A SPATIAL ASSESSMENT OF CONSERVATION OPPORTUNITIES IN THE WILLAMETTE RIVER FLOODPLAIN BETWEEN CORVALLIS AND ALBANY, OREGON

By

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A Spatial Assessment of Conservation Opportunities in the Willamette River Floodplain between Corvallis and Albany, Oregon

Abstract

The Willamette River floodplain has been highly modified by urbanization, conversion of land to agriculture, construction of dams and revetments, and regulation of flow, all of which have reduced floodplain processes that provide valuable ecosystem services such as fish and wildlife habitat and flood storage. Efforts to protect and restore floodplains have increased in recent years as scientists and conservationists have began to recognize the importance of functioning floodplains to help recover native fish populations and mitigate flood effects. Restoration and protection of floodplain processes is linked to both the past land-uses that degraded the ecological systems and the current uses that sustain rural communities and farmers. This project assessed the opportunities to protect and restore floodplain forests and channel complexity in the floodplain of the Willamette River between Corvallis and Albany, Oregon. A geographic information system was used to analyze suitability for conservation in terms of floodplain forest, channel complexity, and human uses on a pixel by pixel basis across the floodplain. Suitability maps show the best locations to protect and restore floodplain processes while minimizing impacts to human uses in the floodplain. Most land highly suitable for conservation purposes is located near the current river channel. Some identified sites can be restored with little or no impact to private lands while others cross multiple ownerships and will be more challenging to restore. The goal of this project is to contribute to conservation planning and actions in the study area.

Key Words: floodplain, riparian, conservation, restoration, suitability analysis, land use, Willamette River.

1 Introduction

The Willamette River floodplain has been highly modified by urbanization, conversion of land to agriculture, construction of dams and revetments, and regulation of flow, all of which have reduced floodplain processes that provide for fish and wildlife habitat and flood storage (Hulse, Gregory, and Baker 2002). While these modifications were deemed necessary for economic development during the nineteenth and twentieth centuries, the last few decades have seen a growing appreciation for the ecosystem services provided by these processes. Flood pulses and periodic inundation of floodplains, for example, are responsible for creation and maintenance of side channels and alcoves and the exchange of nutrients and sediments. The riparian or gallery forests that occur in floodplains provide habitat for a variety of terrestrial species, provide nutrients and organic materials for nutrient and energy cycling, and during floods slow the movement of water and provide refugia for fish. Slow moving sloughs and alcoves are especially important to the Oregon chub, a Willamette Valley endemic species that is listed as endangered under the federal Endangered Species Act (ESA). Also listed as threatened under the ESA, upper Willamette River steelhead and Chinook salmon utilize floodplains for foraging and refuge from high river flows during juvenile life stages.

A number of recent assessments have established the need to restore floodplain habitat to assist recovery of native fish populations (National Marine Fisheries Service 2008; Oregon Department of Fish and Wildlife 2010; Primozich and Bastach 2004) and identified specific areas along the river for conservation and restoration (Floberg et al. 2004; Hulse, Gregory, and Baker 2002; Oregon Department of Fish and Wildlife 2006);

and several agencies and conservation organizations are actively engaged in funding or implementing conservation projects. Existing assessments were developed at regional scales to identify potential conservation opportunities. In order to effectively implement conservation actions, however, data and information at more local scales within specific identified areas must be synthesized and analyzed.

The purpose of the project described in this paper is to assess the opportunities for conservation of the floodplain along a reach of the Willamette River between Corvallis and Albany, Oregon. This reach was identified in the Willamette River Basin Planning Atlas as important because it has high ecological potential for restoration and low economic and demographic constraints (Hulse, Gregory, and Baker 2002). Local conservation organizations, such as Greenbelt Land Trust, are in need of more detailed information to help prioritize projects and more effectively utilize scarce resources.

1.1 Conservation and Restoration Planning Approaches

Successful conservation planning must take into consideration social and economic factors in addition to ecological factors and conservation goals. Concepts and principles from literature on rural resource planning and rural sustainability can be helpful for achieving conservation successes in rural areas. According to Sargent et al. (1991) “the intent of rural *environmental* planning is to develop the ability of rural residents to manage a sustainable environment, a viable community economy, and other aspects that make up the rural ecosystem.”

Integration of ecological information into rural resource planning can be challenging, however. There are mismatches between spatial and temporal scales of ecological processes and planning. Ecological processes occur across wide landscapes and over long time periods, while rural planning, especially land-use planning, occurs at local levels defined by political boundaries and discrete time periods. The cumulative effects of many discrete land-use decisions can be difficult for planners to visualize (Theobald et al. 2005). Available ecological information is complex and interdisciplinary, requiring a framework to integrate it into land-use planning (Theobald et al. 2005; Theobald and Hobbs 2002) and requiring integration of disciplines (Hilty and Groves 2009). Meaningful environmental indicators must be developed to help inform rural planning processes (Theobald et al 2005). Collaboration among citizens, planners, and technical experts is another key principle, thus, ecologists and biologists must be willing to work in collaborative community based processes with citizens and local planners for extended periods of time (Hilty and Groves 2009; Sargent et al. 1991; Theobald et al. 2005; Wilhere et al. 2007).

1.1.1 Conservation and Restoration Planning

In general, conservation planning consists of two primary steps: assessment and action. Conservation assessments are used to determine *where* to conserve, whereas conservation actions refer to the strategies that define *how* to conserve (Hilty and Groves 2009; Redford et al. 2003). At global scales conservation assessments have identified biodiversity hotspots and regions of high species richness or endemism, while at regional scales they have been used to identify regional conservation priorities and areas in which to focus conservation actions. Local-scale assessment and action planning takes place at the county, watershed, or site level and may be utilized as part of land-use planning efforts.

Conservation actions, *how* to conserve, can include a variety of tools. Protection of existing habitats or ecological features can be achieved through acquisition of property or conservation easements, agreements with landowners, or voluntary efforts of landowners. Degraded habitats or ecological processes can be restored by changing land uses, modifying practices, promoting development of native vegetation, and reconnecting fragmented habitats (Hilty and Groves 2009; Margules and Sarkar 2007).

Systematic conservation planning is a step-wise process used to measure, map, and protect biodiversity using networks of protected areas or reserves (Margules and Pressey 2000; Margules and Sarkar 2007). It is designed to review existing reserve networks, evaluate the level of biodiversity protected in existing reserves, and determine the need for and select supplementary reserves to protect biodiversity in a given region. Implicit in the process of systematic conservation planning is the need to identify and involve stakeholders who may be affected by conservation actions, who have decision making authority, and who can provide resources (Margules and Sarkar 2007).

With over 90 percent of low elevation productive lands in private ownership in the United States (Adams 2009; Scott et al. 2001) the importance of working with local landowners and across administrative boundaries cannot be overstated. Artificially imposed administrative or ownership boundaries allow for different land-use practices and management on opposing sides of boundaries that can disrupt physical and ecological processes and patterns that affect the distribution of species and habitats (Landres et al.

1998). Most existing protected areas were created on lands that were less productive and of lower economic value (Scott et al. 2001) and were not necessarily created to represent the greatest ecological values (Adams 2009). To achieve greater ecological values conservation planners should understand the social dimensions of boundaries (Brunson 1998) and should seek to engage private and public landowners in collaborative stewardship across spatial, legal, institutional, and administrative boundaries (Meidinger 1998; Knight and Clark 1998).

1.1.2 Suitability Analysis

Suitability analysis is one planning technique used commonly for spatial conservation prioritization (Ferrier and Wintle 2009) as well as for land-use, regional, urban, and environmental planning (Malczewski 2004). It is based on concepts of map overlays pioneered by Ian McHarg in which attributes are ranked, overlaid, and displayed to show composite suitability related to the features of interest (Malczewski 2004). The technique has limitations, however, if considering 'representation' or 'complementarity' of biodiversity attributes (Ferrier and Wintle 2009).

Examples of suitability analysis in conservation and restoration planning include identification of conifer restoration sites with potential for anadromous fish in western Washington State (Mollot and Bilby 2008), identification of nature conservation priorities in an alpine valley in Italy (Geneletti 2004), and forest conservation planning in Malaysia (Phua and Minowa 2005).

1.1.3 Willamette River Planning

A number of systematic conservation planning efforts have taken place in the Willamette Basin and made available to the public and conservation practitioners, including the *Willamette River Basin Planning Atlas* (Hulse, Gregory, and Baker 2002), the *Oregon Conservation Strategy* (Oregon Department of Fish and Wildlife 2006), the *Willamette Subbasin Plan* (Primozich and Bastach 2004) and The Nature Conservancy's *Willamette Valley-Puget Trough-Georgia Basin Ecoregional Assessment* (Floberg et al. 2004). Identified conservation goals include restoration of floodplain function, critical off-channel habitats, and channel complexity; reconnection of the river and floodplain; protection and restoration of floodplain and riparian forests; and increases in non-structural flood water storage (Hulse, Gregory, and Baker 2002; Oregon Department of Fish and Wildlife 2006; Primozich and Bastach 2004).

Hulse and Gregory (2004) analyzed the potential for protection and restoration of Willamette River floodplains at three scales, 1) river network, 2) reach, and 3) focal area, with a focal area being a specific location identified for restoration. A geographic information system (GIS) was used to identify focal areas on the Willamette River having high ecological potential and low socioeconomic constraints, where restoration was potentially feasible. The authors then suggested example restoration goals at the focal area scale, such as 1) increase channel complexity, 2) increase floodplain forest, and 3) increase non-structural flood storage. They noted that a number of focal-area socioeconomic, political, and ecological constraints would need to be considered in future conservation efforts, including landowner willingness, proximity to population centers, percent of public ownership, presence of transportation infrastructure, presence of remnant channels, type and extent of revetments, historic channel dynamics, flood storage, and fine-grain analysis of historical vegetation (Hulse and Gregory 2004). This research has been important in narrowing the focus of conservation efforts to specific focal areas but it did not analyze how or where to implement conservation actions within focal areas.

1.2 Goals, Objectives, Research Questions, and Deliverables

The purpose of this project was to assess the opportunities for conservation of the floodplain along a reach of the Willamette River between Corvallis and Albany, Oregon. The primary goals were to identify spatially explicit opportunities to protect and restore floodplain processes in the Corvallis-Albany reach; identify limitations that could affect conservation efforts; and ultimately contribute to conservation of the Willamette River.

Specific objectives were to assess the floodplain for suitability for conservation, produce maps for conservation planning purposes, describe factors affecting conservation opportunities, and identify data gaps relating to floodplain conservation along the Willamette River. Maps and suitability models would consider biological, physical, and human factors related to land use and conservation within the study area.

The project was guided by the following research questions and subquestions:

- Where are the best places to protect existing ecological features?
    - Where are remnant channels located? Where are patches of floodplain forest?
- Where are the best places to restore floodplain processes?

  - Where could floodplain complexity be increased by restoring channels and forest?

- What types of constraints might affect conservation and restoration efforts, and where do they exist?
  - How does land use and ownership, in particular, limit or contribute to conservation?

Since one of the goals of this project was to contribute to conservation of the Willamette River, research products will be made available to government agencies and non-governmental organizations interested in land use planning and conservation in the study area. Specifically, reports, maps, and GIS layers obtained or derived for this research will be provided to the Greenbelt Land Trust, a local organization engaged in conservation of the Willamette River floodplain.

1.3 Study Area Description

The study area is located in western Oregon in the Willamette River and Tributaries Gallery Forest sub-ecoregion (Figure 1) of the level 3 Willamette Valley ecoregion (Figure X; Griffith and Omernik 2009) adopted by the Environmental Protection Agency. It extends from Corvallis to Albany, Oregon along the Willamette River and encompasses 3,629 ha of the 500-year floodplain (Figure 2). The Willamette Valley is bounded by the Cascade Range to the east and the Coast Range to the west, drains an estimated 29,785 square kilometers and flows generally northward into the Columbia River. The climate is considered Mediterranean, with cool wet winters followed by warm dry summers (Franklin and Dyrness 1988). Additional maps of the study area can be found in Appendix A.

