WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

Aquatic Plants Technical Assistance Program

1998 Activity Report

June 1999

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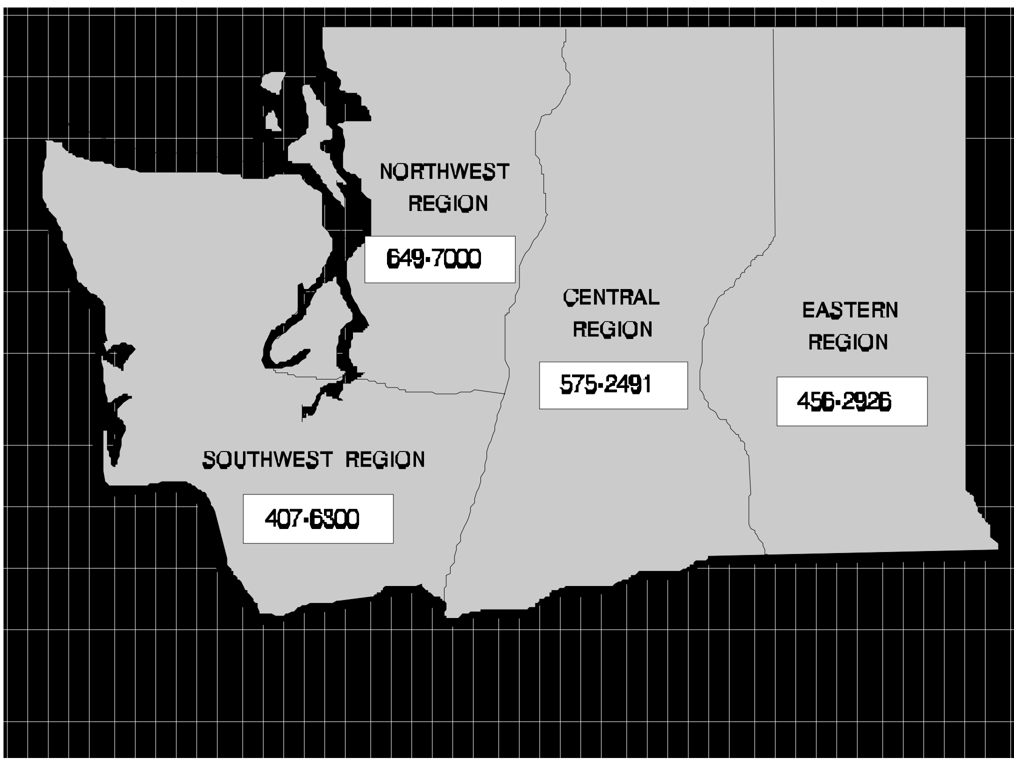

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DEPARTMENT OF
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Aquatic Plants Technical Assistance Program

1998 Activity Report

prepared by
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Environmental Assessment Program
Olympia, Washington 98504-7710

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Abstract

The objectives of the Aquatic Plant Technical Assistance Program are to (1) provide advice on aquatic plant identification, biology, and management to government agencies and the public, (2) document aquatic plant distribution and habitat through site visits, and (3) assist with evaluating projects supported by Freshwater Aquatic Weed Program grant money.

During the 1998 field season, aquatic plant data were gathered during 74 site visits to 68 waterbodies located throughout the state. Several previously unknown populations of non-native invasive aquatic plants were recorded. These included eight previously unknown populations of *Myriophyllum spicatum,* and two populations of *Egeria densa.* A special project to create three different boatlaunch signs educating boaters about invasive aquatic plants was completed and the signs are available for distribution. Other accomplishments during 1998 included gathering additional plants for the herbarium collection, providing educational and technical outreach, taking part in an efficacy evaluation of the herbicide 2,4-D in Loon Lake, and assisting with projects funded by Freshwater Aquatic Weed Program grant money.

Introduction

Legislative action in 1991 (RCW 43-21A.660) established the Freshwater Aquatic Weed Account to provide additional expertise on aquatic plant issues and a source of grant money for local aquatic plant management projects. The need for this program was recognized when the spread of aquatic plant problems in the state's public waters outgrew the ability of agencies to adequately address the problems. To provide the technical expertise for aquatic plants, one full-time position was created within the Environmental Assessment Program of the Department of Ecology. This position was filled in February 1994. The objectives for this position are to:

- provide technical assistance on aquatic plant identification and management to government agencies and the public;
- conduct site visits to identify aquatic plants, evaluate plant community structure and identify the existence or potential for problems, particularly as they relate to invasive non-native aquatic plants; and
- assist with rating grant applications to the Freshwater Aquatic Weed Account.

The purpose of this report is to document the progress of the Aquatic Plant Technical Assistance Program with respect to these objectives during 1998, concentrating on site visit results. Reports on the program results from 1994, 1995, 1996, and 1997 are also available (Parsons 1995a; Parsons 1996, Parsons 1997, Parsons 1998).

To simplify reporting, all plants are referred to by their scientific names. Table 1 lists the common names for the plants most frequently mentioned in the text.

Table 1. Scientific and common plant names.

Scientific Name	Common Names
Cabomba caroliniana	fanwort
Egeria densa	Brazilian elodea
Hydrilla verticillata	hydrilla
Ludwigia hexapetala	water primrose
Lysimachia vulgaris	garden or yellow loosestrife
Lythrum salicaria	purple loosestrife
Myriophyllum aquaticum	parrot feather milfoil
Myriophyllum spicatum	Eurasian milfoil
Nymphaea odorata	fragrant waterlily
Polygonum hydropiper	marshpepper
Utricularia inflata	big floating bladderwort

Technical Assistance

After the Freshwater Aquatic Weed Account was established, an external advisory committee identified technical assistance for aquatic plant taxonomy, ecology, and management as a high priority for the new Freshwater Aquatic Weed Management Program. Technical assistance was later defined as "Provid(ing) technical expertise within Ecology and to other agencies, local governments, lakes groups, and the general public regarding aquatic plant ecology and taxonomy, aquatic plant management, development of integrated aquatic plant management plans, and other aquatic plant management issues. Assistance will be provided through on-site visits, development of technical reports, participation in public workshops, and presentations to private and public groups and societies."

Providing technical assistance involves working with public and private sectors to develop a broad understanding of the roles aquatic plants play in the ecosystem and how human behavior influences aquatic plant communities. Toward this aim, I participated in several workshops, meetings, and conferences and wrote articles for various publications between January 1 and December 31, 1998 (Table 2). I also assisted the public and local governments on an informal basis through phone conversations, identification of mailed plant specimens, and informal meetings that are not listed. Much of this information, as well as other publications the Department of Ecology has produced on aquatic plants in Washington, are available on Ecology's web pages (http://www.wa.gov/ecology).

An additional special project was also undertaken over the course of the year. This was to create three new boatlaunch signs to update and replace signs currently in place at the public boatlaunches. Two new signs were created for lakes and rivers known to contain populations of *Myriophyllum spicatum* and *Egeria densa*. These signs warn boaters about the weeds and ask them to be extra careful to clean their boat and trailer when leaving the waterbody. The other sign is more general, appropriate for any lake. It asks people not to introduce any plants or animals to the lake, and to clean boats, trailers and fishing gear when leaving. The signs are available through Ecology by calling our publications department at (360) 407-7472.

Table 2. Aquatic plant technical outreach activities - 1998.

Function	Date	Location	Role
Western Aquatic Plant Management Society newsletter	1/98		Edited and published the Winter edition
Guest lecturer, the Evergreen State College	2/3/98	Olympia, WA	Taught a section on aquatic plant ecology to a Freshwater Ecology class
Washington Lakes Protection Association newsletter	2/98		Article on *Vallisneria americana* (water celery) biology and ecology
Western Aquatic Plant Management Society Annual Conference	3/25-3/26/98	San Diego, CA	Presented paper titled 'Aquatic plant communities in Washington', attended sessions and board meeting
Washington Lakes Protection Association conference	4/3/98	Issaquah, WA	Presented paper on performing noxious weed surveys, attended sessions
Western Aquatic Plant Mgmt Society newsletter	5/98		Wrote articles, edited and produced newsletter
Guest lecturer, Chehalis Community College	5/5/98	Chehalis, WA	Taught a section on aquatic plant identification
Workshop on Aquatic Plant Monitoring	5/19/98	Republic, WA	Presented classroom and field training to County personnel and volunteers
Met with lake resident, Haven Lake	6/8/98	Mason County	Discussed aquatic plant management techniques, conducted survey
Met with lake resident, Star Lake	6/12/98	Mason County	Discussed aquatic plant management techniques, conducted survey
Ecology Management Team Meeting	7/10/98	Olympia, WA	Short presentation on invasive aquatic plants
Cross training with Central Regional Office personnel	7/27/98	Kittitas County	Provided plant identification assistance, learned about lake issues in central WA
Western Aquatic Plant Management Society newsletter	7/98		Edited and produced newsletter
Washington Lakes Protection Association newsletter	9/98		Wrote article on *Utricularia* spp. (bladderwort)
Met with Thurston County Noxious Weed Board personnel	9/30/98	Black River, Thurston Co.	Mapped *Polygonum hydropiper* population
Met with Lewis County Noxious Weed Control personnel	10/5/98	Mayfield Lake Lewis County	Confirm presence and extent of *Myriophyllum spicatum* population
Noxious Weed Monitor list	11/98		Sponsor two aquatic species, *Ludwigia hexapetala* and *Nymphoides peltata.*
Mason Lake milfoil control planning meeting	11/2/98	Mason-Benson Community Club	Provided technical assistance in formulating a plan for *Myriophyllum spicatum* control
Aid New Zealand government with aquatic herbicide research	11/17/98	Pipe Lake, King County	Collected sediment and water samples for iron analysis
Lake Leland Aquatic Vegetation Management Plan final meeting	11/18/98	Leland Club, Jefferson Co	Provided technical assistance in the final stages of the planning process
Western Aquatic Plant Management Society newsletter	11/98		Wrote an article, edited and produced newsletter
Zebra Mussel Task Force Mtg.	11/20/98	Olympia, WA	Attended final planning meeting
Washington Lakes Protection Association newsletter	12/98		Wrote article on *Typha* (cattail) biology and ecology

Site Visits

Introduction

This section documents aquatic plant surveys conducted during the 1998 field season. The general purpose of site visits was to identify aquatic plants (targeting exotic invasive species), evaluate plant community structures, estimate the extent of, or potential for, aquatic plant problems, and suggest possible management options. Another important aspect of the site visits was to expand the aquatic plant database and herbarium collection. This year we also conducted an intensive plant monitoring project on Loon Lake, Stevens County during June and August as part of an herbicide efficacy study. Preliminary results of this ongoing study will be presented in this section.

Site Visit Objectives

The specific 1998 site visit objectives were to:

- revisit selected lakes with exotic invasive plants in order to assess plant population changes since earlier surveys;
- revisit other selected lakes considered to be at high risk for a non-native plant invasion;
- conduct field surveys in selected lakes that had not been surveyed by this program during previous field seasons;
- confirm rare plant sightings from past field seasons;
- continue plant community monitoring projects on selected lakes; and
- collect detailed plant biomass and distribution data in Loon Lake, Stevens County.

During site visits, meetings with concerned citizens or local government representatives were arranged if appropriate. If new populations of exotic species were found, the local weed board representative or county extension agent was contacted.

Field Methods

For a detailed discussion of field methods and data quality control, refer to the Aquatic Plant Technical Assistance Final Quality Assurance Project Plan in Parsons (1995b). The main goal of field site visits is to create the most comprehensive species list possible for each waterbody. This facilitates the discovery of potentially problematic aquatic plants and provides baseline aquatic plant distribution information.

For most lakes the method used is to circumnavigate the littoral zone in a small boat. When a different plant or type of habitat is observed, samples are collected for identification using a weighted rake, by hand-pulling or by visual observation. In addition, notes on species distribution, abundance, and maximum depth of growth are made. This method was recommended by other aquatic plant researchers (Sytsma, 1994; Warrington, 1994) and was used successfully during the previous four years. However, it should be noted that because the surveys are conducted from the surface, small populations of any plant species might be overlooked.

Secchi depth and alkalinity data were also collected on selected lakes. This was ancillary to the plant data, so time and logistical constraints limited the frequency of sample collection. These parameters were chosen because they have been shown to influence plant community type (Srivastava *et al.*, 1995; Smart, 1990; Kadono, 1982; Hellquist, 1980) and because they are relatively easy to obtain. The alkalinity samples were collected in open water to minimize the diel influence of macrophytes. Alkalinity was measured using a Hach® field test kit model AL-DT with a digital titrator to determine phenolphthalein and total alkalinity as $CaCO_3$. Secchi depth was also measured in deep, open water.

Field visits occurred between late spring and early fall to correspond with the time of maximal growth and flowering. Sampling locations were recorded with a written description, visual placement on a map, and with a Global Positioning System (GPS) unit.

Collections were made of any unusual plant species and of known or suspected exotic species. These were pressed, mounted, and retained in the herbarium collection (see Herbarium section in this report). All data were recorded on field forms and entered into a relational database (see Parsons 1995a for a database design description).

Aquatic Plant Survey Results

During the 1998 field season 74 site visits were made to 68 waterbodies. Highlights of results from these surveys are provided in the following section. In addition, several special projects will be discussed in subsequent sections. These include:

- an update on the *Hydrilla verticillata* eradication project in Pipe and Lucerne Lakes;
- monitoring of *Polygonum hydropiper* in the Black River;
- rare plant finds; and
- a section on the Loon Lake demonstration project.

General Results

Table 3 lists the lakes where aquatic plant data were gathered during the 1998 field season, the extent of the survey, and any aquatic plants listed with the Washington State Noxious Weed

Control Board that were found. A similar table with data summarizing all five years of this program is contained in Appendix A. The author will provide additional information on any of the listed waterbodies upon request.

Table 3. 1998 Site visit and results summary table

County	Waterbody Name	WRIA	Date	Survey Extent	Plants of Concern
Adams	Herman Lake	41	7/28/98	whole lake	*Lythrum salicaria*
Cowlitz	Sacajawea Lake	25	8/4/98	3 sites, shore	none
	Silver Lake	26	8/4/98	south half	none
	Solo Slough	25	8/4/98	1 site, shore	*Ludwigia hexapetala*
					Myriophyllum aquaticum
	Willow Grove Slough	25	8/4/98	1 site, shore	*Cabomba caroliniana*
					Egeria densa
Ferry	Curlew Lake	60	5/19/98	2 sites, boat	none
Grant	Burke Lake	41	9/9/98	whole lake	*Lythrum salicaria*
					Myriophyllum spicatum
	Evergreen Lake	41	9/9/98	whole lake	*Lythrum salicaria*
					Myriophyllum spicatum
	Frenchman Hills	41	7/29/98	1 site, shore	*Lythrum salicaria*
	Moses Lake	41	7/15/98	10 sites, boat	*Lythrum salicaria*
	Park Lake	42	9/10/98	whole lake	none
	Potholes Reservoir	41	7/16/98	10 sites, boat	none
	Quincy Lake	41	9/8/98	whole lake	*Lythrum salicaria*
	Warden Lake	41	7/28/98	whole lake	*Lythrum salicaria*
	Winchester Wasteway	41	7/28/98	1 site, shore	*Lythrum salicaria*
Grays Harbor	Duck Lake	22	8/18/98	main lake	*Egeria densa*
					Lythrum salicaria
					Myriophyllum spicatum
Jefferson	Crocker Lake	17	9/3/98	whole lake	none
	Leland Lake	17	9/3/98	whole lake	*Egeria densa*
King	Pipe Lake	9	6/9/98	whole lake	*Hydrilla verticillata*
		9	11/17/98	3 sites, boat	none
	Washington Lake	8	8/24/98	Juanita Bay	*Egeria densa*
					Myriophyllum spicatum
Kitsap	Buck Lake	15	7/22/98	whole lake	*Lythrum salicaria*
	Island Lake	15	7/22/98	whole lake	none
	Kitsap Lake	15	7/1/98	south end	none
	Mission Lake	15	6/18/98	whole lake	*Utricularia inflata*
	Wildcat Lake	15	8/20/98	whole lake	none
	William Symington Lake	15	9/16/98	whole lake	none
	Wye Lake	15	7/1/98	1 site, shore	*Utricularia inflata*
Kittitas	Cle Elum Reservoir	39	7/29/98	1 site, shore	none
	Lavender Lake	39	7/27/98	whole lake	*Myriophyllum spicatum*
	Wild Duck Lake	39	7/27/98	2 sites, shore	none
Lewis	Mayfield Reservoir	26	10/5/98	south half	*Myriophyllum spicatum*
	Swofford Pond	26	9/15/98	east end	*Myriophyllum spicatum*
Mason	Haven Lake	15	6/8/98	whole lake	none
	Island Lake	14	7/9/98	whole lake	*Myriophyllum spicatum*
	Limerick Lake	14	7/8/98	whole lake	*Egeria densa*
					Utricularia inflata

