WAPATO REVIVAL

COLLABORATIVE RESTORATION OF THE WILLAMETTE RIVER'S AQUATIC ECOSYSTEMS

WAPATO REVIVAL PLAN

PRESENTED BY WAIN | JANUARY 2021

WAPATO REVIVAL

Wapato Revival is a multi-stakeholder approach to revitalizing the Willamette River's Aquatic Ecosystems. This collaborative effort is made up of the partners of the Willamette Aquatic Invasives Network (WAIN), as well as various other organizations and groups. Stakeholders that use this Wapato Revival Plan, research, data, and maps are welcome to consider their work part of Wapato Revival.

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Wapato *(Sagittaria latifolia)* is also known as arrowhead, duck potato, katniss, Omodaka, swamp potato, and tule potato.

OVERVIEW

The purpose of Wapato Revival is to galvanize collaboration in implementing strategic actions aimed at protecting and restoring aquatic and riparian ecosystems and water quality in the Willamette Basin. This Wapato Revival Plan provides guidance on addressing the growing threat of aquatic invasive species (AIS) for aquatic ecosystem health throughout the Willamette Basin. It is intended for use by natural resource managers, scientists, funders, and other stakeholders in the community. The plan emphasizes AIS prevention and early detection and rapid response (EDRR), promotes a prioritized approach for management actions, incorporates restoration, implements education and outreach efforts, and identifies data gaps that point to research needs. Further, it demonstrates the need for coordinated efforts across the Willamette Basin. Wapato Revival projects focus on restoring and protecting aquatic habitats within the Willamette Basin.

Community Paddle and Pull on a tributary of the Willamette River. (Credit: Fred Joe)

ACRONYMS

AIS	Aquatic invasive species
ANS	Aquatic nuisance species
BLM	Bureau of Land Management
BPA	Bonneville Power Administration
BSWCD	Benton Soil and Water Conservation District
DFC	Desired future condition
DSL	Department of State Lands
EDRR	Early detection and rapid response
EFH	Essential Fish Habitat
IPM	Integrated pest management
MMT	Meyer Memorial Trust
NAS	Nonindigenous aquatic species
NRFVA	Natural Resource Function and Value Assessment
ODA	Oregon Department of Agriculture
ODEQ	Oregon Department of Environmental Quality
OISC	Oregon Invasive Species Council
OPRD	Oregon Parks and Recreation Department
OSMB	Oregon State Marine Board
PSU	Portland State University
OSWB	Oregon State Weed Board
SHC	Strategic habitat conservation
SWCD	Soil and water conservation district (non-specific)
USDA-ARS	United States Department of Agriculture – Agricultural Research Service
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WIN	Western Invasives Network
WAIN	Willamette Aquatic Invasives Network
WVCS	Willamette Valley Conservation Study

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Wapato Revival Plan Steering Committee

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EXECUTIVE SUMMARY

The Willamette Basin of Oregon supports diverse species of fish, wildlife, and plants that are central to our natural and cultural heritage. The vibrant Willamette Valley is nestled between the Cascades Range, the Coast Range, and the Calapooya Mountains and is home to approximately 75% of Oregon's population. This Willamette River Aquatic Invasive Species Action Plan is focused on restoring the quality of the Willamette's aquatic ecosystems. Non-native plant and animal species can cause substantial harm to aquatic ecosystems. Dense growth of noxious weeds can choke waterways - disrupting navigation, impeding fish passage, impacting water quality, and limiting recreational opportunities.

In the Willamette River Basin, growth in a number of aquatic plant species has increased in recent years. Specific species include Eurasian watermilfoil (*Myriophyllum spicatum*), a number of water primrose species (*Ludwigia* sp.), South American waterweed (*Egeria densa*), and emerging populations of yellow floating heart *(Nymphoides peltata*). The growing abundance and distribution of plants throughout the Willamette Basin is alarming to natural resource professionals and provides motivation to learn more about this issue and develop a plan of action to protect and restore critical off-channel habitats throughout the watershed.

In 2014, a group of natural resources and conservation professionals who work for diverse government agencies, universities, soil and water conservation districts, watershed councils, non-profits, and other organizations throughout the Willamette Basin came together to form the Willamette Aquatic Invasives Network (WAIN). Through a collaborative process, WAIN identified the need to develop an action plan for the Willamette River focused on addressing the impacts of AIS. The plan will provide guidance for WAIN collaborators and other professionals on where and how to most effectively prioritize protection and restoration of habitats, prioritizing which species and sites to focus on for AIS control work. In doing so, it will create a shared vision to help secure funding, and provide tools to accelerate and improve outreach, research, and on-the-ground restoration, and to foster continued coordination and communication.

"Wapato Revival" is a WAIN-led project that was born from this multi-stakeholder approach to galvanize collaboration in implementing strategic actions aimed at protecting and restoring aquatic and riparian ecosystems and water quality

in the Willamette Basin. The name Wapato Revival was created by marketing professionals who were contracted to help WAIN rebrand their collective work. Wapato (*Sagittaria latifolia*) is a native plant that grows abundantly throughout the Willamette Valley in off-channel habitats and reflects the importance of native vegetation and landscapes that support diverse and healthy aquatic ecosystems. The Wapato Revival Plan is WAIN's action plan to collaboratively and strategically address the issue of AIS to restore aquatic habitats in the Willamette River Basin.

Through a collaborative process, six goals were identified as part of the Wapato Revival Plan:

- **GOAL 1:** Prevent the introduction and establishment of new AIS to the Willamette Basin by supporting EDRR efforts.
- **GOAL 2:** Minimize the harmful ecological, economic, human health, and recreation impacts of AIS patches through containment and effective management.
- **GOAL 3:** Restore aquatic and adjacent riparian habitat to benefit native species and enhance the function of aquatic ecosystems.
- **GOAL 4:** Apply public education and outreach tools to prevent the introduction of new AIS and to bring increased awareness to the importance of protecting natural resources in the Willamette River Basin.
- **GOAL 5:** Promote research projects that aim to address a number of questions about AIS pathways of introduction, distribution, impacts, and management options.
- **GOAL 6:** Foster continued coordination and communication between natural resource managers, scientists, funders, landowners, Indigenous people, and other community members.

For each goal, a number of action items were identified. In some cases, the action items build off of existing efforts to improve efficiencies and information sharing. In other cases, the action items represent new efforts by WAIN collaborators to more effectively prevent or manage AIS. There is an overarching emphasis on prioritizing areas for AIS treatment as well as prevention, with an eye to "protect the best" where feasible. Also included are action items to improve coordination and increase research efforts to close information gaps among resource managers.

To inform prioritization of AIS efforts, ranging from survey and EDRR work to more complex AIS control efforts, the river is divided into meaningful reaches based on geologic and physiographic features of the Willamette River. Using existing

geographic information system (GIS) data from a number of sources, WAIN collaborators worked collectively to identify criteria for high quality habitats (e.g., mapped coldwater refugia), important species present (e.g., Oregon chub occurrences), past restoration investments, public and conserved lands, site of existing AIS populations, and watershed position (e.g., river reach). The highest quality spatial data that was available at the time of plan creation and representing each of these criteria were overlaid with weighting applied to each reach to produce maps that highlight the highest priority areas to work on AIS control and prevention.

In addition to a reach-scale prioritization effort, a more site-specific prioritization scorecard was developed to assist in identifying the highest priority locations for aquatic invasive species efforts (ranging from survey to EDRR to AIS control). The scorecard is designed to be flexible in the data used and how the tool is applied. The tool compliments the GIS analysis and resulting prioritization maps and will be used for tributaries and for instances where the maps may be outdated.

BACKGROUND AND PURPOSE

A number of stressors are impacting key native fish and wildlife species and habitats in the Willamette Basin. These stressors include habitat loss and fragmentation, disruption of floodplain function, water quality, and invasive species (WSC 2015, Oregon Conservation Strategy 2016). Invasive species are defined as those organisms that are "nonnative and cause economic or environmental harm and are capable of spreading to new areas of the state" (ORS 570.755). The Willamette Steering Committee, along with numerous implementers, experts and other stakeholders, developed the *Upper and Middle Willamette River Strategic Action Plan,* whose goal is to "sustain and enhance seasonally important resources for native fish", and specifically identifies invasive species and impaired water quality as limiting factors to anadromous fish (WSC 2015). One of the objectives identified in this plan is to control AIS that threaten water quality and native fish habitat. Implementation of this objective is guided by several action items, including the development of a ***prioritization plan*** for treating core, advancing front, and outlier AIS in the Willamette River. This Wapato Revival Plan from the WAIN is intended to serve as that prioritization plan.

WAIN is comprised of natural resources and conservation professionals who work for diverse government agencies, universities, soil and water conservation districts, watershed councils, non-profits, tribes, local businesses, and other organizations throughout the Willamette Basin who began organizing in 2014 as part of the Western Invasives Network (WIN). A complete list of WAIN collaborators is provided in the appendices.

The purpose of the WAIN is to:

- Foster collaboration to share information, expertise, technologies, scientific data, and best management practices,
- Develop strategies to protect aquatic resources, and
- Restore riparian and aquatic habitat in the Willamette River Basin.

Tackling invasive species in aquatic habitats over such a large geography involves an extensive coordinated effort. WAIN collaborators identified and prioritized the need to develop a written plan that addresses AIS for the Willamette River Basin several years after WAIN formed. The development of an action plan for the Willamette Basin led to rebranding the collective work of WAIN as a project called Wapato Revival, Collaborative Restoration of the Willamette River's Aquatic Ecosystems. This restoration work involves the cooperative efforts of WAIN collaborators throughout the Willamette River Basin to address the goals and strategies outlined in this plan.

Sagittaria latifolia, commonly known as wapato, is a staple in traditional Native American diets across the Pacific Northwest. (Photo credit: Wikicommons)

Wapato Revival will galvanize cooperation in implementing strategic actions aimed at protecting and restoring aquatic and riparian ecosystems and water quality in the Willamette Basin. The Wapato Revival Plan is intended as a framework for natural resource managers, scientists, funders, and other stakeholders in the community to implement the collective goals and strategies outlined here and aspires to provide guidance on addressing the growing threat of AIS for aquatic ecosystem health throughout the Willamette Basin. The plan emphasizes AIS prevention and EDRR, promotes a prioritized approach for management actions, incorporates restoration science, guides education and outreach efforts, and identifies data gaps that point to research needs. Further, it demonstrates the need for coordinated efforts across the Willamette Basin and is intended to promote agreement between various stakeholders. More specifically, it offers guidance on how sites should be prioritized on a reach-scale, suggests ways to improve long-term funding opportunities, provides tools to accelerate and improve project outcomes, and assists in demonstrating the value of protecting the Willamette Basin ecosystem.

Healthy wapato stand at Sam Dawes Landing. (Credit: Willamette Riverkeeper)

PLAN INTEGRATION

The Wapato Revival Plan aims to complement existing action plans for managing AIS as well as restoring riparian and aquatic habitats in the Willamette Basin. Other statewide plans have been developed to address a number of AIS taxa, ecoregion conservation protections, and Willamette River-specific habitat conservation questions. Where appropriate, goals and objectives of these other plans have been adapted to more specifically satisfy the purpose of the Wapato Revival Plan for the Willamette River and its major tributaries. This plan is currently focused on aquatic invasive plants; however, the framework is intended for stakeholders to be nimble in their ability to lay the groundwork and address other taxa in the future as needed. Other plans that were referenced to create the background, goals, strategies and actions for the Wapato Revival Plan are as follows.

The **Upper and Middle Willamette Strategic Action Plan** (Willamette Steering Committee 2015) identifies a pathway towards the conservation and restoration of target habitats, conditions, and ecological processes that create stream and river corridors and riparian forests that are more resilient to the stressors and threats affecting fish, wildlife, and water quality. The primary goal is to sustain and enhance seasonally important resources for native fish by reconnecting floodplain and off-channel habitats (WSC 2015). The same mechanisms to protect these important ecological processes compliment the goals of the Wapato Revival.

Specific to AIS, the **Oregon Aquatic Nuisance Species (ANS) Management Plan** (Hanson and Sytsma 2001) was developed in response to the 1996 National Invasive Species Act. The goal of the Oregon ANS Management Plan is to minimize the harmful ecological, economic, and social impact of ANS through prevention and management of introduction, population growth, and dispersal of ANS into, within and from Oregon. The Plan includes a system to classify all nonindigenous species in Oregon, identifies the proper management for each class, details current authorities and programs, and sets objectives that will lead to the accomplishment of the Plan's goals. These objectives include the establishment of a management structure that coordinates ANS activities, a strong prevention program, a monitoring program that allows for the early detection and eradication of pioneering ANS, a control program aimed at established species, education, and research. As a result of the Oregon ANS Management Plan, the Oregon Legislature established the Oregon Invasive Species Council (OISC) in 2001.

As required by OR 570.750(2)(f), the OISC is tasked with developing the **Oregon Statewide Strategic Plan** for Invasive Species (Statewide Strategic Plan) (OISC 2017a) and the **Oregon Statewide Action Plan** (Statewide Action Plan) (OISC 2017b). The Statewide Strategic Plan is intended to develop objectives and strategies for tackling invasive species at the statewide level over a 10-year period, including a review of state authorities. The plan establishes five objectives and several strategies within each objective. The Statewide Strategic Plan lays the groundwork for statewide and regional action plans, intended to provide a more detailed roadmap for achieving each of the specified strategies. Every two years, the OISC produces Statewide Action Plans intended to guide implementation of the Strategic Plan and to provide a list of specific key players, partners, and actions that will achieve strategies identified in the Strategic Plan.

The **Willamette Valley Synthesis Conservation Opportunity Areas ("Synthesis Project")** (Willamette Synthesis, V2.0 2014) summarizes major Willamette Basin conservation planning efforts with the primary goals of delineating priority terrestrial and freshwater sites where investment in conservation or restoration would best contribute to (1) the health of historically significant and functional habitats, (2) the survival or recovery of imperiled plants and wildlife dependent on those habitats, (3) improved floodplain connectedness to benefit water quality for aquatic biodiversity and (4) overall watershed health.

The **Oregon Conservation Strategy** (ODFW 2016) provides a shared set of priorities for addressing seven key conservation issues with the goals of maintaining healthy fish and wildlife populations by maintaining and restoring habitat functions, preventing declines of at-risk species, and reversing declines in resources where possible. One of the seven key conservation issues/limiting factors is invasive species. The recommended approach for invasives is to emphasize prevention, risk assessment, early detection, and quick control to prevent new invasions. Additionally, to prioritize

Yellow floating heart (YFH), a highly invasive aquatic plant, is now found in the Willamette River and sidechannels. Rooted plants grow to the surface where leaves cover the surface of the water. (Credit: Willamette Riverkeeper)

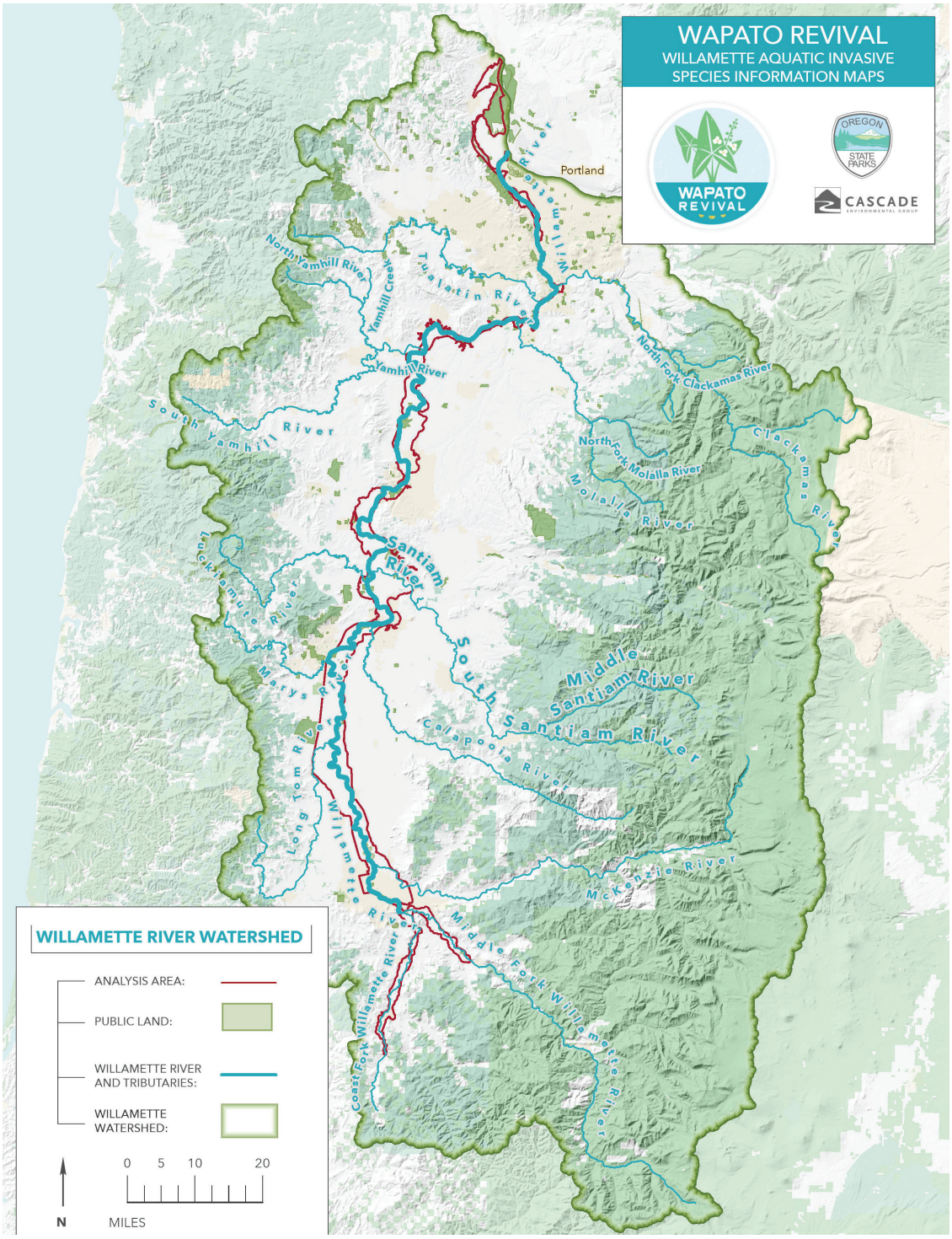
efforts in high priority areas, particularly where "strategy habitats" (e.g., wetlands, natural lakes, flowing water, and riparian habitats) and "strategy species" (e.g., Oregon chub) are known to occur.

The **Natural Resource Assessment and Strategic Action Plan for Restoration and Stewardship of OPRD-Managed Properties in the Willamette Basin** (OPRD 2017) is a 10-year Strategic Action Plan for restoration and stewardship of OPRD-managed sites in the Willamette Basin focused on protecting intact natural resources, restoring degraded habitats, and improving partnerships, funding, site monitoring, and public communication. The Strategic Action Plan spans over 23,700 acres in the Willamette Basin, including the Willamette Valley ecoregions also considered in the Wapato Revival Plan.

WILLAMETTE RIVER BASIN

The Willamette River in northwestern Oregon is flanked by the Cascade Mountains to the east and the Coast Range to the west. From its southern headwaters at about 400 feet in elevation the river flows approximately 187 miles to its confluence with the Columbia River at seven feet above mean sea level in Portland. There are 13 major tributaries of the Willamette River including from south to north the; Coast Fork, Middle Fork, McKenzie, Long Tom, Calapooia, Luckiamute, Santiam, Yamhill, Pudding, Molalla, Tualatin, Clackamas, and Multnomah Channel. The entire basin drains roughly 11,480 square miles of the Willamette Valley and its adjacent foothills. Thirty percent of the basin area is comprised of valley floor, 60% consists of Cascade Mountains foothills, and the remaining areas include parts of the Coast Range (Myers et al. 2006). With the prairie and oak components within the valley, this system creates a stark contrast to the surrounding landscape dominated by coniferous forests (USFWS 2017). This uniqueness features a high degree of species and habitat specialization that is far different from that found in the surrounding matrix of coniferous forests (USFWS 2017). The climate is characterized by mild, wet winters and warm, dry summers. Fertile soil and abundant rainfall make the Willamette Valley the most important agricultural region in the state (ODFW 2016).

WILLAMETTE RIVER WATERSHED MAP

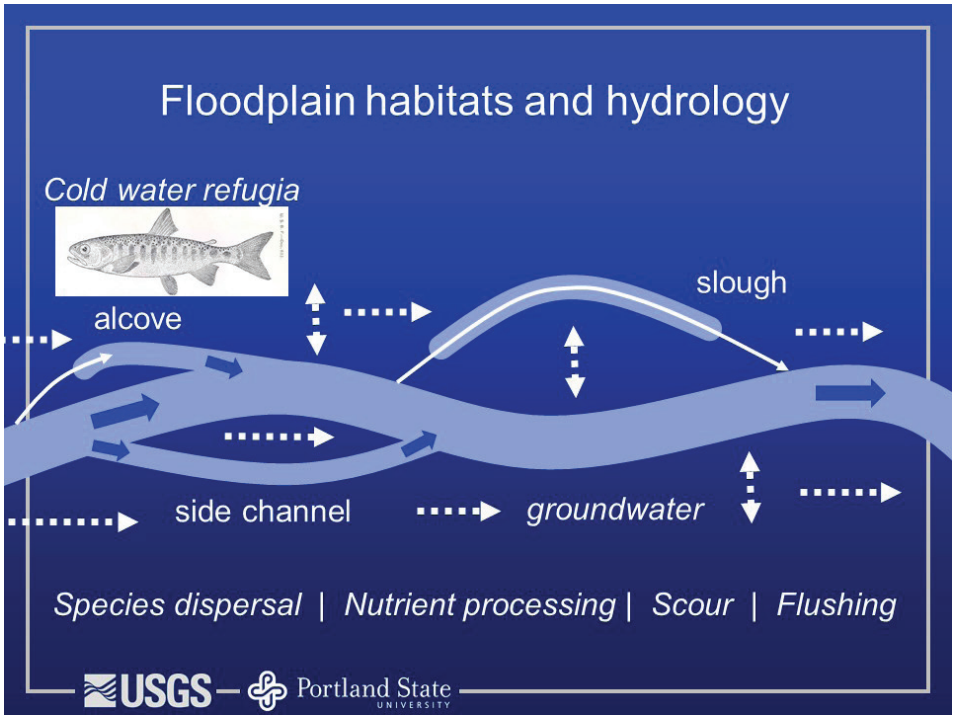


Credit: Simon Apostol, Cascade Environmental Group, LLC

The river is characterized by distinct geomorphological reaches shaped by a number of factors including flood events, dams, and flow modification. A once dynamic braided stream that flowed through dense riparian forests is now largely characterized by a single-thread river bound by agriculture and revetments (Wallick et al. 2007).

Primarily in the middle and upper reaches above Willamette Falls there remain some alcoves, side-channels, sloughs, and oxbow lakes. Alcoves are areas that maintain a downstream connection to the main channel at summer low flow but no upstream connection. They are important habitat for young fish and older alcoves commonly support mature woody vegetation (Hulse et al. 2002). Side channels are areas that maintain both an upstream and downstream connection and commonly form the boundaries of islands in the mainstem. Sloughs are not connected to the main channel during summer flows. Oxbow lakes are u-shaped lakes formed when a wide meander of the mainstem is cut-off. At high flow, all of these off-channel features are connected to the main channel via surface flows. Many of these habitat features have been lost since development increases began in 1850 (Hulse et al. 2002).

OFF-CHANNEL HABITATS AND HYDROLOGY



Credit: Figure modified from Hulse et al. 2002 and Wallick et al. 2013.

In large rivers such as the Willamette a variety of main-channel and off-channel habitats form and shift based on factors including but not limited to flooding frequency, duration and magnitude, sediment loading, and the river's geomorphic response to these events (Wallick et al. 2007). These habitats are connected by a mosaic of surface and groundwater flows. These areas provide important habitat for wildlife and fish, for example juvenile salmonids use alcoves as refugia from the stronger current of the mainstem. Additionally, these various habitats can be sources or sinks for aquatic plants. That is, they can support luxuriant growth of aquatic plants that can disperse to downstream areas. By extension, they can be sites of deposition and establishment from upstream fragments. Scour events during high water can dislodge fragments for further downstream dispersal, flush the area of organic matter, and alter sediment conditions. Conversely, low scour results in increased opportunity for denser plant growth and deeper root establishment that could withstand future high water events.

HISTORIC AND NATURAL LANDSCAPES

The Willamette Basin has a rich history in the region, including being the homeland of a number of Indigenous peoples for over 10,000 years, a busy corridor for fur trading, modern urban development, and fertile agricultural lands. The Willamette Valley is within the traditional territory of the Kalapuya people (Berreman 1937). For millennia, the Kalapuya kept the prairies free of encroaching trees and shrubs by setting frequent, low severity fires. Starchy tubers of the aquatic plant wapato *(Sagittaria latifolia)* are an important staple in the traditional Kalapuya diet. Epidemics of malaria and smallpox ravaged indigenous peoples of the Willamette Valley and led to severe population loss among the Kalapuya. The remaining Kalapuya were forcibly removed from their homelands after signing treaties with the U.S. Government. Descendants are members of today's Confederated Tribes of Grand Ronde, and continue to play a role in managing their homelands. At the time of non-indigenous settlement approximately 150 years ago, the valley was typically described as a landscape dominated by vast open prairies interspersed with solitary oak and pine trees (USFWS 2017). The valley's major rivers were lined with hardwood forests and shrublands. Annual springtime flooding rejuvenated and maintained complex riverine and floodplain habitats (Hulse et al. 2002). As ranching, farming, and logging practices increased, annual flooding posed an

ever increasing risk to life and property. To abate the risk, dams were built and revetments were constructed along the river's banks. The reduced flooding and the conversion of natural areas continues to have an effect on habitats and the wildlife in the Willamette Basin.

