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Targeting watersheds for enrollment in the Conservation Reserve Enhancement Program in Whatcom County, Washington

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TARGETING WATERSHEDS FOR ENROLLMENT IN THE CONSERVATION RESERVE ENHANCEMENT PROGRAM IN WHATCOM COUNTY, WASHINGTON

By:

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CONSERVATION RESERVE ENHANCEMENT PROGRAM
IN WHATCOM COUNTY, WASHINGTON

A Thesis
Presented to
The Faculty of
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Abstract

Anadromous salmon populations of the Pacific Northwest have been decreasing for decades in response to a variety of factors, such as habitat destruction, overharvesting, and declining water quality. In Washington State's Water Resource Inventory Area (WRIA) 1, the State Conservation Commission listed the habitat limiting factors for salmon and steelhead as: sedimentation problems associated with landslides, overharvesting, lack of large woody debris, warmer stream temperatures, and impacts to riparian, floodplain, water quality, and flow conditions.

The Conservation Reserve Enhancement Program (CREP) addresses habitat limiting factors associated with agricultural land use. CREP projects involve the installation of forested riparian buffers along anadromous steams in agricultural areas while providing farmers with financial assistance to compensate for lost production. CREP projects are designed to provide a variety of ecological benefits, such as large woody debris recruitment potential, stream shading and cooling, and pollutant and sediment trapping. The program could have more impact if enrollment is targeted towards watersheds that show the most potential to gain ecological benefits from CREP buffers.

The primary objective of this research is to target WRIA 1 watersheds for CREP enrollment using water quality, salmon habitat, and soil data criteria within a Geographic Information System (GIS) framework. The goal of the research is to provide a targeted approach to CREP enrollment that addresses both salmon habitat limiting factors and soil conservation planning. The results of this study show that

Silver, Bertrand, Johnson, Ten Mile, Schell, Deer, Black Slough, Breckenridge, California, and Lower South Fork Nooksack watersheds show the most potential to benefit from increased CREP enrollments.

TABLE OF CONTENTS

List of Figures and Tables

Chapter I - Introduction

Anadromous salmon populations in the Pacific Northwest have been decreasing for decades throughout their historical habitat. For example, it has been estimated that early chinook salmon populations in the North Fork of the Nooksack River, Whatcom County, Washington have decreased from a historical population of 26,000 to a count of just 170 in 2004, 0.07% of their historical run. The historical counts were estimated from an Ecosystem Diagnosis and Treatment (EDT) model based on simulated historic conditions in the Nooksack River while the current count is an estimated escapement of natural origin spawners (WRIA 1 Salmonid Recovery Plan 2005). Washington's Water Resource Inventory Area (WRIA) 1 includes the Nooksack River Basin (North, Middle, and South Fork), independent tributaries that flow directly to Puget Sound or the Strait of Georgia between Bellingham Bay and the Canadian border, and partial watersheds of two river systems that flow north to the Fraser River system in Canada (Figure 1).

The anadromous salmonid populations of WRIA 1 include all five Pacific salmon species (chinook, chum, pink, coho, and sockeye), steelhead, coastal cutthroat trout, and bull trout/Dolly Varden; these species are native to WRIA 1. Currently, two salmonid species in WRIA 1, chinook salmon (*Oncorhynchus tshawytscha*) and bull trout (*Salvelinus confluentus*), are federally listed as threatened under the Endangered Species Act (ESA) (Anchor Environmental 2003).

Also, coho salmon (*Onocorhynchus kisutch*) in the area are a candidate for listing under ESA (Anchor Environmental 2003).

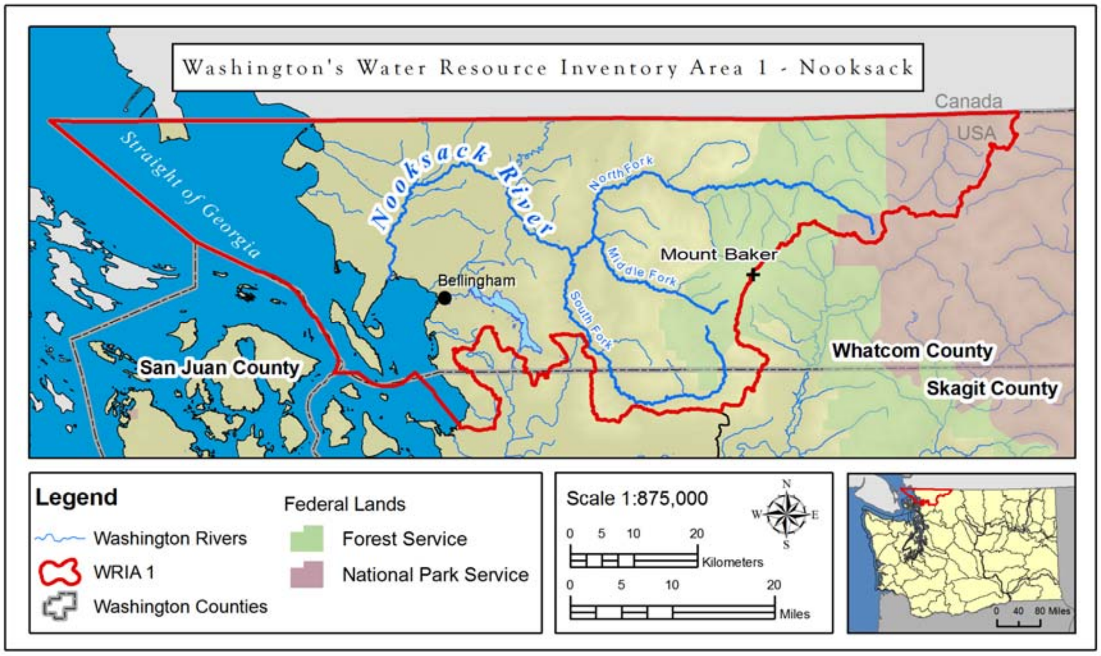

Figure 1: Washington's Water Resource Inventory Area (WRIA) 1

In response to the listings, the Washington State Legislature passed several bills to address the problem in a concerted manner. Two key pieces of legislation (Engrossed Substitute House Bill 2496 and Second Engrossed Substitute Senate Bill 5596, now 77 RCW) initiated the development of “Habitat Limiting Factors” reports to address the declining salmon populations (Smith 2002). The reports highlight that many factors have combined and contributed to declining salmon populations. The Washington State Conservation Commission has listed sedimentation problems associated with landslides, overharvesting, lack of large woody debris, warmer stream temperatures, and impacts to riparian, floodplain, water quality, and flow conditions as the Salmon and Steelhead Habitat limiting factors in WRIA 1 (Smith 2002).

WRIA 1 - Habitat Limiting Factor Research

The Nooksack River sub-basin (downstream of the confluences) has a heavily impacted floodplain from land cover alterations and very poor riparian conditions throughout the mainstem and most tributaries, based on the habitat rating system used in the WRIA 1 habitat limiting factors report (Smith 2002). The lack of shade, loss of wetlands, and channel changes (i.e. levees, dredging, gravel mining, etc.) are probable causes for the warm water temperatures found in the Nooksack River and the Silver, Tenmile, Bertrand, Fishtrap, Kamm, and Anderson Creek watersheds (Smith 2002). Compared to other rivers in the Puget Sound region, the Nooksack River near Ferndale has among the highest levels of nitrogen (including ammonia and nitrate), phosphorous, turbidity, and suspended solids. Also, from 1979 to 1991, turbidity increased between 1 to 2% per year in the lower mainstem Nooksack River (Smith 2002). In addition, inadequate stream flows for salmonid habitat are a pervasive problem throughout WRIA 1, and can contribute to water quality problems. Further, many of the lowland streams and tributaries flow through land converted to agricultural or urban use, which has resulted in channelization, water withdrawals, a loss of wetlands, and altered land cover (Smith 2002).

Collins and Montgomery (2002), Collins *et al* (2002), Coe (2001), and Hyatt *et al* (2004) have further examined the relationship between a specific habitat limiting factor, large woody debris (LWD), and its effect on riparian ecosystems and salmon recovery in the Puget Lowlands.

Collins and Montgomery (2002) and Collins *et al* (2002) examined forest development, wood jams, and restoration of floodplain rivers in the Puget Lowlands of Washington. The authors maintain that historically in Puget Lowland rivers, wood jams were integral to maintaining a networked channel pattern and a dynamic channel-floodplain connection, in addition to creating deep pools that decrease stream temperatures. However, in large rivers of the Pacific Northwest, 19^{th} and 20^{th} century stream cleaning greatly diminished wood abundance, and riparian forest clearing and levee construction reduced the potential for lowland floodplain rivers to recruit wood (Sedell and Luchessa 1981 in Collins *et al* 2002).

Specifically, Collins *et al* (2002) examined the historical changes in the distribution and function of large wood in Puget Lowland rivers. Their historical representation was an 11-km-long protected reach of the Nisqually River with archival data, while their current study area was the Snohomish and Stillaguamish basins. They found that current wood abundance is one to two orders of magnitude less than before European settlement. Also, wood jams are now rare due to a lack of wood that can function as key pieces in jams. The change in wood abundance and size from historical levels appear to have fundamentally changed the morphology, dynamics, habitat abundance, and characteristics of lowland rivers across scales from channel unit to valley bottom. Based on their field studies, it is thought that rivers had substantially more and deeper pools historically (Collins *et al* 2002). Clearly, forested buffers provide large woody debris recruitment potential and shade for streams which improves the habitat for endangered salmonid populations (Collins and Montgomery 2002).

More locally, Coe (2001), working for the Nooksack Indian Tribe, developed a Nooksack River Watershed Riparian Function Assessment. In May 2000, Nooksack Natural Resources and Lummi Natural Resources contracted with Duck Creek Associates to conduct a riparian function assessment for all salmonid bearing and contiguous streams in the Nooksack River watershed. The objectives of their research were to summarize LWD recruitment potential and stream shading for the Nooksack River basin by land use and geographic area, evaluate results, and develop general recommendations for riparian restoration and protection. For the purposes of their study, they divided the Nooksack basin into four subbasins: The North Fork Nooksack and associated tributaries; The Middle Fork Nooksack and associated Tributaries; The South Fork Nooksack and associated tributaries; and the mainstem Nooksack and associated tributaries, downstream of the South Fork confluence.

The study classified the condition of 17,923 acres in riparian areas in the Nooksack basin. The distribution of riparian areas by subbasins was 34% (mainstem), 28% (North Fork), 9% (Middle Fork), and 29% (South Fork). Commercial forestry was the most common zoning class in riparian areas (36%), followed by agriculture (22%), rural (15%), federal forest (15%), rural forest (7%), urban (3%), and federal park (2%) (Table 1).

Table 1: Relative proportion (%) of zoning classes in riparian areas by subbasin (Coe 2001)

Zoning Class	Subbasin			
	Mainstem	North Fork	Middle Fork	South Fork
Urban	8	1	0	0
Agriculture	55	0	0	12
Rural	26	13	9	5
Rural Forest	4	13	10	6
Commercial Forest	7	31	58	67
Federal Forest	0	38	19	9
Federal Park	0	5	4	2

Overall, Large Woody Debris Recruitment Potential (LWDRP) in the Nooksack River basin riparian areas is predominantly low. That is, half of the area in riparian areas scored low for the ability to recruit LWD in the future. Although the mainstem Nooksack contains only 34% of the total riparian area, it included most (52%) of the riparian area in the Nooksack River watershed with low LWDRP (Coe 2001). In fact, no riparian areas with high LWDRP were found along the mainstem Nooksack. In addition, the mainstem Nooksack stream shading hazard was characterized as predominantly high, meaning there is a lack of adequate stream shading to cool river waters. Also in the mainstem Nooksack, 85% of riparian areas in agricultural land scored low for LWDRP.

Hyatt *et al* (2004) conducted a similar study to Coe (2001). Hyatt *et al* (2004) carried out a watershed scale assessment of riparian forests, with implications for restoration. The analysis encompassed all salmon bearing waters of the Nooksack River basin. Through air-photo interpretation, field data collection, and GIS analysis, the researchers examined the size and composition of each riparian stand to determine whether trees were large enough to contribute logs that would form pools. Riparian stands were classified according to whether they passed this pool-forming test. Failures in riparian function were found to be most likely in agricultural lowlands, where pastures, fields, roads, and cleared areas are common (Figure 2). Agricultural zones exhibited a 3-fold increase in failures over commercial forests even though total agriculture acreage was 25% less than commercial forestry (Hyatt *et al* 2004). The Hyatt *et al* (2004) and Coe (2001) research shows a defined lack of LWD and LWDRP in the agricultural areas of WRIA 1, especially along the mainstem of the Nooksack River.

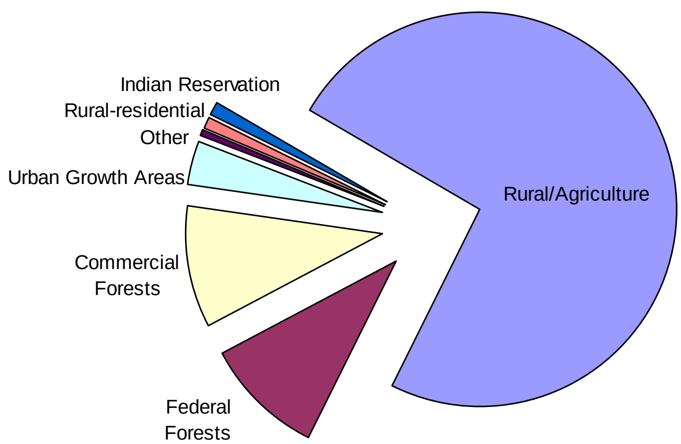

Figure 2. Proportional breakdown of failing riparian stands along anadromous reaches. Most (74%) of failing stands are in the agricultural zone. (Hyatt *et al* 2004)

The Conservation Reserve Enhancement Program (CREP) addresses the lack of adequate LWD near anadromous streams in agricultural areas. CREP is a federal-state land conservation program that targets the mitigation of specific environmental effects of agriculture by providing financial assistance to farmers

(USDA 1998). Each state enrolled in the program chooses its target goal(s). Washington's main goal is to restore the areas enrolled into a properly functioning condition for the growth and distribution of woody species. The eligible areas of WRIA 1 include agricultural parcels adjacent to anadromous streams (Figure 3).

Figure 3: CREP eligible watersheds in Whatcom County, Washington as of February 2005 (WCD 2006)

Research Objective

The objective of this research is to target WRIA 1 watersheds for CREP enrollment using water quality, salmon habitat, and soil data in a Geographic

Information System (GIS) framework. The goal of the research is to provide a targeted approach to CREP enrollment for the watersheds of WRIA 1 that addresses both salmon habitat limiting factors and soil conservation planning.

Watersheds were ranked by (1) the amount of 303(d) listings, Ecology's water quality indicatory; (2) the amount of Fish Habitat Conservation Areas as defined by Whatcom County's Critical Areas Ordinance; (3) a soil erosion vulnerability screening that uses the environmental factors of the Revised Universal Soil Loss Equation (RUSLE); (4) the potential for habitat connectivity, expressed by the amount of existing conservation efforts; and (5) the amount of Prime Agricultural Farmland. Watersheds that are eligible to enroll (farmland adjacent to anadromous streams) and have the highest amounts of: 303(d) listings, Fish Habitat Conservation Areas, erosion vulnerability, existing conservation efforts, and Prime Agricultural Farmland will be highlighted by this targeted approach. The watersheds with the highest amounts of the aforementioned variables will be the watersheds with the greatest potential to benefit from CREP projects.

This information may be used in a variety of ways, including: selection of stream monitoring locations for sediment or sediment-adsorbed pollutants; land-use planning as it relates to earth disturbance activities; and, identification of target areas for conservation dollars, research, and landowner education.

Thesis Organization

This thesis is divided into 5 chapters. Chapter II is a review of literature concerning ecological principles of land use management, the function of riparian zones as salmon habitat, U.S. Farm Bill conservation programs, and the Conservation Reserve Enhancement Program. Chapter III defines the research framework, i.e. the study area, data and sources, and the research methodology. Chapter IV includes the findings, results, and outcomes of the research. Finally, Chapter V concludes the thesis, summarizing the work, including limitations, and providing recommendations on future work.

Chapter II – Literature Review

The many ways that people have used and managed land throughout history is the primary cause of land-cover change throughout the world. One of the most pervasive aspects of human-induced change is the widespread alteration of land through efforts to provide food, shelter, and products for use. Unfortunately, when making decisions on land uses, potential ecological consequences are not always considered (Dale *et al* 2000). In Washington State, salmon populations have plummeted from historical population levels in response to many factors, including the alteration of land use. One such example is the conversion of forested riparian areas to agricultural land which has resulted in the degradation of water quality and loss of essential habitat features. The restoration of salmon bearing streams and stream buffers are essential to salmon recovery plans (WRIA 1 Salmonid Recovery Plan).

As Chapter I illustrated, restoration practices in agricultural areas of the Nooksack Basin are an essential component of the WRIA 1 salmon recovery plan. The CREP is an example of one such restoration incentive, converting farmland adjacent to anadromous streams from production to a forested riparian buffer. Trees provide stream shading and future large woody debris which, in turn, provides stream habitat and further temperature control. A review of the applicable literature on targeting watersheds for agricultural restoration practices reveals four predominant themes: (1) the ecological principles of land management; (2) the relationship of riparian areas to salmon recovery; (3) the U.S. government's role in agricultural conservation programs; and (4) the important role of the Conservation Reserve Enhancement Program.

Land Use

In a 2000 report from the Ecological Society of America Committee on Land Use, Dale *et al* outlined the ecological principles and guidelines for managing the use of land. These guidelines suggest that land managers: (1) examine the impacts of local decisions in a regional context; (2) plan for long-term change and unexpected events; (3) preserve rare landscape elements and associated species; (4) avoid land uses that deplete natural resources; (5) retain large contiguous or connected areas that contain critical habitats; (6) minimize the introduction and spread of nonnative species; (7) avoid or compensate for the effects of development on ecological processes; and (8) implement land-use and management practices that are compatible with the natural potential of the area. These guidelines offer land managers an ecological perspective to choices on how land is used and managed.

When reviewing historical trends in land-use change, the necessity of the aforementioned guidelines is evident. The present distribution of major land uses in the U.S. (Figure 4) reflects a complex pattern of historical conversion of lands to human-dominated uses (Dale *et al* 2000). About 67% of the land in the contiguous U.S. is privately held; developed nonfederal lands have increased by 18% from 1990-2000 to total 92 million acres or 4.4% of the total area. Therefore, the management of private lands is of utmost importance in the overall strategy to incorporate ecological principles in land-use management. Most authority for land-use choices is vested in individual landowners and local governments (Dale *et al* 2000).

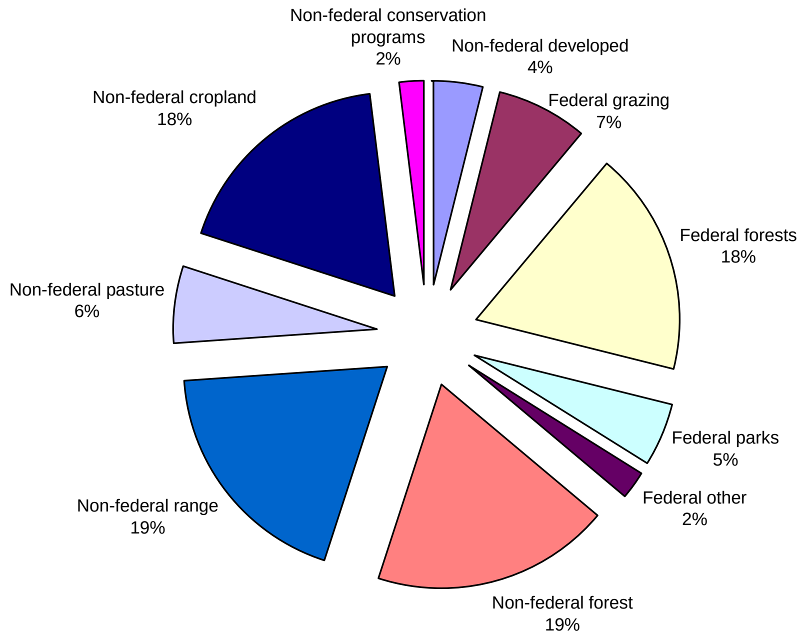

Figure 4: Land use and ownership in the contiguous United States (Dale *et al* 2000)

In an effort to offset the environmental degradation from past land-use management decisions, restoration is employed. Restoration, which involves returning an ecosystem towards its original condition, is used to mitigate the degradation of ecosystems. Undertaking the five actions to develop the science needed by land managers (Table 2) for the planning of restoration projects is an objective for the ecological guidance of land-use. In the Pacific Northwest, a great deal of restoration occurs to mitigate past degradation of salmon habitat. To fully understand why riparian restoration is essential to salmon recovery, one must examine the importance of riparian ecosystems, the historical changes to these ecosystems, how land use affects ecosystem parameters, the purpose of riparian restoration, and the role of forested buffers in restoration plans.

