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Integrating Ecosystem Services, River Restoration and Community: a Case Study at Fisher's Bend

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INTEGRATING ECOSYSTEM SERVICES,

RIVER RESTORATION AND COMMUNITY:

A CASE STUDY AT FISHER'S BEND

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Acknowledgements

The process of developing and managing the Fishers Bend Restoration Feasibility Study provided the basis for my Masters of Environmental Management (MEM) Project starting in Fall 2009 and culminating in June 2011. The MEM project meets part of the requirements for a Master's degree through the Environmental Science and Management Department at Portland State University. Academic guidance and good questions were provided by my major professor, Vivek Shandas, Associate Professor, School of Urban Studies and Planning and by Alan Yeakley, professor in Environmental Science and Management both at Portland State University.

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My role throughout the project has been lead project proponent and project manager. I wrote grants, managed and guided the work of contractors (a Design Team), conducted landowner and community outreach, recruited and facilitated a Project Review Team, managed project data and wrote grant reports.

While this project benefitted from the cooperation and support of many, I want to recognize the contributions of those who took the lead on different parts of this project:

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Abstract

Natural areas and ecosystem services at the edge of urban areas are threatened by increasing development. This paper examines how community based restoration partnerships can work to identify, protect and restore ecosystem services provided by salmon and our local rivers. Floodplains provide a wide range of ecosystem services to urban and rural communities and we should work collaboratively to protect and restore them. Floodplains are especially valuable and important for salmon recovery. By using a case study, we explore the process and feasibility of restoring off-channel salmon habitat at Fisher's Bend in the lower Clackamas river. A feasibility study was conducted to identify costs, benefits and risks of different design alternatives for the side channel. Hydrology of the river and hydraulics of the site were determined by estimating peak and low flow hydrology then running a HEC-RAS hydraulic model. Results indicate that the river overflows into the side channel near the 2 year recurrence interval. On average there is currently about a 50 % chance each year that the river will enter the side channel. These current flows do not provide much opportunity for juvenile salmon to access the side channel where they can grow and thrive in a protected habitat before their journey to the ocean. Further investigation produced results that indicate 95% of the time from 1959-2009 the river discharge was above 726 cfs from October to June. These results highlight that we will need to excavate about 9 feet from current elevations at the side-channel outlet to gain reasonable assurance of a one foot water depth for good salmon access. This depth will provide access from the river during critical periods when adult and juvenile salmon are seeking refuge from predators and high flood flows in the main channel. Although more design is needed for the inlet and outlet it appears the project is feasible and will meet the objective of providing salmonid access to critical habitat. In closing, I recommend investment in natural area protection and restoration at the edges of the urban growth boundary to maintain valuable ecosystem services provided by river floodplains and salmon.

Images of people rescued from rooftops and muddy torrents overflowing river levees during Hurricane Katrina have underscored the need for change in our relationship to river floodplains. People have been lured to floodplains since ancient times because they provide rich soils for agriculture and access to fishing and food sources. In addition, they now provide avenues for transportation, hydro-power development and in some cases a place for urbanization. To allow for development, land managers and private landowners have attempted to control our rivers with dams, dikes and rip-rap. Over the past one hundred years in the United States and throughout the world, rivers and their floodplains have been altered for human use and have not been adequately recognized for their ecosystem services. If people expect to continue benefitting from and using such ecosystem services as clean drinking water, salmon fisheries and flood protection, we need to embrace, protect and restore our floodplains.

With intense growth and urban development at the urban-rural interface, floodplains and the ecosystem services provided by natural areas are threatened. We must develop public-private partnerships to ensure that natural areas continue to provide ecosystem services to our rural and urban communities as they grow.

This paper examines the relationship between ecosystem services, restoration and community partnerships at the southern end of the Portland metro region. By using a case study of the Fishers Bend Natural Area, I investigate the collaborative approach used to begin restoration of critical off-channel habitat for juvenile salmon in the floodplain of the lower Clackamas River. The core objective of this project was to conduct an engineering and design feasibility study to understand what flows and habitat improvements could benefit juvenile salmonids. More specifically, our team attempted to address the following key questions:

1. How does the river interact with the Fishers Bend floodplain site at high flows?
2. How do groundwater and surface water streams contribute to flow in the side channel and existing ponds on site?
3. How can we provide salmonid refuge and access to the site at lower river flows and more frequently through the year?
4. What are the costs, benefits and risks associated with each restoration alternative?

5. How can our actions at this 55 acre site contribute to improving larger watershed conditions, enhance ecosystem services and contribute solutions to regional issues?

The last key question about watershed and regional issues puts this restoration project in context of an urban region trying to meet the challenge of protecting natural areas and the benefits they provide while we grow in population and strive to become a more sustainable community.

With or without our awareness, ecosystem services provide support for our daily lives. They sustain us and our economy. Ecosystem services have been defined most simply as the benefits that humans derive from ecosystems. (MEA 2005) According to the Millenium Ecosystem Assessment 2005, ecosystem services include:

"…provisioning services such as food, water, timber, and fiber; regulating services that affect climate, floods, disease, wastes, and water quality; cultural services that provide recreational, aesthetic, and spiritual benefits; and supporting services such as soil formation, photosynthesis, and nutrient cycling. The human species, while buffered against environmental changes by culture and technology, is fundamentally dependent on the flow of ecosystem services."

Brauman et al. studied and categorized hydrologic ecosystem services. They developed a graphic summary shown on the following page in Figure 1, the water cycle (a) and the ecosystem services provided by rivers and related lands (b). From this they developed five broad categories of hydrologic ecosystem services which are also provided by river floodplains. The following categories include examples added in brackets: 1) improvement of extractive water supply [drinking water and irrigation]; 2) improvement of in-stream water supply [hydro-power, transportation]; 3) water damage mitigation [reduce flooding]; 4) provision of water-related cultural services [recreation, spiritual, aesthetic] and 5) water-related supporting services for plant growth and habitat for fish and aquatic organisms (Brauman et al, 2007). As will be discussed later in this paper, it is expected that this project will primarily benefit recreation and water related supporting services for salmon and aquatic organisms. It will also impact cultural services related to intrinsic and aesthetic values.

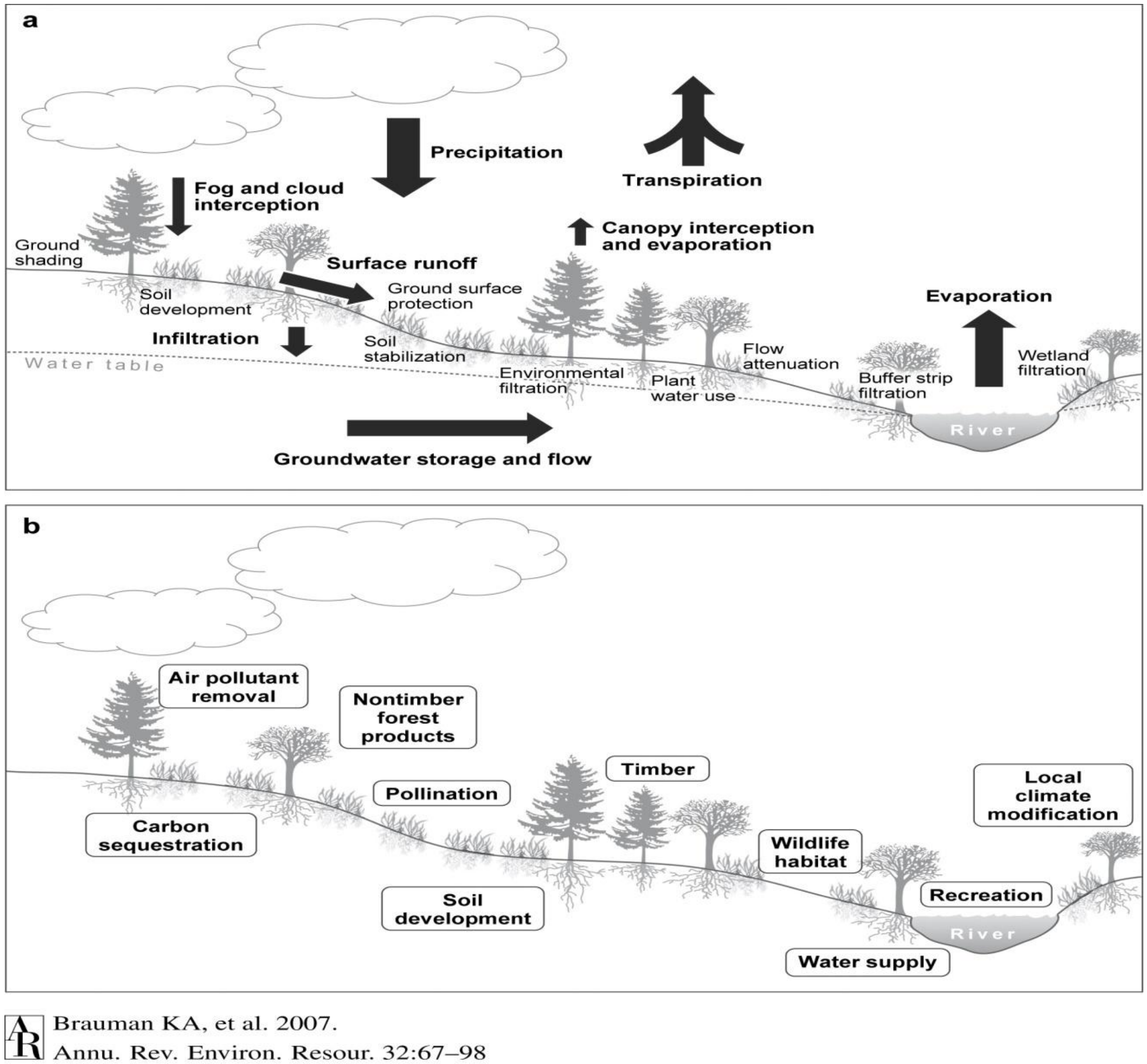

Figure 1: The Water Cycle (a) and its' Ecosystem Services(b): Floodplain ecosystems are driven and supported by the water cycle and provide a myriad of ecosystem services that fish, wildlife and human communities depend upon for survival.

