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OSMB Final Report: Task 3. Containment Strategies for Eurasian Watermilfoil Infested Central OR Lakes

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**OSMB Final Report:
Task 3.
Containment Strategies for Eurasian Watermilfoil
Infested Central OR Lakes**

**Final Report submitted by:
Vanessa Morgan and Mark Sytsma
for Oregon State Marine Board
funded by Aquatic Invasive Species grant
to the Aquatic Bioinvasions Research and Policy Institute
Portland State University**

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Abstract

In recent years, public awareness of aquatic invasive species (AIS) has increased considerably in Oregon and elsewhere in the western U.S.. News articles, boat inspection stations and AIS permit programs have drawn attention to the threat of aquatic invasive species, especially animals like zebra mussels (*Dreissena polymorpha*), quagga mussels (*Dreissena bugensis*), and New Zealand mudsnails (*Potamopyrgus antipodarum*). However, invasive aquatic plants are also capable of causing severe impacts and may similarly be transferred between waterbodies on boats, trailers or other equipment. Heavy infestations can hinder recreational use by motorized and non-motorized boats, snag fishing lines, threaten the safety of swimmers and water-skiers, restrict delivery of irrigation water or quality of drinking water, and negatively impact aquatic habitats used by wildlife. One such plant, Eurasian watermilfoil (*Myriophyllum spicatum*), is wide-spread in much of the United States, but has only recently been found in four waterbodies in central Oregon’s Deschutes and Jefferson counties. This plant and many other macrophytes are capable of surviving when fragments or seed are carried to new waterbodies by natural or human-mediated means. While certain natural vectors like water currents and birds cannot be controlled, a containment strategy aimed at reducing secondary spread of EWM to new waterways via boat traffic would benefit aquatic resources in the region. Towards that goal, we examined boat launches at known infested waterbodies to determine: the extent of Eurasian watermilfoil, whether physical control techniques would reduce boaters’ direct encounters with this weed, and general awareness of AIS and support for local control of EWM by lake users.

Introduction

Eurasian watermilfoil (*Myriophyllum spicatum*) is one of the most widely distributed aquatic weeds in North America with infestations known in nearly every state in Lower 48 as well as three Canadian provinces. Known throughout western Oregon and Washington, including the Columbia River Basin, this perennial, submersed aquatic plant had until recently been undocumented in eastern Oregon. At the state level, EWM is suitably listed as a “B” rated noxious weed, which is defined as “a weed of economic importance which is regionally abundant, but which may have limited distribution in some counties early detection remains a high priority.” Infestations, confirmed by morphological characteristics and genetic analysis, have been confirmed in Crane Prairie Reservoir, Haystack Reservoir, Suttle Lake and one private pond in Jefferson County. Reports of EWM from East Lake appear unsubstantiated; multiple field surveys and subsequent genetic analysis have repeatedly found only two native milfoil species there. Furthermore, no pressed specimens, photographic evidence or genetic samples from any areas of East Lake show evidence of EWM. Such erroneous reports highlight the common confusion regarding milfoil identification, which may be attributed to a number of factors. Numerous milfoils are native in Oregon (including *M. sibiricum*, *M. verticillatum*, *M. hippuroides*, *M. quitense*) while three non-native milfoils (*M. spicatum*, *M. aquaticum* and *M. heterophyllum*) have been introduced here; and milfoil species appear quite capable of

hybridizing, with two different hybrids now confirmed within Oregon (Miller et al. 2013, Thum et al. 2011).¹

While chemical treatments of non-native milfoils can successfully reduce infestations and associated impacts, herbicide use in publicly owned and managed waterbodies is currently constrained by NEPA and NPDES requirements, as well as identification of sufficient funding sources. Such treatments are thus unlikely to happen in the near future in these publicly owned and managed waterways. But while EWM remains, especially in close proximity to boat ramps, the risk that boaters will move it to other uninfested lakes persists. To the extent possible, management of these EWM-infested lakes and reservoirs should ideally aim to limit transport to other waterbodies, while also reducing negative impacts caused by this weed on-site. Techniques might include use of physical barriers (benthic barriers and/or floating booms) and increased education to increase compliance with Oregon’s Aquatic Invasive Species (AIS) Prevention Program.

We assessed the feasibility and need for benthic barriers and/or floating booms at these four waterbodies’ boat ramps, looking for relative abundance of EWM or other problematic aquatic weeds, documenting the ramp types and general layouts, and noting substrate or other site conditions which might impact use of benthic barriers or floating booms. Although available evidence suggests East Lake is not infested with EWM, we nevertheless evaluated the Hot Springs boat ramp for potential use of bottom barriers or booms since macrophytes are so abundant there. We also conducted surveys at various launch sites to evaluate users’ general awareness of aquatic invasive species (AIS) and associated impacts; determine familiarity with the “Clean, Drain, Dry” slogan, prevention techniques for individual boaters, and the perceived importance of controlling aquatic weeds.

Brief descriptions of each waterbody are below, followed by our methods and results for both our boat ramp assessments and AIS awareness surveys. A discussion follows with region-wide considerations, descriptions of management options and site specific recommendations.

¹ Eurasian x northern watermilfoil (*Myriophyllum sibiricum* x *spicatum*) and variable leaf x western watermilfoil (*M. heterophyllum* x *M. hippuroides*)

Waterbody Descriptions

Crane Prairie Reservoir

Crane Prairie Reservoir is a 4,167 acre irregularly-shaped impoundment on the upper reaches of the Deschutes River. Though managed primarily for irrigation purposes, it is also used heavily for fishing, camping and bird watching. Water flows into Crane Prairie primarily via the Deschutes River, but also Charlton Creek, Cutltus River, Cultus Creek, Deer Creek, Snow Creek and the Quinn River.

Crane Prairie is a shallow reservoir, with average summer depths of approximately 11 feet, and a

maximum depth of just 20 feet. Shallow areas are dotted with many dead, tall tree stumps, which deter boat traffic, but provide nesting areas for birds. Public access points around Crane Prairie Reservoir are numerous, including Quinn River, Rock Creek Campground, Browns Mountain, the Crane Prairie Day Use Area, Crane Prairie Campground, Crane Prairie Resort, and Cow Meadow (Figure 1); most of these ramps are managed by the U.S. Forest Service, with the exception of the resort which is under private management.

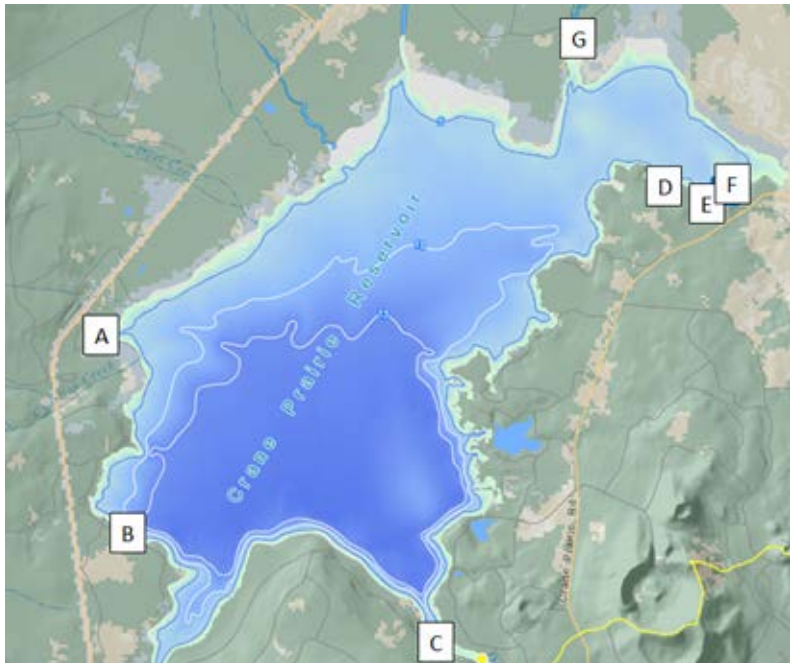


Figure 1. Map of Crane Prairie Reservoir (Deschutes County) showing bathymetry and surveyed access points including A) Quinn River Campground, B) Rock Creek Campground, C) Browns Mountain, D) CP Day Use Area, E) the CP Campground, and F) CP Resort and G) Cow Meadow (map adapted from Atlas of Oregon Lakes).

Suttle Lake

Suttle is a long, narrow, and relatively small (253 acres) glacier-formed lake located close to the town of Sisters; it is popular for kokanee and brown trout fishing, boating, camping and other recreational activities (e.g., swimming, waterskiing, windsurfing). In Jefferson County, Suttle is second only to Lake Billy Chinook in its number of boater use days; over 2,309 trips reportedly made between October 1, 2006 and September 30, 2007 (OSMB 2008). Primary surface inflow is through Link Creek from Blue Lake just upstream, but subsurface flow from permeable volcanic rock contributes as well. Outflow is through Lake Creek, connecting downstream with the Metolius River and then flowing into Lake Billy Chinook. Suttle has a single deep basin and moderately steep sides; average summer depths are 44 feet and maximum depth is 75 feet. There are the five access points around the lake: the Water Ski Area, Link Creek Campground, South

Shore Campground, Blue Bay Campground, and the Cinder Beach Day Use Area (Figure 1). Transparency values indicate mesotrophic conditions, but the lake's high phosphorus levels and abundance of phytoplankton specify Suttle as a eutrophic waterbody (Johanson et al. 1985). Increased recreational activities and associated nutrient inputs are suggested for a possible decline in

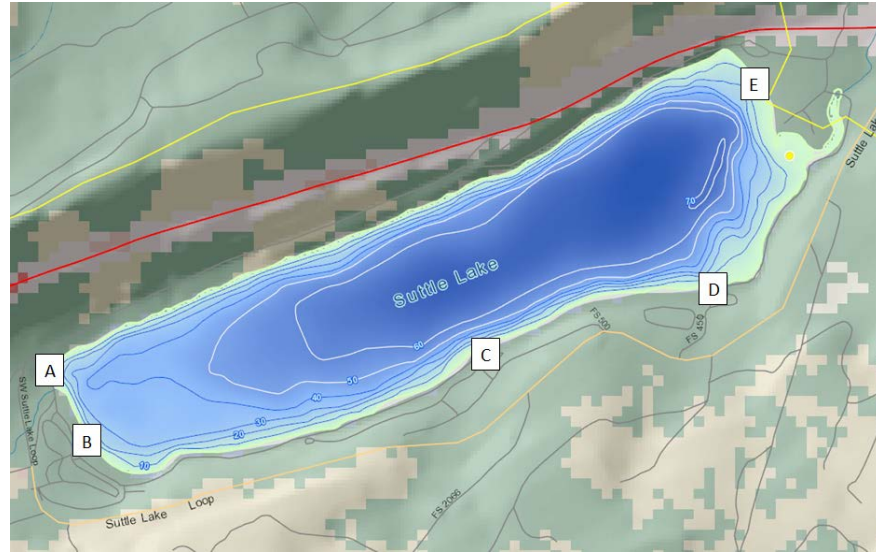


Figure 2. Map of Suttle Lake (Jefferson County) showing bathymetry and surveyed access points including A) Water Ski Area, B) Link Creek Campground, C) South Shore Campground, D) Blue Bay Campground, and E) Cinder Beach Day Use Area (map adapted from Atlas of Oregon Lakes).