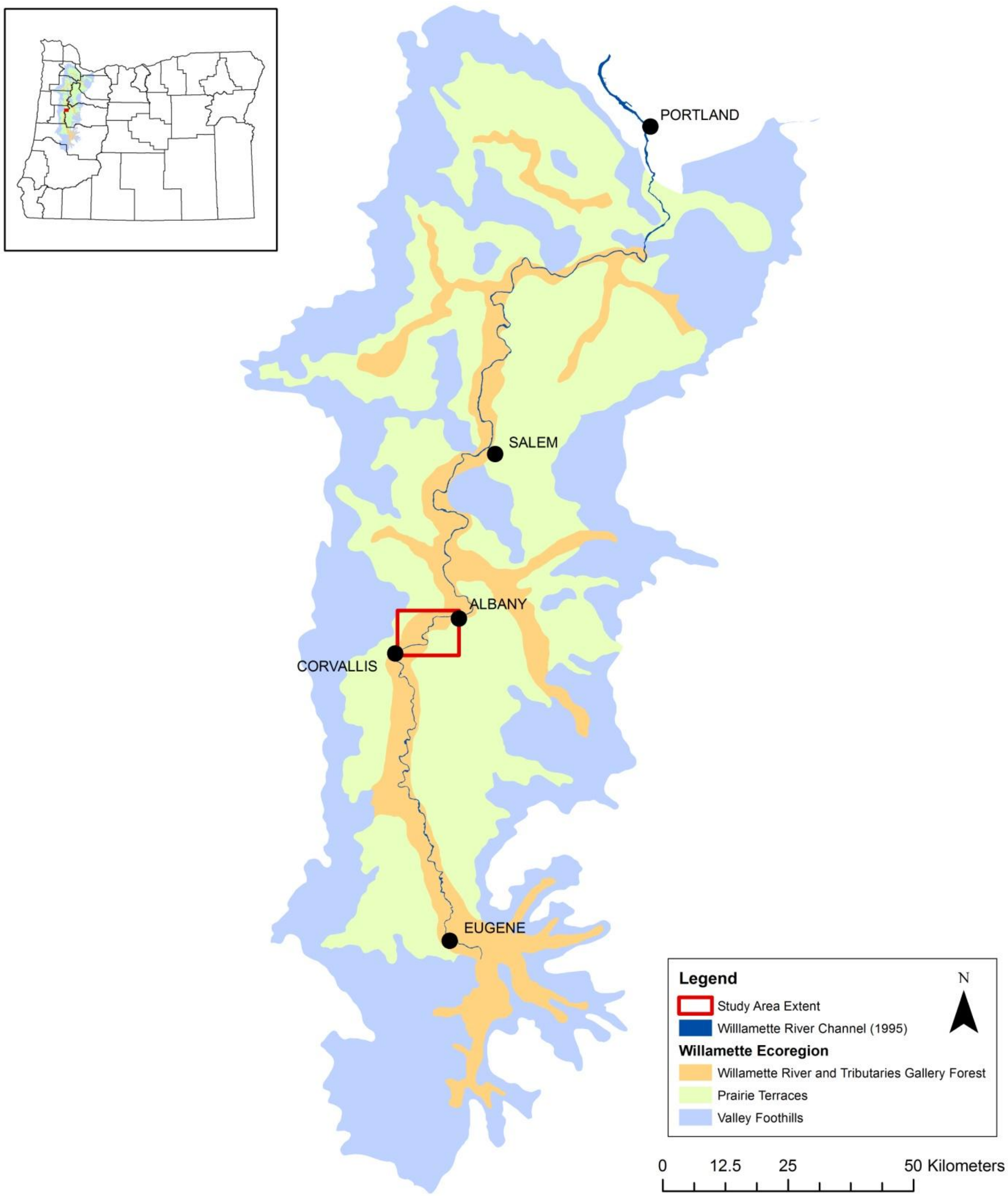

Figure 1. Willamette Valley ecoregion

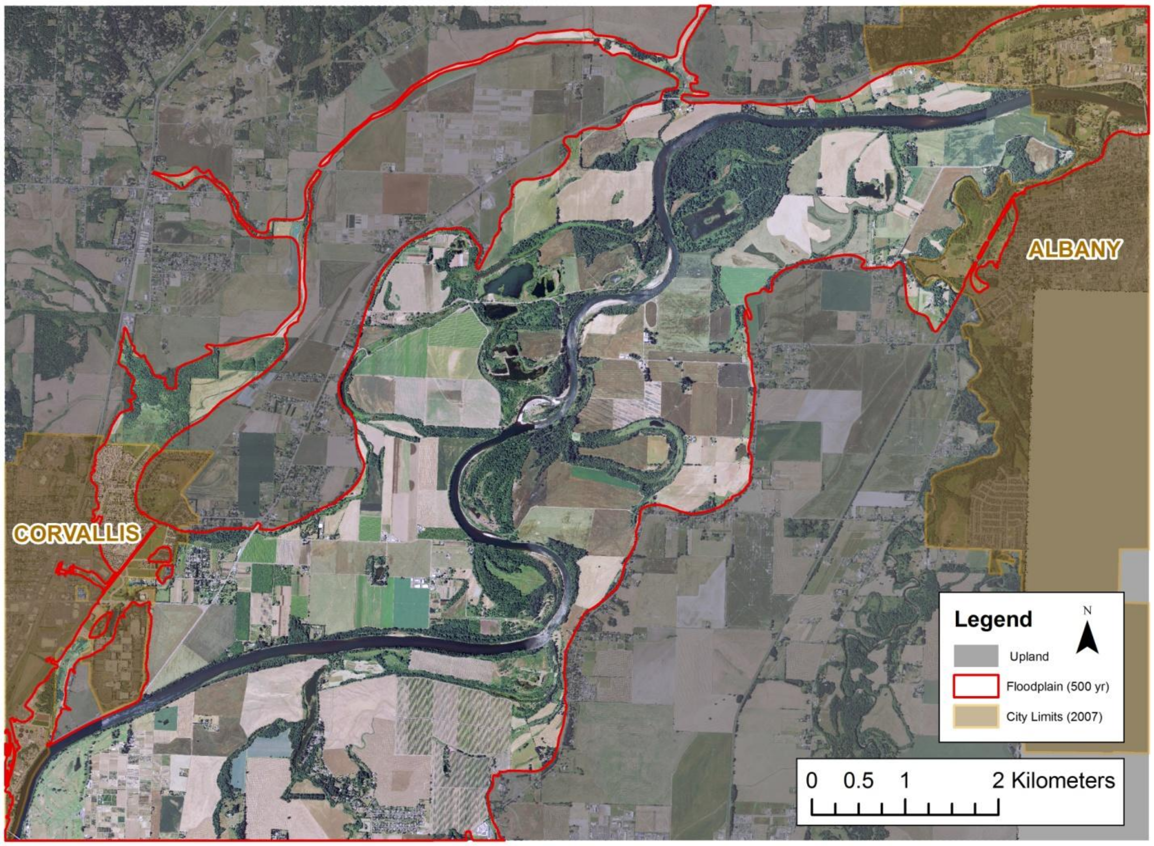

Figure 2. Study area aerial photo. Imagery is from 2009 aerial photographs from the Oregon Geospatial Enterprise Office.

Prior to Euro-American settlement in the mid-19th century the Willamette Valley consisted of broad floodplains, bottomland forests along streams and rivers, oak savannas and grasslands (Habeck 1961; Johannessen et al. 1971). Frequent disturbances caused by Native American burning maintained the open savanna and prairies (Boyd 1986). The broad floodplains were characterized by low-gradient, meandering, braided river channels; oxbow lakes; and meander scars, and were covered with forests (Griffiths and Omernik 2009) that resulted from frequent flood disturbances (Gregory et al. 2002a). According to land survey records from the 1860s and 1870s the study area is thought to have been forested with primarily Oregon ash, black cottonwood, Douglas fir, and big-leaf maple and lesser components of Oregon white oak, laurel, alder, cherry, and willow (Habeck 1961).

As Euro-American immigrants began settling the Willamette Valley, native prairies and forests were rapidly cleared for materials and conversion to agriculture. Between 1850 and 1995, riparian forest complexity, as measured by the length of river with both banks forested, declined by 86% between Eugene and Albany (Oetter et al. 2002). Today, agriculture and developed uses in this area account for approximately 50%, and hardwood and mixed forest 29% of the length of the river, compared to 0% and 89%, respectively, in 1850 (Gregory et al. 2002b).

As the population in the Willamette Valley grew and floodplains were increasingly used for agriculture, concerns over annual flooding increased. Significant floods occurred in 1861, 1890, 1943, 1945, 1964, and 1996 (Gregory et al. 2002c). The U.S. Army Corps of Engineers began planning for flood control dams in the Willamette Valley in the 1930s and 13 dams were eventually constructed between 1941 and 1968, nine of which are located upstream of the study area (National Marine Fisheries Service 2008). Revetments were constructed to protect river banks from eroding, to prevent flooding, and to maintain navigational channels for river transportation (Gregory et al. 2002c).

Along with riparian forests, channel complexity has decreased within the study area due to regulation of the Willamette River by flood control dams and construction of revetments. These structures have reduced the frequency, duration, and intensity of floods that deposit sediments and nutrients in the floodplain, creating and maintaining side channels and alcoves which provide important off-channel habitats for fish and other species. Between 1850 and 1995 in the upper Willamette River from Albany to Eugene (which includes the study area) the total area of river channel and islands decreased from 10,083 ha to 3,332 ha and the total length of all channels decreased from 340 km to 185 km, indicating simplification of the river system (Gregory et al 2002a). The total length of side channels and alcoves decreased by 22% and 74%, respectively between 1850 and 1995 (Gregory et al 2002a). Together, the loss of channel complexity and floodplain forests has compromised the ecological functioning of the floodplains and resulted in the reduction of available habitat for terrestrial species, nutrients available to terrestrial and aquatic systems, and flood refugia for fish (Floberg et al. 2004; Hulse, Gregory, and Baker 2002; Oregon Department of Fish and Wildlife 2006, Primozich and Bastach 2004).

Today the floodplains are characterized by agricultural and urban uses, reduced channel complexity, and remnant forests. Much of the study area is zoned as Exclusive Farm Use and is in agricultural production. Primary crops include grass seed, vegetables, and hazelnuts. Several areas have been used to mine aggregate (sand and gravel) or are permitted for ongoing or future mining (Oregon Department of Geology and Mineral Industries 2010). Urban uses within the study area occur within the cities of Corvallis and Albany and include infrastructure and housing.

2 Methods

Conservation opportunities in the study area were assessed by evaluating spatial factors affecting floodplain forests, channel complexity and land use. A geographic information system (GIS) was employed to analyze geospatial data, conduct a suitability analysis, and produce maps. The GIS framework and suitability analysis are summarized below and a detailed description of the suitability models can be found in Appendix B.

2.1 GIS Framework

All geographic data layers were obtained from public agencies and assembled in a GIS and analyzed using ArcGIS 9.3.1. All layers were projected in the Oregon Lambert Projection, international feet, North American datum 1983, and clipped to a rectangular study extent bounded by the Van Buren Street Bridge at the upriver extent in Corvallis and the Highway 20 Bridge at the downriver extent in Albany (Figure 2). Data layers were analyzed at the rectangular extent and then the results were clipped to the boundaries of the 500-year floodplain.

Vector and raster data sets representing biological, physical, and human factors were used to evaluate floodplain forest, channel complexity, and land-use. Several layers were derived from remotely sensed data sets. A digital elevation model (DEM) produced from high resolution light detection and ranging (LiDAR) was used to map floodplain vegetation and channels. Flood inundation zones were mapped from satellite imagery. Aerial photographs were used for visual analysis and delineation of river features.

2.2 Suitability Analysis

Suitability analysis utilized the layers in Table 1 to develop submodels of floodplain forest, channel complexity, combined floodplain forest-channel complexity, and land use which were composited to produce a final suitability model. Attributes for each layer were stratified into classes and ranked on a scale of 1 to 5 from low to highly suitable for protection or restoration (Table 1). Each classified layer was converted to a raster layer with a 5 m pixel size. The ranked raster layers were then incorporated into suitability submodels using a spatial overlay (weighted sum operation) in ArcGIS in which the numerical ranks for each overlapping layer were added pixel by pixel. All layers were assumed to have equal importance and thus all overlays were weighted equally. The floodplain forest and channel complexity submodels were overlaid in the same fashion to create a combined bio-physical submodel. The combined biophysical and land-use submodels were then overlaid in the same fashion as above to create a composite model of suitability for restoration and protection. The results were then classified using Jenks natural breaks methods which classifies the data based on minimum variance within each class (Jenks 1976). Details of each submodel criteria, ranking, and spatial operations are described in Appendix B.

