Chapter 1 Introduction

Wetlands and riparian areas are transitional ecosystems, positioned physically and ecologically between terrestrial and aquatic systems. They are characterized by seasonal flooding, rich soils and diverse vegetation structure. Healthy wetland and riparian areas filter toxic chemicals and agricultural nutrients from water runoff, recharge ground water, reduce flooding, support a rich and varied flora, and provide important habitat and refugia for both aquatic and terrestrial wildlife. Acre for acre, they provide more ecosystem services than nearly any other ecosystem type in California.

Over the last century and a half, however, California has seen the degradation and loss of nearly 90% of its wetlands and much of its riparian areas. Human activities such as agriculture, vegetation removal, road building, urbanization, poorly managed grazing, and channelization have accounted for much of the loss. Areas once protected by meandering wetlands now flood more readily, and rivers and streams, no longer buffered by vegetated riparian zones, receive large burdens of eroded topsoil and pollutants. Fish and wildlife populations, once abundant, have declined to the point of nearly disappearing due to habitat loss and invasion of non-native species. During the next century, riparian and wetland ecosystems will experience additional stress from temperature extremes, droughts, increasingly variable precipitation, and shifts in the distribution of plants and animals due to global climate change.

In recent decades, Californians have invested heavily in protecting the wetlands and riparian areas that still remain in relatively natural condition, placing some of most pristine examples of these ecosystems in parks, reserves, and wildlife refuges. While these conservation efforts are critically important, they must be accompanied by restoration and conservation of the wetlands and riparian areas on public and private lands that lack official protected status if we hope to prevent further decline of wildlife populations and keep the state's natural resource base healthy and functioning in the face of population growth and climate change (Seavy et al. 2009).

Many land owners and public land managers are engaging in restoration activities. Seeing the effects of uncontrolled erosion and invasion of non-native plants, and concerned about pesticides and other contaminants making their way into waterways, they are taking steps to reverse ecological damage and clean up the waterways flowing across their land. Their small-scale efforts cumulatively can have larger effects. Unfortunately, it is not always clear how to approach restoration work, improve water quality, prevent further damage to waterways, and enhance the ecological health of wetlands and riparian areas while at the same time allowing for human uses such as agriculture and livestock grazing and addressing the uncertainties of climate change. This manual is intended to provide the encouragement and proper guidance that this work deserves.

Purpose of this Manual

This reference manual serves as an introductory guide for those who want to help restore the state's wetlands and riparian zones. It outlines a set of key restoration/management projects, each of which has been shown to have the potential for significantly improving water quality, halting or reversing ecological decline, and serving as a basis for additional restoration. The more widely these projects are implemented across the state, the greater the potential for creating a healthier California—richer with wildlife, benefitting from streams that flow with more abundant and cleaner water, and more resilient in the face of climate change.

Land managers, conservationists, agency staff members, environmental consultants, and funding agencies can use the guidance contained in this manual to better understand the basic features of these projects and learn what planning needs to occur before implementing them; they can also use the information in the manual to locate additional sources of information that will help them better plan for and implement a project and to monitor project function, stream health, and water quality after the project is in place. It is also hoped that this manual will help researchers improve restoration work, help lead agency and regulatory agency staff members to more efficiently formulate reporting and monitoring criteria, and serve as a model for replication of other guidance designed to help Californians prioritize restoration work and water quality practices as global climate change effects unfold.

The projects described in this manual were chosen for inclusion because they can be used over much of the state and have broad applicability and proven efficacy. A great many other restoration projects and more general practices are available to restoration practitioners. State and federal guidelines such as the National Resources Conservation Service FOTG contain hundreds. The projects presented here make up a basic restoration "toolkit," which can be supplemented by any of the many other activities that exist. This will be a living document that will be revised as restoration priorities shift and as new information becomes available.

This manual has been designed to serve those new to restoration work as well as the experienced; it is directed primarily to landowners, land and resource managers, state and federal agency staff members, and environmental consultants. The intended audience includes employees of organizations like Resource Conservation Districts, the Natural Resources Conservation Service, and California Department of Fish and Wildlife. Other audiences that could benefit from this manual include funders, conservation lands managers, water district managers, and farmers and ranchers. This manual refers collectively to these various people as "restoration practitioners."

This manual seeks to assure the restoration practitioner that he or she is not alone in undertaking restoration work and managing water quality. A resource guide accompanying each project is designed to assist with locating the many experts and resources available. The authors hope this manual inspires and encourages readers to take action.

General Considerations in Restoration Work and Water Quality Management

When a land manager or land owner perceives a need to undertake restoration of a riparian area or wetland or to improve the water quality of a stream, it is frequently the case that the affected area or watercourse suffers from three widespread and inter-related forms of ecological decline: erosion has changed hydrological function, altered the habitat, and increased sedimentation; invasive, non-native plant and animal species have displaced natives and lowered overall diversity; and the native flora is much less diverse than it once was, with many former species simply absent. Broad and long-term restoration goals cannot be realized without giving attention to these three conditions and working to improve them. Although the projects described in this manual have much narrower goals and focused purposes than complete ecological restoration, their positive impacts are greatly enhanced when they are carried out with an eye toward understanding how they can be part of an overall effort to stem erosion, remove invasives, and restore native plants on a particular property or piece of land. In a similar way, discrete restoration projects are best considered within a long-term timeframe that takes into account the anticipated stresses of climate change.

Erosion Control

Erosion occurs when flowing water, wind, or other physical processes remove or displace soil. It is a concern in part because soil is a critical resource that does not replace itself. It may take as long as 50,000 years for an inch of soil to form. Because soil forms the basis for plant productivity, maintaining soil depth and quality are key to a site's ability to maintain itself over time and to recover from disturbance. In addition, infiltration rates, soil moisture retention, productivity, and groundwater recharge can all be significantly reduced when the upper layers of soil are removed. Erosion is also a concern because the eroded soil can have a variety of negative impacts when it enters streams or wetlands. As sediment, it alters aquatic habitats, affects water quality, and changes hydrological processes. For all of these reasons, reducing soil erosion should be a basic goal for all natural resource project managers.

Erosion control is an issue for restoration practitioners in two distinct ways. First, because erosion and sedimentation are general problems in riparian and wetland habitats, most restoration work should be designed and carried out to maximize its ability to control natural or human-induced erosional processes in the environment or repair past erosional damage. Some restoration projects (including four of the projects outlined in this manual) include erosion control among their explicit objectives; others can be designed to work in concert with erosion control measures. Second, because the restoration work itself can be a source of unintended erosion, all such work must be carried out in a way that minimizes its potential to disturb soil and deliver sediment to streams. This latter issue deserves further discussion.

Any restoration project that involves transport of materials, installation or removal of structures, vehicle access, or heavy equipment use may disturb soil, deliver sediment to streams, raise dust, or leave soil vulnerable to later erosion. These undesirable effects can be mitigated with a variety of well-known practices such as the placement of wattles. In California's Mediterranean climate, it is generally desirable to implement any restoration work before the advent of winter rains and to halt the work until rains have ceased in the spring. Each particular project calls for certain specific erosion-control measures as well, depending on the habitat and the nature of the anticipated disturbances. For some projects, effective erosion control calls for re-vegetation (see below) and protection of the soil surface until the new plants are established.

While protecting against unintended erosion during restoration work is important, care must be taken to insure that the mitigation measures don't themselves have negative side effects. If incorrectly implemented, erosion control measures can suppress native plant establishment (Keeley et al. 1981; Beyers 2004; Adams et al. 2005), introduce weeds, and obliterate the bare-soil habitat important for some species (Arnold et al. 2012; Hayes and Holl 2003). Erosion control materials sometimes include plastic netting that could entangle or kill wildlife. Therefore, erosion control experts should work with biologists familiar with the area to assure erosion control is well fitted with other biological concerns.

