
A native mussel with a cluster of attached zebra mussels found on Beconia Beach on the south basin of Lake Winnipeg. Photo credit: C. Parks, Province of Manitoba.

ENDANGERED SPECIES ACT COMPLIANCE FOR DREISSENID MUSSEL RESPONSE IN THE COLUMBIA RIVER BASIN STATES of WASHINGTON, OREGON, IDAHO, AND MONTANA

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AIS	Aquatic Invasive Species
ARPA	Archaeological Resources Protection Act
BMPs	Best Management Practices
CRB	Columbia River Basin
EPA	Environmental Protection Agency
ESA	Endangered Species Act
HDPE	High Density Polyethylene
KCl	Potassium Chloride (Potash)
MSDS	Material Safety Data Sheet
NAGPRA	Native American Graves Protection and Repatriation Act of 1990
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
PSMFC	Pacific States Marine Fisheries Commission
PCB	Polychlorinated biphenyl
SPCC	Spill Prevention, Control, and Countermeasures Plan
USFWS	United States Fish and Wildlife Service
WRP	Western Regional Panel on Aquatic Nuisance Species

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CHAPTER 1. INTRODUCTION AND BACKGROUND

Background

Since their introduction to the Great Lakes region of North America in the 1980s, invasive Dreissenid mussels (zebra mussels (*Dreissena polymorpha*) and quagga mussels (*Dreissena rostriformis bugensis*)) have expanded their distribution across North America. From 2012–2017, the states of Washington, Oregon, Idaho, and Montana intercepted a total of 313 dreissenid-fouled watercraft that originated from throughout North America (http://psmfc.maps.arcgis.com/apps/webappviewer/index.html?id=aa6a6527a26a44ddbff097b99241462e. In 2016, invasive mussel larvae were discovered in Tiber and Canyon Ferry Reservoirs in Montana—this was the first documented detection of dreissenids near the perimeter of the Columbia River Basin (CRB). The westward expansion of dreissenids, primarily via watercraft vectors, precipitates the need for contingency plans and other planning efforts to prepare entities for an introduction of dreissenids by facilitating a rapid response (Bossenbroek et al. 2007). Rapid response includes actions that natural resource managers must be prepared to take in the event of a dreissenid introduction.

The Columbia River Basin Interagency Invasive Species Response Plan: Dreissenid Species (a.k.a. CRB Plan) (Heimowitz and Phillips 2018) was developed in 2011 (and updated in 2018) to facilitate the coordination of a rapid, effective, and efficient interagency response to delineate, contain, and when feasible, eradicate dreissenids if introduced to CRB waters. The scope of the CRB Plan covers waters in the Columbia River Basin, including the states of Washington, Oregon, Idaho, and Montana, and tribal lands. The plan highlights the coordination and management structure of a response, the responsibilities and roles of entities involved, notification lists and procedures, and a scientific review and compilation of information associated with different types of control options. The CRB Plan has been tested since its inception via a series of exercises and workshops in the CRB states, and has been updated at regular intervals as new information has become available.

Section 7 of the Endangered Species Act of 1973 (16 U.S.C. 1531-1544, 87 Stat. 884) directs all Federal agencies to use their existing authorities to conserve threatened and endangered species and, in consultation with the U.S. Fish & Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS), to ensure that their actions do not jeopardize listed species, or destroy, or adversely modify, proposed critical habitat. Critical habitat is defined in section 3 of the Act as: (1) The specific areas within the geographical area occupied by the species, at the time it is listed in accordance with the Act, on which are found those physical or biological features (a) Essential to the conservation of the species and (b) Which may require special management considerations or protection; and (2) Specific areas outside the geographical area occupied by the species at the time it is listed, upon a determination that such areas are essential for the conservation of the species. Although sections 7(a)–(d) continue to apply to agency responses to acts of God, disasters, casualties, national defense, or security emergencies, etc., the regulations implementing these sections (described below) provide for expedited procedures to accommodate the need for Federal agencies to respond promptly to emergencies.

In 2017, the USFWS contracted with Pacific States Marine Fisheries Commission (PSMFC) to develop this manual to inform, expedite, and facilitate Section 7 consultations to include response actions that will minimize impacts of invasive mussel control and eradication attempts on listed species and their designated critical habitats. The effort to produce this manual is intended to improve coordination, collaboration, and preparedness among the many entities that would be engaged in invasive mussel rapid response actions in the CRB.

Emergency consultation is an expedited consultation process that considers endangered species concerns while allowing an action agency to respond to an emergency situation. Chapter 2 of this manual provides more information on the emergency consultation process.

Triggering an Endangered Species Act Consultation

Section 7 (a)(2) of the Endangered Species Act requires Federal agencies to ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of any federally listed threatened or endangered species, or result in the destruction or adverse modification of designated critical habitat.

When a Federal agency determines that its action "may affect" a listed threatened or endangered species, or designated critical habitat, the agency is required to consult with the U.S. Fish and Wildlife Service and/or the National Marine Fisheries Service (regarding the standard stated in the previous paragraph) regarding the degree of impact and measures available to avoid or minimize the adverse effects.

Even if a non-federal jurisdiction is leading a rapid response operation, an associated federal action may trigger Section 7 of the ESA, such as:

- Actions on federal land
- Actions that require a federal permit
- Actions that require a federal license
- Actions using federal funds
- Actions implemented by federal agency employees

Purpose of this Manual

This manual is intended to be used with the CRB Plan to implement an immediate and effective response to an introduction of dreissenids to the CRB by describing the core elements of the emergency consultation process, proposed action, listed species and critical habitats within the geographic scope of the CRB, best management practices to avoid, or minimize, impacts to listed species and critical habitat, and steps involved in post-emergency consultation.

The purpose of this manual is to:

- Create a tool that delineates a suite of most-likely rapid response eradication actions for a potential introduction of dreissenids in CRB states;
- Provide an assessment of the potential for those actions to affect Endangered Species Act-listed species and critical habitats; and
- Present best management practices (BMPs) that can avoid, reduce, or eliminate adverse effects of the rapid response actions on listed species, or critical habitat. The BMPs are recommendations that action agencies can use to reduce their effects to listed species and their habitats after engaging emergency consultation procedures with USFWS.

Scope and Intent of this Manual

The information in this manual could help inform the endangered species portion of a National Environmental Policy Act (NEPA) analysis. Emergency response activities not statutorily exempt from NEPA may require the development of a brief Environmental Assessment that describes the need, alternatives, environmental impacts of proposed actions and alternatives, and the list of agencies and persons consulted.

Information in this manual is intended to facilitate emergency consultation procedures and future conference actions associated with an introduction of dreissenids in the CRB. This document is intended to be a living document, updated and modified on a regular basis to incorporate new science and information.

Quagga and Zebra Mussels (Dreissenid spp).

This manual focuses on two members of the genus *Dreissena*; the zebra mussel (*Dreissena polymorpha*) and quagga mussel (*Dreissena rostriformis bugensis*). Although there are differences in the biology of these two species, they share many similar life history traits and cause similar adverse environmental and economic impacts. Both species have European origins and were introduced to the United States in the 1980s via ballast water discharge in the Great Lakes region. Both zebra and quagga mussels can attach to a broad range of surfaces, including pilings, pipes, rock, cement, steel, rope, crayfish, other bivalves, aquatic plants, and each other, forming dense colonies. Both zebra and quagga mussels reproduce with external fertilization; eggs and sperm are released into the water column, with larvae (veligers) emerging within three to five days from fertilized eggs (Benson et al. 2018). Reproduction is triggered by water temperature and in some locations, reproduction can occur continually through the year. (Benson et al. 2018)

Environmental Effects

The environmental impacts of zebra and quagga mussels to lakes and rivers is profound. Both species compete effectively with many native species and may completely replace native mussels, causing dramatic alterations of the native food chain (Hogan et al. 2007). The introduction of zebra and quagga mussels into the CRB, which drains 258,500 square miles in seven western states and Canada, has the potential to threaten native species, particularly salmon and trout and essential fish habitat (Pacific Fishery Management Council 2014), as well as industrial, agricultural, recreational, navigation, and subsistence use of waters.

Once established, dreissenid mussels can dramatically alter the ecology of a water body and associated fish and wildlife populations. As filter feeders, they remove phytoplankton and other particles from the water column, shifting production from the pelagic to the benthic portion (Sousa et al. 2009). In Lake Michigan, dreissenid invasions have caused significant phytoplankton community structure shifts, including dominance in cyanobacteria (deStasio et al. 2014). In Lake Simcoe, Ontario, Canada, there were significant and sustained declines in phytoplankton biovolumes and chlorophyll *a* during the 12 years following invasion by dreissenids (Baranowska et al. 2013).

Dreissenids have accelerated the decline of freshwater bivalves, nearly extirpating native unionids 25 years after invasive mussels were introduced to the Great Lakes region (Burlakova et al. 2014). By attaching themselves to the surfaces of other bivalves, dreissenid mussels can starve freshwater mussels and drive indigenous populations to local extinction (Montgomery and Wells 2010). Dreissenid mussels can also affect dissolved oxygen through respiration, and dissolved calcium carbonate concentrations through shell building (Strayer 2009). The filtering capabilities of dreissenids increase water transparency, decrease chlorophyll concentrations, and increase the amount of pseudofeces (Claxton et al. 1998). Increases in pseudofeces reduce oxygen levels, which makes water pH more acidic and toxic (Snyder et al. 1997). Increased water clarity increases light penetration and causes growth in aquatic plants (Zhu et al. 2006). Dreissenids also bioaccumulate pollutants, which can be passed up the food chain, increasing wildlife exposure to organic pollutants (Snyder et al. 1997). Polychlorinated biphenyl (PCB) concentrations in mussel tissue are correlated to sediment PCB levels, indicating mussels may provide an entry point for PCBs into nearshore benthic food webs (Macksasitorn et al. 2015).

Economic Effects

The economic costs associated with dressienids are significant. The economic impact of zebra and quagga mussels to the hydropower systems on the Columbia and Snake Rivers is of particular concern. If introduced into the CRB, dreissenid mussels could affect all submerged components and conduits of this system, including fish passage facilities, navigation locks, raw water distribution systems for turbine cooling, fire suppression and irrigation, trash racks, diffuser gratings, and drains.

The following studies are examples of documented and estimated costs of a dreissenid introduction:

- The direct economic impacts (impacts to dams, removal from boat launches, direct impacts to fishing) of invasive mussels to the State of Washington is estimated to be $43,112,000. Total economic activity at risk is 500 lost jobs and $27.8 million in labor income (Community Attributes, Inc. 2017).

- The Hoover dam has incurred, or planned, costs totaling $10,231,208 for construction, supplies, services, and operations and maintenance to address dreissenids (Bureau of Reclamation 2016).

- Annual welfare losses (i.e., costs or loss of benefits) of a dreissenid invasion in the CRB is estimated at $64 million, although that estimate did not include losses related to fish and wildlife resources (Warziniack et al. 2011).

- Idaho estimated an infestation of zebra mussels would cost the state $94,474,000 to hydropower facilities, other dams, drinking water systems, golf courses, boat facilities and maintenance, hatcheries and aquaculture industries, loss of angler days, and irrigation (Idaho Aquatic Nuisance Species Task Force 2009).

- Total annual costs to Alberta from invasive mussels is estimated at $75.5 million (Neupane 2013).

- The infestation of zebra mussels in the Great Lakes has cost the power industry $3.1 billion between 1993–1999, including a total economic impact of more than $5 billion (WRP 2009). The power generation industry in the Great Lakes experiences $1.2 million annually per power plant to monitor and control zebra mussels, and $1.7 million annually to research better zebra control methods. Water treatment plants pay $480,000–$540,000 annually to control zebra mussels, and municipal water treatment facilities pay $353,000 annually to control zebra mussels (Colautti et al. 2006).

The Consequences of No Action

This manual has been prepared to facilitate a rapid response to an introduction of dreissenids in the CRB because the anticipated consequences of taking no action would include long-lasting, significant and detrimental economic, environmental, and social effects that would change ecosystem function and processes throughout the CRB and affect quality of life for people who live in the basin. Because of these well-documented consequences, this manual has been prepared assuming that a federal agency would be engaged in a prompt response to an introduction of dreissenids in the CRB. However, there are many factors influencing whether or not attempts to eradicate dreissenids in any CRB waterbody will be successful (especially if dreissenids become established in large river systems, or large water bodies). In addition, the potential impacts of response actions to listed species and critical habitats are never fully known prior to control actions. Therefore, at the time of an actual response, it is prudent to weigh the short-term and long-term economic and environmental costs of eradication attempts with the likely long-term costs of established populations of dreissenids.

References

Baranowska, K.A., R.L. North, J.G. Winter, and P.J. Dillon. 2013. Long-term seasonal effects of dreissenid mussels on phytoplankton in Lake Simcoe, Ontario, Canada. *Inland Waters* 3:285–296.

Benson, A.J., D. Raikow, J. Larson, A. Fusaro, and A.K. Bogdanoff. 2017. Dreissena polymorpha. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. https://ecos.fws.gov/ecp0/profile/speciesProfile?sId=1748 Revision Date: 6/5/2017.

Bossenbroek, J.M., L.E. Johnson, B. Peters, and D.M. Lodge. 2007. Forecasting the expansion of zebra mussels in the United States. *Society for Conservation Biology* 21(3):800–810.

Bureau of Reclamation. 2016. Mussel-related impacts and costs at Hoover, Davis, and Parker Dams (Lower Colorado Dams Office Facilities). Research and Development Office, Science and Technology Program, Final Report ST-2016-1608.

Burlakova, L.E., Tulumello, B.T., Karatayev, A.Y., Krebs, R.A., Schloesser, D.W., Paterson, W.L., Griffith, T.A., Scott, M.W., Crail, T., and D.T. Zanatta, 2014. Competitive replacement of invasive congeners may relax impact on native species: interactions among zebra, quagga, and native unionid mussels. PLoS ONE, open access http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0114926, DOI:10.1371/journal.pone.0114926.

Claxton, W.T., A.B. Wilson, G.L. Mackie, and E.G. Boulding. 1998. A genetic and morphological comparison of shallow- and deep-water populations of introduced dreissenid bivalve *Dreissena bugensis*. *Canadian Journal of Zoology* 76:1269–1276.

Community Attributes, Inc. 2017. Economic impact of invasive species: Direct cost estimates and economic impacts for Washington State. https://invasivespecies.wa.gov/council_projects/economic_impact/Invasive%20Species%20Economic%20Impacts%20Report%20Jan2017.pdf

Colautti, R.I., S.A. Bailey, C.D.A. van Overkijk, K. Amundsen, and H.J. MacIsaac. 2006. Characterised and projected costs of nonindigenous species in Canada. *Biological Invasions* 8:45–59.

deStasio, B.T., M.B. Schrimpf, and B.H. Cornwell. 2014. Phytoplankton communities in Green Bay, Lake Michigan after invasion by dreissenid mussels: Increased dominance by cyanobacteria. *Diversity* 6(4):681–704.

Heimowitz, P., and S. Phillips. 2011 (updated in 2018). Columbia River Basin Interagency Invasive Species Response Plan: Zebra Mussels and Other Dreissenid Species.

Hogan, L.S., E. Marschall, C. Folt, and R.A. Stein. 2007. How non-native species in Lake Erie influence trophic transfer of mercury and lead to top predators. *Journal of Great Lakes Research* 33(1):46–61.

Idaho Aquatic Nuisance Species Task Force. 2009. Estimated potential impact of zebra and quagga mussel introduction into Idaho. Report prepared for the Idaho Invasive Species Council. 2pp.

Macksasitorn, S., J. Janssen, and K.A. Gray. 2015. PCBs refocused: Correlation of PCB concentrations in Green Bay legacy sediments with adjacent lithophilic, invasive biota. *Journal of Great Lakes Research* 41:215–221.

Montgomery, D., and S. Wells. 2010. Pest risk assessment for zebra and quagga mussels in Oregon. Oregon Invasive Species Council, Salem, Oregon.

Neupane, A. 2013. An Estimate of Annual Economic Cost of Invasive Mussels to Alberta. Alberta Environment and Sustainable Resource Development. Edmonton, Alberta, Canada. 4 pp.

Pacific Fishery Management Council. 2014. Appendix A to the Pacific Coast Salmon Fishery Management Plan: Identification and description of essential fish habitat, adverse impacts, and recommended conservation measures for salmon. 219pp.

Snyder, F.L., M.B. Hilgendorf, and D.W. Garton. 1997. Zebra Mussels in North America: The invasion and its implications! Ohio Sea Grant, Ohio State University, Columbus, OH.

Sousa, R., J.L. Gutiérrez, and D.C. Aldridge, 2009. Non-indigenous invasive bivalves as ecosystem engineers. *Biological Invasions*11(10):2367–2385.

Strayer, D.L. 2009. Twenty years of zebra mussels: lessons from the mollusk that made headlines. *Frontiers in Ecology and the Environment* 7(3):135–141.

Warziniack, T.W., D. Finnoff, J. Bossenbroek, J.F. Shogren, and D. Lodge. 2011. Stepping stones for biological invasion: A bioeconomic model of transferable risk. *Environment and Resource Economics* 4:605–627.

Western Regional Panel on Aquatic Nuisance Species. 2009. Quagga-Zebra Mussel Action Plan for Western U.S. Waters.

Zhu, B., D.G. Fitzgerald, C.M. Mayer, L.G. Rudstam, and E.L. Mills. 2006. Alteration of ecosystem function by zebra mussels in Oneida Lake: Impacts on submerged macrophytes. *Ecosystems* 9:1017–1028.

CHAPTER 2. ENDANGERED SPECIES ACT EMERGENCY CONSULTATION PROCESS

Section 7 of the Endangered Species Act of 1973 (16 U.S.C. 1531-1544, 87 Stat. 884) directs all Federal agencies to use their existing authorities to conserve threatened and endangered species and, in consultation with the USFWS and the NMFS, to ensure that any discretionary action a federal agency intends to authorize, fund, or implement is not likely to jeopardize listed species, or destroy, or adversely modify, proposed critical habitat. A "federal nexus" triggers Section 7(a)(2) of the ESA when a federal agency proposes to take an action, such as issuing a permit, authorizing an activity, funding a project or program, or carrying out operations directly.

The ESA provides for expedited procedures to accommodate the need for Federal agencies to respond promptly to emergencies. The Endangered Species Consultation Handbook (1998) states that an emergency is "a situation involving an act of God, disasters, casualties, national defense or security emergencies, etc., and includes response activities that must be taken to prevent imminent loss of human life or property." The USFWS considers an incipient dreissenid outbreak in the Columbia River Basin to meet the regulatory definition of an emergency situation given the clear and significant threat to property if invasive mussels were to establish. **During any emergency situation, the primary objective is to provide recommendations for minimizing adverse effects to listed species and critical habitats without impeding response efforts, and while prioritizing human life and property.**

In emergency situations, consultation does not occur on the emergency; rather, consultation is conducted on the agency response to the emergency and is handled in an expedited manner.

Typically, the Federal action agency contacts the USFWS Regional Ecological Services Office by telephone if an emergency event is determined to be in proximity to listed species or critical habitat (Table 1) [Note: Consultations are administered through the USFWS Ecological Services Program]. In the case of the Columbia River Basin states, USFWS Regions 1 (Oregon, Washington, and Idaho—Pacific Region Office), or 6 (Montana—Mountain-Prairie Region) would be contacted (see USFWS office contact information in CRB Plan).

The Final Rulemaking on Interagency Cooperation under the ESA, 50 CFR Part 402. Section 402.05, provides a modified consultation procedure for the USFWS to respond to emergency situations under Section 7 of the Endangered Species Act.

Detailed guidance for handling emergency consultations is provided in the Endangered Species Consultation Handbook's Sections 8.1 and 8.2. The emphasis for emergency procedures is situations in which using the standard procedures does not allow for the action agency to carry out the emergency response activities in a timely fashion.

Emergency consultations are intended to be administered with as much understanding of the action agency's critical mission as possible while ensuring that anticipated actions will not violate sections 7(a)(2) or 7(d) of the Endangered Species Act. Emergency consultation procedures allow action agencies to incorporate endangered species concerns into their actions during the response to an emergency. During emergency consultation, the Service may provide recommendations for how to minimize or avoid adverse effects to listed species while implementing the emergency response. Such recommendations are strictly advisory and are to be implemented at the discretion of the emergency response personnel.

The key step is early contact with the local USFWS Ecological Services office to work with the action agency to determine the best procedures for addressing the introduction of dreissenids. The contact should be as soon as possible, after a discovery of introduced dreissenid mussels has occurred. Upon contact, an emergency consultation number is issued. Detailed information provided includes the location and severity of the emergency and the response, and specific information regarding impacts to listed species or their habitats. During this initial contact and throughout the emergency response, the USFWS will provide recommendations to avoid or minimize impacts to listed species and their habitats.

Section 7(a)(4) of the ESA requires federal agencies to confer with USFWS and NMFS (the Services), as appropriate, in cases where the agency, or the Services, have determined that a proposed or ongoing federal action is likely to jeopardize the continued existence of species proposed to be listed under Section 4 of the ESA, or result in the destruction or adverse modification of critical habitat proposed to be designated for such species (USFWS and NMFS 1998). The USFWS encourages federal agencies to conference on actions that may affect a proposed species, or proposed critical habitat. In such cases, conference concurrence determinations, or conference opinions, can be adopted as formal concurrences or biological opinions, respectively, after a proposed species is listed, or the critical habitat is designated. This approach can avoid disruption of project implementation due to the need to initiate and complete formal consultation at the time of listing or designation. It also facilitates, or promotes, action agency consideration of the conservation needs of proposed species and the recovery function of proposed critical habitat.

The use of emergency consultation procedures aligns with the CRB Plan. Use of emergency consultation procedures is consistent with the Department of Interior's objectives to use efficient and effective processes that provide for a timely and rapid response to dreissenid introductions. Also, the states in the Columbia River basin (Washington, Oregon, Idaho, Montana, Wyoming, Nevada and Utah) have state-specific Aquatic Nuisance Species Management Plans approved by the Aquatic Nuisance Species Task Force (https://www.anstaskforce.gov/stateplans.php). In addition, Washington (DeBruyckere et al. 2014), Oregon (Draheim et al. updated 2017), Idaho (Idaho Department of Agriculture updated 2015) and Montana (Montana Fish, Wildlife, and Parks 2018) have specific dreissenid mussel rapid response plans that align with state AIS plans. The use of emergency consultation procedures aligns with these state plans.

The lead agency should initiate emergency consultation for actions that have a federal nexus and may affect listed species or designated critical habitat. However, some Federal agencies also support emergency responses on non-Federal lands. If the response on non-Federal lands results in effects to listed species or critical habitat, emergency consultation is initiated. At a minimum, to update the baseline for these species, the USFWS should be notified on what actions were taken and what effects to species or critical habitat occurred as a result of the action(s). The USFWS also provides technical assistance and coordination prior to recurrent emergency events, such as developing species-specific conservation measures and best management practices to avoid and minimize take to listed species and critical habitats.

Figure 1 summarizes the emergency consultation process. Once a detection occurs in a Columbia River Basin waterbody, and it has been deemed possible to eradicate:

A. **The action agency contacts the U.S. Fish and Wildlife Service Regional Office** by telephone or fax (see Appendices for an example emergency consultation notification form). USFWS staff respond within 48 hours, in writing, documenting the emergency, any commitments made, and any conclusions made by the USFWS relative to the potential for jeopardy, or adverse modification.

B. **The action response is implemented on the waterbody to respond to the Emergency.**

C. **Formal Consultation is initiated.** Once the emergency is under control, the action agency initiates a Section 7 formal consultation with the USFWS if listed species, or critical habitat, have been adversely affected. The action agency provides a description of the emergency, a justification for the expedited consultation, and an evaluation of the response to and the impacts of the emergency on affected species and their habitats, including documentation of implementation of USFWS recommendations, and the results of implementation in minimizing take.

D. **Emergency biological opinion is issued by the USFWS.** The USFWS concludes the formal consultation and issues an emergency biological opinion on the effects of the action, including recommendations made by the USFWS to the action agency as well as the results of agency implementation of those recommendations on listed species. The timeframe, format, and contents are similar for emergency and formal consultations.

E. **An Incidental Take Statement may be issued.** If incidental take is anticipated during the emergency response, the USFWS can advise the action agency during the informal consultation phase of ways to minimize take. In some circumstances, the actual or estimated take occurring from the agency's emergency response actions can be determined, and should be documented in the biological opinion for future inclusion in the species' environmental baseline. The incidental take statement in an emergency consultation does not include reasonable and prudent measures, or terms and conditions, to minimize take, unless the agency has an ongoing action related to the emergency. Rather, an emergency consultation incidental take statement documents the recommendations given to minimize take during informal consultation, the success of the agency in carrying out these recommendations, and the ultimate effects on the species of concern through take.

F. **Conservation recommendations** may be issued by the USFWS to help protect listed species and their habitats in future emergency situations or initiate beneficial actions to conserve the species. *Note:* Although the timing of "emergencies" is unpredictable, the types of emergencies, such as a dreissenid introduction, that may affect listed species or critical habitat, can be determined in advance. Emergency response actions and scenarios are routinely practiced by CRB states and agencies to ensure efficient and effective responses and avoidance and minimization of take during an action response to an introduction of dreissenids.

Figure 1. Emergency consultation process for an introduction of dreissenids in the Columbia River Basin.

References

DeBruyckere, L.A., W. Brown, and B. Tweit. 2014. Washington Dreissenid Mussel Rapid Response Plan. 63pp.

Draheim, R., R. Boatner, G. Dolphin, and L. DeBruyckere. 2017. Oregon Rapid Response Plan. 93pp.

Idaho Department of Agriculture. 2015. Idaho Rapid Response Plan for Early Detection of Dreissenid Mussels. 5pp.

Montana Fish, Wildlife & Parks. 2018. The State of Montana's Dreissenid Mussel Rapid Response Guidelines.

US Fish and Wildlife Service and National Marine Fisheries Service. 1998. Endangered Species Consultation Handbook – Procedures for Conducting Consultation and Conference Activities Under Section 7 of the Endangered Species Act.

CHAPTER 3. PROPOSED ACTION

A detection of dreissenids in a CRB water body would likely result in a rapid response action (proposed action) with a federal nexus in the states of Washington, Oregon, Idaho, and Montana via implementation of the CRB plan, and therefore likely trigger the emergency consultation process (Chapter 2).

Any water body in the CRB could be a potential location for the proposed action, from free-flowing rivers and streams, to hydropower reservoirs, and isolated water bodies. Access to any water body is dependent on the road network to each water body, and the amount of development and access sites available. Areas close to public use access sites, such as boat launches and marinas, are the most likely locations where both dreissenid detections and proposed actions would occur as a result of introduction through watercraft or water-based recreation activities.

Specific tasks associated with each action may include detection area isolation, sample collection, site monitoring, site preparation, fish and wildlife salvage, mussel treatment, equipment decontamination, site restoration activities associated with the control action (if necessary), and implementation of conservation and minimization measures and best management practices to avoid and minimize adverse environmental effects.

This chapter describes the types of most likely treatments and activities that would likely occur upon a detection of dreissenids.

Defining the Action Area

The potential action area for any hypothetical rapid response action would include all areas affected directly or indirectly by the response, and not merely the immediate area involved in the response (e.g., upstream, downstream, hatcheries, infrastructure, etc.). Therefore, for the broad purposes of this manual, it could include any water body in the CRB, including all access sites into and out of the water body, staging areas and other infrastructure adjacent to the water body, and any areas downstream of the site (if applicable), and any other areas associated with implementation of the action.

Project Description

Appendix D of the CRB Plan (CRB Plan 2017) describes, in detail, the numerous methods available to control invasive dreissenids in a variety of situations, including hydropower facilities, closed water systems, and open water situations. Appendix D of the CRB plan summarizes the latest science associated with treatment types and efficacy for physical, biological, and chemical controls. Any rapid response action could include detection, isolation of the treatment area, fish and wildlife salvage, eradication tactics, and riparian restoration.

Treatment Steps

The following steps are applicable to all treatments and align with the *Columbia River Basin Interagency Invasive Species Response Plan* (Heimowitz and Phillips 2018).

1. Receive report or lab analysis of a **positive identification** of dreissenids and **make initial notifications** per Section IV-A, Appendix C of the *Columbia River Basin Interagency Invasive Species Response Plan*. Initiate USFWS emergency consultation and/or NMFS consultation.

2. **Activate appropriate organizational elements** of the CRB Interagency Response Plan per Section IV-A of the *Columbia River Basin Interagency Invasive Species Response Plan.*

3. **Verify the reported introduction** per the mutually agreed upon methods and protocols established by the western states.[1]

4. **Determine the extent of the colonization** per Section IV-A, Appendix B of the *Columbia River Basin Interagency Invasive Species Response Plan.*

5. **Establish an external communications system** per Section III, Section IV, and Appendix B of the *Columbia River Basin Interagency Invasive Species Response Plan.*

6. **Obtain and organize resources** needed for a control action per Section IV-A of the *Columbia River Basin Interagency Invasive Species Response Plan.*

[1] https://www.buildingconsensusinthewest.org/monitoring

7. **Prevent further spread via quarantine and pathway management** per Section IV-A, Appendix B of the *Columbia River Basin Interagency Invasive Species Response Plan.*

8. **Initiate available/relevant control actions** per Section IV-A, Appendices B and D of the *Columbia River Basin Interagency Invasive Species Response Plan.* Ensure conservation measures and best management practices are implemented to avoid and minimize any detrimental effects to native fish and wildlife and their habitats.

9. **Initiate post-response consultation requirements** with appropriate agencies per direction from those agencies (USFWS, NMFS, etc.).

Rapid Response Project Activities

This section lists the main steps for most rapid response actions, and identifies each step and associated activities. The purpose of this section is to outline the possible activities that could occur for a typical rapid response action that would need to be considered for inclusion in an Emergency Consultation for that action.

1. Site Mobilization

Equipment expected to be used in any control effort: vehicles, boats, trailers, generators, small fuel and oil containers for small engines, pumps, hose material, silt curtains, portable water tanks, other barrier material, and treatment chemicals.

Site mobilization includes access and vegetation and wildlife considerations. Best management practices for each is included in Chapter 5 in this document.

2. Area Isolation

The areas adjacent to public access site(s) where the detection of dreissenids is confirmed will be immediately closed to boat traffic, and any contaminated watercraft, including derelict vessels, will be removed. Isolation reduces the potential that veligers or juveniles could escape the treatment area, which is important when the invasion is detected early and eradication is most likely. A barrier must significantly limit or eliminate water transfer from the treatment area to the main waterbody. Complete elimination of connectivity for the duration of treatment is preferred.

- Establish mandatory decontamination procedures for all existing watercraft.

- Collect samples inside and outside of the contaminated area for immediate analysis.

- Determine the feasibility of using silt curtains or barriers to close the bay or marina to open water.

Isolation of a portion of the water body is intended to eliminate water transfer from the treatment area to the main water body and prevent the transfer of aquatic life from the main water body into the treatment area. Two methods are commonly used to create this isolation are silt curtains and bladder dams.

- Impervious silt curtains (Figure 2) would be deployed via boat (e.g., commercial silt curtain or HDPE material anchored in place), then secured to shore on the other end, or the boat can deploy the curtain in a circular fashion around the perimeter of a treatment area. Silt curtains can be up to 30.5 m in length, with a skirt of the same depth. Curtains can be fastened together to extend as far as necessary, whereas the skirts have a bottom chain for weight, and can be anchored to the substrate with sand bags.

The skirt is lowered, and sandbag anchors placed once the curtain has been appropriately stretched. This includes dropping the weighted skirt by untying or cutting, binding, and attaching and lowering sandbags into place.

Figure 2. Example of a deployed turbidity curtain.

Removal steps occur in the reverse order.

- Inflatable bladder dams [e.g. PLUG (Portable Lightweight Ubiquitous Gasket) and Tiger (PVC-coated fabric) dams, HDPE liner material] would be deployed by humans on foot.

Inflatable bladder dams (Figure 3) can be positioned across the substrate and pumped full of water to effectively block connectivity. This isolation method may be depth-limited.

Methods for bladder dam deployment may include:

- Bladder dams are unrolled and waded into place on foot, and the bladders are then filled via water pumped into the bladder.

- Any pump intake would be required to draw as specified by NMFS (2001) to protect juvenile fishes 20–30 mm.

Removal steps occur in the reverse order. If water were used from the waterbody being treated, the bladder water would receive treatment before being discharged.

Figure 3. Example of a deployed inflatable bladder dam. Source: hydroloicalsolutions.com.

Methods that could be used to isolate a portion of the water body in addition to silt curtains and inflatable bladder dams may include geotextile fabric filled with an appropriate material as well as a combination of sandbags, PVC-coated fabric and blocks.

- Benthic mats are large, dark tarps anchored to the bottom of a water body to control invasive mussels by restricting water flow, oxygen and food from the mussels beneath the mats, and blocking light to prevent photosynthesis from producing oxygen beneath the mats.[2]

3. Rescue/Salvage

In cases in which listed aquatic species are present, attempts should be made to rescue/salvage listed species (that would not naturally move away from the action area). The guidelines and protocols identified in Reynolds (1996) and NMFS (2000) would be implemented during fish salvage. For all other species, such as mollusks, gastropods, and crustaceans, all attempts would be made to rescue/salvage any listed species and retain them offsite, or move them into another portion of the waterbody where it has been determined they will not be affected by the action.

[2] https://invasivemusselcollaborative.net/management/

Best management practices minimizing impacts to these species would be developed in advance of implementation.

Fish salvage methods may include:

- Boat or backpack electrofishing gear calibrated to the specific onsite water conditions (i.e., conductivity).
- At least one team of three people would wade or operate a boat throughout the treatment area netting fish and placing them in containers of fresh water with air supply until no fish are captured for a period of 5–10 minutes. Number of teams and total collection effort would depend on size of the treatment area.
- Fish would be transferred to a separate holding tank with uncontaminated water calibrated to the ambient treatment area water temperature with oxygen supply.
- A clean water flush calibrated to the ambient treatment area temperature would completely replace the tank volume prior to fish release outside of the treatment area.
- A separate crew with sanitary equipment would conduct the fish transfer via nets and smaller containers adjacent to the treatment area.
- All equipment used during salvage would be treated onsite using the same methods as equipment sterilization (discussed below).

4. Treatment Options

A suite of chemical and non-chemical options exists for controlling invasive mussels in the CRB; some treatments are appropriate solely for hydropower facilities and water delivery systems, in which fish are not present and the water can be treated before being released into a sewage system. Other treatments, which have low toxicity to fish and living organisms, are more appropriate for open water situations. The most likely treatment options that would be implemented for any waterbody in the four Columbia River Basin states would include both chemical and physical treatments. The use of chemicals requires knowledge of permitting, labeling, and chemical-specific application regulations (BOR 2015).

Chemical treatments

- **Muriate of Potash**—requires a Section 18 Pesticide Emergency Exemption from the US Environmental Protection Agency (USEPA)
- **EarthTec QZ™** —(only in water bodies with non-salmonid/trout species)
- **Zequanox®**—the only EPA-registered biocide for mussels

Non-Chemical treatments

- Intense Ultraviolet-B and Ultraviolet-C Radiation
- Ozone oxidation
- Drawdowns/dewatering
- Manual removal

Combinations of treatments may be used, and retreatments may be necessary. Treatment areas would be isolated up to 45 days during treatment to maximize dreissenid mussel exposure time, incorporate variables, such as temperature variations (which affects efficacy of KCl), and provide for re-treatment, if needed. The 45-day isolation period would incorporate two full treatments if a second treatment was necessary to achieve 100% mortality.

Bioassays
Several bioassays would be employed to determine the effectiveness of each treatment.

