A CASE STUDY OF A FLOODPLAIN CHANNEL RESTORATION PROJECT IN THE SOUTHERN WILLAMETTE VALLEY OF OREGON

by

CHRISTOPHER F. JONES

A THESIS

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Dr. Patricia F. McDowell, Chair of the Examining Committee

Date

Committee in Charge: Dr. Patricia F. McDowell, Chair
Dr. Scott D. Bridgham

Accepted by:

Dean of the Graduate School

An Abstract of the Thesis of

Christopher F. Jones for the degree of Master of Science

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Title: A CASE STUDY OF A FLOODPLAIN CHANNEL RESTORATION PROJECT IN THE SOUTHERN WILLAMETTE VALLEY OF OREGON

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Dr. Patricia F. McDowell

A riparian ecological restoration project at Howard Buford Recreation Area, Eugene, Oregon, sought to increase hydrological connectivity between a river and its floodplain and restore a floodplain forest by planting trees and removing exotic invasive species. I evaluate the project's planning and implementation, using recommendations from recent scientific literature. Restoration projects should include the following: planning, implementation, monitoring, adaptive management, and communication. This project's planning was extensive, though short on measurable ecological objectives. Implementation was slower than planned, primarily because the project's coordinator, a non-profit group, lacked control over the county-owned project site. The channel reconstruction failed to achieve hydrological goals, due to design and implementation problems. Remediation is needed. Unlike most projects, this project is being monitored, although inadequate baseline monitoring led to implementation problems. Adaptive management and communication are adequate. The project was delayed repeatedly by county staff; these delays decreased ecological success and increased project costs.

CURRICULUM VITAE

NAME OF AUTHOR: Christopher F. Jones

GRADUATE AND UNDERGRADUATE SCHOOLS ATTENDED:

University of Oregon, Eugene, Oregon, USA
Princeton University, Princeton, New Jersey, USA

DEGREES AWARDED:

Master of Science, Environmental Studies, 2007, University of Oregon
Bachelor of Science in Engineering, Chemical Engineering, 1995, Princeton University

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Most of all, I thank my wife, Julie, and my son, Sylvan, for allowing me to spend hundreds of hours away from them while researching, writing, and revising this thesis.

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CHAPTER I

INTRODUCTION

About This Thesis

In this thesis, I analyze the planning and implementation of an ecological restoration project.

I synthesize recommendations from recent scientific literature on ecological restoration and evaluate the restoration project based on those recommendations. I look specifically at the five primary components of an effective restoration project, as described in the scientific literature: planning and goal-setting, implementation, monitoring, adaptive management, and communication. Where there were differences between the recommendations in the scientific literature and this project's actual planning and implementation, I describe those differences and examine the reasons for and the consequences of those differences. I am particularly interested in examining problems that were encountered in the planning and implementation of this project but were not mentioned in recent scientific literature on ecological restoration.

My objective is to provide insights that will help future restoration project planners create and implement effective riparian restoration projects. As federal, state, and local governments have recognized the ecologically degraded state of rivers, streams, and riparian areas, the number of riparian ecological restoration projects in the United States has increased exponentially, but there is comparatively little published information about the effectiveness of those restoration efforts (Bernhardt et al. 2005).

Information about the Ecological Restoration Project at the Howard Buford Recreation Area

This thesis describes and evaluates an ecological restoration project located within the Howard Buford Recreation Area (HBRA), a 2,363-acre (956 ha) park in Lane County, Oregon, USA. The HBRA is commonly known as Mt. Pisgah, since its dominant feature is the 1,531-foot (467 m) grassy summit of Mt. Pisgah, which rises just over 1,000 feet (300 m) above the valley floor and the nearby confluence of the Coast Fork and the Middle Fork of the Willamette River (FBP 2004d). The HBRA is located in the southern Willamette Valley of Oregon, just east of the city of Eugene and south of the city of Springfield (see Figure 1 for a map showing the HBRA in its geographical context). The Coast Fork Willamette River borders the park on its southern and western edges. The HBRA has been parkland since 1973, when the state of Oregon purchased the land from private landowners. The state deeded the land to Lane County, its current owner, in 1982 (FBP 1999e). Lane County's 1994 HBRA Master Plan designates the primary purposes of the park as nature education, habitat protection, and low-intensity non-motorized recreation (FBP 2001d).

Beginning in 1998, the Friends of Buford Park and Mt. Pisgah (FBP), a non-profit organization based in Eugene, Oregon, began ecological restoration at the HBRA.[1] FBP's mission is to protect and enhance native ecosystems and compatible recreation in the Mt. Pisgah area (FBP 2000b). In partnership with public agencies and private donors, FBP has conducted ecological restoration work in a floodplain adjacent to the Coast Fork Willamette River at the HBRA. The goal of this restoration project is to restore the ecological integrity of the floodplain by restoring a diversity of native plant communities in existing cleared areas, modifying hydrology on the site, removing exotic invasive plants, and expanding habitat for special status species.

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[1] I have been a volunteer board member of FBP since 2001. My role in the ecological restoration project described in this thesis has been primarily indirect, helping to create budgets and set strategy and policy for FBP. I have participated as a volunteer in a few restoration work parties, planting trees at the project site.

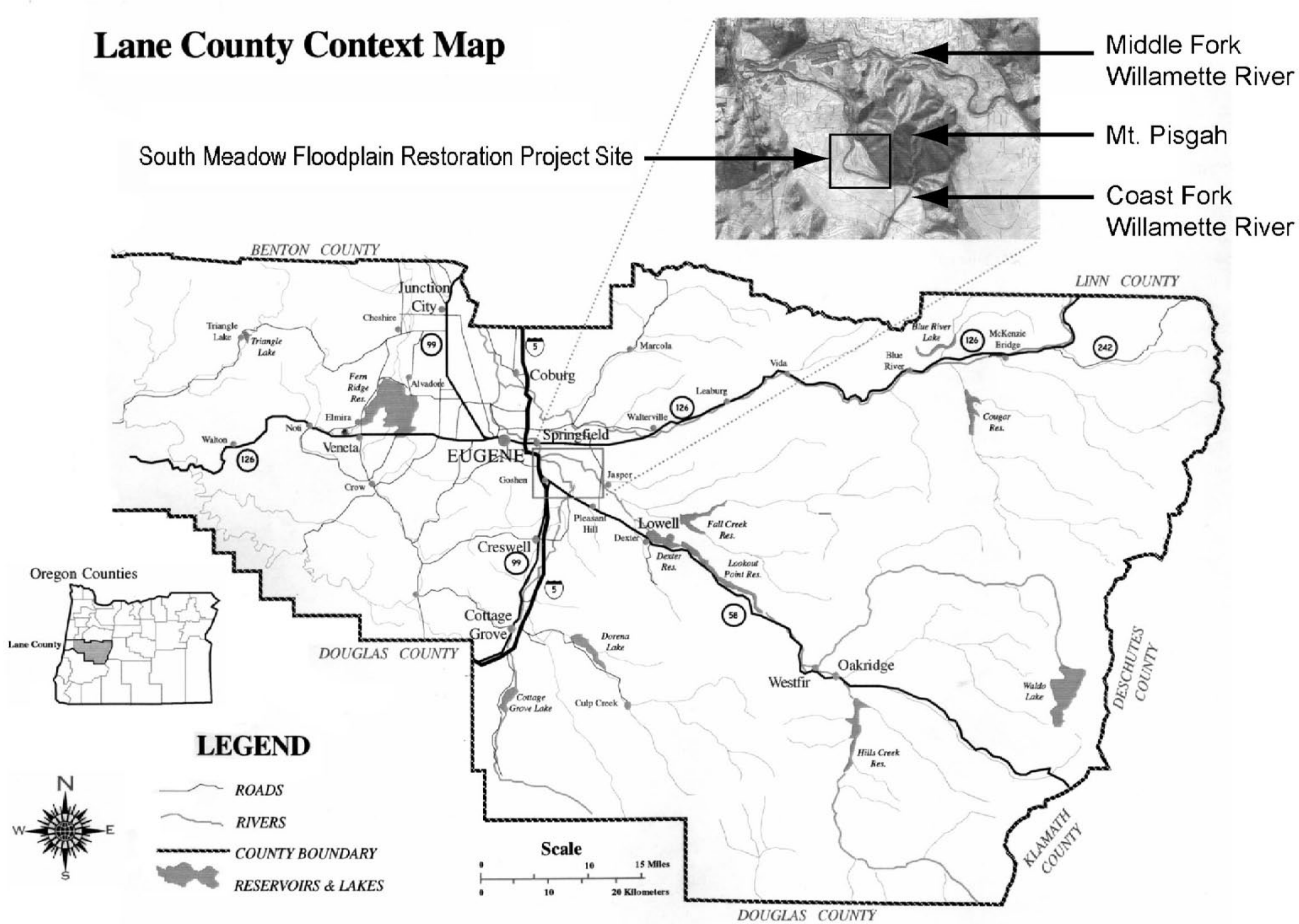

Figure 1. Context map showing the location of the South Meadow in Lane County, Oregon. Note the confluence of the Middle Fork (north of Mt. Pisgah) and the Coast Fork (west of Mt. Pisgah) of the Willamette River (courtesy FBP).

Early phases of the restoration project, from 1998 until 2003, included planting nearly 8,000 native trees and shrubs on the floodplain, significant control of exotic invasive species, and phased removal of grazing cattle from the floodplain. Using adaptive management, FBP developed and refined techniques to maximize the success of their planting, maintenance, and exotic invasive species removal efforts. Later phases of the restoration project, beginning in 2003, included additional planting, continued maintenance of young trees and shrubs, and reconstruction of an historical side channel that crossed the floodplain but was no longer active except during large, infrequent floods. The channel reconstruction was carefully designed by FBP's stewardship technical advisory committee in cooperation with Inter-Fluve, Inc., a professional hydrology firm. The channel was designed so that the Coast Fork Willamette River would overflow into the channel for an average of fifteen days per year, with at least some flow in the channel almost every year. The channel did not perform as expected. After analysis of the reasons for this failure, FBP proposed a second phase of excavation, including creation of a backwater wetland and remediation of the channel inlet. Most of this second phase of excavation was completed in 2006 and included the excavation of a backwater wetland, but the channel inlet has not yet been remediated.

I chose to analyze this ecological restoration project for two reasons. First, I had witnessed pieces of each stage of the project, from early planning and implementation through later assessment and adaptive management, and I wanted to compile a complete picture of the project. I wanted to see what parts of the project were effective and what parts could have been done better. Second, I knew that the channel reconstruction project had not had the desired results, and I wanted to know why. I wanted to find out the causes of this failure, both to satisfy my own curiosity and to provide guidance to future restoration project managers.

Ecological Significance of the Howard Buford Recreation Area

The HBRA and some of the undeveloped land adjacent to it constitute one of the largest remaining patches of native plant communities in the southern Willamette Valley of Oregon (FBP 2000c). The HBRA is home to four globally endangered plant communities: Willamette Valley Oak Savanna, Willamette Valley Oak Woodland, Willamette Valley Wetland Prairie, and Willamette Valley Upland Prairie (FBP 2002h). The first two of these plant communities consist primarily of native Oregon white oaks (*Quercus garryanna*) and native prairie grasses in dry, upland habitats. The second two plant communities are made up of native prairie grasses and forbs in open habitats. Their extent has been significantly reduced since the nineteenth century by agriculture and urban development. FBP's restoration projects are focused on restoring these and other native plant communities.

One of the goals of FBP's restoration projects is improvement of habitat for threatened and endangered species, including the northwestern pond turtle (*Clemmys marmorata*, listed as "critical" on Oregon's Sensitive Species List), Chinook salmon (*Oncorhynchus tshawytscha*, federally listed as "threatened"), and steelhead trout (*Oncorhynchus mykiss*, federally listed as "threatened"), all of which are found in or near the restoration project site (ODFW 1997; FBP 2003a).

Vegetation and Land-use History of the South Meadow Ecological Restoration Site

The ecological restoration project described in this thesis is contained within the 200-acre (80 ha) "South Meadow" area of the HBRA (see Figure 1) (FBP 2004d). Before Euroamericans settled the Willamette Valley beginning in the mid-19th century, the South Meadow was a floodplain forest dominated by Douglas-fir (*Pseudotsuga menziesii*), big-leaf maple (*Acer macrophyllum*), Oregon ash (*Fraxinus latifolia*), black cottonwood (*Populus balsamifera var. trichocarpa*), and willows (*Salix spp.*), with patches of open prairie vegetation (see Figure 2 for a mid-19th century map). By 1936, the year of the earliest known aerial photographs of the South Meadow, the site had been substantially cleared, either for cultivation or for pasture (see Figure 3) (FBP 1999e, 2002c).

Figure 2. Map of dominant vegetation types in the vicinity of the South Meadow in the 1850s. The gray circle highlights the South Meadow, where dominant vegetation was recorded as "floodplain forest mosaic" and "prairie" (adapted from LCP/FBP 2002).

Figure 3. Aerial photo of the South Meadow taken in 1936, showing substantially the same amount of open space as exists today. The Coast Fork Willamette River flows from south to north. This is the earliest known aerial photograph of the site (courtesy FBP).

Contemporary site mapping, recent soil analysis, and aerial photographs taken early in the 20th century indicate that the South Meadow was a wide, active floodplain, with the Coast Fork Willamette River overflowing into multiple side channels during frequent floods. An aerial photograph taken during a large flood in November 1996 shows these historical channels (see Figure 4) (FBP 1999e). Almost the entire South Meadow lies in the 100-year floodplain, with a few elevated sections in the 500-year floodplain (see Figure 5). During the middle of the twentieth century, the Coast Fork Willamette River adjacent to the South Meadow was simplified by landowners, who placed fill in locations that allowed them to cross historical channels more easily, and by the Army Corps of Engineers, who built revetments along both banks of the river (see Figure 5). The entrances to some of the side channels that still cross the site were blocked with rocks, either by landowners or the Army Corps of Engineers, probably to keep water out of the site and to improve the quality of the site as pasture. Two flood control dams, built in 1945 and 1949 by the Army Corps of Engineers about 25 river miles upstream of the South Meadow, collect runoff from nearly sixty percent of the Coast Fork Willamette watershed and have significantly modified the site's hydrology (FBP 1999e, 2000c).

These revetments, channel barriers, and flood control dams significantly reduced the river's ability to interact with its historical floodplain. The river currently occupies a single channel as it passes the South Meadow. The dams have cut off some of the river's sediment supply, causing the river to cut this main channel deeper than it had been historically. The operation of the dams for flood control and the incision of this main channel prevent the river from overflowing into the floodplain except during large, infrequent flood events (FBP 2000c). The geomorphological modifications described above are typical of channelization and bank hardening that has been carried out throughout the Willamette River basin in Oregon. Backwaters, side channels, and sloughs that were once common along the Willamette River are now rare (FBP 2002b).

Before the HBRA was purchased by Oregon as a Willamette Greenway Park in 1973, large parts of the South Meadow were grazed by domesticated livestock, cultivated, or both. Grazing continued throughout the HBRA until 1993, when cattle were

Figure 4. Photograph of the South Meadow as flood waters receded in November, 1996 (courtesy FBP).

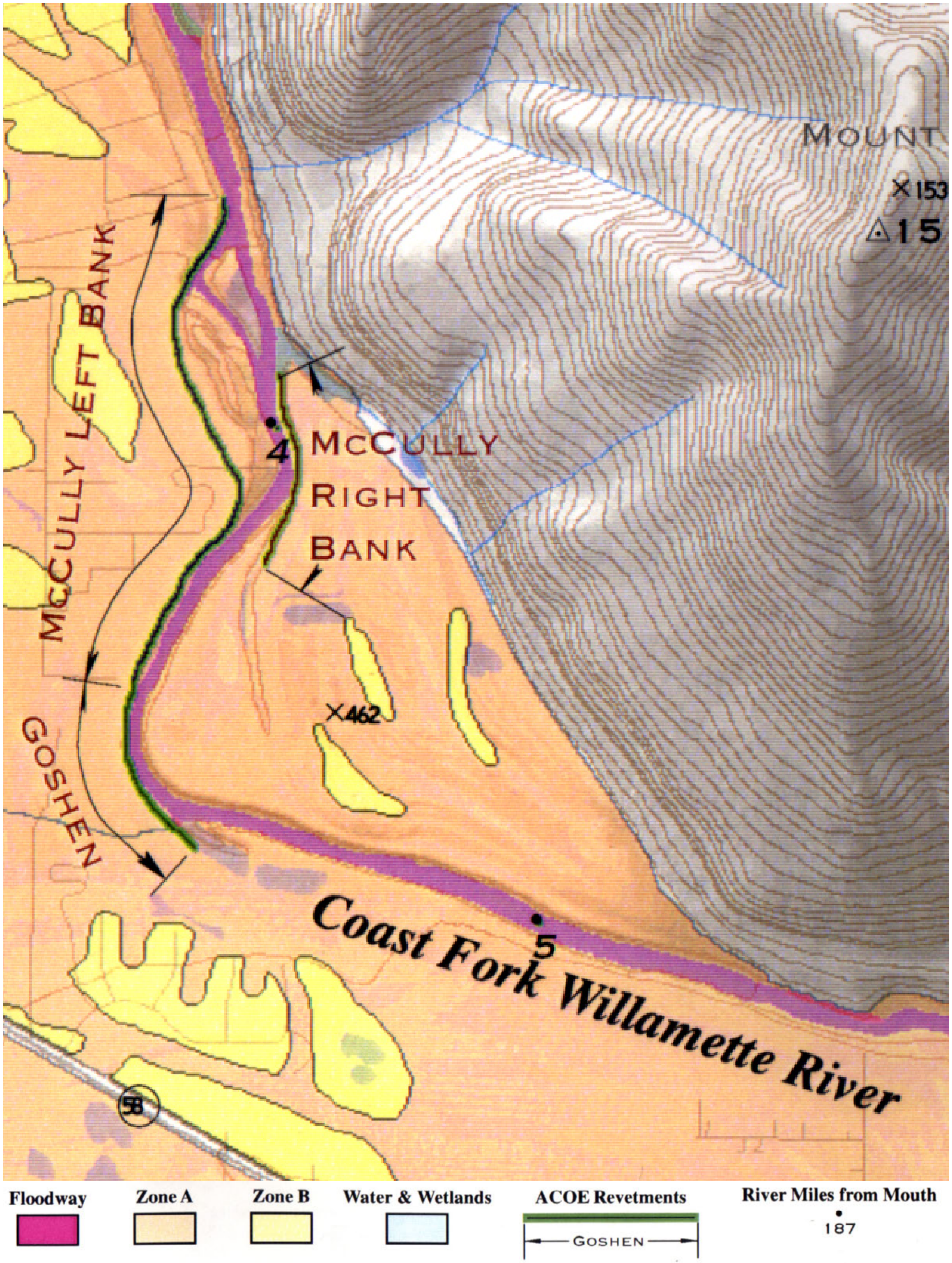

Figure 5. Federal Emergency Management Agency floodplain map of the South Meadow (the colored area east of the river). Zones A and B are the 100-year and 500-year floodplains, respectively. Note Army Corps of Engineers revetments. Approx. scale 1:12000 (adapted from LCP/FBP 2001).

confined to two bottomland sites, including the South Meadow. Grazing continued in most of the South Meadow until 2002, when Lane County's Parks Division phased it out in favor of ecological restoration efforts (FBP 1999e, 2000c, 2001b, 2001d).

Pre-project Vegetation and Animal Presence in the South Meadow

Before FBP began its ecological restoration project in 1998, the 200-acre (80 ha) South Meadow site contained vegetation similar to that visible in the 1936 aerial photograph (see Figure 3), though with fewer trees (see Figure 4). It contained fragments of native floodplain forest, significant populations of introduced grasses, and large populations of exotic invasive plants. Along the river, a mature forest of big-leaf maple, cottonwood, and Oregon ash, with predominantly native understory vegetation, varied in width from ten to one thousand feet (3 to 300 m). Historical river channels that crossed the site were lined with cottonwood and Oregon ash. The open areas of the South Meadow, especially around stumps and fence lines, had high coverage of exotic invasive plants, including Armenian blackberry (*Rubus discolor*) and Scot's broom (*Cytisus scoparius*). Where the open areas were not covered with blackberry and Scot's broom, they were dominated by exotic forbs and pasture grasses (FBP 1999e, 2001d).

Organization of This Thesis

In this first chapter, I begin with an introduction to the thesis and to the ecological restoration project I will analyze. In the second chapter, I summarize and analyze recent scientific literature on ecological restoration in order to describe an ideal restoration project. In the third chapter, I explain the planning and implementation of the South Meadow ecological restoration project and compare it with the ideal restoration project described in the second chapter. I conclude with a chapter that explores ways in which the scientific literature failed to anticipate some of the problems that FBP encountered while planning and implementing this restoration project.

CHAPTER II

PLANNING AND IMPLEMENTING EFFECTIVE ECOLOGICAL RESTORATION PROJECTS IN RIPARIAN AREAS

Introduction

In this chapter, I review and summarize information and recommendations from recent scientific research about ecological restoration projects in riparian areas. The purpose of this chapter is to describe the ideal ecological restoration project from the earliest planning stages to the communication of results.

The chapter contains two main sections. I begin the first section with a definition of ecological restoration and related terms that I use in this thesis. I then explain what riparian areas are and why they are a frequent restoration target. I conclude the section with a discussion of the background knowledge required for ecological restoration of riparian areas.

The second section describes the five components of an ideal restoration project. In the first part, I summarize and analyze current thinking on how to create a restoration project plan and set appropriate goals. I continue with sections on project implementation steps, effective project monitoring, a process called adaptive management, and communication of project results.