Invasive Species Control

Invasive species exert their negative effects both directly and indirectly (Jules et al. 2002; Skorka et al. 2010; Vitousek 1990). Invasive plants compete for resources more effectively than many natives, reproduce and disperse more rapidly, and generally lack the controls on population growth that exist for natives. They tend, therefore, to displace natives and to change habitat structure (Pavlik et al. 1993; Brown and Rice 2000). Non-native animals have similar competitive advantages over native animals, and can impact natives more directly by preying on them (Maze 2009; Wilcove et al. 1998). In general, invasive species degrade habitats, lower animal populations, and reduce floral diversity, leading to simpler, less resilient ecosystems with reduced ability to cycle nutrients and resist erosion and other forms of disturbance (Wilson et al. 1997; Adams and Pearl 2007; Hornaday et al. 2007; Pimentel et al. 2005). For these reasons, controlling invasive species is increasingly becoming one of the main tasks for restoration practitioners in California.

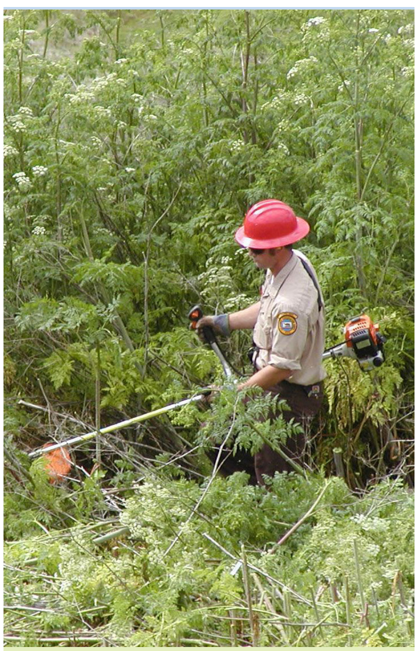


Photo: P1.1 Invasive hemlock control
Photo:ESNERR

It is clear that preventing the introduction of invasive species is less expensive than controlling their spread or removing them. Rarely is enough funding available, however, even for prevention (Leung et al. 2002). Further, many invasive species have been established for so long in many habitats all over the state that prevention is largely a moot point. Therefore, restoration work in the habitats with the most invasive species—such as California's grasslands (Huffaker and Holloway 1949), shrublands (Lambrinos 2000), forests (Blair et al. 2010), and riparian areas—almost always includes invasive species removal and control.

Invasive species control includes a range of practices (e.g., managed grazing, trapping and shooting, targeted application of herbicides, prescribed burning, manual or mechanical removal) designed to reduce the negative impacts of non-native species; the practitioner may focus on reducing the population size or density of a non-native species, lowering the number of its populations, reducing or restricting the area of land occupied by the species, or, more ambitiously, eliminating a non-native species entirely from an area. The scope and focus of the effort depends on the species, the management goals of the property, the extent to which invasives have taken hold, and various practical considerations that ultimately relate to cost.

Readers contemplating one of the projects described in this manual should be familiar with invasive species control as a general concern, and they are advised to consider in some depth how the project may interface with existing or potential efforts targeting invasive species directly. In many of the projects outlined herein, the work required as part of the installation or removal of structures creates opportunities for removal of invasive plants as part of the project. Other projects are intended to change ecological conditions in a way that make them less hospitable to the growth, spread, or establishment of non-natives, thereby creating opportunities for subsequent efforts aimed at reduction or elimination of non-natives.

The science and practice that has developed around the topic of invasive species control is exceedingly complex and in a constant state of flux. Most readers of this manual need only a passing familiarity with its basic principles; for those wishing to inform themselves in greater depth, we provide the following areas of exploration:

- There are many invasive species; each poses a different level of threat and this level can vary by region. Priority lists for invasive plant species exist and are coded by region for California (Bay Area Early Detection Network 2010; California Invasive Plant Council [CalIPC] 2011).

- Many land and resource managers develop a comprehensive invasive species control plan to help prioritize the control of some species relative to others and to guide everyday work to maximize impacts.

- A rigorous monitoring program is often used to control the spread of invasive species in a particular area and to detect the introduction of new populations. In many places throughout the state, Weed Management Areas serve as regional invasive species control networks within which managers share information about recent outbreaks and detection methods (see “additional resources”).

- Controlling existing populations of invasive species sometimes requires restoring the structural components of a system, which typically involves re-vegetation with native plants (see below). The shading provided by replanted native trees, for example, can help control some plant invasions (Holl and Crone 2004).

- Since many invasive species are essentially "here to stay," many managers focus on mitigating their effects than trying to eliminate or control them. An example of mitigation is adding movement corridors for wildlife as a way of combatting habitat fragmentation (Gelbard and Harrison 2003; D'Amore et al. 2010).

- Effective invasive species control often requires stakeholder engagement. Many restoration practitioners have been surprised when stakeholders have expressed concerns about the use of chemicals or the aesthetic impacts of removing non-natives. Such surprises can be avoided through public engagement or education (Selge et al. 2011).

Revegetation with Native Plants

Some native plants can re-establish in an area, or recover their more-natural population sizes, when pressure from competing non-natives is removed or other restoration activities create more amenable conditions. However, many natives lack the dispersal mechanisms necessary to reestablish quickly enough (or from great distances) to prevent the re-growth of invasive plants or the erosion of open soil (Seabloom et al. 2003). And even if propagules are present, they may not exist in large enough numbers to support re-population. It is for these reasons that it is often necessary to "jump-start" the regrowth of native vegetation through deliberate replanting with native plants (a.k.a. revegetation).

Photo P1.2 Revegetation of uplands with native seedlings Photo: ENSERR

Although the replanting of an area can be an effortful and expensive process, it usually needs to be done only once. If the planted seedlings survive and establish, they provide safe sites for the establishment of other native plants (Kettenring and Adams 2011), either by serving as nurse plants (Badano, Perez et al. 2009) or by changing the local conditions.

Revegetation is also an important tool in the effort to control invasive species: by creating shade and competition, revegetation can help reduce the growth of non-native species (Kettenring and Adams 2011; Iannone et al. 2008). The seeds of Jubata grass (*Cortedaria jubata*), for example, germinate less readily when light at the soil surface is reduced (Drewitz and DiTomaso 2004).

In general, revegetation it often a critical facet of restoration because it helps to ameliorate harsh environments, capture naturally dispersing seeds, and protect seedlings while they establish. Revegetation can help protect and maintain soils by providing soil cover and supporting biotic activity (Bochet et al. 2010). By protecting and maintaining soils, revegetation also helps to maintain watershed processes, reducing sediment movement and increasing infiltration and groundwater recharge (Prieto et al. 2012).

Effective re-vegetation with native plants requires a thoughtful approach to selecting the right species with the correct genes. Revegetation with certain native plants can hinder the establishment of other native species (Dale 1991). Picking the wrong suite of species may fail to reduce erosion or to nurse the establishment of other native species (Brown and Rice 2000; Bochet et al. 2010). Using native plant propagules not collected locally can threaten the success of the project or negatively impact locally adapted genepools (McKay et al. 2005).

Climate Change

During the next century California can expect significant changes in temperature and precipitation due to the effects of climate change. Extreme drought as well as extreme rain events may become the new normal and fire seasons are predicted to become more intense. These threats to sensitive habitats and wildlife must be part of the natural resource management equation. Restoration practitioners must plan for resiliency and be prepared to adapt in response to the unknown changes that will occur in California ecosystems as a result of future climate change and related disruptions.

Resiliency is the ability of an ecosystem to recover from disturbance without losing its essential characteristics. All ecosystems have some degree of inherent resilience, but restoration practitioners can increase the resilience of ecosystems in very clear ways. Ecosystems with native vegetation, a high level of biodiversity, natural hydrologic regimes, and limited human-caused disturbance or pollution are always more resilient ecologically than the degraded ecosystems that are usually the targets of restoration. In this way, the enhancement of resilience may be seen as one of the major goals and aspects of restoration work.

