

Effectiveness Monitoring Program: Plan and Protocols



Tillamook Estuaries Partnership

A National Estuary Project

Prepared by

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1.0. Introduction

1.1. Background

The Tillamook Bay Comprehensive Conservation and Management Plan (CCMP) (TBNEP, 1999) included a number of Action Items to implement on-the-ground projects to improve instream, wetland (freshwater and tidal), riparian and upland habitats; water quality; and fish passage in the Tillamook Bay watershed. In 2002, along with other organizational shifts, TBNEP expanded its focus to include all five Tillamook County estuaries (Nehalem Bay, Tillamook Bay, Netarts Bay, Sand Lake Estuary, and Nestucca Bay). The name of the organization was changed to Tillamook Estuaries Partnership (TEP) to reflect this expansion and shift. With this expanded organizational focus, TEP broadened the area in which it works to the watersheds of other Tillamook County estuaries and began implementing projects like those noted above in these watersheds.

Since completion of the CCMP in 1999, on-the-ground habitat improvement projects have been one of the TEP's central efforts. The goal of TEP's Habitat Enhancement Program is to prioritize, develop, and implement on-the-ground projects that address the critical problems of habitat loss, water quality degradation, sedimentation, and impaired floodplain function. TEP staff develops and manages projects, and provide funding and administrative and technical support to partner projects.

TEP typically implements projects with defined sets of actions intended to protect or enhance specific habitat features or habitat-forming processes. These projects include, but are not limited to, fish passage barrier removal or replacement, in-stream and floodplain large wood placement, riparian tree and shrub planting (typically also includes control of invasive plants), and wetland projects (these projects typically include a variety of actions needed to enhance/restore tidal or freshwater wetlands including vegetation planting, invasive plant control, channel construction, large wood placement, etc.). Often projects include more than one of the above actions. For example, passage barrier removal projects also often include large wood placement, road decommissioning, and/or riparian plantings.

Efforts to improve or restore habitats often are broadly classified as restoration efforts. However, there has been considerable debate in the scientific community regarding more specific definitions for such projects and several terms have been used to describe different types of projects (Roni 2005a). These include:

- Restoration – to return an area to its original, undisturbed state.
- Rehabilitation – to restore or improve some aspects of an ecosystem, but not full restoration of all components.
- Enhancement or Improvement – to improve the quality of a habitat through direct manipulation.
- Reclamation – to return an area to its previous habitat type (not necessarily fully restoring all functions).
- Creation – construction of new habitat in an area where it previously did not exist.
- Mitigation – actions taken to compensate for the adverse effects of a variety of activities.

As noted above, TEP implements a variety of project types utilizing many different techniques. Using the above definitions, the projects that TEP typically undertakes would most often be classified as rehabilitation or enhancement. However, for the sake of brevity and simplicity in this document we will hereafter use the term “restoration” in referring to all of TEP’s on-the-ground efforts to improve habitat conditions.

1.2. Monitoring Definitions and TEP’s Monitoring Program

In ecological studies, monitoring typically refers to repeated sampling in an effort to detect changes in biological, chemical and/or physical parameters. To date, monitoring completed for most TEP restoration projects can be classified as Implementation Monitoring. Implementation Monitoring is designed to evaluate management actions to determine whether they were implemented properly or comply with established standards (PNAMP 2005, Roni 2005a, Katz et al. 2006). This type of monitoring is typically completed for restoration projects where engineered solutions or Best Management Practices (BMP’s) have been implemented (Katz et al. 2006) and often collects information suitable for compliance with grant or permit reporting requirements.

Effectiveness Monitoring (sometimes referred to as Project Effectiveness Monitoring) is typically defined as monitoring to determine if restoration actions had the desired effects on physical processes or habitat conditions (e.g., did Project X result in an increase in pool area?) (PNAMP 2005, Roni 2005a, Katz et al. 2006). Validation Monitoring is the term often used to define monitoring to evaluate cause and effect (inferential) relationships between restoration actions and physical or biological responses (e.g., did the change in pool area associated with Project X lead to desired changes in fish abundance?) (PNAMP 2005, Roni 2005a, Katz et al. 2006). The same concepts also can be applied at broader scales to assess the success of integrated restoration actions designed to affect entire streams, watersheds or basins. Up until recently, TEP had not completed these types of monitoring activities for our restoration projects.