If adult mussels are present in a water body, mussel mortality would be assessed via in-lake cage bioassays. Four cages of ~50–100 mussels per cage would be placed within the treatment area. Cages would be constructed of plastic canvas mesh sheets (1–2 mm openings), anchored to the lake bottom. Live, gaping, and dead mussels would be recorded daily until all mussels are dead or until no additional mussels die over three consecutive days.

A. Chemical Treatment—Muriate of Potash

In basin locations in which ESA-listed salmonids and their critical habitat exist, the most likely product to be used, based on least toxicity to aquatic life as well as cost, is potash.

Potassium fertilizers used in agriculture have been shown to precipitate salts when applied in large quantities or through time, which can cause salinity problems in spoils (Magen 1996). There is either a paucity of information on the effects of potassium applied directly to water, or the only actual outcome is increased nutrient loading. Irrigation systems cause compound leaching over time and allow precipitates to accumulate in soils; however, the volume of water and proposed application concentration of potash would dilute into the water body reducing any likelihood of significant eutrophication or a salt precipitate to remain in the treatment area.

Potassium ions (K_+) interfere with the respiration of dreissenids at the gill surface (Fisher et al. 1991, Aquatic Sciences Inc. 1997). Acute lethal effects of potash on juvenile brook trout and juvenile Chinook salmon are not expected at concentrations used to control dreissenids (Densmore et al. 2018). In fact, exposure concentrations of eight times greater than the dose of KCl used as a molluscide (800 mg/L) in a static system during a 96-hour period resulted in no mortality, behavioral, histological, or gross morphological effects on fish of either species (Densmore et al. 2018). Significant mortality among sensitive aquatic invertebrates, such as daphniids, is not unexpected (Densmore et al. 2018). Other invertebrates, such as crayfish, demonstrate some degree of sensitivity to KCl (Densmore et al. 2018). For example, crayfish exposed to KCl at higher concentrations (e.g., 800 mg/L–1,600 mg/L) for at least 24 hours experienced immobilization, but half were able to fully recover in fresh water within 24 hours (Densmore et al. 2018). It was determined that further analysis was needed to fully realize the threats to crayfish and other invertebrate species from KCl.

Potash is a common plant fertilizer which is largely comprised of potassium salts. Forms used to treat dreissenids include potassium chloride (KCL), potassium hydroxide (KOH), and potassium sulfide (K_2SO_4). Liquid potash was successfully used, with 100% effectiveness, to eradicate zebra mussels from the Millbrook Quarry in Virginia, USA (Fernald and Watson 2014).

Target application rates are 95–115 mg/L (KCl), ≤ 10 mg/L (KOH), and 160–640 mg/L (K_2SO_4) after mixing for up to 21 days for effectiveness. Applications may be made at the surface, mid-depth, or deep waters to ensure appropriate mixing and to maintain the desired concentration throughout the treatment area.

Potash consists mostly of potassium chloride (KCl). Potash is not a registered pesticide in the United States and requires a Section 18 Pesticide Emergency Exemption from the US Environmental Protection Agency (USEPA) to allow its use in the four Columbia River Basin states.

Potash Application

Equipment will include High Density Polyethylene storage tanks with spill containment to protect against spills and ensure a constant supply of stock solution. A stock solution of about 12% potassium will be mixed by a chemical supplier and delivered to the site on an as required basis where it will be transferred to the storage tanks and kept in solution by an electric tank mixer. An estimate of metric tons of KCl required to treat the site will be described in advance based on the size of the contained portion of the water body.

Water-based operations will use a work boat outfitted with a specially designed diffuser assembly. Stock solution from the shore-based storage tanks will continuously feed the diffuser through a floating 3.8 cm (1.5 in.) diameter supply line and shore-based centrifugal pump transfer system. Proper diffusion of potassium is a critical element of the treatment method.

Treatment will proceed on a systematic basis by separating the cordoned off areas into segments or treatment zones delineated by water depth. The work platform-based retractable diffuser assembly will consist of perforated vertical flexible hoses having capped and weighted ends attached to the horizontal section. This will allow for an enlarged mixing zone to be achieved while the flexible hose will reduce damage due to submerged obstacles. An echo sounder will be used to monitor water depth and the depth of the submerged diffuser assembly to maintain an optimum height above the bottom of the water body. This system will also reduce the risk of entangling the diffuser assembly on bottom features.

To ensure the potassium diffusion system is operating efficiently and is attaining target potassium concentrations throughout the treatment zone, potassium spot monitoring will be completed during each charge operation. This will provide personnel with information on how quickly and how well the potassium is dispersing through the treatment zone. This information can be used to modify the treatment protocol, either by increasing or decreasing the dosing rate to achieve target concentrations. Following the "charge" activities, a final sampling exercise will be conducted throughout each cordoned off area to characterize potassium concentrations at various depth profiles. Monitoring points at each enclosed area will be spaced depending on the width of the enclosed area at each transect location. Sites will be monitored along each transect to ensure feasible and maximum monitoring coverage of the treated transect area.

Duplicate samples will be collected and analyzed for every tenth sample for quality assurance and quality control (QA/QC) purposes.

To determine the potassium concentrations, water samples will be obtained by two different methods. Surface grabs will be conducted where water depths are less than 2 m and will be collected at least 0.15 m below the surface. A peristaltic pump or Kemmerer bottle will be used to collect samples from each thermocline present in the sectioned off area and at depths greater than 2 m. Samples will be analyzed with a concentration meter, in combination with a potassium probe. Sample identification, location, depth, date, GPS coordinates for each monitoring point and other pertinent information will be recorded in the field logbook and on reporting log sheets. The field instruments will be calibrated prior to use every day with standards of known value. Monitoring will be conducted daily throughout a 12-hour shift.

B. Chemical Treatment—EarthTec QZ™

EarthTec QZ™ is a copper-based algaecide/bactericide (a formulation of copper sulfate pentahydrate) labeled to control zebra and quagga mussels. EarthTec QZ™ is registered in all 50 states as an algaecide/bactericide and in Montana and Washington as a molluscide. EarthTec QZ™ is documented as achieving 100% mortality of mussels when exposed to the product for 96 hours (Watters et al. 2013). The product can be spread on the surface of a water body or pumped into a water body, and disperses rapidly. The product's active ingredient is delivered in the cupric ion form (Watters et al. 2013). Lethal dose and exposure time of zebra mussels to EarthTecQZ™ has been identified under laboratory conditions (Watters et al. 2013, Claudi et al. 2014), and has been tested in the field.

The product's active ingredient is delivered in the cupric ion form—a biologically active form of copper (Watters et al. 2013). Lethal dose and exposure time of zebra mussels to EarthTecQZ™ had been identified under laboratory conditions (Watters et al. 2013, Claudi et al. 2014). EarthTec QZ® does not have any degradation byproducts, and no adjuvants or surfactants are used in the application. EarthTec QZ™ is a liquid formulation that is miscible in water and has ionic diffusion properties that cause it to readily disperse throughout the water column. Application methods vary depending on the scale of project. It would be applied at a rate of up to 2 mg/L, not to exceed 0.1 mg/L total copper. Concentrations may be held constant up to 30 days (depending on dose) to achieve effective treatment for all dreissenid life stages. EarthTec QZ™ copper is highly water soluble and does not precipitate. The product will remain suspended until uptake by bacteria and algae occurs (Master Label for EarthTec QZ™, EPA Reg. No. 64962-1). Dispersion into the waterbody would quickly reduce concentrations to below effect levels outside of the isolated treatment area.

The cupric ion Cu^{2+} form of copper is considered the most toxic form of copper to aquatic life because it is the most bioavailable (Eisler 2000, Solomon 2009). In addition, the cupric ion form of copper is more lethal in soft water compared to hard waters rich in cations because cations reduce the bioavailability (Pagenkopf 1983, Paquin et al. 2002). The toxicity of copper to fish and other aquatic life depends on its bioavailability, which is strongly dependent on pH, the presence of dissolved organic carbon (DOC), and water chemistry, such as the presence of calcium ions.

- Juvenile rainbow trout (*Oncorhynchus mykiss*) were exposed to either hard water or soft water spiked with copper for 30 days (Taylor et al. 2000). Fish in the hard-water, high dose (60 µg/L) treatment groups showed an increased sensitivity to copper.

- The mean 96-hour LC_{50} (with 95% confidence limits) for copper exposure in alevin, swim-up, parr and smolt steelhead (*Salmo gairdneri*) are 28 (27–30), 17 (15–19), 18 (15–22), and 29 (>20) µg/L of copper respectively (Chen and Lin 2001). The mean 96-hour LC_{50} for copper exposure in alevin, swim-up, parr and smolt Chinook salmon (*Oncorhynchus tshawytscha*) are 26 (24–33), 19 (18–21), 38 (35–44), and 26 (23–35) µg/L of copper respectively. The experiments were done by adding copper as $CuCl_2$.

- Aquatic snails (*Biomphalaria glabrata*) had a 24-hour and 48-hour LC_{50} (with 95% confidence intervals) of 1.868 (1.196–3.068) and 0.477 (0.297–0.706) mg/L Cu, respectively (de Oliveira-Filho et al. 2004).

- 1-day-old freshwater snail eggs (*Lymnaea luteda*) were exposed to copper at concentrations from 1 to 320 µg/L of copper for 14 days at 21 °C in a semi-static embryo toxicity test (Khangarot and Das 2010). Embryos exposed to copper at 100 to 320 µg/L died within 168 hours. At lower doses from 3.2–10 µg/L, significant delays in hatching and increased mortality were noted.

EarthTec QZ™ is miscible in water and has ionic diffusion properties that cause it to readily disperse throughout the water column. It would be applied near the water surface and allowed to disperse, or delivered via hose and pump to the depths, sites, and surfaces of the area of infestation. When applying to large areas, it would be dispensed along a route with gaps no greater than 200 feet. Generally, when fish are present, no more than one-half of the body of water is treated at a time, starting near one shore and moving outward in bands so as to allow fish to move away. When treating half of a body of water, the second half must not be treated within 14 days from the last treatment. For effective control of adult and juvenile mussels, it would be applied at the recommended rate of 2 to 16 parts per million (i.e., 2 to 16 gallons of EarthTec QZ™per million gallons of water) to yield a rate of 0.120 to 0.960 mg/L (ppm) metallic copper. A total of at least four days is required for mortality of dreissenids to occur. Colder water temperatures may require longer exposures and doses closer to the high end of the allowable range. Within the half of the water body being treated, repeat applications may be needed to maintain lethal concentrations of copper for sufficient time period. The second half of the water body would not be treated within 14 days of the last treatment of the first half. Effective control can also be achieved by longer exposures (e.g., 5–30 days) at lower doses (1 to 5 parts per million EarthTec QZ™, to yield a rate of 0.06 to 0.30 mg/L (ppm) metallic copper.) When reapplying, a concentration of 1.0 mg/L (ppm) metallic copper in the treated water would not be exceeded.

C. Chemical Treatment – Zequanox®

Zequanox® is a biopesticide consisting of the dead bacterial cells of *Pseudomonas fluorescens* strain CL145 A that, when ingested by zebra and quagga mussels, destroy the digestive lining (https://marronebioinnovations.com/molluscicide/zequanox/). All treatments would be undertaken by state-licensed applicators. Prior to beginning chemical treatment, the area to be treated would be sealed off using non-permeable geo textile membranes, creating a contained open water body.

Zequanox® is maintained at a rate of 100 mg/L for up to eight hours; treatments are often repeated, although the label recommends no more than four Zequanox® applications annually.

Products would be mixed in tanks and injected at the water surface. Following treatment, monitoring would occur every 1–2 days for 14 days post-treatment. Monitoring would consist of collecting surface water samples at various locations inside the treatment area. Samples would be submitted for analysis by mass spectroscopy, with results reported within 1–2 days. Portable meters would be used to inform bump applications in the field.

During the Zequanox® application, concentrations would be estimated using turbidity measurements, on the first and last day of treatment application. Monitoring of concentrations more often is of limited utility, since evidence indicates that the active agent in Zequanox® is degraded within 24 hours after it is added to water (Molloy et al. 2013).

Information provided on the pesticide Zequanox® and the associated mammalian toxicity and ecotoxicity studies that provide supporting evidence to the fact that this product is not likely to have detrimental impacts to non-target organisms.

Zequanox® is a potential tool for controlling dreissenids in shallow water habitats in lakes without significant long-term effects on water quality (Whitledge et al. 2014). However, this biopesticide does cause temporary, but substantial reductions in dissolved oxygen because of the barriers that prevent well-oxygenated water from circulating into treatment zones (Whitledge et al. 2014).

D. Intense Ultraviolet-B and Ultraviolet-C Radiation

UV radiation is an effective method for controlling zebra mussels in all life stages, although veligers are more sensitive than adults. Complete veliger mortality can be obtained within four hours of exposure to UV-B radiation, and adult mortalities can also be obtained if constant radiation is applied. UV radiation can be harmful to other aquatic species, and its effectiveness may be decreased by turbidity and high suspended solids loads (Wright et al. 1997). Doses as low as 26.2 mJ/cm^2 and 79.6 mJ/cm^2 can decrease survival of pre-settlement stage larvae by nearly 50% and 80%, respectively, within four days of exposure (Stewart-Malone et al. 2015).

The use of ultraviolet light to control larval dreissenids in industrial cooling water systems is well documented (Pucherelli and Claudi 2017). To reduce environmental effects, lower costs, and avoid the need for discharge permitting, ultraviolet light irradiation can be used to prevent or limit mussel colonization in industrial facilities, and can be used in water bodies in combination with treatments targeted at adult dreissenids. Site-specific characteristics, such as the ability of the water to transmit ultra-violet light, suspended solids, and flow conditions, affect the efficacy of this treatment (Pucherelli and Claudi 2017). This technique requires continuous ultra-violet light application for up to 120 hours, and is considered only partially effective in killing larval dreissenids.

The ultraviolet light is applied using watercraft and submerged ultraviolet light panels, which are raised and lowered in the water column to target larval dreissenids.

E. Ozone Oxidation

Ozone can be effective at relatively low concentrations (e.g., 0.5 mg/L has been 100% effective on veligers in five hours and adults in seven to 12 days) (Heimowitz and Phillips 2018). Ozone applied through a bubbler system can be effective in very small areas of a water body (less than 1.2 acres) to kill larval dreissenids. Although ozone is less detrimental to the environment, it is costly because of the need to maintain exposure times, which is difficult due to the speed at which it disperses.

F. Physical Treatment—Water Level Management

Sudden water-level drawdowns during several winter conditions can temporarily reduce dreissenids in impounded river sections, although this type of control is considered a method to temporarily reduce large numbers of adults (Leuven et al. 2014).[3] Freezing air temperatures are highly lethal to zebra mussels within a matter of hours (Grazio and Montz 2002). Water drawdowns occur when managers decrease the maximum depth in a body of water that has adequate water level control structures (Grazio and Montz 2002). Winter water drawdowns were used to treat Lake Zumbro, MN and Edinboro Lake, PA in 2000 and 2001. Although complete mortality of invasive mussels was observed in drawdown areas (1.5-meter drawdowns), mussels successfully overwintered in waters deeper than the maximum drawdown depth (Grazio and Montz 2002). A complete drawdown of Lake Zorinsky, NE, in 2010 resulted in the eradication of zebra mussels within the lake, and the lake was refilled and re-opened for recreation in 2012. Total elimination of dreissenids with this management technique is unlikely, however, and the potential costs and benefits before attempting fall/winter lake drawdowns for zebra mussel control should be evaluated on a site-by-site basis.

G. Manual and Mechanical Removal

Information in this section is from Culver et al. (2013).

Removal, either by hand or another mechanical method, can potentially eradicate dreissenid mussels when 1) the structure from which mussels are being removed lends itself to this technique, and 2) when mussels are concentrated within specific areas of a water body or on particular infrastructure within it. Mussel populations can successfully be eradicated using this strategy only if 1) no additional larval or juvenile/adult mussels are entering the water body from infested waters (aqueduct or reservoir) and/or boat traffic, and 2) if enough mussels are removed to reach the point where the population can no longer sustain itself. Achieving the latter can be difficult, due to the mussels' ability to inhabit inaccessible places, limiting removal efforts and increasing chances that individuals will survive. Where there are many inaccessible areas, a combination of tactics will likely be most effective.

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[3] In a study in the Netherlands, the overall density of dreissenids decreased, but six months after the water level was increased, the mussel density slightly increased. Within 18 months, the mussel density had recovered to pre-drawdown levels.

Even when eradication is not possible, this strategy offers an effective method for controlling the population when applied appropriately, and when used in combination with other control tactics. Likewise, if the infested area is large (>20,000 square feet),[1] a combination of oxygen deprivation using tarps and manual/mechanical removal may be useful.

The steps to be taken in manual removal include organizing divers, training divers, determining the distribution of mussels, conducting pre-implementation surveys, preparing the target site, manually removing the mussels using hand-held tools, collecting the mussels, disposing of the mussels, decontaminating persons and gear, and evaluating tactic success. For more information on the specific steps associated with manual and mechanical removal of aquatic invasive species, California Sea Grant has developed an information sheet (2013) for educational purposes (https://caseagrant.ucsd.edu/sites/default/files/3%20Manual%20Mechanical%20Individual_121418.pdf)

5. Summary of Application Rates and Contact Time for Dreissenid Chemical Treatments

The Columbia River Basin Interagency Invasive Species Response Plan: Zebra Mussels and Other Dreissenids (Heimowitz and Phillips 2018) documents the chemical methods available for dreissenid control, including the ones documented in Table 1. Appendix D in the CRB Plan identifies the treatment, target age, efficiency, contact time/concentration, and comments relative to effects on the environment and other species. Information from that appendix is summarized here for the treatments included in this manual.

Table 1. Summary of application rates and contact time for dreissenid chemical treatments.

Chemical Treatment	Target Dreissenid Age	Efficiency	Application Rate	Contact Time
Potash (KCl)	Juveniles and adults	Prevent larval settlement (50%) 95–100% mortality	95–115 mg/L	21 days
Potash (KH_2PO_4)	Juveniles and adults	100%	160–640 mg/L	21 days
Potash (KOH)	Juveniles and adults	95–100% mortality	$\leq$ 10 mg/L	21 days
EarthTec QZ™	Juveniles and adults	100%	0.5–2 mg/L, not to exceed 0.1 mg/L total copper	30 days
Zequanox®	Juveniles and adults	70–100%	150 mg/L	1–2 weeks
UV-B Radiation	Juveniles and adults	50–80%	10–100 mJ/cm^2	5 days
Ozone	Juveniles and adults	100%	0.5 mg/L	7 days

Project Timeline

The rapid response action would be implemented immediately upon detection of dreissenids in the action area. Physical activity onsite is expected to occur until the severity of the invasion is determined through initial treatment and extended treatment area isolation. Additional treatments may be required for 100% effectiveness. Isolation barriers would remain in place until monitoring suggests 100% mussel mortality has occurred and water chemistry is acceptable for barrier removal.

It is more likely that mussel detection and treatment would occur during the warmer months in correlation with increased recreation and mussel growth and activity (approximately April through September), as well as associated with appropriate conditions for effective treatment, however, discussions should occur with state and federal natural resource agencies to adhere to in-water work timing windows (see Best Management Practices), if possible. Restoration would occur only after the final treatment in the case of a site requiring riparian access. Plant restoration, if necessary, would occur October–March.

References

Aquatic Sciences, Inc. 1997. Ontario hydro baseline toxicity testing of potash using standard acute and chronic methods: ASI Project E9015. In Eradication of zebra mussels at Millbrook Quarry, Prince William County, Virginia. Proposal M20065 submitted to the Virginia Department of Game and Inland Fisheries in response to RFP 00375–352. Orchard Park (NY): Aquatic Sciences L.P.

Bureau of Reclamation. 2015. Draft environmental assessment: Two shoreline protection systems. U.S. Dept. of the Interior, Bureau of Reclamation, Pacific Northwest Region, Boise, Idaho office.

Chen, J.-C., and C.H. Lin. 2001. Toxicity of copper sulfate for survival, growth, molting and feeding of juveniles of the tiger shrimp, *Penaeus monodon*. *Aquacult.* 192(1):55–65.

Claudi, R.M., T.H. Prescott, S. Mastisky, and H. Coffey. 2014. Efficacy of copper-based algaecides for control of quagga and zebra mussels. RNT Consulting Report. 58pp.

Culver, C., H. Lahr, L. Johnson, and J. Cassell. 2013. Quagga and Zebra Mussel Eradication and Control Tactics. California Sea Grant College Program Report No. T---076/UCCE---SD Technical Report No. 2013---1. 8pp.

de Oliveira-Filho, E.C., R.M. Lopes, and F.J.R. Paumgartten. 2004. Comparative study on the susceptibility of freshwater species to copper-based pesticides. *Chemosphere* 56(4):369–374.

Densmore, C.L., L.R. Iwanowicz, A.P. Henderson, V.S. Blazer, B.M. Reed-Grimmett, and L.R. Sanders. 2018. An evaluation of the toxicity of potassium chloride, active compound in the molluscicides potash, on salmonid fish and their forage base. Open-File Report 2018–1080. 34pp.

Eisler, R. 2000. Handbook of chemical risk assessment: health hazards to humans, plants and animals. Volume 1: Metals. Lewis Publishers, New York.

Fernald, R.T., and B.T. Watson. 2014. Eradication of zebra mussels (*Dreissena polymorpha*) from Millbrook Quarry, Virginia: Rapid response in the real world. Pp. 195-213 in Quagga and Zebra Mussels: Biology, Impacts, and Control (Nalepa, T.F., and D.W. Schloesser, eds.). CRC Press, Boca Raton, FL. 775pp.

Fisher, S.W., P. Stromberg, K.A. Bruner, and L.D. Boulet. 1991. Molluscicidal activity of potassium to the zebra mussel, *Dreissena polymorpha*: toxicity and mode of action. Aquat. Toxicol. 20:219–234.

Grazio, J.L., and G. Montz. 2002. Winter lake drawdown as a strategy for zebra mussel (*Dreissena polymorpha*) control: results of pilot studies in Minnesota and Pennsylvania. Proceedings 11th International Conference on Aquatic Invasive Species. US Army Engineer Research and Development Center, Alexandria (Virginia), pp 207–217.

Heimowitz, P., and S. Phillips. 2011 (updated in 2018). Columbia River Basin Interagency Invasive Species Response Plan: Zebra Mussels and Other Dreissenid Species.

Khangarot, B.S., and S. Das. 2010. Effects of copper on the egg development and hatching of a freshwater pulmonate snail *Lymnaea luteola* L. *J. Hazard. Mater.* 179(13):665–675.

Leuven, R.S.E.W., F.P.L. Collas, K.R. Koopman, J. Matthews, and G. van der Velde. 2014. Mass mortality of invasive zebra and quagga mussels by desiccation during severe winter conditions. *Aquatic Invasions* 9(3):243–252.

Magen, H. 1996. Potassium chloride in fertigation. 7th International Conference on Water and Irrigation, May 1996, Tel Aviv, Israel.

Molloy, D.P., D.A. Mayer, M.J. Gaylo, L.E. Burlakova, A.Y. Karatayev, K.T. Presti, P.M. Sawyko, J.T. Morse, and E.A. Paul. 2013. Non-target trials with *Pseudomonas fluorescens* strain CL145A, a lethal control agent of dreissenid mussels (Bivalvia: Dreissenidae), 201, *Management of Biological Invasions* 4(1):71–79.

NMFS (National Marine Fisheries Service). 2000. Guidelines for electrofishing waters containing salmonids listed under the Endangered Species Act. National Marine Fisheries Service, Portland, Oregon, and Santa Rosa, California.

Pagenkopf, G.K. 1983. Gill surface interaction model for trace-metal toxicity to fishes: Role of complexation, pH, and water hardness. *Environmental Science and Technology* 17:342–347.

Paquin, P.R., J.W. Gorsuch, S. Apte, G.E. Batley, K.C. Bowles, P.G.C. Campbell, C.G. Delos, D.M. Di Toro, R.L. Dwyer, F. Galvez, R.W. Gensemer, G.G. Goss, C. Hogstrand, C.R. Janssen, J.C. McGeer, R.B. Naddy, R.C. Playle, R.C. Santore, U. Schneider, W.A. Stubblefield, C.M. Wood and K.B. Wu. 2002. The biotic ligand model: A historical overview. *Comparative Biochemistry and Physiology* Part C 133:3–35.

Pucherelli, S.F., and R. Claudi. 2017. Evaluation of the effects of ultra-violet light treatment on quagga mussel settlement and veliger survival at Davis Dam. *Management of Biological Invasions* 8(3):301–310.

Reynolds, J.B. 1996. Electrofishing. Pages 221–253 *in* B. R. Murphy and D. W. Willis, eds. Fisheries techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Solomon, F. 2009. Impacts of copper on aquatic ecosystems and human health. *Environment and Communities*. Pp 25–28.

Stewart-Malone, A., M. Misamore, S. Wilmoth, A. Reyes, W.H. Wong, and J. Gross. 2015. The effect of UV-C exposure on larval survival of the dreissenid quagga mussel. *PLOS One* 10(7):e0133039. 11pp.

Taylor, L.N., J.C. McGeer, C.M. Wood, D.G. McDonald. 2000. Physiological effects of chronic copper exposure to rainbow trout (*Oncorhynchus mykiss*) in hard and soft water: Evaluation of chronic indicators. *Environ. Toxicol. Chem.* 19(9):2298–2308.

Watters, A., S.L. Gerstenberger, and W.H. Wong. 2013. Effectiveness of EarthTec for killing invasive quagga mussels (*Dreissena rostriformis bugensis*) and preventing their colonization in the western United States. *Biofouling* 29(1):21–28.

Whitledge, G.W., M.M. Weber, J. Demartini, et al. 2015. An evaluation Zequanox efficacy and application strategies for targeted control of zebra mussels in shallow-water habitats in lakes. *Management of Biological Invasions* Volume 6.

Wright, D.A., J.A. Magee, and E.M. Setzler-Hamilton. 1997. Use of high energy monochromatic UV light to kill dreissenid larvae. In: F. D'itri (ed), Zebra mussels and aquatic nuisance species. Boca Raton, FL: CRC Press LCC, pp 467–488.

CHAPTER 4. LISTED SPECIES AND CRITICAL HABITAT IN THE FOUR CRB STATES

The purpose of this chapter is to provide information about the listed species and their critical habitats that are known to occur in Washington, Oregon, Idaho, and Montana (the four states that protect the majority of the Columbia River Basin). The intent is to provide easy access to key life history vulnerabilities associated with those species and critical, with the likely effects of an action on species, and additional species-specific best management practices to inform any proposed action to control (or eradicate) dreissenids.

The information in this chapter was obtained from the U.S. Fish and Wildlife Service Environmental Conservation Online System (ECOS), and was supported by each state's heritage database system. This information is accurate as of the date of publication of this manual, and may change in the future. The material in this chapter does not substitute for the need to communicate with the local US Fish and Wildlife Service office to confirm the accuracy of this information as well as any new information and updates made since the development of this document.

The four CRB states have a total of 70 federally listed species and 2 proposed listed species (Table 2). A detailed list of federally listed species by state, including a hyperlink to the ECOS profile, a link to the distribution map, and links to information about critical habitat and critical habitat maps (if appropriate) is provided in Table 3.

Table 2. Number of federally listed threatened and endangered species by CRB state.

	Oregon	Washington	Idaho	Montana
Mammals	2T, 1E	4T, 3E	3T, 1E	3T, 1E
Birds	5T, 1E	5T, 1E	1T	3T, 2E
Amphibians	1T	1T	0	0
Fish	13T, 2E	13T, 1E	1T, 1E	2E
Invertebrates	2T, 3E	1T, 1E	1T, 3E	0
Plants	8T, 11E	8T, 4E	5T, 0E	3T, 0E
TOTALS	**31T, 18E**	**32T, 10E**	**11T, 5E**	**9T, 5E**

Table 3. Listed species and critical habitat in the CRB states. Species highlighted in orange were included in this analysis; species with no highlight were excluded from this analysis because dreissenids would not be found in their habitat, or the species would not be directly or indirectly affected by rapid response actions for dreissenids. This table also includes NOAA trust species (green highlight). NOAA trust species are not included in this analysis.

	ECOS Profile	Oregon	Washington	Idaho	Montana
MAMMALS					
Black-footed ferret (*Mustela nigripes*)	Link				E, XN
Canada lynx (*Lynx canadensis*) CH Map (2014), 5-year review (2017)	Link	T	T	T	T
Columbian white-tailed deer (*Odocoileus virginianus leucurus*)[4]	Link	T	T		
Gray wolf (*Canis lupus*)[5]	Link	E[6]	E[7]		
Grizzly bear (*Ursus arctos horribilis*) CH (1976)	Link		T	T	T
Mazama pocket gopher (*Thomomys azama pugetensis, glacialis, tumuli, and yelmensis*) CH (2014): Olympia CH Map, Roy Prairie CH Map, Tenino CH Map, Yelm CH Map	Link		T		
Northern Idaho ground squirrel (*Urocitellus endemicus*)	Link			T	
Northern long-eared bat (*Myotis septentrionalis*)	Link				T
Columbia Basin Pygmy rabbit (*Brachylagus idahoensis*) (Columbia Basin DPS)	Link		E		
Southern Selkirk Mountains woodland caribou (*Rangifer tarandus caribou*) CH Map, CH (2012)	Link		E	E	
BIRDS					
Least tern (*Sterna antillarum*)	Link				E
Marbled murrelet (*Brachyramphus marmoratus*)[8] CH Map, CH (2016)	Link	T	T		
Northern spotted owl (*Strix occidentalis caurina*) CH Map, CH (2012)	Link	T	T		
Piping plover (*Charadrius melodus*) CH Map, CH (2002)	Link				T
Red knot (*Calidris canutus rufa*)	Link				T
Short-tailed albatross (*Phoebastria albatrus*)	Link	E	E		
Streaked horned lark (*Eremophila alpestris strigata*) CH Map, CH (2013)	Link	T	T		

[4] Columbia River population

[5] Conterminous USA, lower 48 states, except where otherwise designated)

[6] Endangered in the western 2/3 of Oregon as defined by a boundary line that extends south from the Washington border along Hwy 395 to Burns Junction, and continues south on Hwy 95 to the Nevada border. Wolves east of that line are not federally listed.

[7] Endangered in the western 2/3 of Washington, west of Hwy 97, State Route 17 and US 395. WDFW has primary management authority to the east of that line. Wolves that inhabit tribal lands east of highways 97, 17, and 395 are managed by those tribal entities.

[8] Washington, Oregon, and California population

	ECOS Profile	Oregon	Washington	Idaho	Montana
Western snowy plover (*Charadrius alexandrines nivosus*)[9] CH Map, CH[10, 11] (2012)	Link	T	T		
Whooping crane (*Grus americana*)	Link				E, XN
Yellow-billed cuckoo (*Coccyzus americanus*)[12] , Proposed critical habitat - CH Map, CH (2014)	Link	T	T	T	T
AMPHIBIANS					
Oregon spotted frog (*Rana pretiosa*) CH Map, CH (2016)	Link	T	T		
FISH					
Borax Lake chub (*Gila boraxobius*) CH Map, CH (1982)	Link	E			
Bull trout (*Salvelinus confluentus*)[13] CH Map, CH (2010)	Link	T, XN	T	T	T
Chinook salmon (*Oncorhynchus tshawytscha*) CH (2000)	Link				
Upper Columbia spring-run ESU			E		
Snake River spring/summer run ESU		T	T		
Snake River fall-run ESU		T	T		
Puget Sound ESU			T		
Lower Columbia River ESU		T	T		
Upper Willamette River ESU		T			
Chum salmon (*Oncorhynchus keta*) CH (2000)	Link				
Hood Canal summer-run ESU			T		
Columbia River ESU		T			
Coho Salmon (*Oncorhynchus kisutch*) CH (2000)	Link				
Oregon Coast ESU		T			
Lower Columbia River ESU			T		
Sockeye salmon (*Oncorhynchus nerka*)	Link				
Snake River ESU [CH (1993)]		E			
Ozette Lake ESU [CH (2000)]			T		
Steelhead (*Oncorhynchus mykiss*) CH (2005)	Link				
Upper Columbia River DPS			T		
Upper Willamette River DPS			T		
Middle Columbia River DPS		T			

[9] Pacific coast population

[10] Critical habitat was designated in 2005 for 32 areas along the coasts of California, Oregon, and Washington. A recovery plan was finalized in September 2007. On December 17, 2010, the USFWS, along with other federal agencies and the State of Oregon, signed off on a statewide Habitat Conservation Plan. On June 19, 2012, a final rule of critical habitat was published for the coasts of California, Oregon, and Washington.

[11] Ibid.

[12] Western population

[13] Conterminous USA, lower 48 states

	ECOS Profile	Oregon	Washington	Idaho	Montana
Lower Columbia River DPS Snake River Basin DPS Puget Sound DPS		T T	T T T		
Foskett speckled dace (*Rhinichthys osculus spp.*)	Link	T[14]			
Hutton tui chub (*Gila bicolor spp.*)	Link	T			
Kootenai River white sturgeon (*Acipenser transmontanus*) CH Map, CH (2008)	Link			E	E
Lahontan cutthroat trout (*Oncorhynchus clarki henshawi*)	Link	T			
Pallid sturgeon (*Scaphirhynchus albus*)	Link				E
INVERTEBRATES					
Banbury Springs limpet (*Lanx* spp.)	Link			E	
Bliss Rapids snail (*Taylorconcha serpenticola*)	Link			T	
Bruneau hot springsnail (*Pyrgulopsis bruneauensis*)	Link			E	
Snake River physa snail (*Physa natricina*)	Link			E	
Fender's blue butterfly (*Icaricia icarioides fender)* CH Map, CH (2006)	Link	E			
Taylor's checkerspot butterfly (*Euphydryas editha taylori*) CH Map, CH (2013)	Link	E	E		
Oregon silverspot butterfly (*Zpeyeria zerene hippolyta*) CH Map, CH (1980)	Link	T, XN	T		
Vernal pool fairy shrimp (*Branchinecta lynchi*) CH Map, CH (2011)	Link	T			
Vernal pool tadpole shrimp (*Lepidurus packardi*)	Link	E			
PLANTS					
Applegate's milk-vetch (*Astragalus applegatei*)	Link	E			
Bradshaw's desert parsley (*Lomatium bradshawii*)	Link	E	E		
Cook's lomatium (*Lomatium cookii*) CH Map, CH (2010)	Link	E			
Gentner's fritillary (*Fritillaria gentneri*)	Link	E			
Golden paintbrush (*Castilleja levisecta*)	Link	T	T		
Greene's tuctoria (*Tuctoria greenei*)	Link	E			
Howell's spectacular thelypody (*Thelypodium howellii* spp. *spectabilis*)	Link	T			
Kincaid's lupine (*Lupinus sulphureus spp. kincaidii*) CH Map, CH (2006)	Link	T	T		
Large-flowered woolly meadowfoam (*Limnanthes pumila spp. grandiflora*) CH Map, CH (2010)	Link	E			
MacFarlane's four o'clock (*Mirabilis macfarlaneil*)	Link	T		T	
Malheur wire-lettuce (*Stephanomeria malheurensis*) CH Map, CH (1982)	Link	E			
Marsh sandwort (*Arenaria paludicola*)	Link		E		
McDonald's rockcress (*Arabis macdonaldiana*)	Link	E			
Nelson's checker-mallow (*Sidalcea nelsoniana*)	Link	T	T		
Rough popcornflower (*Plagiobothrys hirtus*)	Link	E			

[14] Proposed for delisting

	ECOS Profile	Oregon	Washington	Idaho	Montana
Showy stickweed (*Hackelia venusta*)	Link		E		
Slender Orcutt grass (*Orcuttia tenuis*) CH Map, CH (2006)	Link	T			
Slickspot peppergrass (*Lepidium papilliferum*) CH Map, CH (2014)	Link			T	
Spalding's catchfly (*Silene spaldingii*)	Link	T	T	T	T
Umtanum desert buckwheat (*Eriogonum codium*) CH Map, CH (2013)	Link		T		
Ute Ladies'-tresses (*Spiranthes diluvialis*)	Link		T	T	T
Water howellia (*Howellia aquatilis*)	Link	T	T	T	T
Wenatchee Mountains checker-mallow (*Sidalcea oregana var. calva*) CH Map, CH (2001)	Link		E		
Western lily (*Lilium occidentale*)	Link	E			
White bluffs bladderpod (*Physaria douglasii spp. tuplashensis*) CH Map, CH (2013)	Link		T		
Willamette daisy (*Erigeron decumbens var. decumbens*) CH Map, CH (2006)	Link	E			
PROPOSED SPECIES					
North American wolverine (*Gulo gulo luscus*)					P
Western glacier stonefly (*Zapada glacier*) (Glacier NP, Grand Teton NP, Absaroka/Beartooth Wilderness)					P
Meltwater lednian stonefly (*Lednia tumana*)					P

Endangered (E)—Any species that is in danger of extinction throughout all or a significant portion of its range.