But doing restoration work with climate change in mind is more than just a matter of increasing the resilience of habitats and ecosystems. By increasing the chances of damaging floods, stream-drying droughts, and plant-killing freezes and heat waves, climate change challenges restoration practitioners to consider events that may pose threats to any installed or constructed infrastructure and may change a habitat's structure relatively quickly. For these reasons, restoration practitioners must consider questions such as these: Can the streambanks withstand the "100-year floods" that may occur every decade? Are buffer zones wide enough? The culverts big enough? Are the pieces of large woody debris adequately anchored? Might flooding cause the course of the stream to shift? What areas of vegetation may die off during a long drought and how will this affect the ecosystem?

The long-term directional changes in environmental conditions—warming and drying—that are already occurring as part of climate change may pose the most serious challenges because the responses of species and ecosystems are largely unknown. Nevertheless, a number of generalizations offer some guidance. Many revegetation projects should use the most drought-tolerant species available. Projects that store water and recharge aquifers—such creating a pond for trapping stormwater (Project 4)—might be considered to have high priority. Since many animal species are likely to shift their ranges, it may be wise to consider how restoration might facilitate migration to and from a particular habitat or area.

A number of resources are intended to help restoration practitioners design restoration projects that enhance the ecological function of degraded or damaged areas in a manner that prepares them for the consequences of climate change. Notable among them is Point Blue's Climate-Smart Tool Kit. Restoration practitioners are encouraged to seek out these resources and to tap the experts as they undertake any of these projects.

Photo P1.3 Aerial view of the Elkhorn Slough Photo: Keith Ellenbogen

The Overall Planning and Management Context

It is expected that among the readers of this manual there will considerable diversity in experience, knowledge of restoration practices, professional role, and motivation for implementing restoration projects. Some readers will know the land for which they are responsible with an intimacy difficult for others to appreciate; others will have only general knowledge of the land and its issues, at least at first. Some readers will be working within the confines of agency regulations and management plans whereas others will have relative freedom to implement restoration activities as they choose, within the constraints imposed by local, state, and federal laws. Because of these and many other differences, each reader will be implementing the projects outlined in this manual within a unique context. At one extreme, a project might be the first of its kind on a privately held ranch for which no formal management plan exists; at the other, a project might be one of many inter-related ones undertaken on public land under a long-term management plan.

Photo P1.4 Improving tidal flow as part of a larger effort to improve water quality Photo: ESNERR

The authors have attempted to accommodate these variations among readers and in the contexts within which they work by avoiding hard-and-fast assumptions about how the projects are being approached. It is necessary, however, to discuss up front two issues for which it is impossible to avoid basic assumptions that do not fit the circumstances of all readers.

Choosing a project. Some readers will know exactly which project they want to implement before they open the manual for the first time. They may have noticed a particular problem—such as livestock damaging a riparian area during the dry season—and already know at least the basic outlines of the solution. Other readers face a more general, more widespread, or less-clearly-defined problem (such as a long-term decline in water quality) and know only that some kind of ecological restoration is called for. Since the latter type of reader requires an initial step (choosing a project) that the former type can simply skip, the authors assume that the latter situation is the baseline. Readers who have made their choice of project ahead of time may, as suggested, skip any beginning steps that seem superfluous—or, perhaps, treat them as a process of confirming that their choice is indeed the appropriate one.

The project as part of a larger restoration effort. In many contexts, a long-term management, watershed, or restoration plan guides the choice and implementation of specific restoration projects. When such a plan exists, carrying out one of the projects in this manual is merely one piece of a much larger puzzle. Given that this is not always the case, however—and that when it is the variables are complex and impossible to predetermine—the authors have chosen to assume that the projects in this manual will be implemented in isolation. This means that when a management or restoration plan exists, it is up to the reader to work out the ways in which the implementation of one these projects articulates with the plan or larger restoration effort and with other projects. When no such plan exists, on the other hand, the reader is encouraged to engage in the big-picture thinking and planning that might lead to one of these projects being the starting point of a longer-term and broader-scale effort to restore a longer reach of stream, a larger portion of a property, or a more extensive area of habitat.

Carrying out a Project: An Overview

Regardless of land ownership status, planning history and scope, the extent of impacted habitat, and other factors discussed above, implementing a restoration or water quality management project involves a complex series of steps that begins well before any dams are removed, trees placed, or fences installed. Chapter 2 describes some of these steps and the thinking that goes along with them. After the project's infrastructure is installed, it must be maintained and its functioning monitored relative to the initial goals. Chapter 3 describes these and other post-implementation practices. The following outline is presented to help the reader understand how these two phases fit together with project implementation to make up a typical project in its entirety.

1. Understand the Problem
a. Identify the conditions of greatest concern
b. Examine the whole context
c. Define goals and objectives
d. Choose the project that will best advance the goals

2. Form the Project Team
a. Identify and engage stakeholders
b. Assemble experts
c. Define roles and responsibilities

3. Plan and Prepare
a. Assess resources and capacity
b. Analyze the site
c. Anticipate potential concerns
d. Draft an implementation plan
e. Estimate costs and create a budget
f. Complete environmental review and permitting

4. Implement
a. Acquire materials
b. Carry out construction

5. Manage Adaptively
a. Maintain the project site
b. Monitor project function and impact
c. Report monitoring data
d. Adapt management and/or structures in response to monitoring results

Related Resources

- The California Invasive Plant Council (CalIPC):
  http://www.cal-ipc.org
- Weed Management Area information:
  http://www.cal-ipc.org/WMAs/
- Local Resource Conservation Districts:
  http://www.conservation.ca.gov/dlrp/RCD/Pages/CaliforniaRCDs.aspx
- National Resource Conservation Service:
  http://www.nrcs.usda.gov/wps/portal/nrcs/site/ca/home/
- California Water Quality Monitoring Council:
  http://www.mywaterquality.ca.gov/monitoring_council/index.shtml
- California Wetlands Portal:
  http://sfei.org/projects/3032
- Point Blue Conservation Science, Climate Smart Restoration Principals:
  http://www.pointblue.org/our-science-and-services/conservation-science/habitat-restoration/climate-smart-restoration-principles/
- Point Blue Conservation Science, Climate Smart Tool Kit
  http://www.pointblue.org/our-science-and-services/conservation-science/habitat-restoration/climate-smart-restorationtoolkit/
- California Climate Change Portal:
  http://www.climatechange.ca.gov/
- A U.S. Fish and Wildlife Service issues related to climate change:
  http://www.fws.gov/home/climatechange/

Literature Cited

Adams, M.J. & Pearl, C.A. 2007. Problems and opportunities managing invasive bullfrogs: Is there any hope? In: Gherardi, F. (ed.) Biological invaders in inland waters: Profiles, distribution, and threats, pp. 679-693. Springer.

Adams, V.M., Marsh, D.M. & Knox, J.S. 2005. Importance of the seed bank for population viability and population monitoring in a threatened wetland herb. *Biological Conservation* 124: 425-436.

Arnold, R.A., Bartolome, J.W., Ford, L.A. & Rao, D.R. 2012. Review of Historical and Current Land Use Practices, Characterization of Suitable Habitat, and Habitat Management Recommendations for the Endangered Ohlone Tiger Beetle, Cicindela ohlone (Coleoptera: Cicindelidae). Report submitted to: US Fish and Wildlife Service. Service Project #11130000, USFWS, Ventura, CA.

Badano, E.I., Perez, D. & Vergara, C.H. 2009. Love of nurse plants is not enough for restoring oak forests in a seasonally dry tropical environment. Restoration Ecology 17: 571-576.

Bay Area Early Detection Network 2010. The Bay Area Early Detection Network's Early Detection and Rapid Response List. WEBSITE sponsored by Calflora: Information on California plants for education, research and conservation Berkeley, CA.

Beyers, J.L. 2004. Postfire seeding for erosion control: Effectiveness and impacts on native plant communities. *Conservation Biology* 18: 947-956.

Blair, B.C., Letourneau, D.K., Bothwell, S.G. & Hayes, G.F. 2010. Disturbance, resources, and exotic plant invasion: Gap size effects in a redwood forest. Madroño 57: 11-19.

