WRITTEN FINDINGS OF THE
WASHINGTON STATE NOXIOUS WEED CONTROL BOARD
Updated June, 2013

Scientific name:	*Nymphaea odorata* Aiton
Synonyms:	see list of synonymous names below
Common name:	fragrant water-lily, tuberous water-lily, white water-lily
Family:	Nymphaeaceae
Legal Status:	Class C noxious weed

Description and Variation:

The *Nymphaea odorata* treatment in Flora of North America (Wiersema 1997) recognizes two subspecies, *N. odorata* subsp. *odorata* and *N. odorata* subsp. *tuberosa*. Historical treatments of *N. odorata* included additional varieties, which are now treated as *N. odorata* subsp. *odorata* (see list of synonymous names below). The Class C noxious weed listing includes both subspecies of *N. odorata* as well as any cultivars of *N. odorata*.

Overall Habit:

Nymphaea odorata is an aquatic, perennial plant. Leaves and flowers generally float on the water's surface, growing from submerged rhizomes. Plants are absent of stolons (Wiersema 1997).

Figure 1. (Left) Blooming *Nymphaea odorata* with circular leaves, image by Rob Routledge, Sault College, Bugwood.org. (Right) Dense cover of *N. odorata* leaves with one turned over to show reddish underside and venation, image by Rob Routledge, Sault College, Bugwood.org.

Roots:

Plants have rhizomes that are frequently branched and creeping and are anchored by adventitious roots arising in groups below the leaf bases. They are cylindric in cross section, 2-3 cm in diameter, and covered with short black hairs (DiTomaso and Healy 2003, Wiersema 1997). Rhizomes of *Nymphaea odorata* can tolerate some desiccation (DiTomaso and Healy 2003). The subspecies *tuberosa* and sometimes also the subspecies *odorata*, make constrictions at rhizome joints to form detachable tubers (Wiersema 1997).

Leaves:

No true upright stem is present; rather leaves with petioles grow to the water surface, directly attached to the rhizome. Leaf petioles are glabrous or pubescent (Wiersema 1997) and increase in width and length with increased water depth (Richards et al. 2011). Petioles may be striped or faintly striped in

color if they are subspecies *odorata*, or have brown purple stripes if they are subspecies *tuberosa* (Wiersema 1997). The petioles leave crescent-shaped scars on the rhizome when shed. Petioles of *N. odorata* have central air canals that are part of a convective flow system that moves gases from younger leaves through submerged rhizomes and roots and then out older leaves, thus aerating submerged plant parts (Grosse and Bauch 1991 and Grosse 1996b *in* Richards et al. 2012).

The floating mature leaf blades are rounded to nearly circular in shape with a slit on one side. The leaves also occasionally rise above the water. Leaf blades typically range in size up to 40 cm and have smooth margins. Leaves are green above and typically reddish or purplish, though sometimes green, below (Wiersema 1997). Leaf venation radially central, and is without a web-like pattern (Wiersema 1997).

Flowers:
Large fragrant, flowers are solitary on long peduncles, and 6-19 cm in diameter (Wiersema 1997). Flowers are floating or elevated slightly above the water's surface. Each flower has four green or reddened sepals (Wiersema 1997). Petals are white to pink, and numerous, 17-43, mostly lanceolate to elliptic (Wiersema 1997). Stamens 35-120, yellow, (Wiersema 1997) with the outer stamens transitional to petals and the inner with linear filaments (Hitchcock et al. 1964). There is one pistil in each flower with 10-25 locules (Wiersema 1997).

Flowers open in the morning and close in the afternoon (Hitchcock et al. 1964) and bloom June through October. (Jacobson 2008, Hitchcock et al. 1964). Flowers are pollinated by flies, bees and beetles (Jacobson, 2008).

Fruits and Seeds:
The fruit is a leathery, berry-like capsule with numerous seeds in each locule (Hitchcock et al. 1964). Seeds are ovoid, around 1.5 -4.5 mm long, 1.5-1.75 times long as broad, lacking papillae on the surface (Wiersema 1997).