Consistent with guiding principles of the CCMP, the TEP 2010 Workplan (TEP 2009) included development of a Project Effectiveness Monitoring Program to quantitatively determine the success of restoration projects implemented by TEP. As a result, TEP created and filled a new staff position (Project Manager) to develop and manage the Project Effectiveness Monitoring Program.

For the purposes of this document, the definition of Effectiveness Monitoring that TEP will operate under includes both Effectiveness and Validation monitoring as defined above. In other words, our Monitoring Program will assess how our restoration projects affect physical processes and habitat conditions and, to the extent possible, evaluate the cause and effect relationships between the restoration actions and physical and biological responses. As noted above, TEP has not historically implemented this type of monitoring. However, in 2009 we developed and began implementing an Effectiveness Monitoring plan for the Miami Wetlands Project and will complete Effectiveness Monitoring for all future restoration projects.

This document is an important step in establishing TEP’s long-term Effectiveness Monitoring Program and will guide our future monitoring efforts. The subsequent sections define the goals and objectives of our Effectiveness Monitoring Program, outline the approach, study designs, and monitoring parameters we will use for our monitoring efforts, and include appendices that

reference original documents that detail protocols that TEP will follow when collecting data during project effectiveness monitoring efforts.

2.0. Effectiveness Monitoring Program Goals and Objectives

The Oregon Watershed Enhancement Board (OWEB) has stated that Effectiveness Monitoring should “follow established protocols, be statistically valid, generate quantifiable data, and produce results that, when tested, are repeatable” (http://oregon.gov/OWEB/MONITOR/effective_monitoring.shtml). Further, monitoring programs should assess the performance of restoration projects relative to project goals and provide information that can be made available to interested parties and be used to improve the performance of the monitored project and future projects (Thom and Wellman 1996). In addition, the scale (areal extent) and sampling frequency and intensity for a monitoring program must be suitable to measure the performance indicators accurately and reliably, and assess progress toward the project's objectives, goals, and mission (NRC 1992). Additionally, a monitoring program should define the problem, specify what data are to be collected when, and explain how the data are to be used once collected (NRC 1992). We concur with all these sentiments and they are reflected in the goals and objectives we have developed for our Effectiveness Monitoring Program.

The goal of TEP’s Effectiveness Monitoring Program is to determine if our restoration projects have the desired effects on physical processes and/or habitat conditions and, when possible, to evaluate cause and effect relationships between our restoration actions and physical or biological responses. We recognize that observed physical and biological responses often can be confounded by influences outside of those associated with restoration actions or may be only indirectly affected by some restoration actions. In addition, studies to gather this type of information are complex, technically rigorous and typically require very structured statistical designs (Katz et al. 2006). As a result, our first priority will be collection and analysis of data that can answer questions relative to project- related effects on physical processes and habitat conditions. To the extent possible, we will account for the aforementioned outside influences in our study designs, analyses, and reporting to facilitate evaluation of physical and biological responses.

Objectives of TEP’s Effectiveness Monitoring Program are to:

- Use standardized and widely accepted methods to collect and analyze data on a variety of physical and biological attributes.
- Use a systematic approach in which restoration actions and associated monitoring efforts are integrated in an iterative process.
- Integrate Effectiveness Monitoring with Implementation/Compliance Monitoring. We concur with authors who have pointed out that it is not possible to fully evaluate the effectiveness of a project without knowing how it was implemented.
- Include monitoring line items in restoration project budgets to the extent possible. Because monitoring will be an integral part of our restoration projects, it is critical that we consider its costs and how it will be funded.

- Use the most robust study designs that logistical and financial constraints allow.
- Use existing data and incorporate ongoing data collection programs whenever practicable. Many agencies and organizations have long-term data sets and ongoing data collection efforts for a variety of applicable parameters including fish counts, water quality, precipitation, tides, in-stream habitats, and others.
- Use the results of this monitoring effort in an adaptive management process to inform future projects and refine our restoration and monitoring techniques as needed.
- Make our data and results widely available. Results of our efforts will be provided to our funders and partners. In addition, we will post reports on our website and will seek to present our findings in print and electronic media, journals and professional conferences.
- Keep abreast of the current “state of the art” for restoration and monitoring by networking with professionals and organizations conducting similar work and attending workshops, symposiums and other training forums.
- Although most of our projects are conducted primarily to affect salmonids and their habitats, to the extent possible, our monitoring efforts will collect information on a wide variety of ecological parameters to help us understand how our projects affect other wildlife and plant species.