Bochet, E., Tormo, J. & Garcia-Fayos, P. 2010. Native species for roadslope revegetation: Selection, validation, and cost effectiveness. *Restoration Ecology* 18: 656-663.

Brown, C.S. & Rice, K.J. 2000. The mark of zorro: effects of the exotic annual grass *Vulpia myuros* on California native perennial grasses. *Restoration Ecology* 8: 10-17.

California Invasive Plant Council (CalIPC) 2011. Exotic Pest Plants of Greatest Ecological Concern in California. WEBSITE. California Invasive Plant Council, Sacramento, CA.

D'Amore, A., Hemingway, V. & Wasson, K. 2010. Do a threatened native amphibian and its invasive congener differ in response to human alteration of the landscape? *Biological Invasions* 12: 145-154.

Dale, V.H. 1991. Revegetation of Mount St. Helens debris avalanche 10 years posteruptive. In: *National Geographic Research and Exploration*, pp. 328-341.

Drewitz, J.J. & DiTomaso, J.M. 2004. Seed biology of jubatagrass (*Cortaderia jubata*). *Weed Science* 52: 525-530.

Gelbard, J.L. & Harrison, S. 2003. Roadless habitats as refuges for native grasslands: Interactions with soil, aspect, and grazing. *Ecological Applications* 13: 404-415.

Hayes, G. & Holl, K.D. 2003. Cattle grazing impacts on annual forbs and vegetation composition of mesic grasslands in California. *Conservation Biology* 17: 1694 - 1702.

Holl, K.D. & Crone, E.E. 2004. Applicability of landscape and island biogeography theory to restoration of riparian understorey plants. *Journal of Applied Ecology* 41: 922-933.

Hornaday, K., Pisani, I. & Warne, B. 2007. Recovery Plan for the Pacific Coast Population of the Western Snowy Plover. Report submitted to: U.S. Department of Interior pp. 290. U.S. Fish and Wildlife.

Huffaker, C.B. & Holloway, J.K. 1949. Changes in range plant population structure associated with feeding of imported enemies of Klamath weed (*Hypericum perforatum*). *Ecology* 30: 167-175.

Iannone, B.V., Galatowitsch, S.M. & Rosen, C.J. 2008. Evaluation of resource-limiting strategies intended to prevent *Phalaris arundinacea* (reed canarygrass) invasions in restored sedge meadows. *Ecoscience* 15: 508-518.

Jules, E.S., Kauffman, M.J., Ritts, W.D. & Carroll, A.L. 2002. Spread of an invasive pathogen over a variable landscape: A nonnative root rot on Port Orford cedar. *Ecology* 83: 3167-3181.

Keeley, J.E. & Keeley, S.C. 1981. Post-fire regeneration of Southern-California chaparral. *American Journal of Botany* 68: 524-530.

Kettenring, K.M. & Adams, C.R. 2011. Lessons learned from invasive plant control experiments: a systematic review and meta-analysis. *Journal of Applied Ecology* 48: 970-979.

Lambrinos, J.G. 2000. The impact of the invasive alien grass Cortaderia jubata on an endangered mediterranean-type shrubland in California. Diversity & Distributions 6: 217-231.

Leung, B., Lodge, D.M., Finnoff, D., Jason, F.S., Lewis, M.A. & Lamberti, G. 2002. An ounce of prevention or a pound of cure: Bioeconomic risk analysis of invasive species. Proceedings: Biological Sciences 269: 2407-2413.

Maze, D.M. 2009. Effect of terrestrial mollusc herbivory on *Holocarpha macradenia* (Asteraceae) seedlings in California coastal prairie under different clipping regimes. *Madroño* 56: 1-7.

McCay, T.S. & Komoroski, M.J. 2004. Demographic responses of shrews to removal of coarse woody debris in a managed pine forest. *Forest Ecology and Management* 189: 387-395.

Pavlik, B.M., Nickrent, D.I. & Howald, A.M. 1993. The recovery of an endangered plant I: Creating a new population of *Amsinkia grandiflora*. *Conservation Biology* 7: 510-525.

Pimentel, D., Zuniga, R. & Morrison, D. 2005. Update on the environmental and economic costs associated with alien-invasive species in the United States. *Ecological Economics* 52: 273-288.

Prieto, I., Armas, C. & Pugnaire, F.I. 2012. Water release through plant roots: new insights into its consequences at the plant and ecosystem level. *New Phytologist* 193: 830-841.

Seabloom, E.W., Borer, E.T., Boucher, V.L., Burton, R.S., Cottingham, K.L., Goldwasser, L., Gram, W.K., Kendall, B.E. & Micheli, F. 2003. Competition, seed limitation, disturbance, and reestablishment of California native annual forbs. *Ecological Applications* 13: 575-592.

Seavy, N.E., Gardali, T., Golet, G.H., Griggs, F.T., Howell, C.A., Kelsey, R., Small, S.L., Viers, J.H. & Weigand, J.F. 2009. Why climate change makes riparian restoration more important than ever: recommendations for practice and research. *Ecological Restoration* 27: 330-338.

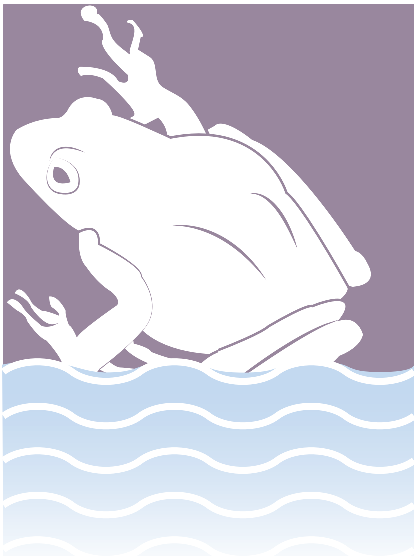
Selge, S., Fischer, A. & van der Wal, R. 2011. Public and professional views on invasive non-native species – A qualitative social scientific investigation. *Biological Conservation* 144: 3089-3097.

Skorka, P., Lenda, M. & Tryjanowski, P. 2010. Invasive alien goldenrods negatively affect grassland bird communities in Eastern Europe. *Biological Conservation* 143: 856-861.

Vitousek, P.M. 1990. Biological Invasions and Ecosystem Processes: Towards an integration of population biology and ecosystem studies. *Oikos* 57: 7-13.

Wilcove, D.S., Rothstein, D., Dubow, J., Phillips, A. & Losos, E. 1998. Quantifying threats to imperiled species in the United States. *BioScience* 48: 607-611.

Wilson, M.V., Hammond, P.C. & Schultz, C.B. 1997. The interdependence of native plants and Fendler's blue butterfly. In: Kaye, T.N., Liston, A., Love, R.M., Luoma, D.L., Meinke, R.J. & Wilson, M.V. (eds.) Conservation and Management of Native Plants and Fungi, pp. 83-87. Native Plant Society of Oregon, Corvallis, OR.



Chapter 2

Getting Ready to Implement a Project

The key to success in carrying out a restoration or water quality management project is adequate planning and preparation. It is difficult to overstate the importance of knowing, at the outset, why the project is being undertaken, how it will be carried out, where it will be sited, how much it will cost, who will be involved in the effort, what materials will be used in its construction, and so on. To give restoration practitioners some idea of what's involved in laying the groundwork for a project, this chapter provides guidance on accomplishing the first three steps outlined in the previous chapter, from *Understand the Problem* to *Plan and Prepare.*

Because the six projects outlined in this manual are all very different from each other, and because the unique aspects of each site and its management and ecology add further variation, this chapter must remain at a general level of specificity. As with the projects themselves, practitioners will need to seek additional information and be ready to adapt the guidelines to their own circumstances.

This chapter is addressed to the single individual assumed to have the greatest responsibility for carrying out the project. Depending on circumstances, this "you" could be the project manager, the restoration practitioner, the land manager, the landowner, or a person combining any of these roles. It could also be two or more people working in partnership.