Table 2: The five actions to develop the science that is needed by land managers (Dale *et al* 2000)

1	Apply ecological principles to land use and land management
2	Explore ecological interactions in both pristine and heavily used areas
3	Develop spatially explicit models that integrate social, economic, political, and ecological land-use issues
4	Improve the use of and interpretation of in situ and remotely sensed data to better understand and predict environmental changes and to monitor the environment
5	Commicate relevant ecological science to users (including land owners and the general public)

Riparian Areas

Riparius is a Latin word meaning “of or belonging to the bank of a river; the modern term *riparian* refers to the biotic communities on the shores of streams and lakes (Naiman and Decamps 1997). The riparian zone includes the stream channel between the low and high water marks and the portion of the terrestrial landscape from the high water mark toward the uplands where vegetation may be influenced by elevated water table or flooding and by the ability of soils to hold water, although exact definitions differ among researchers (Naiman and Decamps 1997). Furthermore, complex interactions between hydrology, geomorphology, light, temperature, and fire influence the structure, dynamics, and composition of riparian zones. The literature suggests that hydrology (and interactions with local geology) is the most important factor (Naiman and Decamps 1997).

Karr and Schlosser's (1978) demonstration that the land-water interface reduces nutrient movements to streams led to an understanding of the role played by riparian zones in controlling nonpoint sources of pollution by sediment and nutrients in agricultural watersheds. Sediments and sediment-bound pollutants carried in surface runoff are deposited effectively in mature riparian forests as well as in streamside grasses. Sediment trapping is facilitated by sheet flow runoff, which allows deposition of sediment particles and prevents channelized erosion of accumulated sediments (Karr and Schlosser 1978)

Riparian buffer zones, an area defined as a certain distance from a stream where land use activities are restricted for stream protection purposes, are becoming an increasingly common management tool (Naiman and Decamps 1997). As previously mentioned, many of the ecological functions of riparian forests have been lost through land use changes. This conversion has dramatically affected salmon populations in the Pacific Northwest, and many studies have been conducted to relate land use to the health of salmon populations.

For example, Pess *et al* (2002) examined landscape characteristics, land use, and coho salmon abundance in the Snohomish River watershed, Washington. The research involved developing a broad-scale analysis that correlated coho salmon abundance with habitat characteristics and land use. Habitat data for the stream reach and watershed included geology, wetland abundance and type, wetland modification, land cover classification (forest, agricultural, rural, and urban), and the relative potential for slope instability (Pess *et al* 2002).

The reaches that were bordered by lands designated as forest supported far more fish than areas under other types of land use. The average adult coho salmon abundance increased with an increase in the proportion of a streamside area in forest at the reach scale. Specifically, the average abundance where more than 50% of the riparian area was designated as forested land was 1.5 to 3.5 times greater than in reaches with less than 50% forest. The reaches supporting the highest salmon abundance were forested over 60% of the riparian area. The average coho abundance was positively correlated with the amount of forest at the watershed scale. More importantly, the areas converted to agriculture or urban uses had negative correlations to coho abundance (Pess *et al* 2002).

Pess *et al* (2002) concluded that riparian forests were positively correlated to salmon abundance. Riparian forests benefit salmon by trapping sediments, regulating stream temperatures, and providing organic matter to streams. Riparian forests also provide wood and the potential for wood which affects the stream's morphology, dynamics, and habitat abundance. For example, wood in streams can create scour pools which add habitat and decrease stream temperatures. Collins *et al* (2002) and Collins and Montgomery (2002) examined the historical changes of wood abundance and functions in Puget Lowland rivers over the past 150 years. The purpose of their study was to document historical conditions in Puget Sound rivers, document changes since European settlement, and use those changes to evaluate hypotheses on the function of wood in streams.

Collins *et al* (2002) and Collins and Montgomery (2002) examined the changes in wood abundance by comparing field data from a protected reach of the Nisqually River with field data from the Snohomish and Stillaguamish rivers and with archival data. The researchers examined in-channel wood, pools, riparian forests, quantity, and location of wood, age and species of wood, and the size and shape of wood. They concluded that the current wood abundance in the Snohomish and Stillaguamish basins are one to two orders of magnitude less than before European settlement in the basins. And, most importantly, the lack of very large wood pieces decreased the abundance of wood jams; wood jams are integral in creating and maintaining a dynamic, anastomosing river patter with numerous floodplain channels and abundant edge habitat. These historical changes of wood abundance affected the morphology, dynamics, and habitat abundance of lowland rivers. Historically, rivers had substantially more and deeper pools. The researchers believe that the protected reach of the Nisqually, coupled with archival data, set a reference for the development of restoration objectives (Collins *et al* 2002; Collins and Montgomery 2002).

Sharma and Hilborn (2001) examined how pool densities affected the smolt abundance in 14 western Washington streams. The researchers found that pools with habitat structure in the form of LWD generally contained far more coho than pools without this form of cover and shelter. LWD appearing elsewhere in the channel, i.e. nonstructural LWD not in association with pools, may have little or no influence on fish numbers. They concluded that pool habitat is the prime and proximal determinant of juvenile coho salmon abundance (Sharma and Hilborn 2001).

Research on how the effects of land use changes on stream function and salmon abundance (Karr and Schlosser's 1978; Pess *et al* 2002; Collins *et al* 2002; Collins and Montgomery 2002; Sharma and Hilborn 2001) show that the historical loss of Puget lowland river forests decreased the control of nonpoint source pollution, LWD recruitment, in-stream pool formation, and salmon abundance. Therefore, riparian restoration in Puget Lowlands should be directed at converting riparian buffers to a forested land use. However, converting agricultural lands to forested buffers shifts the cost of salmon recovery to agricultural producers. CREP compensates producers for the loss of production and helps to sustain the resource base for agricultural production; CREP is just one example of the United States Department of Agriculture (USDA) Farm Bill Conservation Programs.

U.S. Farm Bills

The first United States farm bill was passed by the legislature on May 1933 to "relieve the existing national economic emergency by increasing agricultural purchasing power, to raise revenue for extraordinary expenses incurred by reason of such emergency, to provide emergency relief with respect to agricultural indebtedness, to provide for the orderly liquidations of join-stock land banks and for other purposes" (U.S. Congress 1933). The legislation was deemed the Agricultural Adjustment Act of 1933 and was the first in a succession of farm bills passed by the U.S. Senate. Table 3 represents the history of the U.S. farm bills.

Table 3: History of U.S. Farm Bills (NALC 2006)

2007 Farm Bill (Forthcoming)
The Farm Security and Rural Investment Act of 2002
The Federal Agriculture Improvement and Reform Act of 1996
Food, Agriculture, Conservation, and Trade Act of 1990
Food Security Act of 1985
Agriculture and Food Act of 1981
Food and Agriculture Act of 1977
Agricultural and Consumer Protection Act of 1973
Agricultural Act of 1970
Food and Agricultural Act of 1965
Agricultural Act of 1956
Agricultural Act of 1954
Agricultural Act of 1949
Agricultural Act of 1948
Agricultural Adjustment Act of 1938
Agricultural Adjustment Act of 1933

The purpose of the farm bill has evolved and expanded through time, to include the program areas of agricultural pricing, emergency stocks, support programs, crop allotments, agricultural trade, food stamps, nutrition programs, and soil conservation. In 1973, the farm bills began to give greater attention to conservation. In previous bills, conservation programs fell in rural development categories and were mainly directed at land retirement under the miscellaneous categories. Beginning with the 1973 bill, the legislature created a section exclusively for conservation known as Title X: Rural Environmental Conservation Program (U.S. Congress 1973). The conservation headings changed throughout time: in 1977, the title was Rural Development and Conservation; in 1981 it was changed to Resource

Conservation; and in 1985, 1990, 1996, and 2002, the sections were simply named Conservation (NALC 2006).

The Farm Security and Rural Investment Act of 2002 (2002 Farm Bill) constituted landmark legislation for conservation funding and for focusing on environmental issues. The 2002 Farm Bill simplified existing programs and created new programs to address high priority environmental and production goals (NRCS 2002). Table 4 shows the conservation program components of the 2002 Farm Bill.

Table 4: 2002 Farm Bill Conservation Programs (NRCS 2002)

Conservation Corridor Demonstration Program
Conservation of Private Land Grazing Program
Conservation Security Program
Conservation Reserve Program
Environmental Quality Incentives Program
Farmland Protection Program
National Natural Resources Conseravation Foundation
Resouce Conservation and Development Program
Wetlands Reserve Program
Wildlife Habitat Incentives Program
Grassland Reserve Program
Small Watershed Rehabilitation Program
Source Water Protection

The 2002 Farm Bill authorized the USDA to expand the Conservation Reserve Program (CRP) enrollment up to 39.2 million acres from the pervious cap of 36.4 million acres. Of the total amount available, about 3.0 million acres are reserved for special initiatives within CRP, including a continuous sign-up program for sensitive lands, planting floodplains to sequester greenhouse gases, the Bobwhite Quail Initiative, the Wetland Initiative for larger wetland complexes, the

Farmable Wetland Program, and the Conservation Reserve Enhancement Program (USDA 2004).

The Conservation Reserve Enhancement Program

The Conservation Reserve Enhancement Program (CREP) is an agricultural program that combines state and federal resources under current provisions of the USDA's Conservation Reserve Program (CRP). The CREP is a distinct program that uses CRP authorities to operate. State authorities sign contracts with local landowners to target specific state and national conservation and environmental objectives, such as improving water quality or preserving wildlife habitat (USDA 2000c).

Under this arrangement, the USDA provides participants who enroll their land with a set level of cost sharing. This is the same signing incentive payment for "continuous" signup CRP enrollees, annual land rental rate (the rental rate plus a percentage that may vary by conservation practice and individual CREP agreement), and an annual land maintenance payment. The CREP allows states to supplement federal incentives, to address more state specific goals, and to target certain conservation practices (USDA 2000c).

State enrollment incentives include additional cost sharing to minimize or eliminate out-of-pocket costs for participants, up-front enrollment payments, and the option, or requirement, for participants to extend a conservation contract or provide a permanent easement. CREP enrollment is usually conducted in the same manner as the "continuous" CRP signup option. That is, eligible CREP participants are allowed to sign up at any time without going through the periodic competitive Environmental Benefits Index (EBI) ranking process normally used to select potential CRP participants. Each state defines specific areas (e.g. watersheds) or land characteristics (e.g. highly erodible land) for CREP eligibility, targeting particular goals that coincide with national objectives such as improved water quality or preserving endangered species habitats (USDA 2000c).

In an October 2005 technical review, Arthur Allen elaborated on the fish and wildlife benefits of the Farm Bill Conservation Programs, specifically from CREP. He writes:

> "CREP reflects advancement in the U.S. Department of Agriculture agricultural policy by addressing agriculturally related conservation on a multi-farm, landscape scale and establishing funding support and partnerships with state and non-governmental organizations…By addressing state-identified priorities, landowner needs and social issues, the CREP offers substantial promise to fully integrate economically viable agricultural production and effective conservation" (Wildlife Society 2005, p115).

As of April 2006, CREP is underway in 28 states with a commitment to sign up 1.7 million acres in the program. Figure 5 shows the states enrolled and proposed to enroll in CREP; Table 5 shows a summary of the key aspects of established programs by state.

Figure 5: States with CREP Agreements and Proposals

Table 5: A summary of key aspects of established CREPs by state (Allen 2005; USDA FSA 2006)

State	Year Initiated	Acres Committed	Primary Area of Applicability	Key Environmental Objective*	Primary Conservation Practice**
Arkansas	2001	4,700	Bayou Metro Watershed	Drinking, surface water quality, wildlife habitat	Riparian buffers
California	2001	12,000	North Central Valley	Surface and groundwater quality, soil erosion, air quality, wildlife habitat	Wetland restoration, wildlife food plots, habitat improvement, riparian buffers, filter strips
Colorado	2006	35,000	Colorado High Plains	Wildlife habitat, soil erosion	Planting habitat, food plots, vegetative covers
	2006	30,000	Republican River Basin	Conserve agricultural irrigation water use, soil erosion	Native grasses, vegetative covers, wetland restoration
Delaware	1999	6,000	Chesapeake Bay, Delaware Bay, and Inland Bay watersheds	Lower surface water nutrient loading, water and aquatic habitat quality, upland wildlife habitat	Hardwood trees, filter strips, riparian buffers, wetland restoration
Florida	2002	30,000	Everglades watershed	Increase water quality and storage capabilities, enhance wildlife habitat and biodiversity	Filter strips and riparian buffers, wetland restoration, hardwood trees
Illinois	1998	232,000	Illinois River watershed	Reduce sediment and nutrient loading, enhance terrestrial and aquatic wildlife habitats	Riparian buffers and filter strips
Indiana	2005	7,000	Highland/Pigeon, Tippecanoe and Upper White River watersheds	Reduce sediment, nutrients, pesticides and herbicides run off	Riparian buffers and wetland enhancement
Iowa	2001	9,000	North-central Iowa	Drinking and surface water quality, wildlife habitat	Wetland restoration, riparian buffers and filter strips
Kentucky	2001	10,000	Green River watershed	Recreation, water quality, restoration of ecosystems in Mammoth Cave National Park	Wetland restoration, riparian buffers, filter strips, hardwood trees

State	Year Initiated	Acres Committed	Primary Area of Applicability	Key Environmental Objective*	Primary Conservation Practice**
Louisiana	2005	50,000	Lower Ouachita River Basin	Surface and ground water quality, soil erosion, nutrient runoff, wildlife habitat	Riparian buffers, hardwood trees, and wetland restoration
Maryland	1997	100,000	Chesapeake Bay and tributaries	Water quality and aquatic habitat quality	Riparian buffers and filter strips
Michigan	2000	80,000	Macatawa Raisin rivers and Saginaw Bay watersheds	Surface and drinking water quality supplies and quality, wildlife habitat	Riparian buffers and filter strips, wetland restoration, windbreaks
Minnesota	1998	190,000	Minnesota River and floodplain	Water quality and wildlife habitat	Wetland restoration, riparian easements, buffer and filter strips
Missouri	2000	50,000	83 reservoir watersheds across 36 counties	Drinking water quality, sediment inputs into water supply reservoirs, elevate natural diversity	Contour grass strips, hardwood trees, filter and riparian buffer strips
Montana	2002	26,000	Missouri and Madison River systems	Water quality by reduction of nutrients and sediments in runoff	Wetland restoration, filter strips and riparian buffers
Nebraska	2004	100,000	Nebraska Central Basin	Sediment and nutrient loading in lakes and streams, wildlife habitat in 37 counties	Grassland establishment, wetland restoration, filter strips, riparian buffers
New Jersey	2004	30,000	Watersheds draining into the Atlantic Ocean	Biological and aquatic habitat in Atlantic estuaries, increase open space	Grasslot waterways, filter strips, and riparian buffers
New York	1998	40,000	Catskill/Delaware watersheds	New York City drinking water quality, wildlife and aquatic habitats	Filter strips and riparian buffers, fencing, wetland restoration, tree planting
	2004	1,000	Skaneateles Lake watershed	Syracuse drinking water quality	Tree planting, contour grass strips, diversions, filter strips, riparian buffers
	2004	40,000	12 watersheds across state	Nutrient and pathogen content in sediments and runoff	Tree planting, filter strips, riparian buffers, wetland restoration

State	Year Initiated	Acres Committed	Primary Area of Applicability	Key Environmental Objective*	Primary Conservation Practice**
North Carolina	1999	100,000	Albermarle-Pamlico Estuary	Estuarine fisheries, drinking water quality	Hardwood tree planting, filter strips, riparian buffers
North Dakota	2001	160,000	6 southern watersheds	Critical winter habitats for wildlife, water quality, recreation, rural economy enhancement	Shelterbeds, permanent wildlife habitat, food plots
Ohio	2000	4,000 stream miles	Lake Erie and tributaries	Sediment and nutrient loading, wildlife habitat	Wetland restoration, field windbreaks, filter strips, riparian buffers
	2002	3,500	Upper Big Walnut Creek watershed	Drinking water quality	Filter strips, riparian buffers, hardwood trees
	2004	70,000	Scioto watershed	Drinking water quality, wildlife habitat	Filter strips, riparian buffers, hardwood trees
Oregon	1998	100,000	4,000 miles of streams throughout the state	Improvement in habitat quality for endangered salmon and trout	Filter strips and riparian buffers, wetland restoration
Pennsylvania	2000	200,000	Susquehanna and Potomac River watersheds	Water quality entering Chesapeake Bay	Filter strips, riparian buffers, wetland restoration, contour grass strips
	2004	65,000	Ohio River watersheds	Water quality entering Gulf of Mexico	Filter strips, riparian buffers, wetland restoration, contour grass strips
Vermont	2001	7,500	Statewide	Nutrient loading in Lake Champlain and Hudson-Saint Lawrence waterway	Filter strips, grassed waterways, wetland restoration
Virginia	2000	25,000	Chesapeake Bay watersheds	Water quality entering Chesapeake Bay	Filter strips, riparian buffers, wetland restoration
		10,000	Southern Virginia Rivers	Water quality, wildlife habitat	Filter strips, riparian buffers, wetland restoration
Washington	1998	100,000	All streams crossing agricultural lands providing salmon spawning habitat	Salmon habitats in 3,000 miles of streams	Tree-dominated riparian buffers
West Virginia	2002	9,160	Potomac, New Greenbrier, and Little Kanawha River watersheds	Water quality, wildlife habitat	Riparian buffers, filter strips, hardwood tree planting
Wisconsin	2001	100,000	All or portions of 47 counties across state	Water quality, wildlife habitat	Grasses waterways, filter strips, riparian buffers, wetland restoration

* Each CREP has numerous environmental objectives, not all are listed in the table.
Control of soil erosion is an underlying objective of all CREPs
** Only a generalization of key conservation practices is provided

Washington State's CREP agreement was signed in October 1998 by then Governor Gary Locke. As outlined in Table 5, Washington State's CREP was established to enhance salmon habitat by the use of tree-dominated riparian buffers. Table 6 lists the six specific original objectives of CREP in Washington.

Table 6: Washington's Original CREP Objectives (USDA 1998)

1	Restoration of 100 percent of the area enrolled for the riparian forest practice to a properly functioning condition in terms of distribution and growth of woody plant species.
2	Reduction of sediment and nutrient pollution from agricultural lands adjacent to the riparian buffers by more than 50 percent.
3	Establishment of adequate vegetation on enrolled riparian areas to stabilize 90% of stream banks under normal (non-flood) water conditions.
4	Reduction of the rate of stream water heating to meet State ambient water quality standards by plating adequate vegetation on all riparian buffer lands
5	Provision of a contributing mechanism for farmers and ranchers to meet the water quality requirements established under federal law and under Washington's water quality laws.
6	Provision of adequate riparian buffers on 2,700 stream miles to permit natural restoration of stream hydraulic and geomorphic characteristics which meet habitat requirements of salmonids

The CREP project area includes private agricultural lands along streams identified in the 1992 Salmon and Steelhead Status Inventory (SaSSI) as depressed or in critical condition and that are listed under the Federal Endangered Species Act. Up to 100,000 acres of private cropland and grazing land, including 3,000 - 4,000 miles of riparian area (later increased to 10,000 miles), are eligible for inclusion in this program (Smith 2006). The riparian forest buffer, also known as Conservation Practice 22 or CP 22, is the single conservation practice authorized in the

Washington CREP. It is anticipated that restoring forested riparian buffers will have a significant positive impact on the targeted freshwater streams (NFMS 1999). For enrollment of 100,000 acres, the total financial obligation will be approximately $250 million over 15 years, with $210 million coming from the USDA, and the balance from the State and producers themselves (USDA 1998). Figure 6 shows the amount of riparian buffer acres enrolled in the program as of April 2006; 26 of the 30 eligible counties in Washington have contracts.