County	Waterbody Name	WRIA	Date	Survey Extent	Plants of Concern
Mason con't	Lystair (Star) Lake	22	6/12/98	whole lake	none
	Maggie Lake	15	8/19/98	whole lake	none
	Mason Lake	14	9/14/98	whole lake	*Myriophyllum spicatum*
	Phillips Lake	14	7/20/98	whole lake	none
	Tee Lake	15	8/19/98	whole lake	none
	Trails End (formerly Prickett)	15	6/16/98	whole lake	*Lythrum salicaria*
					Utricularia inflata
	Wooten Lake	15	6/16/98	whole lake	none
Pend Oreille	Horseshoe Lake	55	7/13/98	west half	none
Pierce	American Lake	12	10/6/98	whole lake	none
	Carney Lake	15	7/1/98	1 site, shore	none
	Steilacoom Lake	12	8/26/98	whole lake	none
			10/21/98	1 site, boat	none
Skagit	Cavanaugh Lake	5	8/24/98	whole lake	none
	Cranberry Lake	3	8/25/98	2 sites, shore	none
	Erie Lake	3	8/25/98	whole lake	none
	Heart Lake (35N-01E-36)	3	8/25/98	whole lake	*Myriophyllum spicatum*
Skamania	Coldwater Lake	26	8/27/98	80% of shore	*Myriophyllum spicatum*
Snohomish	Blackmans Lake	7	8/5/98	whole lake	*Lythrum salicaria*
	Martha Lake (27N-04E-01)	8	8/5/98	whole lake	none
	Roesiger (north arm) Lake	7	8/6/98	whole lake	*Myriophyllum spicatum*
					Lythrum salicaria
	Roesiger (south arm) Lake	7	8/6/98	whole lake	*Myriophyllum spicatum*
Spokane	Liberty Lake	57	7/13/98	whole lake	*Myriophyllum spicatum*
	Medical Lake	43	7/14/98	whole lake	none
	West Medical Lake	43	7/14/98	whole lake	none
Stevens	Loon Lake	59	6/24/98	whole lake	*Lysimachia vulgaris*
		59	8/11/98	whole lake	*Myriophyllum spicatum*
Thurston	Black River near Gate	23	8/18/98	1 site, shore	*Polygonum hydropiper*
		23	9/15/98	1 site, shore	
		23	9/30/98	5 mile reach	
	Munn Lake	13	6/3/98	1 site, shore	*Utricularia inflata*
		13	10/14/98	1 site, shore	
	Offutt Lake	13	7/7/98	whole lake	none
	Ward Lake	13	7/6/98	whole lake	none
Yakima	Dog Lake	38	7/30/98	whole lake	none
	Leech Lake	39	7/30/98	whole lake	none
	Unnamed pond (14N-19E-31)	39	7/29/98	1 site, shore	none
	Unnamed Ponds (12N-19E-20)	37	7/29/98	4 sites, shore	*Lythrum salicaria*
	Wenas Lake	39	7/29/98	whole lake	none

The results of these surveys include the discovery of a previously unknown population of *Myriophyllum spicatum* in Mason Lake, Mason County. In addition, we confirmed the presence of *M. spicatum* in several other lakes either through sight visits (Lake Roesiger, Snohomish County; Heart Lake, Skagit County; Duck Lake, Grays Harbor County; Mayfield Reservoir, Lewis County; and Coldwater Lake, Skamania County) or mailed samples (Diamond Lake, Pend Oreille County; Black Lake, Stevens County). One population of *Egeria densa* was confirmed in Lake Washington (King County), and another was reported for Klineline Pond, Cowlitz County. Many of this year's discoveries came from outside the agency. Past years of training County Noxious Weed Board personnel, State Fish and Wildlife Biologists, and volunteers with the Lake Water Quality Assessment Program in aquatic weed identification have greatly increased the number of aquatic non-indigenous species reports we receive from outside the agency.

Appendix B and Figures 1 and 2 contain maps illustrating where known populations of the noxious invasive aquatic plants *Myriophyllum spicatum*, *Egeria densa,* and *Myriophyllum aquaticum* occur in Washington. We have also become concerned about the apparent spread of *Utricularia inflata* in recent years, so we have begun to track populations of this plant as well (Figure 3). The maps include sites that have been visited by Aquatic Plant Management Program personnel and those reported by reliable sources. Also included are waterbodies where weed eradication efforts have been undertaken within the last five years. If no recurrence of the targeted weed occurs in five years, then the lake or pond will be removed from this list.

Figure 1. Known locations of *Egeria densa* in Washington, 1998.

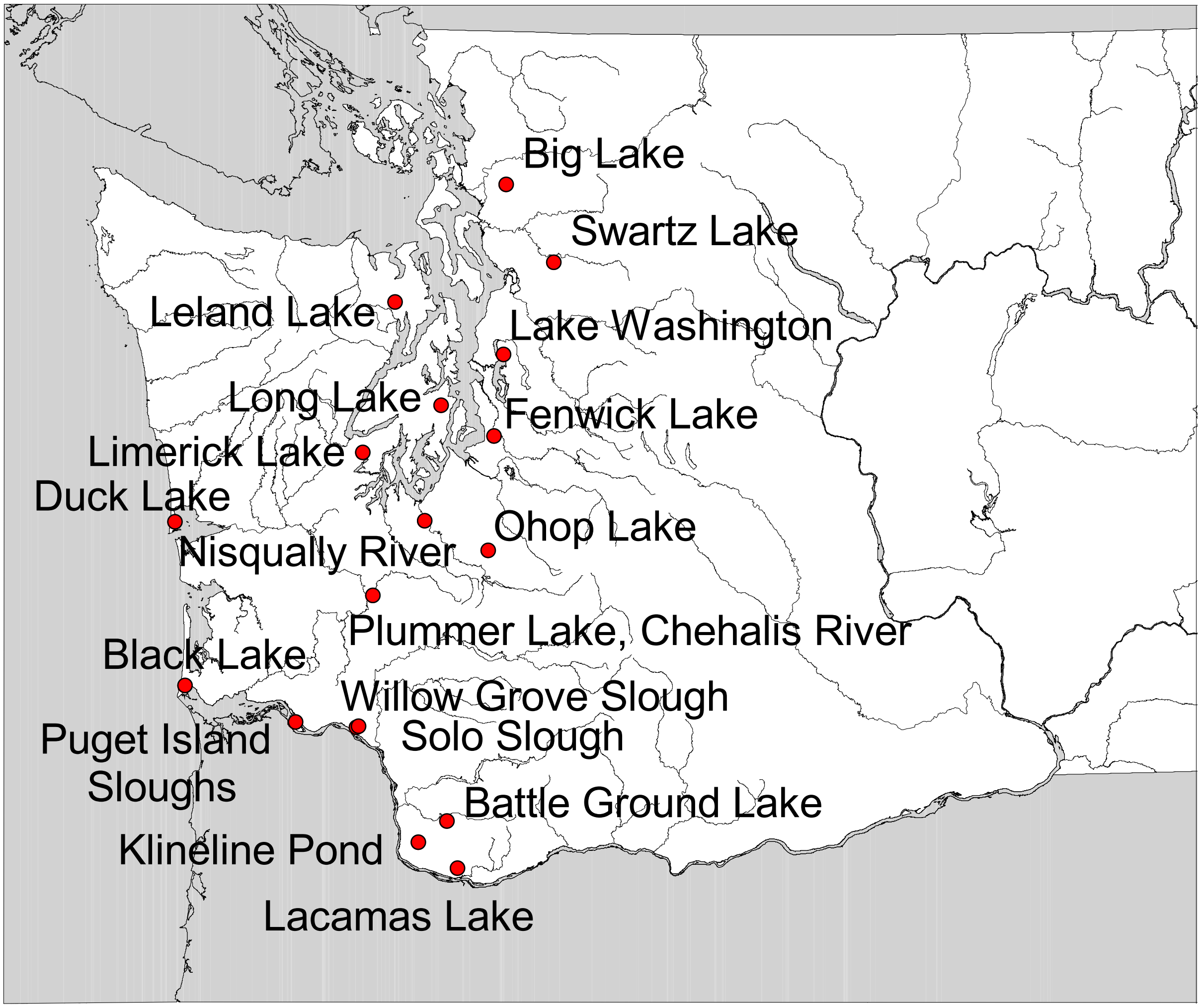


Figure 2. Known locations of *Myriophyllum aquaticum* in Washington, 1998.

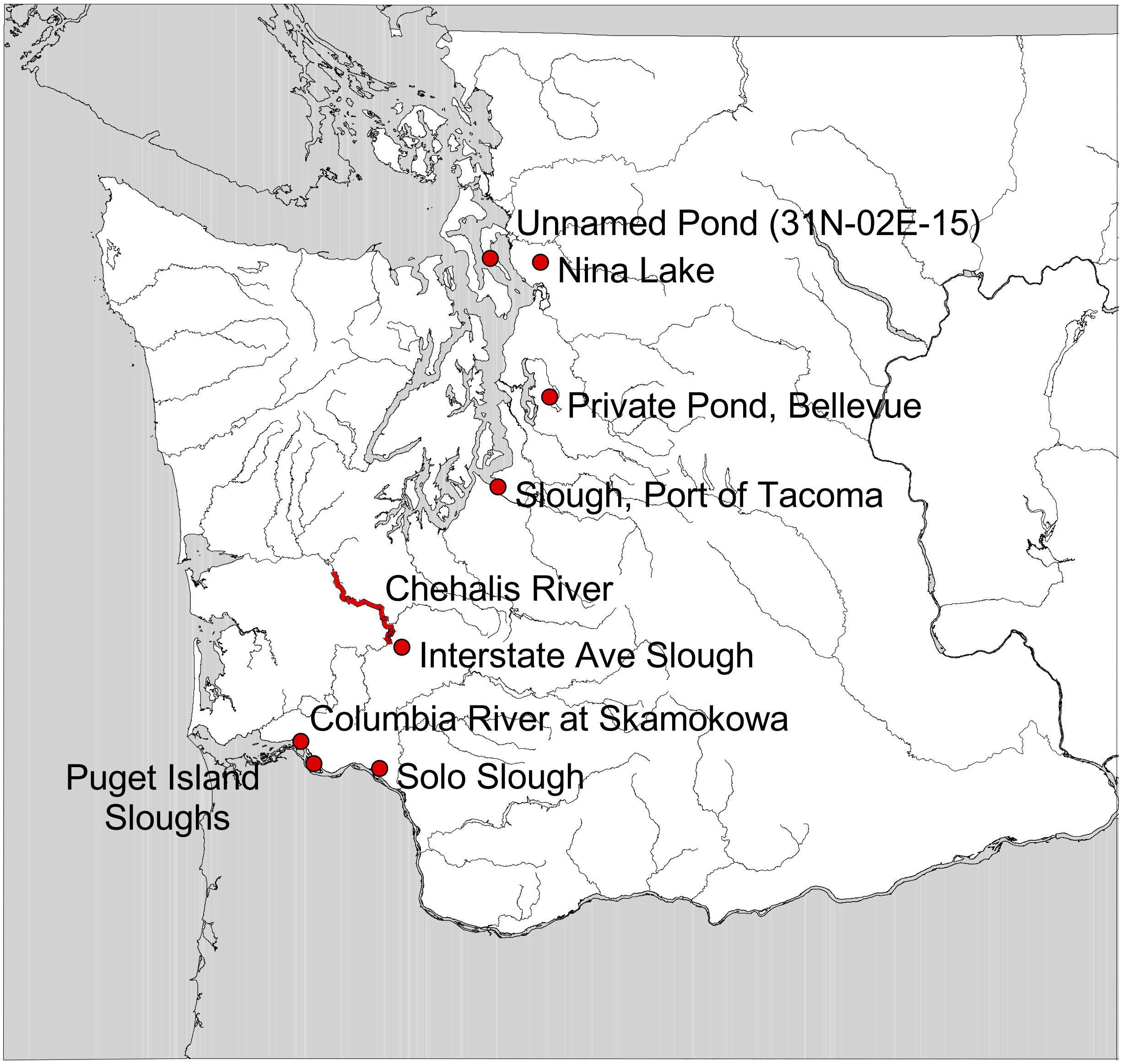
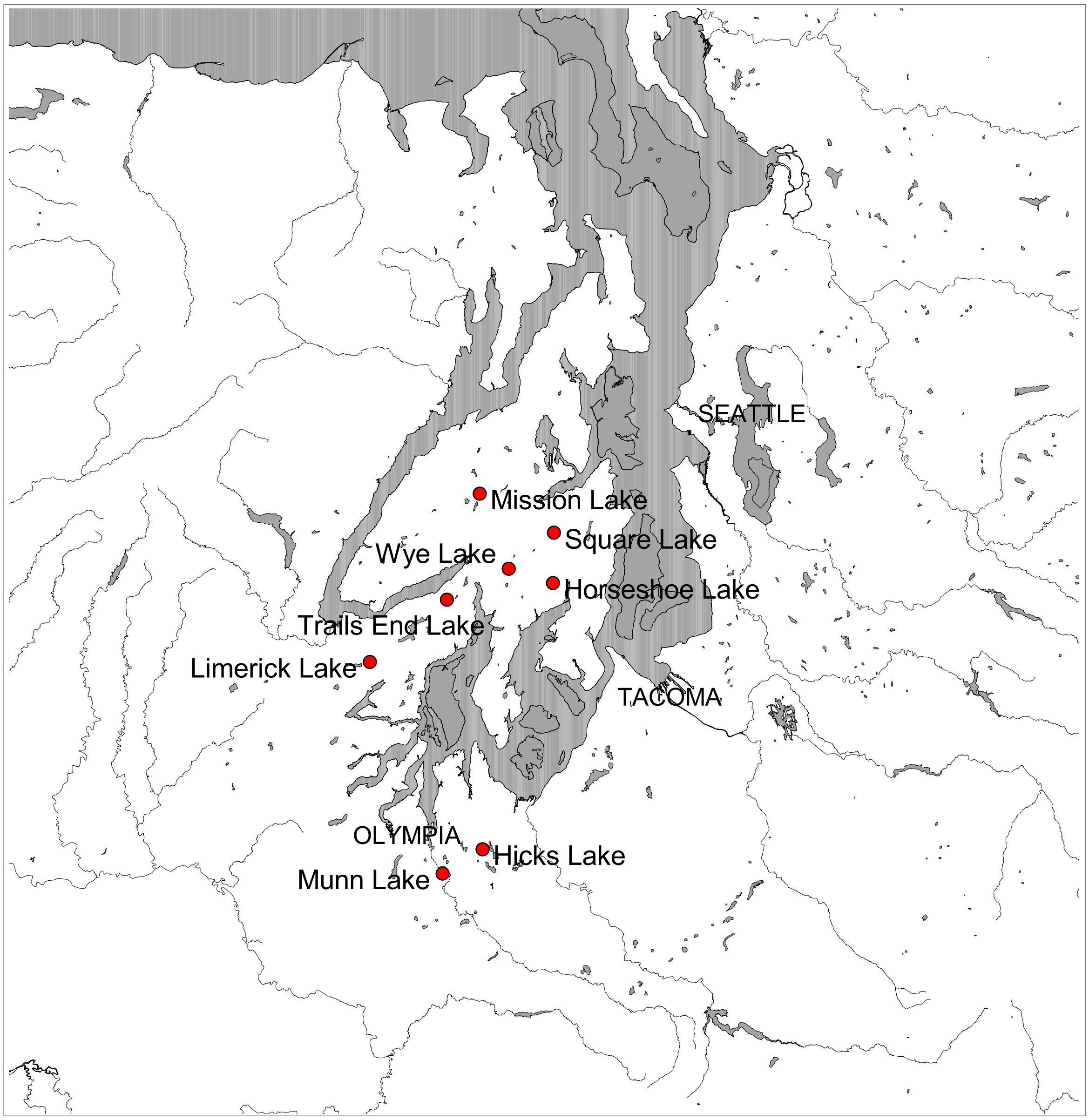


Figure 3. Known locations of *Utricularia inflata* in Washington, 1998.



Hydrilla Verticillata - An Update

The presence of *Hydrilla verticillata* was confirmed in Pipe and Lucerne Lakes (King County) on June 1, 1995. *Hydrilla* is an aggressive, non-native aquatic plant which will out-compete native vegetation if given the opportunity. Where it has become established (in the southern United States as far north as Connecticut and west to California), its rapid growth has radically changed aquatic environments. It is particularly difficult to control due to its many propagation strategies which include tubers, turions, plant fragments, and seeds. Federal and State agencies spend millions of dollars each year attempting to control its growth (Langeland, 1990; Anderson, 1987).

Because this was the first known population of *Hydrilla* in the northwest, aggressive action was taken to attempt its eradication. During the summers of 1995 through 1997, the 73 acre Pipe/Lucerne Lake system was treated with the systemic aquatic herbicide fluridone (brand name Sonar®) each year. The overall results of this treatment regime have been a continual reduction in *Hydrilla* tuber germination. A complete discussion of the events leading to these treatments during the first two years is provided in Parsons (1997).

Herbicide treatment was again chosen as the optimal control method for the summer 1998 due to results of a diver inventory conducted in June. At that time *Hydrilla* could be found growing at a density of one plant per 5 to 20 square meters (Marquez, 1998). While this was a reduction over previous years, it was too high to rely on hand pulling or other spot treatments. Other submersed species that were growing at that time were plant-like macroalgae such as *Nitella*, and filamentous algae. These algae species are not affected by the herbicide, so it is normal for them to proliferate after treatment.

The treatment results from this year will not be known until spring 1999, when new plant growth can be assessed. King County again plans to contract for diver surveys at that time to assess the level of new *Hydrilla* germination. This information will be used to help determine if additional herbicide applications will be recommended, or if other methods can finally be depended upon.

As part of a separate effort, sediment and water samples were collected from three sites in Pipe Lake during November. These, along with dried Hydrilla specimens, were sent to aquatic plant scientists in New Zealand for iron analysis. The New Zealand government is investigating the possibility that high levels of iron in their sediment are the reason that the herbicide Sonar® does not work against *Hydrilla* populations in that country. The preliminary results show that both the soil and water total iron values were within the range of what is seen in New Zealand Lakes; about 0.6 % and about 0.18 ppm respectively. All plant samples but one were also within the range of those from New Zealand. The exception had a higher than normal iron concentration, but this could be due to sample contamination. They have requested additional plant samples next year, if they are available (Hofstra, 1998).

