Pest Risk Assessment for Hydrilla in Oregon

IDENTITY
Name: Hydrilla verticillata
Taxonomic Position: class Liliopsida, order Hydrocharitales, family Hydrocharitaceae, genus Hydrilla Rich., species Hydrilla verticillata (L. f.) Royle
Common names: Hydrilla, water thyme, Florida Elodea, Indian starvine

RISK RATING SUMMARY
Relative Risk Rating: High to Very High
Numerical Score: 9 (on a 1-9 scale)
Uncertainty: Low

The level of uncertainty is allocated based on extensive research on the species at different locations under various habitat conditions. Studies of the species go back several decades all indicating similar conclusions. For this particular species, there is no reason to assume any different establishment or spread pattern or economic and environmental consequence.

RECOMMENDATION
Oregon has abundant freshwater resources that are vulnerable to a large scale *Hydrilla verticillata* infestation due to suitable habitat conditions and constant commercial and recreational traffic between Oregon and states with existing infestations. Considering the ease of transportation, it is our conclusion that a high propagule pressure of hydrilla already exists therefore there is a high to very high risk of establishment in Oregon. In the case of a successful establishment, Oregon would face potentially large economic and

environmental costs. Thus Oregon needs to continue its efforts to keep hydrilla out of the State. In order to effectively prevent an invasion education and inspections of aquaria businesses and nurseries selling pond species must be continued, educational programs for the general public further developed and implemented, and existing state laws enforced. Most importantly the "Never Launch a Dirty Boat" campaign should continue to include Hydrilla as a high priority species in its message about the importance of removing all vegetation and AIS from boats before they enter Oregon waters.

RISK RATING DETAILS

Establishment Potential is High to Very High

Justification: *Hydrilla verticillata* typically infests freshwater lakes, ponds, rivers, canals and man-made reservoirs in temperate climate zones. It is one of the most invasive aquatic plants ever introduced to the United States. Native to Asia, it readily occurs in Europe, Australia, New Zealand, North and South America, Africa and Pacific Islands. It was first imported to the United States from Sri Lanka by a tropical fish and plant farmer and sent to another merchant in Florida in 1951 or 1952 (Schmitz et al. 1988). Either by the deliberate or negligent actions of that business owner, hydrilla was introduced to the Black Creek in the City of Miami and became well established by 1959 in many drainage basins of the state of Florida. Although infestation became noticeable in early 1960s, misidentification of this previously unknown species delayed any serious efforts by the Florida authorities to develop an action plan to control the spread. Correct identification was done in the late 1960s by Dr. Harold St. John (Blackburn et al. 1969).

It is evident that multiple introductions of hydrilla occurred in the United States based on the fact that two out of the 24 worldwide known forms of the species exist in different parts of the country (Les et al. 1997). The first introduction in Florida is of the female strain of dioecious hydrilla known as Hydrilla I and second introduction is of the monoecious hydrilla known as Hydrilla II thought to have happened in 1980s from Korea (Madeira et al. 1997).

Hydrilla is a remarkably adaptable plant that can establish almost in any still or slow-moving freshwater environment and tolerate a wide range of trophic water states (from oligotrophic to eutrophic), alkalinity, pH levels (between 4 and 8.5 with ideal of 7), depth (up to 15 meters), sprouting and growth temperatures (ideal for monoecious from 11 C° to 22 C° and for dioecious from 8 C° to 17 C°). Although it prefers enriched and disturbed areas, it can survive and proliferate in a variety of environments. In a low biodiversity environment it can elongate as fast as 1 inch/day or grow about 450 mg/g/week. Hydrilla can easily compensate low light (as low as 1%) and carbon dioxide levels. (Current Status and Distribution Report, 2007, DNRWI)

In 2008, the US Geological Survey reported occurrences of hydrilla in 19 states east of Mississippi and in 8 states west of the Mississippi River. In Florida, the most invaded state, hydrilla became the most abundant aquatic plant estimated to infestat over seventy percent of the public water in the State. East of the Mississippi River, New York and

Kentucky were the latest addition to the list after the identification of hydrilla in both states in 2008. Louisiana has the most abundant occurrences west of the Mississippi.