Threatened (T)—Any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

Proposed (P)—Any species of that is proposed in the Federal Register to be listed under section 4 of the Act.

Non-essential experimental population (XN)—A population of a listed species reintroduced into a specific area that receives more flexible management under the Act.

Critical Habitat/Proposed Critical Habitat (CH, PCH)—The specific areas (i) within the geographic area occupied by a species, at the time it is listed, on which are found those physical or biological features (I) essential to conserve the species and (II) that may require special management considerations or protection; and (ii) specific areas outside the geographic area occupied by the species at the time it is listed upon determination that such areas are essential to conserve the species.

Species Excluded from Further Analysis

The list of species in Table 3 was reviewed to determine if any could be eliminated from consideration because of known species distribution or its critical habitat (Appendix A). Because the habitat of the listed or proposed species is habitat in which dreissenids would not be found, or which would potentially be directly or indirectly affected by rapid response actions for dreissenids, these species are excluded from further analysis. The following species were excluded from further analysis:

MAMMALS

Black-footed ferret (*Mustela nigripes*)
Canada lynx (*Lynx canadensis*)
Gray wolf (*Canis lupus*)[15]
Grizzly bear (*Ursus arctos horribilis*)
Mazama pocket gopher (*Thomomys azama pugetensis, glacialis, tumul*i, and *yelmensis*)
Northern Idaho ground squirrel (*Urocitellus endemicus*)
Northern long-eared bat (*Myotis septentrionalis*)
Columbia Basin Pygmy rabbit (*Brachylagus idahoensis*) (Columbia Basin DPS)
Southern Selkirk Mountains woodland caribou (*Rangifer tarandus caribou*)
North American wolverine (*Gulo gulo luscus*)

FISH

Borax Lake chub (*Gila boraxobius*)
Foskett speckled dace (*Rhinichthys osculus* spp.)
Hutton tui chub (*Gila bicolor spp.*)

BIRDS

Marbled murrelet (*Brachyramphus marmoratus*)[16]
Northern spotted owl (*Strix occidentalis caurina*)
Short-tailed albatross (*Phoebastria albatrus*)
Whooping crane (*Grus americana*)
Streaked horned lark (*Eremophila alpestris strigata*)

INVERTEBRATES

Bruneau hot springsnail (*Pyrgulopsis bruneauensis*)
Fender's blue butterfly (*Icaricia icarioides fender*)
Taylor's checkerspot butterfly (*Euphydryas editha taylori*)

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[15] Conterminous USA, lower 48 states, except where otherwise designated)
[16] Washington, Oregon, and California population

Oregon silverspot butterfly (*Zpeyeria zerene hippolyta*)
Vernal pool fairy shrimp (*Branchinecta lynchi*)
Vernal pool tadpole shrimp (*Lepidurus packardi*)

PLANTS

Applegate's milk-vetch (*Astragalus applegatei*)
Cook's lomatium (*Lomatium cookii*)
Gentner's fritillary (*Fritillaria gentneri*)
Golden paintbrush (*Castilleja levisecta*)
Greene's tuctoria (*Tuctoria greenei*)
Howell's spectacular thelypody (*Thelypodium howellii* spp. *spectabilis*)
Kincaid's lupine (*Lupinus sulphureus* spp. *kincaidii*)
Large-flowered woolly meadowfoam (*Limnanthes pumila spp. grandiflora*)
MacFarlane's four o'clock (*Mirabilis macfarlaneil*)
Malheur wire-lettuce (*Stephanomeria malheurensis*)
Marsh sandwort (*Arenaria paludicola*)
McDonald's rockcress (*Arabis macdonaldiana*)
Rough popcornflower (*Plagiobothrys hirtus*)
Showy stickweed (*Hackelia venusta*)
Slender Orcutt grass (*Orcuttia tenuis*)
Slickspot peppergrass (*Lepidium papilliferum*)
Spalding's catchfly (*Silene spaldingii*)
Umtanum desert buckwheat (*Eriogonum codium*)
Wenatchee Mountains checker-mallow (*Sidalcea oregana var. calva*)
Western lily (*Lilium occidentale*)
White bluffs bladderpod (*Physaria douglasii* spp. *tuplashensis*)

Potential Effects of Chemical Treatments on Listed Species and Critical Habitats Associated with CRB Water Bodie

Appendix B of this document includes important information about the threatened and endangered species in the CRB whose life history need where designated. Table 4 compiles information for each species, briefly summarizing key species life history attributes and vulnerabilities, the p vulnerabilities, and species-specific BMPs that can reduce those effects.

Table 4. Potential estimated effects of chemical treatments on important life history needs and critical habitat (https://ecos.fws.gov) for listed s water bodies. This table also includes species-specific best management practices to avoid or lessen impacts from chemical treatment activiti

Species	Vulnerabilities	Potential Effects on Key Life Stages	Potential E H
Ungulates **Toxicity of potash to ungulates:** There is no published information on the effects of potash on any life stage of ungulates, or this particular ungulate species. **Toxicity of EarthTec QZ™ to ungulates:** There is no published information on the effects of EarthTec QZ™ on ungulates, however, sheep can be particularly se copper excretion (Oruc et al. 2009). The toxic doses of copper sulfate for cattle are 200–880 mg/kg. Sheep are ten times more sensitive; they have a toxic d **Toxicity of Zequanox to ungulates:** There is no published information on the effects of Zequanox® on any life stage of ungulates, or this particular ungulate sp			
Columbian white-tailed deer (*Odocoileus virginianus leucurus*)	Riparian access development could fragment habitat. Restoration activities could introduce invasive species and cause fragmentation of habitats.	Columbian white-tailed deer are not found in CRB water bodies; they are found in riparian areas associated with the Lower Columbia River. Thus, no life stage of this species would be present in a water body where application of any of the proposed chemical treatments would occur. It is unlikely any potash treatment would occur within the Columbia River system unless the area was capable of being cordoned off prior to treatment (this would avoid/lessen any indirect impacts to ungulates).	No critical hal
Birds **Toxicity of potash to birds:** There is no published information on the potential negative effects of potash on least terns, piping plovers, red knots, western sno chloride (KCl) is used as a supplement (0.2 and 0.4% KCl) in diet or drinking water to reduce the effects of high environmental temperature on poultry by mo **Toxicity of EarthTec QZ™ to birds:** There is limited information is available on the toxicity of copper sulfate to wild birds (Eisler 1998). A flock of captive 3-week copper sulfate; Ten of the geese died nine hours after ingestion of roughly 600 mg/kg copper sulfate (Henderson and Winterfield 1995). Although copper is poses less of a threat to birds than to other animals - The lowest lethal dose (LDLo) for this material in pigeons and ducks is 1,000 mg/kg and 600 mg/kg, resp mallards is 2,000 mg/kg (Tucker and Crabtree 1970). The toxicity of copper to aquatic life depends on its bioavailability, which is strongly dependent on pH, the presence of dissolved organic carbon (DOC), ar (http://npic.orst.edu/factsheets/archive/cuso4tech.html). **Toxicity of Zequanox to birds:** Zequanox has a "practically non-toxic" designation for birds. No mortality was observed after feeding mallards a 2,000 mg/kg The no observable effect limit (NOEL) was set at >2,000 mg/kg and classified Zequanox as "practically non-toxic to mallard."			
Least tern (*Sterna antillarum*)	Anthropogenic disturbance is a key factor affecting least terns at breeding colonies and foraging locations (Burton and Terrill 2012).	Potash—Interior least terns forage on small fish. Numerous studies have demonstrated acute toxicity to fish from muriate of potash, however, mortality	No critical hal

Species	Vulnerabilities	Potential Effects on Key Life Stages	Potential E H
	Terns mid-May through August on river sandbars. Increased turbidity may negatively affect least tern foraging success (USFWS 1990).	occurred at dosages that far exceed dosages that would be used to control dreissenids (e.g., bluegill, *Lepomis macrochirus*), 96 hours @ LC_{50} @ 2,010 mg/L (Mosaic 2004). It is unlikely that an application of muriate of potash would affect the food of interior least terns. Anthropogenic disturbance associated with a potash application could affect least tern nesting and foraging success. EarthTec QZ™—Interior least terns forage on small fish. EarthTec QZ™ is toxic to fish and other aquatic life (Master Label for EarthTec™, EPA Reg. No. 64962-1). Waters treated with this product may be hazardous to other aquatic organisms (Master Label for EarthTec QZ™, EPA Reg. No. 64962-1). It is estimated that EarthTec QZ™ could affect the foraging success of least terns if the product were applied in water bodies in which least terns feed. Zequanox®—Zequanox® would likely not affect least terns.	
Piping plover (*Charadrius melodus*)	Disturbance to nesting plovers Introduction of beachgrass Invertebrate prey mortality	Potash—Piping plovers consume invertebrates. Potash has the potential to affect the prey base of shorebirds in small, shallow water areas where potash is applied. Examples of ecotoxicity of muriate of potash on invertebrates is 48 hours @ EC_{50} @ 337–825 mg/L (*Daphnia magna*), and 96 hours @ LC_{50} @ 940 mg (*Physa heterostropha*) (Mosaic 2004). However, given the mobility of the bird, it is not expected that an action in a shallow portion of a CRB water body would affect the ability of the bird to feed in and around untreated areas of that same water body, and adjacent water bodies. Any effects on prey species (invertebrates) are expected to be minimal long-term because benthic communities typically recolonize quickly after disturbance (McCauley et al. 1977, Albright and Borithilette 1982, Romberg et al. 1995, Wilson and Romberg 1996). EarthTec QZ™—Piping plovers consume invertebrates. EarthTec QZ™ has the potential to affect the prey base of shorebirds in small, shallow water areas where it is applied. Zequanox®—Piping plovers consume invertebrates. Zequanox has the potential to affect the prey base of	Critical habita River Basin is i MT-2 (The Miss through the A Tribes of Fort F lands, state la land) and Uni Reservoir – 77, Charles M. Ru Wildlife Refug critical habita in the CRB. The Missouri Ri Reservoir are s introduction o dreissenids (C Strategies, LLC habitat for pip affected by re prey base cau potential che EarthTec QZ o

Species	Vulnerabilities	Potential Effects on Key Life Stages	Potential E… H…
		shorebirds in small, shallow water areas where it is applied.	
Red knot (*Calidris canutus rufa*)	Disturbance to migratory birds. Introduction of invasive species Invertebrate prey mortality Red knots are rarely observed from May through October in Montana wetlands. At other times of the year, they are found in marine coastal environments.	Potash—Potash has the potential to affect the prey base of shorebirds in small, shallow water areas where potash is applied. EarthTec QZ™—EarthTec QZ™ has the potential to affect the prey base of shorebirds in small, shallow water areas where it is applied. Zequanox®—Red knots consume invertebrates. Zequanox has the potential to affect the prey base of shorebirds in small, shallow water areas where it is applied. However, given the mobility of the bird, it is not expected that an action in a shallow portion of a CRB water body would affect the ability of the bird to feed in and around untreated areas of that same, and adjacent water bodies. Red knots are migratory; they are rarely observed in Montana wetlands.	No critical hal…
Yellow-billed cuckoo (*Coccyzus americanus*)	Degradation of riparian habitat.	The primary diet of yellow-billed cuckoos is caterpillars, which would not be affected by an action involving potash, EarthTec QZ™, or Zequanox®. It is unlikely that chemical treatments would occur in rivers and streams and in broad floodplains. If a treatment were to occur in a large river system, it could only occur in a small area that could be cordoned off for treatment.	Critical habita… habitat along… (surface slope… percent) river… in open riverin… provide wide… conditions (gr… (100 m)). Rive… lower gradien… valleys with a… are essential p… biological fea… (Federal Regis… Riparian habit… be affected b… treatment, po… followed that… to these area…

Amphibians

Toxicity of potash to amphibians: Pollution is the 2nd major threat to amphibian populations (IUCN 2008). Agricultural chemicals are a potential cause of amp… have been reported to occur in agricultural areas where pesticides and fertilizers are applied extensively (Ouellet et al. 1997, Taylor et al. 2005). Agricultural… and behavior (Carey and Bryant 1995). There is no published information on the potential negative effects of potash on amphibian populations, however, i… and in shallow portions sectioned off with barriers, would raise the water temperature, albeit temporarily (note: Potash itself would not alter the water tempe… water temperature in the barricaded portion because of lack of mixing with deeper, colder water in the water body).

Species	Vulnerabilities	Potential Effects on Key Life Stages	Potential E H
Toxicity of EarthTec QZ™ to amphibians: Larval ambystomatids were highly sensitive to Cu with 50% mortality at 18.7, 35.3, and 47.9 ppb for three species. Cu Ecological Laboratory 2016). Concentrations of copper sulfate were found to be toxic to amphibians at or below those recommended for plant control – 0.31 mg/L was lethal to norther mg/L for embryos, and 0.20 mg/L for 12-16 day-old tadpoles of African clawed frogs (*Xenopus laevis*) were determined by Fort and Stover (1997) – they not frogs was reduced at concentrations as low as 0.048 mg/L, and completely inhibited at 1.3 mg/L in embryos (Fort and Stover 1997). Distal hind limb aplasia, larvae exposed to 0.05 mg/L copper (Fort and Stover 1997). **Toxicity of Zequanox to amphibians:** There is no published information on the toxicity of Zequanox to amphibians.			
Oregon spotted frog (*Rana pretiosa*)	Disturbance, including ground disturbance (e.g., road grading) during breeding and larval development. Alterations to existing habitats, including loss of connectivity, disturbance to riparian vegetation, sedimentation, vegetation clearing in and adjacent to breeding ponds and streams, fluctuating water levels, and temperature changes. The Oregon Spotted Frog is a wetland/marsh specialist that prefers floodplain wetlands, side channels, and sloughs associated with permanent waterbodies. Habitats have good solar exposure with low to moderate amounts of cover by emergent vegetation (25–50%; Watson et al. 2003), and silty, rather than gravelly substrate. Habitat requirements are divided into three life-seasons: breeding (oviposition) and early larval habitat, active summer habitat, and overwintering habitat. Dispersal/connective habitat is required to link the three main habitat types during late spring and fall. Breeding and early larval habitat: • areas that experience shallow inundation (3° C in March/April (Environment Canada 2014); and • contain indigenous aquatic vegetation (e.g., rushes, sedges, grasses, pondweeds, buttercups) or moderate amounts of Reed Canarygrass (*Phalaris* spp.). Active Season (summer) habitat: • wetlands that are >40 cm deep (Watson et al. 2003, Environment Canada 2014); and • contain moderately dense, structurally diverse	Oregon spotted frog habitat is closely correlated with the type of habitat a dreissenid action would occur in (i.e., shallow water along a wetland edge). Potash—It is estimated that the addition of potash to a water body occupied by Oregon spotted frog could potentially affect the growth, development, reproduction, and behavior of individuals. EarthTec QZ™—It is estimated that the application of EarthTec QZ™ to a water body occupied by Oregon spotted frog would be toxic to various life stages of this species. EarthTec QZ could affect breeding, larval, and adult stages of Oregon spotted frogs. Zequanox®—Unknown.	65,038 acres c in Whatcom, S Skamania, an in Washington Deschutes, Kl Jackson coun See Vulnerabi for a descripti early larval ha season, over-v dispersal-conn Potash—Pota water temper barricaded fo could affect b larval habitat, habitat, and o EarthTec QZ™ could affect s emergent, an vegetation im breeding and habitats, activ and over-wint Zequanox®—

Species	Vulnerabilities	Potential Effects on Key Life Stages	Potential E H
	submergent, emergent, and floating vegetation (Licht 1969, 1986a,b; McAllister and Leonard 1997, Popescu 2012). Over-winter habitat: • springs, seeps, or low-flow channels that do not freeze in the winter and have more stable levels of dissolved oxygen than other areas (Pearl and Hayes 2004); or • in deeper water, beaver dams or areas of dense submerged vegetation (Hayes et al. 2001, Watson et al. 2003, Chelgren et al. 2006, Govindarajulu 2008, Pearson 2010, COSEWIC 2011). Dispersal/connective habitat: • any aquatic habitat that connects the three main habitat types during late spring and fall.		

Fish

Toxicity of potash to fish: Based upon the acute toxicity testing of KCl using both juvenile brook trout and juvenile Chinook salmon, acute lethal effects of po concentrations commonly used to control invasive dreissenid mussels (100 mg/L) (Densmore et al. 2018). Exposure concentrations of as much as 800 mg/L K applied to these fish in static systems for 96 hours; there was no evidence of mortality attributable to KCl exposure among either species (Densmore et al. 20 based molluscicide applications at levels up to 800 mg/L were also not indicated (Densmore et al. 2018). Several listed fish species forage on invertebrates, potash on invertebrates is 48 hours @ EC_{50} @ 337–825 mg/L (*Daphnia magna*), and 96 hours @ LC_{50} @ 940 mg (*Physa heterostropha*) (Mosaic 2004). Daphniic sensitive aquatic invertebrates is not expected at the KCl concentrations used to control dreissenids (Densmore et al. 2018). Crayfish exposure trials resulted mg/L for at least 24 hours (Densmore et al. 2018). Other ecotoxicology studies: *Lepomis macrochirus* – LC_{50} – 2010 mg/L (Mosaic 2014). Substantial difference introduced toxins, such as potassium, calcium, and magnesium (Pillard et al. 2000).

Toxicity of EarthTec QZ™ to fish: According to the label for this product, "this pesticide is toxic to fish and aquatic invertebrates. Waters treated with this proc weeds and algae can result in oxygen loss from decomposition of dead algae and weeds. This oxygen loss can cause fish and invertebrate suffocation." Th salmonid and prey LC_{50} (96 hour), and the LC_{50} (96 hour) for pond snails falls at the lowest proposed application rate (TOXNET). Direct bioassay of rainbow tr mg/L copper, and LC_{50} of 0.294 mg/L copper (https://www.icais.org/pdf/2017presentations/Monday/PM/1B/230_Hammond.pdf) which are both above the reported after copper sulfate applications for algae control in ponds and lakes, however, oxygen depletion and dead organisms clogging the gills have be plant death and decomposition in the water body (Bartsch 1954, Hanson and Stefan 1984, Masser et al. 2006). Copper also disrupts olfaction in fish, possibly streams (Chapman 1978, Jaensson and Olsen 2010).

Fish eggs are more resistant than young fish fry to the toxic effects of copper sulfate (Gangstad 1986).

- Juvenile rainbow trout (*Oncorhynchus mykiss*) were exposed to either hard water or soft water spiked with copper for 30 days (Taylor et al. 2000). Fish increased sensitivity to copper.
- The mean 96-hour LC_{50} (with 95% confidence limits) for copper exposure in alevin, swim-up, parr and smolt steelhead (*Salmo gairdneri*) are 28 (27–30 and Lin 2001). The mean 96-hour LC_{50} for copper exposure in alevin, swim-up, parr and smolt Chinook salmon (*Oncorhynchus tshawytscha*) are 26 (2 The experiments were done by adding copper as $CuCl_2$.
- The 48-hour LC_{50} for fathead minnow (*Pimephales promelas*) is 19.2 ± 3.1 (mean ± SD) mcg/L Cu (Mastin and Rodgers 2000).

Toxicity of Zequanox to fish: No mortality from Zequanox has been observed in fathead minnows (*Pimephales promelas*), young-of-the-year brown trout (*Sa* of Reclamation 2011). Fish trials conducted with dead bacteria have indicated that applications of killed cells were harmless to fish, yet were still highly letha

Species	Vulnerabilities	Potential Effects on Key Life Stages	Potential E H
but substantial, reductions in dissolved oxygen were observed in treatment locations during the morning following Zequanox treatment in two trials, likely du from circulating into treatment zones from adjacent areas in the lake (Whitledge et al. 2015). A 2018 study evaluated the effects of Zequanox on juvenile lake sturgeon (*Acipenser fulvescens*) and lake trout (*Salvelinus namaycush*) (Luoma et al. 2018) latent mortality was observed in lake trout that were exposed to the highest dose of Zequanox. Statistically significant but biologically minimal differences w sturgeon at the termination of the 33 d post-exposure observation period. Survival was not impacted in the lake trout 100 mg/L treated group for the first 3 w Zequanox exposure. Poor food consumption, emaciation, and abdominal hemorrhaging were observed about 3 to 4 weeks after exposure in some of the l Cold water, cool water, and warm water fish were tested for exposure-related effects to *Pseudomonas fluorescens*, Strain CL145A. (Luoma et al. 2015). Ana continuous dose of SDP affected all species. Calculated concentrations of SDP that would be lethal to 50 percent of the test animals (LC_{50}) for the cold wat respectively. The LC_{50}'s for the cool water species were 185.4, 176.9 and 8.9 mg/L for yellow perch, walleye, and lake sturgeon, respectively. The LC_{50}'s for th bass, smallmouth bass, and channel catfish, respectively.			
Bull trout (*Salvelinus confluentus*)	Threats to any of the nine Primary Constituent Elements[17]: 1. Springs, seeps, groundwater sources, and subsurface water connectivity 2. Migration habitats 3. Food base 4. Complex aquatic environments 5. Water temperature 6. Spawning and rearing habitat 7. A natural hydrograph 8. Sufficient water quality and quantity 9. Sufficient low levels of occurrence of non-native predatory fish, or competing fish species	Disturbance to any water body can increase sedimentation and suspended solids, which can be detrimental to fish, resulting in lethal effects, sublethal effects that alter the physiology of the fish, and behavioral effects that change the activity of the fish and could contribute to mortality through time (Newcombe and MacDonald 1991). Increased turbidity can cause behavioral changes to fish, including stress, reduced feeding, impacts to growth rates, interference with cues necessary in homing and migration, and death (Lloyd 1987). Bull trout are highly susceptible to sediment inputs (USFWS 1998a, Bash et al. 2001). Young bull trout less than 200mm in length forage on invertebrates. Potash—Adult bull trout in the vicinity of the action area would have sufficient ability to avoid the area; any long-term effects on prey species are expected to be minimal because benthic communities typically recolonize quickly after disturbance (McCauley et al. 1977, Albright and Borithilette 1982, Romberg et al. 1995, Wilson and Romberg 1996). However, there may be short-term effects on invertebrate species, which may affect the foraging ability of juvenile bull trout. EarthTec QZ™—All life history stages of bull trout area expected to be negatively affected by the addition of EarthTec QZ™ to a water body.	Potash—Of th could potenti migration hab temperature, rearing habita altering the w during critical shallow portio bodies. EarthTec QZ— EarthTec QZ™ detrimentally habitats, food aquatic enviro spawning and Zequanox—N PCEs would lik Zequanox.

[17] Primary constituent elements are physical and biological features that are essential to the conservation of the species. These include, but are not limited to
water, or other nutritional or physiological requirements; cover or shelter; sites for breeding, reproduction, or rearing of offspring; and habitats that are protec
ecological distributions of a species.

Species	Vulnerabilities	Potential Effects on Key Life Stages	Potential E H
		Zequanox—Bull trout are expected to be negatively affected by Zequanox based on the sensitivity of rainbow and brook trout to this chemical.	
Kootenai River white sturgeon (*Acipenser transmontanus*)	Spawning and rearing habitat are the key limiting factors for Kootenai River White Sturgeon. Spawning and incubation occur from mid-May to August (Duke et al. 1999, Kootenai Tribe of Idaho 2005). Recruitment failure is caused by egg or larval suffocation, predation, and/or other mortality factors associated with early life stages (Anders 1991, Anders and Richards 1996, Duke et al. 1999, USFWS 1999b, Paragamian et al. 2001, Anders 2002). Low turbidity increases predation (KTOI 2005).	Potash—Based on recent studies with salmonids (Densmore et al. 2018), the introduction of potash to Kootenai River white sturgeon habitat, at the levels sufficient to cause dreissenid mortality, would likely not affect this species. Studies on the addition of potassium permanganate to African catfish (*Clarias gariepinus*) eggs improved hatchability (Rasowo et al. 2007). EarthTec QZ™—All stages of white sturgeon are expected to be negatively affected by the addition of EarthTec QZ™ to a water body from direct application of the product, and expected reduction in oxygen after the product has been applied. Zequanox—Small Zequanox applications are not likely to have long-term water quality impacts such as ammonia toxicity (Meehan et al. 2014; Whitledge et al. 2015). However, the impacts of largescale, open-water applications of Zequanox on water quality remain largely unknown (Luoma et al. 2018). The LC_{50} for lake sturgeon was 8.9mg/L (Luomo et al. 2015).	Kootenai Rive critical habita miles of the Ko Critical habita the braided re at river mile 1 confluence w and extends a the Kootenai meander rea 141.4 below S Spawning hab gravel substra habitats are k critical habita
Lahontan cutthroat trout (*Oncorhynchus clarki henshawi*)	Major impacts to habitat and abundance include: 1) reduction and alteration of stream discharge; 2) alteration of stream channels and morphology; 3) degradation of water quality; 4) reduction of lake levels and concentrated chemical components in natural lakes; and 5) introductions of non-native fish species (Coffin and Cowan 1995). LCT spawn in cold, flowing streams.	Potash—Based on recent studies with salmonids (Densmore et al. 2018), the introduction of potash to LCT, at the levels sufficient to cause dreissenid mortality, would likely not affect adults. Degradation of water quality and chemical composition of lake water are two key impacts that affect habitat and species abundance of Lahontan cutthroat trout (Coffin and Cowan 1995); therefore, introduction of potash to LCT habitat/water bodies could temporarily affect this species. EarthTec QZ™—All stages of Lahontan cutthroat trout are expected to be negatively affected by the addition of EarthTec QZ™ to a water body from direct application of the copper-based product as well as an expected reduction in oxygen after the product has been applied. Zequanox®—Zequanox could temporarily reduce the dissolved oxygen in the treatment area of the water body, thus it has the potential to affect this species.	No critical ha

Species	Vulnerabilities	Potential Effects on Key Life Stages	Potential E H
Lost River sucker (*Deltistes luxatus*) Shortnose sucker (*Chasmistes brevirostris*)	Life history information from USFWS (1993): Lost River and shortnose suckers have complex life histories that include stream/river, lake, marsh, and shoreline habitats. Both spawn during the spring over gravel substrates in habitats less than 4.3 ft (1.3 m) deep in tributary streams and rivers. A smaller number of Lost River sucker also spawn over gravel substrates at shoreline springs along the margins of Upper Klamath Lake. Lost River sucker spend most of their lives within lakes although they primarily spawn in streams in late winter and early spring in major tributaries to lakes where they occur (Moyle 2002). A subpopulation of Lost River sucker uses spring areas within Upper Klamath Lake for spawning (Janney et al. 2009). After hatching, larval Lost River sucker drift downstream within spawning tributaries and reach lakes by spring. Larval habitat is generally along the shoreline, in water 6–20 inches deep where emergent vegetation provides cover from predators, protection from currents and turbulence, and abundant food (Cooperman and Markle 2004). As larval suckers grow into the juvenile stage, they increasingly use deeper habitat with and without emergent vegetation. Adult Lost River sucker primarily use deep (greater than 6.6 ft), open-water habitat as well as spring-influenced habitats that act as refugia during poor water quality events (Banish et al. 2009).	Adults of these species generally occupy deep water habitats, and could move to other habitats within a larger water body during a chemical application. Potash—Based on recent studies with salmonids (Densmore et al. 2018), the introduction of potash to LCT, at the levels sufficient to cause dreissenid mortality, would likely not affect adults. Juveniles of these species would use locations where a potash application would likely occur, i.e., shallow water areas. The invertebrate prey base would likely be affected by a potash application, which could affect the survivability of larval and juvenile suckers. Any long-term effects on prey species are expected to be minimal because benthic communities typically recolonize quickly after disturbance (McCauley et al. 1977, Albright and Borithilette 1982, Romberg et al. 1995, Wilson and Romberg 1996). EarthTec QZ™—All stages of Lost River and Shortnose Sucker are expected to be negatively affected by the addition of EarthTec QZ™ to a water body from direct application of the coppr-based product as well as an expected reduction in oxygen after the product has been applied. Zequanox®—It is unknown what effect Zequanox® may have on sucker populations as no specific studies have been conducted. Zequanox could temporarily reduce the dissolved oxygen in the treatment area of the water body, thus it has the potential to affect this species.	About 146 mil 117,848 acres reservoirs for L about 136 mil 123,590 acres reservoirs for s Klamath and Oregon have critical habita
Pallid sturgeon (*Scaphirhynchus albus*)	Habitat includes large, free-flowing, warm-water, and turbid rivers with a diverse assemblage of dynamic physical habitats including floodplains, backwaters, chutes, sloughs, islands, sandbars, and a dynamic main channel (FWS ECOS database). Juvenile and adult Pallid sturgeon rarely observed in habitats lacking flowing water which are removed from the main channel (i.e., backwaters and sloughs).	Potash—Based on recent studies with salmonids (Densmore et al. 2018), the introduction of potash to LCT, at the levels sufficient to cause dreissenid mortality, would likely not affect adults. Juvenile and adult fish mobility would allow fish to move out of the action site prior to potash application. EarthTecQZ™—All stages of pallid sturgeon are expected to be negatively affected by the addition of EarthTec QZ™ to a water body from direct application of the product as well as an expected reduction in oxygen after the product has been applied. Juvenile	No critical hal

Species	Vulnerabilities	Potential Effects on Key Life Stages	Potential E... H...
		and adult fish mobility would allow fish to move out of the action site prior to an EarthTec QZ™ application. Zequanox—Zequanox could temporarily reduce the dissolved oxygen in the treatment area of the water body, thus it has the potential to affect this species.	
Warner sucker (*Catostomus warnerensis*)	When adequate water is present, Warner suckers may inhabit all the lakes, sloughs, and potholes in the Warner Valley. Habitat includes lakes, ephemeral bodies of water, streams, beaver ponds, and pools and runs of streams and large irrigation canals (Lee et al. 1980, Page and Burr 2011). Adults in streams tend to be in pools. In lakes, suckers are generally found in the deepest available water (generally less than 3.4 meters deep) where food is plentiful (USFWS 1998b). The feeding habits of the Warner sucker depend to a large degree on habitat and life history stage, with adult suckers becoming more generalized than juveniles and young-of-year. Young suckers feed on planktonic crustaceans, but as they mature, they develop a subterminal mouth and become primarily benthic feeders eating diatoms, filamentous algae, and detritus.	Potash—Warner suckers would be found in areas where a potash application would occur, especially given the shallow nature of the water bodies in the Warner Valley. Based on recent studies with salmonids (Densmore et al. 2018), the introduction of potash to LCT, at the levels sufficient to cause dreissenid mortality, would likely not affect adults. The introduction of potash, at concentrations sufficient to cause dreissenid mortality, could actually stimulate phytoplankton production. EarthTec QZ™—All stages of Warner sucker are expected to be negatively affected by the addition of EarthTec QZ™ to a water body from direct application of the product as well as an expected reduction in oxygen after the product has been applied. Juvenile and adult fish mobility would allow fish to move out of the action site prior to an EarthTec QZ™ application. Zequanox®—Zequanox® could temporarily reduce the dissolved oxygen in the treatment area of the water body, thus it has the potential to affect this species.	Critical habita... sucker include... streams in Lak... and 80 feet o... stream banks:... Twelvemile Cr... miles of Twent... stream miles o... north of Hart L... of Snyder Cre... miles of Honey... foot riparian z... of the streams... protect the in... ecosystem.