3.0. Approach, Study Designs, and Metrics

As noted above, TEP implements a variety of different restoration activities in many different environments. This impacts effectiveness monitoring inasmuch as study designs, monitored parameters, and other aspects will vary among project types and among environments in which projects are conducted. For example, although there are similarities, monitoring for a tidal wetland restoration project will differ from that needed for a project placing large wood in an upper watershed stream and monitoring for a project in a tidal wetland may differ somewhat from one in a non-tidal wetland. Roni (2005b) recognized this variety in a publication he edited on monitoring stream and watershed restoration projects and, as a result, included nine separate chapters each discussing monitoring of specific restoration treatment types. Similarly, Johnson et al. (2001) identified numerous restoration project types and recommended monitoring protocols for each.

A complete accounting of all possible study designs, monitoring parameters, protocols, etc. for each type of project TEP initiates is beyond the scope of this document. The remainder of this document will instead identify general principles and strategies we will use in developing and implementing restoration projects and associated monitoring efforts and provide examples of and sources for information on protocols we will use for data collection and analysis.

3.1. Systematic Approach to Restoration and Monitoring

TEP will use a systematic approach for its restoration and monitoring efforts. The five components of this approach are: 1) Planning, 2) Implementation, 3) Performance Assessment, 4) Adaptive Management, and 5) Dissemination of Results (Diefenderfer et al. 2003). Under this

approach, restoration and monitoring efforts are closely linked and the foundations for both are formed in the early stages of project planning.

Figure 1 provides a flowchart of the planning process for a restoration project. Although the chart itself is a simple linear model, the reality of project planning is that it is a complex process and stages are often repeated as new information and ideas are generated (Diefenderfer et al. 2003). As is evident from the flowchart, important steps in this process with respect to Effectiveness Monitoring are development of project goals, objectives and conceptual models.