Oregon's neighbors California, Washington and Idaho reported first hydrilla discoveries in 1976, 1995 and 2008, respectively. In California, hydrilla is estimated to have been introduced in 30 different locations. Since then, with the persistent effort of the authorities, 22 of those infestations have been eradicated (Hydrilla Annual Report: 2009, CDFA). The success of two major eradication projects in Clear Lake and the Chowchilla River are the highlights of the long-lasting battle against hydrilla. As of 2009,no new discoveries have been reported in California. In order to achieve success, California has implemented an aggressive Hydrilla Plan whose goal is to eradicate the hydrilla completely from the state (Hydrilla Annual Report: 2009, CDFA)

After the discovery of hydrilla in Pipe Lake and Lucern Lake in the State of Washington, the analysis indicated the type of hydrilla is monoecious. These two lakes are connected by a small canal therefore are affected by any introduction of hydrilla in any one of the lakes. Hydrilla has been thought to have been first introduced to Pipe Lake along with the exotic water lilies that had been present for several years before the identification of hydrilla by the state authorities. The State of Washington promptly started the eradication efforts by using herbicides and hand-pulling methods. Efforts continued until 2007 after which no hydrilla plants were found in either lake. Washington continues its survey to promptly detect any new occurrence. (Water Quality: Hydrilla, 2010, DESW)

In Idaho, hydrilla infestation was discovered in Bruneau River and Boise River in 2008. The State of Idaho took immediate eradication action by implementing herbicide treatment, hand-pulling and diver-assisted suction dredging methods. As of 2009 no newhydrilla has been reported but state continues to survey both rivers (Invasive Species Program, 2009, ISDA).

Although there has not yet been any known occurrences of hydrilla, Oregon seems to be in high risk for hydrilla infestation due to the abundance of suitable environments and proximity to the infested states, California, Washington and Idaho. It is logical to assume high propagule pressure because of the commercial and recreational exchanges between states. As of 2010, hydrilla is on the Noxious Weed List of the state and there is an aggressive and comprehensive effort to keep hydrilla out of the state. Oregon passed House Bill 2118 giving Department of Agriculture responsibility to develop noxious weed prevention plans, create education programs, establish partnerships with stakeholders and provide recommendations to effectively fight invasive species (Oregon Noxious Weed Strategic Plan, ODA).

Spread Potential is High to Very High

Justification: Hydrilla is a very efficient aquatic weed that has a remarkable potential to survive and spread in various environments. Hydrilla can easily establish in a wide range of temperature, pH, light and salinity levels. It effectively competes and displaces native plants. It is known to have spread over the areas from 40° north latitude to 50° north latitude in the continental United States and Europe. Northernmost growth potential of hydrilla is still unknown to scientists. The monoecious variety is thought to have a greater potential to grow more easily in temperate areas due to high adaptability of its tuber growth to short photoperiods. (Langeland, 1996).

Hydrilla can reproduce in four different ways: spread of fragments, growth of tubers and turions and disbursement of seeds. Once it takes root (commonly around boat ramps), hydrilla can grow above ground stems called stolons and underground stems called rhizomes (or tubers) in as little as two growing periods. At maturity in late fall, turions (buds) break off from the stolon and stay dormant until conditions are suitable for growth, typically early spring. Tubers continue to grow into new stems even after the parent stolon is destroyed or decomposed. Both tubers and turions can stay dormant for extensive periods of times under unfavorable conditions. Dioecious variety can survive lot longer than monoecious variety, up to ten years.

Local spread of hydrilla happens with the growth of stolons and rhizomes while long-distance spread occurs with the relocation of fragments, turions and seeds. Up to 50% of fragments of hydrilla with a single whorl of leaves are thought to have a growth potential into new plants (Langeland and Sutton, 1980). Recreational and commercial exchanges between states pose the highest risk of spread of hydrilla due to transportation of small fragments of hydrilla carried under boats and other commercial and recreational vehicles. Hydrilla typically first establishes around the boat ramps suggesting human-aided transportation. Turions may also be carried under the boats or they may float between the connected bodies of waters. Although regurgitation of seeds by birds is one of the ways in which hydrilla can be distributed, the overall share of this method of distribution is negligible compare to fragment and turion transportations therefore it is not a great concern.