Defining Ecological Restoration

The most frequently cited definition of ecological restoration was proposed by the National Research Council (1992): “returning an ecosystem to a close approximation of its condition prior to [human-caused] disturbance” by re-creating ecosystem structure and function and allowing dynamic ecological processes to work. Ecosystem structure comprises the plants, animals, and abiotic features of an ecosystem. Ecosystem functions are the ways in which these organisms and abiotic features interact and are interconnected. The NRC described the objective of restoration as "emulat[ing] a natural, self-regulating system that is integrated ecologically with the landscape in which it occurs" (NRC 1992). Early restoration efforts focused on specific species, but that approach's limits led the NRC to emphasize that restoration must focus on bringing back ecosystems with all of their member species and ecological functions (NRC 1992).

The NRC and other authors cited below have suggested definitions for a number of related terms that I use in this thesis, all of them describing activities that do not meet the NRC's high standard of "restoration." These terms can be useful in describing a range of activities whose goal is to improve ecological structure, function, or both.

- Enhancement: improving ecological structure or function (NRC 1992).
- Mitigation: acting to avoid, reduce, or compensate for environmental damage (NRC 1992).
- Passive Restoration (sometimes called Recovery): letting nature take its course, often after eliminating causes of degradation. It is often a key component of restoration (Meffe and Carroll 1994). In contrast, "Active Restoration" involves making direct physical changes to a site's geomorphology, biological community, or both.
- Preservation: maintaining a functioning ecosystem in a desired state, including preventing degradation (NRC 1992). Preservation is always the preferred option when it is available, since it has lower costs and higher ecological effectiveness than other options. It is not an option for highly degraded sites.
- Reconstruction: changing an ecosystem to a target condition that is ecologically healthy and desirable but that did not exist in the past as a natural condition (Kondolf, Smeltzer, and Railsback 2001).

These definitions are not canonical; other authors have offered alternative definitions for each of these terms. In common usage, there is considerable overlap among terms like preservation, conservation, management, stewardship, and restoration: there are not sharp distinctions. The common goal of all of the above activities has been effectively described as compensating “in a specific, ecologically effective way for alterations typically caused by human activities” (Meffe and Carroll 1994).

Restoration by the NRC’s definition is difficult, if not impossible, to achieve, for two practical reasons. First, we lack sufficient information about pre-disturbance ecosystems to return any ecosystem to its original state, and because most natural ecosystems reflect past natural disturbance histories, it is difficult to know to what point we should restore (Goodwin, Hawkins, and Kershner 1997). Second, social constraints often limit restoration potential of a site; urban streams, for example, are often so highly modified and surrounded by land uses incompatible with restoration that restoration is impossible. Trying to determine an historical natural ecosystem composition for a given site can be very difficult. Even if project managers do gather sufficient historical information, current land use in the watershed and changing environmental conditions may preclude a restoration to a previous state (Hobbs and Norton 1996). The NRC’s definition of restoration should more accurately be called “full restoration,” since most practitioners use the word “restoration” to mean something that falls short of the NRC’s definition (Brookes and Shields 1996). Most “restoration” should strictly be called “enhancement”; it is doubtful that we can fully restore natural systems to a pre-disturbance condition (Boon 1998). Because “restoration” is the most frequently used term in the literature, it is the term I use most often in this thesis, with the understanding that its use here is the most common usage, synonymous with “enhancement.” The other restoration-related term that appears frequently in this thesis is “reconstruction”; this term is used as defined above.

Wise pragmatists have suggested that rather than argue about terminology, we should agree that “restoration occurs along a continuum and that different activities are simply different forms of restoration” (Hobbs and Norton 1996). Instead of arguing about what to call a certain activity, project planners and managers should focus on defining clear goals in order to be able to assess progress toward improving ecological structure and function (Hobbs and Harris 2001).

Definition and Description of Riparian Areas

This paper describes and evaluates a restoration project in a riparian area. In this section, I explain what riparian areas are, why they are ecologically important, what their current condition is in the Pacific Coastal Ecoregion[2] of the United States, and why there is interest in their restoration.

“Riparius” is a Latin word meaning “belonging to the bank of a river” (Naiman, Bilby, and Bisson 2000). Riparian areas are “three-dimensional zones of direct interaction between terrestrial and aquatic ecosystems” consisting of rivers, streams, and their adjacent floodplains (Gregory et al. 1991). The riparian area boundary extends vertically from the bottom of the hyporheic zone (the area of flowing water under and beside a stream’s bed) to the top of the vegetation canopy and outward to the limit of flooding; it also includes all areas uphill from the flood zone from which vegetation falls or could fall onto the floodplain or into the water. Riparian areas include all areas where vegetation influences and is influenced by perennial or intermittent flowing water (Naiman et al. 1992). Riparian ecosystems in the western United States are “the narrow ecotones between aquatic and terrestrial ecosystems that consist of several fluvial surfaces, including channel islands and bars, channel banks, floodplains, and lower terraces” (Goodwin, Hawkins, and Kershner 1997). The structure and function of riparian zones emerge from interactions among hydrology, soils, geomorphology, and living organisms (Kauffman et al. 1997).

These complex interactions produce high plant and animal species diversity. Worldwide, riparian areas increase regional biodiversity by more than 50 percent because

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[2] The Pacific Coastal Ecoregion comprises the western portions of northern California, Oregon, Washington, British Columbia, and southeast Alaska, from the Pacific coast to the crest of the Cascade Mountains of Oregon and Washington in the south and the Coastal Mountains of British Columbia in the north (Naiman, Bilby, and Bisson 2000).

they are home to so many assemblages of species (Naiman, Decamps, and Pollock 1993; Naiman, Decamps, and McClain 2005). Species richness (the number of species per square meter) is high in riparian zones: a 1992 study of Oregon and northern California found that "riparian communities contained approximately twice the number of species observed in upslope communities" (Gregory et al. 1991). In the Pacific Coastal Ecoregion, the home of this paper's case study, half to two-thirds of animals require riparian areas during at least some part of their life cycle (Naiman, Decamps, and McClain 2005).

Healthy riparian areas provide a number of benefits to species that depend on them, including humans. Healthy riparian vegetation provides shade, cover, and organic matter (the base of the food chain) for animals (Brookes, Baker, and Redmond 1996). Riparian corridors serve as migration corridors for both plants and animals, preserving and increasing biodiversity. These corridors are especially important during periods of rapid climate change, because other historical corridors have been interrupted by human modifications and also because river valleys provide "ameliorated microclimates" (Gregory et al. 1991; Naiman, Decamps, and Pollock 1993). Geomorphically and ecologically complex rivers have a greater diversity of habitat, provide more refuges during floods, and produce more organic litter, leading to higher biological production and a greater abundance of organisms, including fish (Gregory et al. 1991). Floodplains that remain connected to rivers and streams store, lower, and delay peak flows during heavy rain and floods. Overbank flow on floodplains recharges groundwater and improves water quality and wildlife habitat (NRC 1992; Philippi 1994; Hey and Philippi 1995; Brookes, Baker, and Redmond 1996). Riparian vegetation and associated microbes remove nutrients from water flowing in and toward streams, improving water quality (Brookes, Baker, and Redmond 1996). Riparian areas provide human aesthetic and recreational benefits. They are attractive contrasts in an urban environment; their linear nature lends itself to recreational trails (Brookes, Baker, and Redmond 1996).

History and Current Condition of Riparian Areas in the Pacific Coastal Ecoregion

Riparian areas in the Pacific Coastal Ecoregion are ecologically diverse areas that humans have greatly simplified in the past two centuries. Rivers in the region, as in much of the rest of the world, have been modified significantly by channelization and the construction of dams, levees, revetments, and related structures. Riparian corridors have become narrow and fragmented in comparison to their historical condition (Wissmar and Beschta 1998). These modifications have reduced the ability of rivers to interact with their historical floodplains, reducing ecological complexity and habitat diversity and decreasing the rivers' ability to retain dissolved nutrients and particulate matter for biological uptake (Gregory et al. 1991).

These simplifications have reduced the heterogeneity of habitat available to salmon and other anadromous fish, who use a variety of habitats – pools, riffles, terraces, backwaters, estuaries – during different parts of their life cycles (Naiman et al. 1992). Anadromous fish are of particular concern to scientists who study riparian areas in the Pacific Coastal Ecoregion; anadromous fish populations have declined significantly throughout the Pacific Coastal Ecoregion in the past century, primarily due to dam construction and riparian habitat degradation and destruction (Beschta 1997; Opperman and Merenlender 2004).

Restoration of Riparian Areas

This paper will focus on ecological restoration of riparian areas. As the benefits of riparian areas and the extent of their degradation became clear to researchers, academic discussion of river and stream restoration began in earnest two decades ago (Gore 1985). The terms "stream restoration" and "river restoration" appeared in the academic literature in 1992 and 1994, respectively; the appearance of these and similar terms in scientific papers has increased steadily since then (Ormerod 2004).

In the Pacific Coastal Ecoregion, scientists and land managers have focused on restoration of riparian areas because they believe that focusing on riparian restoration, including restoration of adjacent floodplains, is likely to be the most effective way to address the preservation of ecological diversity and amelioration of environmental problems at a landscape scale. Efforts to improve riparian conservation at a landscape scale will benefit aquatic, riparian, and avian species and improve water quality. Riparian areas are more likely to be home to threatened or endangered species than are strictly terrestrial ecosystems (Gregory et al. 1991; Naiman, Decamps, and Pollock 1993; Kauffman et al. 1997; Naiman, Bilby, and Bisson 2000; Wissmar et al. 2003).

In an early, comprehensive survey of the state of aquatic ecosystems and attempts to restore them, the National Research Council (1992) predicted that "failure to restore aquatic ecosystems promptly will result in sharply increased environmental costs later, in the extinction of species or ecosystem types, and in permanent ecological damage."

Background Knowledge Required for Riparian Restoration

Because riparian areas' ecological structure and function develop from complex interactions among hydrology, soils, geomorphology, and living organisms, planning and implementing successful ecological restoration projects require the integration of knowledge from multiple areas of scientific study, including fish biology, hydrology, hydrochemistry, soil science, geomorphology, plant and aquatic ecology, disturbance ecology (especially with regard to floods), and the role of riparian vegetation (Beschta 1997; Wissmar et al. 2003; Ormerod 2004). Riparian restoration often requires an understanding of engineering and the methods and effects of human-caused disturbances that degrade rivers and riparian areas, including channelization, other channel modifications, pollution, and streamflow and sediment flow modification caused by dams and diversions (Sear 1994; Goodwin, Hawkins, and Kershner 1997).

Planning a successful restoration project requires gathering adequate historical information. Project managers need to know about historical land- and water-use patterns in the watershed (Beschta 1997; Wissmar et al. 2003). In addition to historical information about human use, natural history information is also necessary to guide project planning. A review of a failed channel reconstruction project in northern

California concluded that the project failed because "no historical geomorphological analysis was undertaken to determine a suitable restoration goal." Analysis of the history of the restored reach would have shown that channel reconstruction was unnecessary and inappropriate (Kondolf, Smeltzer, and Railsback 2001).

Most stream restoration projects are implemented at a small scale, usually hundreds of meters at the most, which emphasizes the need for understanding the effects on biodiversity of proposed changes at multiple scales (Frothingham, Rhoads, and Herricks 2002). This means that project planners must account for land use patterns in the surrounding watershed. Restoration planning involves human interaction and usually takes place in a human-dominated landscape, so it is necessary to understand the social, cultural, and economic value that is currently derived from the restoration site and from the surrounding watershed. These human uses can introduce inflexible land-use constraints that limit restoration of both rivers and floodplains. Human interference with stream behavior is and will continue to be a major factor and should usually be viewed as part of the "natural" system, even while restoration attempts to account for and mitigate this interference (Brookes, Baker, and Redmond 1996; Rhoads et al. 1999; Frothingham, Rhoads, and Herricks 2002; Ormerod 2004).

Boon (1998) provided an effective summary of the above considerations, describing a way of thinking about projects that integrates multiple disciplines, offering guidance about five "dimensions" that project managers should take into account when planning a restoration project:

- Conceptual: Determine whether the project is restoring, preserving, or rehabilitating. Define the project's primary goals.
- Spatial: Pay attention to the watershed scale, connectivity, and geomorphology (what landforms you expect to be on the site and how watershed-scale processes affect those landforms).
- Temporal: Use history, including maps, descriptions, photographs, and geological evidence to guide restoration. Monitoring is necessary to understand responses and to find out if desired changes are occurring.

- Technological: Incorporate modeling and geographic information systems (GIS). Be aware of limitations of models and baseline data. Technology should not be an end in itself.
- Presentational: Be aware that restoration projects must frequently gain acceptance from a wide variety of stakeholders.

Boon's advice is useful for project managers so buried in specific scientific and social disciplines that they may miss the larger picture. The five "dimensions" above are too far removed from the reality of a restoration project, however. They do not focus enough on the ecological dimension, a facet critical to knowing whether your project is on the right track.

How to Create and Carry Out an Ecological Restoration Plan

Once a project manager has gathered the necessary background information, the next step is to create a restoration plan. A good plan will contain reasonable goals, measurable objectives related to those goals, implementation steps designed to meet those objectives, and a monitoring plan designed to measure progress toward the objectives. It will also contain plans for adaptive management and communication of results.

The National Research Council (1992) offered a 28-point "Restoration Checklist" of factors to consider. They reminded project planners to state three things clearly: the problem description, the project's goals, and measurable objectives. Many of the items to which the checklist refers are explained in more detail in this chapter, including defining goals and objectives, choosing evaluation criteria, gathering baseline data, ongoing monitoring, adaptive management, and communication of results.

The following is a detailed, ordered list of steps, integrating the ideas of many authors, for planning and implementing a successful ecological restoration project (Kondolf and Micheli 1995; Hobbs and Norton 1996; Downs and Kondolf 2002; Johnson, Tereska, and Brown 2002):

1. Study historical conditions and evaluate overall watershed condition.
2. Identify processes causing degradation.

3. Create realistic restoration goals for reestablishing ecological structure and function, recognizing ecological, social, and economic limits.
4. Create measurable objectives based on the project's goals.
5. Gather baseline monitoring data after creating a monitoring plan based on usable evaluation criteria and techniques.
6. Define or select practical implementation methods at an appropriate scale to reverse ecological degradation. Ensure that your project is capable of reversing the degradation that is present. In the failed northern California project mentioned above, the authors reported that channel reconstruction should not have been attempted, since it did not address the main causes of limited fish populations: upstream dams cutting off access to high quality habitat, and groundwater pumping lowering water tables (Kondolf, Smeltzer, and Railsback 2001).
7. Secure funding, including funding for monitoring and postproject evaluation. In order to ensure that monitoring funding is available and that monitoring is included in the project, incorporate all monitoring into project planning and budgeting, preferably for at least a ten-year period. Prevent the evaluation budget from being redirected to immediate needs that are less important than monitoring over the long term (Kondolf and Micheli 1995).
8. Request review by agencies and the public, determine if funding is adequate, and revise plans if necessary. Obtain permits if required.
9. Implement. Project implementation is described in detail below. A riparian restoration project's implementation should avoid doing long-term harm to the surrounding ecosystem by removing native riparian vegetation only if absolutely necessary; avoiding degrading nearby restoration activities; avoiding fish spawning season during construction work; and avoiding sediment loading downstream that exceeds normal limits (Palmer et al. 2005).
10. Monitor key variables to evaluate success and assess progress toward goals and objectives.

11. Adjust the project's implementation methods, design, monitoring plan, and even goals and objectives if necessary. This process, called adaptive management, is described in more detail below.
12. Document and communicate the above methods and results so that they can be applied to future projects. The project plan should call for the publication of an ecological assessment of the project site before, during, and after project implementation. The project does not have to achieve its original goals; thorough assessments of projects that do not meet their objectives may point to external factors that limit improvements and information that can be valuable for prioritizing other restoration efforts in the watershed (Palmer et al. 2005).

Setting Appropriate Goals for Restoration Projects

Once project managers have chosen a restoration site and gathered basic historical data, they must define goals and objectives for their projects. This section explains how to choose those goals and suggests goals that should be common to all ecological restoration projects.

Meffe and Carroll (1994) reminded project planners that it is a good idea to have project goals in the first place: "Restoration ecology is simply a tool in the arsenal against biodiversity loss, and not an end unto itself." This may seem an obvious statement, but the authors felt compelled to make it because research has shown that most projects either do not state useful goals or do not monitor to see if their project implementation is achieving the stated goals (see the Monitoring section below for more details).

Most projects are funded in the name of ecological restoration, either implying or stating that improving ecological conditions is the primary goal. A nationwide survey of over 37,000 river and stream restoration projects reported that the most frequently cited project goals were improvements in water quality, riparian zone management, in-stream habitat, fish passage, and bank stabilization (Bernhardt et al. 2005). A survey of project managers in the state of Washington found that while restoration and fisheries goals were paramount, project managers also listed “political/outreach” and “engineering” goals (Bash and Ryan 2002). Non-ecological goals are often acceptable and are sometimes necessary, but any ecological restoration project must be evaluated primarily for ecological effectiveness.

The goals of ecological restoration projects should be closely tied to the definition of restoration: recreating ecosystem structure and function and allowing dynamic processes to work (NRC 1992). Restoring or enhancing biodiversity is often cited as a restoration goal, though the phrase “ecological diversity” is preferable to “biodiversity,” since it includes ecological processes, not just the presence of species (Naiman, Decamps, and Pollock 1993).

Good goals are clear and concise and provide overall guidance for project planning and implementation, but goals are typically not directly measurable. Objectives are detailed, measurable criteria that will indicate whether or not progress is being made toward a project’s goals (Wissmar and Beschta 1998; Hobbs and Harris 2001). Good objectives describe measurable improvements in a riparian area’s ecological conditions, including some or all of: better water quality, a more natural flow regime, improved population viability and habitat quality of target species, a reduced proportion of non-native species, an increase in riparian vegetation, and improved ecosystem functions (Palmer et al. 2005). A project can be evaluated by non-ecological criteria as well, including cost-effectiveness, aesthetic value, recreational value, and advancement of scientific knowledge that benefits future projects (Palmer et al. 2005).

The primary goal of any ecological restoration project should be the restoration of ecological processes, both physical and biological (Kauffman et al. 1997; Wissmar et al. 2003). Those processes include “functioning food webs and systemwide nutrient conservation via relationships among plants, animals, and detritivores” (Kauffman et al. 1997). Restoring the hydrological and biological connectivity between rivers and their floodplains is fundamental to restoring ecological processes (Wissmar et al. 2003). Since nearly all rivers have been modified to reduce this connectivity, physical changes to a site’s geomorphology may be necessary before restoration can begin. Reducing human constraints on channels and floodplains allows rivers to migrate laterally, creating a heterogeneous mosaic of habitat. This mosaic is key to maintaining a biologically rich and diverse environment (Naiman, Decamps, and Pollock 1993; Naiman, Bilby, and Bisson 2000).

Since the goal of restoration is to create a more self-sustaining riparian ecosystem, one objective of restoration projects should be to restore variability to the ecosystem through natural disturbances, especially floods. Frequent disturbance creates geomorphic and biological heterogeneity, which leads to ecological diversity. Restoration projects that focus on reestablishing disturbance regimes will allow hydrological, geomorphic, and biological processes to recover, often at a lower cost and on a larger scale than projects using engineering to try to achieve the same results (Naiman, Decamps, and Pollock 1993; Kauffman et al. 1997). A key strategy in restoring a river's natural disturbance regime is to restore a natural flow regime, including both high flows and low flows. Restoring natural flow regimes below dams is important for fish spawning, riparian plant germination, floodplain soil nutrient recharge, channel modification, and groundwater connectivity (Palmer et al. 2005). Disturbances can also create opportunities for exotic invasive organisms to gain a foothold on a restoration site, however, so project managers should be prepared to control potential problem species. Successfully restored riparian ecosystems are resistant to and resilient in the face of disturbance (Kauffman et al. 1997; Palmer et al. 2005).

Ideally, restoration goals, plans, and techniques should be developed and implemented at a landscape or watershed scale. Identifying important processes leading to ecological degradation and incorporating restoration planning into regional land management and land-use planning will make restoration more successful throughout the watershed (Hobbs and Norton 1996). Improving ecological diversity at the landscape scale will require restoration of a continuous river network instead of the current disconnected fragments of habitat (Naiman, Bilby, and Bisson 2000). In the absence of landscape-scale restoration planning, project planners need to be aware of and understand limits imposed on their projects by conditions outside of their control. Restoration to pre-disturbance conditions may not be possible given existing degradation, channel incision, land-use effects and constraints, poor water quality, and limitations imposed by upstream dams and other flow modifications (Brookes, Baker, and Redmond 1996; Beschta 1997; Frissell and Ralph 1998). In those cases, project managers should focus on restoring native plant communities and on addressing ecosystem damage caused by local disturbances (Beschta 1997; Frissell and Ralph 1998).

Project managers should take care to set reasonable goals. The project's design should consider a range of possible outcomes, with an overarching goal of establishing "the least degraded and most ecologically dynamic state possible" with ecological diversity in species, structure, and function across time and space (Palmer et al. 2005). This recommendation is a pragmatic one, designed to avoid setting impossible goals; rather than trying to recreate and maintain an exact historical state, project managers should try to repair human-caused damage and establish functioning ecosystems (Hobbs and Harris 2001).

Project Implementation Steps

Once project managers have created goals and measurable objectives, they must decide on specific project implementation steps. An important consideration in the design of a restoration project is the most effective order in which restoration operations should be carried out.

