CRITICAL UNCERTAINTIES FOR NATIVE FRESHWATER MUSSELS (BIVALVIA: UNIONOIDEA) IN THE PACIFIC NORTHWEST

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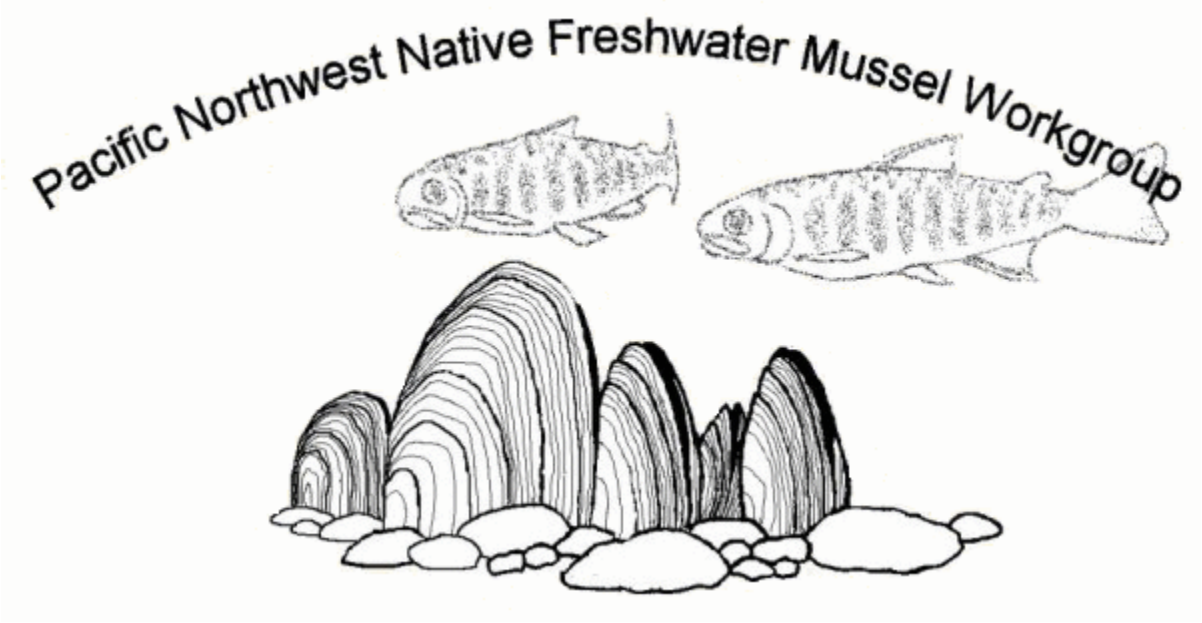

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Purpose

Many factors have affected freshwater mussels throughout North America, including the Pacific Northwest. Artificial impoundments, agriculture and industry have degraded or eliminated mussel habitat and significantly reduced the distribution of host fish species. Freshwater mussels are particularly susceptible to habitat degradation because they are sedentary and cannot move to more favorable environments (Strayer et al 2004, Nedeau et al 2009). Additionally, exotic zebra mussels (*Dreissena polymorpha*) and quagga mussels are out competing native mussels in many North American watersheds (Schloesser et al. 1998). Currently, 70 species of freshwater mussels are federally listed as endangered or threatened (U. S. Fish and Wildlife Service 2010). A national strategy for conservation of native freshwater mussels has been developed for the United States by the National Native Mussel Conservation Committee (1998). However, in the Pacific Northwest, research and conservation efforts have only recently been gaining momentum.

The Pacific Northwest, as referred to in this document, includes the states of Alaska, Oregon, Washington, Northern California, Idaho and Montana; and the Canadian province of British Columbia. Currently there are seven described species of freshwater mussels known to occur in the Pacific Northwest (NatureServe 2010, Table 1). However, recent work suggests members of the genus *Anodonta* may have been incorrectly assigned to species designations. Genetic comparisons of western *Anodonta* species by Chong et al. (2008) revealed three distinct and highly divergent lineages within the western *Anodonta*; 1) *Anodonta beringiana*, which is genetically similar to the Asian species *Anodonta woodiana*; 2) a clade comprised of *Anodonta californiensis* and *Anodonta nuttalliana*; and 3) a clade comprised of *Anodonta kennerlyi* and *Anodonta oregonensis*. The *A. californiensis*/*A. nuttalliana* clade (which includes the previously recognized *A. wahlamatensis*) exhibits basin specific substructuring based on morphological and genetic variation and may contain as many as six distinct groups (Mock et al. 2010). However, the taxonomy for the family Unionidae needs to be resolved and additional factors such as host fish requirements, morphology, life history, and habitat characteristics should be considered before species level designations are made (Crandall et al. 2000).

Table 1. Freshwater mussel species known to occur in the Pacific Northwest and associated conservation status (NatureServe 2010). “G” and “S” ranks refer to global and state/province. Status can be interpreted as follows: 1=critically imperiled, 2=imperiled, 3=vulnerable, 4=apparently secure, and 5=secure. “NR” indicates the species was not ranked. “Q” indicates the taxonomy of the species is questionable and when resolved may reduce the taxon’s conservation priority. The taxonomy of the members of the genus *Anodonta* is currently under review.