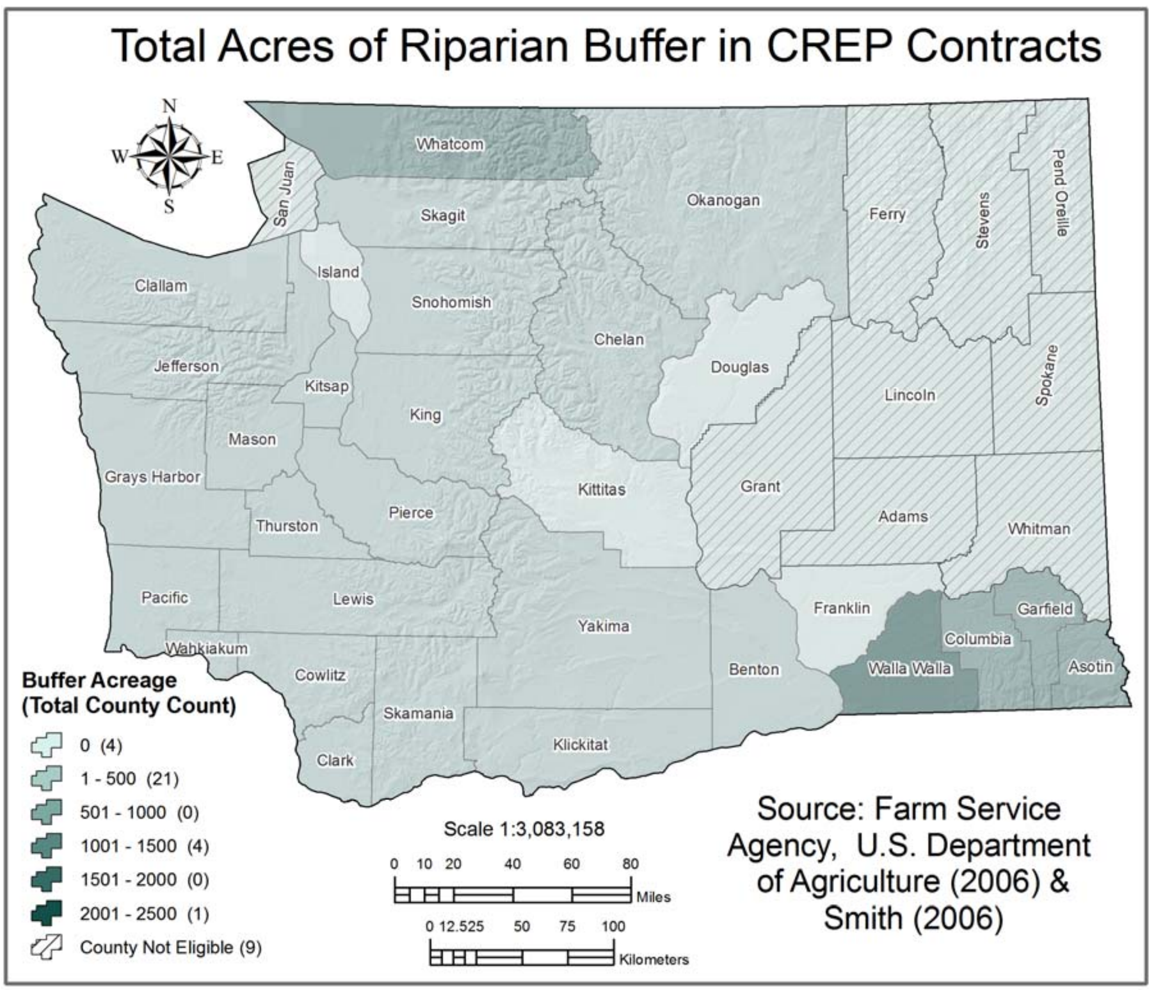

Figure 6: CREP Buffer Acreage in Washington Counties (FSA 2006; Smith 2006)

Washington's CREP is designed to address water quality degradation which is a direct or indirect result of agricultural activities on private lands along freshwater streams. Farming and ranching activities on these lands have led to removal or elimination of native riparian vegetation with resultant increases in water temperature, rates of sedimentation, and changes in channel morphology (NMFS 1999).

In addition to meeting Washington's requirements, CREP acreage must also meet the basic eligibility criteria for CRP. Land must be cropland that has been cropped 2 out of the past 5 years and is physically and legally capable of being cropped. Marginal pastureland is also eligible to be enrolled provided that it is suitable for use as a riparian buffer planted to trees. Producers are eligible if the land has been owned or operated for at least one year prior to enrollment. Land with an existing CRP contract or an approved offer with a contract pending is not eligible for CREP until that contract expires (USDA 1998).

Under the program, farmers and ranchers who voluntarily participate will enter into a contract with the federal government for 10 to 15 years, agreeing to remove portions of their land from agricultural production and replacing the area with a state approved conservation practice. These producers are eligible to receive rental payments and other financial assistance in return for the removal of their lands from agricultural production. For non-irrigated land, farmers and ranchers will be paid the federally-established dry land soil rental rates. Where land is irrigated, an irrigated soil rental rate will be paid when farmers and ranchers agree to lease the appurtenant water right to the State for in-stream use (NMFS 1999).

There are three types of payments for which participants in the Washington State CREP are eligible: annual rental payments, financial assistance in the installation of the conservation practices, and annual maintenance payments. The annual rental payment is based on the soil rental rate, as calculated by USDA's Farm Service Agency (FSA). Producers will receive an incentive payment above the mean annual per acre rental rate of 50 percent for the installation of the riparian buffer. Additionally, producers will receive a 10 percent incentive payment for agricultural lands protected under the Washington Growth Management Act. USDA's Commodity Credit Corporation (CCC) will pay 50 percent of the cost of installing conservation practices (installing new vegetation, fencing, etc.) and the State will pay 37.5 percent of the cost of the conservation practices. Table 7 shows the breakdown of cost sharing between the federal and state government entities in addition to the payment calculation.

Table 7: Payment Sharing between USDA and WA (FSA 2006).

Payment Category	Payment Calculation	Payer	Payment Timeframe
Soil Rental Rate	200% * Soil Rental Rate * per acre	USDA - FSA	Annually
Agricultural Lands of Statewide Significance	10% * Soil Rental Rate * per acre	USDA - FSA	Annually
Cost Share	50% of eligible costs	USDA - FSA	Issued after each phase is complete
Practice Incentive Payment	40% of eligile costs	USDA - FSA	Issued after buffer installation is completed
Signing Incentive Payment	$10.00 per acre, per full contract year	USDA - FSA	Paid after contract approved
Maintenance	$7.00-$10.00 per acre, per full contract year	USDA - FSA	Issued after each phase is complete
Practice Incentive Payment	40% of eligible costs to establish	Washington State	Paid after contract approved
Cost Share	10% of eligible costs	Washington State	Paid by Districts after each phase is complete
Maintenance	100% of eligible costs for 5 years	Washington State	Paid by Districts after each phase is complete

For example, a potential participant offers 10 acres for CREP enrollment. The average soil rental rate (SRR) for the offered land is $70/acre. A fence will also be needed to exclude livestock and the contract will cover at least 15 years. The total estimated establishment costs, including the fence, are $1,000/acre. The annual maintenance will average $50/acre/year for the first five years. Table 8 shows the possible payment breakdown.

Table 8: CREP Payment Example (USDA 2004)

Payment Type	Example	Payment
Signing Incentive Payment (SIP)	10 acres X $10/acres X 15 years	$1,500 one time payment
Annual Rental Payments	10 acres X ($70 SRR X 200%) + $9 maintenance)	$1,490 annually for 15 years
FSA Cost Share	10 acres X $1000/acre X 50%	$5,000
State Cost Share	10 acres X $1000/acre X 10%	$1,000
Practice Incentive Payment (PIP)	10 acres X $1000/acre X 40%	$4,000
Maintenance	10 acres X $50/acre	$500 annually for up to 5 years

Since the program began in Washington, there have been 576 signed contracts, 9,565 acres of riparian buffer planted at an average width of 150 feet and spanning a length of 553 miles (Smith 2006). The program also has had a positive effect on local economies. Over 3.7 million seedlings, 975,863 feet of fencing, and 154 water systems (wells, troughs, and pipeline) have been purchased from in-state vendors. In addition, $1,008,045 is paid each year to landowners by the USDA as a rental payment for the protected buffer (Smith 2006).

CREP enrollment began in Whatcom County in 2000 (WCD 2001). As of September 2006, Whatcom County's CREP had 166 projects, 86.8 miles of stream buffers, and 1,430 acres planted in buffers of native vegetation (WCD 2006). The only CREP practice allowed in the state and in the county is a forested riparian buffer, also known as CP22. Forested buffers provide streams with LWD recruitment potential and other organic matter inputs, improve bank stability, encourage the deposition of sediment and sediment bound pollutants, and also moderate stream temperatures through shading. Farmers are provided financial assistance based on their soil type (Class I-X) and amount of acreage in their buffer (USDA 1998). Eligible land must have (1) the required cropping history (planted in annuals 2 of the past 5 years, planted to perennial grasses or legumes within the past 8 years of less, or capable functioning as a pasture), (2) the land must be able to support trees and shrubs, and (3) the land must be parallel or adjacent to an eligible streams.

The objective of this research is to target WRIA 1 watersheds for CREP enrollment using water quality, salmon habitat, and soil data in a Geographic Information System (GIS) framework. The goal of the research is to provide a targeted approach to CREP enrollment for the watersheds of WRIA 1 based on both salmon habitat limiting factors and soil conservation planning. Chapter III outlines the study area, data, and methods of the targeted enrollment scenario.

Chapter III – Methods

The Washington State Conservation Commission (WSCC) published the Salmon and Steelhead Limiting Factors report for Whatcom County, Washington in April 2002. According to this report, salmon recovery planners face habitat challenges that include increased water temperatures, decreased shading of streams, loss of large woody debris, and impacts to riparian, floodplain, water quality, and flow conditions. As outlined in Chapter II, WRIA 1 studies have shown that most areas failing LWDRP are located in the agricultural and urban land uses of the Nooksack Basin. CREP riparian buffer implementation provides future sources of LWD, stream shading, pollutant trapping, and decreased erosion, among other environmental benefits such as wildlife habitat and carbon sequestration.

Study Area

WRIA 1 (Figure 1) is located at the northernmost end of the Puget Sound lowlands. It covers over 1,410 square miles, with elevations ranging from sea level to the summit of Mt. Baker at about 10,700 feet. Most of WRIA 1 falls within Whatcom County, although approximately 21 square miles of the WRIA are in Skagit County, and 147 square miles fall within British Columbia, Canada (WSR 2006).

Over 1,000 miles of rivers and streams can be found in WRIA 1. WRIA 1 is home to approximately one hundred lakes; Lake Whatcom is the largest at approximately 5,000 acres. In general, the rivers and streams can be broken into two types: the uplands, where streams have steep gradients and cut through bedrock, and the lowlands, where streams have low gradients and meander through glacial and river deposits (WSR 2006).

The major river system in WRIA 1 is the Nooksack River. In the uplands east of Deming, the Nooksack River has three branches: the North Fork, the Middle Fork, and the South Fork (Figure 1). Water in all three forks originates as a combination of run-off from rainfall and snowmelt, groundwater, and, in the case of the North and Middle Forks, glacial melt (Bach 2002). Stream flows in each of the forks combine just east of Deming, forming the mainstem of the Nooksack River that flows to Bellingham Bay in the Strait of Georgia. On average, water in the Nooksack River takes about one day to travel from Deming to Bellingham Bay. During times of intense rain or snowmelt, water reaches Bellingham Bay more quickly. In the lowlands, tributaries such as Anderson Creek, Fishtrap Creek, and many others discharge into the mainstem of the Nooksack River. Water flowing into the Nooksack from the North Lynden watershed, which includes Fishtrap and Bertrand Creeks, originates in Canada (WSR 2006).

In addition to the Nooksack River system, WRIA 1 contains several smaller watersheds that drain directly to the Strait of Georgia or north to British Columbia. The Sumas River watershed originates in WRIA 1 and drains north into Canada, eventually flowing into the Fraser River. In addition, tributaries to the Chilliwack, such as Silesia Creek, also originate south of the international border (WSR 2006).

In terms of population, WRIA 1 is home to over 180,000 people (excluding those that live in the Canadian portion); 1,062 live in the Skagit County portion. The majority of the WRIA's population lives in the watersheds containing Bellingham, 2005 pop. 71,203, with the fewest in the Middle Fork Nooksack watershed, 2005 pop. 147 (WSR 2006, USCB 2005).

Land uses vary throughout WRIA 1. The eastern third (305,526 acres) is dominated by forested lands in the National Forest and National Park systems. The western two-thirds support agriculture, residential development, commercial and industrial development, and forestry. According to the 2000 Whatcom County Assessor's records, almost 60 percent of the land in the western portion of WRIA 1 is either undeveloped or used for forestry or open space (WSR 2006).

According to the 2002 Census of Agriculture, there are 1,485 farms in Whatcom County, totaling 148,027 acres (231 mi^2). Whatcom County land area covers 2,120 mi^2, thus making agricultural areas about 10% of the total land area. The number of farm decreased from 1997 to 2002 (1,679 to 1,485 farms respectively), but the total agricultural land area during the same time increased by 30% (113,797 to 148,027 acres respectively). The apparent increase in agricultural land area was due to a change in the USDA National Agricultural Statistics Service (NASS) survey protocol for the 2002 Census to better account for all farms, including the non-reporting (John Gillies, personal communication, November 2006). The average size of farms rose 47% from 68 acres in 1997 to 100 acres in 2002. Figures 7, 8, and 9 show the type of land in farms, number of farms by size, and the amount of government payments to farmers in Whatcom County (USDA NASS 2006).

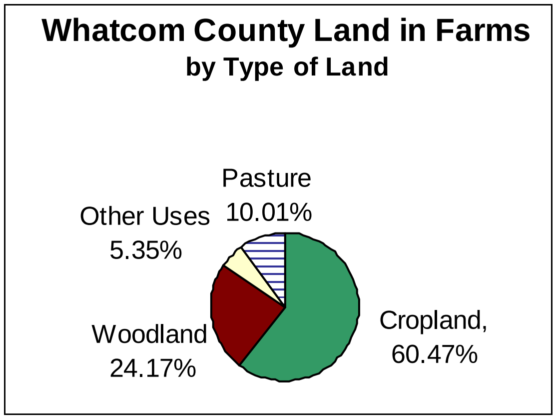

Figure 7: Whatcom County Land in Farms by Type of Land (USDA NASS 2006)

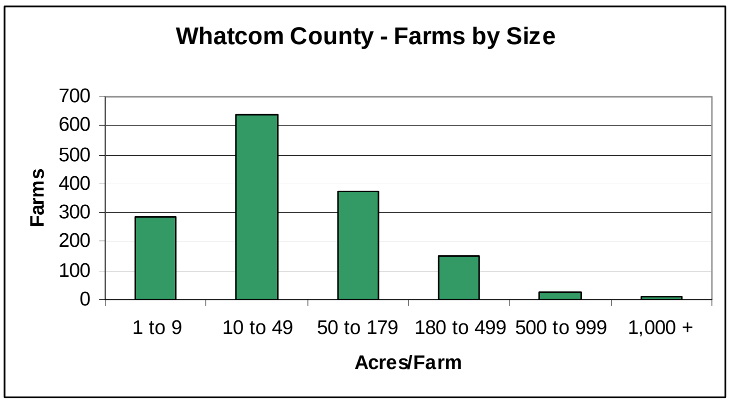

Figure 8: Number of Whatcom County Farms by Size (USDA NASS 2006)

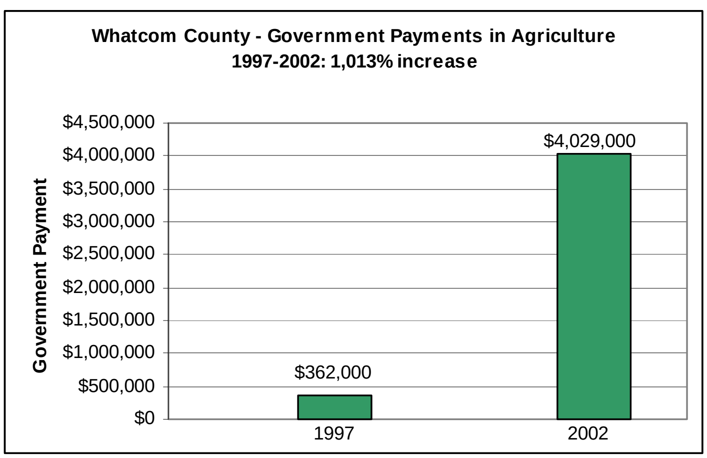

Figure 9: 1997 and 2002 Government Payments to Whatcom County Farmers (USDA NASS 2006)

Agriculture is a vital component to the economy of Whatcom County. Whatcom County ranks first among other Washington counties for berry production and corn for silage, second in milk and other dairy products from cows, third in value of livestock, fourth in cattle and calves, and sixth in the state for total value of farm products sold (USDA NASS 2006).

The soils, climate, and geology of WRIA 1 are examined in the Soil Survey of Whatcom County Area, Washington (USDA 1992). The soil survey area is bounded on the west by the Strait of Georgia, on the South by Skagit County, on the east by the Mount Baker-Snoqualmie National Forest, and on the north by Canada. The northwestern half of the survey area is nearly level to rolling. It includes flood plains, outwash terraces, and glaciomarine drift plains at elevations of sea level to 300 feet above sea level. The southeastern part is dominantly steep and mountainous, except for the floodplains along the three forks of the Nooksack River (USDA 1992).

The climate of the survey area is greatly tempered by winds from the Pacific Ocean. Summers are fairly warm, but hot days are rare. Winters are cool, but snow and freezing temperatures are not common except at higher elevations. At lower elevations, freezing air temperatures generally occur under the influence of dry air masses. During the summer rainfall is extremely light. During the rest of the year, rains are frequent, especially in fall and winter. During winter, ice-laden, northeast winds moving down the valley of the Fraser River are particularly damaging. In some years, either during winter or summer, a large invasion of a continental air mass from the east can cause abnormal temperatures. As a result, several consecutive days are well below freezing in winter or sweltering in summer. The total annual precipitation can vary widely by location and elevation; about 41 inches fall annually in Blaine, 36 in Bellingham, 46 in Clearbrook, and 67 in Glacier (USDA 1992). Figure 10 shows a map of the average annual precipitation in the study area for the years 1961 through 1991.

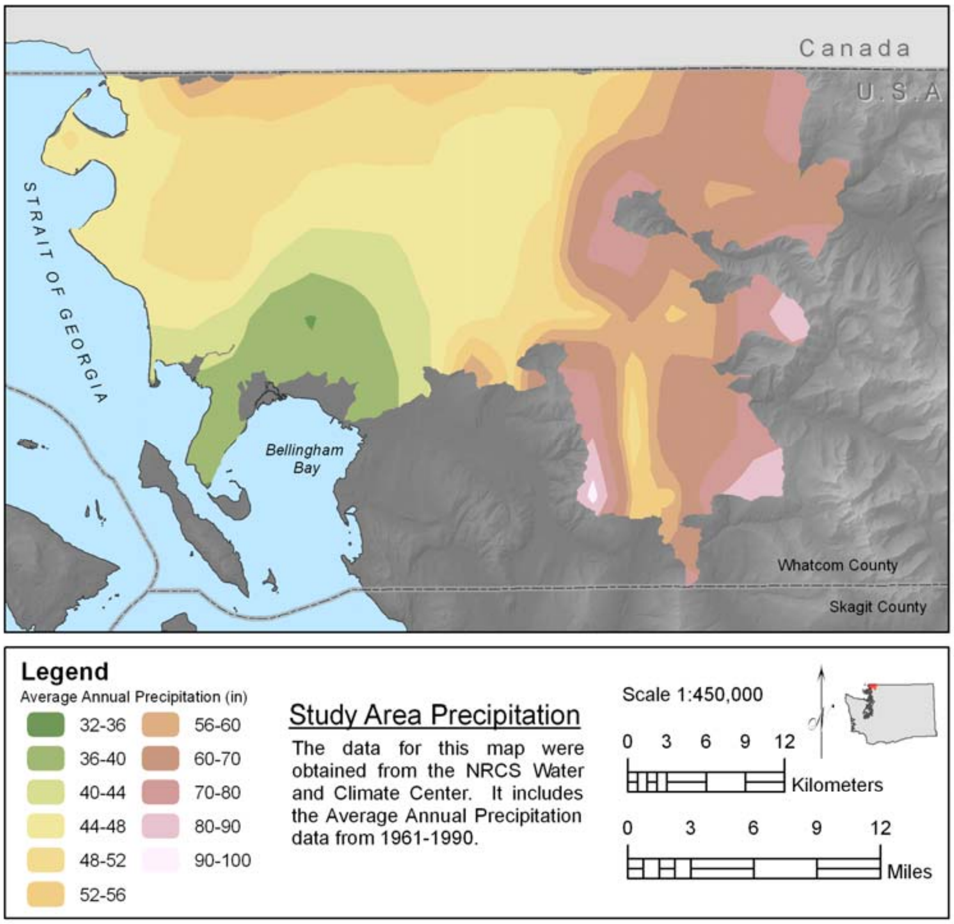

Figure 10: Average annual precipitation (1961-1990) in the study area (NRCS 2006)

` The survey area can be divided into two distinct physiographic regions: the Cascade Range and the Whatcom Basin. The Cascade Range rises abruptly from the floor of the Whatcom Basin, culminating in the snowfields and glaciers of Mount Baker, Mount Shuksan, and the Twin Sisters Mountain. The topography is extremely rugged, consisting of pre-Tertiary metamorphic and Tertiary sedimentary rocks with a mantle that is dominantly Vashon till and some outwash (USDA 1992).