The top priority in any ecological restoration project is preservation of remaining functionally intact ecosystems and natural processes (Wissmar et al. 2003; Downs and Gregory 2004). While preservation of high quality habitat is the most effective method of conserving ecological diversity, preservation is inadequate in many regions because the remaining high quality habitat is insufficient to preserve biodiversity. In those areas, restoration of degraded habitat, in addition to preservation, is the best option (Hobbs and Harris 2001). Before beginning active restoration, managers should consider passive restoration, halting human practices that cause degradation. Removal of the causes of degraded ecological conditions through passive restoration can reduce the need for expensive active restoration efforts (Naiman, Bilby, and Bisson 2000). Passive restoration can include creating buffers, removing grazing or other human uses, and decreasing pollution, among other activities (Kauffman et al. 1997; Wissmar et al. 2003).

In planning and implementing passive restoration, project planners must consider the cause of degraded conditions. Restoration projects are unlikely to succeed if they try to treat symptoms (e.g. invasive species, lack of woody debris) without addressing the fundamental problems (e.g. change in soil properties or hydrology, absence of natural disturbance regimes, anthropogenic modifications and disturbance). Is the degradation's cause local or does it originate outside of the restoration site? Is the disturbance currently present? If so, is it feasible to eliminate it? If the disturbance is removed, will passive restoration work? Project managers should consider that "a restoration project that does not address these […] questions will in all likelihood fail, at least partially" (Goodwin, Hawkins, and Kershner 1997).

The most intrusive type of restoration, when preservation and passive restoration are impossible or inadequate, is active restoration. Active restoration has been widely implemented, sometimes without regard to the root causes of degraded conditions. There has been substantial criticism of and disagreement about active restoration, but it may be the best option for many sites. Active restoration activities can be costly and time-consuming, so it is important to ensure that the preservation and passive restoration options listed above have been fully explored before beginning active restoration steps. Active restoration of riparian areas should consist of a set of ordered steps, beginning with restoration of processes and geomorphology, and followed by modification of the plant and animal communities. Authors disagree on the order of specific steps, but the most sensible sequence, in which each step is dependent on the one before it, is likely to be as follows:

1. Restore hydrological processes, including historical flow and sediment transport regimes (Downs and Gregory 2004). This step may require removing dams or changing the seasonal flows of water and sediment from dams (Wissmar et al. 2003). Reconnecting rivers to their floodplains and to

riparian groundwater can reduce the viability of exotic species and is vital to ecosystem health (Naiman, Bilby, and Bisson 2000).

2. Restore natural channel geomorphology if it will not recover on its own based on restored hydrology (Downs and Gregory 2004). This step may include breaching revetments and levees and removing other human-made structures (Wissmar et al. 2003). Natural geomorphic surfaces and connectivity provide the substrate for the rest of the ecosystem to recover; unless the ecosystem is irreparably damaged, it may recover once the geomorphology is enhanced (Brookes and Shields 1996). Unfortunately, the threshold for irreparable damage may be too low for some project managers; a number of studies have shown that removal of stressors and appropriate geomorphological modifications did not lead to ecological recovery. The reasons cited for this lack of success were insufficient scale of the project, rarity or absence of colonizing populations of desired organisms, long life cycles of desired organisms, failure to completely remove a stressor, and the effect of watershed-scale processes on the restored reach (Ormerod 2004).
3. Restore native riparian plants (Downs and Gregory 2004). This step and the following step may require the removal of exotic species if they will interfere with restoration of native species. Riparian vegetation affects streams in a number of ways that are relevant to ecological restoration. Plants can continue the restoration of geomorphology by trapping sediment, redirecting flows, stabilizing stream banks, and creating islands and bars; flowing water and vegetation can create a geomorphically and hydraulically diverse system of channels. Vegetation moderates stream temperature by reducing solar input and limiting radiation losses; provides resistance to flows in channels and during overbank flows, reducing erosion and slowing floodwaters; and contributes woody debris and organic litter to streams. Woody debris is a key habitat feature in forested watersheds, providing habitat for animals, increasing complexity, and stabilizing stream banks; organic litter is the base

of the food chain in small streams. Vegetation also produces and transports essential nutrients and removes excess nutrients (e.g. nitrogen and phosphorous from agriculture) from runoff (Gregory et al. 1991; Naiman et al. 1992; Beschta 1997).

4. Restore native aquatic plants and animals if they are no longer present (Downs and Gregory 2004).

Each step above is assisted by the step preceding it, but if one of the steps is impossible, project managers should consider the benefits of other steps. In some areas, restoring flow regimes is not possible, or obtaining permits to modify geomorphology is impossible. Ecosystems may still benefit from the removal of exotic invasive species and the reintroduction of native plants and animals. Project managers should be aware that without restoring flow regimes and geomorphology, maintaining the health of the reintroduced plants and animals may require more maintenance and expense than projects would otherwise require.

Monitoring

Monitoring is the only way to know whether a project is meeting its objectives and achieving its goals, yet monitoring, especially long-term monitoring, is the most neglected part of ecological restoration projects. This section explores monitoring, its benefits, and the reasons that it is often neglected.

Long-term monitoring of projects, using well-defined ecological criteria, is central to adaptive management (defined below), to knowing whether project funds are being spent effectively, to applying knowledge from a project to future projects, and to knowing whether your project is achieving its goals. Many authors have reported, however, that monitoring, even including the collection of baseline data, is rare (Kondolf and Micheli 1995; Brookes and Shields 1996; Kondolf 1996; Frissell and Ralph 1998; Bash and Ryan 2002; Moerke and Lamberti 2004). In the survey of Washington restoration projects cited above, only about half of project managers reported collecting baseline monitoring data for their projects (Bash and Ryan 2002). In the study of 37,000 river restoration projects mentioned above, “only 10% of project records indicated that any form of assessment or monitoring occurred” (Bernhardt et al. 2005).

Authors have proposed that the primary barrier to monitoring is a lack of funding (Brookes and Shields 1996; Bash and Ryan 2002). The Washington survey verified this hypothesis, finding that a lack of funding was project managers’ most commonly cited reason for not monitoring. Project managers were critical of funding sources for focusing too much on the initial capital expenses of projects and not enough on baseline and ongoing monitoring, even though monitoring and evaluation are the only way to know if funds are being spent effectively (Bash and Ryan 2002). Many authors have proposed that projects would be more successful if a significant portion of project budgets were dedicated to long-term monitoring, including data collection, analysis, and distribution of results (Frissell and Ralph 1998; Wissmar et al. 2003).

There are two fundamentally different kinds of monitoring: implementation monitoring, which “documents the enhancement project design, compares it with design guidelines and specifications, and determines its appropriateness in the field”; and effectiveness monitoring, which “determines whether the enhancement had the desired effect on the ecosystem and if objectives were met” (Johnson, Tereska, and Brown 2002). Implementation monitoring is useful to determine whether the project plan is being carried out successfully, but effectiveness monitoring is the backbone of project evaluation. It is only through effectiveness monitoring that a project manager will know if implementation actions are having desired effects on the project site’s ecosystem. While implementation measurements, such as the number of trees planted or the number of miles of stream enclosed with fencing, may look good in grant reports, a project’s meaningful outcomes are ecological improvements over time, such as the creation of new high-quality habitat or an increase in the populations of target species (Opperman and Merenlender 2004). Variables used in monitoring should allow for the detection of quantifiable changes in restored areas in order to evaluate success or failure to achieve the project’s objectives (Wissmar et al. 2003).

The most important information to gather is baseline data, information about the physical and biological conditions at the project site before the project begins. To be useful, baseline data collection must begin before the project design is complete (Wissmar et al. 2003). At a minimum, collecting baseline data will allow future researchers to repeat the initial data collection effort and compare their new data with the baseline information (Bash and Ryan 2002; Opperman and Merenlender 2004).

If project managers do not have baseline data, they may be forced to rely on models and estimates, which may decrease the accuracy of predictions about a restoration site's response to initial restoration activities. Hydrological modeling, for example, works well for designing flood control projects, since flood control projects are designed for 100-year floods and models tend to overestimate runoff. Hydrological models work less well for projects designed around small floods, which are usually the floods of interest for ecological restoration projects. Since the most commonly used hydrological models greatly simplify water flows, failing to account for groundwater interactions, variable resistance to flow at different discharges, spatial changes in water infiltration rates, and local wetlands, among other important factors, it is important to provide baseline data to models when designing restoration projects (Haltiner, Kondolf, and Williams 1996).

Kondolf and Micheli (1995) offered substantial detail on what, how, and how long to monitor. Two important steps are planning the monitoring well in the beginning and "the application of standardized, objective measures that can be reproduced despite changes in project personnel." They suggested ten years after project implementation as the minimum time required to find out if a project has improved ecological conditions. A ten-year period is likely to include multiple bankfull (usually 1.5 to 2 year average recurrence interval) floods and one or more larger (5 to 10 year) events. They noted that project managers do not have to monitor every year, recommending monitoring frequently during the period shortly after the completion of the project and then after any flood events, when major changes are most likely to occur. While their recommendations are valid for some types of data, ten years is not long enough for establishment of a self-sustaining riparian forest, and some data should be gathered on a more regular basis so that there is adequate information for statistically valid comparisons.

Adaptive Management

The purpose of monitoring is to determine whether a project is meeting its objectives. When a project manager monitors a project's progress in relation to its objectives, he or she may discover that the chosen implementation methods are not resulting in the desired outcomes. A process called adaptive management allows managers to adjust methods, objectives, and even goals as they gather more information about the results of their project implementation methods.

Adaptive management is the most effective way to manage ongoing restoration projects. It is typically performed on projects implemented in a series of phases over several years and treats management of an ecosystem as a series of experiments, allowing restoration to proceed even when there is uncertainty about the potential effects of management actions. In adaptive management, project managers gather information about the results of management actions and then use those results to modify subsequent actions. Adaptive management is not simply trial and error; initial implementation methods are based on historical data about the ecosystem to be restored, methods that were successful in previous projects, scientific data and hypotheses, and mathematical models (Downs and Kondolf 2002; Johnson, Tereska, and Brown 2002). The two key components of adaptive management that make it different from simple project management are monitoring and the application of monitoring results to future actions (Johnson, Tereska, and Brown 2002).

Adaptive management allows restoration projects to proceed toward their goals even if there is uncertainty about the effectiveness of proposed restoration methods. Project managers can use historical information to plan ways to limit the potential negative effects of management actions, but given the uncertainty involved, complete or partial failure of some restoration methods should be expected. Failure should be viewed as “unexpected outcomes, or surprises, that are valuable lessons […] providing a tool for guideline revisions” (Johnson, Tereska, and Brown 2002).

Communication of Results

Specific, documented results, both successes and failures, should be communicated to other project managers, ideally resulting in better rates of success and prevention of similar failures in future projects (Johnson, Tereska, and Brown 2002). A successful project should demonstrably meet its ecological goals, and “within an adaptive management framework, success should also be defined by a restoration scheme achieving a significant learning experience to benefit future projects” (Downs and Kondolf 2002).

Johnson, Tereska, and Brown (2002) proposed three stages of maturity for ecological restoration projects using adaptive management. Each of the stages focused on the amount of communication that already exists regarding restoration projects. The first stage of maturity consists simply of monitoring and communicating results of implementation steps to provide information about the implementation’s ecological effects. This early stage is necessary when information about the effects of proposed implementation steps does not yet exist or is insufficient to predict an ecosystem’s response to a management change. The second, or “adaptive,” stage, which is the state of most contemporary projects, tests hypotheses developed from information gathered and communicated in previous projects against actual ecosystem responses. This stage also allows the possibility of moving outside the range of known experience in order to achieve desired results. The third, “mature” stage will exist when project managers have significant information about the management options available for their projects, specific instructions for implementation of those management options, and the ability to predict the likely results of that implementation. Project managers will have recipes and models that work. The authors noted that given the diversity and complexity of ecosystems in need of restoration, “it is likely that this [mature] phase may never be attained.” Hobbs and Norton (1996) also expressed an interest in reaching this mature phase: “restoration ecology has largely progressed on an ad hoc, site- and situation-specific basis, with little development of general theory or principles that would allow the transfer of methodologies from one situation to another.” Communication of detailed information about restoration projects to managers of future projects will be the only way to reach this mature stage of restoration project management.

Conclusion

An effective ecological restoration project consists of five parts: planning and goal-setting, implementation, monitoring, adaptive management, and communication. In the next chapter, I describe an ecological restoration project, comparing its planning and goals, implementation, monitoring, adaptive management, and communication to the ideal project described in this chapter. I will conclude with a summary of the project and an analysis of factors that negatively affected the project’s progress and were not addressed in recent scientific literature.

CHAPTER III

DESCRIPTION AND ANALYSIS OF THE SOUTH MEADOW ECOLOGICAL RESTORATION PROJECT

Section III.A: Planning and Goals

Introduction

The first step in an effective ecological restoration project is to define goals for the project. The primary goals of a restoration project should be related to restoring ecological processes. This section describes and evaluates the formal planning documents that have guided ecological restoration in the South Meadow at the HBRA, focusing on three primary planning efforts. The first plan was the Alternatives Team Report, created in 1997. The second was a more detailed set of plans that the Friends of Buford Park and Mt. Pisgah (FBP) developed during 2001 and 2002 into a formal, government-approved management plan for the South Meadow. The third planning effort, developed primarily in 2002 and 2003, involved design for an active restoration project, including channel reconstruction, in the South Meadow.

The creation of these three plans followed a logical sequence. As the project's planners gathered more information about the site and discussed details of project implementation, the plans and goals they developed reflected their increasing understanding. The ecological goals in all three plans were essentially the same, with minor additions and refinements prompted by new information, discussion with project partners, and feedback from the public.

The current Master Plan for the Howard Buford Recreation Area was developed in 1994. It contained nine primary goals for the park, the second of which was "To protect sensitive and significant natural resource areas and restore degraded habitat." In the plan, the South Meadow was identified as an area of "diminished use," which indicated that it was not a significant recreation site and was a potential ecological restoration area (FBP 2001c).

The first formal planning for restoration in the South Meadow began in 1997, but that process had its roots in an act of Congress passed in 1980, the Pacific Northwest Electric Power Planning and Conservation Act. This legislation included a fish and wildlife program designed to "protect, mitigate, and enhance" fish and wildlife habitat "affected by the development and operation of any hydroelectric project on the Columbia River and its tributaries" (Pacific Northwest Electric Power Planning and Conservation Act 1980). Since 1991, the Bonneville Power Administration (BPA) has contracted with the Oregon Department of Fish and Wildlife (ODFW) to carry out required protection, mitigation, and enhancement activities in the Willamette River basin. In 1995, BPA funded ODFW to conduct a habitat study of the area surrounding the confluence of the Middle Fork and the Coast Fork of the Willamette River (see Figure 1 for the location of this confluence area, including the HBRA's South Meadow). The HBRA, and the South Meadow in particular, were included in the study area. This habitat study resulted in the 1997 "Alternatives Team" report described below. The confluence area was chosen because it contained a large proportion of public land with ecologically valuable habitat, along with significant populations of northwestern pond turtles (*Clemmys marmorata*, listed as "critical" on Oregon's Sensitive Species List), Chinook salmon (*Oncorhynchus tshawytscha*, federally listed as "threatened"), and steelhead trout (*Oncorhynchus mykiss*, federally listed as "threatened") (ODFW 1997; FBP 2003a).

Alternatives Team Report

A group of thirteen representatives from state government agencies, local non-profit organizations, and local governments met several times in 1997 to evaluate and recommend habitat enhancement opportunities in the area around the confluence of the Middle Fork and the Coast Fork of the Willamette River. They compiled a written report identifying three high-priority ecological restoration projects in the confluence area. One of the three high-priority areas identified in the report was the HBRA's "South Pasture," the area that is now called the South Meadow[3] (ODFW 1997). The report recommended five restoration activities in the South Meadow (see Figure 6): removing three "plugs" that blocked water flow into historical channels; exploring restoration of wetlands on the east side of the pasture, at the foot of the hill; exploring reestablishment of wetlands and floodplain hydrology in four "abandoned" historical channels after studying the site's hydrology to determine the feasibility of this idea; controlling exotic invasive plants; and restoring riparian forest throughout most of the floodplain (ODFW 1997). These recommendations are essentially the same goals that exist in current planning documents for the South Meadow.

The report recommended an overly ambitious timeline for restoration, given that funding for these projects was not yet available. It recommended studying the site's hydrology in 1997 and 1998. Also for 1998, it recommended removing all exotic plants, developing a site management plan, planting riparian forest "provided cattle are excluded," and removing plugs and implementing other floodplain restoration. The timeline concluded with continued planting in 1999 (ODFW 1997). The report did not mention funding sources for this ambitious plan, only part of which has been carried out as of this writing. While this ambitious timeline would not have allowed adequate time for gathering of baseline information, it was in approximately the right order for the beginning of an ecological restoration project's implementation, according to the scientific literature I summarized in the second chapter of this thesis. The plan did not

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[3] "South Pasture" accurately described the site at the time of the 1997 report. The site is at the south end of HBRA, directly south of the park's main parking lot, and it had been grazed by cattle for decades. At the time of the study, it was one of two areas still being grazed in the park. The term "South Pasture" continued to be the dominant descriptor until mid-2001, when the "South Meadow Management Plan" was nearing final draft form. It is not clear why the Management Plan authors chose "meadow" as the new term of choice. The word "meadow" brings to mind a prairie without grazing animals, the likely intent of the new term. The Alternatives Team's restoration proposal, along with all subsequent proposals, recommended returning most of the pasture to floodplain forest, however, so I expect that "meadow" will at some point be replaced with "floodplain" or a similar term that evokes a new, more accurate visual image.

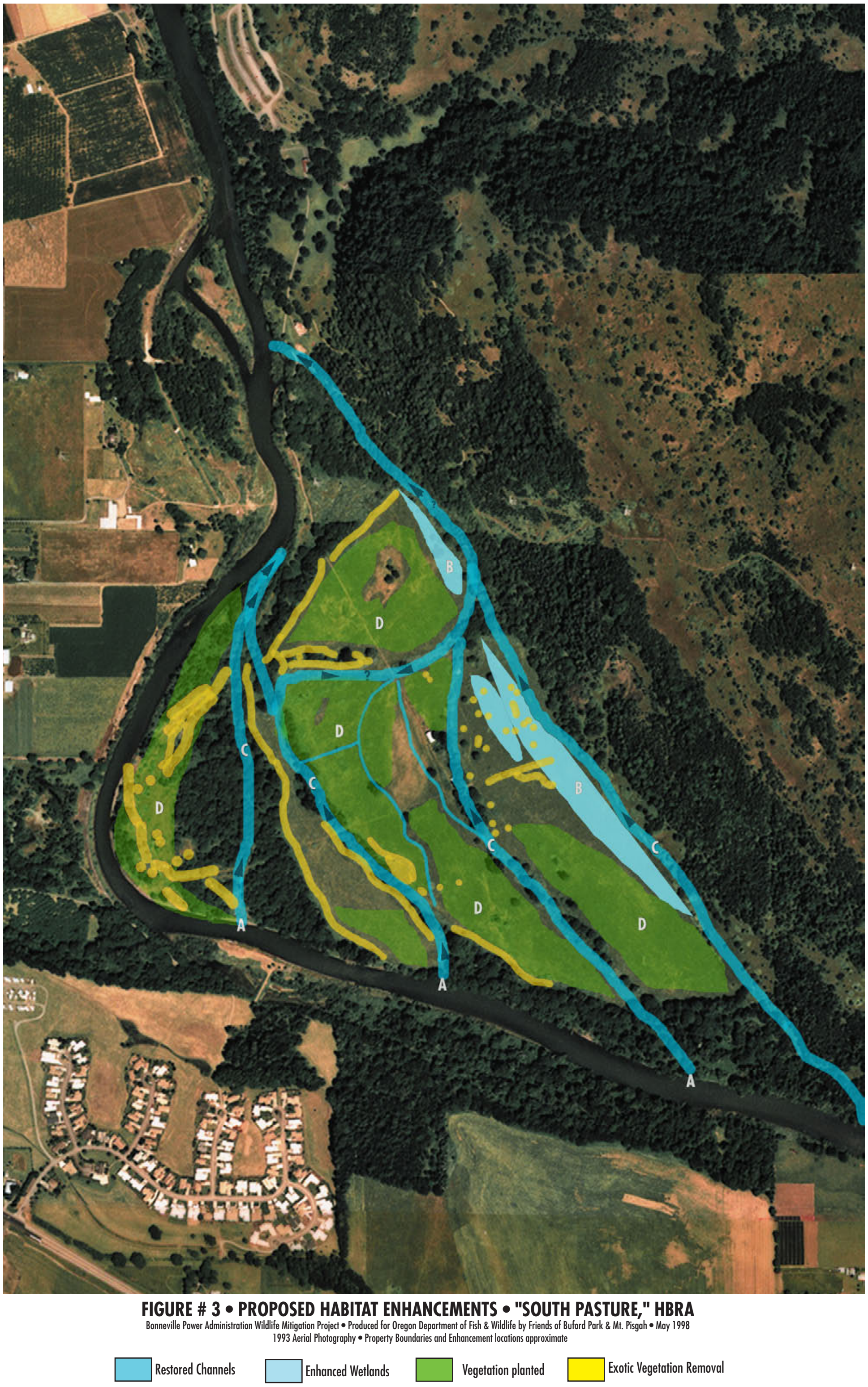

Figure 6. Earliest published version of proposed floodplain enhancements in the South Meadow, from the 1997 Alternatives Team Report (ODFW 1997).

include ongoing monitoring, adaptive management, or communication, focusing only on planning, some baseline monitoring, and implementation.

