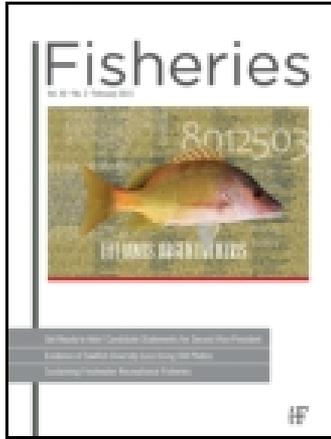


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### Conserving Pacific Lamprey through Collaborative Efforts

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**FEATURE**

# Conserving Pacific Lamprey through Collaborative Efforts

Pacific Lamprey (*Entosphenus tridentatus*) have been an important part of the ecological community and co-evolved with aquatic species of the western rivers of the United States. Scarce information on Pacific Lamprey has hindered conservation and management efforts. To assess and conserve Pacific Lamprey, we developed a conservation initiative composed of three parts: assessment, conservation agreement, and regional implementation plans. We applied a novel ranking system that characterized risk to Pacific Lamprey throughout the U.S. range. We found that the majority of watersheds are at relatively high risk of extirpation, with few secure. The risk assessment results were instrumental in gaining partners' support for a conservation agreement, with the goal of achieving long-term persistence and supporting traditional tribal cultural use of Pacific Lamprey. This extensive support has led to a collaborative effort in developing implementation plans and delivering numerous conservation actions. This approach for assessing Pacific Lamprey status and identifying restoration priorities is easily transferrable to other species.

## Conservación de la lamprea del Pacífico mediante esfuerzos de colaboración

La lamprea del Pacífico (*Entosphenus tridentatus*) ha sido parte esencial de la comunidad ecológica y ha co-evolucionado con especies acuáticas de los ríos del oeste de los EE.UU. La falta de información sobre la lamprea del Pacífico ha entorpecido los esfuerzos de manejo y conservación. Con el fin de evaluar y conservar la lamprea del Pacífico, se desarrolló una iniciativa de conservación que se compone de tres partes: evaluación, acuerdos de conservación y planes regionales de implementación. Se aplica un sistema nuevo de ordenación que caracteriza el riesgo de la lamprea del Pacífico a lo largo de los EE.UU. Se encontró que, con algunas excepciones, en la mayor parte de las cuencas hidrológicas, la especie está en riesgo de extirpación. Los resultados de la evaluación del riesgo fueron esenciales para adquirir el apoyo de los participantes en los acuerdos de conservación, con el objetivo de lograr la persistencia de largo plazo y apoyo del uso cultural de la lamprea del Pacífico. Este amplio apoyo ha dado como resultado un esfuerzo de colaboración para desarrollar planes de implementación y la puesta en práctica de numerosas acciones de conservación. Este enfoque para evaluar el estado de la lamprea del Pacífico y para identificar prioridades de restauración se puede transferir fácilmente a otras especies.

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## INTRODUCTION

### Biology and Ecology

Pacific Lamprey (*Entosphenus tridentatus*) are jawless fishes, considered part of a large, ancient assemblage (Agnatha) that date back to about 500 million years ago (Gess et al. 2006). As such, Pacific Lamprey are among the longest living vertebrates and have persisted through four major extinction events (M. Docker, University of Manitoba, personal communication). Near the end of the Devonian Period (about 350 million years ago), the only Agnathans that remained were the hagfishes and lamprey.

Pacific Lamprey have been an important part of the ecological community that may have influenced the evolution of many aquatic species in the western rivers of the United States. Larval Pacific Lamprey can make up a large portion of the biomass in streams where they are abundant, thus making them an important component along with aquatic insects in processing nutrients, nutrient storage, and nutrient cycling (Close et al. 2002). In addition, adult lampreys die after spawning, leaving marine-derived nutrients in freshwater streams (Beamish 1980). All life stages of Pacific Lamprey appear to be a choice food for both marine and freshwater avian, mammalian, and fish predators, and at times may be preferred over salmonids, acting as a buffer to predation (Roffe and Mate 1984).