The Whatcom Basin ranges in elevation from sea level to about 600 feet above sea level. It lies entirely in the Puget Trough of the Pacific Border physiographic region. The Basin's low topography is a result of several glaciations, marine submergences and rebounds, postglacial fluvial action, and eolian depositions (USDA 1992). It consists of hummocky glaciomarine drift plains; nearly level glaciofluvial terraces that have large bogs; and rolling, drift-capped upland overlooking the broad flood plain of the Nooksack River (USDA 1992).

As mentioned in Chapter II, a majority of anadromous reaches cross through the agricultural land in Whatcom County. Seven species of salmon can be found in WRIA 1 - chinook, chum, coho, pink, sockeye, steelhead, and kokanee (land-locked sockeye). There are also other salmonids (fish that are closely related to salmon): bull trout and dolly varden (native char), sea-run cutthroat, resident cutthroat, rainbow trout, and brook trout (a non-native char). Both chinook salmon and bull trout are listed as "threatened" under the Federal ESA and are protected by that law. Coho salmon in the area are a candidate for listing under ESA (Anchor Environmental 2003).

Data

The data necessary for the targeted enrollment strategy came from a variety of sources. Please see Table 9 for an overview of the data used in the analysis. The 303(d) listings were obtained from the Department of Ecology (Ecology 2005). The R factor of the RUSLE analysis was derived from the isoerodent map in Renard (1997). The K factors were obtained from the SSURGO database (USDA 2006). The Digital Elevation Models (DEM) came from the USGS in 10 meter format, roughly equivalent to 7.5 minute quadrangles or a scale of 1:24,000 (USGS 2006). The DEMs were used to create the LS factor of the RUSLE. The watershed boundaries were obtained from Western Washington University's (WWU) Spatial Analysis Lab (SAL) (WWU 2001). The anadromous streams layer was also obtained from WWU's SAL (WWU 2005). The CREP data were obtained from the Whatcom Conservation District (WCD 2006). The other existing restoration data were obtained from the Nooksack Recovery Team (NRT 2005).

Table 9: Data used in Analysis

Data	Purpose	Sources
Isoerodent Contours	R factor of RKLS - RUSLE Analysis	Renard (1997)
Whatcom County Soils	Prime Agricultural Farmland and K factor of RKLS - RUSLE Analysis	USDA (2006)
Washington WRIA borders	Watershed Eligibility	Ecology (2000)
Whatcom County CAO	FHCA Analysis	WWU (2005)
303(d) Water Courses	303(d) Analysis	Ecology (2005)
WRIA 1 Surface Water Drainages	Watershed Eligibility	WWU (2001)
Existing Restoration Projects	Existing Conservation Analysis	NRT (2005) and WCD (2006)
Whatcom County 10m DEM	LS factors of RKLS	USGS (2006)
Whatcom County CREP Projects	Existing Conservation Analysis	WCD (2006)
Agricultural Parcels	Watershed Eligibility	WWU (2006)

Methods

For this analysis, the selected watersheds of WRIA 1 were ranked by the potential for CREP projects to improve water quality, improve salmon habitat, decrease erosion, improve habitat connectivity, and to protect prime agricultural land. All analysis was done in ESRI's ArcMap 9.1 software. Figure 11 shows a flow chart of the methodology for this analysis.

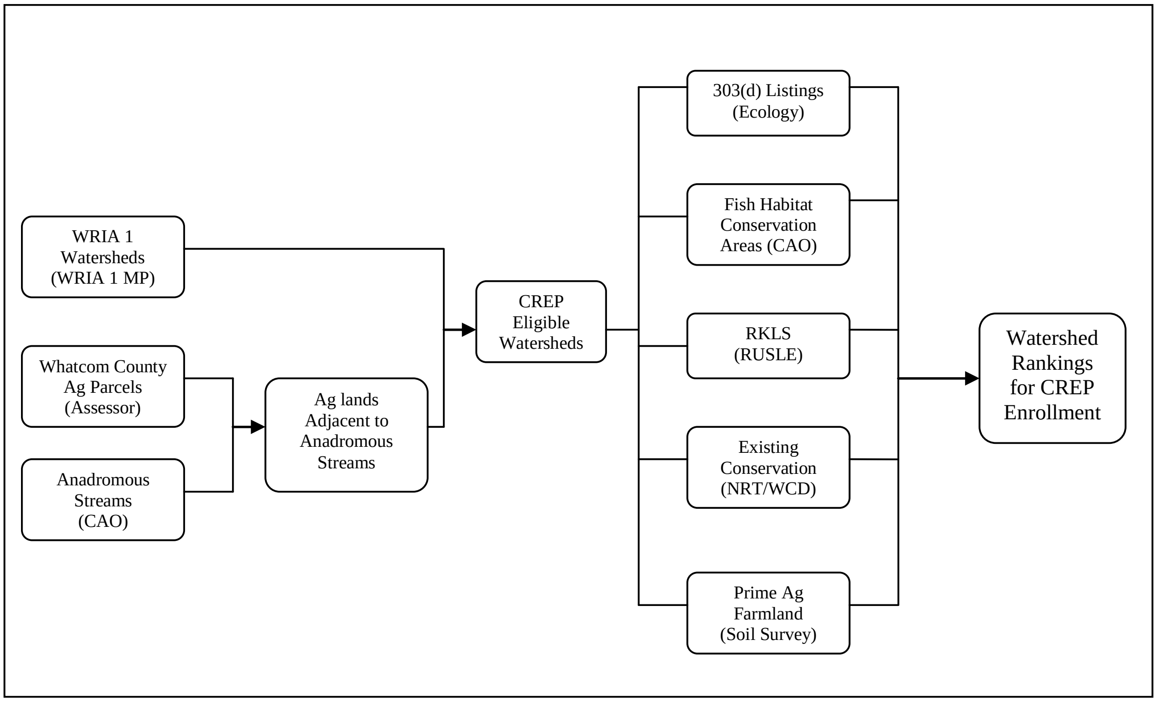

Figure 11: Methodology Flow Chart

To prioritize watersheds for restoration within a river basin, key issues and restoration objectives must first be outlined (Nelson 1997). Key issues and restoration objectives for CREP in Washington were used in this analysis. These include water quality improvement (303(d) listings), salmon habitat improvement (FHCA), erosion reduction (RUSLE), habitat connectivity (existing restoration), and protection of the state's most important soils (prime farmland). As O'Connell *et al* (2003) outline, to prioritize areas for restoration, the average of the ranks for defined indicators should be used. Although this basin scale of analysis usually does not produce a decision-making document, such as restoration site selection on the reach scale, it does promote understanding of the watershed scale operating processes, and it may be used to guide project planning (Kershner 1997).

The first step in creating a targeted watershed approach to CREP enrollment was to select the watersheds that are potentially eligible for CREP enrollment. First, the agricultural parcels were selected out of a Whatcom County parcels GIS layer, using the expression in Figure 12. Second, the agricultural parcels that were located adjacent to an anadromous stream were selected. The anadromous stream layer

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"LAND_USE" = 'AG PROC' OR "LAND_USE" = 'AG RELTD ACT' OR
"LAND_USE" = 'AGRICULTURE' OR "LAND_USE" = 'DAIRY PROD' OR
"LAND_USE" = 'DAIRY PRODS' OR "LAND_USE" = 'FARM CROP ET' OR
"LAND_USE" = 'FARM DAIRY' OR "LAND_USE" = 'FARM POULTRY' OR
"LAND_USE" = 'FARM PRODS' OR "LAND_USE" = 'FARM/RANCHES' OR
"LAND_USE" = 'FARMS' OR "LAND_USE" = 'OSAG CRO MH' OR
"LAND_USE" 'OSAG CRO MH+' OR "LAND_USE" = 'OSAG CROP/ET' OR
"LAND_USE" = 'OSAG DAI LOG' OR "LAND_USE" = 'OSAG DAI MH' OR
"LAND_USE" = 'OSAG DAI MH+' OR "LAND_USE" = 'OSAG DAIRY' OR
"LAND_USE" = 'OSAG MH' OR "LAND_USE" = 'OSAG MH+' OR "LAND_USE"
= 'OSAG POU MH' OR "LAND_USE" = 'OSAG POU MH+' OR "LAND_USE" =
'OSAG POULTRY' OR "LAND_USE" = 'OSAG RAN LOG' OR "LAND_USE" =
'OSAG RAN MH' OR "LAND_USE" = 'OSAG RAN MH+' OR "LAND_USE" =
'OSAG RANCHES' OR "LAND_USE" = 'OSAG' OR "LAND_USE" = 'OTHR AG
LAND' OR "LAND_USE" = 'OTHR AG RLTD'
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Figure 12: GIS Expression to Derive Agricultural Land Uses

contains streams that have known, presumed, or historical salmon presence (Whatcom County 2005). Finally, the 4th order watersheds (roughly equivalent to USGS's 12-14 digit HUC) of WRIA 1 that contained agricultural parcels adjacent to anadromous streams were selected; this selection was exported and became the basis for the analysis. Fifty one watersheds were selected and included in the analysis, as shown in Figure 13 and Table 10. Seven of these watersheds (North Fork Dakota, Bertrand, Fishtrap, Johnson, Breckenridge, Saar, Kendall, and Blaine) were clipped at the U.S. – Canada border. Their area was then recalculated for the portion falling within the United States. Figure 3 shows the eligible watersheds of Whatcom County for the Conservation District (WCD 2005). The watersheds used for this analysis were similar to the Conservation District's eligible watersheds, but this study is broader. More watersheds may become eligible for CREP enrollment as fish passage barriers are removed (Andrew Phay, 2006, personal communication).

After the watersheds were selected for analysis, the next step was to perform the prioritization strategy for each watershed. The prioritization criteria include: 303(d) listings, Whatcom County's Critical Area's Ordinance Fish Habitat Conservation Areas, soil erosion vulnerability screening using the environmental factors of the RUSLE, existing restoration projects, and prime agricultural farmland. The final ranking, an average of the total ranks, represent the watersheds with the most potential to gain benefits from increased CREP enrollment. The watersheds were ranked from the most to least amount of 303(d) listings, Fish Habitat Conservation Area, soil erosion vulnerability, existing restoration, and prime agricultural farmland.

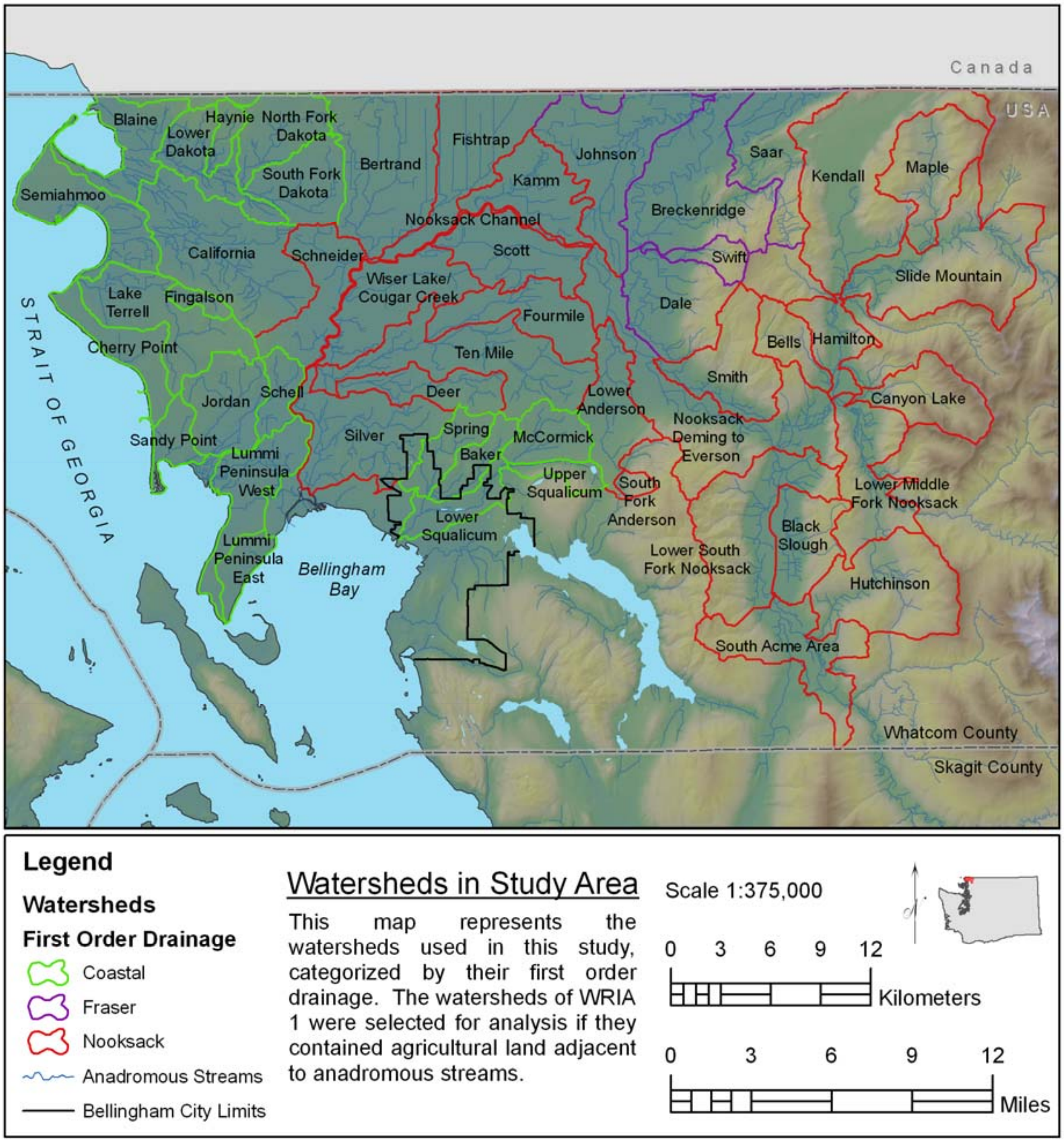

Figure 13: Watersheds used in study by first order drainage (Ecology 2006; WWU 2001)

Table 10: Watersheds used in Analysis showing Area, Drainage Order, and agricultural land adjacent to anadromous streams (WWU 2001, WWU 2006)

Fourth Order Drainage	First Order Drainage	Area (Acres)	Ag land adjacent to anadromous streams (Acres)	Adjacent Ag land % of total watershed area
Baker	Coastal	2572	102.57	3.99
Bells	Nooksack	3129	2.08	0.07
Bertrand	Nooksack	12907	4696.18	36.38
Black Slough	Nooksack	5535	860.39	15.54
Blaine	Coastal	5280	186.61	3.53
Breckenridge	Fraser	13404	2716.73	20.27
California	Coastal	14201	2902.89	20.44
Canyon Lake	Nooksack	5678	1.29	0.02
Cherry Point	Coastal	4211	145.44	3.45
Dale	Fraser	7864	1846.05	23.47
Deer	Nooksack	4375	677.78	15.49
Fingalson	Coastal	1037	185.89	17.93
Fishtrap	Nooksack	10041	2348.8	23.39
Fourmile	Nooksack	6451	897.21	13.91
Hamilton	Nooksack	3761	25.28	0.67
Haynie	Coastal	1435	45.49	3.17
Hutchinson	Nooksack	10616	10.74	0.10
Johnson	Fraser	11714	4542.66	38.78
Jordan	Coastal	5964	1032.7	17.32
Kamm	Nooksack	6469	1772.93	27.41
Kendall	Nooksack	16753	201.69	1.20
Lake Terrell	Coastal	8338	1558.55	18.69
Lower Anderson	Nooksack	5725	569.65	9.95
Lower Dakota	Coastal	4818	454.44	9.43
Lower Middle Fork Nooksack	Nooksack	7876	118.08	1.50
Lower South Fork Nooksack	Nooksack	11629	814.51	7.00
Lower Squalicum	Coastal	3077	59.26	1.93
Lummi Peninsula East	Coastal	2143	156.79	7.32
Lummi Peninsula West	Coastal	6300	440.34	6.99
Maple	Nooksack	7744	101.69	1.31
McCormick	Coastal	3569	388.48	10.88
Nooksack Channel	Nooksack	1062	4.18	0.39
Nooksack Deming to Everson	Nooksack	15640	871.49	5.57
North Fork Dakota	Coastal	4887	444.02	9.09
Saar	Fraser	8039	1474.95	18.35
Sandy Point	Coastal	2326	76.14	3.27
Schell	Coastal	2333	351.24	15.06
Schneider	Nooksack	6254	948.96	15.17
Scott	Nooksack	6902	1612.24	23.36
Semiahmoo	Coastal	6592	322.3	4.89
Silver	Nooksack	10126	390.19	3.85
Slide Mountain	Nooksack	13774	75.16	0.55
Smith	Nooksack	7196	438.67	6.10
South Acme Area	Nooksack	8644	662.4	7.66
South Fork Anderson	Nooksack	707	26.61	3.76
South Fork Dakota	Coastal	5426	1386.47	25.55
Spring	Coastal	2975	53.98	1.81
Swift	Fraser	1854	9.44	0.51
Ten Mile	Nooksack	11849	2507.2	21.16
Upper Squalicum	Coastal	1573	4.08	0.26
Wiser Lake/Cougar Creek	Nooksack	7995	1513.03	18.92

Watershed Water Quality

To carry out the rankings, the 51 watersheds were first ranked by the total area (in acres) of 303(d) listings they contain relative to watershed area from the most amount of acreage listed to the least amount of acreage listed; the 303(d) listings were obtained from the Department of Ecology's (Ecology) 2004 listings. This ranking represents the potential for CREP projects to mitigate degraded water quality. The 303(d) list represents known polluted waters of the state. The most common listings involve high amounts of fecal coliform, high temperatures, and low dissolved oxygen. Watersheds with 303(d) listed bodies have the most potential to benefit from the pollutant trapping, sediment trapping, and cooling capabilities of CREP buffers.

The data for this analysis were obtained from Ecology. To develop its water quality assessment, Ecology compiles and assesses available water quality data on a statewide basis in order to get a better picture of the overall status of water quality in Washington's waters. Assessed waters include all the rivers, lakes, and marine waters in the state where data are available. To develop the list, Ecology compiles its own water quality data and invites other groups to submit water quality data they have collected. All data submitted needed to be collected using Ecology's defined appropriate scientific methods. The listed streams and waterbodies are the result of the assessment submitted to the Environmental Protection Agency (EPA) as an "integrated report" to satisfy federal Clean Water Act requirements of sections

303(d) and 305(b). Category 5 (of 5) of the Assessment is the list of known polluted waters in the state, sometimes referred to as the 303(d) list.

The assessed waters are listed in five categories that describe the status of water quality. Waters that have data showing they are polluted are in Category 5, which indicates that beneficial uses of the waterbody, such as drinking, recreation, aquatic habitat, and industrial use, are impaired by pollutants. Ecology is responsible for listing the state's bodies of water into 5 categories based on water quality parameters, such as temperature, nitrates, phosphorus, and dissolved oxygen. 303(d) listed bodies will require a water quality improvement plan for each parameter they are listed for, known as a Total Maximum Daily Load, or TMDL. A TMDL is the amount of a particular pollutant that a particular stream, lake, estuary, or other waterbody can 'handle' without violating state water quality standards.

Ecology's water quality assessment data are available in a shapefile that accompanies a DBF file of attributes. In a GIS, the shapefile is related to the database, which then allows for the watersheds that contain 303(d) listed (or Category 5) bodies of to be selected out and exported as their own layer. The watersheds that contain 303(d) listed bodies of water were compared in terms of watershed area. Finally, the watersheds were ranked from the most amount of area in 303(d) listings to least amount of area in 303(d) listings in order to get a general sense of water quality across watersheds.

Fish Habitat Conservation Areas

The watersheds were ranked by the amount of Fish Habitat Conservation Area (FHCA) they contain, from most of amount of FHCA area to least amount of FHCA area. This ranking method assesses the potential for CREP projects to satisfy government buffer requirements. Whatcom County's Critical Areas are environmentally sensitive natural resources that have been designated for protection and management in accordance with the requirements of the Growth Management Act (GMA). Protection and management of these areas is important to the preservation of ecological functions and values of the natural environment (Whatcom County 2005). The CAO covers: Geologically Hazardous Areas; Frequently Flooded Areas; Critical Aquifer Recharge Areas; Wetlands; and Fish and Wildlife Habitat Conservation Areas (Whatcom County 2005).