All of the recommendations in the report were recommendations for active restoration. The report did not specifically recommend removal of grazing from the site as a passive restoration step before beginning active restoration, but it did note that restoring a floodplain forest would require the termination of grazing and that Lane County's Parks Division planned to "eventually terminate grazing on the park as visitor use increase[d]" (ODFW 1997).

After the publication of the Alternatives Team's report, a technical advisory team made up of federal, state, county, and local government employees, as well as a few interested private citizens and representatives from local non-profit organizations with an interest in HBRA, visited the South Meadow in the spring of 1998 to discuss implementation of the recommendations in the 1997 report (ODFW 1998). In August of 1998, two members of the team wrote a detailed summary of "three major implementation tasks." The summary focused primarily on gathering baseline data and other information about the site; at this stage in the restoration efforts in the South Meadow, information gathering was the appropriate next step. The first recommended task was topographic mapping. The summary quoted a habitat restoration expert from the Oregon Department of Fish and Wildlife as saying that mapping the site down to 6-inch (15 cm) or 1-foot (30 cm) contours is "extremely important for any kind of restoration work," especially for floodplain areas, where slight changes in elevation can lead to distinct changes in plant community composition and water table levels (FBP 1998b).

The second implementation task was hydrological analysis, which would involve using United States Geological Survey (USGS) gauging station data to predict river discharge rates that would be expected to recur at different time intervals. The memo suggested calculating "river stages for 2, 5, 10, 25, 50, and 100 year flood events" and then combining that data with the topographic data described above in order to predict where flood waters would cover the floodplain during flood events. They expected that this data would also allow for the identification of "topographic barriers," such as fill and revetments, that were preventing flood waters from entering the floodplain. The combined data would inform decisions about the design of modified, restored channels (FBP 1998b). The team also recognized risks of proposed hydrological restoration activities, recommending that a hydrological analysis include an evaluation of both potential flood damage from a large flood and the risk of channel avulsion during a flood event (FBP 1998a).

The third implementation task discussed in the memo was removal of exotic invasive plants and planting of native plants. The discussion of this task was general, with a summary of recommendations on how to remove exotic invasive plants, specifically the widespread Armenian blackberry (*Rubus discolor*), on the site and how to convert a field of exotic grasses into a floodplain forest with native herbaceous cover (FBP 1998b).

Early Restoration Planning by the Friends of Buford Park and Mt. Pisgah

Following the Alternatives Team Report, the first significant planning documents for the South Meadow were a floodplain forest restoration plan and a "South Pasture Enhancement Plan," developed by FBP in January of 1999 and April of 2000, respectively. These documents set goals and objectives for the beginning of floodplain forest restoration. In November of 1999, FBP hired a restoration coordinator (now called stewardship coordinator) for the first time. That stewardship coordinator has been in that position continuously since that time and has been the primary developer of many of FBP's detailed plans (FBP 2000a).

The goals in these two early plans were primarily ecological, with non-ecological goals making their first appearance in the latter plan. FBP's ecological goals were to restore a biologically diverse floodplain forest in the South Meadow, remove exotic invasive plants, and restore hydrological connectivity between the river and the floodplain. These goals are essentially the same goals as those in the Alternatives Team Report, and they remain the primary ecological goals today. The non-ecological goals addressed providing opportunities for recreation and environmental education in the South Meadow (FBP 1999c, 2000f).

Both plans contained objectives, but they were not based on measurable criteria that would demonstrate the ecological effectiveness of the restoration project. All of the objectives in the floodplain forest plan were related to implementation, including planting of about 500 trees, installing fencing to exclude cattle from the planting zones, and mowing exotic invasive blackberries. The South Pasture Enhancement Plan also contained objectives, though these objectives primarily described desired future states rather than measurable criteria that could be monitored and assessed for success.

Development of the South Meadow Management Plan

FBP continued to add detail to the South Pasture Enhancement Plan throughout 2000 and 2001, eventually presenting it to the elected officials responsible for approving such a large-scale plan, the Board of Commissioners of Lane County. The Board of Commissioners was the government body ultimately responsible for management of the park. By the end of 2001, the plan had been renamed the "South Meadow Management Plan," authored jointly by FBP and Lane County's Parks Division. When it was approved by the Lane County Board of Commissioners in 2002, the South Meadow Management Plan became, as it remains today, the guiding document for all ecological restoration in the South Meadow. FBP refers to it frequently in grant proposals, in proposals to the Board of Commissioners, and in proposals to the Parks Advisory Committee, a group of citizens that makes non-binding recommendations to the Board of Commissioners. The South Meadow Management Plan outlined three management goals: "restore the ecological integrity of the floodplain" to improve habitat, flood detention and storage, and water quality; "provide recreational opportunities compatible with ecological stewardship"; and "provide educational opportunities compatible with ecological stewardship" (LCP/FBP 2001). Of the three management goals, ecological goals received the primary emphasis; the recreation and education goals accounted for fewer than three of the document's approximately thirty pages.

Since the South Meadow Management Plan would be a significant addition to the 1994 HBRA Master Plan, the Lane County Board of Commissioners required a public comment period before ratifying the plan (FBP 2002c). FBP presented the plan to the public, emphasizing the benefits of the proposed ecological restoration measures. These benefits included increased connectivity between the Coast Fork Willamette River and its floodplain; additional critical habitat for threatened spring Chinook salmon; additional flood storage; improved water quality, and increased access to recreational and educational opportunities (FBP 2002b). Public comments unanimously supported the plan as proposed (FBP 2002c). After more than four years of ecological restoration planning and meetings that had begun with the Alternatives Team Report in 1997, the Lane County Board of Commissioners unanimously adopted the South Meadow Management Plan in January of 2002 (FBP 2002a).

The South Meadow Management Plan was a strategic plan that set broad goals. Although it provided many specific implementation details, it contained few measurable objectives or monitoring criteria related to ecological effectiveness, thus failing to provide a prospective project manager with a way to know when its goals had been accomplished. Despite an ambitious project timeline, there was no commitment on the part of the government agencies or the non-profit organization involved to fund the recommended projects. Compared to the ideal ecological restoration project described in the scientific literature review chapter of this thesis, the plan contained all of the recommended elements in at least a small measure. It was strong in its implementation details, but it was weak on effectiveness monitoring, measurable ecological objectives, and communication of results.

South Meadow Management Plan: Ecological Goals and Implementation Tasks

The South Meadow Management Plan set one comprehensive ecological goal: restoring the ecological integrity of the floodplain. It listed four specific ecological goals within that larger goal: restoring a diversity of plant communities in existing cleared areas; modifying hydrology on the site; removing exotic invasive plants; and expanding habitat for threatened and endangered species. An ecologically-based rationale accompanied each goal in order to explain the ecological benefits of the goal. The explanation of each ecological goal listed a set of objectives designed to meet the goals. In comparison with the ideal project plan described in the review of scientific literature in the second chapter of this thesis, the plan had concise, sensible, ecologically-based goals. It explained the ecological reasons for choosing those goals, providing supporting reasoning and listing species that were likely to benefit from achievement of the goals. Although a set of objectives accompanied each goal, these objectives were rarely based on measurable ecological criteria. Instead, they were lists of planning and implementation tasks that the plan's authors expected to be necessary for the achievement of the goals.

The description of the first goal, restoring native vegetation, began with a map (see Figure 7) showing a proposed desired future condition with seven plant communities (called "ecotypes" on the map). The description provided a detailed list of "typical native plants found in each" plant community (LCP/FBP 2001). Buried in the description of this goal's implementation was one objective measuring ecological effectiveness: "Restoring healthy populations of a preponderance of these species will be a long-term indicator of project success" (LCP/FBP 2001). It did not specify a definition of "long-term," which in this case meant longer than even the ten years of monitoring recommended in the scientific literature, since project success was tied to the conversion of a meadow into a floodplain forest.

A second map (see Figure 8) showed past and proposed planting phases from 1999 through 2005. The description included a wise recommendation about returning exotic pasture grass fields to native meadow, showing that project planners were thinking carefully about the proper order of implementation steps as well as their feasibility: "Restoration scientists have found conversion of exotic dominated pastures to native meadow an intensive process. Sufficient seed sources should be secured first. This plan recommends deferring enhancements of dry meadow until later phases of restoration, when adequate resources are secured to ensure a good likelihood of success" (LCP/FBP 2001).

The second goal, modifying site hydrology, provided no measurable objectives, but it did provide a rough implementation plan: model and analyze potential changes;

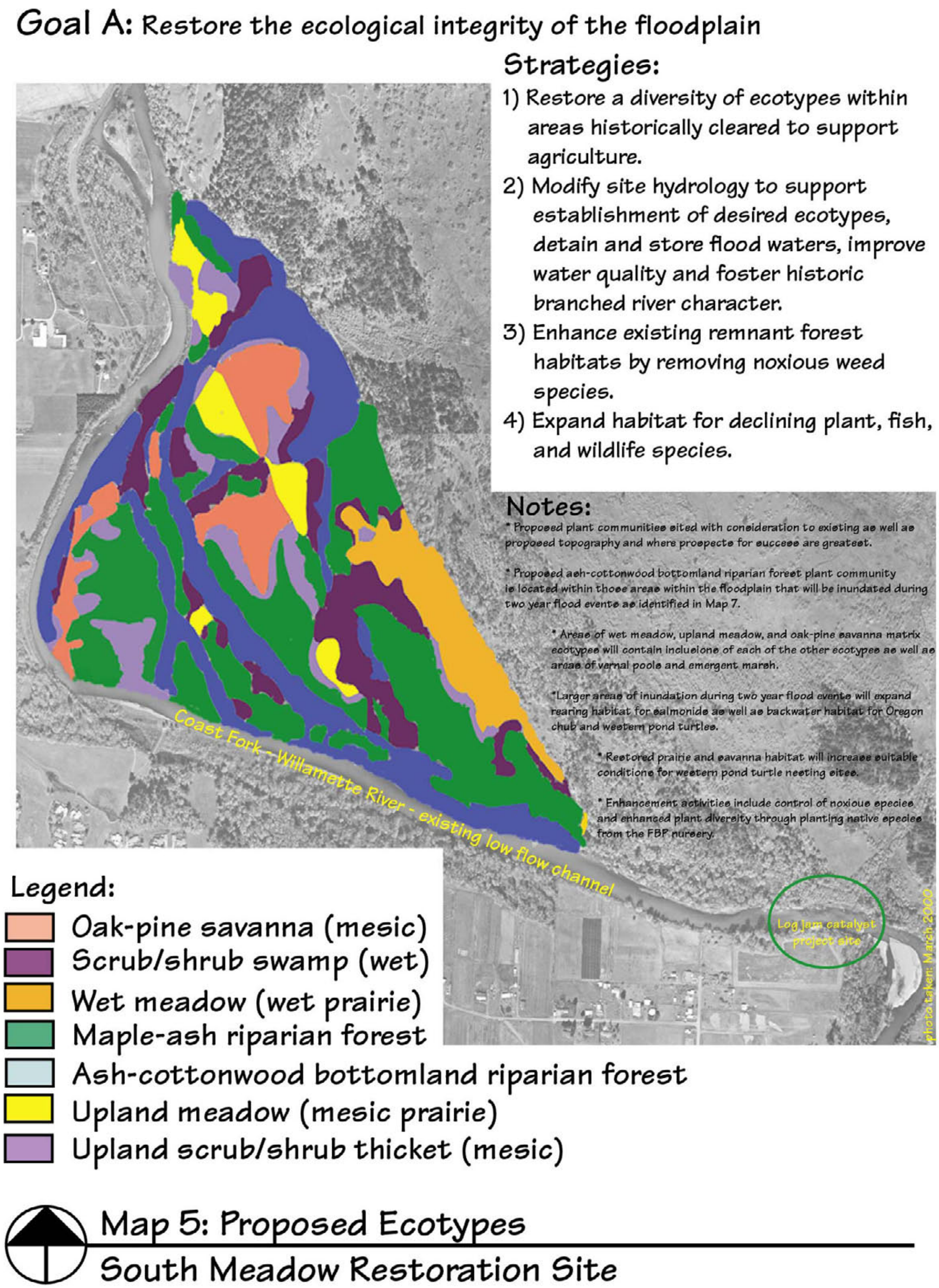

Figure 7. November 2001 map of proposed plant communities adapted from the South Meadow Management Plan’s section on restoring ecological integrity (FBP/LCP 2002).

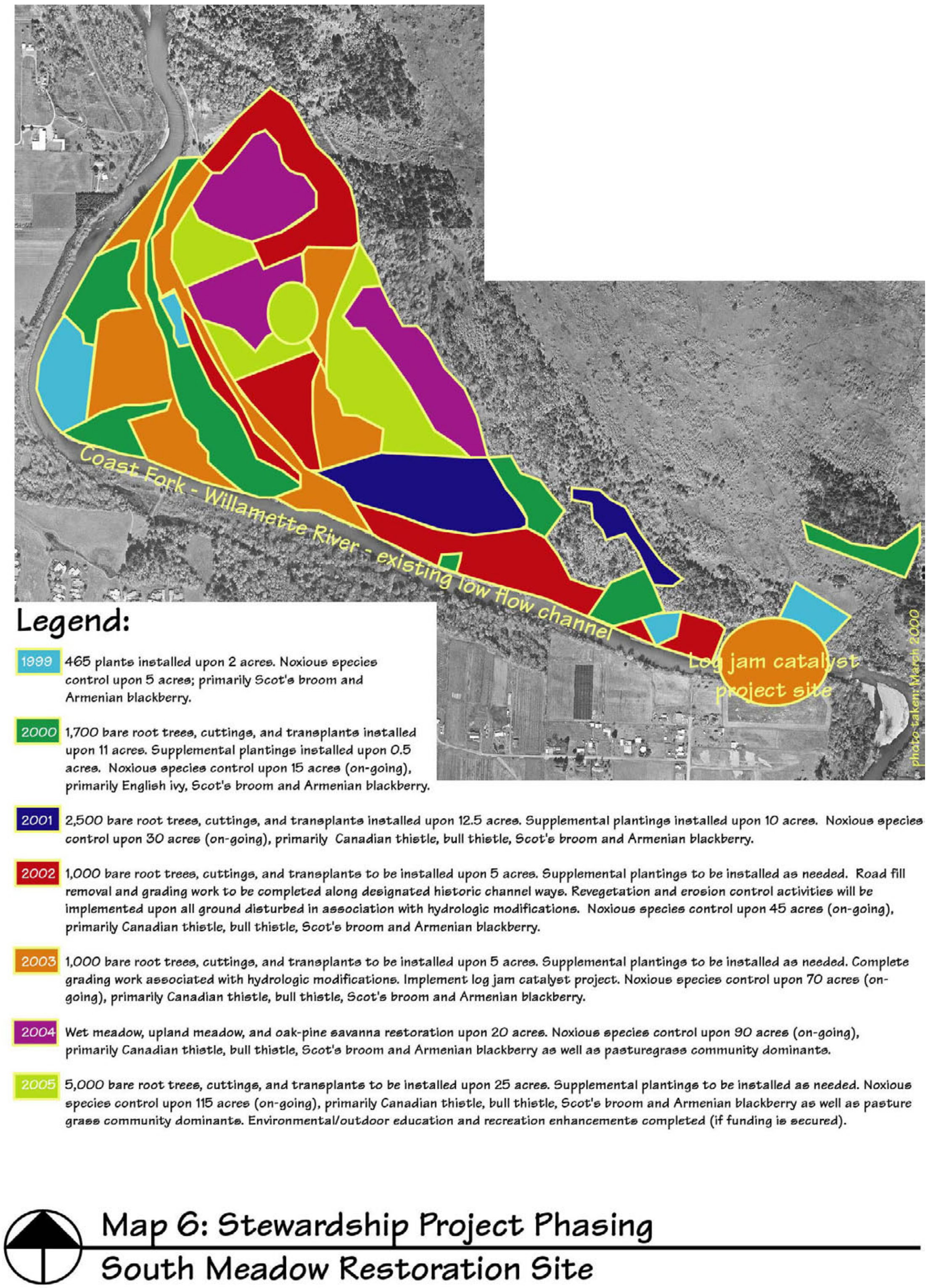

Figure 8. November 2001 map of completed (through 2001) and proposed (2002-2005) restoration actions adapted from the South Meadow Management Plan's section on restoring ecological integrity (FBP/LCP 2002).

create a detailed plan; get permits; remove fill from road crossings; expand backwater slough habitat; lower side channel outlets by creating holes in revetments; and remove plugs and artificial berms at channel inlets (LCP/FBP 2001). The first of these tasks was a planning exercise; the rest were implementation steps that the authors of the South Meadow Management Plan expected to arise from that planning. All of these tasks were performed to some extent in the South Meadow by the end of 2006.

The exotic plant removal goal detailed seven methods for removing noxious species and provided examples of noxious species that were present on the site (LCP/FBP 2001). No measurable objectives were provided in this section.

The goal related to threatened and endangered species listed six tasks: determine actual or potential usage of the site by special status species and create an HBRA special status species list; assess habitat needs for the HBRA species list; incorporate habitat enhancements for these species in restoration projects; re-establish an historical log jam; remove and control noxious species that threaten special status species; and remove fencing (LCP/FBP 2001). These tasks were similar in nature to those for the second goal; they were a mixture of assessment and planning with implementation steps that the authors assumed would result from that planning.

South Meadow Management Plan: Monitoring, Adaptive Management, and Communication

The next section of the South Meadow Management Plan, after the four goals, was "Monitoring Progress & Success of Habitat Enhancements." This section briefly addressed three key elements of a successful ecological restoration project: monitoring, adaptive management, and communication. The plan called for monitoring of restored areas to continue for "at least 5 years following completion of habitat enhancement prescriptions" in order to determine if the selected plantings were appropriate for the locations and to refine planting plans if necessary, a basic adaptive management technique. The plan contained significant plans for implementation monitoring. Implementation monitoring criteria are listed for each of the four goals, including acres planted, acres receiving follow-up management and care, planting survival by species and target plant community, acres of remnant forest habitat treated by exotic species removal, acres of remnant forest receiving follow-up exotic control, relative cover of target weed species, and progress toward accomplishing other recommended implementation tasks (LCP/FBP 2001). Except for qualitative monitoring of the presence of target species, however, there is no mention of monitoring the ecological effectiveness of the project's implementation. As I discussed in the second chapter, effectiveness monitoring is necessary in order to understand whether a project is achieving its ecological goals.

The plan acknowledged that adaptive management and communication would result from monitoring; since "the mechanics of riparian forest establishment are not fully understood," monitoring would help implementers learn about creating riparian forests, knowledge that could be communicated to other restoration project managers and applied to other restoration sites (LCP/FBP 2001). The plan recommended a realistic low-cost regime of qualitative monitoring, including photographic monitoring, observation of presence and status of species in treatment areas, and annual qualitative assessments (LCP/FBP 2001).

South Meadow Management Plan: Initial Hydrological Analysis

The South Meadow Management Plan ended with an appendix authored by Inter-Fluve, Inc., a hydrological engineering firm, entitled "Inundation Analysis and Design Memorandum Along the Coast Fork of the Willamette River Near the Howard Buford Recreation Area." The analysis in this appendix was cursory but useful for preliminary feasibility studies. The report predicted that floods with an average recurrence interval greater than two years would overflow from the river into the floodplain's historical channels (LCP/FBP 2001). This prediction turned out to be consistent with my own observations during floods in 2003, 2005, and 2006.

Inter-Fluve reported that geomorphic analysis showed evidence that the main channel was much lower in elevation than it had been historically. This meant that regular small floods would no longer connect the river to the historical floodplain; only large floods would do so. They estimated that current 10-year floods behave as 2-year floods used to behave on the floodplain; as a result, the South Meadow was more of an upland habitat than it had been historically. This important observation had implications for restoration: it would not be possible to restore the vegetation to the historical 1850s plant communities with a water table significantly lower and a floodplain inundated less often than it had been historically (LCP/FBP 2001).

Planning Channel Restoration

One of the four ecological goals in the South Meadow Management Plan was modifying the site's hydrology to reconnect the river to the floodplain. This section describes and analyzes the planning of hydrological modifications. The planning began in early 2002, and FBP made the first channel modifications in late 2003.

In 2001, FBP contracted with Inter-Fluve to analyze the hydrology of the South Meadow and to create models of flood behavior. In February of 2002, Inter-Fluve performed a detailed survey of portions of the land surface in the South Meadow, mapping historical channels on the site as well as sections of the main channel of the Coast Fork Willamette River (FBP 2002g, 2002c). Based on the ground survey, Inter-Fluve prepared a report and maps that showed options for returning water to the floodplain via five potential channels across the South Meadow (see Figure 9). The potential channels, labeled A through E on the map in Figure 9, were composed primarily of historical channels, but because of incision of the main channel and historical placement of fill in the channels, each one would require excavation to open a continuous path for water. The maps also proposed sites for expansion of an existing wetland and replacement of a culvert that blocked fish passage (FBP 2002d).