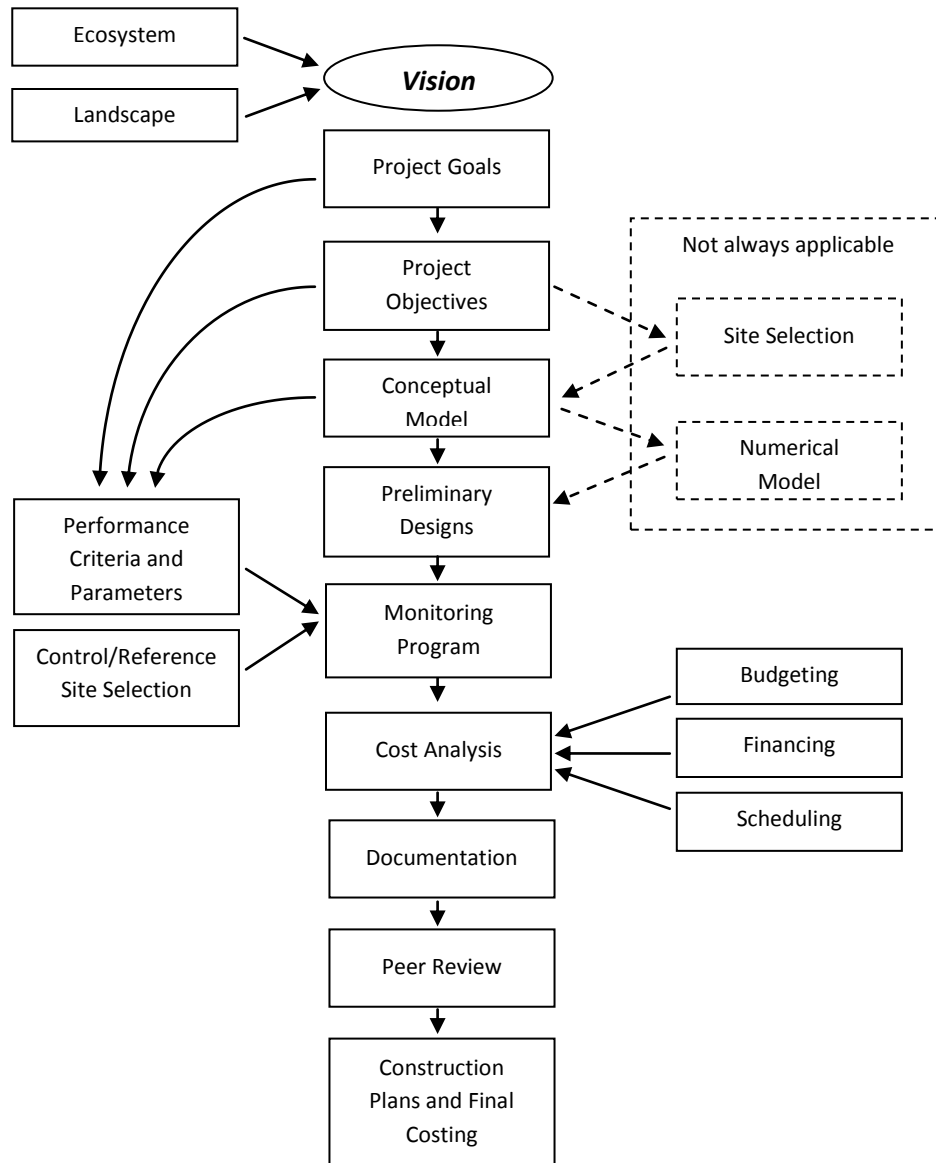


Figure 1. Simplified restoration project planning process (adapted from Diefenderfer et al. 2003).

Goals should be simple and unambiguous, relate directly to the vision for the project, and be prioritized so that their relative importance is clearly defined (NRC 1992, Thom and Wellman 1996). Well-developed, carefully conceived goals and objectives can be readily transitioned into testable hypotheses, performance criteria, and monitoring parameters for use during the

monitoring process (NRC 1992, Thom and Wellman 1996, Diefenderfer et al. 2003, Roni et al. 2005). Objectives are derived from the goals and should be specific, measurable, attainable, relevant and time-bound (SMART objectives).

Conceptual models describe the general functional relationships among essential components of an ecosystem. They identify the direct and indirect connections among physical, chemical, and biological components of an ecosystem; principle components on which to focus restoration and monitoring efforts; and how and where restoration actions will alter these components (boxes) and/or connections (arrows) (Thom and Wellman 1996, Diefenderfer et al. 2003, Fischenich 2008). They typically follow the general form identified in Figure 2. Conceptual models also are useful for identifying performance criteria and monitoring parameters.¹

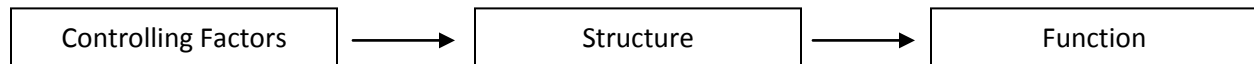


Figure 2. Generalized conceptual model form (from Thom and Wellman 1996).

A real-world example of a conceptual model is provided by Thom and Wellman (1996) for a project to restore riparian vegetation and improve aquatic macroinvertebrate habitats. In this example, Controlling Factors include sunlight, hydrology, geomorphology and nutrients. Structural components include riparian vegetation and its by-products such as shade and detritus. Functional components are the habitat features that riparian vegetation provides for macroinvertebrates such as nesting substrates, food, and refuge and attributes of invertebrate population dynamics such as growth rates. If the project goal is simply to restore the riparian forest then monitoring critical controlling factors and riparian vegetation would be sufficient. However, if the goal is to enhance or restore the macroinvertebrate community associated with the riparian system, then monitoring of macroinvertebrates also would be needed. Although not necessarily required to assess the effects of the project, monitoring of structural components would be needed to evaluate the linkage between riparian vegetation and macroinvertebrates, identify possible breakdowns between the two should the project not produce the desired results, or to determine which structural factors are most important with respect to the macroinvertebrate community.

Roni et al. (2005) diagrammed basic steps for establishing a monitoring and evaluation program for restoration projects (Figure 3). This model incorporates some of same principles and steps as the processes described above and there are stages in this model where products of the planning and modeling processes diagrammed above are directly applicable.

The National Research Council developed a list of questions about processes and outcomes that they recommend be considered during the various phases of a restoration and monitoring effort. This checklist and figures 1, 2 and 3 identify and emphasize the connections between restoration actions and associated monitoring efforts. TEP will follow a process comparable to those described above and depicted in figures 1, 2 and 3 and Table 1 for all restoration and monitoring projects we undertake.

¹ See Section 3.3.