Look-alikes:
There are a number of cultivated varieties of *N. odorata* with varying flower colors and forms, including 'Helen Flower' with large, deep pink fragrant flowers held above the water; cultivar 'Exquisita' has small flowers that are star-shaped and rose colored; and cultivar 'William B. Shaw' flowers are large, flat, creamy pink, internal zone of dark red (Griffiths 1994). *Nymphaea odorata* is also crossed with other species of *Nymphaea* to produce additional water lily cultivars.

When not in flower, the leaves of *N. odorata* can be confused with the native *Nuphar polysepala* (spatterdock or yellow waterlily).

Habitat:
Nymphaea odorata grows in soft sediment of shallow ponds, lakes, slow streams and rivers, pools in marshes, ditches, canals and sloughs (Washington State Department of Ecology 2001, Wiersema 1997). Plants can typically grow in water depths up to 3 meters (Jenifer Parsons pers. comm.). It can grow in acidic or alkaline conditions and at elevations of 0-1700 meters (Wiersema 1997).

Geographic Distribution:
Nymphaea odorata is native to eastern and central North America. *Nymphaea odorata* has been introduced over much of North America, including Washington, for its attractiveness (Hitchcock et al. 1964). It has also been introduced to other areas of the world. Several species of *Nymphaea*, including

N. odorata, are important ornamental plants, and many have been introduced outside their native ranges as ornamental pond plants (Wiersema 1997).

History and Distribution in Washington:
The first record of *Nymphaea odorata* in Washington is from 1911 in Lake Washington (consortium of Pacific Northwest Herbaria database, http://www.pnwherbaria.org/data/search.php). It is rumored to have been introduced during the 1909 Seattle World's Fair (J. Frodge, pers. comm. 2013). Although found throughout Washington, *N. odorata* is especially prevalent in western Washington lakes where it has been intentionally planted by property owners who admired the showy flowers. Surveys conducted in Washington by the Department of Ecology between 1994 - 2012 documented the presence of *Nymphaea odorata* at 155 of 534 survey locations in Washington (Figure 2.).

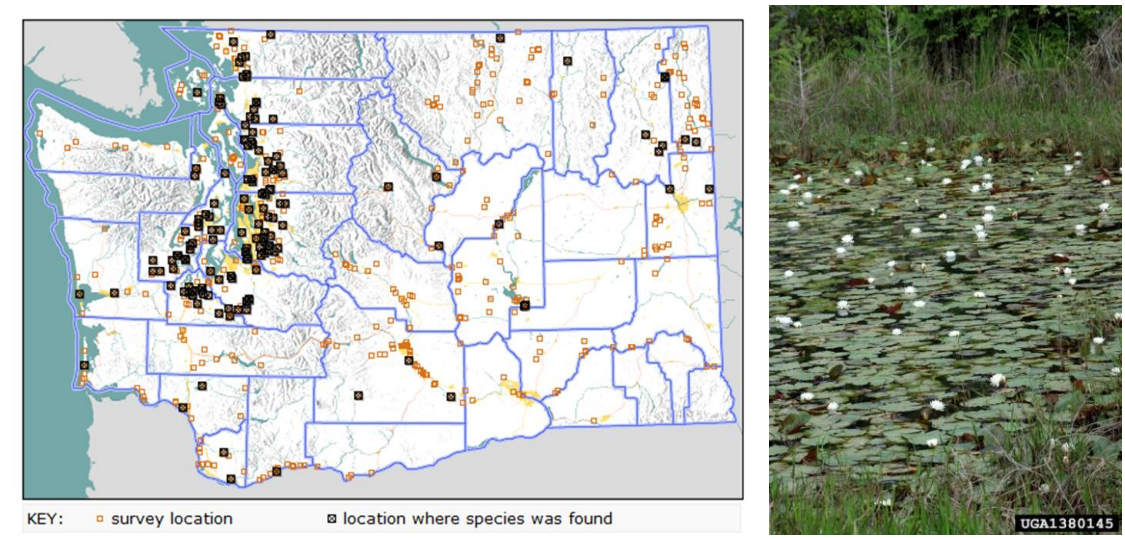

Figure 2. (Left) Washington State Department of Ecology survey map displaying locations of *Nymphaea odorata* found in Washington. (Right) *Nymphaea odorata* growing along a shallow lake edge, image by Chris Evans, Illinois Wildlife Action Plan, Bugwood.org.