The Willamette Basin's ecology, physical landscapes, and land use types vary throughout the river's length. Riparian forests and headwater streams in the Coast Range and Cascade Mountains transition to floodplains, off-channel habitats, sloughs, and side channels throughout the valley floor. Land use in the basin makes a similar transition from private and federally owned forest at the headwater elevations to privately owned farm and forestland at mid-elevations and largely private farmland, urban areas, and public lands in the valley bottom (USFWS 2017).

The Willamette Basin is home to approximately three million of Oregon's four million residents and includes nine of the 10 largest cities in Oregon (ODFW 2016). Major population centers in the valley rely on a mix of groundwater and surface water supplies. A few small cities and many smaller communities rely on groundwater as a primary source of water for municipal use. Approximately 10% of the Willamette Basin area is classified as urban and other uses, 20% is classified as agriculture, and 70% is considered forest (Willamette Steering Committee 2015).

The economy of the Willamette Valley is shaped by a mosaic of large cities, small towns, universities and a strong dependence on natural resources as well as manufacturing, high technology, construction, retail, government, health care, and tourism. Agricultural production includes over 170 different crop and livestock items, including, but not limited to, grass seed, berries, wine grapes, Christmas trees, dairy, oats, mint, hops, nursery stock and hay (OCS 2016, USDA 2019a). The richness of the soils in the Willamette Valley are attributed to numerous Missoula Flood events at the end of the last ice age that swept topsoil from as far away as Montana, Idaho, and Eastern Washington to the valley (Miller 2014). There is also great economic importance to the Willamette River itself with the need for irrigation to support agriculture, the recreation industry, industrial water used for factories and mills, and drinking water used to support urban and rural communities within the Willamette Valley.

WATER QUALITY

In general, water quality in many areas of the Upper Willamette Basin is considered excellent, but declining to good in the middle reach and fair in the lower reach (ODEQ 2019). These declines in lower river water quality are largely attributed to high water temperature, biological oxygen demand (BOD), nitrogen, phosphorus and toxic substances such as PCBs and legacy pesticides. Tributaries and other features within the Willamette Basin are on Oregon's 2018/2020 Clean Water Act Section 303(d) list of impaired waterbodies (ODEQ 2020). Section 303(d) requires identifying waters that do not meet water quality standards and where a Total Maximum Daily Load pollutant load limit needs to be developed (ODEQ 2018). Some reaches of the Willamette River are included on the 303(d) list for temperature, dissolved oxygen, lead, mercury, arsenic, copper, iron, and nitrates. Additionally, the Long Tom River/Fern Ridge Reservoir and Amazon Creek, tributaries to the Willamette River, are listed for aquatic weeds or algae due to negative impacts to aesthetics, fishing, and water contact recreation.

Water quality parameters are often examined to gage the impacts of AIS. The presence of AIS may negatively impact water quality in the following ways, however in some cases, there could be localized shading from AIS that could reduce temperature:

- Increase sedimentation
- Increase water temperature
- Reduce surface water dissolved oxygen concentrations
- Increase nutrient concentrations
- Increase rates of photosynthesis

Boater attempting to paddle through dense ludwigia. (Credit: Holly Crosson, Benton SWCD)

NATIVE FISH AND WILDLIFE

Numerous species of native flora and fauna rely on healthy wetland, aquatic, and riparian habitats in the Willamette Basin for survival and are threatened by presence of AIS. These species are further described in the site-specific Wapato Revival Scoring Tool shown below and detailed in the appendices. For guidance on species of greatest concern, we look to the Oregon Conservation Strategy list of Strategy Species, narrowing it down to those associated with the Willamette Valley ecoregion, and then further to those species that are dependent on wetland, aquatic and riparian areas. These species struggle due to a variety of factors, including habitat conversion, overharvest, and others. Direct and indirect impacts from invasive species also threaten these species in a variety of ways and act as additional stressors. Conservation Strategy Species that depend on aquatic and riparian habitats in the Willamette Basin include the following:

- **Fish Strategy Species** include anadromous salmonids such as those addressed by the Upper Willamette River Conservation and Recovery Plan for Chinook Salmon and Steelhead (ODFW and NMFS 2011) and the Recovery Plan for Lower Columbia River Coho Salmon, Lower Columbia River Chinook Salmon, Columbia River Chum Salmon, and Lower Columbia River Steelhead (NMFS 2013). Additional Strategy fish species are the recently de-listed Oregon chub, lamprey species, bull trout, coastal cutthroat trout, and eulachon.
- **Amphibian Strategy Species** include Northern red legged frog, foothill yellow-legged frog, Columbia torrent salamander, Cascade torrent salamander and Southern torrent salamander. Amphibians use a variety of habitats including aquatic habitats, especially for breeding.
- **Reptiles Strategy Species** includes Western pond turtle and Western painted turtle, that require aquatic habitats during their life cycle.
- **Bird Strategy Species** depend on riparian and aquatic habitats for foraging and nesting; key Strategy species are common nighthawk, willow flycatcher, yellow-breasted chat, and short-eared owl.
- **Invertebrates Strategy Species** include native freshwater mussels (winged floater, Western ridged, and California floater) and insects (stonefly, Taylor's checkerspot butterfly). Invertebrates utilize perennial and seasonal aquatic habitats.
- **Native Plant Strategy Species** that depend on aquatic and wetland habitats and have been severely impacted by invasive species are water howellia, Willamette daisy, white-topped aster, white rock larkspur, peacock larkspur, Nelson's checkermallow, Kincaid's lupine, and Bradshaw's desert parsley.

AQUATIC INVASIVE SPECIES

A number of terms are used to describe an invasive species, including non-native, noxious, non-indigenous, and alien. The Wapato Revival Plan relies on the term invasive species, defined as one that is non-native to an ecosystem and whose introduction causes or is likely to cause economic or environmental harm or harm to human health (Executive Order 13122). Wapato Revival specifically focuses on those invasive species that are plants and that depend on aquatic and riparian habitats. The framework of this plan could also be used to address invasions of species other than plants, such as mussels in the future if the need arises. The Oregon Department of Agriculture (ODA) defines a "noxious weed" as a terrestrial, aquatic or marine plant designated by the Oregon State Weed Board (OSWB) (ORS 569.615). Noxious weeds represent the greatest public menace and are a top priority for action by weed control programs.

The Noxious Weed Policy and Classification System includes prioritizing and implementing noxious weed control projects and assisting in the distribution of funds for weed programs. As the name implies, EDRR is a coordinated set of actions to find and eradicate potential invasive species in a specific location before they spread and cause harm (USGS 2019). EDRR are primary activities of the ODA Noxious Weed Control Program and EDRR weeds have been identified by a number of other organizations such as cities, conservation districts, and the OISC. The ODA Noxious Weed Program, in partnership with the OSWB, uses a risk assessment process to compile the state Noxious Weed List (ODA 2019a). There is a 34:1 benefit-to-cost ratio for EDRR projects (ODA 2019b). Annual treatments for the control of "A" and "T" designated weeds reduce the net acreage of many large infestations of weeds. A-Listed and T-Designated weeds are considered EDRR targets for ODA. Additionally, state noxious weed quarantines prohibit the import, transport, propagation, or sale of a subset of weeds listed on both state and federal noxious weed lists (OAR 603-052-1200 and ORS Chapter 569).

...NON-NATIVE TO AN ECOSYSTEM... LIKELY TO CAUSE ECONOMIC OR ENVIRONMENTAL HARM...

ODA NOXIOUS WEED CLASSIFICATION SYSTEM AND SELECT SPECIES 2019

A-LISTED

DESCRIPTION: A weed of known economic importance which occurs in the state in small enough infestations to make eradication or containment possible; or is not known to occur, but its presence in neighboring states make future occurrence in Oregon seem imminent. • **Recommended action:** Infestations are subject to eradication or intensive control when and where found.

EXAMPLE(S):
- Yellow floating heart *(Nymphoides peltata)* (T)
- Delta arrowhead *(Sagittaria platyphylla) (T)*
- European water chestnut *(Trapa natans)*
- Flowering rush *(Butomus umbellatus) (T)*
- Hydrilla *(Hydrilla verticillata)*

B-LISTED

DESCRIPTION: A weed of economic importance which is regionally abundant, but which may have limited distribution in some counties. • **Recommended action:** Limited to intensive control at the state, county, or regional level as determined on a site specific, case-by-case basis. Where implementation of a fully integrated statewide management plan is not feasible, biological control (when available) shall be the primary control method.

EXAMPLE(S):
- Eurasian watermilfoil *(M. spicatum)*
- Knotweed
  - *Bohemian (Fallopia x bohemica)*
  - *Giant (F. sachalinensis (Polygonum))*
  - *Himalayan (Polygonum polystachyum)*
  - *Japanese (F. japonica (Polygonum))*
- Parrotfeather *(M. aquaticum)*
- Primrose Willow
  - *Large-flower (Ludwigia grandiflora) (T)*
  - *Water primrose (L. hexapetala) (T)*
  - *Floating (L. peploides) (T)*
- Purple loosestrife *(Lythrum salicaria)*
- South American waterweed *(Egeria densa)*
- Yellow flag iris (*Iris pseudacorus*)

T-DESIG-NATED (T)

DESCRIPTION: A designated group of weed species that are selected and will be the focus for prevention and control by the Noxious Weed Control Program. Action against these weeds will receive priority. T-designated noxious weeds are determined by the OSWB and directs ODA to develop and implement a statewide management plan.

EXAMPLE(S):
- T-designated noxious weeds are species selected from either the A or B list.

NOTE: T-listed weeds indicated by (T)

The strategies and priorities laid out in this plan apply to all AIS listed by ODA. As of 2020, when the Wapato Revival plan was developed, yellow floating heart (YFH) *(Nymphoides peltata)* and water primrose species (*Ludwigia* sp.; hereafter referred to as ludwigia to encompass all invasive species of the genus) were the invasive species that were most problematic in the Willamette's aquatic habitats and therefore became a focus within the plan. The species of focus for WAIN collaborators will naturally evolve over time. YFH is considered an EDRR status aquatic plant and an A-listed noxious weed (ODA 2019a). Ludwigia tends to grow in dense patches where they cause dissolved oxygen sags by limiting light penetration necessary for submerged plant growth, reducing mixing with the atmosphere, and increasing plant/bacterial respiration (Carpenter and Weathers 2018). These dense mats also impede recreation activities. An infestation in Dodson Slough (Lane County) is particularly problematic as it is an open area in the Upper Willamette with greater water exchange which makes management with aquatic herbicides challenging and water from the area is used for irrigation. This area also has an increased possibility for spread due to seasonal high water events. Root fragments, stolons, and seeds from YFH can easily separate and take root.

Dodson Slough just downstream of Eugene, Oregon is the largest population of yellow floating heart that has been documented to date in the Willamette Basin. (Credit: Willamette Riverkeeper)

Water primroses *(Ludwigia hexapetala, L. peploides* ssp. *peploides,* and *L. grandiflora)* are B-listed weeds (ODA 2019a) commonly found in alcoves, side-channels and open water areas. All these ludwigia species have been identified within the Willamette Basin. Positive identification of the specific species can be tricky in the field and for the many collaborators. When we do not have a positive species identification, we will simply use the term ludwigia to reference this plant. Dense growth can lead to severe ecological, economic, and human health impacts (Grewell et al. 2016). They are widespread in the Willamette River with patches of greater density between Corvallis and near the confluence with the Yamhill River. Water primroses tend to establish on the banks then grow toward the open water becoming extremely dense. This results in reduced open water habitats that can deleteriously impact restoration sites. A number of ludwigia species are known to spread primarily by vegetative fragments (Okada et al. 2009). A unique challenge in managing ludwigia is the high variability in morphology due to environmental conditions and hybridization that can lead to considerable taxonomic confusion hence the best management approaches (Grewell et al. 2016).

Ludwigia growing in Windsor Slough. (Credit: Willamette Riverkeeper)

Other aquatic and riparian invasive plants known to occur in the Willamette River or its tributaries include: common reed grass *(Phragmites australis* ssp. *australis*), fragrant waterlily *(Nymphaea odorata)*, yellow flag iris *(Iris pseudacorus)*, purple loosestrife *(Lythrum salicaria)*, delta arrowhead *(Sagittaria platyphylla)*, Bohemian, Japanese, and giant knotweed *(Fallopia x bohemica* and *F. japonica, F. sachalinensis,* respectively), Eurasian watermilfoil *(Myriophyllum spicatum)*, South American waterweed *(Egeria densa)* and parrotfeather *(M. aquaticum)*. A more comprehensive list of common aquatic and riparian plant species is provided as an appendix.

In general, a successful invasion of species to a novel environment relies on a number of factors including transport, release, and establishment (Colautti and MacIsaac 2004, Leung and Mandrak 2007). AIS are transported and released via natural (e.g., waterfowl, connected waterbodies) and more importantly, human-mediated vectors (e.g., boats, recreation equipment, live bait, water gardening) (Johnson et al. 2001, Sytsma and Pennington 2016). The human-mediated vectors offer the best opportunities for prevention. Successful establishment, however, can depend on a number of environmental conditions, such as dispersal intensity, and sufficient ecological resources.

Brazilian waterweed and other submerged aquatic vegetation in the Willamette River. (Credit: Kurt Carpenter, USGS)

Parrotfeather (emergent) and duckweed (floating) commonly found in the Willamette River. (Credit: Fred Joe)

Invasive plant species **not yet known to occur** in the Willamette River or its tributaries but are of particular concern include:

- Flowering-rush *(Butomus umbellatus)*
- Variable-leaf watermilfoil *(Myriophyllum heterophyllum)*
- Hydrilla *(Hydrilla verticillata)*
- Swamp stonecrop *(Crassula helmsii)*

These species are included as a table in the appendix as a list of non-native plants of concern to the Willamette River.

Zebra/quagga mussels *(Dreissena polymorpha* and *D. bugensis)* also pose a significant threat to waters of the Pacific Northwest.

Report suspected observations at **800-INVADER**

Oregon Invasive Species Online Hotline

WATCH LIST – ZEBRA MUSSELS

Among other destructive tendencies, zebra mussels have the potential of collapsing entire food webs, reducing fish populations, and devastating fisheries. Volunteers learn about other AIS taxa to watch for during Paddle and Pull events or other personal recreational activity on the water. (Credit: Willamette Riverkeeper)

IMPACTS

Once established, species invasions are widely known to impact ecological structure and function, aesthetics, regional economics, water quality, recreational activities, and restoration efforts. Habitat impacts also include loss of open water habitat and organic enrichment of the sediment and water quality (Miller and Sytsma 2018; Carpenter and Weathers 2018).

For rooted submersed plants, the surface water conditions can result in high photosynthetic rates with resulting high diel swings in dissolved oxygen (DO). Underneath these plants where light penetration is low, respiration rates dominate and DO levels can be very low. A study conducted in two seasonally connected side channels in the Mid-Willamette, Windsor Slough and Mission Lake during summer 2017 found that water temperatures as warm as 30°C and that swings in DO and pH that do not meet Oregon Department of Environmental Quality (ODEQ) water quality standards (Carpenter and Weathers 2018). These standards are established to protect cool-water aquatic life, in particular, year-round and seasonal salmon and steelhead spawning criteria. From an aesthetics point of view, dense growth of aquatic vegetation can result in an unsightly and even odorous muck that can also harbor mosquitos and provide sufficient nutrients to prompt algae blooms. Dense mats of aquatic plants can be hazardous for swimming by increasing risk of drowning. Use of these areas by recreationists is also subsequently inhibited.

Although many aquatic invasive plants are a concern in the Willamette River, invasive ludwigia species have become very widespread and are currently one of the biggest threats to off-channel habitat and aquatic ecosystems.

WHY IS LUDWIGIA SO PROBLEMATIC?

IMPACT	DETAILS AND REFERENCES:
Ludwigia replaces woody plants	Ludwigia differs from many aquatic macrophytes in that it grows in the water and along the shoreline, competing with and displacing riparian vegetation that would provide better shading, large wood sources, and better sources of terrestrial insects that fish feed on (Thouvenot et al. 2013, Hoch and Grewell 2012). This impacts native fish species year round. Additionally, ludwigia occupies wetland transition areas that are otherwise occupied by emergent plant communities such as sedges, rushes, bur-reed, and willows. These wetland transition habitats are critical rearing habitat for native fish and turtles, among other native wildlife.
Ludwigia changes food webs that form the basis of native fish diets	A primary linkage between plants and fish are macroinvertebrates, which depend on plants and are a food source for native fish year round (Schultz and Dibble 2012). Studies in France, Belgium, and Switzerland have quantified reductions in native plant diversity, macroinvertebrate and fish populations due to ludwigia (EPPO 2011, Nehring and Kolthoff 2011, Stiers et al. 2009 & 2011). Some of the ways this occurs are in the following cells; these impacts to macroinvertebrates and food chains impact native fish year round.
Increased water temperature reduces native fish food sources	Ludwigia can increase water temperatures and decrease surface water solar radiation by (1) competing with shade-producing woody riparian plants, (2) decreasing water depth by increasing sedimentation and thereby increasing surface water exposure to solar radiation (Ebersole et al. 2001), and (3) through ludwigia's high rate of transpiration which reduces water quantity (Grewell et al. 2016). Where plant density is very high, surface water temperatures can increase, which reduces the ability of oxygen to dissolve in water and be readily available for a healthy macroinvertebrate community. In addition, many of the aquatic insects that fish like salmonids prefer for food cannot live at elevated water temperatures. In warmer waters, desirable salmonid food sources such as mayfly, stonefly and caddisfly nymphs die off and are replaced by other insects (e.g., midges and mosquito larvae) that are much less desirable as food for salmonids (WDOE 2000).
Dense mats alter food webs	Ludwigia mats intercept sunlight that drives photosynthetic processes and greatly decreases subsurface light conditions, thereby limiting submersed plants and algal species, leading to changes in aquatic food web structure (Grewell et al. 2016, Dibble et al. 1996). Simplification of the macrophyte growth form (structural heterogeneity) negatively affects the abundance of biotic communities such as macroinvertebrates (Walker et al. 2013). Macroinvertebrate communities in ponds invaded by mat-forming macrophytes (including ludwigia) have been found to be less diverse and were comprised primarily by species that tolerate low oxygen levels compared to non-invaded ponds with submerged vegetation (Stiers et al. 2011).

WHY IS LUDWIGIA SO PROBLEMATIC?

IMPACT	DETAILS AND REFERENCES:
Ludwigia creates shallower water over time	Both Mission Lake and Windsor Slough (Slough (at Willamette Mission State Park near Salem) are geomorphically stable features that are currently evolving by fine sediment deposition during typical high flow events. The stability and lack of scour at these sites is typical of the Middle Willamette River where side channels are sparse and reflect historical channel processes that rarely occur under present day flow and sediment supply conditions (Wallick et al. 2013). Increased scour at these sites could be promoted through changes in dam-determined flow events that promote channel scour, manipulations of the water bodies (such as through opening their inlets), strategic placement of engineered wood jams, or dredging. The presence of dense ludwigia mats at these sites is an additional cause of sedimentation, and accelerates the accumulation of fine sediments above normal levels. Although much of the ludwigia biomass decomposes and/or is washed downstream by high fall and winter flows, dense roots and woody stems can persist through the winter, much more so than other more labile submerged aquatic plants. This ludwigia root and stem biomass not only encourages sediment aggradation, but can reduce scouring of sediment material during higher flows. (Skaer et al. 2018). Sedimentation of the waterbodies is therefore higher than it would be without ludwigia, and has year round impacts to native fish.
Ludwigia may reduce macroinvertebrate density	Macroinvertebrate densities were negatively related to the percent cover of Ludwigia in one study, probably due to anoxic conditions and excess detritus (Stiers et al. 2011).
Ludwigia reduces dissolved oxygen in the water column	Dense mats of ludwigia can lead to patches of low dissolved oxygen, and larger scale dissolved oxygen crashes (Bunch et al. 2010), which has direct impacts to native fish that are present at the time, such as lamprey and Oregon chub, and salmonids during shoulder seasons. Heavy ludwigia infestations can reduce DO concentrations enough to result in acute mortality to fish and aquatic invertebrates present (Mosaic 2016, Carpenter and Weathers 2017). The impacts of low DO to native fish would be most pronounced in the late summer.
Ludwigia alters water chemistry in other harmful ways	Ludwigia has been associated with the accumulation of sulfide and phosphate in water and a reduction in pH (Dandelot et al. 2005, CABI 2014). The seasonality of these effects is not clear. Sulfide is a toxicant that can impact the health, productivity, distribution, and survival of aquatic organisms (Bagarinao, 1992). Phosphates fuel growth of algae, which can drive down DO. Low pH can encourage solubility of heavy metals such as mercury; sensitive freshwater species such as salmon prefer pH levels between 7.0 and 8.0, becoming severely distressed and suffering physiological damage due to absorbed metals at pH levels below 6.0 (Fondriest 2013). It is unclear if these impacts are seasonal or year round.

WHY IS LUDWIGIA SO PROBLEMATIC?

IMPACT	DETAILS AND REFERENCES:
Ludwigia produces allelopathic compounds to reduce competition and herbivory	Allelopathic compounds released from ludwigia can negatively affect fish and invertebrates (Schultz and Dibble 2012) and have been shown to impact the germination, growth, and survival of other aquatic plants (Dandelot et al. 2008). Invasive macrophytes that produce allelopathic chemicals can have lethal and sublethal effects on certain fish through direct effects of toxicity, and a potential reduction in food items due to effects on macroinvertebrates (Linden and Lehtiniemi 2005, Erhard 2005).
Invasive aquatic plants provide desirable habitat to non-native fish	Non-native fish species can benefit from shelter and nesting habitat resulting from a macrophyte invasion (Houston and Duivenvoorden 2002, Nico and Muench 2004, Lapointe et al. 2010). Non-native fish can impact native fish through competition for resources or direct predation.

Black Dog Landing Alcove Near RM 113 (SE facing) infested with ludwigia. (Credit: Willamette Riverkeeper)

GOALS AND STRATEGIC ACTIONS

To address the impacts of AIS and restore important off channel habitats within the Willamette Basin, WAIN collaborators worked together to develop a series of goals and strategic actions for the Wapato Revival Plan, providing a framework for natural resource managers, scientists, funders, and other stakeholders to more effectively work together. We identified six goals with specific strategic actions that can be taken to accomplish each goal. The goals for the Wapato Revival Plan are focused on managing AIS, as well as restoring riparian and aquatic habitats in the Willamette Basin, including the mainstem Willamette River and tributaries. The goals were initially developed by cross-walking other statewide action plans that address a number of AIS taxa, ecoregion conservation protections, and Willamette River-specific habitat conservation questions and then tailoring goals from these plans to be more Willamette-specific with a focus on aquatic invasive plant species. A WAIN meeting was held in late 2019 where collaborators vetted a set of draft goals and strategies and provided valuable input. These goals and strategies were then edited to synthesize valuable feedback and input from WAIN collaborators. WAIN leadership and collaborators will periodically take stock of how progress is going and update the plan every five years pending funding.

Ludwigia infested much of Mission Lake located at Willamette Mission State Park prior to treatment of the plant in 2017. Herbicide was used to reduce the population for the first two treatment seasons in 2018 and 2019. By the third season in 2020, plants were controlled by hand pulling all plants in the water with some spot spray on the shoreline. Volunteers will help to maintain control of this population in the future. (Credit: Willamette Riverkeeper)

GOAL 1:

Prevent the introduction and establishment of new AIS to the Willamette Basin by supporting EDRR efforts.

STRATEGIC ACTIONS:

1) Promote regular surveys on the mainstem Willamette that:

- Identify priority and potential EDRR species present in the Basin.
- Utilize community mapping tools, such as Fulcrum, to track AIS species, patch size, location, and other important data.
- Build upon the WAIN EDRR and Watch lists (provided as an appendix).

2) Ensure proper identification of EDRR species by:

- Maintaining a contact list of subject matter experts.
- Periodically updating the WAIN website with species identification tools.
- Annually revisiting and revising the EDRR list in consultation with ODA, consultation with WAIN collaborators, evaluation of mapping data, and other sources of information.

3) Refine rapid response protocols by:

- Identifying lead agencies and other entities and appropriate contacts and roles for response to new AIS.
- Identifying and securing sources of funding that can be readily available to support mobilization of control efforts for EDRR species.
- Clearly identifying reporting protocols (e.g., Invasive Species Hotline), for natural resource managers and the public so response can be efficient and effective.

A large patch of yellow floating heart was discovered by a Willamette Riverkeeper volunteer, Al Grappel. Natural resource managers spent a day surveying the Upper Willamette River near Eugene looking at the extent of this EDRR infestation. (Credit: Willamette Riverkeeper)

GOAL 2:

Minimize the harmful ecological, economic, human health, and recreation impacts of AIS patches through containment and effective management.