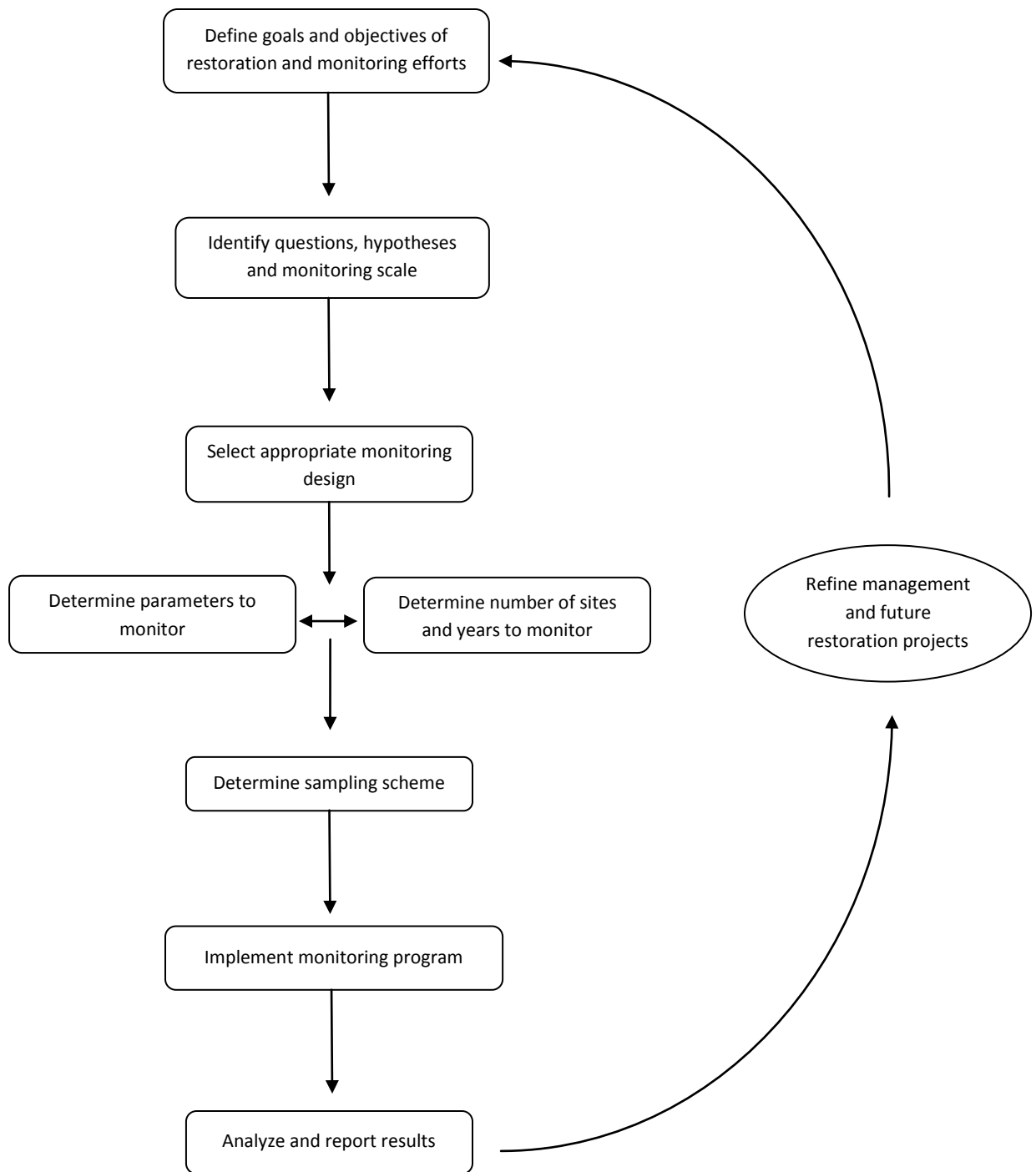


Figure 3. Basic steps for effectiveness monitoring of restoration projects (from Roni et al. 2005).

Table 1. Restoration Checklist (from NRC 1992)

Project Planning and Design

1. Has the problem requiring treatment been clearly understood and defined?
 2. Is there a consensus on the restoration program's mission?
 3. Have the goals and objectives been identified?
 4. Has the restoration been planned with adequate scope and expertise?
 5. Does the restoration management design have an annual or midcourse correction point in line with adaptive management procedures?
 6. Are the performance indicators—the measurable biological, physical, and chemical attributes—directly and appropriately linked to the objectives?
 7. Have adequate monitoring, surveillance, management, and maintenance programs been developed along with the project, so that monitoring costs and operational details are anticipated and monitoring results will be available to serve as input in improving restoration techniques used as the project matures?
 8. Has an appropriate reference system (or systems) been selected from which to extract target values of performance indicators for comparison in conducting the project evaluation?
 9. Have sufficient baseline data been collected over a suitable period of time on the project ecosystem to facilitate before-and-after treatment comparisons?
 10. Have critical project procedures been tested on a small experimental scale in part of the project area to minimize the risks of failure?
 11. Has the project been designed to make the restored ecosystem as self-sustaining as possible to minimize maintenance requirements?
 12. Has thought been given to how long monitoring will have to be continued before the project can be declared effective?
 13. Have risk and uncertainty been adequately considered in project planning?
-