		Conservation Status							
Scientific Name	**Common Name**	**Global**	**BC**	**CA**	**ID**	**MT**	**OR**	**WA**	**AK**
Anodonta beringiana [1]	Yukon floater	G4	--	--	--	--	SNR	--	S3S4
Anodonta californiensis [1]	California floater	G3Q	--	S2?	SNR	--	S2	S1S2	--
Anodonta kennerlyi [1]	Western floater	G4Q	S5	--	SNR	--	SNR	S4	SNR
Anodonta nuttaliana [1]	Winged floater	G4Q	G4	SNR	--	--	S1	SNR	--

		Conservation Status							
Scientific Name	**Common Name**	**Global**	**BC**	**CA**	**ID**	**MT**	**OR**	**WA**	**AK**
Anodonta oregonensis[1]	Oregon floater	G5Q	S4	S?	--	--	S3	S3	--
Gonidea angulata	Western ridgemussel	G3	S1	S1S2	SNR	SNR	S2S3	S2	--
Margaritifera falcata	Western pearlshell	G4G5	S5	SNR	SNR	S2S4	S4	S4	SNR

Little is known about freshwater mussels of the Pacific Northwest, and in order to better design conservation strategies, it is imperative that the scientific community gather data and provide analyses to help conservation planners and management agencies. Consequently, the Pacific Northwest Native Freshwater Mussel Workgroup (hereafter referred to as the Mussel Workgroup) decided in November of 2007 to develop this critical needs document identifying essential gaps in information and research, as well as a formalized regional strategy to address them. This document is intended to guide freshwater mussel conservation, management, research and funding decisions in the Pacific Northwest. The Mussel Workgroup supports the methods described below to prioritize research, conservation and restoration efforts in the region, but acknowledges that strategies not identified in this document may still have specific importance.

Background

The first step in the process was to establish recommended priorities for research and conservation planning. For the purpose of determining critical needs and uncertainties for freshwater mussels, the Mussel Workgroup agreed on four classes to categorize these efforts: biology/ecology, human dimensions, status and trends, and limiting factors. Furthermore, within each class potential areas of concern were recommended (Table 2). While research in all of these areas would be valuable, it was the goal of the Mussel Workgroup to develop comprehensive 5-, 10- and 20-year priorities for freshwater mussel research and conservation efforts in the Pacific Northwest. Accordingly, the Mussel Workgroup decided to adopt guidelines for prioritizing research and conservation efforts. Priority rankings can direct efforts to achieve maximum benefit when no previous decisions have been made about specific research or conservation initiatives (Metrick and Weitzman 1998, Davis et al 2006). Over time the priorities will likely change, and the critical needs document will need to be updated to reflect those changes. The current version will reflect priorities for the next five years. The prioritization framework adopted by the Mussel Workgroup is based on an approach developed for the Entiat Subbasin Plan (Peven 2004) and later adapted for the Columbia River lamprey critical needs document (Columbia River Lamprey Technical Workgroup 2005).

Table 2. Categorization of critical needs for native freshwater mussels in the Pacific Northwest.

Class	Areas of Concern	
Biology/Ecology	• Habitat needs • Host species • Life history	• Population structure/Recruitment • Taxonomy/systematics
Human dimensions	• Overcoming scientific inertia [1] • Ecosystem valuation studies	• Public education and outreach programs • Legislation/regulatory proposals
Status and trends	• Geographic distribution • Local/regional abundance	• Population trends
Limiting factors	• Altered water temperature regimes • Global climate change • Host density and distribution • Hydrologic alteration • Invasive species	• Isolation/habitat fragmentation • Limited water supply • Poor water chemistry • Sedimentation

[1] Currently, there is a need for more research directed at native freshwater mussels in the western U.S. and Canada. A significant shift in focus and funding may be necessary to address other critical needs.

Methods

There were two stages in the prioritization strategy. The first stage was to assign a qualitative ranking to the conservation benefit of each objective. The conservation benefit was defined as "the degree to which gaining the information/achieving the objective will benefit freshwater mussels in the Pacific Northwest." Critical uncertainties were ranked on a five point scale and categorized according to the following guidelines:

Rank	Category	Definition
>4.5	Imminent	Addressing these issues immediately is important. Failure to act on these issues will likely result in considerable detrimental impact on native freshwater mussel populations.
3.5-4.5	Highly important	Addressing these issues is a high priority. Failure to address these issues will likely preclude restoration and enhancement of native freshwater mussel populations

Rank	Category	Definition
2.5-3.5	Important	Addressing these issues is important, but less so than those considered imminent or highly important. Failure to address these issues will likely limit opportunities for restoration and enhancement of native freshwater mussel populations.
1.5-2.5	Needed	Although these issues are important, failure to act on them would be unlikely to preclude opportunities for restoration and enhancement of native freshwater mussel populations. These issues need to be addressed; however when faced with limited time or resources, action could be delayed in favor of a more critical issue.
<1.5	Useful	Addressing these issues is not necessary, but action may prove helpful to restoration and enhancement of native freshwater mussel populations. Action on these issues could be pursued when available resources are not needed to address more critical issues.

The next step was to assess the feasibility of addressing each issue. Feasibility was defined as "the degree to which conservation or research objectives can be accomplished under existing constraints." Feasibility was ranked on a four point scale and categorized according to the following guidelines:

Rank	Category	Definition
<3.5	Easy	Objective can be accomplished in less time than is available, and requires little expenditure in resources, or resources are abundant and easy to access.
2.5-3.5	Achievable	Objective can be achieved in the desired time frame and sufficient resources are available.
1.5-2.5	Difficult	Achieving the objective may be limited either by time or resource availability and ease of access.
<1.5	Demanding	Achieving the objective is time and resource intensive. Time and resources may be limited and resources may be difficult to access.

In order to determine the conservation benefit and feasibility it was decided to circulate a survey (Appendix A) to members of the Mussel Workgroup as well as other scientist and resource managers from across the United States who have experience with freshwater mussel conservation issues (Appendix B). Individuals participating in the survey were asked to rank each area of concern with regards to conservation benefit and feasibility. In addition, space was provided in the survey to write in and rank additional areas of concern.

An initial ranking was then determined for each of the four major categories (biology/ecology, human dimensions, limiting factors and status and trends) by averaging the answers for all areas of concern within each category and comparing means amongst categories. The workgroup assumed the category with the highest mean rank had the most significant and immediate need for focused effort.