Black River *Polygonum hydropiper*

Midway through the 1998 field season we were alerted to citizen concern regarding an emergent aquatic plant in the lower reaches of the Black River in Thurston County. By September the plant had reached maturity and it was determined to be marshpepper, or *Polygonum hydropiper* (Old, 1998). This is a non-native plant that normally does not aggressively outcompete native species. However, in the Black River it is forming an impressive growth from the shoreline into water 3 feet deep. In some areas it completely covers the channel (Figure 4).

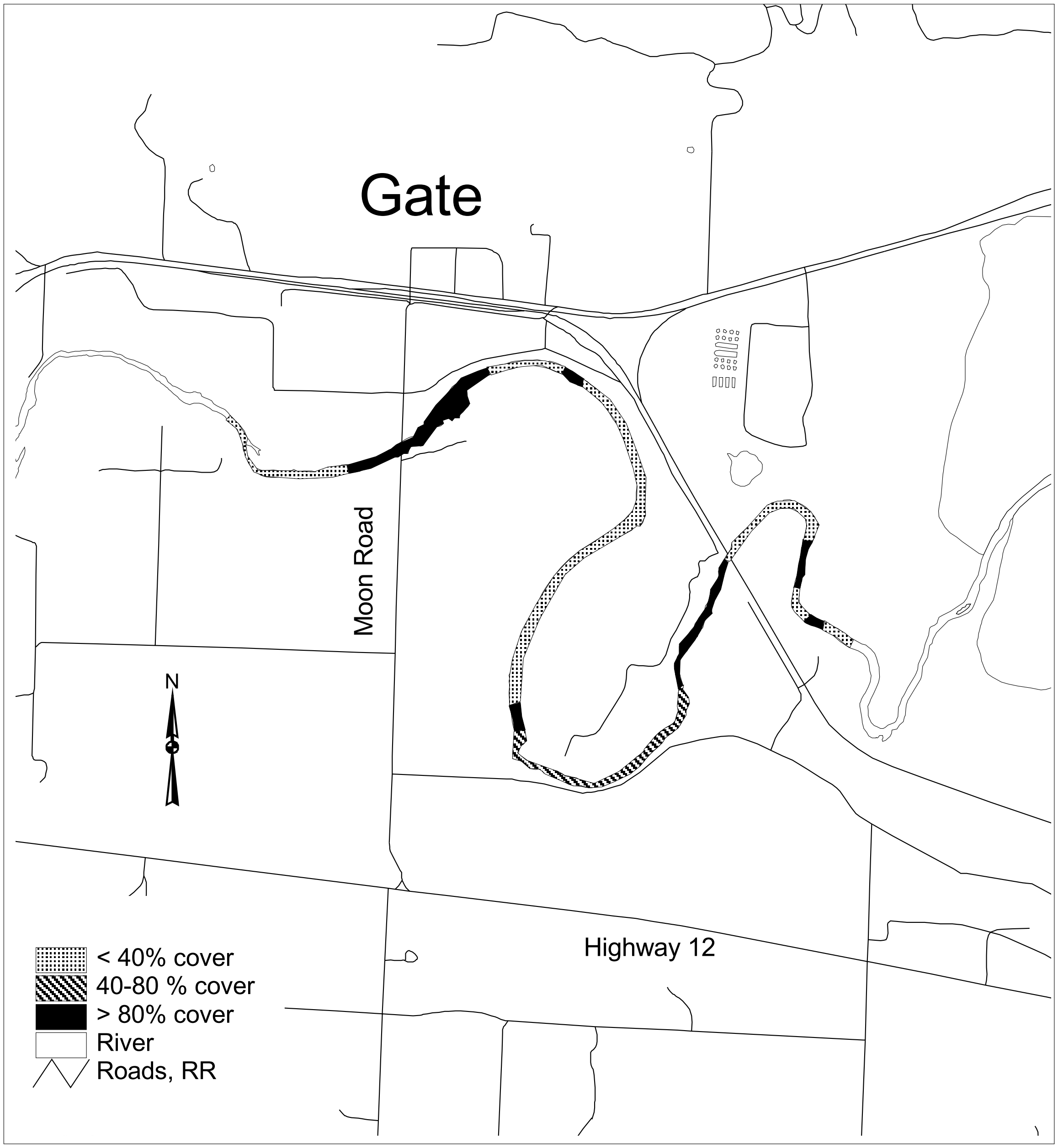
At the end of September we surveyed the river with personnel from the Thurston County Noxious Weed Board to map the extent of the *P. hydropiper* population. It is not known if the plant is growing so vigorously due to an inherent ability to dominate the shallow water habitat, or if it could be simply responding favorably to some quality of the environment in that river segment. In the late 1980's there was a fish-kill that raised concerns about nutrient levels in that stretch of river. This prompted a water quality study conducted by Ecology. The results identified several nutrient sources flowing into this segment of river, mostly from agricultural runoff (Pickett, 1994).

We will continue to monitor this plant population in future years. If it appears that it is expanding its range, methods to curtail its growth will be considered.

Rare Plants

In addition to the weedy species, populations of plants listed as rare by the Washington Natural Heritage Program (WNHP) (Washington Natural Heritage Program, 1994) were observed during the field surveys. *Limosella acaulis* (mudwort), was again observed in Grant County, and several lakes with populations of *Lobelia dortmanna* in Skagit and Mason Counties were visited. In addition, sightings of *Heteranthera dubia,* and *Hydrocotyle ranunculoides* were reported to the WNHP database manager. Previously observed populations of *Potamogeton obtusifolius* were confirmed in Mason, San Juan, and Jefferson Counties and also reported (Haynes, 1998).

Figure 4. Black River *Polygonum hydropiper* density.



Loon Lake Study

Introduction

Site Description

Loon Lake is located in Stevens County, about 1 hour north of Spokane. It is 1100 acres with 7.9 miles of shoreline (Figure 5). The maximum depth is 100 feet, mean depth 46 feet (Dion et al., 1976). It is an oligo-mesotrophic lake with moderate levels of nutrients and generally good water clarity (Hallock, 1997). Loon Lake hosts a diverse plant and animal community, with at least 28 species of submersed vascular plants growing to approximately 22 feet deep. Fish species present include rainbow trout (there is one net pen in operation), planted Eastern brook trout and brown trout, lake trout (Mackinaw), kokanee salmon and warm water species such as largemouth bass, pumpkinseed sunfish and yellow perch (Vail, 1998). The shoreline is about 85% developed with seasonal and year-round residences. The remaining 15% is mostly wetland.

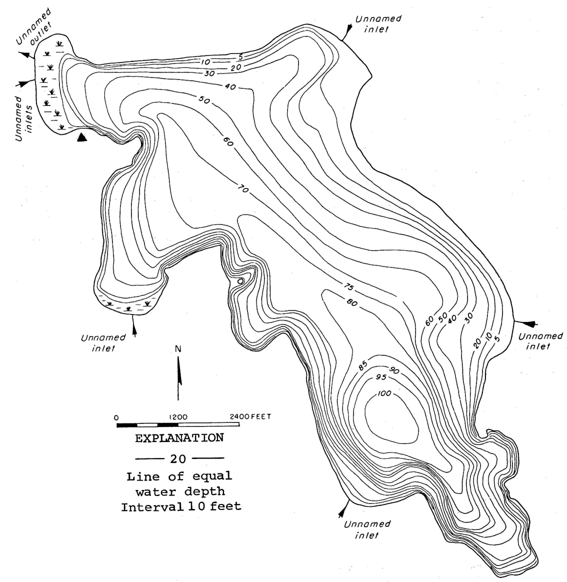


Figure 5. Loon Lake map
from Dion et al. 1976.

History of <u>Myriophyllum spicatum</u> control in Loon Lake

In early September 1996 a patch of *Myriophyllum spicatum* in the lake's northwest end was brought to the attention of the Stevens County Noxious Weed Control Board by two lake residents (Winterod, 1998). Ecology personnel surveyed the lake to ascertain the extent of the weed problem in late September. At that time we found a dense patch in and near the outlet canal where the plant had originally been found, and several small scattered patches and individual plants located in other sections of the lake. We felt that the plant's distribution and coverage was less than three acres; small enough to qualify as an early infestation under the Aquatic Plant Management Fund grant guidelines.

The Loon Lake Property Owners Association, with the Stevens County Noxious Weed Control Board, applied for and received an early infestation grant from the Aquatic Weed Management Fund during the winter of 1996-1997 (Hamel, 1997). They planned to barricade off the heavily infested outlet canal and treat it with the systemic herbicide fluridone (brand name Sonar).

Other isolated *M. spicatum* patches would be treated with bottom barrier or by hand pulling using SCUBA divers (Winterod, 1998).

This treatment was carried out in the summer of 1997. The herbicide treatment of the canal area was declared a success. However, by late summer it was evident that the *M. spicatum* had spread in other parts of the lake to the extent that the bottom barriers and hand pulling were ineffective. The plant was simply growing and spreading at a faster rate than the divers could contain.

During the winter of 1997-1998, Loon Lake residents decided they needed to use an herbicide that would quickly kill small patches of the *M. spicatum*. Sonar® was not an option due to the 8-10 week contact time requirements. In fact, no fast acting systemic herbicide is approved for aquatic use in Washington State. The lake residents decided to contact their state legislators and urge them to allow a demonstration project on the effectiveness of the herbicide 2,4-D in the aquatic formulation Navigate®. 2,4-D was suggested because it has a federal label for aquatic use, and is generally selective against dicotyledonous plants such as *M. spicatum* (flowering plants that produce two seed leaves at germination, versus monocotyledons that produce one) (Murphy and Barrett, 1993). The project was approved, and the legislature directed the Department of Ecology to support the project with technical assistance and money from the Aquatic Weed Management Fund. The treatment was planned for the following summer, 1998.

The following sections detail the scientific study that was conducted as part of the demonstration project. The objective of the scientific study was to determine the herbicide's effectiveness against *M. spicatum,* as well as its impact on native aquatic plants: whereas the goal of the demonstration project was to eliminate *M. spicatum* from Loon Lake. For the scientific study we decided to collect plant data before herbicide treatment and 6 weeks and 1 year after treatment. The study will be continued in 1999 to collect the 1 year post treatment data. This report details only the aquatic plant data from the first summer.

Methods

Drs. John Madsen and Kurt Getsinger at the US Army Corps of Engineers Waterways Experiment Station designed the aquatic plant sampling plan (Madsen and Getsinger, 1998). It called for three methods of assessing the plant community before and after the herbicide treatment:

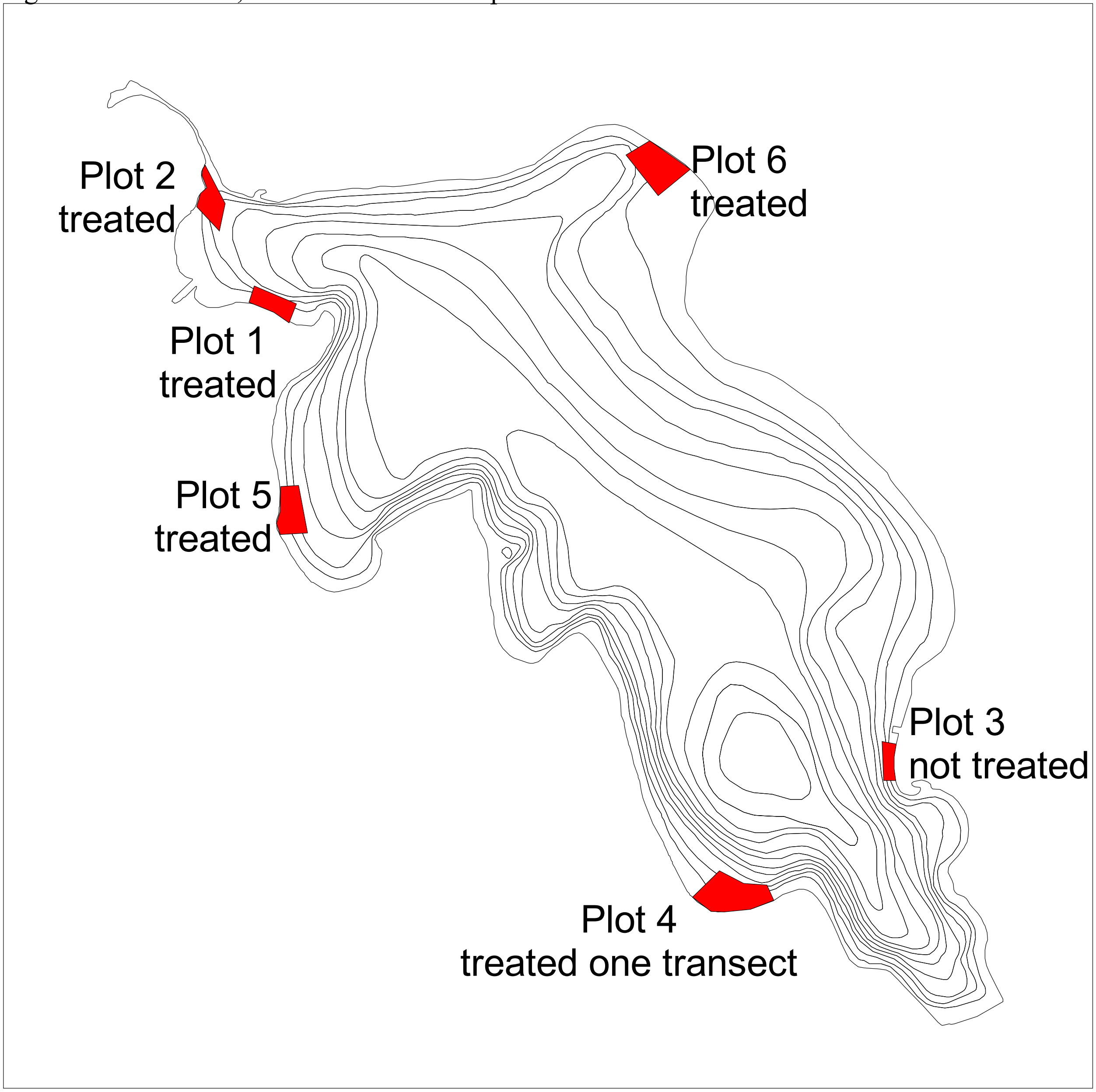
- biomass sampling in 6 plots;
- line intercept frequency sampling for 6 plots; and
- point intercept frequency sampling for the whole lake.

Each method is described below.

Biomass

Six plots were established based on knowledge of the *M. spicatum* distribution from the previous year's surveys (Lamb, 1998). Four plots to be treated with herbicide were located in areas with the densest known growths of *M. spicatum*, and two plots were located in areas thought to be free of *M. spicatum* for the no-treatment control (Figure 6). Although for scientific purposes it would have been preferable to establish control plots in areas with *M. spicatum*, this was not done to

Figure 6. Loon Lake, location of treatment plots.



accommodate the demonstration project's goal of eradicating *M. spicatum* from the lake. Within each plot two 100 meter transects marked at 1 meter intervals were laid out within the area of plant growth (less than 22 feet deep). The transect lines sometimes curved in order to avoid deeper water. Careful notes and Global Positioning System (GPS) points were used to ensure that the transects were in the same locations during both the before and after treatment data collection efforts.

During both the before and after treatment sampling sessions ten biomass samples were collected in each plot; five along each transect line. The sample points during each sample period were located at stratified-random distances along and away from the transect lines. Each sample was located randomly at 20 meter intervals and between 1-5 meters away from the line. (For instance, sample 1 was located a random distance between 1-20 meters, sample 2 between 20-40 meters, etc.)

Sample collection and processing followed methods described by Madsen (1993). The samples were collected by a diver using SCUBA gear and a 0.1 square meter frame made of PVC pipe. The diver placed the frame on the sediment at the predetermined sample site and collected all above ground plant biomass within the frame. The plants were placed in a mesh bag and carried to a nearby boat where the sample was transferred to a labeled plastic bag. When all samples for a plot were gathered, the samples were transported to shore. On shore they were rinsed, trimmed to remove any remaining roots, sorted by species, and placed into preweighed and numbered paper bags.

At the end of each 4 day sample period the paper bags were returned to the lab and dried in a forced air oven at 60° C to a constant weight. They were reweighed to 0.01 gram accuracy. The resulting data were entered into a relational database and analyzed with the statistical package SYSTAT® using summary statistics and Analysis of Variance.

Line Intercept Plant Frequency

This method utilized the same transect lines that were used for biomass sampling (see previous section), and the data were gathered at the same time. For this method, the transect lines were followed by a snorkeler as described by Madsen (1999). All species that were observed crossing the vertical plane made by the transect line were recorded at one meter intervals. Data were gathered at each meter interval where the plants could be seen from the surface or with a quick dive. The data were recorded on white acetate data sheets that do not tear underwater.

The data were entered into a relational database when we returned to the office. The statistical package SYSTAT® was used to perform Chi-square two-by-two analyses on the most common species. Comparisons were made on the presence or absence of species before and after treatment, separating out the treated versus untreated plots.

Point Intercept Plant Frequency

This method utilized samples gathered at predetermined points scattered throughout the lake's littoral zone (Madsen, 1999). To determine the sample points, a 50 meter by 50 meter grid was developed for the littoral zone using Geographical Information System (GIS). A GPS was used to find these points as UTM coordinates in the field.

Once the sampling site was found using the GPS, the samples were gathered from the starboard side of the boat. The rake was tossed twice, and all plants recovered by the rake were recorded. If the sample site was in shallow water, the plant species were recorded from an area of approximately 3 meters by 3 meters by visual observation over the side of the boat. The depth of the sample site was also recorded.

At the end of the four day sampling period the data were entered into a relational database. The statistical package SYSTAT® was used to perform Chi-square two-by-two analyses on the most common species. Comparisons were made on the presence or absence of species before and after treatment.