Table 1. Suitability rankings by data layer

		Suitability Classes (low to high)					
Submodel	Data Layer	0	1	2	3	4	5
Land-use	Zoning		All others				Exclusive farm use, no data
Land-use	Ownership/ protected		Private		Private abutting public/protected		Public, conservation easement
Land-use	Prime farmland (soils)	no data	All areas, statewide importance	If irrigated, if drained	If drained and protected from flooding		Not prime farmland
Land-use	Irrigated lands		Present				Absent
Land-use	Mining permit status		Open permit		None		Closed permit
Channel complexity	Revetments	Absent					Present
Channel complexity	River features 1850, 1895, 1932, 1995, 2009 merged.		Absent				Present
Channel complexity	Inundation	No data	High flow area		Med flow areas		Low flow areas
Floodplain forest	Historical vegetation		All others				Closed forest riparian & wetland, woodland
Floodplain forest	Current vegetation		All other areas		Buffer within 50 m of veg-etation > 3 m		Vegetation > 3 m

3 Results

3.1 Suitability Analysis

The suitability analysis produced three submodels, one combined submodel, and one overall composite model of suitability for protection and restoration. The results and map for each submodel are described briefly in the following subsections. Figure 3 shows the quantity of each suitability class for each submodel and model.

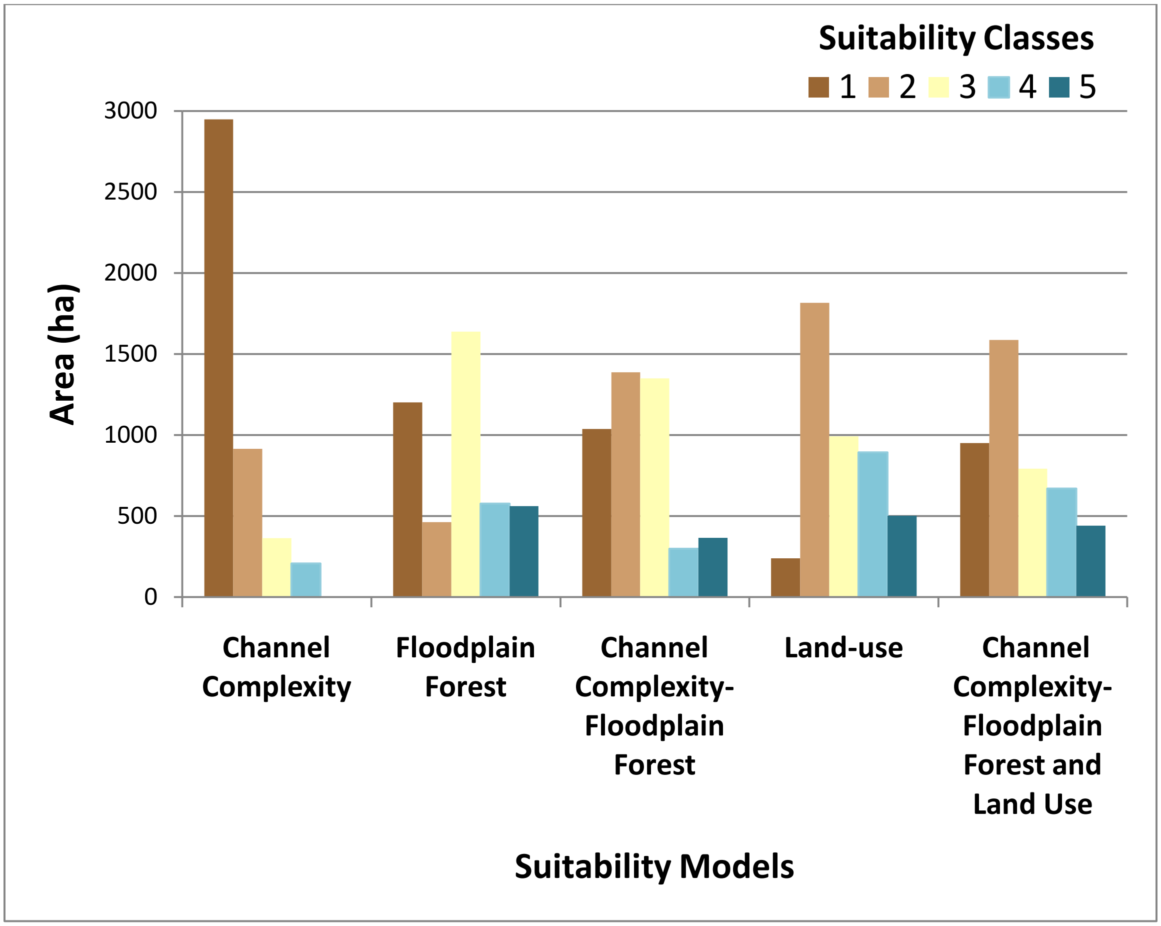

Figure 3. Area of suitability for each model

3.1.1 Channel Complexity Submodel

The additive suitability for protection and restoration of channel complexity varies from 2 to 15. Approximately 66% (2,948 ha) is in the lowest suitability class, while just 4 ha are in the highest suitability class. The middles suitability classes account for the remaining 24% (1,486 ha) of the area. This reflects a relatively narrow area where restoration of channel complexity could be accomplished.

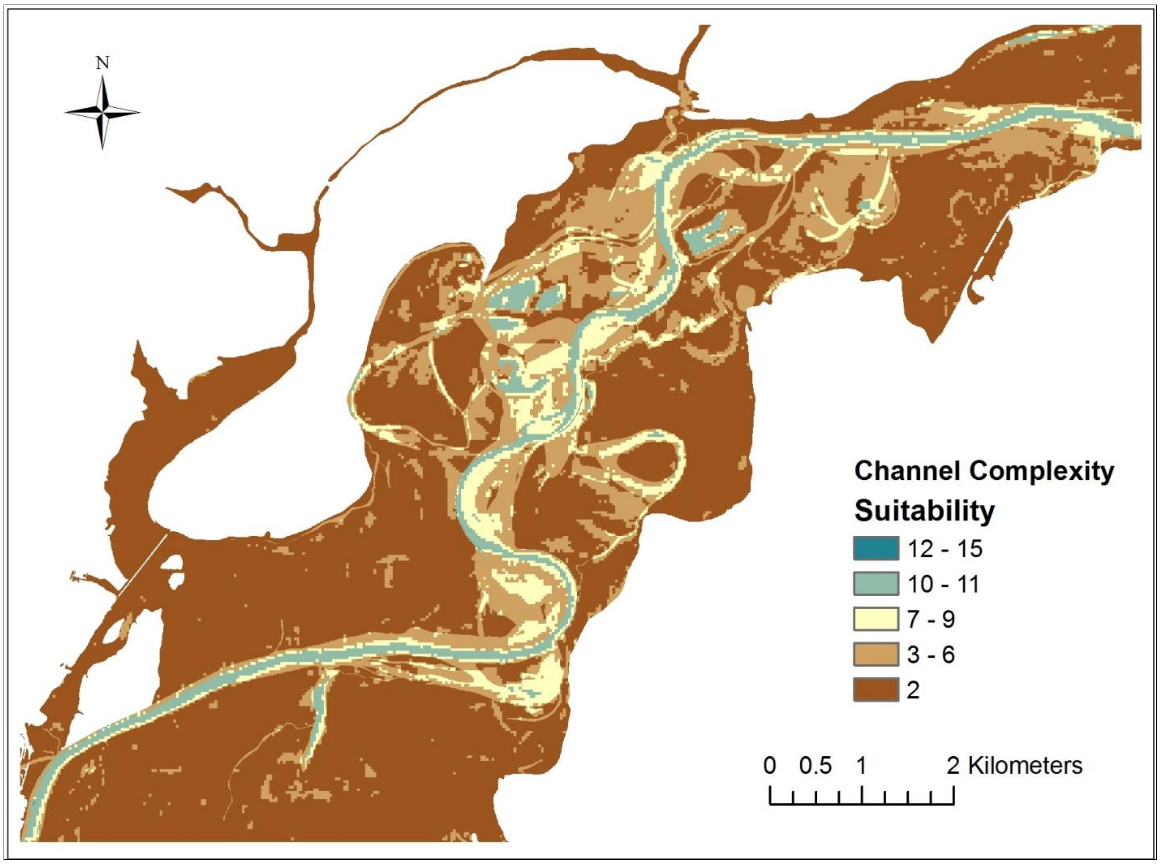

Figure 4. Channel complexity suitability submodel

3.1.2 Forest Floodplain Submodel

The additive suitability for protection and restoration of floodplain forest varies from 2 to 10. The most highly suitable class is 13% (561 ha) of the area concentrated around existing patches of floodplain forest. The influence of the historical river channel, which was classified as 'not forested' in historical vegetation, can be seen in the suitability map (Figure 5).

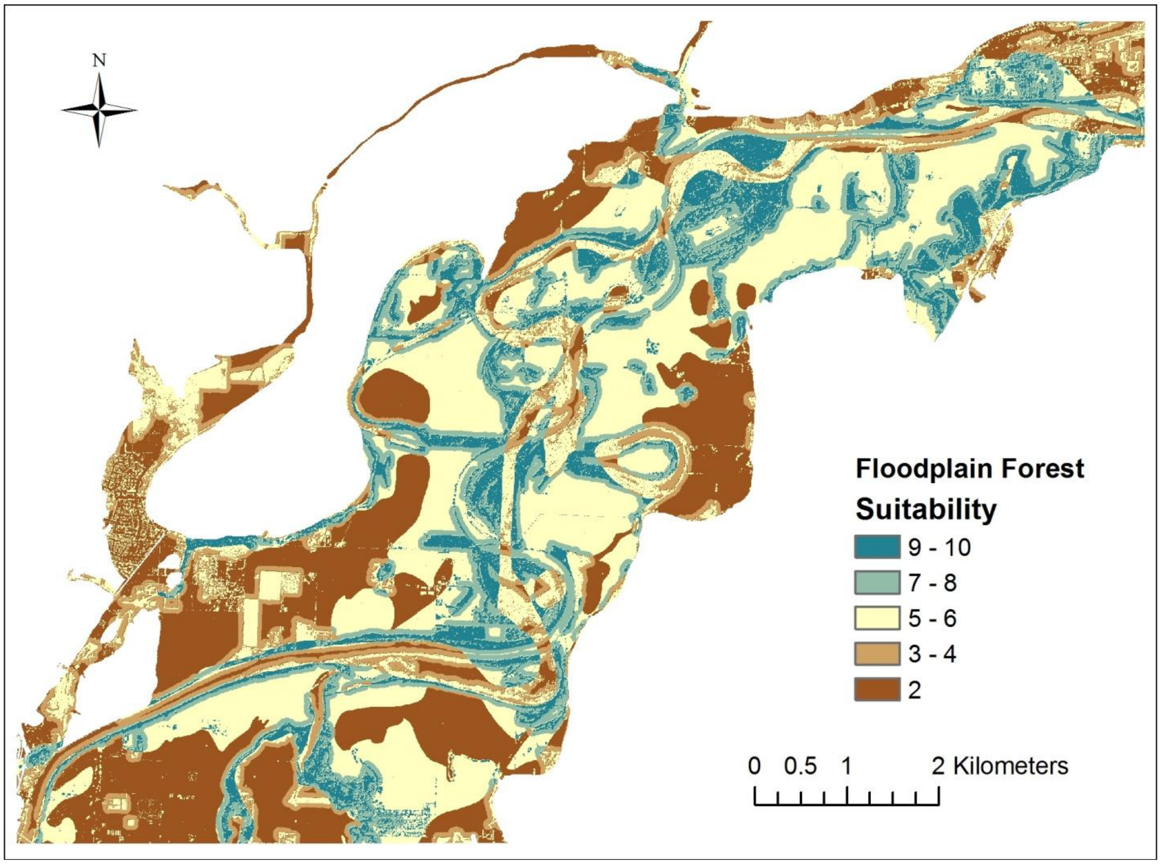

Figure 5. Floodplain forest suitability submodel

3.1.3 Channel Complexity-Forest Floodplain Combined Submodel

The additive suitability for protection and restoration of channel complexity and floodplain forest combined varies from 4 to 25. Figure 6 shows the distribution of potential conservation opportunities prior to consideration of land uses. The most suitable areas (in light blue and dark blue account for 15% (664 ha) and are concentrated along the main channel and smaller channel features.