Once the categories were ranked, each area of concern was analyzed. The mean conservation benefit and mean feasibility were calculated for each area of concern using data from the surveys. Mean conservation benefit versus mean feasibility was plotted for each factor (Figure 1). The graph is separated into 4 quadrants using median values for conservation benefit and feasibility to determine quadrant boundaries.

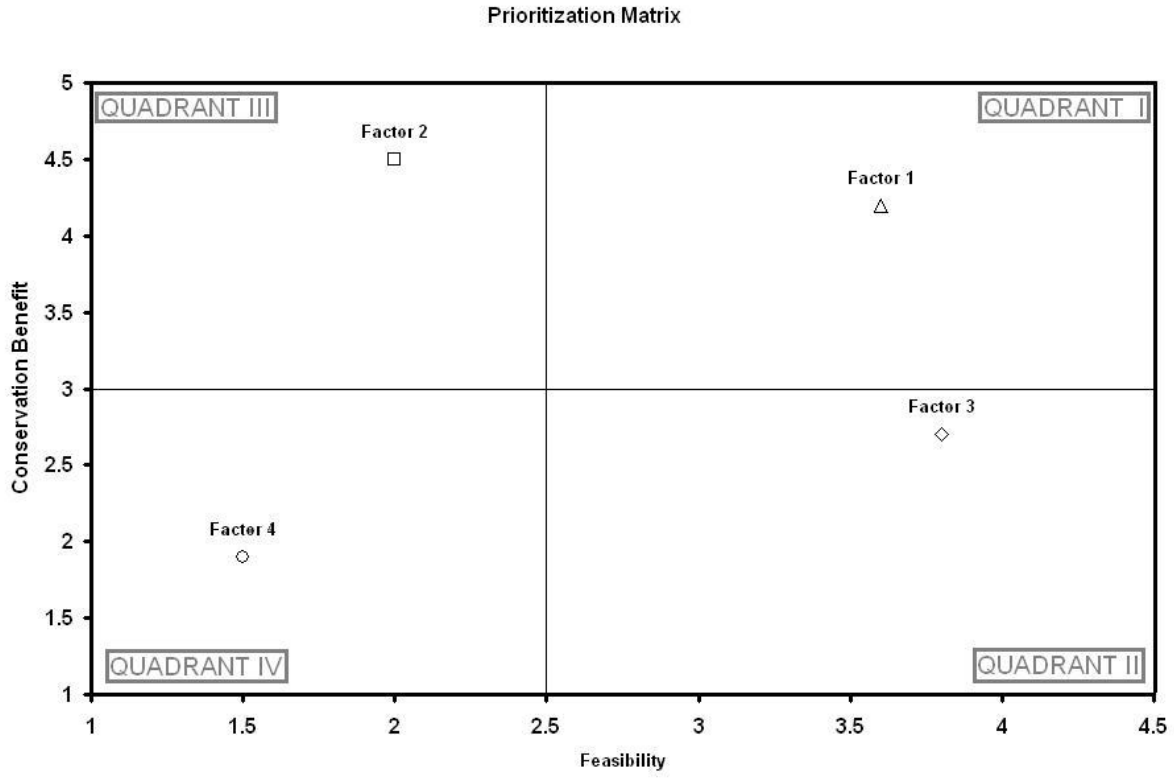


Figure 1. A sample prioritization graph plotting conservation benefit vs. feasibility.

Once the quadrants have been delineated, factors are assigned to tiers according to the quadrant in which each factor lies. Factors in Quadrant I are assigned to the first tier. These are factors whose goals are readily achievable and provide significant benefit. Factors in Quadrants II and III are assigned to the second tier. These factors either have goals that are readily achievable but provide less benefit or are difficult to implement but provide significant benefits upon successful completion. Factors in Quadrant IV are assigned to the third tier. These factors provide limited conservation benefit and are difficult to implement. Factors were assigned to three tiers based on quadrant membership (Table 3).

Table 3. Hypothetical factors from Figure 1 assigned to appropriate tiers in order to prioritize conservation and research goals.

Hypothetical Factor	Tier	Benefit	Feasibility
Factor 1	1	Significant	High
Factor 2	2	Significant	Low
Factor 3	2	Limited	High
Factor 4	3	Limited	Low

Results

Twenty-five surveys were completed and returned to the Mussel Workgroup. Of these 17 were completed by Mussel Workgroup members and 8 were completed by non-workgroup members (Appendix B). Participants were representative of federal, state and local governments; non-governmental organizations, and academics. A majority of participants (11) had 6 to 10 years of experience with freshwater mussels. Four had more than 20 years of experience, and one had 11-20 years of experience. The remaining eight had five or fewer years of experience at the time the survey was completed.

All of the categories had relatively high values for conservation benefit (Table 4). This is likely due to the fact that because so little is known about freshwater mussels in the Pacific Northwest, any new information or conservation efforts could yield useful results.

Table 4. Mean conservation benefit scores for categories of research and conservation for native freshwater mussels. Range = 1-5.

Category	Mean benefit	SD
Status and trends	4.3	0.65
Limiting Factors	3.8	0.90
Biology/Ecology	3.8	0.95
Human dimensions	3.5	0.96

If we were to delineate the quadrants of the prioritization graphs by using the median between the lowest and highest values on each axis, most of the factors that were analyzed in this study would fall within the first tier. Accordingly, the argument could be made that all efforts should be encouraged equally. However the Workgroup decided a different approach to prioritizing the critical needs for freshwater mussels would allow for better focus of efforts and more efficient use of resources. Consequently, it was decided that the mean values for each variable

(conservation benefit and feasibility) should be used as the quadrant boundaries. The mean conservation benefit across all categories was 3.8. The mean feasibility across all categories was 2.4.