STRATEGIC ACTIONS:

1) Limit the introduction and spread of AIS in the Willamette Basin focusing on pathways into and out of affected areas by:

- Prioritizing among AIS patches using the following guiding principles:
  - Address small AIS patches quickly before they grow and cause greater impacts at the site and send propagules downstream.
  - Prioritize control of patches of newer AIS species (e.g., yellow floating heart) over more well-established species (e.g., parrotsfeather).
  - Reduce downstream dispersal intensity by prioritizing control of upstream populations.
  - Prioritize sites that serve as large source populations (e.g., greater than an acre in size) to reduce downstream propagule pressure.
- Prioritizing patches where the downstream outlet to the Willamette River is connected year round hence contributing source material to downstream locations on a year–round basis.

2) Prioritize among AIS patches by considering additional factors:

- Using geospatial data and analysis to identify high-quality habitats and other key factors on a reach scale using the Prioritization Frameowrk described later in the Plan.
- Applying a Willamette-specific score card as a tool to identify important sites to focus AIS containment and management (provided as an appendix).
- Incorporating information on geomorphic position and condition that could improve the success of an AIS control project and provide the greatest ecological benefits (e.g., is there continuous upstream and downstream side channel connectivity with the river?).
- All other factors being equal, implementing a "top down" approach to limit downstream spread on all scales – within a reach of the mainstem, within tributary reaches, or with a basin-wide lens.
- Prioritize projects at sites that would have multispecies benefits especially habitats used by ESA-listed Chinook and steelhead.

3) Evaluate control methods and identify new tools and techniques for greater control efficacy by:

- Utilizing the most effective control practices implemented according to Integrated Pest Management (IPM) principles to achieve effective control outcomes.
- Incorporating non-chemical control approaches where appropriate.
- Evaluating a variety of chemical and non-chemical control methods to gage efficacy and increase the tools available to practitioners.

4) Improve project planning and management tools for improved AIS control by:

- Encouraging prevention and management efforts that address unique within-reach environmental and land ownership conditions.
- Continuing to involve the community to create a sense of ownership and understanding of the challenges in preventing and controlling AIS.
- Maintaining and adding to the current Checklist of Considerations for Managing AIS Projects (refer to appendix).
- Determining how permitting requirements may be streamlined across multi-jurisdictional groups.
- Developing cooperative agreements to allow entities to perform control work across property boundaries (for example, control work on DSL-managed lands).
- Developing a consistent and comprehensive approach to defining shared performance measures and metrics used by all WAIN participants and used for individual projects for reporting and data sharing purposes.

Volunteers pull invasive aquatic plants at a Paddle and Pull event in 2017. (Credit: Willamette Riverkeeper)

GOAL 3:

Restore aquatic and adjacent riparian habitat to benefit native species and enhance the function of aquatic ecosystems.

STRATEGIC ACTIONS:

1) Ensure that ecosystem recovery processes are an essential component of control and management efforts to restore resilience in the system and reduce the need for ongoing management by:

- Identifying opportunities and developing new projects that restore ecosystem processes, which could make a site less susceptible to AIS invasion, e.g., by improving flow both upstream and downstream.
- Compiling and assessing best management practices (BMPs) for areas where information is currently lacking, such as native aquatic species establishment.
- Regularly convening restoration conservation entities, invasive species management entities and the science community to share information and develop priorities to ensure sound ecosystem recovery is part of AIS control projects.
- Working to contain and reduce AIS in high quality or otherwise strategic habitats, where feasible.
- Including a weed control component during the design of restoration projects and applying for grants; particularly in instances where increasing connectivity could result in downstream movement of AIS such as ludwigia.
- Addressing sediment accretion from dense AIS growth in alcoves and side channels.
- Incorporating design elements that make conditions for AIS less hospitable, e.g., providing shade, altering nutrient availability, modifying water depths and substrate, planting native aquatic plant species, designing steep banks, etc.

2) Incorporate native planting into the design of restoration projects that include treatments of AIS:

- By re-planting native aquatic species such as wapato *(Sagittaria latifolia)* and other hardy wetland plant species.
- For projects where AIS have impacted the riparian buffer zone, consider planting native trees and shrubs to help with bank stabilization and shading, and to reduce the chances for re-invasion.

- Work with nurseries, SWCDs, and other partners to promote grow-out of locally-sourced key native aquatic species needed in large quantities to support aquatic revegetation projects.
- Develop a more complete annotated list of native aquatic plant species for the Willamette Basin to aid land managers in planning replanting projects.

GOAL 4:

Apply public education and outreach tools to prevent the introduction of new AIS and to bring increased awareness to the importance of protecting natural resources in the Willamette River Basin.

STRATEGIC ACTIONS:

1) Expand awareness of AIS and the value of natural resources in the Basin through messaging and improved communication tools that meaningfully reach the public in the Willamette Basin by:

- Investing in outreach efforts to promote Wapato Revival to increase broad-based public awareness of the threats and impacts of AIS, the importance of healthy ecosystems, and instill personal responsibility and protection of the Basin's assets.
- Developing a Wapato Revival website which includes tools to share this plan as well as more specific resources about AIS. The website will also tell the story of how professionals are collaborating in the Willamette Basin to improve their practices and address this complex problem.
- Promoting other campaigns such as "Clean, Drain, Dry" and "Play, Clean, Go" for all river users, including non-motorized boaters, anglers, hunters, and campers through signage, social media, and public outreach events.
- Engaging with the general public through community events such as National Invasive Species Week, Oregon State Fair, Willamette River Festival, and other events.
- Utilizing social media and press relations to share information with the public and expand the scope and scale of outreach efforts.

- Training the public in appropriate decontamination protocols to prevent the spread of AIS.
- Using messaging about AIS impacts that is tailored for the audience, which may vary from recreational to habitat to water quality impacts.

2) Directly engage the community in Wapato Revival AIS control efforts by:

- Recruiting volunteers to survey and map AIS using tools such as Fulcrum Community.
- Routinely organizing enjoyable community events such as "Paddle and Pull".
- Providing community workshops to provide public education on AIS.
- Considering development of an "Adopt A Reach" program to help generate more local support on a reach scale.

3) Collaboratively build upon existing education and outreach materials with network partners to leverage expertise and resources by:

- Striving for use of consistent messaging, and where possible, use of the same outreach materials across WAIN collaborating organizations. This may be done under the Wapato Revival umbrella.
- Increasing educational signage about the impacts of AIS at public natural areas, boat ramps, and project sites.
- Developing methods to evaluate effectiveness of education and outreach materials.
- Compiling and sharing data on the social, environmental, and economic impacts of AIS.
- Coordinating with recreational providers to leverage their access to boaters, anglers, and other recreationists to educate the public about their role and responsibility in protecting the Willamette River.

4) Promote focused and inclusive outreach and engagement to build public support and involvement among groups who have been historically under-represented in environmentalism, or those who WAIN has not yet reached, through:

- Developing strong collaborative relationships with Native American tribes and other members of Indigenous communities in the Willamette Basin to share information, strategize, and plan on-the-ground projects that will aid in the preservation and restoration of aquatic habitats.
- Engaging a diverse network of Oregonians through on-the-ground local community efforts.

- Engaging with communities directly through clubs, schools, and other organizations that serve under-represented Oregonians.
- Coordinating between partner education organizations and outreach organizations to leverage reach and capacity.

5) Educate recreationists, regulators, and funders about Wapato Revival to garner their support by:

- Developing messaging that highlights the impacts of AIS in the Willamette Basin ecosystem and the distribution and abundance of native aquatic organisms.
- Demonstrating how available control methods apply to different scenarios based on the target plant species, density of adjacent native plants, presence of higher quality habitat features, or other factors.
- When utilizing chemical control options, explain the rationale and how it ties to IPM principles, alternatives that were evaluated and why they were not chosen, and the positive and any potential adverse impacts expected from the work.

GOAL 5:

Promote research projects that aim to address a number of questions about AIS pathways of introduction, distribution, impacts, and management options.

STRATEGIC ACTIONS:

1) Improve understanding and management of invasives in tributaries by:

- Providing opportunities for natural resource managers who work in tributaries to learn about survey techniques and Fulcrum Community program that has been used to effectively map the distribution of AIS in the mainstem Willamette.
- Increasing information on plant distributions in the tributaries, as this information is lacking compared to the mainstem.
- Integrating information on eDNA from tributaries into the decision-making process and supporting efforts to develop eDNA and other emerging options for better AIS detection.

2) Improve upon mapping and data collection by:

- Promoting reporting and mapping of invasive species observations by all stakeholders via use of WAIN's Fulcrum Community account, iMap Invasives, ODA's WeedMapper, or the Oregon Invasive Species Hotline. Incorporate reporting into all outreach and education materials and provide training.
- Developing minimum data standards that are applicable across data collection formats so data from all sources can be efficiently integrated.
- Adding treatment data to the Fulcrum Community data set.
- Collecting information on native aquatic plant communities (e.g., specific location, and densities). Similarly, identifying the spatial distribution of dense aquatic plant beds in side channels and how they change over time.
- Encouraging all WAIN collaborators to collect data for sites and areas within the Willamette Basin that are surveyed for AIS. Use the null data option in Fulcrum for sites surveyed but where no AIS plants were found.
- Conducting a comprehensive aerial survey for key emergent aquatic plants of the Willamette River, such as native wapato, including off-channel habitats.
- Delineating alcoves, side channels, and sloughs under varying hydraulic regimes to help prioritize the areas where long-term success in controlling AIS may be most feasible.

3) Improve effectiveness monitoring by:

- Developing uniform data collection protocols for effectiveness monitoring following treatments.
- Encouraging organizations to conduct effectiveness monitoring associated with their AIS projects, and to publish this data.
- Helping funders understand that while effectiveness monitoring does cost money, it will help projects be more efficient and effective in the long run.

4) Improve understanding of ecosystem impacts of AIS by:

- Comparing varying densities of emergent and submersed macrophyte growth and how those effect fish, water quality, evapotranspiration rates, and benthic invertebrates in off-channel habitats.
- Clarifying other key relationships between fish communities, water quality, and AIS plants such as ludwigia through regular literature review and Willamette-based field studies.
- Investigating the role dense emergent and/or submerged macrophyte growth play in the long-term effects on river geomorphology as a result of sediment accretion compared to geomorphology effects from natural processes and human-managed hydrologic regimes.

5) Fill information gaps and perform necessary research for improved AIS management by:

- Conducting studies that improve understanding of unique management challenges in the Willamette River, including but not limited to, downstream movement of herbicides, concentration and exposure time relationships, and off-target impacts that could affect future management decisions.
- Increasing support for biocontrol research studies for AIS control agents.
- Performing risk assessments of nearby and emerging AIS and promote best practices for early detection and rapid response.
- Continuing to improve upon prioritization tools for prioritizing between treatment sites and target species.
- Continuing to learn about challenging AIS species, such as determining the viability of yellow floating heart and ludwigia seeds, to inform management decisions and approaches.
- Exploring new detection and mapping techniques, including eDNA and drone technology, to improve our ability to quickly detect and respond to new AIS.

GOAL 6:

Foster continued coordination and communication between natural resource managers, scientists, funders, landowners, Indigenous communities, and other community members.

STRATEGIC ACTIONS:

1) Assemble committees of WAIN focused on implementing specific strategic actions in the Wapato Revival plan. Subcommittees and their respective responsibilities may include:

- **Steering –** Provide support, guidance, and oversight to help lead WAIN; revisit and update the plan every five years; identify funding opportunities to support a WAIN Coordinator role, and to strategically leverage funding and match for the Wapato Revival Plan.
- **Outreach and Education –** Co-create outreach materials; provide opportunities for peer-to-peer learning.

- **Mapping and Data –** Identifying and cataloging infestations; maintaining a database of annual management actions using consistent data submission protocols to track treatments, surveys, and restoration efforts across the Willamette Basin; help to manage online mapping tools on Wapato Revival website.
- **Technical and Scientific Research –** Lead more technical projects, such as updates to the GIS data sets; review plant lists; share updated best management practices; and watch for new invasive species and discuss management concerns and provide technical insights.

2) Identify and secure long-term funding opportunities to sustain coordination of WAIN and to implement AIS control and restoration in the Willamette Basin to provide stability to:

- Maintain a WAIN Coordinator role to facilitate annual WAIN meetings, and to regularly sharing collaborators' accomplishments with partners and funders to highlight the value of the collective work of Wapato Revival projects.
- Promote collaborative efforts such as Wapato Revival - a strategy for generating new interest and securing new sources of funding for aquatic habitat restoration including AIS control in the Willamette Basin.
- Investigate and compile information about the economic implications of AIS impacts to demonstrate the economic importance of control.
- Showcase successful projects to the public, for example, through tours or newsletters.

3) Increase diversity of WAIN collaborators to include more people who work directly with communities that engage Black, Indigenous, and People of Color (BIPOC) and by incorporating diversity, equity, and inclusion principals into elements of WAIN activities, for example by:

- Setting an example in the restoration community that creates a diverse and inclusive environment through partnerships and collaborations.
- Developing specific diversity and inclusion best practices that can be implemented by WAIN collaborators and others who direct AIS management efforts.
- Forming meaningful relationships between WAIN collaborators, tribes, and Indigenous community members around restoring wapato and other culturally important plant species, lamprey, habitat restoration, and other topics of shared interest. Recruit Indigenous community members to more actively participate in the Wapato Revival project and with WAIN. This may include a WAIN committee focused on tribal relations.

- Work with BIPOC communities to plan and implement hands-on outreach and education events.

4) Continuing active engagement of WAIN collaborators representing a wide range of watershed councils, local, state and federal agencies, soil and water conservation districts, non-profits, individuals, etc.:

- Provide annual training to ensure WAIN collaborators are trained in the use of Fulcrum Community and other AIS mapping/reporting tools.
- Provide continued education to WAIN collaborators to stay current on new science, research, and BMPs. This may occur during regular meetings or through topic-specific workshops.
- Provide on-river peer-to-peer workshops for practitioners in the Willamette Basin that includes mapping training, sharing experiences and lessons learned, networking, BMPs for control, species identification, and other topics.
- Educate field staff that work in aquatic environments to properly identify key AIS (including zebra/quagga mussel and other taxa) through short courses and/or guides that could be uploaded to handheld devices.
- Enhancing and improving coordination between agencies and other organizations through a clearly crafted partnership memorandum of understanding (MOU) that identifies roles and responsibilities, similar to Cooperative Weed Management Agency MOUs.
- Convening stakeholders at WAIN meetings to share information about successes, methods, challenges, and make recommendations to subcommittees and the group at large.
- Consider the pros, cons, and work required to convert WAIN into an AIS-focused Cooperative Weed Management Area operating in the Willamette Basin.

Laura Brown from Benton SWCD joined Willamette Riverkeeper staff for a yellow floating heart survey on the reach between McCartney Park and Peoria. (Credit: Willamette Riverkeeper).

MANAGEMENT APPROACHES

A number of management approaches are included in the Wapato Revival Plan to address invasive plants that threaten and impact aquatic ecosystems of the Willamette Basin. Identifying the level of threat or stage infestation is a primary driver in selecting a single or suite of management actions, depending on the objective. A summary of definition of terms provided in the Oregon Conservation Strategy is similarly used in the Wapato Revival Plan and summarized below.

IMPACT	DETAILS AND REFERENCES
Education	Inform the public about the impacts and costs of invasions.
Prevention	Preventing new species introductions is a top priority and the most cost-effective approach to protecting native species, ecosystems, and productivity of the land from invasive species.
Assessment/Risk Analysis	Defining the level of concern and risk associated with new introductions through an assessment process will help to identify the worst invaders and management priorities.
Monitoring	The importance of surveying cannot be overestimated when looking for first-time infestations of undesirable non-native species or evaluating efforts to control existing occurrences.
Early Detection	Early discovery of infestations of previously undocumented non-native species is critical to controlling their spread and achieving complete eradication.
Rapid Response	Immediate treatment of new, isolated infestations will maximize eradication success and decrease the likelihood of populations expanding beyond the initial area of introduction.
Containment	Preventing invasive species from 'hitchhiking' via vulnerable pathways will slow the advance of well-established invasive species into unaffected areas. Some invasive species are tolerable if infestations can be contained and their impacts minimized.
Restoration	A system-wide approach to treating invasive species should consider habitat restoration as part of the ecological healing process. Helping native species and ecosystems recover is an important step following the removal of harmful species.
Adaptive Management	Land managers or landowners should change course on management prescriptions if treatments are not working. Monitoring the results of control actions is an important part of this process.

The Oregon Conservation Strategy
https://oregonconservationstrategy.org/key-conservation-issue/invasive-species/#scrollNav-4

PREVENTION

Prevention is widely regarded as the first line of defense in avoiding deleterious effects of any nuisance species, whether terrestrial or aquatic. The Oregon Statewide Strategic Plan for Invasive Species specifically includes the following prevention strategies: endorsement of pathway management, enhancement of law enforcement, promotion of research, sharing of best management practices (BMPs) and engagement in cooperative partnerships (OISC 2017a). Members of WAIN have worked cooperatively to embrace these prevention measures, in particular, promotion of thoughtful engagement with the research community, sharing of BMPs, and active engagement in cooperative partnerships.

In Oregon, prevention efforts are largely targeted at preventing the introduction and establishment of zebra and quagga mussels and the aquatic plant hydrilla, though other AIS are addressed. The Oregon State Marine Board (OSMB) in partnership with the Oregon Department of Fish and Wildlife (ODFW) administers the AIS Prevention Program provided by HB 2220. ODFW manages the watercraft inspection staff and AIS monitoring activities and OSMB oversees the AIS Prevention Permit (that funds the program) and law enforcement coordination. In 2019, six stations inspected 26,875 watercrafts, with an overall compliance rate of 80% (ODFW and OSMB 2020). Of those inspected, 11 were decontaminated for quagga or zebra mussels.

CHEMICAL CONTROL

Chemical control involves the application of U.S. Environmental Protection Agency (USEPA) and ODA-approved herbicides. Products are typically applied early in the growing season but some applications also occur under dewatered conditions as a "pre-emergent." All applications must be permitted by the ODEQ under the National Pollutant Discharge Elimination System (NPDES) Pesticide General Permit (PGP) and applied by applicators licensed by the ODA. Chemical control of primrose species, parrotfeather, delta arrowhead, and fragrant waterlily in the Willamette River has largely utilized an aquatic formulation of glyphosate (tradename Rodeo). In 2017, the use of imazamox (tradename Clearcast) began being used to control yellow floating heart. In 2019, imazapry (tradename Polaris) was also introduced as a management tool.

There are a number of pros and cons associated with the application of aquatic herbicides. Pros include rapid control that is more cost effective than manual approaches that can require substantial labor and mobilization of staff. Additionally, more recent products available on the market are more selective to a group of target plants. A recent example is the florpyrauxifen-benzyl (tradename ProcellaCOR) that was approved by the USEPA in 2018. ProcellaCOR has demonstrated a particular efficacy against Eurasian watermilfoil (Beets et al. 2019), but yellow floating heart, water primroses, and parrotfeather are also reported to show good control (Heilman 2018, SePRO Corp. 2018). The cons of applying aquatic herbicides are a generally negative public perception, rapid die-off may lead to deleterious effects to water quality as plants decompose, and depending on the product applied, can be non-selective, resulting in impacts to non-target native species. Additionally, each product varies in its toxicological risks impacts to non-plant species including fish, insects, pollinators and others.

As previously mentioned, an NPDES permit for the application of aquatic herbicides is required from ODEQ. As part of the permit requirements a person or entity must be identified with "operational control" over the day-to-day decisions for the application. This person or entity would then be responsible for following the terms and conditions of the permit.

Federal agency involvement in chemical control of AIS can trigger additional permitting and review. At the time of writing, several projects are underway using federal funds and administered by Bonneville Power Administration (BPA) in areas where there are federally listed threatened Chinook salmon (*Oncorhynchus tshawytscha*) and designated critical habitat. For example, in coordination with the Long Tom Watershed Council, treatment of yellow floating heart, water primrose, and parrotfeather has occurred at Sam Daws Landing and Snag Boat Bend (downstream of Harrisburg, OR) using glyphosate and diver-assisted hand-pulling. Due to the federal funding nexus, a Biological Assessment (BA) was prepared for these projects.

Control of ludwigia infestation using chemical application. (Credit: Laurie Holts, City of Eugene)

MECHANICAL AND MANUAL CONTROL

Hand pulling has proven to be an effective tool to address small EDR patches of priority species. WAIN collaborators have successfully collaborated in planning and implementing Paddle and Pull events to engage community in learning more about AIS while also achieving small scale management goals. Hand pulling of AIS has also proven effective on a larger scale by contractors at Delta Ponds in Eugene and Mission Lake at Willamette Mission State Park in Gervais.

Mechanical control can also involve the use of variety of heavy equipment such as rotovators and harvesters to remove biomass of nuisance vegetation. Mechanical controls are typically an ongoing activity that can be expensive and are likely to create short-term turbidity issues and the release of plant fragments that could travel downstream. They also pose a risk to resident species, including turtles, fish, and amphibians which can be present in the removed mats. Temporary fragment barriers can reduce wayward floating pieces, and could be a viable approach to removing vegetation from large areas of dense, dead mats after herbicide use when the mats have not flushed through by higher flows. If conducted at appropriate sites, and with adequate protections, it could be considered if herbicides are not an option at a high-priority location. In the Willamette River, there is anecdotal evidence that landowners along the river have improvised using their own equipment to remove mats.

Volunteers hand pull ludwigia during a Paddle and Pull event on Muddy Creek, a Willamette tributary in Corvallis. (Credit: Fred Joe)

BIOLOGICAL CONTROL

Biological control involves the use of one organism (e.g., parasite, predator and/or pathogen) to suppress the population of another. At present, there are a limited number of biocontrol agents approved by ODA for use in Oregon to suppress nuisance aquatic/riparian vegetation, but include Eurasian watermilfoil, purple loosestrife, and salt cedar (ODA 2019c). Having said that, there is research on a number of target plants found in the Pacific Northwest and potential biocontrol agents, including yellow floating heart (Harms 2018), Brazilian waterweed (Pratt et al. 2019), and water primroses (Hernández and Cabrera Walsh 2014). Research is currently being conducted by the U.S. Department of Agriculture – Agricultural Research Service (USDA-ARS) to evaluate the host specificity of a thrips species *(Liothrips ludwigi)*, a stem boring weevil *(Tyloderma* sp.*)*, and a fruit feeding weevil *(T. nigromaculatum)* (USDA 2019b) to manage Ludwigia species.

Bio-control agents such as *Galerucella* beetles can be very successful in the long term management of purple loosestrife if organisms are released under appropriate conditions, including areas that are:

- Not too flooded
- Have limited disturbance
- Contain sufficient plant material to feed on
- Have potential satellite sites to disperse to

Other treatments such as herbicides may be integrated if applications are timed to leave some patches unsprayed so they have enough food.

Galerucella beetle feeding on purple loosestrife in Oaks Bottom Wildlife Refuge. (Credit: City of Portland Bureau of Environmental Services)

INTEGRATED PEST MANAGEMENT

Integrated pest management (IPM) is a coordinated decision-making and action process that uses the most appropriate pest control methods and strategies in an environmentally and economically sound manner to meet agency pest management objectives (ODA 2020). State agencies and public universities are required to participate in routine IPM Coordinating Committee meetings (ORS 634.657) and to have IPM plans in place. The elements of IPM include:

- Preventing the problem
- Monitoring for the presence of pests and pest damage
- Establishing the density of the pest population, which may be set at zero, that can be tolerated or correlated with a damage level sufficient to warrant treatment of the problem based on health, public safety, economic, or aesthetic thresholds
- Treating pest problems to reduce populations below those levels established by damage thresholds using strategies that may include biological, cultural, mechanical, and chemical control methods and that shall consider human health, ecological impact, feasibility, and cost effectiveness
- Evaluating the effects and efficacy of pest treatments

IPM is underway at Molalla River State Park, focused on knotweed using complementary approaches of biological, chemical, and mechanical control, as well as replanting treated areas. This site has one of the largest monocultures of Japanese knotweed in northwest Oregon. (Credit: Andrea Berkley)

CULTURAL CONTROL

Using cultural control methods, the characteristics of an area are changed, resulting in less hospitable conditions for the invasive plant. This could include the manipulation of water control structures to drawdown water sufficiently enough that would result in desiccation of the plants. Similarly, control structures could be used to flood invasive riparian species. For the Willamette River, changes in hydrology are not easily accomplished, however, at the site level, side channels can be manipulated through restoration projects that result in opening up side channels that increase flushing. Cultural methods also include planting to shade out and compete for resources with undesirable invasive plants, solarization using clear plastic, mulching, grazing, flaming, prescribed burning, and other methods.

CURRENT ACTIVITIES

WAIN collaborators have put a tremendous amount of effort into managing existing infestations of nuisance aquatic plants in the Willamette River, including important side channel habitat and some tributaries. This work also includes critical first steps to document the location and extent of AIS plant growth so that post-management evaluations can be assessed. Further, research on the impacts of AIS on water quality and native fish populations has increased. Education and outreach efforts have galvanized hundreds of volunteers to contribute to many of the activities led by WAIN collaborators. An overview of recent activities is provided in the following sections.

PLANT SURVEYS

As the presence of aquatic invasive plant species increases over time, collaborators of WAIN determined that it would be helpful to document the impacts so there would be a mechanism to monitor change over time on a landscape scale. In the summer of 2016, Willamette Riverkeeper, in partnership with Portland State University (PSU), took the initiative to develop a plan to survey the entire length of the mainstem Willamette River to begin to document the infestation of aquatic invasive plants. For each subsequent field season since, WAIN collaborator have continued to survey sites and entire reaches of the Willamette to collect observational data to monitor change resulting from treatment of sites, as well as flood events, and the consequences of lack of AIS control over time.