Reduction of flooding may be one of the most widely recognized ecosystem services that floodplains supply, but certainly not the only one. Functioning floodplains with their associated forests and wetlands capture and slowly release floodwaters (Boulton, 1998). Both upland and stream-side forests help to clean, filter and slowly release water as it soaks into the ground. Stream-side ecosystems can act as buffers creating time and space for filtration processes to occur. (Naiman, 1997). In addition, they can help maintain stream configurations and temperatures that enhance in-stream processing of pollutants. (Brauman, 2007). Floodplain functions provide downstream communities with flood protection in the winter and provide groundwater storage for domestic drinking water, irrigation, recreation and other uses in the summer.

Media coverage of flooding throughout the world reminds us annually that rivers flood onto their banks whether homes and human development are in the way or not. Dikes, roads, urban and rural development have limited rivers access to their floodplains. Unchecked urban sprawl can destroy the very life-sustaining systems that a city needs to be healthy. (MEA 2005) Unfortunately, floodplains are not exempt, in most cases, from further development. When rivers are not able to interact regularly with their floodplain, many of the ecosystem services that rivers provide may be lost. (Allen 2004)

Human land uses along rivers and in related uplands increase the quantity and quality of water that enters a river or stream. Activities such as upland deforestation, intensive agriculture and urbanization can drastically increase stream flows and flood elevations during normal rain events because the water runs off the land quickly rather than soaking in slowly. Overgrazing in grassland or rangeland areas decreases vegetation, exposes soil to erosion and increases runoff. In urban areas, increased runoff from impervious surfaces and stormwater can degrade streams and displace organisms because of greater frequency and intensity of floods, erosion of stream beds, and displacement of sediments. (Lenat & Crawford, 1994). Streams with reduced forest cover exhibit declines in overall fish abundance and an increase in sediment-tolerant and invasive [fish] species. (Sutherland et al. 2002). A functioning floodplain is a valuable asset that can buffer rivers from human activities and reduce impacts of floods on cities. We have only recently begun to recognize the many values of floodplains.

Floodplains provide an excellent buffer between the river and human activities on land. Ironically, in many urban areas where floodplain ecosystem services are needed most by people, development has limited the ability of floodplains to fully function. (Paul and Meyer, 2001; Yates and Bailey, 2009) As demonstrated by Figure 2 (to be added), in the densely populated

Willamette River Valley, the river is estimated to have undergone a four-fold reduction in length of shoreline in the past 200 years. The river's once expansive floodplain and backwaters have been confined to a narrower and simpler channel in response to dikes, large wood removal, channel dredging, and the draining of its floodplain. (Sedell & Froggatt 1984).

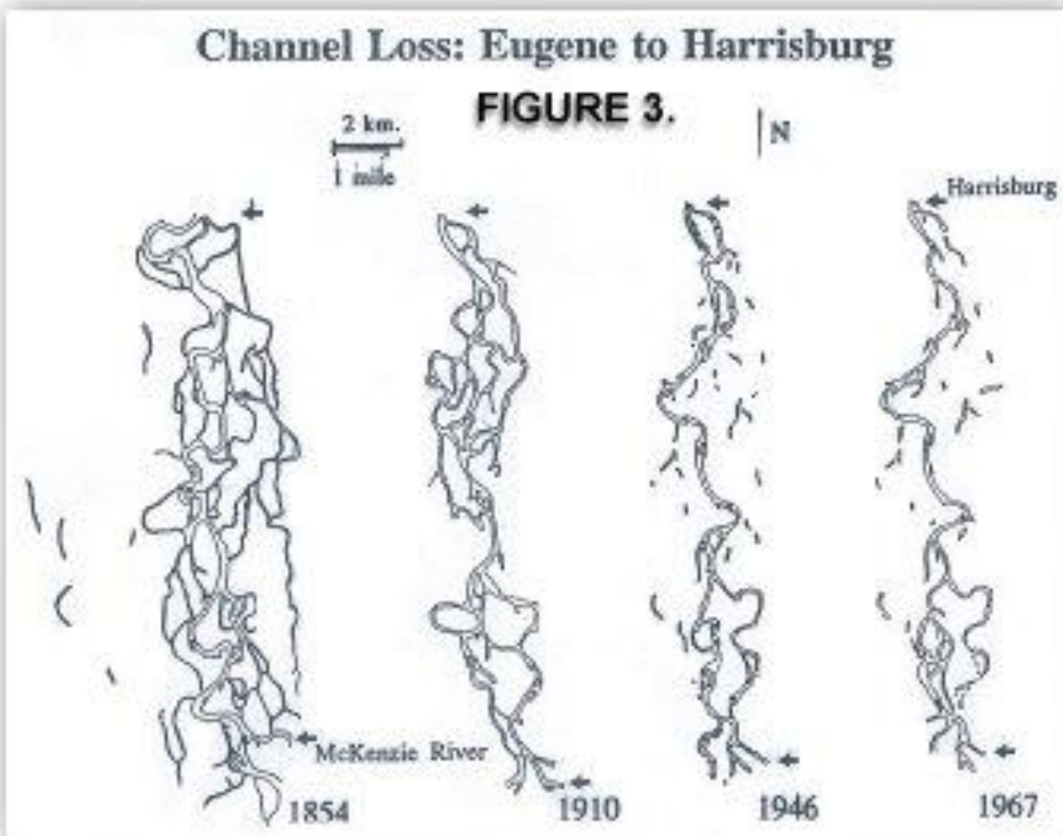

Figure 2: Historic channel loss on the middle Willamette River: Since 1854, the Willamette River has lost much of its sinuosity (curviness) to riverside and floodplain development such as agriculture and urbanization.

Background

In order to maintain valuable ecosystem services we must invest in natural area protection and restoration and build stewardship in communities at the edges of the urban growth boundary where floodplains and natural areas remain relatively intact. As the Portland region grows, we will depend more on ecosystem services provided by the Willamette River and it's tributaries like the Clackamas River. Fortunately, the Portland region has a history of planning for smart urban growth and is beginning to recognize the value of protecting ecosystem services provided by our nearby natural areas and open spaces. (Metro 2010)

Land acquisition and protection by public and non-profit organizations are integral tools for a sustainable future. (Daniels and Lapping 2005). Through the Metro Parks and Open Spaces Program voters have twice approved bond measures to help start this important work, but not all valuable natural areas can be purchased nor can governments do the work alone. (Metro 2005) For the natural areas that are acquired, whether by a public agency or land trust, it is important to begin restoration to protect and enhance the value of ecosystem services that natural areas can provide. Otherwise, if invasive weeds over-run natural areas and they become neglected, governments will lose the support and legitimacy needed to ask for future bond measure funding from the voters. Alternatively, governments can support community groups and nearby landowners to adopt acquired sites thereby leveraging public money and building local stewardship.

Not only does natural area restoration have the potential to enhance ecosystem services, it has the power to transform and build community. The process of developing stewardship of natural areas and open spaces on public and private land can build trust, partnerships and mutual respect between rural and urban landowners. By working together on the land, planting trees and restoring our natural areas, we can learn from each other. Through these partnerships people can realize that it is necessary to protect and enhance natural areas and ecosystem services for us all. By engaging communities in salmon habitat restoration we can build awareness and support for restoring river-based ecosystem services.

Why salmon habitat restoration?

Restored floodplains and natural areas can provide valuable ecosystem services but why should we invest in salmon recovery? Because the salmon life cycle ranges from rivers to oceans, it is important to discuss salmon in the context of the Lower Columbia River region.. Salmon have been integral to people living in the northwest and along the Columbia river for thousands of years. For Native Americans along the Columbia river, salmon has long been integral to their spiritual, social and economic livelihood. Although salmon populations have dwindled in recent years, Native Americans have maintained a strong spiritual and social connection to salmon.(Montgomery 2003). In 1996, Loomis studied how much Washington residents valued salmon through a contingent valuation method. After I used the Consumer Price Index to convert results, surveys indicated that even non-fishing residents were willing to pay up to $102 per year/household to restore salmon habitat leading to a value of $231 million each year using 2000 Washington census data and 2010 dollars. (Loomis et al, 1996)

Besides their intrinsic and spiritual values, salmon have long been integral to the northwest economy. In the late 1800's when the Portland area was young, abundant salmon and old growth timber harvests fueled a growing population. Salmon were thought to be an endless and bountiful resource which lead to unrestrained commercial harvest and canning of salmon. Along with destructive logging practices and the beginning of hydropower dams in the early 1900's local salmon runs were hit hard by human progress. Though numbers of salmon harvested are a fragment of what they once were, even today, salmon are estimated to provide a significant contribution to our regional economy. According to the Independent Economic Advisory Board of the NW Power Conservation Council, based on recent run sizes and harvest levels, salmon and steelhead production in the Columbia River Basin contribute about $142 million in personal income annually to communities on the West Coast (IEAB 2005). Salmon fishing and consumption of salmon have long been a tradition of northwest cultures.

Although northwest residents clearly value salmon, human activities will continue to provide challenges to salmon survival. Population increase and climate change in the northwest are certain to keep the pressure on salmon in the future. The Portland metro region is projected to add 500, 000 new residents by 2025 (Portland Development Commission, 2010) More people and more population density may lead to more urban runoff and toxics entering our streams. Population growth will lead to more pressure on rural areas for residential development and may mean the loss of more floodplains to residential development as people seek marginally developable land to “get away from it all” yet live near urban areas. In the same time period of fifteen to twenty years from now, climate change models predict that the Pacific Northwest will experience a 2 degree celsius temperature increase. (Litell et. al 2009) Stream temperatures and stream flows are expected to change as mountains receive less snowpack and precipitation falls more as rain. (Litell et. al 2009) Lower stream flows in summer and less cold groundwater will raise stream temperatures for juvenile fish meaning their metabolism and energy demand will increase. To compound the problem, warmer temperatures also make salmonids less able to compete for food at warmer temperatures. (Reeves et al 1987) Therefore, thermal temperature refuges, where they exist, will be all the more important to juvenile salmon in tributaries and off channel areas where they can escape from warmer main stem river temperatures.

