

Reducing Invasive Organisms in Trade in Great Lakes Watersheds



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Executive Summary: This report describes grant-funded work undertaken by the Wisconsin Department of Natural Resources to reduce the availability of invasive species in the live aquatic plant trade in Wisconsin. We: 1) surveyed aquatic plant retailers to assess attitudes towards invasive species and knowledge of the invasive species regulations, and to identify barriers to selling non-invasive alternatives; 2) surveyed Wisconsin aquatic plant retailers' stock to locate regulated species for sale; 3) conducted educational visits and provided educational materials to retailers; and 4) surveyed small water bodies to assess the landscape risk from aquatic invasive plants sold in the live plant trade. This report describes the work conducted under this grant, documents the grant deliverables, and fulfills final reporting requirements for our grant agreement.

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Cover photo: Image of a regulated, invasive aquatic plant, parrot feather (*Myriophyllum aquaticum*), for sale in a Wisconsin garden center.

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Introduction

Invasive species are a considerable environmental and economic problem in the United States, contributing to the loss of biological diversity (Wilcove et al. 1998, Clavero and Garcia-Berthou 2005, Pimentel et al. 2005; but see Gurevitch and Padilla 2004), disrupting ecosystem functions and disturbance regimes (Mack and D'Antonio 1998, Ehrenfeld 2010), and costing almost \$120 billion annually (Pimentel et al. 2005). As a large freshwater system that serves as a hub of commerce, industry, tourism, and recreation, the Great Lakes are vulnerable to invasive species. Over 180 non-native species have been introduced to the Great Lakes basin, and the discovery rate of 1.8 new introductions per year is the most of any freshwater system known (Ricciardi 2006). The economic cost of aquatic invasive species (AIS) to the Great Lakes is estimated to be over \$100 million per year (Rosaen et al. 2012).

While intercontinental shipping is responsible for the majority of historical introductions of invasive species to the Great Lakes (Ricciardi 2006), in the past five decades trade in live organisms has made up a considerable proportion, responsible for both deliberate and accidental introductions (Ricciardi 2006). Many others have pointed to the live organism trade as a vector of concern (Padilla and Williams 2004, Kerr et al. 2005, Keller and Lodge 2007), more importantly so with increasing global trade and extension to new markets (Mack and Lonsdale 2001, Hulme 2009, Bradley et al. 2012). For invasive plants, it is well documented that the primary pathway of introduction is through horticultural cultivation (Groves 1998 in Perrings and Dehnen-Schmutz 2005, Mack and Erneberg 2002, Pyšek et al. 2002). For aquatic and wetland plants, horticulture and aquarium releases are primary vectors (Les and Mehrhoff 1999, Reichard and White 2001), including for the Great Lakes (Mills et al. 1993) and in Wisconsin.

Over the course of just three years (2007-2010), 22 populations of seven invasive aquatic plants – all available via the live organism trade - were newly documented in Wisconsin waters. Eight of these findings occurred in man-made or private ponds. These populations were detected by chance alone and not through any systematic survey of water bodies on the landscape. This suggests that the live organism trade vector and establishment of AIS in ponds and other small water bodies may pose a significant threat to inland Wisconsin waters as well as the Great Lakes. Each population established on Wisconsin's landscape represents a potential source for the invasion of additional waters. Small water bodies are constructed and managed for a variety of reasons such as stormwater control, ornamental water gardens, fish stocking, and subdivision recreation. Wisconsin examples show that each of these types of water bodies (which are often sites targeted for trade-sourced plantings) can support populations of AIS that could serve as source populations for future introductions.

Recommendations from Previous Work

The U.S. Environmental Protection Agency (EPA) strategic plan (U.S. EPA 2010) includes invasive species as an emerging ecological challenge; one that has been designated as a major focus area in the Great Lakes Restoration Initiative (GLRI). The *Wisconsin Great Lakes Strategy* (Wisconsin DNR 2009) recommends action to determine the threat of introduction of AIS to Wisconsin waters posed by vectors other than ballast water. Additionally, The *Great Lakes Regional Collaboration Strategy to Protect and Restore the Great Lakes* (Great Lakes Regional Collaboration 2005; hereafter, the 'Strategy') also

addresses the threat of aquatic invasive species and has made recommendations to help reduce the number and severity of AIS introductions. As part of the Strategy recommendations, seven milestones have been established to address the horticultural trade vector of AIS introductions. This project aimed to address the introduction vector related to live organisms in commerce.

The Wisconsin Department of Natural Resources (Wisconsin DNR) has already taken steps that support milestone 3.1, 3.2 and 3.3 of the Strategy as part of an overarching plan to decrease the incidence and impacts of non-indigenous species. The Wisconsin DNR has conducted detailed literature reviews and risk evaluations on over 200 suspected invasive species, including 63 aquatic plants. The species known or expected to be invasive in the state were classified for regulation (“prohibited” or “restricted” categories); those with uncertain invasive potential or without enough information were placed on unregulated watch lists to be reevaluated in the future. A few were deemed to not pose an invasive risk in Wisconsin. In 2009, Wisconsin enacted legislation (ch. NR 40, Wisconsin Administrative Code; hereafter, ‘NR 40’) that prohibits the unpermitted possession, transport, transfer, or introduction of prohibited species, and the unpermitted transport, transfer, or introduction of restricted species. To further address Strategy milestones aiming to reduce invasive species in trade through enforcement and risk assessments (milestones 3.6 and 3.7), the Wisconsin DNR undertook the work reported in this document.

Project Goals

We approached the issue of invasive species in trade from three angles. First, we gathered basic information on retail sources of live aquatic organisms in order to quantify the existence of source populations of AIS and allow us to strategically conduct educational outreach and enforcement activities. Second, we conducted an education and outreach campaign to 1) educate horticultural and pet/aquarium retailers on Wisconsin’s new regulations (i.e. NR 40) and give them resources to share with their customers, and 2) provide pond owners with information on responsible pond ownership and how the invasive species regulations affect them. Third, we examined the relationship between AIS source availability and presence of AIS populations in small water bodies (ornamental ponds, storm water retention ponds, waterways) in the urban landscape to help define how many or which types of water bodies need to be monitored for early detection of AIS. These three goals were intended to enhance and support each other while accommodating an adaptive approach that will most efficiently allow us to reduce the impact of the live organism trade vector and ultimately protect and improve the health of Great Lakes ecosystems.

Project Highlights and Accomplishments

Collaboration with Partners

Throughout the project, we coordinated activities with several agencies and organizations to improve operations and broaden the reach of our work. These partnerships allowed us to reach a larger audience, provide more effective educational materials, efficiently coordinate enforcement activities, and be responsible with our limited resources.

Wisconsin Department of Agriculture, Trade, and Consumer Protection

The Wisconsin Department of Agriculture, Trade, and Consumer Protection (DATCP) is the primary regulatory entity for plant nurseries and dealers in the State of Wisconsin, licensing and inspecting them under state statute (Ch. 94, *Wis. Stats.*). The Wisconsin DATCP is a member of the Wisconsin Invasive Species Council and a key partner in communicating and enforcing the invasive species regulations to the horticultural sector in Wisconsin. The Wisconsin DNR and Wisconsin DATCP established a cooperative agreement to facilitate implementation of ch. NR 40 and structure the flow of information to nurseries regulated by the Wisconsin DATCP.

Under this agreement, the Wisconsin DNR invasive species coordinator receives reports of invasive species violations at nurseries from the existing statewide network of invasive species staff, county coordinators, and the public and notifies Wisconsin DATCP nursery inspectors of violations. The nursery inspectors handle initial contact with the reported nurseries and seek compliance. In most cases, Wisconsin DNR staff will then follow-up to confirm compliance. If voluntary compliance is not achieved, the Wisconsin DNR will proceed through the process of stepped enforcement, which may include written notices, enforcement conferences, citations, and/or fines and penalties. The Wisconsin DATCP may or may not assist the Wisconsin DNR with final enforcement actions or inspections. In addition, the Wisconsin DNR has provided training to nursery inspectors, so that they may help educate nurseries on the regulations and look for ch. NR 40 violations during inspections. For this project, the Wisconsin DATCP also provided Wisconsin DNR a list of state plant nurseries and dealers, including those that self-reported selling aquatic plants.

County AIS Coordinators

A number of county aquatic invasive species (AIS) coordinators had engaged with their local plant nurseries and pet stores prior to the beginning of this project. To learn from their experiences early in our project, we conducted a survey of AIS coordinators to determine the businesses contacted, the type of contact made, and the type of response given by the retailers. This informal survey provided us with some baseline information regarding what has worked and what has not worked with Wisconsin retailers. Throughout the project, we continued to engage with the AIS coordinators by providing regular updates at statewide meetings and by sharing resources.

Citizen-based Networks

We also used the existing structures of Wisconsin's citizen-based monitoring programs to increase the efficacy of our education and outreach. Two programs in particular, the Citizen Lake Monitoring Network (CLMN) and the Clean Boats, Clean Waters (CBCW) programs were especially suited to this goal. The CLMN and CBCW volunteers are concerned about AIS issues, and the organizations are highly functional social networks with a proven efficacy. We provided resources and materials developed for this project to these organizations, and asked for their help in distributing them to network volunteers and other interested people. In addition, we observed the CBCW outreach model while developing our own outreach strategy in order to integrate lessons already learned.

Great Lakes Management Transition Board

Project PIs (Van Egeren and Wilkinson) have been active members in the Great Lakes AIS Management Transition Board (MTB). The MTB is a mechanism for state, federal, and provincial agency resource managers to inform invasive species researchers of their operational needs in the context of planning and conducting several large GLRI-funded AIS research projects coordinated by Dr. David Lodge (University of Notre Dame) and Lindsay Chadderton (The Nature Conservancy's Great Lakes Program). The research projects are intended to create models, monitoring plans, and species risk assessment techniques that can be used in common by all Great Lakes states to improve regional AIS program consistency. The MTB also has led to better communication and information sharing among Great Lakes states, provinces, federal agencies and research scientists.

Specifically of interest to our project was the creation of tools for risk assessment of new aquatic plants, crayfish, mollusks, fish, reptiles, and amphibians that may enter trade. Although Wisconsin had already implemented a species assessment process (ch. NR 40) prior to formation of the MTB, we helped to review and give direction to the risk assessment tools that are being developed by project scientists for the Great Lakes region. In addition, participation in the MTB allowed Wisconsin DNR staff to use the lists of species from the researchers' risk assessment tools in developing lists of species to be assessed for the revision of the state's invasive species rule currently in progress. We intend to share our final report and subsequent publications with the MTB and associated researchers in order to facilitate coordination among regional management agencies.

Sea Grant/Great Lakes Commission

To increase the reach of our educational efforts, we coordinated with the University of Wisconsin Sea Grant Institute throughout the project to leverage the national Habitatitude campaign. On June 19, 2012 we provided several educational presentations on invasive species during a day-long workshop in Fond du Lac, Wisconsin for aquarium industry and aquarium hobbyist representatives. This workshop included the Habitatitude campaign as well as educational materials from our program efforts. Additionally, we provided consultation to the Illinois/Indiana Sea Grant program during their efforts to establish an educational program for retailers for a separate GLRI-funded project.

Finally, during the time of this project, the Great Lakes Commission was working on a regional GLRI effort in collaboration with local Sea Grant offices and other regional groups to assess and address the issue of aquatic invasive species through Internet trade. We

provided consultation directly to the coordinator of the project and participated in several regional working group meetings with this group. Our experiences with providing education to retailers in Wisconsin, as well as the materials we developed were integrated with this Great Lakes Commission effort.

2012 Social Survey of Retailers, Landscapers, and Growers

From January through March 2012 we developed a social survey in coordination with the University of Wisconsin's Survey Center to assess retailer knowledge of regulations, awareness of preventative measures, and inventory of invasive species stock. The mail survey was conducted in three waves, with the first mailing occurring on March 22 and the final on May 9. This project consisted of a sample of 583 aquarium stores, pet stores, plant nurseries, and garden stores believed to be selling aquatic plants. The breakdown of respondents per sample group is displayed in Table 1. The sample included aquarium stores, pet stores, plant nurseries, and garden stores that were potentially selling aquatic plants. Wisconsin DNR staff obtained a list of licensed nurseries (growers and dealers) from the Wisconsin DATCP. We then conducted an informal phone survey of 1,313 licensed nurseries, as well as a number of unlicensed nurseries gathered by searching Internet and telephone listings, to determine which ones sold aquatic plants. Those that reported selling aquatic plants are identified as "reported" in the sample. For some retailers we were unable to determine their aquatic plant sale status before mailing out the survey – these retailers are labeled as "Unknown." All pet and aquarium stores that were included were identified to be selling fish or other aquatic materials. The final response rate was 64.9% with 323 respondents completing the survey. See Appendix B for full 2012 response data.

Retailer Knowledge of Regulations

A core goal of our retailer social survey was to assess retailer knowledge of Wisconsin's invasive species regulations, specifically the state's comprehensive administrative rule (ch. NR 40, Wis. Admin. Code). It is difficult to assess factual knowledge in a survey without creating the feeling of "being tested." In order to avoid creating a testing atmosphere, we instead asked the question, "How knowledgeable do you feel you are about invasive species regulations in Wisconsin?" This question then assesses the respondents' confidence level more than their actual knowledge of the subject. Results to this question are shown in Figure 1. Additionally we asked respondents to describe how strong or weak they felt the regulations were (Figure 2).

We also looked at whether or not respondents planned to sell regulated species to gain further insights into their understanding of regulated species. These results are shown in Tables 2 and 3 in the "Retailer Inventory" section.