Secchi disk measurements between the 1940's and 1980's, but consistent measurements are not readily available over the last two decades. Oregon Lake Watch volunteers adopted Suttle Lake in 2013 and plan to continue monitoring water quality and for early detection of AIS in future years.

Haystack Reservoir

Built to store water for irrigation of lands fed by the North Unit Main Canal, Haystack Reservoir is 282 acres at full pool, with average depths of 27 ft and maximum depth near the dam face of 75 ft. Water levels can vary considerably, both daily and seasonally as managers pull water for irrigation purposes. Haystack is primarily popular for fishing since it is open year-round and is stocked by ODFW with moderate numbers of trophy-sized rainbow trout, however boater use days (929 in 2006-07) are considerably less than Crane Prairie, East Lake, or Suttle Lake. Other activities include wildlife viewing, windsailing, and boating (motorized & non-motorized), including an annual drag boat race held in late August. Haystack is a markedly eutrophic lake, with ample macrophytes (including EWM) growing in shallow littoral areas and regular algae blooms. Boating access points include Haystack West and Haystack Campground, though a fishing pier and campground also provide use by fishermen, windsurfers, etc. (Figure 3).

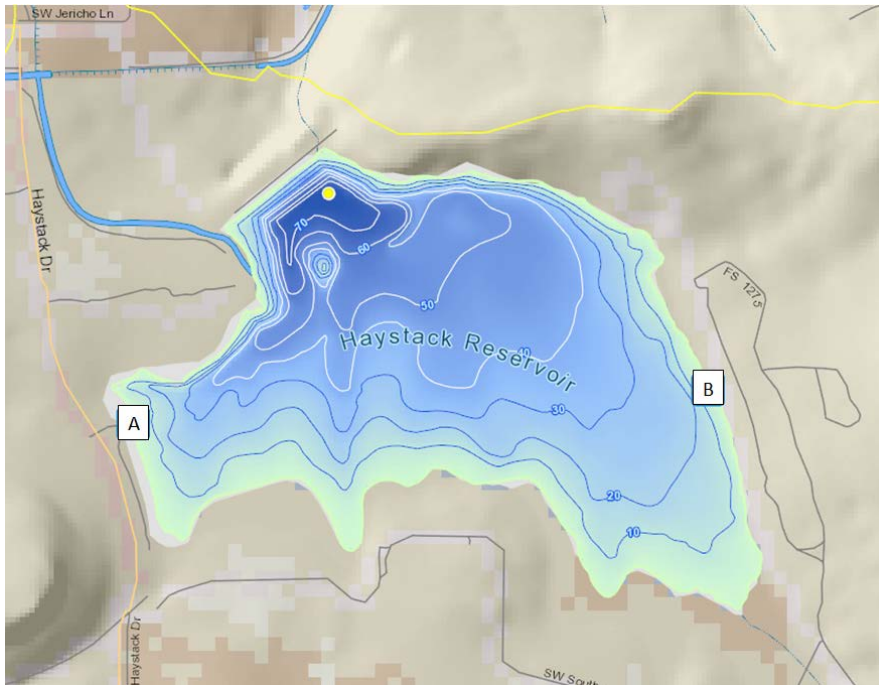


Figure 3. Map of Haystack Reservoir (Jefferson County) showing bathymetry and surveyed access points including A) Haystack West and B) Haystack Campground. (map adapted from Atlas of Oregon Lakes).

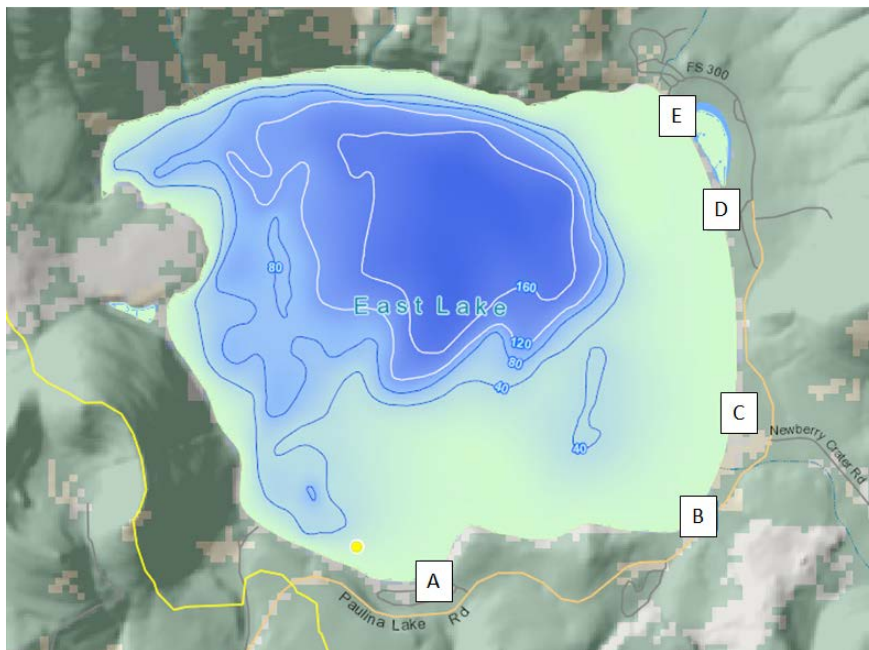


Figure 4. Map of East Lake (Deschutes County) showing bathymetry and access points including A) East Lake Campground, B) Hot Springs Ramp, C) East Lake Resort and D-E) Cinder Hill Campground (north and south) (map adapted from Atlas of Oregon Lakes).

East Lake

Sitting within the Newberry volcano's caldera, just east of Paulina Lake is East Lake, a popular 1,044-acre lake known for its unique setting and productive trout fishing. Much of the northern portion of the lake is over 100 ft deep; the lake's maximum depth is 180 ft and its average depth 67-ft. Inflow into the lake is primarily through known hot springs near the lake's southeastern corner, other hot springs below the surface, and through seasonal snowmelt. Contributions from the springs yield high levels of conductivity and alkalinity, moderate phosphorus levels. Dense beds of macrophytes are reliably found near the springs, but the lake overall is considered at the lower end of mesotrophic. There is no surface outflow from East Lake, but waters slowly seeping through the underlying volcanic rock are thought to contribute to Paulina Lake which is 40-ft. lower. Multiple large Forest Service campgrounds are situated on the southern and eastern portions of the lake, along with a private resort; recreational activities include fishing, boating (motorized & non-motorized), swimming, and camping. Access points include: East Lake Campground, Hot Springs Ramp, East Lake Resort and Cinder Hill Campground (north and south) (Figure 4).

Methods

Ramp Surveys

We assessed the need and feasibility of benthic barriers or floating booms at major boating access points at Crane Prairie, Suttle Lake, and Haystack Reservoir (despite the lack EWM or other noxious weeds at East Lake, we did evaluate the Hot Spring ramp due to the heavy growth of native macrophytes found there). Need was determined by the presence and abundance of EWM or other macrophytes that appeared to interfere or impede recreational use. Surveys for macrophytes were conducted using adaptive sampling techniques depending on water clarity, water depth and substrate type, but typically involved use of a plant rake attached either to a graduated pole or a rope or visual inspection using polarized lenses or a viewing tube to reduce glare from the water surface. The presence/absence of macrophytes and their relative abundance were noted within approximately 100 feet of each launch site. Recommendations on feasibility were based upon lake and ramp characteristics (ramp type, substrate), as determined from the OSMB boating access site dataset and direct observation.

AIS Awareness Surveys

A human-subject survey was conducted between August and September 2013. A three stage survey, including an observational survey, a brief boater survey, and an in-depth boater survey,

was used (Appendix A).² Surveys targeted all watercraft, including both motorized and non-motorized boats (canoes, kayaks, etc.). During the observational stage (Step 1), surveyors noted specific characteristics and behaviors of recreational boats and boaters, at a variety of access points at each of the four lakes as boaters were putting in or pulling out their craft. These observational notes were included only if boaters participated in the subsequent portions of the survey. Subjects were then asked if they were willing to participate the boater survey (Step 2) with nine simple questions, taking approximately five to ten minutes to complete; questions focused on when and where they last boated, where they planned to boat next, awareness of AIS prevention laws and preventative practices, and general knowledge regarding AIS. Upon completion of this section subjects that appeared interested were asked to answer the in-depth boater survey (Step 3) with an additional six questions, taking approximately five minutes to complete. This section aimed at understanding participants': perceptions about invasive species in Oregon; familiarity with select aquatic weeds; knowledge of EWM in that waterbody; and understanding of and support for aquatic weed control.

Results

Ramp Surveys

Surveys for EWM distribution and ramp conditions are described below. A table summarizing the AIS related signage at all boat ramps is in Appendix B along with images of each type of sign.