We assumed that the category with the highest mean benefit score should require the greatest attention. In addition, the category with the highest conservation benefit score, Status/Trends, had the lowest standard deviation, indicating that there was a higher degree of accord among the respondents when rating potential areas of research in freshwater mussel Status/Trends.

There was a high degree of concurrence on the importance of status and trends. The overall mean conservation benefit was 4.3, and the standard deviation was 0.65. Of the factors included in the Status and Trends category, distribution and abundance ranked in the first tier while population trends ranked in the second tier (Figure 2).

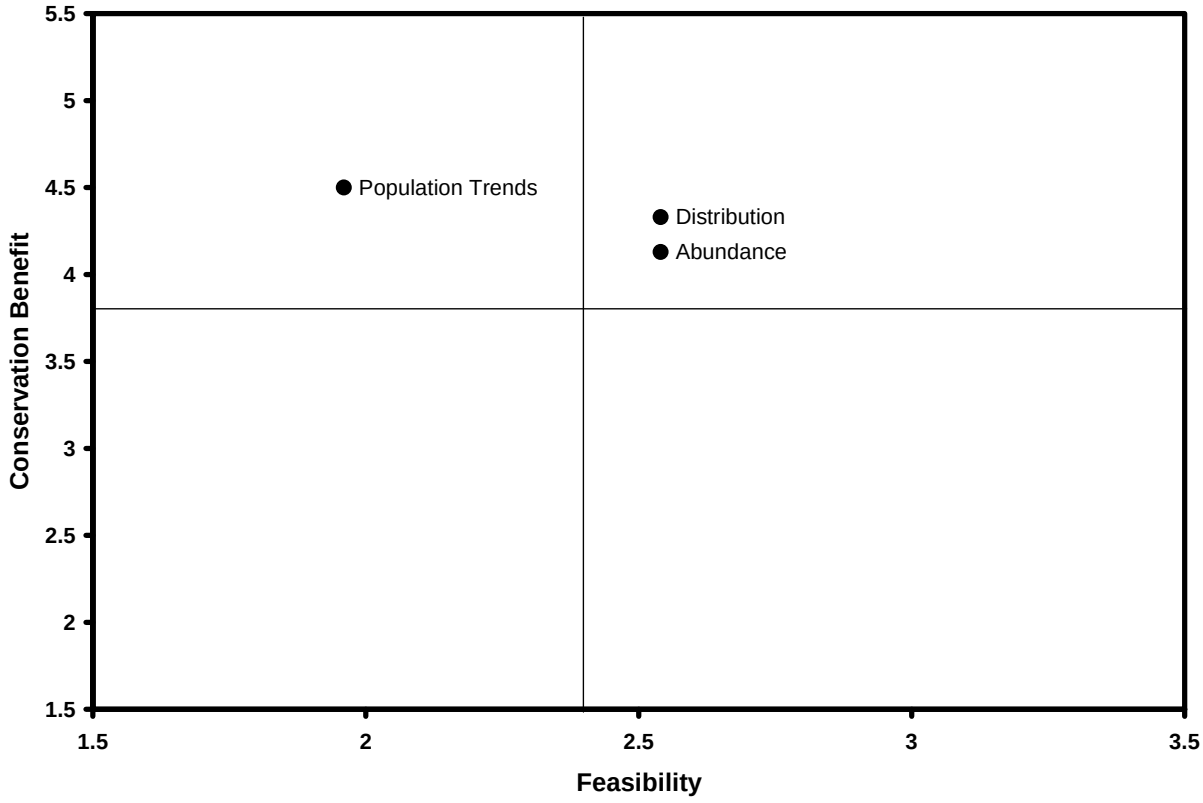


Figure 2. A prioritization graph of factors assigned to the Status and Trends category.

Analysis of the benefit and feasibility for the individual factors assigned to the Biology/Ecology category indicated that research on habitat and hosts are first tier factors. All other areas of investigation (population structure, taxonomy and life history) were second tier factors (Figure 3).