We asked a series of questions related to actions that would imply knowledge of regulations. Figure 3 shows 2012's responses to asking how frequently retailers did each of the following:

- Check for updates on State regulated plant lists when placing orders.
- Check for updates on Federal regulated plant lists when placing orders.
- Educate customers on how to properly dispose of unwanted aquatic plants.
- Dispose of unwanted aquatic plants in the trash or compost.

Table 1. Breakdown of 2012 survey respondents by sample group. "Licensed" refers to nurseries holding a Wisconsin DATCP grower or dealer license. "Unlicensed" are nurseries without a license. "Reported" refers to stores known to sell aquatic plants (either self-reported or referred to us by a county AIS coordinator). "Unknown" includes stores whose aquatic plant status was unknown.

Sample Group	ID Range	Number of Outlets within Group
Licensed/Reported	1000s	170
Licensed/Unknown	2000s	244
Unlicensed/Reported	3000s	33
Unlicensed/Unknown	4000s	26
Pet stores	5000s	110
TOTAL	n/a	583

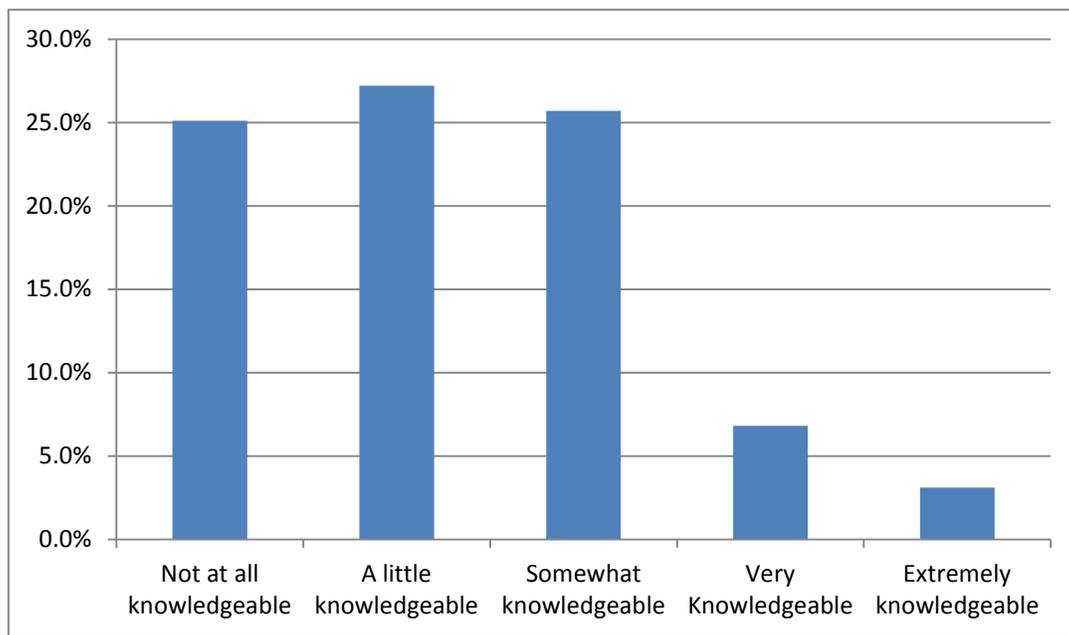


Figure 1. 2012 social survey responses to the question "How knowledgeable do you feel you are about invasive species regulations in Wisconsin?"

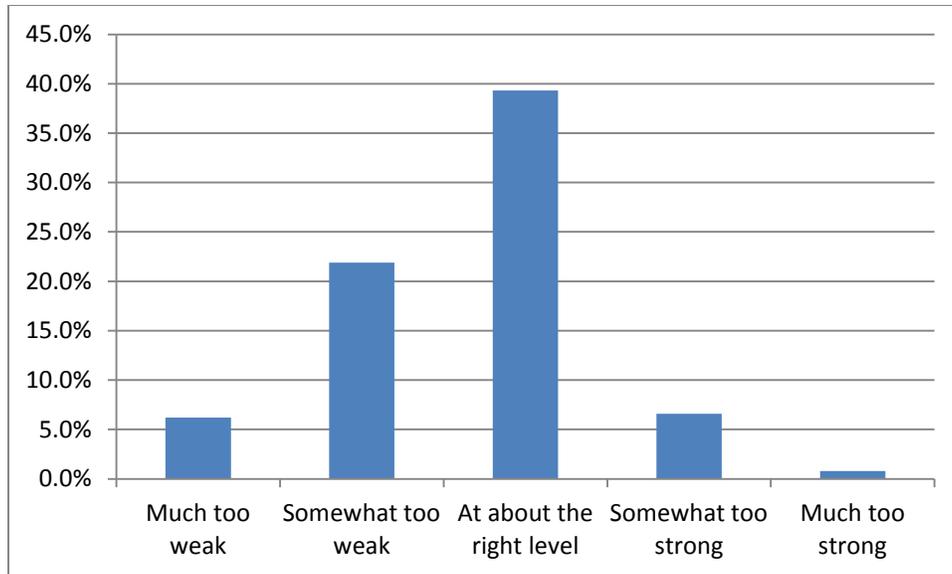


Figure 2. 2012 social survey responses (%) to the question, "In your opinion, how strong or weak are Wisconsin regulations on non-native invasive aquatic plants? Would you say the regulations are..."

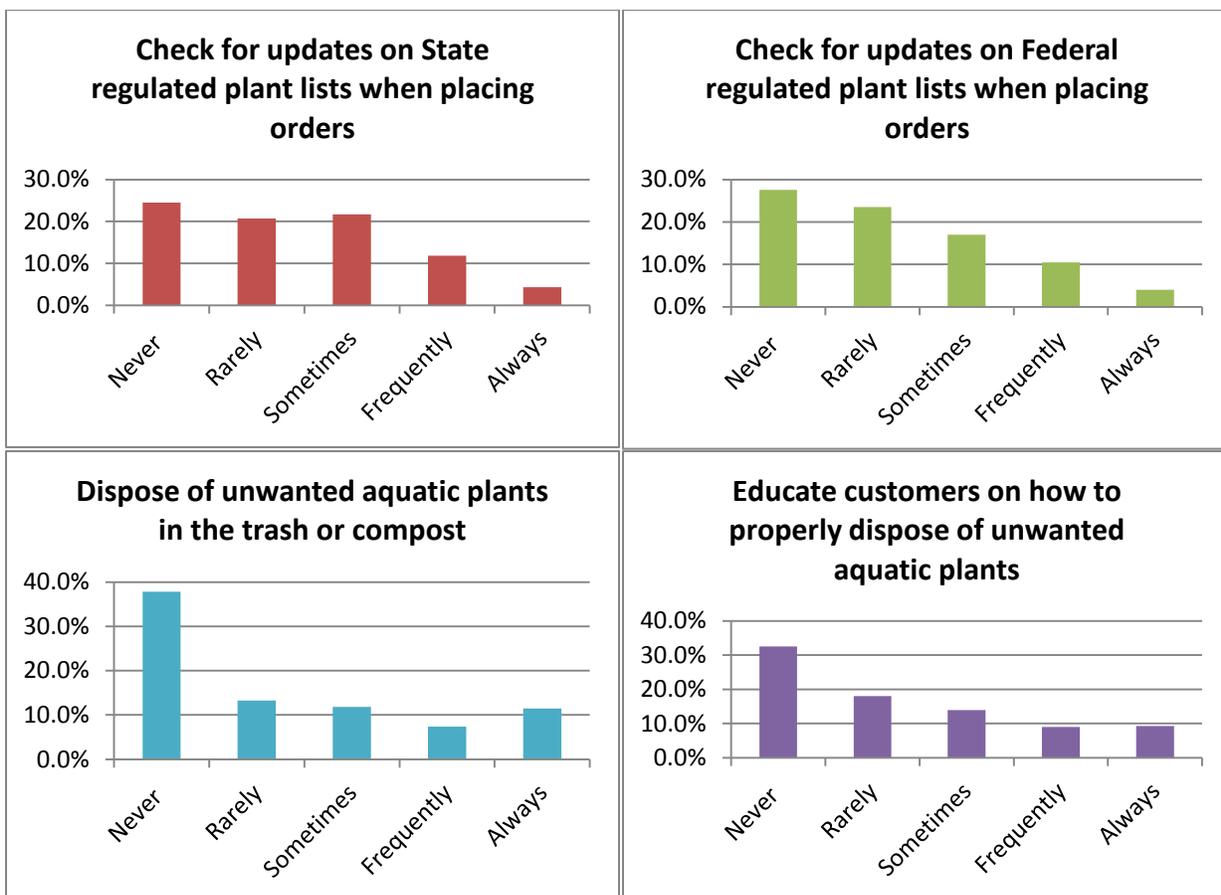


Figure 3. 2012 social survey responses (%) to regulatory action questions.

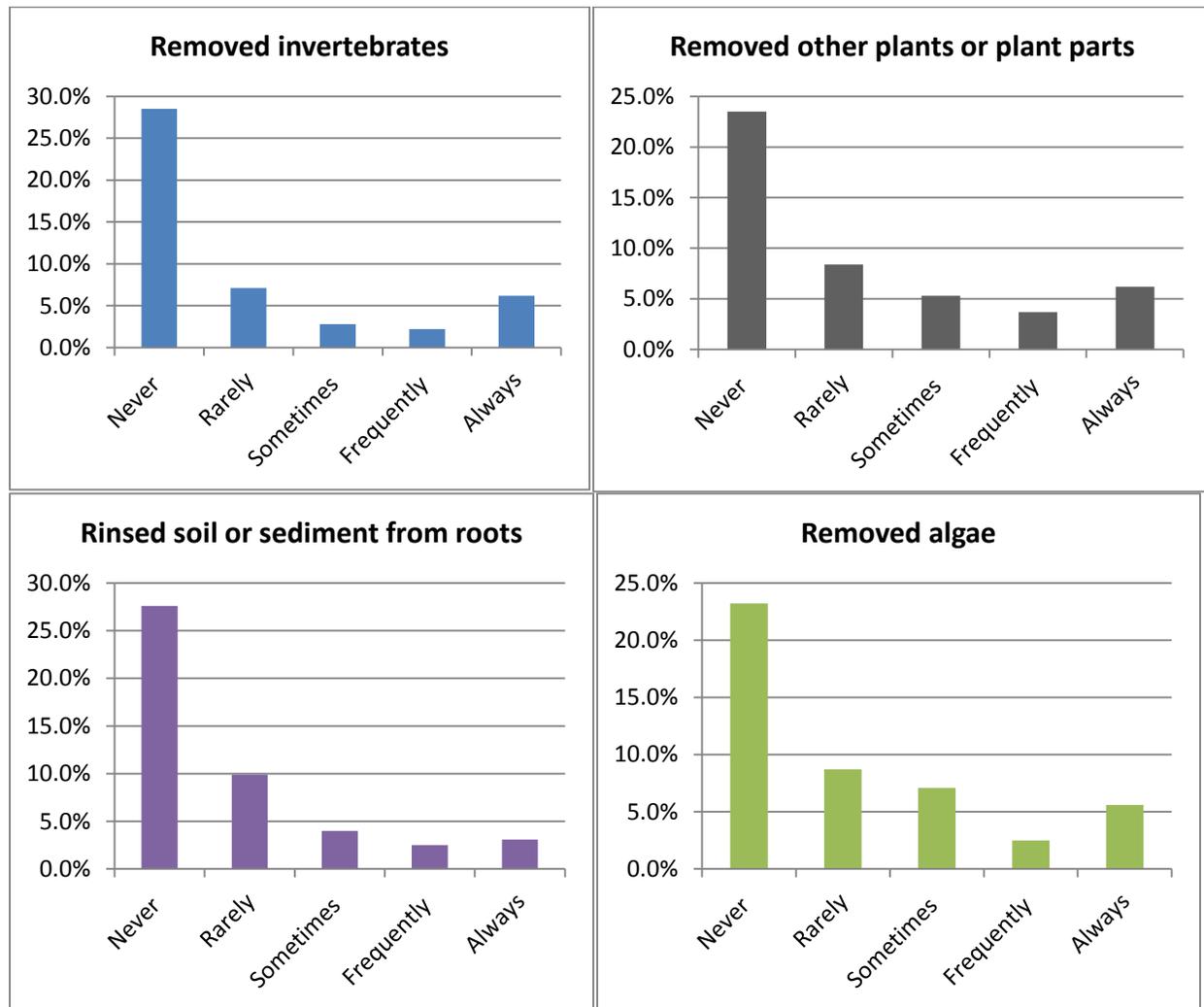


Figure 4. 2012 social survey responses (%) to prevention behavior questions.

Retailer Awareness of Preventive Measures

To gain insights into retailers' awareness of and familiarity with preventive measures and best management practices to reduce the spread of invasive species we asked questions related to actual behaviors. Figure 4 shows the responses to the series of prevention behavior questions. We asked, "In the past 12 months, prior to setting your aquatic plant stock out for sale, how often did you take the following actions?"

- Removed invertebrates
- Removed other plants or plant parts
- Removed algae
- Rinsed soil or sediment from roots

Retailer Inventory of Invasive Species Stock

Part of the social survey used two pages of tables where we asked retailers to indicate their familiarity with a variety of aquatic plants. They also asked to indicate if they have stocked any of the plants in the past five years and to indicate whether or not they planned to sell the species within the next twelve months. The percentages reported in the following tables are based upon the responding sample of 323 cases. However for most of the plants, roughly 60–65% of the respondents did not indicate whether or not they have ever stocked or plan to stock any of the plants. In such cases where the answers are left blank it is impossible to know whether or not that retailer has ever sold or planned to sell the plants. Thus, the familiarity percentage is accurate, but we assume the percentages referring to stocking behavior to be somewhat higher in actuality.