Biology:
Growth and Development:
In spring new leaves grow from the rhizomes and unfurl as they grow up through the water until they reach the surface (Borman et al. 1997). Flowers open in the morning and close in the afternoon for three consecutive days (Schneider and Chaney 1981). Self fertilization is prevented by the timing of pollen release; flowers are receptive to pollen the first day, and release pollen the second and third day. After the flower has closed for the final time, the stalk forms a spiral and draws the fruit below the water (Schneider and Chaney 1981). The fruits take 3 to 5 weeks to mature and split open when they have matured to release the seeds (Richards and Cao 2012). Seeds are covered by a loose aril that forms a sac around each seed to trap gas and cause the seed to float to the surface (Richards and Cao 2012).

Reproduction:
Plants reproduce by seed and spread by growth of underground rhizomes. If broken up, rhizome fragments will also float to new areas and create new plant patches. The tubers will also readily detach and float off to form new plants, an important means of spread for those plants that make tubers (Williams 1970). Seed germination of *Nymphaea odorata* is enhanced by cold stratification (DiTomaso and Healy 2003). Richard and Cao (2012) studied the germination and early growth of *N. odorata* seeds

and found that *N. odorata* seeds can germinate in water depths of up to 90 cm. Seedlings and juvenile plant that germinate in water grow as submerged aquatics until emergent floating leaves are produced. Else and Riemer (1984) found that seeds crowded together and the presence of ethylene gas promoted germination, but Richard and Cao (2012) found that seed crowding was not a requirement for germination. Seeds of *N. odorata* are naturally exposed to light when they float to the surface after they are release from their fruit and Richards and Cao's 2012 research suggests that sunlight does promote germination.

Economic Importance:
Detrimental:

Shallow lakes are particularly vulnerable to being totally covered by *N. odorata*. In an aerial photo from April 1974 of Giffin Lake, a 110 acre lake near Sunnyside in eastern Washington, there is open water and data indicate 11-25 percent of the lake was covered by emersed plants (unknown species). Twenty years later, nearly 100 percent of the lake's surface was covered by *N. odorata*. When allowed to grow in dense stands, the floating leaves prevent wind mixing and extensive areas of low oxygen can develop under dense floating leaves during the summer (Frodge et al. 1990). The dense leaf cover also shades the water below, reducing or eliminating native submersed aquatic plants (Cook 1990).

Left unmanaged, *Nymphaea odorata* will fill in areas of shallow water and soft sediment resulting in restricted lake-front access, reduced swimming opportunities and difficult boating. *Nymphaea odorata* is frequently listed as a plant being controlled on permit requests received by Ecology (J. Jennings, personal communication 2013). In several of the integrated aquatic plant management plans funded by Ecology, *N. odorata* was considered the second nuisance plant after Eurasian watermilfoil (*Myriophyllum spicatum*) and was targeted for control.

Beneficial:
Nymphaea odorata is a fragrant, ornamental pond plant. Many hybrids have been developed in a variety of colors. The fragrant water lily and its hybrids is an extremely popular water garden plant and can be readily obtained at nurseries and through mail order catalogs.

Beaver, moose, muskrat, porcupine, and deer eat water lily leaves and roots and waterfowl eat the seeds. Water lilies also provide cover for largemouth bass, sunfish, and frogs.

Control:
Prevent the spread of *Nymphaea odorata* to new locations by cleaning boats, boat trailers and any other equipment of *N. odorata* seeds and rhizomes. The introduction of *N. odorata* can also be prevented by selecting non-invasive aquatic species for ornamental pond plantings. Plant suggestions can be found in Garden Wise, Non-invasive Plant for your Garden published by the Washington State Noxious Weed Control and other resources. Never plant ornamental pond plants in a natural waterbody such as a lake, pond or river.