The Lower Columbia River Salmon Recovery Plan

To meet the challenge of preserving salmon runs people from all sectors of lower Columbia river communities are working together to find solutions and promote salmon recovery. The primary mandate guiding salmon recovery planning at the federal level is the Endangered Species Act (ESA). Section 4(f) of the ESA requires the National Marine Fisheries Service (NMFS) to develop and implement recovery plans for species listed as endangered or threatened under the Act. Lower Columbia River Coho, Spring chinook and Winter steelhead were all listed as threatened under the ESA for the Clackamas River and others in the 1990s. Once a species is listed a recovery plan is developed and describes a process to remove the threats to the long-term survival of a species. It outlines how to reverse species decline and restore the listed species and its ecosystem to a point where the species' future is safeguarded and the protections of the ESA are no longer necessary. A recovery plan serves as a road map for species recovery. It describes the current species status, the 'gap' that needs addressing to reach recovery, as well as ongoing or proposed actions designed to aid in the recovery of the species. Working with a diverse stakeholder group, the Oregon Department of Fish and Wildlife recently completed the Lower Columbia River Salmon Recovery Plan (LCRP) in 2010. The Plan recognized the Clackamas River as one of the last strongholds in the lower Columbia for threatened salmon.(ODFW 2010)

Restoration with a watershed perspective

The Clackamas River Watershed (Figure 3) enters the Willamette River at mile 25 below the falls at Oregon City and supports naturally spawning anadromous fish including salmon, steelhead, sea-run cutthroat trout and Pacific lamprey. The river is home to ESA listed Lower Columbia River Coho, Lower Columbia River Steelhead and Chinook. The Lower Columbia Salmon Recovery Plan (2010) regards the Lower Clackamas floodplain as a high restoration priority.

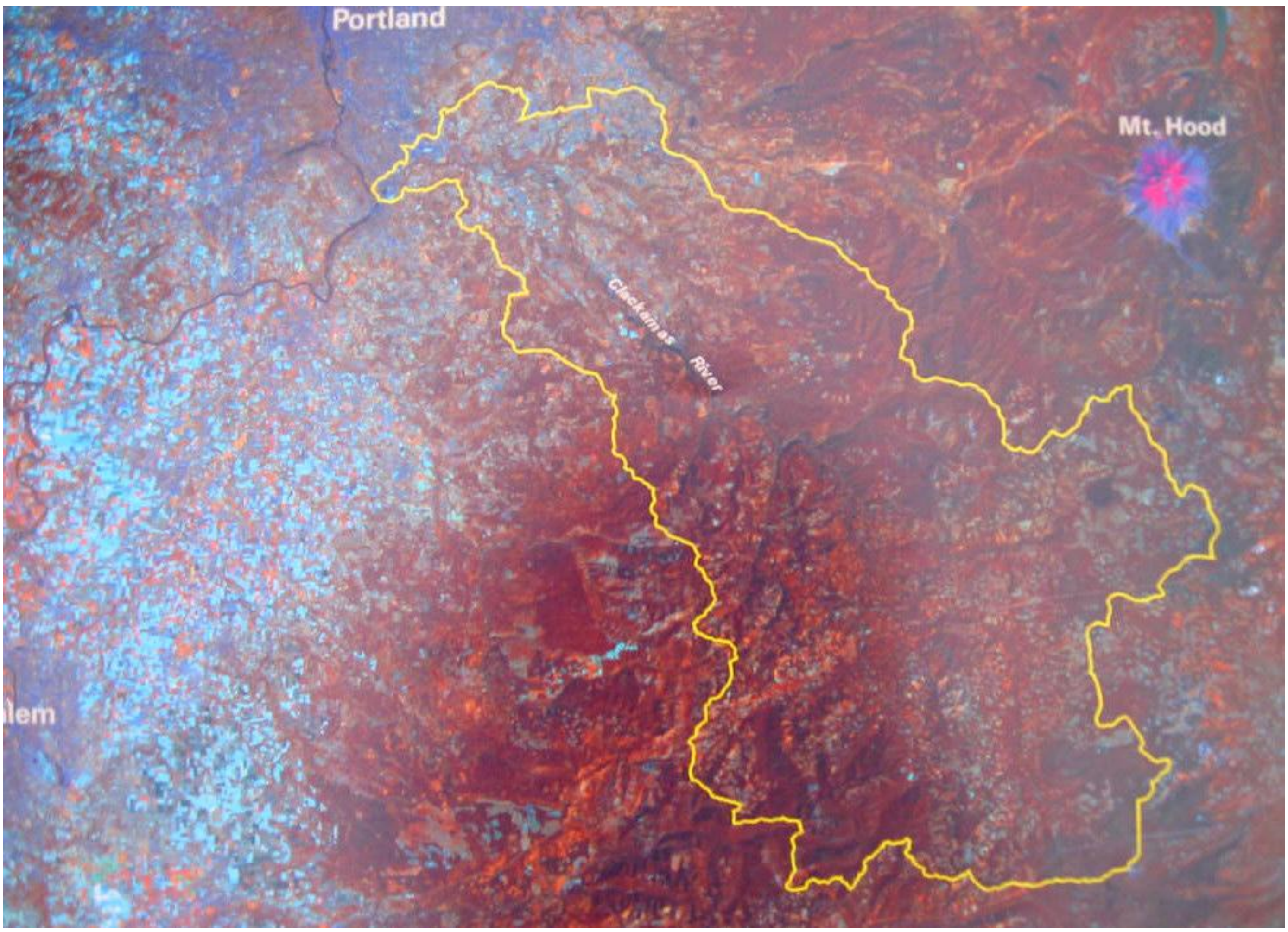

Figure 3: The Clackamas River Watershed

Despite some challenges, the Clackamas River is a gem and a hub of biodiversity within the Lower Columbia River and in the Willamette Basin. In the lower Clackamas River, there is great potential for restoring historic floodplain habitat. Historically, the Clackamas River was one of the "most prolific salmon rivers in the Columbia River Basin". (US Fish Commission, Stone, 1877 as stated in PGE 1999)

Today, there is scientific consensus that the Clackamas river has great restoration potential. The Clackamas Watershed Assessment, Clackamas EDT, Basin Action Plan, Willamette Sub-basin Plan, Oregon Watershed Enhancement Board's Willamette Priorities (OWEB) and the Lower Columbia Salmon Recovery Plan have all identified mainstem floodplain restoration as the top priority salmon recovery action in the lower Clackamas river.

In order to do salmon restoration one should understand what factors are limiting salmon populations at the watershed scale. In the Clackamas three major limiting factors for salmon were identified in the Clackamas watershed assessment: channel complexity, habitat diversity and water temperature. (WPN 2005) Floodplain restoration is a great way to address all three factors.

Channel complexity and habitat diversity

Most rivers and streams in the west are limited in large wood and lack braided channels that used to provide great habitat for salmon. The Clackamas has the same challenge as large wood was either logged out of river basins or was later removed on purpose in the 1970's as it was thought to inhibit salmon passage. In addition, upstream dams catch large wood and keep it from migrating to the lower river. Ditching, berms, riprap and other actions that straighten channels reduce meandering, reduce channel complexity and the quality of fish habitat. The actions that confine channels, combined with minimal large wood, increase water velocities, reducing important slow-water habitats, particularly for juvenile fish during winter and spring high flow events. (WPN 2005)

Channel stability has been changed through the placement of dikes and channelization, which has restricted connections between the river and floodplain. Habitat diversity has been impacted through loss of large wood in the channel and loss of side channels and other off-channel areas (Wampler 2004). The narrowing of the channel has impacted key habitats for fish.

Confinement of the lower Clackamas River channel, loss of large wood, and reduced streamside trees and other riparian vegetation has contributed to the loss of side-channels and other habitats. Processes that transport and retain large wood in the lower river have been altered through modified streamside forests, removal of wood from the channel, channel confinement, and retention by the river's dams (Wampler 2004). Slow water habitats such as side channels, alcoves and the margins of complex wood jams, provide a diverse array of water depths and velocities, which provide cover for adult fish and refuge areas for juveniles. (WPN 2005)

Temperature

The Clackamas Basin is temperature limited and it is a primary limiting factor for salmon. (ODEQ, WPN 2005) Cool water temperature is an important consideration in supporting salmon and trout. The rate of chemical reactions and biological activity generally increases at warmer temperatures. The dissolved oxygen concentration decreases at higher temperatures causing stress on aquatic organisms. Some compounds, such as ammonia, are more toxic as water temperature increases. Increased temperature in combination with nutrients stimulates nuisance algal blooms, and increases the survival rate of pathogens. (WPN 2005) Cumulatively, higher temperatures cause stress in fish and may lead to death. For example, high water temperatures were a contributing factor to the massive fish kill of over 33,000 salmon in the Klamath river in 2002. (CDFG 2004)

Salmon have evolved under water temperature patterns that historically existed in the Clackamas River basin. Cooling water in the autumn serves as a signal for upstream migrations, and fall spawning is initiated when water temperatures decrease. Eggs generally incubate over the winter or early spring when temperatures are coolest, and juvenile fish rear in habitats that remain cool throughout the summer. Temperature is a major limiting factor in the Clackamas during the late summer and early fall, particularly for the fall and spring Chinook salmon that spawn during this period. (WPN 2005)

The Clackamas River mainstem is listed under section 303(d) of the Clean Water act for temperature which means that it exceeded State temperature standards of 64 degrees. This prompted DEQ to develop a 2005 TMDL (total maximum daily load) for temperature. This designation may help to highlight the temperature problems in the basin and may provide some funding for future restoration work.

Hydrology and floodplain interactions

Not only is it important to understand limiting factors but the hydrology of a river should be studied both on a watershed and site specific scale in order to develop floodplain restoration plans. The physical setting of a river will influence how flow is translated in the riverbed and how flow is then experienced by salmon.(Poff et. al. 2010) Salmon eggs need plenty of cool, clean, oxygen-rich water flowing over them to hatch and thrive. Too much scour or heavy flood flows can wash out a whole year of salmon redds. Too little flow can lead to increased stream temperatures where young salmon fry emerge from gravels early and may affect long term development or survival.

Though anadromous salmon gain over 95% of their mass in the open ocean, modeling results for Columbia River Chinook suggest that first year and estuarine survival are key factors influencing a juvenile salmon's success (Kareiva et al.2000). In addition to rearing in the main-channel of rivers, salmon rear in floodplain habitats. Peak flood flows and floodplain habitats can provide opportunities for juvenile salmonids if they can access good off-channel rearing and refuge habitat. The refuge that floodplain off-channel habitats provide from both high flows and high sediment loads may improve juvenile salmon growth rates (Crouse et al 1981.) and decrease mortality. (Erman et al. 1988). In addition, when floodplains are inundated, the increase in overall available habitat reduces competition and lowers predation risk (Sommer et al. 2001) Peak flows, low flows and elevation of the side channel determine when the channel can be accessed by salmon.