Given the dynamic nature of the rivers on the West Coast of the United States and the persistence of Pacific Lamprey, it appears that this species has been successful in pioneering and colonizing emerging habitat across the Pacific Rim from Japan to Mexico. Three genetic studies on the broad-scale population structure of Pacific Lamprey reached a similar conclusion, that there was a high level of historic gene flow for populations separated by large geographic distances (Goodman et al. 2008; Lin et al. 2008; Docker 2010). When interpreted on an evolutionary timescale, these data indicate a shared evolutionary history and a lack of reproductive isolation on small geographic scales. However, components of the available data suggest the possibility of some geographic population structure and adaptive variation: (1) higher number of drainage-specific haplotypes in southern regions, and (2) significant differences in gene frequencies among collection localities. Spice et al. (2012) found that Pacific Lamprey do not exhibit strong site fidelity, but they exhibit limited dispersal, which results in regionally panmictic populations and

is supported by the findings of Hess et al. (2013). This would support the concept that the population abundance for a specific watershed may be somewhat dependent on the abundance of neighboring larger watersheds for Pacific Lamprey.

### Cultural Importance

Pacific Lamprey have been harvested for many generations by Native American tribes from the West Coast of North America to the interior Columbia and Snake rivers for subsistence, religious, medicinal, and spiritual purposes (Close et al. 2002). Because of the tribes' close connection with Pacific Lamprey, they were the first people to express concern about the precipitous declines in population numbers and constriction of distribution. This decline greatly reduced the tribes' fishing opportunities and impacted the flow of traditional ecological knowledge surrounding Pacific Lamprey (Petersen Lewis 2009). The Native American tribes of the Columbia River convened a Lamprey Summit in 2004 to raise awareness of declines in Pacific Lamprey to the U.S. Fish and Wildlife Service (USFWS) and other state, federal, and local partners in the region. The summit outcome was a commitment by these partners and the USFWS to collaborate on efforts to conserve the species. The USFWS was petitioned to list Pacific Lamprey under the Endangered Species Act (Nawa 2003), but the findings did not warrant listing. The USFWS committed to develop the Pacific Lamprey Conservation Initiative (Initiative) in collaboration with Native American tribes; federal, state, and local agencies; and other entities. The Initiative is a strategy to improve the status of Pacific Lamprey throughout their range in the continental United States, the geographic scope that these entities have management influence for Pacific Lamprey.

### Background for Assessing Status

In the Pacific Northwest, research has focused on anadromous salmonids, and this large information base has greatly advanced tools for guiding salmonid conservation and restoration. However, relative to salmonids, lamprey are among the most poorly studied groups of fishes on the U.S. West Coast, despite their diversity and presence in many rivers, including coastal streams (Moyle et al. 2009). Until the current assessment, a systematic evaluation of Pacific Lamprey status in the U.S. has not been conducted (Luzier et al. 2009). Pacific Lamprey have not been important to commercial or recreational fisheries of the West Coast, likely explaining the paucity of information on abundance and distribution collected by state and federal agencies. This lack of information for anadromous lamprey repeats across the globe (Thiel et al. 2009) and has hampered efforts to guide conservation and restoration measures. There have been some geographically limited planning efforts for Pacific Lamprey conservation (USACE 2009; CRITFC 2011); however, a wide-ranging, comprehensive conservation plan has not been developed.

In order to inform a comprehensive conservation plan, our first step was to identify an approach to consistently evaluate the risk of extirpation to Pacific Lamprey in watersheds and then summarize the risk across watersheds (conservation risk) for a larger geographic area. We reviewed assessment approaches applied to anadromous lamprey worldwide that also had limited information. A number of anadromous lamprey species are considered to be in an imperiled status in Europe (Mateus et al. 2012). Assessing threats and demographics guided the selection of special areas to conserve lamprey species (Goodwin et al.



Adult Pacific Lamprey from Cedar Creek, Washington. Photo credit: U.S. Fish and Wildlife Service.

2008). Loss of larval habitat (Kirchhoefer 1995), migration barriers, water quality, and habitat issues (Igoe et al. 2004) have been identified as causes for the decline of lamprey species in Europe and Great Britain. Kelly and King (2001) evaluated three species of lamprey in Ireland, providing a detailed and comparative account of lamprey ecology, particularly regarding those river life stages most likely to be affected by human activity. Areas were identified where more information is needed to form a basis for decision making regarding conservation requirements. In Canada, only half of the lamprey species have been assessed by the Committee on the Status of Endangered Wildlife in Canada, and NatureServe conservation rankings have been applied to a number of lamprey species (excluding Pacific Lamprey) at the national and subnational levels (Renaud et al. 2009). Pacific Lamprey in Canada have not been ranked through NatureServe at the national level, but in British Columbia they have been ranked as secure at the subnational level (Renaud et al. 2009). Moyle et al. (2009) conducted a systematic analysis using available information for lamprey in California. This approach used criteria that included aspects of lamprey biology, vulnerability to environmental change, and limiting factors; they found that all species are either declining, exist in low numbers, or are isolated populations.