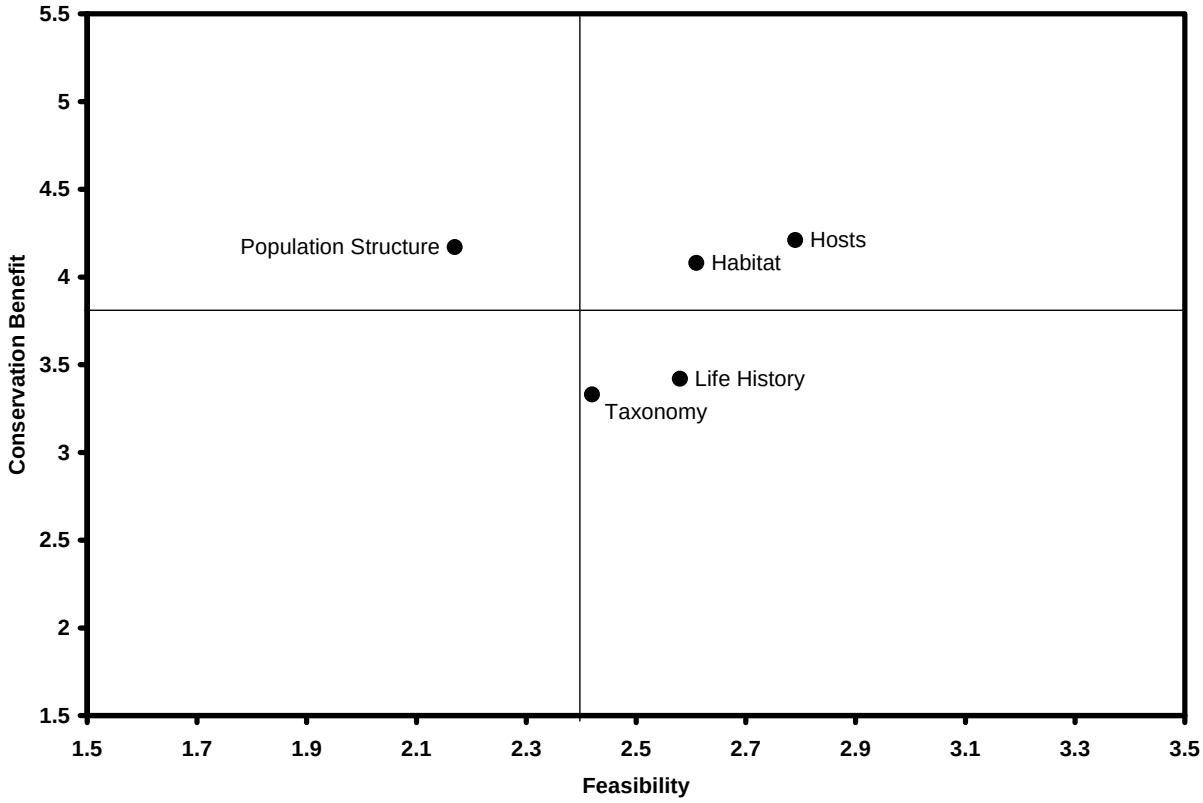


Figure 3. A prioritization graph of factors assigned to the Biology/Ecology category.

While Limiting Factors tied with Biology/Ecology for overall mean conservation benefit at 3.8, and the standard deviation of the mean was lower (indicating a higher level of concurrence among respondents), review and discussion of the additional comments revealed that many people felt there were other significant limiting factors missing from the survey. Given the number of suggestions we received to add factors within this category, trying to gather data on every possible recommendation was not feasible. Consequently, the Workgroup decided to consider limiting factors in its entirety rather than try to parse out individual limiting factors.

Human dimensions had the lowest mean conservation benefit rating and the highest standard deviation. There was a wide range in the responses both within and among the factors assigned to the Human Dimensions category. However, the consensus among the respondents was that public outreach and legislation/regulatory action were second tier factors while ecosystem valuation and overcoming scientific inertia were third tier factors (Figure 4).

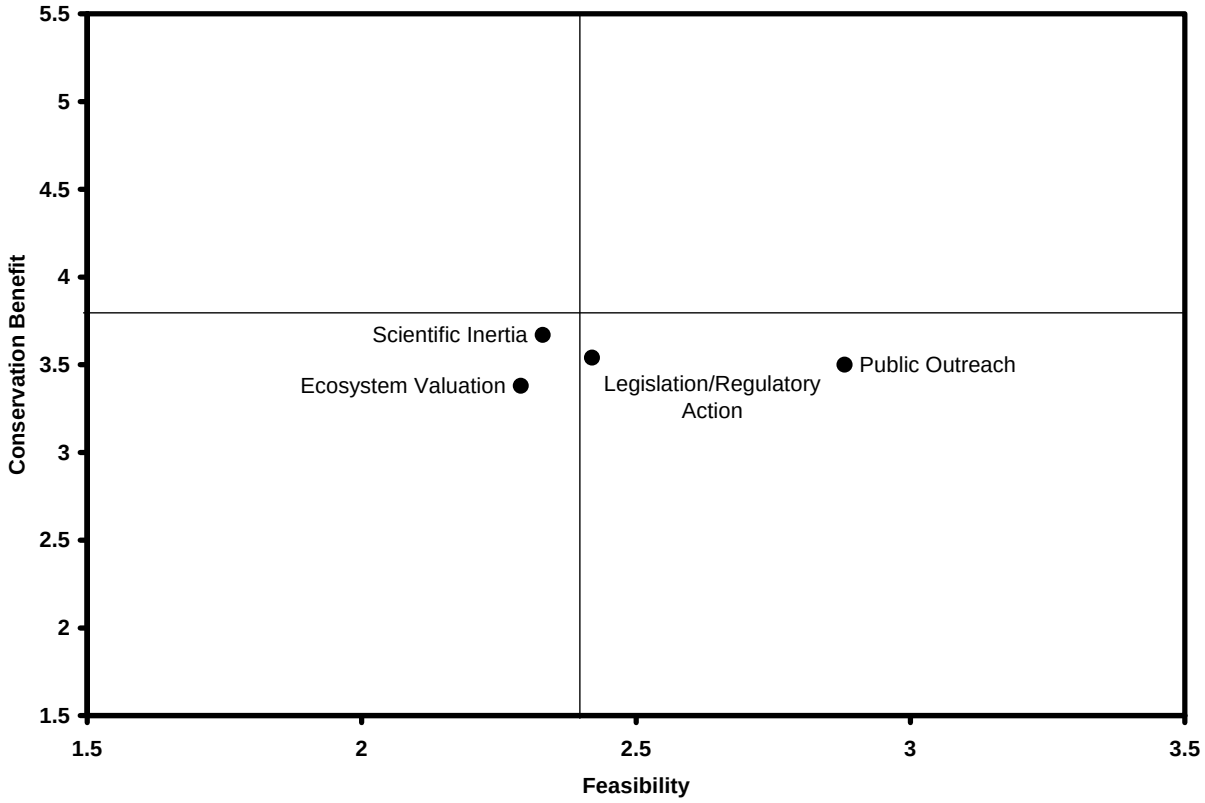


Figure 4. A prioritization graph of factors assigned to the Human Dimensions category.

In summary, four factors were placed in the top priority tier by reviewers (Table 5). Of these, distribution and abundance were within the class of factors (Status and Trends) identified as the most critical. Biological and ecological factors related to the identification of appropriate hosts and habitats were also within the top priority tier. Six factors were placed in the second priority tier including population trends and structure, life history, and taxonomy. Of those six, two factors from the class characterized as human dimensions were identified, public outreach and legislative/regulatory action. Finally, the third tier contained two other human dimension factors (scientific inertia and ecosystem valuation).