Results and Discussion

Herbicide Application Summary

The herbicide treatment occurred on July 8, 1998 and consisted of 6,000 pounds of granular 2,4-D applied over 60 lake surface acres containing *M. spicatum*. This application rate was calculated to attain the 1-2 ppm target concentration necessary for *M. spicatum* control. The product used was labeled Aqua-Kleen®. However, according to the distributor, the formulation is the same as Navigate®. The treated areas included study plots 1, 2, 5, and 6 (Lamb, 1998). One transect from the untreated plot 4 ended up too close to the treatment area to be considered untreated. Therefore, plot 4 was split during statistical analysis and the treated transect was added to the treatment group.

Water samples were collected during and after the treatment to test for actual 2,4-D concentration. According to laboratory results, the herbicide concentration spiked to the targeted concentration in the treatment plots on the day of treatment (1 ppm), then greatly diminished by 3 days after treatment (Getsinger, 1999). There was little herbicide detected off site in samples collected 100 meters from the treatment areas. This pattern is typical for aquatic 2,4-D applications, and met the goals for this demonstration project.

General Results

Loon Lake hosts a diverse, moderately dense plant community to a depth of about 22 feet. A total of 24 submersed, 4 floating-leaved, and 2 emergent species were found during this study (Table 4). Many additional emergent species grow along the shoreline which are not included on this list. Ten of the 30 listed species were dicotyledonous. The species distribution was patchy and mixed, with no single species clearly dominating the submersed community. *Myriophyllum spicatum* was still relatively uncommon in most of the lake.

Table 4: Aquatic plant species in Loon Lake.

Scientific name	Common name	Growth form*	Type**
Brasenia schreberi	watershield	f	d
Ceratophyllum demersum	Coontail; hornwort	s	d
Chara sp.	muskwort	s	macroalgae
Eleocharis sp.	spike-rush	e	m
Elodea canadensis	common elodea	s	m
Fontinalaceae	aquatic moss	s	moss
Heteranthera dubia	water star-grass	s	m
Juncus sp. or Eleocharis sp.	small grass-like plants	s	m
Megalodonta beckii	water marigold	s	d
Myriophyllum sibiricum	northern watermilfoil	s	d
Myriophyllum spicatum	Eurasian water-milfoil	s	d
Najas flexilis	common naiad	s	m
Nitella sp.	stonewort	s	macroalgae
Nuphar polysepala	spatter-dock, yellow water-lily	f	d
Nymphaea odorata	fragrant waterlily	f	d
Polygonum amphibium	water smartweed	f	d
Potamogeton amplifolius	large-leaf pondweed	s	m
Potamogeton gramineus	grass-leaved pondweed	s	m
Potamogeton illinoensis	Illinois pondweed	s	m
Potamogeton natans	floating leaf pondweed	s	m
Potamogeton pectinatus	sago pondweed	s	m
Potamogeton praelongus	whitestem pondweed	s	m
Potamogeton richardsonii	Richardson's pondweed	s	m
Potamogeton robbinsii	fern leaf pondweed	s	m
Potamogeton sp (thin leaved)	thin leaved pondweed	s	m
Potamogeton zosteriformis	eel-grass pondweed	s	m
Ranunculus aquatilis	water-buttercup	s	d
Scirpus sp.	bulrush	e	m
Utricularia sp.	bladderwort	s	d
Vallisneria americana	water celery	s	m

* s = submersed, f = floating-leaved, e = emergent
** m = monocot, d = dicot

Biomass

A total of 23 species were found in at least one of the biomass samples. Total biomass ranged from 0 to 2,049.6 g/m^2 dry weight, with an average of 129 g/m^2 dry weight. Plant distribution was very patchy, with several samples containing no measurable plant matter, and other samples with as many as seven different species. The most commonly collected plant was *Potamogeton robbinsii* (42% of total samples); this plant also had the greatest total biomass.

Table 5 lists the mean biomass for the most common species collected, divided into pretreatment, post treatment and treated versus untreated plots. *Potamogeton praelongus* and *P. richardsonii* were combined because of suspected hybridization and resultant difficulty in distinguishing the two species. The biomass of all but four of these species was higher after than before treatment for both treated and untreated plots. For many species peak biomass is attained at the end of summer, so this is probably a normal seasonal difference. The data were analyzed with Analysis of Variance (ANOVA) after using a $\log_{10}+1$ transformation to approximate a normal distribution. The resultant P-values are reported as P in Table 5.

Table 5. Mean biomass of selected species (g/m^2).
Arrows indicate an increase or decrease through time.

	Treated Plots			Untreated Plots		
Species	before	after	P	before	after	P
Chara	0.93	14.46	**0.041	10.39	17.59	0.478
Elodea canadensis	5.42	8.03	0.782	29.63	19.49	0.370
Heteranthera dubia	0.17	1.04	0.129	0.29	0.57	0.532
Megalodonta beckii *	1.38	8.37	0.064	5.08	20.8	0.620
Myriophyllum sibiricum *	2.54	1.2	0.450	7.16	4.87	0.822
Myriophyllum spicatum *	6.58	0.14	**0.012			
Najas flexilis	.03	0.53	0.070	0	1.19	0.195
Potamogeton amplifolius	7.44	20.19	0.195	12.03	35.75	0.459
Potamogeton gramineus	0.46	2.06	0.174			
Potamogeton robbinsii	100.82	59.83	0.580	21.2	16.33	0.562
Potamogeton praelongus + P. richardsonii	3.36	43.5	0.697	4.05	31.14	0.111
Vallisneria americana	0.31	47.5	**0.030	0.41	3.92	0.080

* dicotyledon
** significant change ($p \leq .05$)

When looking for herbicide effects, you would expect a decrease in biomass after treatment in the treated plots relative to the untreated plots. No plant demonstrated this particular effect. However, it should be kept in mind that *M. spicatum* could not be tested for this effect since it was not present in the untreated plots. If a significance level of $p \leq .05$ is used, the ANOVA results showed that three species in the treated plots differed significantly after treatment. *Myriophyllum spicatum* decreased significantly, and *Vallisneria americana* and *Chara* increased significantly. None of the species in the untreated plots differed significantly after treatment.

The significant increase in *V. americana* and *Chara* are probably due to a normal seasonal change. The significant decrease in *M. spicatum* could be due to the herbicide effect. No *M. spicatum* was present in the untreated plots for comparison. However, casual observation indicated that the *M. spicatum* present in areas not treated increased noticeably over the six week time period.

An additional analysis of variance test was conducted on all the biomass data grouped as either monocots or dicots (except *Chara*, which was kept separate because it is a macroalgae, not a flowering plant). Table 6 shows the mean biomass for these groups before and after treatment for treated and untreated plots. There was a decrease in average monocot biomass in treated plots. However, when tested statistically, no group showed a significant difference before or after treatment for the treated plots ($p > .05$). The herbicide's selectivity for dicots would lead one to expect this group to decrease in treated plots. However, though the *M. spicatum* decreased significantly, when grouped with other dicots such as *M. beckii*, this effect is lost statistically.

Table 6. Mean biomass (g/m^2) of monocots and dicots.

Plant Category	Treated Plots		Untreated Plots	
	before	after	before	after
Monocots	119.22	102.46	69.96	108.38
Dicots	11.77	13.38	12.33	17.59

Line Intercept Plant Frequency

Species were recorded at a total of 1,732 transect intervals including all observations (before and after treatment, treated and untreated plots). A total of 24 species were identified on the transect surveys. Table 7 lists the species found and their percent frequency. *Potamogeton amplifolius* was the most frequently observed plant, and several, such as *Polygonum amphibium* and *P. richardsonii* were uncommon on the transect lines. Two species, *Myriophyllum sibiricum* and *Megalodonta beckii,* were combined due to the difficulty experienced in differentiating them under water. Along many of the transects the species assemblage was diverse, with many one meter intervals containing 4 or 5 different species. No plants were observed in 12.5% of intervals. These were mostly located in areas where the transects crossed bottom barriers placed the previous year for *M. spicatum* control, or in areas of sandy substrate.

The data were separated into treated and untreated groups for the Chi-square analysis. The two-by-two comparisons for each group consisted of presence or absence data and before or after treatment. The probability was adjusted using a Bonferroni correction to account for multiple comparisons. Results given in percent present before and after treatment and P-values are given for the most common species of the two treatment regimes in Table 8 and Table 9.

Table 7. Species observed on line intercept transects.

Scientific name	Common name	Percent Frequency*
Brasenia schreberi	watershield	10.7
Chara sp.	muskwort	23.9
Elodea canadensis	common elodea	9.2
Heteranthera dubia	water star-grass	2.5
Juncus sp. or Eleocharis sp.	small grass-like plants	0.6
Megalodonta beckii	water marigold	**22.4
Myriophyllum sibiricum	northern watermilfoil	
Myriophyllum spicatum	Eurasian water-milfoil	8.5
Najas flexilis	common naiad	6.0
Nuphar polysepala	spatter-dock, yellow water-lily	0.5
Polygonum amphibium	water smartweed	0.2
Potamogeton amplifolius	large-leaf pondweed	31.9
Potamogeton gramineus	grass-leaved pondweed	9.4
Potamogeton illinoensis	Illinois pondweed	0.8
Potamogeton natans	floating leaf pondweed	1.0
Potamogeton pectinatus	sago pondweed	5.8
Potamogeton praelongus	whitestem pondweed	4.1
Potamogeton richardsonii	Richardson's pondweed	0.1
Potamogeton robbinsii	fern leaf pondweed	22.4
Potamogeton sp (thin leaved)	thin leaved pondweed	2.6
Potamogeton zosteriformis	eel-grass pondweed	5.4
Ranunculus aquatilis	water-buttercup	0.7
Utricularia sp.	bladderwort	4.9
Vallisneria americana	water celery	9.8

*An estimate of relative abundance. Includes percent frequency of observation for both dates and treated and untreated plots combined.
** combined M. beckii and M. sibiricum due to difficulty in identification

Table 8. Macrophyte frequency, untreated plots

Species	% present before treatment	% present after treatment	P-value
No plants	12	10	.56
Chara sp.	45	34	.05
Elodea canadensis	10	31	.000**
Megalodonta beckii * + *Myriophyllum sibiricum* *	30	31	.861
Potamogeton amplifolius	35	37	.762
Potamogeton gramineus	1	4	.191
Potamogeton robbinsii	5	26	.000**
Vallisneria americana	2	8	.019

* dicotyledon
** significant difference

Table 9. Macrophyte frequency, treated plots

Species	% present before treatment	% present after treatment	P-value
No plants	13	13	.929
Brasenia schreberi *	15	12	.200
Chara sp.	21	20	.599
Elodea canadensis	5	7	.074
Megalodonta beckii * + *Myriophyllum sibiricum* *	18	20	.397
Myriophyllum spicatum *	16	5	.000**
Potamogeton amplifolius	29	32	.304
Potamogeton gramineus	10	12	.329
Potamogeton robbinsii	17	30	.000**
Vallisneria americana	3	18	.000**

* dicotyledon
** significant difference

The majority of common species showed no significant difference in frequency before and after treatment in either the treated or untreated plots. The exceptions to this were significant increases in *Potamogeton robbinsii* and *Elodea canadensis* in the untreated plots, significant increases in *P. robbinsii* and *Vallisneria americana* in the treated plots and a significant decrease in *Myriophyllum spicatum* in the treated plots. (*Myriophyllum spicatum* was not present in the untreated plots). The significant increases were likely caused by normal seasonal growth and spreading of the plants. It is notable that the only significant decrease was in the target plant, *Myriophyllum spicatum*, indicating that the herbicide treatment was successful in decreasing the frequency of *M. spicatum* in areas where the herbicide was applied. These results are similar to those obtained from the biomass data, and indicate selectivity of the herbicide against *M. spicatum*.

Point Intercept

A total of 27 species were observed during the point intercept frequency survey. Some of these were relatively rare, so only species observed at least 10 times in the before and after treatment surveys combined were used in the chi-square analysis. The probability was adjusted using a Bonferroni correction to account for multiple comparisons. Results from the analysis are given in Table 10.

Table 10. Results of Chi-square analysis on the point intercept frequency data.

Species	% present before treatment	% present after treatment	P-value
No plants	12	13	.804
Brasenia schreberi	11	8	.455
Chara sp.	41	32	.091
Elodea canadensis	19	30	.019
Heteranthera dubia	5	10	.066
Megalodonta beckii	14	16	.615
Myriophyllum sibiricum	24	27	.600
Myriophyllum spicatum	6	5	.727
Najas flexilis	4	17	.000*
Potamogeton amplifolius	16	26	.051
Potamogeton gramineus	5	8	.203
Potamogeton natans	7	5	.350
Potamogeton pectinatus	2	4	.233
Potamogeton praelongus	12	19	.093
Potamogeton robbinsii	28	34	.173
Potamogeton zosteriformis	5	2	.182
Vallisneria americana	6	12	.050

* significant difference

These results show that on a lake-wide basis the only plant with a significantly different frequency after treatment was *Najas flexilis*, which increased. This plant is an annual, so the seedlings may have been too small during the June survey (before treatment) to have been picked up by the sampling rake. *Myriophyllum spicatum* did not show a significant change after the treatment, in contrast to what was found with the line-intercept survey method and the biomass data. This is probably due to the different scopes of these sampling methods. The treatment plots for the line intercept and biomass methods were located in areas known to contain the highest concentrations of *M. spicatum*, and also were areas where the herbicide was applied. In contrast, the point intercept method sampled the entire littoral zone, and included areas where the *M. spicatum* was sparsely distributed, and left untreated. Therefore the treatment effect would be more pronounced for the biomass and line intercept data, where samples were collected from plots receiving the greatest degree of treatment. The fact that *M. spicatum* was only present in

5-6 percent of the samples from the whole littoral zone is evidence of its early stage of invasion in Loon Lake.

Conclusions

Overall, the results of this study show that the herbicide 2,4-D in its aquatic formulation Aqua-Kleen® effectively reduced the biomass and frequency of *M. spicatum* in the treatment plots six weeks after treatment. Native aquatic plants were not significantly reduced by the herbicide, and in most cases their biomass and frequency increased over the experiment's duration. These results are consistent with other studies showing *M. spicatum* to be extremely sensitive to 2,4-D (Bird, 1993; Green and Westerdahl, 1990). The sampling regime will again be followed in June 1999 to assess levels of plant growth 1 year after treatment. It should be noted that casual observation during the post-treatment sampling showed many healthy *M. spicatum* plants outside the areas sampled. So, though results of this study show promise, much work is yet to be done at Loon Lake before the *M. spicatum* problem is under control.

Alkalinity Results

There is a wide range of alkalinity values reported for Washington lakes, with the general trend of lower values in the Western and Northeast portions of the state, and higher values in the Columbia Basin. Appendix C lists the alkalinity results for 1995 through 1998 using a Hach® field test kit. Confidence in these values should be limited to the ±10 mg/l limit reported by the Hach® Company (1994).

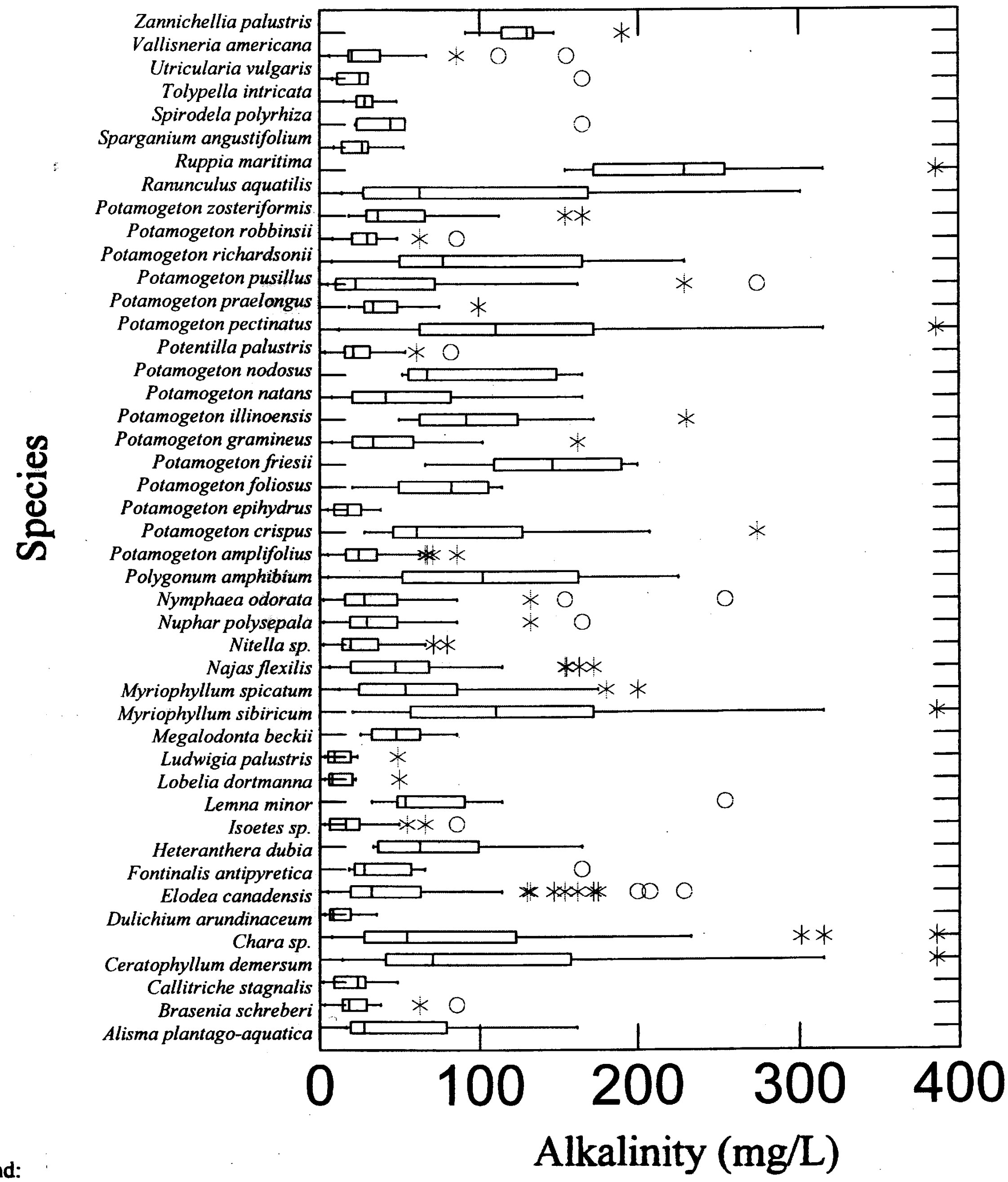
Figure 7 presents the alkalinity ranges of common submersed and floating leaved plant species (those observed in at least five different lakes). Many species appear to have a broad range of tolerance. However, there are several that have only been observed in lakes within a limited alkalinity range. For example, *Potamogeton epihydrus,* and *Dulichium arundinaceum* were only found in lakes with low alkalinity (< 40 mg/L $CaCO_3$). Other species that seem to prefer low alkalinity (< 50 mg/L $CaCO_3$) include *Callitriche stagnalis*, *Lobelia dortmanna, Ludwigia palustris* and the macroalgae *Tolypella intricata*. On the other end of the scale *Potamogeton friesii, Potamogeton nodosus*, and *Zannichellia palustris* were only found in lakes with > 50 mg/L $CaCO_3$. *Ruppia maritima* was not found in any lake with less than about 150 mg/L $CaCO_3$. *Zannichellia palustris* appears to have the most distinctive mid-range of tolerance, with all occurrences in lakes between 90 - 200 mg/L $CaCO_3$.