Most of these evaluations related to lamprey conservation have been challenged by the scarcity of demographic information and the biology and ecology of anadromous lamprey species. However, a recurring approach for informing lamprey conservation is to pool information on populations and synthesize information on the biology, ecology, and habitat requirements for lamprey species. Most of these systematic analyses also focused on specifically identifying the threats or limiting factors that are impacting the lamprey populations. The USFWS and partner agencies have applied similar systematic assessment approaches to evaluate aquatic species status and guide development of conservation plans (USFWS 2008a). The USFWS has specifically used NatureServe to evaluate the relative conservation status of Bull Trout (*Salvelinus confluentus*) at a core area level (USFWS 2008a). This systematic approach of assessing an aquatic migratory species, with limited information, can be applied at various spatial scales (Faber-Langendoen et al. 2012), is well documented, scientifically supported, and widely used by many USFWS partners.

Andelman et al. (2004) conducted a review of protocols for identifying species at risk in the context of viability assessments for the U.S. Forest Service. They reviewed nine published protocols (including the NatureServe ranking system, USFWS listing factors, International Union for Conservation of Nature classification system, and others) and concluded that all were useful, but NatureServe ranks may be the most suitable for identifying species at risk on national forests because of the flexibility of scale, potential for use of existing information, and ability to integrate threats analyses.

#### Conservation Initiative

The goal of the Initiative is to collaborate on efforts that reduce or eliminate threats to Pacific Lamprey and to achieve long-term population persistence while supporting traditional tribal cultural use. We applied the Strategic Habitat Conservation (SHC) approach to Pacific Lamprey through an Initiative that is composed of a three part process: The Assessment and Template for Conservation Measures (Assessment; Luzier et al. 2011); a conservation agreement (Agreement; USFWS 2012); and

regional implementation plans. The USFWS adopted SHC, which is a landscape (riverscape) approach to conservation that emphasizes planning, science, partnership, and learning from experience (USFWS 2008b). The Assessment uses current knowledge of historic and current distribution, abundance and trends in abundance, and threats to Pacific Lamprey and their habitat to assess relative risk to populations. The Agreement is a voluntary commitment of the USFWS, tribes, and other partnering agencies and organizations to collaborate on efforts to achieve the Initiative goal. The regional implementation plans identify and prioritize conservation actions, research and monitoring needs, as well as potential funding sources for these activities across regions. Lamprey restoration efforts are coordinated with restoration activities for other aquatic species (e.g., salmon, steelhead, and bull trout) that should lead toward healthier riverscapes.

## METHODS

The SHC approach (USFWS 2008b) is composed of biological planning, conservation design, conservation delivery, and an adaptive management feedback loop. Biological planning is the systematic application of scientific knowledge about species to guide habitat management actions. We did this in the Assessment by using the demographic information and identified threats to assess the relative risks of extirpation of Pacific Lamprey. By evaluating the results of the risk assessments and ongoing conservation measures, we identified gaps in conservation actions. This constituted our conservation design approach, which shaped the Conservation Agreement and is guiding regional implementation planning. Conservation delivery is guided by the regional implementation plans and adjusted through a feedback loop. This adaptive management approach is informed by all of the regions sharing information on evaluation of conservation action effectiveness and evaluation of population status.

#### Assessment

To characterize the conservation risk of Pacific Lamprey, we took a novel approach in applying the NatureServe ranking system (Faber-Langendoen et al. 2012). The three factors used in NatureServe are rarity (distribution and abundance), trends in abundance, and threats (Luzier et al. 2011). We made the following changes to the default rank calculator values to better reflect the quality of the information for Pacific Lamprey rarity, trends, and threats: (1) changed the weighting of the historic distribution, current distribution, population size, and ratio of current to historic distribution so all equal 1; (2) added the ratio of current to historic distribution (the addition of this ratio lets us factor in the risk associated with rearing and spawning in less spatially diverse areas) with a weight of 1; (3) changed the relative weights of the three major factors (rarity, trends, and threats) from 0.65, 0.20, and 0.15 to 0.60, 0.10, and 0.30, respectively. This change increases the weight for threats from standard NatureServe ranks, reflecting the fact that we were highly confident in our threat information, and our trend data are either lacking or uncertain (Luzier et al. 2011). The weights used for the ranking factors reflect the relative confidence in the data.