Aquatic invertebrates Toxicity of potash to mollusks: Freshwater mollusks are particularly sensitive to environmental change, which has made them the most threatened fauna in N potassium concentrations decreased the diversity of mussel populations in the Missouri River Basin (Imlay 1973). Any river or stream with a potassium concen mussels could be found in rivers with concentrations of less than 4 mg/L (Imlay 1973). Toxicity studies using two bivalves—Alabama Rainbow (*Villosa nebulos* Round Rocksnail (*Leptoxis ampla*), and Pebblesnail (*Somatogyrus* spp.) concluded that native mussels may be more sensitive to potassium than zebra muss *vibex*) mussels—the authors suggested potassium should not be used as a molluscicide (Gibson et al. 2018). Alabama Rainbow had an EC_{50} value of 15,966 EC_{50} value of 11,938µg/L (95% CI = 10,089–14,134 µg/L). Mn EC50 value could not be calculated for Round Rocksnail, however it is expected to be much mo 100µg/L, 50% of the test organisms were classified as dead at the end of the trial but only a third of the test organisms died at the highest concentration (10 Partial kills (≤33%) were observed at all 5 concentrations. The pebblesnails had an EC_{50} value of 7285 µg/L (95% CI = 5739–9245µg/L), which is lower than eith Toxicity of EarthTec QZ™ to invertebrates and mollusks: EarthTec QZ™ is toxic to invertebrates. The 48-hour LC_{50} for the non-biting midge (*Chironomus tentan* Reported 48-hour LC_{50} concentrations for *Daphnia magna* include 0.00115 mmol CuSO4/L85 and 18.9 ± 2.3 (mean ± SD) µg/L Cu (Mastin and Rodgers 2000) hours. Reported values were 21-31 µg/L, 20-31 µg/L, and 20-29 µg/L, respectively (Ingersoll and Winner 1982). The 24- and 48-hour EC50(with 95% confidence 0.039) mg/L Cu, respectively (de Oliveira-Filho et al. 2004). Copper disrupts surface epithelia function and peroxidase enzymes in mollusks (USEPA 2009). Aquatic snails (*Biomphalaria glabrata*) had a 24-hour and 48-h (0.297-0.706) mg/L Cu, respectively (de Oliveira-Filho et al. 2004). 1-day-old freshwater snail eggs (*Lymnaea luteda*) were exposed to copper at concentrati embryo toxicity test (Khangarot and Das 2010). Embryos exposed to copper at 100 to 320 µg/L died within 168 hours. At lower doses from 3.2-10 µg/L, signific Toxicity of Zequanox to mollusks/mussels/invertebrates: Exposure to Zequanox caused no mortality to blue mussels (*Mytilus edulis*) or any of six native North A *compressa, Strophitus undulatus, Lampsilis radiata, Pyganodon cataracta*, and *Elliptio complanata*) (US Bureau of Reclamation 2011). Exposure of duck mus white-clawed crayfish (*Austropotamobius pallipes*) to Zequanox in a 72-hour static renewal toxicity test at concentrations of 100-750mg active ingredient/lit plumosus: 1075mg active ingredient/liter, and A. pallipes: ≥750mg active ingredient/liter, demonstrating that Zequanox does not negatively affect these spe mortality (i.e., 150mg active ingredient/liter) (Meehan et al. 2014). Nicholson (2018) conducted a replicated aquatic mesocosm experiment using open-water applications of Zequanox® (100 mg/L of the active ingredient) macroinvertebrates to Zequanox® exposure in a complex aquatic environment. Short-term increases occurred in phytoplankton and periphyton biomass (2 controls), and insect emergence (490% of controls). Large declines initially occurred among small cladoceran zooplankton (88–94% reductions in *Chydorus* abundances generally rebounded within three weeks. Declines also occurred in amphipods *Hyalella azteca* (mean abundance 77% less than controls) and recover during the experiment. Short-term impacts to water quality included a decrease in dissolved oxygen (minimum 1.2 mg/L), despite aeration of the m			
Banbury Springs limpet (*Lanx* spp.)	Potash is lethal to mollusks. Although vulnerability to a potash application is very high, the likelihood of dreissenids establishing in the habitat type for this mollusk is low.	At the concentrations used to cause 100% mortality to dreissenids, potash would likely cause 100% mortality to mollusks, which demonstrate higher sensitivities to potash than dreissenids (Gibson et al. 2018).	No critical ha
Bliss Rapids snail (*Taylorconcha serpenticola*)	Potash is lethal to mollusks. Although vulnerability to a potash application is very high, the likelihood of dreissenids establishing in the habitat type for this mollusk is low.	At the concentrations used to cause 100% mortality to dreissenids, potash would likely cause 100% mortality to mollusks, which demonstrate higher sensitivities to potash than dreissenids (Gibson et al. 2018).	No critical ha
Snake River physa snail (*Physa natricina*)	Potash is lethal to mollusks. Although vulnerability to a potash application is very high, the likelihood of dreissenids establishing in the habitat type for this mollusk is low.	At the concentrations used to cause 100% mortality to dreissenids, potash would likely cause 100% mortality to mollusks, which demonstrate higher sensitivities to potash than dreissenids (Gibson et al. 2018).	No critical ha

Plants Toxicity of potash to plants: Potassium plays a critical role in plant growth and metabolism, and contributes to the survival of plants under abiotic or biotic str environment (Truong 2017). At the concentrations used to kill dreissenids, potash would not negatively affect these plant species because of the demonstra al. 2013). Toxicity of EarthTec QZ™ to plants: One of the limiting factors in the use of copper compounds is their serious potential for phytotoxicity, or poisonous activity photosynthesis. 200 ppm of copper was found in grass five months after it was sprayed with copper sulfate to control liver fluke (TOXNET 1975–1986). Blue-gre become increasingly resistant to the algaecide after 26 years of use (Pimental 1971). Toxicity of Zequanox® to plants: Phytotoxicity (degree of toxic effects to plants) of microbial suspensions of Zequanox® were tested on some of the most co water plantain (*Alisma plantago-aquatica*), small-flower umbrella sedge (*Cyperus difformis*), nightshade, bindweed, mallow, and curly dock (*Rumex crispis*; water and sprayed on the plant species. No phytotoxic symptoms were observed at either test concentration in any of the tested plants.			
Bradshaw's desert parsley (*Lomatium bradshawii*)	Saturated, or flooded prairies adjacent to creeks and small rivers in the Willamette Valley are a habitat type that is declining because of agriculture and development. Restoration activities could introduce invasive species and cause fragmentation of habitats	The majority of Bradshaw's lomatium populations occur on seasonally saturated or flooded prairies, adjacent to creeks and small rivers in the southern Willamette Valley. Any chemical application would not occur in this specific habitat type, but could occur along a small river adjacent to this habitat type. Disturbance to the site and damage to any existing plants as a result of equipment use and access to the water body could detrimentally affect individual plants.	No critical hal
Nelson's checker-mallow (*Sidalcea nelsoniana*)	Nelson's checker-mallow most frequently occurs in Oregon ash (*Fraxinus latifolia*) swales and meadows with wet depressions, or along streams. The species also grows in wetlands within remnant prairie grasslands. Some populations occur along roadsides at stream crossings where non-native plants, such as reed canarygrass (*Phalaris arundinacea*), blackberry (*Rubus* spp.), and Queen Anne's lace (*Daucus carota*), are also present. Nelson's checkermallow primarily occurs in open areas with little or no shade and will not tolerate encroachment of woody species. Restoration activities could introduce invasive species and cause fragmentation of habitats.	Any chemical application would not occur in the habitat type for Nelson's checker-mallow, however, an application could occur in streams adjacent to this habitat type. Disturbance to the site and damage to any existing plants as a result of equipment use and access to the water body could detrimentally affect individual plants.	No critical hal
Ute Ladies'-tresses (*Spiranthes diluvialis*)	The orchid occurs along riparian edges, gravel bars, old oxbows, high flow channels, and moist to wet meadows along perennial streams. It typically occurs in stable wetland and seepy areas associated with old landscape features within historical floodplains of major rivers. It also is found in wetland and seepy areas near freshwater lakes or springs. Restoration activities could introduce invasive species and cause fragmentation of habitats	Any chemical application would not occur in the habitat type for Ute Ladies'-tresses, however, an application could occur in an adjacent freshwater lake, perennial stream, oxbow, or river. Disturbance to the site and damage to any existing plants as a result of equipment use and access to the water body could detrimentally affect individual plants.	No critical hal

Water howellia (*Howellia aquatilis*)	This species is restricted to small, vernal, freshwater wetlands, glacial pothole ponds, or former river oxbows that have an annual cycle of filling with water over the fall, winter and early spring, followed by drying during the summer months (USFWS ECOS database). These habitats are generally small [< 2.47 ac] and shallow [< 3.3 ft]. Howellia was found in shallow water or around the edges of deep ponds. Restoration activities could introduce invasive species and cause fragmentation of habitats	Disturbance to the site and damage to any existing plants as a result of equipment use and access to the water body could detrimentally affect individual plants.	No critical hal
Willamette daisy (*Erigeron decumbens* var. *decumbens*)	Willamette daisy populations are known mainly from bottomland habitats, but one population is found in an upland prairie remnant. Restoration activities could introduce invasive species and cause fragmentation of habitats	None of the proposed three chemicals would not negatively affect Willamette daisy at the concentrations used to kill dreissenids. Disturbance to the site and damage to any existing plants as a result of equipment use and access to the water body could detrimentally affect individual plants.	Critical habita daisy is locate Yamhill, Lane, Douglas Coun well as Lewis C Washington. C includes wet p suitable habit

Table 4 References

Albright, R., and P.K. Borithilette. 1982. Benthic Invertebrate Studies in Grays Harbor, Washington. Washington State Department of Game, Aberdeen, Washington.

Anders, P.J. 1991. White sturgeon (*Acipenser transmontanus*) movement patterns and habitat utilization in the Kootenai River system, Idaho. Montana, and British Columbia. MS Thesis. Eastern Washington University. Cheney, WA. 153 pp.

Anders, P.J. 2002. Biological characterization of white sturgeon (*Acipenser transmontanus*). Chapter 1 (Pages 1-32) in: Conservation Biology of White Sturgeon. Ph.D. Dissertation, University of Idaho, Aquaculture Research Institute, Center for Salmonid and Freshwater Species at Risk. Moscow, ID. 221 pp.

Anders, P., and D. Richards. 1996. Implications of Ecosystem Collapse on White Sturgeon *(Acipenser transmontanus)* in the Kootenai River, Idaho, Montana, and British Columbia. In: Proceedings of the International Congress on the Biology of Fishes, San Francisco State University, CA. July 14–18, 1996. pp. 27–40.

Banish, N.P., B.J. Adams, R.S. Shively, M.M. Mazur, D.A. Beauchamp, and T.M. Wood. 2009. Distribution and habitat associations of radio-tagged adult Lost River and shortnose suckers in Upper Klamath Lake, Oregon. Transactions of the American Fisheries Society 138:153–168.

Bartsch, A.F. 1954. Practical methods for control of algae and water weeds. *Public Health Rep.* 69(8):749–57.

Bash, J., C. Berman, and S. Bolton. 2001. Effects of turbidity and suspended solids on salmonids. A report prepared for the Washington State Transportation Commission.

Boone, C., C. Bond, K. Buhl, and D. Stone. 2012. *Copper Sulfate General Fact Sheet*; National Pesticide Information Center, Oregon State University Extension Services. http://npic.orst.edu/factsheets/cuso4gen.html.

Bureau of Land Management. 2008. Richfield Field Office, Proposed Resource Management Plan and Final Environmental Impact Statement. BLM-UT-PL-08-004-1610, UT-050-2007-090 EIA, FES 08-25.

Burton, R.K., and S.B. Terrill. 2012. Least tern literature review and study plan development. Final Report by H.T. Harvey & Associates to the US Army Corps of Engineers. File 3081. 54pp.

Carey, C., and C.J. Bryant. 1995. Possible interrelations among environmental toxicants, amphibian development, and decline of amphibian populations. *Environmental* Health Perspectives 103, 13–17.

Chapman, G.A. 1978. Toxicities of Cadmium, Copper, and Zinc to Four Juvenile Stages of Chinook Salmon and Steelhead. *Trans. Am. Fish. Soc.* 107(6):841–847.

Chelgren, N.D., C.A. Pearl, J. Bowerman, and M.J. Adams. 2006. Oregon Spotted Frog (*Rana pretiosa*) movement and demography at Dilman Meadow: implications for future monitoring. U.S. Geological Survey, Reston, VA.

Chen, J.-C., and C.H. Lin. 2001. Toxicity of copper sulfate for survival, growth, molting and feeding of juveniles of the tiger shrimp, *Penaeus monodon*. *Aquacult.* 192(1):55–65.

Coffin, P.D., and W.F. Cowan. 1995. Lahonton Cutthroat Trout (*Oncorhynchus clarki henshawi*) Recovery Plan. Prepared for Region 1 US Fish and Wildlife Service. 89pp.

Cooperman, M.S., and Markle, D.F., 2004, Abundance, size and feeding success of larval shortnose and Lost River suckers from different habitats of the littoral zone of Upper Klamath Lake: *Environmental Biology of Fishes* 71:365–377.

(COSEWIC) Committee on the Status of Endangered Wildlife in Canada. 2011. COSEWIC Wildlife Species Assessments (detailed version) May 2011. [Accessed June 6, 2011]

Creative Resource Strategies. 2017. Vulnerability and Habitat Suitability of Fort Peck Lake Recreation, Water, Water Supply, and Fish and Wildlife Features to Invasive Mussel Impacts. A report prepared for the US Army Corps of Engineers. 48pp.

Dai, N.V., W. Bessei, and Z. Nasir. 2009. The effect of potassium chloride supplementation in drinking water on water and feed intake and egg quality of laying hens under cyclic heat stress. *Arch.Gefluegelk* 73(3):179–188.

de Oliveira-Filho, E.C., R.M. Lopes, and F.J.R. Paumgartten. 2004. Comparative study on the susceptibility of freshwater species to copper-based pesticides. *Chemosphere* 56(4):369–374.

Densmore, C.L., L.R. Iwanowicz, A.P. Henderson, V.S. Blazer, B.M. Reed-Grimmett, and L.R. Sanders. 2018. An evaluation of the toxicity of potassium chloride, active compound in the molluscicides potash, on salmonid fish and their forage base. Open-File Report 2018–1080. 34pp.

Duke, S., P. Anders, G. Ennis, R. Hallock, J. Hammond, S. Ireland, J. Laufle, R. Lauzier, L. Lockhard, B. Marotz, V.L. Paragamian, and R. Westerhof. 1999. Recovery plan for Kootenai River white sturgeon (*Acipenser transmontanus*).

Eisler, R. 1998. Copper Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. *Biological Science Report USGS/BRD/BSR--1997-0002*; U.S. Geological Survey, Patuxent Wildlife Research Center: Laurel, MD 20708, Report No. 33.

Environment Canada. 2014. Recovery Strategy for the Oregon Spotted Frog (Rana pretiosa) in Canada [Proposed]. Species at Risk Act Recovery Strategy Series. Environment Canada, Ottawa. 21 pp. + Appendix.

Fort, D.J., and E.L. Stover. 1997. Development of short-term, whole embryo assays to evaluate detrimental effects on amphibian limb development and metamorphosis using X. laevis. In: Environmental Toxicology and Risk Assessment: Modeling and Risk Assessment, F.J. Dwyer, T.R. Doane, and M.L. Hinman, eds. American Society for Testing and Materials, Philadelphia, PA, vol. 6. ASTM STP 1317:376–390.

Gangstad, E.O. 1986. Freshwater vegetation management. Fresno, CA: Thomson Publications.

Gibson, K.J., J.M. Miller, P.D. Johnson, and P.M. Stewart. 2018. Acute toxicity of chloride, potassium, nickel, and zinc to federally threatened and petitioned mollusk species. *Southeastern Naturalist* 17(2):239–256.

Govindarajulu, P.P. 2008. Literature review of impacts of glyphosate herbicide on amphibians: what risks can the silvicultural use of this herbicide pose for amphibians in B.C.? B.C. Min. Environ., Victoria, BC. Wildlife Report No. R-28.

Hanson, M.J., and H.G. Stefan. 1984. Side effects of 58 years of copper sulfate treatment of the Fairmont Lakes, Minnesota1. *J. Am. Water Resour. Assoc.* 20(6):889–900.

Hayes, M.P., J.D. Engler, S. Van Leuven, D.C. Friesz, T. Quinn, and D.J. Pierce. 2001. Overwintering of the Oregon Spotted Frog (Rana pretiosa) at Conboy National Wildlife Refuge, Klickitat County, Washington 2000–2001. Final report to the Washington Department of Transportation. Washington Department of Fish and Wildlife, Olympia, WA. 86 pp. Cited in Pearl and Hayes (2004).

Henderson, B.M., and R.W. Winterfield. 1975. Acute copper toxicosis in the Canada goose. *Avian Dis.*19(2):385–7.

Imlay, M.J. 1973. Effects of potassium on survival and distribution of freshwater mussels. Malacologia 12, 97-113.

Ingersoll, C.G., and R.W. Winner. 1982. Effect on *Daphnia pulex* (de geer) of daily pulse exposures to copper or cadmium. *Environ. Toxicol. Chem.* 1(4):321–327.

IUCN (International Union for Conservation of Nature). 2008. 2008 IUCN Red List of Threatened Species. URL: www.iucnredlist.org (last accessed 20 November 2008).

Jaensson, A., and K.H. Olsén. 2010. Effects of copper on olfactory-mediated endocrine responses and reproductive behaviour in mature male brown trout *Salmo* trutta parr to conspecific females. *J. Fish Biol.* 76(4):800–817.

Janney, E.C., B.S. Hayes, D.A. Hewitt, P.M. Barry, A. Scott, J. Koller, M. Johnson, and G. Blackwood. 2009. Demographics and 2008 Run Timing of Adult Lost River (*Deltistes luxatus*) and Shortnose (*Chasmistes brevirostris*) Suckers in Upper Klamath Lake, Oregon, 2008. USGS Open-File Report 2009-1183. 41 p.

Johnson, P.D., A.E. Bogan, K.M. Brown, N.M. Burkhead, J.R. Cordeiro, J.T. Gamer, P.D. Hartfield, D.A.W. Lepitzki, G.L. Mackie, E. Pip, T.A. Tarpley, J.S. Tiemann, N.V. Whelan, and E.E. Strong. 2013. Conservation status of freshwater gastropods of Canada and the United States. *Fisheries* 38:247–282.

Khangarot, B.S., and S. Das. 2010. Effects of copper on the egg development and hatching of a freshwater pulmonate snail *Lymnaea luteola* L. *J. Hazard. Mater.* 179(13):665–675.

Kootenai Tribe of Idaho (KTOI). 2005. Anders, P., R. Beamesderfer, M. Neufeld, and S. Ireland (eds). Kootenai River White Sturgeon Recovery Implementation Plan and Schedule (2005–2010). Prepared by S. P. Cramer and Associates for the Kootenai Tribe of Idaho, with assistance from the Kootenai River White Sturgeon Recovery Team. 50 pp.

Landé, S.P., and S.L. Guttman. 1973. The effects of copper sulfate on the growth and mortality rate of *Rana pipiens* tadpoles. *Herpetologica* 29:22–27.

Lee, D. S., C. R. Gilbert, C. H. Hocutt, R. E. Jenkins, D. E. McAllister, and J. R. Stauffer, Jr. 1980. Atlas of North American freshwater fishes. North Carolina State Museum of Natural

History, Raleigh, North Carolina. i-x + 854 pp.

Licht, L.E. 1969. Comparative breeding behavior of the red-legged frog (Rana aurora aurora) and the western spotted frog (*Rana pretiosa pretiosa*) in southwestern British Columbia. *Canadian Journal of Zoology* 47: 1287–1299.

Licht, L.E. 1986a. Comparative escape behavior of sympatric *Rana aurora* and R*ana pretiosa*. *The American Midland Naturalist* 115:239–247.

Licht, L.E. 1986b. Food and feeding behavior of sympatric red-legged frogs, Rana aurora, and spotted frogs, *Rana pretiosa*, in southwestern British Columbia. *The Canadian Field-Naturalist* 100:22–31.

Lloyd, D.S. 1987. Turbidity as a water quality standard for salmonid habitats in Alaska. *North American Journal of Fisheries Management* 7:34–45.

Luoma, J.A., K.L. Weber, K.L., and D.A. Mayer. 2015. Exposure-related effects of *Pseudomonas fluorescens*, strain CL145A, on coldwater, coolwater, and warmwater fish: U.S. Geological Survey Open-File Report 2015–1104, 1632 p., https://dx.doi.org/10.3133/ofr20151104.

Luoma, J.A., T.J. Severson, J.K. Wise, and M.T. Barbour. 2018. Exposure-related effects of Zequanox on juvenile lake sturgeon (*Acipenser fulvescens*) and lake trout (*Salvelinus namaycush*). *Management of Biological Invasions* 9(2):163–1756.

MBI (Marrone Bio Innovations). 2009. Zequanox Ecological Testing. http://marronebioinnovations.com /products/zequanox/ecological_testing/.

Masser, M.P., T.R. Murphy, and J.L. Shelton. 2006. *Aquatic Weed Management: Herbicides*; Southern Regional Aquatic Center, U.S. Department of Agriculture, Cooperative State Research, Education, and Extension Service, U.S. Government Printing Office: Washington, DC.

Mastin, B.J., and J.J. Rodgers. 2000. Toxicity and bioavailability of copper herbicides (Clearigate, Cutrine-Plus, and Copper Sulfate) to freshwater animals. *Arch. Environ. Contam. Toxicol.* 39(4)445–451.

McAllister, K.R., and W.P. Leonard. 1997. Washington State status report for the Oregon Spotted Frog. Washington Dep. Fish and Wildlife, Seattle, WA. 38 pp.

McCauley, J.E., R.A. Parr, and D.R. Hancock. 1977. Benthic Infauna and Maintenance

Dredging: A Case Study. *Water Res.* 11:223–242.

Meehan, S., A. Shannon, B. Gruber, S.M. Racki, and F.E. Lucy. 2014. Ecotoxicological impact of Zequanox, a novel biocide, on selected non-target Irish aquatic species. *Ecotoxicol Environ Saf* 107:148-53.

Mosaic. 2004. Material Safety Data Sheet. MSDA Number: MOS002. 9pp.

Moyle, P.B. 2002. Inland fishes of California. Revised edition. University of California Press, Berkeley.

Newcombe, C.P., and D.D. MacDonald. 1991. Effects of suspended sediments on aquatic ecosystems. *North American Journal of Fisheries Management* 11: 72–82.

Nicholson, M.E. 2018. Aquatic Community Response to Zequanox®: A Mecocosm experiment. A thesis submitted to the Department of Biology In conformity with the requirements for the degree of Master of Science, Queen's University Kingston, Ontario, Canada. 167pp.

Oruc, H.H., M. Cengiz, and A. Beskaya. 2009. Chronic copper toxicosis in sheep following the use of copper sulfate as a fungicide on fruit trees. *J. Vet. Diagn. Invest.* 21(4):540–543.

Ouellet, M., Bonin, J., Rodrigue, J., Desgranges, J.L., Lair, S., 1997. Hindlimb deformities (ectromelia, ectrodactyly) in free-living anurans from agricultural habitats. *Journal of Wildlife Diseases* 33:95–104.

Page, L.M. and B.M. Burr. 2011. *Peterson field guide to freshwater fishes of North America north of Mexico*. Houghton Mifflin Harcourt, Boston, Massachusetts, USA.

Paragamian, V.L., G. Kruse, and V. Wakkinen. 2001. Kootenai River white sturgeon spawning and recruitment evaluation. Report of Idaho Department of Fish and Game (Number 01-27) to Bonneville Power Administration. Portland.

Pearl, C.A., and M.P. Hayes. 2004. Habitat associations of the Oregon Spotted Frog (*Rana pretiosa*): a literature review. Final report. Washington Dep. Fish and Wildlife, Olympia, WA.

Pearson, M. 2010. Oregon spotted frog habitat prioritization in preparation for OSF introduction to new habitats. Unpublished report prepared for: Oregon spotted frog recovery team, Fraser Valley Conservancy, B.C. Conservation Foundation, and South Coast Conservation Program. 31pp.

Pillard, D., D.L. DuFresne, D.D. Caudle, J.E. Tietge, and J.M. Evans. 2000. Predicting the toxicity of major ions in seawater to Mysid shrimp (*Mysidopsis bahia*), sheepshead minnow (*Cyprinodon variegatus*), and inland silverside minnow (*Menidia beryllina*). *Environmental Toxicology and Chemistry* 19(1):183–191.

Pimentel, D. 2005. Aquatic nuisance species in the New York State Canal and Hudson River Systems and the Great Lakes Basin: An economic and environmental assessment. *Environmental Management* 35(5):692–701.

Popescu, V.D. 2012. Habitat selection by Oregon Spotted Frogs (*Rana pretiosa*) in British Columbia. Unpublished report prepared for the Canadian Wildlife Service and the Oregon Spotted Frog Recovery Team. 29 pp.

Rasowo, J., O. Oyoo, I. Ngugi, and C. Chege. 2007. Effect of formaldehyde, sodium chloride, potassium permanganate and hydrogen peroxide on hatch rate of African catfish *Clarias gariepinus* eggs. *Aquaculture* 269:271–277.

Relyea, R.A., and N. Mills. 2001. Predator-induced stress makes the pesticide carbaryl more deadly to gray treefrog tadpoles (*Hyla versicolor*). Proceedings of the National Academy of Sciences of the United States of America 98, 2491–2496.

Romberg, P., C. Homan and D. Wilson. 1995. Monitoring at Two Sediment Caps in Elliott Bay. In Puget Sound Water Quality Authority, Puget Sound Research '95 Proceedings. Vol. 1, p. 289-299.

Savannah River Ecology Laboratory. 2016. Annual Technical Progress Report of Ecological Research for FY16. Cooperative Agreement DE-FC09-07SR22506. 133pp.

Taylor; L.N., J.C. McGeer, C.M. Wood, D.G. McDonald. 2000. Physiological effects of chronic copper exposure to rainbow trout (*Oncorhynchus mykiss*) in hard and soft water: Evaluation of chronic indicators. *Environ. Toxicol. Chem.* 19(9):2298–2308.

Taylor, B., Skelly, D., Demarchis, L.K., Slade, M.D., Galusha, D., Rabinowitz, P.M., 2005. Proximity to pollution sources and risk of amphibian limb malformation. *Environmental Health Perspectives* 113:1497–1501.

Thompson, L.J. Copper. 2007. *Veterinary Toxicology, Basic and Clinical Principles*; Gupta, R. C. Ed.; Academic Press: Oxford, England. pp 427–429.

TOXNET. 1975–1986. National library of medicine's toxicology data network. Hazardous Substances Data Bank (HSDB). Public Health Service. National Institute of Health, U. S. Department of Health and Human Services. Bethesda, MD: NLM.

Truong, K. 2017. The Effects of Nitrogen and Potassium on the Growth of *Brassica rapa*, Best Integrated Writing, 4.

Tucker, R., and D.G. Crabtree. 1970. Handbook of toxicity of pesticides to wildlife. U.S. Department of Agriculture, Fish and Wildlife Service. Bureau of Sport Fisheries and Wildlife. Washington, DC: U.S. Government Printing Office.

U.S. Bureau of Reclamation. 2011. Finding of No Significant Impact and Final Environmental Assessment Controlling Quagga Mussels in the Cooling Water System at Davis Dam Using Zequanox™ (MOI-401) Laughlin, Nevada and Bullhead City, Arizona No. LC-11-12.

US Environmental Protection Agency. 1986. Guidance for reregistration of pesticide products containing copper sulfate. Fact sheet no 100. Office of Pesticide Programs. Washington, DC.

U.S. Environmental Protection Agency. 2009. Office of Prevention, Pesticides and Toxic Substances, Office of Pesticide Programs, U.S. Government Printing Office: Washington, DC.

USFWS. 1990. Recovery plan for the interior population of the least tern (*Sterna antillarum*). US Fish and Wildlife Service, Twin Cities, Minnesota.

U.S. Fish and Wildlife Service. 1993. Lost River (*Deltistes luxatus*) and shortnose (*Chasmistes brevirostris*) sucker recovery plan. Prepared by K. Stubbs and R. White for USFWS, Region 1, Portland, Oregon.

U.S. Fish and Wildlife Service. 1998a. 50 CFR Part 17, Endangered and Threatened Wildlife and Plants, Determination of Threatened Status for the Klamath River and Columbia River Distinct Population Segments of Bull Trout. *Federal Register*. Vol. 63, No. 111. http://www.gpo.gov/fdsys/pkg/FR-1998-0610/pdf/98-15319.pdf

U.S. Fish and Wildlife Service. 1998b. Recovery plan for the native fishes of the Warner Basin and Alkali Subbasin. U.S. Fish and Wildlife Service, Portland, Oregon.

USFWS. 1999b. Recovery Plan for the White Sturgeon (*Acipenser transmontanus*): Kootenai River Population. U.S. Fish and Wildlife Service, Portland, Oregon. 96 pp. plus appendices.

Wang, M., Q. Zheng, Q. Shen, and S. Guo. 2013. The critical role of potassium in plant stress response. *International Journal of Molecular Sciences Basel*, 14(4):7370–7390.

Watson, J.W., K.R. McAllister, and D.J. Pierce. 2003. Home ranges, movements, and habitat selection of Oregon Spotted Frogs (*Rana pretiosa*). *J. Herpetol.* 37:292–300.

Whitledge, G.W., M.M. Weber, J. Demartini, et al. 2015. An evaluation Zequanox efficacy and application strategies for targeted control of zebra mussels in shallow-water habitats in lakes. *Management of Biological Invasions* Volume 6.

Williams, J.D., A.E.Bogan, and J.T.Gamer. 2008. Freshwater Mussels of Alabama & the Mobile Basin in Georgia, Mississippi and Tennessee.The University of Alabama Press, Tuscaloosa.

Wilson, D. and P. Romberg. 1996. The Denny Way Sediment Cap. 1994 Data. King County Department of Natural Resources Water Pollution Control Division, Seattle, Washington.

Effects of Non-Chemical Treatments on Listed Species and Critical Habitats of Species Associated with CRB Water Bodies

Very few studies have been conducted on the effects of non-chemical dreissenid treatments on species and critical habitats in the Columbia River Basin, or in other locations (Table 5).

Table 5. Potential estimated effects of non-chemical treatments on listed species and critical habitats of species associated with CRB water bodies. This table also includes species-specific best management practices to avoid or lessen impacts from non-chemical treatment activities.

Species	Potential Effects on Key Life Stages and Critical Habitats	Species-specific BMPs
Intense Ultraviolet-B and Ultraviolet-C Radiation Increased in ambient levels of UV-B radiation have significantly contributed to amphibian population declines (Blaustein and Wake 1995). Researchers have found that UV-B radiation can kill amphibians directly, cause sublethal effects such as slowed growth rates and immune dysfunction and work synergistically with contaminants, pathogens and climate change (Kiesecker and Blaustein 1995, Long et al. 1995, Anzalone et al. 1998, Blaustein et al. 1998, Belden and Blaustein 2002).		
Oregon spotted frog (*Rana pretiosa*)	Embryo mortality and/or deformities, reducing larval survival, and affecting swimming activity. Based on the effects of UV-B light on other amphibian species, Oregon spotted frogs and their critical habitat would likely be negatively affected by the use of UV-B light, causing embryo mortality and/or deformities, reducing larval survival, and affecting swimming activity.	Capture and remove Oregon spotted frogs prior to use of this control. Any activities in riparian areas within the geographic scope of this species should be minimized to avoid fragmenting riparian habitat, or introducing invasive species.

Species	Potential Effects on Key Life Stages and Critical Habitats	Species-specific BMPs
		Use existing access roads and entries. Avoid introducing invasive species. Avoid fragmentation of habitat via restoration activities.
Other frog species	Western Toad (*Bufo boreas*)—Exposure to UV-B increases embryo mortality, causes developmental abnormalities and hampers antipredator behavior. Exposure to high levels of UV-B increases susceptibility of embryos to infection by a parasitic fungus *Saprolignia ferix* (Worrest and Kimeldorf 1976, Blaustein et al. 1994b, Kats et al. 2000; Kiesecker and Blaustein 1995; Kiesecker et al. 2001). Common Toad (*Bufo bufo*)—Exposure to UV-B increases embryo mortality and reduces larval survival (Lizana and Pedraza 1998, Häkkinen et al. 2010). Common Froglet (*Crinia signifera*)—Exposure to UV-B increases embryo mortality (Broomhall et al. 2000). Common Tree Frog (*Hyla arborea*)—Exposure to UV-B causes skin darkening (Langhelle et al. 1999). California treefrog (*Hyla cadaverina*)—Exposure to UV-B increases embryo mortality (Anzalone et al. 1998). Gray Treefrog (*Hyla chrysoscelis*)—Exposure to UV-B causes embryonic deformities (Starnes et al. 2000). Gray Treefrog (*Hyla versicolor*)—Exposure to UV-B causes skin darkening and decreased swimming activity. Exposure to UV-B and carbaryl decreases swimming activity of larvae (Zaga et al. 1998).	Capture and remove frogs prior to use of this control. Any activities in riparian areas within the geographic scope of this species should be minimized to avoid fragmenting riparian habitat, or introducing invasive species. Use existing access roads and entries. Avoid introducing invasive species. Avoid fragmentation of habitat via restoration activities.

Species	Potential Effects on Key Life Stages and Critical Habitats	Species-specific BMPs
	Green and Golden Bell Frog (*Litoria aurea*)—Adult and larval frogs show behavioral avoidance of high levels of UV-B (van de Mortel and Buttemer 1998). Peron's Tree Frog (*Litoria peronii*)—Adult and larval frogs show behavioral avoidance of high levels of UV-B (van de Mortel and Buttemer 1998). Verreaux's Tree Frog (*Litoria verreauxii*)—Exposure to UV-B increases embryo mortality (Broomhall et al. 2000). Pacific Treefrog (*Pseudacris regilla*)—Exposure to UV-B causes developmental and physiological abnormalities and reduces larval survival. Exposure to UV-B in combination with high levels of nitrates reduces larval survival (Hays et al. 1996, Ovaska et al. 1997, Hatch and Blaustein 2003). Western Chorus Frog (*Pseudacris triseriata*)—Exposure to UV-B causes embryonic deformities (Starnes et al. 2000).	
Ozone Oxidation Ozone is a natural atmospheric compound that is used to control biofouling in cooling water, wastewater treatment, and hatchery facilities to kill aquatic microorganisms and viruses. When ozone breaks down it gives rise to oxygen free radicals, which are highly reactive and capable of damaging many organic molecules through the process of oxidation (US Army Corps of Engineers 2012). Ozone is considered very harmful to aquatic life (Leynen et al. 1998). As a result, it is recommended that discharged cooling water not contain any dissolved oxygen (Leynen et al. 1998).		
Fish	Adult and larval fish exposed to ozone experience a range of negative effects, from several physiological consequences to mortality, at concentrations from 0.0093 mg/L to 1.44 mg/L (Buley et al. 2017). Ozone may be damaging to peripheral tissues in fish, but there is a paucity of literature describing any behavioral or other physiological effects induced by elevated ozone concentrations (Buley et al. 2017). Ozone can destroy the epithelium covering the gill lamella in bluegill fish, which causes either immediate mortality or leaves the fish highly susceptible to microbial infections (Paller and Heidinger 1979). Ozone is toxic to all life stages of fish, however, it is less toxic to eggs than to the larval stages of several fish species (Asbury and Coler 1980).	Remove fish from area prior to treatment.

Species	Potential Effects on Key Life Stages and Critical Habitats	Species-specific BMPs
Drawdowns/dewatering Winter drawdowns can decrease taxonomic richness of macrophytes and benthic invertebrates and shift assemblage composition to favor taxa with r-selected life history strategies and with functional traits resistant to direct and indirect drawdown effects (Carmignani and Roy 2017). Fish assemblages, though less directly affected by winter drawdowns (except where there is critically low dissolved oxygen), can be indirectly negatively affected via decreased food resources and changes in spawning habitat (Carmignani and Roy 2017). Other adverse impacts of drawdowns (New Hampshire Department of Environmental Services 2018) may include: Large amounts of aquatic plants and organisms that succumb to the drawdown begin to decay shortly after drawdown, but nutrient release to the waterbody may not occur until full-pond level is achieved. Nutrients released from decayed material will quickly be used by algae and cyanobacteria, leading to increased cell production. Shallow lakes have shown shifts from clear, plant-dominated conditions to turbid, algal dominated systems. Algal or cyanobacteria blooms may follow. Aquatic food web changes may result in shifts in plant and animal structure. Oxygen concentrations throughout the water column may be impacted. Changes in the bottom sediment may also occur. Softer sediments may become compacted or frozen segments that are now lighter than water could loosen and float around in large masses or as floating islands in the waterbody, only to settle once again in a new location. Impacts to aquatic animal species can be significant. These impacts range from stranding animals to food chain modifications, or stressors associated with the drawdown. Fish, frogs, salamanders, turtles, aquatic insect larvae, mussels and others can be affected by a drawdown. Agile and faster moving organisms may be able to move upstream or downstream to other unimpacted habitats, however, these fish may be confined to smaller, shallower areas where they become easy prey to consumers, or suffer from oxygen deprivation. Slower moving, more sedentary organisms have a greater risk to negative impacts. Freshwater mussels, snails, insects and crayfish may not be able to find suitable habitat, and may succumb to the drawdown.		
Macroinvertebrates	Macroinvertebrates that are semivoltine (have more than one generation or brood/year), have long life cycles, have low to moderate mobility (e.g., clams and crawlers), or are fine-sediment burrowers) can be sensitive to drawdowns and dewatering (Carmignani and Roy 2017). Taxon richness decreases with intensity of water level regulation; freezing and flushing of sediments in late winter can result in impoverished macroinvertebrate	

Species	Potential Effects on Key Life Stages and Critical Habitats	Species-specific BMPs
	fauna; invertebrates with long life cycles seem especially vulnerable to unnatural water level fluctuations (Aroviita and Hamalaiien 2008). Low mobility organisms and filter feeders decrease with increasing drawdown (White et al. 2011). Benthic organisms increase more than threefold after drawdowns are reduced (Benson and Hudson 1975). Drawdowns can strand benthic invertebrates, resulting in mortality; diversity is reduced in drawdown zones (Kraft 1988). Benthic invertebrates may be susceptible to water-level changes that alter sediment exposure, temperature regime, wave-induced sediment distribution, and basal productivity (McEwan and Butler 2010). Macroinvertebrate abundance is lower in zones or areas that have been dewatered as a result of water fluctuations, or low flows, hypolimnetic draws are associated with reduced abundance of aquatic invertebrate communities and macroinvertebrates downstream of a dam, and altered flows are associated with reduced abundance of fluvial specialists, but not habitat generalists (Haxton and Findlay 2011).	
Fish	Fall and spring spawners, juvenile life stages in littoral zones, and insectivorous fish can be sensitive to drawdowns. Littoral spawning in the fall—Low water levels in spring can prevent fish access to spawning areas; the amount of fall to late spring drawdown is inversely correlated to year-class strengths of coregonid fishes (Gaboury and Patalas 1984). Fish that spawn on reservoir bottoms with winter drawdowns can experience dissolved oxygen deficiency in late winter, which affects survival of eggs and year-class strength (Sutela et al. 2002). Late winter drawdowns reduced lake whitefish abundance by more than 80% during three years of drawdowns because of reduced recruitment and decreased survival (Mills et al. 2002).	Consider life history needs of fish to avoid drawdown times that could affect spawning, or juvenile life stages.