The goals for the surveys were: to locate presence or absence of EDRR patches to aid in a more rapid treatment response; to locate large source patches in need of more significant restoration investments; to identify sites or reaches of the river with less AIS impacts that may be higher priority for protection of natural resources through future EDRR; and to monitor change of time on a landscape scale.

In an effort to involve different land managers in helping to crowd source and easily share data collected across a large geography and time span, the survey team selected Fulcrum, an online application (app) available for smartphone and tablets, to use as a data collection tool. The app has the ability to mark points on a map using a smartphone or tablet and then geo-reference photos and data to the point. A standardized data form was created to collect consistent information when a priority weed was observed. The data is easily able to be exported for sharing as well as imported into Google Earth or more powerful GIS programs.

The focus for these surveys was a list of priority plants for treatment and EDRR, and a watch list of other species (see appendix for specific lists). Surveys for EDRR are completed during the field season from June – early October when plants are more likely to have reached their full growth potential for the growing season.

Early detection is one of the most important features of a successful invasive species control program, therefore it is important to survey for target species in order to detect them early. WAIN collaborators have found that conducting surveys by canoe and/or sea kayak on the navigable waterways of the Willamette Basin is the most

effective way to monitor new and established infestations of priority AIS, as well as get a pulse on the extent of healthy ecosystems on the river. Recommendations include traveling in a team of two to three boats to allow surveyors to cover both sides of the mainstem, and explore navigable alcoves, sloughs, and side channels. Having multiple boats moving downriver as a pod helps manage risk on the water, as well as provides added eyes and perspective. While traveling on the river for Paddle and Pull events and recreation, we also encourage land managers and volunteers with an eye for AIS to always keep an eye out for plants on the EDRR and Watch Lists.

A combination of Willamette River Water Trail Guides, Google Maps, and Fulcrum have been used to help locate and record locations of EDRR species that would otherwise be difficult to access by land. Surveys are most effective when well-coordinated, covering complete reaches of the river in any given year. Once a strong baseline has been established, periodic comprehensive surveys will still be needed, but input of data for smaller stretches of the river by numerous organizations will add depth and currency to the data.

Other survey techniques include using aerial photography, either recently available imagery from sources such as Google Earth or conducting flights. ODA conducted an aerial survey of the Willamette focusing on the reach between Corvallis and Salem using a fixed wing aircraft during the 2014 field season to determine the spatial distribution of ludwigia. Use of aerial photography should include ground-truthing in at least a few locations to ensure the interpretation of aerial imagery is accurate. Analysis of imagery can be conducted by eye or using software to remotely sense invasive species when analyzing a large area or a large number of aerial images.

Volunteers for a Paddle and Pull event find water hyacinth, a highly invasive weed, in Golden Gardens Park in Eugene. (Credit: Laurie Holts, City of Eugene)

PLANT SURVEY RECORDING METHODS

At present there are a number of different databases that track AIS on the Willamette River including ODA's "WeedMapper", USGS's "Nonindigenous Aquatic Species" (USGS NAS) database, the Institute for Natural Resources "iMapInvasives" database, and the "Willamette Aquatic Invasive Mapping Project" using a Fulcrum Community application co-developed by PSU and Willamette Riverkeeper for use by WAIN collaborators. In looking at the portability of shared data by these and other databases, it makes sense to consider following as many of the mapping standards developed by the North American Invasive Species Management Association as practicable, while balancing this with retaining the ease of creating numerous records while traveling on the river. Data fields currently being evaluated to achieve greater consistency between databases for future data recording include: land ownership status, presence or absence of target AIS species (which permits recording of healthy systems without weeds), and treatment history.

Data Collected through Fulcrum Community for Weed Observations

- Observer name
- Observation date
- AIS observed or surveyed
- Presence or absence of AIS at the location
- Phenological stage of the plant
- Patch size (choose among provided size categories)
- Coverage and distribution of AIS within the patch
- Habitat type
- Sediment type
- Did you hand pull the observed patch?
- Site hazards (related to accessing the site from the navigable waterway)
- Notes
- Photos

If you would like to participate in the effort to crowd source data using Fulcrum Community, please sign up by email at: **restoration@willametteriverkeeper.org**

TREATMENT HISTORY

Since 2016, WAIN has collected records from collaborators to document management efforts for AIS in the Willamette Basin. Collectively between 2016-2019, more than 12 agencies and organizations in the Willamette Basin have worked on the Wapato Revival project to control the spread of aquatic invasive plants. WAIN collaborators have worked both independently and in partnership to control aquatic invasive plants at more than 60 different sites throughout the Willamette Basin totaling more than 2,000 acres. To date, management efforts have included hand-pulling and aquatic herbicides. Data is submitted annually at the end of the field season to the WAIN Coordinator for compilation.

A primary focus of Wapato Revival projects is to protect and restore native aquatic habitats. With that goal, WAIN has sought to gather more specific information that will document the success and lessons learned from a particular control project. This allows us to measure progress in terms of percent controlled and acres treated.

Project Information and Treatment Data Shared by WAIN Collaborators

- Contact information for project manager
- Lead agency/organization
- River reach
- Site name or river mile and location coordinates (latitude/longitude)
- Number of years the site has been controlled
- Species of target plant(s)
- Project size (e.g., acres, stream miles)
- General assessment of pre-treatment conditions
- Control method(s) (e.g., manual, chemical, etc.)
- Control dates

There are a number of platforms for collecting and sharing information right from your smartphone. **WeedMapper, iMapInvasives, and Fulcrum** sync with one another annually.

RESEARCH

Research on the impacts of AIS on water quality in various areas of the Willamette River has increased in recent years. Research studies to date have taken place at Mission Lake, Windsor Slough, Collins Bay, and in Willamette Slough at Minto Brown Island Park. The USGS and PSU in partnership with Willamette Riverkeeper, Oregon State Parks, BSWCD and other WAIN collaborators have conducted a number of more detailed studies on changes in ambient water quality conditions in off-channel habitats. Monitoring results in Windsor Slough and Mission Lake, where excessive growth aquatic plants, filamentous algae, and cyanobacteria are routinely found, point to substantial impacts to water quality. In addition, USGS completed a study that examined water-quality conditions (including temperature) in the Willamette River and many of its adjacent off-channel features, such as alcoves and side channels, during the summer months between 2015-2016. Results from this study demonstrated a relation between the geomorphology, hydrology, ecology, and water quality of an off-channel feature (Smith et al. 2020). Other ongoing studies have assessed relationships between fish communities, aquatic vegetation, and water quality.

Future research in the Willamette to better understand the impacts of AIS on water quality and habitat will aid in more effective management and restoration by refining scientific understanding of the conditions under which ludwigia may be a limiting factor and identifying how much control of ludwigia is needed before water quality improves. Other areas of research interest include the influence of persistent ludwigia stems and roots on sediment deposition in off-channel features during high flows and the potential increase in water loss through evapotranspiration from dense emergent ludwigia beds.

USGS scientists survey Windsor Slough to collect baseline water quality data during the 2016 field season. (Credit: Willamette Riverkeeper)

EDUCATION, OUTREACH, AND CONVENING

The dedication of WAIN collaborators to contribute their time and energy into the prevention, management, and research of AIS in the Willamette Basin is evidenced by their participation in numerous education and outreach opportunities as well convening as a group for annual meetings and more frequent meetings of the steering committee to create the Wapato Revival Plan. Specific education and outreach efforts include the Paddle and Pull events where community members join natural resource managers in the field to paddle a reach of the Willamette and hand pull small patches of priority AIS within the reach. WAIN collaborators have also facilitated workshops to educate the members of the public about AIS in a hands-on way. These workshops emphasize identification of aquatic plant species, best management practice for hand pulling, use of Fulcrum Community, and more. WAIN collaborators have planned and led peer-to-peer workshops in the field to share best management practices and lessons learned with one another. Various WAIN collaborators have also developed plant identification materials such as *Water Weeds: Guide to Aquatic Weeds for Benton County* (BSWCD 2020). Collaborators have also presented about the collective work of WAIN at conferences including, Meyer Memorial Trust's Within Our Reach, the ODA's Noxious Weed Symposium, the Western Regional Panel on Aquatic Invasive Species, the Oregon Lakes and Reservoirs Annual Meeting, Oregon State Weed Board Meetings, and more.

Wapato Revival partners enjoy river tours and Paddle and Pull volunteer opportunities! (Credits: Fred Joe)

PRIORITIZATION FRAMEWORK

The Wapato Revival Plan is intended to protect aquatic species and habitats in the Willamette River Basin by addressing priority AIS species, both small patches and larger infestations, and preventing the introduction of new AIS populations. Early on in discussions about management of AIS such as invasive ludwigia, WAIN collaborators identified the need to better prioritize their work by focusing limited time and funding to the highest priority locations. The group brainstormed and voted on several factors they felt were important in determining if a particular location was a higher priority than another for working to remove AIS, or for working to ensure AIS do not become established (prevention and EDRR). The top factors were used to develop specific criteria for spatial prioritization.

Two approaches were then developed to prioritize management actions for AIS in the Willamette River:

1) Spatial data was sought that would well represent prioritization criteria across the geographic range of the plan based on geomorphic reaches. By combining a number of spatial data layers, priority sites can be delineated on a reach scale. The purpose of this effort is to visualize big picture patterns including how jurisdictional boundaries overlap geomorphic reaches. As treatments and research progresses, these maps can be updated to reflect current conditions.

2) To better prioritize individual projects at the site-scale, or in areas that are beyond the spatial scope of the priority maps, a scoring approach was adapted from a method used by OPRD (2017) that addresses an expanded list of criteria and allows use of qualitative and quantitative information. The "Scoring Tool" can be found in the appendix.

PRIORITIZATION BASED ON GEOMORPHIC REACHES

The purpose of the geomorphic reaches GIS analysis is to identify the highest priority locations for AIS efforts (ranging from survey to EDRR to AIS control), and display them visually in maps ("heat maps") - one for each of eight river sections. The work was completed by OPRD in 2019, utilizing a variety of existing datasets that sufficiently represent key prioritization criteria that were identified by WAIN collaborators as the most important for determining the relative priority of a particular location along the Willamette River. Several WAIN collaborators participated in data curation and review.

At an early convening of WAIN collaborators, the group brainstormed and used multi-voting to identify a manageable set of the top criteria that the group felt should be used to determine a site's relative priority for AIS work. A steering committee then sought out existing spatial data that had good coverage within the plan area, resulted from a fairly thorough survey effort, and would sufficiently inform the analysis. The six criteria identified by WAIN, and the datasets that were ultimately chosen to express the criteria in the GIS analysis, are listed below. Additional datasets were considered but for various reasons were not used – see appendix for details. We include this list of omitted datasets because, although not used in the GIS analysis, they represent criteria that AIS site managers may want to consider when thinking about prioritization.

CRITERION #1: ARE HIGH-QUALITY HABITATS PRESENT?

Data sources used:

- Cold water points (ISE SLICES Cold Water Refugia 2011-2016, combined with USGS water temperature points where a location is two degrees C colder than an adjacent mainstem location, 2015-2016)
- Riparian and Aquatic locations from Willamette Valley Synthesis Conservation Opportunity Areas (The Nature Conservancy, 2019) combined with Oregon Wetland Priority Sites (The Wetlands Conservancy, 2009)

CRITERION #2: ARE IMPORTANT SPECIES PRESENT?

Data sources used:

- Native fish at sampled sites is greater than 85% (SLICES Percent Native Fish, 2015-2016)
- Native freshwater mussel occurrences (Freshwater Mussels Database, Pacific Northwest Native Freshwater Mussel Working Group, 2019)
- Oregon chub occurrences (ODFW "92-17" dataset)

CRITERION #3: HAS THE SITE RECEIVED PAST RESTORATION INVESTMENTS?

Data sources used:

- Oregon Watershed Restoration Inventory (Oregon Watershed Enhancement Board, 2019)
- Salmon Plate program investments (OPRD, 2019)

CRITERION #4: IS THE SITE PERMANENTLY PROTECTED (IN PUBLIC OR CONSERVATION OWNERSHIP?

Data sources used:

- Federal, state, local, and NGO ownership (various datasets combined, verified where possible, OPRD 2019), including city, county, education district, federal, NGO, parks and recreation departments, port, regional, state, and water district ownerships.

CRITERION #5: DOES THE SITE CURRENTLY HAVE AIS? IS THE SITE A LARGE, MEDIUM OR SMALL INFESTATION OF A HIGH-THREAT SPECIES?

Data sources used:

- AIS data from WeedMapper (ODA, 2019) combined with AIS observation data from WAIN (Willamette Aquatic Invasives Mapping community data on Fulcrum, WAIN, 2019). Sites with yellow floating heart or ludwigia species and > 1-acre ("large" sites), or 500 square feet up to 1 acre ("medium" sites), or less than 500 square feet ("small" sites), were weighted more than sites with other aquatic invasive species.

CRITERION #6: IS THE SITE HIGHER UP IN THE WATERSHED?

Data sources used:

- Watershed position, either on the mainstem or in a tributary. Note: This criterion is not represented in the heat maps. Users of the maps are encouraged to compare locations and, all other things being equal, rate a location that is more upstream in the Willamette Basin as a higher priority for control.

For each dataset list above, a set of three predefined model parameters were used as inputs (specific parameters are provided as an appendix). The steering committee determined the parameters for each dataset, with review from the larger WAIN group. Model parameters are:

- **Weight –** how much the dataset influences the resulting model outputs.
- **Area of influence –** the distance from a data point where it influences the resulting model outputs.
- **Shape of drop-off of influence –** the shape (sharp vs. gradual) of the drop-off of influence of the data point as you move away from it.

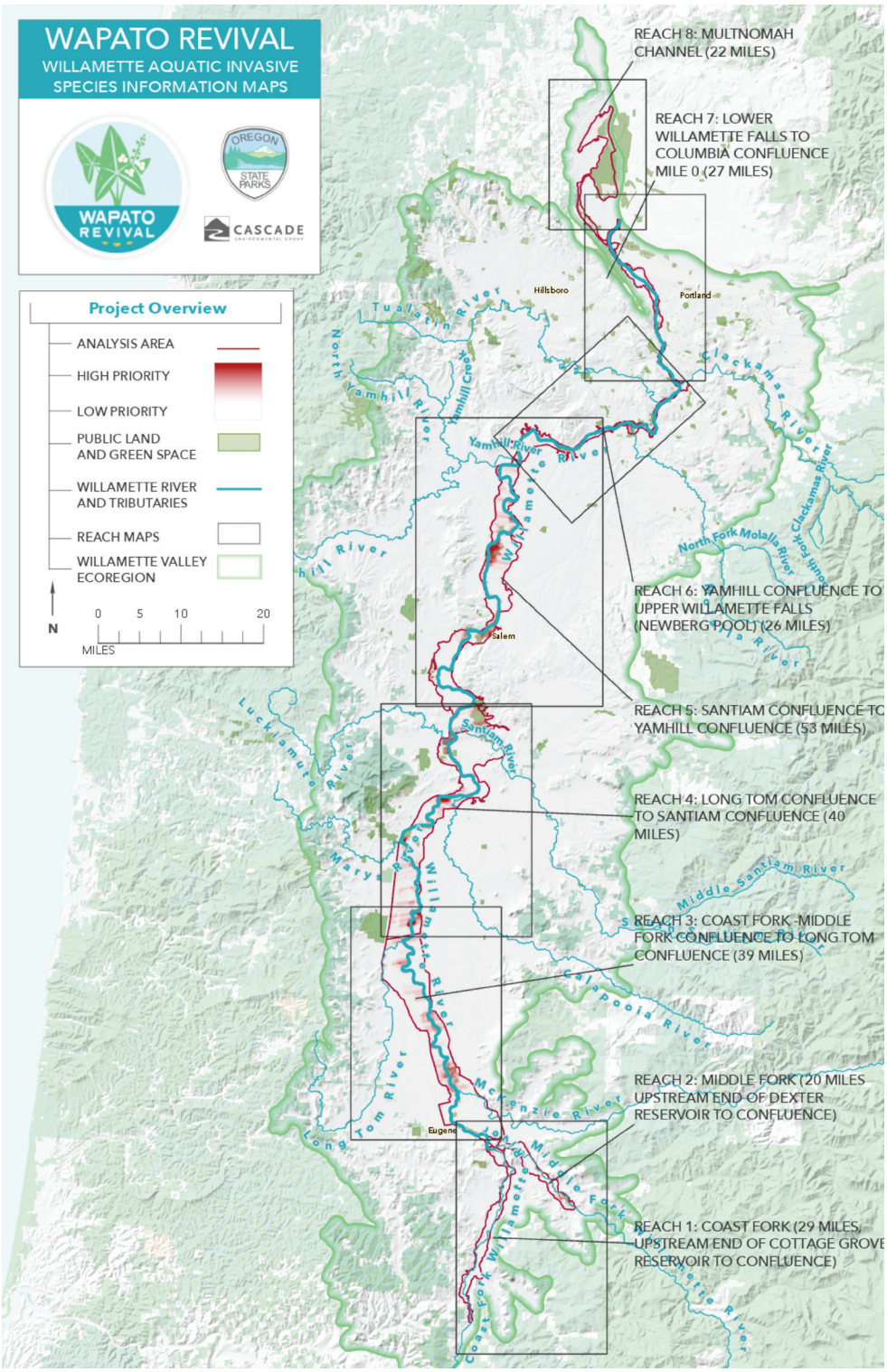
GEOMORPHIC REACHES

A framework to divide the river into meaningful reaches was developed based on geologic and physiological features of the Willamette River (Wallick et al. 2007) and is used herein. The river was split into eight reaches based loosely on geomorphology, partners, jurisdictions, and reach length. These reaches are represented in eight maps moving upstream to downstream.

- **Reach 1:** Coast Fork (upstream end of Cottage Grove Reservoir to confluence); 29 miles
- **Reach 2:** Middle Fork (upstream end of Dexter Reservoir to confluence; 20 miles
- **Reach 3:** Coast Fork-Middle Fork confluence to the Long Tom confluence; 39 miles)
- **Reach 4:** Long Tom confluence to the Santiam confluence; 40 miles
- **Reach 5:** Santiam confluence to the Yamhill confluence; 53 miles
- **Reach 6:** Yamhill confluence to Upper Willamette Falls ("Newberg Pool"); 6 miles
- **Reach 7:** Lower Willamette Falls to the confluence with the Columbia River at mile 0; 27 miles
- **Reach 8:** Multnomah Channel; 22 miles

View from the volunteers perspective as they prepare to spend a day hand pulling ludwigia on Muddy Creek (in Corvallis), a tributary to the Willamette River. (Credit: Fred Joe)

KEY MAP OF GEOMORPHIC REACHES APPLIED IN THE WAPATO REVIVAL PLAN



Credit: Simon Apostol, Cascade Environmental Group, LLC

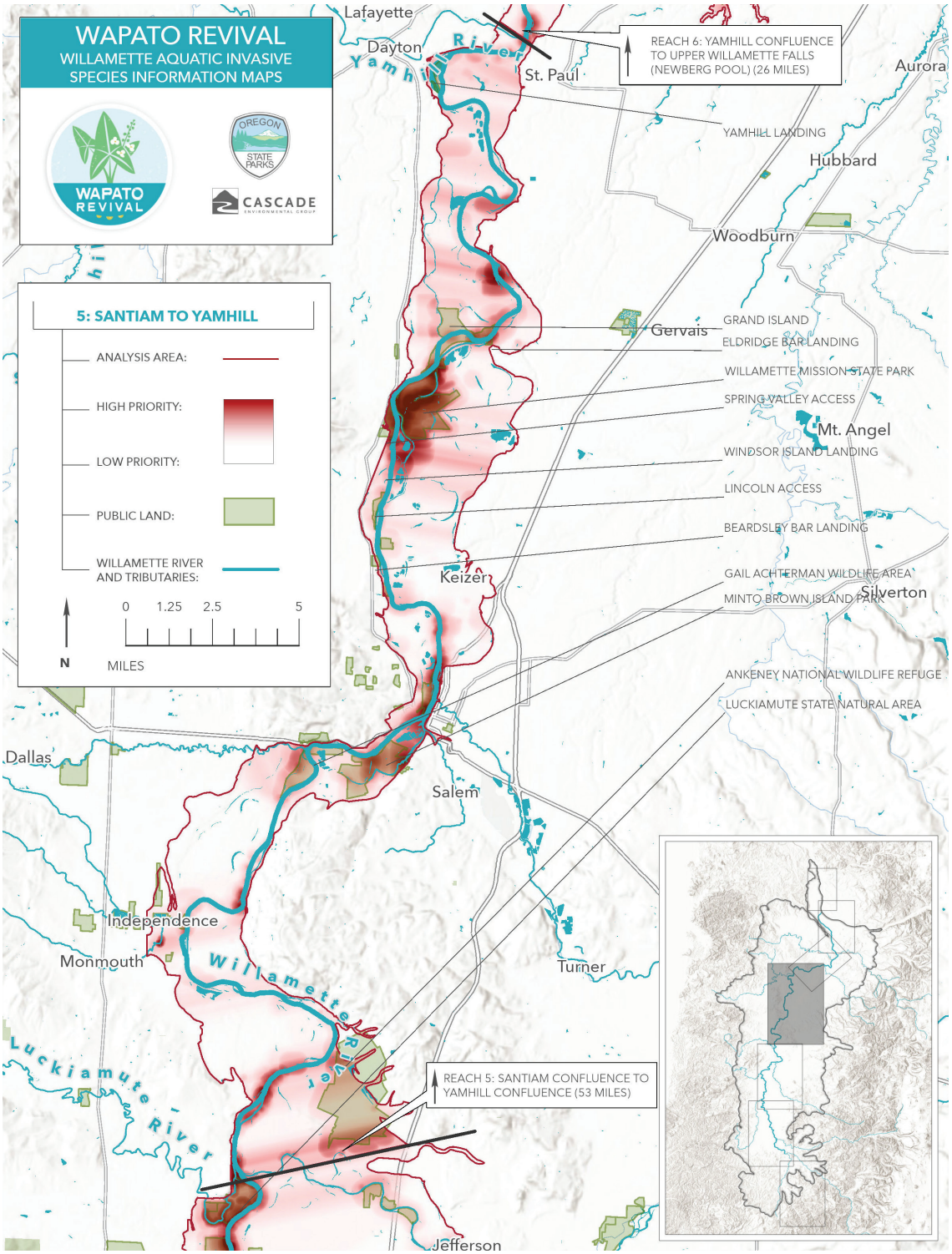
MAPS AND HOW TO USE:

The maps are provided to inform prioritization of AIS efforts, ranging from survey and EDRR work to more complex AIS control efforts. All other things being equal, a location that is more upstream in the Willamette Basin (either on the mainstem or in a tributary) is a higher priority for control than a site more downstream. We found that many of the available datasets provided information for the mainstem Willamette, but few provided information for tributaries (including the Coast Fork and Middle Fork), or for Multnomah Channel. Therefore, users should recognize that fewer datasets were used in these reaches than elsewhere, making it difficult to compare sites in different reaches to one another.

The data used in the model is not perfect; in each case, it represents the best available data at the time of the modelling project, but will change over time and will not represent all areas of the basin accurately. WAIN may revise the model as new datasets and new science becomes available in the future. It should be again noted that because the datasets do not cover all of the reaches, cross analysis between reaches should be avoided. Also, these maps are focused on reach-scale analysis and where tributary or site-specific analysis is needed, prioritization methods discussed below are more applicable.

An example reach scale heat map follows. A complete set of all maps are included in the appendix.

EXAMPLE PRIORITIZATION MAP OF REACH 5: SANTIAM TO YAMHILL



Credit: Simon Apostol, Cascade Environmental Group, LLC

PRIORITIZATION BASED ON SITE-SPECIFIC SCORING

Large-scale geographic data can provide a broad view of aquatic habitat quality, restoration efforts, land ownership, etc. but on the site-scale, other attributes that are not able to be represented spatially, or where we currently have no datasets, require a more fine-tuned approach that allows WAIN collaborators to evaluate sites to select priority treatment areas using limited resources. An example of these other criteria: (1) Are there "shovel ready" projects that have a defined scope, permits in place, and sufficient matching funds to satisfy grant requirements? (2) Is it a small EDRR site high in the watershed? (3) Are there other unique aspects of the site that would increase its priority?

A scoring methodology based on OPRD's Natural Resource Function and Value Assessment (NRFVA) (2017) was adapted for evaluating AIS management actions on the Willamette River. Similar to the NRFVA, this scoring system relies on a limited number of major categories with subsequent more fine-tuned questions to score a site based on habitat value, water quality and channel function, land ownership, and species information.

The resulting Scoring Tool is comprised of a data sheet where the user records a score of each of the criteria. Following the data sheet is the scoring rubric which guides the user on what score to choose for their site. In the end, the site gets a total score which can be used to compare to other sites.

The Wapato Revival scoring tool for spatial prioritization of AIS management in the Willamette Basin is provided as an appendix.

CONCLUSIONS

As the Wapato Revival Plan is implemented, measuring success will be key. In managing invasive plant infestations, most stakeholders agree when a problem exists but evaluating success is often more challenging as expectations are not always similarly aligned. The desire to completely eradicate a nuisance aquatic plant may be shared but all parties should recognize in advance whether that goal is possible given factors such as the size of the infestation, geographic reach, funding, and available control methods. Particularly where populations are widespread, it is critical for stakeholders to identify how the success of a management effort will be measured. Most measures of success rely on follow-up effectiveness monitoring to estimate percent reduction over time and, in fact, this approach can be more favorable to funders compared to reporting how much was spent per acre. In short, success should be measured in ways that are mutually agreed upon and demonstrate ecological gains in terms of improving and protecting habitat.