We applied the NatureServe ranks to discrete watersheds (4th code Hydrologic Unit [HUC 4]), a scale that is rarely used for assessing species status with this tool. We used data at the HUC 4 scale because it provided the highest degree of specificity for demographics and threats, assessing patterns of relative risk of extirpation, and to identify any relative

strongholds or weak areas for Pacific Lamprey conservation. The findings of risk rank and threats by HUC 4 were summarized for 10 regional management units (RMUs) to assess conservation risk at a scale that promotes collaboration among resource managers on conservation and restoration activities. The RMUs are Northern California, Southern California, coastal Oregon, lower Columbia/Willamette, Mid-Columbia, upper Columbia, Snake, mainstem Columbia and Snake, Puget Sound/coastal Washington, and Alaska (Figure 1). Maps by region were constructed to display the spatial arrangement of risk by watershed (Luzier et al. 2011; Goodman and Reid 2012). Through this novel application of NatureServe, we could provide the range of ranks for the watersheds within RMUs

and consider the spatial arrangement of risk levels for these watersheds.

We assessed the conservation risk for all of the RMUs except the mainstem RMU and Alaska. The mainstem RMU represents a migratory corridor that summarizes threats that impact the populations of the other RMUs of the Columbia River Basin. This summary of threats was applied to the RMUs that migrate through this corridor. There is little information about distribution and status for Pacific Lamprey in Alaska, which precluded a NatureServe risk assessment.

We conducted a series of meetings across the RMUs to consistently collect data on rarity, trends, and threats by HUC 4 (Luzier et al. 2011; Goodman and Reid 2012). This