Understand the Problem

This initial step involves investigation, analysis, and clarification. Depending on your role and circumstances, you may want other people—such as stakeholders, colleagues, or consulting experts—to assist you with the decision-making and other work that may be required (if that is the case, the authors recommend that you take a look ahead at the *Form the Project Team* step). At the other end of the spectrum of possibilities, you may already understand the problem well and have a good idea of which project you want to implement.

Identify the Conditions of Greatest Concern

The ecosystems on any piece of land that has been subject to anthropogenic modification are no longer functioning "naturally." Since agriculture, grazing, housing development, stream channelization, flood control measures, grading, interference in the fire regime, growth of invasive species, and other human impacts are so extensive and widespread in California, you can simply assume that the wetlands or riparian areas under your responsibility are no longer in a natural and wild condition and that their ecosystems do not function as they did 200 years ago. If your goal is to restore them to a hypothesized pristine state, you could direct infinitely large amounts of time and resources at the effort and still fall far short of reaching that goal.

In restoration work, therefore, it is important to target your efforts at what is in greatest need of attention. Beyond the general concept of ecological health (or, in this case, its absence), there is no objective standard for "greatest need"—it is very much dependent on your specific situation.

One key consideration is whether your land (or part of it) is dedicated to human uses such as agriculture, grazing, or recreation. If that is the case, restoration directed primarily at returning ecosystems to a more "natural" state is likely to be both unrealistic and contrary to some management goals. Instead, you will probably want to focus on conditions that are detrimental to the land's human uses and which, when remediated, will also benefit wildlife and water quality.

It may also be the case that "external" factors play a strong role in determining what is in greatest need of attention. Downstream water users may demand that poor water quality be your greatest concern; a regulatory agency might do the same for conditions unfavorable to an endangered species on the land. Stakeholders frequently influence what restoration should focus on as well: fishers may want you to focus on conditions that have caused a fishery or fish population to decline, hunters on those that have been detrimental to waterfowl.

Even when circumstances have focused your attention on a particular problem like poor water quality or erosion, it is desirable to be aware of all of the ecological conditions that might be considered undesirable and which could, through restoration work, be improved. This awareness is important because the elements of ecosystems are always interconnected: a project intended primarily to improve poor water quality is likely to have positive impacts on a variety of other ecological conditions. Problems are rarely isolated, and their priority as targets of restoration increases with the number of other problems that might be ameliorated through the same solutions.

Because many problems are not only interconnected but also causally layered, it is important to have clarity about what leads to what. Many problems have both proximal and ultimate causes; effective solutions depend on addressing the latter. This is made easier if you are careful to distinguish the many layers of causation. See Figure 2.1 for an example.

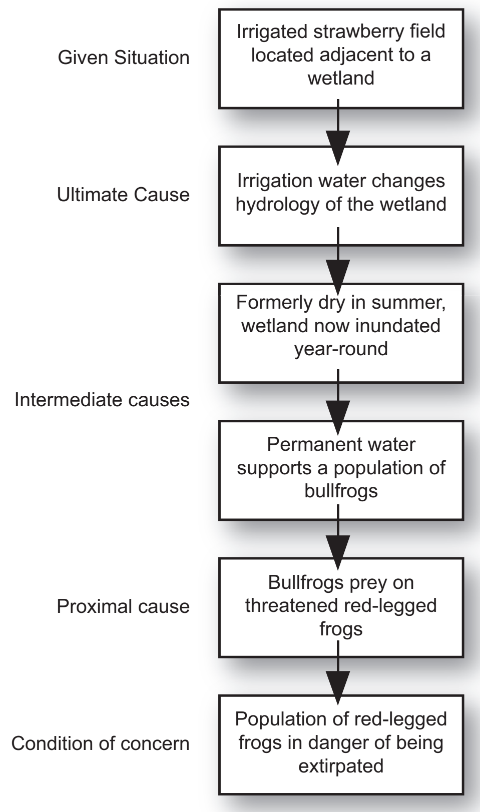


Figure P2.1. An example of a condition of concern (or problem) having multiple layers of causes. A restoration solution that addresses the "ultimate cause" may have the best chances of success.

Examine the Whole Context

Because the interconnectedness of ecosystems extends outward geographically, most problems or conditions of concern will have causes or contributing factors that exist outside of the immediate vicinity. Nitrates deposited in rainfall or particulates originate from far away urban or agricultural areas; adjacent agricultural land or other land subject to intensive human use can be a source of non-point-source pollution, invasive plant propagules, or sediment; wells in nearby properties can lower the water table; upstream neighbors can add coliform bacteria to stream water. Even if you have little control over factors such as these, it is important to be aware of them in fashioning solutions. It could also be the case that a neighbor contributing to a problem could become a potential ally or partner in solving that problem (see *Form the Project Team* below).

The larger context of a problem also includes such factors as applicable laws and regulations, the land use history of the property, land use plans that may be in effect, and global factors such as climate change and its possible impacts on future sea level rise, salt water intrusion, coastal erosion, drought, precipitation, and the chances of flooding.

If a watershed plan, restoration plan, or management plan exists for the property, it is likely that the broader context was examined as a part of drawing up the plan. If that is the case, you may only need to refer to the relevant parts of the plan.

Define Goals and Objectives

To a large extent, the goals of restoration flow directly from the identified conditions of greatest concern. A problem of poor water quality, for example, clearly means that the primary goal of restoration is improvement of the water quality. But there is more to goal-setting than simply changing the way you express an identified problem.

First, goals can be developed that take into account that the problems identified as primary are related to other problems that can be remediated at the same time. For example, in dealing with the problem described in Figure 2.1 (predation of threatened native frogs by introduced frogs) it may be possible to address several other problems associated with the juxtaposition of a wetland and a strawberry field, such as movement of weeds or animals into the field from the wetland, shading of the field by trees at the margin of the wetland, and nitrate pollution of the wetland by agricultural runoff. Each of these problems could be the subject of a stated goal. Further, goals can express desired end results that can be realized only over long or very long periods of time. If a management plan, restoration plan, or watershed plan is in place, these larger or longer-term goals may be the same as those in the plan, or they may integrate tightly with them.

Second, the setting of goals can also involve objectives; these are more specific than goals and can therefore be connected to measurable outcomes. For example, for a general goal of improving water quality, some possible corresponding objectives are "nitrate levels remain below 0.02 ppm" and "pH does not fall below 6.8." It is important that objectives be realistic and based on well-established parameters for ecological health. A set of well-conceived objectives can serve as an important touchstone during the planning and implementation stages of the project, and then again during the adaptive management stage (described in Chapter 3).

Choose the Project that Best Advances the Goals

A discrete restoration project, like any of those outlined in this manual, is a strategy for solving a particular problem or set of related problems. In that sense, you choose a project after you have identified the problem and outlined the goals associated with alleviating the problem. The authors acknowledge, however, that you may have had one particular project in mind all along and that the process described above serves mainly as a post hoc justification for implementing that project.

If you haven't settled on a particular project, the problem-identification and goal-setting processes described above should make the choosing of a project much easier. In fact, the project that best advances your goals may by this point be so obvious that it hardly seems like a choice. If, for example, you're a farmer with strawberry fields adjacent to a wetland, establishing a buffer zone between the two (Project 5) is clearly the way to go. At the other extreme, choosing a project may require an involved process of collaborative deliberation and possibly more investigation.

It is important to recognize that one possible end result of identifying the problem, considering the context, and defining goals is a decision that the best solution is something other than implementing one of the projects in this manual. These projects have broad utility and application, but they represent only a small proportion of restoration and water quality management possibilities. Your problem may very well call for other kinds of solutions.

It is also possible that the best way to address the conditions of greatest concern on the land for which you are responsible is to implement multiple projects. Then, a primary issue becomes how to order the projects in time. In many streams, for example, improving fish habitat and water quality requires both removing in-stream barriers (Project 1) and placing large woody debris in the stream (Project 2). Which of these should be carried out first?—it could make a big difference.