In the case of *Egeria densa*, only 1 respondent said they were familiar – the same retailer had stocked and planned to stock the plant in the future. Conversely, 102 retailers said they were familiar with *Anacharis*; 56 had sold this plant, 32 were planning to sell it in the future. During the course of this study we determined that the plant retailers commonly refer to as *anacharis* is actually *Egeria densa*. The variance in this data demonstrates one of the challenges faced with regulating the plant industry – naming conventions, even scientific ones, can vary widely.

Table 2. Floating and emergent species reported in the 2012 social survey.

Common name(s), Scientific name	Regulated or unregulated	Familiar with this plant	Stocked this plant in past 5 years	Plan to stock this plant in next 12 months
Floating species				
American lotus, <i>Nelumbo lutea</i>	unregulated	43.7%	13.3%	8.0%
European frog bit, <i>Hydrocharis</i> spp.	regulated	17.3%	2.5%	0.9%
Floating marsh pennywort, <i>Hydrocotyle</i> spp.	unregulated	29.7%	8.7%	3.7%
Water chestnut, <i>Trapa</i> spp.	regulated	20.4%	1.5%	0.3%
Water clover, water shamrock, <i>Marsilea</i> spp.	unregulated	25.1%	7.1%	2.8%
Water lettuce, <i>Pistia</i> spp.	unregulated	52.0%	32.8%	23.2%
Yellow floating heart, <i>Nymphoides peltata</i>	regulated	21.7%	6.8%	2.5%
Emergent or marginal species				
Flowering rush, <i>Butomus umbellatus</i>	regulated	26.6%	8.4%	4.6%
Manna grass, sweet grass, <i>Glyceria maxima</i>	unregulated	25.1%	7.7%	3.7%
Narrow-leaf cattail, <i>Typha angustifolia</i>	regulated	43.7%	15.2%	7.7%
Common reed, Pampas reed, <i>Phragmites australis</i>	regulated	38.1%	6.2%	3.4%
Pickerel weed, <i>Pontederia</i> spp.	unregulated	37.2%	19.2%	15.8%
Purple loosestrife, <i>Lythrum salicaria</i>	regulated	51.1%	2.2%	0.3%
Sweet flag, <i>Acorus calamus</i>	unregulated	44.0%	27.2%	18.9%
Wand loosestrife, <i>Lythrum virgatum</i>	unregulated	15.2%	0.9%	0.3%
Water dropworts, Vietnamese water celery, <i>Oenanthe aquatic</i> , <i>O. javanica</i>	unregulated	14.6%	4.3%	2.2%
Yellow iris, pale yellow iris, <i>Iris pseudacorus</i>	unregulated	52.9%	23.5%	13.0%

Table 3. Submerged species reported in the 2012 social survey.

Common name(s), Latin name	Regulated or unregulated	Familiar with this plant	Stocked this plant in past 5 years	Plan to stock this plant in next 12 months
Submerged species				
Anacharis, <i>Hydrilla</i> spp., <i>Egeria</i> spp.	regulated	31.6%	17.3%	9.9%
Australian swamp stonecrop, New Zealand pygmyweed, <i>Crassula</i> spp.	regulated	7.4%	0.9%	0.0%
Brazilian waterweed, <i>Egeria</i> spp.	regulated	8.0%	1.9%	0.0%
Brittle naiad, waternymph, <i>Najas minor</i>	regulated	9.0%	1.5%	0.3%
Coontail, hornwort, <i>Ceratophyllum</i> spp.	unregulated	22.3%	12.1%	9.0%
Curly-leaf pondweed, <i>Potamogeton crispus</i>	regulated	14.6%	0.9%	0.0%
East Indian hygrophila, temple plant, hygro, <i>Hygrophila</i> spp.	unregulated	14.9%	6.8%	4.6%
Eurasian watermilfoil, <i>Myriophyllum spicatum</i>	regulated	22.9%	1.5%	0.6%
Fanwort, <i>Cabomba</i> spp.	regulated	16.7%	7.1%	5.0%
Glosso, mudmat, <i>Glossostigma</i> spp.	unregulated	8.0%	3.1%	2.0%
Hydrilla, <i>Hydrilla</i> spp.	regulated	13.7%	1.9%	0.9%
Oxygen-weed, African elodea, African waterweed, <i>Lagarosiphon</i> spp.	regulated	8.7%	1.9%	0.6%
Parrot feather, <i>Myriophyllum aquaticum</i> , <i>M. brasiliense</i>	regulated	30.3%	16.4%	8.0%
Water celery, eelgrass, <i>Vallisneria americana</i>	unregulated	22.6%	7.4%	5.3%
Waterweed, elodea, <i>Elodea canadensis</i>	unregulated	20.4%	6.2%	4.3%

2012 Retailer Plant Stock Surveys

In March through June 2012, we surveyed publicly available retail stock in aquarium stores, pet stores, plant nurseries, and garden stores for invasive aquatic plants. The stores surveyed had reported to the Wisconsin DATCP that they sold aquatic plants or had told Wisconsin DNR staff in an informal telephone survey of 1,313 licensed nurseries that they sold aquatic plants. Unlicensed nursery stores were also surveyed. Locations of unlicensed stores were gathered by searching Internet and telephone listings. Pet and aquarium store locations were also gathered from Internet and telephone listings.

We visited 297 stores to conduct stock surveys (Figure 5). Visits were unannounced and conducted anonymously by a Wisconsin DNR employee, similar to Maki and Galatowitsch (2004). For stores with multiple locations in Wisconsin, we visited at least two locations, and at least 10% of stores for each chain. We visited 91% of licensed nurseries that reported selling aquatic plants (153 stores), 100% of the unlicensed nurseries that we located (32 stores), and 100% of the pet and aquarium stores (112 stores). Several stores we visited were unable to be surveyed due to being closed for business at the time of the visit or because they were not an actual retail location (i.e. a home business); however, we collected data on enough stores to exceed our numerical targets: 130 licensed nurseries (100 target), 26 unlicensed nurseries (no target, maximum of 50), and 79 aquarium and pet stores (50 target).

Surveyors recorded the presence/absence of 21 regulated aquatic plant species and 36 currently unregulated but potentially invasive aquatic plant species. The unregulated species included species on our watch list (species evaluated but not listed in ch. NR 40) as well as species being evaluated for listing under the revision of ch. NR 40, which began in the summer of 2012. Surveyors recorded complete label information for each plant, including scientific name, common name, and variety. Merchant identifications were considered correct unless the surveyor was able to confirm that the plant was a taxon other than what was labeled. Surveyor identifications were made in the store with vouchers taken by photo. Purchases were also made when additional study of a plant was required for identification. For some genera, morphological identification of sterile plants was not possible, and specimens were sent to the Thum lab at Grand Valley State University for genetic identification (*Cabomba* spp. and *Myriophyllum* spp.). If a purchase was made, the number and type of hitchhikers present was recorded.

We found live aquatic plants for sale in 160 stores, and five additional stores sold aquatic plants but did not have any for sale at the time of our visit (Figure 6). These included 66 stores selling aquarium plants (pet stores and aquarium stores) and 99 stores selling plants for ponds (water garden stores, garden centers, and nurseries).

We identified a regulated plant in 33% of stores selling aquatics (52 stores; Figure 6). Of the 58 species we searched for, we found 25 for sale (Table 4). Four prohibited species were being sold: *Cabomba caroliniana*, *Egeria densa*, *Myriophyllum aquaticum*, and *Nymphoides peltata*. Three restricted species were being sold: *Glyceria maxima*, *Phragmites australis*, and *Typha angustifolia*. *C. caroliniana* was the most common regulated plant sold in aquarium stores, while *M. aquaticum* was the most common regulated plant sold for use in ponds. Most species (60%) were sold for use either in aquaria or ponds, not both. One notable exception was the prohibited plant *E. densa*, which was sold commonly in aquarium stores as a background plant and also in pond stores as an oxygenator. This trend may change as more plants become regulated and stores search for substitutions.

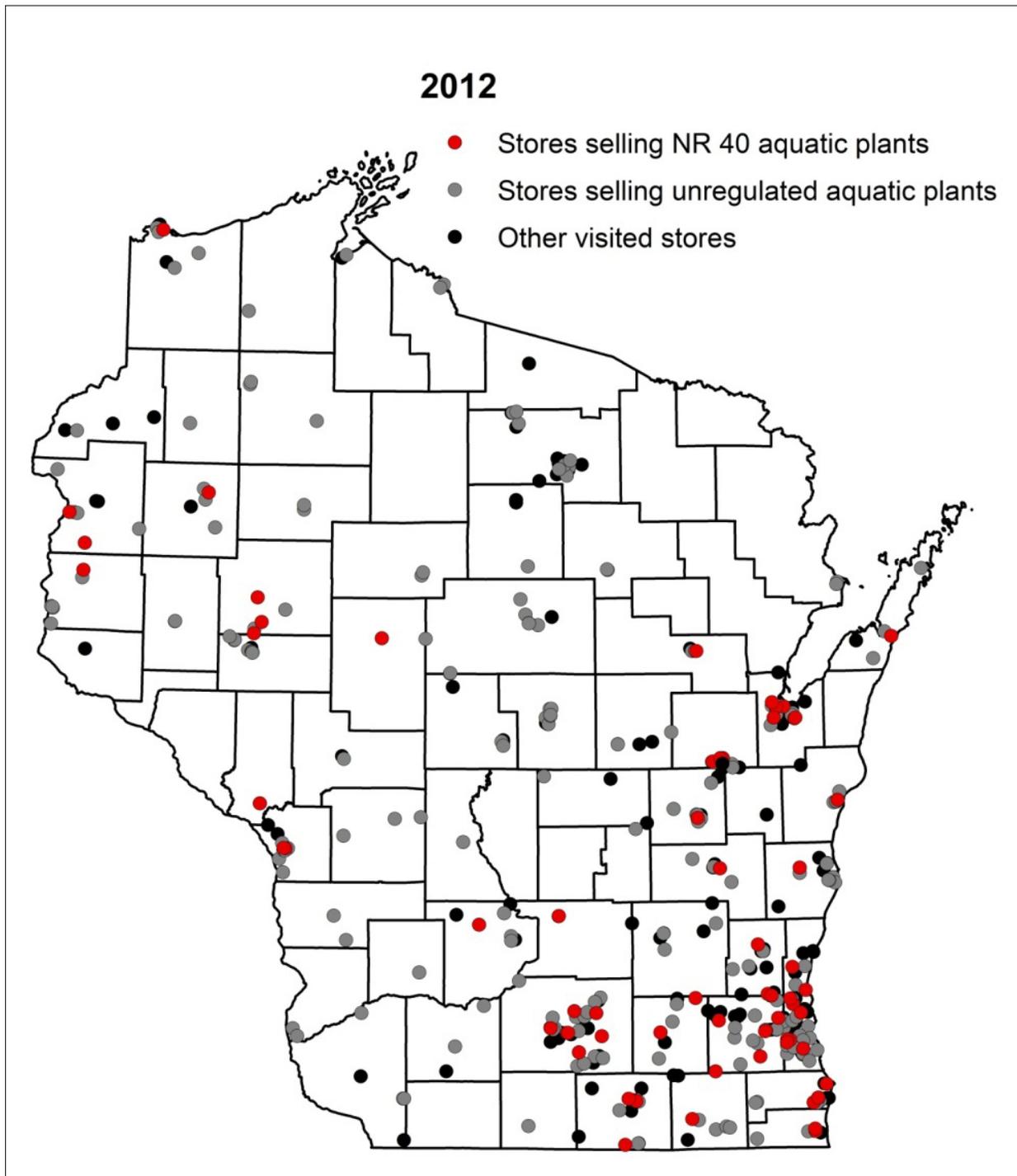


Figure 5. Locations of 297 stores visited for aquatic plant stock surveys in 2012. Stores in black were visited, but either did not carry aquatic plants or were closed at the time of visit.