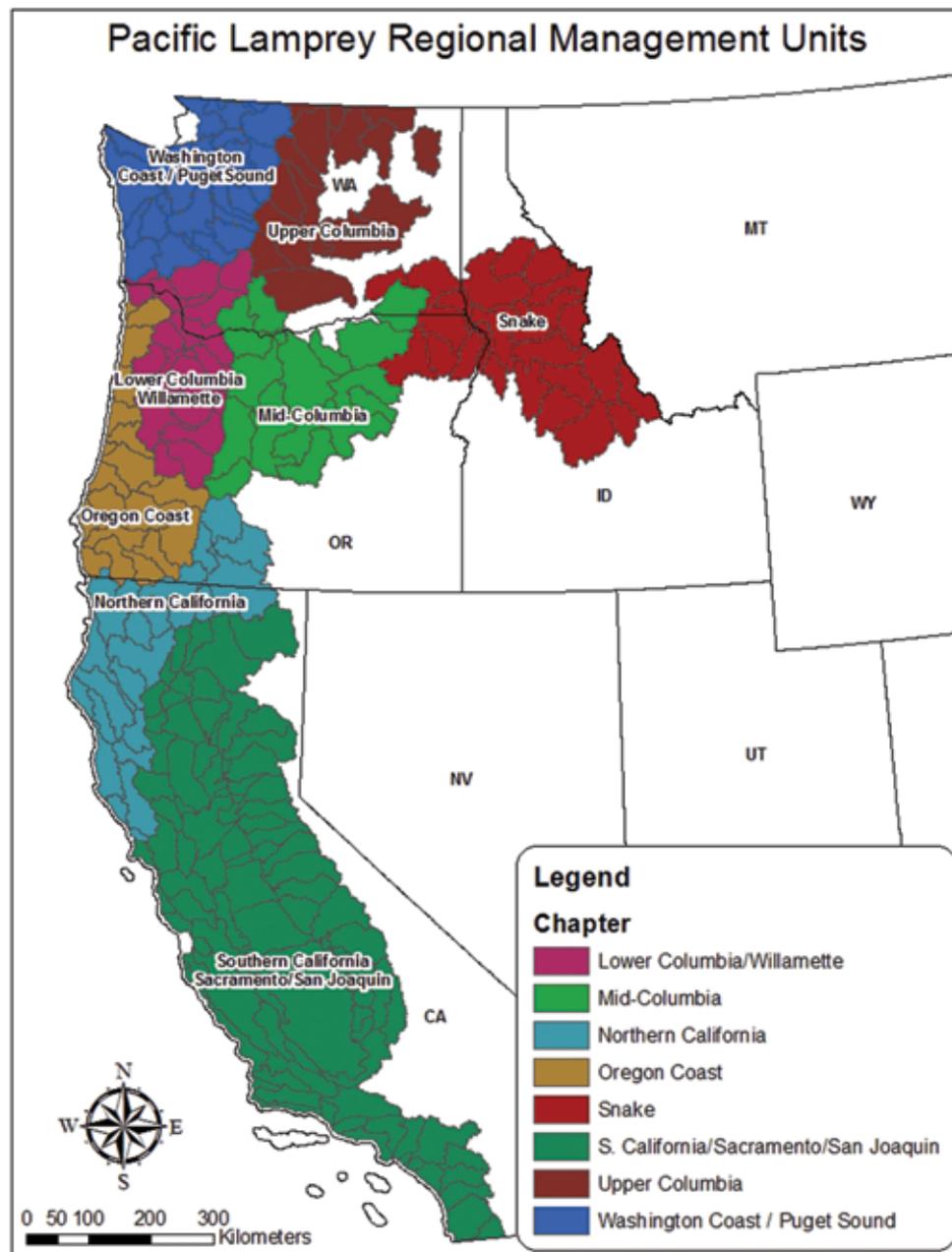


Figure 1. Pacific Lamprey distribution has been divided into 10 regional management units (RMUs): Northern California, Southern California, coastal Oregon, lower Columbia/Willamette, Mid-Columbia, upper Columbia, Snake, mainstem Columbia and Snake, Puget Sound/coastal Washington, and Alaska.

information was organized around the NatureServe categories used in the rank calculator to provide consistency for future status assessments of Pacific Lamprey. The NatureServe technical experts confirmed that our application of the rank calculator (including revised weights) and the spatial scale to Pacific Lamprey was consistent with their principles for conservation assessment (B. Young and M. Ormes, NatureServe, personal communication).

#### Conservation Agreement

The Agreement provides a mechanism for the involved parties to collaborate and pool available resources to expeditiously and effectively implement conservation actions and to share success of restoration actions and research, monitoring, and evaluation results for Pacific Lamprey. Working through a steering committee of partners, we jointly developed the guiding principles of the Agreement. We worked with these parties to finalize the Agreement language in order to maximize the number of supporters.

#### Implementation Plans

We are in the process of developing implementation plans for each of the 10 RMUs. For each watershed in a region, the threats identified in the Assessment and by local experts will be summarized. Then the regions will identify ongoing and planned conservation actions and determine the gaps in conservation needs.

## RESULTS

### Assessment

Abundance and distribution of Pacific Lamprey throughout California, Oregon, Washington, and Idaho has declined and contracted. Threats such as barriers to mainstem and tributary passage, streamflow management, stream and floodplain degradation, and reduced water quality are impacting all freshwater life stages. The majority of watersheds are at relatively high risk, with very few that are relatively secure. The patchy distribution of watersheds at low risk limits the potential for a rescue effect for high-risk watersheds (Figure 2).

In Northern California (north of Point Conception), Pacific Lamprey were extirpated from at least 55% of their historical habitat by 1985. The primary threat responsible for extirpations was large impassible dams, which excluded migrating adults from access to high-quality spawning and rearing habitat in the

foothills and higher elevations. In Southern California, results indicate that no viable populations of Pacific Lamprey currently occupy drainages south of the Big Sur River on the central coast, and there is evidence for a general northward range contraction (Goodman and Reid 2012).

The NatureServe rank indicates that Pacific Lamprey for the coastal Oregon RMU are at relatively lower risk than those of other RMUs in the range. The most serious threat in this region is stream and floodplain degradation, which was classified as a moderate threat (Luzier et al. 2011).