As stated earlier, the survey participants provided opinions on many more limiting factors than were included in the original survey. The work group decided to exclude further detailed analysis of limiting factor data as it was likely incomplete and would require follow-up with survey participants. A more thorough examination of limiting factors would be beneficial particularly as other critical needs are met.

Table 5. Prioritized list of factors by tier and class.

Priority Tier	Class	Factor
1	Status and trends	Distribution
1	Status and trends	Abundance
1	Biology/ecology	Hosts
1	Biology/ecology	Habitat
2	Status and trends	Population trends
2	Biology/ecology	Population structure
2	Biology/ecology	Life history
2	Biology/ecology	Taxonomy
2	Human dimensions	Public outreach
2	Human dimensions	Legislative/regulatory action
3	Human dimensions	Scientific inertia
3	Human dimensions	Ecosystem valuation

Discussion

This survey provides a preliminary, prioritized road map to fill knowledge gaps and initiate conservation efforts for freshwater mussels in the Pacific Northwest. With a paucity of freshwater mussel data in this region, identifying priorities can focus limited resources and expertise on key issues. In this geographic area, much of the funding for freshwater research is focused on Pacific salmon, commercially and culturally important species. In the last several years, mussel advocates have reached out to salmon and other fish biologists to increase their awareness of freshwater mussels, the important ecosystem roles of freshwater mussels, and the possible role of mussels as harbingers of water quality. These efforts are making a difference and have resulted in the incorporation of mussels in survey schemes, restoration efforts, and permitting. Continuing to find those links and in roads will be an important part of an overall strategy to raise the profile of freshwater mussels in the Pacific Northwest.

In addition to links with other species and disciplines, we must also consider the links among the priorities identified in this document. For example, formulating a clear picture

of the current distribution and abundance of mussel species relies on an understanding or way of cataloging the taxonomy of the species encountered. In addition, any efforts to pursue protection of freshwater mussels under the Federal Endangered Species Act require that organisms be identified to species. Finally, including mussels in effective restoration efforts necessitates knowledge of the habitat types needed for mussels at all life history stages.

Since this survey was completed, strides have been made to increase the knowledge base for freshwater mussels in general and in the Pacific Northwest. Many individuals and institutions are working on these and other issues related to freshwater mussel conservation. Significant gaps still exist, but advances have been made.

A continued trajectory of increased knowledge, conservation, and advocacy should be supported through the work of individuals at all levels of government, academia, and non-governmental organizations. Continued outreach to the public, policy makers, and colleagues in the natural sciences and natural resource management is needed. Making the connection between freshwater mussels and existing programs, target species (e.g. salmonids, invasive species), and key issues (e.g. climate change, water quality and water quantity) will likely bring the biggest conservation benefit in the short term.

Acknowledgments

The mussel workgroup extends its sincere thanks to all internal and external survey participants. Their combined years of experience and expert knowledge of freshwater mussels was extremely valuable to the success of this project. The authors would also like to thank the members of the workgroup for their support and patience during the analysis and preparation phase of this document. A special thanks to the members of the work group who contributed comments which greatly improved the content.

Literature Cited

Chong, J. P., J. C. Brim Box, J. K. Howard, D. Wolf, T. L. Myers and K. E. Mock. 2008. Three deeply divided lineages of the freshwater mussel genus Anodonta in western North America. Conservation Genetics 9:1303-1309.

Crandall, K.A., O.R.P. Bininda-Emonds, G.M. Mace, R.K. Wayne. 2000. Considering evolutionary processes in conservation biology. TREE 15(7): 290-295.

Davis, F. W., C. Costello, and D. Stoms. 2006. Efficient conservation in a utility-maximization framework. Ecology and Society 11: 33. [online] URL: http://www.ecologyandsociety.org/vol11/iss1/art33/.

Columbia River Lamprey Technical Workgroup. 2005. Critical Uncertainties for Lamprey in the Columbia River Basin: Results from a Strategic Planning Retreat of the Columbia River Lamprey Technical Workgroup. Columbia Basin Fish & Wildlife Authority, Portland, Oregon.

Metrick, A. and M. L. Weitzman. 1998. Conflicts and choices in biodiversity preservation. Journal of Economic Perspectives 12:21-34.

Mock, K.E., J.C. Brim Box, J.P. Chong, J.K. Howard, D.A. Nez, D. Wolf, and R.S. Gardner. 2010. Genetic structuring in the freshwater mussel *Anodonta* corresponds with major hydrologic basins in the western United States. Molecular Ecology 19(3): 569-591.

Nedeau, E., A. K. Smith and J. Stone. 2005. Freshwater Mussels of the Pacific Northwest. U.S. Fish and Wildlife Service, Vancouver, Washington.

National Native Mussel Conservation Committee. 1998. National Strategy for the Conservation of Native Freshwater Mussels. Journal of Shellfish Research 17:1419-1428.

NatureServe. 2010. NatureServe Explorer: An Online Encyclopedia of Life. Online database available at http://www.natureserve.org/explorer/. Last accessed 9/2/2010.

Peven, C. 2004. Prioritization Framework for Management Strategies in the Entiat Subasin Plan. Northwest Power and Conservation Council, Portland, Oregon.

Schloesser, D. W., W. P. Kovalak, D. Longton, K. L. Ohnesorg and R. D. Smithee. 1998. Impact of zebra and quagga mussels (*Dreissena spp*.) on freshwater unionids (Bivalvia: Unionidae) in the Detroit River of the Great Lakes. American Midland Naturalist 140:299-212.

