POPULATION AND HABITAT MONITORING OF *HOWELLIA AQUATILIS* (WATER HOWELLIA) AT THE HARVARD–PALOUSE RIVER FLOOD PLAIN SITE, IDAHO: SIXTH-YEAR (2004) RESULTS

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ABSTRACT

Water howellia (*Howellia aquatilis*) is an aquatic macrophyte that is listed as threatened by the U.S. Fish and Wildlife Service. The single known Idaho location of the species occurs on the flood plain of the Palouse River in northern Idaho, in three small ponds formed by fluvial processes. The ponds are the low points of abandoned channels or channel migration scars and dry each summer. Threats to the population include invasion by three non-native species–reed canarygrass (*Phalaris arundinacea*), sweet flag (*Acorus calamus*), and climbing nightshade (*Solanum dulcamara*). Water howellia populations and pond water depths at the site have been monitored since 1999. Photopoints were established in 2000. This is the sixth annual report documenting monitoring results. In 2004, flowering took place in late June when the water was 23-36 cm deep. Although absent from pond 1 for the third consecutive year, water howellia occupied more area in pond 3 than in any previously monitored year, and was unusually dense in pond 2. In addition, several water howellia plants appeared in portions of pond 3 where reed canarygrass abatement efforts had taken place; plants had not been documented in those areas in earlier monitoring years. In 2003, we installed transects in ponds 2 and 3 for measuring cover and frequency of water howellia and associated plants, and for detecting the results of weed abatement efforts on reed canarygrass and sweet flag. In 2004, we established a monitoring transect in pond 1 and added a third transect in pond 2. We took photos from established photopoints on 28 June 2004. We continued weed suppression measures for reed canarygrass and sweet flag in ponds 2 and 3. For reed canarygrass these consisted of clipping, covering, and limited excavation; we pulled sweet flag shoots in pond 2. Monitoring information, along with results of weed suppression measures, will provide a basis for possible future management of the site.

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BACKGROUND

Water howellia (*Howellia aquatilis*) is an annual aquatic plant belonging to a monotypic genus in the family Campanulaceae. It has specific habitat requirements and has been rare throughout the period of botanical record. There are presently 213 known extant occurrences rangewide: 138 in western Montana (personal communication, S. Mincemoyer, 7 June 2005), one in northern Idaho (Idaho Conservation Data Center 2005), one in Oregon (Mincemoyer 2005), 67 in eastern and western Washington (personal communication, S. Moody, 4 October 2005), and six in California (personal communication, R. Bittman, 2 June 2005). It occurs in ephemeral ponds and at the margins of permanent ponds, which in most cases are glacial potholes (Shapley and Lesica 1997). The ponds are shallow and surrounded by deciduous shrubs and trees. The bottoms are vegetated with aquatic, emergent, and other wetland plants. A detailed description of water howellia, its biology, and its habitat can be found in Shelly and Moseley (1988). Water howellia is listed as threatened by the U.S. Fish and Wildlife Service (USFWS). A habitat and population monitoring program is one of the recovery actions specified in the draft Recovery Plan (Shelly and Gamon 1996).

The life cycle of water howellia is tied to the hydrology of the ponds that comprise its habitat. Viability in the short term depends on hydrologic conditions necessary for seed production and germination. Ponds must dry out in order for germination to occur. Habitat management for water howellia requires an understanding of pond hydrology and geometry (Shapley and Lesica 1997) and the effects of colonization by exotic plants (Lesica 1997). In Idaho, the only known water howellia site is on the flood plain of the Palouse River, in ponds formed in depressions left by the gradual migration of the river channel (Lichthardt and Moseley 2000). Three ponds, each less than 0.1 hectare (0.25 acre) in area, occur on a parcel of private land occasionally used for pasture. The site is monitored by the Idaho Conservation Data Center (IDCDC) and referred to as the Harvard-Palouse River Flood Plain Conservation Site.

In 1999, the fluvial processes of the flood plain were examined by looking at historical photos, mapping vegetation at the site, and surveying a cross-section of the flood plain (Lichthardt and Moseley 2000). Water depth gauges were installed in each pond. Water depth and the cover and distribution of water howellia have been monitored annually since 1999 (Lichthardt and Moseley 2000, Lichthardt 2001, Lichthardt and Gray 2002, Lichthardt and Gray 2003, Lichthardt and Gray 2005). In 2001, accurate diagrams of the ponds were made for the purpose of monitoring pond vegetation (Lichthardt and Gray 2001). Also in 2001, we began using excavation and covering to control the spread of two invasive, rhizomatous species within the ponds – reed canarygrass (*Phalaris arundinacea*) and sweet flag (*Acorus calamus*). We established transects in 2003 (Lichthardt and Gray 2005) and 2004 to monitor changes in vegetation. This report contains data on population and water levels recorded from 1999 to 2004 and describes ongoing weed control activities at the site.

The three ponds occur on a broad floodplain of the Palouse River. All three are depressions set within elongate, arcing meander scars. The entire scar holds water in the

winter months. Each pond consists of an irregular, oval portion and a narrower, channel-like portion–the pond "tail"–which is partly to mostly shaded (Appendix 1). The pond bottoms support herbaceous emergent vegetation dominated by water parsnip (*Sium suave*), short-awn foxtail (*Alopecurus aequalis*), American water-plantain (*Alisma plantago-aquatica*), simple-stem bur-reed (*Sparganium emersum*), and, at pond 3, common spikesedge (*Eleocharis palustris*). The ponds are surrounded by tall shrubs–Pacific ninebark (*Physocarpus capitatus*), Bebb's willow (*Salix bebbiana*), Drummond's willow (*Salix drummondiana*), black hawthorn (*Crataegus douglasii*), and thinleaf alder (*Alnus incana*)–and a few large conifers including grand fir (*Abies grandis*), Engelmann spruce (*Picea engelmannii*), Douglas-fir (*Pseudotsuga menziesii*), and lodgepole pine (*Pinus contorta*). A complete species list can be found in Lichthardt and Moseley (2000).

THREATS

In early to mid-summer, pond 3 is covered by a surface algal bloom (Figure 1). This may be caused or exacerbated by runoff from a feedlot across the road to the east. When the water is high in spring, the pond is likely connected to water coming off the feedlot through a culvert just to the south. In the early spring, dead spikesedge stems from the prior year are also covered with algae. The effects on water howellia are unknown. During the algal bloom, less light penetrates the pond.

Figure 1. Algae on the surface of pond 3. The large grass visible in the upper half of the photo is reed canarygrass.

Three non-native, vascular plant species appear to present a threat to water howellia at the Harvard–Palouse River sites: reed canarygrass, climbing nightshade (*Solanum*

dulcamara), and sweet flag. Reed canarygrass is present in all three ponds, climbing nightshade in ponds 2 and 3, and sweet flag in pond 2.

At all three ponds, reed canarygrass is present but sparse under the shrubs at the pond edges, but in the open it has developed dense swards raised well above the pond bottoms. Most of the areas mapped as reed canarygrass in the pond diagrams (Appendix 1) are dense monocultures and are free of standing water by May. Reed canarygrass is native in the U.S. However, the aggressive form of reed canarygrass that is replacing native wetland vegetation is thought to be a European cultivar or a hybrid between it and the native form (Maurer et al. 2003, Merigliano and Lesica 1998). It is a prolific producer of seeds, and grows and spreads quickly. The seeds are able to germinate immediately after ripening, and tillers are produced within five to seven weeks (Apfelbaum and Sams 1987). Low light limits both germination of seeds and establishment from rhizome fragments; however, once a plant is established in open sunlight, the parent clone is able to support expansion of tillers into heavily shaded areas that would have been unsuitable for seed or rhizome establishment (Maurer et al. 2003). A diverse, closed canopy of native plants reduces the ability of reed canarygrass to establish, possibly because complex communities are more likely to include broad-leaved plants that increase shading (Lindig-Cisneros and Zedler 2002). A monoculture of mannagrass (*Glyceria striata*) exhibited lower resistance to reed canarygrass germination than a mixture of mannagrass and other species (Lindig-Cisneros and Zedler 2002). Water howellia appears to flourish in portions of the ponds vegetated by mannagrass and foxtail, and it is possible that ponds 1 and 2 were dominated by those two grasses before the invasion by non-native species.

Competition from reed canarygrass is favored by the addition of sediments (Werner and Zedler 2002) and nutrients (Maurer and Zedler 2002). Enrichment with nitrate-N results in supression of native-species biomass in communities invaded by reed canarygrass (Green and Galatowitsch 2001). For this reason, overflow from the culvert south of pond 3 may exacerbate reed canarygrass invasion.

It appears that reed canarygrass raises the level of the pond bottoms where it is established by depositing thick layers of thatch each fall and subsequently sending masses of rhizomes through that layer of dead biomass. Thick reed canarygrass stands in ponds 2 and 3 are on higher ground than water howellia, perhaps indicating a long-term presence. In Pond 1, reed canarygrass domination has been more recent, and raised portions of the pond bottom are discontinuous.

Another aggressive, non-native species, climbing nightshade (Figure 2), is abundant in pond 3 and present at lower cover in pond 2. It is a rhizomatous perennial plant with a woody base. Its seeds are disseminated by animals, including white-tailed deer (Myers et al. 2004) and birds (Smith 1975). The plants root at nodes, are capable of rapid growth, and can germinate in shade (Smith 1975). The “tail” of pond 3 has been invaded by climbing nightshade, and it is scattered in the body of the pond, particularly near the edges. Its roots spread over the mud bottom where water howellia germinates.

Figure 2. Climbing nightshade, pond 3. 28 June 2004.

A stand of sweet flag occupies about 70 sq m of pond 2. Sweet flag is a clonal emergent plant up to 2 m tall that forms dense swards very similar to cattails (*Typha* spp.). In 2003, we observed it flowering for the first time (mid-August) and collected specimens. The plants have been tentatively identified as *Acorus calamus*, an exotic species. The sweet flag provides a high level of shade and in fall its senescent leaves cover the pond bottom. In spite of this, water howellia was found growing throughout the sweet flag sward from 2001 through 2004. In 2004, we found only a few water howellia plants in a meter-wide strip at the interface of the sweet flag and reed canarygrass colonies.