The Habitat Conservation Areas (HCAs) are protected to: ensure the continued existence and enhancement of fish and wildlife populations by protecting and conserving valuable fish and wildlife habitat; encourage the preservation of marine shorelines and natural river and stream functions that support fish and wildlife populations; preserve critical wildlife habitats so that isolated populations of species are not created and habitat fragmentation is avoided, especially along riparian corridors; and maintain the natural geographic distribution of fish and wildlife habitat (Whatcom County 2005).

HCAs are designed, in part, to protect ESA listed species. ESA listed species are those officially designated by the State Department of Fish and Wildlife and/or the U.S. Fish and Wildlife Service under the Federal ESA as endangered, threatened, sensitive, or candidate. Such species include Chinook salmon, bull trout, bald eagle, and California red-legged frog. Listed species are known to be experiencing, or have experienced, failing or declining populations due to factors such as limited numbers, disease, predation, exploitation, or a loss of suitable habitat (Whatcom County 2005).

Accordingly, Fish Habitat Conservation Areas (FHCA) include a buffer around all salmonid bearing streams that are categorized as having a current known, current presumed, or presumed potential/known historic distribution (Whatcom County 2005). The CAO mandates a 100ft buffer along these fish bearing streams. Landowner enrollment in CREP satisfies the CAO buffer. Therefore, watersheds with high amounts of FHCA would show more potential for landowners to enroll in CREP.

To carry out this ranking in a GIS, anadromous streams were buffered by 100ft, the buffer size required by the CAO. The buffers in each watershed under analysis were clipped out by watershed boundary in order to calculate the amount of buffer area in each watershed. The watersheds were then ranked relatively by the amount of buffer they contained, from most to least, as compared to their overall size.

Soil Erosion Vulnerability Screening

The third ranking method incorporates the environmental factors of the Revised Universal Soil Loss Equation (RUSLE), which include the RKLS factors. This ranking represents the potential for CREP projects to lessen soil erosion. The RUSLE is a set of mathematical equations that estimate average annual soil loss and resulting from interrill and rill erosion (Renard 1997). It is derived from the theory of erosion processes and tested with more than 10,000 plot-years of data from natural rainfall plots and numerous rainfall-simulation plots. RUSLE is an exceptionally well-validated and documented equation. A strength of RUSLE is that it was developed by a group of nationally-recognized scientists and soil conservationists who had considerable experience with erosional processes. RUSLE retains the structure of its predecessor, the Universal Soil Loss Equation (USLE) (Hickey *et al* 2001).

In a general sense, the RUSLE may be divided into environmental variables and land management variables. The environmental variables consist of climate, topography, and soil data, which remain largely consistent over time. The management variables of crop type and erosion control measures change more frequently on a shorter time scale. Considering the environmental variables alone does not allow for an absolute measure of erosion; however, it does allow for an evaluation of basin-scale potential for soil erosion (Burns *et al* 2002). The environmental variables of RUSLE include: the rainfall dependency of erosion (R); slope length and slope angle (LS); and the aspects of a soil that contribute to its relative susceptibility to erosion (K) (Renard 1997). Both RUSLE and USLE are expressed as follows:

A = R * K * LS * C * P

Where

A = estimated average annual soil loss (tons · acre $^{-1}$ · year $^{-1}$)
R = average annual erosivity factor (hundreds of ft · tonf · in · acre $^{-1}$ · yr $^{-1}$)
K = soil erodibility factor (ton · acre · h · [hundreds of acre-ft · tonf · in] $^{-1}$)
L = slope length factor (dimensionless)
S = slope steepness factor (dimensionless)
C = cover-management factor (dimensionless)
P = support practice factor (dimensionless)

The R factor was derived from research data from many sources (Renard 1997). The data indicate that when factors other than rainfall are held constant, soil losses from cultivated fields are directly proportional to a rainstorm parameter: the total storm energy (E) times the maximum 30 minute intensity (I_{30}). Storms less than 0.5 inches are not included in the erosivity computations because these storms generally add little to the total R value. R factors represent the average storm EI values over at least a 22-year record, the use of longer records is advisable (Renard 1997). R is an indication of the two most important characteristics of a storm determining its erosivity: amount of rainfall and peak intensity sustained over and extended period (Renard 1997).

The K factor is the soil erodibility factor, representing both the susceptibility of soil to erosion and the rate of runoff (Renard 1997). Soils high in clay have low K values, about 0.05 to 0.15, because they are resistant to detachment. High sand soils also have low K values, about 0.05 to 0.2, because these soils have high infiltration rates and reduced runoff, and sediment eroded from these soils is not easily transported. Medium textured soils, such as the silt loam soils, have moderate K values, about 0.25 to 0.4, because they are moderately susceptible to detachment and they produce moderate runoff. Soils having a high silt content are the most erodible of all soils; they are easily detached and tend to crust and produce high rates of runoff. Values of K for these soils tend to be greater than 0.4 (Renard 1997).

The L factor is the slope length factor, representing the effect of plot size on erosion. It is the ratio of soil loss from the field slope length to that from a 72.6-foot (22.1-meter) length on the same soil type and gradient. Slope length is the distance from the origin of overland flow along its flow path to the location of either concentrated flow or deposition (Renard 1997). Surface runoff will usually concentrate in less than 400 ft., which is a practical slope-length limit in many situations (Renard 1997). For this analysis, the slope length upper bound was 150 meters, due to the aforementioned recommendation by Renard (1997), and because the grid cell widths under analysis were 10 meters. Therefore, 15 grid cells were used for maximum flow accumulation.

The S factor is the slope steepness factor, representing the effect of slope steepness on erosion. Soil loss increases more rapidly with slope steepness than it does with slope length due to the velocity of runoff. It is the ratio of soil loss from the field gradient to that from a 9 percent slope under otherwise identical conditions. The relation of soil loss to gradient is influenced by density of vegetative cover and soil particle size.

The environmental variables necessary for analysis are all publicly available in a GIS format. The R point factors were obtained from the isoerodent map published in Renard (1997). These given point factors were interpolated for the study area using the ArcMap Spatial Analyst tool kriging. The K factor was obtained from the NRCS SSURGO Database. The LS factor was computed using USGS 10m Digital Elevation Models (DEM) and ArcGIS tools of Flow Direction and Flow Accumulation. The S factor was computed using a 10m USGS DEM and the Slope tool in the ESRI's Spatial Analysis Toolbox. The S values used in analysis represent the mean S values of the entire watershed, as derived from the Spatial Analyst Zonal Statistics tool. The L factor was computed using a 10m USGS DEM and ESRI's Hydrology tools of Flow Direction and Flow Accumulation and the following formula:

$$LS = (\text{Flow Accumulation} * \text{Cell Size}/22.13)^{0.4} * (\sin \text{slope}/0.0896)^{1.3}.$$

This technique for estimating the LS factor of RUSLE was first proposed by Moore and Burch (1986). They derived an equation for estimating LS based on flow accumulation and slope steepness. Each environmental factor raster was multiplied together to get a dimensionless RKLS unit per watershed. Each watershed was then ranked according to this soil erosion vulnerability screening.

Habitat Connectivity

The fourth ranking method involves existing restoration projects and the opportunity for contiguous projects. The Washington State Department of Fish and Wildlife Stream Habitat Restoration 2004 Guidelines outline that:

> "Riparian restoration and management may be undertaken on sites ranging from narrow stream fringes to upland habitat to wide riparian corridors with gradual transitions to adjacent uplands. Riparian restoration can be implemented on small sites with limited budgets. However, the benefits to fish, wildlife, water quality, and the physical condition of the stream are much greater when applied on long continuous lengths of stream and across entire floodplain widths, as opposed to applying it on isolated patches" (WDFW 2004, p3).

In addition, Smith (2006) notes that habitat values increase when fragmentation is reduced, and CREP projects that are contiguous with one another, or contiguous with other restoration projects, are greatly desired. Consequently, this ranking represents the potential for contiguous projects in each watershed. CREP project locations and sizes were obtained from the Whatcom Conservation District (WCD). Other county restoration project locations were obtained from the Nooksack Recovery Team's (NRT) database of restoration projects (NRT 2005). The NRT database is updated once per year and includes the point locations of riparian restoration projects in Whatcom County. The NRT gathers this information from many sources, including the WCD, Whatcom County, City of Bellingham, and the Nooksack Salmon Enhancement Association (NSEA), among others. The watersheds were ranked by the total number of restoration projects they contain, from most to least. It is assumed that landowners in watersheds with existing restoration projects could potentially be more inclined to enroll in CREP.

Prime Agricultural Land

The fifth ranking method involves watersheds being ranked by the amount of prime agricultural farmland they contain and compared relatively by watershed area. This ranking represents the ability of CREP projects to protect the area's most valuable soils. The Soil Survey of Whatcom County lists the prime agricultural soil map units of Whatcom County. High enrollment of CREP in watersheds that contain the most prime agricultural farmland would protect the county's most valuable resources for agricultural sustainability. About 67,000 acres, or 13 percent of the soil survey area, all in the western part, meet the requirements for prime farmland without drainage measures, flood control, or irrigation (USDA 1992).

Prime farmland is one of several types of important farmland defined by the USDA. It is of major importance in meeting the Nation's short- and long-range needs for food and fiber. Because the supply of high-quality farmland is limited, the USDA recognizes that responsible levels of government should encourage and facilitate the wise use of our Nation's prime farmland (USDA 1992).

Prime farmland, as defined by the USDA (1992), is the land that is best suited to food, feed, forage, fiber, and oilseed crops. It may be cultivated land, pasture, woodland, or other land, but it is not urban or built-up land or water areas. It either is used for food or fiber crops or is available for those crops. The soil qualities, growing season, and moisture supply are those needed for a well managed soil to produce a sustained high yield of crops in an economic manner. Prime farmland has an adequate and dependable supply of moisture from precipitation or irrigation. The temperature and growing season are favorable. The level of acidity or alkalinity is acceptable. Prime farmland has few or no rocks and is permeable to water and air. It is not excessively erodible or saturated with water for long periods and is not frequently flooded during the growing season. The slope ranges mainly from 0 to 8 percent (USDA 1992). Prime farmland produces the highest yields with minimal expenditure of energy and economic resources, and farming it results in the least damage to the environment (USDA 1992).

All prime and other important farmlands were used in this analysis. This includes the following categories and unit descriptions: Category 1 - all areas are prime farmland; Category 2 - prime farmland if irrigated; Category 3 - prime farmland when protected from flooding; Category 4 – prime farmland when irrigated; and, Category 5 – prime farmland when drained and protected from flooding. These categories constitute 75 of the 191 soil map units in the Soil Survey of Whatcom County Area, Washington and 240,205 acres of the total 340,770 acres in the study area.

Final Ranking

Russell *et al* (1997) discussed how prioritizing sites for restoration involves ranking the potential suitability of sites from most suitable to least suitable. The individual ranks were then averaged to create the prioritized list of watersheds (O'Connell *et al* 2003). For this analysis, all watersheds were ranked based on the amount of 303(d) listings (from most to least), the amount of Fish Habitat Conservation Areas (from most to least), the potential soil erosion vulnerability (from most to least), the opportunities for habitat connectivity (from most to least), and the amount of prime agricultural farmland (from most to least).

Chapter IV - Results

The results of the rankings are shown in Tables 11 - 16 and mapped in Figures 19 - 25. Each ranking is discussed in the topic headings of Watershed Water Quality (303(d) listings), Fish Habitat Conservation Areas, Soil Erosion Vulnerability, Habitat Connectivity (existing restoration), and Prime Agricultural Land.

Watershed Water Quality

Table 11 shows the rankings based on the 303(d) listings. Figure 19 shows the amount of 303(d) listings, in acres, for the study area. Twenty-six watersheds of the study area contained 303(d) listed bodies of water. The five watersheds with the most acreage listed relative to watershed area include Blaine, Lower Squalicum, Kamm, Silver, and the Lower South Fork Nooksack. These watersheds account for 39 of the total 77 listings and 190 acres of the total 350 acres listed in the study area. The 303(d) listed bodies of water represent Category 5 of Ecology's water quality assessments, and are the known polluted waters of the state. The 303(d) listed bodies will require a water quality improvement plan for each parameter they are listed for, known as a Total Maximum Daily Load, or TMDL. A TMDL is the amount of a particular pollutant that a particular stream, lake, estuary, or other waterbody can 'handle' without violating state water quality standards (Ecology 2005).

Fish Habitat Conservation Area

Table 12 shows the rankings based on the amount of Fish Habitat Conservation Area relative to the amount of watershed area. Figure 20 shows the total amount of FHCA, in acres, by watershed. All 51 watersheds in analysis contained FHCA. The Nooksack Channel contained the most FHCA which can be expected, considering it drains the area directly adjacent to the Nooksack River. The Lower Dakota, Saar, Schell, Silver, California, Haynie, Johnson, Deer, and Black Slough watersheds round out the ten watersheds that contain the most FHCA, respectively.

Soil Erosion Vulnerability Screening

Figures 14, 15, 16, 17, and 18 show the RUSLE factor outputs of the soil erosion vulnerability screening and the final RKLS output. Figure 21 shows the RKLS values by watershed. Under this analysis, the ten watersheds that are the most vulnerable to soil erosion include Saar, Nooksack Deming to Everson, Lower Middle Fork Nooksack, Slide Mountain, Canyon Lake, Dale, Breckenridge, Lower South Fork Nooksack, South Acme Area, and Swift, respectively. These watersheds are mainly on the eastern portion of the study area. This area has a more rugged topography (LS factor) and an increased rainfall erosivity factor (R factor).

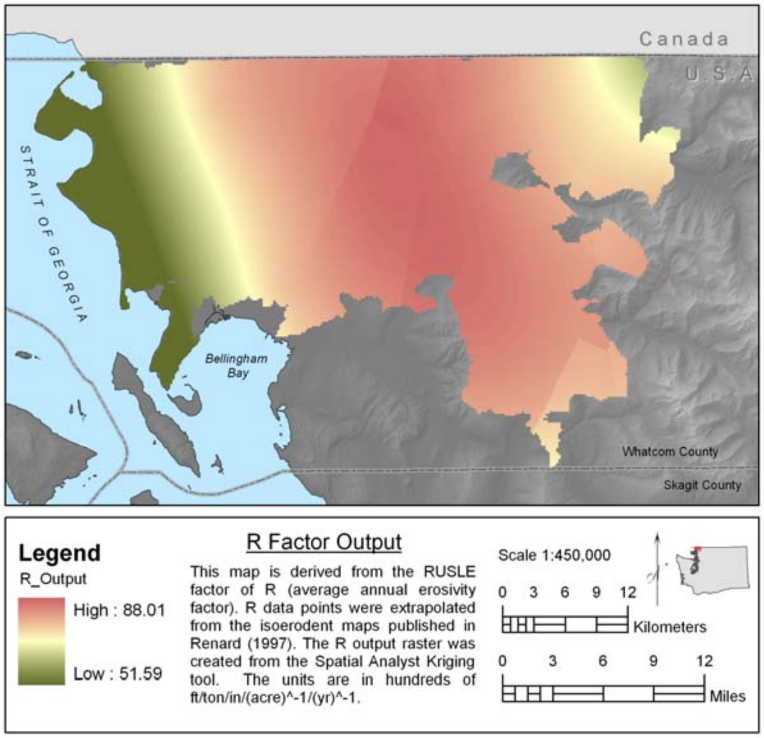

Figure 14: R factor output (average annual erosivity factor))

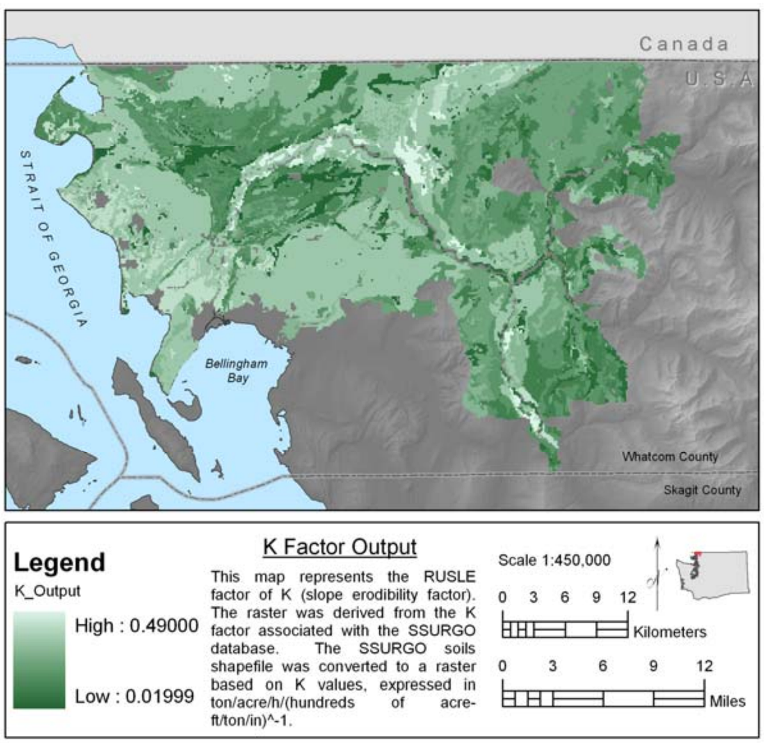

Figure 15: K factor output (soil erodibility factor)

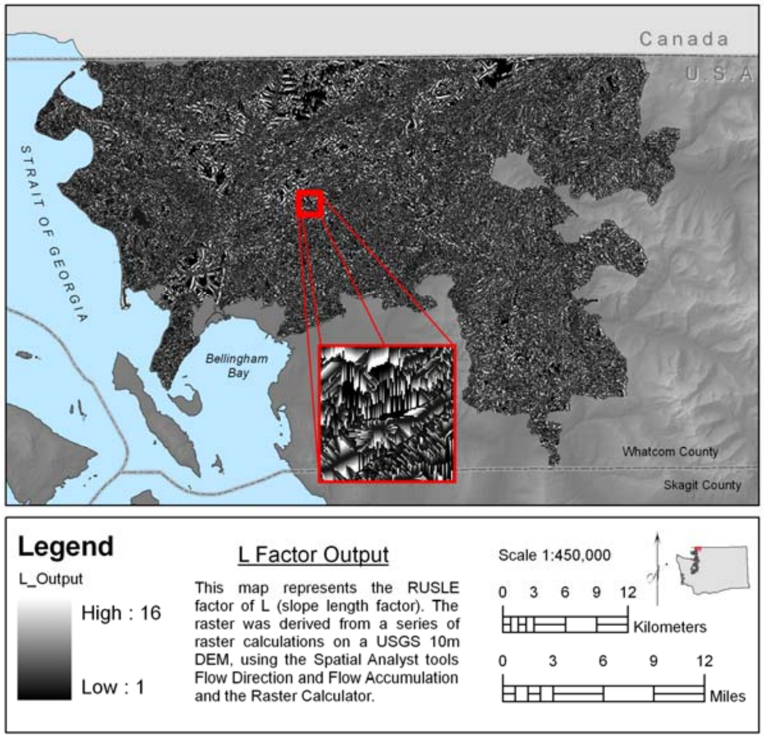

Figure 16: L factor output (slope length factor)

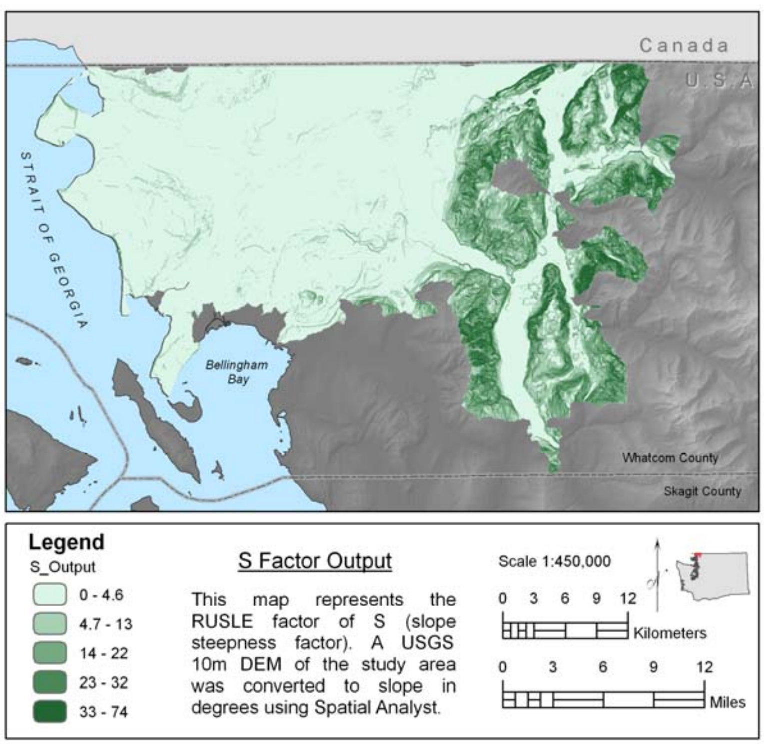

Figure 17: S factor output (slope steepness factor)