The Wapato Revival Plan will need to be revised over time as the community of AIS practitioners learns and as circumstances change. This document is organized in a way that provides more basic and unchanging information in the body of the document, as opposed to the appendices where the "living documents" that could require updates on a substantially shorter timeframe are found. To allow for sufficient adaptive management within the larger framework, it is recommended that the appendices be evaluated annually but the body of the document be reviewed every five years. At that time, the WAIN steering committee will recommend plan revisions to the greater WAIN collaborators.

The six goals outlined in the Wapato Revival Plan are the outcome of a deeply collaborative process and reflect the commitment of WAIN collaborators to provide EDRR to prevent the introduction and establishment of new AIS, minimize the impacts of existing AIS, apply outreach and education tools, and promote research and communication, all through the lens of restoring habitats that traditionally supported native species such as wapato (*Sagittaria latifolia*).

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WAPATO REVIVAL PLAN APPENDICES

APPENDICES

WAIN Collaborators

Non-native Plants of Concern to the Willamette River

Native Aquatic Plants in the Willamette River Basin

GIS Maps and Methodology

Scoring Tool for Spatial Prioritization of AIS Management in the Willamette Basin

Checklist of Considerations for Managing AIS

WAIN Collaborators

A number of organizations have participated in WAIN over time. Steering committee members that have contributed to the development of the Wapato Revival Plan are indicated in **bold**.

Benton Soil & Water Conservation District

Bonneville Environmental Foundation

Luckiamute Watershed Council

Calapooia Watershed Council

Cascade Pacific Resource Conservation & Development

City of Albany

City of Eugene

City of Portland

City of Salem

City of Keizer

Clackamas Soil & Water Conservation District

Clean Water Services

Columbia Inter-Tribal Fish Commission

East Multnomah Soil & Water Conservation District

Greater Yamhill Watershed Council

Integrated Resource Management

Long Tom Watershed Council

Marion County

Marion Soil and Water Conservation District

Multnomah County Drainage District

McKenzie River Trust

Metro

Middle Fork Willamette Watershed Council

Mosaic Ecology

North Santiam Watershed Council

Northwest Power & Conservation Council

Natural Resource Conservation Service

Oregon Department of Agriculture

Oregon Department of Fish and Wildlife

Oregon Department of State Lands

Oregon Parks and Recreation Department

Oregon Sea Grant

Oregon State Marine Board

Oregon State University

Pacific States Marine Fisheries Commission

Polk Soil & Water Conservation District

Port of Portland

Portland State University

Santiam Water Control District

South Santiam Watershed Council

The Nature Conservancy

Tualatin Soil & Water Conservation District

United States Army Corps of Engineers

United States Geological Survey

United States Bureau of Land Management

United States Fish & Wildlife Service

United States Forest Service

Upper Willamette Soil & Water Conservation District

Willamette Riverkeeper

Wisdom of the Elders

Non-native Plants of Concern to the Willamette River

Species	Common Name	Status[1]	Distribution in Willamette Basin	Notes/May Be Confused With
EDRR (highest priority for survey and control)				
Butomus umbellatus	flowering rush	ODA A (T)	N/A	There are occurrences of this plant in the Columbia Basin
Eichhornia crassipes	water hyacinth	non-native	see notes	Intermittent observations hand-pulled
Hydrilla verticillata	hydrilla	ODA A	N/A	*Elodea* sp. and *Egeria densa*
Sagittaria platyphylla	delta arrowhead	ODA A (T)	N/A	There is a known occurrence of this plant in Portland
Arundo donax	giant reed grass	ODA B	N/A	
Lysimachia vulgaris	garden yellow loosestrife	ODA A (T)	rare	
Myriophyllum heterophyllum	variable-leaf watermilfoil	non-native	N/A	Submersed leaves may be confused with *M. spicatum, M. hippuroides,* hybrid with native *M. hippuroides* present in Fern River Reservoir
Phragmites australis ssp. *australis*	common reed grass	ODA B	rare	Can be confused with the native *Phragmites australis* ssp. *americanus*. Patches actively managed in Multnomah Channel
Priority for Control (species to focus on for control projects, but not eradicable except in particularly important habitats)				
Ludwigia hexapetala	water primrose	ODA B (T)	widespread	*L. peploides*
Ludwigia peploides	floating primrose-willow	ODA B (T)	locally abundant	*L. hexapetala*
Nymphoides peltata	yellow floating heart	ODA A (T)	rare	*Brasenia schreberi*
Other (widespread, focus on control only when part of a comprehensive restoration project)				
Cyperus esculentus	nutsedges	ODA B	widespread	
Egeria densa	S. American waterweed	ODA B	widespread	*Elodea canadensis* or *E. nuttallii*
Iris pseudacorus	yellow flag iris	ODA B	widespread	
Lythrum salicaria	purple loosestrife	ODA B	widespread	
Myriophyllum aquaticum	parrotfeather	ODA B	widespread	Submersed leaves may be confused with *M. spicatum, M hippuroides, M. heterophyllum*

Non-native Plants of Concern to the Willamette River, cont.

Other, cont.				
Myriophyllum heterophyllum	variable leaf watermilfoil	Non-native	rare	
Myriophyllum spicatum	Eurasian watermilfoil	ODA B	locally abundant	Submersed leaves of *M. aquaticum , M hippuroides, M. heterophyllum*
Nymphaea odorata	fragrant waterlily	Non-native		*Nuphar polysepala*
Polygonum bohemicum, P. sachalinense, P. polystachyum, and Fallopia japonica	bohemian, giant, Himalayan, Japanese knotweeds	ODA B	locally abundant	
Potamogeton crispus	curly pondweed	Non-native	locally abundant	native pondweed species

[1] Oregon Department of Agriculture (ODA) Noxious Weed Classification Definitions

Native Aquatic Plants in the Willamette River Basin

Species	Common Name	Distribution in Willamette Basin	Notes/May be Confused With
Alisma triviale	Northern water plantain	common	*Sagittaria latifolia, Sagittaria platyphylla*
Azolla spp.	water ferns	widespread	
Brasenia schreberi	water shield	locally abundant	*Nymphoides peltata*
Callitriche spp.	water starworts	common	
Ceratophyllum demersum	coontail	common	*Ranunculus aquatilis*
Elodea canadensis	Canadian waterweed	widespread	*Elodea nuttallii* or *Egeria densa*
*Elodea nuttallii**	Nuttall's waterweed	uncommon	*Elodea canadensis* or *Egeria densa*
*Howellia aquatilis**	water howellia	rare, endangered	Found in wetland and riparian habitats. When in flower, this aquatic plant can be easily distinguished. Sterile plants look similar to pondweeds and other submerged aquatics with narrow, delicate leaves.
Lemna spp.	duckweeds	widespread	*Wolffia* sp.
Ludwigia palustrus	marsh seedbox	widespread	Other invasive *Ludwigia* sp.
Myriophyllum hippuroides	Western watermilfoil	widespread	Submersed leaves may be confused with other native and non-native *Myriophyllum* species
Nuphar polysepala	spatterdock	widespread	*Nymphaea odorata*
Potamogeton epihydrus	ribbonleaf pondweed	widespread	Other *Potamogeton* species
P. gramineus	variableleaf pondweed	widespread	
P. natans	floating-leaf pondweed	widespread	
P. pusillus	small pondweed	widespread	
P. richardsonii	Richard's pondweed	widespread	
P. zosteriformis	flatstem pondweed	common	

Native Aquatic Plants in the Willamette River Basin, cont.

Species	Common Name	Distribution in Willamette Basin	Notes/May be Confused With
*Rotala ramosior**	lowland rotala	rare	*Ammannia robusta**, *Lythrum portula*
*Rorippa columbiae**	Columbian yellowcress	rare	Other *Rorippa* spp.
Sagittaria latifolia	wapato	widespread	*Alisma triviale,* other *Sagittaria* sp.
*Scirpus pendulus**	nodding bulrush	rare	*S. cyperinus, S. microcarpus, and S. pallidus*
Sparganium angustifolium	narrowleaf bur-reed	common	Other *Sparganium* sp., yellow flag iris (prior to seed development)
Sparganium emersum	European bur-reed	common	
Spirodela polyrhiza	greater duckweed	common	*Lemna* sp. and *Wolffia* sp.
*Utricularia gibba**	floating bladderwort	rare	*Utricularia spp.*
*U. minor**	lesser bladderwort	rare	*Utricularia spp.*
*Wolffia borealis**	Northern watermeal	rare	*Lemna* spp.
Wolffia brasiliensis	Brazilian watermeal	rare	*Lemna spp.*
*Wolffia columbiana**	Columbian watermeal	locally abundant	*Lemna spp.*

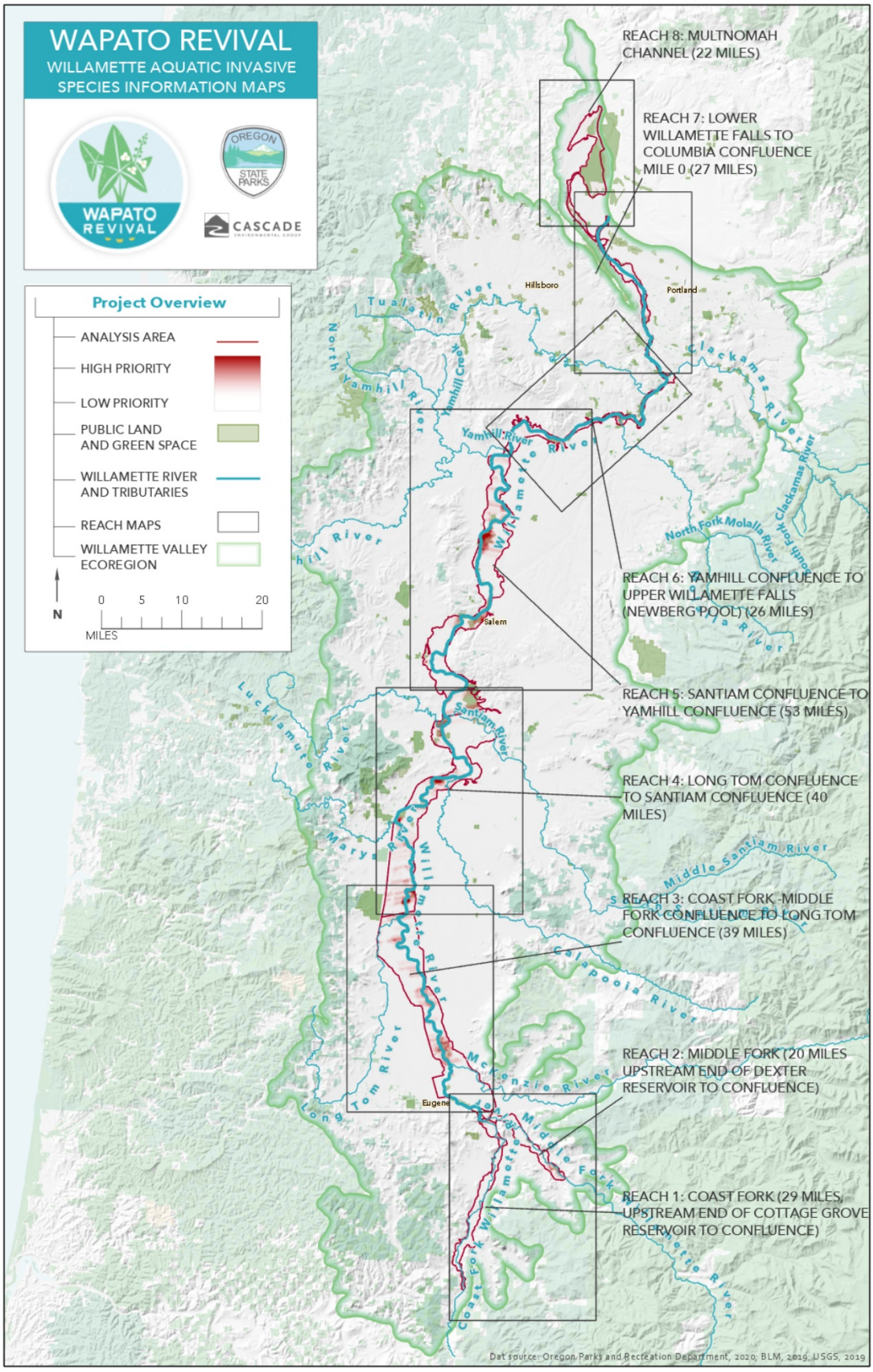
* Indicates rare/sensitive/at risk species

GIS Maps and Methodology

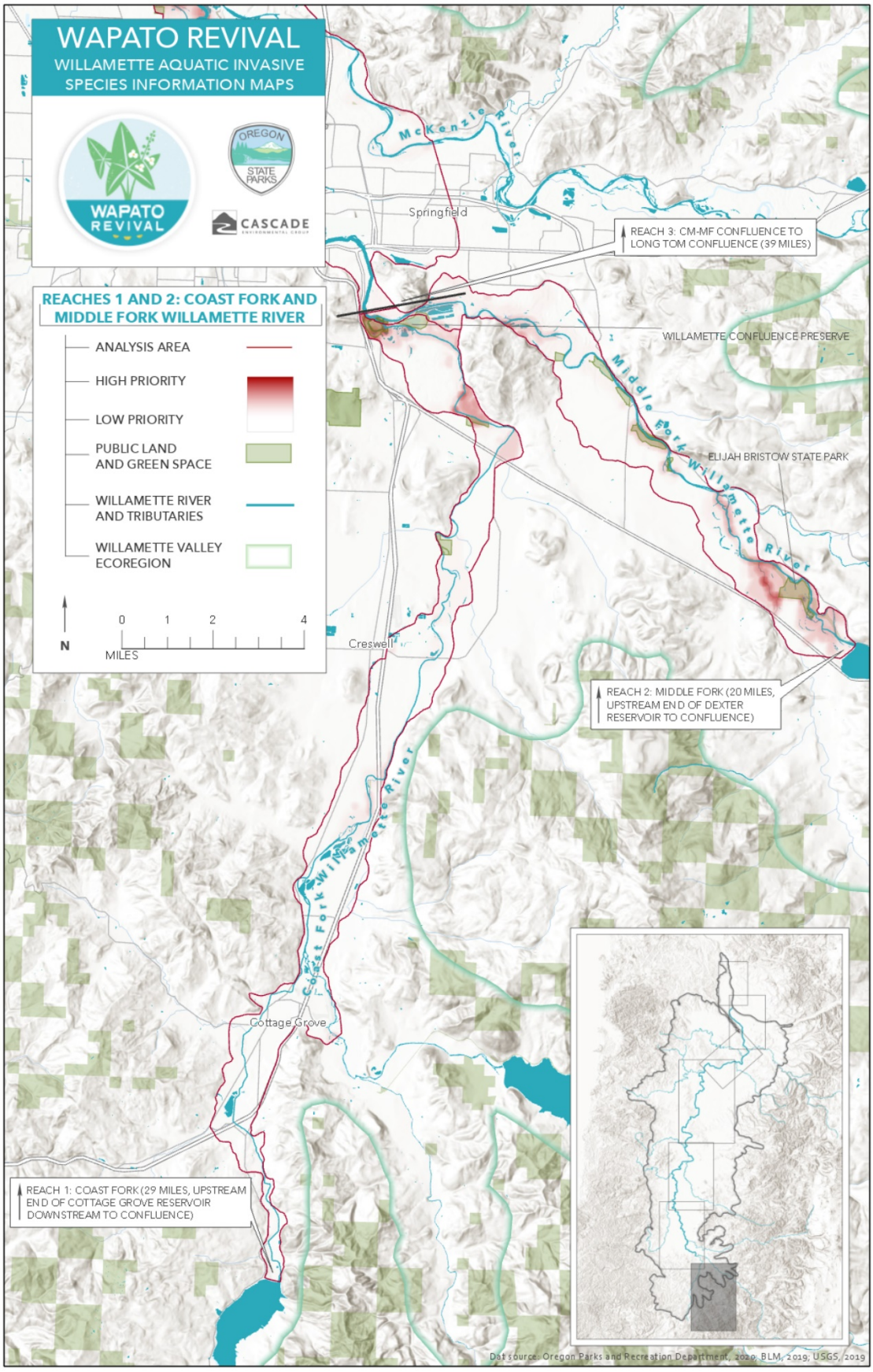
A complex prioritization tool was developed to identify high-priority aquatic habitats to protect and restore by controlling populations of aquatic invasive plants on the mainstem Willamette River. The product of this work is a set of heat maps that illustrate the priority locations where AIS treatments are needed. The darker the red color, the higher priority for control measures to protect the highest-quality habitats on the mainstem Willamette River. The larger the red area, indicates the geographic scale of the area to protect. The area of the watershed where the analysis was completed is outlined in red. To develop this tool, a subset of WAIN collaborators worked with David Quillin, a GIS analyst with Oregon State Parks, to collect a series of data sets from agencies and organizations working throughout the Willamette Basin. These specific data sets and parameters were used to develop a model to create the priorities for present and future AIS control within the mainstem Willamette River analysis area. The results of this model formed the basis for the final maps that were produced for each reach of the Willamette to illustrate the priority areas for restoration and AIS control.

MAPS ARE ALSO AVAILABLE INDEPENDENTLY AT 11” X 17”