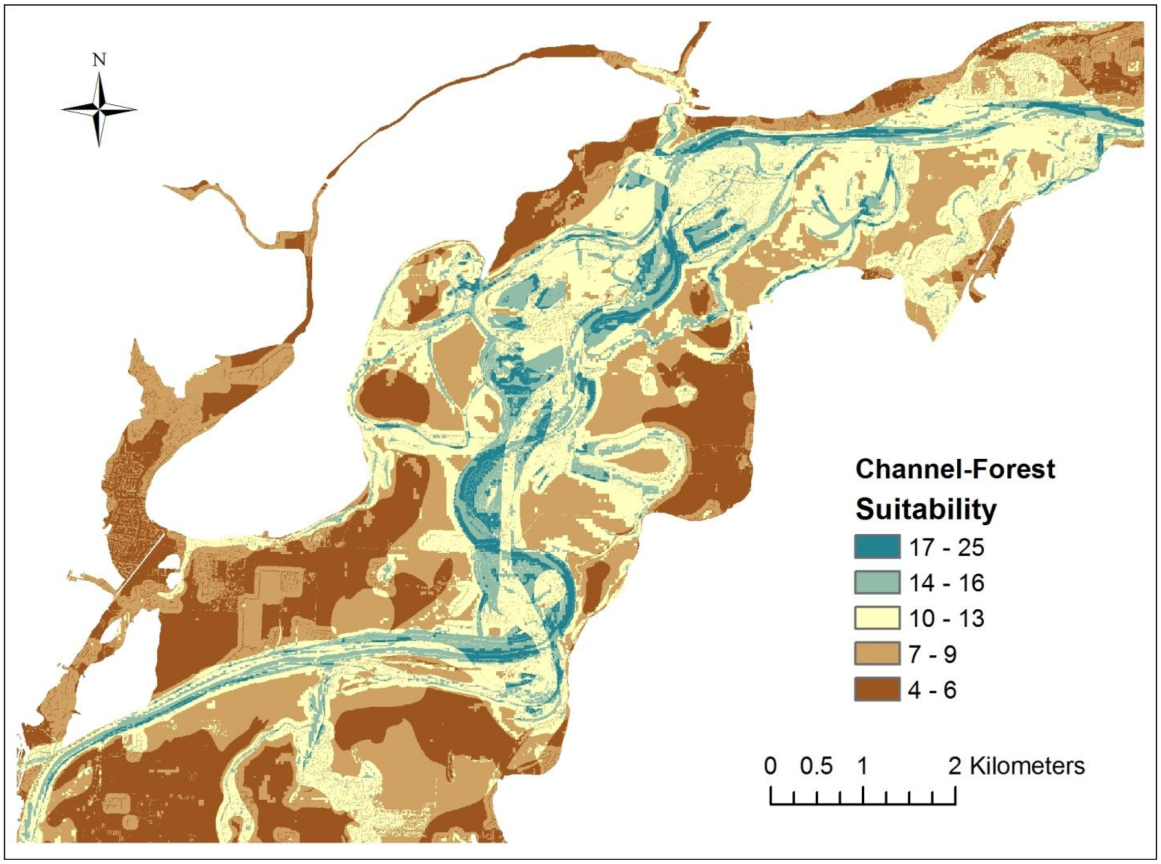

Figure 6. Channel complexity-floodplain forest combined suitability submodel

3.1.4 Land-use Submodel

The additive suitability for protection and restoration of the floodplain based on land use indicators varies from 7 to 25. Higher scores indicate greater suitability for restoration and protection and reflect an inverse relationship to suitability for other land uses. Hence high scores also indicate low suitability for mining or agricultural uses. Low suitability scores indicate low suitability for restoration or protection, but a higher suitability for other uses such as agriculture or mining. Thirty-one percent (1,394 ha) of the study area are in the 2 most suitable classes for conservation.

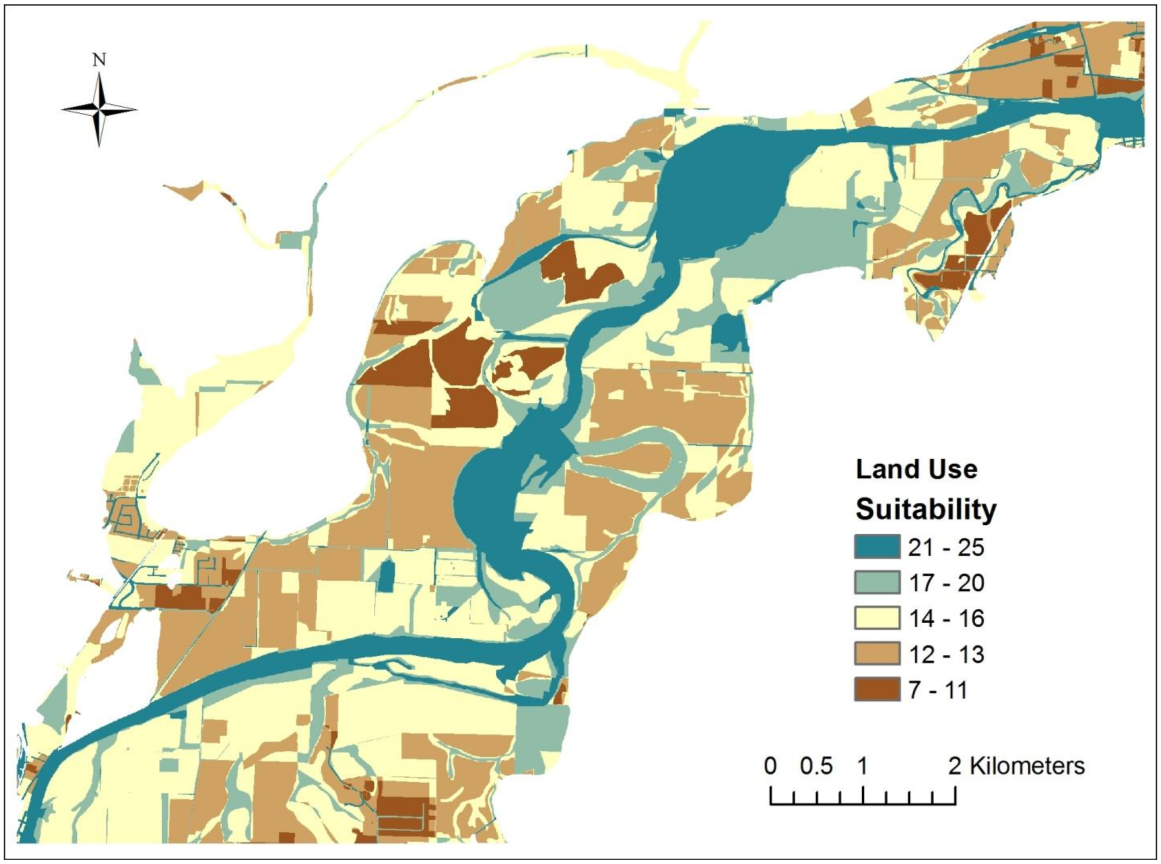

Figure 7. Land-use suitability submodel

3.1.5 Composite Suitability Model

The additive suitability for protection and restoration of floodplain forest based on a composite of channel complexity-floodplain forest and land-use submodels varies from 11 to 50. The two most suitable classes account for 25% (1,110 ha), the middle class for 18% (793 ha) and the two least suitable classes for 57% (2536 ha). Figure 8 shows that much of the most highly suitable areas are located in the center of the floodplain near the current channel. Other smaller side channel features are indicated as suitable for conservation.

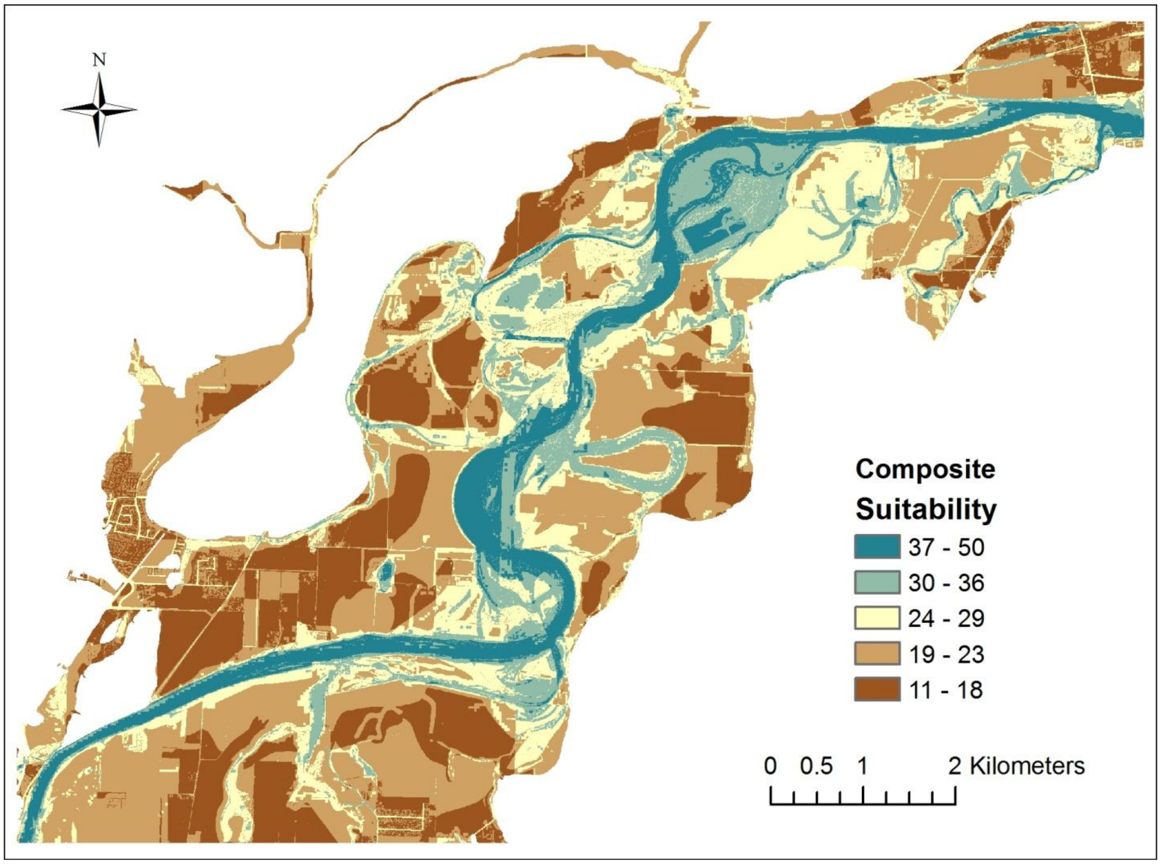

Figure 8. Composite suitability model of channel complexity-floodplain forest and land-use

3.2 Visual Analysis

Visual analysis of the spatial information identified several opportunities to restore floodplain forests and channel complexity (Figure 9). Breaching or removing all or part of the road or levee labeled could allow more frequent inundation of the forested area behind this levee. There are several small side channels that appear to be fully or partly disconnected from the river by revetments. These present opportunities to restore channel complexity. There could be an opportunity to connect the ponded water to the river so that it functions as an alcove and provides refuge to salmonids.

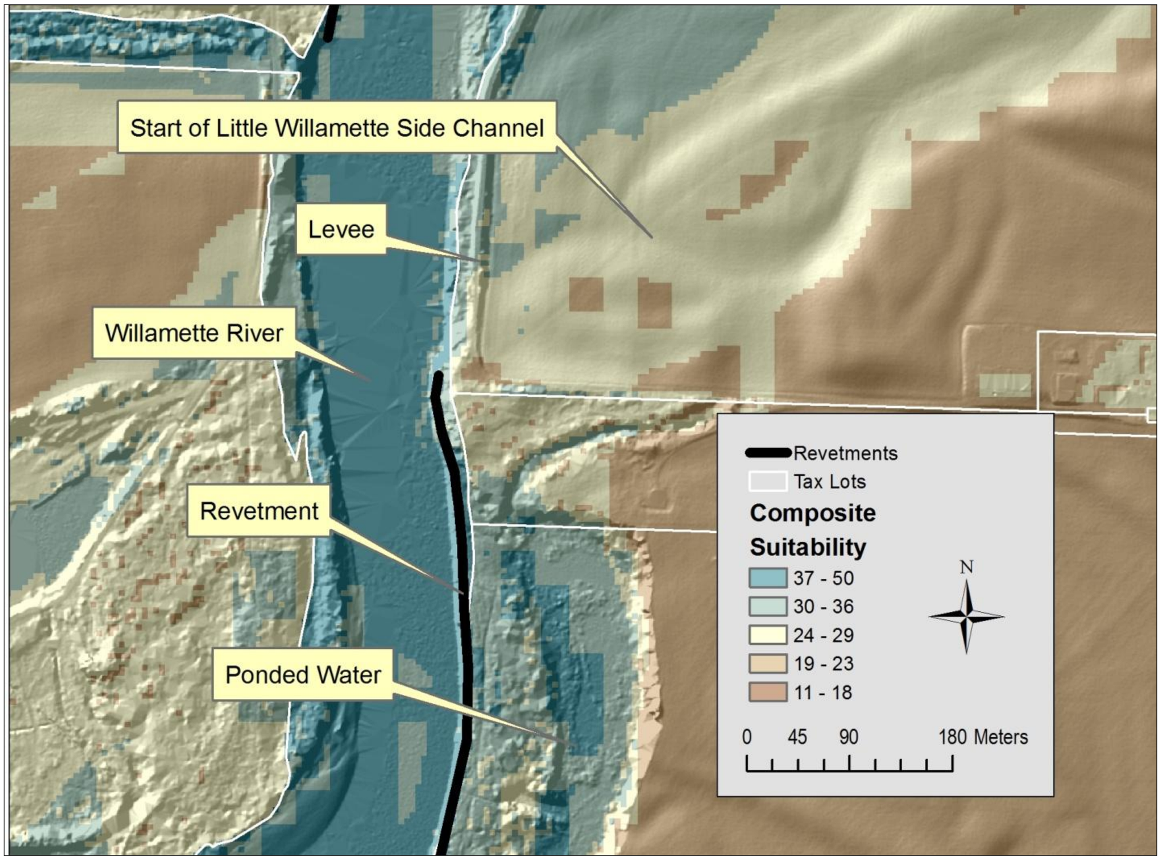

Figure 9. Restoration opportunities exist where revetments or levees could be modified to increase flows to side channels and alcoves.

