Project Title: Prioritizing restoration and enhancement of passage at stream-road crossings for aquatic vertebrates in the face of changing hydrologic regimes in the North-Pacific Landscape Conservation Cooperative

Project Leader or Principal Investigator: Jason Dunham, U.S. Geological Survey, Forest and Rangeland Ecosystem Science Center, jdunham@usgs.gov, 541-750-0990; Rachel Reagan, U.S. Geological Survey, Western Fisheries Research Center, rreagan@usgs.gov, 541-386-5606.
Cooperators/Partners: Christine Hirsch, U.S. Forest Service, Siuslaw National Forest, chirsch@fs.fed.us 541-750-7034; Barb Ellis-Sugai, U.S. Forest Service, Siuslaw National Forest, bellissugai@fs.fed.us 541-750-7056.

Project Summary: Fish passage restriction barriers fragment habitat and restrict movement for all aquatic species, including anadromous fishes at thousands of locations across the NPLCC. This project builds upon existing data and collaborations to incorporate climate change and economic considerations into a decision support framework for prioritizing restoration of passage. Planned outcomes will help guide on-the-ground decisions in terms of adapting to anticipated climate effects, allocating limited resources for restoration, and providing tools that can be adapted across the NPLCC and beyond.

Project Proposal: Our project relates directly to ***Action 4.2: Assist one or more partners to incorporate climate change information into habitat conservation, restoration, adaptation, and enhancement efforts. Priority Topic D (Effects of the changes in the hydrologic regime on anadromous fish)*** under the NPLCC Science/TEK Strategy Implementation Plan objectives. The project also addresses elements of Actions 2.2 and 4.1. Climatic influences on hydrological processes have critical implications for maintaining water infrastructure. Decisions to replace or modify structures at stream-road crossings are of particular importance, involving literally thousands of bridges, culverts, drains and other structures, and massive ($\geq 10^7$ USD) investments. Modification of these structures is also a top priority for restoring connectivity to native aquatic species in the North Pacific region, including salmon and trout, which provide important ecosystem services, subsistence fisheries, and commercial and recreational values. Many stream-road crossings are not passable and restrict/block passage. *Based on current assessments* (GAO 2001), *land management agencies (U.S. Forest Service and Bureau of Land Management) estimate that efforts to restore fish passage may ultimately cost over $375 million alone (other lands not included in this estimate) and take decades to accomplish*. Given the scope and magnitude of the issues introduced above, it is perhaps no surprise that the design of stream-road crossings is one of the few examples of how concerns over climate impacts have directly impacted on-the-ground enhancement and adaptation to benefit native fishes (Al Doelker, Oregon-Washington BLM, personal communication; James Capurso, U.S. Forest Service, Pacific Northwest Region, personal communication; Janine Castro, National Marine Fisheries Service, personal communication). More specifically, changes in the design of crossings (i.e., building larger structures to accommodate higher magnitude floods) have been negotiated, but

there are a host of other concerns, as exemplified in recent legal decisions regarding subsistence fisheries and restoration of fish passage (Columbia Basin Bulletin). *Here, we propose to provide new tools that managers can use to explicitly consider cost-benefit tradeoffs, under different scenarios, involving stream-road crossings in the context of uncertain climate impacts.* We expect these tools to be relevant for a host of applications involving water infrastructure, including Biological Opinions, ESA and NEPA, managing flood risks, FERC relicensing, evaluating resource adequacy and rates, infrastructure studies and policy (e.g. 2014/2024 Columbia River Treaty) reviews (Oregon Climate Assessment Report). Our goal is to maximize the benefits of passage restoration to anadromous fish and the diversity of aquatic organisms, by evaluating biotic, physical, economic, and climate elements (Fig. 1). Our approach will integrate physical, biological, and economic dimensions of decisions in the context of the overarching influences of climate as they relate to managing water infrastructure (stream-road crossings). We will continue to directly engage managers in this effort to provide a specific local application and a generalized approach that can be adapted to other local efforts to explicitly incorporate climate uncertainty into on-the-ground management actions. In other words, this is not a proposal to develop tools that we hope managers will use. Rather, managers will be engaged directly from the beginning. Additionally, this project will take advantage of an interdisciplinary team from the academic community, as this project would provide a training, experience, and leadership opportunity for a young researcher (Rachel Reagan, U.S. Geological Survey Pathways Intern and Master's Student in the Department of Fisheries and Wildlife at Oregon State University). Engaging committee members and faculty provides access to resources, innovation, and expertise.