During Restoration

1. Based on the monitoring results, are the anticipated intermediate objectives being achieved? If not, are appropriate steps being taken to correct the problem(s)?
 2. Do the objectives or performance indicators need to be modified? If so, what changes may be required in the monitoring program?
 3. Is the monitoring program adequate?
-

Post-Restoration

1. To what extent were project goals and objectives achieved?
 2. How similar in structure and function is the restored ecosystem to the target ecosystem?
 3. To what extent is the restored ecosystem self-sustaining, and what are the maintenance requirements?
 4. If all natural ecosystem functions were not restored, have critical ecosystem functions been restored?
 5. If all natural components of the ecosystem were not restored, have critical components been restored?
 6. How long did the project take?
 7. What lessons have been learned from this effort?
 8. Have those lessons been shared with interested parties to maximize the potential for technology transfer?
 9. What was the final cost, in net present value terms, of the restoration project?
 10. What were the ecological, economic, and social benefits realized by the project?
 11. How cost-effective was the project?
 12. Would another approach to restoration have produced desirable results at lower cost?
-

3.2. Study Designs

Several potential study designs are appropriate for monitoring restoration projects, all have strengths and weaknesses and none is suitable for all situations. Designs can be differentiated into two general classes: Before-After and Post-Treatment designs (Roni et al. 2005). As the names suggest, the primary difference in these two study design classes is whether or not pre-project data is collected.

Under most circumstances a Before-After (BA) design is preferred because direct comparisons can be made between pre- and post-project conditions. There are several variations on the BA design, differentiated based on number of sites studied (spatial replication) and existence of controls (Roni et al. 2005). The simplest BA design is to collect pre- and post-project data on a set of parameters in proximity to the restoration site only. This approach provides temporal replication (repeated measures over time) only and is typically most appropriate for monitoring an individual restoration project at a single site. The downside of this design is that because it lacks control data it can be difficult to differentiate treatment effects from natural variability.

A typically more robust design that incorporates both temporal and spatial replication is the Before-After Control Impact (BACI) design. This design evaluates one or more control or reference sites² over the same period as the treatment site. Addition of one or more control sites can increase the ability to differentiate treatment effects from natural variability. However, care must be taken when selecting control sites; poorly chosen controls can confound results and considerably reduce the power of the design.

A replicated BACI design (aka Multiple BACI - MBACI) is potentially the most powerful of all study designs in that it includes both temporal and spatial replication (monitoring of multiple treatment and control sites before and after restoration actions) (Roni et al. 2005). However, it is obviously more costly and challenging to implement than BA or BACI designs and some project types do not lend themselves to replication (e.g., dam removal). Further, use of this type of design may also be limited due to few similar projects being implemented during a given period.

Post-Treatment designs are applicable in situations where collecting pre-project data is not possible (e.g., evaluating historical projects or responses to unplanned events). In such instances, the project area is compared to a similar site where such treatments have not occurred (a control or reference site). Two basic types of Post-Treatment designs have been identified: Intensive Post-Treatment Design (IPT) and Extensive Post-Treatment Design (EPT) (Roni et al. 2005). For an IPT design data is collected at one or a few paired control and treatment sites over multiple years (spatial and temporal replication - essentially a BACI design without pretreatment data). An EPT design includes only spatial replication; data is collected at many paired treatment and control sites over a very short period of time (typically one sampling event at each site with all samples collected over a 1-3 year time period).

TEP typically implements no more than a few projects annually and often has one or more years of planning prior to project implementation. As a result, BA and BACI designs will likely be the preferred designs for TEP restoration projects. Because MBACI designs require several similar projects and several controls, it is unlikely that our organization will have an opportunity to implement this type of design (i.e., it is unlikely that TEP will have an opportunity to implement several similar restoration/monitoring projects over the same time period). However, we will utilize this design if the opportunity arises.