3.3 Limitations

Limitations of this analysis are related to classification of suitability, subjectivity of classification, and availability of data. The initial data classification was somewhat subjective and much of it could have been classified differently. For example data with only 2 classes could have been classed as high and moderate-high rather high and low. The final suitability maps were classified using the Jenks natural breaks methods which classifies the data based on minimum variance within each class. Other classification methods could be used or the range of a class could be wider or narrower, which would change the distribution of data on the maps. The final results are a reflection of the initial classification of input data combined with classification of the resulting data. Other data sources if available could have been incorporated into the analysis, such as the locations of buildings, which could have informed the land-use submodel, or locations of specific habitats types or species of concern.

3.4 Potential Sources of Error

There are potential errors in all of the data. Sources of potential error include inaccurate mapping or modeling of features, misclassification of remotely sensed data, differing resolution of data layers, and spatial alignment of data layers. The data layers were developed at different scales and resolutions and in some cases from historical maps and surveyors' notes, which all introduce potential error.

4 Discussion

The suitability analysis is intended to be used as a guide to assist in ongoing conservation planning in the Corvallis-Albany floodplain. It identifies areas of the floodplain that may be most suitable for protection or restoration of floodplain forests and channel complexity. In general, suitability for protection and restoration is highest near the river and lowest away from the river.

The results show that conservation benefits can potentially be achieved by linking private lands to public lands and restoring channel complexity and floodplain forests across private lands. Scott et al. (2001) found that most low elevation productive lands are privately owned and protected areas are often located in less productive areas at higher elevations. This is true in the project study area. There are, however, several relatively small publicly owned and one privately owned pieces of protected property within the study area. The publicly owned properties were acquired by the State of Oregon as part of a Greenway program and for the most part are located on lands that are less suited for farming due to rocky soils, extremely wet and poorly drained soils, or difficult topography. Several have been mined in the past and were acquired for the Greenway program because they were of low economic value after mining ended. Even though they may be located on the less productive areas (for farming) they actually provide some of the best ecological value because they contain remnant channels and forests that are critical to floodplain functions. The one privately owned protected property contains a mix of productive and less productive areas and provides a unique opportunity to restore floodplain forest to both. There are also less productive, high ecological value areas located on private land that could be protected and restored with little impact to current farm operations. These areas are logical places to engage private owners in conservation efforts and begin building collaborative relationships. Incentive programs such as fee title purchase, conservation easements, or crop land rental/retirement programs to offset economic losses to landowners could be utilized (Hulse and Gregory 2004).

An example of high ecological value opportunities that crosses multiple ownerships is shown in Figure 10. The disconnected Little Willamette side channel crosses four separate tax lots, of which three are privately owned, with one protected by a conservation easement. The last is owned by the State of Oregon. A conservation corridor could be created along this channel in which trees are planted and water is allowed to flow more frequently by removing blockages. Ecological benefits could be realized while minimizing impacts to farmland.

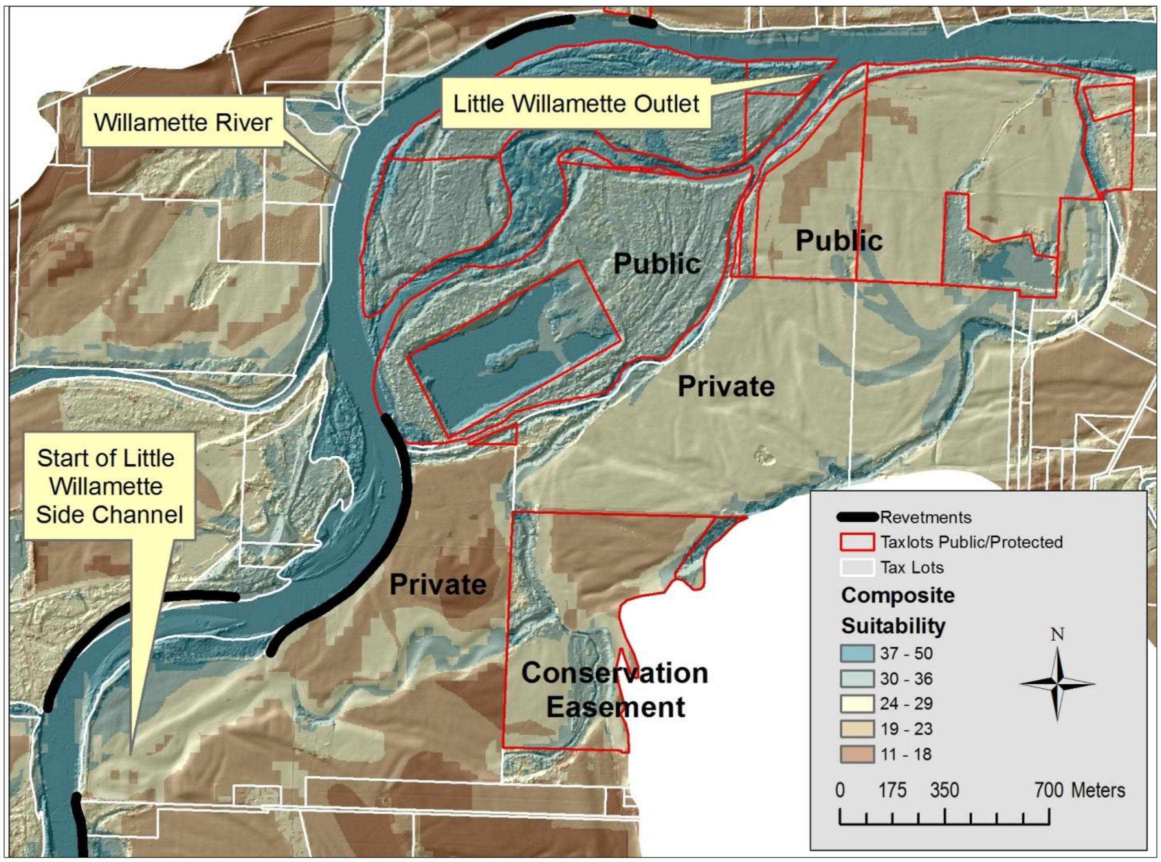

Figure 10. High ecological value conservation opportunities

Working on private lands can be challenging as landowners in the study area have long traditions of farming and utilize the land to earn a living. Involving landowners early in conservation planning and collaborating to meet landowner social and economic concerns as well as conservation goals should be considered (Hilty and Groves 2009).

5 Conclusion

This project identified lands potentially suitable for protection and restoration of floodplain forests and channel complexity and found that most are located near the current river channel. Potential impacts to private lands vary from none if projects are carried out on public lands, to minimal if carried out on low economic value private lands, to high impact if implemented across multiple private and public ownerships. Working across private land boundaries is likely to be challenging but there are ecologically valuable places located on less productive areas of private land where conservation efforts can begin with little impact to farming operations. Conservation practitioners should utilize rural sustainability concepts and collaborate with private landowners to maintain healthy rural economies, communities, and ecosystems.

This research addressed only the biological, physical, and human factors in the context of the spatial aspects of floodplain forests, channel complexity and land-use. It did not consider other conservation values, business plans and interests of farm or mine operators, landowner interests in conservation, effects of reconnecting channels, or flow regulation policy or modification.

Future research should investigate the effects and unintended consequences of increased floodplain inundation as a result of channel reconnections or increased river flows. Changes in river flow regulation policy that result in increased frequency or duration of floodplain inundation could have considerable ecological benefit but need to be investigated thoroughly for impacts to landowners in the floodplain. Impacts on other conservation values such as biodiversity or presence of focal species of conservation concern (e.g. western pond turtles or great blue heron rookeries) should also be considered in future evaluations, along with the potential for more integrated approaches to landscape scale conservation. Finally, additional work is needed to understand the business and economic interests of the farm and mine operators in the study area and their willingness to participate in conservation activities.

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Appendix A Study Area Maps

Appendix A contains additional maps that may be useful to understanding the study area and the data that went into the suitability analysis.