Peak flows have the ability to transport sediments, form channels, cause scour, create erosion and affect salmonid access to the floodplain. Whether a given level of flow will create a bed-moving disturbance in the river or overbank flow is determined by channel geometry, floodplain height and streambed composition. (Poff et al 2010) To make off-channel habitat suitable for salmon, flows need to be adequate to flush sediments, yet not so powerful that they displace large wood structures and riparian vegetation that support aquatic life. Understanding when and how the bank will overflow into a side channel during peak flows and how salmon can access a side channel at lower flows is important for restoration design.

When starting the project at Fishers Bend we had some background on Clackamas hydrology. The Clackamas River drains nearly 1000 square miles and includes land uses of wilderness, commercial forests, agriculture and urbanized areas that all affect the hydrology of the river . Water withdrawals occur for both agriculture and municipal use. There is a stream gauge 1000 feet below River Mill Dam, about 14 miles upriver that was used to develop peak and low flow scenarios for a current conditions hydraulic model of the river (USGS 2010) This information was helpful later to calibrate models for peak flow and low flow hydrology developed specifically for the Fishers Bend site.

In contrast to the large amount of information and knowledge we had about the lower Columbia and the Clackamas watershed before this project, we knew very little about the Fishers Bend Natural Area itself. It is important to understand what we know about the site and what we do not to guide our study of the site. The formation of an applicable and ecologically true restoration goal involves investigation into historic patterns, current constraints, and cataloging of habitats (Ebersole and Liss 1997). We wanted to know what restoration actions would address limiting factors for salmonids and in turn provide cost-effective benefits for ecosystem services.

As a community of restoration professionals and concerned citizens how are we to start addressing all the issues that salmon face? One approach outlined in this paper is to identify critical salmon habitat, protect and restore it. In this way, if climate or environmental conditions worsen for salmon at least there will be some habitat areas where salmon can find refuge. One place with great potential for salmon refuge and juvenile rearing is Fishers Bend.

The Fishers Bend site is located at the base of the proposed Clackamas River Bluffs natural area in the dynamic floodplain of the Clackamas River (Figure 4). The Bluffs natural area is at the edge of Damascus, the first incorporated city in Oregon in nearly 30 years.

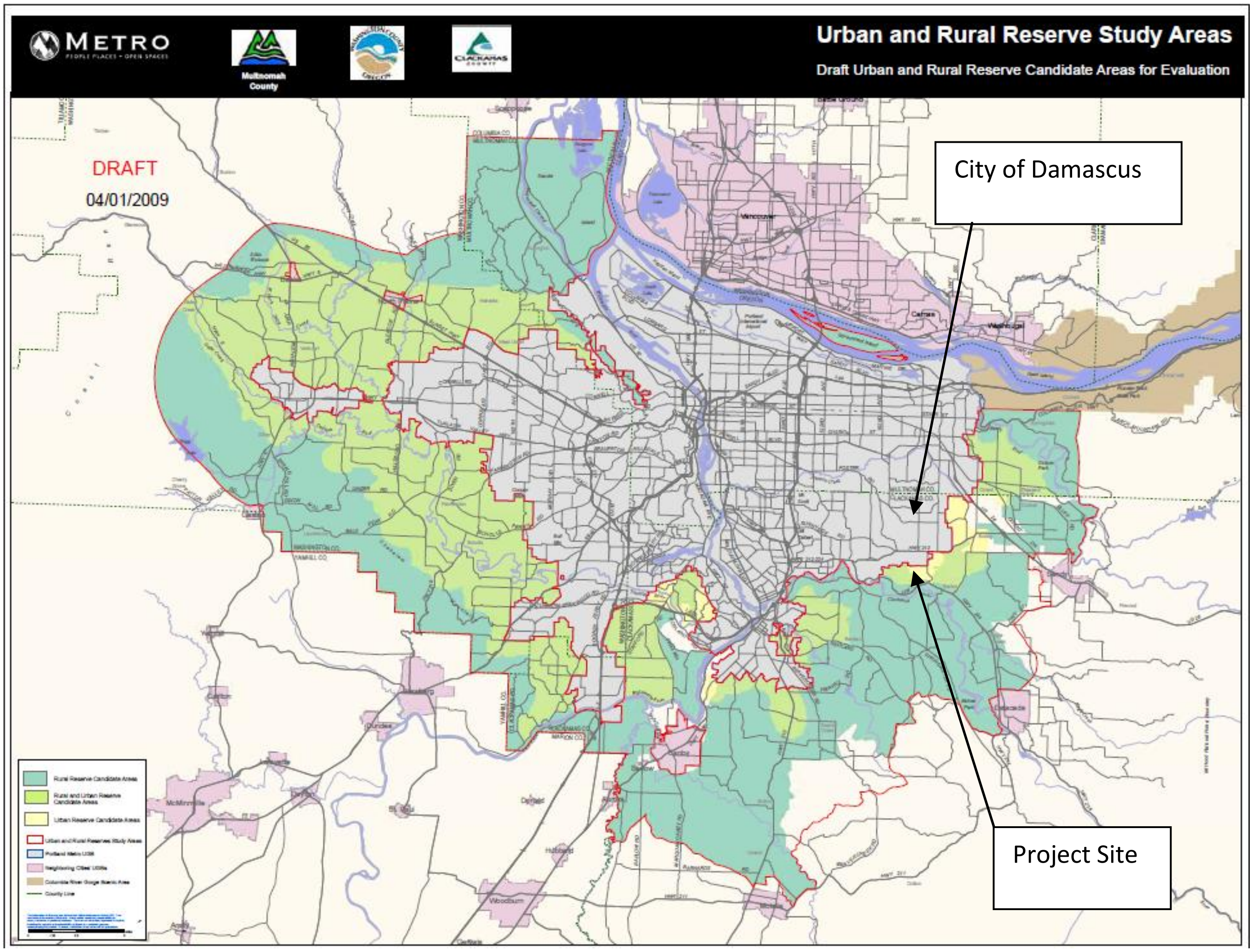

Figure 4: Fishers Bend project site at the edge of Metro UGB

It is expected that Damascus will grow from its current population of nearly 10,000 residents to a community of over 60,000 people. (City of Damascus, 2009). According to the Metro Open Spaces program goals for the area, the Fishers Bend site is in a unique and important natural area where change is coming rapidly:

The Clackamas River Bluffs represent the last remaining opportunity to protect a large regional park site within this rapidly developing portion of Clackamas County. Uncommon habitat types in this area, resulting from wet and dry conditions in close proximity, create a rich diversity of plant and animal habitats (e.g., oak, madrone, and fir mixed into side canyons of cedar). The site also abuts the Clackamas River North Bank Greenway from Barton Park to Clackamette Park and provides an important link to the lower river and the developing communities of Damascus and Happy Valley.

The Fisherman's Bend Floodplain Complex (the Project site) is located between river mile 11.1 and 11.8 on the lower Clackamas River. The 55 acre site is located half on private land, known as Chrysalis Farms and half on public land owned and managed by Clackamas County Parks. Both landowners are dedicated to stewardship and conservation. The site includes a 2600 foot active, but degraded side channel, four groundwater and surface-water-fed ponds, remnant wetlands, a perched former side-channel and a 1500 foot currently channelized stream set in a mature ash-cottonwood, cedar and Douglas fir forest.

The Clackamas Basin Action Plan (www.clackamasriver.org) recognizes the project site as ODOT/Fishermans Bend Project #102. This site is one of ten high-priority side-channels in the lower river investigated by the Clackamas Basin Action Plan Technical Advisory Committee for its restoration potential.

When this site was identified for restoration, we knew a lot about the Clackamas river and what factors were limiting fish populations but we knew little about the site itself. For restoration planning and project success, it is important to first understand the larger watershed's challenges and restoration priorities then apply that knowledge to the specific restoration site (Roni et.al 2002).

Methods

A Case Study on the Clackamas

The Fishers Bend site in its location at the urban-rural fringe is presented as a case study to demonstrate how natural area acquisition and restoration can be a tool to protect and enhance ecosystem services and build community partnerships. This project focuses on salmon habitat restoration on one site but we hope the process can be used to inspire and inform other collaborative conservation project planning in the region and throughout the NW where managers and landowners are working to restore salmon habitat.

The Fishers Bend restoration project was first envisioned during a river cleanup event in 2002. Table 1 provides an overall timeline of the project since it was first conceived.

Table 1: Fishers Bend 15 Year Timeline

Project Elements	Start Date	End Date
PHASE 1– Project ID		
1.1 Site Identification	May ‘02	Dec‘06
1.2 Site Clean ups	May ‘02	Ongoing
1.3 Preliminary characterization and maps	Aug '06	Oct‘06
1.4 Preliminary report	Nov ‘06	Dec ‘06
PHASE 2 - Acquisition		
2.1 ID owners	Aug '07	Oct '07
2.2 Secure purchase	Aug ‘07	Aug ‘08
PHASE 3 – Feasibility Study		
See details	Apr ‘09	May '11
PHASE 4 – Invasive Removal		
4.1 Survey and characterize invasives	Oct ‘09	Sept ‘10
4.2 Treat and monitor invasives	Jun ‘10	Ongoing
PHASE 5 – Design and Permitting		
5.1 Secure funding	Jun ‘11	Mar ‘12
5.2 Refine designs and submit permit applications	Apr ‘12	Oct ‘12
PHASE 6 - Construction	Jun ‘13	Sep ‘13
PHASE 7 - Effectiveness Monitoring	Sep ‘13	Sep ’17

During a river cleanup on the Clackamas River in 2002, I floated past the Fishers Bend site and was immediately struck by the natural beauty and the restoration potential of the site. During the next three years the site was added to our Clackamas watershed assessment and action planning process for its apparent side channel restoration potential along with 10 other sites on the lower river. It was not until 2005 that I again visited the site with the Conservation Director at Three Rivers Land Conservancy (TRLC), Virginia Bowers, to tour the site. Since TRLC managed a property across the road, I proposed a partnership. We wrote and received a very small grant to map the site and characterize water resources. From this grant, we also hired a hydrologist to make recommendations and suggest next steps. The results of this preliminary study launched a partnership with Ms. Bowers that lasted from May 2005 until June 2011 when the first phase of the project was completed

With knowledge of Clackamas conditions and an awareness of restoration potential for the site, I wrote the grants in Spring 2009. We applied for funding to conduct a feasibility study at Fishers Bend about the same time that I was accepted into the MEM program at Portland State University. The project was subsequently funded by both the Oregon Watershed Enhancement Board and the Nature Conservancy.