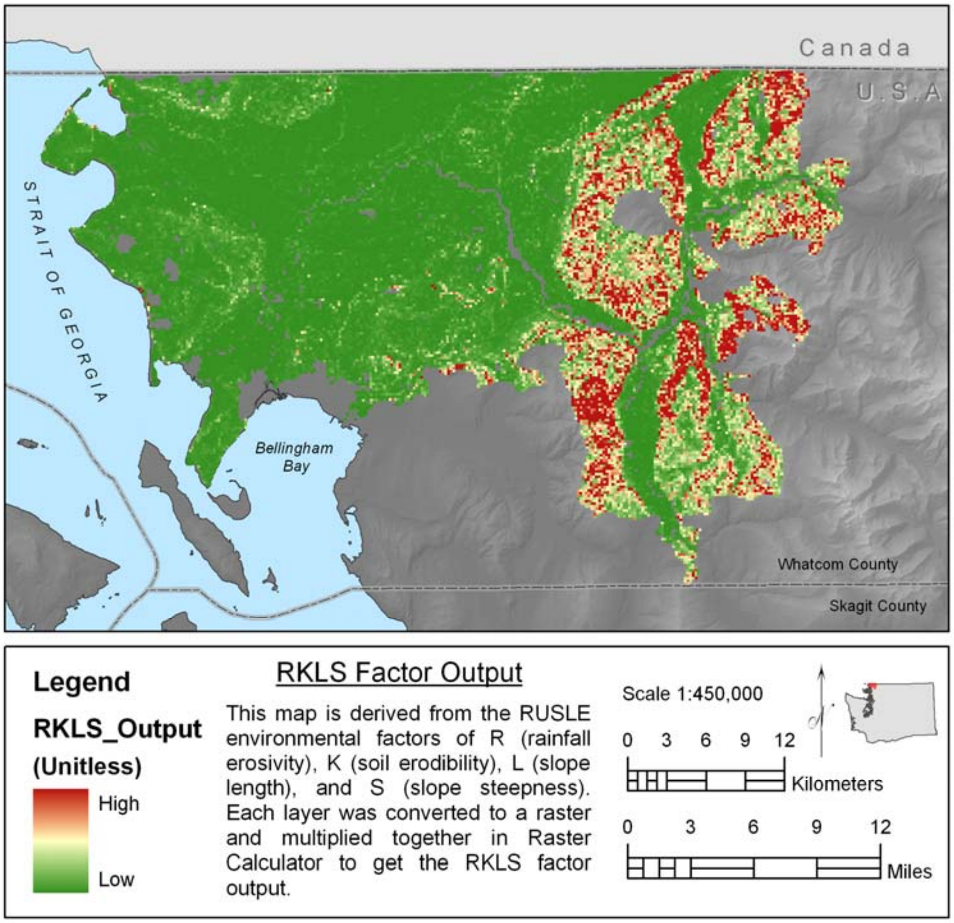

Figure 18: RKLS factor output

Habitat Connectivity

The results of the habitat connectivity analysis are displayed in Table 14. Figure 22 shows the total number of restoration projects by watershed. It is assumed that more existing restoration projects allow for an increased potential for contiguous projects, increasing habitat connectivity. The watersheds showing the most potential for contiguous restoration projects include the Ten Mile, Lower South

Fork Nooksack, Bertrand, South Acme Area, Silver, Nooksack Deming to Everson, Black Slough, California, Johnson, and Fourmile watersheds.

Prime Agricultural Land

Table 15 shows the rankings of the 51 watersheds by the relative amount of prime agricultural land each watershed contains. Figure 23 shows the total amount of prime farmland acreage in each watershed. The ten watersheds that contain the greatest amount of prime agricultural land include Jordan, Johnson, South Fork Dakota, Scott, Lummi Peninsula East, Wiser Lake/Cougar Creek, Bertrand, Fourmile, Lummi Peninsula West, and Kamm, respectively. Prime farmland, as defined by the USDA, is the land that is best suited to food, feed, forage, fiber, and oilseed crops. Prime farmland produces the highest yields with minimal expenditure of energy and economic resources, and farming it results in the least damage to the environment (USDA 1992).

Final Ranking

The final watershed ranking is shown in Table 16 and Figure 24. The final ranking was determined by averaging all individual ranks. The ten watersheds that show the most potential to benefit from CREP projects include Silver, Bertrand, Johnson, Ten Mile, Schell, Deer, Black Slough, Breckenridge, California, and the Lower South Fork Nooksack, respectively. The Silver, Bertrand, Ten Mile, Deer, Black Slough, and Lower South Fork Nooksack watersheds drain to the Nooksack

River. The Schell and California watersheds drain to the coast. The Johnson and Breckenridge watersheds drain north to the Fraser River. This is representative of the overall first order drainage types of all the watersheds under analysis. The first order drainages of all the watersheds in analysis include the Nooksack River (61%), Coast (26%), and Fraser (13%).

Table 11: 303(d) Watershed Ranking

Watershed	Area (Acres)	303(d) Area (Acres)	303(d) Count	Relative Area	Rank
Blaine	5,280	52.57	3	0.9956%	1
Lower Squalicum	3,077	28.39	8	0.9227%	2
Kamm	6,469	28.9	7	0.4467%	3
Silver	10,126	42.55	11	0.4202%	4
Lower South Fork Nooksack	11,629	45.5	10	0.3913%	5
Deer	4,375	13.78	3	0.3150%	6
Schell	2,333	7.06	2	0.3026%	7
South Acme Area	8,644	21.76	4	0.2517%	8
Baker	2,572	5.31	1	0.2065%	9
Lower Anderson	5,725	11.8	2	0.2061%	10
Black Slough	5,535	11.28	2	0.2038%	11
Lower Dakota	4,818	7.36	1	0.1528%	12
Bertrand	12,907	16.33	5	0.1265%	13
Lower Middle Fork Nooksack	7,876	8.12	3	0.1031%	14
Johnson	11,714	11.19	3	0.0955%	15
Bells	3,129	2.85	1	0.0911%	16
Lummi Peninsula West	6,300	5.57	1	0.0884%	17
Fishtrap	10,041	5.84	1	0.0582%	18
California	14,201	7.22	1	0.0508%	19
Breckenridge	13,404	6.48	2	0.0483%	20
Dale	7,864	2.85	1	0.0362%	21
Kendall	16,753	5.84	1	0.0349%	22
Canyon Lake	5,678	1.95	1	0.0343%	23
Hamilton	3,761	0.41	1	0.0109%	24
Ten Mile	11,849	1.27	1	0.0107%	25
Slide Mountain	13,774	1.41	1	0.0102%	26
Cherry Point	4,211	0	0	0.0000%	39
Fingalson	1,037	0	0	0.0000%	39
Fourmile	6,451	0	0	0.0000%	39
Haynie	1,435	0	0	0.0000%	39
Hutchinson	10,616	0	0	0.0000%	39
Jordan	5,964	0	0	0.0000%	39
Lake Terrell	8,338	0	0	0.0000%	39
Lummi Peninsula East	2,143	0	0	0.0000%	39
Maple	7,744	0	0	0.0000%	39
McCormick	3,569	0	0	0.0000%	39
Nooksack Channel	1,062	0	0	0.0000%	39
Nooksack Deming to Everson	15,640	0	0	0.0000%	39
North Fork Dakota	4,887	0	0	0.0000%	39
Saar	8,039	0	0	0.0000%	39
Sandy Point	2,326	0	0	0.0000%	39
Schneider	6,254	0	0	0.0000%	39
Scott	6,902	0	0	0.0000%	39
Semiahmoo	6,592	0	0	0.0000%	39
Smith	7,196	0	0	0.0000%	39
South Fork Anderson	707	0	0	0.0000%	39
South Fork Dakota	5,426	0	0	0.0000%	39
Spring	2,975	0	0	0.0000%	39
Swift	1,854	0	0	0.0000%	39
Upper Squalicum	1,573	0	0	0.0000%	39
Wiser Lake/Cougar Creek	7,995	0	0	0.0000%	39

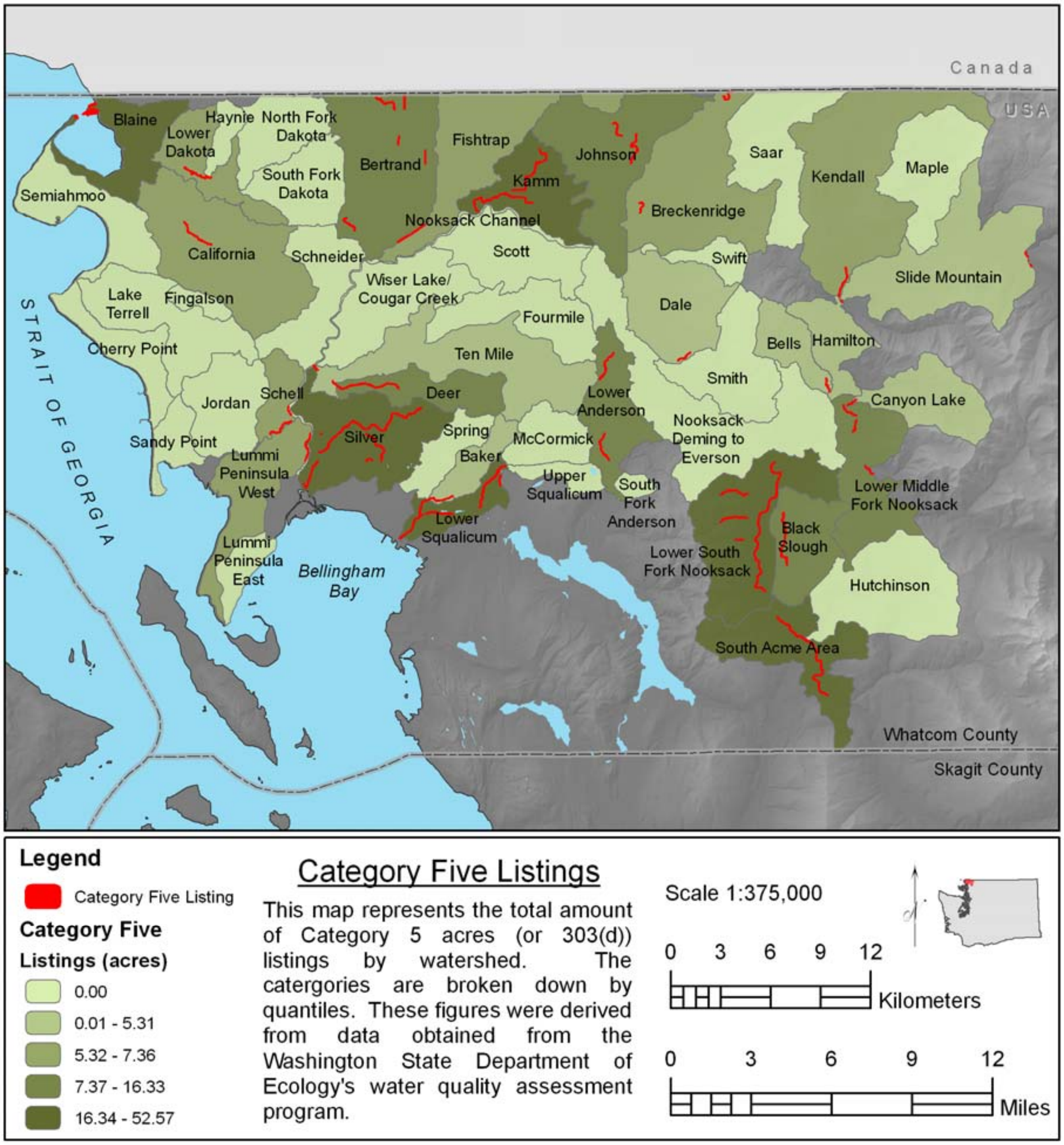

Figure 19: Ecology's Category 5 or 303(d) listings (acres) by watershed

Table 12: Fish Habitat Conservation Area Watershed Ranking

Watershed	Area (Acres)	FHCA (sq m)	FHCA (Acres)	Relative Area	Rank
Nooksack Channel	1,062	2,195,902.19	542.62	51.09%	1
Lower Dakota	4,818	2,247,105.39	555.27	11.52%	2
Saar	8,039	3,437,777.74	849.49	10.57%	3
Schell	2,333	902,206.89	222.94	9.56%	4
Silver	10,126	3,817,870.38	943.42	9.32%	5
California	14,201	5,301,496.34	1,310.03	9.22%	6
Haynie	1,435	513,712.15	126.94	8.85%	7
Johnson	11,714	4,143,847.66	1,023.97	8.74%	8
Deer	4,375	1,470,236.27	363.30	8.30%	9
Black Slough	5,535	1,798,778.36	444.49	8.03%	10
Dale	7,864	2,466,053.39	609.38	7.75%	11
Blaine	5,280	1,618,708.38	399.99	7.58%	12
Bertrand	12,907	3,848,013.92	950.86	7.37%	13
Upper Squalicum	1,573	464,560.96	114.80	7.30%	14
Ten Mile	11,849	3,485,839.81	861.37	7.27%	15
Breckenridge	13,404	3,913,720.10	967.10	7.22%	16
Jordan	5,964	1,731,936.57	427.97	7.18%	17
Lower Middle Fork Nooksack	7,876	2,285,063.66	564.65	7.17%	18
Fishtrap	10,041	2,801,007.53	692.14	6.89%	19
Hamilton	3,761	1,033,995.03	255.51	6.79%	20
Lummi Peninsula West	6,300	1,725,625.07	426.41	6.77%	21
Swift	1,854	485,713.83	120.02	6.47%	22
Spring	2,975	774,410.88	191.36	6.43%	23
Slide Mountain	13,774	3,558,029.10	879.21	6.38%	24
Fingalson	1,037	260,527.36	64.38	6.21%	25
Lower Squalicum	3,077	772,465.09	190.88	6.20%	26
Kamm	6,469	1,583,788.93	391.36	6.05%	27
Baker	2,572	625,504.43	154.57	6.01%	28
Lower Anderson	5,725	1,390,645.09	343.64	6.00%	29
Semiahmoo	6,592	1,598,767.60	395.06	5.99%	30
South Acme Area	8,644	2,093,270.41	517.26	5.98%	31
North Fork Dakota	4,887	1,135,712.23	280.64	5.74%	32
Nooksack Deming to Everson	15,640	3,633,478.67	897.85	5.74%	33
Lake Terrell	8,338	1,908,757.33	471.66	5.66%	34
Wiser Lake/Cougar Creek	7,995	1,731,498.67	427.86	5.35%	35
Lower South Fork Nooksack	11,629	2,518,180.23	622.26	5.35%	36
South Fork Anderson	707	152,669.36	37.73	5.34%	37
Scott	6,902	1,480,639.24	365.87	5.30%	38
Maple	7,744	1,547,636.03	382.43	4.94%	39
McCormick	3,569	702,024.70	173.47	4.86%	40
Hutchinson	10,616	2,077,025.77	513.24	4.83%	41
Bells	3,129	600,802.58	148.46	4.74%	42
South Fork Dakota	5,426	999,715.12	247.03	4.55%	43
Schneider	6,254	1,133,067.75	279.99	4.48%	44
Sandy Point	2,326	378,003.55	93.41	4.02%	45
Fourmile	6,451	993,088.61	245.40	3.80%	46
Smith	7,196	902,392.91	222.99	3.10%	47
Canyon Lake	5,678	635,580.92	157.06	2.77%	48
Kendall	16,753	1,430,416.99	353.46	2.11%	49
Cherry Point	4,211	204,967.99	50.65	1.20%	50
Lummi Peninsula East	2,143	68,015.78	16.81	0.78%	51

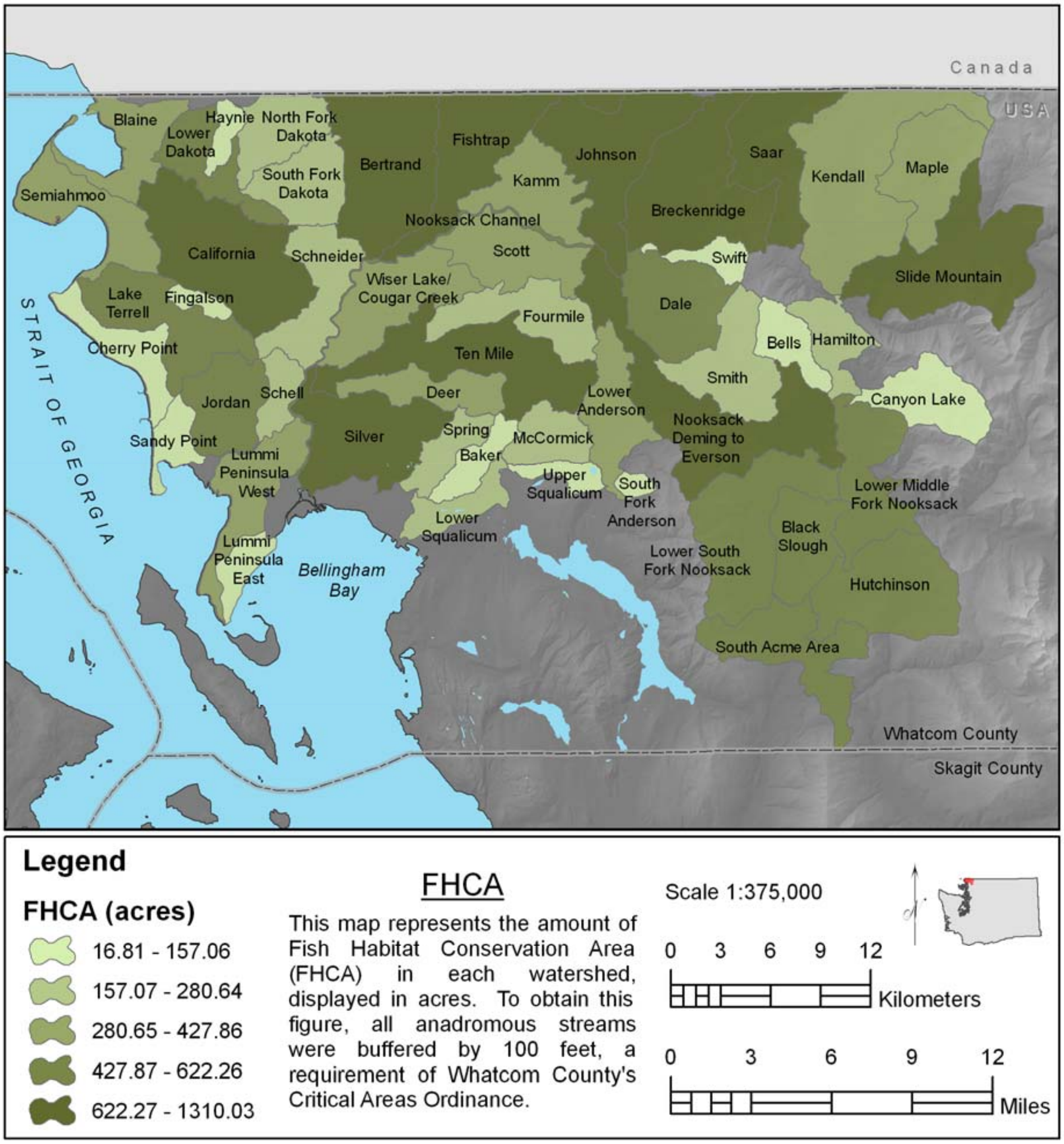

Figure 20: Fish Habitat Conservation Area (acres) by watershed

Table 13: RKLS Watershed Ranking

Watershed	Area (Acres)	RKLS (unitless)	Rank
Saar	5,678	802.08	1
Nooksack Deming to Everson	8,039	751.04	2
Lower Middle Fork Nooksack	16,753	718.05	3
Slide Mountain	11,629	660.46	4
Canyon Lake	7,876	638.21	5
Dale	7,744	626.85	6
Breckenridge	15,640	615.37	7
Lower South Fork Nooksack	4,211	608.78	8
South Acme Area	3,761	586.33	9
Swift	1,854	574.59	10
Smith	13,774	567.73	11
Kendall	7,196	538.38	12
Black Slough	7,864	531.06	13
Maple	5,535	518.55	14
Bells	3,129	467.23	15
Upper Squalicum	10,616	443.87	16
Hutchinson	5,725	423.54	17
Hamilton	8,644	390.70	18
Cherry Point	13,404	358.02	19
Lower Anderson	6,592	334.53	20
Ten Mile	1,573	245.07	21
Lower Squalicum	11,849	230.49	22
Baker	1,435	228.72	23
Bertrand	2,572	220.37	24
South Fork Anderson	6,300	219.54	25
Blaine	3,077	169.22	26
Johnson	11,714	146.26	27
McCormick	4,818	144.66	28
Silver	3,569	130.82	29
Schell	707	125.22	30
Spring	2,326	123.47	31
Semiahmoo	2,333	111.91	32
Deer	2,975	103.43	33
Fourmile	5,280	102.51	34
Lower Dakota	4,375	99.56	35
California	14,201	91.67	36
Haynie	5,964	89.45	37
Sandy Point	10,041	86.53	38
North Fork Dakota	10,126	85.37	39
Lummi Peninsula East	12,907	73.02	40
Jordan	4,887	71.07	41
Kamm	7,995	69.67	42
Wiser Lake/Cougar Creek	2,143	66.76	43
Lummi Peninsula West	6,254	62.39	44
South Fork Dakota	6,451	58.40	45
Lake Terrell	6,469	56.63	46
Scott	8,338	54.07	47
Schneider	1,037	49.25	48
Nooksack Channel	5,426	41.55	49
Fingalson	1,062	37.74	50
Fishtrap	6,902	36.04	51