Implicit in the choice of project is, in most cases, a choice of site as well. This means that the location of the project is tied up in the process of deciding which project to pursue. When this is not the case—such as when any of various riparian habitats could be fenced to exclude livestock or many different reaches of a stream could benefit from emplacement of large woody debris—deciding on the exact site or sites for implementing the project must be made part of the process of selecting which project to implement.

The project-based approach to restoration reflected in this manual is admittedly piecemeal. Although working incrementally to effect small, local improvements in ecological health is generally dictated by real-world constraints, it doesn't mean that you must be resigned to seeing only small, local results. A single project can have enormous benefits—which is the premise behind a manual outlining only six relatively small-scale projects. But this can be true only if the project is well chosen to address the problems at hand and is well matched to the unique situations of the local context.

Form the Project Team

Photo P2.2 UCSC volunteers remove invasive Ice Plant at Elkhorn Slough National Estuarine Research Reserve. Photo: ESNERR

Although some restoration projects can be implemented at a small enough scale for a single person to manage the entire process from problem identification to post-installation management, it is more typical for a project (or larger multiple-project restoration effort) to be too big and complex for one person to handle. Many aspects of a project require special expertise or certification, and more general tasks such as overall management, record-keeping and accounting, regulatory compliance, and stakeholder outreach are often so complex and time-consuming that they are best accomplished by multiple individuals. For these reasons, many projects are best carried out by a team of people working together.

As with any team, the members must share a sense of common purpose and a commitment to cooperation. Beyond these basic requirements, the project team will vary in its size, mode of operation, leadership, term of existence, and membership. Some members will be engaged through the span of the entire project; others may be brought in for shorter periods for specialized tasks. The team may overlap with the group of stakeholders discussed below.

In some cases, a need for expertise and shared decision-making in the step described above (*Understand the Problem*) will require that the core members of the project team come together before or during that initial step.

Identify and Engage Stakeholders

Stakeholders are those individuals, organizations, or agencies that have an actual or potential “stake” in the restoration project—the project in some way intersects with their economic, professional, political, or moral interests. Typical stakeholders include funders, permitting and other oversight agencies, landowners, site managers, easement holders, neighbors, those controlling site access, biologists, conservation groups, and researchers. As is apparent from this list, stakeholders are important for a variety of reasons. They may provide the financial resources backing the project, act as gatekeepers in the regulatory bureaucracy, offer much-needed expertise, be key to securing community support, and even determine whether or not a project many proceed. For these reasons, securing the support and buy-in of all possible stakeholders is crucial for the long-term success of the project.

Frequently, a project needs not only the passive support of stakeholders but also their active engagement with the project. Engaging them may involve face-to-face meetings, site tours, coordinated public-relations campaigns, public education and outreach efforts, strategic partnering, and so on. You must understand stakeholders' interests, acknowledge those interests at every available juncture, provide opportunities for participation in the planning process, and keep stakeholders well informed of project goals and timelines.

Photo P2.3 Repairing water control levy Photo: ESNERR

Assemble Experts

While some projects may not require the participation of experts, in others it is absolutely essential. In many cases a project simply has a better chance of success if experts are involved. The types of experts needed will vary depending on the type, scale, and complexity of the project. Expertise may be needed in any of the following areas: hydrology, geology, soil science, civil engineering, fish science, botany, restoration ecology, range management, forestry, biology, environmental compliance, stakeholder engagement, and project management. The individuals recruited to provide these forms of expertise may be involved in the project anywhere from a brief period to the entire span of the project. Those involved for longer periods may be considered part of the project team.

Each project described in this manual includes a list of areas for which special expertise may be needed.

Define Roles and Responsibilities

The larger the scale of a project and the greater its complexity, the greater the need for a variety of project roles to be clearly defined and assigned to specific individuals on the project team. While experts in science, engineering, and construction have their roles defined by the nature of their expertise, other more general roles usually require explicit description and assignment. These roles include leadership, project management, record keeping, environmental compliance, stakeholder engagement, budget oversight, and scheduling. For smaller-scale projects, many of these roles can be handled by a single individual; for larger projects and multiple-project efforts, they are best distributed among several individuals or assigned to experts.

Plan and Prepare

The topics discussed earlier in this chapter—*Understand the Problem* and *Form the Project Team*—are crucial elements of planning and preparing for a project, but they do not cover everything that needs to be considered before a project is implemented. This section outlines those additional steps.

Assess Resources and Capacity

Among the most important questions to ask at the beginning of a project is "can we pull this off?" Any project requires financial resources, organizational or labor capacity, and stakeholder buy-in. It is important to know if you can access or develop an adequate level of each of these key elements before commitments are made to proceed. A few practical make-or-break details such as site access are also important to consider. You may want to complete this assessment before assembling the project team; another approach is to make it the first thing the project team does.

Analyze the Site

It is important to know as much about the project site as possible before you begin to implement the project. Three types of formal analysis are often called for before doing restoration or water quality management work in or around a stream, riparian zone, or wetland:

Photo P2.4 Cattail Swale Photo: ESNERR

Hydrological analysis. The scope of the analysis required will depend upon the site and the objectives of the restoration project. For projects that involve changing stream flows or creating water storage capacity, you should hire a hydrologist to assess historic flows, river channel hydrology, and flood plain morphology.

Soils analysis. For many of the projects, it is a good idea for a soil scientist or geologist to determine the permeability of the soils at the site and their potential for erosion or impaction.

Biological assessments. There are several possible reasons for performing biological assessments. A survey may be needed to determine the presence and/or status of sensitive plant or animal species and/or non-native species (such as bullfrogs) known to prey on or compete with native species. If the project is intended to improve fish habitat, you will want an assessment of current habitat conditions and population sizes. As part of the biological assessment process, it may be wise to conduct a relatively thorough survey of the flora and fauna around the site to create a baseline dataset against which to compare data from post-implementation surveys (see Chapter 3). This is necessary if you want to be able to make rigorous conclusions about the ecological or water-quality impacts of the restoration project.

In addition to carrying out these formal assessments, you may want to carefully assess site access issues. Will an existing road allow the necessary equipment to get to the site? If a road must be built, what impacts will it have? Does site access involve movement through an adjacent property? Will it be necessary to secure permission to move through the property?

Assess the Potential for Impacting Cultural Resources

While a formal cultural resources survey is not necessary for most restoration projects, it is important to consider what historical and archaeological resources may be present in an area and to assess the potential for disturbing them. Identifying historical structures, middens, and similar cultural resources in advance will save both time and money in the long run. Keep in mind that any structure or artifact greater than 50 years old is considered a cultural resource and that many dams and bridges fall into this category because they were built in the 1930s. Be cognizant, too, of the fact that middens, habitation sites, and burials are often found adjacent to riparian corridors or wetlands and that the outward signs of their presence are difficult to detect. Digging in fence posts, excavating for ponds, and building embankments can disturb these areas. If archaeological or historical sites are uncovered during a project, the discovery will bring the project to halt and it could take many months to get back on track. It is recommended that restoration practitioners review historical maps, interview neighbors, and peruse county records as part of the process of analyzing the site. The upfront cost is minimal and the effort well worth the time investment.

Anticipate Potential Concerns

Although the manipulation of the environment that is performed during restoration work is intended to have positive impacts alone, it can have undesirable consequences under certain conditions or when subjected to unforeseen events. For example, a pond built to hold storm water (Project 4) could cause flooding if its outflow is blocked by debris. To minimize the possible harms of restoration infrastructure or installations, you need to anticipate everything that could possibly go wrong: unusually severe flooding, vandalism, drought, infrastructure failure, death of seedlings planted for revegetation, and so on. When they are anticipated, allowances for these events and circumstance can be built in to the project or in to the post-implementation maintenance schedule.