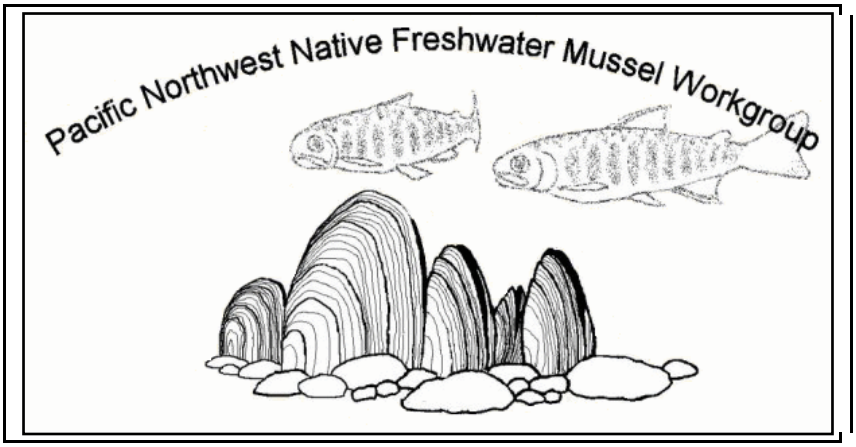
Strayer, D. L., J. A. Downing, W. R. Haag, T. L. King, J. B. Layzer, T. J. Newton and S. J. Nichols. 2004. Changing perspectives on pearly mussels, North America's most imperiled animals. Bioscience 54:429-439.

U. S. Fish and Wildlife Service. 2010. Box score. Endangered Species Bulletin 35(1):50.

Appendix A:
The Critical Needs Survey

SURVEY: CRITICAL NEEDS AND UNCERTAINTIES FOR FRESHWATER MUSSELS IN THE PACIFIC NORTHWEST

Presented by:



http://www.fws.gov/columbiariver/musselwg.htm

SURVEY: CRITICAL NEEDS AND UNCERTAINTIES FOR FRESHWATER MUSSELS IN THE PACIFIC NORTHWEST

Introduction

Little is known about freshwater mussels of the Pacific Northwest, and in order to better design conservation strategies, it is imperative that the scientific community gather data and provide analyses that can help conservation planners and management agencies. Consequently, the Pacific Northwest Native Freshwater Mussel Workgroup (hereafter referred to as the Mussel Workgroup) is developing a critical needs document that specifies areas in the realm of freshwater mussels where more information and research are essential. Because little data are available, the critical needs document will rely on the "Best Professional Judgment" of individuals involved in research, resource management or public advocacy/activism and who have experience with freshwater mussels. To that end, this survey is being distributed amongst qualified individuals in an effort to develop a consensus opinion. If you have received a copy of this survey, please fill it out and return it to:

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(Electronic documents are preferred)

The first step in the process is to establish recommended priorities for research and conservation planning. For the purpose of determining critical needs and uncertainties for freshwater mussels, the Mussel Workgroup has agreed on the following four classes to categorize these efforts.

- Biology/Ecology – this category includes efforts to determine life history, host species, habitat needs and taxonomy/systematics.
- Human dimensions – this category includes; ecosystem valuation studies, developing proposal for legislation/regulatory action and developing public education and outreach programs.
- Status and trends – this category includes efforts to assess local/regional abundance, geographic distribution and population trends.
- Limiting factors – this category includes efforts to assess the limiting effects of invasive species, isolation/habitat fragmentation and global climate change on freshwater mussel populations.

While research in all of these areas would be valuable, it is the goal of the Mussel Workgroup to develop comprehensive 5-, 10- and 20-year visions for freshwater mussel research and conservation efforts in the Pacific Northwest. Consequently, the Mussel Workgroup decided to develop guidelines for prioritizing research efforts. Priority rankings can help in directing efforts when no previous decisions have been made about a specific research initiative. Over time the priorities will likely change, and the critical needs document will need to be updated to reflect those changes. The current version will reflect priorities for the next five years.

The first step in the process is to prioritize specific objectives that are critical to conservation of freshwater mussels in the Pacific Northwest. The prioritization framework is based on an approach developed for the Entiat Subbasin Plan [1] and later adapted for the Columbia River lamprey critical needs document [2].

There are two stages to the prioritization strategy. The first stage is to assign a qualitative ranking to the conservation benefit of each objective. The conservation benefit is defined as "the degree to which gaining the information/achieving the objective will benefit freshwater mussels in the Pacific Northwest." Critical uncertainties will be ranked on a 5 point scale and categorized according to the following guidelines:

Rank	Category	Definition
>4.5	Imminent	Addressing these issues immediately is important. Failure to act on these issues will likely result in considerable detrimental impact on native freshwater mussel populations.
3.5-4.5	Highly important	Addressing these issues is a high priority. Failure to address these issues will likely preclude restoration and enhancement of native freshwater mussel populations
2.5-3.5	Important	Addressing these issues is important, but less so than those considered imminent or highly important. Failure to address these issues will likely limit opportunities for restoration and enhancement of native freshwater mussel populations.
1.5-2.5	Needed	Although these issues are important, failure to act on them would be unlikely to preclude opportunities for restoration and enhancement of native freshwater mussel populations. These issues need to be addressed; however when faced with limited time or resources, action could be delayed in favor of a more critical issue.
<1.5	Useful	Addressing these issues is not necessary, but action may prove helpful to restoration and enhancement of native freshwater mussel populations. Action on these issues could be pursued when available resources are not needed to address more critical issues.

[1]Peven, C. 2004. Prioritization Framework for Management Strategies in the Entiat Subasin Plan. Northwest Power and Conservation Council, Portland, Oregon.

[2] Columbia River Lamprey Technical Workgroup. 2005. Critical Uncertainties for Lamprey in the Columbia River Basin: Results from a Strategic Planning Retreat of the Columbia River Lamprey Technical Workgroup. Columbia Basin Fish & Wildlife Authority, Portland, Oregon.