Species	Potential Effects on Key Life Stages and Critical Habitats	Species-specific BMPs
	Littoral spawning in the spring—Dewatered areas in early spring can limit the recruitment of spring spawners, such as northern pike (Kallemeyn 1987). Spring spawning could be negatively impacted by the effects of drawdowns that occur during years when winter and spring droughts occur (McDowell 2012). Littoral juvenile life stage—Different species of fish use differing behavioral strategies to address water fluctuations in natural and man-made lakes. One study tested fish behavior when lake level was decreased in the fall; larger burbot were more successful competing for suitable shelter than smaller burbot until a certain level, at which the largest fish abandoned shelter use while smaller fish persisted in sheltering behavior (Fischer and Ohl 2005). In contract, stone loach showed no hierarchical order or size-related shelter use (Fischer and Ohl 2005). Insectivorous fish—Hypolimnetic draws are associated with reduced abundance of aquatic fish and invertebrate communities and macroinvertebrates downstream of a dam (Haxton and Findlay 2008).	
Manual and Mechanical Dreissenid Removal Physical harvesting of dreissenids can reduce the diversity and abundance of soft-sediment benthic community taxa (Wittman et al. 2012). Following best management practices for manual removal minimizes any effects on non-target organisms (Culver et al. 2013). Steps involved in manual removal (Culver et al. 2013) include: organize divers, train divers, conduct pre-implementation survey, prepare target site, manually remove mussels using hand-held tools, collect removed mussels, dispose of removed mussels, decontaminate persons and gear, and evaluate efficacy of effort. Effort to remove mussels manually can be minimized by using a suction pump made from PVC and a SCUBA tank to vacuum the mussels into collection bags, however, use of this technique can significantly disrupt benthic macroinvertebrate community structure (Wittman et al. 2012). Suction harvesting side effects can include high turbidity, reduced clarity, and algae blooms from nutrient release caused by disturbance of bottom sediment, which can reduce oxygen conditions and ultimately affect ecosystem communities (New York State Department of Environmental Conservation 2005). Suction harvesting also has the potential to release sediment-bound heavy metals into the water column, which can affect the food chain in the water body (New York State Department of Environmental Conservation 2005).		

Species	Potential Effects on Key Life Stages and Critical Habitats	Species-specific BMPs

Oxygen Deprivation

Bottom/benthic barriers or mats can be installed on portions of lake bottoms and weighted, resulting in oxygen deprivation. This tactic is used for low to moderate mussel infestations in difficult to access locations, and can be enhanced by combining it with tactics that target larval stages (Culver et al. 2013). This method is not as effective in locations with large infestations.

Steps involved in oxygen deprivation (Culver et al. 2013) include: organize divers and boat operators, locate needed supplies, review the need for area closures, determine mussel distribution, conduct pre-implementation survey, conduct a pilot study, install tarps, add chemicals/biocides if needed, monitor during installation, remove tarp, decontaminate persons and gear, and evaluate efficacy of effort.

Benthic barriers interfere with respiration in fish and macroinvertebrates. Benthic barriers comprised of anchored textile/plastic are generally placed over vegetation to prevent the growth and establishment of plants whereas benthic barriers can be created by depositing silt to smother bottom-dwelling organisms (US Army Corps of Engineers 2012). Response to silt barriers can include feeding inhibition, reduced metabolism, avoidance, or mortality (Collins et al. 2011).

Table 6. Examples of results of sediment dose-response experiments for fish and macroinvertebrates.

Organism	Suspended sediment concentration (mg 1-1)	Duration (h)	Impact	Reference
Fish - Chinook salmon	207 000	1	100% mortality of juveniles	Newcomb & Flagg 1983
Fish - Cyprinids	100 000	168	Some survival	Wallen 1951
Copepod – Cladocera	25 000	Unknown	Feeding inhibition	Alabaster and Lloyd 1982
Mollusk – Bivalvia	600	Unknown	Feeding inhibition and reduced metabolism	Aldridge et al. 1987
Benthic invertebrates	743	Unknown	Reduce population (85%)	Wagener and LaPerriere 1985

Although studies have shown that benthic barriers may impact non-target organisms, especially benthic dwellers, and will affect chemistry at the sediment-water interface, impacts are limited to the area of installation, and because only a small percentage of lake bottoms are typically exposed to benthic barriers, lake-wide impacts are not expected and have not been observed (Mattson et al. 2004).

References

Alabaster, J.S., and D.S. Lloyd. 1982. Finely divided solids. *In* Water Quality Criteria for Freshwater Fish. J.S. Alabaster & D.S. Lloyd (eds.) Butterworths: London; 1–20.

Aldridge D.W, B.S. Payne, and A.C. Miller. 1987. The effects of intermittent exposure to suspended solids and turbulence on three species of freshwater mussels. *Environmental Pollution* 45:17–28.

Anzalone, C.R., L.B. Kats, and M.S. Gordon. 1998. Effects of solar UV-B radiation on embryonic development in *Hyla cadaverina, Hyla regilla* and *Taricha torosa*. *Conservation Biology* 12:646–653.

Aroviita, J., and H. Hämäläinen. 2008. The impact of water-level regulation on littoral macroinvertebrate assemblages in boreal lakes. *Hydrobiologia* 613:45–56.

Asbury, C., and R. Coler. 1980. Toxicity of dissolved ozone to fish eggs and larvae. *J. Water Pollut. Control Fed.* 52(7):1990–1996.

Belden, L.K., and A.R. Blaustein. 2002. Exposure of red-legged frog embryos to ambient UV-B in the field negatively affects larval growth and development. *Oecologia* 130:551–554.

Benson, N.G., and P.L. Hudson. 1975. Effects of a reduced drawdown on benthos abundance in Lake Francis Case. *Trans Am Fish Soc* 104:526–528.

Blaustein, A.R., P.D. Hoffman, D.G. Hokit, J.M. Kiesecker, S.C. Walls, and J.B. Hays. 1994. UV repair and resistance to solar UV-B in amphibian eggs: a link to population declines? Proceedings of the National Academy of Sciences USA 91, 1791–1795.

Blaustein, A.R., J.M. Kiesecker, D.P. Chivers, D.G. Hokit, A. Marco, L.K. Belden, and A. Hatch. 1998. Effects of ultraviolet radiation on amphibians: field experiments. *American Zoologist* 38:799–812.

Blaustein, A.R., and D.B. Wake. 1995. The puzzle of declining amphibian populations. *Scientific American* 272:52–57.

Broomhall, S.D., W.S. Osborne, and R.B. Cunningham. 2000. Comparative effects of ambient ultraviolet-B radiation on two sympatric species of Australian frogs. *Conservation Biology* 14:420–427.

Buley, R.P., C.T. Hasler, J.A. Tix, C.D. Suski, and T.D. Hubert. 2017. Can ozone be used to control the spread of freshwater aquatic invasive species? *Management of Biological Invasions* 8:13–24.

Carmignani, J.R., and A.H. Roy 2017. Ecological impacts of winter water level drawdowns on lake littoral zones: a review. *Aquatic Sciences* 79(4):803–824.

Collins, A.L., P.S. Naden, D.A. Sear, J.I. Jones, I.D.L. Foster, and K. Morrow. 2011. Sediment targets for informing river catchment management: international experience and prospects. *Hydrobiological Processes* 25:2112–2129.

Culver, C., H. Lahr, L. Johnson, and J. Cassell. 2013. Quagga and zebra mussel eradication and control tactics. California Sea Grant College Program Report No. T-076/UCCE-SD Technical Report No. 2013-1. 9pp.

Fischer, P., and U. Öhl U. 2005. Effects of water-level fluctuations on the littoral benthic fish community in lakes: a mesocosm experiment. *Behav Ecol* 16:741–746.

Gaboury, M.N., and J.W. Patalas. 1984. Influence of water level drawdown on the fish populations of Cross Lake, Manitoba. *Can J Fish Aquat Sci* 41:118–125.

Grimås, U. 1961. The bottom fauna of natural and impounded lakes in northern Sweden (Ankarvattnet and Blåsjön). *Inst Freshw Res Drottningholm Rep* 42:183–237.

Häkkinen, J., S. Pasanen, and J.V.K. Kukkonen. 2001. The effects of solar UV-B radiation on embryonic mortality and development in three boreal anurans (*Rana temporaria*, *Rana arvalis*, and *Bufo bufo*). *Chemosphere* 44:441–446.

Hatch, A.C., and A.R. Blaustein. 2003. Combined effects of UV-B radiation and nitrate fertilizer on larval amphibians. *Ecological Applications* 13(4):1083–1093.

Hays, J.B., A.R. Blaustein, J.M. Kiesecker, P.D. Hoffman, I. Pandelova, A. Coyle, and T. Richardson. 1996. Developmental responses of amphibians to solar and artificial UV-B sources: a comparative study. *Photochemistry and Photobiology* 64:449–456.

Haxton, T.J., and C.S. Findlay. 2008. Meta-analysis of the impacts of water management on aquatic communities. *Can J Fish Aquat Sci* 65(447):437–447.

Kallemeyn, L.W. 1987. Effects of regulated lake levels on northern pike spawning habitat and reproductive success in Namakan Reservoir, Voyageurs National Park. National Park Service, Midwest Region, Research/Resources Management Report MWR-8.

Kats, L.B., J.M. Kiesecker, D.P. Chivers, and A.R. Blaustein. 2000. Effects of UV-B on antipredator behavior in three species of amphibians. *Ethology* 106:921–932.

Kiesecker, J.M., and A.R. Blaustein. 1995. Synergism between UV-B radiation and a pathogen magnifies amphibian embryo mortality in nature. Proceedings of the National Academy of Sciences USA 92, 11049–11052.

Kiesecker, J.M., A.R. Blaustein, and L.K. Belden. 2001. Complex causes of amphibian population declines. *Nature* 410:681–684.

Kraft, K.J. 1988. Effect of increased winter drawdown on benthic macroinvertebrates in Namakan Reservoir, Voyageurs National Park. National Park Service, Midwest Region, Research/Resources Management Report MWR-12.

Langhelle, A., M.J. Lindell, and P. Nyström. 1999. Effects of ultraviolet radiation on amphibian embryonic and larval development. *Journal of Herpetology* 33:449–456.

Leynen, M., L. Duvivier, P. Girboux, and F. Ollevier. 1998. Toxicity of ozone to fish larvae and Daphnia magna. Elsevier, *Ecotoxicology and Environmental Safety* 41(2):176–179.

Lizana, M., and E.M. Pedraza. 1998. The effects of UV-B radiation on toad mortality in mountainous area of central Spain. *Conservation Biology* 12:703–707.

Long, L.E., L.S. Saylor, and M.E. Soulé. 1995. A pH/UV-B synergism in amphibians. *Conservation Biology* 9:1301–1303.

Mattson, M.D., P.J. Godfrey, R.A. Barletta, and A. Aiello. 2004. Eutrophication and Aquatic Plant Management in Massachusetts. Final Generic Environmental Impact Report.

McEwen, D.C., and M.G. Butler. 2010. The effects of water-level manipulation on the benthic invertebrates of a managed reservoir. *Freshw Biol* 55:1086–1101.

McDowell, C.P. 2012. Winter drawdown effects on swim-up date and growth rate of age-0 fishes in Connecticut. Thesis, University of Connecticut, Storrs, Connecticut, USA.

McEwen, D.C., and M.G. Butler. 2010. The effects of water-level manipulation on the benthic invertebrates of a managed reservoir. *Freshw Biol* 55:1086–1101.

Mills, K.H., S.M. Chalanchuk, D.J. Allan, and R.A. Bodaly. 2002. Abundance, survival, condition, and recruitment of lake whitefish (*Coregonus clupeaformis*) in a lake subjected to winter drawdown. *Adv Limnol* 57:209–219.

Neils, D.E. 2016. New Hampshire Department of Environmental Services Water Monitoring Strategy. R-WD-16-02.

Newcomb T.W. & T.A. Flagg. 1983. Some effects of Mount St. Helens ash on juvenile salmon smolts. US National Marine Service Review, Report No. 45, pp 8–12.

New York State Department of Environmental Conservation. 2005. A Primer on Aquatic Plant Management in New York State. 63pp.

Ovaska, K., T.M. Davis, and I.N. Flamarique. 1997. Hatching success and larval survival of the frogs *Hyla regilla* and *Rana aurora* under ambient and artificially enhanced solar ultraviolet radiation. *Canadian Journal of Zoology* 75:1081–1088.

Paller, M.H., and R.C. Heidinger RC. 1980. Mechanisms of delayed ozone toxicity to bluegill *Lepomis machrochirus rafinesque*. Environmental Pollution Series A, *Ecological and Biological* 22:229–239.

Starnes, S.M., C.A. Kennedy, and J.W. Petranka. 2000. Sensitivity of embryos of Southern Appalachian amphibians to ambient solar UV-B radiation. *Conservation Biology* 14:277–282.

Sutela, T., A. Mutenia, and E. Salonen. 2002. Relationship between annual variation in reservoir conditions and year-class strength of peled (*Coregonus peled*) and whitefish (*C. lavaretus*). Hydrobiologia 485:213–221.

US Army Corps of Engineers. 2012a. Alteration of Water Quality. GMLRIS.ANL.GOV.

US Army Corps of Engineers. 2012b. Benthic Barriers. 6pp.
van de Mortel, T.F., and W.A. Buttemer. 1998. Avoidance of ultraviolet-B radiation in frogs and tadpoles of the species *Litoria aurea*, *L. dentata* and *L. peronii*. Proceedings of the Linnaean Society New South Wales 119:173–179.

Wagener, S.M., and J.D. LaPerriere. 1985. Effects of placer mining on the invertebrate communities of interior Alaska. *Freshwater Invertebrate Biology* 4:208–214.

Wallen I.E. 1951. The direct effect of turbidity on fishes. Bulletin of the Oklahoma Agricultural and Mechanical College, vol. 48, pp. 1-27.

White, M.S., M.A. Xenopoulos, R.A. Metcalfe, and K.M. Somers. 2011. Water level thresholds of benthic macroinvertebrate richness, structure, and function of boreal lake stony littoral habitats. *Can J Fish Aquat Sci* 68:1695–1704.

Wittman, M.E., S. Chandra, J.E. Reuter, A. Caires, S.G. Schladow, and M. Denton. 2012. Harvesting an invasive bilvalve in a large natural lake: species recovery and impacts on native benthic macroinvertebrate community structure in Lake Tahoe, USA. *Aquatic Conser: Mar. Fresh. Ecosyst.* 22:588–597.

Worrest, R.D., and D.J. Kimeldorf. 1976. Distortions in amphibian development induced by ultraviolet-B enhancement (290–310 nm) of a simulated solar spectrum. *Photochemistry and Photobiology* 24:377–382.

Zaga, A., E.E. Little, C.F. Rabeni, and M.R. Ellersieck. 1998. Photoenhanced toxicity of a carbamate insecticide to early life stage anuran amphibians. *Environmental Toxicology and Chemistry* 17:2543–2553.

CHAPTER 5. BEST MANAGEMENT PRACTICES

Practices that avoid or minimize impacts to listed species and critical habitats

Federal agencies must ensure actions are not likely to jeopardize the survival of listed species nor adversely modify critical habitats. Best management practices (BMPs) are intended to reduce adverse effects to wildlife, plants, and their habitats. The following list of BMPs includes general measures as well as nationwide standard conservation measures[18] intended to reduce impacts to listed species and associated critical habitats.

All BMPs should be reviewed before any rapid response action to identify those BMPs that would avoid and minimize take. All BMPs pertinent to a specific control action should be reviewed during discussions initiating the emergency consultation process with the USFWS and in advance of the action to ensure optimal protections for listed species.

General Best Management Practices

1. Properly Handle and Remove Hazardous and Solid Waste

a. Provide enclosed solid waste receptacles at all project areas. Non-hazardous solid waste (trash) would be collected and deposited in the on-site receptacles. For more information about solid waste and how to properly dispose of it, see the EPA Non-Hazardous Waste website.

b. Develop a written contingency plan for all project sites where hazardous materials (e.g., pesticides, herbicides, petroleum products) will be used or stored. To clean up small-scale accidental hazardous spills, ensure appropriate materials/supplies (e.g., shovel, disposal containers, absorbent materials, first aid supplies, clean water) are available on site. Report all hazardous spills. Emergency response, removal, transport, and disposal of hazardous materials shall be done in accordance with the U.S. Environmental Protection Agency. Store at least 150 feet from surface water and in areas protected from runoff hazardous materials and petroleum products in approved containers, or

18 https://www.fws.gov/migratorybirds/pdf/management/nationwidestandardconservationmeasures.pdf

chemical sheds.

c. All chemicals shall be handled in strict accordance with label specifications. Proper personal protection (e.g., gloves, masks, protective clothing) shall be used by all applicators. The material safety data sheet (MSDS) from the chemical manufacturer shall be readily available to the project coordinators for detailed information on each chemical to be used, in accordance with applicable Federal and State regulations concerning the use of chemicals.

d. To protect the health of workers, pesticide applicators shall wear appropriate personal protective gear (e.g., clothing, gloves, and masks) in accordance with state applicators' licensing requirements when applying, mixing, or otherwise handling pesticides.

e. Avoid chemical contamination of the project area by implementing a spill prevention, control, and countermeasures (SPCC) plan. A copy of the plan will be maintained at the work site.

    i. Outline BMPs, responsive actions in the event of a spill or release, and notification and reporting procedures. Take corrective actions in the event of any discharge of oil, fuel, or chemicals into the water, including:

        a. Containment and cleanup efforts will begin immediately upon discovery of the spill and will be completed in an expeditious manner, in accordance with all local, state, and federal regulations. Cleanup will include proper disposal of any spilled material and used cleanup material.

        b. The cause of the spill will be determined, and appropriate actions taken, to prevent further incidents or environmental damage.

        c. Spills will be reported to the appropriate state and/or federal agency.

        d. Work barges will not be allowed to ground out.

        e. Excess or waste materials will not be disposed of or abandoned waterward of ordinary high water or allowed to enter waters of the state. Waste materials will be disposed of in an appropriate manner consistent with applicable local, state, and federal regulations.

f. Materials will not be stored where wave action or upland runoff can cause materials to enter surface waters.

ii. Outline the measures to prevent the release or spread of hazardous materials found on site and encountered during construction but not identified in contract documents, including any hazardous materials that are stored, used, or generated on the construction site during construction activities. These items include, but are not limited to, gasoline, diesel fuel, oils, and chemicals.

iii. Maintain at the site applicable spill response equipment and material.

2. Minimize Disturbance and Restore Disturbed Areas

a. Minimize construction impacts on fish and wildlife, including avoiding unnecessary disturbance to habitats by driving on existing roads, working only in the required area, and minimizing direct disturbance to streams and open water sources. Maximize use of disturbed land for all project activities (i.e., siting, lay-down areas, and construction).

b. Complete restoration activities at individual project sites in a timely manner to reduce disturbance and/or displacement of wildlife in the immediate project area. Minimize project creep by clearly delineating and maintaining project boundaries (including staging areas).

c. Use existing roadways or travel paths for access to project sites.

d. Avoid the use of heavy equipment and techniques that will result in excessive soil disturbances or compaction of soils, especially on steep or unstable slopes.

e. To avoid direct and indirect adverse effects to special status plants and habitats, mark the areas and communicate to equipment operators.

f. Replant bank stabilizing vegetation that is removed or altered because of restoration activities with native vegetation and protect it from further disturbance until new growth is well established.

g. Source seedlings, cuttings, and other plant propagules for restoration from local ecotypes.

h. Implement pre-watering, and other preparations at project site and staging areas, prior to ground-disturbing activities, to maintain surface soils in stabilized conditions where support vehicles and equipment will operate.

i. Apply water, or an approved dust palliative during ground-disturbing activities including clearing, grubbing and earth moving activities, to keep soils moist throughout the process and immediately after completion.

j. Incorporate the use of sediment barriers, or other erosion control devices, downstream of ground-disturbing activities.

k. Limit stream crossings to designated and existing locations.

l. Obliterate all temporary roads and paths upon project completion

3. Comply with all Terms, Conditions, and Stipulations in Permits and Project Authorizations—Eliminate or reduce adverse effects to endangered, threatened, and sensitive species and their critical habitats.

4. Protect Wetland Areas

a. Avoid contaminating natural aquatic and wetland systems with runoff by limiting all equipment maintenance, staging laydown, and dispensing of fuel, oil, etc., to designated upland areas, i.e., equipment shall be stored, serviced, and fueled a minimum of 150 feet from aquatic habitats and other sensitive areas.

b. Implement sedimentation and erosion controls, when and where appropriate, during wetland restoration or creation activities to maintain the water quality of adjacent water sources.

c. Avoid removal of riparian vegetation.

d. Complete any construction associated with the project onsite in compliance with each state's water quality standards, including:
    i. Petroleum products, fresh cement, lime, concrete, chemicals, or other toxic or deleterious materials will not be allowed to enter surface waters or

onto land where there is a potential for reentry into surface waters.

ii. Fuel hoses, oil drums, oil or fuel transfer valves, fittings, etc., will be checked regularly for leaks, and materials will be maintained and stored properly to prevent spills.

iii. When fill (e.g., gravel) is required in the staging area and water access location, only clean rock is permitted, and all fill will be removed post-action. Fill would not be permitted to enter the water. During construction activities, the minimum amount of vegetation will be removed to gain access. Wetland sites will be avoided to the extent possible.

5. Protect Special Status Species and Wildlife

a. Implement, to the extent feasible, habitat management activities during the non-breeding/nesting season for waterfowl. When project activities cannot occur outside the bird nesting season, conduct surveys prior to scheduled activity to determine if active nests are present within the area of impact and buffer any nesting locations found during surveys.

b. Wildlife surveys, and corresponding needed rescue/salvage, should occur if the creation of a riparian access route is necessary. Trained biologists would conduct all manner of surveys necessary to identify the abundance and distribution of ESA-listed taxa. Where possible, all nest trees/shrubs would be avoided, and all mobile wildlife would either be relocated from the immediate access route or encouraged to depart the site to avoid and minimize impacts to individuals and species and their habitats. In most cases, electrofishing would be employed as a fish salvage technique prior to treatment using the guidelines and protocols identified in Reynolds (1996) and NMFS (2000). Mollusks and crustaceans would not be salvaged.

c. To protect special status species:

(a) Close trails, roads, and/or areas to ensure that human access does not disturb special status species;

(b) Prior to habitat and ground disturbing activities, evaluate potential habitat for special status species and, if appropriate, conduct presence/absence surveys and take additional mitigation measures (e.g., avoid location, change timing of action), if necessary, to ensure that planned activities do not affect special status species;

(c) Implement all terms and conditions resulting from section 7, Endangered Species Act consultation; and

(d) Additional conservation measures for plants—If one or more ESA-listed plant species are present and may be affected by the action, the project may require protective measures and corresponding consultation. All appropriate measures will be taken to avoid introduction of invasive plants and noxious weeds into the action area.

6. Protect Cultural Resources

Cultural resources should be identified and avoided in all treatment areas. If cultural resources are discovered during activities, all work in the immediate vicinity of the cultural resource should cease until an archaeologist designated by the lead action agency surveys and records the location, and issues a written notice to resume activities. Generally, best practices include avoidance, minimization, mitigation, monitoring, and standard measures to reduce visual contrast (BLM 2017).

Activities that involve hand labor, such as thinning brush, are least likely to impact cultural resources, compared to ground disturbing activities that use mechanized equipment.

a. Minimize potentially adverse effects to cultural resources through cultural resource reviews, surveys, and compliance with section 106 of the National Historic Preservation Act (NHPA).

b. Federal lands with archaeological and historical resources receive protection under federal laws mandating the management of cultural resources, including, but not limited to, Archaeological Resources Protection Act (ARPA), AHPA, Native American Graves Protection and Repatriation Act of 1990 (NAGPRA), and National Historic Preservation Act (NHPA). Stop ground-disturbing activities if cultural resources are discovered on federal lands. Do not resume activities until authorized in writing by the federal government. Follow state archaeological reporting guidelines on all state lands.

7. Monitor Post-Action—Monitoring is required during restoration project implementation and for at least one year following the action to ensure that restoration activities implemented at individual project sites are functioning as intended and do not create unintended consequences to fish, wildlife, and plant species and their critical habitats or adversely impact human health and safety. Corrective actions, as appropriate, shall be taken to address potential and existing adverse effects to fish, wildlife, and plants.

8. Train Personnel—Provide environmental awareness training program to all personnel to brief them on the status of the special status species and the required avoidance measures.

9. Notify the Public and Post Action Areas

a. Temporarily close staging and action areas to public use for public safety. Make information available to the public on the purpose and timing of the closure.
b. Flag and identify sensitive resource areas, equipment entry and exit points, road and stream crossings, staging, storage and stockpile areas, and no-spray/application areas and buffers.

10. Ensure Responsible Use of Clean Equipment

a. Provide vehicle wash stations prior to entering sensitive habitat areas to prevent accidental transport of non-native and invasive species.
b. Avoid soil contamination by using drip pans underneath equipment and containment zones at construction sites and when refueling vehicles or equipment.
c. Consistently check equipment for leaks and other problems that could result in the discharge of petroleum-based products or other material into the water or riparian area.

11. Protect the Integrity of the Water Body

1. Contain the in-water treatment area by installing a vertical floating curtain barrier that extends from the surface of the water to the bottom of the water body, restricting flow and open water exchange. The barrier outlining the treatment area should contact the shoreline and encompass any existing public boat ramps, docks, or other infrastructure.

12. Protect Disturbance/Effects to Listed Species During Key Vulnerable Life History Stages—The following in-water work treatment windows are designated for each state by state and federal agencies. The guidelines restrict in-water work during certain periods to protect fish and wildlife resources during vulnerable and critical life stages. In-water work should be conducted only during the approved in-water work window, as described by each of the four CRB states or federal agencies. **If an action is proposed outside of the**

recommended windows, the action entity should receive approval for all appropriate variances to these windows to avoid any potential effects on listed species and their habitats. Also note that each state has designated state-listed species in addition to federal listed species and critical habitats. Contact your state fish and wildlife agency to ensure protections for state-listed species are implemented.

Washington

The Washington Department of Fish and Wildlife (WDFW) provides recommended treatment windows (last revised on 2/23/2016) for aquatic herbicide treatment. WDFW recognizes that aggressive treatment of emerging invasive species may sometimes be advisable during these treatment windows. In these situations, the Washington Department of Ecology and the permittee must consult WDFW to determine ways to minimize or mitigate treatment impacts to fish and wildlife. Contact the local WDFW regional office. **The annual treatment window is July 15–October 31, unless the specific water body is listed in the treatment window table.** If an action is proposed outside of this window, the Department of Ecology and the permittee must consult WDFW to determine an alternate timing window or if priority species are present, potential species impacts and appropriate mitigation.

Oregon

ODFW, under its authority to manage Oregon's fish and wildlife resources, developed the Oregon Guidelines for Timing of In-Water Work (last revised in 2000) to assist the public in minimizing potential impacts to important fish, wildlife, and habitat resources. The guidelines are based on ODFW district fish biologists' recommendations. Primary considerations are given to important fish species including anadromous and other game fish and threatened, endangered, or sensitive species. Time periods are established for in-water work to avoid the vulnerable life stages of these fish including migration, spawning, and rearing.

ODFW, on a project-by-project basis, may consider variations in climate, location, and category of work that would allow more specific in-water work timing recommendations. The appropriate ODFW district office will make these more specific timing recommendations through the applicable planning or permitting process. ODFW in-water timing guidelines are typically applied to activities that are proposed in streams, rivers, upstream tributaries, and associated reservoirs and lakes. The timing guidelines are not typically applied in ocean waters or wetlands.

Montana

The US Fish and Wildlife Service has established in-water timing work with the US Army Corps of Engineers. **In bull trout feeding, migrating, overwintering habitat:** In-channel work can only occur from July 1 to September 30.

In bull trout spawning and rearing habitat: In-channel work can only occur from May 1 to August 31.

Idaho
National Marine Fisheries Service (NMFS) staff provide guidelines for in-water work in Idaho.

Instream work windows for all other streams in the project area (Lower Salmon River, Lower Snake River, and Clearwater River Basins).

Stream type	**Instream work window**
Perennial, no listed fish	Base the timing on the nearest listed fish found downstream from the project area
Perennial, listed steelhead only	Preferred window is August 1 through October 30; exceptions may be made on a project-specific basis to begin work as early as July 15.
Perennial, listed steelhead and salmon	August 1 through October 30 when unlisted Chinook and coho spawning habitats are not present in the action area; July 15 through August 15 when Chinook spawning habitat is present in action area; August 1 through September 15 when coho spawning habitat is present in the action area.
Perennial, listed steelhead as well as listed salmon or bull trout	July 15 through August 15 Intermittent August 1 to October 30, or any time work can be completed while the stream is not flowing

13. Mitigation—Any native fish and wildlife habitat destroyed in the development of an access corridor would be restored with appropriate, native species once the final treatment is completed. Replacement plant species will be recommended by a local state botanist. No ground disturbance outside of the area previously opened for treatment site access is be required. Mitigation methods may include:

- Mowing the site for ease of planting and to reduce initial plant competition during establishment.

- Removal of any fill using proper equipment.

- Planting to include hand tools, a power auger, hydraulic auger operated by equipment, or stinger operated by equipment. A 1 m buffer of herbaceous vegetation will be left between the shoreline and upland plantings to prevent potential sediment runoff.

- Installing weed matting or plant protection material to keep competition down while plants establish, and keep any loose sediment in place.

- Seeding, either via top seeding or seed drill depending upon herbaceous species and site characteristics.

- Seed native grasses, forbs, and pollinator species as available.

- Silt fence or weed-free straw will be used to contain runoff, if necessary.

- Monitoring plant establishment with adaptive management to ensure appropriate plant survival of 80% at 24 months.

Best Management Practices to Avoid the Spread of Invasive Species

Agencies throughout North America institute best management practices to reduce the likelihood of introducing invasive species, particularly via plant seed or propagules, during maintenance, construction and vegetation management activities. The following general best management practices, adapted from a variety of sources (Creative Resource Strategies, LLC 2019; Elwell and Phillips 2016; Halloran et al. 2013, US Forest Service 2012; British Columbia Ministry of the Environment 2011), can help prevent the spread of invasive species.

A. Education and Support

Knowledge of invasive species and techniques to avoid their spread is critical to the implementation of all BMPs.

A.1 Provide trainings and educational materials for staff and contractors.

- Conduct training sessions on sanitation procedures for other equipment.
- Provide brochures and other materials on weed identification.
- Provide checklists and instructions for execution of BMPs in the field.
- Communicate the impact of invasive species and the importance of prevention.

B. Planning and Records

B.1 Include an invasive species risk evaluation as a component of initial project planning.

Evaluate the risk of:

- Spreading invasive seeds and other propagules from the project site to new areas. Identify invasive species in and surrounding the site. Identify control and sanitation measures that would reduce risk.
- Bringing invasive propagules into the site during project activities. Consider any use and transportation of project vehicles outside of the project area. Identify sanitation measures that would reduce this risk.

B.2 Incorporate design components that minimize the movement of invasive propagules into or out of the site.

B.3 Incorporate sanitation and invasive control measures into plans, budgets, and contracts.

- Consider the use of specialized gear and clothing, tools for sanitation, and any staff training.
- Allocate time for prevention and sanitation activities.

B.4 Schedule activities to minimize the potential for spread of invasive propagules into or out of the site.

- Consider life stages of invasive plants. Avoid activities that may spread propagules when plants are fruiting.
- Consider the toxicity, ecological fate, persistence, and unintended consequences of pesticides. Consider timing to avoid impacts to pollinators, nesting birds and mammals, and to trail users, medicine and food harvesters, and other public use.

B.5. Record observations of all suspected priority invasive species and others of concern. Note the date, location in as much detail as possible, approximate size of the patch, species identity if known, and stage of the plant (flowering, fruiting, etc.).

F. Soil Disturbance

Disturbing soil creates opportunities for the establishment of weed species.

C.1 Minimize soil disturbance—Whenever possible, activities should be avoided in areas containing fruiting, or rhizomatous invasive plants.

When soil must be disturbed, use proper erosion control practices—Minimize soil disturbance in areas containing invasive plants. Should invasive plants be detected early, use a certified pesticide applicator and spray within limits of pesticide permit, and/or take other actions as may be deemed appropriate.

Stabilize disturbed soils as soon as possible by seeding, mulching or using stone or other materials that are free of invasive plant materials. Site-specific revegetation efforts should address site preparation, species selection, and overall maintenance of the area. The activities to reduce invasive plants are intended to complement other practices addressing erosion control, proper drainage, and protecting infrastructure. Materials, such as fill, loam, gravel, mulch or hay should not be brought into project areas from sites where invasive plants are known to exist or have existed.

C.2 Manage and contain any water runoff, which can carry weed propagules.

C.3 Plan for cleaning time.

F. Project Materials

Project materials are common dispersal vectors for weed propagules to new locations. Soils, erosion control materials (especially if reused), landscape materials, water, and other materials can all contain propagules. Use of these BMPs can prevent the introduction of weed species to a project site through contaminated materials.

D.1 Use project materials that are known to be weed free.

Whenever possible, re-use weed-free materials from onsite rather than importing new materials. When re-using materials is not possible, obtain materials from local vendors, ideally those offering weed-free materials. Inspect materials for weed propagules.
Use certified weed-free seed. Monitor for weeds after the installation of new materials.
Treat any state/local-listed priority weeds found at early stages to maximize effectiveness of control.

D.2 Prevent contamination and germination of weed propagules in unused stockpiles of materials.

Cover exposed materials to protect from wind and rain. Inspect stockpiles prior to use. Treat any weeds found before the material is used.

D.3 Prevent contamination when transporting project materials.

Never move materials from a weed-infested to an un-infested location.
Cover materials during travel to prevent either contamination of clean materials, or spread of propagules from infested materials.

F. Travel and Maintenance of Equipment—Disinfection Protocols

Workers can spread invasive species as they travel from site to site. These BMPs should be implemented at all visits to sites known to, or suspected to, contain invasive species.

All vehicles should be examined for potential weed propagules: mud, soil, vegetation on vehicle undercarriages, wheel wells, bumpers and grills. Wearing appropriate clothing, boots, and other gear, and cleaning them before leaving a site can prevent them from transporting weeds to new sites. Following these BMPs will minimize introduction of invasive species by equipment, vehicles, and people traveling among project sites.

E.1 Locate and use a staging area that is free of invasive plants.

E.2. Avoid driving off-road, or parking in areas infested with invasive species. Arrange routes to travel to uninfested sites first, when the vehicle is clean. Visit weedy/infested sites last.

E.3. Inspect and Clean

Designate cleaning areas for tools, equipment and vehicles—Ideal locations include paved or sealed surfaces. Avoid waterways and sensitive habitat areas. If equipment must be used or staged in areas where invasive plants occur, all equipment, gear (i.e., boots), machinery, and hand tools should be cleaned of all viable soil, plant, and animal material before leaving the project. Acceptable methods of cleaning include but are not limited to:

- Portable wash station that contains runoff from washing equipment (containments must be in compliance with wastewater discharge regulations). If on-site cleaning is not an option, clean equipment at a commercial car wash facility. For vehicles and other large equipment, pay particular attention to the undercarriage and treads of tracks and tires.