Crane Prairie Reservoir

Six of the seven boating access points evaluated at Crane Prairie were free of rooted EWM (Table 1); however moderate populations were found near the Quinn River Campground (Figure 5). At this site, moderately abundant EWM was found in a single area just north of the boat ramp; plants were in shallow depths (0.1 to 0.5 m) intermixed with a variety of native plants including native northern watermilfoil (*Myriophyllum sibiricum*). Curlyleaf pondweed (*Potamogeton crispus*) was found growing at three other access points (most notably the boat docks at Crane Prairie Resort and the Crane Prairie Campground), but did not appear to be interfering with use of docks or launch sites since plants remained close to the sediment.

Suttle Lake

EWM was found rooted near two of Suttle Lake's boat ramps (Table 1), Blue Bay Campground and the Water Ski ramp. At Blue Bay campground, a single patch of EWM (approximately 3-m

² Each subject was provided the Informed Consent document in Appendix A and was encouraged to contact the primary researcher to learn more about the project. Subjects' responses were voluntarily submitted and ceased at any time if the surveyed boater felt uncomfortable.

diameter) was found straight off the dock in depths between 2.2 and 3.4 meters; surrounding areas had sparse to moderately abundant assemblages of native plants between depths of 2.2 to 5.5 meters (Figure 5). At the Water Ski Area ramp, moderate populations of native macrophytes and macro-algae were found towards the end of the dock between depths of 2.8 to 4.5 meters. Sparse EWM was found in a single rake sample taken directly off the north side of the deepest end of the dock (Figure 6). Visibility at this site was limited by wave action and suspended algae, but we estimate the patch at < 0.5 m diameter. Fragments of EWM were found floating near the Cinder Beach Day Use Area, but no EWM was found rooted in the area.

Haystack Reservoir

Extensive beds of EWM were found rooted near both of Haystack Reservoirs' boat launches. At Haystack West (Figure 7), areas within 2 m of the dock appear clear of EWM and other plants, but large, moderate to dense beds of EWM lie both north and south of the dock in depths between 2.4 to 4.1 m; a native plant - coontail (*Ceratophyllum demersum*) - was found repeatedly in areas up to 5.4 m deep east of the dock. Piles of dried EWM were evident along sections of the shoreline and near the ramp. Similar to Haystack West, Haystack Campground, at the eastern edge of the reservoir, has moderate to dense beds of EWM at moderate depths and coontail in deeper regions.

East Lake

Aquatic plants grow in particularly high abundance near the Hot Spring ramp at East Lake, including areas directly around the launch and dock. The warm, nutrient rich waters supplied by the hot springs in this area produce this natural abundance of macrophytes, which is striking compared to most other littoral areas of the lake. Plants found growing here included a variety of native species, including whorled watermilfoil (*Myriophyllum verticillatum*) and northern watermilfoil (*M. sibiricum*) (Table 1). However, no EWM was found at this site, nor were any other non-native plants. Multiple samples of milfoils have been sent for genetic analysis from this and other areas of East Lake, and none have suggested EWM or any of the hybrid milfoils (R. Thum, pers. comm).

The areas around East Lake's other launches and boat docks were either largely clear of macrophytes or had sparse to moderate growth of native plants, often including northern watermilfoil; none of these areas appeared impaired or negatively impacted by macrophytes.



Figure 5. Aquatic plant beds at Quinn River Campground boat launch, Crane Prairie Reservoir; green polygons represent areas with sparse native plants; blue represents areas with sparse to moderate northern watermilfoil (*Myriophyllum sibiricum*); and the yellow polygon represents an area with moderately abundant Eurasian watermilfoil (*Myriophyllum spicatum*) mixed with native plants.

Table 1. Plant species noted by relative abundance found within 100' of popular boat launches at Crane Prairie Reservoir, Suttle Lake, Haystack Reservoir and East Lake.

| Waterbody & Access Points | <i>Ceratophyllum demersum</i> (coontail) | <i>Chara</i> sp. (muskgrass) | <i>Eleocharis</i> sp. (spikerush) | <i>Elodea canadensis</i> (common waterweed) | <i>Elodea nuttallii</i> (Nuttall's waterweed) | <i>Hippuris vulgaris</i> (common mare's-tail) | <i>Myriophyllum sibiricum</i> (northern watermilfoil) | <i>Myriophyllum spicatum</i> (Eurasian watermilfoil) | <i>Myriophyllum verticillatum</i> (whorled milfoil) | <i>Nitella</i> sp. (nitella) | <i>Potamogeton crispus</i> (curlyleaf pondweed) | <i>Potamogeton foliosus</i> (leafy pondweed) | <i>Potamogeton praelongus</i> (whitstem pondweed) | <i>Potamogeton richardsonii</i> (Richardson's pondweed) | <i>Potamogeton</i> sp. (thin-leaf pondweed) | <i>Ranunculus aquatilis</i> (water-buttercup) | <i>Sagittaria</i> sp. (arrowhead) | <i>Stuckenia pectinata</i> (sago pondweed) | <i>Utricularia vulgaris</i> ssp. <i>macrorhiza</i> (common bladderwort) |
|--------------------------------|--|------------------------------|-----------------------------------|---|---|---|---|---|---|------------------------------|--|--|---|---|---|---|-----------------------------------|--|---|
| Crane Prairie Reservoir | | | | | | | | | | | | | | | | | | | |
| Quinn River Campground | | | | | S | S-M | M | | | | | | D | | S | S | | | |
| Rock Creek Campground | | | | S-M | S | | | | | | | | M | | | | S | | |
| Browns Mountain | | | | | | | | * | | | | | | | | | | | |
| CP Day Use Area | | | M | | M | | | | | | S | | S | | | | | M | |
| CP Campground | | | | | S-M | | | | | | S-M | | | | | | | | |
| CP Resort | | | | | M | | | | | | M | | | | | | | | |
| Cow Meadow | | | | | | | | | | | | | | | | | | | |
| Suttle Lake | | | | | | | | | | | | | | | | | | | |
| Waterski Area | M | | | M | | | S | M | M | | | | | | | | | M | |
| Link Creek Campground | M | | | | D | | | | M | M | M | M | | | | | | S | |
| South Shore Campground | S | | M/D | M | | S | | | | | | | | M | | | | | |
| Blue Bay Campground | S | | | M | | | M | S | | | | | S | | | | | | |
| Cinder Beach Day Use Area | | | | | | | | * | | | | | | | | | | | |
| Haystack Reservoir | | | | | | | | | | | | | | | | | | | |
| Haystack West | M | | | | | | | S-D | | | | | | | S | | | | |
| Haystack Campground | D | | | | | | | M-D | | | | | | | | | | | |
| East Lake | | | | | | | | | | | | | | | | | | | |
| Hot Springs Ramp | S | | | | | D | D | | D | | | | | | | | | | D D |

* No plants found rooted, but floating fragments of EWM found.

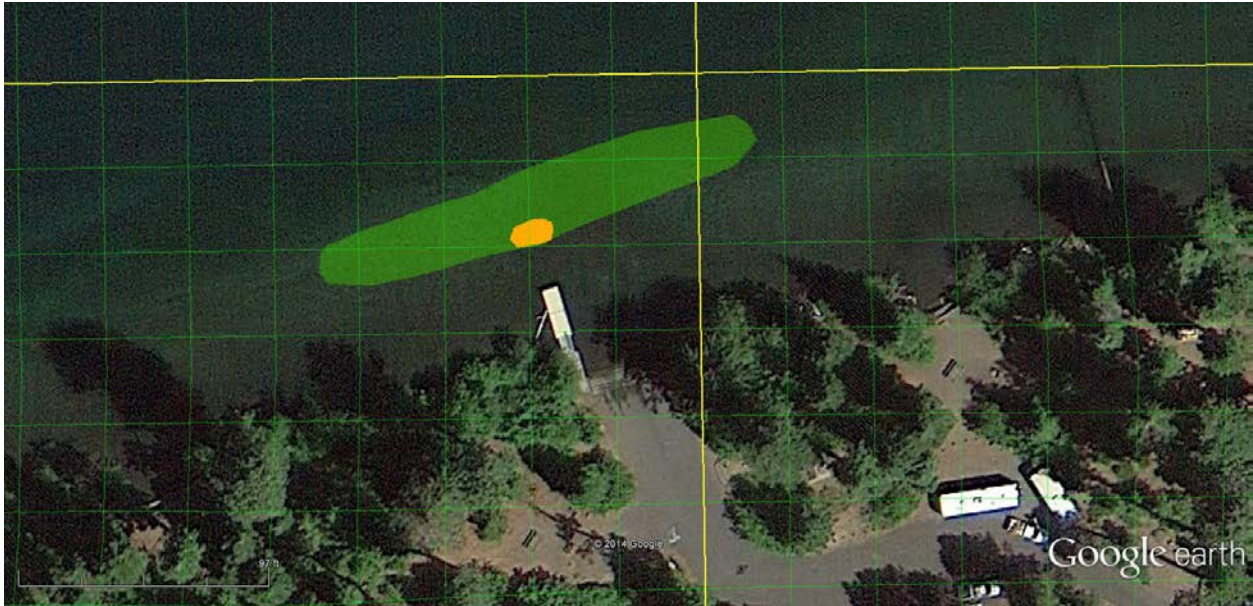


Figure 6. Aquatic plant beds at Blue Bay Campground, Suttle Lake; the green polygon represents an area of mixed native plants and orange represents Eurasian watermilfoil (*Myriophyllum spicatum*).