The Columbia River Basin is composed of the Snake, Upper Columbia, Mid-Columbia, Lower Columbia, and Willamette RMUs. The NatureServe ranks indicate that Pacific Lamprey are at high risk throughout much of the Columbia River Basin, particularly in the Snake River, the Mid-Columbia, and the Upper Columbia RMUs. Results from the mainstem RMU threat assessment (Luzier et al. 2011) identified that the primary threat affecting these populations is adult and juvenile passage at mainstem dams. Tributary passage, stream and floodplain degradation, and water quality are also affecting Pacific Lamprey in these RMUs. Pacific Lamprey of the Lower Columbia and Willamette rivers are at relatively lower risk; however, the risk levels are still high to moderate.

Because of the lack of information on demographic and threat factors, the watersheds in the Puget Sound/Strait of Juan de Fuca/Coastal Washington geographic area were not assessed with the NatureServe ranking approach. However, several of these watersheds were appraised using expert opinion with the available information on short-term trends and general threats. The abundance of the Pacific Lamprey in these watersheds was characterized as rapidly declining (Luzier et al. 2011).

### Conservation Agreement

The Agreement was signed by 12 tribes from California, coastal Oregon, and the Columbia River Basin; four state fish and wildlife agencies; eight federal agencies; non-governmental organizations; and a number of local governments that span the geographic range of Pacific Lamprey in the continental United States. The goal is securing long-term persistence of Pacific Lamprey and supporting traditional tribal cultural use throughout their historic range in the U.S. Through the Agreement, the parties committed to restoring Pacific Lamprey, enhancing watershed conditions, and data sharing in each RMU.



Signatories to Pacific Lamprey Conservation Agreement signed June 20, 2012, in Portland, Oregon. Photo credit: US Fish and Wildlife Service.

## DISCUSSION

Partner commitment to the Initiative is the first time that wide-ranging support has been focused on Pacific Lamprey conservation. The Assessment was supported because it was systematic, transparent, repeatable, and relied on data, research, and expert opinion from multidisciplinary scientists, managers, and decision makers. The completion of the Assessment was the key to bringing people to the table to commit to collaborative conservation, through the signing of the Agreement. By including the traditional tribal cultural use of Pacific Lamprey in the goal of the Agreement, numerous Native American tribes from the states of Washington, Oregon, and California supported and signed it. This broad tribal support was instrumental in solidifying support of the four states and the many federal agencies. In addition, the voluntary nature of the Initiative

provided an atmosphere where our partners were more willing to explore collaborative conservation strategies. This was likely related to avoiding the regulatory process of the Endangered Species Act, which can sometimes be constraining. This unprecedented interest in Pacific Lamprey has increased the potential for funding conservation actions (USFWS 2012).

The partners adopted a consistent approach for regional implementation planning and it is active through all RMUs. These plans will allow each region to prioritize actions and collaboratively address conservation and restoration needs for Pacific Lamprey. The regions committed to sharing success and failures of restoration actions and research, monitoring, and evaluation results for Pacific Lamprey among the RMUs. Partners are working together to fund activities prioritized in the regional plans.