- High pressure air.

- Brush, broom or other tool (used without water) – this is likely to be the BMP most practiced to avoid unintentional transport of invasive species as equipment moves from site to site.

Aquatic sites— Before leaving any aquatic site or any site in wet condition, thoroughly remove all organic matter (e.g., mud, plants, algae) from nets, sampling devices, boots (especially the tread), and any other equipment or clothing that has come into contact with water or aquatic sediments.

- Watercraft—Inspection and decontamination procedures for watercraft entering and leaving waterbodies should follow the Uniform Minimum Standards and Protocols for Watercraft Inspection and Decontamination Programs for Dreissenid Mussels in the Western United States (Elwell and Phillips 2016).

- Firefighting activities—US Forest Service and Bureau of Land Management prevention activities associated with the transport of water during firefighting activities should be used to prevent the spread of invasive species, sanitize equipment, and address disposal and safety concerns.

- Working in water bodies:

    - Sample from least to most invasive species-contaminated areas within the waterbody, for example, sample upstream to downstream or from areas of less weed growth to dense weed growth.

    - Minimize wading and avoid running boats onto sediment. For example, use bank sampling poles instead of wading.

    - Avoid getting plants and sediment inside boats or other sampling gear.

    - Use a catch pan underneath dredges, etc., to keep potential invasive species off boat decks and out of bilges.

    - Clean, Drain, Dry

        - CLEAN – Remove any visible vertebrates, invertebrates, plants, plant fragments, seeds, algae, and dirt. If necessary, use a scrub brush and rinse with clean water either from the site or brought for that purpose. Continue this process until the equipment is clean.

        - DRAIN all water in bilges, samplers, and other equipment that could hold water before leaving the site.

        - DRY – Fully wipe down all equipment until dry.

    - Decontaminate, if possible—Decontaminate using options for aquatic invasive species (Elwell and Phillips 2016).

F. Transport & Disposal of Plants

After invasive plant removal, plant parts must be properly disposed of to prevent establishment in other locations.

F.1 When disposing on site, minimize the chance of viable material spreading by choosing a location where viable plant material will be contained, buried, or destroyed. Conduct monitoring at and near debris piles to treat any weeds that may have spread during the disposal and degradation process.

Drying/Liquefying: For large amounts of plant material, or for plants with rigid stems, place the material on asphalt, and under tarps, or heavy plastic to prevent the material from blowing away. For smaller amounts of plant material, or for plants with pliable stems, bag the material in heavy- duty (3 mil or thicker) garbage bags. Keep the plant material covered or bagged for at least one month and up to 3 months. Material is nonviable when it is partially decomposed, very slimy, or brittle. Once material is nonviable, it can be disposed of in an approved landfill or brush pile.

Brush Piles: Plant materials from most invasive plants can be piled on site to dry. However, for some species, care must be taken to pile stems so that the cut surfaces are not in contact with soil. This method is not recommended for any invasive plant with seeds or fruit attached, unless plants can be left within the limits of the infestation.

Burying: Plant material from most invasive plants can be buried a minimum of three feet below grade. This method is best used on a job site that is already has disturbed soils.

Burning: Plant material should be taken to a designated burn pile. (All necessary permits must be obtained before burning).

F.2 Herbicides—If herbicides are applied at the disposal sites, only licensed applicators are allowed to apply herbicide treatments.

F.3 When disposing off site, select appropriate disposal locations and transport properly. Invasive plant material must be covered during transport and transport vehicles swept clean at the transported location.

G. Revegetation and Landscaping

Proper revegetation and landscaping work can create weed-resistant plant communities. Without proper care, however, landscaping activities and materials can serve as vectors for invasive species.

I.1 Select vegetation appropriate to the site to maximize weed resistance.

I.2 Use plants from a local source.

Use local ecotypes whenever possible for best plant establishment. Verify the taxonomy of species to be planted. Ensure all species to be used are approved.

I.3 Mitigate the risks of unintentional invasive species introductions during site preparation activities.

Whenever possible, time site preparation activities when invasive species are not producing seed.

Treat any invasive species found during the site preparation process.

Minimize soil disturbance to the amount necessary for planting.

Chapter 5 References

British Columbia Ministry of Environment. 2011. Best Management Practices for Invasive Plants in Parks and Protected Areas of British Columbia: A Pocket Guide for BC Parks Staff, Volunteers and Contractors.

Bureau of Land Management. 2017. Handbook of Guidelines and Procedures for Inventory, Evaluation, and Mitigation of Cultural Resources. 39pp.

Creative Resource Strategies, LLC. 2019. City of Portland Invasives 2.0 – A Strategic Investment in Portland's Future. 59pp.

Elwell, L, and S. Phillips. 2016. Uniform Minimum Protocols and Standards for Watercraft Inspection and Decontamination for Dreissenid Mussels in the Western United States (UMPS III). Pacific States Marine Fisheries Commission, Portland, OR 53pp,

Halloran, J., H. Anderson, and D. Tassie. 2013. Clean equipment protocol for industry. Peterborough Stewardship Council and Ontario Invasive Plan Council. Peterborough, ON.

National Marine Fisheries Service(NMFS). 2000. Guidelines for electrofishing waters containing salmonids listed under the Endangered Species Act. National Marine Fisheries Service, Portland, Oregon, and Santa Rosa, California.

New York State Department of Environmental Conservation. 2018. Inter-agency Guidelines for Implementing Best Management Practices to Control Invasive Species on DEC Administered Lands of the Adirondack Park.

Reynolds, J.B. 1996. Electrofishing. Pages 221–253 *in* B. R. Murphy and D. W. Willis, eds. Fisheries techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland.

US Forest Service. 2012. Non-native Invasive Species Best Management Practices. 282pp.

CHAPTER 6. POST-EMERGENCY CONSULTATION

As soon as practical after the emergency event is under control, the action agency initiates consultation if the emergency response may affect listed species and/or critical habitat. If adverse effects to a listed species are necessary to respond to the emergency, consultation should begin as soon as possible after the emergency to discuss effects to any listed species that may have occurred.

The action agency drafts a biological assessment that includes a justification for expedited consultation, a description of activities that occurred during the emergency, documentation of how the USFWS recommendations were implements, and resulting effects to listed species and their habitats.

Because emergency consultations are "after the fact" consultations, they do not strictly follow the standard Biological Opinion format. Rather, they focus on assessing the effects, identifying restoration opportunities, and re-evaluating environmental baselines.

An emergency consultation includes an estimate of the amount of take that occurred during the emergency, documentation of USFWS recommendations to minimize effects, an evaluation of the action agency's success in implementing the recommendations, and a determination of the ultimate effect of the take of listed species.

Take or other adverse effects resulting from the emergency are not attributable to the Federal action agency. Rather, incidental take by the Federal agency could only occur because of the response to the emergency. Because the incidental take statement is issued after-the-fact, reasonable and prudent measures are not included in the biological opinion for the emergency actions unless ongoing actions will result in incidental take.

APPENDIX A. LISTED SPECIES AND CRITICAL HABITAT EXCLUDED FROM FURTHER ANALYSIS

Mammals

Black-footed Ferret (*Mustela nigripes*) (MT)

The historic range of this species aligned with the colonies of three species of prairie dogs—black-tailed, white-tailed, and Gunnisons's (*Cynomys* spp.) (Anderson et al. 1986). Their habitat, and the associated habitat of prairie dogs, is primarily open mixed grass, or short grass prairie, and is classified as "black-tailed prairie dog town grassland complex." The most recent distribution of black-footed ferrets in Montana can be accessed at http://fieldguide.mt.gov/speciesDetail.aspx?elcode=AMAJF02040.

Canada Lynx (*Lynx canadensis*) (OR, WA, ID, MT)

The Canada lynx is a boreal forest carnivore, and occurs across most of North America. Its habitat is moist, cool, boreal spruce-fir forests in northwestern Montana/northern Idaho and north-central Washington.[19] The distribution of Canada lynx can be accessed at https://wildcatconservation.org/wild-cats/north-america/canada-lynx/.

Gray wolf (*Canis lupus*) (OR, WA)

The gray wolf (*Canis lupus*) was once found throughout much of the continental United States and are listed as endangered in the western 2/3 of Oregon and Washington. Gray wolves are one of the most wide-ranging land animals. They occupy a wide variety of habitats, from arctic tundra to forest, prairie, and arid landscapes. Click on the following links for additional information on wolves in Oregon (https://dfw.state.or.us/Wolves/) and Washington: Oregon, Washington.

Grizzly bear (*Ursus arctos horribilis*) (WA, ID, MT)

There are five areas where grizzlies remain today—Yellowstone ecosystem, Northern Continental Divide ecosystem, Cabinet-Yaak ecosystem, Selkirk ecosystem, and Northern Cascades ecosystem.[20] Grizzly bears are found many different habitats, from dense forests to subalpine meadows, open plains and arctic tundra.

[19] https://www.fws.gov/mountain-prairie/es/canadaLynx.php
[20] https://www.fws.gov/mountain-prairie/es/grizzlyBear.php

Mazama pocket gopher (Thomomys azama pugetensis, glacialis, tumuli, and yelmensis) (WA)

The Olympia, Roy Prairie, Tenino, and Yelm pocket gophers are regionally endemic subspecies of the Mazama pocket gopher found only in Washington. The Olympia, Tenino, and Yelm pocket gophers are only found in Thurston County whereas the Roy Prairie pocket gopher is only found in Pierce County. Preferred habitat is prairies, grasslands, and meadows. The Joint Base Lewis-McChord and Olympia airport contain the largest areas occupied by any of the four listed species.

Northern Idaho ground squirrel (*Urocitellus endemicus*) (ID)

Populations of the northern Idaho ground squirrel have been found in Adams and Valley Counties of western Idaho, though the species historic range extends into neighboring Washington County.[21] It occurs in dry meadows surrounded by ponderosa pine and Douglas-fir forests, including lands managed by the U.S. Forest Service—Payette National Forest (1,500 to 7,500-foot elevations).

Northern long-eared bat (*Myotis septentrionalis*) (MT)[22]

Northern long-eared bats spend winter hibernating in caves and mines, called hibernacula. They use areas in various sized caves or mines with constant temperatures, high humidity, and no air currents. Within hibernacula, surveyors find them hibernating most often in small crevices or cracks, often with only the nose and ears visible. During the summer, northern long-eared bats roost singly or in colonies underneath bark, in cavities or in crevices of both live trees and snags (dead trees). Males and non-reproductive females may also roost in cooler places, like caves and mines. Northern long-eared bats seem to be flexible in selecting roosts, choosing roost trees based on suitability to retain bark or provide cavities or crevices. This bat has also been found rarely roosting in structures, like barns and sheds.

Columbia Basin Pygmy rabbit (*Brachylagus idahoensis*) (Columbia Basin Distinct Population Segment (DPS)) (WA)

Pygmy rabbits are typically found in areas that include tall, dense stands of sagebrush (*Artemisia* spp.), which provide food and shelter year-round. Pygmy rabbits dig their own burrows in deep, loose soils, but occasionally make use of burrows abandoned by other species (USFWS 2012).

Southern Selkirk Mountains woodland caribou (*Rangifer tarandus caribou*) (WA, ID)

The southern Selkirk Mountains population of woodland caribou occupies high-elevation habitat in the Selkirk Mountains of northern Idaho and northeastern

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[21] https://ecos.fws.gov/ecp0/profile/speciesProfile?spcode=A0EK

[22] https://www.fws.gov/midwest/Endangered/mammals/nleb/nlebFactSheet.html

Washington.[23] In 2018, three male animals were documented in the herd.[24]

Wolverine (*Gulo gulo luscus*) (WA, ID, MT, OR)

In North America, wolverines occur within a wide variety of habitats, primarily boreal forests, tundra, and western mountains throughout Alaska and Canada; however, the southern portion of the range extends into the contiguous United States. Currently, wolverines are found in the North Cascades in Washington and the Northern Rocky Mountains in Idaho, Montana, Oregon (Wallowa Range), and Wyoming.

Birds

Marbled murrelet (*Brachyramphus marmoratus*) (OR, WA)[25]

Marbled murrelets use forests that primarily include old-growth (characterized by large trees, a multi-storied stand, and moderate to high canopy closure), but also use mature forests with an old-growth component. Trees must have large branches or deformities for nest platforms, with the occurrence of suitable platforms being more important than tree size alone. Because marbled murrelets feed primarily on fish and invertebrates in nearshore marine waters, they require nearshore marine habitats with sufficient prey resources. Because the habitat of this species is not habitat in which dreissenids would be found, this species is excluded from further analysis.

Northern spotted owl (*Strix occidentalis caurina*) (OR, WA)[26]

Northern spotted owls live in forests characterized by dense canopy closure of mature and old-growth trees, abundant logs, standing snags, and live trees with broken tops. They prefer older forest stands with multi-layered canopies of several tree species of varying size and age, both standing and fallen dead trees, and open space among the lower branches to allow flight under the canopy. Typically, forests do not attain these characteristics until they are at least 150 to 200 years old. Although the breeding season varies with geographic location and elevation, spotted owls generally nest from February to June. Because the habitat of this species is not habitat in which dreissenids would be found, this species is excluded from further analysis.

Short-tailed albatross (*Phoebastria albatrus*) (OR, WA)

The short-tailed albatross is a pelagic bird that nests on islands in Japan and moves to feeding areas in the North Pacific after they breed and their chicks fledge in June. Because their habitat is marine, this species is excluded from further analysis.

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[23] https://www.fws.gov/idaho/promo.cfm?id=177175825

[24] https://www.opb.org/news/article/caribou-continental-united-states-south-selkirk-extinct/

[25] USFWS (1997)

[26] https://www.fws.gov/oregonfwo/articles.cfm?id=149489595

Whooping crane (*Grus americana*) (MT)[27]

About 145 whooping cranes migrate across Montana from Wood Buffalo National Park to the Aransas National Wildlife Refuge. The spring migration occurs from late April to mid-June. Whooping cranes are occasionally sighted in southwestern Montana's Centennial Valley. The Whooping Crane has been observed in the marsh habitat present at Medicine Lake National Wildlife Refuge and Red Rock Lakes National Wildlife Refuge. Observations of individual birds in other areas of the state include grain and stubble fields as well as wet meadows, wet prairie habitat, and freshwater marshes that are usually shallow and broad with safe roosting sites and nearby foraging opportunities (Montana Bird Distribution Committee 2012). The Whooping Crane generally probes in the mud or sand in or near shallow water, but may also take prey from the water column, or pick items from the substrate (Ehrlich et al. 1992).

Streaked horned lark (*Eremophila alpestris strigata*) (OR, WA)[28]

The streaked horned lark was listed as a threatened species on October 3, 2013. Habitat used by streaked horned larks is generally flat with substantial areas of bare ground and sparse low-stature vegetation primarily composed of grasses and forbs. Suitable habitat is generally 16-17% bare ground and may be even more open at sites selected for nesting. A key attribute of habitat used by larks is open landscape context. Critical habitat was designated for the streaked horned lark October 3, 2013, for 16 sites; in the Willamette Valley, designated critical habitat is located on the Service's Willamette Valley National Wildlife Refuge Complex at the William R. Finley, Ankeny and Baskett Slough units. The current range and distribution of the streaked horned lark can be divided into three regions: 1) the south Puget Lowlands in Washington; 2) the Washington coast and lower Columbia River islands (including dredge spoil deposition and industrial sites near the Columbia River in Portland, Oregon); and 3) the Willamette Valley in Oregon. The largest known populations of streaked horned larks breed in the southern Willamette Valley at the Corvallis Municipal Airport and on the Fish and Wildlife Service's Willamette Valley National Wildlife Refuge Complex. **Avoid disruption during the breeding season (late March into June).**

Fish

Borax Lake chub (*Gila boraxobius*) (OR)

Borax Lake is a 10-acre lake in southeastern Oregon fed by hot springs. Water temperatures can reach 105 degrees. It is small and shallow, about 4.1 hectares (10 acres) in size. Spring inputs near the bottom of a deep vent, 32 meters (100 feet) below

[27] http://FieldGuide.mt.gov/speciesDetail.aspx?elcode=ABNMK01030
[28] https://www.fws.gov/oregonfwo/articles.cfm?id=149489450

the surface, range from 40 to 148°C (104 to 300°F). Surface water temperatures typically range from 16 to 38°C (61 to 100°F) but fluctuations occur, and temperatures occasionally exceed 38°C (100°F), causing fish kills as water temperature exceeds the chub's critical thermal maximum (Scoppettone et al. 1995). Borax Lake would be unsuitable habitat for dreissenids, therefore, this species is excluded from further analysis.

Foskett speckled dace (*Rhinichthys osculus spp.*) (OR)

Both Foskett and Dace springs are extremely small and shallow with limited habitat for fish. Foskett Spring originates in a pool about five meters (16.4 feet) across, then flows toward Coleman Lake in a narrow, shallow channel. The source pool has a loose, sandy bottom and is thick with aquatic plants. The spring outflow channel eventually turns into a marsh and finally dries up before reaching the dry lake bed of Coleman Lake. Dace Spring is about 1km (0.6 mile) south of Foskett Spring and is smaller and more choked with plants. The spring outflow terminates in a cattle trough. Fish at Foskett Spring live in the main spring pool, outflow channel, and tiny outflow rivulets that are at times only a few inches wide and deep. The fish find cover under overhanging bank edges, grass, exposed grass roots, and filamentous algae. Existing habitat is currently fenced from cattle use and is in stable condition. Because the habitat of this species is not habitat in which dreissenids would be found, this species is excluded from further analysis.

Hutton tui chub (*Gila bicolor spp.*) (OR)

The Hutton tui chub is the only fish found in the Alkali Subbasin in southwestern Oregon, in Hutton Spring, in Lake County. The spring, which has varied in size from 20 feet to 40 feet in diameter, and is about 15 feet deep in the center, is privately owned. Because the habitat of this species is not habitat in which dreissenids would be found, this species is excluded from further analysis.

Invertebrates

Fender's blue butterfly (*Icaricia icarioides fender)* (OR)

Fender's blue butterfly occurs in native prairie habitats. Most Willamette Valley prairies are early seral (one stage in a sequential progression) habitats, requiring natural or human-induced disturbance for their maintenance. Because the habitat of this species is not habitat in which dreissenids would be found, this species is excluded from further analysis.

Taylor's checkerspot butterfly (*Euphydryas editha taylori*) (OR, WA)

Habitat requirements for the Taylor's checkerspot consist of open grasslands and grass/oak woodland sites where food plants for larvae and nectar sources for adults are available. These sites include coastal and inland prairies on post-glacial, gravelly outwash and balds. Taylor's checkerspot larvae have been documented feeding on members of the figwort or snapdragon family (Scrophulariaceae), including paintbrush (*Castilleja hispida*) as well as native and non-native Plantago spp. in the plantain family (Plantaginacea). The last remaining population in Oregon also depends upon *P. lanceolate*. Because the habitat of this species is not habitat in which dreissenids would be found, this species is excluded from further analysis.

Oregon silverspot butterfly (*Zpeyeria zerene hippolyta*) (OR, WA)

The Oregon silverspot occupies three types of grassland habitat. One type consists of marine terrace and coastal headland salt-spray meadows (e.g., Cascade Head, Bray Point Rock Creek-Big Creek and portions of Del Norte sites). The second consists of stabilized dunes as found at the Long Beach Peninsula, Clatsop Plains, and the remainder of Del Norte. Both of these habitats are strongly influenced by proximity to the ocean, mild temperatures, high rainfall, and persistent fog. The third habitat type consists of montane grasslands found on Mount Hebo and Fairview Mountains. Conditions at these sites include colder temperatures, significant snow accumulations, less coastal fog, and no salt spray. Because the habitat of this species is not habitat in which dreissenids would be found, this species is excluded from further analysis.

Vernal pool fairy shrimp (*Branchinecta lynchi*) (OR)

Vernal pool fairy shrimp occur primarily in vernal pools, seasonal wetlands that fill with water during fall and winter rains and dry up in spring and summer. Typically, the majority of pools in any vernal pool complex are not inhabited by the species at any one time. Different pools within or between complexes may provide habitat for the fairy shrimp in alternative years, as climatic conditions vary. Because the habitat of this species is not habitat in which dreissenids would be found, this species is excluded from further analysis.

Vernal pool tadpole shrimp (*Lepidurus packardi*) (OR)

Vernal pool fairy shrimp occur primarily in vernal pools, seasonal wetlands that fill with water during fall and winter rains and dry up in spring and summer. Typically, the majority of pools in any vernal pool complex are not inhabited by the species at any one time. Different pools within or between complexes may provide habitat for the fairy shrimp in alternative years, as climatic conditions vary. Because the habitat of this species is not habitat in which dreissenids would be found, this species is excluded from further analysis.

Western glacier stonefly (Zapada glacier) (MT)

Western glacier stoneflies are known to occur in 16 streams; 6 in Glacier National Park, Montana, 4 in Grand Teton National Park, Wyoming and 6 in the Absaroka/Beartooth Wilderness, Montana. All occupied streams are high-elevation, alpine streams originating from cold water sources, including glaciers and small icefields, permanent and seasonal snowpack, alpine springs, and glacial lake outlets. Recent collections of the western glacier stonefly were in habitats with daily maximum water temperatures less than 6.3°C (43°F). Western glacier stoneflies occupy the most upstream reaches of alpine streams, typically occurring within the first one half mile of stream, starting at the meltwater source. Therefore, they are sensitive to temperature changes and are considered to be a barometer for the effects of climate change in the alpine environment.

Meltwater lednian stonefly (*Lednia tumana*) (MT)

This species is listed as proposed threatened. Its habitat is alpine snow-melt streams at the base of glaciers in Glacier National Park. Because the habitat of this species is not habitat in which dreissenids would be found, this species is excluded from further analysis.

Bruneau hot springsnail (*Pyrgulopsis bruneauensis*) (ID)

It is only found in 89 of the 155 small geothermal springs and seeps along an 8-kilometer length of the Bruneau River, extending about 2.5 miles above and below the confluence of Hot Spring, in Owyhee, County, Idaho (USFWS 2007). It prefers wetted rock faces of springs and flowing water, with large cobbles and boulders. The principal threat to the Bruneau hot springsnail is the reduction and/or elimination of its geothermal habitats as a result of groundwater withdrawal, primarily for agriculture. Spring temperatures are the predominant factor that determines the springsnail's distribution and abundance; the springsnail requires constant springwater temperatures to survive.

Plants

Applegate's milk-vetch (*Astragalus applegatei*) (OR)

Applegate's milk-vetch occurs in flat-lying, seasonally moist, strongly alkaline soils dominated by greasewood (*Sarcobatus vermiculatus*) with sparse, native bunch grasses and patches of bare soil. Because the habitat of this species is not habitat in which dreissenids would be found, this species is excluded from further analysis.

Cook's lomatium (*Lomatium cookii*) (OR)

This plant occurs only where soil types have a hard pan or clay pan layer close to the soil surface, creating seasonally wet soils and vernal pools. This species is known from the Agate Desert near Medford, Jackson County, Oregon and French Flat in the Illinois Valley in Josephine County, Oregon on land owned by The Nature Conservancy (Agate Desert Preserve), Jackson County, Oregon Department of Fish and Wildlife, City of Medford, Oregon Department of Transportation, Bureau of Land Management (French Flat), and private landowners. Because the habitat of this species is not habitat in which dreissenids would be found, this species is excluded from further analysis.

Gentner's fritillary (*Fritillaria gentneri*) (OR)

Fritillaria gentneri occurs within a broad array of plant associations but often occupies grassland and chaparral habitats within, or on the edges of, dry, open, mixed-species woodlands at elevations below 1,544 meters (5,064 feet). Because the habitat of this species is not habitat in which dreissenids would be found, this species is excluded from further analysis.

Golden paintbrush (*Castilleja levisecta*) (OR, WA)

Golden paintbrush occurs in upland prairies, on generally flat grasslands, including some that are characterized by mounded topography. Low deciduous shrubs are commonly present as small to large thickets. In the absence of fire, some of the sites have been colonized by trees, primarily Douglas-fir, and shrubs, including wild rose and Scotch broom, an aggressive non-native shrub. The mainland population in Washington occurs in a gravelly, glacial outwash prairie. Other populations occur on clayey soils derived from either glacial drift or glacio-lacustrine sediments (in the northern end of the species' historic range). All of the extant populations are on soils derived from glacial origins. At the southern end of its historic range, populations occurred on clayey alluvial soils, in association with Oregon white oak woodlands. Because the habitat of this species is not habitat in which dreissenids would be found, this species is excluded from further analysis.

Greene's tuctoria (*Tuctoria greenei*) (OR)

This grass typically occurs in vernal pools in open grassland and is threatened by the destruction of rare vernal pool habitat. Because the habitat of this species is not habitat in which dreissenids would be found, this species is excluded from further analysis.

Howell's spectacular thelypody (*Thelypodium howellii spp. spectabilis*) (OR)

Howell's spectacular thelypody occurs in moist, moderately well-drained, somewhat alkaline meadow habitats, typically growing with salt tolerant species. Because the habitat of this species is not habitat in which dreissenids would be found, this species is excluded from further analysis.

Kincaid's lupine (Lupinus sulphureus spp. kincaidii) (OR, WA)

Kincaid's lupine is found mainly in the Willamette Valley, Oregon where it occupies native grassland habitats. Kincaid's lupine is typically found in native upland prairie. Because the habitat of this species is not habitat in which dreissenids would be found, this species is excluded from further analysis.

Large-flowered woolly meadowfoam (*Limnanthes pumila spp. grandiflora*) (OR)

Woolly meadowfoam occurs at the edge of vernal pools at elevations of 375 to 400 meters (1,230 to 1,310 feet). Because the habitat of this species is not habitat in which dreissenids would be found, this species is excluded from further analysis.

MacFarlane's four o'clock (*Mirabilis macfarlaneil*) (OR, WA)

Macfarlane's four-o-clock grows on rockslides, canyon walls, and sandy to gravelly talus slopes. Elevation ranges from 300 to 900 m (980 to 2050 feet). Because the habitat of this species is not habitat in which dreissenids would be found, this species is excluded from further analysis.

Malheur wire-lettuce (*Stephanomeria malheurensis*) (OR)

Malheur wirelettuce occurs in the high desert of the northern portion of the Great Basin and is located in an area south of Burns, Oregon. It occurs on top of a dry, broad hill on volcanic soil intermixed with layers of limestone. Dominant plants at the site are big sagebrush (*Artemisia tridentata*), gray rabbitbrush (*Chrysothamnus nauseosus*), green rabbitbrush (*Chrysothamnus viscidiflorus*), and, more recently, invasive cheatgrass (*Bromus tectorum*). Malheur wirelettuce may be one of the few species able to survive on and around the otherwise barren harvester ant hills at the site. Because the habitat of this species is not habitat in which dreissenids would be found, this species is excluded from further analysis.

Marsh sandwort (*Arenaria paludicola*) (WA)

Marsh sandwort is a coastal species that was historically known to occur in wetlands, and in freshwater marshes. Plants have been documented in areas with or without standing water and in acidic, organic bog soils and sandy substrates with high organic content. Because the habitat of this species is not habitat in which dreissenids would be found, this species is excluded from further analysis.

McDonald's rockcress (*Arabis macdonaldiana*) (OR)

This species is restricted to soils derived from ultramafic rocks, chiefly peridotite. Soils may range from recently exposed serpentine to very old weathered lateritic soils. A pronounced red color is often evident in the lateritic soils because of the abundance of iron. These soils are also high in heavy metals such as copper, chromium and nickel. The habitat is often very steep and unstable, with an open tree canopy of generally less than 5 percent cover. Elevation ranges up to about 4,900 feet on the slopes of Preston Peak and Sanger Peak in the Siskiyou Mountains. Vegetation association ranges from dry Jeffrey Pine, knobcone pine, or incense cedar woodlands to brushy or very open, rocky scree slopes. In addition to scattered trees, associated vegetation includes a diverse array of herbs and shrubs, such as montane penny-cress, Bolander's lily, and multiple species of buckbrush, fescue grass, iris, snakeroot, lomatium, stonecrop, violet, phlox, onion, and others. Serpentine barren habitats in general often support a great variety of endemic plants, many of which are sensitive or rare. Because the habitat of this species is not habitat in which dreissenids would be found, this species is excluded from further analysis.

Rough popcornflower (*Plagiobothrys hirtus*) (OR)

Rough popcornflower grows in open, seasonal wetlands in poorly- drained clay or silty clay loam soils at elevations ranging from 30 to 270 m (100 to 900 ft). The taxon depends on seasonal flooding and/or fire to maintain open habitat and to limit competition with invasive native and non-native plant species. This plant occurs in open microsites within the one-sided sedge (*Carex unilateralis*)-meadow barley (*Hordeum brachyantherum*) community type within interior valley grasslands. The plant occurs on soils in the Conser Silty Clay Loam Series (NRCS mapped soil unit SSURGO 44A). Because the habitat of this species is not habitat in which dreissenids would be found, this species is excluded from further analysis.

Showy stickweed (*Hackelia venusta*) (WA)

Showy stickseed grows on sparsely vegetated, granitic scree on unstable, steep slopes on the east slope of the central Cascade Mountains of Washington. Because the habitat of this species is not habitat in which dreissenids would be found, this species is excluded from further analysis.

Slender Orcutt grass (*Orcuttia tenuis*) (OR)

O. tenuis is dependent on vernal pools; however, it has been reported from other natural and artificial wetlands such as stock ponds, and borrow pits. The plants tolerate inundation and therefore live in deeper pools or in deeper areas of pools than Green's tuctoria. Primary habitat requirement appears to be inundation of sufficient duration and quantity to eliminate most competition and to meet the plant's physiological requirements for prolonged inundation, followed by gradual desiccation. Occupied pools are or were underlain by iron-silica cemented hardpan, tuffaceous alluvium, or claypan. Because the habitat of this species is not habitat in which dreissenids would be found, this species is excluded from further analysis.

Slickspot peppergrass (*Lepidium papilliferum*) (ID)

The native plant occurs in specialized habitats known as slickspots, which are mini-playas or natric (high sodium soil) sites with distinct clay layers. Slickspots tend to be highly reflective, are usually relatively light in color and occur dispersed throughout the sagebrush-steppe ecosystem in southwest Idaho. More than 90 percent of the occupied slickspot peppergrass habitat occurs on federal lands with the remaining occupied habitat owned by the state of Idaho private land owners. Because the habitat of this species is not habitat in which dreissenids would be found, this species is excluded from further analysis.

Spalding's catchfly (*Silene spaldingii*) (OR, WA, ID, MT)

This species grows on mesic grassland prairies at low- to mid- elevations. Associated species include Idaho fescue (*Festuca idahoensis*), bluebunch wheatgrass (*Agropyron spicatum*), Nutka rose (*Rosa nutkana*), purple avens (*Geum triflorum*), sticky geranium (*Geranium viscosis*sum), balsamroot (*Balsamorhiza sagittata*), and scattered Ponderosa pine (*Pinus ponderosa*). Because the habitat of this species is not habitat in which dreissenids would be found, this species is excluded from further analysis.

Umtanum desert buckwheat (*Eriogonum codium*) (WA)

The solitary population occurs between 340–400 m (1,120–1,300 ft) on flat to gently sloping microsites near the top of a steep, north-facing basalt ridge overlooking the Columbia River. Because the habitat of this species is not habitat in which dreissenids would be found, this species is excluded from further analysis.

Wenatchee Mountains checker-mallow (*Sidalcea oregana var. calva*) (WA)

The Wenatchee Mountains checker-mallow (Sidalcea oregana var. calva) is an endemic plant found only in mid-elevation wetlands and moist meadows within Chelan County in eastern Washington State. This plant is currently known from only five populations. The largest population has an estimated 11,000 plants and the remaining 4 populations range in size from 8 to 300 individuals. Because the habitat of this species is not habitat in which dreissenids would be found, this species is excluded from further analysis.

Western lily (*Lilium occidentale*) (OR)

This species has been reported from sites in a narrow band along the Pacific Coast no more than four miles inland from Coos County, Oregon about 200 miles south to Humboldt County, California. Western lily typically occurs within, or at the edges of fens and in poorly drained forest or thicket openings. It also grows in coastal prairie/scrub near the ocean. Fens are composed of highly organic soils with a fluctuating water table, and often situated above Blacklock or other soils that serve to perch a seasonal water table. Because the habitat of this species is not habitat in which dreissenids would be found, this species is excluded from further analysis.

White bluffs bladderpod (Physaria douglasii spp. tuplashensis) (WA)

The buckwheat is a woody plant that can live up to 150 years and is limited to a weathered basalt outcrop on the top edge of the Umtanum Ridge in Benton County, where it is threatened by fire, invasive species, off-road vehicle destruction and stray cattle. Because the habitat of this species is not habitat in which dreissenids would be found, this species is excluded from further analysis.

APPENDIX B. IMPORTANT LIFE HISTORY INFORMATION FOR SPECIES AND CRITICAL HABITATS ASSOCIATED WITH CRB WATER BODIES

Mammals

Columbian white-tailed deer (*Odocoileus virginianus leucurus*) (OR, WA)

Information provided here is summarized in USFWS (1983) and from USACE and USFWS (2018).

Listing History

On March 11, 1967, the Secretary of the Interior identified the Columbian white-tailed deer (CWTD) as an endangered species under the authority of the Endangered Species Preservation Act of October 15, 1966. On March 8, 1969, the Secretary of the Interior again identified the CWTD as an endangered species. On August 25, 1970, the Acting Secretary of the Interior proposed to list the CWTD as an endangered subspecies under the authority of new regulations implementing the Endangered Species Conservation Act of 1969. The CWTD was automatically listed under the ESA when it was enacted in 1973.

On July 24, 2003, the Douglas County, Oregon, population was delisted due to recovery. October 17, 2016, the USFWS published a final rule to "downlist" the CWTD to threatened status.

Life History/Biological Requirements

Islands and bottomlands along the lower Columbia River around 9.8 ft (3 m) above sea level with vegetation over 2.3 ft (0.7 m) high in the vicinity of forage species are preferred. Native vegetation of the Columbia River tidal area includes dense, tall shrub and tree community including Sitka spruce, dogwood, cottonwood, red alder, and willow species. These and other species such as rose, sumac, and elderberry are common food and cover sources.

Breeding occurs from mid-September through late February, with a peak in November. Does reach sexual maturity by 6 months of age or when their weight reaches approximately 2.2 pounds [lbs (36 kilograms (kg))]. Maturation and fertility depends on the nutritional quality of available forage. Fawns are born in early summer after a 200-day gestation period.

Distribution and Critical Habitat

Columbian-white tailed deer are associated with riparian habitats in the Lower Columbia River and Douglas County, Oregon.[29] This species occupies tidal spruce habitats—densely forested swamps covered with tall shrubs and scattered spruce, alder, cottonwood, and willows—on islands along the Columbia River. Islands and bottomlands along the lower Columbia River around 9.8 ft (3 m) above sea level with vegetation over 2.3 ft (0.7 m) high near forage species are preferred. Native vegetation of the Columbia River tidal area includes dense, tall shrub and tree community including Sitka spruce, dogwood, cottonwood, red alder, and willow species. These and other species such as rose, sumac, and elderberry are common food and cover sources.

In Douglas County, Oregon, this species uses willow and cottonwood habitat along rivers and streams as well as oak-savannah habitats in upland areas.

Although habitat types and locations have been identified for the Columbian white-tailed deer, no critical habitat has been designated. Currently, the Columbia River DPS has a discontinuous range of approximately 149 mi^2 (240 km^2) or about 60,000 ac^2 (24,281 ha^2) in limited areas of Clatsop, Multnomah, and Columbia Counties in Oregon, and Cowlitz, Wahkiakum, Pacific, Skamania, and Clark Counties in Washington. Within that range, CWTD currently occupy an area of approximately 16,000 ac^2 [6,475 ha^2].