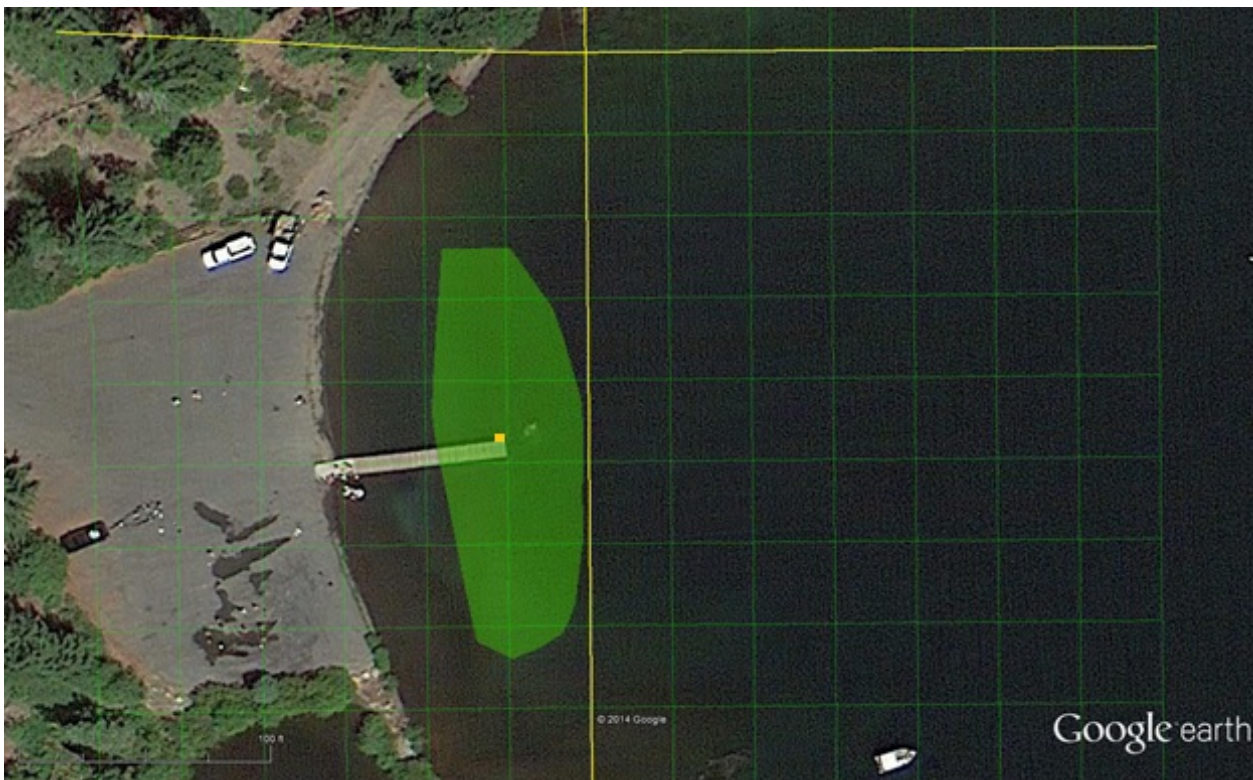


Figure 7. Aquatic plant beds near the Water Ski Area, Suttle Lake; the green polygon represents areas of mixed native plants and orange represents Eurasian watermilfoil (*Myriophyllum spicatum*).

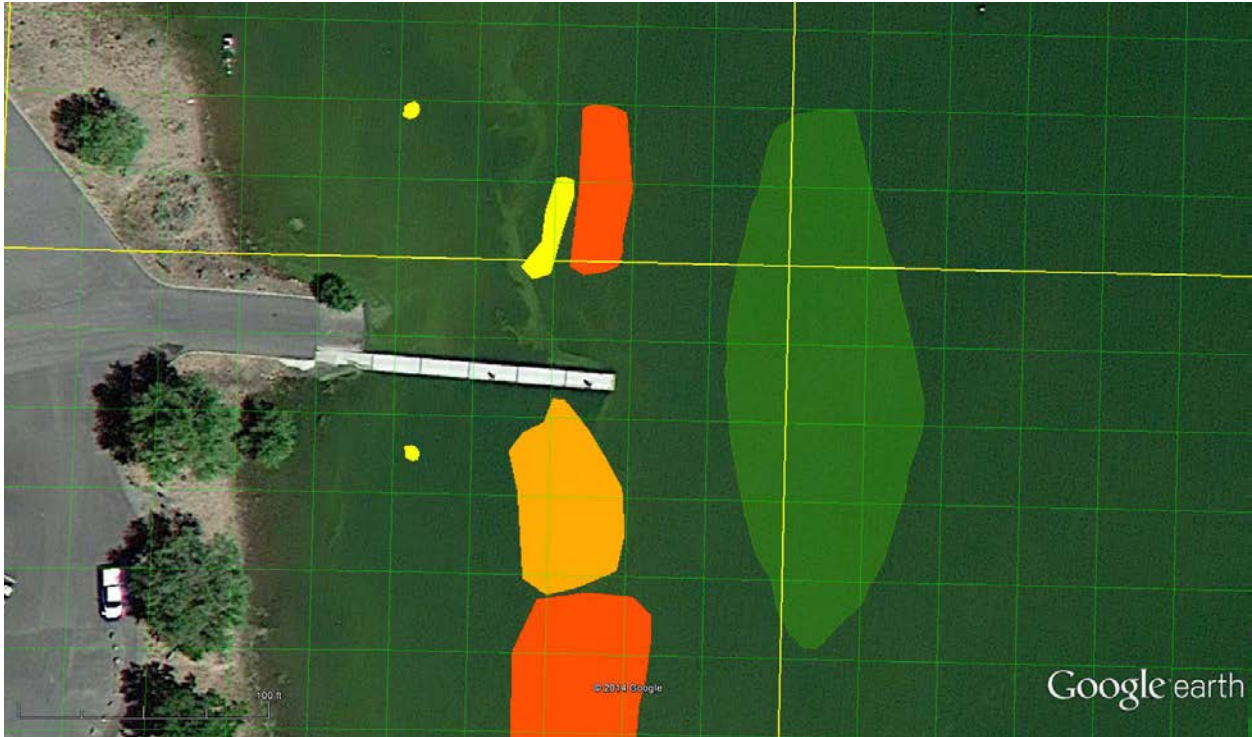


Figure 8. Aquatic plant beds near Haystack West boat launch, Haystack Reservoir; the green polygon represents general area with native coontail (*Ceratophyllum demersum*); Eurasian watermilfoil (*Myriophyllum spicatum*) is represented by yellow (sparse), orange (moderate), and red (dense) polygons.

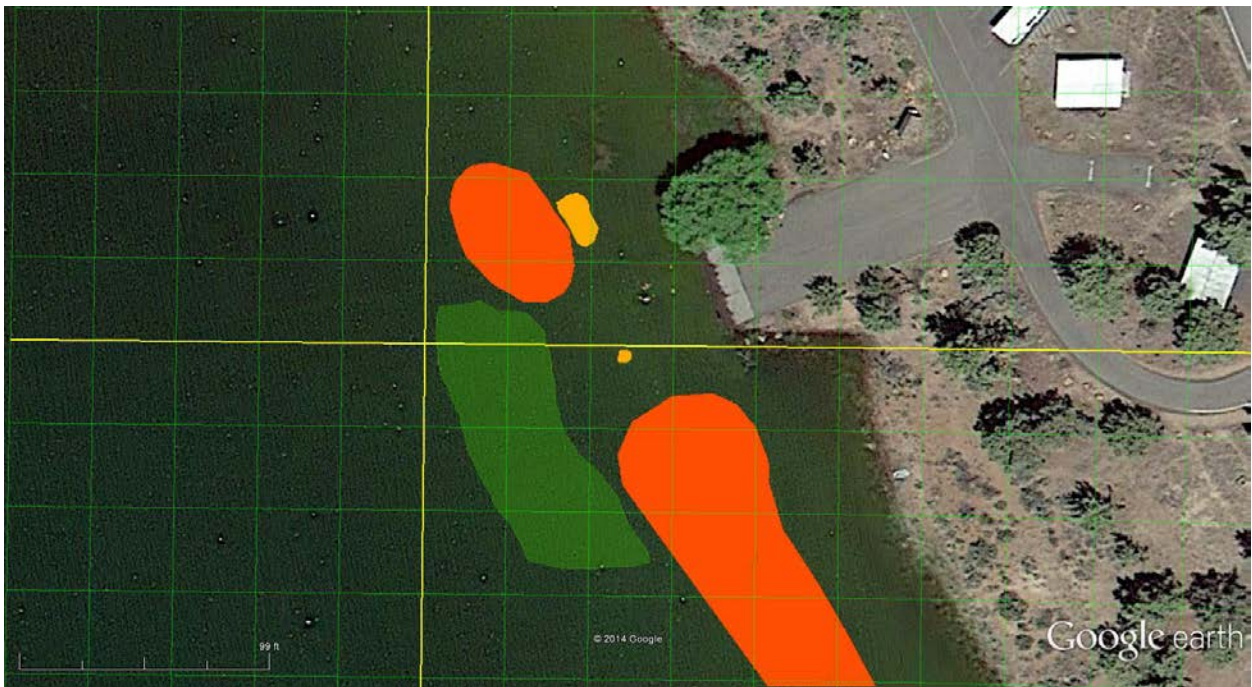


Figure 9. Aquatic plant beds at Haystack Campground boat launch, Haystack Reservoir; the green polygon represents an area of the native coontail (*Ceratophyllum demersum*); Eurasian watermilfoil (*Myriophyllum spicatum*) is represented by orange (moderate) and red (dense) polygons.

AIS Awareness Surveys

Lake Use

A total of 47 boaters were surveyed between August 12 and September 9, 2013 at Crane Prairie Reservoir, East Lake, Haystack Reservoir, and Suttle Lake. Boaters reported visiting these waterbodies chiefly for fishing and general recreation (including paddling, wildlife viewing, waterskiing, or windsurfing) and over 70% reported boating within the last month (Table 2).

Table 2. Number of days since watercraft was last used as reported by survey participants at the four targeted lakes.

| # Days | Haystack | | | | All Lakes |
|----------|---------------|-----------|-----------|-------------|-----------|
| | Crane Prairie | East Lake | Reservoir | Suttle Lake | |
| 1 | 6.3% | 0.0% | 0.0% | 6.7% | 4.3% |
| 2-6 | 12.5% | 11.1% | 0.0% | 13.3% | 10.6% |
| 7-14 | 31.3% | 11.1% | 14.3% | 26.7% | 23.4% |
| 15-31 | 25.0% | 66.7% | 28.6% | 26.7% | 34.0% |
| 31-364 | 18.8% | 11.1% | 57.1% | 20.0% | 23.4% |
| 365+ | 6.3% | 0.0% | 0.0% | 0.0% | 2.1% |
| unknown* | 0.0% | 0.0% | 0.0% | 6.7% | 2.1% |
| n = | 16 | 9 | 7 | 15 | 47 |

* One survey participant had recently purchased their boat and was therefore uncertain about the last day the boat was used.