In addition to natural and unintentional boat-aided methods of spread, deliberate and/or uninformed actions by some nurseries that carry pond plants and aquariabusinesses continue to be a problem for many states. In California, for example, hydrilla was detected five different times and each time local counties took immediate action to remove the plant and clean the area to prevent any infestation (Hydrilla Eradication Report, 2008, CDFA).

In order to control hydrilla, use of low concentration fluridone (5-10 ppb) has been the most popular method since 1980 along with some other methods such as use of other herbicides, sterile triploid grass carp, mechanical harvesting, large and small scale dredging, water draw down followed by drying of hydrosoil. In the US many states successfully eradicated or at least controlled hydrilla mainly with fluridone while other methods have been either not as effective or too costly. Evidently, hydrilla became resistant to low concentration fluridone in time and needs to be treated with either high concentration fluridone or another control method. Therefore, each state in the United States uses combination of several methods based on the scale of the problem and availability of funding.

California's efforts to eradicate hydrilla in Clear Lake resulted in a great reduction of occurrence from 196 identified spots to 76 in 2009 (Hydrilla Annual Report: 2009, CDFA). State used an integrated pest management approach that combines manual removal, small and large scale dredging, biological control and aquatic herbicides (primarily fluridone). Although alleviated by the treatment, as one of the nearest infested bodies of water to Oregon, Clear Lake still poses a great risk due to the boating and fishing tourism. Spread potential of hydrilla in Oregon will be very highly correlated to the success of California in its eradication program.

Hydrilla treatment efforts along Boise River in Idaho near Oregon have been very effective since 2008. Keeping hydrilla out of Boise River will certainly lower the risk for Oregon, however, successful establishment and survival of hydrilla throughout the United States indicates high possibility of recurrence. (Invasive Species Program, 2009, ISDA).

Continuous recreational and commercial traffic between Oregon and neighboring states combined with the declining funding to fight invasive species exposes Oregon to a constant risk. Although Oregon remains to be unaffected, multiple introductions of hydrilla, considering its remarkable ability to establish, can create problems especially if they go unnoticed.

Economic Impact Potential is High

Justification: Since its establishment in the United States, hydrilla causes significant economic losses to various communities. Its growth pattern enables hydrilla to proliferate very quickly and detrimentally affect the water use. It significantly reduces the water collection and distribution in drainage canals, irrigation systems, dam trash racks, utility cooling reservoirs and various other structures that are used in agriculture, power generation and many other industries. Hydrilla interferes with commercial and recreational activities such as boating, fishing, swimming, waterskiing, tourism, and real estate development and sales. Although some scientists argue that hydrilla offers a suitable habitat for largemouth bass and economically benefits the fisheries, there is also counterargument that if the density of hydrilla exceeds 30%, it adversely affects the bass growth therefore harms the businesses (Colle and Shireman, 1980). In addition to the loss of value of commercial and recreational activities, cost of hydrilla management imposes a huge burden to the communities. In 1999, scientists faced a new challenge that hydrilla in some treatment areas became resistant to low concentration and required a higher concentration of fluridone (15 to 50 ppb) (Netherland, 1999). That not only has increased the cost of treatment of hydrilla, but also presented a danger to non-target aquatic plants. Research and development of new hydrilla treatment methods has become a necessity thus pushing the cost up even further.