Threats

Conversion of brushy riparian land to agriculture, urbanization, uncontrolled sport, commercial hunting, and other factors caused the extirpation of CWTD over most of its range. A lack of dense woody cover between open pastures has been identified as a major limiting habitat factor. The population had also been severed into two small, spatially separated groups, historically, making genetic diversity another risk factor.

Other potential threats include catastrophic flood damaging suitable habitat, as well as hoof rot, which is a crippling hoof disease exacerbated by wet conditions that has plagued the Columbia River population.

29 https://www.fws.gov/oregonfwo/articles.cfm?id=149489413

Birds

Least tern (*Sterna antillarum*) (MT)[30]

Information provided here is summarized in USFWS (1990) and from USACE and USFWS (2018).

Listing History

The interior least tern was listed as an endangered species on June 27, 1985 in the States of Arkansas, Colorado, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana (Mississippi River and its tributaries north of Baton Rouge), Mississippi (Mississippi River), Missouri, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Tennessee, and Texas (except within 80 km of Gulf Coast).

Life History/Biological requirements

Interior least terns spend about 4-5 months at their breeding sites. They arrive at breeding areas from late April to early June. Courtship behavior of least terns is similar throughout North America. Courtship occurs at the nesting site or at some distance from the nest site. Breeding site fidelity is high.

From late April to August they occur primarily on barren to sparsely vegetated riverine sandbars, dike field sandbar islands, sand and gravel pits, and lake and reservoir shorelines. The nest is a shallow and inconspicuous depression in an open, sandy area, gravelly patch, or exposed flat. Small stones, twigs, pieces of wood and debris usually lie near the nest. Least terns nest in colonies or terneries, and nests can be as close as just a few meters apart or widely scattered up to hundreds of meters.

The birds usually lay two or three eggs. The average clutch size for interior least terns nesting on the Mississippi River during 1986–1989 was 2.4 eggs. Egg-laying begins by late May. Both sexes share incubation which generally lasts 20-25 days, but has ranged from 17 to 28 days.

The interior least tern's home range during the breeding season usually is limited to a reach of river near the sandbar nesting site where they feed primarily on fish.

Distribution and Critical Habitat

No critical habitat has been designated for the interior population of the least tern. The interior least tern is migratory and historically bred along the Mississippi, Red and Rio Grande River systems and rivers of central Texas. The breeding range extended from Texas to Montana and from eastern Colorado and New Mexico to southern Indiana. It

[30] USFWS (1990)

included the Red, Missouri, Arkansas, Mississippi, Ohio and Rio Grande River systems (Figure 54). Incidental occurrences of least terns in Michigan, Minnesota, Wisconsin, Ohio and Arizona have been reported.

The interior least tern continues to breed in most of the aforementioned river systems, although its distribution generally is restricted to less altered river segments.

Least terns nest on barren to sparsely vegetated sandbars along rivers, sand and gravel pits, lake and reservoir shorelines, and occasionally gravel rooftops. Recreational activities on rivers and sandbars disturb nesting least terns, causing them to abandon their nests. The interior least tern breeding season is April through August – nesting season is mid-May through August. Nesting in small colonies, least tern nests are shallow depressions scraped in open sandy areas, gravelly patches, or exposed flats. Both parents incubate their eggs for about 24 days. Chicks leave the nest only a few days after hatching, but the adults continue to care for them, leading them to shelter in nearby grasses and bringing them food. The interior least tern's home range during the breeding season usually is limited to a reach of river near the sandbar nesting site where they feed primarily on fish.

Threats

Threats to the survival of the species include the actual and functional loss of riverine sandbar habitat. Channelization and impoundment of rivers have directly eliminated nesting habitat.

Piping plover (*Charadrius melodus*) (MT)

Information provided here is summarized in Atkinson and Dood (2006).

Breeding Season Habitat

In north-central North America, plovers typically nest on barren sand and gravel beaches along the Great Lakes, and on alkali flats, gravel shorelines and river sandbars in the Great Plains (USFWS 2002c). While data suggests that habitat use by plovers is dynamic (USFWS 2002c), alkali lakes and wetlands associated with the Missouri Coteau landform, located inside the Prairie Pothole Region, appear to support a significant portion (34 -75%) of the Great Plains population in any given year (Haig and Plissner 1993, Murphy et al. 2000, Plissner and Haig 2000, Haig et al. 2005, Skagen and Thompson 2005). Remaining nest sites occur primarily along rivers and reservoirs although fresh water lakes, dry alkali lakes, sandpits, industrial ponds and gravel mines may also be utilized (Haig et al. 2005).

Piping plovers are a migratory species. Piping Plovers primarily select unvegetated sand or pebble beaches on shorelines or islands in freshwater and saline wetlands.

Vegetation, if present at all, consists of sparse, scattered clumps (Casey 2000). Open shorelines and sandbars of rivers and large reservoirs in the eastern and north-central portions of Montana provide prime breeding habitat. In Montana, and throughout the species' range, nesting may occur on a variety of habitat types. If conditions are right, alkali wetlands, lakes, reservoirs, and rivers can all provide the essential features required for nesting. The alkali wetlands and lakes found in the northeastern corner of the state generally contain wide, unvegetated, gravelly, salt-encrusted beaches. Rivers that flood adequately can supply open sandbars or gravelly beaches, as can large reservoirs, with their shoreline beaches, peninsulas, and islands of gravel or sand. Sites with gravel substrate provide the most suitable sites for nesting (Montana Piping Plover Recovery Committee 1994). One of the most limiting factors to nesting site selection is vegetational encroachment. Piping Plovers avoid areas where vegetation provides cover for potential predators. Fine-textured soils are easier to treat mechanically than rocky or gravelly soils when vegetation is determined as a limiting factor in an area's ability to provide suitable nesting habitat, but fine soils are not typically a preferred nesting substrate (Montana Piping Plover Recovery Committee 1994). Nests are simple scrapes dug into the nest substrate which may or may not be lined with pebbles (Montana Piping Plover Recovery Committee 1994, 1995, Haig 1992).

Migrants begin arriving at breeding areas in southern Washington in early March and in central California as early as January, although the main arrival is from early March to late April. Since some individuals nest at multiple locations during the same year, birds may continue arriving through June. Males make a nest scrape, which is a depression in the sand or substrate made by leaning forward on his breast and scratching his feet while rotating his body axis. The earliest nests on the California coast occur during the first week of March in some years and by the third week of March in most years. Peak initiation of nesting is from mid-April to mid-June. Hatching lasts from early April through mid-August, with chicks reaching fledging age approximately 1 month after hatching.

Riverine Habitat

Characteristic riverine nesting sites include reservoir beaches and large dry, barren sand or gravel bars within wide, unobstructed river channels (USFWS 1988). Nests are usually located after the spring and early summer flows recede and dry areas on sandbars are exposed. Along the Platte River, Nebraska, relatively large sandbars, averaging 286 m long and 55 m wide, appear to be selected when available (Faanes 1983). In addition, preferred vegetative cover at nest sites is generally low (Schwalbach 1988). Although Faanes (1983) reported vegetative cover of 25% on nesting sandbar habitat along the Platte River, other research suggests that the optimum range is much lower: estimates range from 0-10% (Armbruster 1986). Likewise, along the Missouri River in South Dakota, plover colony sites were characteristically barren or with short (<10cm) sparse (<10%)

vegetative cover (Schwalbach 1988).

Foraging Habitat
Plovers feed by pecking at or just below the substrate surface (Cairns 1977, USFWS 2002c, Haig and Elliot-Smith 2004) and require feeding grounds that are rich in surface invertebrates (Shaffer and Laporte 1994). While adults typically concentrate feeding efforts within 5 m of the water's edge (Whyte 1985), chicks tend to feed on firmer ground at greater distances from the shoreline (Cairns 1977).

Critical Habitat
In 2002, the USFWS officially designated critical habitat for the Northern Great Plains breeding population (USFWS 2002c). Under the Endangered Species Act, critical habitat refers to specific geographic locations that contain features essential for conserving a species and may require special management considerations. While critical habitat can be, and is, designated on private lands, it only relates to those activities on private lands that require federal permits or funding that are required to be reviewed under the Act. For piping plovers, primary constituent elements include components essential for courtship, breeding, sheltering, brood-rearing, foraging, roosting, intraspecific communication and migration. Furthermore, it stated that the one overriding primary biological element that must be present at all sites is the maintenance of the dynamic ecological processes that create and maintain piping plover habitat.

On prairie alkali lakes and wetlands the physical primary constituent elements include shallow, seasonally to permanently flooded, wetlands with sandy to gravelly, sparsely vegetated beaches as well as springs and fens along the edges of alkali lakes and wetlands. Along rivers, sparsely vegetated channel sandbars, sand and gravel beaches on islands and temporary pools on sandbars are considered primary. At reservoirs and inland lakes such elements include sparsely vegetated shoreline beaches, peninsulas, islands composed of sand and gravel or shale and their interface with the water bodies.
In its final ruling, the USFWS identified a total of 19 habitat units in the states of Minnesota, Montana, Nebraska, North Dakota, and South Dakota as critical to aiding piping plover recovery (USFWS 2002c).

Within Montana, 40,423.1 hectares (99,887.5 acres) including four separate units comprised of various ownership patterns are designated as critical habitat (Table 7).

Table 7. Land ownership within unit boundaries for critical piping plover habitat in Montana. Source: USFWS (2002).

Critical Habitat Unit	Ownership (in hectares)				
	Federal	State	Tribal	Private	Total
MT-1 Sheridan County	5,405	119		2,254	7,779
MT-2 Missouri River					202
MT-3 Fort Peck Reservoir	31,311				31,311
MT-4 Bowdoin NWR	38,049	119		2,254	40,423

Sheridan County (Unit MT-1), in the extreme northeastern corner of the state, includes 20 alkali lakes and wetlands. Essential nesting habitat is dispersed throughout this unit. The Missouri River units (MT-2 and MT-3) consist of both reservoir and river reaches: Fort Peck Reservoir is located entirely within the Charles M. Russel NWR, while unit MT-2 encompasses approximately 201.8 km of the Missouri River just west of Wolf Point to the Montana-North Dakota border.

The river reach below Fort Peck Reservoir to the confluence of the Milk River is not included as it is highly degraded and contains few sandbars. Bowdoin NWR is the site of the fourth critical habitat unit (MT-4). Despite sporadic breeding records at Alkali Lake in Pondera County, Bowdoin NWR, located in east-central Phillips County, represents the typical western edge of the Northern Great Plains breeding population of piping plovers.

In Phillips County, three historic lake beds at Nelson Reservoir most likely provided essential habitat to breeding piping plovers however this area was flooded when the reservoir was created for irrigation purposes. While Nelson Reservoir was originally proposed for critical habitat inclusion, it was excluded from the final listing as a Memorandum of Understanding (MOU) between the Bureau of Reclamation (BOR), the USFWS, and local Irrigation Districts was in place that would minimize the threat of flooding to active piping plover nest sites. Additionally, as part of the terms and conditions of a 1990 biological opinion on the operation of Nelson Reservoir by the BOR, conservation measures had been employed to minimize take, and would continue.

Occupied nesting habitat on North Alkali Lake in Pondera County occurs on Blackfeet tribal land and was not designated critical habitat at the request of the tribal government. Habitat on tribal lands determined essential to conserve the species may be designated. This was the case for sand bars along the Missouri River along the Fort Peck Reservation. The USFWS believes this designation is consistent with the special trust responsibility the Federal government has to Indian people to preserve and protect their lands and resources.

In Montana, spring arrival of the species most often occurs from late April through early May with departure occurring by late August (Montana Piping Plover Recovery Committee 1997). Recent analysis of migration data from banded Great Lakes birds suggests that critical habitat units are used heavily during migration (Stucker and Cuthbert 2006). Further, while stopover length could not be quantified in this study the authors speculate that it may be variable in length for the Great Lakes population, ranging from several days to one month based on anecdotal reports (Stucker and Cuthbert 2006).

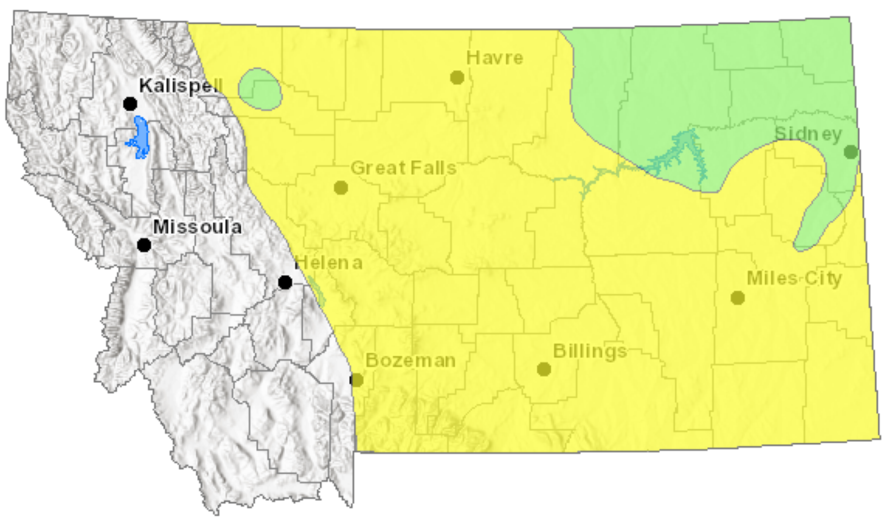

Figure 4. Summer range (green) and migratory range (yellow) of piping plovers in Montana. Source. Montana Natural Heritage Program.

Red knot (Calidris canutus rufa)[31] (MT)

Red knots are a migratory species. Migratory stopovers in Montana are rare, but are most common at larger wetlands. A total of 60 percent of documented migratory stopovers in Montana have been at Freezeout Lake, Benton Lake National Wildlife Refuge, and Lake Bowdoin National Wildlife Refuge (Montana Natural Heritage Program Point Observation Database 2016). Red knots are rarely observed at Montana wetlands during migration in May or July through October (Montana Natural Heritage Program Point Observation Database 2016). There are only about 50 observations documented for individuals stopping at Montana wetlands, with only 0–4 for any given year since the 1970s; 60 percent of observations have been in May associated with

31 http://fieldguide.mt.gov/speciesDetail.aspx?elcode=ABNNF11020

northward migration (Montana Natural Heritage Program Point Observation Database 2016).

Western snowy plover (*Charadrius alexandrines nivosus*)[32] (OR, WA)

Information included here is from USFWS (2007) and USACE (2018).

Listing History

On March 5, 1993, the Pacific coast population of the western snowy plover was listed as threatened. The Pacific coast population is defined as those individuals that nest within 50 mi (80.5 km) of the Pacific Ocean on the mainland coast, peninsulas, offshore islands, bays, estuaries, or rivers of the United States and Baja California, Mexico.

Life History/Biological requirements

The Pacific coast population of the western snowy plover breeds primarily above the high tide line on coastal beaches, sand spits, dune-backed beaches, sparsely-vegetated dunes, beaches at creek and river mouths, and salt pans at lagoons and estuaries. Less common nesting habitats include bluff-backed beaches, dredged material disposal sites, salt pond levees, dry salt ponds, and river bars.

Migrants begin arriving at breeding areas in southern Washington in early March and in central California as early as January, although the main arrival is from early March to late April. Since some individuals nest at multiple locations during the same year, birds may continue arriving through June. Males make a nest scrape, which is a depression in the sand or substrate made by leaning forward on his breast and scratching his feet while rotating his body axis.

The earliest nests on the California coast occur during the first week of March in some years and by the third week of March in most years. Peak initiation of nesting is from mid-April to mid-June. Hatching lasts from early April through mid-August, with chicks reaching fledging age approximately 1 month after hatching.

In winter, western snowy plovers are found on many of the beaches used for nesting as well as on beaches where they do not nest, in man-made salt ponds, and on estuarine sand and mud flats.

Distribution and Critical Habitat

Critical habitat was designated for the western snowy plover December 7, 1999, again on September 29, 2005, and most recently on June 6, 2012. The current Pacific coast breeding population extends from Damon Point, Washington, south to Bahia

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32 Pacific coast population

Magdalena, Baja California, Mexico [including both Pacific and Gulf of California coasts Figure 58)]. The western snowy plover winters mainly in coastal areas from southern Washington to Central America.

Threats

Habitat degradation caused by human disturbance, urban development, introduced beachgrass (*Ammophila* spp.), and expanding predator populations have resulted in a decline in active nesting areas and in the size of the breeding and wintering populations.

Yellow-billed cuckoo (*Coccyzus americanus*) (OR, WA, ID, MT)

Information in this section from USACE (2018).

Listing History

The western yellow-billed cuckoo was listed as threatened October 3, 2014, while critical habitat was proposed August 15, 2014, but a final designation has not been made. The western DPS includes Arizona, California (Baja California, Baja California Sur, Chihuahua, western Durango, Sinaloa, and Sonora), western Colorado, Idaho, western Montana, western New Mexico, Nevada, Oregon, western Texas, Utah, Washington, western Wyoming, and southwest British Columbia.

Life History/Biological requirements

As summarized by Cornell University (https://www.allaboutbirds.org/guide/Yellow-billed_Cuckoo/lifehistory): Yellow-billed cuckoos use wooded habitat with dense cover and water nearby, including woodlands with low, scrubby, vegetation, overgrown orchards, abandoned farmland, and dense thickets along streams and marshes. In the Midwest, look for cuckoos in shrublands of mixed willow and dogwood, and in dense stands of small trees such as American elm. In the Southwest, yellow-billed cuckoos are rare breeders in riparian woodlands of willows, cottonwoods and dense stands of mesquite to breed.

Yellow-billed cuckoo prey largely on caterpillars. On the east coast, periodic outbreaks of tent caterpillars draw cuckoos to the tent-like webs, where they may eat as many as 100 caterpillars at a sitting. Fall webworms and the larvae of gypsy, brown-tailed, and white-marked tussock moths are also part of the cuckoo's lepidopteran diet, often supplemented with beetles, ants, and spiders. They also take advantage of the annual outbreaks of cicadas, katydids, and crickets, and will hop to the ground to chase frogs and lizards. In summer and fall, cuckoos forage on small wild fruits, including elderberries, blackberries and wild grapes. In winter, fruit and seeds become a larger part of the diet.

Pairs may visit prospective nest sites multiple times before building a nest together. Nest heights can range from 0.98 yds (0.9 m) to as much as 30 yds (27.5 m) off the ground, with the nest placed on a horizontal branch or in the fork of a tree or large shrub. In the West, nests are often placed in willows along streams and rivers, with nearby cottonwoods serving as foraging sites.

The male and female yellow-billed cuckoo build a loose stick nest together, using twigs collected from the ground or snapped from nearby trees and shrubs. The male sometimes continues bringing in nest materials after incubation has begun. Clutch size can range from 1-5 eggs with up to 2 clutches per year.

Distribution and Critical Habitat

Critical habitat is proposed, but not yet designated for yellow-billed cuckoo. Critical habitat was proposed in 2013The breeding range of the yellow-billed cuckoo formerly included most of North America from southern Canada to the Greater Antilles and northern Mexico (AOU 1957, 1998).

In recent years, the species' distribution in the west has contracted. The northern limit of breeding in the western coastal States is now in Sacramento Valley, California, and the northern limit of breeding in the western interior States is southern Idaho [AOU 1998; Hughes 1999. The species overwinters from Columbia and Venezuela, south to northern Argentina (Ehrlich et al. 1992; AOU 1998).

Threats

The greatest threat to the species has been reported to be loss of riparian habitat. It has been estimated that 90% of the cuckoo's stream-side habitat has been lost (USFWS 2018a). Habitat loss in the west is attributed to agriculture, dams, and river flow management, overgrazing and competition from exotic plants such as tamarisk.

Amphibians

Oregon spotted frog (*Rana pretiosa*) (OR, WA)

Information in this section from USACE (2018) and other sources.

Listing History

The Oregon spotted frog was listed as threatened August 29, 2014.

Life History/Biological requirements

Adult Oregon spotted frogs begin to breed by 1 to 3 years of age, depending on sex, elevation, and latitude. Males may breed at 1 year at lower elevations and latitudes, but generally breed at 2 years of age. Females breed by 2 or 3 years of age, depending on elevation and latitude. Breeding occurs in February or March at lower elevations and between early April and early June at higher elevations. Males and females separate soon after egg-laying, with females returning to fairly solitary lives. Males often stay at the breeding site, possibly for several weeks, until egg-laying is completed. Females may deposit their egg masses at the same locations in successive years.

The Oregon spotted frog life cycle requires shallow water areas for egg and tadpole survival; perennially deep, moderately vegetated pools for adult and juvenile survival in the dry season; and perennial water for protecting all age classes during cold wet weather. The Oregon spotted frog inhabits emergent wetland habitats in forested landscapes, although it is not typically found under forest canopy. Historically, this species was also associated with lakes in the prairie landscape of the Puget lowlands. This is the most aquatic native frog species in the Pacific Northwest, as all other species have a terrestrial life stage. Post-metamorphic Oregon spotted frogs are opportunistic predators that prey on live animals, primarily insects, found in or near the water.

Distribution and Critical Habitat

Critical habitat was designated for the Oregon spotted frog May 11, 2016. Historically, the Oregon spotted frog ranged from British Columbia to the Pit River basin in northeastern California. Currently, the Oregon spotted frog is found from extreme southwestern British Columbia south through the Puget Trough and in the Cascades Range from south-central Washington at least to the Klamath Basin in southern Oregon (Figure 63). Oregon spotted frogs occur in lower elevations in British Columbia and Washington and are restricted to high elevations in Oregon.

Oregon Spotted Frogs are highly aquatic and live in or near permanent bodies of water, including lakes, ponds, slow streams and marshes. They prefer areas with thick algae and vegetation for cover, but may also hide under decaying vegetation. They are most often found in non-woody wetland plant communities (species such as sedges, rushes and grasses). Most Oregon Spotted Frogs hibernate and aestivate. Oregon Spotted Frogs distribute through a wide range of altitudes and in Washington have been found from 40 to 620 meters above sea level (McAllister and Leonard 1997). Adults eat insects, mollusks, crustaceans and arachnids. Larvae eat algae and organic debris. The timing of breeding is related to ice melt on lakes, ponds and marshes. Breeding occurs from February to March in the lower elevations, and from March to April in the higher elevations in the Cascade Range. Oregon Spotted Frogs lay their eggs in the shallows of a permanent water source.

Oregon Spotted Frogs are generally associated with wetland complexes > 4 ha (10 acres) in size with extensive emergent marsh coverage that warms substantially from spring to fall (Pearl and Hayes 2004). Hayes (1994a, b) stressed the reliance of this species on warm-water habitats. Washington's remaining populations of Oregon Spotted Frogs occupy palustrine wetlands connected to riverine systems. The perennial creeks and associated network of intermittent tributaries provide aquatic connectivity between breeding sites, active season habitat and overwintering habitat. Additionally, perennially flowing waters may provide the only suitable habitat during extreme summer drought or during winter when still-waters become hypoxic (low dissolved oxygen levels that are detrimental to aerobic organisms). Associated wetlands have a mix of dominance types including aquatic bed, emergent, scrub-shrub, and forested wetlands. The seasonally inundated wetland margins are frequently hay fields and pasture. The less disturbed sites have wet meadows and prairie uplands. Some occupied sites are engineered by American Beaver (*Castor canadensis*, hereafter "beaver"). All the remaining Oregon Spotted Frog sites have moderate to severe habitat alteration including a history of cattle grazing and/or hay production as well as encroaching or established rural residential development. Hydrology has been altered to some extent at all sites with the most extensive changes at Conboy Lake National Wildlife Refuge and surrounding area.

Watson et al. (2000; Black River) found that different life stages of Oregon Spotted Frogs had different hydrological needs that varied by season. For development of eggs and larvae, relatively stable water levels were needed during the breeding season. For survival of transformed frogs, deeper water pools were critical during the summer dry season. Adequate water levels over emergent vegetation were important for survival of all age classes during the wet season and coldest time of the year. In general, frogs selected sedge-dominated and hardhack (*Spiraea douglasii*)–dominated types and avoided reed canarygrass types, alder/willow, and deep water. Uplands were not used. During the breeding season, frogs preferred sedge-dominated habitat particularly sedge/rush found in association with breeding sites. During the dry season, frogs preferred hardhack-dominated habitats. The hardhack was in the deepest waters and these retained water during dry periods. Also, the hardhack shaded out reed canarygrass preventing dense, impenetrable grass cover. Aquatic connectivity was essential; frogs did not move terrestrially to isolated ponds. The predominant use of shallow water habitat by Oregon Spotted Frogs was illustrated by Watson et al. (1998, 2003), who found Oregon Spotted Frogs (n = 295 radio-telemetry locations) selected water depths of 10–30 cm (~4–11.7 in.) with less emergent vegetation and more submergent vegetation than adjacent habitats.

Threats
Habitat alteration appears to be the primary threat to the Oregon spotted frog. Breeding locations makes Oregon spotted frogs acutely vulnerable to fluctuating water levels, disease, predation, poor water quality, and extirpation from stochastic events. Hydrologic changes, resulting from activities such as water diversions and removal of beavers, increase the likelihood of fluctuating water levels and temperatures, and may also facilitate predators.

Fish

Bull trout (*Salvelinus confluentus*) (OR, WA, ID, MT)
Information in this section from USACE (2018) and other sources.

Listing History
The USFWS issued a final rule listing the Columbia River population of bull trout as threatened on June 10, 1998, while critical habitat for this species was listed on October 18, 2010. Bull trout are currently listed throughout their range in the United States as a threatened species.

Life History/Biological requirements
Bull trout have four documented life history forms:

- The stream-resident form lives out its life in small headwater streams;
- The fluvial form lives as an adult in large rivers but spawns in small tributary streams (it often attains a large size, reaches sexual maturity at about five, and undergoes long migrations between mainstem rivers and small tributary spawning streams);
- The lacustrine-adfluvial form spawns in tributary streams but lives as an adult in lakes (McPhail and Baxter 1996), often making long migrations between lakes and spawning streams; and
- One anadromous form of bull trout exists in the Coastal Puget-Sound population—it spawns in rivers and streams, but rears young in the ocean. The species is known to occur in numerous counties throughout the Columbia River Basin states.

Habitat components that appear to influence bull trout distribution and abundance include water temperature, cover, channel form and stability, valley form, spawning and rearing substrates and migratory corridors (with resting habitat). All life history stages of bull trout are associated with complex forms of cover, including large woody debris, undercut banks, boulders and deep pools (Wydoski and Whitney 2003).

Distribution and Critical Habitat
Bull trout critical habitat was designated on October 18, 2010. In the Columbia River Basin, bull trout historically were found in about 60% of the basin. They now occur in less than half of their historic range. Populations remain in portions of Oregon, Washington, Idaho, Montana, and Nevada (Table 8).

Table 8. Acres and miles of Bull trout critical habitat in Idaho, Montana, Oregon and Washington.

	Stream Miles	Acres of Lakes or Reservoirs	Marine Shoreline Miles
Idaho	293	27,296	
Montana	1,058	31,916	
Oregon	911	24,610	
Washington	1,519	26,542	966

Bull trout have specific habitat requirements that influence their distribution and abundance. They are seldom found in waters where temperatures exceed 59 to 64 degrees Farenheit, and they require stable stream channels, clean spawning and rearing gravel, complex and diverse cover, and unblocked migratory corridors.

There are 118 bull trout core areas in Oregon, Washington, Idaho, Montana, and Nevada that are recognized by the US Fish and Wildlife Service (USFWS 2002b). Within the CRB, a total of 95 core areas are described (USFWS 2002b). They generally spawn from August to November during periods of decreasing water temperatures. Egg incubation is normally 100 to 145 days and fry remain in the substrate for several months.

To determine whether or not an action will affect bull trout critical habitat requires an analysis of how the action would affect the nine primary constituent elements (PCEs), or the habitat components essential for the primarily biological needs of foraging, reproducing, rearing of young, dispersal, genetic exchange, or sheltering.

1. Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to contribute to water quality and quantity and provide thermal refugia.

2. Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and freshwater and marine foraging

habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.

3. An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish. Bull trout shift their diet as they grow, feeding on aquatic insects when young (benthic invertebrates and plankton (Carl et al. 1989), and feeding on fish as they grow. Diet is primarily a reflection of food availability, e.g., in water bodies in which bull trout are the only fish species, bull trout forage on benthic invertebrates and plankton (Carl et al. 1989). When other fish species are present, bull trout begin to forage on fish when the bull trout are between 100 and 200 mm (Stewart et al. 1982; Boag 1987; Pratt 1992).

4. Complex river, stream, lake, reservoir, and marine shoreline aquatic environments, and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks and unembedded substrates, to provide a variety of depths, gradients, velocities, and structure.

5. Water temperatures ranging from 2 to 15 °C (36 to 59 °F), with adequate thermal refugia available for temperatures that exceed the upper end of this range. Specific temperatures within this range will depend on bull trout life-history stage and form; geography; elevation; diurnal and seasonal variation; shading, such as that provided by riparian habitat; streamflow; and local groundwater influence.

6. In spawning and rearing areas, substrate of sufficient amount, size, and composition to ensure success of egg and embryo overwinter survival, fry emergence, and young-of-the-year and juvenile survival. A minimal amount of fine sediment, generally ranging in size from silt to coarse sand, embedded in larger substrates, is characteristic of these conditions. The size and amounts of fine sediment suitable to bull trout will likely vary from system to system.

7. A natural hydrograph, including peak, high, low, and base flows within historic and seasonal ranges or, if flows are controlled, minimal flow departure from a natural hydrograph.

8. Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.

9. Sufficiently low levels of occurrence of non-native predatory (e.g., lake trout, walleye, northern pike, smallmouth bass); interbreeding (e.g., brook trout); or competing (e.g., brown trout) species that, if present, are adequately temporally and spatially isolated from bull trout.

Critical habitat includes the stream channels within the designated stream reaches, the shoreline of designated lakes, and the inshore extent of marine near shore areas, including tidally influenced freshwater heads of estuaries (USFWS 2014). In freshwater areas, critical habitat includes the stream channels within the designated stream reaches and a lateral extent as defined by the bankfull elevation on one bank to the bankfull elevation on the opposite bank (USFWS 2014). If bankfull elevation is not evident on either bank, the ordinary high-water line determines the lateral extent of critical habitat (USFWS 2014).

Associated flood plains, shorelines, riparian zones and upland habitat are important to critical habitat areas and that activities in these areas may affect bull trout critical habitat (USFWS 2014).

Adfluvial populations (fish that spawn in tributary streams and rear in streams for several years before migrating to lakes to grow to maturity) are found in large, oligotrophic, high altitude lakes. These populations spawn either in stream tributaries, or in the lake's inlet or outlet (Carl et al. 1989). In large oligotrophic lakes, bull trout use all parts of the lake, foraging in the littoral zone in the fall and spring, and moving to deep water in summer (Goetz 1989). Bull trout move below the thermocline in lakes when the temperature of the littoral zone exceeds 15 degrees Celcius (Bjornn 1961). Even in the spring, bull trout are more abundance in deep water than near the surface (Chisholm et al. 1989). Emigration from spawning streams to lakes occurs throughout the summer (Chisholm et al. 1989).

The critical habitat designations applies only to stream channels defined by ordinary high-water line, or bank-full elevation. This designation does not extend to the floodplain or adjacent land.

To be included as critical habitat, an area had to currently be occupied (as documented within the last 20 years) and provide one or more of the following functions: (1) spawning, rearing, foraging, or over-wintering habitat to support essential existing bull trout local populations; (2) movement corridors necessary for maintaining essential migratory life-history forms; and/or (3) suitable habitat that is considered essential for recovering existing local populations that have declined or that need to be re-established to achieve recovery. Identification of these areas was based on the existence of primary constituent elements.

Primary constituent elements are physical and biological features that are essential to the conservation of the species. These include, but are not limited to: space for individual and population growth and for normal behavior; food, water, or other nutritional or physiological requirements; cover or shelter; sites for breeding, reproduction, or rearing of offspring; and habitats that are protected from disturbance or are representative of the historic geographical and ecological distributions of a species. All the areas proposed as critical habitat for bull trout are within the historic geographic range of the species and contain enough of these physical or biological features (primary constituent elements) essential to the conservation of the species for the species to be able to carry out normal biological function.

Table 9. Stream/shoreline distance (miles/kilometers) designated as bull trout critical habitat by critical habitat unit.

Critical Habitat Unit	Stream/Shoreline Miles	Stream/Shoreline Kilometers
Klamath River Basin	50	80
Clark Fork River Basin	1,136	1,828
Kootenai River Basin	56	91
Willamette River Basin	111	178
Hood River Basin	30	48
Deschutes River Basin	50	80
Umatilla-Walla Walla River Basins	218	350
Grande Ronde River Basin	308	496
Imnaha-Snake River Basins	92	148
Hells Canyon Complex	125	202
Malheur River Basin	38	60
Coeur d'Alene Lake Basin	122	197
Lower Columbia River Basin	94	152
Middle Columbia River Basin	188	302
Northeast Washington River Basins	25	40
Snake River Basin in Washington	68	109
Snake River	17	27
Olympic Peninsula	388	624
Olympic Peninsula (Marine)	406	653
Puget Sound	646	1,039
Puget Sound (Marine)	560	902
Saint Mary - Belly	36	59

Kootenai River white sturgeon (*Acipenser transmontanus*) (ID, MT)

Information in this section from USFWS (1999) and USACE (2018).

Listing History

The Kootenai River population of white sturgeon was listed as endangered on September 6, 1994.

Life History/Biological requirements

The Kootenai River White Sturgeon is a land-locked species found along 167.7 miles of the Kootenai River extending from Kootenai Falls, Montana, located 31 river miles below Libby Dam, Montana, downstream through Kootenay Lake to Corra Linn Dam at the outflow from Kootenay Lake in British Columbia. The Kootenai River population of white sturgeon became isolated from other white sturgeon in the Columbia River basin during the last glacial age (approximately 10,000 years ago). Once isolated, the population adapted to the predevelopment habitat conditions in the Kootenai River drainage.

The species has been declining since the mid-1960, and its population has experienced almost no reproduction since 1974 because of habitat fragmentation—construction of the Libby Dam in Montana altered river flow patterns and reduced river productivity, human development (which has contributed to loss of ecological functions), dikes constructed along the river channel (which reduced riparian function and floodplain interaction), and pollution.

Historically, spring runoff events re-sorted river sediments providing a clean cobble substrate conducive to insect production and sturgeon egg incubation. Side channels and low-lying deltaic marsh lands were un-diked at this time, providing productive, low velocity backwater areas. Nutrient delivery in the system was unimpeded by dams and occurred primarily during spring runoff. Floodplain ecosystems like the predevelopment Kootenai River are characterized by seasonal floods that promote the exchange of nutrients and organisms in a mosaic of habitats and thus enhance biological productivity.

Distribution and Critical Habitat

Critical habitat was initially designated for white sturgeon September 6, 2001, with a revised designation July 9, 2008. The Kootenai River population is one of several land-locked populations of white sturgeon found in the Pacific Northwest. Although officially termed and listed as the "Kootenai River population of white sturgeon", this white sturgeon population inhabits and migrates freely in the Kootenai River from Kootenai Falls in Montana downstream into Kootenay Lake, British Columbia, Canada. A total of 18 miles of the Kootenai River in Idaho is designated critical habitat. Specific actions needed for recovery include spring flow augmentation during the reproduction period;

a conservation aquaculture program to prevent near-term extinction; habitat restoration, and research and monitoring programs to evaluate recovery progress (Duke et al. 1999).

Threats

Modification of the Kootenai River white sturgeon's habitat by human activities has changed the natural hydrograph of the Kootenai River, altering white sturgeon spawning, egg incubation, and rearing habitats; and reducing overall biological productivity. These factors have contributed to a general lack of recruitment in the white sturgeon population since the mid-1960's.

