg cover (> 3 ft tall) to 30% (after 10 years)
   c) canopy cover ≥ 70% (after 10 years)

Project Funding and Resources

1. Contract termination date: 3/31/04
2. Length of contract: 3 years
3. Monitoring required by contract? ☑ Yes ☐ No
4. Contractually required monitoring duration: 3 years
5. Duration of monitoring desired for attribute and trajectory: 3 and 10 years
6. Monitoring funds included in grant? ☐ Yes ☑ No Amount:
7. Monitoring funds from other sources? ☐ Yes ☑ No Source and amount:
8. Total monitoring funds available: 0$ volunteers only

Monitoring Types

✓ Preproject			Comments:
✓ Implementation	✓ Qualitative	✓ Quantitative	
✓ Effectiveness	✓ Qualitative	✓ Quantitative	
___Validation	___Qualitative	___Quantitative	

Monitoring Objective(s)

Quantitatively evaluate proposed increases in bank stability from current conditions to > 90% within 3 years.
Quantitatively evaluate proposed increases in woody vegetation cover from current conditions to 30% within 10 years.
Quantitatively evaluate proposed increases in canopy cover over channel from current conditions to 70% within 10 years.

Monitoring Methods

1. Method(s) and reference(s):
   a) line intercept transect at bankfull (Gerstein and Harris 2005)
   b) line intercept transect at bankfull and top of bank (Harris et al. 2005)
   c) spherical densiometer (Flosi et al. 1998)
2. Method documents obtained and reviewed? ☑ Yes ☐ No
3. Estimated time required at each site: 2 hours per visit
4. Estimated equipment costs, if any: none
5. Control site employed: ☐ Yes ☑ No
6. Reference site employed: ☐ Yes ☑ No

EXAMPLE SITE PHOTOGRAPHS

October 2003, preproject. *Photo: S.Nossaman*

October 2003, upon project completion. *Photo: S. Nossaman*

February 2004, Parsons Creek high flow. *Photo*: S. Nossaman

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Publication 8363
ISBN-13: 978-1-60107-630-4

Development of this publication was supported by the California Coastal Conservancy.

An electronic copy of this publication can be found at the ANR Communication Services catalog Web site, http://anrcatalog.ucdavis.edu.

UC PEER **REVIEWED** This publication has been anonymously peer reviewed for technical accuracy by University of California scientists and other qualified professionals. This review process was managed by the ANR Associate Editor for Natural Resources.

pr-5/09-SB/RW