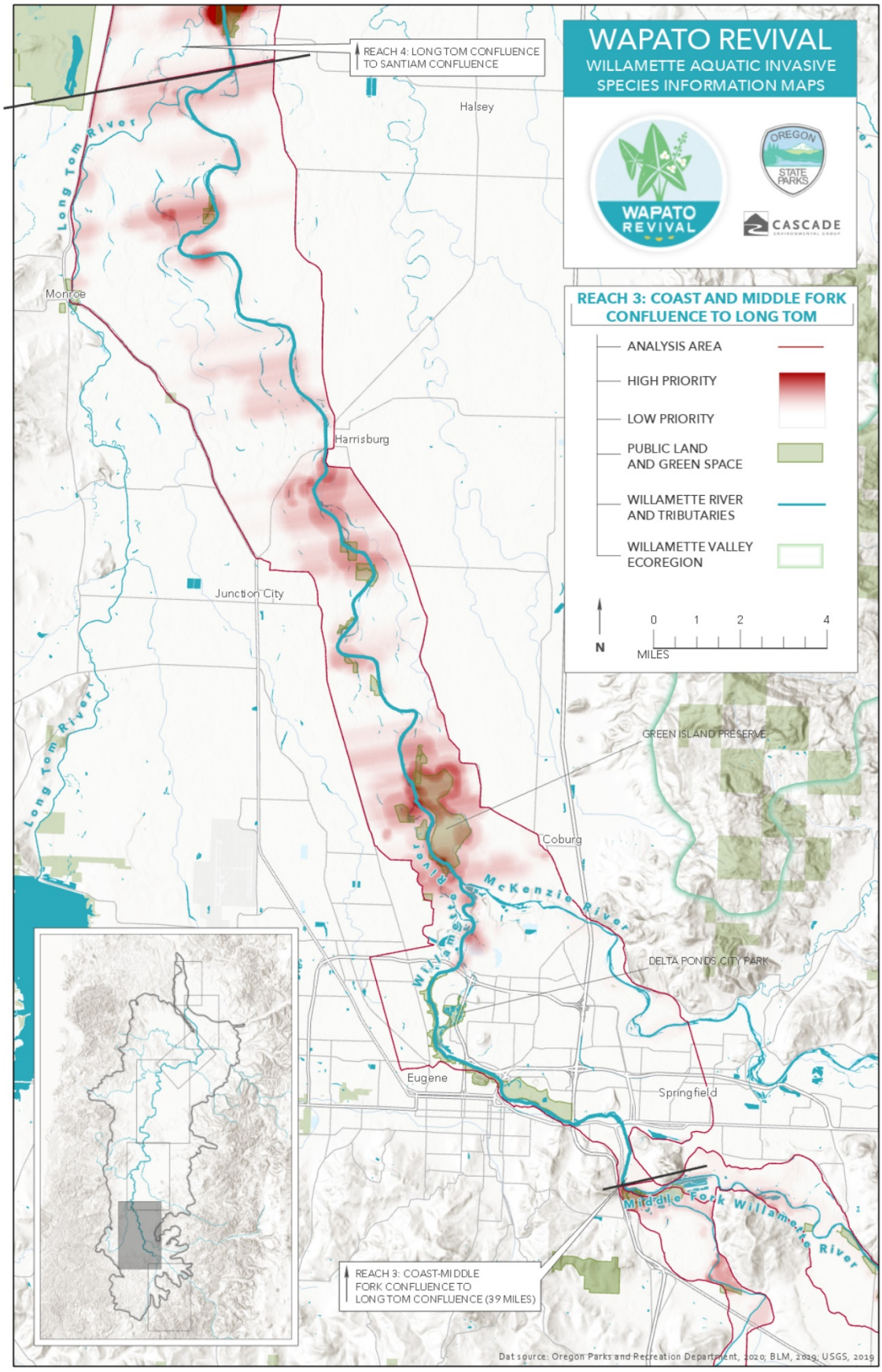
KEY MAP: REACHES OF THE WILLAMETTE RIVER



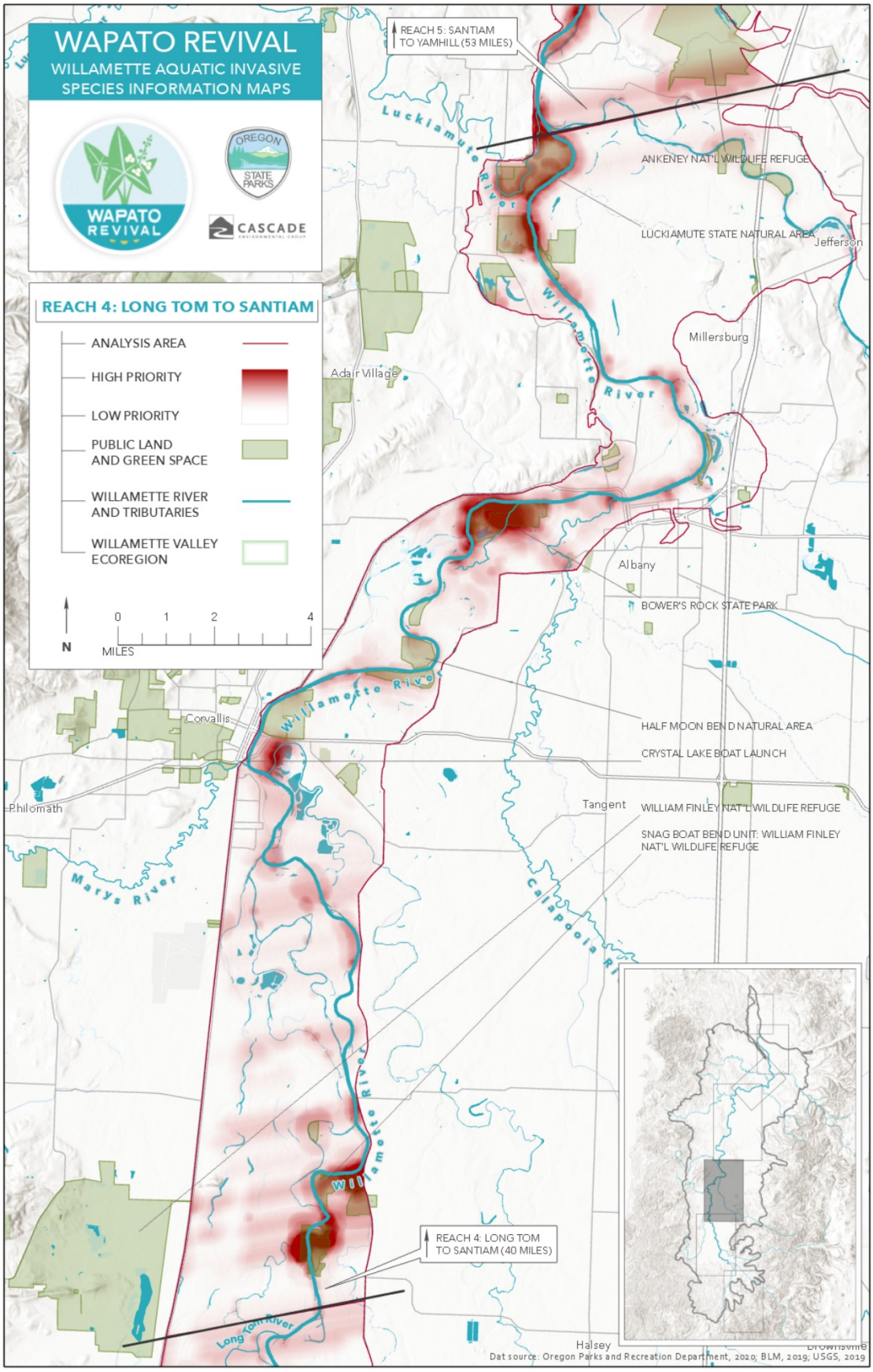
REACHES 1 AND 2: COAST FORK AND MIDDLE FORK



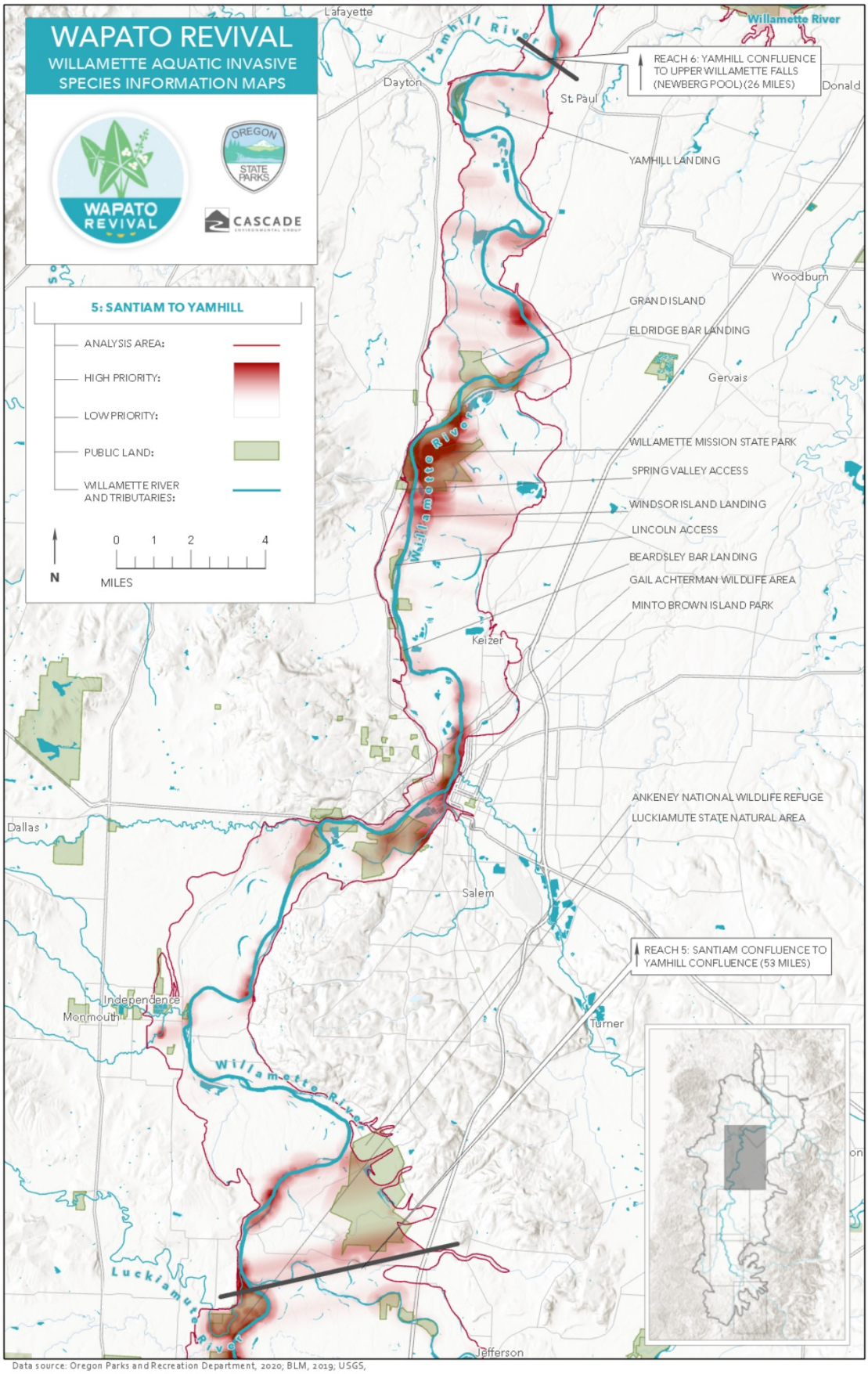
REACH 3: COAST AND MIDDLE FORK CONFLUENCE TO LONG TOM



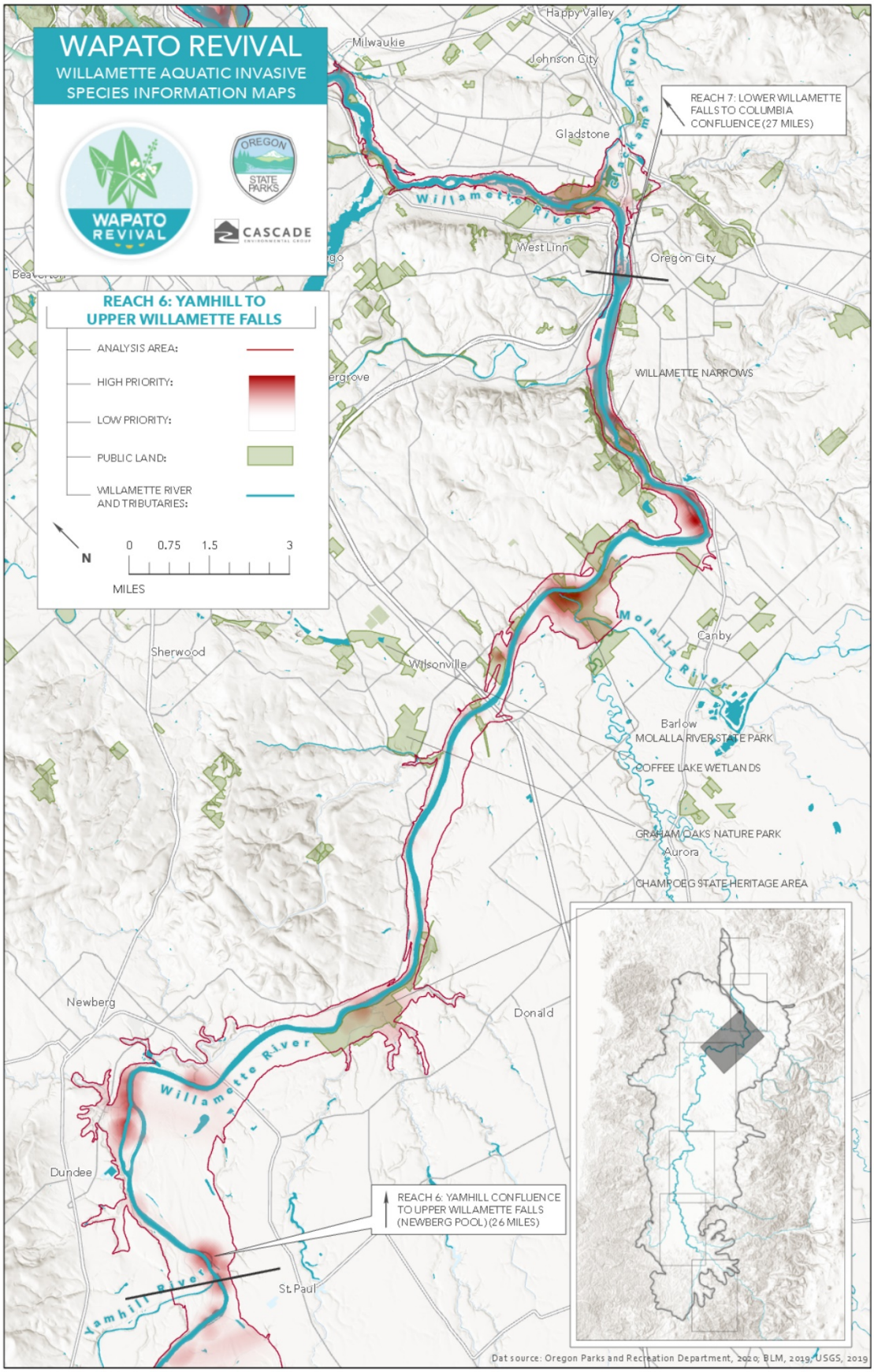
REACH 4: LONG TOM TO SANTIAM



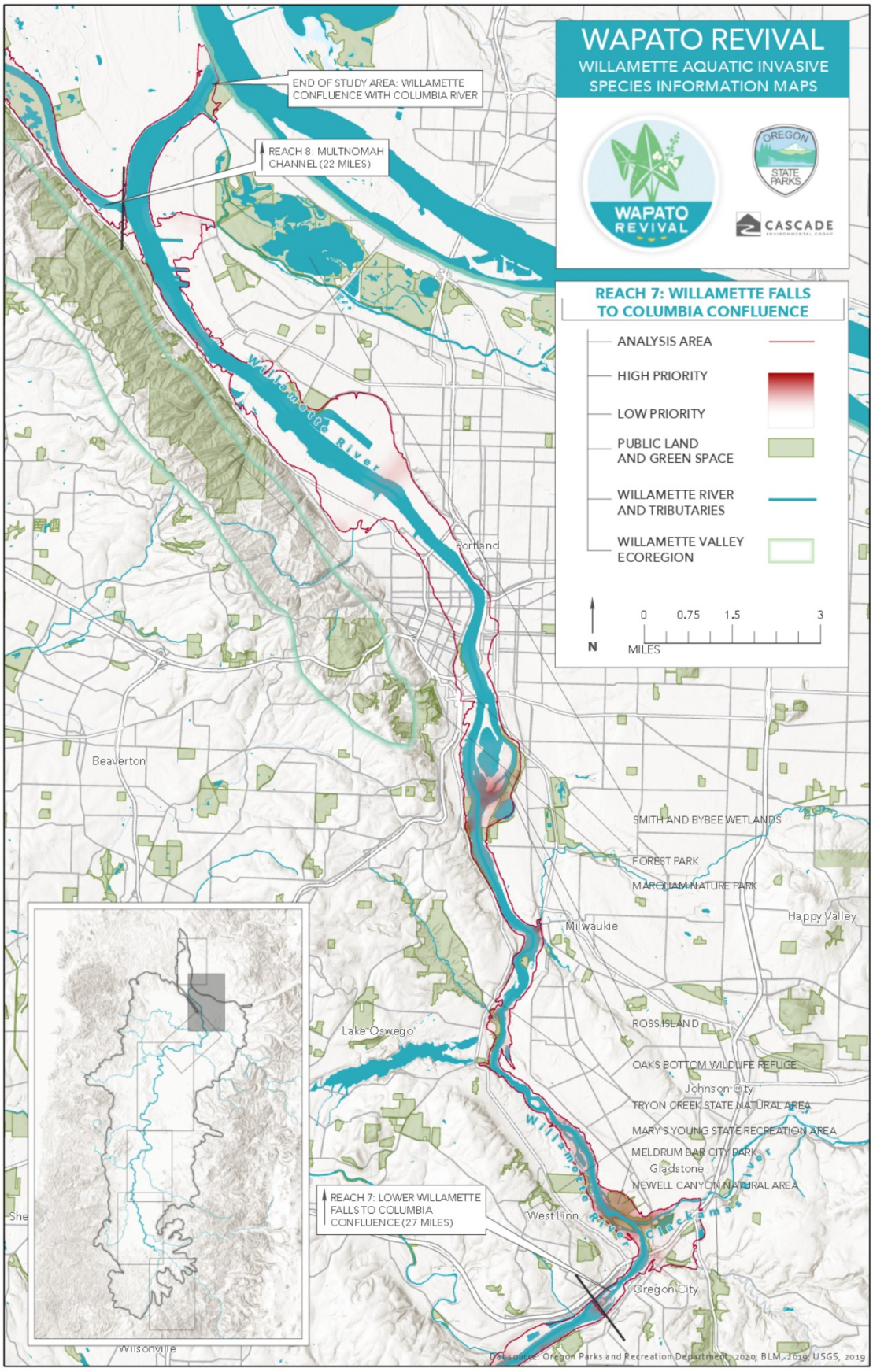
REACH 5: SANTIAM TO YAMHILL



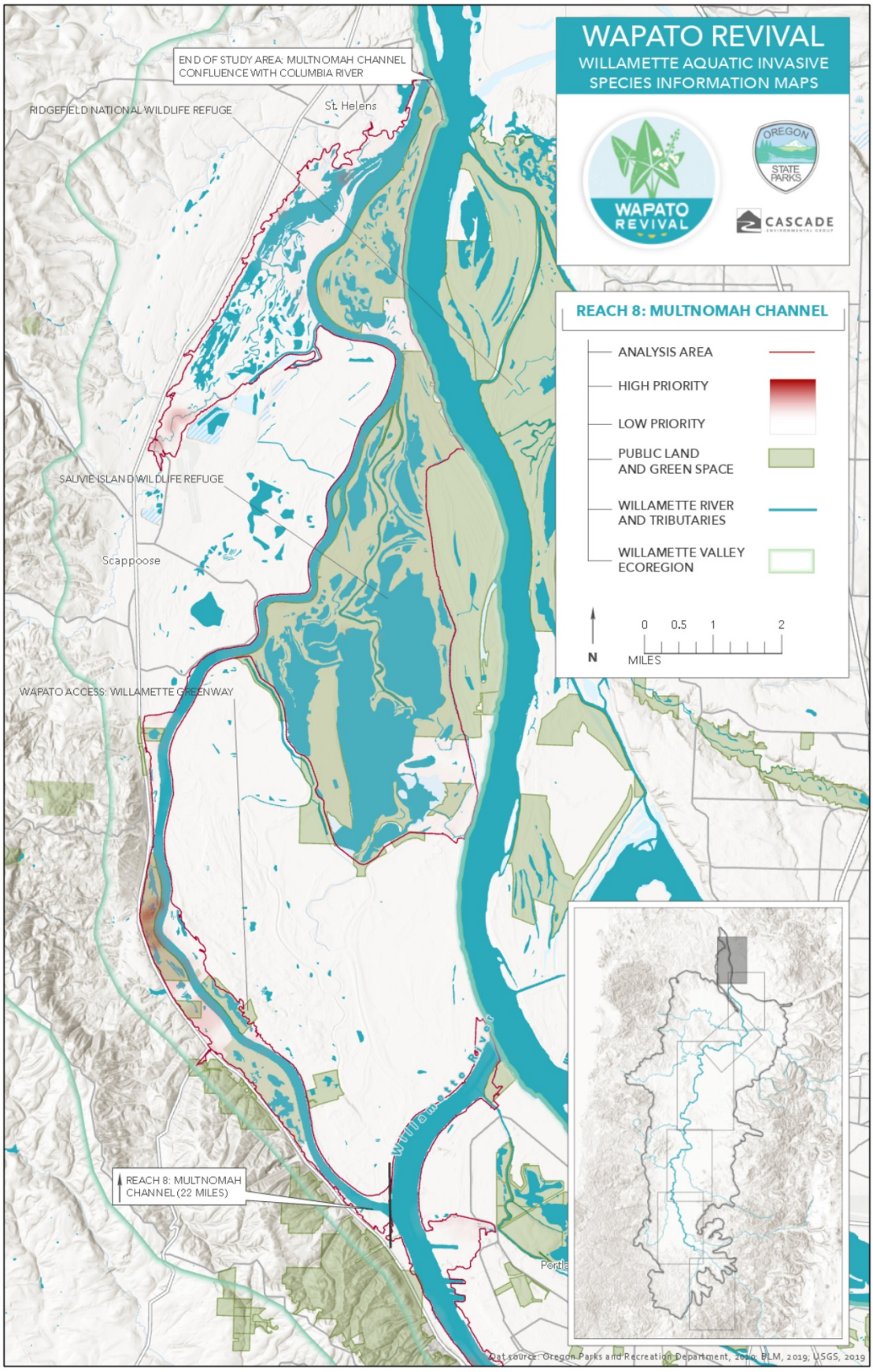
REACH 6: YAMHILL TO UPPER WILLAMETTE FALLS



REACH 7: WILLAMETTE FALLS TO COLUMBIA CONFLUENCE



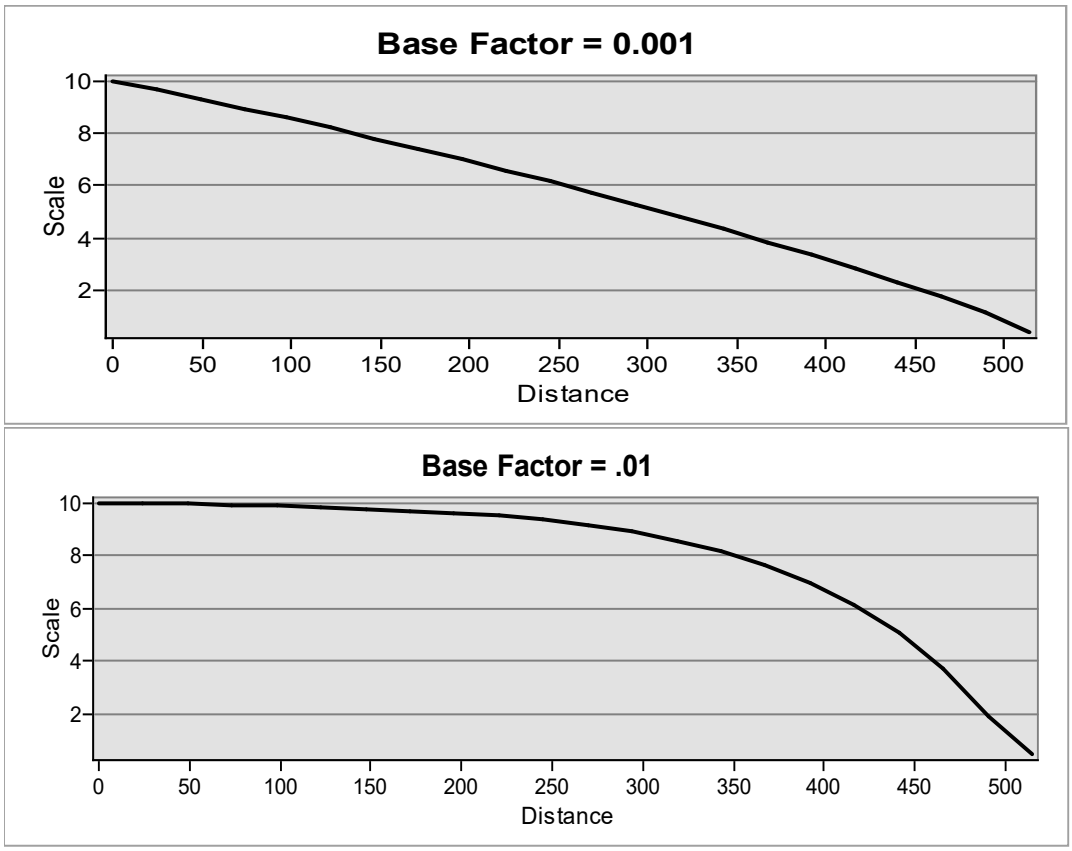
REACH 8: MULTNOMAH CHANNEL



Map Development

The GIS Analysis was performed using the following model processing steps:

1) Each contributing dataset is converted to a raster data format using ESRI's Euclidean Distance tool with a base cell size of 25 meters.
2) Apply an exponential transformation function to each raster for the purpose of reclassifying the data into a uniform evaluation scale. Using the parameters 'Range of Influence' (distance from feature) and "Shape of Influence" (a multiplier value [base factor] that controls how steep the exponential function decreases). For this analysis base values were kept between 0.01 and .001 to allow for a gradual control of the features influence over the determined distance. Evaluation scale value range were inversed from 10 (most favorable) to 1 (least desirable).



3) The resulting raster data from the Exponential transformation is combined into a single raster using ESRI's Weighted Sum tool. The 'weight' parameter is used in this step as a multiplier to place a greater influence for that dataset on the final result. Since this is an additive process, those areas with the highest values are the most desirable locations.
4) Using the three-parameter formula, this model can accommodate as few or as many datasets deemed necessary by the WAIN committee to satisfy the analysis criteria.

Datasets and Model Parameters Used in Prioritization Maps

Criteria and Dataset	Weight	Range of Influence* (Meters)	Shape of Drop-off of Influence** (Linear)	Data Source	Comments
1. High Quality Habitats					
Riparian and aquatic sites from Willamette Valley Synthesis Conservation Opportunity Areas	1.5	500	0.001	The Nature Conservancy	These sites are also commonly referred to as “Willamette anchor habitats.” This dataset was combined with The Wetlands Conservancy wetland priority sites (below). Sites were clipped to the 2-year boundary for modelled inundation from the Slices Framework.
Wetland priority sites	Combined with dataset above	Combined with dataset above	Combined with dataset above	The Wetlands Conservancy	This dataset is similar to the TNC Conservation Opportunity Areas (above), with some differences; the two datasets were combined to reduce redundancy and capture those differences.
Mapped cold water refuge points	1.5	500	0.001	Slices Framework (Institute for a Sustainable Environment [ISE] Lab)	Data represented as “cold slices,” where a location was found with water temperature at least 2 degrees Celsius colder than an adjacent main-stem river point. Covers 2011-2015 sampling.
Mapped cold water refuge points	Combined with dataset above	Combined with dataset above	Combined with dataset above	USGS (Mangano, et al, 2017)	Same methodology as above defines these cold points. Covers 2015-2016 sampling.

Datasets and Model Parameters Used in Prioritization Maps, cont.

2. Important Species Present					
Percent native fish	2	1000	0.001	Slices Framework (ISE Lab and OSU, 2016)	Represents multi-year sampling effort in many locations across the main-stem river. Source: https://oregonexplorer.info//places/basins/willamette?qt-basin_quicktab=1
Native freshwater mussel occurrences	0.5	200	0.001	Freshwater Mussel Working Group, 2019	Best dataset to date on native freshwater mussel occurrences. Dataset is growing each year as new data is submitted.
Oregon chub occurrences	0.5	500	0.001	ODFW, 2019 ("92-17 dataset")	Roll-up of many years of chub sampling data across the Willamette Basin.
3. Past Restoration Investments					
Restoration site locations entered into OWRI database	1.5	200	0.01	OWEB Watershed Restoration Inventory, 2019	Recipients of OWEB, OSWB and DSL funding are required to add their sites to the OWRI database; it is unclear what percentage of them do. Most MMT-funded projects in the basin also received OWEB funds, so should be in the database. BPA was unable to provide spatial data for its investments. The OWRI database may include projects voluntarily added by project managers that utilize other funding sources.
Restoration site locations using Salmon Plate funding	Combined with dataset above	Combined with dataset above	Combined with dataset above	OPRD	Includes a variety of sites throughout the basin.

Datasets and Model Parameters Used in Prioritization Maps, cont.

4. Public and Conserved Lands					
Federal, state, local and NGO land ownership	1.5	500	0.01	Various sources (see comments)	A mashing of various land ownership and land management dataset together, tried to reduce redundancies and verify, where possible. No guarantees on accuracy or quality of the data. Sources reflect city, county, education district, federal, NGO, parks and recreation departments, port, regional, state, and water district ownerships.
5. Does the site currently have aquatic invasive species? Is the site a large, medium or small infestation of a high-threat species?					
Sites with yellow floating heart and/or ludwigia species, over 1 acre in patch size	3	1000	0.001	ODA WeedMapper data, which includes WAIN community fulcrum data	High threat species and large patch size makes these sites a priority for management. The large patch size means that the site is contributing a relatively large amount of propagules downstream.
Sites with yellow floating heart and/or ludwigia species, over 1 acre in patch size	2	500	0.001	Same as above	High threat species and medium patch size. Medium-sized patches contribute propagules downstream and also may have more management options than large sites. These locations are a medium-high priority for management.
All other mapped AIS sites, all species and patch sizes	1	200	0.001	Same as above	Other AIS are considered lower risk (or are so widespread or poorly mapped they are a lower priority, such as parrotfeather). These sites are a lower priority for management.

Datasets and Model Parameters Used in Prioritization Maps, cont.

6. Watershed position					
River reach***	N/A	N/A	N/A	Each reach polygon was derived from the ISE Slices Framework	These reaches were determined loosely based on geomorphology, boundaries of partners and counties, and key confluence locations. They were also designed to be somewhat similar in length. Exceptions to ISE Slices Framework sources include: the Coast Fork, Middle Fork, and Multnomah Channel reaches where Slices Framework data do not currently extend. The polygons for these reaches was derived from1996 Flood data, 2-year floodplain data, and topography.

*The technical term for this parameter is “upper threshold.”
**The technical term for this parameter is “base factor”.
*** This criterion is not represented in the GIS model or resulting heat maps. In other words, no weighting was used and watershed position was not added to the model. Users of the maps are encouraged to compare locations and, all things being equal, rate a location that is more upstream in the Willamette Basin as a higher priority for control.

Datasets Considered but Not Used in Prioritization Maps

Criteria and dataset	Data Source	Discussion
Essential salmon habitat	DSL	Overly broad coverage across the basin. Not based on sampling, but based on theoretical salmonid use locations (i.e. a range map). Line data problematic for representation in the model. Somewhat redundant for salmonid representation with use of both ESH data and the Percent Native Fish data from the Slices Framework.
Wapato (*Sagittaria latifolia*) occurrences	WAIN	Some location information is in the WAIN AIS mapping dataset, but does not represent the extent and locations of wapato very well. Many known locations are missing from the data, for example. The data dictionary does not ask the user to note wapato, so wapato occurrences are only noted in the "notes" area if a user chooses to mention it. We were unable to locate other wapato datasets with good coverage.
Native turtles	Native Turtle Working Group and ODFW	The dataset was reviewed and found to be missing many known native turtle locations. The dataset had a small number of sites mapped in total. Additionally, not all areas of the basin were represented.
Lamprey	USFWS	Overly broad coverage across the basin. Not based on sampling, but based on theoretical lamprey use locations (i.e. a range map). There remains a lot of uncertainty about actual lamprey presence or absence at sites in the basin. Line data problematic for representation in the model.