² Although there is some disagreement regarding terminology, controls typically are sites that are nearly identical to the project site in its pre-treatment state, whereas reference sites are ideal or pristine areas where conditions are unaltered by human activities (Roni et al. 2005). TEP's Effectiveness Monitoring Program will use these distinct definitions when referring to and selecting control and reference sites.

There may be some opportunities to utilize an IPT design to evaluate the effectiveness of historical TEP projects. However, a brief review of these projects and available data indicates that there are some applicable pre-project data available from some of these sites that may allow for analysis using a BA or BACI design. More effort is needed to fully assess available data on these projects and develop a strategy to evaluate these projects a posteriori.

3.3. Performance Criteria and Monitoring Parameters

Performance criteria (aka performance indicators) identify the expected structure, function and appearance of a system and are used to assess progress made relative to project goals and monitoring parameters are structural and functional features that can be measured (NRC 1992, Thom and Wellman 1996). For example, the Oregon Department of Environmental Quality (DEQ) dissolved oxygen standard for estuarine waters (6.5 mg/L - based on juvenile salmonid survival) could be used as a water quality performance criteria for a tidal wetland project and the monitoring parameter to assess progress towards that performance criteria would be sampling of dissolved oxygen levels. Performance criteria and monitoring parameters for each project will be developed early in the project planning stages through careful development of project goals and objectives and conceptual models.

Performance criteria define the acceptable range of values for a parameter that is measured; the closer they are tied to project goals and objectives the easier it is to judge progress (Thom and Wellman 1996). They are typically based on data from baseline studies, reference systems, regulatory standards, and/or published information on the species or system targeted by the restoration effort. Thom and Wellman (1996) advise that it is not necessary to develop a large number of complex criteria if a small, simple set will suffice and the NRC (1992) has stated that “criteria should include both structural and functional attributes of the ecosystem, and should be based on known antecedent conditions of the target or reference ecosystem.”

Selection of monitoring parameters should focus on developing a science-based, easily-measured set of metrics that provide feedback on performance of a system toward meeting project goals (Thom and Wellman 1996). These authors identify an approach for selecting monitoring parameters that recognizes the need to establish these parameters well before monitoring takes place and that is based on the generalized conceptual model depicted in Figure 2 of this document. The three steps in this approach are:

- 1). Simplify the system into controlling, structural and functional components.
- 2). Identify one or more measurable parameters within each of these three components.
- 3). Compile a subset of parameters from this initial set based upon ecological consideration.

NRC (1992) provides an annotated list of possible structural, functional, and holistic ecological performance criteria and associated monitoring parameters to assist in selection of these metrics. Johnson et al. (2001) provides a table that identifies general project types and the parameters on which monitoring should focus. This document is specific to the Pacific Northwest and salmonids and, thus, the identified parameters are particularly pertinent to TEP’s monitoring efforts.

4.0. Monitoring Protocols

Every restoration project is different and, as identified above, this variation effects selection of performance criteria and monitoring parameters. The criteria and parameters selected for a project will dictate what methods are used to gather data relative to these metrics. Most criteria and parameters likely to be included in a monitoring program are well established (Thom and Wellman 1996) and there are well-documented data collection and processing protocols (i.e., methods tried and proven reliable under many conditions) for assessing these metrics. These authors caution against using new or poorly documented methods that can open questions of accuracy and repeatability. They also suggest that, whenever possible, one should consider field methods that provide for collection of data on more than one parameter. For example, a soil sample may provide information on several different parameters including soil conditions, root development, hydrology and invertebrate communities (Thom and Wellman 1996).

As discussed above, each project is unique and applicable protocols will vary among projects. Numerous protocols are applicable to the monitoring efforts of TEP and it is beyond the scope of this document to compile an exhaustive and annotated list of protocols that TEP's monitoring program may use. Other publications have already provided such lists, most notably Johnson et al. (2001) and Roegner et al. (2009), both of which provide information on protocols applicable to TEP project. Although these documents provide an extensive account of available and applicable protocols, they do not necessarily represent all possible protocols that we will use for our monitoring program. Restoration and monitoring are evolving fields and ongoing research will undoubtedly generate new information, ideas, strategies, techniques, and technologies. TEP will remain current with respect to the state of knowledge relative to this topic and will strive to use the most current and widely accepted methods for all our restoration and monitoring efforts.

We will select the appropriate protocols to use for a given project through the approaches identified above. Table 2 lists a variety of different restoration project types that TEP typically conducts and identifies likely monitoring methods that will be employed. This table is not intended to rigidly define the scope of monitoring efforts for given project types. Rather, it is included as general guidance and to identify likely data collection efforts for the various types of restoration projects TEP typically conducts.