Just three boaters were from out-of-state, each from Idaho. The remainder was from Oregon and their boats were generally last used in the same or other nearby waterbodies (Figure 5). Boaters at Suttle Lake reported the largest array of previously used waterbodies, including many central Oregon waterbodies, but also reflecting activity within the Willamette Valley, the Oregon coast, and SW Washington; this may be a reflection of Suttle Lake's popularity and position close to Highway 20. Many participants did not have a planned destination in mind for their next trip; however for those that did, East Lake was the most common response, followed by the Columbia River, Crane Prairie Reservoir, Lake Billy Chinook, Paulina Lake, and Suttle Lake (Figure 6)

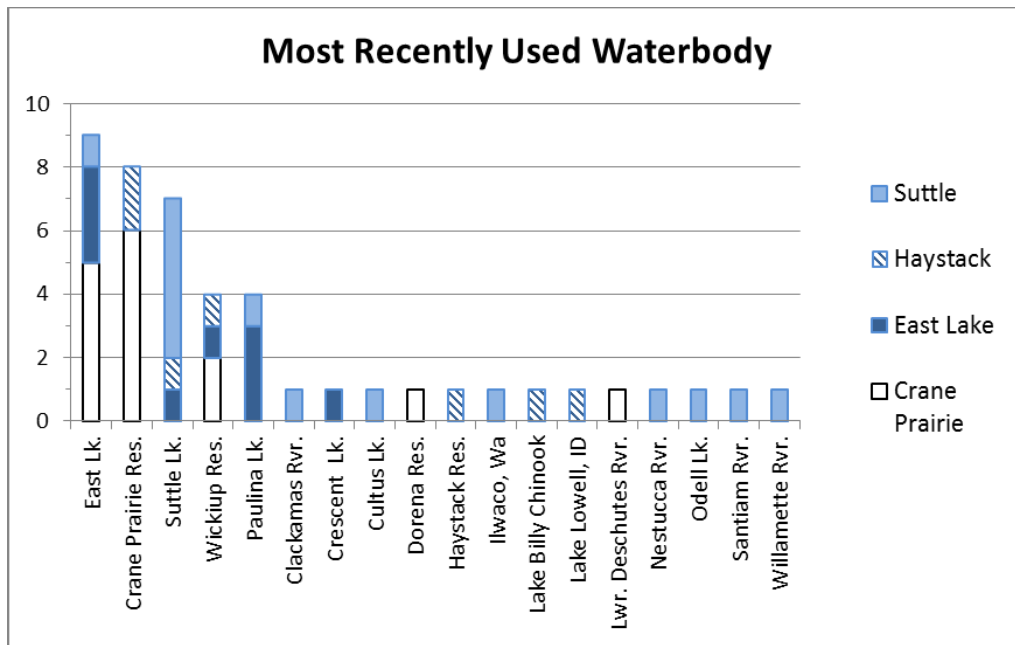


Figure 10. Most recently used waterbodies reported by survey participants at four central Oregon lakes.

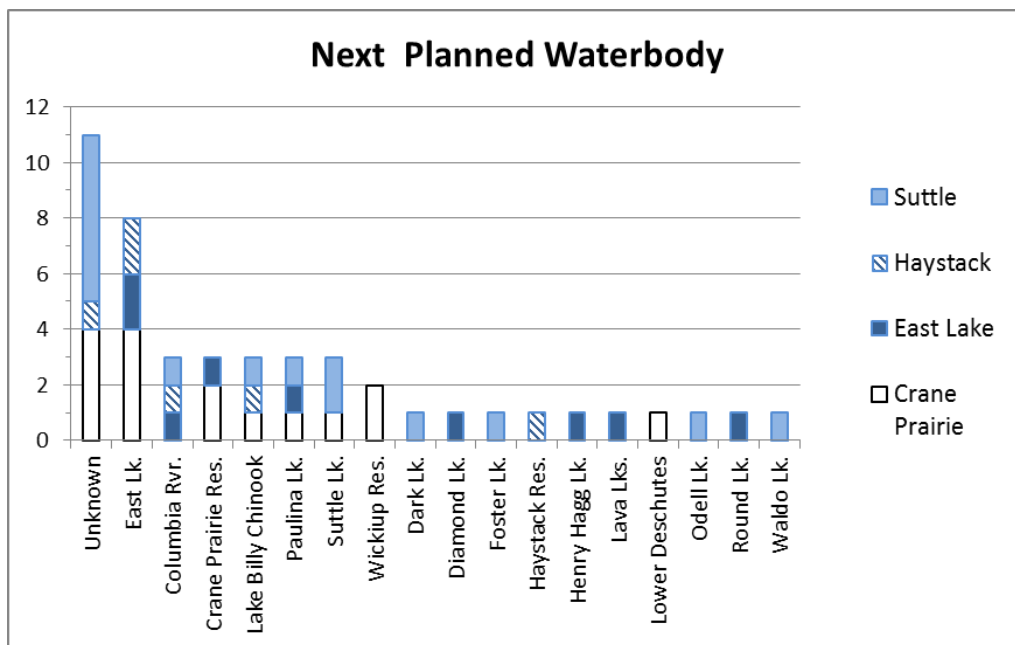


Figure 11. Next intended boating location reported by survey participants at four central Oregon lakes.

Observed & Self-Reported Boat Cleaning Behavior

Nearly all completed surveys involved boats taking out of the water (n=44), and 25.5% of observations (n=12) included both launches and take-outs. Of the boats seen leaving the water, 31.8% were observed to have vegetation and/or mud on the hull, motor or trailer upon initially

exiting the water; subsequent inspection and cleaning by the users resulted in just three boats leaving the access point with vegetation still attached. Many boaters notably did not make any attempt to empty their bilges, live wells or other standing water in their boats, resulting in nearly 30% of observed watercraft departing with potential standing water potentially on board and/or aquatic plants attached (Figure 7). Five individuals stated their intent to clean, drain, and/or dry their boat at home, but since there was no way to verify subsequent actions, we categorized their boats as uncleaned.

A large majority (81%) of people were familiar with the “Clean, Drain, Dry” slogan and reported practicing it either always (49%) or sometimes 32%) (Figure 8); of those who were unfamiliar with the phrase, many still reported practicing it consistently or occasionally. However two-thirds of those surveyed said they would use one if available (Figure 9). Two-thirds of those surveyed were willing to use a boat wash station; when the remaining third was asked what it would take to change their behavior, the majority said nothing would (often citing that they wash at home), but some noted that low cost or convenient locations could make boat wash stations a viable option (Figure 9). None of the access points surveyed at these four waterbodies had a boat wash station. Interestingly, half of those who departed without cleaning/draining their boat said they would be willing to use a boat wash station.

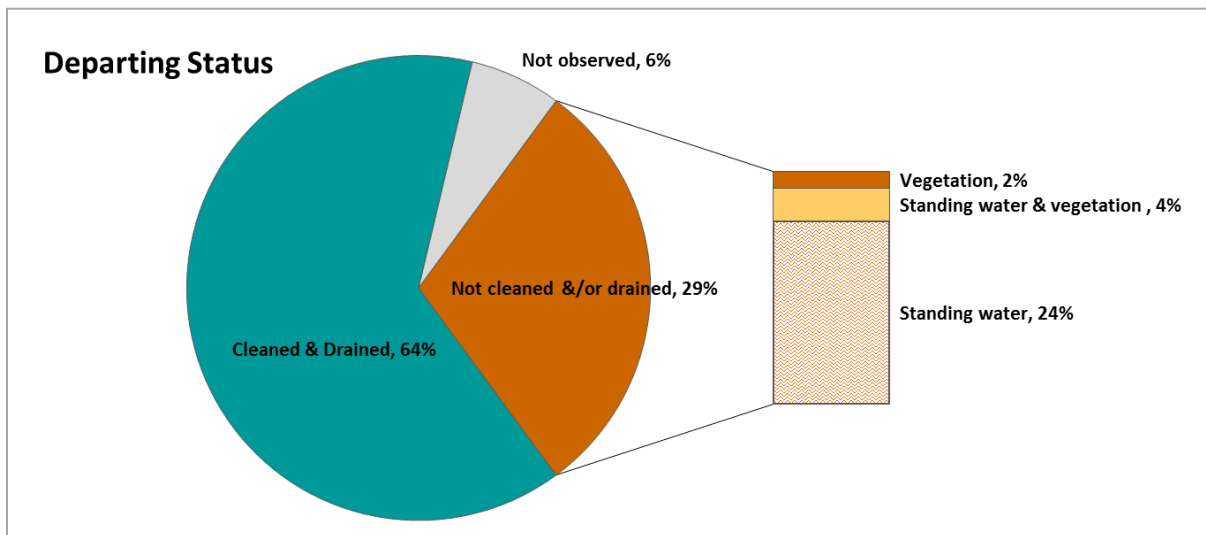


Figure 12. Status of departing watercraft at all lakes based upon whether boats and trailers were cleaned and/or drained; watercraft with standing water and/or vegetation were considered not cleaned, even if the owner suggested an intent to clean/drain them at home.