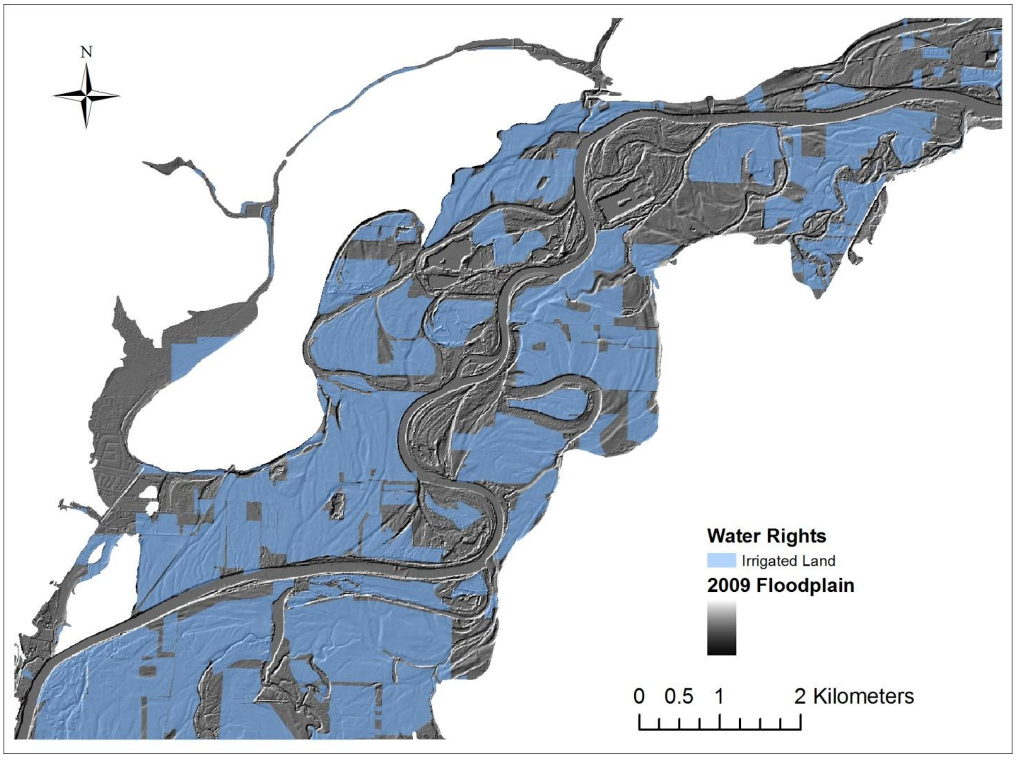

Figure 1. Irrigated lands

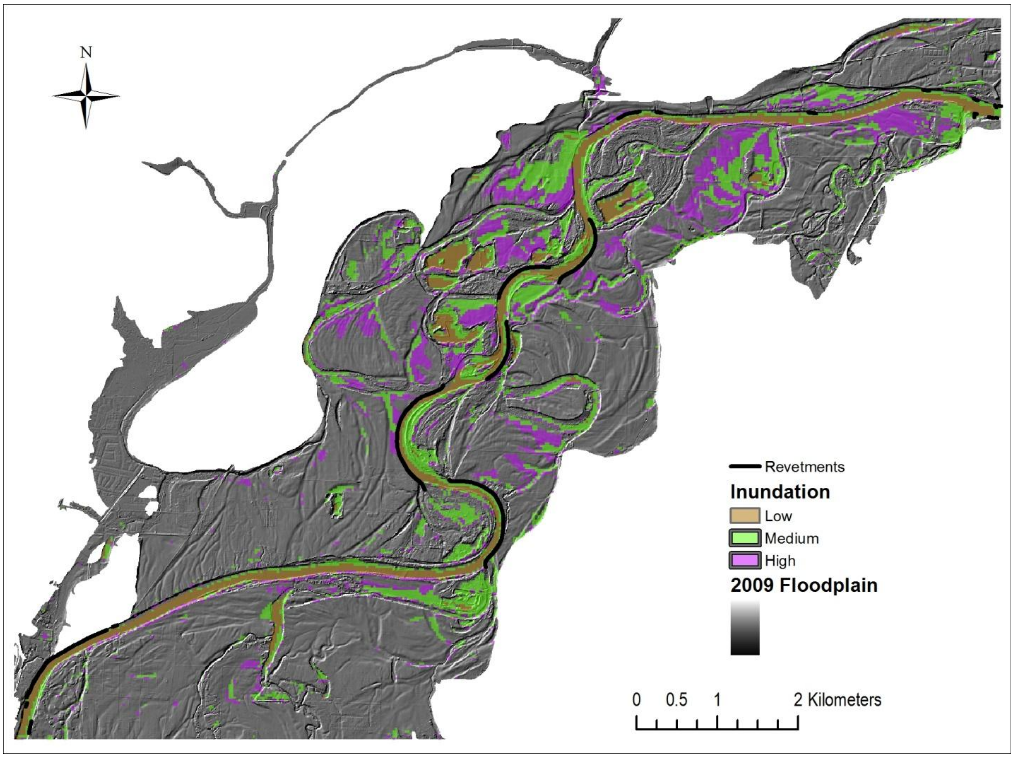

Figure 2. Inundation area under three different river flows

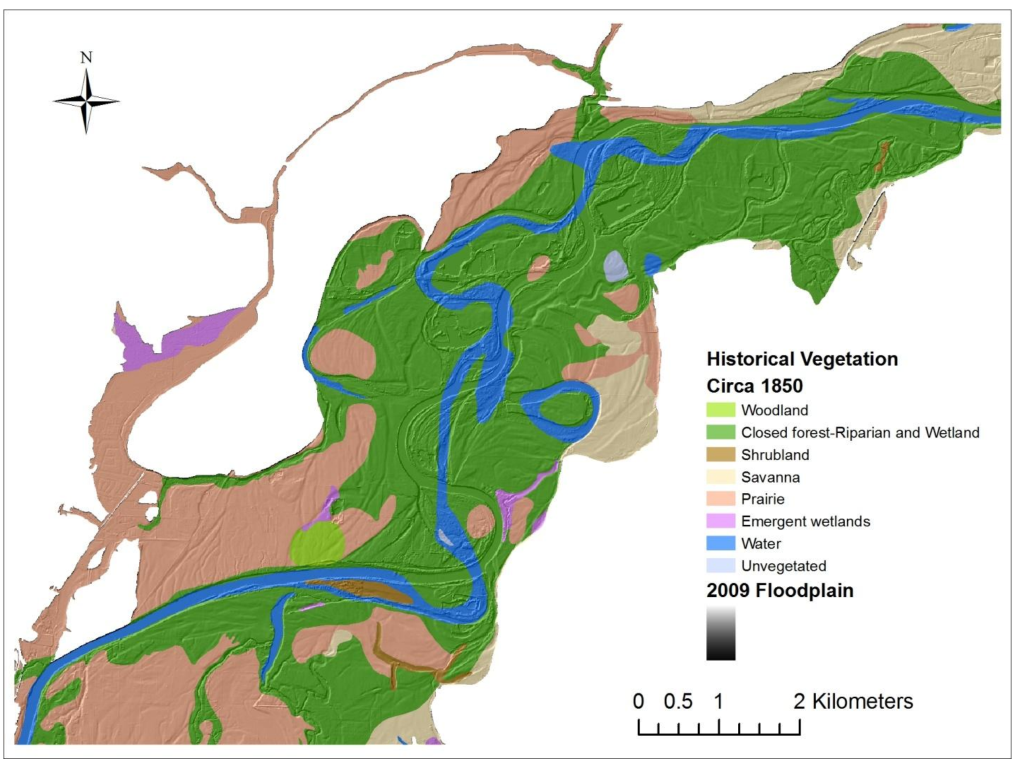

Figure 3. Historical vegetation

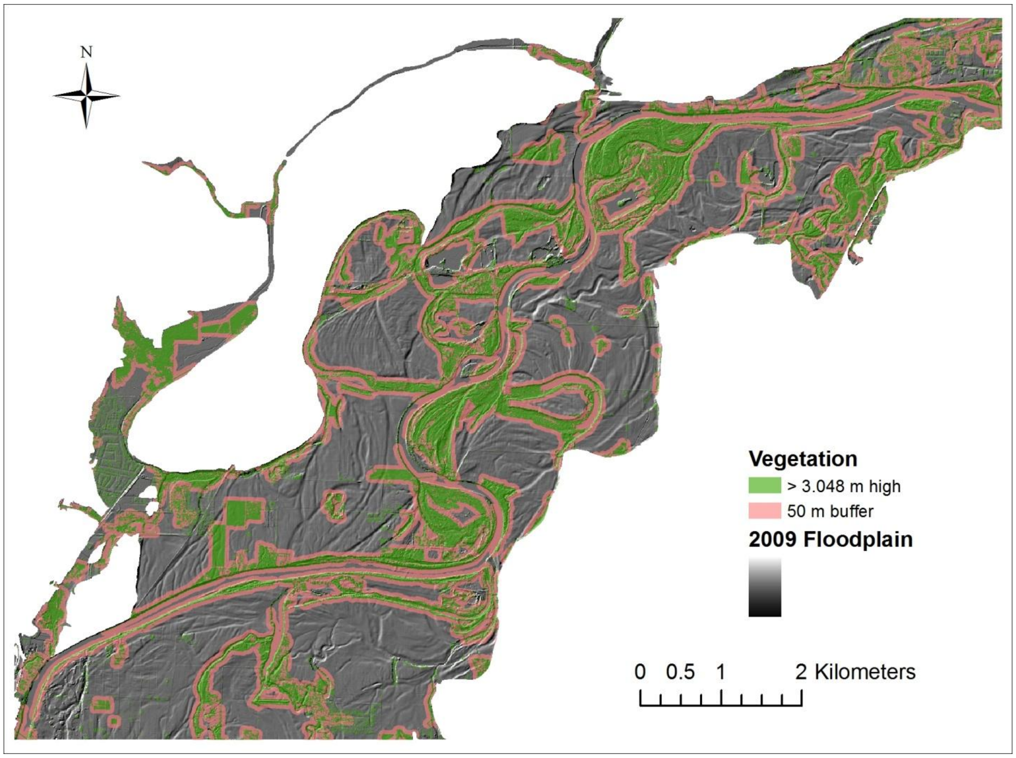

Figure 4. Current vegetation with 50 m buffers

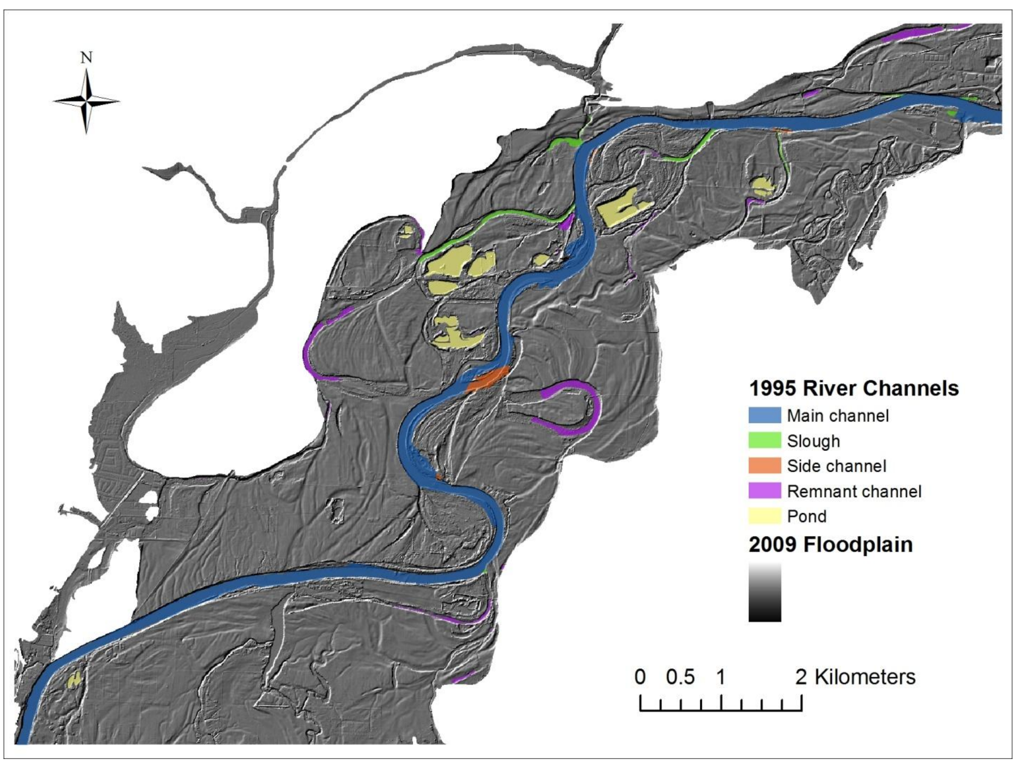

Figure 5. 1995 river channels

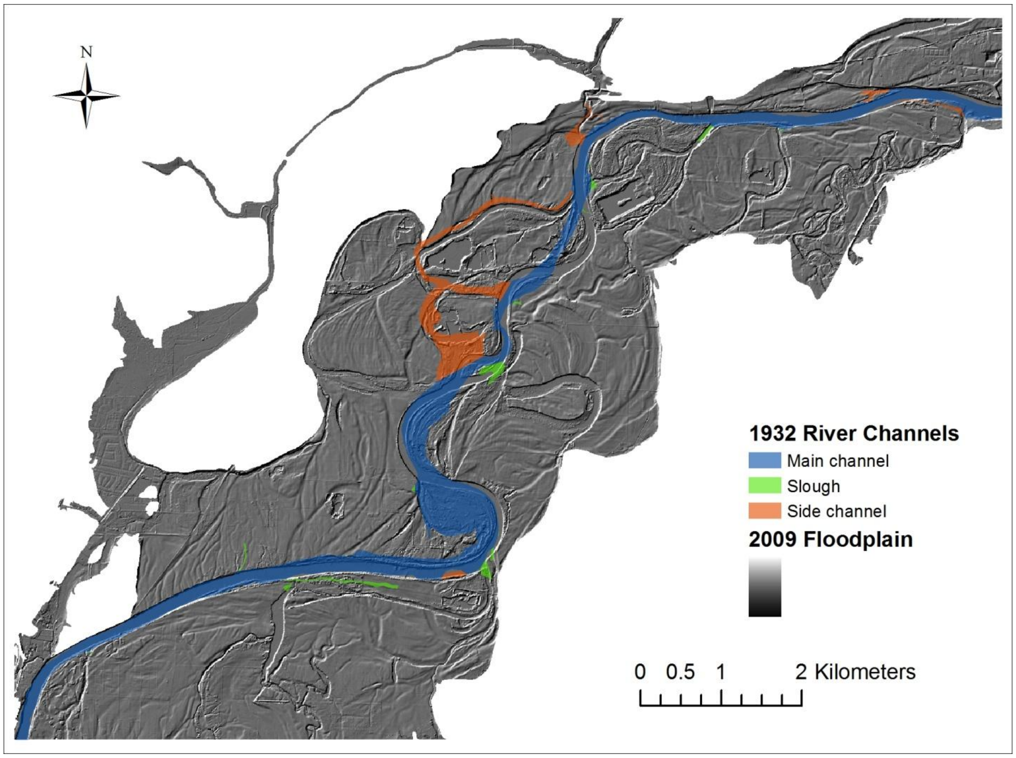

Figure 6. 1932 river channels

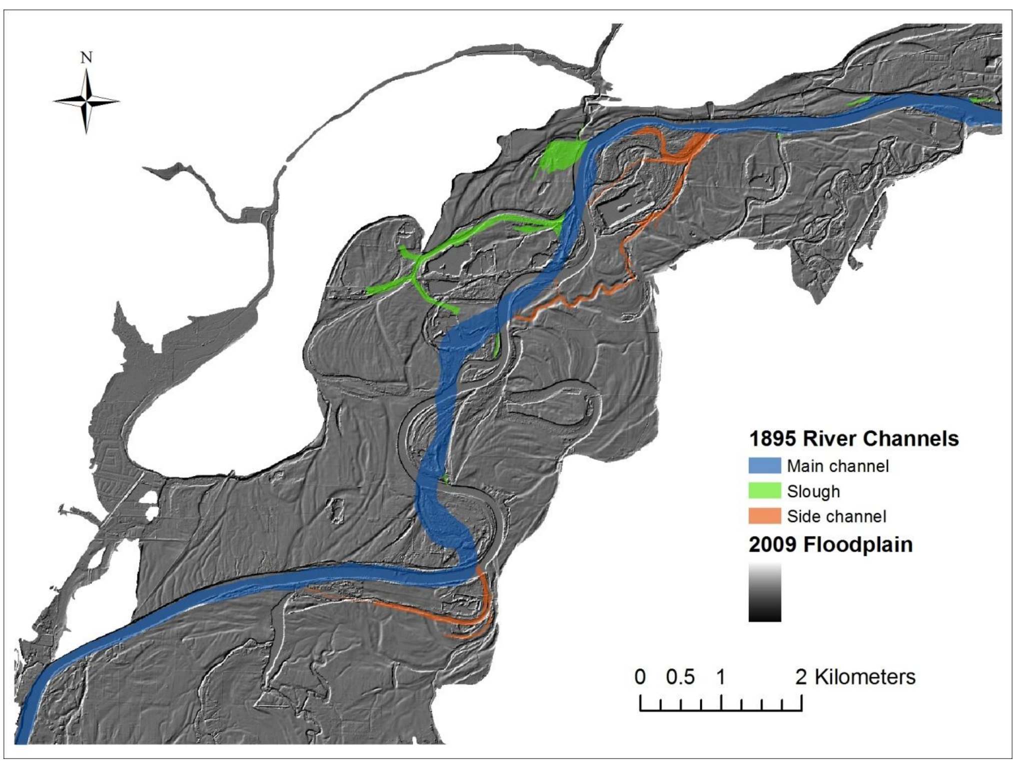

Figure 7. 1895 river channels

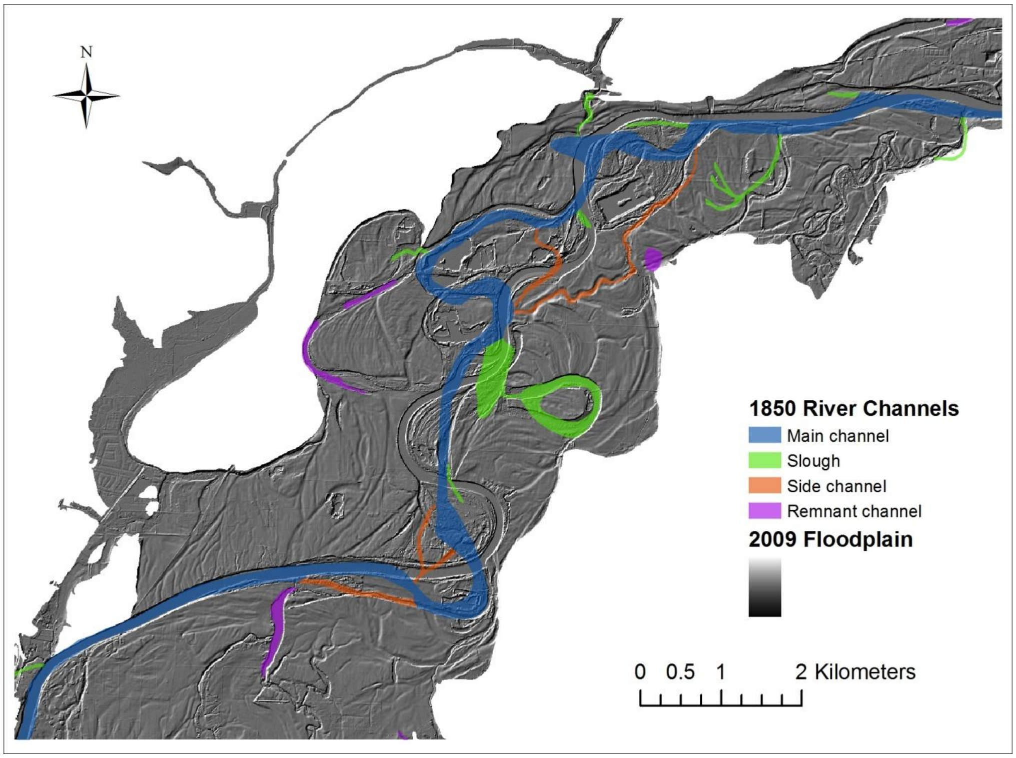

Figure 8. 1850 river channels

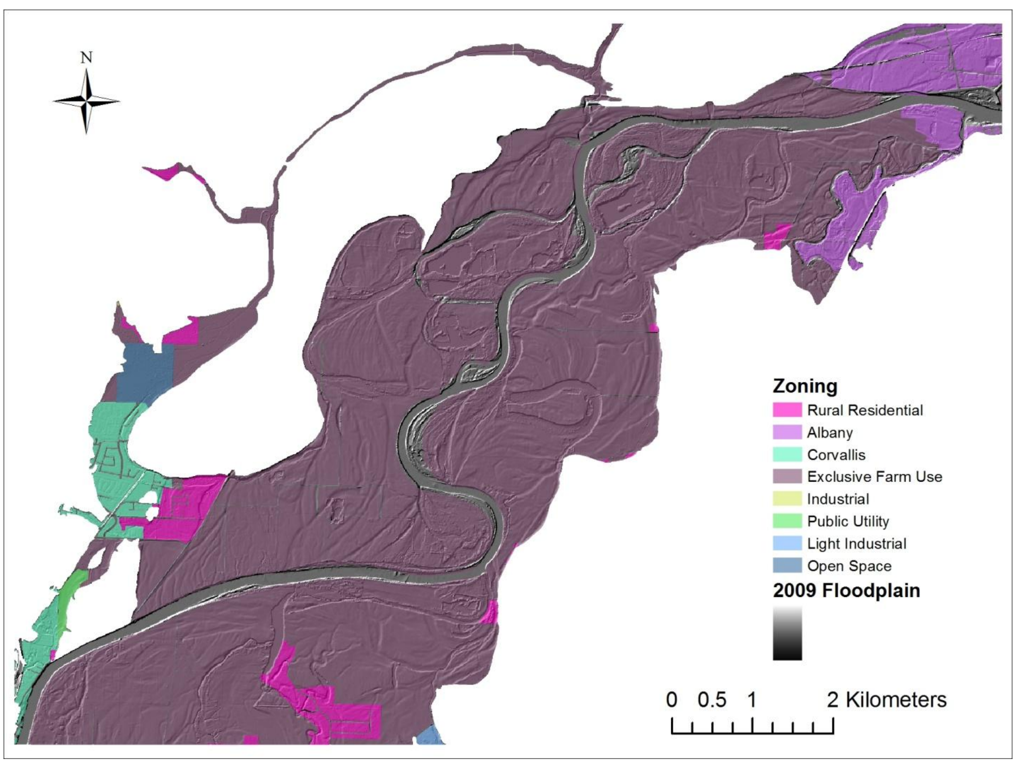

Figure 9. Land use zoning

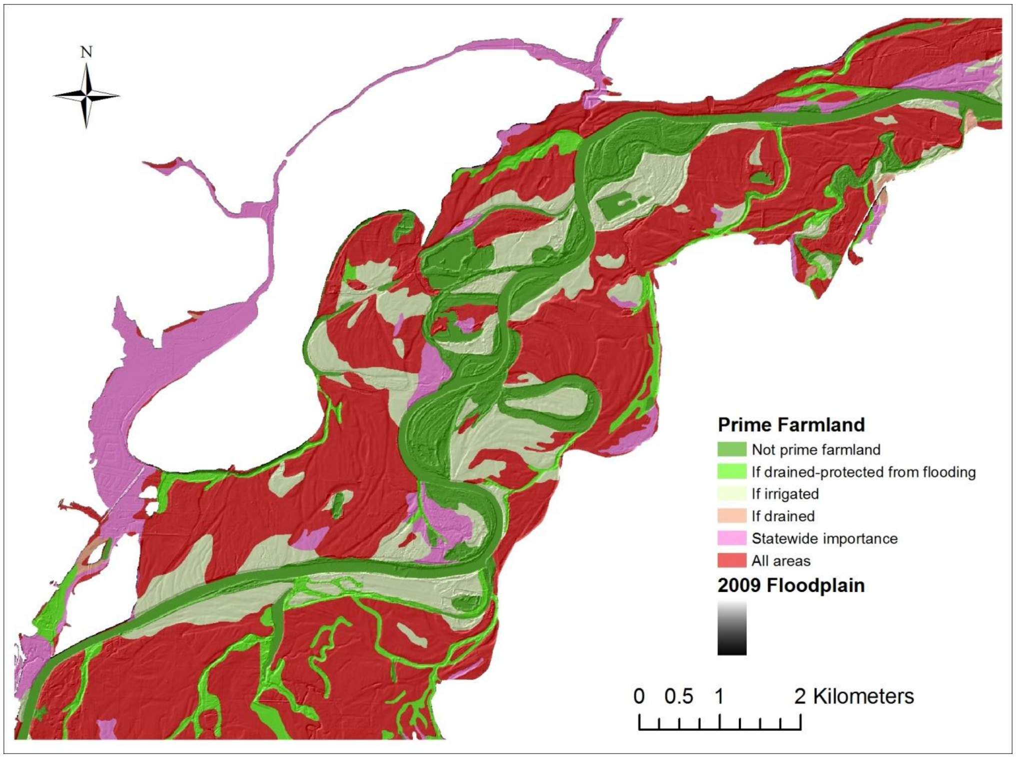

Figure 10. Prime farmland based on soil capabilities

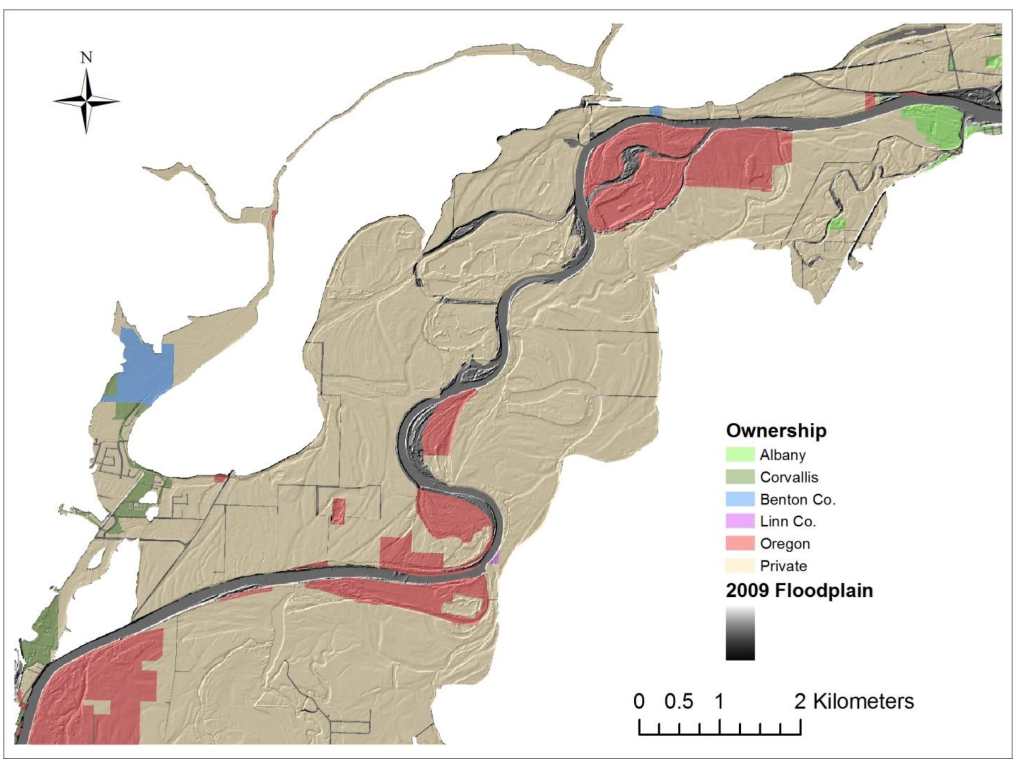

Figure 11. Ownership types

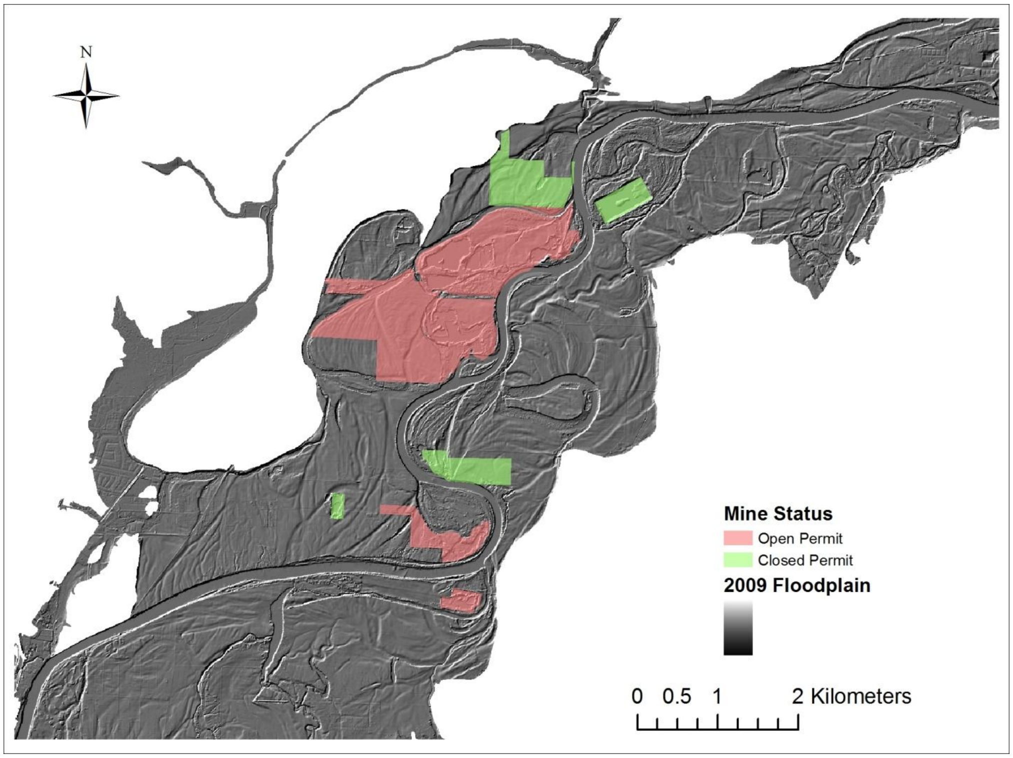

Figure 12. Open and closed mine permits associated with tax lots

Appendix B Suitability Models

The general framework for applying suitability criteria to the data layers was to "protect the best and restore the rest", stratifying the attributes numerically from 1 to 5, depending upon their range of initial attributes, from *low* to *high*. The general concept was that an area in good condition should receive a *high* suitability, indicating it should be protected and an area in less than good condition, should receive a *low* suitability indicating it could be restored. In practice, desired features that already existed received a suitability of high, indicating protect, and those that did not exist at a particular location received a suitability of low, indicating restore. Table 1 shows the ranking classes of the data layers and attributes. Table 2 shows the source of data layers used in the analysis.

Table 1. Suitability rankings by data layer

		Suitability Classes (low to high)					
Submodel	Data Layer	0	1	2	3	4	5
Land-use	Zoning		All others				Exclusive farm use, no data
Land-use	Ownership/ protected		Private		Private abutting public/protected		Public, conservation easement
Land-use	Prime farmland (soils)	no data	All areas, statewide importance	If irrigated, if drained	If drained and protected from flooding		Not prime farmland
Land-use	Irrigated lands		Present				Absent
Land-use	Mining permit status		Open permit		None		Closed permit
Channel complexity	Revetments	Absent					Present
Channel complexity	River features 1850, 1895, 1932, 1995, 2009 merged.		Absent				Present
Channel complexity	Inundation	No data	High flow area		Med flow areas		Low flow areas
Floodplain forest	Historical vegetation		All others				Closed forest riparian & wetland, woodland
Floodplain forest	Current vegetation		All other areas		Buffer within 50 m of veg-etation > 3 m		Vegetation > 3 m

Table 2. Data layers and the source used in the analysis

Data Layer	Source
Aerial photographs 2009	Oregon Geospatial Enterprise Office
Digital elevation model, 1 meter resolution Lidar	Oregon Geospatial Enterprise Office
FEMA Floodplain	Oregon Geospatial Enterprise Office
Historical vegetation	Pacific Northwest Ecosystem Reseach Consortium
Historican River Features	Pacific Northwest Ecosystem Reseach Consortium
Irrigation place of use and water rights	Oregon Dept. of Water Resources
Landsat 5 images	U.S. Geological Survey website, Global Visualization Viewer
Mining permits	Oregon Dept. of Geology and Mineral Industries
Revetments	Pacific Northwest Ecosystem Reseach Consortium
Soils, Benton and Linn Counties (SSURGO)	Natural Resources Conservation Service, Soil Data Mart
Taxlots Benton County	Benton County, Oregon
Taxlots Linn County	Linn County, Oregon
Zoning Benton County	Benton County, Oregon
Zoning Linn County (from taxlots)	Linn County, Oregon

Floodplain Forest Submodel

The floodplain forest submodel evaluates historical and current floodplain vegetation to identify areas more or less suitable for protection and restoration of floodplain forests. A historical vegetation layer, circa 1851, was used to identify areas that once contained floodplain forest.