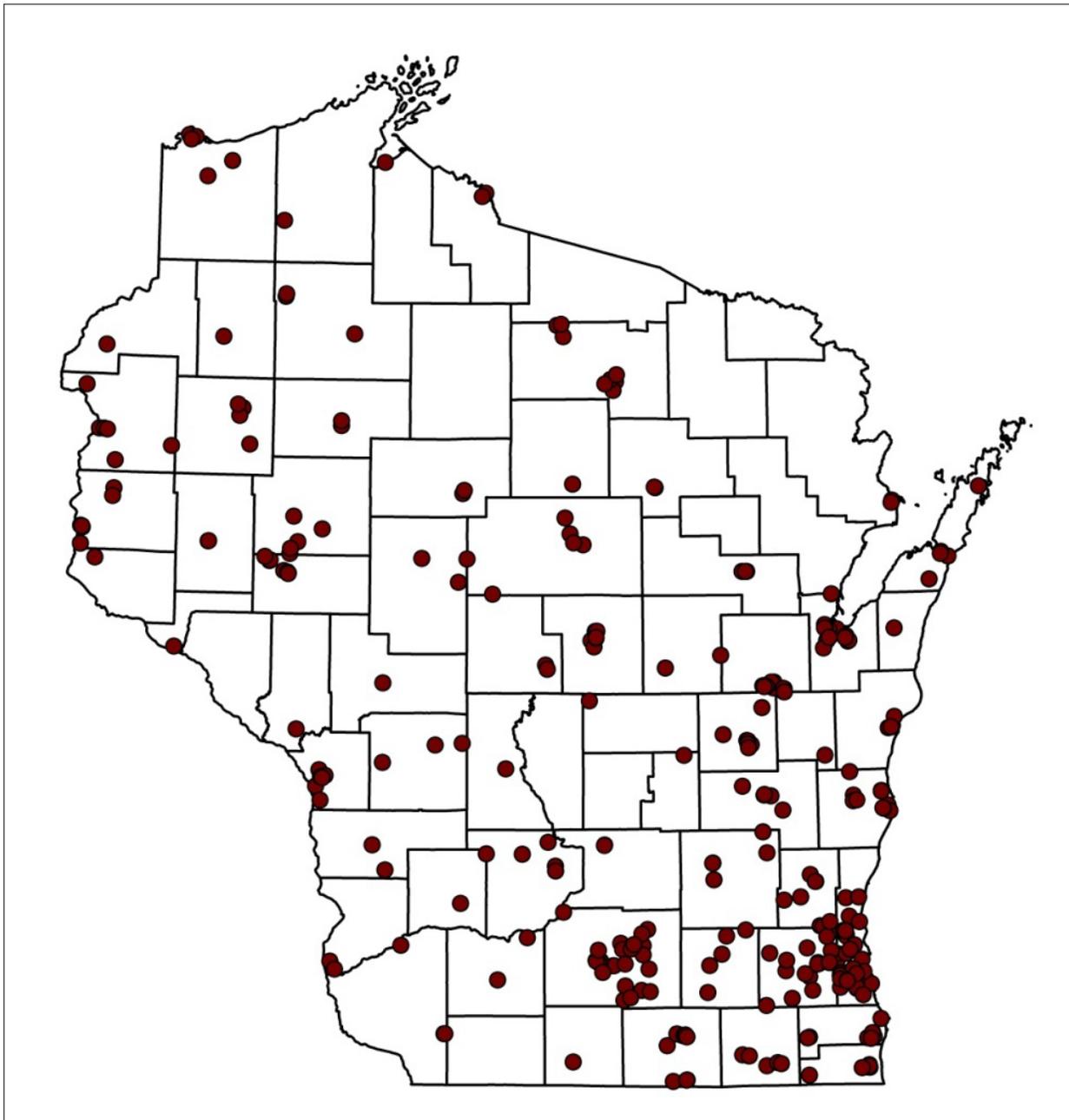


Figure 6. *Locations of aquatic plant retailers in Wisconsin. Map includes the 165 stores we found selling aquatic plants, plus the additional chain store locations for those chains selling aquatic plants.*

When flowers and aerial leaves were not present, identifying *Cabomba* beyond the specific level required DNA sequencing using ITS and trnL-F. The *Cabomba* genus is not well-sequenced, with only *C. caroliniana* and *C. furcata* having GenBank ITS accessions. Both species and several others are sold in the live plant trade. We had 19 samples of *Cabomba*. Based on genetic testing done in both 2012 and 2013, we found that six of our 2012 *Cabomba* samples were morphologically identifiable as *C. caroliniana*, two were identified as *C. caroliniana* using DNA, and four were genetically identified as closely related to *C. caroliniana*, but with many polymorphic sites, which may indicate an interspecific hybrid. The remaining samples were not genetically tested and only identified morphologically to genus. Ch. NR 40 regulates hybrids, cultivars, and genetically modified variants of listed species, so the possible *C. caroliniana* hybrids were tallied with the *C. caroliniana* samples for this report. The *Cabomba* sp. samples are not counted as violations in this report. It is likely, however, that several are *C. caroliniana* or the hybrid because all tested specimens were one of the two. It appears that *C. caroliniana* and the hybrid are the most commonly used in trade in Wisconsin. Education and enforcement of ch. NR 40 related to *Cabomba caroliniana* violations will continue to be very complex.

In 2012, labeling of stock was more common in nursery stores than in aquarium stores ($p < 0.0001$). Only 20% of nursery stock was unlabeled, while 38% of aquatic plants for sale in aquarium stores were completely unlabeled. Nursery stores used scientific name (defined as a minimum of genus plus species epithet) 28% of the time, while only 4% of stock at aquarium stores was labeled fully with scientific name ($p < 0.0001$). By species, the floating nursery species *Eicchornia crassipes* and *Pistia stratiotes* were unlabeled more frequently than other nursery stock. These were often referred to as "floaters" without any individual labels. *Nymphaea* spp., water lilies, very rarely included a scientific name label, although they were usually labeled with the genus name and cultivar. *Lysimachia nummularia* was labeled with scientific name more often than other species.

Mislabeled species for sale in the aquarium trade has been documented with the taxonomically difficult *Myriophyllum* (June-Wells et al. 2012, Thum et al. 2012), as well as with *Egeria densa* (June-Wells et al. 2012). Overall, we observed no differences between mislabeling in nursery stores (1% of labeled stock) and aquarium stores (4%) in 2012 ($p = 0.1316$). We also documented the frequency of mislabeling by species. Most species were labeled correctly all the time. Mislabeled species included *Cabomba caroliniana* (14% of labeled stock), *Egeria densa* (15%), *Iris pseudacorus* (4%), *Myriophyllum aquaticum* (40%), *Oenanthe javanica* (6%), and *Lythrum salicaria* was mislabeled the only time we encountered it (actually, a native mislabeled as *Lythrum salicaria*). Some consider the label anacharis to be a mislabel for *Egeria densa* (June-Wells et al. 2012) because it is an old (and now incorrect) genus name, however, it has been adopted as a common name for *Egeria densa* in the aquarium industry. Although it is reportedly applied to other species (*Elodea canadensis*, *Hydrilla verticillata*, *Lagarosiphon major*), we only observed anacharis or wide-leaf anacharis referring to *Egeria densa* in our survey of Wisconsin stores. If we consider Anacharis to be a mislabeling of *Egeria densa*, then 62% of our stores mislabeled that species.

Aquatic plant purchases were made at 32 stores in 2012. We recorded the incidence of hitchhikers for each of the purchases. Hitchhikers were defined as any macroscopic taxa received with the purchase that was not the object of purchase. This included other vascular plants but also liverworts, moss, snails, and a spider. A third of purchases (10) included at least one hitchhiking taxon. Hitchhiking aquatic plants were in six purchases (19%), with the genera *Lemna*, *Utricularia*, *Azolla*, *Wolffiella*, *Egeria*, and *Riccia* represented.

Table 4. Aquatic plants found at retail stores in 2012. Results are presented as the percent of stores carrying each species for all stores combined, for stores selling pond plants (nurseries), and for stores selling aquarium plants. Blanks are equivalent to 0%. *Cabomba* spp. identified only to genus are tallied along with *C. caroliniana* and hybrid in parentheses.

Scientific Name	Common Name	Regulation Status	% All Stores	% Nursery Stores	% Aquarium Stores
<i>Arundo donax</i>	Giant reed, giant cane	Unregulated	2%	3%	0%
<i>Azolla pinnata</i>	Mosquito fern, water velvet	Unregulated			
<i>Butomus umbellatus</i>	Flowering rush	Restricted			
<i>Cabomba caroliniana</i> & hybrid (& <i>Cabomba</i> sp.)	Fanwort	Prohibited	8(12)%	1(2)%	18(27)%
<i>Callitriche stagnalis</i>	Pond water-starwort	Unregulated			
<i>Cirsium palustre</i>	European marsh thistle	Prohibited/Restricted			
<i>Conium maculatum</i>	Poison hemlock	Prohibited/Restricted			
<i>Crassula helmsii</i>	Australian swamp crop, New Zealand pygmyweed	Prohibited			
<i>Egeria densa</i>	Brazilian waterweed	Prohibited	14%	11%	18%
<i>Eichhornia azurea</i>	Anchored water hyacinth	Unregulated			
<i>Eichhornia crassipes</i>	Water hyacinth	Unregulated	38%	59%	11%
<i>Epilobium hirsutum</i>	Hairy willow herb	Prohibited/Restricted			

Table 4 continues on next page.

Table 4. Continued. *Aquatic plants found at retail stores in 2012.*

Scientific Name	Common Name	Regulation Status	% All Stores	% Nursery Stores	% Aquarium Stores
<i>Glossostigma cleistanthum</i>	Mudmat	Unregulated			
<i>Glyceria maxima</i>	Tall or reed manna grass, sweet grass	Prohibited/Restricted	1%	1%	0%
<i>Hydrilla verticillata</i>	Hydrilla	Prohibited			
<i>Hydrocharis morsus-ranae</i>	European Frogbit	Prohibited			
<i>Hydrocotyle ranunculoides</i>	Floating marsh pennywort	Unregulated	1%	1%	0%
<i>Hygrophila polysperma</i>	East Indian hygrophila	Unregulated			
<i>Ipomoea aquatica</i>	Swamp morning-glory	Unregulated			
<i>Iris pseudacorus</i>	Yellow Iris	Unregulated	21%	34%	5%
<i>Lagarosiphon major</i>	Oxygen-weed, African elodea, African waterweed	Prohibited			
<i>Landoltia punctata</i>	Dotted duckweed	Unregulated			
<i>Limnobium spongia</i>	Frog's bit, American spongeplant	Unregulated			
<i>Limnophila sessiliflora</i>	Limnophila, Asian marshweed	Unregulated	3%	1%	8%
<i>Ludwigia grandiflora</i> (incl subsp. <i>hexapetala</i>)	Water primrose, primrose willow	Unregulated			

Table 4 continues on next page.

Table 4. Continued. Aquatic plants found at retail stores in 2012.

Scientific Name	Common Name	Regulation Status	% All Stores	% Nursery Stores	% Aquarium Stores
<i>Lysimachia nummularia</i>	Creeping Jenny, moneywort	Unregulated	48%	71%	12%
<i>Lythrum salicaria</i>	Purple loosestrife	Restricted			
<i>Lythrum virgatum</i>	European wand loosestrife	Unregulated			
<i>Marsilea minuta</i>	Dwarf water clover, pepperwort	Unregulated	1%	0%	3%
<i>Marsilea mutica</i>	Nardoo, Australian water-clover	Unregulated	4%	6%	0%
<i>Marsilea quadrifolia</i>	Water shamrock or European waterclover	Unregulated	2%	1%	5%
<i>Myriophyllum aquaticum</i> & varieties	Parrotfeather	Prohibited	16%	23%	6%
<i>Myriophyllum crispatum</i>	Upright watermilfoil	Unregulated			
<i>Myriophyllum pinnatum</i>	Cut-leaf watermilfoil	Unregulated			
<i>Myriophyllum spicatum</i>	Eurasian watermilfoil	Restricted			
<i>Myosotis scorpiodes</i>	Forget-me-not	Unregulated	5%	8%	0%
<i>Najas minor</i>	Brittle, lesser, bushy, slender, spiny, or minor naiad/waternymph	Prohibited			
<i>Nasturtium officinale</i>	Watercress	Unregulated	1%	2%	0%
<i>Nelumbo nucifera</i> & hybrids	Sacred lotus	Unregulated	8%	12%	0%

Table 4 continues on next page.

Table 4. Continued. *Aquatic plants found at retail stores in 2012.*

Scientific Name	Common Name	Regulation Status	% All Stores	% Nursery Stores	% Aquarium Stores
<i>Nymphaea</i> spp.	Hardy waterlilies	Unregulated	52%	76%	18%
<i>Nymphoides cristata</i>	Crested floating heart, white water snowflake	Unregulated			
<i>Nymphoides indica</i>	Water snowflake	Unregulated			
<i>Nymphoides peltata</i>	Yellow floating heart	Prohibited	1%	2%	0%
<i>Oenanthe aquatica</i>	Vietnamese water-celery, Japanese parsley, Chinese celery	Unregulated			
<i>Oenanthe javanica</i>	Vietnamese water-celery, Japanese parsley, Chinese celery	Unregulated	13%	20%	0%
<i>Ottelia alismoides</i>	Duck lettuce	Unregulated			
<i>Peltandra virginica</i>	Green arrow arum, tuckahoe	Unregulated	1%	1%	0%
<i>Phalaris arundinacea</i>	Reed canary grass	Unregulated	6%	9%	0%
<i>Phragmites australis</i>	Phragmites, common reed	Restricted	3%	4%	0%
<i>Pistia stratiotes</i>	Water lettuce	Unregulated	37%	56%	14%
<i>Potamogeton crispus</i>	Curly-leaf pondweed	Restricted			
<i>Rorippa amphibia</i>	Great yellow cress, great water cress	Unregulated			
<i>Sagittaria sagittifolia</i>	Hawaii arrowhead, Japanese arrowhead	Unregulated			

Table 4 continues on next page.

Table 4. Continued. *Aquatic plants found at retail stores in 2012.*

Scientific Name	Common Name	Regulation Status	% All Stores	% Nursery Stores	% Aquarium Stores
<i>Salvinia</i> spp.	Salvinia species, water velvet, cat's tongue	Unregulated			
<i>Stratiotes aloides</i>	Water soldiers	Unregulated			
<i>Trapa natans</i>	Water chestnut	Prohibited			
<i>Typha angustifolia</i>	Narrow-leaf cattail	Restricted	2%	3%	0%
<i>Typha laxmannii</i>	Graceful cattail	Unregulated	7%	11%	0%
<i>Typha X glauca</i>	Hybrid cattail	Restricted			

2012 Outreach and Educational Efforts

A primary goal of this project was to educate retailers in the horticulture and aquarium industries. We designed educational materials to communicate the ecological and economic impact of aquatic invasive species, the identities of regulated species in Wisconsin, best practices to reduce their spread, and non-invasive alternatives to their use. The educational goal was to increase knowledge and understanding of the issues and ultimately to change retailer behavior -- decreasing the availability of invasive species to the Wisconsin public. Both the retailer social surveys and the retailer stock surveys served as tools to assess the impact of our education and outreach activities on vendor behavior.