WEED ABATEMENT

Potential weed control measures at the water howellia ponds are limited. We are restricted to small equipment or hand tools. Burning would require landowner approval and is likely a liability risk. Herbicide spraying is not considered an option due to the presence of water howellia and other native species. In 2001, we began experimenting with several measures on a limited scale to assess their feasibility. Weed control work is done in late summer after water howellia has produced seed and there is no standing water in the ponds. No weed abatement has been initiated in pond 1. In 2004, we continued weed control efforts in ponds 2 and 3.

Pond 2

Pond 2 is the largest pond. Nearly 80% of the open area is covered by reed canarygrass and sweet flag (Figure 3). In addition to the raised area of nearly solid reed canarygrass on the north side of the pond, reed canarygrass also occurs as satellite islands raised well

above the pond bottom. In 2002 we removed four such islands, 0.5-0.75 m in diameter, from the west edge of the main body of the pond, by excavation (Lichthardt and Gray 2003). In 2003, water howellia completely occupied the depression left by one such island.

Figure 3. Senescent sweet flag shoots lying on pond 2 bottom. 8 October 2004. The tall, large grass is reed canarygrass. The short grass near the center of the photo is mostly foxtail, and generally supports the thickest growth of water howellia.

We mapped a satellite colony of sweet flag and then clipped it twice (on 9 July and 25 August, 2002) in an effort to starve the rhizomes. This method has apparently been used with some success in the control of cattails (*Typha* spp.). A small satellite was selected for this test, because we could clip the entire clump, leaving no leaves standing to feed the rhizomes. Pulling the leaves was faster and more effective than cutting. Often, the crown would come off with the leaves, depriving the plant of some of its reserve as well as its ability to photosynthesize. In 2004, we pulled shoots from the same satellite.

Pond 3

The body of pond 3 is primarily covered with common spikesedge. Its tail is vegetated by forbs and shaded by willow and alder. A solid growth of reed canarygrass adjoins the pond in two separate places that may once have been part of the pond. From these places the grass is continuing its colonization of the pond, especially where it can take hold in rotting wood.

Weed abatement efforts have been concentrated on the western side of the pond. Reed canarygrass occupies higher ground adjoining the west edge of the pond, and from this

source was formerly spreading into the pond. Gillespie and Murn (1992) mowed reed canarygrass twice a year for five years. They found that it kept seedheads removed, and that several wetland forbs and sedges populated the mowed reed canarygrass area, but not the unmown. We have clipped and covered portions of the reed canarygrass on the west side of the pond since 2001. Initially, we used a shovel to establish a straight line along the east edge of the colony. We marked the ends of the line with steel fenceposts. We then dug reed canarygrass east of the line, and clipped it west of the line. We covered the clipped grass with plastic roofing and canvas dropcloths to discourage regrowth (Figure 4). The coverings have proven to be relatively successful. Some reed canarygrass shoots emerged through cracks between the coverings, but growth was largely suppressed. The canvas dropcloth was colonized primarily by native plants, with some climbing nightshade.

We have excavated some reed canarygrass sod each year in an attempt to lower the level of the pond bottom (Figure 4). This appears to be an effective strategy, as we found water howellia growing in some of these excavated areas in 2004. Excavated areas were also thickly colonized by water plantain seedlings in the early spring of 2004.

Figure 4. Weed abatement in pond 3, using excavation and plastic roof covering. 20 September 2004.

Figure 4 shows a portion of the weed abatement area on the western side of pond 3. The excavation in the foreground is an attempt to eradicate reed canarygrass rhizomes and to lower the pond bottom level. The plastic roofing covers clipped vegetation. The broadleaved vegetation on the right is primarily northern bugleweed (*Lycopus uniflorus*)

growing on a large log in the pond. The green flag in the background marks one of the new locations for water howellia.

Reed canarygrass is also spreading from higher ground on the east side of the pond into the pond tail. In 2002, we used shovels to create an abrupt edge, then covered the edge and approximately a 2-m width of reed canarygrass with plastic tarp anchored by woody debris. In 2004, the tarp was in place and appeared to be suppressing growth of reed canarygrass. This area might be a second potential target for excavation of reed canarygrass rhizomes in 2005.

MONITORING

We monitor water howellia and several aspects of its habitat: the area occupied by water howellia plants; the water depth of the ponds; the stream flow and water depth of the nearby Palouse River; the major vegetation groupings revealed by mapping; and species composition and cover measured by both line transects and 50 cm x 50 cm quadrats. Water depth of ponds and aereal cover of water howellia have been recorded every year from 1999 to 2004. Photopoints were established in 2000 and an additional photopoint was added at each pond in 2001. Photos have been taken from the points every year from 2000 to 2004. The ponds were mapped in 2001, with some additional mapping conducted in 2004. In 2003, five transects were installed in pond 3 and two transects were installed in pond 2. In 2004, one transect was added in pond 2 and one transect was established in pond 1. Line transect data to measure plant community changes were gathered from ponds 2 and 3 in 2003 and 2004. Cover data from quadrats placed along the transects were collected in pond 3 in 2003, and from ponds 2 and 3 in 2004. The cover data will show changes in cover of plant species in each pond. Because the new transects in ponds 1 and 2 were not added until October, transect data was not collected in 2004.

Water howellia

We surveyed the subpopulations on 28 June 2004 when water was 23-36 cm deep at the deepest point in each pond and water howellia was in flower and early fruit. We moved carefully through each pond, flagging locations of water howellia with wire flags, and estimating its aereal cover. Monitoring data were used to update the Element Occurrence Record for water howellia (Appendix 2). The aereal extent of water howellia in each of the six years is shown in Table 1. Results are discussed below for each pond.

Table 1. Approximate area (sq m) occupied by water howellia, 1999-2004.

	Pond 1	**Pond 2**	**Pond 3**
Year	Square meters		
1999	0.5	50	0.5
2000	No data	110-130	0.5
2001	3.0[1]	345	1.0[2]
2002	0	400	4.4
2003	0	350	4.6
2004	0	350	15.5

[1] Four plants estimated.
[2] Eight to twelve plants estimated.

Pond 1

In 2004, we found no water howellia in pond 1. The last year that it was present was 2001. The pond vegetation is presently dominated by reed canarygrass.

Pond 2

Nearly the entire inundated area of pond 2 was occupied by water howellia, in varying densities. It was most abundant in areas vegetated by short-awn foxtail and mannagrass (*Glyceria occidentalis* and *Glyceria* sp.), where it formed thick and nearly continuous cover at the water surface. It was also dense and continuous for 15 m into the tail. Beyond the first 15 m of the tail, there were a few plants in a pool supporting retrorse sedge (*Carex retrorsa*), and it was abundant in a pool further west of the retrorse sedge pool. Water howellia was present throughout the sweet flag sward except for a 1-m wide band along the reed canarygrass/sweet flag interface on the east side of the pond. No water howellia grew in the raised stand of thick reed canarygrass.

Pond 3

In pond 3, more area was covered by water howellia in 2004 than in any previous year of monitoring. One new location was documented in the northwest sector of the pond where water howellia has not been previously observed, and additional new plants were found west of a large log in the western quarter. The new locations were in areas where reed canarygrass had been excavated.

Ten years of monitoring on the Flathead National Forest in Montana showed extreme variation in frequency and cover of water howellia (Mantas and Sutter 1998). Also, there was a close relationship between population size and the previous year's climate, with

high summer precipitation resulting in low abundance the following year. High summer rainfall would presumably cause the ponds to dry out later. Our data on water levels showed that ponds 2 and 3 dried early in 2003; water howellia cover was higher than in any year since monitoring began in pond 3, and growth was extremely dense in pond 2.

Water levels and streamflow

Water levels in the three ponds are recorded at each visit (Appendix 3). Water level is read directly from a vertical section of PVC pipe located in the deepest part of the pond. The pipe extends 1 m above ground and is marked off in 1-cm increments. The gauge can generally be read from a distance using binoculars, but the marks fade and need to be remarked annually. Whenever depth measurements are taken, the U.S. Geological Survey Water Resources web site is checked for current discharge rate and stage of the Palouse River (Appendix 3). These data are for a point on the river 24 km downstream.

Pond drying is shown graphically in Figure 5. The earliest date at which the ponds have been visited is March 27, so the time scale is represented as "days from March 26." Drying occurs at a fairly steady rate until late June, the time at which water howellia begins flowering. After that, drying is rapid; ponds 1 and 3 are dry or nearly so by mid-July, and pond 2 is dry by the end of July. We consider the ponds dry when there is no standing water, although the soil remains saturated.