Current vegetation was mapped from LiDAR (light detection and ranging) data acquired in 2008 and 2009. A digital surface model representing vegetation was classified based upon height, with vegetation < 3.048 m assumed to be agricultural crops while vegetation >3.048 m assumed to be natural or mostly native floodplain vegetation. A buffer of 50 m was placed around forested areas to add an adjacency component.

All layers were then converted to a grid with a cell size of 5 m by 5 m, attributed according to the suitability classes, and then overlaid to create a composite suitability submodel for floodplain forest protection and restoration.

Channel Complexity Submodel

The channel complexity submodel evaluates historical and current channels, revetments, and inundation patterns to identify areas more or less suitable for protection and restoration of channel complexity. The locations of river channels, both past and present, may indicate areas of high channel complexity or potential for restoration of channel complexity. Revetments constructed by the Army Corps of Engineers to prevent erosion and channel migration may provide opportunities to improve river and floodplain interactions. Inundation patterns show where interaction between the river and floodplain occurs under differing river flows and which channels are inundated most often. Inundation is also influenced by rainfall runoff and is not considered separately in this analysis.

Locations of revetments were classified as *high* and locations without revetments were classified as *low* suitability for protection and restoration.

Data layers showing historical river channels from 1850, 1895, 1932, and 1995 were used to identify past and present primary and secondary channels, soughs and alcoves, remnant river features disconnected from the river. These layers were merged together to create composite channel layer. Additional river channel features were digitized from 2009 aerial photographs and 2008-2009 LiDAR digital elevation models and added to the composite river channel layer. All river channels polygons were classified as *high* and all other areas were classified as *low* suitability for protection and restoration.

Inundation patterns under three river flows were derived from satellite images. Landsat 5 TM, band 4 near infrared images were obtained for 2/11/1996, 1/12/1997, and 4/2/1997 corresponding with river discharges of 2,155; 1,365; and 348 m^3/s, as measured at a US Geological Survey gage located near Albany, Oregon. Images were selected from those with little cloud cover and to represent a range of river flows. The 1996 image was taken two days after a peak flow event of 3,313 m^3/s on 2/9/1996. The peak flow inundation area was not used in the analysis because virtually the entire floodplain was inundated and therefore no difference in suitability ranking could be applied. The images were classified based on presence of water and then merged together to form a composite inundation layer. The frequency of inundation was assumed to be inversely related to river flows with more frequently inundated areas occurring at lower relative river flows. Therefore the low flow channels that are inundated more often were prioritized higher for protection and restoration. Areas inundated at 348 m^3/s were classified as *high*, areas at 1,365 m^3/s at *moderate*, and areas at 2,155 m^3/s at *low* suitability for protection and restoration.

All layers were then converted to a grid with a cell size of 5 m by 5 m, attributed according to the suitability classes, and then overlaid to create a composite suitability submodel for channel complexity protection and restoration.

Floodplain Forest-Channel Complexity Composite Submodel