Spawning and rearing habitat are the key limiting factors for Kootenai River White Sturgeon. Spawning and incubation occur from mid-May to August (Duke et al. 1999). Depths for spawning white surgeon in the Lower Columbia River range from 3.5 to 25m—habitat suitability is poor for depths less than 2m, and moderate for depths of 2 to 4m (Parsley and Beckman 1994). Higher velocities are associated with more suitable substrate for white sturgeon egg incubation, greater egg dispersal, and reduction of egg predation (Barton et al. 2006). The greatest occurrence of white sturgeon spawning occurs in the area downstream of the mouth of Deep Creek at river kilometer mile 237.5 and 228.4 (Barton et al. 2006). Generally, habitat suitability is better in the straight reaches compared to meandering reaches because of coarser substrates and higher velocities (Barton et al. 2006). White sturgeon seldom spawn in the straight reach.

Lahontan cutthroat trout (*Oncorhynchus clarki henshawi)* (OR)

Information in this section from USFWS (1995) and USACE (2018).

Listing History

The Lahontan cutthroat (LCT) was listed as endangered October 13, 1970 and downlisted to threatened status on July 16, 1975 to facilitate management and allow regulated angling.

Life History/Biological requirements

Historically, LCT were found in a wide variety of cold-water habitats: Large terminal alkaline lakes (e.g., Pyramid Lakes); oligotrophic alpine lakes (e.g., Lake Tahoe); slow meandering low-gradient rivers (e.g., Humboldt River); moderate gradient montane rivers (e.g., Carson, Truckee, Walker, and Marys Rivers); and small headwater tributary streams. Habitat preferences are similar to other salmonids. Lahontan cutthroat inhabit small streams characterized by cool water, pools in close proximity to cover and velocity breaks, well vegetated and stable stream banks, and relatively silt free, rocky substrate in riffle-run areas. Fluvial LCT generally prefer rocky areas, riffles, deep pools, and habitats near overhanging logs, shrubs, or banks.

Typical of cutthroat trout subspecies, Lahontans are an obligatory stream spawner. Spawning occurs from April through July, depending on stream flow, elevation, and water temperature. Females mature at 3 to 4 years of age, and males at 2 to 3 years of age. Consecutive year spawning by individuals is uncommon. Lake residents migrate up tributaries to spawn in riffles or tail ends of pools. Distance traveled varies with stream size and race of cutthroat trout. Populations in Pyramid and Winnemucca Lakes reportedly migrated over 100 mi (160.9 km) up the Truckee River into Lake Tahoe. Lahontan cutthroat trout spawning migrations have been observed in water temperature ranging from 41–60.8 °F (5–16 °C).

Stream resident LCT are opportunistic feeders, with diets consisting of drift organisms, typically terrestrial and aquatic insects. In lakes, small LCT feed largely on insects and zooplankton, and larger LCT feed on fish.

Distribution and Critical Habitat

No critical habitat has been designated for Lahontan cutthroat trout. The Lahontan cutthroat is an inland subspecies of cutthroat trout endemic to the physiographic Lahontan basin of northern Nevada, eastern California, and the Coyote Lake basin in southeast Oregon. Lahontan cutthroat trout currently occupy between 155 and 160 streams; 123 to 129 streams within the Lahontan basin and 32 to 34 streams outside the basin, with approximately 482 mi (775.7 km) of occupied habitat.

Major impacts to LCT habitat and abundance include: 1) reduction and alteration of stream discharge; 2) alteration of stream channels and morphology; 3) degradation of water quality; 4) reduction of lake levels and concentrated chemical components in natural lakes; and 5) introductions of non-native fish species. These alterations are typically associated with agricultural use, livestock and feral horse grazing, mining, and urban development. Alteration and degradation of LCT habitat have also resulted from logging, highway and road construction, dam building, and the discharge of effluent from wastewater treatment facilities.

Lahontan cutthroat trout are native to the following southeastern Oregon streams: Willow Creek, Whitehorse Creek, Little Whitehorse Creek, Doolitle Creek, Fifteen Mile Creek in the Coyote Lake Basin; and Indian Creek, Sage Creek, and Line Canyon Creek, tributaries of McDermitt Creek in the Quinn River basin (which flows into Nevada).

Lahontan cutthroat trout are obligate but opportunistic stream spawners. Typically, they spawn from April through July, depending on water temperature and flow characteristics. Autumn spawning runs have been reported from some populations. The fish may reproduce more than once, though post-spawning mortality is high (60 to 90 percent). Lake residents migrate into streams to spawn, typically in riffles on well washed gravels. The behavior of this subspecies is typical of stream spawning trout; adults court, pair, and deposit and fertilize eggs in a redd dug by the female. Although the Lahontan cutthroat in Oregon were originally classified as Willow-Whitehorse cutthroat trout, genetic and taxonomic investigations led to the re-classification in 1991 (Williams 1991).

Lahontan trout are stocked in Mann Lake, the only place in Oregon stocked with this desert race of cutthroat trout.[33]

The Quinn River Lahontan Cutthroat Trout SMU is comprised of four populations, three of which are now extinct due to hybridization with non-native rainbow trout. Sage Creek is the only population to persist in the SMU, has an extremely limited distribution and abundance, and is vulnerable to hybridization.[34] Distribution of Lahontan cutthroat trout in the Oregon portion of the Quinn River Basin is limited to 15 km in Sage and Line Canyon creeks.[35]

The Coyote Lake SMU is comprised of five native cutthroat trout populations. Distribution is naturally fragmented, restricted by barrier falls and a discontinuous stream network. Three populations have low abundance and limited productivity. Lahontan cutthroat trout are the only fish species present in Willow, Whitehorse, and Antelope basins.[36]

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33 ODFW: https://myodfw.com/fishing/southeast-zone
34 https://www.dfw.state.or.us/fish/ONFSR/docs/final/09-cutthroat-trout/ct-summary-quinn-river.pdf
35 Ibid.
36 https://www.dfw.state.or.us/fish/ONFSR/docs/final/09-cutthroat-trout/ct-summary-coyote-lake.pdf

Pallid sturgeon (*Scaphirhynchus albus*) (MT)

Information in this section from listed sources and USACE (2018).

Listing History

The Pallid sturgeon was listed as endangered under the Endangered Species Act on September 6, 1990. Since listing, the status of the species has improved and is currently stable.

Life History/Biological requirements

The Pallid sturgeon is native to the Missouri and Mississippi rivers and adapted to the pre-development habitat conditions that historically existed in these rivers. These conditions generally can be described as large, free-flowing, warm-water, and turbid rivers with a diverse assemblage of dynamic physical habitats. Floodplains, backwaters, chutes, sloughs, islands, sandbars, and a dynamic main channel formed the large-river ecosystem that met the habitat and life history requirements of Pallid Sturgeon and other native large-river fishes.

Historic data on preferred or occupied habitat is lacking. Recent data suggests Pallid sturgeon primarily utilize main channel, secondary channel, and channel border habitats throughout their range. Juvenile and adult Pallid sturgeon are rarely observed in habitats lacking flowing water which are removed from the main channel (i.e., backwaters and sloughs). Specific patterns of habitat use and the range of habitat parameters used may vary with availability and by life stage, size, age, and geographic location.

Habitat requirements of larval and young-of-year Pallid sturgeon remain largely undescribed across the species' range, primarily as a result of low populations of spawning adults and poor recruitment.

Distribution and Critical Habitat

No critical habitat has been designated for the Pallid sturgeon. Since listing in 1990, wild and hatchery Pallid sturgeon have been documented in the Mississippi and Missouri Rivers.

Pallid Sturgeon are a migratory species that use the lower Yellowstone River primarily during spring and summer, but during fall and winter use the Missouri River below the confluence with the Yellowstone (Tews 1994, Bramblett 1996). Some Pallid Sturgeon use the Fort Peck tailrace yearlong, but others move downstream in spring (in one case more than 300 kilometers) (Tews 1994).

Pallid Sturgeon use large, turbid rivers over sand and gravel bottoms, usually in strong current; also impoundments of these rivers (FWP). In Montana, Pallid Sturgeon use large turbid streams including the Missouri and Yellowstone rivers (Brown 1971, Flath 1981) (Figure 5). They use all channel types, primarily straight reaches with islands (Bramblett 1996). They primarily use areas with substrates containing sand (especially bottom sand dune formations) and fines (93% of observations) (Bramblett 1996). Stream bottom velocities ranged between 0.0 and 1.37 meters per second, with an average of 0.65 meter per second (Bramblett 1996). Depths used were 0.6 to 14.5 meters and averaged 3.30 meters, and they seem to move deeper during the day (Bramblett 1996). Channel widths from 110 to 1100 meters are used and average 324 meters (Bramblett 1996). Water temperatures used ranged from 2.8 to 20 degrees C (Tews 1994, Bramblett 1996). Water turbidity ranged from 12 to 6400 NTU (Turbidity Units) (Tews 1994). Once Pallid Sturgeon spawn, the resulting larvae have a strong tendency to drift great distances downstream over a long period of time (Kynard 1998).

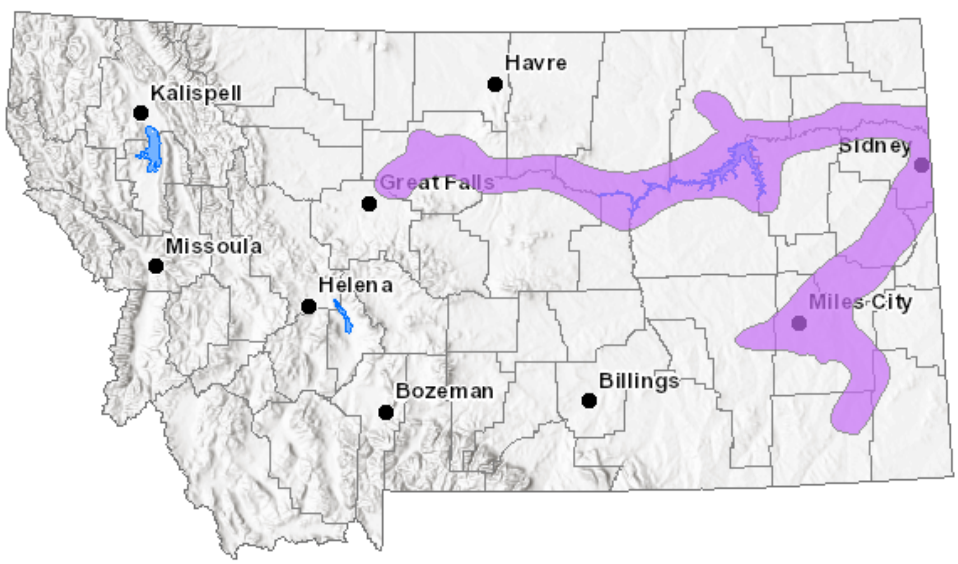

Figure 5. Pallid sturgeon use of the Missouri and Yellowstone Rivers.

Threats

Limiting factors include: 1) activities which affect in-river connectivity and the natural form, function, and hydrologic processes of rivers; 2) illegal harvest; 3) impaired water quality and quantity; 4) entrainment; and 5) life history attributes of the species (i.e., delayed sexual maturity, females not spawning every year, and larval drift requirements). The degree to which these factors affect the species varies among river reaches.

Invertebrates

Banbury Springs limpet (*Lanx spp.*) (ID)

Currently this species only exists at four cold-spring locations along the Snake River in Idaho that are isolated from each other: Thousand Springs, Box Canyon Springs, Briggs Springs and Banbury Springs. Primary factors affecting the lanx in its four remaining coldwater spring complexes and tributaries are habitat modification, spring flow reduction, groundwater quality, the invasive New Zealand mudsnail and inadequate regulatory mechanisms.

Bliss Rapids snail (*Taylorconcha serpenticola*) (ID)

ECOS—The Bliss Rapids snail occurs in cold water springs and spring-fed tributaries to the Snake River, and in some reaches of the Snake River. The Bliss Rapids snail is primarily found on cobble boulder substrate, and in water temperatures between 59–61 degrees Fahrenheit. Recent surveys indicate the species is distributed discontinuously over 22 miles, from River Mile (RM) 547-560, RM 566-572, and at RM 580 on the Snake River. The species is also known to occur in 14 springs or tributaries to the Snake River. The species does not occur in reservoirs.

It lives on stable rocks in flowing waters in the free-flowing reaches of the Snake River and in several cold-water springs in the Hagerman Valley (Bogan 2000). During the daytime, the snail resides on the sides and undersides of rocks.

Historically, this species occurred from Indian Cove Bridge to Twin Falls (Hershler et al. 1994). Populations occur in the lower reaches of the Malad River and in the Snake River between the springs above Hagerman and King Hill[37].

Snake River physa snail (*Physa natricina*) (ID)

The Snake River physa snail is a freshwater mollusk found in the middle Snake River of southern Idaho. It has an ovoid shell that is amber to brown in color, and has 3 to 3.5 whorls (curls or turns in the shell). The physa can reach a maximum length of about 6.5 millimeters. The Snake River physa is believed to have evolved in the Pliocene to Pleistocene lakes and rivers of northern Utah and southeastern Idaho. While much information exists on the family Physidae, very little is known about the biology or ecology of this species. It is believed to be confined to the Snake River, inhabiting areas of swift current on sand to boulder-sized substrate. In 1995, the Service reported the known modern range of the species to be from Grandview, Idaho (RM 487) to the Hagerman Reach of the Snake River (RM 573). More recent investigations have shown

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[37] http://fishandgame.idaho.gov/ifwis/cwcs/pdf/Bliss%20Rapids%20Snail.pdf

this species to occur outside of this historic range to as far downstream as Ontario, Oregon (RM 368), with another population known to occur downstream of Minidoka Dam (RM 675). While the species' current range is estimated to be over 300 river miles, the snail has been recorded in only 5% of over 1,000 samples collected within this area, and it has never been found in high densities. The species' status is uncertain within the current known range, but portions of the middle Snake River (e.g., Milner Reservoir, RM 663 to Lower Salmon Falls Reservoir, RM 572) are of questionable habitat value given current water quality and water use issues. In addition, the sampling in this reach has been limited. Very few live specimens have been recovered from reservoirs which have been extensively sampled. The recovery area for the species extends from Snake River mile 553 to Snake River mile 675. It is currently listed as an Endangered species.

The species historical range included Idaho.

Plants

Bradshaw's desert parsley (*Lomatium bradshawii*) (OR, WA)

The majority of Bradshaw's lomatium populations occur on seasonally saturated or flooded prairies, adjacent to creeks and small rivers in the southern Willamette Valley. Soils at these sites are dense, heavy clays, with a slowly permeable clay layer located 15-30 cm (6-12 in) below the surface. This clay layer results in a perched water table during winter and spring, and is critical to the wetland character of these grasslands, known as tufted hair-grass (*Deschampsia cespitosa*) prairies. Bradshaw's lomatium occurs on alluvial (deposited by flowing water) soils. The species occurs on soils in the Wapto, Bashaw and Mcalpin Series (NRCS mapped soil unit STATSGO 81). Note: The distribution of this species should be reviewed prior to any actions along creeks and small rivers in the southern Willamette Valley to determine presence and the potential to affect this species as a result of any activities associated an action.

Nelson's checker-mallow (*Sidalcea nelsoniana*) (OR, WA)

Within the Willamette Valley, Nelson's checkermallow most frequently occurs in Oregon ash (*Fraxinus latifolia*) swales and meadows with wet depressions, or along streams. The species also grows in wetlands within remnant prairie grasslands. Some populations occur along roadsides at stream crossings where non-native plants, such as reed canarygrass (*Phalaris arundinacea*), blackberry (*Rubus* spp.), and Queen Anne's lace (*Daucus carota*), are also present. Nelson's checkermallow primarily occurs in open areas with little or no shade and will not tolerate encroachment of woody species. Note: The distribution of this species should be reviewed prior to any actions streams in its distribution in Oregon and Washington to determine presence and the potential to affect this species as a result of any activities associated an action.

Ute Ladies'-tresses (*Spiranthes diluvialis*) (WA, ID, MT)

Information in this section from the USFWS ECOS database and USACE (2018).

Listing History

Ute ladies'-tresses was listed as threatened on January 17, 1992. On October 12, 2004 there was a petition filed to delist Ute ladies'-tresses. The petition states that there is substantial new information indicating that the population size and distribution are much larger than known at the time of listing; there is more information on life history and habitat needs, allowing for better management, and threats are not as great in magnitude or imminence as understood at the time of listing. This plant remains listed as threatened.

Ute ladies'-tresses is a perennial herb with erect, glandular-pubescent stems 5-24 in (12.7 to 61 cm) tall arising from tuberous-thickened roots. It reproduces exclusively by seed. The plant's life cycle consists of four main stages: seedling, dormant, vegetative, and reproductive. Fruits are produced in late August or September with seeds shed shortly thereafter. Seeds are microscopic, dust-like, and readily dispersed by wind or water. This plant may remain dormant for eight to eleven years and may revert to below ground existence for one to four or more growing seasons before re-emerging with new above-ground shoots.

The vegetative shoots are produced in October and persist through the winter as small rosettes. These resume growth in the spring and develop into short-stemmed, leafy plants. It blooms from early July to late October. Flowering typically occurs earlier in sites that have an open canopy and later in well-shaded sites. Bees are the primary pollinators of Ute ladies'-tresses, particularly solitary bees.

In perennial streamside populations, Ute ladies'-tresses typically occur on shallow sandy loam, silty-loam, or clayey-silt alluvial soils overlying more permeable cobbles, gravels, and sediments. It is dominated by perennial graminoids and forbs, particularly *Agrostis stolonifea, Elymus repens, Juncus balticus, and Equisetum laeigatum*. Ute ladies'-tresses populations may persist for a short time in the grassy understory of woody riparian shrublands, but do not appear to thrive under these conditions (Ward and Naumann 1998).

Distribution and Critical Habitat

No critical habitat has been designated for this species. Populations of Ute ladies'-tresses orchids are known from three broad general areas of the interior western United

States—near the base of the eastern slope of the Rocky Mountains in southeastern Wyoming and adjacent Nebraska and north-central and central Colorado; in the upper Colorado River basin, particularly in the Uinta Basin; and in the Bonneville Basin along the Wasatch Front and westward in the eastern Great Basin, north-central and western Utah, extreme eastern Nevada, and southeastern Idaho. The species is also known to occur in Bonneville, Fremont, Jefferson, and Madison counties along the Snake River, has been discovered in southwestern Montana, and in the Okanogan area and along the Columbia River in North Central Washington.

The orchid occurs along riparian edges, gravel bars, old oxbows, high flow channels, and moist to wet meadows along perennial streams. It typically occurs in stable wetland and seepy areas associated with old landscape features within historical floodplains of major rivers. It also is found in wetland and seepy areas near freshwater lakes or springs. Note: The distribution of this species should be reviewed prior to any actions along riparian areas, rivers, and streams in its known distribution to determine potential to affect this species as a result of any activities associated an action.

Water howellia (*Howellia aquatilis*) (OR, WA, ID, MT)

Information in this section from USFWS ECOS database and USACE (2018).

Listing History

Water howellia was listed as threatened on July 14, 1994.

Life History/Biological requirements

Water howellia is an annual aquatic species in the bellflower family (Campanulaceae). Individuals are mostly submerged and rooted in bottom sediments. Stems branch near the soil surface and are 1.5-2.8 in (4-7 cm) long. The leaves are numerous and linear to linear-filiform, measuring 0.4-0.6 in (1-5 cm) long, with an entire margin or with a few teeth. The flowers are axillary, 0.08-0.11 in (2-2.7 mm) long, and a corolla is present (in emergent flowers) or lacking (in underwater flowers). The corolla is white to pale lavender and is deeply cleft on one side. The fruit is 0.3-0.4 in (8-10 mm) long. The seeds number 1-5 and are 0.08-0.2 in (2-4 mm) long. This species typically blooms May through August.

Information on herbarium labels or Oregon collections describe the habitat as "ponds in woods", "pond in shaded woods", and "stagnant ponds in the timber". Information from other locales indicate that this species is restricted to small, vernal, freshwater wetlands, glacial pothole ponds, or former river oxbows that have an annual cycle of filling with water over the fall, winter and early spring, followed by drying during the summer months. These habitats are generally small [< 2.47 ac (1 ha)] and shallow [< 3.3 ft (1 m deep)]. Bottom surfaces are reported as firm, consolidated clay, and organic sediments. Most locations were surrounded by deciduous trees and howellia was found in shallow water or around the edges of deep ponds. Associated species include duckweed (*Lemna* spp.), water starworts (*Callitriche* spp.), water buttercup (*Ranunculus aquaticus*), yellow water-lily (*Nuphar polysepalum*), bladderwort (*Utricularia vulgaris*), and pondweeds (*Potamogeton* spp.)

Distribution and Critical Habitat
No critical habitat has been designated for this species. Historically, water howellia was known to occur in one location in Mendocino County, California, four locations in northwest Oregon, two additional locations in Washington, and one location in northern Idaho.

As of drafting the recovery plan for this species in 1995, water howellia was known to occur in six locations; one in Idaho, three in Washington, and one in Montana, and one in California.

Threats
Habitat destruction appears to be the main threat and cause for decline of water howellia. Road and pasture development, grazing and trampling, timber harvest, invasive species, and wetland succession have been documented as potential factors.

Willamette daisy (Erigeron decumbens var. decumbens) (OR)

This species occurs on alluvial soils (deposited by flowing waters). The Willamette daisy occurs on soils in the Wapto, Bashaw and Mcalpin Series (NRCS mapped soil unit STATSGO 81). The species is known to have been extirpated (destroyed or no longer surviving) from an additional 19 historic locations. Willamette daisy populations are known mainly from bottomland, but one population is found in an upland prairie remnant. Currently, 18 sites are known, distributed over an area of 700,000 hectares (1.7 million acres), between Grand Ronde and Goshen, Oregon. Note: The distribution of this species should be reviewed prior to any actions along riparian areas, rivers, and streams in its known distribution to determine potential to affect this species as a result of any activities associated an action.

Appendix References

Anderson, E., S.C. Forrest, T.W. Clark, and L. Richardson. 1986. Paleobiology, biogeography, and systematics of the black-footed ferret, Mustela nigripes (Audubon and Bachman), 1851. *Great Basin Naturalist* 8:11–62.

AOU (American Ornithologists' Union). 1957. Checklist of North American Birds. 5th edition. Lord Baltimore Press, Baltimore, Maryland.

AOU 1998. Checklist of North American birds. 7th ed. American Ornithologists' Union, Washington, DC.

Armbruster, M.J. 1986. A review of habitat criteria for least terns and piping plovers using the Platte River. National Ecology Research Center, U.S. Fish and Wildlife Service, Fort Collins, Colorado. Unpublished Report.

Atkinson, S.J., and A.R. Dood. 2006. Montana Piping Plover Management Plan. 78pp.

Barton, G.J., R.R. McDonald, J.M. Nelson, M. Donato, P. Van Metre, and B. Mahler. 2006. Altered dynamics of Kootenai River white sturgeon spawning habitat and flow modeling: p. 2–6.

Bjornn, T.C. 1961. Harvest, age structure, and growth of game fish populations from Priest and upper Priest lakes. *Trans. Am. Fish. Soc.* 90: 27–31.

Boag, T.D. 1987. Food habits of bull char, *Salvelinus confluentus,* and rainbow trout, *Salmo gairdneri,* coexisting in a foothills stream in northern Alberta. *Can. Field-Nat.* 101: 56–62.

Bogan, A.E. 2000. *Taylorconcha serpenticola*. The IUCN Red List of Threatened Species 2000: e.T40049A10311274.

Bramblett, R.G. 1996. Habitats and movements of pallid and shovelnose sturgeon in the Yellowstone and Missouri Rivers, Montana and North Dakota. Ph.D. Thesis. Montana State University, Bozeman. 210 pp.

Brown, C.J.D. 1971. Fishes of Montana. Montana State University, Bozeman, MT. 207 pp.

Cairns, W.E. 1977. Breeding biology and behaviour of the piping plover *Charadrius melodus* in southern Nova Scotia. M.S. Thesis. Dalhousie University, Halifax, Nova Scotia. 115 pp.

Carl, L.M., M. Kraft, and L. Rhude. 1989. Growth and taxonomy of bull charr, *Salvelinus confluentus, in* Pinto Lake, Alberta. *Environ. Biol. Fish* 26: 239–246.

Casey, D. 2000. Partners in Flight Draft Bird Conservation Plan Montana. Version 1.0. 287 pp.

Chisholm, I., M.E. Hensler, B. Hansen, and D, Skaar. 1989. Quantification of Libby Reservoir levels needed to maintain or enhance reservoir fisheries: summary report 1983–1985. US Dept. of Energy, Bonneville Power Administration, Division of Fish and Wildlife, Portland, Oregon, 136p.

Duke, S., P. Anders, G. Ennis, R. Hallock, J. Hammond, S. Ireland, J. Laufle, R. Lauzier, L. Lockhard, B. Marotz, V.L. Paragamian, and R. Westerhof. 1999. Recovery plan for Kootenai River white sturgeon (*Acipenser transmontanus*).

Ehrlich, P.R., D.S. Doblin, and D. Wheye. 1992. Birds in jeopardy: the imperiled and extinct birds of the United States and Canada, including Hawaii and Puerto Rico. Stanford University Press, Stanford, California.

Faanes, C.A. 1983. Aspects of the nesting ecology of least terns and piping plovers in central Nebraska. *Prairie Naturalist* 15: 145–154.

Flath, D.L. 1981. Vertebrate species of special interest or concern. Wildlife Division of Montana Department of Fish, Wildlife, and Parks.

Goetz, F. 1989. Biology of the bull trout, *Salvelinus confluentus*, a literature review. Willamette National Forest. Eugene, Oregon. 60 pp.

Haig, S.M. 1992. Distribution and status of piping plovers in winter. Abstract, 6th Annual Meeting of the Society for Conservation Biology. 69 pp.

Haig, S. M., and E. and Elliot-Smith. 2004. Piping plover. In: Poole, A. (ed) *The Birds of North America Online*. Ithaca: Cornell Laboratory of Ornithology; retrieved from the Birds of North America Online database: http://bna.birds.cornell.edu/BNA/account/Piping_Plover/.

Haig, S.M., C.L. Ferland, F.J. Cuthbert, J. Dingledine, J.P. Goossen, A. Hecht, and N. McPhilllips. 2005. A complete species census and evidence for regional declines in piping plovers. *Journal of Wildlife Management* 69:160–173.

Haig, S.M. and J.H. Plissner. 1993. Distribution and abundance of piping plovers: results and implications of the 1991 international census. *Condor* 95:145–156.

Hayes, M.P. 1994b. Current status of the spotted frog in western Oregon. Oregon Department of Fish and Wildlife Technical Report #94-1-01. Portland, Oregon.

Hayes, M.P. 1995. The Wood River spotted frog population. Final report prepared for The Nature Conservancy. 19 pp + Appendices.

Hershler, R., T.J. Frest, E.J. Johannes, P.A. Bowler, and F.G. Thompson. 1994. Two new genera of hydrobiid snails (Prosobranchia: Rissooidea) from the northwestern United States. *Veliger* 37:221–243.

Kynard, B. 1998. Twenty-two years of passing shortnose sturgeon in fish lifts on the Connecticut River: what has been learned? Pp. 255–264 In: Fish migration and fish bypasses. M. Jungwirth, S. Schmutz, and S. Weiss (eds.). Fishing News Books, London.

McAllister, K.R., and W.P. Leonard. 1997. Washington State status report for the Oregon Spotted Frog. Washington Dep. Fish and Wildlife, Seattle, WA. 38 pp.

McPhail, J.D., and J.S. Baxer. 1996. A review of bull trout (*Salvelinus confluentus*) life-history and habitat use in relation to compensation and improvement opportunities. Fisheries Management Report No. 104, Department of Zoology, UBC, 6270 University Boulevard, Vancouver, BC.

Montana Bird Distribution Committee. 2012. P.D. Skaar's Montana bird distribution. 7th Edition. Montana Audubon, Helena, Montana. 208 pp. + foldout map.

Montana Piping Plover Recovery Committee. 1994. 1993 Surveys for piping plover (*Charadrius melodus*) and least tern (*Sterna antillarum*) in Montana. Unpublished report. 116 pp. plus appendices.

Montana Piping Plover Recovery Committee. 1995. 1994 Surveys for piping plover (*Charadrius melodus*) and least tern (*Sterna antillarum*) in Montana. 117 pp. plus appendices.

Murphy, R.K., M.J. Rabenberg, M. L. Sondereal, B.R. Casler, and D.A. Guenther. 2000. Reproductive success of piping plovers on alkali lakes in North Dakota and Montana. *Prairie Naturalist* 32: 233–241.

Parsley, M.J., and L.G. Beckman. 1994. White sturgeon spawning and rearing habitat in the lower Columbia River: *North American J. of Fish Management* 14:812–827.

Pearl, C.A., and M.P. Hayes. 2004. Habitat associations of the Oregon Spotted Frog (*Rana pretiosa*): a literature review. Final report. Washington Dep. Fish and Wildlife, Olympia, WA.

Plissner, J. H., and S.M. and Haig. 2000. Status of a broadly distributed endangered species: results and implications of the second international piping plover census. *Canadian Journal of Zoology* 78:128–139.

Pratt, K.L. 1992. A Review of bull trout life history. 00. 5-9. In Proceedings of the Gearhart Mountain Bull Trout Workshop, ed. Howell, P.J. and D.V. Buchanan. Gearhart Mountain, Oregon. Corvallis, Oregon: Oregon Chapter of the American Fisheries Society. August 1992. 8 pp.

Schwalbach, M. J. 1988. Conservation of least terns and piping plovers along the Missouri River and its major western tributaries in South Dakota. M.S. Thesis, South Dakota State University, Brookings, SD.

Scoppettone, G.G., P.H. Rissler, B. Nielsen, and M. Grader. 1995. Life history and habitat use of Borax Lake chub (*Gila boraxobius* Williams and Bond) with some information on the Borax Lake ecosystem. National Biological Service. Northwest Biological Science Center, Reno Field Station.

Shaffer, F., and P. Laporte. 1994. Diet of piping plovers on the Magdelen Islands, Quebec. *Wilson Bulletin* 106: 531–536.

Skagen, S.K. and G. Thompson. 2005. U.S. Shorebird Conservation Plan: northern plains/ prairie potholes regional shorebird conservation plan: version 1. 33 pp.

Stewart, R.J., R.E. McLenehan, J.D. Morgan, and W.R. Olmstead. 1982. Ecological studies of arctic grayling, *Thymallus arcticus,* Dolly Varden, *Salvelinus malma,* and mountain whitefish, *Prosopium williamsoni,* in the Liard River drainage, B.C. Report to Westcoast Transmission Company and Foothills Pipe Lines Ltd. by E. V. S. Consulting, North Vancouver, British Columbia.

Stucker, J.H., and F.J. Cuthbert. 2006. Distribution of non-breeding Great Lakes piping plovers along the Altantic and Gulf of Mexico coastlines: 10 years of band re-sightings. Report to U.S. Fish and Wildlife Service, East Lansing and Panama Field Offices. 20 pp.

Tews, A. 1994. Pallid sturgeon and shovelnose sturgeon in the Missouri River from Fort Peck Dam to Lake Sakakawea and in the Yellowstone from Intake to its mouth. Fort Peck pallid sturgeon study. Montana Department of Fish, Wildlife, and Parks Final Rep. to U.S. Army Corps Engineers. 87pp.

US Fish and Wildlife Service. 1983. Revised Columbian White-tailed Deer Recovery Plan. US Fish and Wildlife Service. Portland, Oregon. 75 pp.

US Fish and Wildlife Service. 1988. Recovery Plan for piping plovers (*Charadrius melodus*) of the Great Lakes and Northern Great Plains. U. S. Fish and Wildlife Service, Twin Cities, MN.

US Fish and Wildlife Service. 1999. Recovery Plan for the White Sturgeon (*Acipenser transmontanus*): Kootenai River Population. U.S. Fish and Wildlife Service, Portland, Oregon. 96 pp. plus appendices.

US Fish and Wildlife Service. 1990. Interior Population of the Least Tern (*Sterna antillarum*) Recovery Plan.

US Fish and Wildlife Service. 1995. Lahontan cutthroat trout, *Oncorhynchus clarki henshawi*, Recovery Plan. Portland, OR 147pp.

U.S. Fish and Wildlife Service. 2002a. Chapter 15, Coeur d'Alene Lake Basin Recovery Unit, Oregon. 92 p. *In*: U.S. Fish and Wildlife Service. Bull Trout (*Salvelinus confluentus*) Draft Recovery Plan. Portland, Oregon.

U.S. Fish and Wildlife Service. 2002b. Bull Trout (*Salvelinus confluentus*) Draft Recovery Plan (Klamath River, Columbia River, and St. Mary-Belly River Distinct Population Segments). U.S. Fish and Wildlife Service, Portland, Oregon.

U.S. Fish and Wildlife Service. 2002c. Endangered and threatened wildlife and plants; designation of critical habitat for the Northern Great Plains breeding population of piping plover: final rule. *Federal Register* 67: 57638–57717.

U.S. Fish and Wildlife Service. 2007. Recovery Plan for the Pacific Coast Population of the Western Snowy Plover (*Charadrius alexandrinus nivosus*). In 2 volumes. Sacramento, California. xiv + 751 pages.

U.S. Fish and Wildlife Service. 2012. Recovery Plan for the Columbia Basin Distinct Population Segment of the Pygmy Rabbit (*Brachylagus idahoensis*). Portland, Oregon. ix + 109 pp.

U.S. Fish and Wildlife Service. 2014. Final Biological Opinion on the Effects to Bull Trout and Bull Trout Critical Habitat from the Implementation of Proposed Actions Associated with the Plan of Operations for the Montanore Minerals Corporation Copper/Silver Mine As proposed by the U.S. Forest Service, Kootenai National Forest.

US Fish and Wildlife Service. 2018a. Yellow-billed cuckoo (western population). Available at: https://www.fws.gov/oregonfwo/articles.cfm?id=149489511.

US Army Corps of Engineers and US Fish and Wildlife Service. 2018b. Final Missouri River Recovery Management Plan and Environmental Impact Statement.

Ward, J. and T. Naumann. 1998. Ute ladies'-tresses orchid (*Spiranthes diluvialis* Sheviak) Inventory, Dinosaur National Monument and Browns Park National Wildlife Refuge. Report prepared for the National Park Service by Dinosaur National Monument.

Watson, J.W., K.R. McAllister, D.J. Pierce and A. Alvarado. 1998. Movements, habitat selection, and population characteristics of a remnant population of Oregon spotted frogs (*Rana pretiosa*) in Thurston County, Washington. Washington Department of Fish and Wildlife, Olympia, Washington.

Watson, J.W., K.R. McAllister, D.J. Pierce, and A. Alvarado. 2000. Ecology of a remnant population of Oregon spotted frogs (*Rana pretiosa*) in Thurston County, Washington. Washington Department of Fish and Wildlife. Olympia. 84 pp.

Watson, J.W., K.R. McAllister, and D.J. Pierce. 2003. Home ranges, movements, and habitat selection in Oregon spotted frogs (Rana pretiosa). J. Herpetology 37:64- 74.

Whyte, A. J. 1985. Breeding ecology of the piping plover (*Charadrius melodus*) in central Saskatchewan. M.S. Thesis, University of Saskatchewan, Saskatoon, Saskatchewan.

Williams, R.N. 1991. Genetic analysis and taxonomic status of cutthroat trout from Willow Creek and Whitehorse Creek in southeastern Oregon. BSU Evolutionary Genetics Lab Report 91-3. Boise, ID. 15pp.

Wydoski, R.S. and R.R. Whitney. 2003. Inland fishes of Washington. Second edition. University of Washington Press, Seattle, Washington.