Many of the potential economic losses caused by hydrilla have not been fully studied yet but many states spend millions of dollars every year to alleviate the overall impact of hydrilla to each locality. State of Florida, where hydrilla is by far the worst aquatic invader, spent over $50 million to eradicate it in 1980s until 1991. Florida estimated to have spent $10 million and $15 million in 1995 and 1996, respectively. In 2004, Florida spent $2 million to $3 million to control hydrilla in Lake Tohopekaliga alone. Although Florida by far spends the most money for hydrilla management, cost of cleaning to other states has been significant as well. South and North Carolina spend over $3 million every year. In 1991, hydrilla infestation in a hydroelectric plant in South Carolina resulted in a $2.5 million cleaning and repair costs in addition to $2 million in lost electricity production. It costs $1,200 per acre to harvest hydrilla in Potomac River in order to clear the way for boats while Washington spends $100,000 every year for only two lakes in King County. Massachusetts reported a cost of $40,000 per year to clean only one pond in Barnstable County. Between the years of 2003 and 2006, Maine spent around $25,000 to control hydrilla in Pickerel Pond (Northeast Aquatic Nuisance Species Panel, 2009).

In addition to cleaning costs, loss of revenue has been a burden for industries that depend on the water quality and biodiversity. Florida has estimated to have lost 32% of the fish population to mechanical cleaning of hydrilla in Lake Orange that cost the state $6,000 per hectare. Largemouth bass weight and overall growth are significantly less in the areas where hydrilla covers the majority of the water surface versus areas that has lower density of hydrilla. States such as Alabama, Florida and Georgia that have large revenues from recreational largemouth bass fishing were impacted by the decline in number of visitors since the hydrilla infestation started.

Other potential economic impacts include the increased risk of flood where hydrilla clogs the drainage canals. Lakefront properties are at an increased risk at hydrilla dominated locations. Currently, there is no strong consensus on how much the risk of flood increases in hydrilla infested areas. The outcome of a simulation model for Lake Istokpoga ran by South Florida Water Management District in 1993 suggests that in worst-case scenario of 50% infestation of the lake, flood risk to the surrounding area is doubled relative to the low density infestation. In spite of lack of definite risk and potential loss figures, Florida continues to evaluate flood risk in all the infested areas to be able to develop aquatic management plans to eliminate the risk.

Environmental Impact Potential is Very High

Justification: The growth pattern of hydrilla gives it a significant advantage over native species in areas where hydrilla successfully establishes and spreads. In heavily affected areas, it occupies 50% to 70% of the top 0.5% of the water column and forms canopies. Formation of canopies reducethe light penetration altering oxygen and water circulations (Schmitz et al. 1988). Thick canopies considerably reduce the levels dissolved oxygen, turbidity, pH, alkalinity, chlorophyll, color and phosphorus (Schmitz et al. 1993). Due to these changes, hydrilla replaces the native vegetation and becomes a monoculture. (Sutton 1986). A study conducted by Lewisville Aquatic Ecosystem Research Facility (LAERF) in Lewisville, Texas in 21 ponds confirmed the detrimental effect of hydrilla on native vegetation. In the first growing season, American pondweed, southern naiad and muskgrass (all native plants) ranged in coverage between 30 to 90 percent. By the second growing season, hydrilla became well established and successfully outcompeted both naiad and muskgrass fully and pondweed partially (Grodowitz et al. 2007).

In densely populated areas, hydrilla alters the habitats of fish and other aquatic species by affecting nutrient cycles. It causes major shifts in the richness of zooplankton and epiphytic and benthic micro invertebrates, major sources of aquatic species. Reports from heavily infested areas indicate that hydrilla coverage significantly decreases sizes and the overall numbers of highly valued game fish including largemouth bass, bluegill, redear and black crappie (Colle and Shireman 1980). A study in 1983 by the EPA's Environmental Research Laboratory, Gulf Breeze, Florida reported a great shift in the density of microinvertebrates in Orange Lake and Lake Pearl when hydrilla coverage exceeded 60% due to the more favorable habitat conditions. Vegetation density provided a safe breeding environment for microinvertebrates and a competitive advantage to small fish over large sportfish such as largemouth bass in predator dominance. The overall population and the size of the sportfish declined significantly during the periods in which hydrilla was dominant vegetation. With the control and eradication efforts, the trend was reversed in favor of large sportfish (Shireman et al. 1983).

Waterfowl enthusiast argue that hydrilla, like other submerged plants, provides food and habitat for waterfowl. However, the cost of hydrilla to the overall ecosystem significantly surpasses the benefit to waterfowl, therefore, the persistent effort to control and eradication of hydrilla is recommended.