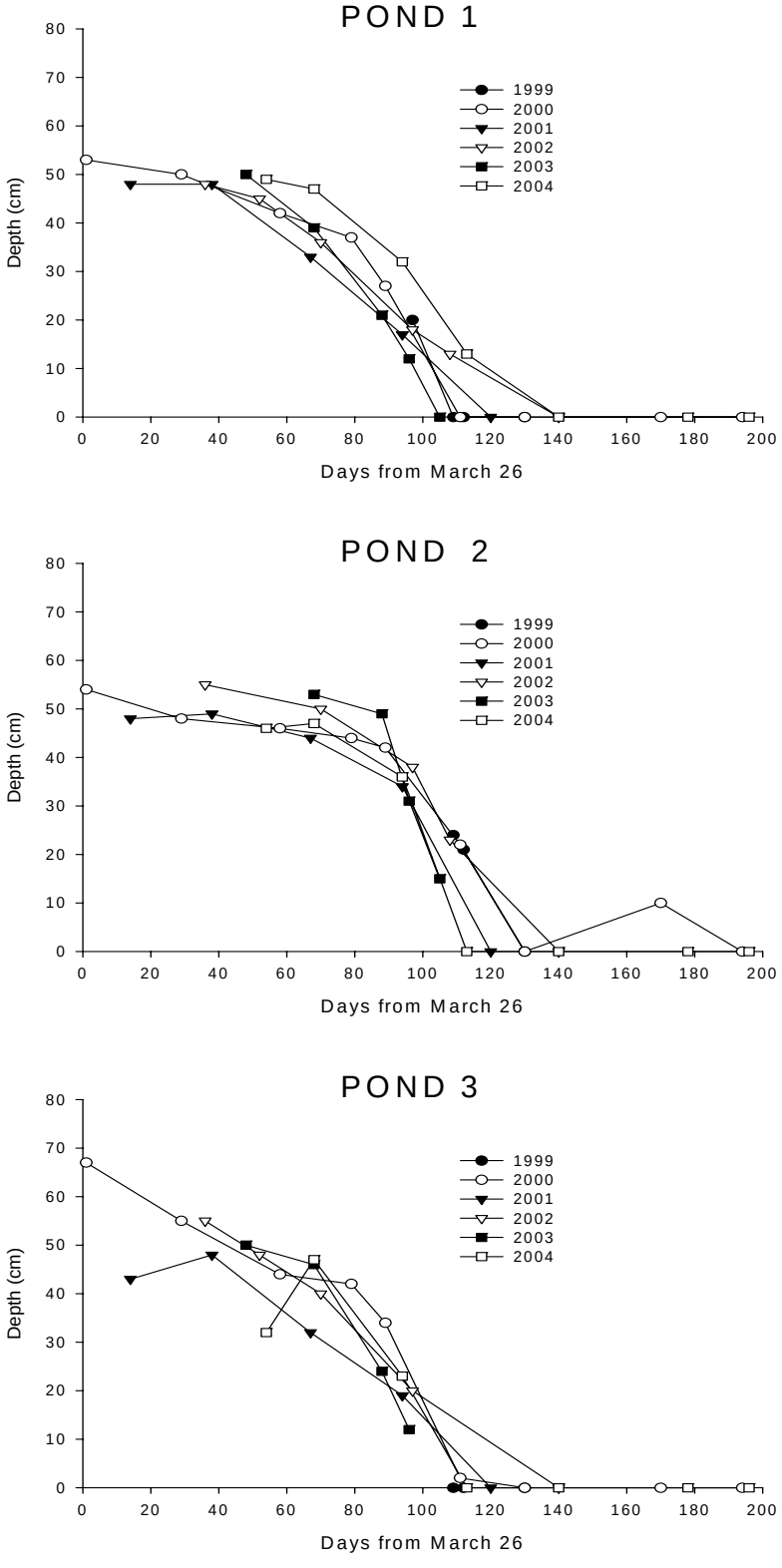

Figure 5. Depth of water (cm) in ponds between 26 March and 8 October, 1999-2004. Day 100 is 4 July.

Vegetation maps

Pond 1: In 2001, pond vegetation was mapped by measuring distance and azimuth from the pond gauge to the boundaries of the various plant communities or colonies (Appendix 1). At that time, the central area of the pond was occupied by large clumps of inflated sedge (*Carex vesicaria*), along with water parsnip and scattered clumps of reed canarygrass. The sedge community was bordered by a wide strip of reed canarygrass that extended to the pond edge. A clump of willow (*Salix* sp.) with sparsely interspersed reed canarygrass occurred on the northwest edge of the pond. The north, east, and south edges of the pond are relatively abrupt and bordered by shrubs

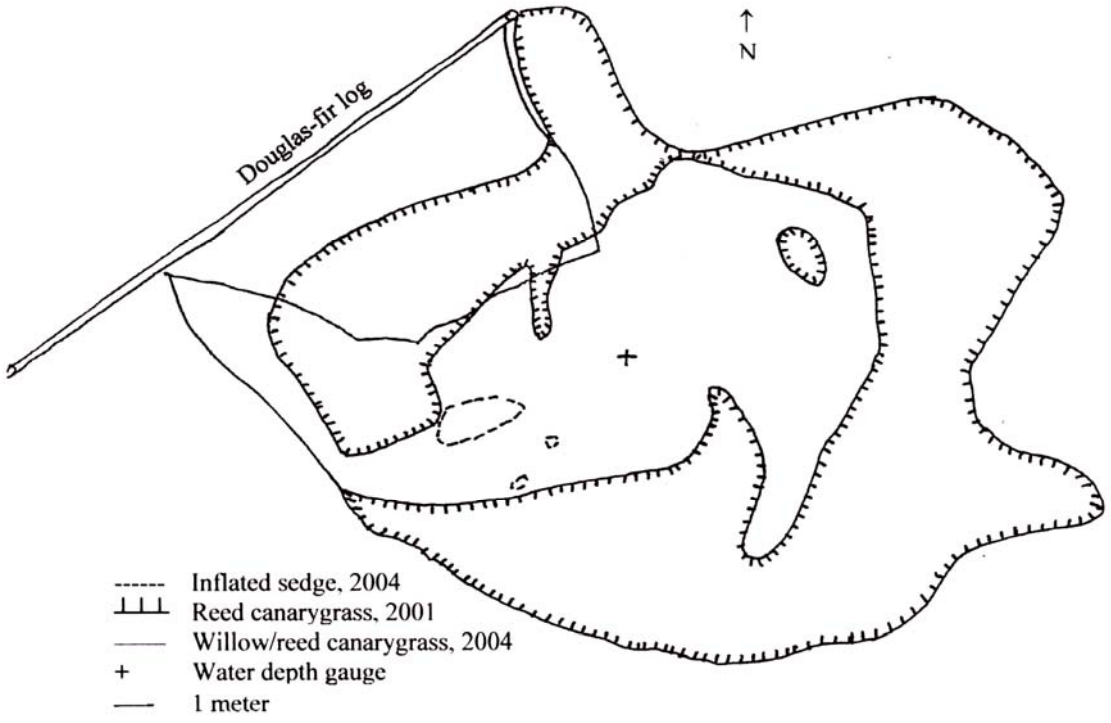

Figure 6. Diagram of pond 1 vegetation.

In 2001, the central portion was mapped as inflated sedge. By 2004, the extent of the area occupied by inflated sedge had decreased to the area delineated by dashed lines. By 2004, the entire pond was dominated by reed canarygrass (mixed with water parsnip in the central area). Only five inflated sedge plants remained (Figure 6). The willow stand in the northeast portions appears to have expanded since 2001. A few patches of short-awn foxtail were scattered near the inflated sedge clumps (Appendix 1).

In 2004, we found the water gauge used to measure water levels and azimuths uprooted and laid aside. Although we re-established the gauge where we thought it had been, it may not be in the exact original position. We also established a transect that runs through the gauge from 90º to 270º (Figure 7). The transect may be used in the future to collect vegetation data and to relocate the gauge if it is disturbed again. In 2001, a small amount of water howellia occurred along the southeast edge of the pond. Since that year, we have found no water howellia in the pond.

Figure 7. Photo of pond 1 vegetation dominated by reed canarygrass. The tape between fenceposts marks the transect established in 2004. It runs east to west and passes through the water depth gauge. 8 October 2004.

Pond 2: Pond 2 vegetation was mapped in 2001, and the boundary of the sweet flag colony was re-mapped in October 2004 (Figure 8). This is the largest pond, the open

portion being approximately 650 sq m in area, with a very long, gradually narrowing tail (approximately 190 sq m in area) to the west. Approximately 80% of the main pond is occupied by sweet flag and reed canarygrass. Most of the area occupied by reed canarygrass is above the late-spring water level and therefore not part of the pond proper, although it may have been at one time.

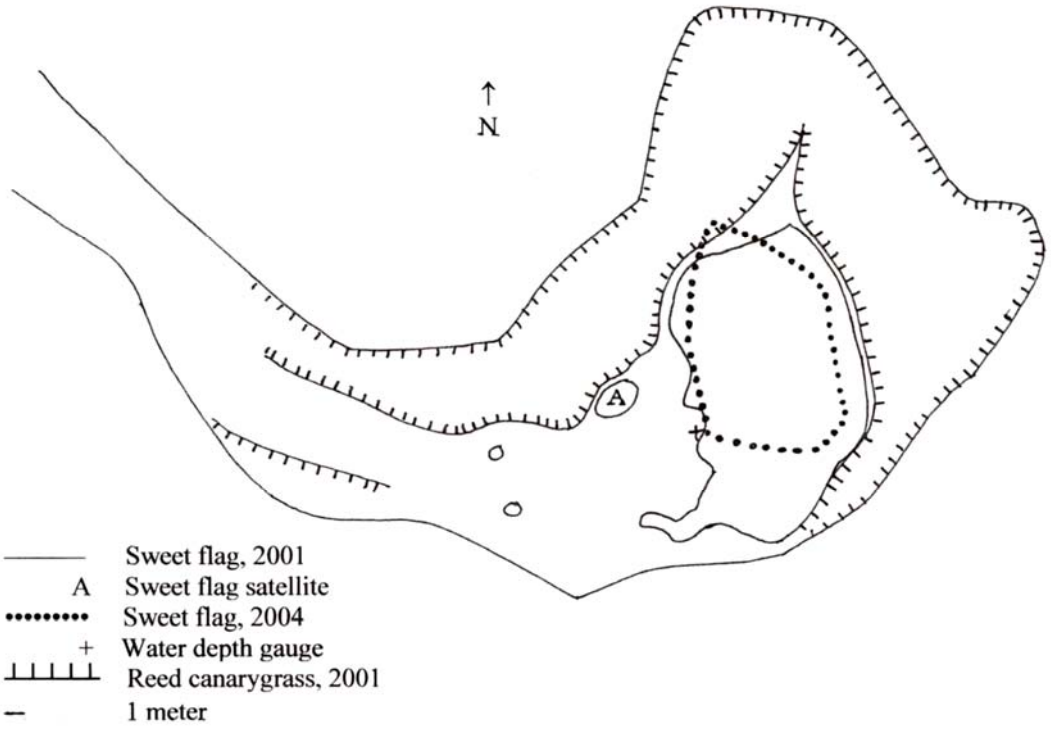

Figure 8. Diagram of pond 2 vegetation. It shows the extent of reed canarygrass and changes in the area occupied by sweet flag.

We pulled shoots from the roots of a satellite clone of sweet flag in 2001 and 2004. (Figure 8, area marked with A). The area mapped as sweet flag in 2001 appears smaller than that mapped in 2004. Tall shrubs may be encroaching on the sweet flag colony from the south. Re-mapping the pond in 2005 may give insight into the vegetation dynamics.

Pond 3: The main pond is about 100 sq m in size with a short, narrow tail approximately 6 m long that is partly shaded (Appendix 1). The main pond is occupied by a dense sward of common spikesedge that is not evident when water howellia is flowering, but emerges as the pond dries. The shaded, tail portion of the pond in the south end is occupied by foxtail and other grasses and emergent forbs, with an overhead canopy of thinleaf alder and willow. We mapped new locations for water howellia in the western side of the pond where we have clipped and excavated reed canarygrass (Figure 9).