In July, FBP and Inter-Fluve gathered representatives from agency and non-profit stakeholders and project partners, including Lane County Parks Division, U.S. Army Corps of Engineers, and Mt. Pisgah Arboretum (whose lease within the HBRA included part of the proposed project site, the downstream ends of channels D and E). The meeting took the form of a design workshop, during which the representatives reviewed the maps,

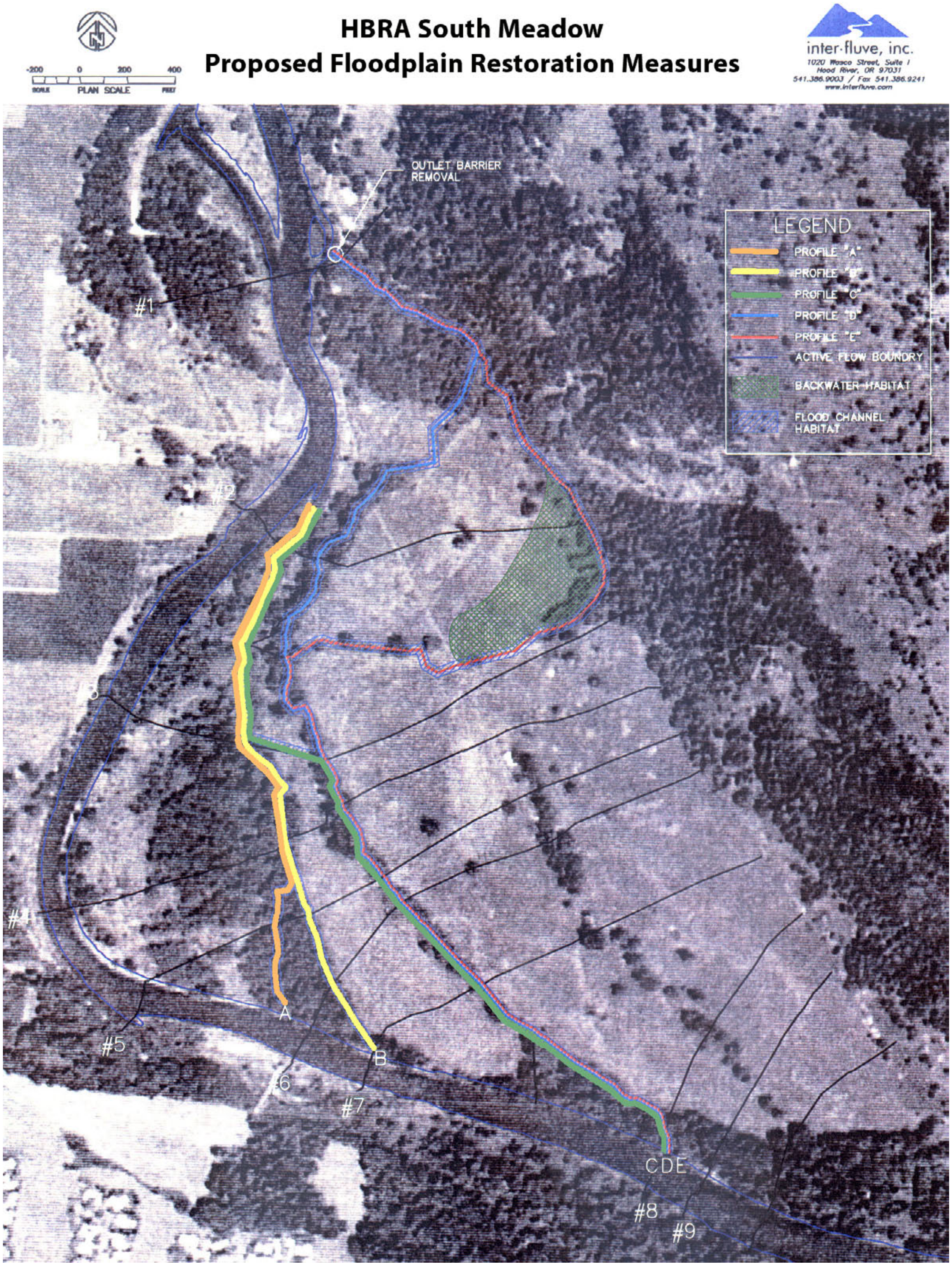

Figure 9. Proposed floodplain restoration measures, September 2002. Note channel letters at the south end of the South Meadow (Inter-fluve 2002).

the hydrological analysis, and a list of questions posed in Inter-Fluve's report. The participants focused on site modifications that would, with the least amount of construction work, "expand the area of inundation during two-year events because an event of this size is of the greatest ecological significance to aquatic species and overall floodplain function" (FBP 2001a). This focus was consistent with floodplain restoration recommendations from the scientific literature that recommend restoring sources of natural disturbance and restoring hydrological connectivity between rivers and their floodplains. The Inter-Fluve report had cited channel C as the profile requiring the least amount of excavation to open, followed by A and B. The D and E channels would require significantly more work to open (Inter-Fluve 2002). At some point during this workshop, one of the participants pointed out that the inlet to channel A was located on a seven-acre inholding within the park, the corner of a piece of land extending across the river from the south.

The participants in the design workshop decided to focus their efforts on a single channel, channel C, since it appeared to have the lowest excavation costs. Based on the workshop, FBP presented a revised project design to Lane County's Parks Advisory Committee (PAC) in September of 2002 (FBP 2002d). The revised project design consisted of three recommendations (FBP 2002d):

- Restoring more frequent flows to channel C by removing obstructions,
- Replacing a culvert blocking fish passage and expanding wetland habitat within the Mt. Pisgah Arboretum leased area (if the Arboretum decided to proceed with these actions), and
- Exploring a willing-seller acquisition of a conservation easement on or fee title of the private inholding located at the inlet of channel A.

After reviewing the proposed restoration measures, the PAC unanimously recommended that the county's Board of Commissioners approve the plans (FBP 2002g).

After the PAC forwarded its recommendations to the Board of Commissioners, two events forced changes in the project plans. The second recommendation was dropped after the Mt. Pisgah Arboretum's board of directors decided to defer any action on channels that passed through their leased area within the HBRA. They had decided to observe the results of the channel C excavation before committing to changing water flows in their popular water lily pond (FBP 2002d). The third recommendation turned out to be impossible in the short term. The owners of the land on which the channel A inlet sat were not interested in discussing selling the land or selling a conservation easement on the land that would allow restoration work to proceed (Chris Orsinger, personal communication). Those two changes left the first recommendation, opening channel C, as the only remaining approved option.

Channel C Restoration Planning

Channel C had become the only available restoration option, but there were still major design choices to make. FBP's Stewardship Technical Advisory Committee (STAC), which advised the non-profit organization on ecological restoration and stewardship issues, formed a South Meadow Design Subcommittee. The subcommittee met for dozens of hours, including field visits to the South Meadow, in 2002 and 2003, in order to develop a detailed project plan. Subcommittee members included a hydrologist, a botanist and wetland specialist, a restoration specialist, another botanist, a wildlife and fisheries biologist, and FBP's stewardship coordinator. The subcommittee also consulted with Inter-Fluve staff (FBP 2002d).

The subcommittee created a list of three floodplain restoration objectives. The objectives are described below and pictured in Figure 10 (FBP 2002d). The three primary floodplain restoration objectives on which the STAC subcommittee settled were:

1. "Enhance backwater habitat," excavating a large backwater area at the north (downstream) end of channel C in order to benefit wildlife species, including migrating spring Chinook salmon (*Oncorhynchus tshawytscha*, federally threatened), Oregon chub (*Oregonichthys crameri*, federally endangered), northwestern pond turtle (*Clemmys marmorata*, state critical), northern red-legged frog (*Rana aurora*, state sensitive), and invertebrates on which these species feed (FBP 2002d).

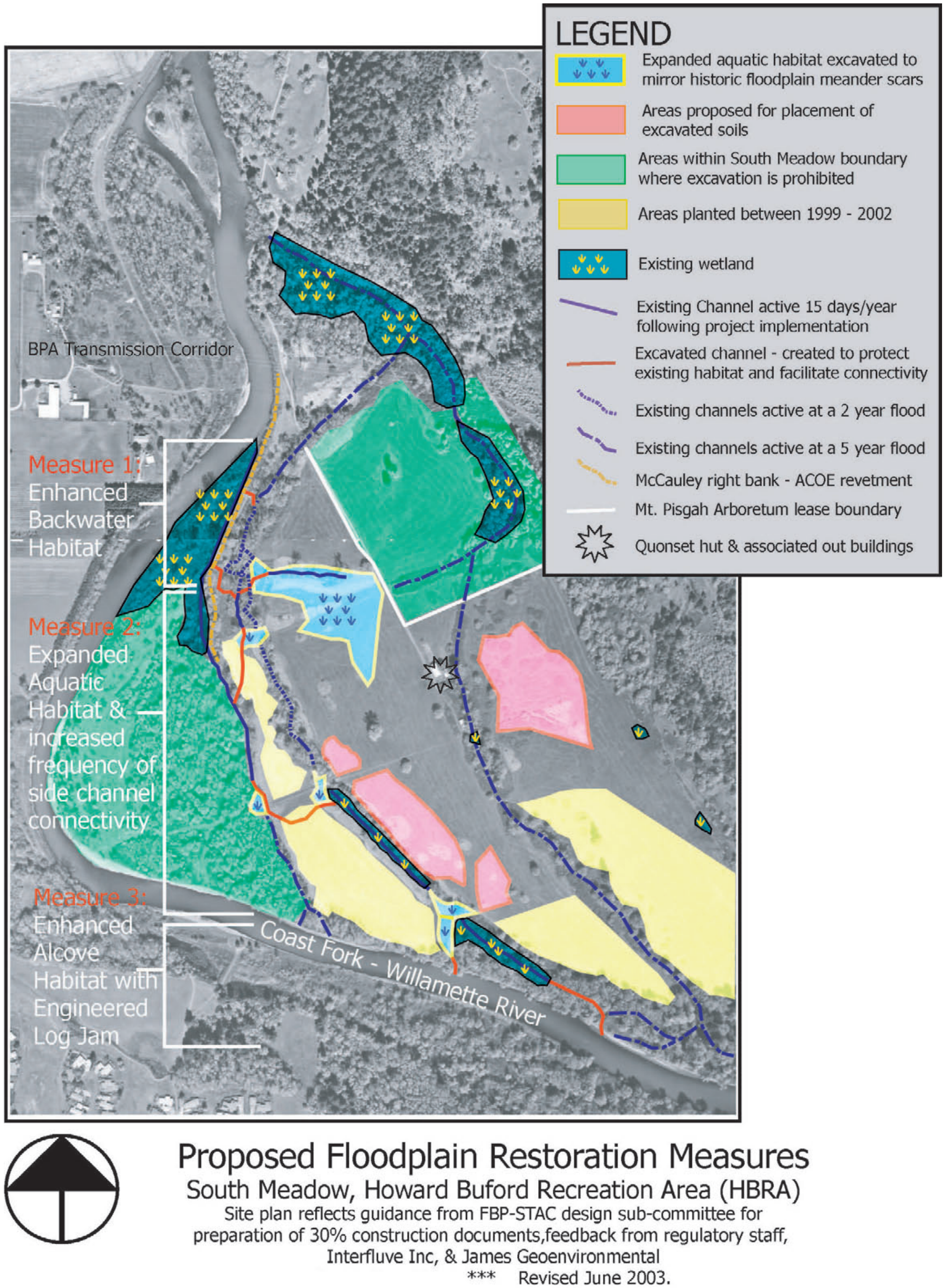

Figure 10. Map of proposed floodplain restoration measures submitted with permits in summer 2003. Note two inlets at the south end of the South Meadow; only the east inlet was constructed. Construction of the large backwater area at center labeled "expanded backwater habitat" was delayed until 2006 due to lack of funding (courtesy FBP).

2. “Expand aquatic-palustrian (wetland) habitat” by lowering areas adjacent to channels C, D, and E in order to allow groundwater to reach the surface more frequently. The cited benefits of this project were expansion of cottonwood-ash forest and wetland shrub habitat; increased floodwater detention; and improved water quality through filtration and biological processing of pollutants (FBP 2002d).
3. “Enhance alcove ‘frontwater’ habitat (removing inlet barriers)” on channel C, removing a significant amount of fill from the channel inlet and from road crossings that had been constructed in the channel (FBP 2002d).

FBP presented the refined design to the Parks Advisory Committee, which approved the new design in December of 2002 (FBP 2002d). The subcommittee met shortly afterwards to rate each of the three proposed restoration objectives according to the potential benefits and costs of each (FBP 2002f). The “restoration measure selection matrix” that they created is reproduced in Table 1. The matrix served as a concise representation of the predicted ecological benefits as well as the ecological and financial costs of each proposed action. In the table, “low,” “medium,” and “high” refer to the amount of benefit or cost that the subcommittee expected to result from each proposed restoration measure.

FBP asked a local hydrologist to evaluate the proposed changes, Inter-Fluve’s model, and the floodplain in general. He commented that Inter-Fluve’s predictions used a hydraulic model (HEC-RAS) that “treat[ed] the ground surface as a solid [and therefore focused only] on the conveyance of surface water delivered to the site from upstream.” He recommended further study of the site’s hydrology, primarily the interaction between the water level in the river and the level of groundwater tables throughout the South Meadow (FBP 2002d). Based on his recommendations, FBP installed piezometers in the South Meadow in late 2002 and began monitoring water levels in early 2003 (see the section on monitoring below for more details).

Table 1. South Meadow Floodplain Hydrology Restoration Measure Selection Matrix (FBP 2002e)

	Expand backwater habitat	Expand aquatic habitat	Expand frontwater habitat
Benefit: increased diversity of plant communities	medium/low	high/medium	low
Benefit: improved water quality, flood storage, etc.	low	medium	low
Benefit: expanded habitat for special status species	medium/low	medium/low	low
Benefit: increased frequency and area of surface flows	[not listed]	high/medium	medium
Cost: soil disturbance	medium/low	high	low
Cost: construction cost	medium	high	high
Cost: revegetation effort	medium	high	high
Cost: increased noxious species control efforts	medium	medium	high
Cost: increased potential introduction of noxious species	medium	low	high
Cost: increased potential for stranding of fish	low	[not listed]	low
Cost: required ongoing intensive site management	medium	high	high
Cost: risk of channel capture	none	none	low

During the first half of 2003, the subcommittee consulted with soil scientists, monitored groundwater levels, spoke with Lane County Parks Division staff, and incorporated feedback from biologists and from regulatory agencies including the U.S. Fish and Wildlife Service. The final design plans, including a map of "Proposed Floodplain Design Measures" (see Figure 10), were submitted to permitting agencies by June of 2003 (FBP 2004g). I discuss the implementation of the channel reconstruction project in the next section.

Conclusion

These three plans, developed during three different periods preceding major changes to the South Meadow project site, showed increasing refinement of their ecological goals as project planners gathered information and discussed their plans with project partners, other stakeholders, and other interested parties. The plans always contained concise and useful ecological goals, though they contained few measurable objectives related to those goals. In comparison with the ideal restoration project described in the scientific literature review, the plans were strong on implementation planning, but they were weak in the areas of monitoring, adaptive management, and communication of project results.

Section III.B: Project Implementation

Introduction

In this section, I compare FBP's implementation of the South Meadow ecological restoration project from 1999 to 2006 with the recommended order of project implementation steps summarized in the scientific literature review chapter. I provide analysis of the reasons that the implementation steps proceeded in the order they did and how the order of implementation steps differed from the recommended order.

In the second chapter of this thesis, I listed the most effective order of implementation for an ecological restoration project, in five steps. First, remove causes of ecological degradation. Second, restore natural hydrological processes, including historical flows of water and sediment. Third, restore natural channel geomorphology. Fourth, restore native riparian plants. And last, restore native aquatic plants and animals if necessary.

In the South Meadow project, the order of implementation steps began with planting of native trees and shrubs, an effort that is ongoing. The primary local cause of ecological degradation was cattle grazing, which was terminated three years after planting had begun. Restoration of channel geomorphology was the third main implementation step in this project; it occurred in 2003 and 2006. Restoration of natural flows has not yet happened, though it is under investigation. It is unclear whether restoration of aquatic organisms will be necessary.

FBP performed all activity described in this section in conjunction with volunteers, other organizations, and contracted crews, unless otherwise noted.

Step One: Restoration of Native Riparian Plants

Most of FBP's labor in the South Meadow has been devoted to restoration of native riparian plants. Although restoration of native plants is the fourth step in implementation of the ideal restoration project described above, it was the first step in

FBP's implementation. I have divided FBP's native plant restoration efforts into four areas of activity: exotic invasive plant removal, seed collection and native plant nursery activity, planting, and maintenance of new plantings.

Exotic Invasive Plant Removal: Restoration work in the South Meadow began in the year after the Alternatives Team made its recommendations. In the fall of 1998 and the winter of 1999, FBP worked with the Oregon Department of Fish and Wildlife (ODFW), Mt. Pisgah Arboretum (MPA), and Lane County Parks (LCP) staff to clear exotic invasive vegetation in about twelve acres (5 ha) of the South Meadow, removing Armenian blackberry (*Rubus discolor*) and Scot's broom (*Cytisus scoparius*) (MPA 1998; FBP 1999e, 1999c, 2001c). In 2000, FBP and MPA removed Armenian blackberry, Scot's broom, teasel (*Dispaucus sylvestris*), and bull thistle (*Cirsium vulgare*) from forty acres (16 ha) of the South Meadow (FBP 2000e). FBP also removed a few small populations of English ivy (*Hedera helix*), attaining what was believed to be 100% removal of this plant from the South Meadow. In a grant report, FBP noted that its exotic plant removal methods were "consistent with the Oregon Aquatic Habitat Restoration and Enhancement Guide" (FBP 2000c).

From 2000 through 2002, FBP removed over 5,000 feet (1,500 m) of old fencing (FBP 2000c, 2002c). FBP described this activity as "the first step in control of blackberry that occupies the ground between remnant forest and the newly planted fields [and] important to facilitate the colonization of understory species occurring within the remnant forest into the recently planted areas" (FBP 2001a).

FBP continued expanding its exotic species control area and scope, adding ten acres (4 ha) in 2002 and adding many more exotic species to its control efforts, including sweet cherry (*Prunus avium*), English hawthorn (*Crataegus monogyna*), tansy ragwort (*Senecio jacobaea*), Queen Anne's lace (*Daucus carota*), oxeye daisy (*Leucanthemum vulgare*), two more species of thistle (*Cirsium spp.*), mullein (*Verbascum thapsus*), tall fescue (*Festuca arundinacea*), and teasel (*Dispaucus sylvestris*) (FBP 2002d). FBP continued regular mowing of previously-controlled areas (FBP 2005i, 2005g, 2005h).

Seed Collection and Native Plant Nursery: FBP's seed collection activities and native plant nursery began at a modest level and expanded at a rate commensurate with other activities in the South Meadow in an attempt to keep up with the native plants needed for the South Meadow project. FBP's volunteer botanists began collecting seeds from native plants within the park in 1998 in order to re-seed disturbed ground and favor native plants over the regeneration of exotics (FBP 1998b). By 2000, they were collecting seed from 17 different herbaceous species for propagation in FBP's small nursery or broadcast seeding in areas of exotic plant control (FBP 2000c). FBP relocated its native plant nursery in 2003 to a new site within the HBRA. At that site, they built fences, constructed planting beds and a shaded area for potted plants, and set up an irrigation system. In preparation for re-seeding the many acres of bare soil resulting from channel modifications, FBP gathered large quantities of native seeds from within the HBRA during the summer of 2003 (FBP 2004g). Seed collection and nursery activity expanded again in 2004 and 2005, including construction of a greenhouse and seed-processing building, to keep with the increasing demand for native seed and plants for newly-exposed floodplain soil (FBP 2005d).

Planting: FBP began planting trees and shrubs in the South Meadow in 1999. In February and March, FBP conducted an "experimental planting" of about 500 native trees (cottonwood [*Populus balsamifera var. trichocarpa*], Oregon ash [*Fraxinus latifolia*], willow [*Salix spp.*], and big-leaf maple [*Acer macrophyllum*]) in two areas of the South Meadow covering about five acres (2 ha). Most of the willows and cottonwoods were planted as cuttings of trees from within the South Meadow (FBP 1999e, 1999b). FBP expanded its planting areas each year through 2004. They planted 1,350 trees on 6.5 acres (3 ha) in 2000 (Oregon ash, big-leaf maple, and black cottonwood), along with 350 cuttings of three species of shrubs: Pacific willow (*Salix lucida var. lasiandra*), Pacific ninebark (*Physocarpus capitatus*), and red-osier dogwood (*Cornus sericea*). The shrub cuttings were collected from existing shrubs within the South Meadow (FBP 2000c, 2000e, 2002c). From January through April 2001, FBP planted 2,600 trees on 12 acres (5 ha) of new planting areas as well as 350 trees on 8 acres (3 ha) of previously-planted areas in order to replace failed plantings. They also planted about 250 cuttings of red-osier dogwood and Pacific willow taken from the South Meadow, along with 100 shrubs (black hawthorn [*Crataegus douglasii*], choke cherry [*Prunus virginiana*], Douglas's spiraea [*Spiraea douglasii*], osoberry [or Indian plum, *Oemleria cersiformis*], ocean spray [*Holodiscus discolor*], Pacific ninebark, red-osier dogwood, snowberry [*Symphoricarpos albus*], and western serviceberry [*Amelanchier alnifolia*]) propagated in FBP's native plant nursery (FBP 2001a). FBP added five acres (2 ha) of new planting areas in the winter of 2002; a cumulative total of 25 acres (10 ha) had been planted with native trees and shrubs since 1999. They planted 1,050 trees (Oregon ash, big-leaf maple, and ponderosa pine [*Pinus ponderosa*]) in the new planting area (FBP 2002d, 2002b). They also planted 1,195 native trees and shrubs of at least 18 species in areas that had already been planted, either to replace dead plants or to fill in shrubs in areas already planted with trees (FBP 2002d).