Draft an Implementation Plan

After a project has been chosen, the site analyzed, resources assessed, and potential concerns anticipated, it is time to draft an implementation plan. At a minimum, such a plan should consist of a materials list and step-by-step lists of site preparation tasks and construction/removal tasks. It can be put together only after careful consideration of site constraints, available resources, and project goals and objectives; this consideration may need to involve consultation with experts, particularly someone with expertise in engineering. Each task should identify the team member or contractor responsible for task completion.

Each project description provides information that may be helpful in drafting an implementation plan for that project. In particular, the *Implementation* section of each project discusses materials and methods. The *Potential Concerns* section often contains information applicable to the drafting of the implementation plan as well.

Estimate Costs and Create a Budget

Particularly when they are implemented at larger scales, the projects described in this manual can require considerable financial resources to plan, implement, and maintain. Obviously, you need to have a clear understanding of the total cost in order to insure that a project can be seen through to completion. Since you will eventually need an itemized budget—to report to funders, facilitate payments to contractors, and keep records for tax and oversight purposes—you might as well begin creating your budget early in the planning process, based on estimates of all the individual costs, from permits to materials and construction labor, and on estimates of funding sources. The numbers can be refined later when they are more precisely known.

Budgeting and accounting are crucial to the success of a project, but they are too complex—and individual circumstances too variable—to be discussed here in any detail. Many resources exist to guide you in making your projections and creating a realistic budget. In addition, each project description includes a *Costs* section that provides general information helpful for estimating costs.

Complete Environmental Review and Permitting

Because environmental review and permitting for restoration is complex and constantly changing, the best bet for success is to work with an expert who is experienced with such projects in the same geographical area where the project is being considered. Experienced project managers say that the total cost for environmental review and permitting can be as high as 50% of the total project cost. The timeline for securing all the needed permits ranges from 30 days to a year—so plan accordingly. A public trust agency such as CDFW or your local Resource Conservation District can help you understand how to best navigate the permitting process.

Chapter 3

After the Project is in Place

Ecological restoration is a long-term process with no particular endpoint. This is as true for individual projects as it is for restoration overall. After a project has been constructed, installed, or otherwise carried out, restoration practitioners should give their attention to several related tasks: maintenance, monitoring, reporting of data, and adaptive management. These tasks are critical to the long-term success of any restoration project.

Maintenance

Each project will have a certain level of maintenance associated with its management. Maintenance may be as simple as seasonal mowing of a buffer zone or clearing brush from a water-control structure after a storm event; it can be much more extensive as well, such as removing sediment from a stormwater retention pond or re-placing large woody material in a stream. It is important that the members of the restoration team discuss all levels of required maintenance in advance and include this in the overall design of the project. Together they should assign the proper person to be responsible for conducting the maintenance and creating the appropriate schedule for the work.

Maintenance can be integrated with the processes of monitoring and adaptive management discussed below. The regular visits to the project site required by conscientious maintenance can become excellent opportunities for assessment of overall conditions or collection of data. Further, because the need for maintenance can often depend on or be associated with the functioning of the project, a change in maintenance needs may indicate that a project is not working as it should and might need to be modified.

Monitoring

Photo P3.1 Seine netting in a pond. Photo: ESNERR

The purpose of any restoration or water quality management project is to realize a set of goals and objectives related to ecological health and improvement of environmental conditions. The only way to know if a project is working towards realizing those goals is to monitor the project and the environmental conditions it influences. Monitoring is the regular collection of observations and data that point to the status of habitats, vegetation and flora, physical and hydrological processes, ecological functioning, and water quality in the area impacted by a restoration project.

Regular monitoring of a site and tracking of the data collected will reveal whether or not, and at what rate, the project is changing the environmental conditions as originally envisioned. If the measured changes are not consistent with the project's goals, the project (or the context in which it exists) can be modified appropriately; this is the process referred to above as adaptive management.

There are many different monitoring techniques; the ones you may want to use will depend on your project objectives, the desired accuracy and precision, and your available resources. This chapter directs you to some of the more commonly used and most respected resources on this topic. Fortunately, there is a wealth of expertise in California, including private consultants, public entities, and government advisors. By learning from others, restoration practitioners can not only gain important knowledge, they can also help improve restoration efforts all over California.

Types of Monitoring

Readers will find that several types of monitoring are discussed in the literature related to riparian and wetland restoration. Most frequently mentioned are *implementation monitoring, effectiveness monitoring*, and *validation monitoring*.

Implementation Monitoring. This monitoring is conducted during and immediately after project implementation to determine if the work was completed successfully and according to plan and if meets permit requirements. Implementation monitoring (which is not really "monitoring" since it is typically conducted just once) is mainly an oversight function; if you are not required to perform a formal implementation assessment by a regulatory agency, you can focus your efforts on effectiveness monitoring.

Effectiveness Monitoring. This is the type of monitoring typically conducted after restoration work. It takes place over a relatively long period of time, perhaps 5 or more years, depending on the goals of the project. Effectiveness monitoring allows site changes to be assessed over time; it provides the data you can use to determine if a project's goals and objectives are being met.

Validation Monitoring. This third category of monitoring is similar to effectiveness monitoring except that it is more rigorous and may continue for an even longer time frame. Its goal is to confirm "the cause-and-effect relationship between the project and biotic or water quality response." As such, its use is generally restricted to scientific research projects. Although the care and rigor associated with validation monitoring are good standards to strive for in collecting monitoring data, most restoration practitioners will find that some level of effectiveness monitoring is adequate for their needs.

Levels of Monitoring

Two levels of monitoring are often distinguished. Basic monitoring involves qualitative information collection such as using photo points to track change over time and visual observations of vegetative cover and wildlife usage; it may also employ simple water quality testing. Basic monitoring is simple to do and can be cost effective when trained volunteers are involved. Extensive monitoring includes quantitative data collection using specialized tools and techniques and may require expertise in such areas as sedimentation rates, water chemistry, hydrology, and engineering. The level of monitoring to employ will depend on objectives, desired accuracy and precision, timing and available funding. In practice, basic and extensive monitoring exist along a continuum. A decision to conduct basic monitoring does not preclude using one or more data collection methods that might be considered part of an extensive monitoring effort.

Baseline Data

It was noted in Chapter 2 that restoration practitioners should assess and record the conditions at a site before beginning any restoration work. The data collected at this time can provide an important baseline against which to measure and evaluate the changes that occur after project implementation. Ideally, each of the parameters measured during post-implementation monitoring will have been measured prior to implementation; assuring that this is the case will obviously require a fair amount of foresight and good planning.

If baseline data were not collected prior to implementation of the project, it is still possible to at least estimate prior conditions. Nearby sites that are similar in important ways to the project site before implementation may represent prior conditions reasonably well. For certain parameters, it may be possible to obtain meaningful prior-state data from previous surveys, collection records, aerial photos, interviews of previous landowners or fishers, and other sources.

Developing a Monitoring Plan

A monitoring plan outlines all the facets of the monitoring effort: what kinds of data to collect, how they will be collected, who will do the collecting and data analysis and when, and how the data will be shared and used for adaptive management. The first two elements (the "what" and the "how" of data collection) are contained within a monitoring protocol, which is discussed separately below.

Three preparatory tasks should be accomplished before the plan is formally developed:

1. Establish a monitoring team. Bring together a team of advisors, partners, and/or colleagues to assist in developing the other elements of the monitoring plan and the monitoring protocol. It may be wise to utilize the expertise involved in the project planning process and to include such people as engineers, consultants, landowners, land managers, and staff members from permitting agencies. For small-scale projects, it may be possible for a single individual to carry out the monitoring, especially if he or she has access to expert advice.

2. Clarify the goals and objectives of the restoration project. Revisit the goals and objectives set down during the planning process (see Chapter 2) and refine them as needed or in response to what was learned during project implementation. These will play a central role in the development of the monitoring protocol (see below).

