Pacific Northwest Aquatic Invasive Species Profile:

Nasturtium officinale (Watercress)

Daniel J. Barker

FSH 423

7 December 2009

Figure 1. Watercress, *Nasturtium officinale*. Clockwise from top left: flowers of *N. officinale*; leaves of *N. officinale*; fruit pods of *N. officinale*; a patch of *N. officinale*

Diagnostic Information

Scientific name:

Order: Capparales

Family: Brassicaceae

Genus: *Nasturtium*

Species: *Nasturtium officinale*

(Synonym species name: *Rorippa nasturtium-aquaticum*)

Common name: Watercress

Identification Key

Nasturtium officinale is an emergent perennial herb (Figure 1). It is usually found in clumps in cold, gently flowing, shallow freshwater. It will be emergent through the winter in waters that do not freeze. Older leaves are compound with many wavy-edged, oval or lance-shaped leaflets growing from a central stalk. The leaves taste strong of pepper, leading to its commercial use in salads in the United States. The leaves are between 4 and 12 cm long, with the end leaflet typically being the largest. *Nasturtium officinale* has a 10 to 60 cm stem with thin and fibrous roots at the bottom. At the top of stems and short stalks, its flowers are 3-5 mm long and have 4 white pedals. They are found above the water between March and October. Its fruits are 10 to 25 mm long and 2 mm wide and found on stalks that are 8 to 12 mm long. They are thin, slightly curved cylinders and contain 4 rows of small, round seeds. (WDOE 2009)

Nasturtium officinale can be mistaken for Western bittercress (*Cardamine occidentalis*), which tends to grow in wet soil rather than water, has longer flower stalks, a larger and wavy end leaflet, and larger fruits (WDOE 2009). *Nasturtium officinale* can also be confused with *Amoracia lacustris,* and other *Nasturtium* and *Rorippa* species, including *Nasturtium microphyllum*, which has just one row of seeds in its pods (WIDNR 2009).

Life-History and Basic Ecology

Life Cycle

Nasturtium officinale produces leafy shoots beginning in the spring. In late spring, the plant begins to flower. Its fruits ripen about 2 months after it first flowers. After the fruits shed their seeds, the seeds will germinate, however they remain dormant until the following spring. *Nasturtium officinale* stops flowering in late summer, at which time it will again produce leafy shoots. (Howard and Lyon 1952)

Feeding Habits

As a plant, *Nasturtium officinale* needs its doses of carbon dioxide, sunlight, and nutrients for photosynthesis. While it can obtain nutrients from both the water and soil, it requires its nitrate from the water and iron from the substrate. An analysis in The British Isles shows that the plant grows in waters with plentiful potassium, calcium, magnesium,

nitrate, and sulfate. However, phosphate quantities were low and it is known that phosphorous fertilizers are the only ones used in commercial production of watercress. (Howard and Lyon 1952)

The two root systems of *N. officinale* allow the plant to shift its nutrient uptake depending on environmental conditions. For example, when large amounts of phosphorous are present in the water, more phosphorous uptake will occur in the adventitious roots. Conversely when less phosphorous is available in the water column, the plant uptakes more phosphorous from the substrate through its basal roots system. (Cumbus and Robinson 1977)

Reproductive Strategies

There are two reproductive strategies for *Nasturtium officinale.* It sometimes uses vegetative reproduction, in which its stems fall over to form adventitious roots and subsequently creep. It also can reproduce through pollination, either on its own or by an insect. In rainy conditions *N. officinale* keeps its flowers mostly closed, which can lead to self-pollination. Insects sometimes cross-pollinate the plant when visiting its flowers, as it has two nectaries, which are located at the base of its short stamen. Seeds from the fruit later fall close to the mother plant and germinate immediately. (Howard and Lyon 1952)

With dual reproduction mechanisms, *N. officinale* can proliferate differently depending on the environmental conditions. When establishing on bare soil, it tends to reproduce by seedlings. However, under circumstances of heavy vegetation, the plant tends to use the vegetative reproduction strategy. (Howard and Lyon 1852)

The primary means of dispersal for *N. officinale* are via wind, water, animals, and humans (WIDNR 2009). Because of the small size of the plant, it can easily be moved by the wind. Additionally, its seeds can float in water, allowing it to disperse some distance from its mother plan (Howard and Lyon 1952). *N. officinale* also has a wide variety of predators, including snails, shrimp, insects, birds, cows, deer, and muskrat, which can aid in its dispersal. Humans can play a role in the dispersal of *N. officinale* and is discussed further in the Invasion Process section.