My role throughout the project has been the lead proponent and project manager. I managed contractors (a Design Team), landowner and community outreach, recruitment and facilitation of a Design Team and Project Review Team, managed project data and wrote grant reports while Ms. Bowers provided the role of fiscal agent and support. To build community awareness and long term stewardship of the site we wanted the technical team to support a project review team of public and private partners. Together we would investigate conditions and explore restoration alternatives through the feasibility study. A Project Review Team was recruited to represent community and agency stakeholders on the Clackamas. The primary partners on the Review Team included: The Columbia Land Trust, North Clackamas Parks, Chrysalis Farms, the Clackamas River Basin Council, the US Forest Service and Oregon Department of Fish and Wildlife. The process we used to conduct the study is outlined in Figure 5:

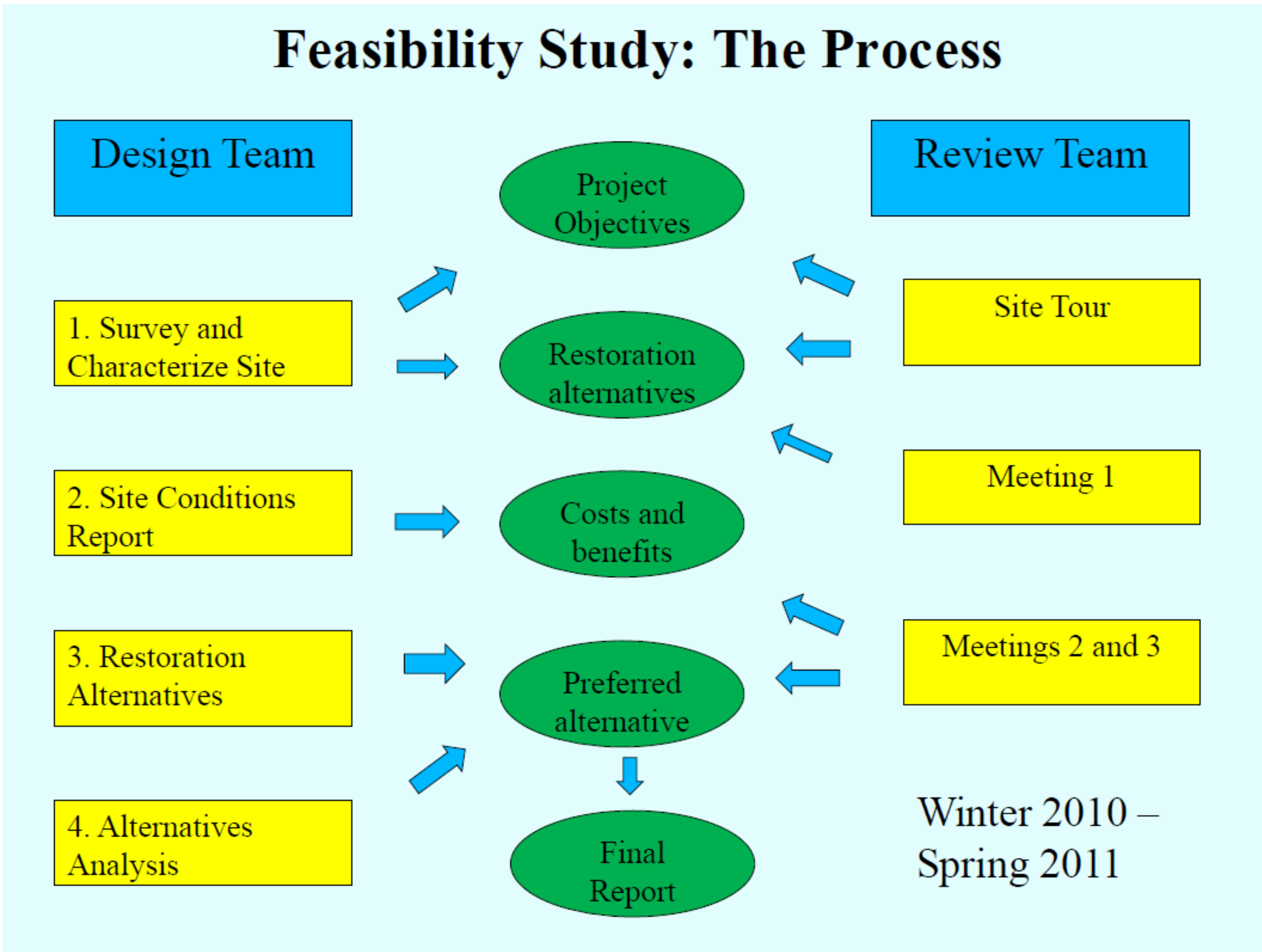

Figure 5: The Feasibility Study Process

The Feasibilty Study

As project manager, I chose to conduct a restoration feasibility study (Table 2) to assess the site's restoration potential and develop restoration alternatives.

Table 2: Fishers Bend Feasibility Study 2 Year Timeline

Project Elements	Start Date	End Date
TASK 1– Start up		
1.1 Project identification	Apr ‘09	June ‘09
1.2 Secure primary partners	Apr ‘09	Aug ‘09
1.3 Secure start-up funding	Apr '09	Nov '09
TASK 2- Scoping		
2.1 Project scoping	Oct '09	Jan '10
2.2Hire Design Team	Dec ‘09	Mar ‘10
2.3 Data gathering	Feb ‘10	July ‘10
TASK 3 – Characterization		
3.1 Characterize site and assess conditions	Apr ‘10	Sept '10
3.2 Develop alternatives	May ‘10	July ‘10
2.4 Involve partners and community - meeting #1	July ‘10	Ongoing
TASK 4 – Design Alternatives		
4.1 Develop alternatives analysis	July ‘10	Aug ‘10
4.2 Develop conceptual plan	July ‘10	Aug ‘10
3.4 Involve partners and community - meeting #2	Sep ‘10	Ongoing
4.3 Select and develop preferred alternative	Sep ‘10	Feb ‘11
4.4 Involve partners and community - meeting #3	Dec '10	Ongoing
4.5 Submit reports	Feb ‘11	May ’11

A site conditions report was developed (Sections 1-4 of Appendix I) that included the following components: Introduction; Background and a Site Assessment. The Assessment includes: a topographic survey, bathymetric survey, soil and groundwater assessment, fluvial geomorphology, riparian and wetland characterization, hydrology and hydraulics.

Once we characterized site conditions and created a map of the site we were able to provide enough background to the review team to develop restoration objectives that would guide the rest of our feasibility study and ultimately help to determine project success.

After being presented the site conditions, the following objectives were reviewed and approved by the Project Review Team:

1. Increase off-channel salmon rearing habitat
2. Enhance high-flow refugia and provide access to cold-water refugia habitats
3. Improve riparian and wildlife habitat
4. Involve the community
5. Provide educational opportunities

One of the primary pieces of information we needed from the site conditions report was how the hydrology of the river interacted with the topography of the site. The study sought to gain a better understanding of the physical setting of the site, its hydrology and how the physical setting of Fishers Bend interacted with peak river flows. From previous observations, we knew the degraded side channel received over bank flood flows only in the highest winter flows and roughly two-thirds of the site would become inundated. We were concerned that salmon may have been stranded in floodplain ponds during these high flow events and we wanted to provide salmon with more frequent access to the side channel to meet our objective of increasing off-channel rearing habitat and high flow refuge habitat. Knowledge of how the river interacted with the site was key to assessing its restoration potential. We specifically wanted to know what high flows activated the side channel and what low flows could provide access for salmonids to the floodplain at the outlet.

A long-term USGS gage (14210000) has been recording water stage since 1908 in the Clackamas River about 1,000 feet downstream of River Mill Dam, about 9 river miles upstream of the Fisher's Bend site. Data from this gage was used to develop peak flow and low flow scenarios for the current conditions hydraulic model (USGS 2010). The Clackamas River basin at the USGS gage has an area of 671 square miles.(TetraTech 2010) These numbers do not include a basin area correction for the nine miles below the gage to the restoration site so results may be slightly higher than actual. The basin area correction will be added to future designs.

To determine peak flow hydrology for the site, a Log Pearson Type III statistical analysis was performed using HEC-SSP v.1.1 (USACE 2009) for 51 peak flow events between water years 1959 and 2009. This period of record was selected as it is most representative of current conditions following the construction of North Fork Dam in 1958. The results of the analysis for the 2, 10, and 100 year recurrence intervals are presented in Table 3.(TetraTech 2010)

Low flows were analyzed using daily average flow data from USGS gage 14210000 for water years 1989-2009. Two flows were selected for evaluation in the hydraulic model: the median low flow for this 21-year period (678 cfs on 9/2/1998), and the lowest observed flow for the 2009 water year (800 cfs on 9/17/2009) Results are presented in Table 4. (TetraTech 2010)

Ground and bathymetric surveys were processed to create ten cross sections for entry into the open channel hydraulic model. The selected hydraulic model was the US Army Corps of Engineers' HEC-RAS v.4.1 (USACE 2010). Additional geometric information for the Fisher's Bend site, including reach lengths and bank locations, was imported from ArcGIS (ESRI 2009) using the HEC-GeoRAS tool.(Tetratech 2010) This model was used to study the hydraulics or how water interacted with the site at various flows. All five flows were entered into the model: median low flow, water year 2009 low flow, 2, 10 and 100 year peak flows. Model output is included as Appendix I-B.

Beyond high and low flows more information was needed to understand the hydrology of the site. As Poff and Mertes suggest, simply studying the peak flows to a floodplain site may be inadequate. Poff states that "water delivery from upstream (combined with associated changes in surface hydrologic connectivity between the floodplain and main channel) is only one potential inundation mechanism". Other water sources include floodplain tributaries, increases in water table elevation in the alluvial aquifer, and direct precipitation as mediated by local drainage patterns on the floodplain. (Poff 2010; Mertes 2000)

To monitor and identify these other contributing water sources, wells were located in the floodplain with piezometers to determine the influence of groundwater and a water level logger was located in the largest pond to determine whether the pond elevation responded to changes in river elevation through hyphoreic flow or whether it may be more influenced by uphill seeps and springs. Visual observations over the past two years indicated that surface flow of about 8 cfs from the tributary stream reaches the downstream pond from November to May and is subsurface the rest of the year. Low flow from the tributary stream was estimated at 1.0 cfs. Flow was estimated visually and not measured with instruments due to limited funding at this level of design. It will be measured in subsequent years for further design.