In comparing these data with similar studies from Florida, Japan, and New England, both similarities and differences are seen (Table 11). Except for *Vallisneria americana*, median values for all plants common to the Florida and Washington studies were lower in Florida. However, the 322 lakes included in the Florida study had a mean alkalinity of 24 mg/L $CaCO_3$, and the maximum was 131 mg/L $CaCO_3$. Whereas in Washington the mean of the 115 lakes tested is 99 mg/L $CaCO_3$, and the maximum was over 2,500 mg/L $CaCO_3$. Thus, the differences could be a product of the higher average alkalinity in Washington lakes.

The data from lakes in Japan and New England are more similar to the results from Washington (Table 11). There are still a few notable differences, such as for *Ceratophyllum demersum* and *Potamogeton natans.* In Washington the median of both plants is roughly double that of the other studies, however, the ranges are quite similar. *Myriophyllum spicatum, Potamogeton friesii, P. pectinatus* and *P. richardsonii* were also found in lakes with higher alkalinity in Washington than in the other studies. This is probably due to the absence of highly alkaline lakes in New England. The only plant found under notably lower alkalinity in Washington was *P. epihydrus*. Two other plants appear to tolerate somewhat higher alkalinity in New England; *P. praelongus* and *P. nodosus*.

The differences in observed values from these studies could be due to different physiological characteristics of the plants from different regions (different ecotypes), to differences in plant community composition, or to other factors influencing the plants such as other water quality, sediment, or climatic differences. Differences could also be due to artifacts of sample size and the distributions of alkalinity concentrations in regional lakes.

Figure 7. Box plot of alkalinity ranges for selected macrophytes.



Legend:

bar within the box - median

hinges (box edges) - within which 25% to 75% of the values lie

whiskers - include values within 1.5 Hspreads of the hinges (Hspread is the absolute value of the difference between the values of the two hinges).

asterisk - values within 3 Hspreads of the hinges

open circle - values outside 3 Hspreads of the hinges

Table 11: Comparison of Alkalinity Ranges

Species	**Other Studies** Alkalinity Range mg/l CaCO3	median mg/l CaCO3	n*	**Washington Lakes** Alkalinity Range mg/l CaCO3	median mg/l CaCO3	n*
Brasenia schreberi [J]	3 to 47	16		3 to 85	18	21
Brasenia schreberi [F]		3	43			
Ceratophyllum demersum [J]	9 to 451	35		14 to 386	70	63
Ceratophyllum demersum [F]		24	92			
Lemna minor [F]		24	124	32 to 254	53	7
Myriophyllum spicatum [J]	13 to 145	35		12 to 200	53	37
Nitella spp. [F]		14	64	2 to 79	19	34
Nymphaea odorata [F]		9	194	2 to 254	28	48
Potamogeton amplifolius [N]	4 to 151	28	78	5 to 85	24	54
P. crispus [N]	15 to 208	93	31	28 to 274	60	24
P. epihydrus [N]	2 to 161	**	169	5 to 38	17	24
P. foliosus [N]	17 to 168	73	62	20 to 114	82	8
P. friesii [N]	43 to 151	85	11	65 to 200	146	6
P. gramineus [N]	3 to 151	**	117	8 to 162	33	24
P. illinoensis [N]	24 to 151	80	24	49 to 230	91	18
P. illinoensis [F]		40	47			
P. natans [N]	3 to 162	21	152	8 to 165	40	22
P. nodosus [N]	6 to 283	76	20	51 to 165	67	8
P. pectinatus [N]	37 to 283	113	26	12 to 931	112	63
P. pectinatus [F]		15	26			
P. praelongus [N]	10 to 151	44	39	18 to 99	33	17
P. pusillus [N]	3 to 206	**	172	5 to 274	22	19
P. richardsonii [N]	17 to 131	44	27	8 to 229	77	35
P. robbinsii [N]	4 to 122	26	49	8 to 85	29	22
P. zosteriformis [N]	6 to 151	49	74	18 to 165	36	26
Spirodela polyrrhiza [J]	18 to 103	51		22 to 165	44	5
Vallisneria americana [F]		27	118	6 to 155	20	21

* n = number of lakes observed
** values for more than one variety combined, original values not available to calculate a median
[N] From Hellquist 1980, a study of lakes in New England.
[J] From Kadono1982, a study of lakes in Japan.
[F] From Hoyer et al. 1996, a study of lakes in Florida.

Herbarium

Methods Used in Aquatic Plant Identification

All plants were identified to the lowest taxonomic group possible, usually to species unless critical features of the plant were missing (such as flowers or fruits). To assure proper identification, a number of books and other sources have been consulted as cross references (Appendix D). In addition, several people from within and outside the agency are consulted in cases where identification is difficult. If this is not conclusive, the plant is sent to national taxonomic experts for an opinion. Kartesz (1994), The Jepson Manual (Hickman, 1993), and personal consultation with authors of the Flora of North America (Flora of North America Editorial Committee, 1993) are used to ensure the nomenclature is current. In the case of questionable *Myriophyllum* species, samples were sent to Oluna Ceska for identification by analysis of the plant's flavonoid chemistry (Ceska, 1977).

Methods Used in Collection and Preservation

The methods used to preserve collected aquatic plants were those of Haynes (1984). First, all available plant parts (roots, stem, and flowering parts) were collected and sealed in a wet plastic bag. Within three days, but usually sooner, the plants were washed, identified, and arranged on a sheet of 100% rag herbarium paper. If the plant was too limp to maintain its shape in air, it was arranged on the paper in a tray of water. The herbarium sheets with plants and a written site description were then sandwiched between newspaper, blotter paper and cardboard in a plant press. When the specimen dried, it was fixed to the paper with herbarium glue or binding tape (if it was not already sufficiently adhered from the wet pressing process). A label with identification and collection information was attached. These finished reference specimens are stored in a sealed herbarium cabinet located in the Ecology headquarters building benthic laboratory.

Currently, the herbarium collection contains 110 unique taxa from 39 families (Appendix E). There are a total of 346 specimens, and in most cases each species is represented by more than one specimen. Each time a noxious weed is found, a collection is made to be kept as a record. Additional taxa will be added to the herbarium as they are collected in future years. Also, specimens from aquatic plant mapping projects funded under the Aquatic Weed Management grant program are housed in this herbarium. The collection is available to both Ecology staff and the public as a reference and permanent record.

Aquatic Weed Management Fund Related Activities

The regular 1998 funding cycle for the Aquatic Weed Management Fund (AWMF) was canceled due to a shortage of available funds for distribution (as was also the case in 1997). For information on this grant program and the use of the monies contact the AWMF administrator at the Department of Ecology, Water Quality Program. Grants were still made available for projects to control early infestations of noxious aquatic weeds. One such grant was awarded during 1998 for mapping and containment of *Myriophyllum spicatum* in Diamond Lake, Pend Oreille County.

Aquatic Plant Field Guide

During 1994, money from the AWMF was targeted for the development and production of an Aquatic Plant Field Guide. The guide will include 110 aquatic plants with photographs, line drawings, written descriptions, and notes on the values and natural history of the plants. We selected a consultant team headed by Shapiro and Associates to develop the guide. Since then this team has compiled photographs and drawings of the plants, and composed written descriptions. All pages required extensive review by aquatic plant technical assistance personnel for accuracy and readability. During 1998 the consultant requested additional funds to complete the project. AWMF personnel, and Ecology management did not feel the additional expenditure was justified, so the contract was terminated. All materials produced by the consultant will be handed over to Ecology early in 1999. We will be completing the project ourselves.

References

Anderson, L.W.J. 1987. "Exotic pest profile number 11: *Hydrilla verticillata"*. California Department of Food and Agriculture. Sacramento, CA

Bird, K.T. 1993. "Comparisons of herbicide toxicity using *in vitro* cultures of *Myriophyllum spicatum*." J. Aquat. Plant Manage. 31:43-45.

Ceska, O. 1977. "Studies on Aquatic Macrophytes, Part XVII: Phytochemical differentiation of *Myriophyllum* taxa collected in British Columbia." University of Victoria, No 0316533.

Dion, N.P., G.C. Bortleson, J.B. McConnell, and L.M. Nelson. 1976. Reconnaissance data on lakes in Washington: Pend Oreille, Spokane, and Stevens Counties. Water Supply Bulletin 43, Vol 7. US Geological Survey.

Flora of North America Editorial Committee. 1993. Flora of North America. Oxford University Press. New York.

Getsinger, K. 1999. US Army Corps of Engineers Waterways Experiment Station. Personal communication.

Green W.R. and H.E. Westerdahl. 1990. "Response of Eurasian watermilfoil to 2,4-D concentrations and exposure times." J. Aquat Plant Manage. 28:27-32.

Hach Company. 1994. User Manual for Digital Titrator Model 16900-01. Loveland, CO.

Hallock, D. 1997. Water Quality Specialist, Washington State Department of Ecology. Personal communication.

Hamel, K. 1997. Aquatic Plant Specialist, Washington State Department of Ecology. Personal communication.

Haynes, R. 1984. "Techniques for collecting aquatic and marsh plants." Ann. Missouri Botanical Garden, 71:229-231.

Haynes, R. 1998. Director of the Herbarium, University of Alabama. Personal communication.

Hellquist, Barre C. 1980. "Correlation of alkalinity and the distribution of *Potamogeton* in New England." Rhodora 82:331-344.

Hickman, J.C. 1993. "The Jepson Manual, Higher Plants of California." University of California Press, Berkeley, CA.

Hofstra, D. 1998. National Institute of Water and Atmospheric Research, New Zealand. Personal communication.

Hoyer, M.V., D.E. Canfield, C.A. Horsburgh, K. Brown. 1996. "Florida Freshwater Plants." University of Florida Press, Gainesville, FL.

Kadono, Y. 1982. "Occurrence of aquatic macrophytes in relation to pH, alkalinity, calcium, chloride and conductivity." Japanese Journal of Ecology 32:39-44.

Kartesz, J.T. 1994. "A synonymized checklist of the vascular flora of the United States, Canada, and Greenland." 2nd ed. Vol. 1 and 2. Timber Press, Portland, OR.

Lamb, D. 1998. Resource Management Inc. Personal communication

Langeland, K.A. 1990. Hydrilla: a Continuing Problem in Florida Waters. University of Florida Center for Aquatic Plants. Gainesville, FL.

Madsen, J. 1999. Point intercept and line intercept methods for aquatic plant management. Technical Note A-99-X, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS. In press.

Madsen, J. 1993. Biomass techniques for monitoring and assessing control of aquatic vegetation. Lake and Reservoir Management. 7(2):141-154.

Madsen, J. and K. Getsinger. 1998. Aquatic Plant Sampling Plan for Loon Lake, Stevens County, Washington. Unpublished report, US Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS

Marquez, E. 1998. Resource Management Inc. Personal communication

Murphy, K.J. and P.R.F. Barrett. 1993. Chemical Control of Aquatic Weeds IN "Aquatic Weeds: The Ecology and Management of Nuisance Aquatic Vegetation" A.H. Pieterse and K.J. Murphy ed. Oxford University Press, New York.

Old, R. 1998. Scientific advisor to the Washington State Noxious Weed Control Board. Personal communication.

Parsons, J. 1998. Aquatic Plant Technical Assistance Program 1997 Activity Report. Washington State Department of Ecology, Olympia, WA Publication No. 98-311.

Parsons, J. 1997. Aquatic Plant Technical Assistance Program 1996 Activity Report. Washington State Department of Ecology, Olympia, WA Publication No. 97-319.

Parsons, J. 1996. Aquatic Plant Technical Assistance Program 1995 Activity Report. Washington State Department of Ecology, Olympia, WA Publication No. 96-332.

Parsons, J. 1995a. Aquatic Plant Technical Assistance 1994 Activity Report. Washington State Department of Ecology, Olympia, WA, Publication No. 95-331.

Parsons, J. 1995b. Aquatic Plant Technical Assistance Implementation Plan - 1995 Field Season. Washington State Department of Ecology, Olympia, WA, Publication No. 95-334.

Pickett, P. 1994. Black River Dry Season Total Maximum Daily Load Study. Washington State Department of Ecology, Olympia, WA. Publication No. 94-106.

Smart, R.M. 1990. Effects of Water Chemistry on Submersed Aquatic Plants: a Synthesis. Miscellaneous Paper A-90-4, Department of the Army, Waterways Experiment Station, Corps of Engineers, Vicksburg, Miss.

Srivastava, D.S., C.A. Staicer, B. Freedman. 1995. "Aquatic vegetation of Nova Scotian lakes differing in acidity and trophic status." Aquatic Botany 51: 181-196.

Sytsma, M. 1994. Oregon Department of Environmental Conservation. Personal communication.

Vail, K. 1998. Fisheries Biologist, Washington State Department of Fish and Wildlife. Personal communication.

Washington Natural Heritage Program. 1994. Endangered, Threatened and Sensitive Vascular Plants of Washington. Washington State Department of Natural Resources, Olympia, WA. 52 pp.

Warrington, P. 1994. British Columbia Ministry of the Environment. Personal communication.

Winterod, S. 1998. Stevens County Noxious Weed Control Board. Personal communication.