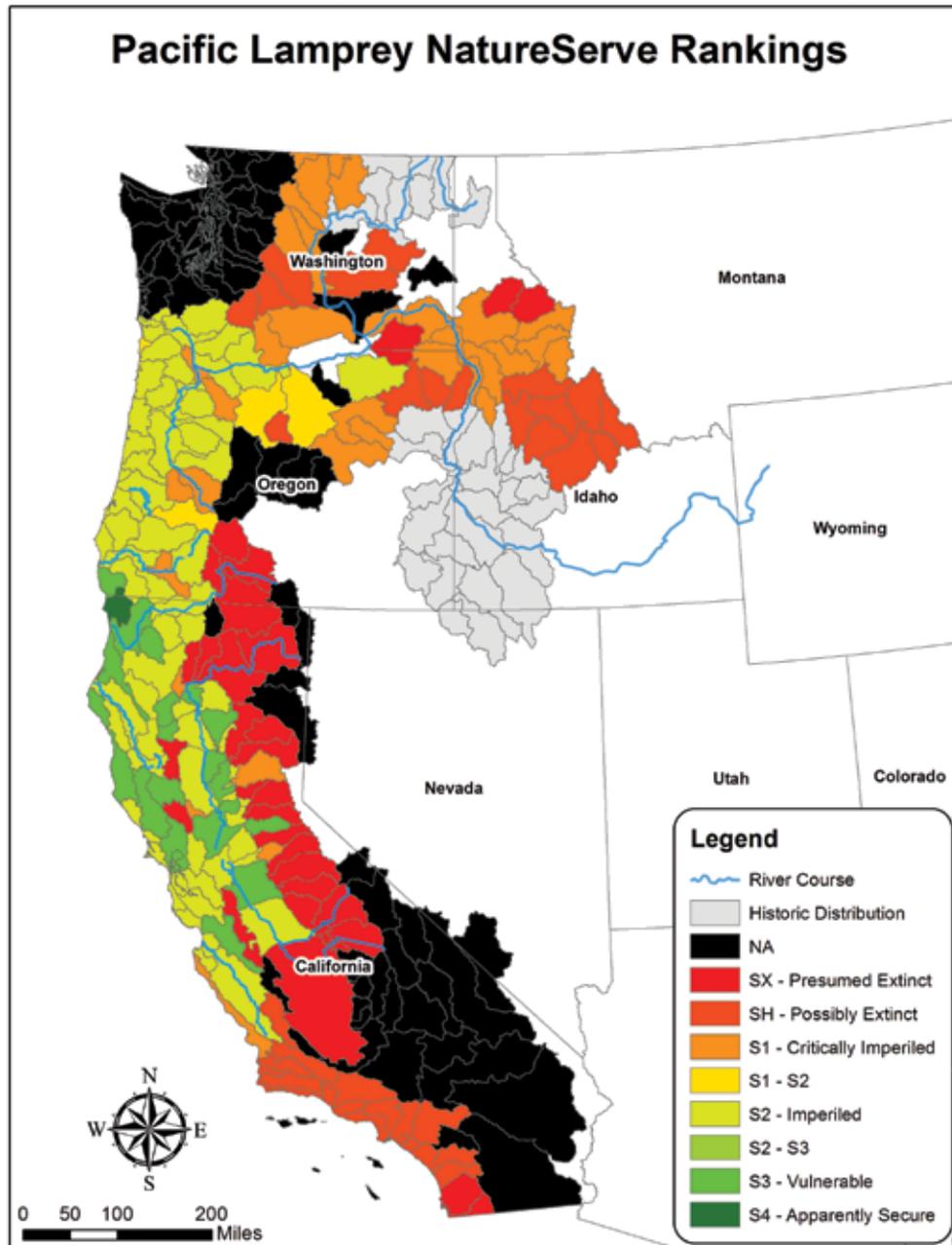


Figure 2. Calculated NatureServe relative risk ranks for Pacific Lamprey (Luzier et al. 2011; see tables 4-1 through 4-6). NA is for HUCs with insufficient data.

The Initiative and the planning process have yielded immediate benefits in addressing the most serious threats and information gaps for Pacific Lamprey. Examples of these include systematic evaluation of adult passage at Columbia River dams (Keefer et al. 2012), juvenile lamprey enumeration and condition sampling at Columbia River dams (McCann and Chockley 2011), artificial propagation research and translocation (Jolley et al. 2013), distribution sampling (Hayes et al. 2013), species identification, development of best lamprey management practices for stream disturbing activity (USFWS 2010), evaluation of lamprey during instream work activities (Jolley et al. 2012), increased funding for restoration activities (Luzier et al. 2011), and funding of lamprey tributary passage structures (Jackson et al. 2011; Luzier et al. 2011).

The Initiative coordinates restoration of habitats that cover close to a million square kilometers in California, Oregon, Washington, and Idaho. These efforts to restore the habitats of Pacific Lamprey and increase their abundance will also benefit many other aquatic species of the western rivers of the United States because of the Pacific Lamprey's key ecological role. The demonstrated support by the signatories of the Agreement and swift implementation of actions has raised the general awareness of the cultural and ecological importance, status, and conservation needs of Pacific Lamprey.

The USFWS's SHC approach proved to be useful in developing and implementing a conservation strategy for Pacific Lamprey, a wide-ranging and highly mobile species with little commercial value and a paucity of information. From this experience, we conclude that the organization of information and the resulting risk assessment were the keys to getting a wide range of partners to the table to explore collaborative conservation strategies for Pacific Lamprey. This relationship allowed us to develop an Agreement that solidified the parties' commitment to developing implementation plans, delivering numerous conservation actions on the ground, and sharing monitoring and evaluation results. Applying the principles of SHC proved helpful in organizing information and jointly developing conservation strategies that the numerous partners committed to monitor and evaluate, closing the loop on adaptive management.

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