The next step is to assess the feasibility of addressing each issue. Feasibility is defined as "the degree to which conservation or research objectives can be accomplished under existing constraints." Feasibility will be ranked on a 4 point scale and categorized according to the following guidelines:

Rank	Category	Definition
<3.5	Easy	Objective can be accomplished in less time than is available, and requires little expenditure in resources, or resources are abundant and easy to access.
2.5-3.5	Achievable	Objective can be achieved in the desired time frame and sufficient resources are available.
1.5-2.5	Difficult	Achieving the objective may be limited either by time or resource availability and ease of access.
<1.5	Demanding	Achieving the objective is time and resource intensive. Time and resources may be limited and resources may be difficult to access.

Section I: Demographics.

In order to present a strong case for our recommendations, the first section of this survey is designed to establish that the critical needs document will be based on the consensus of qualified individuals. Please answer the following questions about yourself.

Name: _____

Organization/Employer: **Error! Not a valid bookmark self-reference.**

1. From the following list, please choose the selection that best describes your current employment. If you are retired, please choose the selection that best describes your former career.

    a. - Select -

2. How many years of experience do you have with freshwater mussel research, conservation or advocacy?

    a. - Years -

3. Are you a member of the Pacific Northwest Native Freshwater Mussel Workgroup?

    a. - Y/N ? -

4. Are you a member of any other organizations whose goals specifically include research on or conservation of freshwater mussels (i.e. the Freshwater Mollusk Conservation Society, the American Malacological Society, etc.)?

    a. - Y/N ? -

If you answered yes to question #4, please list the organizations.

i. _____

ii. _____

iii. **Error! Not a valid bookmark self-reference.**

Section II: Assessing Biological Benefit and Feasibility

Following is a list of potential areas of concern proposed by the Pacific Northwest Native Freshwater Mussel Workgroup. Please rank the biological benefit and feasibility of each item. In the appropriate box for biological benefit, select a number from 1-5 with 1 being the least biological benefit and 5 being the greatest biological benefit. In the appropriate box for feasibility select a number from 1-4, with 1 being the least feasible and 4 being the most feasible. At the end of each section blanks are provided for you to add and score other issues that you feel need to be addressed

Biology/Ecology	**Benefit**	**Feasibility**
• Determining host species …….	- Select -	- Select -
• Establishing taxonomy/systematics …….	- Select -	- Select -
• Determining habitat needs …….	- Select -	- Select -
• Assessing recruitment and population structure ..	- Select -	- Select -
• Describing life history ……..	- Select -	- Select -
• Other ____	- Select -	- Select -
• Other ____	- Select -	- Select -

Human Dimensions	**Benefit**	**Feasibility**
• Developing educational and public outreach programs	- Select -	- Select -

• Developing proposals for legislation/regulatory action	- Select -	- Select -
• Ecosystem valuation studies	- Select -	- Select -
• Challenging scientific inertia*	- Select -	- Select -
• Other ____	- Select -	- Select -
• Other ____	- Select -	- Select -

* Currently, the scientific and academic community in the Pacific Northwest is not significantly engaged in research initiatives directed at native freshwater mussels.

Limiting factors	**Benefit**	**Feasibility**
• Assessing the impact of invasive species	- Select -	- Select -
• Assessing the impact of isolation/habitat fragmentation	- Select -	- Select -
• Assessing the impact of Hydrologic alteration	- Select -	- Select -
• Assessing the impact of sedimentation	- Select -	- Select -
• Assessing the impact of limited water quantity	- Select -	- Select -
• Assessing water chemistry impacts such as increased ammonia, low DO and extreme pH levels.	- Select -	- Select -
• Assessing the impact of global climate change	- Select -	- Select -
• Assessing host density and distribution	- Select -	- Select -
• Assessing the impacts of altered water temperature regimes	- Select -	- Select -
• Other ____	- Select -	- Select -
• Other ____	- Select -	- Select -

Status	Benefit	Feasibility
• Determining geographic distribution of fresh-water mussel species in the Pacific Northwest.	- Select -	- Select -
• Assessing local/regional abundance of fresh-water mussel species in the Pacific Northwest.	- Select -	- Select -
• Assessing population trends of freshwater mussel species in the Pacific Northwest.	- Select -	- Select -
• Other ____	- Select -	- Select -
• Other ____	- Select -	- Select -

Section III: Comments and Suggestions

Please provide any comments or suggestions in the following space. If you are not familiar with the Pacific Northwest Native Freshwater Mussel Workgroup, please visit our website at http://www.fws.gov/columbiariver/musselwg.htm.

Appendix B:

Survey participants' names and affiliation at the time of survey submission.

Name	Affiliation
Brian Adair	Entrix, Inc.
Jeff Adams	Washington Sea Grant
Steven Ahlstedt	U.S. Geological Survey (retired)
Kevin Aitkin	U.S. Fish and Wildlife Service
Kathryn Tackley (Barko)	U.S. Army Corps of Engineers Contractor
Tony Brady	Genoa National Fish Hatchery
Robert S. Butler	U.S. Fish and Wildlife Service
Lee Cain	Astoria School District, OR
John Fleckenstein	WA DNR, Natural Heritage Program
Jamie Glasgow	Wild Fish Conservancy
Molly Hallock	WA Dept. of Fish and Wildlife
Sarina Jepsen	The Xerces Society
Jess Jones	U.S. Fish and Wildlife Service
Jim Layzer	U.S. Geological Survey
Christina Luzier	U.S. Fish and Wildlife Service
Shelly Miller	OR Dept. of Fish and Wildlife
Dick Neves	U.S. Geological Survey
Robert Plotnikoff	Tetra Tech, Inc.
Michelle Steg-Geltner	The Nature Conservancy
Al Smith	OR Dept. of Fish and Wildlife (retired)
Cynthia Tait	U.S. Forest Service

Name	Affiliation
Arden Thomas	Snohomish County government (WA)
Kelly Toy	Jamestown S’Klallam Tribe
John D. Williamson	OR Dept. of Fish and Wildlife
Larry Zuckerman	Western Watersheds Project