BIBLIOGRAPHY

Blackburn, R. D., R. W. Weldon, R. R. Yeo, and T. M. Taylor. 1969. Identification and distribution of certain similar-appearing submersed aquatic weeds in Florida. Hyacinth Control J. 8(1): 17-21.

Colle, D.E. and J.V. Shireman. 1980. Coefficients of condition for largemouth bass, bluegill, and redear sunfish in hydrilla-infested lakes. Transactions of the American Fisheries Society 109:521-531.

Current Status and Distribution Report, 2007. Department of Natural Resources, State of Wisconsin
http://dnr.wi.gov/invasives/classification/pdfs/LR_Hydrilla_verticillata.pdf

Grodowitz M. J., Owens C. S., Smart R. M., Nachtrieb J. G. 2007. Impact of Herbivory and Plant Competition on the Growth of Hydrilla in Small Ponds. ERDC/TN APCRP-BC-08

Hydrilla Eradication Program Annual Progress Report: 2009. California Department of Food and Agriculture
http://www.cdfa.ca.gov/phpps/ipc/hydrilla/pdfs/hydrilla2009_annualreport-summary.pdf

Hydrilla (Hydrilla verticillata), General Information Department of Ecology, State of Washington
http://www.ecy.wa.gov/programs/wq/plants/weeds/hydrilla.html

Invasive Species Program, 2009. Idaho State Department of Agriculture
http://www.agri.state.id.us/Categories/PlantsInsects/RegulatedAndInvasiveInsects/Documents/2009%20ISDA%20Pest%20Survey%20Report.pdf

Langeland, K. A. and D. L. Sutton. 1980. Regrowth of hydrilla from axillary buds. J. Aquat. Plant Manage. 18:27-29. Hydrilla Eradication Report, 2008, CDFA

Langeland, K. A. 1996. *Hydrilla verticillata* (L.F.) Royle (Hydrocharitaceae "The Perfect Aquatic Weed". Castanea 61:293-304

Les D.H. Mehrhoff L.J., Cleland M.A. and J.D. Gabel. 1997. *Hydrilla verticillata* (Hydrocharitaceae) in Connecticut. Journal of Aquatic Plant Management 35:10-14.

Madeira, P., T. Van, D. Steward and R. Schnell. 1997. Random amplified polymorphic DNA analysis of the phenetic relationships among world-wide accessions of *Hydrilla verticillata*. Aquatic Botany 59:217-236.

Netherland, M. D. 1999. Management impacts on the quiescence and sprouting of subterranean turions of dioecious hydrilla (*Hydrilla verticillata* (L.f.) Royle). Ph.D. diss., University of Florida, Gainesville.

Northwest Aquatic Nuisance Species Panel. 2009. Ecological and Economic Costs Associated with Hydrilla (*Hydrilla verticillata*) http://www.northeastans.org/hydrilla/ecoleconhydrilla.htm

Oregon Noxious Weed Strategic Plan, 1999. Oregon Department of Agriculture http://www.oregon.gov/ODA/PLANT/WEEDS/strategic_plan_execsum.shtml

Schmitz, D.C., B.V. Nelson, L.E. Nall, and J.D. Schardt. 1991. Exotic Aquatic Plants in Florida: A Historical Perspective and Review of the Present Aquatic Plant Regulation Program. Proceedings of the Symposium on Exotic Pest Plants, Univ. Miami, Nov. 2-4, 1988, Miami, FL.

Schmitz, D.J., J.D. Schardt, A.J. Leslie, F.A. Dray, Jr., J.A. Osborne, and B.V. Nelson. 1993. The Ecological Impact and Management History of Three Invasive Alien Aquatic Plant Species in Florida. Pages 173-194 in: B.N. McKnight (editor). Biological Pollution: The Control and Impact of Invasive Exotic Species. Indian Academy of Science, Indianapolis, IN.

Sutton, D. L. 1986. Culture of hydrilla (*Hydrilla verticillata*) in sand root media amended with three fertilizers. Weed Sci. 34:34-39.