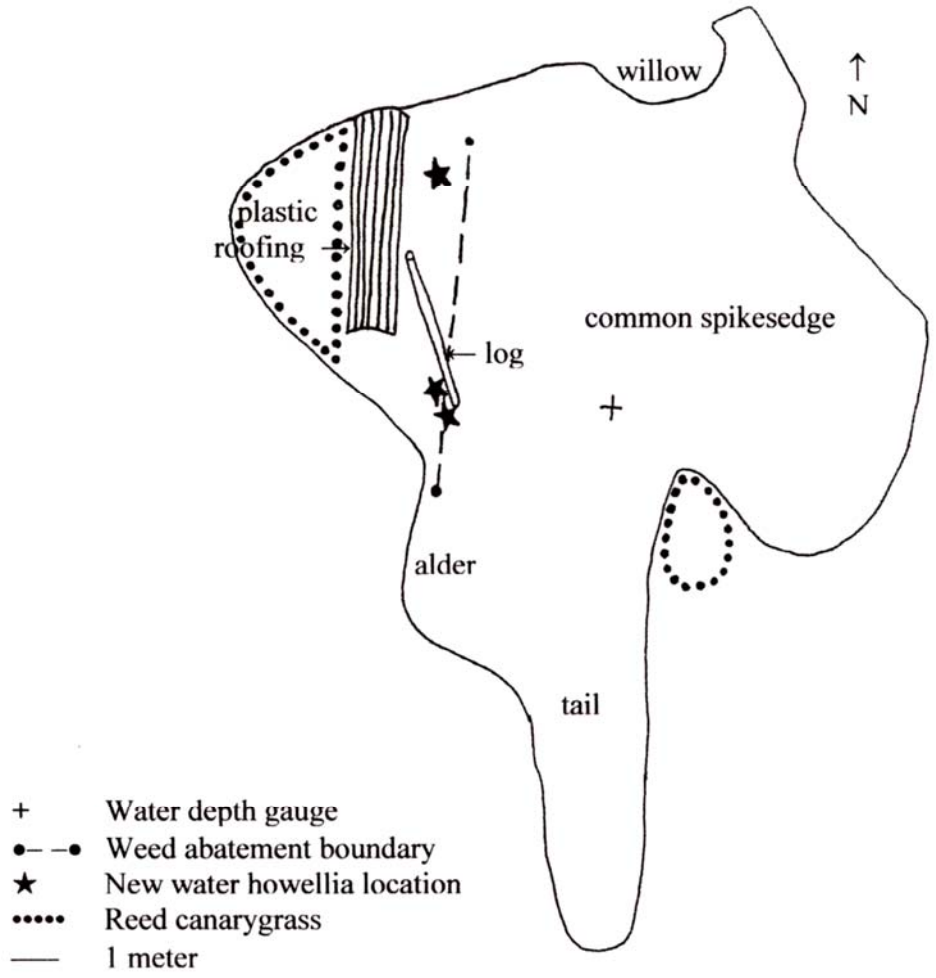

Figure 9. Diagram of pond 3 vegetation. It shows the eastern boundary of weed abatement efforts and new locations of water howellia where reed canarygrass clipping and excavation had taken place in previous years.

Vegetation monitoring transects

During 2003, we installed transects in ponds 2 and 3 in order to more easily detect the expansion of exotic plants within the ponds and to describe changes related to our weed control efforts. In 2004, we established one transect in pond 1 and a third transect in pond 2. We reversed the numbering of the five transects in pond 3 in order to accommodate the potential addition of transects to the south. The ends of the transects are marked with steel fenceposts.

We used a line intercept method to measure plant community changes along permanently marked transects. A line intercept 20 cm wide (10 cm either side of the tape) is used to maximize intercepting plants rather than bare areas. The boundary between communities is generally abrupt. Because reed canarygrass is considered a primary threat, it is recorded whenever it is intercepted by the line, even when it occurs within another community type. A distinction is made between reed canarygrass that is part of a colony or that is a small "pioneer" plant. We collected line intercept data in ponds 2 and 3 in both 2003 and 2004.

We also collected percent canopy cover data for all species that occur in 50 cm x 50 cm quadrats placed at 1 m intervals along the tape, beginning at zero. Overhead canopy cover is not recorded. Cover is estimated to the nearest percent, with cover values below one percent recorded to the nearest tenth of a percent, and traces recorded as 0.1 percent. In 2003, we collected cover data only in pond 3, but in 2004 we collected cover data in both ponds 2 and 3. Tables in Appendix 4 contain data on plant communities and cover for both ponds.

We established one transect in pond 1 in October 2004 (Appendix 1). Because we installed the transect late in the growing season, we did not gather vegetation data in 2004.

At pond 2, three parallel transects, approximately 5 m apart, run in a direction of 263º and are marked at each end with metal fenceposts (Appendix 1). Transects were sited to intersect a number of communities as well as some of our weed control efforts. They intersect the edges of the *Acorus* colony where it sharply transitions to native communities or reed canarygrass colonies. The beginnings of the transects are on the east end, and the 50 cm x 50 cm quadrats are placed on the north side of each transect, beginning at 0 m. The third transect, added in October, 2004, will be used in 2005. Measurements to the ends of transects 1 and 2 are recorded on plot data sheets in Appendix 4.

At pond 3, five such transects were installed (Appendix 1). Transects run east to west and are approximately 3 m apart. Transects 1 – 3 intersect the area where reed canarygrass excavation has taken place. In addition to recording transitions between communities, these transects were used to place 50 cm x 50 cm quadrats for estimating cover. The corner of the quadrat is placed on the north side of the tape at each meter tick starting at 0 (east end). Measurements to the ends of transects 1 through 5 are recorded on plot data sheets in Appendix 4.

Photopoints

We took photos at the established photopoints for all three ponds on 28 June 2004. Photopoint locations are described in Appendix 5, and the photos are presented in Appendix 6.

RESULTS AND DISCUSSION

Water howellia growth was vigorous in 2004. Although pond 1 had no plants for the third consecutive year, the area covered by water howellia in pond 3 was greater in the main body and tail of the pond, and there were new locations in areas where reed canarygrass had been clipped and excavated in 2003. In 2004, the water howellia growth in pond 2 was particularly dense in the more open areas of short-awn foxtail and mannagrass, and for 15 m into the pond tail. The ponds dried relatively early in 2003. The early drying date and the weed abatement efforts may explain the increase in water howellia cover in 2004.

Average reed canarygrass cover in pond 3 decreased from5.36 percent in 2003 to 4.12 percent in 2004., presumedly due to the reed canarygrass excavation conducted in autumn, 2003. The average cover of the native graminoid, common spikesedge, increased from 37.20 percent in 2003 to 39.28 percent in 2004. However, short-awn foxtail cover decreased from 5.06 to 4.44 percent from 2003 to 2004. Weed abatement efforts have apparently been beneficial for water howellia.

RECOMMENDATIONS

1) We recommend that monitoring be continued on an annual basis. Two new transects have been established, one each in ponds 1 and 2. We recommend adding one more transect to each pond and selecting a transect in each pond in which to conduct weed abatement.

2) Weed control measures should be maintained and expanded to pond 1. In pond 2, removal of satellite islands of sweet flag and reed canarygrass should continue, and one transect should be chosen for concentrated weed control efforts. At a minimum, reed canarygrass at pond 3 can be held in check by clipping reproductive stems, removing new plants, and curtailing its advance through the use of weed blocking materials. Continued excavation of reed canarygrass would probably expand the area of habitat occupied by water howellia.

3) A more accurate means of measuring populations of water howellia may be desirable. However, it is very difficult to count plants with accuracy. Stems break easily when handled, although this may not have much effect on seed production and might even serve to disperse seed. Even if population size could be determined with reasonable accuracy, this may not even be the best measure of population vigor. Isolated plants are undoubtedly more highly branched and produce more flowers, making cover a better measure of population vigor than stem number. A qualitative method that captures variability in the entire pond is preferable to one that intensively samples only portions of the pond (Mantas and Sutter 1998). In 2005, a more accurate estimate of plant cover will be made within transects set up in 2003 and 2004. However, complete pond searches and censuses, based on area occupied by howellia, will also be conducted.

4) Limited mapping was done in ponds 1 and 2 in 2004. The vegetation in ponds 2 and 3 should be mapped in 2005 to compare with 2001 maps. A detailed map of the pond 2 tail would help in documenting water howellia distribution and cover, and re-mapping the reed canarygrass extent in all three ponds would be instructive.

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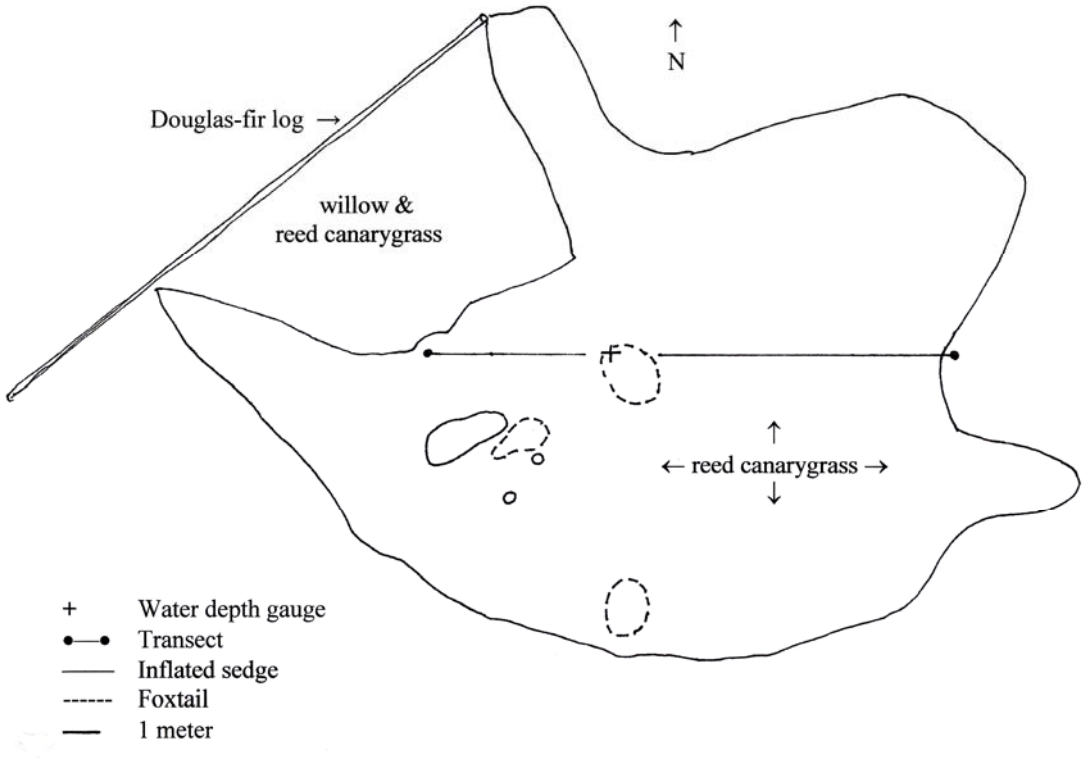
Appendix 1