We implemented a focused educational program during the summer and fall of 2012. Our targeted, strategic outreach effort that focused on the areas that pose the highest risk for the establishment of new invasive plants leveraged both efforts by the local Sea Grant offices to increase the visibility of the Habitatitude campaign that encourages responsible care for pond and aquarium organisms and new state efforts to increase awareness and compliance with invasive species laws. Lessons learned from our efforts will help guide Wisconsin DNR's educational approach to retailers beyond the timeframe of this project.

Education Plan

Early in 2012 we finalized an "Education and Outreach Plan" (Appendix A). This plan was designed using a multifaceted educational approach based upon theories of social marketing and accepted models of behavioral change (Hines et al. 1987, Hungerford and Volk 1990). The methods included carefully crafted mailed correspondence, phone and email interactions, and individually designed, in-person educational visits. Studies in other regions have shown that intensive in-person contact at workshops, seminars, and such are generally more effective than publication distribution alone when it comes to influencing behavior change (Woodman 2012, Israel et al. 1999, Larson et al. 2005). In light of this, all retailers received an educational mailing, while a subset of retailers also received an in-person educational visit. This second group we consider "visited." The group that only received the mailed information is considered "unvisited." We included this distinction in the educational approach to determine whether or not the extra effort of an in-person visit would result in an increased likelihood of behavior change. We measured the overall effectiveness of our educational efforts by the self-reported information in the completed social surveys as well as by in-store stock surveys completed before and after the educational efforts.

Educational Efforts

The educational efforts in 2012 followed the Education and Outreach Plan and were expanded and adjusted as needed. Data from the 2012 social surveys was used to help develop the educational materials for vendors and finalize the educational approach.

The first stage of education was an educational mailing. In June, we mailed 100 outreach packets to the pet and aquarium stores included in the social survey. The outreach packets included a cover letter, a handout to explain how invasive species regulations apply to the particular business, a picture guide of Wisconsin's regulated aquatic invasive plants, a brochure about invasive fish, and an invitation to an invasive species workshop. The cover

letter also included links to Wisconsin DNR's invasive species webpage for more information. Numerous personal correspondences were made with vendors in response to questions that resulted from the communication.

In July, we mailed 451 similar outreach packets to licensed and unlicensed nurseries included in the social survey. These packets did not include the fish brochure or workshop invitation, but additionally included a full list of regulated invasive plants (including terrestrial plants).

The retailers in this study included several large national chain stores. For these businesses, additional correspondence was made via telephone and email with the store's regional aquatic plant buyer or manager. Outreach packets were provided to the corporate contacts via email for these larger chain stores (e.g., Petco, Walmart, etc.). In these cases, we were able to directly educate the person who makes buying decisions for the chain's Wisconsin stores. Each individual retail location also received a mailed informational packet, resulting in approximately 120 additional mailings.

The second stage of education included in-person visits for a subset of retailers. For the in-person educational visit component of the project, we selected retailers that reported through the mailed survey that they were planning to sell species listed in ch. NR 40 (76 stores) and those retailers that were found to be selling NR 40-regulated species during the stock survey visits (58 stores). Since some of these stores were covered by both categories, the total number of stores selected was 110.

Twenty of the 110 stores were randomly selected to serve as a control for the educational efforts (they did not receive an in-store visit). Additionally, 20 of the compliant stores were randomly selected to receive an in-store visit. These site visits were conducted between July and October. Information from these visits has been logged and observations are being used to assist in the development of final outreach materials. During the educational site visits, our educator met with the owner or plant buyer, provided the educational packet, and discussed invasive species regulations and best management practices. Where appropriate, plant identification assistance was provided. Stores that had large aquatic plant selections were provided the book *Aquatic Plants of the Upper Midwest: A Photographic Field Guide to Our Underwater Forests* (Skawinski 2011). This resource was provided to assist with plant identification and awareness of native alternatives.

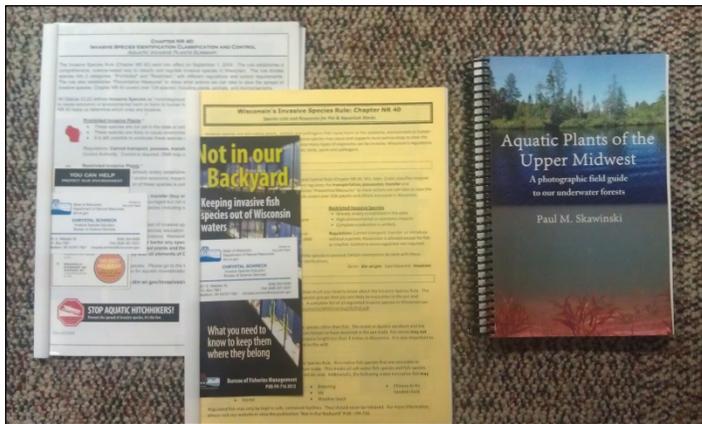
Personal correspondence was made throughout the reporting period with several vendors in response to the mailings and in-person visits. Data from both the social surveys and the stock surveys was used to develop the educational materials for vendors and finalize the educational approach. In 2012 a number of outreach materials were developed, as shown in the technology transfer section of this report. These publications can also be viewed in full in Appendices D-P.

**Educational Packet for
Aquatic Plant Nurseries**

Materials: invasive plant picture ID guides, a list of all regulated invasive species, a list of regulated plants, an overview of the regulations, information on best practices to prevent the spread and release of invasive species, and *Invasive aquatic plants and their other names*: pictures and synonyms of regulated aquatic plants.

**Educational packet for
Pet and Aquarium Stores**

Materials: invasive plant picture ID guides, a list of all regulated invasive species, a list of regulated plants, an overview of the regulations, information on best practices to prevent the spread and release of invasive species, *Invasive aquatic plants and their other names*: pictures and synonyms of regulated aquatic plants, *Are your snails okay?*, *What is a crayfish?*



The images to the left depict the educational packets that were delivered during in-person visits with retailers as well as the supplemental plant identification book that was used. Retailers expressed appreciation for all of the materials and the care that was taken with in-person visits.

2013 Social Survey of Retailers, Landscapers, and Growers

From January through March 2013, we developed a second social survey in coordination with the University of Wisconsin Survey Center to assess retailer knowledge of regulations and awareness of preventative measures, and to inventory invasive species stock. An additional intent of this second survey was to assess the effectiveness of the educational efforts and determine any changes between 2012 and 2013. The survey went out in three waves, with the first one mailed on April 1, 2013, and the final on May 9, 2013.

The 2013 survey used the same sample groups as the 2012 survey, but the number decreased due to business closures and those that were identified as not selling aquatic plants. The final sample size for 2013 was 525 stores, including pet stores, plant nurseries and garden stores (Table 5). The final response rate for the 2013 sample was 59.8% with 275 respondents completing the survey. See Appendix C for full 2013 response data.

Table 5. Breakdown of 2013 survey respondents by sample group. “Licensed” refers to nurseries holding a Wisconsin DATCP grower or dealer license. “Unlicensed” are nurseries without a license. “Reported” refers to stores known to sell aquatic plants (either self-reported or referred to us by a county AIS coordinator). “Unknown” includes stores whose aquatic plant status was unknown.

Sample Group	ID Range	Number of Outlets in Group
Licensed/Reported	1000s	156
Licensed/Unknown	2000s	233
Unlicensed/Reported	3000s	30
Unlicensed/Unknown	4000s	21
Pet stores	5000s	85
TOTAL	n/a	525

Retailer Knowledge of Regulations

Once again in 2013 we set out to assess retailer knowledge of Wisconsin’s invasive species regulations, specifically ch. NR 40, Wis. Admin. Code. We repeated the questions, “How knowledgeable do you feel you are about invasive species regulations in Wisconsin?” and “How strong or weak do you feel Wisconsin’s invasive species regulations are?” Results for these two questions are shown in Figures 7 and 8, respectively. We also asked a series of questions related to actions that would imply knowledge of regulations (Figure 9).

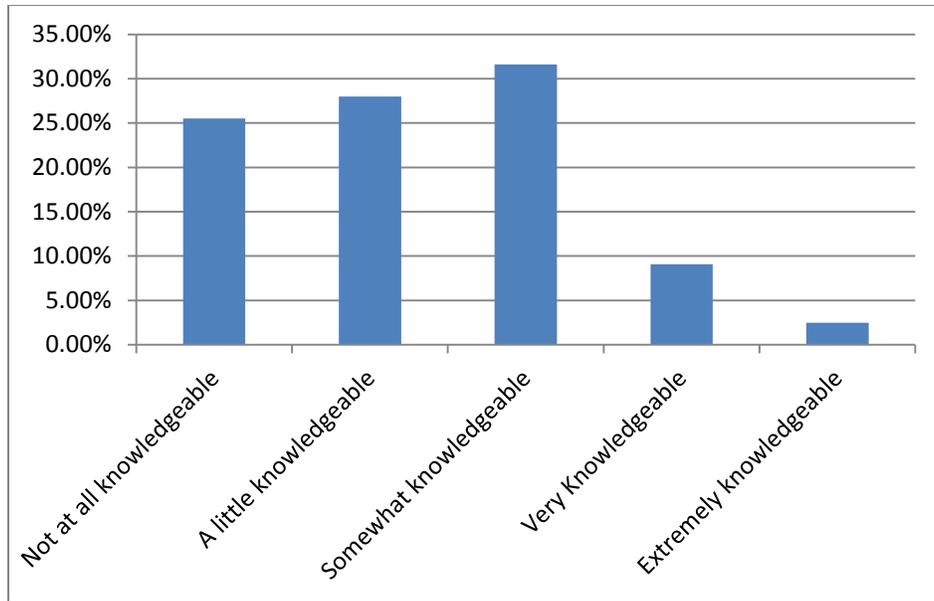


Figure 7. 2013 social survey responses to the question “How knowledgeable do you feel you are about invasive species regulations in Wisconsin?”

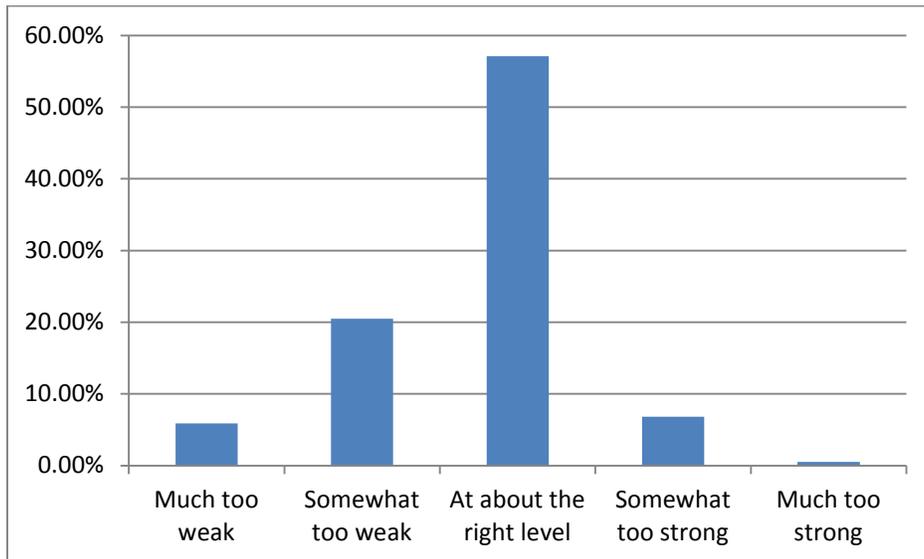


Figure 8. 2013 social survey responses to the question, “In your opinion, how strong or weak are Wisconsin regulations on non-native invasive aquatic plants? Would you say the regulations are...”