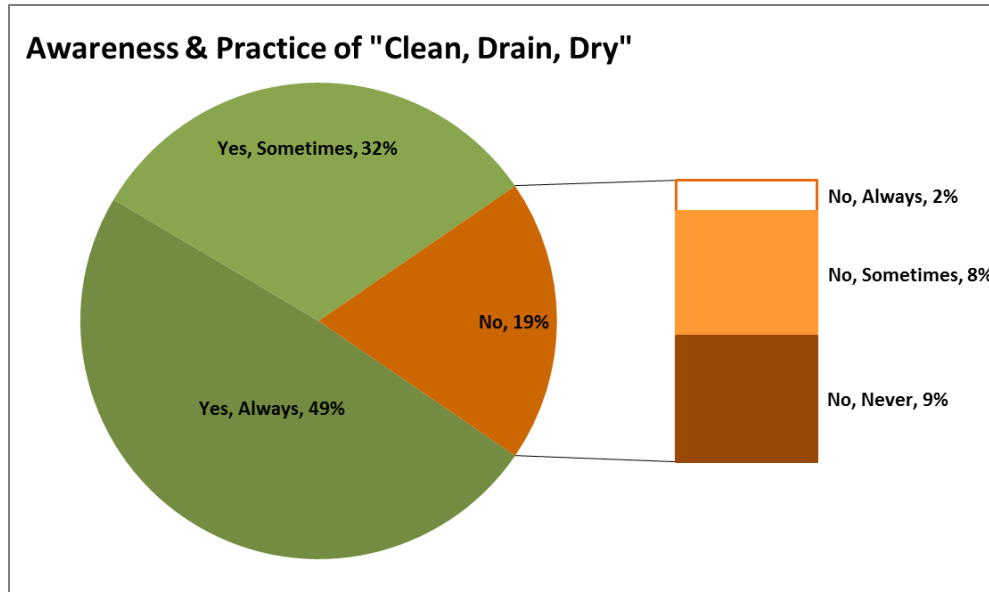


Figure 13. The percentage of survey participants (n=47) who were aware of the phrase "Clean, Drain, Dry" and their self-reported tendency to practice the involved cleaning steps.

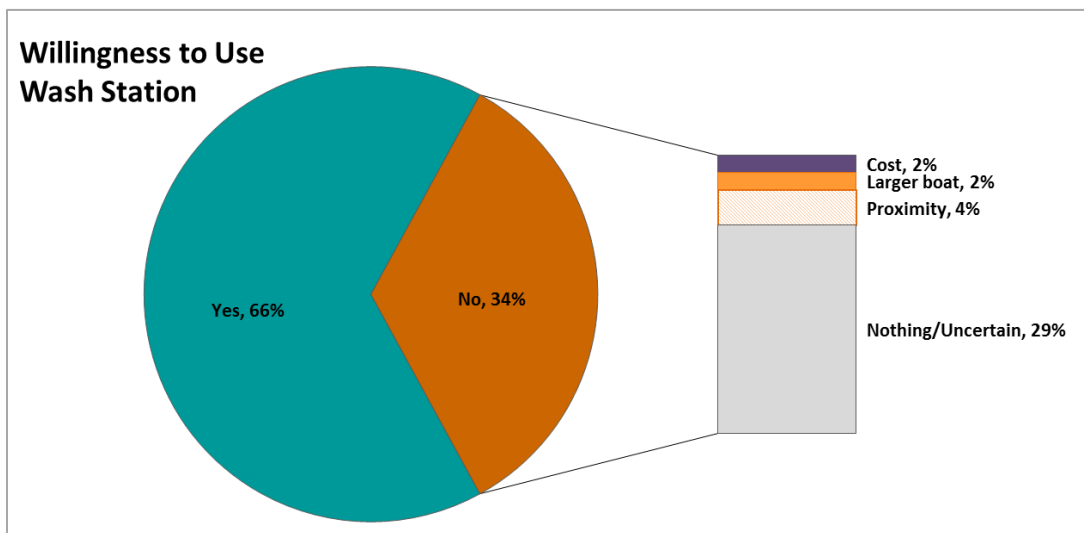


Figure 14. The percentage of survey participants (n=47) willing or unwilling to use a boat wash station; for those unwilling to use one, the factors that would potentially alter this decision.

Knowledge of Aquatic Invasive Species

Approximately 36% of respondents believe invasive species are a very important issue in Oregon, with another 64% saying it is somewhat important. That no one said invasive species were of little or no importance may result from this question being in the in-depth boater survey which was asked only of people who appeared engaged and interested in the survey. Nearly half the people surveyed reported they would be able to recognize one or more AIS; animals such as zebra mussels, quagga mussels, and New Zealand mudsnails were mentioned more frequently than plants (i.e. EWM, hydrilla, yellow flag iris, or yellow floating heart) (Figure 10). Numerous

individuals stated they would notice anything unusual based upon their familiarity with the waterbody; one respondent said his more than 40 years of history fishing at the lake would alert him if anything was “out of the ordinary”.

When asked if they had simply heard of a particular species (as opposed to being able to identify it), many were familiar with EWM, fewer reported having heard of hydrilla (*Hydrilla verticillata*), Brazilian Elodea (*Egeria densa*), zebra mussels (*Dreissena polymorpha*), and quagga mussels (*D. bugensis*) (Figure 11). Other emergent and floating leaf plants and select animals were known to single individuals. However, when next asked if they were aware that EWM had been found in that specific waterbody, just three of 28 people answered positively; two of those surveys were from Suttle Lake and one was from East Lake.³ Nearly half the respondents reported having

first-hand experience with aquatic plants negatively impacting their use of a waterbody, although not necessarily the one where the survey was conducted. Additionally, support for conducting

Familiarity with AIS Identification

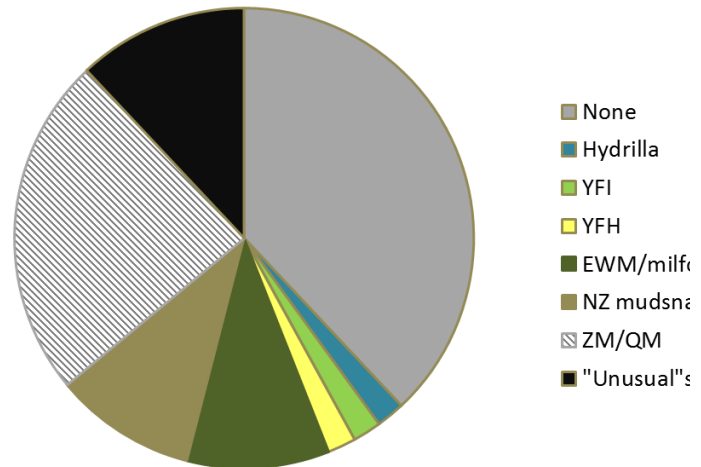


Figure 15. Survey participants self-reported familiarity with identifying AIS species.

Awareness of Specific Invasive Species

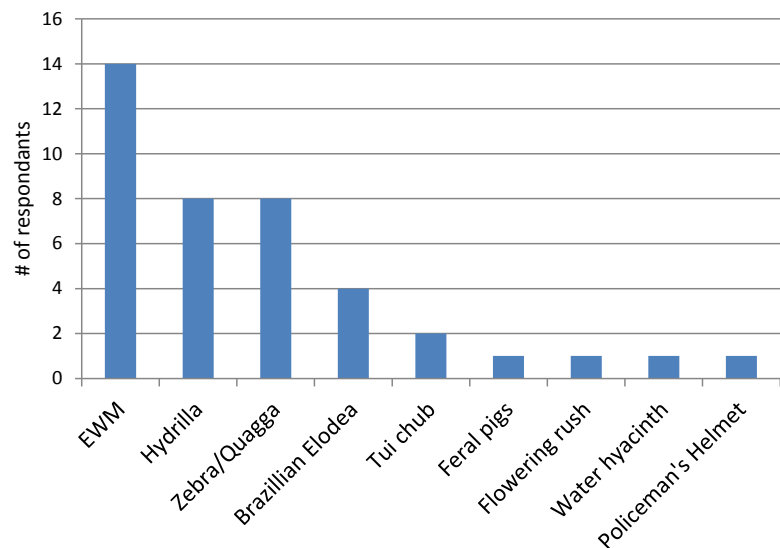


Figure 16. The number of survey participants who verbally identified various invasive species.

³ At East Lake, this question was asked in the same manner as at the other three lakes, despite our assertion that reports of EWM at East Lake are erroneous. To prevent any misunderstanding, we explained the issue of misidentification to each participant at the conclusion of the survey.

some type of control aimed at EWM was fairly high with 64.3% answering positively, 21.4% responding negatively, and another 14.3% with no defined opinion.

Public Awareness

Approximately 81% of survey participants are aware of the AIS Prevention Program permit, though few (10.6%) had ever been asked by officials to see it. Those aware of the AISPP permit requirement were more mindful of the Oregon law prohibiting launches of dirty boats than those who were not (81.6% and 66.7%, respectively) and were more familiar with the ‘Clean, Drain, Dry’ slogan (86.8% and 55.6%). Just 27.7% of the participants confirmed having gone through a boat inspection station at some point, either in Oregon (n=8) or Idaho (n=5). Signage appeared to be consistent in its visibility to boaters, with approximately 43% to 53% of people seeing AIS signs either as they were arriving or before departing (Table 3). The weakest link in the participants’ knowledge on AIS appears to be the process for reporting suspected invasive species, with three out of four people not knowing what to do if they found something they suspected to be EWM, zebra/quagga mussels, etc..

Table 3. The percentage of survey participants who reported seeing AIS related-signs either upon arrival (n=47) or upon take-out (n=43).

| Waterbody | Arriving | | Departing | | Combined | |
|---------------|----------|-------|-----------|-------|----------|-------|
| | Yes | No | Yes | No | Yes | No |
| Crane Prairie | 31.3% | 68.8% | 31.3% | 68.8% | 43.8% | 56.3% |
| Eask Lake | 44.4% | 55.6% | 44.4% | 55.6% | 42.9% | 57.1% |
| Haystack Res. | 28.6% | 71.4% | 28.6% | 57.1% | 44.4% | 55.6% |
| Suttle Lake | 60.0% | 40.0% | 40.0% | 46.7% | 53.3% | 46.7% |
| All Lakes | 42.6% | 57.4% | 36.2% | 57.4% | 46.8% | 53.2% |

Discussion

Options

Benthic barriers

Benthic barriers, sometimes referred to as bottom barriers or bottom screens, work to smother aquatic plants and deprive them of sunlight. This technique may be used to control plants in a specific place such as boat ramps, docks or swimming beaches; they may also be used as a rapid response to newly discovered weeds where hand-pulling or diver-assisted dredging is too labor and/or cost intensive. Benthic barriers will typically control most aquatic plants with the exception of floating-leaf plants like water fern (*Azolla* spp.) or unrooted submersed species like coontail (*Ceratophyllum demersum*). It is important to note that barriers are a non-selective control method – they will kill desirable native macrophytes as well as invertebrates (Eakin and Barko 1995, Ussery et al 1997).