After completing channel reconstruction work in 2003, FBP embarked on a massive planting effort from November of 2003 through February of 2004. The construction zone consisted of two four-acre (2 ha) areas: the area in and adjacent to the reconstructed channel, and an area of low fill mounds created with soil excavated during the project. FBP planted 498 trees (eight species), 2,663 shrubs (eighteen species), 53 fascines (bundles of cuttings, mostly willows, placed along the channel bed to reduce erosion), and 4,430 plugs (eight species) of grasses and forbs (FBP 2005d). As in previous years, FBP added trees and shrubs to previously-planted areas, planting 617 trees and shrubs (eleven different species) to replace dead plants, increase plant diversity, and increase the density of native plants (FBP 2004g, 2005d). In all, FBP planted 8,261 trees, shrubs, fascines, and plugs in 2003 and 2004: 5,793 in the new channel, 1,851 on the fill mounds, and 617 in existing planting areas (FBP 2004g).

Maintenance of New Plantings: Maintenance consisted of two primary tasks: irrigating young trees during the dry summer months and controlling competing grasses around the trees (FBP 2000c).

FBP began monthly irrigation of young trees during the Willamette Valley's hot, dry summer months immediately following its first experimental planting in 1999 (FBP 1999f). In each of the following years, FBP improved its irrigation system in order to be able to irrigate the increasing number of young trees in its care. In 2000, FBP installed a photovoltaic panel powering a pump drawing water from the river into a 2,500-gallon (9,500 L) tank on a raised wooden stand (FBP 2000b). This water pump and tank also supplied water to grazing cattle, who, prior to that time, had been drinking directly from the river (FBP 2000c, 2000a). In early 2001, FBP's staff and the Stewardship Technical Advisory Committee evaluated irrigation options, from a drip irrigation system (expensive), to not watering young trees at all (up to 50% tree mortality expected, with expensive replanting), to a hose-and-bucket system (inexpensive but labor-intensive). They chose the hose-and-bucket system for its low costs and because it "conserved water (in application), provided an opportunity to multi-task stewardship tasks (tend to vegetation management tasks while buckets drain), and provided job opportunities for the community" (FBP 2001a). The stewardship coordinator reported that the hose-and-bucket watering system appeared to be a success, that it had been both effective and conservative (FBP 2001a). In 2002, FBP refined the hose-and-bucket irrigation system, improving the layout of the pipes in order to increase water pressure to the buckets. The four-person crew was able to water an average of 1,000 plants each day (FBP 2002d). Irrigation continued each summer until trees reached three years of age (FBP 2005d).

During each spring, summer, and fall, FBP mowed and mulched extensively around planted trees and shrubs to conserve moisture and suppress competition for water and nutrients (LCP/FBP 2001; FBP 2002c, 2002d, 2004d, 2004e, 2005d). FBP's stewardship coordinator wrote that their mulching procedure would reduce the potential need for herbicides, reduce the amount of mowing necessary, and enhance soil conditions (FBP 2001a). After completion of channel reconstruction, FBP staff mowed every two to four weeks in restoration areas and in open areas adjacent to the restored channel in order to limit the spread of weed seeds into the channel's bare soil (FBP 2005g, 2005e).

Step Two: Removing Local Causes of Ecological Degradation

One of the main causes of ecological degradation in the South Meadow was grazing of cattle and the modifications to geomorphology and vegetation that accompanied it. The county's Parks Advisory Committee (PAC) recommended in early 1998 that LCP discontinue grazing in the South Meadow after the summer of 1998 so that active restoration could begin (FBP 2001c; LCP/FBP 2001). Instead, grazing was phased out over more than four years. It is not clear why it took so long for the county to discontinue grazing in the South Meadow, despite its stated preference for doing so, despite the obvious incompatibility between grazing and newly-planted native trees described below, and despite clear recommendations to do so in the scientific literature. In hindsight, the PAC made the right recommendation, and the planted trees would probably have fared significantly better without the damage they sustained from trespassing cattle.

LCP began phasing out grazing by designating a 5-acre (2 ha) exclosure in which FBP planted native floodplain trees in 1999 (FBP 1999b; LCP/FBP 2001). Efforts to keep cattle away from the trees were in vain; in the first year, cattle found their way into the planting areas multiple times, causing significant damage to more than half of the newly-planted trees and pulling up every tree's weed suppression cloth at least twice (FBP 1999a). Representatives from FBP and LCP met with the rancher to devise ways to contain cattle more effectively within designated grazing areas. The installation of movable electric fencing in the spring of 2000 decreased cattle trespass into planted areas (FBP 2000c, 2000a).

Cattle continued to share the South Meadow with the newly-planted trees in 2001, escaping from their grazing areas a few times. The rancher responded quickly to reported escapes, and while cattle were observed among the young trees, damage was limited (FBP 2001a). Conflicts between grazing and restoration came to a head in the dry summer of 2002. The electric fencing that had improved cattle control for the previous two summers failed to contain the cows. The rancher discovered that the electric fence, which was using the soil of the meadow as its ground, was inactive during the driest part of the summer months because of low soil moisture. FBP staff reported that cattle escaped from their enclosures more than 25 times in the spring and summer, causing significant damage to young plants, tearing up and eating mulching material, and pulling protective plastic tubing off of trees. The cattle escapes diverted FBP's staff away from restoration tasks to cattle management as well as damage assessment and repair. FBP's stewardship coordinator predicted that the damage caused by the cattle would extend the period of intensive management required for the damaged trees by slowing their growth; this extension would mean incurring mowing and irrigation costs for additional years until the trees could outcompete surrounding vegetation (FBP 2002d). In December of 2002, the county terminated grazing in the South Meadow (FBP 2005d).

Step Three: Restoration of Channel Geomorphology

Reconnection of one or more floodplain channels to the river had been an ecological restoration goal in the South Meadow since the publication of the Alternatives Team Report in 1997. After years of design, approval, and applications for funding, the first phase of channel reconstruction occurred in 2003. The second phase, excavation of a backwater wetland, occurred in 2006. Planning for the restoration of channel geomorphology began in 2000 and proceeded in parallel with native plant restoration.

Implementation of channel reconstruction began with aerial topographic mapping in 2000 and 2001 (FBP 2001d, 2002c). In February of 2002, Inter-Fluve performed a detailed survey of the land surface in the South Meadow, mapping historical channels on the site as well as sections of the main channel of the Coast Fork Willamette River (FBP 2002g, 2002c). Design of the channel modifications began in 2002 and was complete by June of 2003, when FBP submitted its final design for channel modifications to permitting agencies. The final design included a backwater wetland and a 4,000-foot (1,200 m) channel across the floodplain composed of new, modified, and existing historical segments (see Figure 10). All permits were obtained by late summer, just before construction work was scheduled to begin (FBP 2005d). Permits and clearances obtained by FBP in 2003 included (FBP 2004f):

- National Oceanic and Atmospheric Administration Biological Opinion
- United States Army Corps of Engineers General Authorization Wetland Enhancement permit
- United States Army Corps of Engineers Right to Enter Easement (permission to breach the revetment)
- Oregon Division of State Lands General Authorization for Wetland Restoration Enhancement
- United States Fish and Wildlife Service Section 7 Endangered Species Act Consultation
- United States Fish and Wildlife Service Cultural Resources Clearance
- Lane County Willamette Greenway Permit
- Lane County Floodplain Development Permit

Construction in 2003 was limited to reconstruction of channel C, including one channel inlet (see Figure 10). Funding constraints forced the delay of construction of the backwater wetland until 2006. Channel reconstruction was completed by the end of October, 2003. The primary construction work involved lowering the channel inlet and outlet by cutting a hole in the river's bank and in sections of an Army Corps of Engineers levee; removing fill in locations where ranchers had created road crossings across the channel bed; and excavating floodplain soil to connect segments of the channel together. In November, FBP installed erosion control fabric along the channel, scattered native seeds, and planted plugs of grasses and fascines of tree cuttings in the channel (FBP 2004g, 2005i).

FBP had planned and obtained permits for construction of a five-acre backwater wetland area at the reconstructed channel's outlet, but funding for this backwater wetland construction was not available in 2003. After a period of further planning, monitoring, and fundraising, FBP constructed the backwater wetland in the fall of 2006. Planting of the excavated area with plants and seeds from FBP's native plant nursery began immediately after construction (Chris Orsinger, personal communication). FBP also wanted to lower the elevation of the channel inlet in 2006, but agencies' concerns about fish trapping in low areas of the reconstructed channel did not allow for the lowering of the inlet that year (see the upcoming section on assessment and adaptive management for a discussion of the channel inlet) (Chris Orsinger, personal communication).

Restoration of Natural Hydrological Processes and Restoration of Aquatic Organisms

Restoration of natural hydrological processes is listed in my scientific literature review as the first step in implementation of an ideal restoration project, but hydrological changes have not yet been implemented in this project. High flows in the Coast Fork Willamette River are substantially controlled by the U.S. Army Corps of Engineers (ACE), which operates two flood control dams upstream of the South Meadow. These two dams drain 56% of the Coast Fork Willamette River's watershed (Gregory and Ashkenas 2007). To date, the ACE has not adjusted its dam discharges to create more natural flows, though they have established a partnership with The Nature Conservancy to investigate creating more natural flows in the Coast Fork Willamette and the adjacent Middle Fork Willamette River (Gregory and Ashkenas 2007). The report describing how these flows might be structured is still in draft form; it is likely to be a few years before the ACE takes any action based on the report's recommendations.

Restoring hydrological processes would expand the scope of the South Meadow project to a watershed scale. Numerous authors of scientific papers have pointed out the necessity and usefulness of restoring more natural flow regimes to rivers and floodplains that lie below dams. Without natural high-flow regimes, continual revegetation may be necessary to perpetuate floodplain forests (Kauffman et al. 1997). Native species that evolved in the presence of frequent floods should benefit from more frequent large pulses of flood water.

To my knowledge, FBP has not undertaken an investigation of restoration of aquatic organisms in the South Meadow. Recent monitoring has established the presence of a variety of native aquatic organisms in the reconstructed channel and backwater area, so at this point, it appears unlikely that such restoration will be necessary. Further monitoring may indicate specific species that might benefit from targeted restoration efforts.

Project Implementation Delays

The South Meadow project experienced continual delays that slowed down or deferred implementation of aspects of the project. In this section, I provide examples and explore the causes and effects of these delays.

One of FBP's early grant reports acknowledged the implementation delays that are caused by working in partnership, either by choice or by necessity, with government agencies and other organizations. Especially in the early period of this restoration project, FBP had to wait for permission from Lane County to proceed with management and restoration activities. Before the county approved an overall management plan for the South Meadow in 2002, restoration activities were reviewed individually by county staff, and it was not clear from season to season whether planned activities would be allowed to proceed (FBP 2002c). While public review of projects happening on public land is beneficial, review of individual activities was time-consuming for county staff and caused implementation delays for FBP. Approval of the South Meadow Management Plan decreased these delays by approving a wide range of activities in advance.

Delayed submission and approval of grant agreements slowed down restoration work, especially in 2002. Because of the seasonality of restoration activities, short delays resulted in a cascade of effects. Lack of funding delayed mowing in the spring, allowing grass to grow tall enough to provide nesting habitat for native birds. The nesting season delayed mowing until fledglings had left their nests, which meant that weedy grasses were allowed to produce seed and there was less cut grass to use for mulching around planted trees. The stewardship coordinator summarized the other effects of this and other delays succinctly: "the start-stop-start approach inhibited the [stewardship crew's] ability to complete tasks, diluted the sense of progress toward reforestation success, and compromised the crew's outlook on the project, directly compromising overall motivation for project participation" (FBP 2002d).

Restoration work was further delayed in the summer of 2002 when FBP's stewardship crew was forced to stop work by county staff while managers at the county negotiated with the county's staff union regarding "concerns of unfair competition for bargained work tasks" (FBP 2002d). The union was concerned that activities performed by the stewardship crew were legitimate union work that the county should pay county employees to perform, and they demanded a work stoppage during negotiations. This work stoppage further exacerbated the problems caused by the funding delays described above, and it potentially compromised the health of FBP's trees by delaying installation of the irrigation system by four weeks during the warm months of early summer (FBP 2002d).

Both of the above examples emphasize the seasonal nature of restoration work. Even short delays in restoration projects can have significant effects. Because young plants will die if they are planted too late in the year or not watered during dry months, a short delay in implementation may result in delaying an implementation step, along with steps that depend on it, for a full year. In some cases, short delays could result in mortality of plants that otherwise would have survived, causing project managers to perform expensive remediation.

Some delays can have positive results. The lack of funding for the backwater excavation in 2003 meant that this excavation was delayed for at least a year, and ultimately until 2006. This delay may lead to a more effective and more cost-effective project, since the hydrological model FBP used for the initial excavation design was based on estimates that proved to be inaccurate instead of on baseline monitoring data (see the section on assessment and adaptive management for more details). If the backwater wetland had been constructed based on the model used for planning in 2002 and 2003, water may have flowed into the backwater wetland less frequently than desired. The result of this shortfall would have been expensive remediation (much more expensive than the currently proposed remediation of the channel inlet) or a decision to proceed without remediation but with less benefit to target habitats and species.

Future Project Implementation Steps

In the next few years, FBP plans to continue its activities in the South Meadow, including planting and maintenance of native trees, shrubs, and forbs; removal of exotic invasive plants; and monitoring of plant survival, hydrological data, and the presence of animals. They expect to continue geomorphological modifications by lowering the elevation of the reconstructed channel's inlet, addressing concerns of permitting agencies by expanding the scope of the project if necessary.

Opportunities for further restoration are described in the South Meadow Management Plan. They include reconstructing channels A and B (channel A is still on private land), which would connect to the reconstructed channel C (see Figures 9 and 10). After having a chance to observe the South Meadow's channel reconstruction since 2003, the Mt. Pisgah Arboretum may be willing to explore restoration options that involve the land that it leases from Lane County. Options that were proposed and deferred in 2002 included excavation work to open channels D and E and reconnection of the outlet of those channels with the river through removal of a culvert that blocks fish passage.

Conclusion

At first glance, it appears that the restoration steps in this project were implemented out of order, but only one step, the removal of grazing cattle, was delayed long enough to have a significant negative impact on other aspects of the project. Instead of proceeding in a linear fashion, one step at a time, FBP chose to pursue removal of cattle, planting of native trees and shrubs, and changes in channel geomorphology simultaneously. Planting of nearly 8,000 native trees and shrubs proceeded in measured steps from 1999 through 2002. During that time, FBP refined its planting and maintenance techniques, so that when they planted more than 8,000 plants immediately after the channel reconstruction project, those plants had a better chance of survival. I discuss these refinements in the section on assessment and adaptive management.

Because this project is happening at a scale that is relatively small compared to the size of the Coast Fork Willamette River watershed, FBP has had little chance to accomplish the first step in the implementation of an ideal project, restoration of natural hydrological processes. It appears that some progress toward implementation of that step is being made, however. It is possible that FBP's South Meadow project will benefit from more natural flows within a few years.

Section III.C: Monitoring

Introduction

Monitoring of the South Meadow restoration project began soon after the earliest planting and exotic invasive plant control efforts. An FBP grant application submitted in the summer of 1999 specified twice-yearly monitoring of tree survival and health. The grant application described FBP's partnership with a University of Oregon forest biology professor and interns to create a monitoring plan, gather baseline data, and map the trees that had already been planted (FBP 1999e).

Early monitoring "focused upon identifying populations of native species for seed collection, identifying populations of noxious weeds requiring control, tracking areas of blackberry control [… and a] census of live trees planted in 1999 and 2000" (FBP 2000c).

There was no formal baseline monitoring of the site before the project began. As I discussed in the review of scientific literature on restoration projects, monitoring of projects is uncommon. Inadequate funding is often cited as the primary reason for the absence of monitoring. Since the South Meadow restoration project was led by a small non-profit group, it is not surprising that baseline monitoring was not performed. Once the project began, FBP incorporated monitoring into all of its project plans and grant applications, often forming partnerships with dedicated, highly-qualified volunteers from the community to accomplish as much monitoring as possible on a limited budget.

Qualitative Plant Monitoring

Photographic monitoring of sites within the South Meadow had begun by 1999 (FBP 1999d), and it has continued throughout the duration of the project. Photographs are typically taken in the spring, when plants in the South Meadow begin to flower (FBP 2001b, 2002d, 2005h, 2005d). While photography is a qualitative, not a quantitative, monitoring method, it captures large amounts of visual information that is difficult to convey in numbers, and it can alert the project manager to areas that may need more attention or detailed study. FBP uses these photographs for visual comparison of the same areas from year to year. These visual representations of restoration progress can also be persuasive fundraising tools.

Qualitative monitoring is also significantly less expensive than quantitative monitoring, especially when a project manager is trying to get a general idea of the condition of an area. In early 2001, FBP conducted qualitative monitoring in its planting areas in order to identify areas that needed additional planting either to increase density or to replace plants that had not survived (FBP 2001a). FBP has also conducted presence-absence surveys of exotic invasive plants in order to map their locations and plan control efforts (FBP 2001a).

Quantitative Plant Monitoring

FBP planned a plant survival census for spring of 2001 to monitor tree survival and growth rates. As is common in restoration projects, available funding for monitoring was negligible, so FBP had recruited volunteer interns. The interns did not follow through with the monitoring in the spring, but they did survey all of the plantings in the fall of 2001, when "data was collected pertaining to tree mortality, individual vigor, and height of individual trees" (FBP 2001a).

FBP's stewardship report for 2002 recognized the importance of monitoring, both in determining if projects were meeting their objectives and in assessing restoration methods for adaptive management, saying that monitoring is "critical in determining if strategies implemented last year were effective in enhancing the survival rates for [the 2,600] trees planted in 2001" (FBP 2002d). Interns were available in the spring of 2002, contributing more than three hundred hours to the monitoring project and producing precise numerical results. Of the 7,726 trees and shrubs of twenty different species planted by FBP in the South Meadow from 1999 to 2002, 5,844, or 76%, had survived (FBP 2004g).

Plant survival data were collected again in 2005 and 2006 by students in the University of Oregon's Environmental Leadership Program. The students in this program monitored plant survival in the South Meadow, finding that while plant survival remained high and the maintenance regime appeared adequate, many of the trees had been heavily browsed, limiting their growth rates (FBP 2005f, 2005e; Mulford and Fleenor 2006).

Qualitative Reptile, Amphibian, and Bird Monitoring

After it had begun monitoring vegetation, FBP added reptiles, amphibians, and birds to its monitoring routines. Most of the monitoring for these animals was conducted in the spring, when the target animals were most likely to be present, active, and observable. Reptile and amphibian surveying began in December of 2002 and has continued to the present. Bird surveys began in 2003 and have been conducted each spring since then (FBP 2005d). Since the primary intent of the surveys was to gather data about the effect of the 2003 and 2006 channel reconstruction projects on these animals, both of these surveys began far enough in advance of the reconstruction that the first data sets served as baseline monitoring data (FBP 2004c).

FBP used two methods to monitor for reptiles and amphibians. The first method was simple visual observation by staff and interns traveling along established walking routes. The second method involved the installation of sixteen "herpetile arrays," each with five one-square-foot boards to provide cover for the animals. Staff and volunteers monitored the arrays by lifting each board and identifying any reptile and amphibian species found underneath (FBP 2004g). A fall 2004 report summarized the findings to date: roughskinned newts (*Taricha granulosa*), common garter snakes (*Thamnophis sirtalis*), northern red-legged frogs (*Rana aurora*), ensatinas (*Ensatina eschscholtzii*), northwestern salamanders (*Ambystoma gracile*), gopher snakes (*Pituophis catenifer*), racers (*Coluber constrictor*), northwestern garter snakes (*Thamnophis ordinoides*), southern alligator lizards (*Elgaria multicarinata*), western fence lizards (*Sceloporus occidentalis*), and non-native bullfrogs (*Rana catesbeiana*). The report noted some limitations of the current monitoring method: "We did not perform nocturnal surveys and are sure to have missed species due to the limits of our methods and processes" (FBP 2004a).

Volunteers also monitored for birds, performing twice-weekly point count surveys on established routes each spring, generally from early April until late June or early July. The monitoring recorded the presence of birds as well as suitable nesting sites, bird behavior, and habitat use. Monitors typically observed between twenty and forty bird species on a given visit, tallying about sixty species total during a season (FBP 2004c, 2004g, 2005d). Both the bird monitoring and the reptile and amphibian monitoring were qualitative presence-absence monitoring, designed to reveal any changes in the animals' use of areas of the South Meadow over time. FBP's stewardship coordinator designed both surveys so that if funding or labor for quantitative monitoring became available, FBP could expand the existing monitoring regime to perform quantitative monitoring using the established monitoring stations (Jason Blazar, personal communication).

Soil Baseline Survey

In late 2002 and early 2003, a local geologist performed and reported on an initial investigation of the soils in the South Meadow. He took soil cores and mapped the soils in the South Meadow to increase FBP's understanding of how the soils in the South Meadow would affect the success of the channel reconstruction (FBP 2004g).

The geologist made recommendations about how the excavated soil from the project should be used. He recommended depositing the excavated soil from the channel reconstruction and the backwater wetland excavation in mounds elsewhere in the South Meadow, with the original topsoil at the surface, and then seeding the soil with a native seed mix in order to stabilize it. He suggested that excavated material from the road crossings and the revetments, since it was likely to be sandy or even rocky, should be mixed evenly with the rest of the excavated soil rather than deposited in a pile on its own (James 2003).

Hydrological Monitoring

At the end of 2002, FBP contracted a drilling company to install four piezometers in the South Meadow in order to investigate the relationship between the groundwater table and river levels. FBP also installed five staff gauges in low areas of the South Meadow where water frequently pooled during the rainy winter months (FBP 2004g).