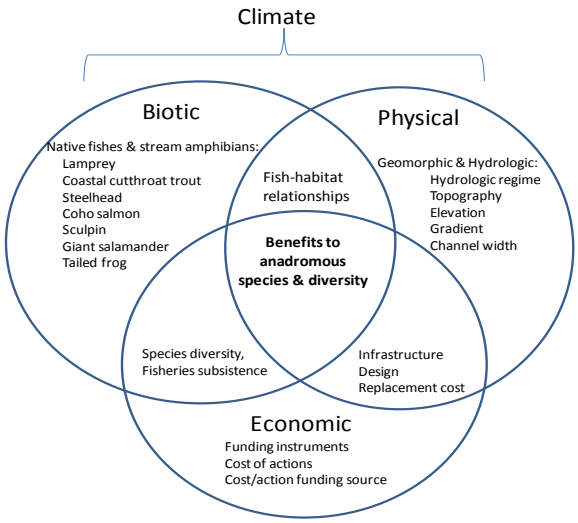

Figure 1. Relationships among biotic, physical, and economic elements to be integrated in this effort. Climate-driven physical and biotic scenarios will be developed and evaluated to illustrate how specific allocations of limited resources to restoration and maintenance of infrastructure (stream-road crossings) influence anadromous species, as well as a host of associated aquatic species.

The location for our effort is the Siuslaw National Forest (SNF). The SNF represents an ideal physical setting for developing a decision support tool and approach for balancing ecological gain with economic costs to prioritize stream crossings on a managed landscape. Forest roads

built for forestry harvest, land development, safety routes, and recreation—cross streams that support anadromous and resident fish and other aquatic organisms. Many stream-road crossings (>200) are believed to restrict passage. This setting and the suite of issues exemplifies much of the North-Pacific LCC domain. It is also important to note that the SNF maintains strong relationships with a host of local partners, including watershed councils, state and county agencies, tribes, and other stakeholders. We view this as critical to our project's success in terms of incorporating diverse perspectives and adopting the tools for application beyond the tenure of this project.

Objective and Need: Our objective in this work is to develop climate-aware tools that allow managers to more efficiently allocate scarce resources in restoring passage to benefit anadromous and other native fishes in the NPLCC. The need is great as evidenced by the magnitude and extent of passage impairment at thousands of stream-road crossings across the NPLCC. This need is exemplified by a recent federal court injunction issued on March 29, 2013, that directs the State of Washington to identify and repair any culverts in focused areas of Washington coast that block access to 200 meters or more of salmon habitat. The court ruled in favor of the Tribes (made up of many Northwest Tribes) saying that "The Tribes and their individual members have been harmed economically, socially, educationally, and culturally be the greatly reduced salmon harvests that have resulted from fish passage barriers" (Columbia Basin Bulletin). This project meets objective ***Action 4.2: Assist one or more partners to incorporate climate change information into habitat conservation, restoration, adaptation, and enhancement efforts. Priority Topic D (Effects of the changes in the hydrologic regime on anadromous fish)*** NPLCC Science/TEK Strategy Implementation Plan The project also addresses elements of Actions 2.2 and 4.1.