Various materials have been used including woven synthetic fabrics, burlap, pond liner material, and perforated black Mylar; these materials must be anchored securely to the bottom in order to prevent gas build-up from decaying plant material from “ballooning” or dislodging the barrier material (Gunnison and Barko 1992). Anchors may be made of natural, local materials such as rocks or sand bags tied with twine, but are sometimes incorporated into a frame-work of wood or PVC weighted with sand or rebar. Proper and secure anchoring, along with subsequent monthly monitoring, is needed in order to ensure barriers do not lose effectiveness by lifting and allowing light penetration, or become a hazard to swimmers or navigation.

Installation of barriers is easiest during the winter or early spring before plants start actively growing. By installing when plant biomass is lowest, the risk that the barriers will billow or balloon out of place is reduced. Barriers may be deployed from boats or with assistance from snorkelers or certified SCUBA divers in deeper water areas (> 1.2 m). If water control structures are present, installation can sometimes take advantage of draw-down periods.

Managers treating EWM in Washington (Seattle City Light 2010) and oxygen weed (*Lagarosiphon major*) in Ireland (Caffrey et al. 2010) are increasingly relying upon burlap as the material of choice since it naturally degrades after two to five years and its porous nature allows gases to escape.⁴ Burlap (sometimes called ‘Geojute’) fabric 12.5’ to 20’-wide is rolled into place and then weighted with natural materials (rocks, sand bags) which decay along with the burlap ((D. Freeland, pers. comm.). More traditional barriers have been 100 sq. ft. synthetic fabric squares with sand-weighted PVC frames. These tend to last four to five years, but may require greater maintenance and associated cost since approximately 5% require repair annually and they eventually must be removed since they are made of synthetic materials. This type of barrier has been used on EWM control in Idaho’s Noxon Reservoir Clark Fork system where barriers are typically removed in the late fall due to the potential 10’ drawdown and then reinstalled in the spring (B. Burkey, pers. comm.). Recolonization by milfoil fragments or other invasive plants coming from upstream areas is a recurring problem that decreases efficacy and increases management costs.

Booms

EWM forms fragments either by allofragmentation, wherein disturbance by boat motors, waves, swimmers, etc. cause mechanical breakage of stems; or by auto-fragmentation wherein roots form along internodes near the top ~20 cm of the stem and then detach at self-induced abscission points. Auto-fragmentation occurs after EWM reaches peak biomass, typically sometime in late summer or early fall. Fragments then float, moving with the current and/or waves, until they descend to the bottom, anchor into the sediment and form new plants.

⁴ Oxygen weed (*Lagarosiphon major*), similar to EWM, is an aggressive introduced canopy-forming submerged macrophyte unknown in North America.

Floating booms are most often used to contain floating-leaf species like giant salvinia (*Salvinia molesta*); these are typically used while such plants are being chemically treated or manually or mechanically harvested. However, booms with anchored curtains of varying lengths are also available; these can be used to help prevent floating plant fragments from drifting into marinas, docks, or swimming areas. Booms placed around a launch may prevent aquatic plants from interfering with boats launching or taking-out of the water, and may help prevent new plants – accidentally introduced on boats or trailers – from spreading to distant areas of the waterbody.

Table 4. Summary of suggested non-chemical control options for Eurasian watermilfoil.

| | Benthic Barrier | Floating Boom | Diver Assisted Dredging |
|------------------------|--|---|--|
| Pros: | <ul style="list-style-type: none"> • Immediate open water • Materials readily available • Relatively easy installation | <ul style="list-style-type: none"> • Simple technology • After deployment, operation requires little input • May help contain new introductions to launch site | <ul style="list-style-type: none"> • Selectively remove only unwanted species • Allows control in difficult to reach areas (around pilings, anchors, etc.) |
| Cons: | <ul style="list-style-type: none"> • Non-selective • Ongoing maintenance (to check anchors, recolonization, etc.) • Potential damage from propeller backwash, anchors, fish hooks, etc. • difficulty with secure anchoring • Interference with fish spawning and/or benthic invertebrates | <ul style="list-style-type: none"> • Installation may disturb sediments, potential release of nutrients/toxic materials • May impede navigation • Vandalism | <ul style="list-style-type: none"> • Disturbance to sediment, potential release of nutrients/toxic materials • Difficulty removing root crowns of plants in rocky or hard sediment • Less effective on plants with seeds, turions, tubers |
| Estimated Cost: | \$0.40-0.50/sq.ft. | \$5-\$16/ft. | \$1,500 to \$2,000/day ¼ to 1 acre/day (density dependent) |

Diver-assisted Dredging

SCUBA divers using hoses attached to small dredges can selectively suction plant material from the sediment, thereby removing all of the weed's vegetative fragments and roots. Divers trained to recognize the target plant(s) can accurately remove just those, thereby retaining desirable natives and reducing disturbance. Targeted plant material is suctioned out of the water and deposited into a screened basket; water and loose sediment can be returned to the water, though especially turbid water should be directed to an area screened-in with a silt curtain to reduce impacts to the surrounding area. This method is quite effective in areas with looser sediments since the entire plant is readily removed; root crowns of EWM can be difficult to remove in rocky or harder sediments, but can often be dislodged with a knife or other sharp tool.

In areas with shallow, clear water, snorkeling and hand-removal of plants can be an effective simplified alternative to diver-dredging, but care must be taken to ensure the swimmers safety and to minimize spread of plant fragments. Hand-removal is typically only effective in localized areas to control low-density populations of EWM or other weeds.

Alternative Options

A variety of different control options for EWM might apply in other settings, but are not covered in-depth here because of issues with cost effectiveness and/or risk of exacerbating the infestations. The use of biological control and cutting are briefly discussed below.

- Milfoil weevil (*Euhrychiopsis lecontei*) – an insect native to North America and typically found on northern watermilfoil (*M. sibiricum*), but that preferentially feeds upon EWM. High cost and potential predation by fish make this a less viable option for control of EWM in these central Oregon lakes. Use of grass carp (*Ctenopharyngodon idella*) has been successful in controlling EWM, but strict restrictions by ODFW prevents use of grass carp in any water with public access, within the 100-yr floodplain or that cannot be screened at all inlets and outlets.
- Cutting involves simply removing the tops of plants either with a boat-mounted blade/sickle-bar (in deeper water areas) or a weighted V-shaped cutting blade designed to be thrown and dragged along the sediment, thereby cutting plants off at the root crown (in shallower areas). Large rafts of floating plant material then float to the surface, and must be removed to prevent them becoming a nuisance to recreational users and to eliminate spreading plant fragments into other areas.

Discussion

Multiple infestations of EWM in central Oregon within recent years are troubling, with the potential for wide-ranging negative impacts upon both the environment and recreational uses of lakes, reservoirs and slow-water river areas. Movement of EWM and other aquatic plants into this area is likely the result of accidental transport with boats and/or movement with waterfowl. But in sum, waterbodies in central Oregon have not been heavily impacted by EWM or many other aquatic invasive plants when compared to areas west of the Cascades or many other areas in the United States. Sites surveyed in 2009 by the Deschutes National Forest and in 2011 & 2012 by the Crooked River Weed Management Area showed only four confirmed EWM sites: Crane Prairie, Haystack Reservoir, Suttle Lake and Warner pond (a privately owned pond downstream of Suttle Lake). A fragment of EWM found in the Metolius Arm of Lake Billy Chinook (id confirmed by genetic analysis) suggests EWM is likely on the move from upstream infestations.

Thus, preventing or restricting the movement of EWM to any new waterbodies is desirable wherever possible. Controlling infestations at these three publicly accessible waterbodies will improve chances of regionally eradicating this noxious weed; help avoid negative impacts at other valued recreational boating and fishing locations, like Lake Billy Chinook or Wickiup Reservoir; and reduce impacts to irrigators such as those downstream of Haystack Reservoir.

The heaviest growths of EWM in the region appear to be at Haystack Reservoir; both access points, Haystack West and the eastern Haystack Campground, have considerable stands established within 100' of the launches. Benthic barriers could reduce chances of boaters exiting

the water with EWM attached, however since this lake often has large daily and seasonal water-level fluctuations, regular maintenance would be required to check for barriers lifting due to prop-wash, entanglement with fishing hooks or billowing due to plant decay. Additionally, barriers are generally not recommended in depths of less than six feet. Thus, the combination of water-level fluctuations and the gradual slope of the areas surrounding both of these access points would limit the area to which barriers could be applied. And given the extent of the infestation elsewhere in the lake, the long-term effectiveness of this method would be reduced by recolonization by EWM fragments on top of the barriers. For these reasons, we do not suggest use of benthic barriers at Haystack, but rather increased EWM-specific signage at all access points in order to increase boater awareness and improve consistent use of proper cleaning procedures.

Single small patches of EWM were found near two ramps at Suttle Lake; each less than 3 m in diameter. Both sites were in areas with sufficient water depth to avoid complications with prop-wash and had suitably uniform substrates. Benthic barriers would therefore seem a suitable option for control of these patches. Careful removal by diver-assisted dredging could also prove effective in these areas, but we would recommend whole-lake surveys to identify other areas for possible control first.

According to comprehensive surveys conducted at Crane Prairie Reservoir in 2009, EWM is fairly widely distributed there, with an estimated five acres estimated in the northern section between the Deschutes River and Cultus Creek inlets and scattered other populations (Nelson 2009). EWM does not appear to have heavily infested any of the boat ramp areas since 2009; just the Quinn River campground launch was found to have EWM growing nearby, though it is not impeding use of the launch area or the channel to deeper water. Rather, the EWM here was restricted to one shallow water area, intermixed with many native plants. Since the use of benthic barriers would indiscriminately kill all plants, we would advise against this method at this site. Alternatively, manual removal by trained personnel could be conducted by on foot or by snorkeling; uprooted plants could easily be disposed of well above the waterline. This method would minimize disturbance to native plants including the native watermilfoil. Because Crane Prairie is so shallow and heavily trafficked by boaters, the use of floating booms to mark dense populations of EWM may reduce allofragmentation and subsequent spread; appropriate signage attached to the booms could also serve deliver an educational message regarding EWM and the need for following “Clean, Drain, Dry” upon departure.