Environmental Optima and Tolerances

Nasturtium officinale is found in shallow, cold, gently moving, fresh water in lakes, reservoirs, streams, rivers, and on damp soil (WDOE 2009). It is often found in gently flowing streams, or “areas of running water adjacent to springs and riverbanks or on wet soil” (Purdue 2009). It has less tolerance for stagnant or very fast moving water (WIDNR 2009). The substrate can be gravel, sand, silt, or clay, but not on acid or alkaline peats (Howard and Lyon 1952).

The soil pH range for *N. officinale* is between 4.3 and 8.3 (Figure 2) (Purdue 2009). It is locally abundant in nutrient rich waters and

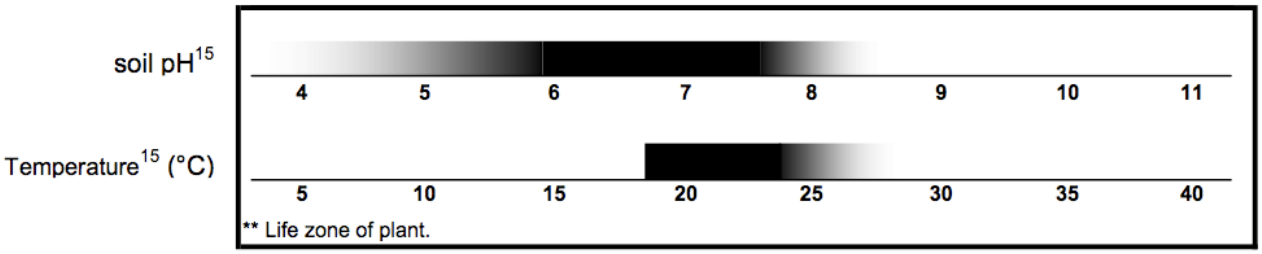

Figure 2. Preferred soil pH and temperature (°C) for *Nasturtium officinale*. Darker shading represents more optimal conditions.

prefers abundant sunlight (WIDNR 2009). It also has a high tolerance for chloride in the water (Howard and Lyon 1952).

Sources show varying accounts of the temperature range for the *N. officinale*. Wisconsin Department of Natural Resources (2009) suggests it prefers at least 18°C (Figure 2), while the Purdue University's Horticulture Department says "the reported life zone of watercress is 6 to 27°C" (2009). Additionally, the species is known for its ability to overwinter (Figure 3). Although any exposed part of the plant is susceptible to frost damage, it will survive as long as the water does not freeze (Purdue 2009) and grows throughout the winter (WIDNR 2009).

Biotic Associations

A number of parasites and pathogens are associated with *Nasturtium officinale* in the United States. The Florida State of Horticultural Society (1968) provides a list of known diseases. *Cercospora nasturii* is a fungus that causes leaf spot, which can lead to a loss of foliage in severe cases. *Sclerotina sclerotiorum* rots the foliage and stems above water, which will eventually petioles and stems and impedes establishment of new watercress beds. Crook root is caused by *Spongospora subterranea* and drastically harms foliage production and will decay the plant's roots. Viruses can be transmitted by rubbing leaves or through aphids. In Wisconsin, *N. officinale* is also associated with crook root fungus, as well as yellow spot virus (WIDNR 2009). Yellow spot virus causes chlorotic spotting and blotching on leaf veins (UIdaho 2009).

Figure 3. *Nasturtium officinale* in an unfrozen spring-fed stream in the University of Wisconsin – Madison Arboretum in December 2008.

Current Geographic Distribution

Nasturtium officinale is native to Western Asia, India, Europe, and Africa (WIDNR 2009), however it is now distributed almost globally (Howard and Lyon 1952). It is considered as being introduced to North and South America, southern Africa, Australia, and New Zealand (Howard and Lyon 1952). There is no known altitudinal limit for *N. officinale*, having been found as high as 6,500 feet near Manali in the Kulu valley of India (Howard and Lyon 1952). Since being introduced to the United States and Canada, it is now found in almost every state and most provinces (Figure 4) (USDA 2009). *N. officinale* is especially prevalent in the Pacific Northwest, having been found in nearly every county in Idaho, Oregon, and Washington (Figure 5) (USDA 2009). The county data comes from literature, herbarium specimens, and confirmed observations as researched by USDA (2009).

Figure 4. Distribution of *N. officinale* in the United States and Canada. Green represents where it has been recorded, white where it has not.