Methods: Completion of the work proposed herein will provide tools for evaluating restoration of stream-road crossings in the context of their potential benefits to stream biota, threats to infrastructure posed by climate change, influences of crossing designs, and long-term costs and benefits of management decisions or actions in the context of different biotic and climate scenarios. In this study, we will **collaborate** with the Forest Service and local, state, and tribal partners to identify management values and trade-offs associated with passage restoration at stream-road crossings. With this input in place, we can **develop a conceptual model** that embraces values associated with biological, structural (e.g., crossing designs), and economic costs and benefits associated with passage restoration alternatives in the face of climate change. Once complete, we will transform the conceptual model into a **quantitative decision support tool**. We will capitalize on an existing large-scale study of aquatic organism passage and probabilistic **models of species presence and abundance** in relation to stream-road crossings to estimate the value of passage restoration (based on models of species presence derived from surveys at >400 sites on the SNF in 2012; J. Dunham, Principal Investigator, unpublished results). We will **model and project dynamics** of disturbance to stream-road crossings using

contemporary terrain-based models of hydrologic and geomorphic dynamics (NetMap) to evaluate the probability of failure for stream-road crossings. To **Model climate change impacts** to incorporate potential change, vulnerabilities, and uncertainties, we will use methods similar to Prudhomme (et al. 2010). The model will help **evaluate scenarios and how these costs, benefits, and risks are linked to management decisions** or actions associated with alternatives and designs for restoring passage at stream road crossings. Ultimately, by attaining these objectives, we will **provide a working example** and set of tools that can be applied across the domain of the NPLCC to inform restoration of passage at stream-road crossings. These tools will also provide insights into evaluating other site-based stream restoration activities where analogous issues are at stake (e.g., geomorphic restoration of channels, managing diversions, etc.). **Geographic Extent:** The geographic focus of the project will cover the Siuslaw National Forest, a coastal rainforest in Oregon. While local in scope, this approach can be modified and applied to other watersheds in the region throughout the North Pacific LCC.

Timeline of Schedules, Products, and Outcomes:

	2013					2014											
Work and Reporting Schedule	August	September	October	November	December	January	February	March	April	May	June	July	August	September	October	November	December
Project start-up	X																
Identify key decisions/trade-offs/scenarios	X	X															
Develop conceptual model			X	X													
Develop quantitative tool					X	X	X	X	X	X	X						
Evaluate cost, benefits, risks									X	X	X	X	X				
Present findings														X	X		
Draft Report (Oct.1, 2014)													X	X			
Project Report/Project Completion (Dec.1, 2014)																X	
Draft manuscript																	X

Disclaimer regarding Data Sharing:

There are no restrictions on sharing of the data expected from this project.

Budget:

Budget represents work in FY2013 (July-September) and FY2014 (January-December)

Budget FY2013/14	Requested	Contributed
a.Personnel	31,612 (7 PP)	$30,000 (PI, in-kind)
b. Fringe	-	
c. Travel	500	
d.Equipment	-	
e.Supplies	1,220	
f.Contractual	-	
g.Construction	-	
h.Other	-	
i.Total Direct	33,332	$30,000
j.Indirect	6,666	
k.Totals	**39,998**	**$30,000**

Note: This work would contribute to a larger study already underway, estimated at $300,000.

Biosketch for Jason B. Dunham, Ph.D. **May 2013**

Education

Oregon State University, BS, Zoology, 1987; Arizona State University, MS, Zoology, 1995; University of Nevada-Reno, Ecology, Evolution and Conservation Biology, Ph.D., 1997

Recent appointments

U.S. Geological Survey, Supervisory Research Aquatic Ecologist (GS-14): 2005 – date; Oregon State University Department of Fisheries and Wildlife, Courtesy Graduate Faculty: 2005 – date; Guest Instructor, Willamette University, 2013; College of Idaho, Adjunct Faculty, 2004; University of Idaho, Lecturer, Ecohydraulics Research Group: 2003-2005; Boise State University, Adjunct Faculty, Department of Biology: 2003-2005; U.S. Forest Service, Research Fishery Biologist (GS-13): 2000-2005

Experience relative to proposed work

Published on a variety of topics related to fish passage restoration. Hosted a national workshop on fish passage in 2010 that led to a nationwide network of studies on Forest lands to evaluate stream-road crossings and restoration effectiveness. Leading a programmatic study of crossings on the SNF as part of this effort. In June 2013, results of all projects will be featured at the National Fish Passage Conference. Hosting a follow-up workshop hosted to draft a synthesis of results from this nationwide effort. Work proposed herein will build on this base of information.