Difficulties with proper identification and occasional heavy-growths of native milfoils have understandably caused confusion in some cases. The history at East Lake readily demonstrates this. Initial reports of EWM from East Lake came from reliable sources, but had no documentation (herbarium submissions, photographs or genetic analysis). However, subsequent sampling by multiple agencies and multiple samples sent for genetic analysis show no evidence of EWM in East Lake, but do confirm healthy (sparse to dense growths) of two native milfoils.

Recommendations

- Confirm any suspected EWM populations with genetic testing, botanists familiar with aquatic macrophytes, and pressed specimens; previous genetic tests conducted through Molecular Ecology Laboratory at Grand Valley State University.
- Prioritize regular early detection surveys for Paulina Lake, Wickiup Reservoir, Lake Billy Chinook (especially the Metolius River arm).
- Extend outreach to Oregon State Police, Fish & Wildlife Division, as well as local irrigators (e.g., North Unit Irrigation District, Central Oregon Irrigation Unit, Tumalo Irrigation District).
- Encourage resort owners and campground operators to post EWM-specific signs where appropriate (i.e., for confirmed infestations) and general AIS signs that convey a consistent message regarding reporting of AIS and the “Clean-Drain-Dry” message.
- Stay informed of EWM control efforts on private properties to gather a complete picture of regional efficacy data for chemical treatments, drawdown, etc.
- Review signage at launches near infested waterways to ensure reporting guidelines are consistent and clear.

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Appendix A

Central Oregon Milfoil Containment 2013

Step 1: Observational Survey (to be filled out by researcher)

1. Coming from in state/out of state? _____ If out of state, name: _____
2. Kind of boat (motorized, non-motorized, canoe, fishing): _____
3. Details about the day (fishing tournament, etc): _____
4. Did the boat launch clean (no vegetation or invertebrates)? _____
5. Did the boat leave clean? _____
If not, what was on it (vegetation, invertebrates)? _____
6. Was there any effort to remove the fouling organisms? _____
Drain bilge/live well? _____

Step 2: Boater Survey (to be filled out by researcher)

1. When was the last time your boat was in the water? _____
2. What waterbody did you and your boat come from? _____
What waterbody are you visiting next? _____
How many waterbodies have you visited in the last month? _____
3. Do you know about the invasive species prevention program permit? ___yes ___no
 - a. Have you ever been asked to show your permit? ___yes ___no
4. Are you aware of the phrase "clean, drain, dry"? ___yes ___no
 - a. Have you done this before? ___always ___sometimes ___never
 - b. Do you know which parts of the boat might be susceptible to invasive species attachment?
___yes ___no
5. Have you ever been through a boat inspection station?
 - a. Oregon
 - b. other: _____
6. Would you use a boat wash station at a boat ramp? ___yes ___no
 - a. If no, what would it take for you to change your behavior?

7. Are you aware of a state law that prohibits launching a boat that has invasive species on it?
___yes ___no
8. Do you know how to report a suspected invasive species? ___yes ___no
 - a. Would you be able recognize or name an invasive species? ___yes ___no

9. Did you see any signage regarding invasive species when you arrived at the lake?
___yes ___no
Left the lake? ___yes ___no

Central Oregon Milfoil Containment 2013

Step 3: In-Depth Boater Survey (to be filled out by researcher)

1. How important are invasive species as an issue in Oregon?
___very ___somewhat ___not at all
2. Have you heard of Hydrilla? Eurasian watermilfoil (EWM)? Brazilian elodea?
 - a. Others _____?
3. Do you know that EWM has been found in this lake?
___yes ___no
4. How informed are you regarding aquatic weed control options?
___ very informed ___ somewhat informed ___ uninformed
5. In your experience, have aquatic plants negatively impacted your use of a waterbody?
___ yes ___ no ___ no opinion
6. Are you in favor of controlling EWM here? ___ yes ___ no ___ no opinion

Central Oregon Milfoil Containment 2013



Department of Environmental Science and Management

PO Box 751 503-725-4982 tel
Portland, Oregon 97207-0751 503-725-9040 fax

Informed Consent

You are invited to participate in a research study conducted by Professors Angela Strecker and Mark Sytsma from Portland State University, Department of Environmental Science and Management. These researchers hope to learn about boater behavior and attitudes on aquatic invasive species. You were selected as a possible participant in this study because you are a boater here at one of our focus locations (Tenmile Lake, Crane Prairie Reservoir, Haystack Reservoir, East Lake or Suttle Lake).

If you decide to participate, you will be asked to verbally answer questions. The first part of the survey will last approximately 10 minutes. If you agree to answer the more in-depth questions, this second part of the survey will last approximately 15 minutes. While participating in this study, it is possible that you will feel some embarrassment or discomfort, at which point the interviewer will disregard your responses or will terminate the interview. You may not receive any direct benefit from taking part in this study, but the study may help to increase knowledge which may help others in the future. To encourage participation, we will enter your name in a draw for a \$50 gift certificate from a local vendor.

Any information that is obtained in connection with this study and that can be linked to you or identify you will be kept private and will not be shared. This information will be kept private by storage at Portland State University in a password-protected computer file. Paper copies will be kept in a locked filing cabinet.

Your participation is voluntary. You do not have to take part in this study and you may withdraw from this study at any time.

If you have questions or concerns about your participation in this study, contact Angela Strecker (strecker@pdx.edu, 503-725-2427) or Mark Sytsma (sytsma@pdx.edu, 503-725-2213) at PO Box 751, Portland State University, Portland OR 97201. If you have concerns about your rights as a research subject, please contact Human Subjects Research Review Committee, Research and Strategic Partnerships, PO Box 751, Portland State University, Portland OR 97207-0751 (hsrrc@lists.pdx.edu, 1-877-480-4400).

Please indicate to the researcher that you have read and understand the above information and agree to take part in this study. The researcher will provide you with a copy of this form for your own records.

Appendix B

Table 5. AIS related signs at surveyed boat launches with specifics components noted.

| Lake / Access Point | Help Wanted | | | | | Stop Aquatic Hitchhikers | | NOTES |
|--------------------------------|------------------|---------------------------------|-------------------------|---|---|--------------------------|--------------|-------|
| | EWM (USFS) | Stop Harmful Species (multiple) | Stop OR Invaders (OSMB) | Non-Motorized Boaters AISPP (OSMB/ODFW) | ZM Notice (BOR) | (BOR) | | |
| Crane Prairie Reservoir | | | | | | | | |
| Browns Mountain | | | | | | | | None |
| Rock Creek Campground | x | | | | | | | |
| Quinn River | x | | x | | | | | |
| Cow Meadow | x | | | | | | | |
| Day Use Area | x | | | | | | | |
| Campground | X | | | | | | | |
| Crane Prairie Resort | | | | | | | | None |
| Haystack Lake | | | | | | | | |
| Haystack Campground | | | | | | | x | |
| Haystack West | | | | x | x | | | |
| Suttle Lake | | | | | | | | |
| Water Ski Area | x | x | | | | | | |
| South Shore Campground | x | x | | | | | | |
| Link Creek Campground | x | x | | | | | | |
| Blue Bay Campground | x | x | | | | | | |
| Lodge at Suttle Lake | | | | | | | | None |
| Cinder Beach Day Use Area | | | | | | | | None |
| East Lake | | | | | | | | |
| Cinder Hill - North | | | | | | | | None |
| Cinder Hill - South | | x | | | | | | |
| Campground | | x | | | | | | |
| East Lake Resort | | | | | | | | None |
| Hot Springs Ramp | | x | | | | | | |
| Sign Details | | | | | | | | |
| Clean, Drain, Dry | Yes (indirectly) | Yes (indirectly, 5 days) | No | yes (dry "if possible") 866-INVADER | Yes (indirectly, dry for 2 days) 303-236-4007 ext 221 or contact locally: (blank) | Yes | | |
| Reporting | 866-INVADER | 866-INVADER | None | www.oregoninvasaivehotline.org | | | 877-STOP-ANS | |
| Milfoil specifics? | Yes | No | No | No | No | No | No | |
| AISPP Information | No | No | No | Yes | No | No | No | |
| Dirty Launches | Yes | No | Yes | No | No | No | No | |
| Transport of AIS | No | Yes | No | No | No | No | No | |



Figure 17. USFS "Help Wanted" sign.



Figure 18. Multi-agency "Stop Harmful Species" sign.



Figure 19. BOR "Stop Aquatic Hitchhikers" sign.



Figure 20. OSMB "Stop Oregon's Invaders" sign.



Figure 21. OSMB/ODFW "Non-motorized boaters" sign.

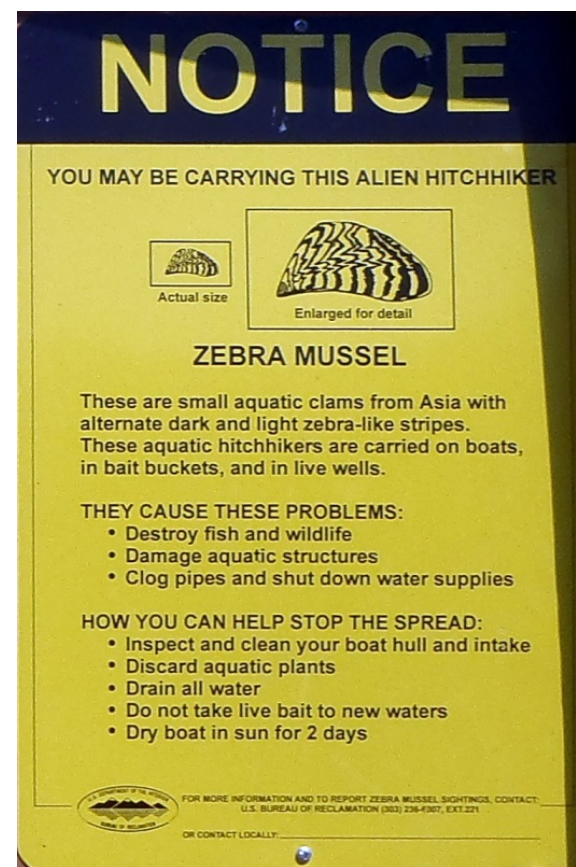


Figure 22. BOR "Zebra Mussel Notice" sign.