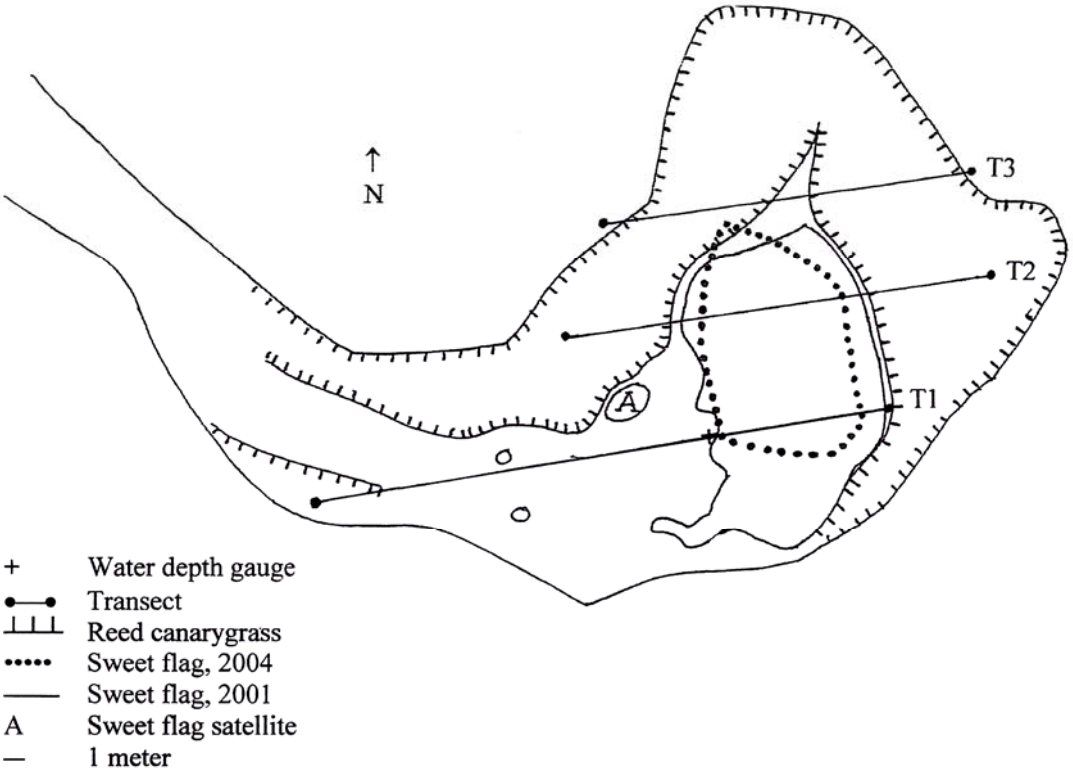
Pond diagrams.

Pond 1

2004 Map

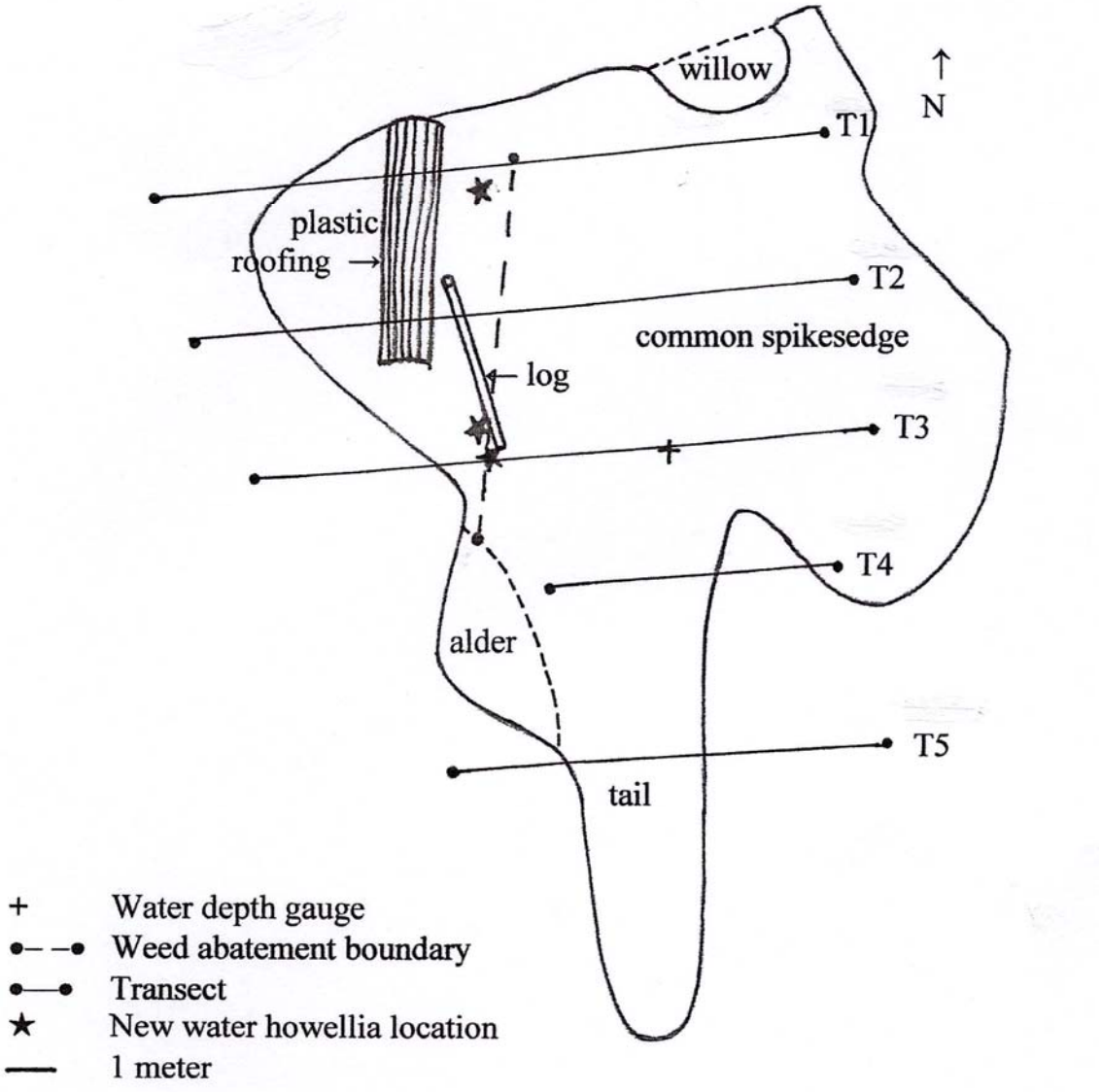


Pond 2



+ Water depth gauge
Transect
Reed canarygrass
Sweet flag, 2004
Sweet flag, 2001
A Sweet flag satellite
1 meter

Pond 3


willow
N
T1
plastic
roofing
T2
common spikesedge
log
T3
T4
alder
T5
tail
+ Water depth gauge
Weed abatement boundary
Transect
New water howellia location
1 meter

Appendix 2

Element Occurrence Record for water howellia.

Record No. 1
Scientific Name: HOWELLIA AQUATILIS
Common Name: WATER HOWELLIA
Federal Status: LT State Status: GP2
Global Rank (G1 rare - G5 common): G2 State Rank (S1 rare - S5 common): S1
First Observed (date): 1967
Last Observed (date): 2004-06-28

Township Range Section(s) Comments on section(s)

041N.....003W...08.....NE4 center, NE4SW4SW4

Latitude: 465503N Longitude: 1164422W
County: Latah
Quad Name: HARVARD
Place Name: HARVARD PONDS
Elevation (ft)
minimum: 2560 maximum:
Location

Near junction of State Routes 6 and 9; on W side of State Route 9, 50 yds S of intersection; pond 3 is just inside property fenceline. Also in two ponds at the southern edge of a large meadow on the margin of the floodplain (south of the river).

Managed Area(s):

Land Ownership:
Private land (in will to National Audubon Society).

Habitat:
Vernal pools, formed in channel scars, along the edge of the floodplain of the Palouse River. Substrate is acidic. Associated species are *Cornus stolonifera, Alnus incana, Crataegus douglasii, Amelanchier alnifolia, Glyceria occidentalis, Alisma plantago-aquatica* var. *americanum*, *Phalaris arundinacea, Cicuta douglasii, Carex vesicaria, Alopecurus aequalis, Lemna* sp., *Physocarpus capitatus, Sium suave, Dactylis glomerata, Pseudotsuga menziesii, Ranunculus flabellaris, Myosotis scorpioides, Salix bebbiana* (pond 3), *Salix drummondiana* (ponds 1 and 2), *Eleocharis palustris* (pond 3), and *Acorus* sp. (pond 2). In late summer, both pools were without water; bottoms were moist, solid, and vegetated with primarily *Sium suave, Carex vesicaria*, and *Acorus*. 2001: Pond 1: ca. 4 plants in a 3 sq. m area at SE edge of pond with *Sium suave* and *Phalaris arundinacea*; approximate 1999 location. Pond 2: plants occur throughout the free water area of the pond, or about 400 sq. m. Plants are dense over much of the pond and are scattered throughout the *Acorus* colony. Pond 3: 20-30 plants as scattered individuals or groups up to 0.75 sq. m in size. Plants are in 12-16 cm of water, usually within a meter of the water's edge, with sparse *Eleocharis palustris*; open to partial shade.