Further investigation of low flows were conducted to determine the elevation at which the side channel outlet would be connected to the river. The existing elevation of the pond outlet is 126 feet at its confluence with the Clackamas River. Exceedance flow analysis of discharges between October and June in water years 1959-2009 was conducted. Hydrology data was taken from USGS gage 14210000 – Clackamas River at Estacada, OR – located about 9 river miles upstream. The HEC RAS model was then run.

Backed with an understanding of regional and Clackamas Basin priorities and a better understanding of how river hydrology interacted with site conditions, we developed restoration objectives to guide us, we then developed a range of potential restoration alternatives including a cost and risk analysis (Table 3) and selected a preferred restoration alternative (Table 4). The habitat improvements will include large wood and boulder structures to provide cover for juvenile salmon. Juvenile salmon should be able to exit the side channel before June when the water starts to recede.

Methods – Community Involvement

One of the main objectives of this project has been to involve the community. The design process started in late 2009 by gathering existing information on the site and the watershed. In spring 2010, the Design Team, which consisted of fish biologists, engineers, wetland and river ecologists constructed topographic, bathymetric, geomorphic and vegetation surveys to characterize the site. A report on existing conditions was developed and presented to the Project Review Team in July 2010. As mentioned before the Project Review Team consisted of the US Forest Service, ODFW, Clackamas County, Columbia Land Trust, CRBC and Chrysalis Farms. The design and review teams had three joint meetings during 2010 to review data, evaluate alternatives and choose a preferred alternative design. The meetings are summarized below along with a discussion about some major decisions the group made together.

Meeting One - Site tour and existing conditions

In July 2010 the Project Review Team was invited to tour the entire project site. The Review Team was presented with the site conditions report and a site map. A broad range of project options were discussed and reviewed. They were combined and developed into the restoration alternatives. They are summarized in Table 3 .

Meetings Two and Three - Restoration alternatives and developing a preferred alternative

The alternatives from Table 3 were presented along with cost estimates and a risk analysis to the Review Team. Three major decisions were made by the group. 1) No fish passage work would be done on the upper ponds or on the stream as the minimal benefits to fish did not justify the costs. 2) There would be no major excavation of the old side channel to reach ground water as groundwater was considered too deep, too risky and costly to reach. 3) Excavation would focus on the berm at the inlet and providing access at the outlet. The Review Team chose a preferred alternative shown in Table 4. The preferred alternative includes a combination of riparian enhancement, opening downstream access to salmon, adding large wood for cover and to create habitat structure, connecting a stream and existing ponds and then removing a berm to allow side-channel flow at more frequent and lower river flows.

Table 3: Restoration Alternatives

Measure	Description	Construction Costs	Assumed Habitat Benefits	Risks
1A 1B	Stream Channel and Backwater Connection to Pond	$ 64,600 $162,000	Provides connection to rearing habitat in pond	Sedimentation, scour
2	Excavation of Subsurface Channels	$212,700	Provides connection to upstream habitat for adults and juveniles	Sedimentation, scour
3	Regrade Stream for Fish Passage	$101,000	Provides connection to upstream habitat for adults and juveniles	Sedimentation, scour
4A	Pond Wildlife Wetland Enhancements	$18,400	Enhances pond habitat for fish, amphibians, reptiles and birds	Low
4B	Fish Screen	$30,600	Prevents downstream passage of invasive fish species	Debris buildup
4C	Eradication of Invasive/Predatory Fish	$18,400	Eliminates invasive fish species	Incidental take, unsuccessful removal
5	Weir Modification	$23,000	Allows increased control of stream flow	Lack of operation
6	Revegetation, Bank Plantings, and Wetland Restoration	$218,800	Restores native riparian and wetland habitat in upstream reach	Invasive vegetation not eradicated
7	Groundwater Gallery for Flow Augmentation	$171,400	Allows controlled increase of flow in stream	Lower flow than predicted
8	Reconnect Existing Overflow Channel - High Flow	$190,900	Increases floodplain inundation area during high flows	Scour, sedimentation, damage to downstream habitat elements
9	Introduce LWD, Root Wads to High Flow Channels	$ 111,000	Provides rearing, cover, and thermal refugia habitat for fish. Provides organic nutrients	Scour, vandalism
10	Remove Invasives and Restore Native Vegetation	$808,100	Restores native riparian and upland vegetation	Invasive vegetation not eradicated
11	Lower Elevation of Raised Fields/Pastures	$959,300	Returns filled ground to the active floodplain	Flooding to toe of highway slope
12	Flow Deflectors on South Bank	$167,500	Assists left overbank flow during flood events	Flood damage

Table 4: Summary of Preferred Alternative

Measure	Description	Estimated Cost	Assumed Habitat Benefits	Risks
1	Backwater and Stream Channel Connection to Pond	$ 171,000	Provides connection to rearing habitat in pond	Sedimentation, scour
4	Wetland, Pond, & Wildlife Enhancements	$ 142,000	Enhances habitat for fish, amphibians, reptiles and birds, and eliminates invasive fish species in the ponds	Incidental take, unsuccessful removal of invasives
8	Facilitate Upstream Connection of Existing Overflow Channel	$ 523,000	Increases floodplain inundation area during high flows	Scour, sedimentation, damage to downstream habitat elements
9	Introduce LWD, Root Wads to High Flow Channels	$ 111,000	Provides rearing, cover, and thermal refugia habitat for fish. Provides organic nutrients	Scour, vandalism
10	Remove Invasives & Restore Native Vegetation	$ 653,000	Restores native riparian and upland vegetation	Invasive vegetation not eradicated
	Total Estimated Cost	**$ 1,600,000**		

[1] – Breakdown of costs for Measure #10:

- Remove invasives (20.1 acres) = $185,000
- Vegetative restoration – light (17.5 acres) = $321,000
- Vegetative restoration – heavy (4.8 acres) = $147,000

During the design process and meetings the landowners expressed some concerns. A summary of their major concerns and how they were addressed are summarized in Table 5.

Table 5: Landowner concerns and solutions

Landowner concerns	Proposed solutions	Evaluative comments
Groundwater contamination from herbicide treatment of invasive plants	The land owners have taken the initiative to experiment with a reduced concentration of herbicide to treat knotweed.	In the first year of treatment knotweed biomass was reduced but the plants are still viable. I recommend that if the landowners want to use an experimental approach to eradicate knotweed that they establish and use test plots, do exact stem counts and monitor the amount of herbicide used. It may be more effective and less impact on groundwater to treat the plants once rather than risk long term low dosage which could create tolerance in the plants and may add low levels of herbicide into groundwater.
Erosion of the road bank	Rock was placed long ago to reduce the likelihood of the road being undercut. We are proposing minimal disturbance on the side channel tominimize erosion potential.	Potential erosion should be considered in design. Log and boulder placement should be considered to address this potential risk.
Access to park by beach party goers - garbage, noise and drunkenness were all a concern	A gate and guardrail has limited access to the site from the highway and has reduced parties.	Noise and littering from summer beach parties has been reduced mostly to boaters who use the beach during the day. They often leave in early evening as they still need to float down river to the boat ramp and take out at Carver.
Access to the river and the site for bank fishing and passive recreation.	Winter access could be allowed to the parking lot for fishing. Summer passive recreation use has not been resolved.	A question remains about how to allow for passive recreation like wildlife viewing and swimming but limit noisy and polluting summer beach parties. A no alcohol rule could help but enforcement would be challenging. The gate could be closed in summer at 5 pm and not open on weekends.

The benefits of working with a design team and a community review team is that the two teams can learn about the river and the project from each other. This collaborative process was intended to build community knowledge, awareness and support for the project.

Results

Since the primary objective of this study was to determine restoration feasibility and analyze flows needed to activate and maintain the side channel for salmonids, we will focus our results on high overbank flows and low flows necessary for salmon access.

From the USGS gage at Estacada, we found that the Clackamas River has an annual average flow rate of 3000 cfs. The results from analysis of peak flow hydrology, using a Log Pearson Type III statistical analysis and HEC-SSP v.1.1 (USACE 2009) for 2, 10 and 100 year recurrence intervals are presented in Table 6.

Table 6. Clackamas River peak flow hydrology

Recurrence	**Exceedence Probability**	**Discharge (cfs)**
100 year	0.01	77,900
10 year	0.10	50,700
2 year	0.50	27,700

It was determined through HEC - RAS hydraulic modeling that overbank flow occurs just over the 2 year recurrence interval at the Fishers Bend side channel. Table B-1 in Appendix B contains the data from the model run. This means that there is about a 50 % chance in a given winter that the river will have overbank flow into the side channel. We also found from modeling that the river backs up into the site from below at just above the 2 year flood event (27,700 cfs) at a level of 1.25 feet deep at the outlet suggesting that salmon can access the site at these higher flows and use the side channel to get out of fast water in the main stem of the river.

If we do no restoration at all, we assume the site functions as a refuge at overbank flows of 27,700 cfs but we wanted to explore options for lowering the elevation of the downstream access point to provide a higher range of flows that salmon could access the side channel. This is important for improved salmon survival as flows around 3000 cfs are when coho salmon start seeking off channel refuge in the Clackamas (Cramer 2010, personal communication)

Low flows were analyzed using daily average flow data from the USGS gage at Estacada, number 14210000, for water years 1989-2009. Two flows were selected for evaluation in the hydraulic model: 1) the median low flow for this 21-year period (678 cfs on 9/2/1998), and, 2) lowest observed flow for the 2009 water year (800 cfs on 9/17/2009. Results indicate that the Clackamas River 95% exceedance flow for this time period at the location of the proposed pond outlet is about 725 cfs with a water surface elevation of about 118 ft. This elevation is similar to the 99% exceedance flow for the period November–June for the same study period. Based on existing LiDAR coverage and ground survey of the existing pond outlet channel, the existing channel bottom (thalweg) elevation is about 126 feet. To provide a connection between the river and the outlet channel with about 1 foot of depth for average 95% of the time between October and June, an excavation depth of about 9 feet is needed to lower the channel to 117 ft.(Tetratech 2010) Results are summarized in Table 7.