Mechanical Methods:
Mechanical controls such as cutting and harvesting are sometimes used to control *N. odorata*. Cutting is accomplished with a hand held cutting tool or a mechanical device connected to a boat. Harvesting utilizes a specialized boat equipped with a cutter and collection system in one. Harvesting has been used extensively on Long Lake, Thurston County to control *N. odorata*. Cutting is less efficient than harvesting because cut plants must then be removed from the water (Department of Ecology). Both

methods create areas of open water. However, the *N. odorata* will grow back, so several treatments per growing season are usually required (DiTomaso et al. 2013). Several lake residents have reported success in eliminating *N. odorata* from waterfront lots by the process of carbohydrate depletion. During each growing season, residents faithfully removed all emerging leaves. They reported that it took about two to three seasons to kill the plants.

Underwater rototilling (called rotovation) was successfully used to remove *N. odorata* from a small Seattle area lake. Rotovation dislodges the large, fleshy rhizomes which can then be removed from the water. Although rotovation is a much more expensive process than harvesting or cutting, it results in the permanent removal of *N. odorata* rhizomes. It would be important to remove all rhizome fragments and tubers to prevent regrowth.

Thurston County has experimented with using a barge-mounted backhoe to excavate *Nymphaea odorata* rhizomes from the sediment. Like rotovation, excavating the rhizomes results in permanent removal of the plant, but care must be taken to remove rhizome fragments and tubers. Both rotovation and excavation requires that the project proponent obtain a number of environmental permits before proceeding.

Cultural Methods:
Localized control (in swimming areas and around docks) can be achieved by covering the sediment with an opaque fabric which blocks light from the plants (bottom screening). However, it is sometimes very difficult to place and secure the fabric to densely packed, tough, fleshy *N. odorata* rhizomes. Barriers should be installed in early spring (DiTomaso et al. 2013).

Managers of reservoirs and some lake systems may have the ability to lower the water level as a method of managing aquatic plants. Response of the *N. odorata* to water level drawdown has been variable. DiTomaso et al. (2013) notes this method achieves less than 50% control and that plants will recover from rhizomes.

Biological Control:
There are no approved biological agents for *Nymphaea odorata*. General release of biocontrol agents for *N. odorata* is improbable because water lilies are an important ornamental pond plant. In its native range, many insects are known to feed on the roots, leaves and flowers of *N. odorata* (Harms and Grodowitz 2009). It is unknown at this time how many of those insects are found in the western U.S., however, *N. odorata* appears to be less impacted by invertebrate herbivores that the native yellow waterlily (*Nuphar polysepala*) in Washington (J. Parsons, personal observation).

A study of impacts of grass carp on various aquatic plant species found that these herbivorous fish had little to no impact on *N. odorata* in Washington (Bonar et al. 2002). Therefore grass carp are not recommended for *N. odorata* management in Washington.

Herbicide Control:
Note: Use of pesticides in water is regulated in Washington. All applicators must have an aquatic endorsement on their pesticide applicators license, which is issued by the Washington Department of Agriculture. In addition, coverage under a permit issued by the Department of Ecology is required. See http://www.ecy.wa.gov/programs/wq/pesticides/index.html for details.

Glyphosate, Imazapyr, Imazamox and granular or ester 2,4-D provide excellent control of *N. odorata* (Glomski and Nelson 2008, Langeland et al. 2009, DiTomaso et al. 2013). Triclopyr, fluridone and penoxulam are reported to provide fair to good *N. odorata* control (Glomski and Nelson 2008; Langeland et al. 2009). Generally glyphosate is the recommended herbicide for *N. odorata* control because it can be directly applied to the floating leaves, unlike fluridone or endothall which must be applied to the water. The application of glyphosate allows specific plants or areas of plants to be targeted for removal. Generally two applications of glyphosate are needed. The second application controls the plants that were missed during the first herbicide application (K. Hamel pers. comm.).

A drawback of using herbicides is mats of decomposing *Nymphaea odorata* rhizomes can sometimes float to the surface to form floating islands (Durden and Blackburn 1972). These can be difficult to manage and remove. Treating small sections of *N. odorata* at a time over the course of several years can help reduce the problems of island formation and management (K. Hamel, pers. comm. 2012). Though this can depend on the situation, in one Thurston County lake rhizome mats formed no matter what size patch was treated (J. Civille, pers. comm. 2013).