Population Data:
1988: 30 plants estimated in northern pond (#3). Observation of previous years confirmed in survey by Bob Moseley, IDCDC. 1995: Ca 50 plants, perhaps more, in flower in about 15 inches of water in ponds 1 and 2 south of the river. Observation on a cursory visit by Loring Jones, INPS, and Bertie Weddell, Pullman, WA. 1996 (July; ponds 1 and 2): More plants were evident than in previous years; population is 75-90% flowering. No plants were flowering in the east pool

(pond 1); the west pool had ca 100 flowering in 0-3" of water. (September): Both pools were without water. 1999: An estimated 100 to 500 plants observed, occupying approximately 0.5 sq m in pond 1, 50 sq m in pond 2, and 0.5 sq m in pond 3. Thorough survey by B. Moseley, and J. Lichthardt, IDCDC. 2000: Pond 1 was dry; in ponds 2 and 3, *Howellia* occupied approximately the same area and locations as in 1999. Thorough survey by Karen Gray (IDCDC) and Bertie Weddell. 2001: 1000 - 5000 estimated genets (most at pond 2); less than 1% were in flower, the rest in fruit or vegetative; high population vigor, with many more plants in ponds 2 and 3 compared to previous visits. Thorough survey by Juanita Lichthardt and Karen Gray, IDCDC. 2002: pond 1: no plants; pond 2: most of the pond occupied by *Howellia* or about 440 sq. m; pond 3: about 4.5 sq. m of the pond occupied. Thorough survey by Juanita Lichthardt and Karen Gray, IDCDC. 2003: pond 1: no plants; pond 2: about 390 sq. m occupied by *Howellia*; pond 3: about 4.6 sq. m of the pond occupied, primarily along the east edge and in the southern tail. Plants in flower and fruit. Thorough survey by Juanita Lichthardt and Karen Gray, IDCDC. 2004: Pond 1: no plants; Pond 2: 440 sq meters; Pond 3: 15.5 sq meters. Thoroughly surveyed by Janice Hill and Karen Gray, IDCDC.

Population Size (acres unless otherwise stated): 400 SQ M
Comments:
Overall site quality assessed as good in 2001.
Specimens:
R. K. Moseley 1264 (ID).
Best Source or Contact:
Idaho Conservation Data Center.

Appendix 3

Depth of water howellia ponds with concurrent river discharge rate and stage, 1999 to 2004.

Depth of water howellia ponds with concurrent river discharge rate and stage[1], 1999 to 2004.

Date	Water depth (m)			Discharge[1]	Stage[1]
	Pond			(cfs)	(m)
1999:	1	2	3		
July 1[2]	.20	no data	no data	50	1.68
July 13[3]	0	.24	0	28	1.62
July 16	0	.21	0	25	1.58
Aug. 3	0	0	0	14	1.55
2000:					
March 27	.53	.54	.67	918	2.68
April 24	.50	.48	.55	500	2.32
May 23	.42	.46	.44	122	1.83
June 13	.37	.44	.42	338	2.13
June 23	.27	.42	.34	76	1.74
July 15	0	.22	.02	24	1.58
Aug. 3	0	0	0	12	1.52
Sept. 12	0	.10	0	44	1.65
Oct. 6	0	0	0	17	1.55
2001:					
April 9	.48	.48	.43	302	2.08
May 3	.48	.49	.48	550	2.30
June 1	.33	.44	.32	40[4]	1.66
June 28	.17	.34	.19	53[5]	1.68
July 24	0	0	0		
2002:					
May 1	.48	.55	.55	760	2.50[6]
May 17	.45	no data	.48	438	2.24
June 4	.36	.50	.40	210	1.95
July 1	.18	.38	.20	49	1.71
July 12	.13	.23	no data	no data	no data
Aug. 13	0	0	0	no data	no data
2003:					
May 13	.50	no data	.50	170	1.9
June 2	.39	.53	.46	119	1.8
June 22	.21	.49	.24	31	1.6
June 30	.12	.31	.12	21	1.6
July 9	0	.15	no data	no data	no data
2004:					
May 19	.49	.46	.32	90	5.8
June 2	.47	.47	.47	304	6.84
June 28	.32	.36	.23	34	5.41
July 17	.13	0	0	18	5.11
August 13	0	0	0	7.0	no data
Sept. 20	0	0	0	35.0	no data
October 8	0	0	0	16.0	no data

[1] Discharge rate and stage measured at the USGS gage, 24 km downstream.
[2] All three ponds contained water on July 1, prior to installation of gauges. Pond 1 depth is an estimate.
[3] Gauges installed.

Appendix 4

Vegetation monitoring data.

Howellia aquatilis vegetation monitoring — line intercept data

Pond 2-Transect 1: The beginning of transect 1 is 9.3 m at 83º from the water depth gauge, and the end is at 19.3 m at 263º from the gauge. The transect passes through the gauge, and is 28.6 meters long.

26 September 2003			**13 August 2004**		
M from start	Dominant species	Notes	M from start	Dominant species	Notes
0-0.25	*Myosotis scorpioides*		0-0.5	*Myosotis scorpioides* and *Alopecurus aequalis*	
0.2-1.0	*Alopecurus aequalis-Glyceria occidentalis*	Some scatt. *Acorus calamus* ramets.	0.5-1.0	*Alopecurus aequalis*	(With a few *Acorus calamus* & *M. scorpioides*
1.0-8.0	*Acorus calamus*		1.0-8.0	*Acorus calamus*	
8.0-17.4	*Alopecurus aequalis*		8.0-9.2	*Alopecurus aequalis*	
17.4-17.5	*Phalaris arundinacea*		9.2-9.9	*Bare ground*	
17.5-25.2	*Alopecurus aequalis*		9.9-10.4	*Phalaris arundinacea*	
19.0	*Acorus calamus*	2 ramets (isolated)	10.4-12.3	*Glyceria occidentalis*	Scatt. *Sparganium emersum*
25.2-27.4	*Phalaris arundinacea*		12.3-12.5	*Sium suave* and *Glyceria occidentalis*	
27.4	*Acorus calamus*	Single ramet	12.5-16.3	*Glyceria occidentalis*	Scatt. *A. aequalis* and *Sparganium emersum*
27.4-28.5	*Alopecurus aequalis*		16.3-17.6	*Phalaris arundinacea* and *Glyceria occidentalis*	
27.9	*Phalaris arundinacea*	Pioneering ramet from colony S of tape	17.6-19.3	*Glyceria occidentalis* and *A. aequalis*	(Scatt. *P. arundinacea*, *S. emersum*, and *Sium suave*
28.5-28.6	*Phalaris arundinacea*		19.3-22.6	*Glyceria occidentalis* and *Alopecurus aequalis*	With *S. emersum* and *Ranunculus* (?).
			22.6-25.2	*A. aequalis*	With *S. emersum* & *Ranunculus* (?)
			25.2-27.5	*Phalaris arundinacea*	
			27.5	*Acorus calamus*	
			27.5-28.5	*A. aequalis*	With *M. scorpioides*
28.6		Fencepost	28.5-28.6	*Carex retrorsa*	Fencepost at 28.6 feet

Pond 2, Transect 1, continued					
Shrub canopy					
			0.0-0.3	*Physocarpus capitatus*	
20.3-25.4	*Alnus incana*	More or less continuous	21.1-22.4	*Alnus incana*	
			24.4-25.2	*Alnus incana*	
			25.8-26.7	*Alnus incana*	

Howellia aquatilis community monitoring — line intercept data

Pond 2, Transect 2: The beginning of transect 2 is 15.8 m at 65º from the gauge and the end is 8.0 m at 304º from the gauge. It is 20.9 m long.					
26 September 2003			**13 August 2004**		
M from start	Dominant species	Notes	M from start	Dominant species	Notes
0-6.6	*Phalaris arundinacea*		0-6.4	*Phalaris arundinacea*	
6.6-15.6	*Acorus calamus*		6.4-15.2	*Acorus calamus*	
15.6-20.2	*Phalaris arundinacea*		15.2-15.6	*A. calamus* & *Phalaris arundinacea*	
20.4-20.9	*Alopecurus aequalis*		16.6-19.0	*Phalaris arundinacea*	
			19.0-19.4	*Alopecurus aequalis*	And litter
			19.4	*Phalaris arundinacea*	
			19.4-20.9	*Alopecurus aequalis*	
20.9		Fencepost	20.9		Fencepost

Howellia aquatilis community monitoring — line intercept data

Pond 3 - Transect 1*, northernmost transect: The beginning of transect 1 is 6.97 m at 26º from the water depth gauge, and the end is at 11.51 m at 295º from the gauge. The transect is 13.7 m long.					
7 October 2003			**13 August 2004**		
M from start	Dominant species	Notes	M from start	Dominant species	Notes
0-7.7	*Eleocharis palustris*		0-7.7	*Eleocharis palustris*	
7.7	*Phalaris arundinacea*	Pioneer	7.7-8.2	Blue plastic roofing	Weed block
7.8-8.3	Plastic roofing	Weed block	8.2-11.3	*Phalaris arundinacea*	With *Carex* sp., *Rumex salicifolius* var. *triangulivalvis*, *Epilobium ciliatum*, *Trifolium hybridum*, and *Lycopus uniflora*
8.3-10.1	Excavated area	Sparse native grasses and *P. arundinacea*	11.3-13.7	*Phalaris arundinacea* and *Pteridium aquilinum*	
10.1-11.0	Wood	Live and dead down stems			
11.0-11.9	Excavation	Previously *Phalaris arundinacea*			
11.9-14.0	*Pteridium aquilinum & Calamagrostis Canadensis*				
Shrub layer					
0.6-2.5	*Salix bebbiana*	Open cover at canopy edge			
8.7-12.6	*Cornus sericea-Rosa*		8.9-9.7	*Cornus sericea*	
12.4	*Salix bebbiana*	Overhanging branch	12.5-13.1	*Salix bebbiana*	
13.3-end	*Crataegus douglasii*		13.3	*Rosa* sp.	

* Transect numbering was reversed in 2004 to accommodate potential addition of transects to the south in the pond. Transect 1 in 2004 was numbered Transect 5 in 2003.

Howellia aquatilis community monitoring — line intercept data

Pond 3 - Transect 2: The beginning of transect 2 is 4.78 m at 52º from the water depth gauge, and the end is at 9.38 m at 278º from the gauge. The transect is 13 m long.