Table 2. Typical projects conducted by Tillamook Estuaries Partnership and the data collection efforts likely to be carried out during effectiveness monitoring for such projects.

		Data Collection Focus											
		Water Level Monitoring ¹	Road-Stream Crossing Survey ²	Vegetation Community Monitoring ³	Planting Survival Monitoring ⁴	Water Quality Monitoring ⁵	Fish Surveys ⁶	Shade Monitoring ⁷	Other Wildlife Survey ⁸ s	Repeat Photography ⁹	Aquatic Habitat Inventory ¹⁰	Macro-invertebrate Sampling ¹¹	Topographic Monitoring ¹²
Project Type	Barrier Removal / Replacement		✓			✓	✓			✓	✓	✓	✓
	In-stream Habitat Enhancement					✓	✓		✓	✓	✓	✓	
	Riparian Planting / Fencing			✓	✓	✓		✓	✓		✓	✓	
	Freshwater Wetland Restoration / Enhancement	✓		✓	✓	✓	✓	✓	✓		✓	✓	✓
	Road Removal / Relocation					✓			✓	✓	✓	✓	
	Tidal Wetland Restoration / Enhancement	✓		✓	✓	✓	✓	✓	✓		✓	✓	✓

✓ = Recommended ✓ = Optional

Typical protocols employed for identified survey types:

1. Monitoring wells equipped with data recorders or measured manually.
2. Data collection protocols employed to assess road-stream crossings for passage analyses (e.g., Hoffman 2006, Bailey 2012)
3. Several methods may be employed including, but not limited to, line-intercept transects, 1-m² herbaceous plots and 5-m radius tree/shrub plots.
4. Long term survival monitoring of planted species.
5. Repeat sampling for a variety of water quality variables including temperature, salinity, dissolved oxygen, bacteria, etc. Methods will vary, but may include repeat collection of grab samples or data loggers.
6. Surveys for adult and/or juvenile salmonids. May include one or more of the following methods: spawning surveys, snorkel counts, mark-recapture trapping, etc.
7. Collect site-specific shading data using Solar Pathfinder™ or other similar device.
8. Surveys for select wildlife. May include amphibian calling surveys, avian species surveys, track surveys, live-trapping, etc.
9. Repeat photos from established photo points.
10. ODFW Aquatic Habitat Inventory or similar technique designed to quantify aquatic habitat conditions.
11. Sampling macroinvertebrate community
12. Techniques designed to quantify geomorphology including, but not limited to, channel cross sections and elevation monitoring.
13. Techniques designed to quantify soil properties including, but not limited to, texture, salinity and organic matter.

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Appendix

The following is a list of reference publications that provide examples of monitoring protocols that TEP will use during our Effectiveness Monitoring efforts. This is not intended as an exhaustive list and these are by no means the only monitoring protocols that TEP will utilize. Instead, these documents provide information on protocols that are currently being used by TEP and others monitoring habitat restoration efforts in the Pacific Northwest and are widely recommended by technical specialists. Exclusion of a source from this list in no way implies that TEP will not consider or use such methods in its Effectiveness Monitoring efforts.

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- Hotchkiss, R.H. and C.M. Frei. 2007. Design for fish passage at roadway-stream crossings: synthesis report. U.S. Department of Transportation Publication No. FHWA-HIF-07-033.
- Hubler, S. 2008. PREDATOR: Development and use of RIVPACS-type macroinvertebrate models to assess the biotic condition of wadeable Oregon streams (November 2005 models). DEQ08-LAB-0048-TR Version 1.1.
- Johnson, D.H., N. Pittman, E. Wilder, J.A. Silver, R.W. Plotnikoff, B.C. Mason, K.K. Jones, P. Roger, T.A. O'Neil, and C. Barrett. 2001. Inventory and monitoring of salmon habitat in the Pacific Northwest – Directory and Synthesis of Protocols for Management/Research and Volunteers In Washington, Oregon, Idaho, Montana, and British Columbia. Washington Department of Fish and Wildlife, Olympia, Washington. 212 pp.
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- Water Quality Interagency Work Group. 1998. Stream Macroinvertebrate Protocol, Draft 4. Oregon Plan for Salmon and Watersheds. <http://www.cbr.washington.edu/salmonweb/oregon/Macro.html>