The floodplain forest and channel complexity submodels were overlaid to produce a composite submodel showing floodplain forest and channel complexity features. Resultant suitability scores for each submodel were summed with equal weights to produce this composite submodel.

Land-use Submodel

The land-use submodel evaluates farm soils, irrigation, mining, zoning, and ownership to identify areas more or less suitable for protection and restoration. Farm land soils and irrigation indicate areas of high value farmland that may be worth more economically. Mining of sand and gravel from the floodplain has economic value and can affect the ability to protect or restore specific areas. Zoning under Oregon law defines allowable uses for land affects land relative land values. Ownership of parcels is evaluated as publicly owned lands are often considered important for conservation because they provide less economic value, are already protected and may act as a core conservation area.

A soils layer from the Natural Resources Conservation Service was used to display areas of prime farm land classification. Areas of greater importance were classified as lower suitability for protection and restoration relative to those of lower importance. Soil polygons attributed as “Not Prime” were classified as *high* , as “If Drained/Protected From Flooding” as *moderate/high*, as “If Drained” or “If Irrigated” as *moderate*, and as “All Areas” or “Statewide Importance” as *low* suitability for protection and restoration.

Areas with state water rights and shown as irrigated on a Place of Use layer from Oregon Water Resources Department was used to indicated irrigated farmlands. Polygons indicating municipal water rights covered large blocks of the study area and were not included in the analysis. All polygons indicating irrigated land were classified as *low* and areas with no irrigation uses or rights were classified as *high* suitability for protection or restoration.

Mining is indicated by mining permits issued by the Oregon Department of Geology and Mining Industries. Permits associated with specific tax lots were mapped and classified according to permit status. Tax lots with no associated mine permits were classified as *high*, those with closed permits as *moderate*, and those with open permits as *low* suitability for protection and restoration.

County zoning was applied to each tax lot in the study area. For areas under city jurisdictions zoning was defined as the city name and assumed to be urban uses. Tax lots zoned as “Exclusive Farm Use” was classified as *high* and all other uses were classified as *low* suitability for protection and restoration.

Ownership was determined from county tax lot layers and classified by ownership type, protection status, and adjacency. Publicly owned land and land protected by conservation easements were classified as *high*, tax lots adjacent to any public or protected land as *moderate*, and private lands as *low* suitability for protection and restoration.

All layers were then converted to a grid with a cell size of 5 m by 5 m, attributed to the suitability classes, and then overlaid to create a composite suitability submodel for land-use.

Composite Suitability Model

The two submodels for combined channel complexity-floodplain forest and land-use were overlaid to produce a composite suitability model for protection and restoration of floodplain forests and channel complexity, taking into consideration land-use. Equal weights were used in the overlay and suitability classes were summed according to their numerical ranking. The suitability was classified into 5 classes using Jenks natural breaks method.

ModelBuilder

ModelBuilder and Spatial Analyst were used in ArcGIS 9.3.1 to assemble and analyze the suitability models. A diagram of the analysis steps for channel complexity is shown in Figure 1. The other suitability models followed the similar processes.

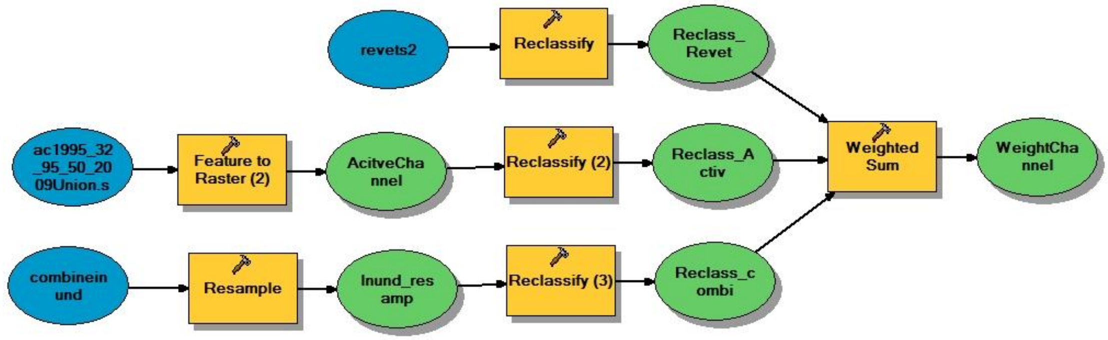

Figure 1. ModelBuilder diagram of analysis steps for channel complexity submodel