26 September 2003			**13 August 2004**		
M from start	Dominant species	Notes	M from start	Dominant species	Notes
0-8.2	*Eleocharis palustris*	No *Solanum dulcamara*	0-7.4	*Eleocharis palustris*	
6.7	*Phalaris arundinacea*?		7.4-7.6	*Phalaris arundinacea*	
7.4-7.8	log		7.6-8.1	*Lycopus uniflora*	On log?
			8.1-8.3	*Equisetum palustre*	With *Rumex salicifolius* var. *triangulivalvis* and *Alisma plantago-aquatica*
8.2-9.9	Weed block		8.3-8.8	Plastic roofing	Weed block
8.7-9.2	*Phalaris arundinacea*	+ *Solanum dulcamara* and natives emerging through canvas tarp	8.8-9.6	*Phalaris arundinacea*	With *Alisma plantago-aquatica*, & lesser amts. of *Solanum dulcamara* and *L. uniflora*
9.9-12.8	*Phalaris arundinacea*	excavated	9.6-10.5	*Alisma plantago-aquatica*	
			10.5-11.7	*Agrostis* sp., *Epilobium ciliatum*, *Equisetum pratense*, *Trifolium hybridum*, and *Juncus* sp.	
			11.7-12.6	*Phalaris arundinacea*	
			12.6-13.0	*P. arundinacea* and several forbs	
Shrub layer					
12-12.8	*Crataegus douglasii*	Dead branches	12.3-13.0	*Symphoricarpos albus*	
			12.5-12.7	*Crataegus douglasii*	

* Transect numbering was reversed in 2004 to accommodate potential addition of transects to the south in the pond. Transect 2 in 2004 was numbered Transect 4 in 2003.

Howellia aquatilis Community monitoring — line intercept data

Pond 3, Transect 3*: The beginning of transect 3 is 4.05 m at 83º from water depth gauge; the end is at 8.11 m at 266º from the gauge. Transect: 12m long.					
26 September 2003			**13 August 2004**		
M from start	Dominant species	Notes	M from start	Dominant species	Notes
0-0.7	*Eleocharis palustris*	With scattered *Solanum dulcamara*	0-1.8	*Eleocharis palustris*	Some *Phalaris arundinacea*
0.7	*Phalaris arundinacea*	Pioneer plant	1.8-2.8	*Eleocharis palustris*	
0.7-1.5	*Eleocharis palustris*	Small amount of *S. dulcamara*	2.8-3.8	*Phalaris arundinacea* and *Eleocharis palustris*	
1.2	*Phalaris arundinacea*	Pioneer—slightly>1 dm off tape	3.8-4.8	*Eleocharis palustris*	
1.5-2.5	*Eleocharis palustris*	Some bare ground	4.8-5.7	*Carex vesicaria*	With *Sparganium emersum* and *Alisma plantago-aquatica*
2.5-3.2	*Phalaris arundinacea?*	Very low, + dead *Carex vesicaria*	5.7-8.7	*Alopecurus aequalis*	And intermittent *S. emersum*, *Solanum dulcamara*, *P. arundinacea*, *A. plantago-aquatica*, *L. uniflora*, and *Veronica scutellata*
3.2-4.4	*Eleocharis palustris*		8.7-9.5	*Lycopus uniflora* and *Galium trifidum* mix	Edge of blue plastic 8.7-9.1, then tarp to 9.5 m
4.4-5.6	Dead wood/bare soil		9.5-11.7	*Phalaris arundinacea*	
4.9-5.2	*Carex vesicaria*	Just outside transect; I dm to NW	11.7-12.2	*Phalaris arundinacea* and *Pteridium aquilinum*	
5.6-5.9	*Phalaris arundinacea*				
5.9-8.7	*Alopecurus*	With *Alisma plantago-aquatica* and *Mentha arvensis*			
8.7-10.0	Plastic and tarp				
10.0-12.1	*Calamagrostis canadensis*	With *Symphoricarpos albus*			

Pond 3, Transect 3, continued.					
Shrub canopy					
6.2-8.2	*Alnus incana-Physocarus capitatus*	Sparse cover	6.0-7.1	*Alnus incana*	
10.5-12.1	*Crataegus douglasii* and *Pteridium aquilinum*		7.1-10.4	*Crataegus douglasii*	Dead branches
			9.7-10.7	*Rosa* sp.	
			10.1-10.3	*Philadelphus lewisii*	
			10.5-10.7	*Philadelphus lewisii*	
			11.1-12.2	*Crataegus douglasii*	

*Transect numbering was reversed in 2004 to accommodate potential addition of transects to the south in the pond. Transect 3 runs through the water gauge. The numbering of transect 3 remains the same as in 2003.

Howellia aquatilis Community monitoring — line intercept data

Pond 3-Transect 4*: The beginning of transect 4 is 5.25 m at 121º from the water depth gauge, and the end is at 4.47 m at 215º from the gauge. The transect is 7 m long.					
21 October 2003			**13 August 2004**		
M from start	Dominant species	Notes	M from start	Dominant species	Notes
0	*Phalaris arundinacea*		0-1.0	*Phalaris arundinacea*	Mostly overhanging
0-0.6	Dead wood and litter		1.0-3.1	Litter and wood	
			3.1-3.8	Mix of *Alopecurus aequalis* and *Rumex salicifolius* var. *triangulivalvis*	With lesser amts. of *Solanum dulcamara*, *Galium trifidum*, and *Eleocharis palustris*
3.6-5.3	*Eleocharis palustris*	With *Solanum dulcamara*	3.8-5.3	*Eleocharis palustris*	
5.3-6.4	*Phalaris* (?)	With *Solanum dulcamara*	5.3-5.7	*Eleocharis palustris* and *Solanum dulcamara*	
6.4-7.8	*Solanum dulcamara*	Alder litter	5.7-7.0	*Solanum dulcamara* with mix of *Glyceria* sp., *Eleocharis palustris*, and *Veronica scutellata*	
Shrub canopy					
0.5-3.6	*Salix bebbiana*		0.7-3.2	*Salix bebbiana*	
4.8-7.8	*Alnus incana*		4.7-7.0	*Alnus incana*	

* Transect numbering was reversed in 2004 to accommodate potential addition of transects to the south in the pond. Transect 4 in 2004 was numbered Transect 2 in 2003.

Howellia aquatilis Community monitoring — line intercept data

Pond 3-Transect 5* (southernmost): The beginning of transect 5 is 7.57 m at 144º from the water depth gauge, and the end is at 7.60 m at 212º from the gauge. The transect is 8.5 m long.

21 October 2003			13 August 2004		
m from start	Dominant species	Notes	m from start	Dominant species	Notes
0-3.0	*Phalaris arundinacea*	Covered by tarp	0-0.4	*Phalaris arundinacea*	
3.0-4.2	*Alopecurus aequalis*	Dead branches, *Cirsium vulgare* rosette	0.4-1.8	Black tarp with *Phalaris arundinacea* overhanging	
4.2-4.7	Large stump		1.8-3.0	Brown tarp	
4.7-6.0	*Alopecurus aequalis* with *Solanum dulcamara*		3.0-4.1	*Phalaris arundinacea* and *Alopecurus aequalis*	
6.0-8.5	*Solanum dulcamara*	With alder litter and dead branches	4.1-4.4	Wood (old decaying log)	
8.0	*Calamagrostis Canadensis*	A few	4.4-6.1	*Alopecurus aequalis* (with a few *Solanum dulcamara*	
			6.1-7.8	*Solanum dulcamara*	
			7.8-8.5	Litter and wood (with a few *Solanum dulcamara*)	
Shrub canopy					
3.8-4.1	*Salix bebbiana*		0.9-2.4, 2.6-3.3	*Rosa* sp.	
4.7-5.7	*Salix bebbiana*		2.1-2.3, 3.7-4.3, 4.4-6.6, 6.9-8.5	*Salix bebbiana*	
7.8-8.5	*Salix bebbiana*		7.1-8.5	*Crataegus douglasii*	
8.5		fencepost	8.0-8.5	*Philadelphus lewisii*	

* Transect numbering was reversed in 2004 to accommodate potential addition of transects to the south in the pond. Transect 4 in 2004 was numbered Transect 2 in 2003.

Pond 2-Transect 1
***Howellia aquatilis* vegetation monitoring — cover data**
13 August 2004 (Cover data not collected in 2003)

Percent cover in 50 cm x 50 cm quadrats placed at 1 m intervals:
The beginning of transect 1 is 9.3 m at 83º from the water depth gauge, and the end is at 19.3 m at 263º from the gauge. The transect passes through the gauge.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Acorus calamus		90	70	40	50	60	60	50	40	5	1								1									1	
Alopecurus aequalis	30	1	4	.1					2	.1		40	2		40				15	20	6	1	10	50	10	10		10	30
Carex vesicaria		1																											
Cicuta douglasii																													
Galium trifidum																													
Glyceria occidentalis									2	1	5	50	20	50	5	80	2	7	3	30	20	20	2						
Lemna minor			.1	.1	.1	.5	.1	.5	.1		.1										.1		.1			.1	.1	.1	
Myosotis scirpioides	20																									.1	2	12	25
Phalaris arundinacea										1	4		3				10	50		1					10	50	40	50	
Ranunculus sp.?													12								30	2	60	30	10	2			
Ricciocarpus natans		2	1	20	.1	.1	1	4	2		2										1	1			1	1	1		2
Sium suave	20						1	1			5	.1	20					1	8	2		5			15		.2		7
Sparganium emersum													30	5	5	5	4		4		7	7	20	10	15	2	2		1

Pond 2-Transect 2
***Howellia aquatilis* vegetation monitoring — cover data**
13 August 2004 (Cover data not collected in 2003)

Percent cover in 50 cm x 50 cm quadrats placed at 1 m intervals.
The beginning of transect 2 is 15.8 m at 65º from the gauge and the end is 8.0 m at 304º from the gauge.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20								
Acorus calamus							10	30	70	80	8	70	80	80	80	70													
Alopecurus aequalis																10				3	80								
Carex vesicaria																													
Cicuta douglasii	2	10					10	2	1	.1	.1	.1	.1							30	30								
Galium trifidum																				6									
Glyceria occidentalis																													
Lemna minor																													
Myosotis scirpioides																					.5								
Phalaris arundinacea	90	90	95	95	95	95	80	30	10							7	95	95	80	15									
Ranunculus sp.?																													
Ricciocarpus natans											.5	1	1	1	2														
Sium suave													6	6	4														
Sparganium emersum																													
Unknown seedling																30													

Pond 3-Transect 1*
***Howellia aquatilis* vegetation monitoring — cover data**
7 October 2003 and 13 August 2004

Percent cover in 50 cm x 50 cm quadrats placed at 1 m intervals.
The beginning of transect 1 is 6.97 m at 26º from the water depth gauge, and the end is at 11.51 m at 295º from the gauge.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
Agrostis scabra											1	3		
Agrostis stolonifera														30
Alisma plantago-aquatica								10	4					
2003							3	10						
Alopecurus aequalis									5					
2003	4								5					
Calamagrostis canadensis										3			20	
2003									1	3			20	50
Carex arcta									1					
Carex praegracilis									1					
Carex sp.	3													
2003	3													
Cornus sericea *2003*											95			
Eleocharis palustris	90	95	99	99	99	99	95	60						
2003	90	95	99	99	99	99	95	50						
Epilobium ciliatum										7	12	10		
Equisetum (*arvense?*)														20
Galium trifidum										3				
Lycopus uniflorus										11				
Mentha arvensis *2003*								2						
Phalaris arundinacea							1		10	30	30	10	14	
2003							1		3	1	30	10	4	
Pteridium aquilinum													80	
2003													80	80
Rosa sp.											3	10		
2003											3	10		
Rumex									12	5				
									0.1					
Solanum dulcamara										5				
2003		1							1					
Symphoricarpos albus													40	7
2003													40	
Veronica scuttelata									1					
Unk. *Ranunculaceae*														4
Unk. 3-lobed seedling														4
Plastic weed block									30					
2003									30					
	0	1	2	3	4	5	6	7	8	9	10	11	12	13

* Transect numbers were reversed in 2004 to accommodate potential transect additions to the south. Transect 5 (2003) is now Transect 1, the northernmost transect.