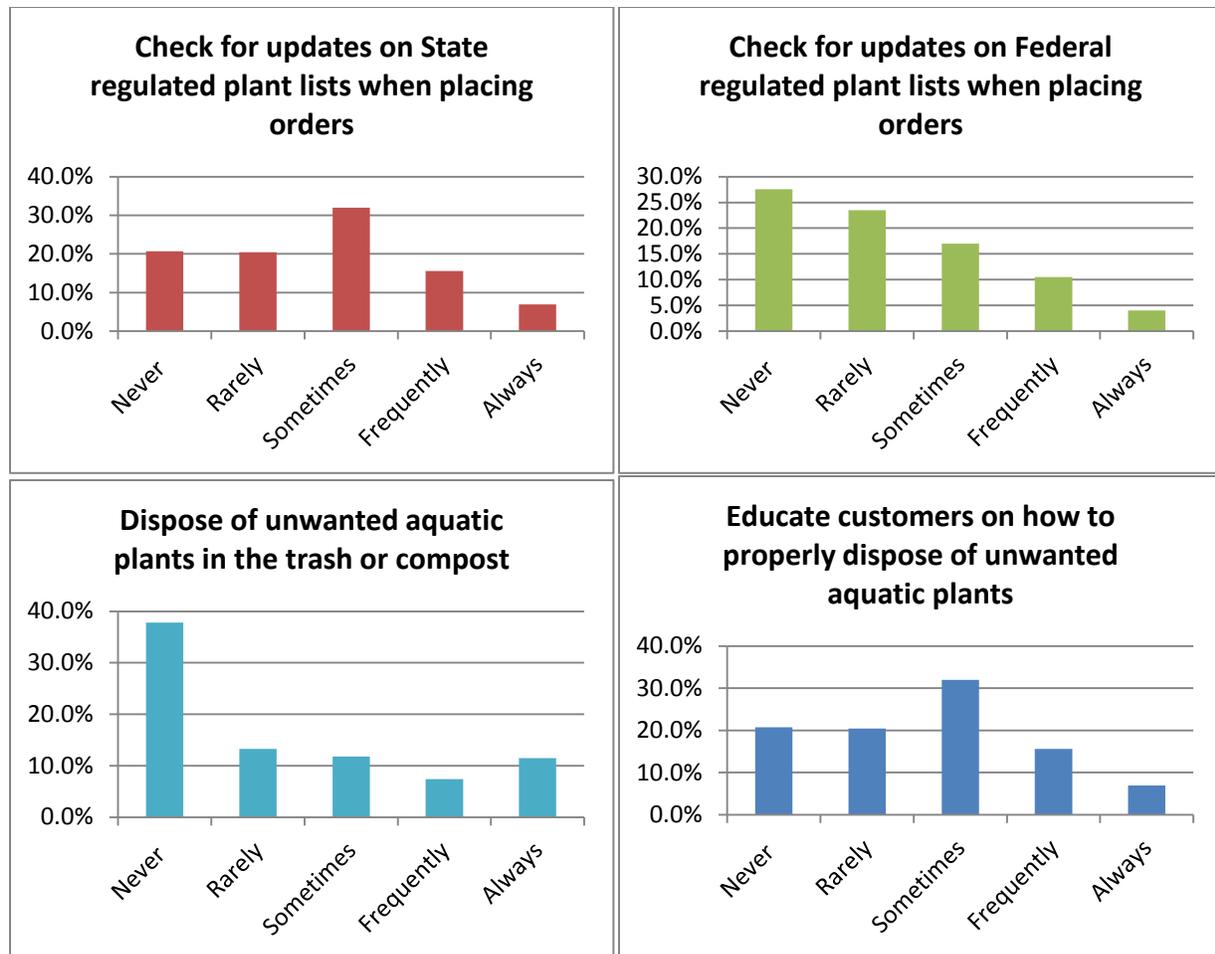


Figure 9. 2013 social survey responses (%) to regulatory action questions.

Retailer Awareness of Preventive Measures

To gain insights into retailers’ awareness of and familiarity with preventive measures and best management practices to reduce the spread of invasive species we asked questions related to actual behaviors. Figure 10 shows the responses to the series of prevention behavior questions we asked. We asked, “In the past 12 months, prior to setting your aquatic plant stock out for sale, how often did you take the following actions?”

- Removed invertebrates
- Removed other plants or plant parts
- Removed algae
- Rinsed soil or sediment from roots

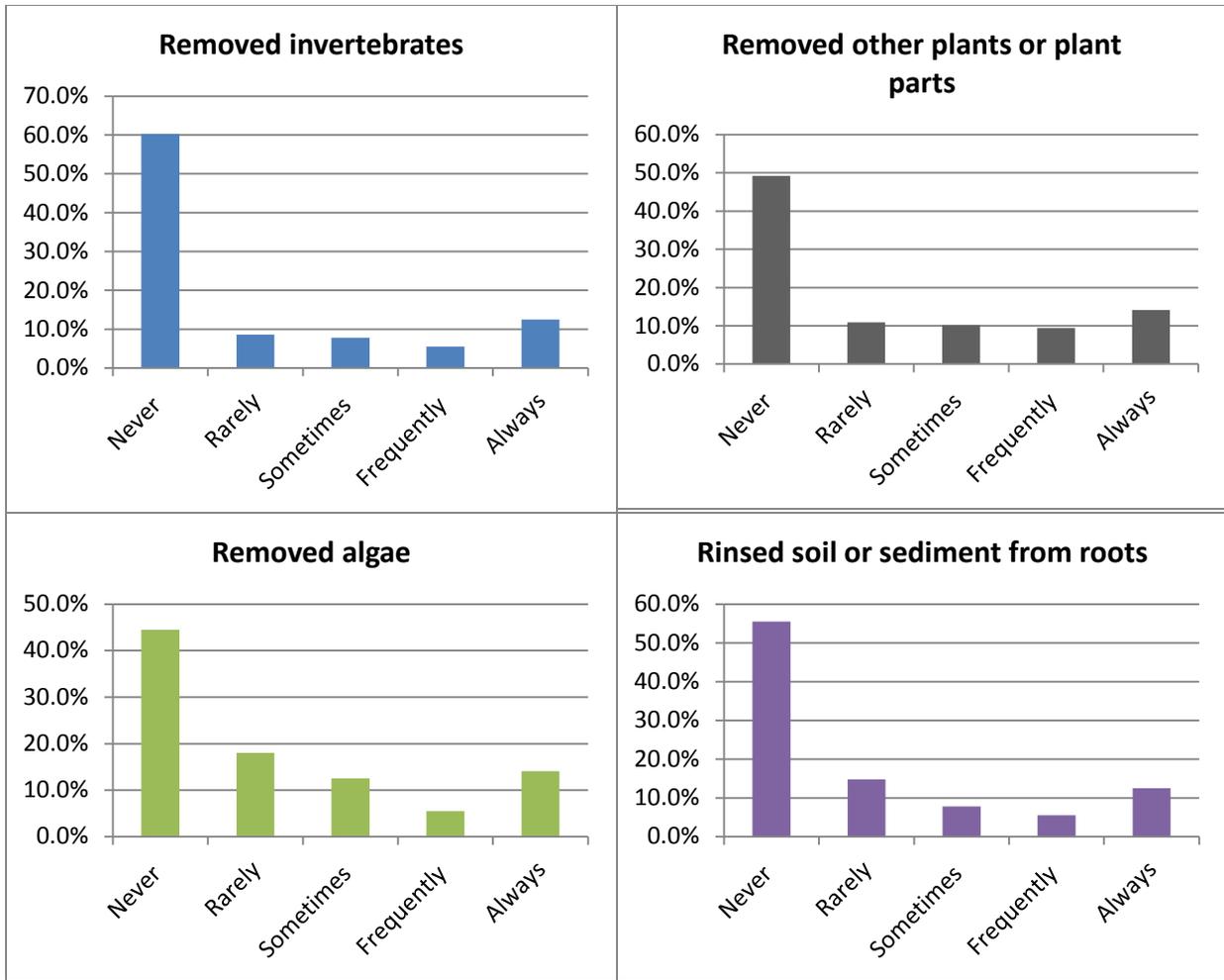


Figure 10. 2013 social survey responses (%) to prevention behavior questions.

Retailer Inventory of Invasive Species Stock

In 2013, we again asked retailers to indicate their familiarity with a variety of aquatic plants, as well as their stocking history and future intentions. The percentages reported in the following tables (Tables 6-7) are based upon the responding sample of 275 cases. In 2013, the percentage of retailers that answered all three parts of this series of questions was greater than it was in 2012. The percentage of respondents that did not indicate whether or not they have ever stocked or plan to stock a plant ranged from 28% to 42% for the bulk of the plants in 2013, versus the 60% to 65% range in 2012.

Table 6. Floating and emergent species list reported in the 2013 social survey.

Common name(s), Latin name	Regulated or unregulated	Familiar with this plant	Stocked this plant in past 5 years	Plan to stock this plant in next 12 months
Floating species				
American lotus, <i>Nelumbo lutea</i>	unregulated	42.9%	10.2%	4.0%
European frog bit, <i>Hydrocharis</i> spp.	regulated	18.2%	4.0%	0.0%
Floating marsh pennywort, <i>Hydrocotyle</i> spp.	unregulated	32.4%	8.0%	3.6%
Water chestnut, <i>Trapa</i> spp.	regulated	28.7%	2.2%	0.4%
Water clover, water shamrock, <i>Marsilea</i> spp.	unregulated	27.6%	6.5%	2.9%
Water hyacinth, <i>Eichhornia crassipes</i> *	unregulated	60.7%	32.4%	23.3%
Water lettuce, <i>Pistia</i> spp.	unregulated	59.3%	33.8%	23.3%
Yellow floating heart, <i>Nymphoides peltata</i>	regulated	23.6%	4.7%	1.1%
Emergent or marginal species				
Flowering rush, <i>Butomus umbellatus</i>	regulated	32.7%	8.7%	2.2%
Manna grass, sweet grass, <i>Glyceria maxima</i>	unregulated	33.1%	3.6%	1.8%
Narrow-leaf cattail, <i>Typha angustifolia</i>	regulated	54.2%	13.8%	7.3%
Common reed, Pampas reed, <i>Phragmites australis</i>	regulated	46.5%	4.7%	1.1%
Pickereel weed, <i>Pontederia</i> spp.	unregulated	41.5%	18.9%	12.0%
Purple loosestrife, <i>Lythrum salicaria</i>	regulated	61.8%	1.8%	0.4%
Sweet flag, <i>Acorus calamus</i>	unregulated	46.5%	24.4%	14.9%
Wand loosestrife, <i>Lythrum virgatum</i>	unregulated	20.4%	0.7%	0.7%
Water dropworts, Vietnamese water celery, <i>Oenanthe aquatic</i> , <i>O. javanica</i>	unregulated	18.9%	6.2%	1.5%
Yellow iris, pale yellow iris, <i>Iris pseudacorus</i>	unregulated	61.1%	20.4%	12.7%

Table 7. Submerged species reported in the 2013 social survey.

Common name(s), Latin name	Regulated or unregulated	Familiar with this plant	Stocked this plant in past 5 years	Plan to stock this plant in next 12 months
Submerged species				
Anacharis, <i>Hydrilla</i> spp., <i>Egeria</i> spp.	regulated	26.5%	12.7%	3.6%
Australian swamp stonecrop, New Zealand pygmyweed, <i>Crassula</i> spp.	regulated	7.3%	0.7%	0.0%
Brazilian waterweed, <i>Egeria</i> spp.	regulated	9.5%	2.2%	0.7%
Brittle naiad, waternymph, <i>Najas minor</i>	regulated	9.1%	1.1%	0.0%
Coontail, hornwort, <i>Ceratophyllum</i> spp.	unregulated	24.4%	11.6%	6.5%
Curly-leaf pondweed, <i>Potamogeton crispus</i>	regulated	14.9%	1.5%	0.4%
East Indian hygrophila, temple plant, hygro, <i>Hygrophila</i> spp.	unregulated	15.3%	6.5%	3.3%
Eurasian watermilfoil, <i>Myriophyllum spicatum</i>	regulated	24.7%	2.2%	0.4%
Fanwort, <i>Cabomba</i> spp.	regulated	16.7%	6.2%	1.8%
Glossos, mudmat, <i>Glossostigma</i> spp.	unregulated	8.0%	2.2%	1.5%
Hydrilla, <i>Hydrilla</i> spp.	regulated	12.4%	0.7%	0.0%
Oxygen-weed, African elodea, African waterweed, <i>Lagarosiphon</i> spp.	regulated	11.3%	1.1%	0.7%
Parrot feather, <i>Myriophyllum aquaticum</i> , <i>M. brasiliense</i>	regulated	33.1%	16.0%	4.7%
Water celery, eelgrass, <i>Vallisneria americana</i>	unregulated	23.3%	5.8%	5.1%
Waterweed, elodea, <i>Elodea canadensis</i>	unregulated	20.7%	4.4%	2.5%

2013 Retailer Plant Stock Surveys

In May through June 2013, we visited 146 stores (Figure 11). Many, however, were closed or no longer carried aquatic plants. We were able to resurvey 110 stores that had been surveyed in 2012, and conducted initial surveys in 13 stores that had not been surveyed in 2012. Most of those had self-reported in the 2012 social survey that they carried aquatic plants. Of the stores that were resurveyed, 80 had received one-on-one education on ch. NR 40 regulations and plant identification; 30 stores had not received any additional education between the 2012 and 2013 stock surveys.

We identified a regulated plant in 30% of stores selling aquatic species in 2013 (31 stores). Some of these were unvisited control stores: 28% of educated stores were selling regulated plants, and 38% of unvisited stores were selling regulated plants. We found 27 aquatic plant species for sale in 2013 from our list of 58 invasives (Table 8). We found four species listed as prohibited in ch. NR 40: *C. caroliniana*, *E. densa* and *M. aquaticum* were found in 2012, and *Hydrocharis morsus-ranae* was found in one store. *Nymphoides peltata*, which was found in 2012, was not observed in any stores in 2013. For restricted species, *Glyceria maxima*, *Phragmites australis*, and *Typha angustifolia* again were found, as well as *Butomus umbellatus*. *C. caroliniana* and *M. aquaticum* were again the most common regulated plants sold in aquarium stores and pond stores, respectively.

We identified *Cabomba* sp. with a mix of genetic testing and morphological analysis again in 2013. We identified two samples as *C. caroliniana*, three as the possible *C. caroliniana* interspecific hybrid, and one as *Cabomba haynesii*.