Recent publications (go here for more) relevant to climate and stream-road crossings

Arismendi, I., Johnson, S.L., Dunham, J.B., Haggerty, R., Hockman-Wert, D.P., 2012, The paradox of cooling streams in a warming world- Regional climate trends do not parallel variable local trends in stream temperature in the Pacific continental United States: Geophysical Research Letters, v. 39, p. L10401.

Arismendi, I., Safeeq, M., Johnson, S.L., Dunham, J.B., Haggerty, R., 2012, Increasing synchrony of high temperature and low flow in western North American streams- double trouble for coldwater biota? DOI-10.1007/s10750-012-1327-2: Hydrobiologia, p. online.

Hoffman, Jr., R., Dunham, J.B., Hansen, B.P., 2012, Aquatic Organism Passage at Road Stream Crossings - Synthesis and Guidelines for Effectiveness Monitoring: U.S. Geological Survey Open-File Report 2012-1090, p. 64.

Dunham, J.B., Hoffman, Jr., R., Arismendi, I., 2011, Practical Guidelines for Monitoring Movement of Aquatic Organisms at Stream-Road Crossings: Stream Notes, U.S. Forest Service Rocky Mountain Research Station, p. 1-7.

Rachel E. Reagan

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EDUCATION:

University of Oregon, B.S., Biology, 1993

Oregon State University, Current M.S. student, Fish and Wildlife Department. GPA: 4.0

- My research interests are focused on working with local communities, natural and cultural resource managers, and interdisciplinary researchers to apply scenario-based decision support tools to understand how changes in hydrology, biology, and climate affects aquatic resources.

PROFESSIONAL EXPERIENCE AND RESEARCH:

- **U.S. Geological Survey, Western Fisheries Research Center**
  Pathways Intern, August 2012 to present
- **U.S. Geological Survey, Western Fisheries Research Center (WFRC)**
  Fishery Biologist, May 1998 to July 2012
- **Johnson Controls World Service**
  Biologist 1, March 1997 to April 1998
- **National Park Service, Olympic National Park**
  Biological Science Technician, July to October, 1995 and 1996
- **Oregon State University, Oregon Cooperative Fisheries Research Unit**
  Faculty Research Assistant, March to July, 1995 and 1996
- **Oregon Department of Fish and Wildlife**
  Experimental Biological Aide, October 1995 to February 1996
- **California Department of Fish and Game**
  Fish and Wildlife Scientific Aide, September 1994 to March 1995

SELECTED PUBLICATION AND REPORTS: (More available upon request)

Ferguson, J.W., B.P. Sandford, **R.E. Reagan**, L.G. Gilbreath, E.B. Meyer, R.D. Ledgerwood, and N.S. Adams. 2007. Bypass system modification at Bonneville Dam on the Columbia River improved the survival of juvenile salmon. Transactions of the American Fisheries Society 136:1487-1510.

Reagan, R.E., N.S. Adams, D.W. Rondorf, G. Fitzgerald, R. Spateholts, T. Hoffman, and D.E. Olson. 2005. Distribution, migration behavior, habitat use, and species interactions of fall-released juvenile hatchery spring Chinook salmon in the Deschutes River, Oregon, 2003. Annual report of research to U.S. Fish and Wildlife Service, Vancouver, Washington.

Reagan, R.E.. S.D. Evans, L.S. Wright, M.J. Farley, N.S. Adams, and D.W. Rondorf. 2005. Movement, distribution, and passage behavior of radio-tagged yearling Chinook salmon and steelhead at Bonneville Dam, 2004. Annual Report of Research to the U.S. Army Corps of Engineers, Portland, Oregon.