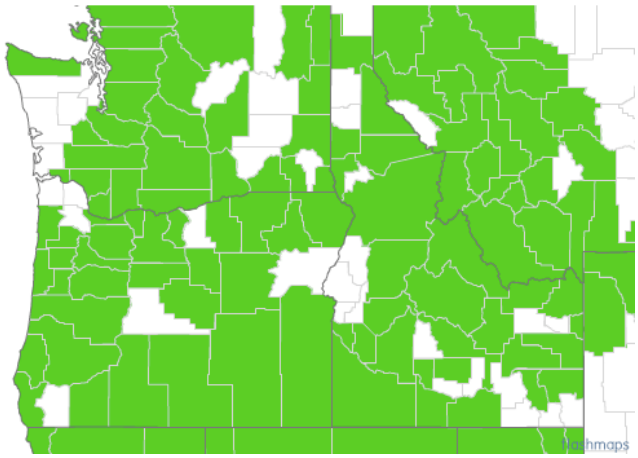

Figure 5. Distribution of *N. officinale* in Pacific Northwest counties (UGA Center for Invasive Species and Ecosystem Health 2009). Green represents areas documented, white where it has not.

History of Invasiveness

The earliest record of *Nasturtium officinale* in North America is 1826 (Les and Mehrhoff 1999). Although early settlers of Plymouth, Massachusetts, and the Massachusetts Bay colony reference watercresses as early as 1620, it is unclear as to what kind of watercress it was (Les and Mehrhoff 1999). Several other mentions of watercress propagules occur over the following two centuries, however the first known citation of *N. officinale's* introduction to the United States was by Ives et al. in New Haven, Connecticut, in 1831 (Les and Mehrhoff 1999). By all likelihood, it was introduced from Europe (WDOE 2009). By 1833, *N. officinale* was listed as an exotic species and by the end of the 19th century, it reached all the way to the Pacific coast (Les and Mehrhoff 1999).

N. officinale was introduced for cultivation and has since spread throughout the country. It is currently grown commercially around the United States (WDOE 2009). Belonging to the mustard family (Brassicaceae), watercress is an edible plant that is commonly used in salads and cooking. It is known for its spicy, peppery taste (WDOE 2009). It is highly nutritious, with plenty of vitamins, proteins, and minerals (Purdue 2009). Additionally, watercress has historically been widely used for medicinal purposes, dating back to Roman times (WDOE 2009). Among its medicinal uses are as a potential anti-carcinogen (WIDNR 2009), a diuretic, expectorant, purgative, stimulant, stomachic, and tonic (Purdue 2009). It has been used as a treatment for anemia, eczema, kidney and liver disorders, tuberculosis, boils, warts, and tumors (Purdue 2009). Watercress is now well established and naturalized across North America (USGS 2009).

Invasion Process

Pathways, Vectors, and Routes of Introduction

The pathway by which *Nasturtium officinale* was introduced to the United States is the horticultural plant trade, more specifically probably through the horticultural seed trade industry. Watercress was probably brought from Europe for cultivation (WDOE 2009). The first recorded date for introduction of watercress to the United States in New Haven, Connecticut, in 1831 (Les and Mehrhoff 1999). Once present in the United States, it escaped from cultivation in the form of both seeds and vegetative propagules, and may have been deliberately planted in streams (Les and Mehrhoff 1999). Horticultural plant trade is one of the ten primary pathways of aquatic introductions (Olden 2009). In the United States, about 85 percent of aquatic invasive plants were introduced for horticulture (Olden 2009).

The vector of introduction for *N. officinale* to the United States was probably through shipping. Being introduced in 1831, it seems likely that the only mechanism that could have been used to transport the plant is a ship. Therefore, the route of introduction was likely whatever shipping route between Europe and America actually brought the propagules of watercress that eventually established.

Since becoming established, watercress has likely spread through other pathways, vectors, and routes. Within the United States, although horticultural plant trade may still play a significant role, other pathways are very plausible for introducing the plant. For example, recreational boating could be a significant pathway within the U.S. if boaters do not clean their vessels thoroughly and take them to other water bodies. Watercress could contaminate propagules that are stocked into water bodies or release from aquaculture facilities (it is also sometimes used for wastewater treatment in freshwater fish farms). With each of these subsequent invasion pathways, the specific

vectors and routes differ from that of the initial introduction from the horticultural plant trade.

Factors Influencing Establishment and Spread

Propagule pressure likely played a significant role in the initial introduction of *Nasturtium officinale* to the United States. The presence of watercress was mentioned many times by early settlers in New England (Les and Mehrhoff 1999). The more times a species is introduced to a place, and the more individuals are introduced each time, the more likely that species is to establish (Lockwood et al. 2007).