The identification of parrot feather samples was also done by genetic analysis in 2013. There are a number of different *Myriophyllum* spp. sold in the aquarium trade and misidentification is common without genetic testing (Thum et al. 2012). We found similar confusion with *M. aquaticum* in the nursery trade. In 2012, we encountered parrot feather 26 times, however most were vouchered with photos, and genetic testing was unsuccessful on the pressed sample we had. Of the 13 samples from 2013, two were *M. aquaticum*, five were the *Myriophyllum* sp. "red 1" from Moody and Les (2010) and Thum et al. (2012), one was the *Myriophyllum* sp. "red 2" from Moody and Les (2010) and Thum et al. (2012), three were *Myriophyllum crispatum*, and two were an unknown *Myriophyllum* species, even after genetic analysis. The unknown *Myriophyllum* were sold as *Myriophyllum propium*, which is not an accepted taxonomic name. This species was found in the nursery trade in Connecticut but also could not be identified (CAES 2009). The *Myriophyllum crispatum* samples were often sold as red-stemmed parrot feather, but not all of the plants labeled as red-stemmed parrot feather were *M. crispatum*. The *M.* sp. "red 1" and "red 2" samples are both closely related to *M. aquaticum* and may be a variety of *M. aquaticum* or a closely related undescribed species. For this project, *M. propium* sales (unknown *M.* sp.) were treated as compliant with ch. NR 40, and all other parrot feather sales were tallied as not compliant, following the education stores received prior to the discovery of the many species/varieties being sold as parrot feather. The ability to regulate *M. aquaticum* depends on our ability to accurately differentiate it from other *Myriophyllum* species, and currently this is very difficult.

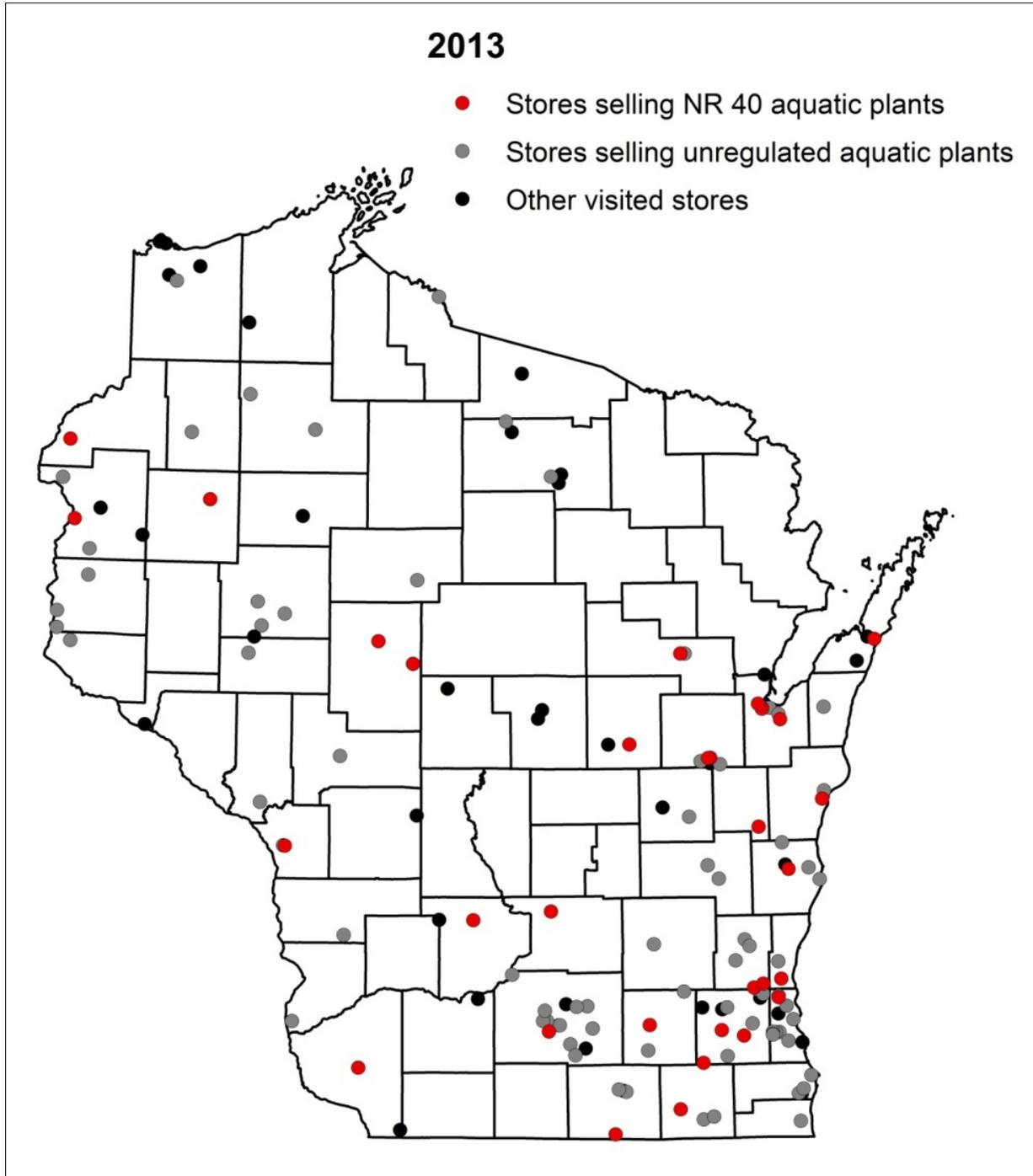


Figure 11. Locations of 146 stores visited for aquatic plant stock surveys in 2013. Stores in black were visited, but either did not carry aquatic plants or were closed at the time of visit.

Table 8. Aquatic plants found at retail stores in 2013. Results are presented as the percent of stores carrying each species for all stores combined, for stores selling pond plants (nurseries), and for stores selling aquarium plants. Blanks are equivalent to 0%.

Scientific name	Common name	Regulation Status	% All Stores	% Nursery Stores	% Aquarium Stores
<i>Arundo donax</i>	Giant reed, giant cane	Unregulated	4%	6%	0%
<i>Azolla pinnata</i>	Mosquito fern, water velvet	Unregulated			
<i>Butomus umbellatus</i>	Flowering rush	Restricted	3%	4%	0%
<i>Cabomba caroliniana</i> & hybrid (& <i>Cabomba</i> sp.)	Fanwort	Prohibited	5%	1%	12%
<i>Callitriche stagnalis</i>	Pond water-starwort	Unregulated			
<i>Cirsium palustre</i>	European marsh thistle	Prohibited/Restricted			
<i>Conium maculatum</i>	Poison hemlock	Prohibited/Restricted			
<i>Crassula helmsii</i>	Australian swamp crop, New Zealand pygmyweed	Prohibited			
<i>Egeria densa</i>	Brazillian waterweed	Prohibited	7%	6%	10%
<i>Eichhornia azurea</i>	Anchored water hyacinth	Unregulated			
<i>Eichhornia crassipes</i>	Water hyacinth	Unregulated	53%	78%	12%
<i>Epilobium hirsutum</i>	Hairy willow herb	Prohibited/Restricted			
<i>Glossostigma cleistanthum</i>	Mudmat	Unregulated			
<i>Glyceria maxima</i>	Tall or reed manna grass, sweet grass	Prohibited/Restricted	1%	1%	0%

Table 8 continues on next page.

Table 8. Continued. Aquatic plants found at retail stores in 2013.

Scientific name	Common name	Regulation Status	% All Stores	% Nursery Stores	% Aquarium Stores
<i>Hydrilla verticillata</i>	Hydrilla	Prohibited			
<i>Hydrocharis morsus-ranae</i>	European Frogbit	Prohibited	1%	1%	0%
<i>Hydrocotyle ranunculoides</i>	Floating marsh pennywort	Unregulated	1%	1%	0%
<i>Hygrophila polysperma</i>	East Indian hygrophila	Unregulated			
<i>Ipomoea aquatica</i>	Swamp morning-glory	Unregulated			
<i>Iris pseudacorus</i>	Yellow Iris	Unregulated	23%	36%	2%
<i>Lagarosiphon major</i>	Oxygen-weed, African elodea, African waterweed	Prohibited			
<i>Landoltia punctate</i>	Dotted duckweed	Unregulated			
<i>Limnobium spongia</i>	Frog's bit, American spongeplant	Unregulated			
<i>Limnophila sessiliflora</i>	Limnophila, Asian marshweed	Unregulated	2%	1%	5%
<i>Ludwigia grandiflora</i> (incl subsp. <i>hexapetala</i>)	Water primrose, primrose willow	Unregulated			
<i>Lysimachia nummularia</i>	Creeping Jenny, moneywort	Unregulated	55%	81%	12%
<i>Lythrum salicaria</i>	Purple loosestrife	Restricted			
<i>Lythrum virgatum</i>	European wand loosestrife	Unregulated			
<i>Marsilea minuta</i>	Dwarf water clover, pepperwort	Unregulated	1%	1%	0%
<i>Marsilea mutica</i>	Nardoo, Australian water-clover	Unregulated	6%	9%	0%

Table 8 continues on next page.

Table 8. Continued. *Aquatic plants found at retail stores in 2013.*

Scientific name	Common name	Regulation Status	% All Stores	% Nursery Stores	% Aquarium Stores
<i>Marsilea quadrifolia</i>	Water shamrock or European waterclover	Unregulated	3%	1%	5%
<i>Myriophyllum aquaticum</i> & varieties	Parrot feather	Prohibited	9%	13%	2%
<i>Myriophyllum crispatum</i>	Upright watermilfoil	Unregulated	3%	4%	0%
<i>Myriophyllum pinnatum</i>	Cut-leaf watermilfoil	Unregulated			
<i>Myriophyllum spicatum</i>	Eurasian watermilfoil	Restricted			
<i>Myosotis scorpiodes</i>	Forget-me-not	Unregulated	16%	25%	0%
<i>Najas minor</i>	Brittle, lesser, bushy, slender, spiny, or minor naiad/waternymph	Prohibited			
<i>Nasturtium officinale</i>	Watercress	Unregulated	2%	3%	0%
<i>Nelumbo nucifera</i> & hybrids	Sacred lotus	Unregulated	7%	10%	0%
<i>Nymphaea</i> spp.	Hardy waterlilies	Unregulated	56%	75%	26%
<i>Nymphoides cristata</i>	Crested floating heart, white water snowflake	Unregulated			
<i>Nymphoides indica</i>	Water snowflake	Unregulated			
<i>Nymphoides peltata</i>	Yellow floating heart	Prohibited			
<i>Oenanthe aquatic</i>	Vietnamese water-celery, Japanese parsley, Chinese celery	Unregulated			
<i>Oenanthe javanica</i>	Vietnamese water-celery, Japanese parsley, Chinese celery	Unregulated	16%	23%	5%
<i>Ottelia alismoides</i>	Duck lettuce	Unregulated			
<i>Peltandra virginica</i>	Green arrow arum, tuckahoe	Unregulated	3%	4%	0%

Table 8 continues on next page.

Table 8. Continued. *Aquatic plants found at retail stores in 2013.*

Scientific name	Common name	Regulation Status	% All Stores	% Nursery Stores	% Aquarium Stores
<i>Phalaris arundinacea</i>	Reed canary grass	Unregulated	14%	22%	2%
<i>Phragmites australis</i>	Phragmites, common reed	Restricted	7%	10%	0%
<i>Pistia stratiotes</i>	Water lettuce	Unregulated	47%	67%	12%
<i>Potamogeton crispus</i>	Curly-leaf pondweed	Restricted			
<i>Rorippa amphibian</i>	Great yellow cress, great water cress	Unregulated			
<i>Sagittaria sagittifolia</i>	Hawaii arrowhead, Japanese arrowhead	Unregulated			
<i>Salvinia</i> spp.	Salvinia species, water velvet, cat's tongue	Unregulated	1%	1%	0%
<i>Stratiotes aloides</i>	Water soldiers	Unregulated			
<i>Trapa natans</i>	Water chestnut	Prohibited			
<i>Typha angustifolia</i>	Narrow-leaf cattail	Restricted	2%	3%	0%
<i>Typha laxmannii</i>	Graceful cattail	Unregulated	7%	10%	0%
<i>Typha X glauca</i>	Hybrid cattail	Restricted			

In 2013, labeling rates were similar in nursery and aquarium stores ($p=0.4275$). Only 19% of nursery stock and 26% of aquarium stock was unlabeled. Nursery stores were still more likely than aquarium stores to label using the full scientific name (42% vs 19%, respectively; $p<0.001$).

Most species were correctly labeled all the time. Mis-labeled species included *Cabomba caroliniana* hybrid (67% of labeled stock), *Egeria densa* (29%), parrotfeathers (*Myriophyllum aquaticum*, *M. crispatum*, "*M. propium*", *M. sp. red 1* and *M. sp. red 2*) (46%), *Phragmites australis* (29%), and *Oenanthe javanica* (19%). Mislabeling was more common in aquarium stores (10% of labeled stock) in 2013 than in nursery stores (3%; $p<0.05$).

Aquatic plant purchases were made at 29 stores in 2013. Hitchhikers were received with only 14% of purchases in 2013, down from 2012. All of these included aquatic plants, with the genera *Lemna*, *Azolla*, and *Egeria* again found as hitchhikers. *Schoenoplectus* was a hitchhiker in one purchase, as well.

Change in Stock, 2012-2013

We tested for significant changes in prevalence among the most common species found in retail stores with McNemars chi-squared (Table 9). The prohibited species decreased significantly, except *Nymphoides peltata*. Restricted species showed no change from 2012. Overall, 43% (3/7) of regulated species decreased. Most unregulated species did not change prevalence in 2013, with the exception of *Phalaris arundinacea* and *Typha laxmannii*. *P. arundinacea* and *T. laxmannii* are both invasive species, but neither were covered in the one-on-one education visit.