Monitoring of the piezometers and staff gauges began in January of 2003 and continues to the present. FBP staff and volunteers typically gathered monitoring data at least twice a week during wet months and less often in the dry summer months. Initial measurements confirmed the hypothesis that the well-drained soils of the South Meadow meant that the groundwater table levels were closely tied to the level of water in the river's main channel (FBP 2004g, 2005h, 2005e).

Unfortunately for the designers of the inlet of the reconstructed channel, there were no significant high water events between January 2003 and the construction of the channel in October of that year (FBP 2006). A flood that would have allowed for significant baseline data collection occurred in December of 2002, two weeks before monitoring began; project managers just missed monitoring this flood with their staff gauges. The peak flow of 10,100 cfs, on December 31, 2002, would have given FBP and Inter-Fluve one data point of useful information about the height of the water at the channel inlet (USGS 2006b). Even though staff gauges were not in place, FBP staff could have visited the site to record the height of the flood debris left behind on the bank by this high flow, but it appears that they did not do so. This complete lack of useful baseline data meant that Inter-Fluve and FBP did not have adequate information to accurately predict the river discharge at which the river would enter the reconstructed channel. Instead, the channel's designers relied solely on a poorly-constructed hydrological model that could have been corrected with adequate baseline data. The results of this flawed model and lack of baseline data are discussed in more detail in the next section on assessment and adaptive management.

When the first floodwaters entered the reconstructed channel in December of 2003, FBP determined that the discharge at which the river overtopped the channel's inlet was considerably higher than the discharge predicted by Inter-Fluve's models (I discuss this discrepancy at length in the next section). In order to avoid this problem in future phases of the geomorphological modifications to the South Meadow, and in order to understand how to remediate the reconstructed channel's inlet, FBP installed additional monitoring stations. In the fall of 2004, they installed three additional staff gauges, for a total of eight; and two crest gauges, one at the channel's inlet and one at the outlet. In March of 2005, FBP staff and volunteers installed an integrated pressure transducer / data logger in the main channel of the river. The pressure transducer indirectly measures the river's depth, and the data logger automatically and periodically records the information, which can be transferred to a computer for analysis (FBP 2005d, 2005g).

The monitoring data gathered from the staff gauges, piezometers, and the pressure transducer were used as baseline data to plan remediation of the channel's inlet. These data were also used to refine FBP's understanding of the correlation between groundwater levels and river levels; to plan the second phase of excavation, creation of the backwater wetland; and to provide better information about the best types of plants to locate in different areas of the South Meadow (FBP 2005f). FBP asked a doctoral student studying hydrology in the University of Oregon's Geography Department to analyze the relationship between groundwater table levels and river levels, using the additional data that FBP had collected. The study's results indicated that excavation of a new backwater area near the outlet of the reconstructed channel would not affect water elevation in existing pools, but the study recommended installing additional piezometers in order to understand subsurface flows with more accuracy (FBP 2005h).

Detailed Monitoring Plans Required by Grants

One of the reasons for the increase in monitoring as the project progressed was that some of the grants funding the project required a monitoring plan with measurable objectives and provided funding for monitoring. A grant from the Oregon Watershed Enhancement Board to FBP was the primary funding source for the channel reconstruction work in 2003. The terms of the grant required FBP to submit and carry out a detailed monitoring plan. Items in the monitoring plan included gathering hydrological data, assessing use of the channel by aquatic species, measuring the extent of native plant cover in the excavated zones, and qualitatively describing the response of exotic invasive plant species to different types of control methods. All of this monitoring was to be carried out over at least a three-year period (FBP 2005d). The monitoring plan contained a table detailing the types of monitoring that FBP would perform, including physical measures: channel morphology, woody debris, riparian vegetation, upland vegetation, stream flow, and water temperature; and biological measures, including the presence of adult fish, juvenile fish, reptiles, amphibians, and birds. For each monitored item, there is a description of the type of monitoring (i.e. "ocular assessment," "presence-absence," "point count surveys," "observe staff gauges"), the frequency of observation (ranging from hourly to annually), and the length of time monitoring would continue (typically five years). The final report for this two-year grant included a summary of the monitoring data observed to date under these criteria after two years of monitoring under the plan (FBP 2005d).

Conclusion

Although there was little baseline monitoring before this restoration project began, FBP has since performed considerable monitoring of both abiotic and biological features of the site. As is common in restoration projects, a lack of consistent funding for monitoring has led to inconsistent monitoring from year to year, but whenever funds and labor have been available, monitoring has been a high priority for the project. The next section will discuss some of the changes FBP made to its plans and management techniques based on the results of the monitoring described above.

Section III.D: Assessment and Adaptive Management

Introduction

Adaptive management treats management of a restoration project as a series of ongoing experiments, allowing restoration to proceed even when there is uncertainty about the potential effects of management actions. Implementers gather information about the results of management actions and use those results to modify subsequent actions.

In the South Meadow restoration project, FBP performed significant ongoing assessment of the effectiveness and cost of their implementation methods, including planting techniques, exotic invasive plant removal methods, irrigation techniques, and geomorphological modifications in the reconstructed channel. They used these assessments to implement adaptive management, continually adjusting methods to improve results and attempting new methods that they expected to yield better results. In this section, I provide examples of the assessments performed by FBP and the adaptive changes in project implementation methods they made based on those assessments.

FBP consistently monitored and reported on implementation objectives, as required by grants. For the most part, this monitoring did not lead to significant changes in practice, but it did allow staff to understand how much restoration was possible with a given amount of funding and staff time. When funding was not adequate in 2003 to excavate and plant both the reconstructed channel and the backwater wetland, for example, FBP had enough budgeting and implementation experience to realize that it had to defer excavation of the backwater wetland (FBP 2005d).

Early Assessments of and Changes to Planting and Plant Maintenance Techniques

A few months after its first experimental planting of trees in 1999, FBP's staff researched irrigation needs for their newly-planted trees. It is unclear why FBP did not gather this information and create an irrigation plan before planting the trees. At the time, FBP was just beginning restoration work in the South Meadow and had not yet hired a stewardship coordinator. FBP's executive director spoke to a staff member from the Oregon Department of Fish and Wildlife about a riparian tree planting project from the mid-1990s. The project managers had not watered their trees, and all of the deciduous trees had died. FBP decided to water its new trees at least once a month during the dry summer months (FBP 1999f).

As early as the spring of 2000, FBP began assessing its planting techniques. A stewardship report described the difference in survival of bare root trees that were nine to twelve inches tall when planted compared with taller trees. Of the smaller trees, only about half survived. The stewardship coordinator recommended planting only trees larger than eighteen inches in the future (FBP 2000d). FBP also began marking all of its surviving trees with plastic flags after finding it difficult to locate them among tall grasses during monitoring and weed management (FBP 2000c).

Also in 2000, FBP assessed its use of woven cloth weed suppression mats, finding them "ineffective" in suppressing competing grasses (FBP 2000c). In 2001, in a trial of a different technique, staff and volunteers removed vegetation in a six foot diameter around each tree, laid waxed cardboard on the bare earth, and secured the cardboard with landscaping staples. The stewardship coordinator expected that this new vegetation management technique would conserve soil moisture, increase plant survival rates, reduce the potential need for chemical treatment of weeds, and reduce the mowing area around the plants (FBP 2001a).

In 2001, FBP used its hose-and-bucket irrigation system for the first time. The next year, staff made several refinements to the system based on their experience with it during the first year. Among other improvements, they added a manual crane to move the pump in and out of the river, changed pipe configuration to increase water pressure, and added more buckets. All of these changes made irrigation easier and faster, an important change, since there were thousands of additional trees to water (FBP 2002d).

In a restoration project outside of the HBRA but in an area ecologically similar to the South Meadow, FBP had experimented with installing biodegradable solid plastic tubes around newly-planted trees, replacing plastic mesh tubes that they had used previously. Staff found that the solid tubes reduced tree mortality from rodent herbivory; the tube's manufacturer also claimed that the tube increased humidity inside the tube, increasing tree growth rates and reducing irrigation needs. Whatever the reasons, staff observed that plant survival rates were significantly higher when the solid plastic tubes were used, so they installed them around each tree planted in the South Meadow beginning in 2002 (FBP 2002d, 2002c).

Even FBP's plant survival census was improved by adaptive management. After interns completed the 2002 census, the stewardship coordinator suggested changes to improve the census in the following spring, including "use of hand held digital data recorders to facilitate data entry, requir[ing] interns to have a strong knowledge of woody plants, segregat[ing] notes of stress characteristics (grazing or herbivory), and map[ping] location of mole, gopher, and vole activity" (FBP 2002d).

FBP experimented with control methods for Armenian blackberry (*Rubus discolor*), a widespread exotic invasive plant that has proven difficult to control in the Willamette Valley. After a few years of trying different techniques, they found that, at least on level sites, repetitive mowing (three to five times per year for multiple years) was effective in controlling blackberry. They avoided mowing in the spring in order to allow native plants to produce seeds; once native plants had produced seeds, summer mowing dispersed the native seeds, favoring them over some exotic invasive plants. Many blackberry control areas have been planted with native trees, which should suppress the exotic plants once the trees grow large enough to provide significant shade (FBP 2002c). FBP continues to experiment with and report on a variety of blackberry control methods.

Evaluation of the Hydrological Performance of the Restored Channel

During the design process, the engineers at Inter-Fluve were confident in their models, since they had fifty years of accumulated data from a United States Geological Survey (USGS) stream gauge just 1.5 miles upstream from the proposed reconstructed inlet (Inter-Fluve 2001). Inter-Fluve's HEC-RAS 3.0 hydrological models and their hydrological analysis of the gauge data predicted that water would enter the reconstructed channel inlet for an average of fifteen days per year, the desired design value, at a river discharge of 7,769 cubic feet per second (cfs) (220.0 cubic meters per second [cms]) (Inter-Fluve 2005). As I discuss below, the engineers did not provide any estimate of the accuracy of this figure based on the uncertainties in their model.

The first significant flood event after completion of the reconstruction project occurred in December of 2003, just six weeks after excavation equipment left the site. On December 13, 2003, it rained 2.68 inches (6.81 cm) at the Eugene airport, a record for that day (NWS 2003). Rivers throughout the Willamette Valley rose to near or above bankfull levels; some rivers reached flood stage. The discharge measured on the gauge on the Coast Fork Willamette at Goshen, Oregon, less than two miles upstream of the South Meadow, peaked at 16,300 cfs (462 cms) on December 14, 2003. A flood of that size or larger would be expected to recur about four times every ten years; this flood was the largest on the Coast Fork since 1996 (USGS 2006b). Water entered the reconstructed channel from the river, overtopping the lowered channel inlet for about fifteen hours.

Because the flood peaked in the middle of the night, nobody witnessed the floodwaters overtopping the reconstructed channel inlet. FBP's stewardship coordinator visited the inlet in the evening before the flood peaked and observed that the river was about three inches below the inlet (Jason Blazar, personal communication) when the discharge was just over 9,800 cfs (280 cms) on the Goshen gauge (NOAA 2003). It was immediately apparent that something had gone wrong with the channel inlet's design or construction, since the river was supposed to overflow into the channel at 7,769 cfs (220.0 cms). FBP and Inter-Fluve began analyzing the inlet, the design model, and gauge data to try to determine what had gone wrong and how to remediate the inlet in order to meet the design goal (FBP 2005d).

Inter-Fluve's analysis determined that the inlet had overflowed at 9,900 cfs (280 cms). My own calculation, based on interpolation of the Goshen gauge data and the stewardship coordinator's observations, is that the river entered the channel at about 10,300 cfs (292 cms, margin of error 1-2%). The USGS provides historical records of average daily flows, which are the values that are usually used to calculate flood return intervals. An average daily flow of 9,900 cfs (280 cms) has an average return interval of 3.4 days per year, and 10,300 cfs (292 cms) corresponds to 2.7 days per year (USGS 2006a). This is a much lower frequency than FBP and Inter-Fluve's design goal, which was for the river to flow into the channel for an average of fifteen days per year (FBP 2005d).

Inter-Fluve and FBP's analysis of why the channel had not behaved as expected during the December 2003 flood event represented a key adaptive management step and provided a set of lessons for future project planners. In April of 2005, Inter-Fluve submitted a "Technical Memorandum" to FBP with its summary of what had gone wrong with the channel inlet and its recommendations for remediation (Inter-Fluve 2005). The memo concluded that there had been three problems with the modeling and construction: the value of a key modeling variable was off by 50 percent, Inter-Fluve chose a non-optimal data set for estimating 15-day-per-year discharge levels, and the channel inlet was constructed too high.

The first conclusion was that the value for a modeling variable called "Manning's n," a coefficient that describes the channel's roughness, or resistance to water flow, was 50% too high in Inter-Fluve's model. Inter-Fluve had estimated Manning's n based on a survey of the river's main channel during a low-flow period and on examination of photographs of the river in flood. After the flood, Inter-Fluve determined a more accurate Manning's n value for moderate river flows by comparing known discharge levels at the nearby USGS gauge with data from FBP's staff gauges and iterating their model with different values of Manning's n until the model matched FBP's observations (Inter-Fluve 2005). It is unclear why Inter-Fluve made this significant error in the calculation of a key modeling variable. They probably would not have made the error if they had had baseline data from staff gauges to refine their model. Without baseline monitoring data from a high flow event, which FBP missed by only a few weeks, Inter-Fluve estimated Manning's n instead of being able to calculate it directly using on-site monitoring data. In any event, as I describe below, I do not think that this modeling error was a major cause of the channel inlet's poor performance.

The second conclusion was that the original estimate of a discharge that would occur for fifteen days per year was too high, even though the river discharge's return interval had nothing to do with whether the river flowing at the predicted discharge would overflow into a channel inlet of a given elevation. Inter-Fluve recalculated its estimate based on hourly data from a twelve-year period instead of daily data from a fifty-year period, claiming that the hourly data allowed for more accuracy. They calculated a fifteen-day discharge of 6,286 cfs (178.0 cms), compared to their original estimate of 7,769 cfs (220.0 cms), which they recalculated as a flow occurring only eight days per year on average (Inter-Fluve 2005). Their analysis is unconvincing and ultimately unhelpful. They made an unsupported claim that the twelve-year set of hourly data would predict future river discharges more accurately than the fifty-year data set. This claim is dubious, given that climate can vary greatly from decade to decade; some periods have much more precipitation than others. The engineers' primary fault was failing to point out the imprecision of the design specification. Inter-Fluve's models generated precise numbers, but those numbers were only as accurate as the data and assumptions used to generate them. First, using hourly data instead of daily data puts the analysis into the realm of semantics: what does "fifteen days per year" mean? Does it mean that water flows into the channel for at least one hour on fifteen different days, or does it means that water flows into the channel for 360 hours per year (fifteen 24-hour days)? Those two figures alone differ by an order of magnitude; this semantic difference is not addressed in any of the memos from Inter-Fluve to FBP. Second, the engineers did not provide a range of potential values for their discharge estimates, instead providing only a single number, specified to the decimal point. When the initial specification (fifteen days per year) is so imprecise, the estimated discharge should not be accurate to four significant figures. Third, climate fluctuates significantly from year to year and from decade to decade. Inter-Fluve's recommendations based on analysis of historical climate data should have included a range of uncertainty to acknowledge that climate is variable and that a limited set of data was available.

The third conclusion in the memo, and the only one that is unquestionable, was that the channel's inlet had been constructed about 1.5 feet (45 cm) too high. FBP volunteers surveyed the channel inlet in January 2004 and in April 2005; there was no flooding large enough to enter the channel inlet between the two surveys. They found that the inlet differed significantly from the original design. The two surveys found that the channel inlet elevation was constructed about 1.5 feet (45 cm) higher than the design elevation of 475.1 feet (144.8 m) above sea level (FBP 2005b, 2005a). There was no explanation of how this error occurred, but it appears to have been the most significant error. Inter-Fluve did not provide the discharge at which water would have entered the channel if the inlet had been constructed according to the specifications, so it is not possible to conclude from the memo whether the error in Manning's n or the construction error was more significant in the failure of the inlet to meet the design specification. My analysis of FBP's monitoring data indicates that water probably would have flowed into a properly-constructed inlet between about 7,600 and 8,000 cfs (215 and 225 cms) (FBP 2006). This estimate is based on a small set of hand-recorded data, about five staff gauge readings, gathered during one high-water period at the inlet, so it is hard to know how predictive it is. If it is correct, it points to the construction error, not the modeling variable, as the major source of error, since the target discharge generated by the model was 7,769 cfs (220.0 cms).

Inter-Fluve concluded the memo with an adaptive management recommendation to remediate the inlet by constructing a second inlet near the first one, with the inlet elevation four feet (1.2 m) lower than the as-built elevation of the original inlet. They recommended erring on the side of increased flow, lowering the channel's inlet to allow water to flow into the channel for an average of twenty days per year, or whenever the river's discharge exceeded 5,670 cfs (160.6 cms) (Inter-Fluve 2005).

Preparing for Channel Remediation and Backwater Wetland Excavation

Immediately after completion of the reconstructed channel, FBP began gathering data that would help refine its plans to excavate a backwater wetland at the channel's outlet. As described in the monitoring section above, FBP staff and volunteers installed additional staff gauges, installed a pressure transducer / data logger in the river, and gathered monitoring data at each of these gauges at least twice weekly during wet months. FBP and Inter-Fluve used this additional data to refine the hydraulic model that they were using to describe the river's interaction with the floodplain, increasing the model's accuracy (FBP 2005d). Refinements and design modifications in 2005 led to a final design for the excavated backwater that was implemented in 2006.

Conclusion

FBP's adaptive management has been strong throughout the project. They continually evaluated their planting and vegetation management techniques to figure out how to improve them, implementing changes in the next cycle of activity. They used quantitative and qualitative monitoring to assess the effectiveness of their techniques. FBP attempted an assessment of the hydrological performance of the channel reconstruction project by asking Inter-Fluve for an analysis and by performing a survey of the channel inlet. Inter-Fluve's analysis left a few questions unanswered, though its recommendations for remediation of the channel inlet appeared to be sound.

Section III.E: Communicating Project Results

Introduction

Communicating information about the results of an ecological restoration project's implementation is a vital part of any project. There are two kinds of communication that are important to ecological restoration projects: communicating with the public in order to explain the project and gain public and political support for it; and communicating with other project managers in order to improve the state of the art in restoration methods. FBP successfully performed both kinds of communication. Through public communication, FBP gained support from politicians, other local non-profit organizations, and interested members of the general public. Public communication also led to direct communication with managers of other local restoration projects. Sections of grant reports about the effectiveness of ecological restoration methods resulted in useful information for managers of future restoration projects.

This section explains the types of communication that FBP used and gives examples of the lessons they shared about the planning and implementation of this floodplain restoration project.

Public Communication

FBP included a wide range of types of public communication in its efforts to explain their floodplain restoration project to the public and to gain public support. These efforts included (FBP 2003b, 2004d, 2005i, 2005h):

- Signs at entrances to the South Meadow while the channel excavation was in progress (see Figure 11 for an example);
- A press release and media tours of the project after excavation was complete, leading to multiple newspaper articles and local television news reports;
- Articles about the project in FBP's newsletter, *The Rookery*;

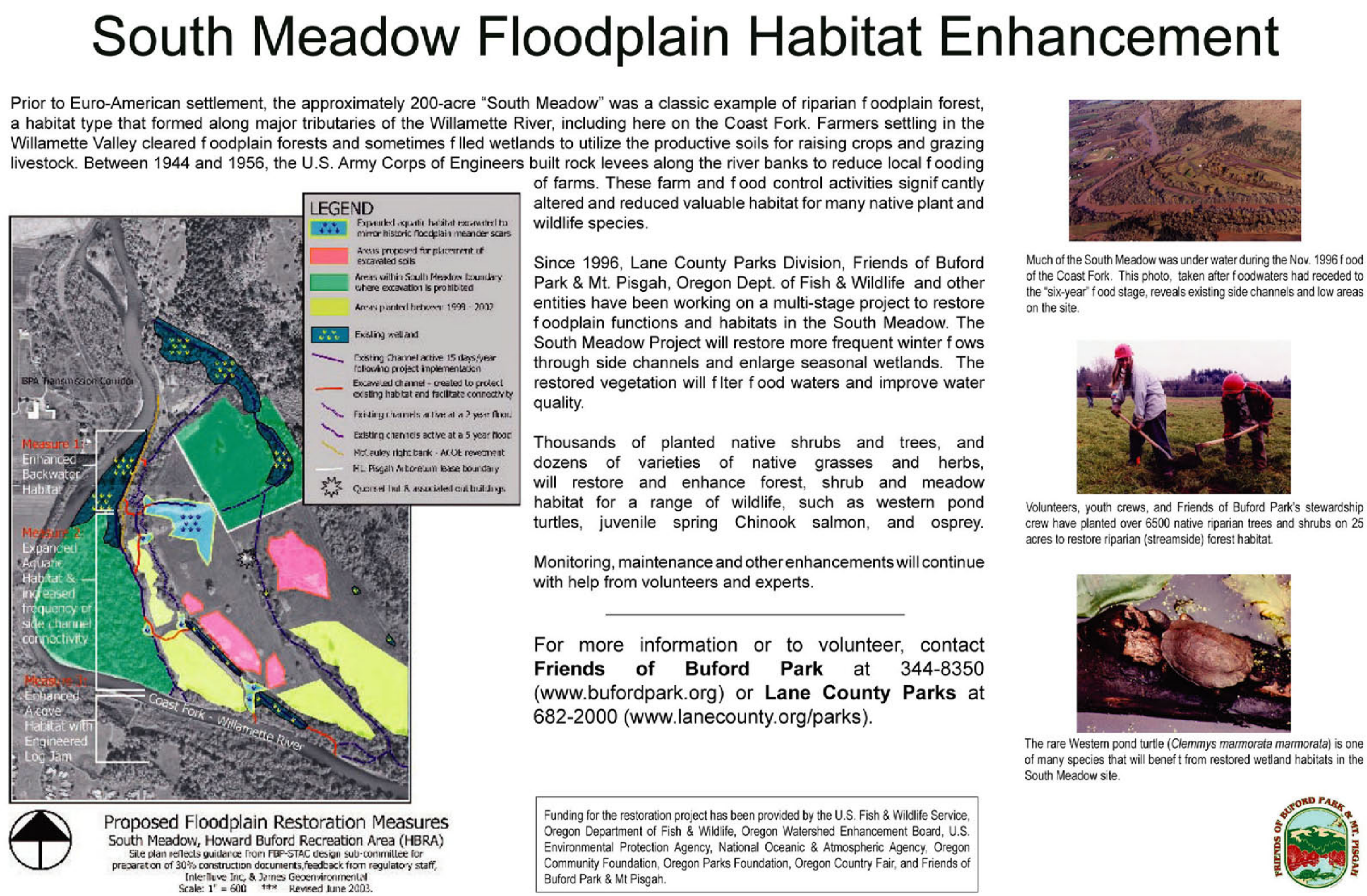

Figure 11. Educational sign placed at the entrance to the South Meadow during channel reconstruction in 2003 (courtesy FBP).