Table 7 - River hydrology and elevations of future side channel outlet

Exceedence Flow	Discharge (cfs)	Outlet Elevation (feet)
99% Oct - Jun	605	117.8
95% Oct - Jun	726	118.0

These results indicate that 99% of the time from 1959-2009 the river levels were above 605 cfs from October to June and equally that 95% of the time it was above 726 cfs. With this information we will be able to decide how much certainty and how much excavation we need for salmon to access the side channel at the downstream end and how much material we need to excavate.

Projected ecosystem service benefits

By restoring the Fishers Bend site we will be contributing to the improvement of local and regional ecosystem services. It is anticipated that water-related cultural services and supporting services for fish and wildlife habitat will benefit the most from our restoration work at Fishers Bend. These two ecosystem services identified by Brauman et al are listed in Table 4 along with other relevant ecosystem services found at Fishers Bend. They are each listed, ranked and a rationale describes why each received a ranking from Low to High. A low ranking means that the ecosystem services derived from this restoration project are not expected to produce a significant benefit to the community.

Table 8: Ecosystem services benefits of restoration at Fishers Bend

Service	**Benefit**	**Rationale for Ranking**
Supporting services for plants, fish and aquatics	High	Improved riparian condition, off channel rearing and adult refuge, channel complexity and habitat diversity are all needed. Since juvenile rearing habitat is so rare in the lower Clackamas and even the lower Willamette the benefits are ranked high.
Cultural services for recreation, spiritual and intrinsic values	Med High	Being a very accessible and visible public site it may be become quite valuable to folks
Increased outdoor recreation	Med. High	Bank fishing, wildlife viewing, nearby natural area access, swimming
Increased adult salmon catch	Low	With more side channel habitat restoration occurring in the watershed we may notice an increase in return of adults if other conditions are favorable for salmon.
Increased marine nutrients	Low	We do not expect spawners at this site but more adults are likely to return to the river
Drinking water filtration	Low	This benefit is not expected to increase
Carbon sequestration	Med	As trees are planted and get established this will start
Soil development and nutrient cycling	None	Not expected to increase, perhaps decrease from more flow in channel

This project will benefit water related cultural services such as recreation, spiritual and aesthetic values. Our restoration project is intended to remove invasive species and will eventually improve public access to the site by establishing a trail and opening the parking lot to the public during part of the year. The improved access to the site will also allow for passive recreation such as wildlife viewing and hiking that will improve cultural services and provide intrinsic and aesthetic value. The fact that the site is on a city bus line may make it one of the most accessible and best quality fishing and swimming holes in the region. When river restoration results in both on-site recreation and increases in populations of rare or endangered fish, there will often be an existence and bequest value adding to the impact of ecosystem services benefits (Krutilla, 1967; Loomis and White, 1996) When our work is completed this will surely be one of the closest and most accessible salmon refuges to the Portland Metro region. With thoughtful and adaptive management, we expect improved access and habitat for bank fishing, wildlife viewing, swimming and the added spiritual, educational and intrinsic values of a publicly accessible and well-managed natural area.

Enhancement of 30 acres of riparian floodplain will improve supporting services for wildlife and fish. Our restoration plan will enhance native vegetation already on site and jump start riparian succession. In addition by reducing competition from invasive plants, native species recruitment will occur naturally. Native plants will provide better food, more plant biodiversity and structure for wildlife. The existing tree canopy at Fishers Bend needs inter-planting of additional trees, especially conifers. Adding mid-level shrubs will help to feed and provide cover for a broader diversity of wildlife. Our plan will encourage wildlife diversity, provide long term large wood for in stream habitat structure, help maintain cool water temperatures by providing tree shade and stabilize stream banks. Restored riparian areas can more effectively uptake nutrients and capture sediments thereby improving drinking water quality. Deeper roots of native riparian species can better prevent soil erosion and sequester carbon. By restoring the floodplain forest we will enhance the ecosystem services described by Brauman as water-related supporting services for aquatic organisms and fish.

Current floodplain ecosystem services provided at the site include adult salmon refuge during high flows as well as supporting services such as soil development and nutrient cycling. .

Refugia habitat will increase due to extensive large wood placement throughout the 30 acre floodplain. By lowering the inlet to the side channel this will allow the floodplain to function more frequently at lower flows. By providing juvenile salmon refuge from predators and allowing access to side channels where they experience increased growth rates through the first year they are more likely to survive and return as adults. By increasing the number of adult salmon returns all the ecosystem service benefits provided by adult salmon including recreational, spiritual, economic and marine nutrient benefits of salmon can potentially be realized. Soil development and nutrient cycling are likely to decrease due to our project as increased flows through the channel will move sediment through the floodplain complex rather than settling as in the past.

This paper does not attempt to calculate a break-even point for investment of funds but we did consider the cost of similar projects in our alternatives analysis. To calculate a break-even point would require us to conduct an ecosystem services valuation or monetization project which is beyond the scope of this project. This paper also does not distinguish between environmental benefits and ecosystem services. In fact, I use them interchangeably. Although a quantitative ecosystem services valuation was not planned or conducted within the scope of this project, I recommend that monetization be a next step. It is important however to be mindful that monetization cannot and should not be expected to capture the myriad functions, values and benefits provided by a restored floodplain forest or any ecosystem. In addition, spiritual and intrinsic values are difficult to monetize as people do not typically pay for these. Some researchers have warned against valuation for restoration projects because restoration projects rarely can expect to provide a full suite of ecosystem functions and processes for many years after construction. (Palmer and Filoso 2009) In addition, with current policies, practices and funding levels for restoration monitoring it would be difficult to expect that we could assign or ascertain accrued ecosystem services benefits from restoration projects. (Bernhardt 2005, Palmer and Filoso 2009) However, an effort to develop such a monitoring protocol and funding to do an ecosystem valuation of floodplain projects on the Clackamas could provide a great opportunity for a community-university partnership.

Discussion

This paper examined how communities can work together to identify, protect and begin to restore ecosystem services provided by our local rivers. By using a case study, we described the process used to study the feasibility of restoring off-channel habitat in the lower Clackamas river.

After completion of the Feasibility Study, results indicated that the project will provide a half mile of off-channel juvenile salmon rearing habitat and enhance approximately 25 acres of riparian floodplain habitat by placing large wood, removing invasives and planting native trees and shrubs. Our investigations found that more off-channel habitat can be created by placing large wood structures and encouraging the river to scour an existing side channel on the south side of the project site. Proposed riparian enhancements and removal of invasives will provide improved habitat for song birds and cover for other wildlife species known to be in the area such as coyote, beaver, river otter and western pond turtles.

By addressing limiting factors for salmonids in our restoration project, we are building resilience and helping to improve survival of Clackamas juvenile and adult salmon populations. We are addressing channel complexity, habitat diversity and temperature. By adding large wood structures and boulders to the floodplain site we will provide cover and refuge from high flows for both adult and juvenile salmon. Improved side-channel access for juveniles will provide critical rearing habitat where juveniles can find cover from predators, forage for food and grow for their journey to the ocean. Access to cold water habitat in summer could be an added benefit. Enhanced riparian areas will provide food and habitat for a diversity of aquatic species that feed young salmon. Improved shading will help keep water temperatures cool. By designing for limiting factors, we are addressing regional priorities while improving conditions at the local level.

Community benefits of restoration

Besides the benefits realized through the review team process, I want to explicitly identify and summarize expected benefits of this restoration project to the local community. The local community will benefit from expanded ecosystem services particularly related to recreation as identified in Table 4: Ecosystem Services and Environmental Benefits. Primary recreational benefits from our restoration activities will be the enhanced quality of nature walks and wildlife viewing due to riparian forest enhancement and better access to the river for bank fishing, swimming or other river-related activities. Local youth have already started benefiting from educational opportunities at the site thanks to educational tours provided by Chrysalis Farms. Hundreds of students visited the farm in the past two years, with plans this summer to include the local Boys and Girls Clubs and scouts. Starting this summer the PSU Student Watershed Monitoring Project (SWRP) will sponsor student monitoring of water quality parameters such as temperature, DO and turbidity at the site. The growing community of Damascus and residents of the Metro region in general will benefit from the existence value of endangered salmon close to an urban area. Finally, by involving representatives of the Clackamas restoration community on the Project Review Team such as the Forest Service, ODFW, CRBC and the County this community has learned more about the Clackamas river and they have developed ownership for success of the project. This not only builds support for the project now but will increase chances for long term community based maintenance and adoption of the site after project construction.

As discussed earlier, the goal of community ownership of restoration sites is important for long term success and sustainability of local government and nonprofit natural area acquisition efforts. I recommend that a long term study in the Damascus area be conducted to explore how values about the Clackamas River and related ecosystem services change over time as the area grows and community demographics change.

Long term viability of the project

The long term viability of restoration actions should be seriously considered in any restoration project. The life of the project depends on two major variables: how long do the project proponents and funders expect their investment to last and how does the hydrology, channel morphology and the geomorphology of the river affect or change the project. One thing to expect from rivers and floodplains is that they will continually change as a dynamic ecosystem. Typically changes occur during high flows or channel-forming flows. Sometimes a careful observer can notice changes from one year to the next. Sometimes ill-conceived restoration projects are blown out in the first flood.

Long term viability of proposed site improvements should be considered early in the design process. At Fishers Bend, the design team started to consider long term viability in the alternatives analysis and cost benefit analysis. For example, as a design and review team we considered an infiltration gallery (harvesting groundwater and piping it into the channel) that would have potentially required a lot of maintenance and ongoing costs. We chose a more passive restoration approach that will remove a berm and allow the river to do the work of creating channels rather than excavate a large amount of soil ourselves. Though we chose a viable alternative, there are at least three dynamic processes occurring at Fishers Bend that are important to consider in design and could still affect long term viability of the project.

Some changes are occurring on the SE bank across the river from our site (Figure 6). First, the river appears to be down-cutting against the rip rap where houses are located.