Appendix A

Site Visit Summary Table 1994-1998

County	Waterbody Name	WRIA	Date	Survey Extent	Noxious Aquatic Weeds
Adams	Sprague Lake	34	9/16/97	south half	none
	Herman Lake	41	7/28/98	whole lake	*Lythrum salicaria*
Asotin	Snake River at Chief Timothy S.P.	35	8/4/97	3 sites	none
Chelan	Antilon Lake	47	8/31/94	from shore, N and S ends	none
	Chelan Lake	47	8/31/94	from City Park shore	*Myriophyllum spicatum*
	Dry Lake	47	8/31/94	from shore, east end	none
	Fish Lake	45	6/16/97	west shore	none
	Roses Lake	47	8/31/94	south shore	none
			6/17/97	whole littoral	none
	Wapato Lake	47	8/31/94	entire shoreline	*Myriophyllum spicatum*
			6/27/95	whole littoral	
			8/8/95	whole littoral	
			9/11/95	whole littoral	
			6/24/96	whole littoral	
			7/15/96	milfoil sites	
			9/16/96	milfoil sites	
			7/16/97	whole littoral	
	Wenatchee Lake	45	9/1/94	west end, east boat launch	none
Clallam	Beaver Lake	20	7/9/96	whole littoral	none
	Crescent Lake	19	7/10/96	4 sites	none
	Ozette Lake	20	7/9/96	3 sites	none
	Pleasant Lake	20	7/11/96	whole littoral	none
	Sutherland Lake	18	7/11/96	whole littoral	none
	Unnamed (30N-04W-17)	18	7/13/95	ID from plant sample	*Myriophyllum spicatum*
Clark	Battleground Lake	28	4/13/94	from dock only	*Egeria densa*
	Caterpillar Slough	28	8/15/95	spot check from boat	*Myriophyllum spicatum*
	Columbia River at Ridgefield	28	8/15/95	spot check from boat	*Myriophyllum spicatum* *Lythrum salicaria*
	Lacamas Lake	28	9/3/97	whole littoral	*Egeria densa*
	Vancouver Lake	28	8/15/95	spot check from shore	none
Columbia	Snake River at Little Goose Dam	35	8/5/97	spot check, boat	*Myriophyllum spicatum*
	Snake River near Lyons Ferry	35	8/5/97	spot check, boat	*Myriophyllum spicatum*
Cowlitz	Sacajawea Lake	25	8/4/98	3 sites, shore	none
	Silver Lake	26	9/7/94	several locations thu' lake	*Myriophyllum spicatum*
			9/19/95	several sites, from boat	none
			8/4/98	south half	none
	Solo Slough	25	4/13/94	spot check from shore	*Myriophyllum aquaticum*
			7/14/94	spot check from shore	*Cabomba caroliniana*
			8/16/95	from shore	*Egeria densa*
			8/8/96	from shore	*Ludwigia hexapetala*
			5/28/97	spot check from shore	*Myriophyllum spicatum*
			8/4/98	1 site, shore	
	Willow Grove Slough	25	4/13/94	spot check from shore	*Cabomba caroliniana*
			7/14/94	spot check from shore	*Myriophyllum spicatum*
			8/16/95	several sites, from boat	*Egeria densa*
			8/4/98	1 site, shore	*Lythrum salicaria*
					Myriophyllum spicatum
Douglas	Jameson Lake	44	6/26/96	1 site from shore	none
Ferry	Curlew Lake	60	8/22/95	5 sites, whole littoral	none
			8/2/96	4 sites (luanches)	none
			8/13/97	5 sites (launches)	none
			5/19/98	2 sites, boat	none
	Ellen Lake	58	8/23/95	whole littoral	none
	Ferry Lake	52	8/13/97	whole littoral	none
	Swan Lake	52	8/13/97	whole littoral	none
	Trout Lake	58	8/22/95	whole littoral	none
	Twin Lakes	58	8/23/95	4 sites, both lakes	none
			8/14/97	3 sites, both lakes	none
Franklin	Scooteney Reservoir	36	7/26/95	spot check from shore	*Myriophyllum spicatum*
	Snake River - Lower Monumental Dam	33	8/20/96	spot check, boat	*Myriophyllum spicatum*
	Snake River at Ice Harbor Dam	33	8/19/96	spot check, boat	*Myriophyllum spicatum*
	Snake River at Levey Park	33	8/19/96	spot check, boat	none

County	Waterbody Name	WRIA	Date	Survey Extent	Noxious Aquatic Weeds
Franklin con't	Snake River at Windust Park	33	8/20/96	spot check, boat	none
	Snake River at Lyons Ferry	34	8/5/97	spot check, boat	*Myriophyllum spicatum*
Garfield	Snake River at Lower Granite Dam	35	8/4/97	spot check, boat	none
Grant	Alkali Lake	42	7/16/96	whole littoral	none
	Babcock Ridge Lake	41	7/24/95	2 sites, whole littoral	*Myriophyllum spicatum* *Lythrum salicaria*
	Banks Lake	42	6/25/96	spot check, shore	none
	Billy Clapp Lake	42	8/30/95	4 sites, whole littoral	*Myriophyllum spicatum*
	Blue Lake	42	7/16/96	whole littoral	none
	Burke Lake	41	6/28/94	entire shoreline	*Lythrum salicaria*
			9/19/96	whole littoral	*Myriophyllum spicatum*
			9/24/97	whole littoral	
			9/9/98	whole lake	
	Canal Lake	41	8/30/95	4 sites, whole littoral	*Lythrum salicaria*
	Corral Lake	41	7/25/95	whole littoral	*Lythrum salicaria*
	Crater Lake	41	7/24/95	spot check from shore	none
	Deep Lake	42	6/25/96	whole littoral	none
	Dry Falls Lake	42	6/25/96	spot check, shore	none
	Evergreen Lake	41	6/27/94	entire shoreline	*Lythrum salicaria*
			9/12/95	8 transects, whole littoral	*Myriophyllum spicatum*
			9/18/96	8 transects, whole littoral	
			9/23/97	8 transects, whole littoral	
			9/9/98	whole lake	
	Frenchman Hills	41	7/29/98	1 site, shore	*Lythrum salicaria*
	Lenore Lake	42	7/17/96	whole littoral	none
	Long Lake (17N-29E-32)	41	8/31/95	2 sites, whole littoral	none
	Moses Lake	41	7/15/98	10 sites, boat	*Lythrum salicaria*
	Park Lake	42	6/26/96	whole littoral	none
			9/10/98	whole lake	none
	Potholes Reservoir	41	8/7/94	6 sites on N & W side	*Myriophyllum spicatum*
			7/16/98	10 sites, boat	none
	Quincy Lake	41	6/28/94	entire shoreline	*Lythrum salicaria*
			9/13/95	3 transects, whole littoral	
			9/17/96	3 transects, whole littoral	
			9/22/97	whole littoral	
			9/8/98	whole lake	
	Rocky Ford Cr	41	7/28/97	spot check, shore	*Lythrum salicaria*
	Soda Lake	41	7/25/95	whole littoral	none
	Stan Coffin Lake	41	6/29/94	entire shoreline	*Myriophyllum spicatum* *Lythrum salicaria*
	Warden Lake	41	7/25/95	2 sites, whole littoral	*Lythrum salicaria*
			7/28/98	whole lake	
	Winchester Wasteway	41	7/26/95	spot check from shore	*Lythrum salicaria*
			7/28/98	1 site, shore	
	Windmill Lake	41	8/30/95	south end	none
Grays Harbor	Aberdeen Lake	22	7/22/96	whole littoral	none
	Duck Lake	22	9/9/95	2 sites, from shore	*Egeria densa*
			8/18/98	main lake	*Lythrum salicaria*
					Myriophyllum spicatum
	Failor Lake	22	6/25/97	whole littoral	none
	Quinault Lake	21	10/7/96	75% of littoral	none
	Sylvia Lake	22	7/22/96	whole littoral	none
Island	Cranberry Lake	6	8/24/94	4 sites around lake	none
			9/5/96	spot check, shore	none
	Crockett Lake	6	9/4/96	spot check, shore	none
	Deer Lake	6	9/4/96	whole littoral	none
	Goss Lake	6	9/5/96	whole littoral	none
	Lone Lake	6	9/4/96	whole littoral	*Lythrum salicaria*
Jefferson	Anderson Lake	17	7/8/96	whole littoral	none
	Crocker Lake	17	5/24/94	northwest half - littoral	none
			6/14/95	whole littoral	
			6/11/96	whole littoral	

County	Waterbody Name	WRIA	Date	Survey Extent	Noxious Aquatic Weeds
Jefferson con't	Crocker Lake con't	17	8/27/97	whole littoral	
			9/3/98	whole lake	
	Leland Lake	17	5/24/94	entire shoreline	*Egeria densa*
			6/14/95	whole littoral	
			10/3/95	whole littoral	
			11/8/95	Egeria site	
			6/11/96	whole littoral	
			7/2/96	whole littoral	
			10/2/96	whole littoral	
			8/27/97	spot check	
			9/3/98	whole lake	
	Tarboo Lake	17	7/2/96	whole littoral	none
King	Lucerne Lake	9	6/9/95	outlet	*Hydrilla verticillata*
			7/15/95	spot check	*Myriophyllum spicatum*
	Meridian Lake	9	7/10/97	whole littoral	*Lythrum salicaria* *Myriophyllum spicatum*
	Morton Lake	9	8/19/97	whole littoral	none
	Pipe Lake	9	6/1/95	several sites, divers	*Hydrilla verticillata*
			6/9/95	near boatlaunch, outlet	*Myriophyllum spicatum*
			7/12/95	from shore	
			7/15/95	6 sites, biomass samples	
			8/1/95	6 sites, biomass samples	
			6/18/96	spot check, boat	
			7/21/97	3 sites	
			6/9/98	whole lake	
			11/17/98	3 sites, boat	
	Sawyer Lake	9	8/7/97	whole littoral	*Myriophyllum spicatum*
	Steel Lake	9	5/11/94	entire shoreline, divers	*Myriophyllum spicatum*
	Washington Lake	8	8/24/98	Juanita Bay	*Egeria densa* *Myriophyllum spicatum*
	Wilderness Lake	9	8/19/97	whole littoral	*Lythrum salicaria* *Myriophyllum spicatum*
Kitsap	Buck Lake	15	7/22/98	whole lake	*Lythrum salicaria*
	Horseshoe Lake	15	8/22/96	whole littoral	none
	Island Lake	15	7/22/98	whole lake	none
	Kitsap Lake	15	8/3/95	2 sites, whole littoral	none
			8/28/97	4 sites	none
			7/1/98	south end	none
	Long Lake	15	9/12/94	several locations	*Egeria densa*
			3/17/95	6 transects, whole littoral	*Myriophyllum spicatum*
			7/22/97	2 sites	*Lythrum salicaria*
			8/28/97	3 sites	
	Mission Lake	15	9/9/96	whole littoral	none
			6/18/98	whole lake	*Utricularia inflata*
	Panther Lake	15	8/2/95	whole littoral	none
	Square Lake	15	7/22/97	spot check, shore	none
	Wildcat Lake	15	10/4/95	4 sites, whole littoral	none
			8/20/98	whole lake	none
	William Symington Lake	15	9/16/98	whole lake	none
	Wye Lake	15	7/1/98	1 site, shore	*Utricularia inflata*
Kitsap/Mason	Tiger Lake	15	9/9/96	whole littoral	none
Kittitas	Cle Elum Reservoir	39	7/29/98	1 site, shore	none
	Easton Lake	39	8/30/94	spot check from shore	none
			6/18/97	spot check, shore	none
	Kiwanis Pond	39	8/30/94	spot check from shore	none
	Lavender Lake	39	6/18/97	whole littoral	*Myriophyllum spicatum*
			7/27/98	whole lake	
	unnamed fishing pond	39	8/30/94	most of shoreline	none
	Unnamed Ponds near Easton	39	6/18/97	spot check, shore	none
	unnamed ponds	39	8/30/94	spot checks	Lythrum salicaria at one
	Wild Duck Lake	39	7/27/98	2 sites, shore	none

County	Waterbody Name	WRIA	Date	Survey Extent	Noxious Aquatic Weeds
Klickitat	Columbia River at Bingen	29	8/14/95	spot check from shore	*Myriophyllum spicatum*
	Columbia River at Maryhill	30	8/14/95	spot check from boat	*Myriophyllum spicatum*
	Horsethief Lake	30	8/14/95	spot check from shore	*Myriophyllum spicatum*
Lewis	Carlisle Lake	23	8/20/97	whole littoral	none
	Chehalis River	23	7/27/95	shoreline, from boat	*Myriophyllum aquaticum*
			9/10/96	1 site from shore	
			7/23/97	spot check, shore	*Egeria densa*
			8/20/97	1 mile of river	
	Interstate Ave Slough	23	8/20/97	spot check, shore	*Myriophyllum aquaticum*
	Mayfield Reservoir	26	10/5/98	south half	*Myriophyllum spicatum*
	Plummer Lake	23	8/20/97	whole littoral	*Egeria densa*
	Swofford Pond	26	9/15/98	east end	*Myriophyllum spicatum*
Lincoln	Sprague Lake	34	8/6/94	cove at NE end of lake	none
Mason	Benson Lake	14	7/23/96	whole littoral	none
	Devereaux Lake	15	8/16/94	spot check from shore	none
	Haven Lake	15	8/16/94	entire shoreline	none
			6/8/98	whole lake	none
	Isabella Lake	14	7/19/94	entire shoreline	none
			8/2/95	checked for rare plant	none
			8/18/97	whole littoral	*Lythrum salicaria*
	Island Lake	14	7/23/96	whole littoral	*Myriophyllum spicatum*
			6/24/97	whole littoral	
			7/9/98	whole littoral	
	Limerick Lake	14	8/15/94	entire shoreline	*Egeria densa*
			7/13/95	spot check, boat	*Utricularia inflata*
			7/22/97	2 sites	
			7/8/98	whole lake	
	Lost Lake	14	8/11/94	entire shoreline	none
			6/10/97	whole littoral	none
	Lystair (Star) Lake	22	6/12/98	whole lake	none
	Maggie Lake	15	8/19/98	whole lake	none
	Mason Lake	14	8/7/96	whole littoral	none
			9/14/98	whole lake	*Myriophyllum spicatum*
	Nahwatzel Lake	22	6/26/97	whole littoral	none
	Phillips Lake	14	7/20/98	whole lake	none
	Spencer Lake	14	8/15/94	most of shoreline	*Lythrum salicaria*
			7/13/95	spot check, boat	*Lythrum salicaria*
			8/22/96	south end, boat	none
			7/22/97	2 sites	none
	Tee Lake	15	8/19/98	whole lake	none
	Trails End (formerly Prickett)	15	6/16/98	whole lake	*Lythrum salicaria*
					Utricularia inflata
	Wooten Lake	15	8/16/94	most of shoreline	none
			6/16/98	whole lake	none
Okanogan	Aeneas Lake	49	7/25/94	entire shoreline	none
	Alta Lake	48	6/29/95	whole littoral	none
	Big Twin Lake	48	8/9/95	most of littoral	none
	Bonaparte Lake	49	8/27/96	whole littoral	none
	Buffalo Lake	53	8/21/95	3 sites, boat	none
	Conconully Lake	49	7/26/94	7 sites thru' shoreline	*Myriophyllum spicatum*
	Conconully Reservoir	49	7/26/94	north end	none
			9/18/97	whole littoral	*Myriophyllum spicatum*
	Crawfish Lake	52	8/28/96	whole littoral	none
	Davis Lake	48	8/9/95	whole littoral	none
	Duck (Bide-a-Wee) Lake	49	8/28/96	spot check, shore	none
			9/18/97	spot check	none
	Fish Lake	49	7/26/94	entire shoreline	none
	Green Lake	49	6/29/95	2 sites, whole littoral	none
	Leader Lake	49	8/29/96	whole littoral	none
	Little Twin Lake	48	8/9/95	whole littoral	none
	Omak Lake	49	8/28/96	north end, boat	none

County	Waterbody Name	WRIA	Date	Survey Extent	Noxious Aquatic Weeds
Okanogan	Palmer Lake	49	7/27/94	boatlaunches, from shore	none
			6/28/95	whole littoral	none
	Patterson Lake	48	8/10/95	2 sites, whole littoral	none
	Pearrygin Lake	48	8/10/95	3 sites, whole littoral	*Lythrum salicaria*
	Sidley Lake	49	8/27/96	spot check, shore	none
	Spectacle Lake	49	7/27/94	5 sites, various locations	none
			8/27/96	whole littoral	none
			9/17/97	3 sites	none
	Wannacut Lake	49	7/28/94	3 sites	none
	Whitestone Lake	49	7/27/94	5 sites, various locations	*Myriophyllum spicatum*
			6/28/95	6 sites, whole littoral	*Lythrum salicaria*
			8/26/96	whole littoral	
			9/17/97	whole littoral	
Pacific	Black Lake	24	7/12/94	spot check, shore	*Egeria densa*
			8/8/96	most of shoreline	
			8/26/97	whole littoral	
	Island Lake	24	7/14/94	entire shoreline	none
			8/26/97	whole littoral	none
	Loomis Lake	24	7/13/94	most of shoreline	none
			8/25/97	whole littoral	*Myriophyllum spicatum*
	O'Neil Lake	24	7/12/94	entire littoral	none
			8/25/97	spot check, shore	none
	Surfside Lake	24	7/13/94	5 sites from bridges	none
			8/25/97	spot check, shore	none
Pend Oreille	Bead Lake	62	8/12/97	coves, 5 sites	none
	Browns Lake	62	7/31/96	spot check, shore	none
	Davis Lake	62	8/2/94	most of littoral	none
			7/30/96	north end, boat launch	*Myriophyllum spicatum*
			8/12/97	whole littoral	
	Diamond Lake	55	8/2/94	boatlaunch, from shore	none
			7/31/96	east end, boat launch	none
			8/11/97	west half	none
	Fan Lake	55	8/3/94	entire shoreline	*Lythrum salicaria*
			8/12/97	whole littoral	
	Frater Lake	59	8/1/96	spot check, shore	none
	Half Moon Lake	62	7/31/96	north end	none
	Horseshoe Lake	55	7/13/98	west half	none
	Little Spokane River	55	8/2/94	at Fertile Valley Rd crossing	*Myriophyllum spicatum*
			8/2/94	at Haworth Rd crossing	none
	Marshall Lake	62	8/1/94	3 sites, mostly at inlets	none
	Mill Lake	62	8/1/96	2 sites, shore	none
	Nile Lake	62	8/1/96	spot check, shore	*Myriophyllum spicatum*
	Pend Oreille River	62	8/1/96	spot check, shore	*Myriophyllum spicatum*
	Sacheen Lake	55	8/2/94	3 sites, covered entire shore	*Myriophyllum spicatum* *Lythrum salicaria*
	Skookum Lake, North	62	7/31/96	spot check, shore	none
	Skookum Lake, South	62	7/31/96	whole littoral	none
	Sullivan Lake	62	8/1/96	north and south, boat	none
	Unnamed Wetland near Usk	62	8/1/96	shore	none
Pierce	American Lake	12	10/4/94	4 sites	none
			10/6/98	whole lake	none
	Bay Lake	15	9/28/95	whole littoral	*Lythrum salicaria*
	Carney Lake	15	7/1/98	1 site, shore	none
	Clear Lake	11	7/21/94	entire shoreline	*Myriophyllum spicatum*
			6/12/96	whole littoral	
			6/23/97	whole littoral	
	Harts Lake	11	6/17/96	spot check, shore	*Myriophyllum spicatum*
			7/3/96	whole littoral	
	Ohop Lake	11	7/25/96	whole littoral	*Egeria densa*
			9/25/97	whole littoral	
	Rapjohn Lake	11	7/25/96	whole littoral	none
	Silver Lake	11	6/17/96	spot check, shore	none
	Spanaway Lake	12	9/11/96	whole littoral	*Lythrum salicaria*
	Steilacoom Lake	12	6/19/96	spot check, boat	none
			8/26/98	whole lake	none
			10/21/98	1 site, boat	none