3. Assess available resources. Different data collection methods require different levels of training and skill, and their costs vary considerably depending on what equipment is needed and if analysis by a lab is required. Therefore, the monitoring team needs to know who is available for collecting monitoring data, what their time constraints are, and what level of expertise and knowledge they have, and it needs to know what level of funding is available to compensate monitors' time, to train monitors if necessary, to buy and maintain needed equipment, and to analyze samples. These parameters will determine the practical constraints on the monitoring protocol—the types and amounts of data that can be collected, the frequency of data collection, and the duration of the monitoring process.

Once these steps are completed, the monitoring team can focus on the design of the monitoring protocol, which, as the core of the monitoring plan, must exist in a least a draft form before the parts of the monitoring plan related to personnel, finance, and management can be developed.

Designing a Monitoring Protocol

The monitoring protocol, as noted above, sets out the specifics of data collection. It begins by specifying which parameters need to be monitored. These are determined largely by the original goals and objectives of the project. You may find it helpful to define each parameter in the form of a question that can be answered through the collection of monitoring data. For example, for a project intended to create upland habitat for the California red-legged frog (CRLF), you would want monitoring to answer two primary questions: "Are CRLF using this habitat?" and "Does the habitat reflect the known characteristics of viable CRLF upland habitat?"

For each parameter, the protocol then specifies how the data will be collected. The "how" of data collection has a number of components: method (e.g., photo point, pit trapping, water sampling and analysis); frequency of data collection; and duration of data collection. See the example in Figure 3.2.

Project: Trees planted on streambank
Selected goal: Decrease water temperature

Data to Collect	Method	Frequency of data collection	Duration of data collection	Expertise required	Cost
Number of trees planted	Field survey: count	once	n/a	low	low
% of trees surviving	Field survey: count and calculate	annually	medium term (several years)	low	low
% cover	Field survey: estimate area	annually	long term: at least 5 years	moderate	moderate
Water temperature	Measurement with probe thermometer at 6 established sites, 2 each above, within, and below project area	monthly	long term: at least 5 years	moderate	moderate

Figure P3.2 Example of a Monitoring Protocol Design Table

In developing the monitoring protocol, it is important to consider the cost of each method and the expertise required to conduct the data collection. If you have completed the resource-assessment step described above, then this is a matter of limiting the scope of data collection to that which can be accommodated by the available resources. Although the example in Figure 3.1 gives only relative cost levels for each form of data-collection, you will want to estimate costs in actual dollars per year.

Although many aspects of the monitoring protocol must be adhered to throughout the duration of the monitoring effort in order for the data to be valid and useful for drawing conclusions, a certain degree of flexibility does exist. Certain monitoring tasks can be phased out over time, for example, if the data collected no longer serve your needs.

Conversely, new forms of data collection can be added if it is determined that it is helpful to have this additional information. Allowing flexibility in the monitoring protocol makes possible significant cost savings.

Reporting Monitoring Data

The primary purpose of monitoring is to provide useful feedback for the restoration effort on a particular piece of property or in a particular watershed or wetland. Fulfilling this purpose does not require that the monitoring data be shared with anyone outside the restoration team (unless this is required by funders or permitting agencies). But sharing monitoring data with others can have important benefits. When the larger community of restoration practitioners has access to monitoring data from all over the state, its members can better assess the effectiveness of particular practices and projects in meeting the goals of restoration, ultimately leading to improvements in those practices and cost saving to funders.

If you are going to report your monitoring data, you must ensure the data are of high quality. Data quality is a product of the monitoring protocol and its application, and is ultimately dependent on the training and expertise of those who collect the data and how strictly the rules and conventions of data collection are enforced.

Next, you must decide how to share your monitoring data. One method often used by local watershed groups is to publish annual monitoring reports and make the reports available on the Internet. Another method, potentially more valuable because of the breadth of access it offers, is to upload the data regularly to a database.

There are a number of excellent sites to which you can upload monitoring data:

- The California Habitat Restoration Project Database (CHRPD) captures, manages, and disseminates data about habitat restoration projects in California benefiting anadromous fish. The CHRPD currently contains data from the California Department of Fish and Wildlife's Fisheries Restoration Grants Program (FRGP), the CALFED Ecosystem Restoration Program (ERP), the National Fish and Wildlife Foundation, the State Coastal Conservancy, the NOAA Restoration Center, the U.S. Fish and Wildlife Service, the California Conservation Corps, and the Cantara Trustee Council. State Water Quality Database: http://www.calfish.org/ProgramsData/ConservationandManagement/RestorationProjects.aspx

- San Francisco Bay Joint Ventures:
  http://www.sfbayjv.org/resources.php
- California Environmental Data Exchange Network (CEDEN):
  http://www.ceden.org/
- Central Valley Joint Venture:
  http://centralvalleyjointventure.org/science/monitoring
- The California Avian Data Center:
  http://data.prbo.org/cadc2/

Using Monitoring Data: Adaptive Management

When monitoring data show that a restoration project is improving ecological conditions in a manner consistent with its original goals, you can claim success and congratulate yourself and other members of your team on a job well done. It is rare, however, for a restoration project to work exactly as planned and anticipated. A project can fall short of meeting its goals or objectives, work well for a time and then fail, or have mostly positive results but one or more negative ones that can't be overlooked. If you have collected monitoring data according to a well-designed plan, these data will not only indicate that the project's goals aren't being met, they will also help you figure out how to modify or redesign the project so as to better meet its goals. As noted at the beginning of this chapter, this use of data to inform management is referred to as adaptive management.

A recommended strategy is for the monitoring team to regularly review the monitoring data for signs that restoration goals are not being met. Depending on the nature of the gap between desired and actual results, the team can then recommend changes or adjustments in the project or in the way it is managed.

You may find it helpful to build in to the monitoring plan a pre-determined "decision point" for each parameter being monitored This is a point in time (often expressed as the number of months or years after project implementation) when the monitoring team reviews the data on that parameter and decides if any adaptive action is called for. For example, for the project described in Figure 3.1, the team could decide that the decision point for "% cover" is five years after planting—if the trees are not creating the desired amount of cover by that time, remediative action will be taken (this might involve planting additional trees of a different species).

When reviewing monitoring data to determine whether or not some adaptive change should be undertaken, it is important to keep in mind the likely accuracy of the data. This is determined in part by the monitoring protocol and by the other factors affecting data quality that were discussed above. If you have a relatively low level of confidence in the accuracy of the data, you may want to delay any management decisions until better or corroborating data are available.

The concept of adaptive management can also be applied at a scale larger than that of an individual restoration project. Monitoring data collected for a single project can help restoration practitioners design similar projects for other sites or implement additional projects that work in concert with an existing one to improve habitat or stream conditions. In the broadest sense, adaptive management becomes the necessary approach for dealing with the long-term shifts in climate and environmental conditions that can be expected to occur over the next several decades.

Practitioners who implement any of the projects outlined in this manual should be prepared to make adaptive management decisions during the first few years after installing the project, and possibly longer, based on monitoring data. Conditions should be expected to change after the implementation of a project, either positively or negatively, and possibly dramatically in light of climate change.

Photo P3.3 Large scale repair on existing water control structure Photo: ESNERR

Developing a Riparian Bird Index to Communicate Restoration Success in Marin County, California

Point Blue Conservation Science has developed a Riparian Bird Index in an effort to create a simple means for clearly identifying restoration success and to provide pathways for improving ecosystem performance from investment in restoration.

The Riparian Bird Index, based on historical bird survey data from reference and restoration sites in Marin County, is essentially a species richness score for a given area that is weighted by the degree to which each species detected is associated with target riparian vegetation. The score can be converted into a simple rating of "poor," "fair," "good," or "excellent" to communicate restoration success to a diverse audience.

The Riparian Bird Index is a biologically meaningful way to evaluate restoration performance and to communicate this to a wide range of stakeholders. It can be used to initiate discussions among agency staff, biologists, restoration practitioners, and individual landowners on how to improve restoration performance.

Riparian Bird Index PDF

Information source: N. E. Seavy, and T. Gardali. 2012. Developing a Riparian Bird Index to Communicate Restoration Success in Marin County, California. Ecological Restoration 30: 157–160. PRBO publication #1865.