Harvesting *Nymphaea odorata* before treating the water with a systemic herbicide such as fluridone has been shown to stress the plants and provide greater control (as was demonstrated during the 1991 fluridone application to Long Lake, Thurston County) (K. Hamel, pers. comm. 1996).

Rationale for Listing:
Nymphaea odorata is an ornamental pond plant that has been introduced to lakes all over Washington. It successfully spreads by rhizomes and seeds, forming extensive areas of growth, especially in shallow lakes. These dense stands impact water quality by preventing wind mixing and extensive areas of low oxygen can develop under water lily beds during the summer. Recreational activities are impacted by *N. odorata* restricting lake-front access and eliminating swimming opportunities. Also, the dense leaf cover produces shade that reduces or eliminates native submersed aquatic plants. Listing *N. odorata* as a Class C noxious promotes awareness of its negative impacts and how to best control populations. County noxious weed control boards can require mandatory control of *N. odorata* at the local level.

List of Synonymous Names from: USDA the National Genetic Resources Program, Germplasm Resources Information Network :
Castalia lekophylla Small [= *Nymphaea odorata* subsp*. odorata*]
Castalia minor (Sims) Nyár. [= *Nymphaea odorata* subsp*. odorata*]
Castalia odorata (Aiton) Wood [≡ *Nymphaea odorata* subsp*. odorata*]
Castalia odorata var. *latifolia* R. M. Harper [= *Nymphaea odorata* subsp*. odorata*]
Castalia pringlei Rose [= *Nymphaea odorata* subsp*. odorata*]
Castalia pudica Salisb. [= *Nymphaea odorata* subsp*. odorata*]
Castalia reniformis (Walter) Hitchc. [= *Nymphaea odorata* subsp*. odorata*]
Castalia spirilis (Raf.) Cockerell [= *Nymphaea odorata* subsp*. odorata*]
Castalia tuberosa (Paine) Greene [≡ *Nymphaea odorata* subsp*. tuberosa*]
Leuconymphaea odorata (Aiton) Kuntze [≡ *Nymphaea odorata* subsp*. odorata*]
Leuconymphaea parkeriana (Lehm.) Kuntze [= *Nymphaea odorata* subsp*. odorata*]
Leuconymphaea reniformis (Walter) Kuntze [= *Nymphaea odorata* subsp*. odorata*]
Leuconymphaea tuberosa (Paine) Kuntze [≡ *Nymphaea odorata* subsp*. tuberosa*]
Nymphaea lekophylla (Small) Cory [= *Nymphaea odorata* subsp*. odorata*]
Nymphaea minor (Sims) DC. [= *Nymphaea odorata* subsp*. odorata*]
Nymphaea odorata var. *chlorhiza* Raf. [= *Nymphaea odorata* subsp*. odorata*]

Nymphaea odorata var. *gigantea* Tricker [= *Nymphaea odorata* subsp*. odorata*]
Nymphaea odorata var. *glabra* Casp. [= *Nymphaea odorata* subsp*. odorata*]
Nymphaea odorata var. *godfreyi* D. B. Ward [= *Nymphaea odorata* subsp*. odorata*]
Nymphaea odorata var. *minor* Sims [= *Nymphaea odorata* subsp*. odorata*]
Nymphaea odorata var. *parviflora* Raf. [= *Nymphaea odorata* subsp*. odorata*]
Nymphaea odorata var. *rosea* Pursh [= *Nymphaea odorata* subsp*. odorata*]
Nymphaea odorata var. *rubella* Raf. [= *Nymphaea odorata* subsp*. odorata*]
Nymphaea odorata f. *rubra* (Guillon) Conard [= *Nymphaea odorata* subsp*. odorata*]
Nymphaea odorata var. *stenopetala* Fernald [= *Nymphaea odorata* subsp*. odorata*]
Nymphaea odorata [unranked] *rubra* Guillon [= *Nymphaea odorata* subsp*. odorata*]
Nymphaea odorata var. *villosa* Casp. [= *Nymphaea odorata* subsp*. odorata*]
Nymphaea parkeriana Lehm. [= *Nymphaea odorata* subsp*. odorata*]
Nymphaea reniformis Walter [= *Nymphaea odorata* subsp. *odorata*]
(=) *Nymphaea rosea* Raf.
Nymphaea spirilis Raf. [= *Nymphaea odorata* subsp*. odorata*]
Nymphaea tuberosa Paine [≡ *Nymphaea odorata* subsp*. tuberosa*]
Nymphaea tuberosa var. *maxima* hort. ex Conard [= *Nymphaea odorata* subsp*. tuberosa*]
Nymphaea tuberosa var. *parva* C. C. Abbott [= *Nymphaea odorata* subsp*. tuberosa*]