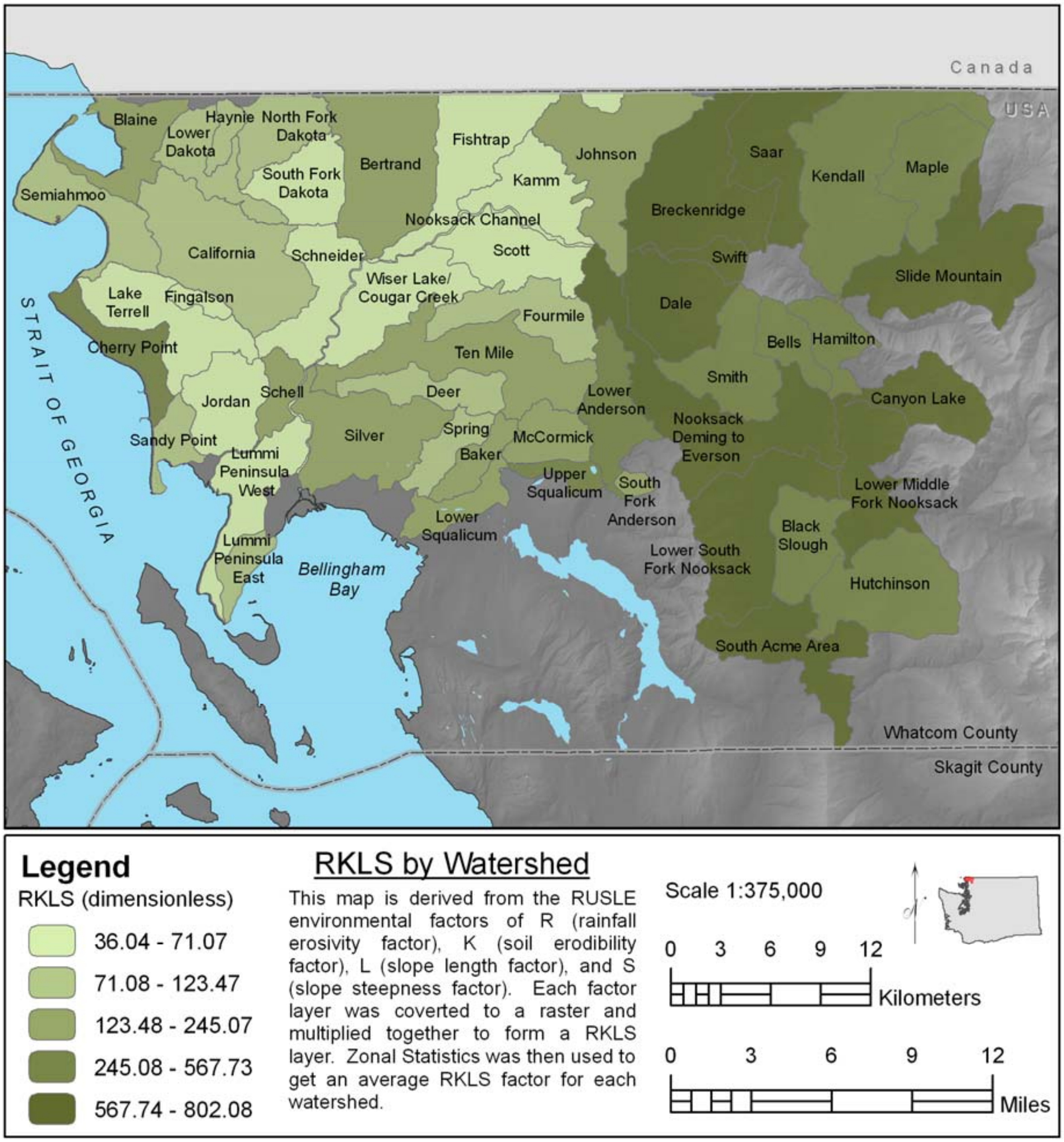

Figure 21: RKLS values (unitless) by watershed

Table 14: Existing Restoration Projects Ranking by Watershed

Watershed	Area (Acres)	# Restoration Projects	# CREP Projects	Total Count	Rank
Ten Mile	11,849	40	24	64	1
Lower South Fork Nooksack	11,629	38	10	48	2
Bertrand	12,907	30	10	40	3.5
South Acme Area	8,644	37	3	40	3.5
Silver	10,126	25	6	31	5
Nooksack Deming to Everson	15,640	25	3	28	6
Black Slough	5,535	12	14	26	7
California	14,201	20	5	25	8
Johnson	11,714	6	17	23	9
Fourmile	6,451	14	7	21	10
Lower Squalicum	3,077	20	0	20	11
Breckenridge	13,404	6	13	19	12
Deer	4,375	14	2	16	13.5
Kamm	6,469	12	4	16	13.5
Slide Mountain	13,774	15	0	15	15
Fishtrap	10,041	13	1	14	16.5
Hutchinson	10,616	14	0	14	16.5
Schell	2,333	7	6	13	18
Kendall	16,753	12	0	12	19.5
North Fork Dakota	4,887	9	3	12	19.5
Lower Anderson	5,725	9	1	10	21.5
Scott	6,902	6	4	10	21.5
Dale	7,864	5	4	9	24
Lake Terrell	8,338	9	0	9	24
Lower Dakota	4,818	8	1	9	24
Jordan	5,964	4	4	8	26
Lower Middle Fork Nooksack	7,876	6	1	7	28
South Fork Dakota	5,426	4	3	7	28
Wiser Lake/Cougar Creek	7,995	4	3	7	28
Hamilton	3,761	6	0	6	32
Haynie	1,435	3	3	6	32
Nooksack Channel	1,062	4	2	6	32
Schneider	6,254	2	4	6	32
Smith	7,196	4	2	6	32
Lummi Peninsula West	6,300	2	3	5	35
Maple	7,744	4	0	4	36.5
Saar	8,039	4	0	4	36.5
Blaine	5,280	3	0	3	38.5
Canyon Lake	5,678	3	0	3	38.5
McCormick	3,569	2	0	2	40.5
Semiahmoo	6,592	2	0	2	40.5
Baker	2,572	1	0	1	43.5
Fingalson	1,037	1	0	1	43.5
South Fork Anderson	707	1	0	1	43.5
Spring	2,975	1	0	1	43.5
Bells	3,129	0	0	0	48.5
Cherry Point	4,211	0	0	0	48.5
Lummi Peninsula East	2,143	0	0	0	48.5
Sandy Point	2,326	0	0	0	48.5
Swift	1,854	0	0	0	48.5
Upper Squalicum	1,573	0	0	0	48.5

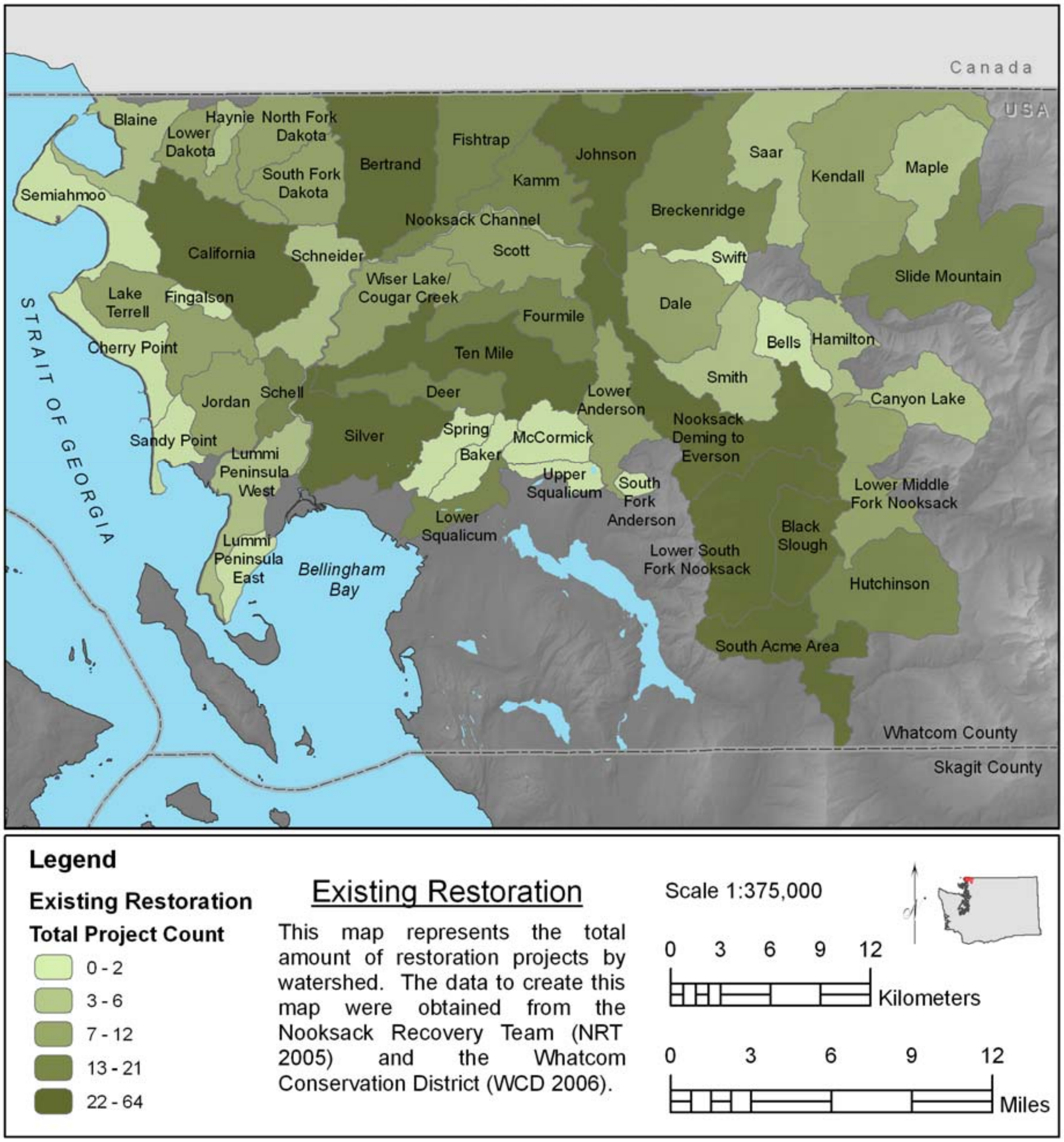

Figure 22: Number of existing restoration projects by watershed

Table 15: Prime Agricultural Land by Watershed

Watershed	Area (Acres)	Prime Ag Land (Acres)	Relative Area	Rank
Jordan	5,964	5,962.22	99.97%	1
Johnson	11,714	11,675.59	99.67%	2
South Fork Dakota	5,426	5,401.50	99.55%	3
Scott	6,902	6,823.10	98.86%	4
Lummi Peninsula East	2,143	2,118.20	98.84%	5
Wiser Lake/Cougar Creek	7,995	7,872.31	98.47%	6
Bertrand	12,907	12,602.85	97.64%	7
Fourmile	6,451	6,263.80	97.10%	8
Lummi Peninsula West	6,300	6,070.19	96.35%	9
Kamm	6,469	6,216.44	96.10%	10
Ten Mile	11,849	11,355.46	95.83%	11
McCormick	3,569	3,383.26	94.80%	12
North Fork Dakota	4,887	4,627.93	94.70%	13
Spring	2,975	2,806.25	94.33%	14
Lower Anderson	5,725	5,394.59	94.23%	15
Silver	10,126	9,518.00	94.00%	16
Schneider	6,254	5,874.14	93.93%	17
Schell	2,333	2,176.68	93.30%	18
Deer	4,375	4,081.55	93.29%	19
Fishtrap	10,041	9,352.98	93.15%	20
California	14,201	13,182.68	92.83%	21
Baker	2,572	2,267.80	88.17%	22
Cherry Point	4,211	3,690.11	87.63%	23
Lake Terrell	8,338	7,177.52	86.08%	24
Lower Dakota	4,818	3,943.01	81.84%	25
Semiahmoo	6,592	5,385.01	81.69%	26
Fingalson	1,037	831.52	80.19%	27
Breckenridge	13,404	10,615.58	79.20%	28
South Fork Anderson	707	547.91	77.50%	29
Blaine	5,280	4,000.84	75.77%	30
Upper Squalicum	1,573	1,183.75	75.25%	31
Sandy Point	2,326	1,743.56	74.96%	32
Haynie	1,435	920.04	64.11%	33
Dale	7,864	4,948.21	62.92%	34
Saar	8,039	4,906.28	61.03%	35
Kendall	16,753	9,747.18	58.18%	36
Nooksack Deming to Everson	15,640	9,098.34	58.17%	37
Hamilton	3,761	2,103.13	55.92%	38
Lower Squalicum	3,077	1,544.05	50.18%	39
Black Slough	5,535	2,585.29	46.71%	40
Lower South Fork Nooksack	11,629	4,569.39	39.29%	41
South Acme Area	8,644	3,060.88	35.41%	42
Maple	7,744	2,495.18	32.22%	43
Smith	7,196	2,229.07	30.98%	44
Nooksack Channel	1,062	321.14	30.24%	45
Slide Mountain	13,774	3,679.30	26.71%	46
Lower Middle Fork Nooksack	7,876	1,522.70	19.33%	47
Swift	1,854	343.45	18.52%	48
Bells	3,129	537.08	17.16%	49
Hutchinson	10,616	1,049.18	9.88%	50
Canyon Lake	5,678	398.95	7.03%	51

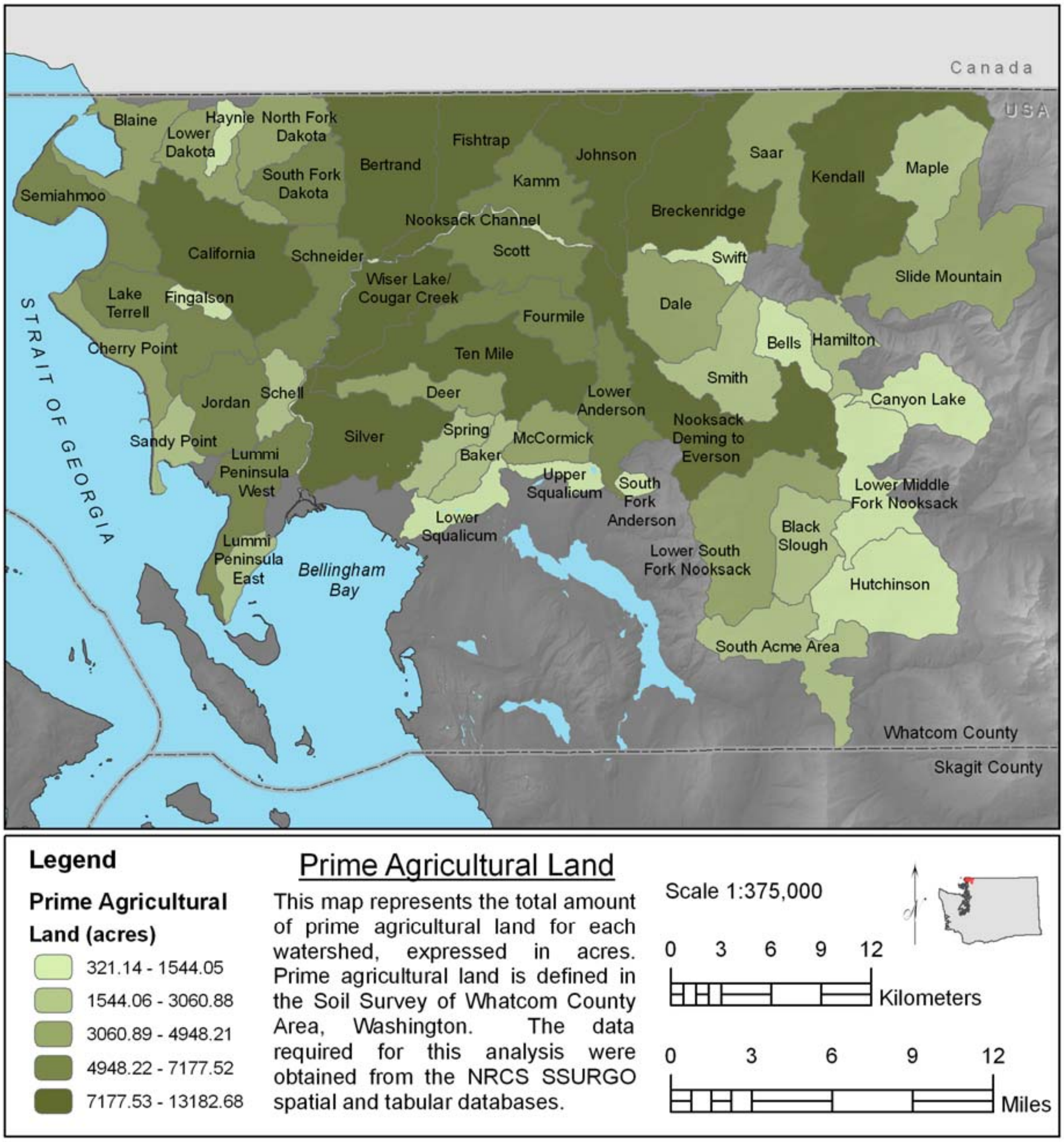

Figure 23: Prime agricultural land by watershed expressed in acres

Table 16: All Watershed Rankings

Watershed	303(d)	FHCA	Erosion	Existing Restoration	Prime Ag Land	AVG	FINAL
Silver	4	5	29	5	16	11.8	1
Bertrand	13	13	24	3.5	7	12.1	2
Johnson	15	8	27	9	2	12.2	3
Ten Mile	25	15	21	1	11	14.6	4
Schell	7	4	30	18	18	15.4	5
Deer	6	9	33	13.5	19	16.1	6
Black Slough	11	10	13	7	40	16.2	7
Breckenridge	20	16	7	12	28	16.6	8
California	19	6	36	8	21	18.0	9
Lower South Fork Nooksack	5	36	8	2	41	18.4	10
South Acme Area	8	31	9	3.5	42	18.7	11
Kamm	3	27	42	13.5	10	19.1	12
Lower Anderson	10	29	20	21.5	15	19.1	13
Dale	21	11	6	24	34	19.2	14
Lower Dakota	12	2	35	24	25	19.6	15
Lower Squalicum	2	26	22	11	39	20.0	16
Blaine	1	12	26	38.5	30	21.5	17
Lower Middle Fork Nooksack	14	18	3	28	47	22.0	18
Saar	39	3	1	36.5	35	22.9	19
Slide Mountain	26	24	4	15	46	23.0	20
Nooksack Deming to Everson	39	33	2	6	37	23.4	21
Jordan	39	17	41	26	1	24.8	22
Fishtrap	18	19	51	16.5	20	24.9	23
Baker	9	28	23	43.5	22	25.1	24
Lummi Peninsula West	17	21	44	35	9	25.2	25
Hamilton	24	20	18	32	38	26.4	26
Fourmile	39	46	34	10	8	27.4	27
Kendall	22	49	12	19.5	36	27.7	28
North Fork Dakota	39	32	39	19.5	13	28.5	29
Haynie	39	7	37	32	33	29.6	30
Upper Squalicum	39	14	16	48.5	31	29.7	31
Scott	39	38	47	21.5	4	29.9	32
Spring	39	23	31	43.5	14	30.1	33
Wiser Lake/Cougar Creek	39	35	43	28	6	30.2	34
South Fork Dakota	39	43	45	28	3	31.6	35
McCormick	39	40	28	40.5	12	31.9	36
Hutchinson	39	41	17	16.5	50	32.7	37
Canyon Lake	23	48	5	38.5	51	33.1	38
Nooksack Channel	39	1	49	32	45	33.2	39
Lake Terrell	39	34	46	24	24	33.4	40
Semiahmoo	39	30	32	40.5	26	33.5	41
Swift	39	22	10	48.5	48	33.5	42
Bells	16	42	15	48.5	49	34.1	43
Maple	39	39	14	36.5	43	34.3	44
Smith	39	47	11	32	44	34.6	45
South Fork Anderson	39	37	25	43.5	29	34.7	46
Cherry Point	39	50	19	48.5	23	35.9	47
Schneider	39	44	48	32	17	36.0	48
Lummi Peninsula East	39	51	40	48.5	5	36.7	49
Fingalson	39	25	50	43.5	27	36.9	50
Sandy Point	39	45	38	48.5	32	40.5	51