Scoring Tool for Spatial Prioritization of AIS Management in the Willamette Basin

Purpose and Application

This scoring tool is intended to provide guidance on spatial prioritization for the management of aquatic invasive macrophytes for the Willamette Basin, to assist land managers, grantors, and others in identifying the highest priority locations for aquatic invasive species efforts (ranging from survey to EDRR to AIS control). The tool is designed to be flexible in the data used and how the tool is applied. The tool complements the GIS analysis and resulting prioritization maps and should be used instead of the GIS analysis and maps in two specific cases: (1) In locations beyond the scope of the GIS analysis and maps, such as tributaries, and (2) As new information is collected and new data is available about Willamette Basin sites along the main-stem river, the prioritization maps will become outdated. This scoring tool can then be employed to guide spatial prioritization until such time that updated GIS spatial analysis can be performed.

Tool Development

The tool utilizes the same set of prioritization criteria used in the GIS analysis, which were identified by the WAIN during several meetings. In this scoring tool, the criteria that are the same as those used in the GIS analysis are called the “Primary Criteria”. The primary criteria were used in the GIS analysis because they were identified as important by WAIN *and* had spatial data available to represent them. However, there were many other criteria that WAIN participants identified as important for use in prioritization over the course of meetings in 2018 and 2019 that were not able to be included in the GIS analysis because there was not widespread data available to represent them. In this scoring tool, those additional criteria are incorporated and are called the “Secondary Criteria”. The tool therefore represents a broader set of criteria to inform spatial prioritization for AIS detection/control than the GIS analysis/prioritization maps do, while also providing consistency with the GIS analysis and prioritization maps for the primary criteria.

How to Use the Scoring Tool

The scoring tool is intended to inform prioritization of AIS efforts, ranging from survey and EDRR work to more complex AIS control efforts. The data available for any particular site will vary widely ranging from very little information available to a wide range of information available. Users of the tool and those using tool results should recognize that available data may be imperfect, and in some cases may be based off anecdotal rather than scientifically derived information. For the purposes of broad spatial prioritization, anecdotal information is recognized as having value and is acceptable for use in the tool, as long as it is noted as such in the “Source” column of the scoring worksheet. Anecdotal information is defined as "casual observations or indications rather than rigorous or scientific analysis”, and "information passed along by word-of-mouth but not documented scientifically”. Scorers will need to collect as much information as possible about a site prior to filling out the scoring tool to ensure it is as accurate as possible. When using the tool to compare sites against one another, users should strive to gather the same types of information about the sites to the extent feasible, so that the comparison is as close to an “apples-to-apples” comparison as possible. The results of the tool represent the best available data at the time and are expected to change over time as new information becomes available and as users re-run the tool. The tool will not represent all areas of the basin equally well as the data available for different areas varies widely. WAIN may revise the tool as new data and understanding about AIS becomes available in the future.

Scoring Tool Worksheet
To score a site against primary and secondary criteria, fill out this scoring tool worksheet using the scoring rubric on the following pages to guide the assignment of points.

Date			
Site Name			
Site Location			
General Notes			
Criteria	Data Source *Write data source, note if anecdotal*	Points *Enter from scoring rubric*	Notes *Things you want to track, or things readers of your scoring sheet should know*
PRIMARY CRITERIA			
Are high-quality habitats present?			
Cold Water Points/Refuges		(0/0.8/1.5)	
Riparian, Wetland and Aquatic Priority Sites		(0/0.5/1/1.5)	
Are important species present?			
Native Fish		(0/2)	
Native Freshwater Mussels		(0/0.5)	
Oregon Chub		(0/0.5)	
Has the site received past restoration investment?			
Restoration Investment		(0/1.5)	
Is the site permanently protected (in public ownership or otherwise conserved)?			
Public or Conservation Land Ownership or Easement		(0/1.5)	
Does the site currently have AIS? Is the AIS patch a large, medium or small patch of a high-threat species?			
Species and Size of Infestation		(1/2/3)	
Where is the site located in the watershed?			
Location in the Willamette Watershed		(0.5/1/1.5/2/2.5)	

Criteria	Data Source *Write data source, note if anecdotal*	Points *Enter from scoring rubric*	Notes *Things you want to track, or things readers of your scoring sheet should know*
SECONDARY CRITERIA			
Essential Salmon Habitat		(0/0.5)	
Wapato (*Sagittaria latifolia*)		(0/0.2/0.5)	
Native Turtles		(0/0.2/0.5)	
Pacific Lamprey		(0/0.2/0.5)	
Other Rare/Special Status Species		(up to 0.8)	
Connectivity		(0/0.3/0.6/1)	
Proximity to AIS Control Sites		(0/0.1/0.3/0.5)	
Site Size		(0/0.1/0.2/0.3/0.5)	
Water Quality		(0/0.3)	
Native Aquatic Vegetation Beds		(0/0.1/0.3)	
Site Access		(0/0.2/0.3)	
Educational Opportunities		(0/0.3)	
Community Support and Involvement		(0/0.3)	
Risk of Spread by Watercraft		(0/0.3)	
Bonus Points		(up to 0.5)	
Grand Total		Add together all scores from above	

Scoring Rubric

Primary Criteria: Are high-quality habitats present?

- **Cold Water Points/Refuges**

Rationale:
Cold water areas support a variety of native fish and other aquatic species that are declining and that depend on cold water for survival. Water quality and access to and within cold water areas can be impacted by AIS.

Data Sources:
Oregon Administrative Rule 340-041-0002 (10) defines "Cold Water Refugia" as “those portions of a water body where, or times during the diel temperature cycle when, the water temperature is at least 2 degrees Celsius colder than the daily maximum temperature of the adjacent well-mixed flow of the water body”. This definition is used in recent cold water point monitoring performed by researchers along the Willamette River mainstem, and in the data used in this plan’s GIS analysis. This definition is also currently being used by DEQ and others for regulatory purposes. Recent data collection from USGS as part of a study along the lower Willamette is accessible at https://doi.org/10.5066/F7VQ315D (Mangano, et al, 2015-2016) and https://doi.org/10.5066/F7KH0MJP (Piatt, et al, 2017).

Additional data on cold water points using the OAR definition is available from The Slices Framework, a tool intended for use in making decisions about conservation and restoration in the Willamette River floodplain. Slices Framework data is accessible at Oregon Explorer – Willamette Basin Slices – PDF Maps. Version 9.0 or higher of Adobe Acrobat Reader is required to access special features in the PDF maps. Thematic map layers can be turned on and off using the Layers Pane (View - Show/Hide - Navigation Panes - Layers). The layer that shows cold water refuges is “Cold Water Refuge 2011-2015”.

There are a variety of other methods and definitions that can be used to characterize a location as providing cold water refugia for listed or other aquatic species. See this source for more information: “Primer for Identifying Cold-Water Refuges to Protect and Restore Thermal Diversity in Riverine Landscapes” (Torgerson, et al 2012).

Scoring methodology:

Site does not provide cold water refugia based on available data.	Site meets one or more definitions of cold water refugia in Torgerson, et al 2012, but does not meet the definition in OAR 340-041-0002 (10) (the definition used for Slices and USGS datasets).	Site meets cold water refugia definition in OAR 340-041-0002 (10) (the definition used for Slices and USGS datasets).
0 points	0.8 points	1.5 points

- **Riparian, Wetland and Aquatic Priority Sites**

Rationale:
Various mapping efforts have attempted to delineate those areas that are the highest priority for investment of conservation and restoration resources. These efforts have used a variety of criteria and data sources and are used in this prioritization tool to provide a landscape scale, broad sense of priority.

Data Sources:
Two datasets in particular are helpful in delineating priority aquatic, riparian and wetland priority locations. Note that these overlap in most areas but not in every area so it is worth checking the second dataset if your site is not contained in the first. The first is the Willamette Valley Synthesis, V2.0, wherein The Nature Conservancy worked with government agencies and non-profit partners to produce a synthesis of the major Willamette Basin conservation planning efforts, producing polygons that show the highest priority areas for a variety of restoration and conservation goals. The data can be accessed at DataBasin.org – Datasets - Willamette Valley Synthesis Conservation Opportunity Areas (version 2.0).

The second data source is Willamette Valley Wetland Priority Sites, available for download from the Oregon Geospatial Data Library, or viewable as a map in Oregon Explorer – Map Viewer – Layers – Restoration – Willamette Valley Ecoregion Wetland Priority Sites. The Oregon Natural Heritage Information Center and The Wetlands Conservancy created the Wetland Priority Sites GIS layer for the Willamette Valley, identifying areas with concentrations of important wetland habitats and opportunities for successful wetland restoration.

Scoring Methodology:

The site is not contained within a defined priority area.	A third or less of the site is contained within a defined priority area (< 33 percent).	A significant portion of the site is contained within a defined priority area (between 33-66 percent).	All or nearly all of the site is contained within a defined priority area (between 66-100 percent).
0 points	0.5 points	1 point	1.5 points

Primary Criteria: Are important species present?

- **Native Fish**

Rationale:
Sites used more heavily by native fish over non-native fish are a higher priority for AIS detection/control work. AIS detection/control helps preserve the habitat functions upon which native fish depend.

Data Sources:
Not every site is able to be monitored for fish use. For those that have data available, points are allocated in the table below based on the percent native fish out of all fish sampled. Data may be available from local ODFW staff, watershed councils, from the Slices Framework (limited to portions of the mainstem Willamette and sampled from 2010-2013; data is not available on newer Slices PDF maps but is on older maps). The GIS analysis in this plan utilized data from the Slices Framework.

Scoring Methodology:

Available data shows less than 85% native fish, or, no or limited fish data is available for the site.	Native fish at sampled site(s) is greater than or equal to 85%.
0 points	2 points

- **Native Freshwater Mussels**

Rationale:
Native freshwater mussels are declining in the Willamette basin and are impacted by a wide variety of factors. Researchers have found that mussels have disappeared from nearly one-fifth of the watersheds they once inhabited, and mussel species diversity has declined in 35% of Western watersheds. AIS can impact water quality, quantity, substrate, and other habitat characteristics important for native freshwater mussels.

Data Sources:
The Pacific Northwest Native Freshwater Mussel Working Group performs surveys and maintains a database of known locations where native freshwater mussels have been found. This data was used in the GIS analysis in this plan but is not available online. The Working Group website also has guidance on how to conduct mussel surveys if you would like to know if mussels are using your site, and contact information to inquire about known mussel locations that may have already been mapped at your site.

Scoring Methodology:

No native freshwater mussels found at the site, or no data available.	Native freshwater mussels are present at the site.
0 points	0.5 points

- **Oregon Chub**

Rationale:
Oregon chub have recently been delisted from the Endangered Species list but are still of conservation concern. In 2019, there were 133 known populations of Oregon chub, and the species is well distributed throughout its historic range. Oregon chub represent native fish/aquatic species that depend on quality riverine and pond habitats that are quite different from those upon which cold water fish depend, providing a wider representation of native fish in the watershed in this scoring tool.

Data Sources:
ODFW conducts surveys and maintains data on known locations of Oregon chub. These data are available from ODFW and are summarized in annual reports available from ODFW or on the ODFW Native Fish Investigations Program website under Reports and Publications.

Scoring Methodology:

No Oregon chub found at the site, or no data available.	Oregon chub are present at the site.
0 points	0.5 points

Primary Criteria: Has the site received past restoration investment?

- **Restoration Investment**

Rationale:
Targeting AIS survey/control efforts in areas that have had past restoration investment helps ensure those past investments are being protected by continuing to address threats to the site and can provide opportunities for funding leverage between projects, as well as complementary outcomes for fish and wildlife between projects.

Data Sources:
If you are unsure if your site has received past restoration investments, the Oregon Watershed Restoration Inventory (OWRI) is a database that relies on a combination of mandatory and voluntary project reporting. Mandatory reporting is required to OWRI for restoration grants administered by OWEB, DEQ 319 grants, and some ODFW R & E program grants and DSL permits. Voluntary reporting is encouraged and is open to anyone. The database can be downloaded from the OWEB website under Project Data and Reporting – OWRI. The data is also viewable in a map in Oregon Explorer – Map Viewer – Layers – Restoration – Oregon Watershed Restoration Inventory. Oregon Explorer has additional layers on restoration by federal agencies that may be useful.

An additional source of information on restoration investments is the Conservation Registry, a cooperative effort launched by Defenders of Wildlife and several conservation partners, which moved to LandScope in 2017. Its online database tracks and maps various on-the-ground restoration and management actions. This registry can be accessed at LandScope.org – Connect and Share – Find Conservation Projects.

Scoring Methodology:

The site has not received past restoration investments related to its aquatic, riparian, and/or wetland habitats.	The site has received past restoration investments related to its aquatic, riparian, and/or wetland habitats.
0 points	1.5 points

Primary Criteria: Is the site permanently protected (in public ownership or otherwise conserved)?

- **Public or Conservation Land Ownership or Easement**

Rationale:
Public and conserved lands are perceived as having, on average, greater likelihood of restoration investments being maintained and fewer hurdles to performing survey and control work. Additionally, improving public lands provides benefits to the general public.

Data Sources:
For the purposes of this scoring tool, public and conserved lands include federal, state, tribal, county, city, education district, non-governmental conservation organization, parks and recreation department, port, regional, and water district ownership, or sites under long term conservation easement. The Oregon Spatial Data Library has a downloadable dataset, Oregon's Natural Areas – 2015, created by the Institute for Natural Resources that illustrates and describes public land ownership, management and other conservation lands, including voluntarily provided privately protected areas. The same dataset is viewable in Oregon Explorer – Map Viewer – Layers – Planning and Cadastral – Ownership - Protected Areas Database of the United States GAP Management (2015). Also click on the Easements (2015) dataset located in the same area in Oregon Explorer.

Scoring Methodology:

The site is not public, in conservation ownership, or with conservation easements.	The site is public or is in conservation ownership or with a conservation easement.
0 points	1.5 points

Primary Criteria: Does the site currently have AIS? Is the AIS patch size a large, medium, or small patch of a high threat species?

- **Species and Size of Infestation**

Rationale:
The size of an AIS patch reflects where the site is in the invasion curve and influences site management goals. For example, sites with a small patch size may be an important focus for management because eradication may be possible, the cost of control will be low, and the site can be managed before larger-scale impacts occur. The size also influences how the patch affects surrounding areas, with larger patches an important focus for management because they can be assumed to put out relatively larger amounts of propagules that can impact adjacent or downstream areas, and because the ecological uplift of control will be greater. Medium sized patches may be important for control for some of the reasons already mentioned, and because there may be more control options available for medium sized patches than for large patches. Every patch size has pros and cons. The scoring below reflects much conversation among WAIN participants about these pros and cons.

WAIN participants also discussed which AIS species should be weighted higher for control focus than others. Yellow floating heart (*Nymphoides peltata*) is not yet widely established in the Willamette basin and is considered a high-threat species based on ODA-documentation for this species, reflected in its listing as an A-listed noxious weed in Oregon by ODA. For this reason, yellow floating heart is weighted higher than most other AIS in this scoring tool. Ludwigia species are also weighted high. All other AIS are weighted lower.

Note that this criterion is different than Site Size, described later in this scoring rubric. This criterion addresses weed patch size.

Data Sources:
The most accurate method to characterize the species and patch sizes at your site are your own observations. However, visibility or access may be limited, so it is advisable to also check Oregon WeedMapper, a collection of spatial information on the distribution of noxious weeds listed by the Oregon Department of Agriculture (ODA). WeedMapper is periodically updated with data from ODA staff and multiple other sources including WAIN's Community Fulcrum which focuses specifically on mapping AIS in the Willamette Basin. WeedMapper data can be viewed on the ODA website under Programs – Weeds and WeedMapper.

Scoring Methodology

Sites with AIS (but not ludwigia or yellow floating heart), any patch size.	Sites with patch size of under 500 square feet of a non-native ludwigia species.	Sites with patch size of between 1 acre and 500 square feet of a non-native ludwigia species.	Sites with yellow floating heart (any patch size) and/or over 1 acre in patch size of a non-native ludwigia species.	Sites with A-listed aquatic weeds, or high-threat aquatic weeds that are brand new to the Willamette Basin (EDRR sites for new weeds).
1 point	2 points	2 points	3 points	3 points

Primary Criteria: Where is the site located in the watershed?

- **Location in the Willamette Watershed**

Rationale:
Landscape-scale invasive species survey and control must consider pathways of spread in order to queue work in a logical order and reduce the risk of re-infestation in treated areas. For AIS, a common method of thinking of pathways is considering water flow direction. For example, many Japanese knotweed control programs focus survey and control effort first in the upper portions of a watershed and then work downstream. There are other reasons why AIS survey and control work might be prioritized in the upper portions of a watershed, such as superior fish habitat or habitat quality, but those characteristics are captured elsewhere in this scoring rubric.

Data Sources:
The scoring methodology below refers to broad areas within the Willamette watershed and it should be simple to determine the location of your site. If assistance is needed, there is a watershed map available at Oregon Explorer – Map Viewer – Layers – Water and Air – Watersheds – Hydrologic Boundaries: 4th Level (HUC8).

Scoring Methodology:

Willamette River main stem from Willamette Falls downstream, or within smaller lower Willamette tributary watersheds (Johnson Creek, Tryon Creek, Columbia Slough, etc.).	Within the following watersheds: Clackamas River, Tualatin River, Molalla River, Pudding River, Yamhill River; or smaller tributaries entering the Willamette River between Salem and Willamette Falls.	Within the following watersheds: Santiam River (North or South), Luckiamute River, Calapooia River; or smaller tributaries entering the Willamette between Corvallis and Salem.	Within the following watersheds: Long Tom; or smaller tributaries entering the Willamette River between Eugene and Corvallis.	Within the following watersheds: Coast Fork Willamette River, Middle Fork Willamette River, or McKenzie River; or smaller tributaries entering the Willamette River around Eugene.
0.5 points	1 point	1.5 points	2 points	2.5 points

Secondary Criteria

- **Essential Salmon Habitat**

Rationale:
The Essential Salmonid Habitat designation is defined as that habitat necessary to prevent the depletion of native salmonid species (Chum, Sockeye, Chinook and Coho Salmon, Steelhead and Cutthroat Trout) during their life history stages of spawning and rearing. The Oregon Department of State Lands (DSL) has authority to require permits for work within "essential indigenous anadromous salmonid habitat" (essential salmonid habitat, or ESH) for anadromous salmonid populations listed as sensitive, threatened or endangered by a state or federal government. Essential salmonid habitat maps are revised at regular intervals to reflect current fish habitat distribution data. DSL consults with the Oregon Department of Fish and Wildlife (ODFW) annually and adopts updated ESH maps approximately every five years through the state's rulemaking process. During ESH rulemaking, ODFW provides DSL with the most up-to-date fish habitat distribution data, including the spawning and rearing habitat for all anadromous salmonids in Oregon. The ESH dataset was not used in the GIS analysis because it had overly broad coverage for the mainstem river, presented challenges in display due to line feature type, and was somewhat redundant with Percent Native Fish data from Slices for the mainstem areas.

Data Sources:
Oregon Explorer's Map Viewer includes a layer under Animals and Plants – Fish Distribution – Essential Salmon Habitat.

Scoring Methodology:

The site is not along, not immediately adjacent to, and not connected most of the year to Essential Salmon Habitat.	The site is along Essential Salmon Habitat or is immediately adjacent and connected most of the year to Essential Salmon Habitat.
0 points	0.5 points

- **Wapato (*Sagittaria latifolia*)**

Rationale:
Wapato is a native wetland plant that has been shown to be impacted by AIS in some areas and able to co-occur with AIS in other areas. It often rebounds well after AIS control. It is a relatively hardy species in Willamette Basin wetlands but has been reduced significantly from historic extents. It has historically and continues to be harvested and eaten by Native Americans.

Data Sources:
No datasets currently exist for wapato locations, which is why this criterion was not used in the GIS analysis. WAIN's Community Fulcrum data dictionary may add in a wapato observation feature in the future, but for now visual survey for wapato at your site is needed to check for presence.

Scoring Methodology:
Note that a site with only wapato beds should not receive points for having both wapato beds and native aquatic vegetation beds (located later in this scoring rubric).

The site does not support wapato.	The site supports one or a few smaller patches of wapato.	The site supports extensive wapato beds.
0 points	0.2 points	0.5 points

- **Native Turtles**

Rationale:
Native turtles in Oregon are declining, with the Western pond turtle and Western painted turtle both listed as state sensitive, and the Western pond turtle a federal species of concern. Western pond turtle is also under review by the US Fish and Wildlife Service for listing under the Endangered Species Act. Native turtles use habitats that are impacted by AIS, including reducing physical access to waterbodies, changing food webs, occupying nesting sites in riparian areas, and altering water quality and quantity. Detection and control work at sites that support native turtles provides an opportunity for preserving or restoring turtle habitat.

Data Sources:
The Native Turtle Working Group collects data on turtle observations, but the dataset is incomplete (it was reviewed and found to be missing many known turtle sites) and has a small number of sites mapped in total. Not all areas of the basin are represented. Turtle use at your site is best determined by visual surveys conducted in summer using the "Guidance for Conserving Oregon's Native Turtles including Best Management Practices" (ODFW, 2015). Watershed councils, site volunteers, neighbors, and other individuals and partners may also possess information about turtle use at your site.

Scoring Methodology:

The site does not support turtles.	The site seems to support turtles, such as through anecdotal information, or observation of predated nests nearby, but the current use of the site by native turtles has not been confirmed by recent visual observation.	The presence of native turtles using the waterbody has been confirmed by visual or other means within the past 3 years.
0 points	0.2 points	0.5 points

- **Pacific Lamprey**

Rationale:
Pacific lamprey (*Entosphenus tridentatus*) is a native anadromous fish species that has been in decline, with reduced habitat availability and quality as threats. They are an important part of aquatic food chains and have historic and modern significance to Oregon's tribes. Pacific lamprey is a federal species of concern and are state sensitive in Oregon. Western brook lamprey and Western river lamprey face similar threats and have also declined from historic levels, but there is less data is available on their distribution and occurrence.

Data Sources:
Data is available on the current and historic distribution of Pacific lamprey in Oregon from the US Fish and Wildlife Service's Pacific Lamprey Conservation Initiative website. The website provides maps and a data clearinghouse. This Pacific Lamprey dataset was not used in the GIS analysis because it had overly broad coverage for the mainstem river, presented challenges in display due to line feature type, and was somewhat redundant with Percent Native Fish data from Slices for the mainstem. However, it does provide good information on broad scale Pacific lamprey distribution. It does not provide confirmation that specific sites themselves have lamprey using them. That information would only be available from site or reach-level fish surveys. If you are not aware of any surveys completed for your site, check with your local watershed council or ODFW.

Scoring Methodology:

The site does not support Pacific lamprey.	The site may be used by Pacific lamprey: they have been confirmed in the larger watershed in which the site is located but have not been confirmed onsite.	The presence of Pacific using the site has been confirmed by direct observation, survey or sampling at the site in the past 5 years.
0 points	0.2 points	0.5 points

- **Other Rare or Special Status Species Present**

Rationale:
Rare, declining and special status fish, turtles, and mussels were addressed above. There are other animal and plant species that rely on healthy wetland, aquatic and riparian habitats for survival and are threatened by establishment of AIS. We look to the Oregon Conservation Strategy list of Strategy Species, narrowing it down to those associated with the Willamette Valley ecoregion, and then further to those non-fish, non-turtle and non-mussel species that are dependent on wetland, aquatic and riparian areas:

Amphibians:
- Northern red legged frog (*Rana aurora*) is associated with shallow-water ponds and wetlands with emergent vegetation.
- Foothill yellow-legged frog (*Rana boylii*) utilize streams with coarse-substrate gravel bars, bedrock substrate with potholes, and low-flow backwaters.
- Columbia torrent salamander (*Rhyacotriton kezeri*) use cold mountain streams, springs, and seeps.
- Cascade torrent salamander (*Rhyacotriton cascadae*) use cold, fast-flowing headwater streams, seeps, and waterfall splash zones in forested areas, as well as in reaches and off-channel habitat with gravel or cobble substrate and persistent, shallow water.
- Southern torrent salamander (*Rhyacotriton variegatus*) inhabit cold mountain streams, springs, and seeps, preferring loose gravel stream beds and high-gradient streams.

Birds:
- Common nighthawk (*Chordeiles minor*) use gravel bars along large rivers.
- Willow flycatcher (*Empidonax traillii*) depend on riparian shrub habitat, requiring a dense, continuous or near-continuous shrub layer, especially of willows.
- Yellow-breasted chat (*Icteria virens auricollis*) is associated with dense, brushy riparian thickets.
- Short-eared owl (*Asio flammeus flammeus*) require large expanses of marshes and wet prairies for foraging and nesting.

Insects:
- Stonefly (*Capnia kersti*) is currently only known to one site in the Willamette Valley, and is associated with low elevation, seasonally dry stream beds.
- Great spangled fritillary (*Speyeria cybele*) is a butterfly species using moist meadows and depends on violets, especially stream violet in Western Oregon.

Plants:
- Howellia (*Howellia aquatilis*) is typically found at the edges of low-elevation vernal pools and other seasonal wetland habitat, generally in shaded areas.
- Willamette daisy (*Erigeron decumbens*) is found in seasonally wet prairie.
- White-topped aster (*Sericocarpus rigidus*) is found in seasonally wet prairie.
- White rock larkspur (*Delphinium leucophaeum*) is found in well-drained areas within open wet prairies and along riverbanks, as well as in non-wetland/riparian areas.
- Peacock larkspur (*Delphinium pavonaceum*) grows within wet prairies and shady edges of Oregon ash forests.
- Nelson's checkermallow (*Sidalcea nelsoniana*) grows in wet and dry prairies, wetlands, edges of woodlands, and riparian areas.
- Kincaid's lupine (*Lupinus oreganus*) grows in wet and dry prairies, wetlands, edges of woodlands, and riparian areas.
- Bradshaw's desert parsley (*Lomatium bradshawii*) grows in wet prairies with shallow, poorly drained clay soils, often near creeks or small riverbanks.