References:

Bonar, S.A., B. Bolding, M. Divens. 2002. Effects of triploid grass carp on aquatic plants, water quality, and public satisfaction in Washington State. North American Journal of Fisheries Management 22:96-105.

Borman, S., R. Korth, J. Temte. 1997. Through the Looking Glass, a field guide to aquatic plants. Reindl Printing, Inc, Merrill, WI. 248 pp.

Cook, C.D.K., 1990. Origin, autecology, and spread of some of the world's most troublesome aquatic weeds. Pp. 31-38. In: A.H. Peiterse and K.J. Murphy (ed.) Aquatic Weeds, The ecology and management of nuisance aquatic vegetation. Oxford University Press, New York.

DiTomaso, J. M., G. B. Kyser et al. 2013. Weed Control in Natural Areas in the Western United States. Weed Research and Information Center, University of California. 544pp.

DiTomaso, J. M. and E. A. Healy. 2003. Aquatic and Riparian Weeds of the West. University of California Agriculture and Natural Resources Publication 3421.

Durden, W., R.D. Blackburn. 1972. Control of fragrant waterlily (*Nymphaea odorata*). Hyacinth Control Journal 10: 30-32.

Else, M. J. and D. Riemer. 1984. Factors affecting germination of seeds of fragrant waterlily (*Nymphaea odorata*). Journal of Aquatic Plant Management. 22: 22-25.

Jacobson, A. L. 2008. Wild Plants of Greater Seattle. Second Edition. Arthur Lee Jacobson. Pg. 166-167.

Griffiths, M. 1994. Index of Garden Plants. Royal Horticultural Society. Timber Press.

Hitchcock, C. L., A. Cronquist, M. Ownbey, J. W. Thompson. 1964. Vascular Plants of the Pacific Northwest. Part 2: Salicaceae to Saxifragaceae. University of Washington Press.

Langeland, K., M. Netherland, W. Haller. 2009. Efficacy of herbicide active ingredients against aquatic weeds. University of Florida, Cooperative Extension Service pub. SS-AGR-44.

Richards, J. H. and C. Cao. 2012. Germination and early growth of *Nymphaea odorata* at different water depths. Aquatic Botany. 98: 12-19.

Richards, J. H., G. Troxler, D. W. Lee, and M. H. Zimmerman. 2011. Experimental determination of effects of water depth on *Nymphaea odorata* growth, morphology and biomass allocations. Aquatic Botany 95: 9-16.

Schneider, E.L., and T. Chaney. 1981. The floral biology of Nymphaea odorata (Nymphaeaceae). The Southwestern Naturalist 26(2):159-165.

Sinden-Hempstead, M. and K. T. Killingbeck. 1996. Influences of water depth and substrate nitrogen on leaf surface area and maximum bed extension in *Nymphaea odorata*. Aquatic Botany. 53: 151-162..

Washington State Department of Ecology. 2001. An Aquatic Plant Identification Manual for Washington's Freshwater Plants. Publication 01-10-032.

Wiersema, J. H. *Nymphaea*. In: Flora of North America Editorial Committee, eds. 1993+. Flora of North America North of Mexico. 16+ vols. New York and Oxford. Vol. 3. 1997.

Williams, G.R. 1970. Investigations in the white waterlilies (*Nymphaea*) of Michigan. The Michigan Botanist 9:72-86.

USDA, ARS, National Genetic Resources Program. Germplasm Resources Information Network - (GRIN) [Online Database]. National Germplasm Resources Laboratory, Beltsville, Maryland.
URL: http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?410492 (11 April 2013)