Pond 3-Transect 2*
***Howellia aquatilis* vegetation monitoring — cover data**
26 September 2003 and 13 August 2004

Percent cover in 50 cm x 50 cm quadrats placed at 1 m intervals.
The beginning of transect 2 is 4.78 m at 52º from the water depth gauge, and the end is at 9.38 m at 278º from the gauge.

	0	1	2	3	4	5	6	7	8	9	10	11	12
Agrostis sp.												10	5
Agrostis stolonifera													
Alisma plantago-aquatica									5	4	5		
2003									10				
Alopecurus aequalis								1					
2003								1	10				
Calamagrostis Canadensis											10		2
2003										10	10		
Carex sp. (small) *2003*										4			
Cirsium sp.													2
Cornus sericea													1
Crataegus douglasii													3
Eleocharis palustris	99	90	95	95	95	95	95	80	20				
2003	99	90	95	95	95	95	95	80	20				
Epilobium ciliatum								3		1	3	4	4
Equisetum (*arvense?*)	.1											2	4
Galium trifidum									3	20	15		1
2003									3		15		
Gnaphalium palustre												3	.1
Juncus sp.												20	
Lycopus uniflorus								2	10	10	4		
Mentha arvensis													
Phalaris arundinacea								3					7
2003												10	70
Plantago major													3
Pteridium aquilinum													
2003													30
Ranunculus sp.											1	3	3
Rosa sp.													
Rumex salicifolius ssp. *tri.*									5	5			
2003									5	20			
Scutellaria galericulata	2							1					
2003								1	5	3			
Smilacina stellata													5
Solanum dulcamara										4			
2003										7			
Sparganium emersum											1		
Trifolium hybridum												5	

Pond 3, Transect 2, continued													
Veronica scuttelata										12	1		
2003										7			
Canvas tarp weed block										40			
2003										40			
Plastic weed block									50				
2003									50	60			
	0	1	2	3	4	5	6	7	8	9	10	11	12

* Transect numbers were changed in 2004 to accommodate potential transect additions to the south. Transect 4 (2003) is now Transect 2.

Pond 3-Transect 3*
***Howellia aquatilis* vegetation monitoring — cover data**
26 September 2003 and 13 August 2004

Percent cover in 50 cm x 50 cm quadrats placed at 1 m intervals.
The beginning of transect 3 is 4.05 m at 83º from the water depth gauge, and the end is at 8.11 m at 266º from the gauge.

	0	1	2	3	4	5	6	7	8	9	10	11
Agrostis sp.												
Agrostis stolonifera												
Alisma plantago-aquatica						2		25	2	6		
2003								25		5		
Alopecurus aequalis				5			95	5	20	1		
2003				5			95	5	20	5		
Calamagrostis canadensis								5		4	30	30
2003								5		10	.1	10
Carex vesicaria				50		25						
2003						50						
Cirsium sp.									1			
2003									1			
Cornus sericea *2003*										2		
Eleocharis palustris	50	70	70	50	95	1	1	25				
2003	50	50	40	40	75			25				
Epilobium ciliatum										2		
2003										5	3	
Equisetum (*arvense?*)											10	1
2003											10	10
Galium trifidum								4	20	7	1	
2003									50	5	2	
Lycopus uniflorus								4	5	20		
Mentha arvensis									2			
2003									3			
Osmorhiza chilensis												1
Phalaris arundinacea		5	1	10		1		1				
2003		20	10	5								
Pteridium aquilinum *2003*												50
Ranununculus (orthorynchus?)											7	3
2003											10	3
Rosa woodsii											3	3
2003											4	
Rumex salicifolius ssp. *tri.*									4	2		
2003						5						
Scutellaria galericulata								2				
2003								2	3	7		
Smilacina stellata											10	25

Pond 3, Transect 3, continued.												
2003											5	7
Solanum dulcamara	10					1		10	5			
2003	10	10				1		10	5			
Sparganium emersum						5	9					
Symphoricarpos albus								1			20	1
2003								1			20	
Veronica scutellata								10	30	2		
2003									50			
Viola glabella												1
2003												5
Unknown species											1	
Canvas tarp weed block										40		
Plastic weed block										10		
2003										80		
	0	1	2	3	4	5	6	7	8	9	10	11

* Transect numbers were reversed in 2004 to accommodate potential transect additions to the south. Transect 3 (2003) remains Transect 3.

Pond 3-Transect 4*
***Howellia aquatilis* vegetation monitoring — cover data**
21 October 2003 and 13 August 2004

Percent cover in 50 cm x 50 cm quadrats placed at 1 m intervals.
The beginning of transect 4 is 5.25 m at 121º from the water depth gauge, and the end is at 4.47 m at 215º from the gauge.

	0	1	2	3	4	5	6
Alopecurus aequalis	3				10	5	
2003	3				10	5	
Eleocharis palustris				1	70	30	1
2003					70	20	
Epilobium ciliatum			1	4			
Equisetum hyemale *2003*	2						
Glyceria sp.							20
Phalaris arundinacea	10			2		3	5
2003	2						50
Rumex salicifolius ssp. *triangulivalvis*				4	1	4	
Salix bebbiana	7	99	99	50			
2003	7	99	99	50			
Scutellaria galericulata				25			
Solanum dulcamara	1	20	2	2	20	60	10
2003		1	10	25	20	80	50
Veronica scutellata							1

* Transect numbers were changed in 2004 to accommodate potential transect additions to the south. Transect 2 (2003) has been renamed Transect 4 (2004).

Pond 3-Transect 5*
***Howellia aquatilis* vegetation monitoring — cover data**
21 October 2003 and 13 August 2004

Percent cover in 50 cm x 50 cm quadrats placed at 1 m intervals:
The beginning of transect 5 is 7.57 m at 144º from the water depth gauge, and the end is at 7.60 m at 212º from the gauge.

	0	1	2	3	4	5	6	7	8
Alopecurus aequalis				40	7	15	10		
2003				40	20	15	10		
Calamagrostis canadensis								20	20
2003								20	20
Crataegus douglasii	1							40	99
2003	1								
Epilobium ciliatum				4	3				
Equisetum sp.									1
Galium trifidum					3	3			
Glyceria sp. (not long spikelets)							10	4	
Mint (*Stachys?)*				20	4				
Lycopus uniflora					1				
Phalaris arundinacea	60			2				1	
2003	50			2					
Rosa sp.			4						
2003			4						
Salix bebbiana					10				
Scutellaria galericulata							5	4	1
Solanum dulcamara				4	11	6	70	50	4
2003				3	4	6	50	50	20
Symphoricarpos albus			5						
2003			5						
Veronica scutellata							5	4	
Plastic	40	100	90						
2003	50	99	90						

* Transect numbers were changed in 2004 to accommodate potential transect additions to the south. Transect 1 (2003) is now Transect 5 (2004).

Appendix 5

Locations of photopoints for water howellia.

Photo-point	
POND 1	
1	From base of large spruce at east edge of pond, 125˚ from gauge, standing next to tree on its south side.
2	From blaze on trunk of large downed Douglas-fir, 330˚ from gauge and 315˚ from large spruce on opposite side of pond.
3	From slope end (south end) of downed Douglas-fir (flat spot), 280˚ from gauge.
4	Standing in water, approximately 10 m at 250˚ from gauge; focal length (f.l.)=50 mm.
POND 2 (points 1 and 2 are on the slope above the pond)	
1 (east)	From under the drip-line of a grand fir located at the forest edge, which is the largest tree in the vicinity. Tree is next to a large cut-stump. Stand 4-5 m at 40˚ from trunk, approximately south of gauge.
2 (west)	Just under the drip-line of a pole grand fir and east of a pole size Douglas-fir, up slope from a tall alder at the pond edge, 235˚ from the gauge. Saplings are the only trees downslope. Point is approx. 4 m down slope of the trunk of a pole grand fir growing next to a maple. Photo taken at azimuth 40˚, with tallest alder at left of frame.
3	Standing at the mouth of the tail portion of the pond, at the deepest point. One photo is taken toward the gauge and the other looking into the pond tail.
POND 3	
1	Standing on 3-ft high platform, in opening among hawthorn on highway side of pond; gauge at left (f.l.=30 mm).
2	From below and slightly north of platform, at pond edge (where shrubs rooted); 80˚ from gauge (f.l.=50 mm).
3	From pond edge, 10˚ from gauge.
4	Standing at edge of reed canarygrass, 326˚ from gauge.

(19˚ east declination used for bearings)

Appendix 6

Photos taken at photopoints.

Photo 1: Pond 1, Photopoint 1.

Photo 2: Pond 1, Photopoint 2.

Photo 3: Pond 1, Photopoint 3.

Photo 4: Pond 1, Photopoint 4.

Photo 5: Pond 2, Photopoint 1.

Photo 6: Pond 2, Photopoint 2.

Photo 7: Pond 2, Photopoint 3, toward gauge.

Photo 8: Pond 2, Photopoint 3, toward pond tail.

Photo 9: Pond 3, Photopoint 1.

Photo 10: Pond 3, Photopoint 2.

Photo 11: Pond 3, Photopoint 3.

Photo 12: Pond 3, Photopoint 4.