Data Sources:
Sources of information vary for species listed above. The surest way to know if any of these species are present is to perform a survey for them using accepted scientific survey methods appropriate to the species. Other sources of information include: Oregon Department of Agriculture (plants), Oregon Department of Fish and Wildlife, US Fish and Wildlife Service (federally listed species), Oregon Biodiversity Information Center (rare flora and fauna, Rare and Endangered Invertebrate Program), Xerces Society (invertebrates), eBird.org, Audubon Society (birds), and other sources.

Scoring Methodology:

Species listed above are not known or expected to be present.	Species listed above are likely present (based on habitat suitability and range and confirmed presence nearby).	Species listed above are confirmed/ documented on site or on adjacent habitat of same type.
0 points	0.05 x number of species	0.1 x number of species
Maximum of 0.8 points total		

- **Connectivity**

Rationale:
The level of connection of a site with floodwaters (winter/spring) and in low water conditions (summer/fall) are important for two reasons. One, a site that is more connected provides important floodwater storage and conveyance functions for a watershed, as well as important habitat and water quality functions. Second, a site that is better connected has a greater risk of spreading AIS propagules to the surrounding area and is therefore a higher priority for AIS survey and control.

Data Sources:
There are numerous ways to characterize floodplain connectivity and many data sources. Some data sources, such as Slices maps, are only available for portions of the Willamette river basin. Below is a scoring methodology that incorporates 2-year floodplain inundation and upstream and downstream connectivity as ways to characterize floodplain connectivity. Because we are interested in frequently inundated sites, we are not looking at 100-year floodplain connectivity. Data sources include: visual observation; Google Earth aerials; and Slices modeled 2-year inundation maps available as “Willamette River Floodplain 100 Meter Slices Framework Maps” (open the PDF maps in Acrobat and turn on the layers to view the 2-year inundation coverage).

Scoring Methodology:

No part of the site is connected by floods annually (Google Earth, visual observation) or within the Slices modeled 2-year inundation, and the site is not connected on the upstream or downstream end during low water.	Less than half of the site is connected by floods annually or within the Slices modeled 2-year inundation; OR, the site is connected at the upstream or downstream end (or both) sometimes but not every year during low water.	Most of the site (or the entire site) is connected by floods annually or within the Slices modeled 2-year inundation; OR, the site has upstream or downstream connectivity (but not both) every year during low water.	The site is connected at both upstream and downstream ends every year during low water.
0 points	0.3 points	0.6 points	1 point

- **Proximity to AIS Control Sites**

Rationale:
AIS control at adjacent or nearby sites helps reduce propagule pressure in an area and can help individual projects in the area be more successful. Control at multiple sites in an area can also build local partnerships and provide opportunities for matching and leveraging funding among control sites. Additionally, coordinated control in one area can lead to large areas of contiguous restored habitat, providing greater benefits to fish, wildlife, and water quality than more spread out control effort.
Data Sources:

The Willamette Aquatic Invasives Network Community Fulcrum dataset, available through WAIN, includes some information on control efforts. WAIN also tracks control work in a spreadsheet through annual voluntary reporting. Another good source of information about control is the Oregon Watershed Restoration Inventory (OWRI), a database that relies on a combination of mandatory and voluntary project reporting for restoration and invasive species control projects. The database can be downloaded from the OWEB website under Project Data and Reporting – OWRI. The data is also viewable in a map in Oregon Explorer – Map Viewer – Layers – Restoration – Oregon Watershed Restoration Inventory. Oregon Explorer has additional layers on restoration work by federal agencies that may be useful. Finally, talking to your local watershed council can help you identify AIS control projects near your site.

Scoring Methodology:
The term "significant" below means AIS control work that is more extensive than periodic hand pulling of small patches.

The site is isolated. No significant AIS control work has or is occurring within 2 miles.	The site is between 1 and 2 miles from a site where AIS control has or is occurring.	The site is less than 1 mile from another AIS control site.	The site is immediately adjacent to another AIS control site.
0 points	0.1 points	0.3 points	0.5 points

- **Site Size**

Rationale:
The size of a site is an important indicator of habitat viability for most species, and larger size allows for increased genetic diversity within plant communities. Preserving or enhancing large sites is a priority over small sites. Note that this criterion differs from AIS patch size addressed previously in this scoring rubric. For this criterion, the whole site should be measured, including infested and non-infested areas that are all part of the same functional "site" – a whole pond, side channel, alcove, etc.

Data Sources:
Aerial photos, such as in Google Earth, can be used to delineate site boundaries and estimate site size.

Scoring Methodology:

Site size < 5 acres	5-25 acres	25-100 acres	100-250 acres	> 250 acres
0 points	0.1 points	0.2 points	0.3 points	0.5 points

- **Water Quality**

Rationale:
Beyond cold water refugia, other parameters of water quality can be considered when prioritizing AIS detection/control locations.

Data Sources:
Water quality information can be viewed spatially in Oregon Explorer – Map Viewer – Layers – Water and Air – Water Quality – Water Quality Streams (2012) and Water Quality Lakes (2012). These maps contain a spatial representation of lakes, streams and stream segments with water quality information from Oregon's 2012 Integrated Report Assessment Database and 303(d) List.

Scoring Methodology:

The site is not within an area shown in the Oregon Explorer map as green "Cat2: Attaining, specific water quality standards are met (streams)" or "Cat 2: Attaining some criteria/uses (lakes)".	The site is within an area shown in the Oregon Explorer map as green "Cat2: Attaining, specific water quality standards are met (streams)" or "Cat 2: Attaining some criteria/uses (lakes)".
0 points	0.3 points

- **Native Aquatic Vegetation Beds**

Rationale:
Native aquatic vegetation beds provide habitat for invertebrates that are the base of the aquatic food chain. They can be comprised of a wide variety of native aquatic macrophytes, or large monocultures of one or a few native species. Note that this criterion differs from pure wapato beds discussed previously, although wapato may be one component of a more diverse native aquatic vegetation bed that earns points here. Aquatic vegetation beds are a Strategy Habitat, under "Specialized and Local Habitats", in the Oregon Conservation Strategy.

Data Sources:
Native aquatic vegetation beds are difficult to map at the scales at which most vegetation mapping is done in the Willamette Basin. WAIN Community Fulcrum may, in the future, include the option of mapping these beds, but no widespread data is available at this time. Visual observation and measurement are needed to characterize presence at a site.

Scoring Methodology:

The site does not include native aquatic vegetation beds.	The site has one or more small patches of native aquatic vegetation beds comprised of at least two native plant species.	The site has one or more large native aquatic vegetation beds comprised of at least two native plant species.
0 points	0.1 points	0.3 points

- **Site Access**

Rationale:
Sites with good vehicle and boat access will generally be easier to access and less expensive for implementing detection/control work, including long-term maintenance, than sites with difficult access.

Data Sources:
Analyze site access. If contracted services are likely to be needed to perform detection or control work, speaking with a contractor at an early stage about access can help clarify the specific access needs of the contractor and their equipment.

Scoring Methodology:

Poor access by road or by boat.	Easy road or boat access (not both), or access to part of the site but not throughout the site.	Excellent access by boat and/or road throughout the site.
0 points	0.2 points	0.3 points

- **Educational Opportunities**

Rationale:
Sites with high public use or visibility provide important opportunities for education about AIS, including achieving education goals and strategies in the WAIN AIS strategic plan.

Data Sources:
Evaluate the current or likely future use of the site for educational opportunities, including tours, workshops, volunteer weed work, interpretive signage, etc. In order for the site to provide "significant" AIS education opportunities, it needs to be a site that has or could have many people participate.

Scoring Methodology:

The site does not provide significant opportunity for AIS education.	The site provides significant opportunities for AIS education.
0 points	0.3 points

- **Community Support and Involvement**

Rationale:
Sites with involvement or other support by local communities (volunteers, neighbors, organized groups, watershed councils, etc.) may be easier to survey and to maintain AIS control long-term using through volunteerism, and may receive more support for project implementation, than sites without.

Data Sources:
Evaluate the current level of involvement and community support for work at the site.

Scoring Methodology:

The site does not have community support or involvement.	The site has significant community support and involvement.
0 points	0.3 points

- **Risk of Spread by Watercraft**

Rationale:
Sites with formal watercraft launches or take-outs (motorized or non-motorized) are more likely to be locations where AIS occurs (and should be detected), and where AIS can be picked up and spread. Detection of AIS at these sites, or reduction in AIS through AIS control, would reduce these risks. A secondary benefit of working at these sites is that they provide educational opportunities for users through simple signage, such as Clean Drain Dry or other AIS messaging.

Data Sources:
Determine if your site has formalized launches, put-ins or take-outs. If you can't access the site, this may be able to be determined by looking at Google Earth aerials.

Scoring Methodology:

The site does not have formal watercraft launches, put-ins, or take-outs.	The site does have formal watercraft launches, put-ins, or take-outs.
0 points	0.3 points

- **Bonus Points**

Rationale:
This bonus category is intended to capture additional important functions or values provided by the site that are not otherwise accounted for in the criteria above. These unique attributes are:

- Ample large woody debris in channels (visual observation)
- Numerous basking logs for turtles (visual observation; also see *Guidance for Conserving Oregon's Native Turtles including Best Management Practices* (ODFW, 2015)
- Beaver activity onsite (visual observation, aerial maps)
- Heron rookery present (visual observation; mapping may be available from ODFW, Audubon or Klamath Bird Observatory)
- Site is registered as an Oregon Natural Area in the *Oregon Natural Areas Plan* (OPRD, 2015) available from the OSU Institute for Natural Resources website

- Presence of headwater streams (roughly, first through third order streams which can be viewed in topographic maps, or on the ODFW website – Natural Resources Information Management Program – Stream Flow Maps – Willamette Basin – Streams and Rivers in the Water Availability Basin (WAB) Map)
- Located at a dynamic river confluence (visual observation, aerial maps)
- Site contains at least 1000 feet of frontage on a perennial river, stream, lake or reservoir (measure in Google Earth)
- Estuary-like conditions, such as mud flat areas resulting from regular river level fluctuations (visual observation)
- Other unique and significant aquatic habitat, floodplain or water quality attributes at the site

Data Sources: See above.

Scoring Methodology:

The site has no bonus category features.	The site has one or more bonus category features. List them in scoring sheet.
0 points	0.1 x number of bonus features present
Maximum of 0.5 points total	

Checklist of Considerations for Managing AIS

Detect AIS

Detection is the first and most critical step in an effective weed control effort.

- □ Educate yourself and your colleagues about aquatic invasive species, particularly what species to look for in your area, and how to identify them. Numerous sources of information are available, including workshops, the Willamette Aquatic Invasives Network, Oregon Department of Agriculture, Portland State University Center for Lakes and Reservoirs, Cooperative Weed Management Areas, Western Invasives Network, published literature, published plant identification manuals, and contractors.

- □ Report sites that you find using Community Fulcrum from WAIN, Oregon Invasive Species Hotline, or Oregon WeedMapper.

- □ Determine land ownership at the location where you have detected AIS. If possible, notify the landowner.

Rapidly Respond (for small patches)

Rapid response, especially with populations of weeds that are still small, can prevent the spread of the species and have a very high benefit to cost ratio compared to waiting to control.

- □ If this is a site you are responsible for managing (or are able to volunteer to manage), and the detected AIS patch is small, determine if you can hand pull the patch or cut it (the most appropriate method depends on the species). If you are unsure, contact WAIN or your local soil and water conservation district for advice. For patches in water, take care to not allow material to float downstream.

- □ Determine appropriate disposal methods (e.g. drying in the sun, bagging and removal from the site).

- □ Some of the considerations in the list below may also apply to smaller projects.

Plan Your AIS Control Project (for complex projects)

Larger AIS control projects require careful planning. Below are some considerations for the planning stage of a project. These are not in chronological order.

- □ Ensure that you have the correct plant identification. Online and print resources are available that help clear up confusion on plant identification and show common lookalike species. Benton Soil and Water Conservation District's *Water Weeds* guide is one example.

- □ Get to know who and what is currently utilizing your site. Take time to learn what you can about:

    - Fish and wildlife utilizing the site: Are there sensitive species present? How and when are they using the habitat? What control timing or methods for control might have adverse impacts on these species, and what alternatives can be used for control that minimizes or avoids impacts? For example, mechanical control of AIS in an area with turtles should be timed carefully.

    - Plant species onsite: Are there sensitive species present or other vegetation (such as beds of wapato) you might want to ensure you protect during control work? Where

are they located? What control timing or methods for control might have adverse impacts on these species, and what alternatives can be used for control that minimizes or avoids impacts? For example, *Howellia aquatilis* is a federally threatened aquatic plant that is assumed to be extirpated from Oregon but may persist in some areas. Aquatic habitats should be checked for *Howellia* prior to large scale weed control work.

- People utilizing the site or with an interest in the site: Is the area used by birders, anglers, paddlers, neighbors or others? How will the site users be impacted, and how should they be kept informed of changes onsite? Is the area a collection area used by tribal community members? Who should you contact to inform or discuss the control project with?

- Before beginning control work, make sure you have spent adequate time at your site, preferably in different seasons, to provide a solid understanding of the site's hydrology, human users, fish and wildlife, flora, and other observations that will provide the necessary information to ensure your AIS control plan takes these influential factors into account.

□ Step back and look more broadly around your site. Determine:

- If the AIS area extends onto neighboring property, is there an opportunity for collaborative work across boundaries? Is this something you can work directly with the neighbors on, or do you need to garner assistance from a soil and water conservation district, watershed council, Oregon Department of Agriculture, or others?

- Identify drinking water and irrigation intakes in or downstream from your site if you are considering chemical control methods. Depending on the use and location of these points of diversion, and the chemicals you are planning to use, you may need special permitting or be limited in methods. Domestic or public water system drinking water source areas are shown in a mapping tool, "Drinking Water Protection Interactive Map Viewer", provided by the Oregon Department of Environmental Quality. Oregon Water Resources Department has an "Interactive Water Right Map" identify points of diversion for domestic water users with water rights permits. DEQ's Drinking Water Protection Program staff can also help answer questions.

- Looking at a broader landscape scale, thinking about what the underlying processes are that enable the invasive species problem? For example, was the riparian corridor clearcut, opening the canopy and allowing Japanese knotweed to flourish? Is the area a side channel cut off from flushing flows due to upstream dams? Determine if addressing any of these underlying processes or causes could make your site less hospitable for AIS.

- Ask the question: Where are we trying to take the ecosystem and how does this work fit in? Are there other planned or potential changes proposed for the site, or other benefits that could be enjoyed by controlling the AIS in a specific way? For example, is it possible to open the upstream end of the channel to higher flows, helping with AIS control while also improving off-channel habitat for native fish?

- Are there restoration actions already planned onsite that depend on the AIS control work, or action that could be done that would improve the success of this project? Think about the site's need and potential for ecological uplift more broadly and over a longer term. Also, think about the order of projects – should the AIS control work be done before, during, or after other planned actions at the site?

- Is your problem site specific or reach specific? In other words, will this project address the problem in a logical location? If there is an upstream or neighboring AIS infestation that will bring the species back to your site, can you work on the other infestation as part of this project?

- Where is your site in reference to the highest priority areas for work in your area? Is this project focused on a logical geography? If there is more valuable habitat, or an area that otherwise might rank higher in prioritization, in your reach? Is it feasible to work in that area as part of this project, or prior to this project?

- What plans and strategies already exist for this area, such as watershed plans, management plans, weed control plans, etc.? How does your project and your site fit into those plans?

□ Determine your AIS control strategy and methods:

- Working with relevant stakeholders, determine your site goals and desired future condition (DFC). For example, is the goal of your project to eradicate all of your target AIS over the entire site, with a DFC of native emergent vegetation with no AIS? Is your goal to reduce the cover of AIS to levels that are manageable with hand-pulling once per year, and your DFC open water with trace amounts of AIS? These are two examples of many.

- Further refine your broad goals into specific, measurable objectives. Specifically, how do you want the site to change, and what specific descriptors define your DFC? This step is critical to be able to monitor your progress toward success, to be able to adapt and adjust your project, and to know when you are done. You may need to gather additional information by following some of the steps below to determine your objectives.

- Discuss control methods with others in your area, such as soil and water conservation districts, WAIN, or other organizations. Determine what the current understanding is among practitioners is as to most efficacious approaches.

- Review life history(ies) and phenology of your target species. Understanding the plant's biology will help you target efforts at the best time and avoid wasting resources.

- Combining much of the information gathered in the above steps, select a general approach for control (mechanical, hand pulling, herbicide, other, combinations), and if possible, determine more in-depth details such as the equipment type, specific chemicals, and workers needed.

- Determine the life-span of the project. How many months or years of planning, implementation, and follow up will be needed to achieve the goal and get closer to the desired future condition? For more complex or larger scale projects, goals and DFC may differ in the short-term, mid-term and long-term time scales.
- Related to project timeline, does your project need to be phased? This may depend on the scale of the project, available budget, or other factors. If phasing is needed, determine the most logical size and order of phases. For example, are there vector areas, such as channel outlets or boat launches, which should undergo control work before other areas?
- Identify access and staging routes. Difficult-to-access locations may limit the control methods available, or lengthen the duration of the project.
- Determine broadly how you will monitor progress. Will you use photo points for visual tracking of change over time, or more intensive plant cover or plant mass measurements? The Oregon Watershed Enhancement Board has guidance for photo point monitoring. A Review of Aquatic Plant Monitoring and Assessment Methods by Madsen and Wersal (2012) provides a good overview of methods.

□ Identify permitting needs

- Depending on the landowner for the site(s) where you're planning to do AIS control, you may need a permit or letter of permission. This includes sites managed by Oregon Parks and Recreation Department (Special Use Permit) and the Oregon Department of State Lands (Short Term Access Agreement; Notice for Certain Exempt Voluntary Habitat Restoration Projects).
- Check the Oregon Pesticide Licensing Guide provided by the Oregon Department of Agriculture for the required licenses needed for AIS control using herbicide.
- If your control methods will disturb sediment or soil at the site, determine if the site has known cultural resources, such as archeological sites, historic objects, burials, building, or structures. The Oregon State Historic Preservation Office can provide guidance.
- If federal funding is used for the project or other federal action is associated with a project such that there is a federal nexus with the project, certain federal approvals or processes may be needed, including those associated with the Endangered Species Act, and Section 106 of the National Historic Preservation Act, among others.
- The National Pollutant Discharge Elimination System (NPDES) Waste Discharge General Permit (2300A) is required for all pesticide applications over or within three feet of water. The permit is administered by the Oregon Department of Environmental Quality. The requirements of the permit, available on DEQ's website, apply to all projects over or within three feet of water. These include recordkeeping, checking for water intakes, and following specific measures to preserve water quality. Over specific threshold levels, you also may be required to register with DEQ, pay a fee, and create a Pesticide Discharge Management Plan.

- In-water work periods apply to any work in-stream that would result in physical alteration of stream habitat under Oregon legislative statutes. In-water work periods are guidelines set by the Oregon Department of Fish and Wildlife and vary by location. ODFW can grant waivers for in-stream work outside of the guidelines.

- Permitting requirements change, and they can vary by location. Talk to others working on AIS control in your area, or check with the following agencies to determine the specific permitting needs for your site and your project: Oregon Department of State Lands, National Marine Fisheries Service, Department of Environmental Quality, Oregon Department of Agriculture, U.S. Army Corps of Engineers, Oregon Department of Fish and Wildlife, U.S. Fish and Wildlife Service, Counties (including county water systems departments).

□ Build a project budget using the approaches and requirements determined in the steps above, and breaking them down into specific tasks. This requires determining who will do each task, ad if contracted labor or materials/equipment are needed, determining costs. Several companies provide AIS control services in the Willamette basin. Contact WAIN (restoration@willametteriverkeeper.org), local CWMAs or SWCDs for recommendations. Ensure your budget is thorough, including costs for necessary maintenance, and with contingencies built in for rate increases or unforeseen issues that could arise.

□ Seek funding to implement the project. The entity who owns the land may have internal funding to wholly or partly pay for the project. If partial funding is available, that funding can be used to leverage other funding, such as from grants or adjacent landowners. Grant funding may be available from public or private sources who focus on a variety of environmental issues. AIS can impact recreation, waterfowl, wetlands, fish, a variety of wildlife, and water quality. Grants focused on one or more of these issues may fit your project. Common grant sources used for AIS control in the Willamette Basin include: ODA, OWEB, BPA, MMT, USFWS NAWCA, and DSL.

Prepare Final Details Prior to Implementation

Numerous preparatory tasks will be identified during the planning stage. Good preparation will help ensure smooth implementation.

□ As you visit your site and prepare for implementation, ensure that you, your partners and contractors are not vectors for spread of invasive species into or out of your site, spreading them to other sites. Practice good apparel and equipment hygiene. Clean all watercraft. Specific methods for cleaning can be found online, and vary by AIS species.

□ When hiring pesticide applicators, check references, insurance coverage, and current pesticide applicator licensing to ensure they are qualified, experienced and licensed for the work. Additionally, choose pesticide applicators with experience in identifying native and non-native plant species to better ensure success using and IPM approach, especially where native and non-native species may be co-occurring.

□ Apply the information you determined previously on sensitive species and ensure you are implementing avoidance or harm minimization measures during implementation. For example, think through specifics for controlling AIS around native plants you wish to retain. Can you work on the invasive species when other plants are dormant, or have already gone to seed?

- □ Secure permits well in advance of when you wish to begin implementation.
- □ Finalize access and staging routes. In sensitive areas, you may need to stake or flag, or even place temporary fencing, around sensitive areas.
- □ Update your knowledge on the current science around the invasive species and techniques you plan to use. The community of practice for AIS control is constantly learning new information and methods.
- □ Prepare any public information materials needed for the project, such as neighbor letters, news releases, and onsite signage. Check with WAIN to see if standardized talking points, messages or signs have already been developed that you can use for consistency in messaging regarding AIS control.
- □ Ensure all baseline monitoring information has been collected prior to implementation (such as established photo points to show visual change throughout your project over multiple years, other qualitative methods, or quantitative methods). Baseline monitoring should be structured in such a way that you can determine if your measurable objectives have been achieved, or not, after the project is implemented.

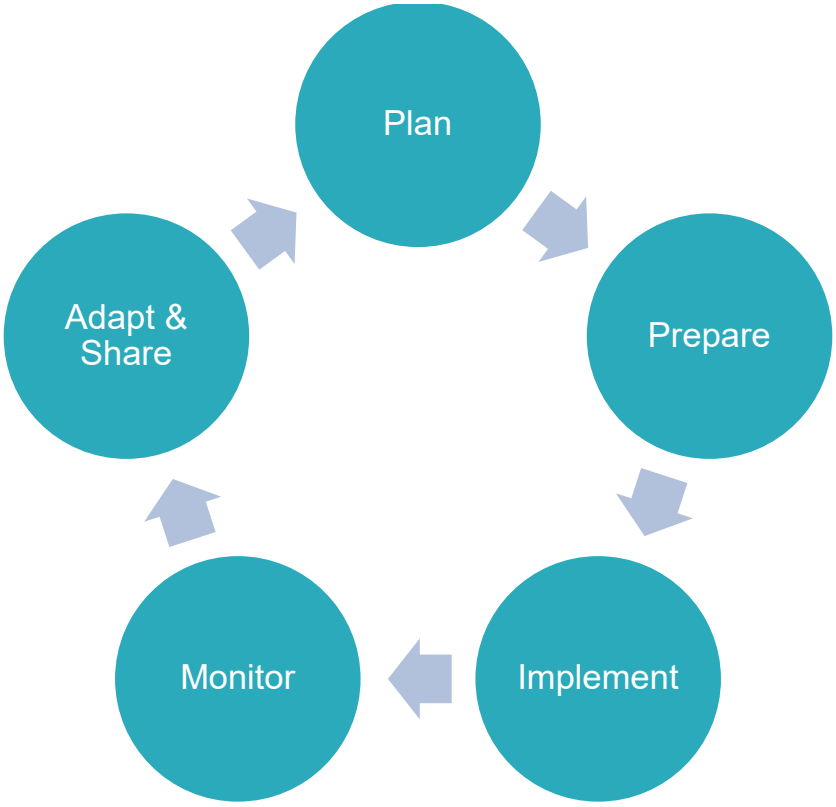
Implement Your AIS Control Project

- □ Document the tasks completed throughout the project and take ample notes and photos. A project tracking log is a handy tool for this.
- □ Visit the site regularly during implementation to check on contractors and monitor progress. Adjust project approach as needed during implementation.
- □ Continue to practice good apparel and equipment hygiene to avoid bringing invasive species into or out of your site.
- □ Spend time onsite during implementation to answer questions that come from visitors or neighbors. Be prepared with talking points and outreach materials.

Monitor Results, Adapt, and Share

These final steps are often overlooked but can help you and partners improve projects over time.

- □ Monitor your site using appropriate methods to determine if your measurable objectives have been achieved or not.
- □ If objectives have not yet been met, determine if the project should continue as currently designed to meet them, or if a change is needed to achieve better success.
- □ Return to the planning stage and update project plans with lessons learned. Apply your refined plan to the next round of work on this project, and/or the next project.
- □ When the project is complete, or at logical points during the project, share with others in the AIS control community, neighbors, and other stakeholders what worked well and what did not. Share your lessons learned with your partners.



Five Step Management Process


WAPATO
REVIVAL