Figure 6: Homes protected by rock riprap

If down-cutting continues to lower the elevation of the river it could make high flows lower over time which means that high flows may reach the Fishers Bend side channel less often. Another change that appears to be occurring is erosion of the bank upstream of the rip rap. If erosion continues it could cut around the houses or even through them. This would have profound effects and it is likely that the landowners would move to counteract this action by placing more rip rap if they are allowed. What they do not seem to understand or care about is that rip rap does not stop erosion it just makes the river transfer that erosive energy elsewhere downstream. If a massive bank failure occurred across the river it would likely affect how and when water enters the side channel.

The third dynamic process is that the Fishers Bend floodplain is currently functioning to trap and settle sediment at the site during high flows. It is estimated from soil borings in well site one that up to 8 feet of sediment has been deposited since the last time it was an active main channel. (Tetra Tech 2010) It is apparent from site visits that after each flood a new layer of sediment is deposited. The risk is that sediments could plug the outlet or the inlet of the side channel making maintenance necessary. The current hypothesis of the design team is that by lowering and opening the entrance to the side channel to more frequent and lower flows that the channel will be kept open by these flows. Wood and boulder structures will be placed to focus flows and essentially scour a new channel. Further engineering and design will shed more light on this hypothesis.

Lessons to learn from similar projects

The practice of floodplain restoration is dynamic. It is important that we learn lessons from our work and each other. Our restoration efforts are best viewed as experiments, from which we can learn valuable lessons to improve future project design (Kondolf, 1995). There are recently constructed floodplain reconnection and juvenile rearing channels throughout the northwest that can provide "lessons to learn." I will draw lessons from projects on the Columbia, Willamette and focus mostly on a very local side-channel project on the Clackamas just upriver from Fishers Bend.

Lessons from the region

I chose to review lessons learned from a floodplain reconnection project at Mirror Lake, sponsored by Oregon State Parks on the Columbia River. Like Fishers Bend, the project provides 0.5 miles of habitat reconnection to a off channel rearing area. The one lesson we share is, "stay focused on project goals." During both of our initial project phases we rejected several alternatives that would not have achieved our specific goals. For Fishers Bend, we rejected the idea of excavating large amounts of soil to reach groundwater because one of our restoration goals was to embrace passive restoration techniques where possible. We also rejected a tributary stream restoration project because it could not have provided off channel rearing.

In 2008, Dave Hulst and Stan Gregory hosted a Willamette floodplain restoration "lessons learned" conference. Hulst wrote, "lessons from the 2008 conference indicated that the past decade of floodplain restoration projects in the Willamette floodplain have been primarily opportunistic… The next decade offers the potential to move from an era of opportunism to one of strategy once new prioritization and assessment tools and information become widely available." For the Fishers Bend project, I have gone to great lengths to nest the project in local and regional restoration priorities. I have a great interest in learning more about one of the prioritization and monitoring tools they describe as "slices". Slices take 100 meters of a river reach and characterize it. Each slice can then be monitored over time and compared to other slices in the same river floodplain.

Lessons from the Clackamas

Just upstream on the Clackamas, a cluster of constructed side channels were completed in 2005 less than a mile from Fishers Bend. I have toured these sites several times to watch construction and see how it is functioning. Two major issues the project proponents have dealt with are instructive for Fishers Bend.

1) The entrance to the side channel may get plugged by gravel and boulders.

This is a challenge for all side channels as gravel moves downriver and gets deposited. The entrance to the side channel upstream was located at a pool tail out where gravel is often deposited during high flows. The project managers addressed this by constructing a second entrance upstream where the pool is much deeper and the side channel entrance will be securely within deep water. Could the entrance plug at Fishers Bend? Yes, it is possible that the constructed entrance could become blocked by sediment or gravel. Although there is more design to do on the inlet we have discussed conceptual designs. To address the possibility of gravel accumulation, we will construct a log crib that will encourage scouring of sediments to keep the entrance clear. We also considered another entrance to the side channel upstream but it was discarded due to erosion potential of the river bank near a home.

2) The main river could migrate into the constructed side channel

The project upstream was threatened by the river eroding a bank that separated the side channel from the main channel. This would have altered half of the project. Two years after project completion, extra reinforcement of the river bank was needed in the form of log cribs to protect the bank from being eroded by the river. It appears this action secured the bank and will prolong the life of the constructed side channel. Could this happen at Fishers Bend? The historic stability of the river and side channel was discussed in D above. It is possible that at some point in the future the river will migrate back into the side channel but it would likely be many years based on the aerial photos and the current morphology. In addition, since the river is starved of large wood and sediment from the dams upstream it is likely that there will not be significant changes to the geomorphology of the lower river until the dams are removed. Since the dams were recently relicensed for another 50 years it will be at least that long.

The fact is that we can never be completely sure that a restoration project is going to work. The best we can do is to study the site, learn from others, practice adaptive management when inevitable changes and challenges arise, document the rationale for our thoughtful decisions and learn from our mistakes.

The next steps at Fishers Bend are to: 1) secure funding for the next phase of design, and 2) raise funds that allow us to continue work removing invasive species from the site. We expect that community partnerships and stewardship activities will grow as more funding becomes available in the near future. With continued funding, invasive species control, and further design, on-the-ground work can begin. If all goes well with funding and permits, access to the side-channels and placement of large wood could start in summer 2013.

There are some interesting design challenges to address as we move forward with this project. The first design challenge will be to construct an entrance to the overflow channel that will remain open and continue to allow moderately high flows into the side channel. To avoid gravel accumulation at the entrance, which could partially block flow over time, it is assumed that we will create a scour pool by using a wood crib and large wood keyed deep into the bank to keep the entrance clear. The second challenge will be to design the outlet so that existing pond levels are preserved and side channel access can be gained by salmonids from at least November to May.

Another challenge will be to concentrate over bank flow in the middle of the site as it currently tends to spread out over the entire floodplain. Currently, once the water hits the tributary stream in the middle of the floodplain, it spreads out and slows down dropping out and depositing fine sediment. This is one of the benefits of the floodplain but sediments could build up at the downstream end where we want to provide fish access to floodplain ponds and the side channel. Although the preferred alternative recommends lowering the inlet and outlet, we hypothesize that by directing over bank flows from upriver that enter the floodplain site into a deeper, constructed and vegetated, benched channel that flows will become concentrated enough to flush sediments and maintain access for fish at the outlet. It is a fine balance between concentrating flow enough to periodically flush sediments yet slowing high flows enough to provide salmon refuge through retention of log structures and newly planted vegetation that is intended to provide improved habitat for salmon and other wildlife.

Riparian habitat at Fisher's Bend will be in much better condition once invasive species are removed. To be successful with riparian restoration, we must deal with the source of invasive knotweed upstream. From 2004 to 2007 over 150,000 stems of knotweed were treated in the floodplain and tributaries upstream of the project site. This has effectively eradicated it from the river down to Deep Creek. What remains wholly untreated is Deep Creek whose mouth is just upstream of the project site and it is completely infested with knotweed. Regular monitoring and treatment of knotweed on our project site will be necessary until Deep Creek, the primary source of knotweed is dealt with properly. Collaborative partnerships will be needed to address this challenge.

Ongoing monitoring of the site before after project construction will be important to success of the restoration project. For design purposes, we recommend continued monitoring of groundwater, pond levels and surface water to further investigate the relationship between them. As for effectiveness monitoring after construction, all too often, project managers do not include this type of monitoring in their funding requests. By thinking ahead about the monitoring needs of the project it may help to secure funds that can cover this important aspect of restoration, otherwise, how are we and others to learn from our work? Monitoring for completion will be required for most grants related to the project. This will document changes in vegetation and habitat structure and signal whether we need to intervene, for instance, to control invasive weeds.

Effectiveness monitoring can be done to determine whether project objectives are met on a local, watershed or regional scale.(OWEB 2011) Such in depth monitoring will likely require partnerships with a school or university. With thoughtful monitoring, we can protect our investment and help to ensure that habitat improvements will benefit fish and wildlife and related ecosystem services.

Regional implications

The Fishers Bend site is unique in that it is immediately adjacent to a major metropolitan urban area, yet it provides critical habitat functions and values needed by juvenile and adult salmon in a watershed that still has good potential for salmon recovery. For example, just downstream from Fishers Bend, Richardson Creek in Damascus still has naturally spawning coho and steelhead.(Ecotrust 2002) In contrast, not one creek within the Portland city limits still has a viable salmon run.

The similarities of the Fishers Bend site to other floodplain sites is part of what makes it valuable for restoration. By investigating historic photos and walking the side channel at Fishers Bend one can see that it used to be a major branch or main channel of the Clackamas River. Like other off channel areas, it can provide a relatively cold water refuge and cover for juvenile salmon once they access the floodplain site. Since the Fishers Bend site is on an inside bend there will be less erosive potential on future constructed restoration elements such as large wood structures. As Figure 2 of the Willamette historic channel shows there are potentially many old channels like Fishers Bend that could be restored throughout the mainstem of the Willamette and in its tributaries. The history of side channels as part of the river means that currently inaccessible ponds or isolated backwaters like Fishers Bend could, with renewed access to salmon, contribute significantly to salmon recovery in the Willamette and its tributaries.

Salmon and river-related ecosystem services are threatened in the lower Columbia and the Clackamas for many reasons such as overfishing, dams, hatcheries, the loss of historic habitat and urban development. In this project we focused on improving habitat and water quality because they are two major limiting factors that can be addressed locally through collaborative and community-based conservation. Our restoration work will enhance high flow refugia for adult salmon by placing large wood in the floodplain, it will provide juvenile salmon access to an off-channel rearing area with shelter from predators and access to a coldwater refuge in summer.

In this paper and the project, I do not imply that we can solve the Clackamas river's limiting factors by doing one project but through this case study we can demonstrate a way to begin restoration of a regionally significant and strategic natural area. We can provide an example for how to tailor local restoration objectives to address regionally significant conservation issues. It is not expected that our actions at Fishers Bend will completely protect or restore the broad array of valuable ecosystem services provided by the Clackamas river but perhaps by example we can encourage communities up and down stream to start recognizing and investing in their local ecosystem services.

In summary, I want to emphasize that ecosystem services are more than marketable and tradable commodities, rather they are extremely valuable and irreplaceable community assets to be protected, restored and passed down to future generations in better condition than we found them. As more projects that address limiting factors and regional restoration priorities are completed and watershed conditions improve, the cumulative effects of restoration on a watershed scale has potential to improve salmon survival, enhance ecosystem services, build community and lead to a more sustainable future for us all.

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