County	Waterbody Name	WRIA	Date	Survey Extent	Noxious Aquatic Weeds
Pierce con't	Tanwax Lake	11	7/21/94	entire shoreline	none
			9/12/96	whole littoral	none
San Juan	Cascade Lake	2	9/9/97	whole littoral	none
	Hummel Lake	2	9/8/97	whole littoral	none
	Mountain Lake	2	9/9/97	whole littoral	none
	Sportsman Lake	2	9/10/97	whole littoral	none
Skagit	Beaver Lake	3	8/25/94	entire shoreline	none
	Big Lake	3	8/23/94	3 sites, extreme ends	*Egeria densa*
			8/23/94	& launch	*Myriophyllum spicatum*
	Campbell Lake	3	6/7/94	entire shoreline	none
			8/13/96	whole littoral	*Myriophyllum spicatum*
			7/2/97	whole littoral	
	Cavanaugh Lake	5	8/24/98	whole lake	none
	Clear Lake	3	8/25/94	boatramp only	*Myriophyllum spicatum*
	Cranberry Lake	3	8/25/98	2 sites, shore	none
	Erie Lake	3	8/24/94	Entire shoreline	none
			8/13/96	spot check, shore	none
			7/2/97	whole littoral	none
	Everett Lake	4	8/15/96	spot check, shore	none
	Heart Lake (35N-01E-36)	3	8/13/96	whole littoral	none
			8/25/98	whole lake	*Myriophyllum spicatum*
	Heart Lake (Fidalgo)	3	8/24/94	most of shoreline	none
	McMurray Lake	3	6/6/94	entire shoreline	*Myriophyllum spicatum*
			8/23/94	entire shoreline	
	Pass Lake	3	7/2/97	spot check, shore	none
	Sixteen Lake	3	6/6/94	entire shoreline	*Myriophyllum spicatum*
Skamania	Coldwater Lake	26	8/27/98	80% of shore	*Myriophyllum spicatum*
Snohomish	Blackmans Lake	7	8/5/98	whole lake	*Lythrum salicaria*
	Goodwin Lake	7	6/20/95	3 sites, littoral survey	*Myriophyllum spicatum*
	Martha Lake (27N-04E-01)	8	8/5/98	whole lake	none
	Nina Lake	7	6/20/95	2 sites, from shore	*Myriophyllum aquaticum*
	Roesiger (north arm) Lake	7	8/6/98	whole lake	*Myriophyllum spicatum*
					Lythrum salicaria
	Roesiger (south arm) Lake	7	8/25/94	east side, littoral	none
			6/21/95	spot check, boat	none
			8/29/95	most of shoreline	none
			8/6/98	whole lake	*Myriophyllum spicatum*
	Shoecraft Lake	7	8/15/96	whole littoral	*Myriophyllum spicatum*
	Stevens Lake	7	9/10/97	4 sites	none
Spokane	Amber Lake	34	8/5/94	at boatramp, from shore	none
	Badger Lake	34	8/5/94	2 sites at extreme ends	none
	Chapman Lake	34	8/24/95	3 sites	none
	Clear Lake	43	8/4/94	4 sites, most of shoreline	none
	Downs Lake	34	8/3/94	from shore - one location	none
	Eloika Lake	55	8/3/94	3 sites, missed some places	*Myriophyllum spicatum*
	Fishtrap Lake	43	8/4/94	3 sites	none
	Liberty Lake	57	7/13/98	whole lake	*Myriophyllum spicatum*
	Long Lake (reservoir)	54	8/6/94	2 sites near boatlaunch	*Lythrum salicaria*
			8/25/95	1 site	*Nymphoides peltata*
	Medical Lake	43	7/14/98	whole lake	none
	Medical, West Lake	43	7/14/98	whole lake	none
	Silver Lake	34	8/4/94	only at boatramp (closed)	none
			8/24/95	2 sites	none
	Williams Lake	34	8/5/94	boatlaunch and south end	none
			9/16/97	whole littoral	none
Stevens	Deep Lake	61	7/30/97	whole littoral	none
	Deer Lake	59	7/29/97	whole littoral	none
	Jumpoff Joe Lake	59	7/29/97	whole littoral	none
	Loon Lake	59	9/25/96	whole littoral	*Myriophyllum spicatum*
			7/31/97	1 site	*Lysimachia vulgaris*
			6/24/98	whole lake	*Lythrum salicaria*
			8/11/98	whole lake	
	Waitts Lake	59	7/30/97	whole littoral	*Lythrum salicaria*

County	Waterbody Name	WRIA	Date	Survey Extent	Noxious Aquatic Weeds
Thurston	Black Lake	23	7/8/94	north end	none
			4/18/95	1 site to test methods	none
	Black River near Gate	23	8/18/98	1 site, shore	*Polygonum hydropiper*
			9/15/98	1 site, shore	
			9/30/98	5 mile reach	
	Clear Lake	11	8/7/95	1 site	none
	Hicks Lake	13	5/24/95	3 sample sites, shoreline	*Utricularia inflata*
	Lawrence Lake	13	11/7/95	spot check from shore	none
	Long Lake	14	6/6/95	spot check	*Myriophyllum spicatum*
			9/20/95	milfoil site	
			10/18/95	spot check	
			11/2/95	milfoil site	
	Munn Lake	13	6/3/98	1 site, shore	*Utricularia inflata*
			10/14/98	1 site, shore	
	Offutt Lake	13	7/7/98	whole lake	none
	Summit Lake	14	7/23/97	west end	none
	Ward Lake	13	7/6/98	whole lake	none
Wahkiakum	Columbia River at Cathlamet	25	8/16/95	spot check, boat	*Lythrum salicaria* *Myriophyllum spicatum*
	Columbia River at Skamokawa	25	8/8/96	spot check, boat	*Lythrum salicaria*
	Puget Island Sloughs	25	5/16/95	2 sloughs, from shore	*Egeria densa* *Myriophyllum aquaticum*
Walla Walla	Snake River - Lower Monumental Dam	33	8/20/96	spot check, boat	*Lythrum salicaria* *Myriophyllum spicatum*
	Snake River at Charbonneau Park	33	8/19/96	spot check, boat	none
	Snake River at Fishhook Park	33	8/19/96	spot check, boat	none
	Snake River at Ice Harbor Dam	33	8/19/96	spot check, boat	*Myriophyllum spicatum*
Whatcom	Cain Lake	3	8/14/96	whole littoral	none
	Samish Lake (East Arm)	3	6/30/97	whole littoral	none
	Samish Lake (West Arm)	3	6/30/97	whole littoral	none
	Silver Lake	1	7/1/97	whole littoral	none
	Terrell Lake	1	8/14/96	whole littoral	*Lythrum salicaria*
	Toad (Emerald) Lake	1	7/3/97	whole littoral	none
	Whatcom Lake	1	6/21/95	3 sites, littoral, west basin	*Myriophyllum spicatum*
	Wiser Lake	1	8/14/96	spot check, shore	none
			7/1/97	whole littoral	none
Whitman	Rock Lake	34	8/5/94	south boatramp, from shore	none
			9/15/97	spot check, shore	none
	Snake River at Central Ferry	35	8/5/97	spot check, shore	*Myriophyllum spicatum*
	Snake River at Little Goose Dam	35	8/5/97	spot check, boat	*Myriophyllum spicatum*
	Snake River at Lower Granite Dam	35	8/4/97	spot check, boat	*Myriophyllum spicatum*
Yakima	Dog Lake	38	7/30/98	whole lake	none
	Giffin Lake	37	7/19/95	from shore	none
	Leech Lake	39	7/30/98	whole lake	none
	Morgan Lake	37	7/19/95	spot check, from shore	none
	pond nr hwy 12	37	8/8/94	one spot, from shore	none
	Unnamed pond (14N-19E-31)	39	7/18/95	spot check, from shore	none
			7/29/98	1 site, shore	none
	Unnamed Ponds (12N-19E-20)	37	7/18/95	spot check, from shore	*Myriophyllum spicatum*
			7/29/98	4 sites, shore	*Lythrum salicaria*
	Wenas Lake	39	7/29/98	whole lake	none
	Yakima River	37	8/8/94	from Selah to Arboretum	*Lythrum salicaria*
			9/27/94	Arboretum to Union Gap	*Lythrum salicaria*
			7/19/95	Mabton Bridge	none

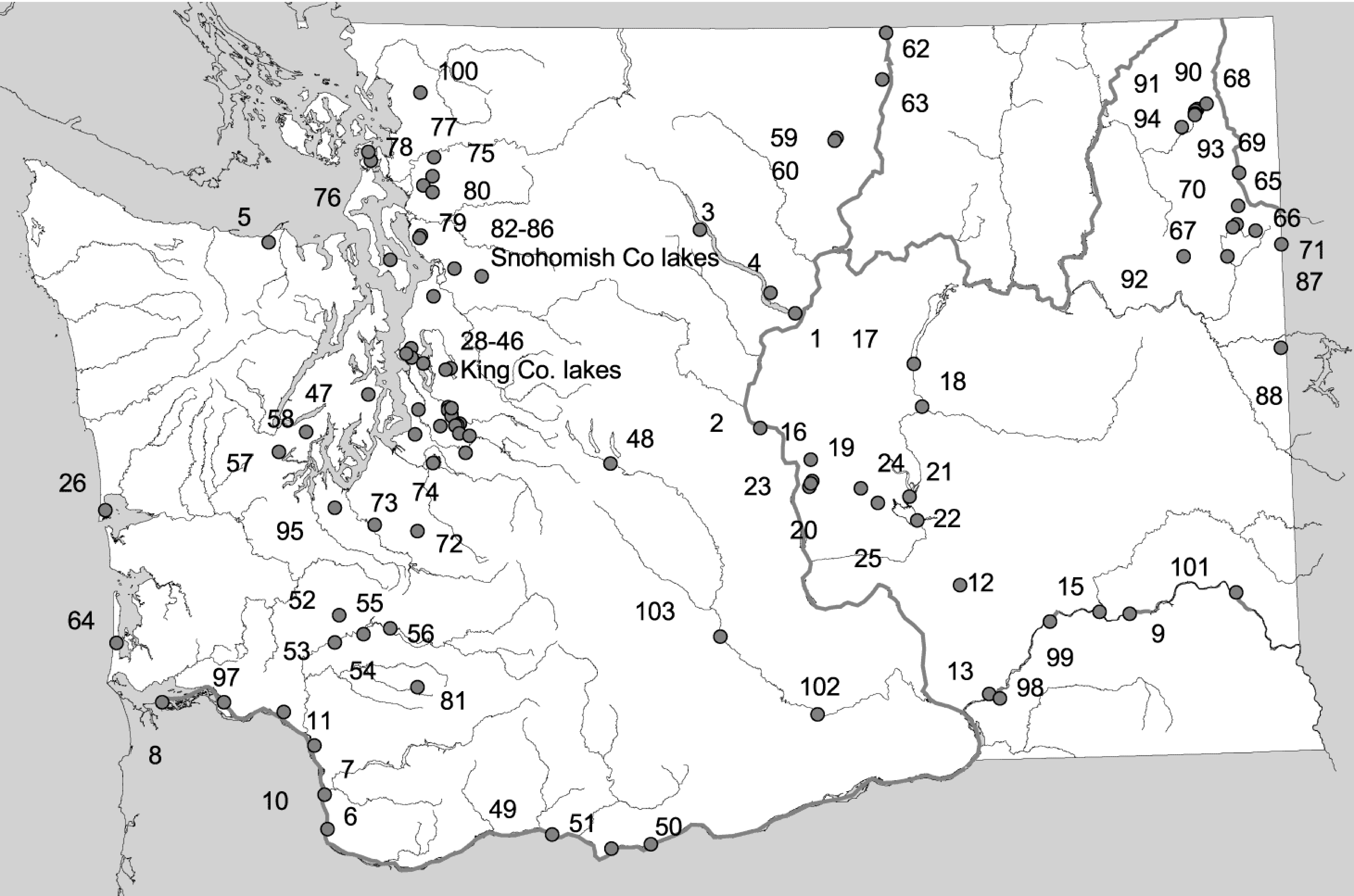
Appendix B

Myriophyllum spicatum Distribution Map

Lakes Known to Contain Eurasian milfoil (*Myriophyllum spicatum*), 1998

County	No.	Waterbody Name	County	No.	Waterbody Name
Chelan	1	Chelan Lake	Lewis	52	Carlisle Lake
	2	Cortez (Three) Lake		53	Cowlitz River
	3	Domke Lake		54	Mayfield Reservoir
	4	Wapato Lake		55	Riffe Lake
Clallam	5	unnamed pond		56	Swofford Pond
Clark	6	Caterpillar Slough	Mason	57	Island Lake
	7	Columbia River at Ridgefield		58	Mason Lake
Clatsop, OR	8	Columbia River at Astoria	Okanogan	59	Conconully (Salmon) Lake
Columbia	9	Snake River, Little Goose Dam		60	Conconully Reservoir
Cowlitz	10	Kress Lake		61	Okanogan River
	11	Willow Grove Slough		62	Osoyoos Lake
Franklin	12	Scooteney Reservoir		63	Whitestone Lake
	13	Snake River, Ice Harbor Dam	Pacific	64	Loomis Lake
	14	Snake River, Lower Mon. Dam	Pend Oreille	65	Davis Lake
	15	Snake River at Lyons Ferry		66	Diamond Lake
Grant	16	Babcock Ridge Lake		67	Little Spokane River
	17	Banks Lake		68	Nile Lake
	18	Billy Clapp Lake		69	Pend Oreille River
	19	Burke Lake		70	Sacheen Lake
	20	Evergreen Lake		71	Trask Pond
	21	Moses Lake	Pierce	72	Clear Lake
	22	Potholes Reservoir		73	Harts Lake
	23	Stan Coffin Lake		74	Hidden Lake
	24	Winchester Wasteway	Skagit	75	Big Lake
	25	Winchester Wasteway Ext.		76	Campbell Lake
Grays Harbor	26	Duck Lake		77	Clear Lake (34N-05E-07)
Island	27	Goss Lake		78	Heart Lake
King	28	Angle Lake		79	McMurray Lake
	29	Bass Lake		80	Sixteen Lake
	30	Desire Lake	Skamania	81	Coldwater Lake
	31	Green Lake	Snohomish	82	Goodwin Lake
	32	Lucerne Lake		83	Roesiger Lake
	33	Meridian Lake		84	Shoecraft Lake
	34	Number Twelve Lake		85	Silver Lake (28N-05E-30)
	35	Otter (Spring) Lake		86	Stevens Lake
	36	Phantom Lake	Spokane	87	Eloika Lake
	37	Pipe Lake		88	Liberty Lake
	38	Sammamish Lake	Stevens	89	Black Lake
	39	Sawyer Lake		90	Gillette Lake
	40	Shadow Lake		91	Heritage Lake
	41	Shady Lake		92	Loon Lake
	42	Ship Canal		93	Sherry Lake
	43	Steel Lake		94	Thomas Lake
	44	Union Lake	Thurston	95	Long Lake
	45	Washington Lake		96	Scott Lake
	46	Wilderness Lake	Wahkiakum	97	Columbia River, Cathlamet
Kitsap	47	Long Lake	Walla Walla	98	Snake River, Ice Harbor Dam
Kittitas	48	Lavender Lake		99	Snake River, Lower Mon. Dam
Klickitat	49	Columbia River, Bingen	Whatcom	100	Whatcom Lake
	50	Columbia River, Maryhill	Whitman	101	Snake River at Lower Granite Dam
	51	Horsethief Lake	Yakima	102	Byron Lake
				103	Unnamed Ponds nr. Parker

Myriophyllum spicatum Locations 1998



Appendix C

Alkalinity Results, 1995-1998

Note: In 1996 and 1998 a known standard addition was used to test the accuracy of the field test kit. An average correction value was calculated from the results and applied to the values from these years as recommended by the manufacturer (Hach, 1994). In 1997 a different procedure was used, and the results were highly variable. Therefore no correction value was calculated for that year. However, because the uncorrected values from 1997 were similar to values from other years in duplicated lakes, I felt the uncorrected values could be reported. Additional confidence in the 1997 data was gained when results nearly exactly matched the results from independent laboratory analyses (Parsons, 1997a).