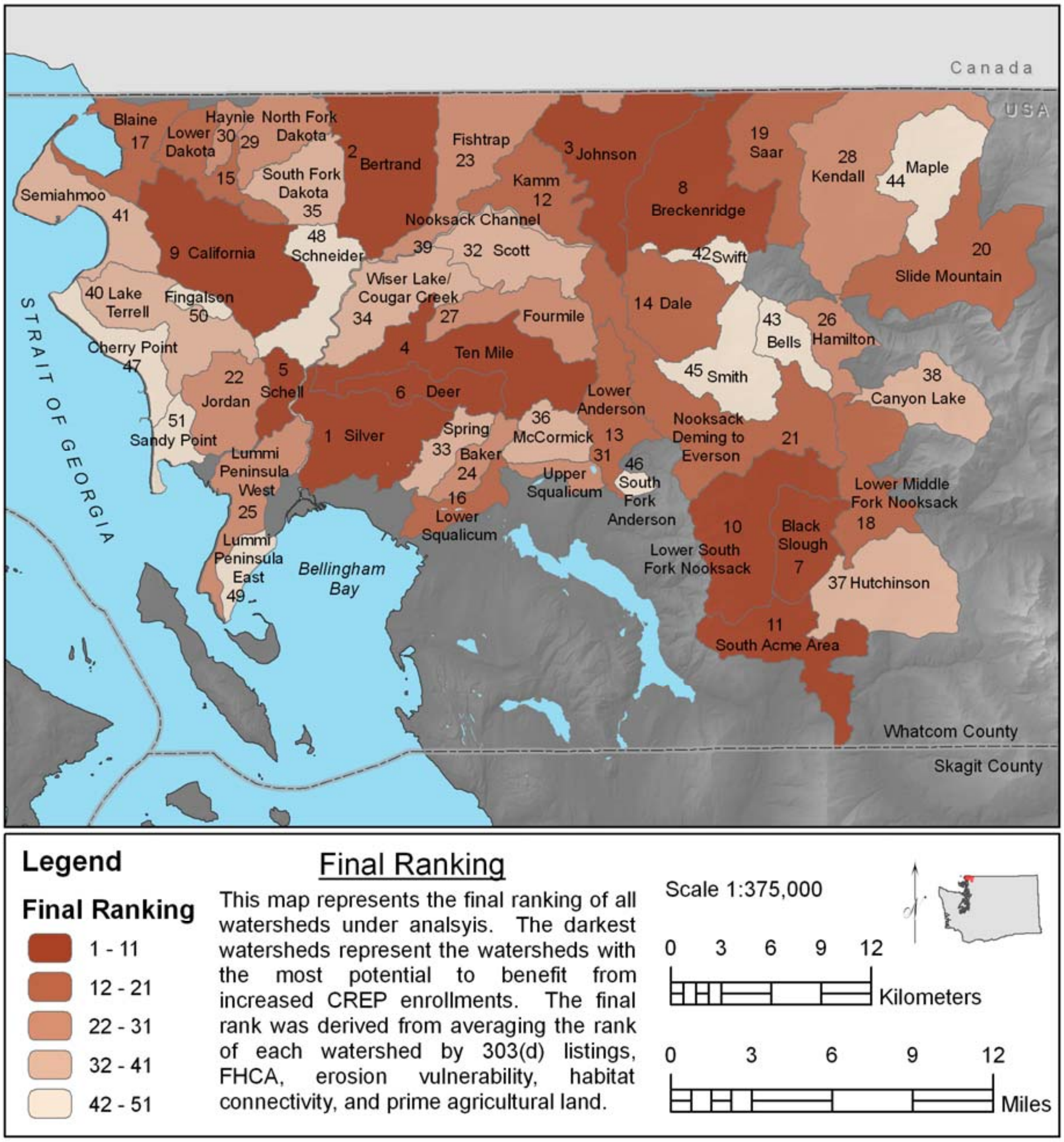

Figure 24: Watersheds by Final Rank

Discussion

Salmon recovery planners have highlighted the need for the restoration of riparian areas, especially in agricultural areas (Coe 2001; Hyatt *et al* 2004; Kahler *et al* 2001; Nelson 1997; and Rhodes 1999). CREP projects involve the installation of forested riparian buffers on agricultural lands adjacent to anadromous streams. The goal of CREP projects are to increase LWD and LWDRP, reduce sediment and nutrient runoff from adjacent agricultural land, stabilize stream banks, reduce stream water heating, and provide farmers and ranchers with financial assistance (USDA 1998).

The goal of this research was to provide a targeted approach to CREP enrollment in WRIA 1 that addresses both salmon habitat limiting factors and soil conservation planning. Although watershed scale analysis usually does not produce a decision-making document, such as restoration site selection on the reach scale, it does promote understanding of the watershed scale operating processes and it may be used to guide project planning (Kershner 1997).

To carry out this ranking, the watersheds of WRIA 1 that are eligible for CREP enrollment were ranked according to their potential for CREP projects to provide ecological benefits (Figure 24). The watersheds were ranked based on water quality assessments, Fish Habitat Conservation Area, soil erosion vulnerability, the potential for habitat connectivity, and by the amount of prime agricultural land they contain. The individual rankings were then averaged, as opposed to weighted, and compiled into a final ranking. The Silver Creek watershed was selected as the watershed that shows the most potential to receive the ecological benefits of CREP enrollment. The Silver Creek watershed scored very high for 303(d) listings, FHCA, and the potential for contiguous projects.

The Fraser River watershed's final average rankings were higher than the other first order drainages. The Fraser River watersheds averaged a final rank of 17, the Nooksack River watersheds averaged a final rank of 24, and the coastal watersheds averaged a final rank of 30. The 10 watersheds with the highest amount of agricultural land adjacent to anadromous streams (Figure 25) averaged a final rank of 14. These 10 watersheds averaged 26% of their total watershed area in agricultural land uses adjacent to anadromous streams. The Johnson watershed had the most amount of its total watersheds area in an agricultural land use adjacent to an anadromous stream, at 38.78%. The 10 watersheds with the most amount of agricultural land adjacent to anadromous streams, in order, are the Johnson (38.78%), Bertrand (36.38%), Kamm (27.41%), South Fork Dakota (25.55%), Dale (23.47%), Fishtrap (23.39%), Scott (23.36%), Ten Mile (21.16%), California (20.44%), and Breckenridge (20.27%) watersheds. Four of the ten aforementioned watersheds (Johnson, Bertrand, Ten Mile, and California) ranked in the top ten for existing restoration projects.

The objective of this research was to develop a tool that allows for a multi-criteria evaluation of watersheds for CREP enrollment. The rankings for each criterion can be used by producers and conservation planners in identifying locations where riparian buffers can most effectively improve water quality, salmon habitat, and/or soil conservation. This potentially enhances land-use planning by delivering a final ranking system to assist policy and decision makers, county and local officials, landowners, and interested citizens in making wise land management decisions. It is anticipated that information on the spatial distribution of these variables will aid managers in developing regional or basin-wide strategies for buffer placement, although information to verify their utility has yet to be gathered. The results may also be used for selecting stream monitoring locations for sediment or sediment-adsorbed pollutants, land-use planning as it relates to earth disturbance activities, and identification of target areas for conservation dollars, research, and landowner education.

Data Limitations

Five ranking criterion were applied to the watersheds in the study area. However, other criterion exist that would aid in the targeted enrollment scenario. These other possible ranking criteria, in addition to other data limitations, are further outlined in this section.

The first watershed ranking method was implemented to highlight the watersheds with the most acres of 303(d) listings. This includes all 303(d) listing types. If a water body is listed for violation of a water quality parameter that riparian vegetation does not address, CREP buffers will not be able to mitigate these water quality concerns. Therefore, further refinement of this method would have to include only selecting the 303(d) listings where CREP projects have the potential to mitigate the degraded water quality. The types of 303(d) listings that CREP projects may alleviate include temperature, sediment, and nutrient listings.

The second watershed ranking method was selected to highlight the watersheds with the most amount of Fish Habitat Conservation Area, as defined by the Whatcom County Critical Areas Ordinance. The CAO mandates a 100ft buffer on anadromous streams. Landowners who enroll in CREP meet the CAO requirement. However, water bodies that fall under the jurisdiction of the Shoreline Master Program (SMP) have a larger buffer requirement (Whatcom County 2005). Further refinement of this method would have to include FHCA for both the CAO and SMP.

The third watershed ranking method was selected to highlight the watersheds with the highest soil erosion vulnerability. The environmental factors of RUSLE were used to create this ranking. Considering only the environmental variables does not allow for a completely accurate estimation of erosion, however, it does allow an evaluation of the basin-scale potential for erosion (Burns *et al* 2002). To further refine this method, the RUSLE land management factors of cover management (C) and support practice (P) could be applied to the watersheds. The management variables may change year to year, so it would be difficult to obtain current and accurate management variable coverage without extensive fieldwork. However, if the land management factor data could be obtained, it would allow for a completely accurate measure of soil erosion across watersheds (Burns *et al* 2002). There exists a host of alternatives to the RUSLE approach, including fuzzy logic and learning algorithms. But, by using RUSLE, researchers have a certain amount of validation and acceptance of the relationship as being consistent with the physical system, at least for agricultural lands (Burns *et al* 2002).

The fourth watershed ranking method was selected to highlight the watersheds with the most potential for contiguous riparian restoration projects. Further refinement of this method would involve selecting out the parcels that are already in a contiguous riparian restoration corridor. In addition, this ranking method highlights watersheds that have taken a lead on restoration projects and leaves out watersheds that may benefit from increased CREP enrollments. Future studies should either eliminate this criterion or assign it a lower weight than the other criteria in this analysis.

The final independent watershed ranking method was selected to highlight the watersheds that contain the most amount of prime agricultural farmland. Prime farmland produces the highest yields with minimal expenditure of energy and economic resources, and farming it results in the least damage to the environment (USDA 1992). Further refinement of this method could include selecting only soils of statewide significance or single categories of prime farmland based on defined research goals.

The final ranking method involves averaging the ranks of the five independent ranking methods (O'Connell 2003). All the ranking factors were considered equal for the analysis. Further refinement of this method could include weighting the factors by importance. For soil conservation planners, the prime agricultural farmland rankings may be more important than the FHCA. For those working towards water quality improvements, the 303(d) listings may be more important than protecting prime agricultural farmland. Society and landowners are demanding many other environmental and social services (e.g., wildlife habitat and income diversification) from riparian buffers on agricultural lands. Therefore, resource planners need to plan buffer systems in the right places to provide multiple services (Bentrup and Kellerman 2005).

Accordingly, water, soil, and habitat data were treated equally for this analysis. However, by treating the factors equally, predominantly agricultural watersheds were not brought to the top of the final ranking. For instance, the Silver Creek watershed ranked the highest in this analysis, but only 3% of its watershed is in an agricultural land use adjacent to anadromous streams. Figure 25 shows the amount of agricultural lands adjacent to anadromous streams for each watershed. Further refinement of this method would require an alternative approach to emphasize predominantly agricultural watersheds, such as only using watersheds with a certain percentage of agricultural land adjacent to anadromous streams, or using weighted criterion.

The steps to develop a weighted criteria approach require expert knowledge and science within the discipline of the application within a spatial context (Berry *et al* 2005). Now that software, powerful PC computers, and necessary data sets are readily available, the scientific understanding of calibrations and weights of spatial models is emerging as the most limiting factor in precision conservation (Berry *et al* 2005). Precision conservation deals with the integration of spatial technologies with the spatial analysis of mapped data to implement conservation practices that contribute to soil and water conservation in agricultural and natural ecosystems (Berry *et al* 2005).

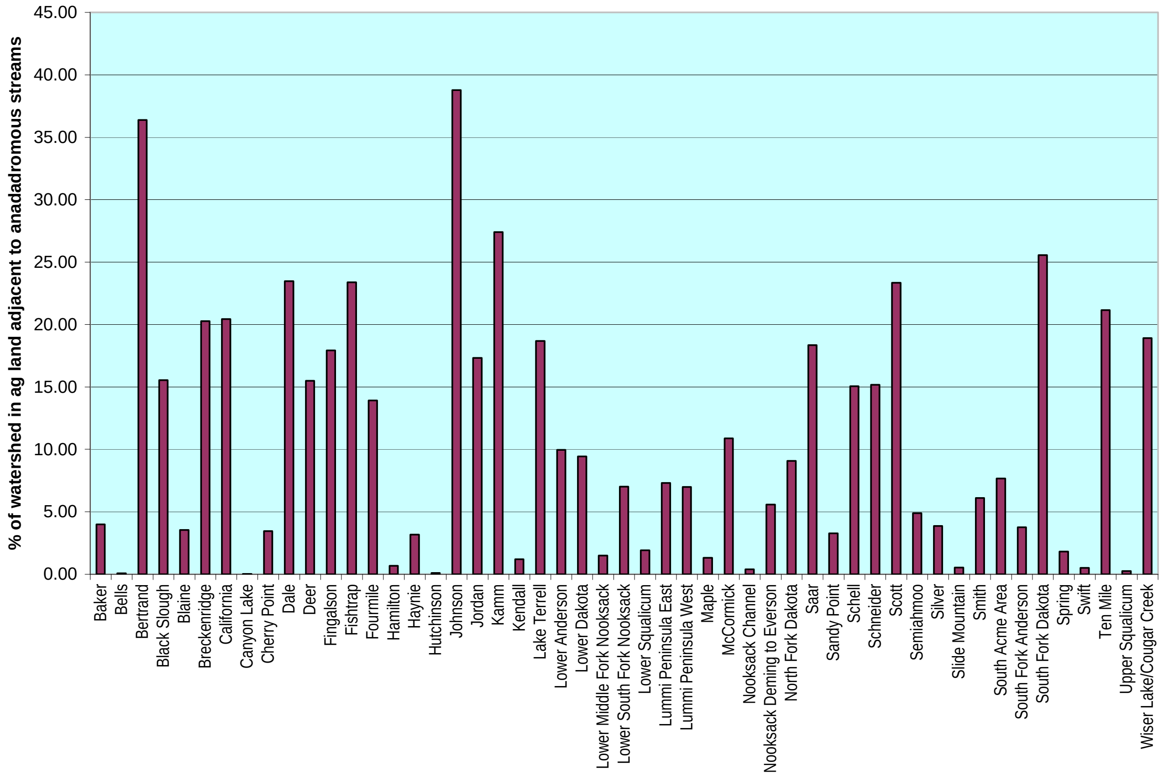

Figure 25: The percent of agricultural lands adjacent to anadromous streams

Recommendations for Future Studies

Many aspects of the CREP in Whatcom County could be further analyzed. For example, the optimal locations of CREP projects could be sited on the watershed scale using terrain analysis to select areas where buffer vegetation could intercept sheet/rill flows from significant upslope areas (Tomer *et al* 2003). This approach could help agricultural producers achieve environmental goals with greater efficiency.

Also on the watershed scale, a computer simulation model could identify the relative contributions of sediments, nutrients, and pollutants to water bodies (Farrand 2004). To develop this model, planners would first need to select soils and production practices that are representative of the subbasins within the watershed under analysis. Then, modeling could identify the relative contributions from subbasins within the watershed. This type of analysis could lead to the evaluation of CREP's quantitative goals.

On a larger scale, the erosion vulnerability screening could be applied to all large river basins in Washington. This would involve the environmental factors of RUSLE. The objective of this research would be to develop a tool that allows for the evaluation of the relative vulnerability of soils to erosion across all water quality planning basins in Washington. This would allow for a qualitative comparison with sediment TMDL allocations.

The ecological benefits of CREP projects could also be considered for future studies. The quantitative analysis would allow for an evaluation of the extent to which riparian buffers can restore riparian and stream function and species composition. This analysis could involve comparing macroinvertebrate community compositions, nutrients, and sediments of streams adjacent to CREP projects to streams without adjacent CREP projects. In addition, soil chemical and physical properties of CREP project areas could be analyzed and compared to non-buffered areas.

Future studies could also address landowner intentions. CREP contracts are created for 10 or 15 years. Since the program began in Whatcom County in 2000, some of the original CREP contracts will be coming up for renewal in the near future. A future study could survey those landowners who are enrolled in CREP to assess their intentions with the CREP buffers. The survey could identify future plans for the buffers, assess landowner knowledge of conservation easements, and establish possible reasons a landowner would sign a riparian conservation easement. A conservation easement is a legally binding agreement to keep the buffer in a conservation practice.

Finally, the economic implication of CREP buffers could be an area for future study. A cost benefit analysis could be done to show how strategic placement of riparian buffers allow for the most environmental benefits with the least amount of financial losses. Also, the economic effect of CREP buffers on the farm scale is recommended as a future study. This type of research allows economists to analyze the financial gains and losses associated with the installation of CREP buffers and the removal of lands for agricultural production (Dixon and Sherman 1990; Jaroszewski *et al* 2000; Khanna *et al* 2003).

Conclusion

The Conservation Reserve Enhancement Program (CREP) reflects advancement in USDA agricultural policy by addressing agriculturally related conservation on a multi-farm, landscape scale and by establishing funding support and partnerships with state governments. By addressing state-identified priorities, landowner needs and social issues, the CREP offers substantial promise to fully integrate economically viable agricultural production and effective conservation (Wildlife Society 2005).

Washington State's CREP contract is up for renewal in 2007 (Smith 2006). The Washington State Conservation Commission CREP Coordinator, Carol Smith, has made recommendations to incorporate in the renewal. Smith (2006) recommends incorporating a minimum 35' buffer so that small parcels can be enrolled more easily, expanding eligible practices to potentially include wetland restoration among other practices, including all types of agriculture lands in Washington for eligibility, providing more financial incentives, seeking changes so that local committees can approve additional costs, and considering creating a separate program to address habitat restoration on small parcels. These renewal recommendations may allow for increased enrollment into the program. A targeted enrollment scenario highlights the most ecologically advantageous sites for enrollment. If these renewal recommendations are approved, the multi-criteria approach utilized in this analysis will allow for the inclusion of more decisive factors.

The program's renewal and secured state funding is essential because CREP is an imperative link between salmon recovery and agriculture. In Washington State, agriculture covers 20% of the land and is the state's largest employer, contributing about 20% of the state's gross production. Also, about 37% of salmon streams on private land pass through the agricultural lands of Washington. Much of the agricultural land is located in or near historic high value floodplain and salmon habitat; it is important that efforts continue to improve riparian habitat while maintaining viable agriculture. Once land is converted to urban or industrial development, the prospects to preserve or restore riparian habitat greatly decreases while environmental impacts increase. CREP is an important tool to improve riparian habitat while reducing the farmer's financial burden for restoration and conservation (Smith 2006).

The program could have more impact if enrollment is targeted towards watersheds that show potential to gain ecological benefits from CREP buffers. The objective of this research was to target WRIA 1 watersheds for CREP enrollment using water quality, salmon habitat, and soil data in a Geographic Information System (GIS) framework. The goal of the research was to provide a targeted approach to CREP enrollment that addresses both salmon habitat limiting factors and soil conservation planning. The results of this study show that Silver, Bertrand, Johnson, Ten Mile, Schell, Deer, Black Slough, Breckenridge, California, and Lower South Fork Nooksack watersheds show the most potential to benefit from increased CREP enrollments. This study and its results offer resource planners a multi-criteria ranking tool to prioritize CREP enrollments based on various conservation goals.

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