- Outreach to community members, businesses, and high school and university students to recruit volunteers for planting, seed collection, monitoring, vegetation management, and other restoration activities;
- Booths at community events with information about the project and about FBP's other restoration work;
- Public tours of the site during community events at the HBRA;
- Public presentations to community groups and also to FBP's members during semi-annual public meetings;
- Frequent communication with staff and elected officials of Lane County about restoration plans, grant applications, project implementation, and sources of delays;
- An all-day workshop and tour at the South Meadow for park managers, academics, and restoration project managers; and
- A tour led by the Oregon Department of Agriculture's weed management staff, who highlighted FBP's effective blackberry control methods.

As a measure of the effectiveness of this communication, FBP reported in 2005 that the South Meadow project "has already served as a model for at least five other local floodplain restoration projects" that were either planned or in progress (FBP 2005c).

Communication in Grant Reports

Many of the lessons and restoration methods that FBP staff learned were reported back to funding agencies. Agencies required grant reports — for Oregon Watershed Enhancement Board (OWEB) grants, the final 10% of grant funds were not released until the final report was received — that included sections on "lessons learned" and "recommendations for more effective implementation of similar projects." These agencies provide funding to a range of restoration projects and are able to communicate these lessons to other project managers, either directly or through creation of "best practices" manuals. OWEB, for example, published a statewide survey of riparian restoration projects on its web site in 2002. The survey focused primarily on the effects of planting and plant maintenance techniques on the survival of trees planted in riparian restoration projects. It provided specific examples of techniques that increased tree survival, such as watering during dry months and using solid tree tubes; both techniques had increased the survival rates of FBP's trees.

FBP described specific, detailed, practical lessons in their grant reports to OWEB, the primary funder of the South Meadow excavation projects. The lessons can be applied readily, at least within habitat types similar to those in the South Meadow project, with little further knowledge, by other restoration project managers. A few of these detailed restoration lessons follow as examples of FBP's clear and useful communication about restoration:

> BLACKBERRY CONTROL: Repetitive mowing (usually using a 5' flail mower on a small tractor) is an effective control method for blackberry on relatively level floodplain sites. Native species have rebounded in areas where we have mowed, and blackberry exhibit considerably reduced vigor. We mow control areas 3 to 5 times per year in winter, summer, and fall. We avoid mowing in spring, so that native plants can produce seed, which are dispersed by a summer mowing. Maintenance mowing of these sites is easier after the first mowing. However, continued maintenance over a period of some years is required. In pilot areas, volunteers have dug up blackberry root balls (after repetitive mowing) and planted big leaf maples, which when mature should suppress blackberry with the deep shade of their canopy. Blackberry control remains a challenging aspect of restoring floodplain habitats (FBP 2002c).
>
> VEGETATION MANAGEMENT: During the first three years, mowing grass around trees two or three times each spring reduces the grasses' competition for sun and soil moisture. After tree height exceeds maximum grass height, a land manager could consider reducing the frequency or altogether eliminating mowing of tall grasses around trees (FBP 2002c).
>
> IRRIGATION METHOD: […] Our plan called for irrigating trees approximately four times each of the two summers after planting. After irrigating for two season[s], we expect root system development should be adequate for survival. Since irrigation material needs are therefore temporary, we chose to minimize material cost by delivering water by hand in buckets from temporary lateral lines connected to above ground arterial lines running through each planting area. Small holes in the buckets allowed a laborer to leave the filled bucket at a tree location. After about 30 minutes, the water had slowly drained to create a deep soil

> column of moisture, to encourage deep root growth. This approach chooses reduced irrigation material costs and higher seasonal labor costs, which creates indirect economic benefit to individuals employed as seasonal laborers (FBP 2002c).
>
> SHORTER PLANTING DAYS: Planting trees is physically taxing, and usually occurs in cold, winter weather. To maintain productivity of labor crews, consider working crews additional 6-hour days per week, instead of fewer 8-hour days (FBP 2002c).

Other project implementation lessons and recommendations communicated in FBP's grant reports included:

- Mulching: FBP described mulching as labor-intensive but beneficial. It suppressed weeds, improved soil quality, minimized herbicide use, and provided temporary habitat for reptiles and amphibians (FBP 2002c).
- Solid tree tubes: As described in the previous section on adaptive management, FBP recommended solid plastic tubes to limit rodent herbivory (FBP 2002c).
- Planting: FBP described in detail the process of planting a single bare root tree. Given the high survival rate of their trees, they expected that their methods might be useful to other project managers (FBP 2002c).
- Grant reports also included lessons learned about planning restoration projects:
- Working with government and non-profit partners: "Budgets should acknowledge the additional staff time necessary to work with governmental and non-profit partners. Landowner permissions […] for certain restoration activities can take time. Yet engaging a landowner or other partners in restoration decisions is also an educational process that has value for future cooperation." Unanticipated delays can limit the ability of project managers "to implement scheduled management actions in a timely fashion" (FBP 2002c).
- Grazing: In the South Meadow, even with the use of movable electric fences to gradually reduce the grazing area, cattle escaped and significantly damaged

plantings. Grazing was terminated four years after planting began. "If restoration plantings are to occur adjacent to a grazed area, significant investment in fencing and constant monitoring may be required to protect the investment in the restoration plantings. The best approach, if feasible, is to terminate grazing in advance of planting and, as part of site preparation, control weeds on the formerly grazed area prior to excavation or native plantings" (FBP 2005d). The scientific literature summarized in the second chapter made it clear that anthropogenic sources of disturbance should be removed before active restoration begins, but that did not happen in this project. Lane County, the landowner, appears to have felt the need to balance multiple uses of the South Meadow; the county did so until it became clear that grazing and restoration were incompatible.

Both of the above lessons point out challenges for project managers who are trying to implement restoration projects but who have limited control over implementation timelines and decisions. I explore this issue at more length in the conclusion of this thesis.

In a final grant report to OWEB in 2005, FBP summarized "recommendations for more effective implementation" of floodplain channel restoration projects (FBP 2005d). FBP had relied on a "nationally recognized river restoration and engineering firm," Inter-Fluve, for accurate modeling, and excavation, but they were disappointed with the results. Based on their experience, they recommended that project managers (FBP 2005d):

- "Obtain and analyze pre-project hydrology data, and correlate it with past observations." The report recommended ensuring that project managers have adequate baseline data, including data from flows matching those desired for effective restoration. They also recommended using photographs to match water elevations and river discharges with survey data.
- "Carefully survey the elevation of staff gages and monitoring wells" in order to ensure the accuracy of your hydrology data, and thereby, your models and predictions.

- "Consider designing for more frequent water in side channels, given climate change trends that may result in lower flows and hotter, [drier] summers." This recommendation continued with recommendations about choosing historical data sets carefully. I do not think that this third recommendation is as important a factor as the others. Rivers are unpredictable enough from year to year that the accuracy of a hydrological prediction for a given year is limited.
- "Survey during project construction. Before excavation equipment leaves the site, survey elevations of the channel to ensure there was not an error in the depth of excavation." Make sure that your project, as constructed, matches the design. This recommendation is the most important, and I found it surprising that Inter-Fluve did not require it as a routine part of the construction, if only to preserve their reputation.

Conclusion

FBP has communicated frequently and effectively with the public throughout the course of the restoration efforts in the South Meadow. One measure of the public support for FBP's efforts was the growth of FBP's annual budget, which determined the amount of restoration activity it was able to perform. FBP's annual budget increased from about $50,000 per year in 1998 and 1999, when it began restoration in the South Meadow, to an average of $230,000 per year from 2002-2005 (Chris Orsinger, personal communication).

Although FBP has diligently and effectively reported their recommendations and findings in grant reports, those findings are not readily available to all ecological restoration project managers for whom the findings might be useful, since OWEB does not produce and distribute technical restoration manuals on a regular basis (aside from the 2002 survey mentioned above, the technical restoration manuals on OWEB's web site date from 1999 and earlier). FBP has brought employees from government agencies and restoration project managers to the South Meadow for workshops and tours, which shows their willingness to communicate the lessons of this project to other restoration managers.

This thesis describes some of the lessons learned in this project, some of which may be useful for restoration project managers. These limited avenues of communication, however, will not lead to the "mature" stage of ecological restoration described by Johnson, Tereska, and Brown (2002).

FBP, as a small non-profit organization, probably does not have the resources to ensure that its lessons are communicated to the broadest possible audience, though it may be able to use its limited resources more effectively by choosing low-cost communication methods that reach a large audience. It would probably be most efficient for OWEB to create and post to its web site an annual technical handbook of the recommendations and techniques submitted by FBP and by managers of hundreds of other restoration projects. By doing so, OWEB would increase the effectiveness of all of the restoration projects that it funds.

CHAPTER IV

CONCLUSION

Introduction

In this thesis, I set out to examine an ecological restoration project, comparing its planning and implementation with recommendations in the scientific literature. I looked specifically at the restoration project's planning and goal-setting, implementation, monitoring, adaptive management, and communication. Where there were differences between the recommendations described in the scientific literature and the project's actual planning and implementation, I described those differences and examined the reasons for and the consequences of those differences. In this section, I summarize those findings.

In this final chapter, I also explore ways in which the scientific literature failed to account for the realities of this restoration project's planning and implementation. I describe an additional reason to collect baseline hydrological data. I describe some of the delays that FBP encountered in the planning and implementation of this project and explain the reasons for some of those delays. I conclude that FBP's lack of control over this restoration project's funding and over the project site led to significant delays that decreased the project's success and increased its costs.

Comparison of this Project with the Ideal Project

In comparison with typical ecological restoration projects described in the scientific literature, this project was excellent. It had a detailed project plan with well defined goals, though it was weak on objectives measuring ecological effectiveness. It had a project implementation order that, while not the same as the ideal project, made sense within the limits imposed by political constraints and human activities in the watershed. It had a significant amount of monitoring. FBP used adaptive management continually. FBP communicated frequently and effectively about the project.

Planning: The major plans for restoration in the South Meadow, culminating in 2002 with the South Meadow Management Plan, contained increasingly refined ecological goals as project planners gathered information and discussed their plans with project partners and other stakeholders. The plans always contained concise and useful ecological goals, although they contained few measurable objectives related to those goals. In comparison with the ideal restoration project described in the scientific literature review, the plans were strong on implementation planning, but they were weak in the areas of monitoring, adaptive management, and communication of project results.

Project Implementation: Instead of proceeding with the linear set of implementation steps described in the ideal project, FBP chose to pursue removal of cattle, planting of native trees and shrubs, and changes in channel geomorphology simultaneously. Planting of nearly 8,000 native trees and shrubs proceeded in measured steps from 1999 through 2002. During that time, FBP refined its planting and maintenance techniques, so that when they planted more than 8,000 plants immediately after the channel reconstruction project, those plants had a better chance of survival. Because this project is happening at a relatively small scale, FBP has had little chance to accomplish the first step in the implementation of an ideal project, restoration of natural hydrological processes. It appears that some progress toward implementation of that step is being made, however. It is possible that FBP's South Meadow project will benefit from more natural flows within a few years.

Monitoring: Although there was little baseline monitoring before this restoration project began, FBP has performed considerable monitoring of both abiotic and biological features of the site. As is common in restoration projects, a lack of consistent funding for monitoring has led to inconsistent monitoring from year to year, but whenever funds and labor have been available, monitoring has been a high priority for the project. The monitoring for this project has taken place over too short a time frame to determine if the species being targeted are benefiting. A riparian forest takes decades to mature. The channel modifications have been in place for only a few years, and the reconstructed side channel has flooded just three times. It is likely that reconnecting the South Meadow floodplain to the river and returning an open area populated primarily by exotic invasive plants to a native gallery forest will produce benefits to the greater ecosystem around the project, but many years of monitoring will be necessary to determine whether these benefits are being produced.

Adaptive Management: FBP's adaptive management has been strong throughout the project. They continually evaluated their planting and vegetation management techniques to figure out how to improve them, implementing changes in the next cycle of activity. They used quantitative and qualitative monitoring to assess the effectiveness of their techniques. FBP assessed the hydrological performance of the channel reconstruction project by asking Inter-Fluve for an analysis and by performing a survey of the channel inlet. Inter-Fluve's analysis left a few questions unanswered, though its recommendations for remediation of the channel inlet appeared to be sound.

Communication: FBP has communicated effectively with the public throughout the course of the restoration efforts in the South Meadow. One measure of the public support for FBP's efforts was the growth of FBP's annual budget, which determined the amount of restoration activity it was able to perform. FBP's annual budget increased fivefold from 1998 to 2005. Although FBP has diligently and effectively reported their recommendations and findings in grant reports, those findings are not readily available to all ecological restoration project managers for whom the findings might be useful, since OWEB, the primary funding agency, does not produce and distribute technical restoration manuals on a regular basis. OWEB would increase the effectiveness of all of the restoration projects that it funds by creating and posting to its web site an annual technical handbook of the recommendations and techniques submitted by FBP and by managers of hundreds of other restoration projects.

Lessons Learned from this Project: Baseline Data and Modeling

Hydrological modeling was a major precursor to the channel reconstruction portion of this restoration project. The reconstructed channel's inlet did not perform as expected, necessitating expensive remediation to allow the channel to perform as originally designed. The primary cause of this failure was a construction error, but the hydrological model also contained significant errors that could have been avoided.

The scientific literature on ecological restoration cited in the second chapter of this thesis recommended gathering baseline data. Project managers will not know if they have improved ecological function if they do not have a baseline from which to measure improvement. The channel reconstruction project in the South Meadow provided another good reason to gather baseline data that the papers mentioned less frequently but that is worthy of emphasis: baseline hydrological data can improve modeling of future conditions. If a project manager planning floodplain channel reconstruction wants water to flow into a channel's inlet at a specific river discharge, it is useful to calibrate the discharge with elevation locally by gathering data at the proposed channel inlet site. If project managers can observe discharges exceeding the design value before project implementation, models of the channel's behavior will be more accurate than they would be with only estimates. Likewise, because of potential interactions with the groundwater table, baseline monitoring of water table levels can help project managers understand how water is likely to behave once it enters the channel.

Models contain estimates and assumptions that should lead to a range of predictions and recommendations rather than a single number. The river was expected to flow into the reconstructed channel inlet in the South Meadow at exactly 7,769 cfs (220.0 cms), but given the assumptions made in the model, a range of probable flows would have allowed the project's designers to either modify the design or know to expect variance in the actual results. Models that make predictions that depend on climate may contain additional uncertainty. Estimates for 15-day exceedence values of river discharges that would cause flooding in the reconstructed channel ranged from 6,286 cfs (178.0 cms) to 7,769 cfs (220.0 cms), all based on reasonable choices of data sets. In addition to this uncertainty, the data is only descriptive of the past, not necessarily predictive of the future, further increasing uncertainty.

Lessons Learned from this Project: Delays in Project Planning and Implementation

My scientific literature review did not turn up discussion of causes and effects of delays in planning and implementation of ecological restoration projects. The South Meadow project experienced continual delays that slowed down or deferred planning and implementation of aspects of the project.

Planning ecological restoration projects, especially on government-owned property, can involve significant delays caused by politics and bureaucracy. Non-ecological political factors may delay or prevent decisions from being made in a timely manner. Causes of delays during planning of projects in the South Meadow included: slow processing of permits, followed by planning of design changes required by permitting agencies; decision-making delays by the county's Board of Commissioners due to the limited time they had available to deal with any single issue; requirements that plans be approved after public hearings and feedback; and delays in getting grant applications approved by county officials, followed by delays in agencies' funding of those grants. When projects are dependent on outside funding, it is unlikely that project managers can create and adhere to a detailed long-term plan, since funding from outside sources is not reliably available over long periods (i.e. more than two years).

I described examples of project implementation delays in section III.B above. Implementation delays in this project were frequently caused by waiting for permission from Lane County, the landowner, to proceed with project implementation activities. Some of these delays were alleviated by the approval of the South Meadow Management Plan in 2002. Grant submission delays and a work stoppage demanded by the county's staff union resulted in a cascade of implementation delays. These delays highlighted the seasonal nature of restoration work, in which short delays sometimes have effects much more significant than a delay of the same length in a project outside of the realm of ecological restoration.

Lessons Learned from this Project: Lack of Control over the Funding for the Restoration Project and over the Restoration Project Site

The root cause of most of the delays and difficulties described above is a lack of control over implementation of the restoration project, an issue about which I was unable to find any discussion in the scientific literature. Control over the planning and implementation of ecological restoration projects comes in two primary forms: control over funding and control over the restoration project site.

At the start of this project and throughout its implementation, FBP had no independent source of funds. All funds for implementation of this project were raised from private donors, foundations, and government agencies. The majority of funds raised came from grants. Grant funds come with significant strings attached. Grants usually require reporting, which is recommended in the scientific literature as an important part of a restoration project, but which adds time and expense to a project. Grant funds are restricted to specific expenses; grant applications often include a budget with line items for individual expenses, and special permission may be needed to deviate from the approved budget. The goals of individual funders may intersect with only a subset of a project's goals, meaning that project managers may have to choose to do only part of a project or raise additional funds to achieve other goals (FBP 2004b). Grants often require matching funds from other sources, increasing the administrative work required to raise funds for a project.

Raising funds from agencies and implementing restoration work on land that project managers do not control means that project managers often have to work with multiple partners. A biological assessment prepared for one of the channel reconstruction permits listed one county agency, three state agencies, five federal agencies, five non-profit groups, and three foundations as project partners (FBP 2003a). Each group will have different goals, requirements, permits, forms, reports, funding stability and duration, and available time to dedicate to the project. Meeting the needs of all of these groups can significantly lengthen both planning and implementation of projects. It may help for one organization to take a strong leading role, as FBP did in this project, and for that group to obtain commitments from the other project partners to dedicate the time necessary to keep the project on schedule.

Performing restoration work on sites that project managers do not directly control is the second primary limitation on control over a restoration project. FBP's grant reports acknowledged that obtaining permission from Lane County staff and elected officials took time that should have been included in project planning and implementation timelines. Having to return to the landowner repeatedly for permission to implement project steps added time and uncertainty to the project (FBP 2002c). Even when the county had approved a project, other problems arose. As described above, a labor dispute between the county's staff and management caused implementation delays that were unrelated to the goals or objectives of the restoration project. Government entities serve many constituencies, and public processes can move slowly, as evidenced by the four-year process of removing grazing cattle from the South Meadow.

Some proposed restoration sites in the South Meadow were unavailable for restoration. One of the channel inlets proposed for restoration was discovered to be on a piece of private land adjacent to the park. The county's Parks Advisory Committee approved exploration of acquisition of the land or of a conservation easement that would allow restoration to proceed on the property, but when FBP approached the property's owners, they were unwilling to discuss any changes to the status of the land. Two of the proposed restoration areas, channels D and E, flowed into an area within the park leased by the Mt. Pisgah Arboretum. The MPA staff and board of directors opted to defer any restoration measures within their leased area, so FBP was unable to proceed with any measures related to those channels until MPA is willing to reopen discussion about them.

Conclusion

In comparison with typical projects described in the scientific literature, this project was excellent. Analysis of this project revealed a few lessons that I did not find in my literature review. The first lesson is that baseline data is useful not only to know whether your project is meeting its objectives, but also to know whether you are designing your project effectively.

The second lesson is that delays in implementation of ecological restoration projects appear to be common, especially when project managers are working on sites that they do not control.

The third, and most important, lesson from this project is that a lack of control over project funding and the project site can cause significant delays and other problems in the planning and implementation of restoration projects. Project managers working on sites that they do not control and who have to raise funds from year to year to fund their projects will need to remain flexible and open to the possibility of delays and the potential need to scale back their project implementation plans.

Project managers, even those who do have control over funding and the project site, will never have complete control over an ecological restoration project site. Federal and state laws and regulations regarding endangered species, rivers, and other aspects of the environment will require that project managers obtain permits for significant changes. Ecological restoration projects are usually dependent on weather and climate, over which project managers have no control. In the end, I return to the National Research Council's definition of ecological restoration, in which they described a restored ecosystem as "a natural, self-regulating system that is integrated ecologically with the landscape in which it occurs" (NRC 1992). Every restoration site is part of a larger landscape that affects what happens on the restoration site. Project managers cannot control the larger landscape, but they can always try to implement projects that compensate "in a specific, ecologically effective way for alterations typically caused by human activities" (Meffe and Carroll 1994).

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