County	Waterbody Name	Date	Alkalinity ($mg/l\ CaCO_3$)
Adams	Herman Lake	7/28/98	159
Chelan	Roses (Alkali) Lake	6/17/97	254
	Wapato Lake	6/27/95	180
		8/8/95	172
		6/24/96	200
		6/17/97	175
Clallam	Beaver Lake	7/9/96	30
	Crescent Lake	7/10/96	49
	Ozette Lake	7/9/96	8
	Pleasant Lake	7/11/96	14
	Sutherland Lake	7/11/96	65
Columbia	Snake River at Little Goose Dam	8/5/97	43
Ferry	Curlew Lake	8/22/95	99
	Ellen Lake	8/23/95	70
	Swan	8/13/97	60
	Trout Lake	8/22/95	82
	Twin Lakes	8/23/95	33
Grant	Alkali Lake	7/16/96	229
	Babcock Ridge Lake	7/24/95	130
	Billy Clapp Lake	8/30/95	51
	Blue Lake	7/16/96	207
	Burke Lake	9/19/96	172
		9/24/97	134
	Canal Lake	8/30/95	154
	Corral Lake	7/25/95	230
	Deep Lake	6/25/96	147
	Evergreen Lake	9/12/95	57
		9/18/96	70
		9/23/97	63
		9/9/98	51
	Lenore Lake	7/17/96	931
	Long Lake (17N-29E-32)	8/31/95	118
	Moses Lake	7/15/98	119
	Park Lake	6/26/96	190
		9/10/98	149
	Potholes Reservoir	7/16/98	125
	Quincy Lake	9/13/95	233
		9/17/96	386
		9/22/97	301
		9/8/98	303
	Soda Lake	7/25/95	97
	Warden Lake	7/28/98	165
Grays Harbor	Aberdeen Lake	7/22/96	28
	Failor Lake	6/25/97	11
Grays Harbor	Quinault Lake	10/7/96	24

Con't	Sylvia Lake	7/22/96	16
Island	Deer Lake	9/4/96	20
	Goss Lake	9/5/96	26
	Lone Lake	9/4/96	74
Jefferson	Anderson Lake	7/8/96	58
	Crocker Lake	8/27/97	20
	Leland Lake	6/14/95	22
		10/3/95	30
		6/11/96	26
	Tarboo Lake	7/2/96	9
King	Meridian Lake	7/10/97	28
	Pipe Lake	6/18/96	31
	Sawyer Lake	8/7/97	48
Kitsap	Buck Lake	7/22/98	15
	Horseshoe Lake	8/22/96	5
	Island Lake	7/22/98	13
	Kitsap Lake	8/3/95	36
		7/1/98	35
	Mission Lake	9/9/96	35
		6/18/98	19
	Panther Lake	8/2/95	6
	Wildcat Lake	10/4/95	18
	William Symington Lake	9/16/98	28
Kitsap/Mason	Tiger Lake	9/9/96	5
Kittitas	Lavender Lake	6/18/97	24
		7/27/98	24
Mason	Benson Lake	7/23/96	6
	Haven Lake	6/8/98	13
	Isabella Lake	8/18/97	32
	Island Lake	6/24/97	16
		7/9/98	13
	Limerick	7/8/98	18
	Lystair (Star) Lake	6/12/98	8
	Maggie Lake	8/19/98	3
	Mason Lake	9/14/98	17
	Nahwatzel Lake	6/26/97	5
	Phillips Lake	7/20/98	6
	Tee Lake	8/19/98	8
	Trails End (Prickett) Lake	6/16/98	3
	Wooten Lake	6/16/98	9
Okanogan	Alta Lake	6/29/95	91
	Conconully Reservoir	9/18/97	56
	Crawfish Lake	8/28/96	21
	Davis Lake	8/9/95	162
	Green Lake	6/29/95	225
	Leader Lake	8/29/96	102
	Little Twin Lake	8/9/95	163
	Omak Lake	8/28/96	2986
	Patterson Lake	8/10/95	79
	Pearrygin Lake	8/10/95	114
	Spectacle Lake	8/27/96	77
		9/17/97	70
	Whitestone Lake	6/28/95	110
		9/17/97	114

Pacific	Black Lake	8/26/97	10
	Loomis Lake	8/25/97	23

Pend Oreille	Davis Lake	7/30/96	46
	Diamond Lake	7/31/96	35
	Horseshoe Lake	7/13/98	20
	Skookum Lake, South	7/31/96	9
	Sullivan Lake	8/1/96	52
Pierce	American Lake	10/6/98	32
	Clear Lake	6/12/96	20
		6/23/97	18
	Harts Lake	7/3/96	67
	Ohop Lake	7/25/96	28
	Rapjohn Lake	7/25/96	28
	Spanaway Lake	9/11/96	48
	Steilacoom Lake	8/26/98	46
	Tanwax Lake	9/12/96	29
San Juan	Cascade Lake	9/9/97	54
	Mountain Lake	9/9/97	22
	Sportsman Lake	9/10/97	44
Skagit	Campbell Lake	8/13/96	85
	Campbell Lake	7/2/97	54
	Cavanaugh Lake	8/24/98	8
	Erie Lake	7/2/97	52
	Heart Lake (35N-01E-36)	8/13/96	82
Skamania	Coldwater Lake	8/27/98	12
Snohomish	Blackmans Lake	8/5/98	18
	Goodwin Lake	6/20/95	25
	Martha Lake (27N-04E-01)	8/5/98	23
	Shoecraft Lake	8/15/96	25
Spokane	Liberty Lake	7/13/98	12
	Medical Lake	7/14/98	481
	West Medical Lake	7/14/98	263
	Williams Lake	9/16/97	112
Stevens	Deep Lake	7/30/97	165
	Deer Lake	7/29/97	32
	Jumpoff Joe Lake	7/29/97	109
	Loon Lake	9/25/96	85
		8/11/98	60
	Waitts Lake	7/30/97	132
Thurston	Offutt Lake	7/7/98	14
	Ward Lake	7/6/98	2
Whatcom	Cain Lake	8/14/96	18
	Samish Lake (East Arm)	6/30/97	16
	Silver Lake	7/1/97	25
	Terrell Lake	8/14/96	38
	Toad (Emerald) Lake	7/3/97	29
	Whatcom Lake	6/21/95	19
	Wiser Lake	7/1/97	53
Whitman	Snake River at Little Goose Dam	8/5/97	43
Yakima	Dog Lake	7/30/98	18
	Leech Lake	7/30/98	19
	Wenas Lake	7/29/98	37

Appendix D

Plant Identification References

Aulbach-Smith, C.A., and S.J. de Kozlowski. 1996. Aquatic and Wetland Plants of South Carolina. South Carolina Department of Natural Resources, Columbia, SC.

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

Brayshaw, T.C. 1985. Pondweeds and Bur-reeds, and their relatives: Aquatic families of monocotyledons in British Columbia. British Columbia Provincial Museum, Occasional paper series, No. 26. Victoria, B.C.

Brayshaw, T.C. 1989. Buttercups, waterlilies and their relatives in British Columbia. Royal British Columbia Museum. Memoir No. 1. Victoria, B.C.

Coffey, B.T. and J.S. Clayton. New Zealand waterplants. Ruakaur Agricultural Certre, Hamilton, New Zealand

Cook, C.D.K. 1990. Aquatic plant book. SPB Academic Publishing. The Hague, The Netherlands.

Correll, D.S. and H.B. Correll. Aquatic and wetland plants of Southwestern United States Vol 1 & 2. Stanford University Press, Stanford, CA.

Crow, G.E. and C.B. Hellquist. 1981. Aquatic vascular plants of New England: Part 2. Typhaceae and Sparganiaceae. University of New Hampshire, Durham, N.H.

Crow, G.E. and C.B. Hellquist. 1982. Aquatic vascular plants of New England: Part 4. Juncaginaceae, Scheuchzeriaceae, Butomaceae, Hydrocharitaceae. University of New Hampshire, Durham, N.H.

Crow, G.E. and C.B. Hellquist. 1983. Aquatic vascular plants of New England: Part 6. Trapaceae, Haloragaceae, Hippuridaceae. University of New Hampshire, Durham, N.H.

Crow. G.E. and C.B. Hellquist. 1985. Aquatic vascular plants of New England: Part 8. Lentibulariaceae. University of New Hampshire. Durham, N.H.

Flora of North America Editorial Committee. 1993. Flora of North America, Vol 1, Introduction. Oxford University Press, New York.

Flora of North America Editorial Committee. 1993. Flora of North America, Vol 2, Pteridophytes and Gymnosperms. Oxford University Press, New York.

Flora of North America Editorial Committee. 1997. Flora of North America, Vol 3, Magnoliophyta. Oxford University Press, New York.

Guard, J.B. 1995. Wetland Plants of Oregon and Washington. Lone Pine Press. Redmond, WA.

Hellquist, C.B. and G.E. Crow. 1982. Aquatic vascular plants of New England: Part 5. Araceae, Lemnaceae, Xyridaceae, Eriocaulaceae, and Pontederiaceae.

Hellquist, C.B. and G.E. Crow. 1984. Aquatic vascular plants of New England: Part 7. Cabombaceae, Nymphaeaceae, Nelumbonaceae, and Ceratophyllaceae. University of New Hampshire, Durham, N.H.

Hickman, J.C. ed. 1993. The Jepson manual - higher plants of California. University of California Press. Berkeley, CA.

Hitchcock, C.L. and A. Cronquist. 1973. Flora of the Pacific Northwest. University of Washington Press, Seattle, WA.

Hotchkiss, C.L. 1967. Underwater and floating-leaved plants of the United States and Canada - Resource publication 44. Bureau of Sport Fisheries and Wildlife, US Fish and Wildlife Service. Washington, D.C.

Hotchkiss, N. 1972. Common marsh, underwater & floating-leaved plants of the United States and Canada. Dover Publications, Inc. New York.

Hoyer, M.V., D.E. Canfield, C.A. Horsburgh, K. Brown. 1996. Florida freshwater plants. University of Florida Press, Gainesville, FL.

Kartesz, J.T. 1994. A synonymized checklist of the vascular flora of the United States, Canada, and Greenland. 2nd ed. Vol. 1 and 2. Timber Press, Portland, OR.

Kirk. D.R. 1975. Wild edible plants of western North America. Naturegraph Publishers. Happy Camp, CA

Mühlberg, H. 1982. The complete guide to water plants. EP Publishing Ltd. Germany.

Pieterse and Murphy 1989. Aquatic Weeds. Oxford University Press.

Pojar, J. and A. MacKinnon. 1994. The Plants of the Pacific Northwest Coast; Washington, Oregon, British Columbia and Alaska. Lone Pine Publishing, Redmond, WA.

Prescott, G.W. 1978. How to know the freshwater algae. Wm. C. Brown Co. Publishers. Dubuque, Iowa.

Prescott, G.W. 1980. How to know the aquatic plants. Wm. C. Brown Co. Publishers. Dubuque, Iowa.

Preston, C.D. 1995. Pondweeds of Great Britain and Ireland. Botanical Society of the British Isles. London.

Rataj, K. and T.J. Horeman, 1977. Aquarium plants, their identification, cultivation and ecology. T.F.H. Publications, Neptune City, N.J.

Scheurmann, I. 1993. Aquarium Plants Manual. Barron's Educational Series, Inc. New York.

Schmidt, J.C. 1990. How to identify and control water weeds and algae 4th ed. Applied Biochemists, Inc. Milwaukee, WI.

Smith-Kuebel, C. and T.R. Lillybridge. 1993. Sensitive plants and noxious weeds of the Wenatchee National Forest. USDA Forest Service, Wenatchee National Forest. Wenatchee, WA.

Stodola, J. 1987. Aquarium plants, a complete introduction. T.F.H. Publications, Inc. Neptune City, N.J.

Stodola, J. 1967. Encyclopedia of water plants. TFH Publications, Inc Jersey City, N.J.

Steward, A.N.; L.J. Dennis, and H.M. Gilkey. 1963. Aquatic plants of the Pacific Northwest. Oregon State University Press, Corvallis, OR.

Tarver, D.P., J.A. Rodgers, M.J. Mahler, R.L. Lazor. 1979. Aquatic and wetland plants of Florida, 2nd ed. Bureau of Aquatic Plant Research and Control, Florida Department of Natural Resources, Tallahassee, FL.

Warrington, P.D. 1993. Identification keys to the aquatic plants of British Columbia. Unpublished manuscript.

Warrington, P.D. 1980. Studies on aquatic macrophytes part XXXIII; aquatic plants of British Columbia. Province of British Columbia, Ministry of Environment. Victoria, BC.

Westerdahl, H.E. and K.D. Getsinger eds. 1988. Aquatic plant identification and herbicide use guide; vol II: aquatic plants and susceptibility to herbicides. Technical report A-88-9, US Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Whitley, J.R., B. Bassett, J.G. Dillard, and R.A. Haefner. 1990. Water plants for Missouri ponds. Missouri Department of Conservation. Jefferson City, MO.

Winterringer, G.S., and A.C. Lopinot. 1977. Aquatic plants of Illinois. Illinois State Museum. Springfield, Ill.

Appendix E

Herbarium Specimens, Grouped by Family

Herbarium Specimens - Grouped by Family

Family	Scientific name	Common name
Alismataceae		
	Alisma gramineum	narrowleaf water-plantain
	Sagittaria cuneata	Arumleaf arrowhead, wapato
	Sagittaria graminea	slender arrowhead
	Sagittaria rigida	bur arrowhead
Apiaceae		
	Cicuta douglasii	western water-hemlock
	Hydrocotyle ranunculoides	water-pennywort
	Lilaeopsis occidentalis	lilaeopsis
Asteraceae		
	Megalodonta beckii	water marigold
Azollaceae		
	Azolla mexicana	mexican water-fern
Boraginaceae		
	Myosotis laxa	small flowered forget-me-not
	Myosotis scorpioides	common forget-me-not
Brassicaceae		
	Rorippa nasturtium-aquaticum	water-cress
	Rorippa palustris	marsh yellowcress
	Subularia aquatica	awlwort
Butomaceae		
	Butomus umbellatus	flowering rush
Cabombaceae		
	Brasenia schreberi	watershield
	Cabomba caroliniana	fanwort
Callitrichaceae		
	Callitriche hermaphroditica	northern water-starwort
	Callitriche heterophylla	different-leaved water-starwort
	Callitriche stagnalis	pond water-starwort
	Callitriche verna	spring water-starwort
Campanulaceae		
	Lobelia dortmanna	water gladiole; water lobelia
Ceratophyllaceae		
	Ceratophyllum demersum	Coontail; hornwort
Characeae		
	Nitella sp.	stonewort
	Tolypella intricata	macro algae
Crassulaceae		

Family	Scientific name	Common name
Cyperaceae		
	Carex unilateralis	one-sided sedge
	Cyperus erythrorhizos	red rooted cyperus
	Dulichium arundinaceum	Dulichium
	Eleocharis acicularis	needle spike-rush
	Eleocharis sp.	spike-rush
	Scirpus acutus	hardstem bulrush
	Scirpus americanus	american bulrush
	Scirpus cyperinus	wool-grass
	Scirpus fluviatilis	river bulrush
	Scirpus maritimus	seacoast bulrush
	Scirpus nevadensis	Nevada bulrush
	Scirpus subterminalis	water clubrush
Elatinaceae		
	Elatine sp.	waterwort
	Elatine triandra	three-stamen waterwort
Equisetaceae		
	Equisetum fluviatile	water horsetail
Fontinalaceae		
	Fontinalis antipyretica	water moss
Haloragaceae		
	Myriophyllum aquaticum	parrotfeather
	Myriophyllum hippuroides	western watermilfoil
	Myriophyllum quitense	waterwort watermilfoil
	Myriophyllum sibiricum	northern watermilfoil
	Myriophyllum sp.	water-milfoil
	Myriophyllum spicatum	Eurasian water-milfoil
	Myriophyllum verticillatum	whorled watermilfoil
Hippuridaceae		
	Hippuris vulgaris	common marestail
Hydrocharitaceae		
	Egeria densa	Brazilian elodea
	Egeria najas	Asian anacharis
	Elodea canadensis	common elodea
	Elodea nuttallii	Nuttall's waterweed
	Hydrilla verticillata	hydrilla
	Vallisneria americana	water celery
Isoetaceae		
	Isoetes sp.	quillwort
Juncaceae		

Family	Scientific name	Common name
Lamiaceae		
	Lycopus asper	rough bungleweed
Lemnaceae		
	Wolffia sp.	water-meal
Lentibulariaceae		
	Utricularia inflata	big floating bladderwort
	Utricularia macrorhiza	common bladderwort
	Utricularia minor	lesser bladderwort
	Utricularia sp.	bladderwort
	Utricularia vulgaris	common bladderwort
Menyanthaceae		
	Menyanthes trifoliata	buckbean
	Nymphoides peltata	water fringe
Najadaceae		
	Najas flexilis	common naiad
	Najas gradalupensis	Guadalupe water-nymph
Nymphaeaceae		
	Nuphar polysepala	spatter-dock, yellow water-lily
Onagraceae		
	Ludwigia hexapetala	water primrose
	Ludwigia palustris	water-purslane
Poaceae		
	Cinna latifolia	wood reed-grass
	Glyceria borealis	northern mannagrass
	Zizania aquatica	wild rice
Polygonaceae		
	Polygonum amphibium	water smartweed
	Polygonum hydropiper	marshpepper smartweed
	Polygonum hydropiperoides	common smartweed
Pontederiaceae		
	Heteranthera dubia	water star-grass
Potamogetonaceae		
	Potamogeton alpinus	red pondweed
	Potamogeton amplifolius	large-leaf pondweed
	Potamogeton crispus	curly leaf pondweed
	Potamogeton diversifolius	snailseed pondweed, diverse leaf
	Potamogeton epihydrus	ribbonleaf pondweed
	Potamogeton foliosus	leafy pondweed
	Potamogeton friesii	flat-stalked pondweed
	Potamogeton gramineus	grass-leaved pondweed

Family	Scientific name	Common name
	Potamogeton obtusifolius	bluntleaf pondweed
	Potamogeton pectinatus	sago pondweed
	Potamogeton praelongus	whitestem pondweed
	Potamogeton pusillus	slender pondweed
	Potamogeton richardsonii	Richardson's pondweed
	Potamogeton robbinsii	fern leaf pondweed
	Potamogeton vaginatus	sheathing pondweed
	Potamogeton zosteriformis	eel-grass pondweed
Primulaceae		
	Lysimachia nummularia	creeping loosestrife
	Lysimachia thyrsiflora	tufted loosestrife
	Lysimachia vulgaris	garden loosestrife
Ranunculaceae		
	Ranunculus aquatilis	water-buttercup
	Ranunculus flammula	creeping buttercup
Ruppiaceae		
	Ruppia maritima	ditch-grass
Scrophulariaceae		
	Gratiola neglecta	hedge-hyssop
	Limosella acaulis	mudwort
	Limosella aquatica	mudwort
	Lindernia dubia	false-pimpernel
	Veronica anagallis-aquatica	water speedwell
Sparganiaceae		
	Sparganium angustifolium	narrowleaf bur-reed
	Sparganium eurycarpum	broadfruited bur-reed
	Sparganium nutans	small bur-reed
	Sparganium sp.	bur-reed
Zannichelliaceae		
	Zannichellia palustris	horned pondweed