Based on the environmental constraints of watercress, the species usually establishes in colder, gently flowing, fresh water where there is abundant sunlight. Wisconsin Department of Natural Resources (2009) indicates that watercress establishes when there is some sort of disturbance in a stream, although it is not specified what type of disturbance promotes watercress establishment. Watercress is a very plastic plant, having multiple reproductive strategies and nutrient uptake abilities. These traits may allow it to fill unoccupied ecological niches in a stream community.

Watercress also utilizes an allelochemical deterrent for herbivorous invertebrates, which may help it establish and spread in communities that have not adapted to the deterrent (Newman et al. 1996).

Potential Ecological and Economic Impacts

In most areas, *Nasturtium officinale* is not considered to be problematic, as it is restricted to colder, gently flowing, fresh water streams. However, it can become very invasive and outcompete other species in a stream. A study in the Driftless area of Wisconsin showed that *N. officinale* grows more in larger springs, due to the reduced flow rate of the water and was “by far the most abundant invasive species” in the area, having outcompeted native species (Tenorio and Drezner 2006). Anecdotes from the early settlement of Connecticut and Massachusetts explain watercress can become so dense that it blocks stream flow and floods adjacent meadows (Les and Mehrhoff 1999). One may hypothesize that because watercress is an ecosystem engineer in that it alters stream flow, it may provide new environmental conditions for other invasive species. A species that affects a disturbance regime, such as watercress and flooding, is considered a driver of ecological change (Lockwood et al. 2007). It is possible that by altering stream flow, the invasion of watercress could lead to further invasion by another non-native species. Such an event is called an invasional meltdown (Lockwood et al. 2007). Despite these risks, watercress is not considered to be particularly weedy (Les and Mehrhoff 1999) and is thought to have little impact on natural communities (WIDNR 2009).

When managed, as with most invasive species, watercress prevention and control can often be

expensive or timely (WIDNR 2009). Flooding could potentially cause damage to impacted properties. It may facilitate establishment of another non-native that could have major economic ramifications. It could also push a native species to extinction, which would have large economic costs for preservation of that native species.

Of course, watercress does have notable economic benefits in the United States. Already listed are its uses for horticulture and medicinal purposes. As a potential anti-carcinogen, it could create a huge market in the future, should those benefits come to fruition. Additionally, watercress is used as a wastewater treatment (WIDNR 2009), such as in wastewater from freshwater fish farming (Redding et al. 1997). Conventional wastewater systems are costly solutions to remove the large amounts of nutrients from these waters and plants can be used as a lower-cost option to filter the water.

Management Strategies and Control Methods

There is little management or control for *Nasturtium officinale*. It is banned only in Connecticut and on watch lists only in Ohio and Vermont. Management tools are not well documented, however Wisconsin Department of Natural Resources (2009) outlines its management strategies for prevention and control. For prevention, the agency lists education, monitoring, research, watercraft inspection, and distribution watch as its strategies, but does not give further details. Wisconsin DNR considers two tools for controlling watercress. First, for nuisance relief, one can apply glysophate. This chemical has negative impacts on non-target plant species and has low efficacy in flowing water, where watercress inhabits. The second control tool is handpulling, which has also been employed in Washington (WDOE 2008). Handpulling is labor intensive and costly when volunteers are not used. However, as demonstrated in Washington, it is relatively easy to control and two days of work can improve stream conditions (WDOE 2008).

Current Research and Management Efforts

While some research on *Nasturtium officinale* does exist in the context of invasive species ecology, most research is geared toward the horticulture industry and how to better produce the plant. In fact much of the research is examining the influence of environmental conditions on watercress, as well as the impacts of fungi and viruses. Consequently, knowing more about the species may allow invasive species ecologists to better formulate eradication and control strategies, should managers decide they wish to remove it.

There is much room for research on watercress. Managers may be interested to know how it affects native communities, whether it facilitates the introduction of other non-natives leading to an invasional meltdown, and the array of

management options to prevent or control the species. In light of global climate change, managers may be able to predict the future of the species in their locales.

Due to its wide acceptance as a naturalized species and use for food, there is little management against *N. officinale*. It seems that only in instances of extreme conditions is there any sort of management effort. For example, Thomason Creek in northeastern Washington was heavily overgrown with invasive weeds, including watercress. Volunteers worked for two days to clear watercress, which opened up the stream's flow and improved its water quality (WDOE 2008).

Literature Cited

Cumbus, I.P., and Robinson, L.W. (1977). The function of root systems in mineral nutrition of watercress (Rorippa Nasturtium-aquaticum (L) Hayek). *Plant and Soil* 47: 395-406

Howard, H.W., and Lyon, A.G. (1952). Nasturtium officinale R. Br. (Rorippa Nasturtium-Aquaticum (L.) Hayek). *Journal of Ecology* 40: 228-245

Les, D.H., and Mehrhoff, L.J. (1999). Introduction of nonindigenous aquatic vascular plants in southern New England: a historical perspective. *Biological Invasions* 1: 281-300

Lockwood, J., et al. (2007). *Invasion Ecology*. Blackwell Publishing. Malden, Massachusetts.

Newman, R.M., et al. (1996). Watercress allelochemical defends high-nitrogen foliage against consumption: effects on freshwater invertebrate herbivores. *Journal of Ecology* 77: 2312-2323

Redding, T., et al. (1997). The treatment of aquaculture wastewaters – a botanical approach. *Journal of Environmental Management* 50: 283-299

Strandberg, J.O., and Tucker, II, C.A. (1968). Diseases of watercress in Florida. *Proceedings of Florida State Horticultural Society* 81: 194-196

Tenorio, R.C., and Drezner, T.D. (2006). Native and invasive vegetation of karst springs in Wisconsin's Driftless area. *Hydrobiologia* 568: 499-505

Other Sources

Olden, Julian. 2009. Fall 2009 Lectures, Fisheries 423: Aquatic Invasion Ecology. University of Washington.

United States Department of Agriculture – Natural Resources Conservation Service. (2009, December 6). Plants Database Profile,

Nasturtium officinale, W.T. Aiton, watercress. Retrieved from http://plants.usda.gov/java/profile?symbol=NAOF

United States Geological Survey. (2009, December 6). Nonindigenous Aquatic Species, *Nasturtium officinale*. Retrieved from http://nas3.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=229

University of Georgia – Center for Invasive Species and Ecosystem Health. (2009, December 6). Watercress, *Nasturtium officinale* Ait. F. Retrieved from http://www.invasive.org/weedus/subject.html?sub=14217

University of Idaho. (2009, December 6). Plant Viruses Online, Watercress yellow spot virus. Retrieved from http://www.agls.uidaho.edu/ebi/vdie/descr873.htm

University of Purdue – Department of Horticulture and Landscape Architecture. (2009, December 6). NewCROP Factsheets, watercress. Retrieved from http://www.hort.purdue.edu/newcrop/med-aro/factsheets/WATERCRESS.html

Washington Department of Ecology. (2009, December 6). Aquatic Plant Identification Manual for Washington's Freshwater Plants, *Nasturtium officinale*, watercress. Retrieved from http://www.ecy.wa.gov/programs/wq/plants/plantid2/descriptions/rornas.html

Washington Department of Ecology. (2008). *Working for Washington's future: healthy watersheds, healthy people*. Retrieved from http://www.ecy.wa.gov/pubs/0801018.pdf

Wisconsin Department of Natural Resources. (2009, December 6). *Nasturtium officinale* Invasive Species Classification. Retrieved from http://dnr.wi.gov/invasives/classification/pdfs/LR_Nasturtium_officinale.pdf

Expert Contact Information in the Pacific Northwest

1) Washington State Recreation and Conservation Office
Washington Invasive Species Council

Report a Sighting
1-877-9-Infest
http://www.InvasiveSpecies.wa.gov/sighting_form.shtml

Wendy Brown	Gen Keesecker
Executive Coordinator	Project Associate
(360) 902-3088	(360) 902-3010

E-mail: InvasiveSpecies@rco.wa.gov

Telephone: (360) 902-3000
FAX: (360) 902-3026
Telephone Device for the Deaf (TDD): (360) 902-1996

2) Oregon Department of Agriculture – Plant Division
Oregon Invasive Species Council

Report a Sighting
1-866-INVADER
(503) 986-4660
http://oregoninvasiveshotline.org
E-mail: invasives-info@oda.state.or.us

3) Idaho Department of Agriculture
Idaho Invasive Species Council
Amy Ferriter
Invasive Species Program Manager
Telephone: (208) 332-8686
Fax: Fax: (208) 334-2170
E-mail: aferriter@agri.idaho.gov

4) Invasive Plant Council of British Columbia

Report a Sighting
1-888-WEEDSBC
Telephone: (250) 392-1400
Fax: (250) 305-1004
E-mail: info@invasiveplantcouncilbc.ca

5) University of Washington
School of Aquatic and Fisheries Sciences
Julian Olden
Assistant Professor, Olden Research Lab
(206) 616-3112
E-mail: olden@u.washington.edu