The number of stores carrying regulated invasive plants decreased overall from 2012 to 2013, according to a McNemars chi-squared test on the number of stores carrying any regulated plants each year (Chi=14.7692, df=1, P=0.0001215). This means that there were more compliant stores in the second year of the survey: 46.3% of stores in this paired test carried a regulated species in 2012, while only 23.6% of stores in 2013 surveys were non-compliant.

To formally assess the effectiveness of the outreach program across both sampling years, we tallied the number of regulated and unregulated invasive species offered for sale in stores grouped by education type (mailer regulated, mailer unregulated, visit regulated, visit unregulated). For this analysis, we included only the 90 stores that carried aquatic plants in both years of the study. We then used a 2x4 chi-square test to observe patterns in the species available in trade from 2012 to 2013. We used adjusted residuals (MacDonald and Gardner 2000) to compare among count categories. By comparing year-to-year changes in regulated species to year-to-year changes in a control group of unregulated invasive species, we were able to separate the effect of education from background changes in retail stock.

We found that the visit plus mailer education was effective at reducing the number of regulated species in trade, while the mailer alone was not (Figure 12). The number of invasive species in trade varied across education/species group (X-squared = 11.056, df=3, p-value=0.011), with the number of regulated species in the visited group higher than expected in 2012 (adj. residual 2.91) and lower than expected in 2013 (adj. residual -2.93).

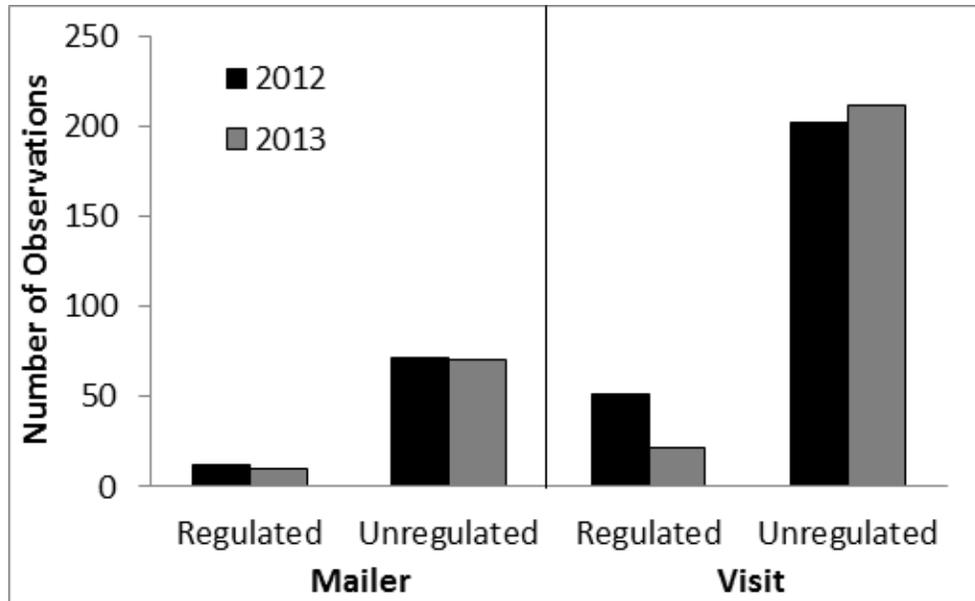


Figure 12. Number of stores selling invasive aquatic plants surveyed in each sampling year, grouped by education and regulation status. 2012 was pre-education, 2013 was post-education.

We used a mixed effect model (R function `glmer` in package `lme4`) to test for differences in mislabeling before and after education across treatment groups. We found that the one-on-one visit did not improve the rate of mislabeled plants (model estimate -2.37 , $p = .156$) in visited versus unvisited stores. The status of the labeling (correctly labeled or not), the predictor of this model, was derived from the 718 aquatic plant labels we verified throughout the course of this study. This was completed primarily during the in-store visits but some labels were confirmed during laboratory inspection or genetic testing. Seventy-five percent ($n = 540$) of the plant specimens were labeled, and of those, only 20 were mislabeled (2.8%). The majority of the plants for sale had some type of label: 40% were labeled with common or varietal names, 35% included a scientific name, and 25% were unlabeled. The two most commonly mislabeled species over both years were *Oenanthes javanica* and *Miriophyllum aquaticum*, followed by the *Cabomba* genus and *Egeria densa*.

We compared the number of hitchhiking taxa on voucher purchases between 2012 and 2013 with a Pearson chi-square test. We made a similar number of purchases in each year, but found no change in the proportion of stores with unwanted taxa ($X^2 = 2.62$, $df = 3$, $p\text{-value} = 0.1055$). We had too few stores with hitchhikers to investigate the effect of the mailer versus one-on-one visit on implementation of best management practices to remove hitchhikers.

Table 9. Changes in the number of stores carrying a particular species from 2012 to 2013. Table shows McNemar's Chi-squared summary statistics. *Cabomba caroliniana* includes hybrids and *Myriophyllum aquaticum* includes varieties.

Scientific Name	Common Name	Regulation Status	M. Chi	df	p	Change Direction
<i>Cabomba caroliniana</i>	Cabomba, fanwort	Prohibited	4.000	1	*	Decrease
<i>Egeria densa</i>	Anacharis	Prohibited	10.032	1	**	Decrease
<i>Myriophyllum aquaticum</i>	Parrotfeather	Prohibited	23.670	1	***	Decrease
<i>Nymphoides peltata</i>	Yellow floating heart	Prohibited	0.500	1	ns	
<i>Butomus umbellatus</i>	Flowering rush	Restricted	1.330	1	ns	
<i>Phragmites australis</i>	Phragmites, common reed	Restricted	0.800	1	ns	
<i>Typha angustifolia</i>	Narrow-leaf cattail	Restricted	0.000	1	ns	
<i>Arundo donax</i>	Giant reed	Unregulated	0.000	1	ns	
<i>Eichhornia crassipes</i>	Water hyacinth	Unregulated	0.000	1	ns	
<i>Iris pseudacorus</i>	Yellow iris	Unregulated	0.840	1	ns	
<i>Limnophila sessiliflora</i>	Ambulia	Unregulated	0.250	1	ns	
<i>Lysimachia nummularia</i>	Creeping Jenny	Unregulated	0.410	1	ns	
<i>Marsilea mutica</i>	Nardoo, Australian water-clover	Unregulated	0.000	1	ns	
<i>Marsilea quadrifolia</i>	Water shamrock, European waterclover	Unregulated	0.000	1	ns	
<i>Myosotis scorpiodes</i>	Water forget-me-not	Unregulated	2.720	1	ns	
<i>Nelumbo nucifera</i>	Sacred lotus	Unregulated	2.290	1	ns	
<i>Nymphaea spp.</i>	Hardy water lilies	Unregulated	1.530	1	ns	
<i>Oenanthes javanica</i>	Vietnamese or Chinese water-celery, Japanese parsley	Unregulated	0.056	1	ns	
<i>Peltandra virginica</i>	Green arrow arum, tuckahoe	Unregulated	1.330	1	ns	
<i>Pistia stratiotes</i>	Water lettuce	Unregulated	0.740	1	ns	
<i>Phalaris arundinacea</i>	Reed canary grass	Unregulated	5.786	1	*	Decrease
<i>Typha laxmannii</i>	Graceful cattail	Unregulated	4.167	1	*	Decrease

2013 Outreach and Educational Efforts

Outreach and educational efforts in 2013 focused on two audiences, retailers and consumers. The retailer component consisted of following-up with non-compliant retailers (see “Follow Up Enforcement Actions” below) and continuing correspondence with those that had remaining questions or concerns. The consumer component focused on two core audiences, educators and pond owners or water gardeners. During our 2012 educational visits with retailers, we were told repeatedly that biology teachers repeatedly requested one specific regulated invasive plant, *Egeria densa*. This knowledge led us to focus some of our consumer efforts directly on biology teachers, as described below.

Teacher Outreach and Education

Historically, *Egeria densa*, also known as anacharis or, incorrectly, as elodea, has been used by biology teachers to study cell structures and cellular processes like cytoplasmic streaming. Due to its ability to invade both still and flowing water ecosystems including lakes, ponds, ditches, and rivers, *E. densa* is listed as a prohibited invasive plant in Wisconsin. It can form dense stands that crowd out native vegetation and reduce an area’s value as a fish habitat; it can also interfere with recreational activities such as fishing and swimming.

In order to address the issue of teachers continuing to seek out *Egeria densa* and other regulated species, we felt it necessary to communicate directly with teachers. Having an alternative to suggest to the educators was crucial to the success of our outreach. Luckily, there are alternative plants that biology teachers can use in their labs. *Elodea canadensis* is one native alternative to study. Another alternative is *Egeria najas*, also known as narrow-leaf anacharis. Both of these species are suitable for the general labs that *E. densa* has been used for in the past.

We distributed a cover letter, the elodea brochure, and the aquatic plants handout to all middle and high school biology and general science teachers in Wisconsin. We obtained the names and addresses of the teachers from the Wisconsin Department of Public Instruction (DPI). The DPI also sent an email announcement out on our behalf to the Wisconsin science teachers’ listserv.

During this process we also learned that both college professors and elementary school teachers were using *E. densa*, and in some cases, other regulated species. Thus we compiled a list of the appropriate contacts for all Wisconsin colleges, universities, and technical schools so that we could provide the same information about invasive aquatic plants to professors. This information was distributed via email in January 2014. Additional DNR staff will be contacting elementary school teachers in 2014 about this issue as well.

Pond Owner and Water Gardener Outreach and Education

Pond owners and water gardeners comprise one of the major consumer groups of aquatic plants purchased from plant nurseries. We reached out to this audience through two routes: indirectly through retailers and directly through direct mailings.

In late July, 2013 we mailed packets of 30 pond brochures out to 325 retailers – all of which we confirmed were selling aquatics through our 2012 surveys. The pond brochure was distributed to these retailers to provide to their customers. In addition, these retailers received a cover letter, a handout on Elodea, and a picture guide to aquatic plants. This mailing went out to parent stores for all retailers and all of the Wisconsin locations for the chain stores Petco, Petsmart, and Menards.

In early December 2013, we sent a cover letter, pond brochure, and aquatic plant guide directly to approximately 15,500 landowners that have ponds or other water bodies on or neighboring their properties. The recipients stemmed from seven counties in southeast Wisconsin. The goal of this effort was to directly educate pond owners about the risks of invasive species, how to identify them, and what to do about them on their properties. We identified recipients through geospatial analysis of water body locations in conjunction with county parcel ownership records.

Response to both of these efforts was positive in that both retailers and consumers called or emailed to request further materials and express their participation. Critical to the success of our educational efforts were the development of educational materials. These publications along with the presentations that resulted from our efforts are described in the “Technology Transfer” chapter of this report.

Follow Up Enforcement Actions

In order to handle any non-compliant retailers in 2013, a cooperative agreement was finalized with Department of Agriculture, Trade, and Consumer Protection (DATCP) staff to clarify how any continued follow up actions would proceed. Internal DNR protocols were also finalized to address cross-program coordination. In May, educational and enforcement follow-ups began with the non-compliant stores found through the follow-up stock surveys.

- Non-compliant plant nurseries that received an educational visit were reported to the Wisconsin DATCP for cooperative enforcement follow-through.
- Non-compliant pet stores that received an educational visit were issued a notice of non-compliance by the Wisconsin DNR and went through the stepped enforcement process.
- Non-compliant retailers that did not receive an educational visit in 2012 received educational communication from the Wisconsin DNR and follow-ups to ensure compliance.

During May and June 2013, project staff found regulated plant species remaining at 30 retailers. Regulated invasive fish and crayfish were found at two additional retailers. Of the 32 retailers reported, eight had not received educational visits in 2012.

Seven retailers received in-person educational visits from the Wisconsin DNR, four retailers were issued a Notice of Non-compliance, and three retailers received educational information via mail. The remaining retailers were reported to the Wisconsin DATCP for cooperative enforcement. Compliance was achieved with all retailers where the stepped enforcement process was completed. However, seventeen of the cases reported to the Wisconsin DATCP were still in process at the end of 2013.

During 2013, the Wisconsin DNR received a total of 48 reports of retailer invasive species regulation violations; well over half of these reports came directly from the efforts of this project. In 2012, the Wisconsin DNR received a total of 19 reports. The retailer violations found through this project in 2012 were not reported since educational follow-up was part of the study design. Without a concerted effort to look for violations, it is evident that many will go unchecked. This indicates the need for increased agency efforts to inspect for violations or for increased collaboration with partners. The public is always encouraged to report violations, and in 2014, AIS County Coordinators have been encouraged to engage with local retailers more to increase the likelihood of catching reoccurring violations.

2012 Urban Landscape Surveys

This study also examined the relationship between AIS source availability and presence of AIS populations in small water bodies. We intended to observe which AIS sold in the live plant trade are found growing in ponds around areas with high retail availability, and whether or not proximity to retail store affected the AIS found. Additionally, we hoped to learn which types of ponds are susceptible either to planting and growth of AIS found in the live plant trade.

The area selected for this portion of the study (Figure 13) was a developed region of southeastern Wisconsin, where numerous small water bodies, a relatively dense population, and several retail sources of live aquatic plants create many opportunities for novel introductions of invasive plants of trade. All ponds included in the study were within 5 km of a drainage to Lake Michigan and less than 5 acres in size. Pond selection was randomized across six strata relating to the dominant land use in a 500-m buffer around the pond (>50% agricultural, >50% developed, other; from 2006 National Land Cover Database) and retail availability of aquatic invasive species (high or low).

High or low availability of aquatic invasive species was determined by the number of regulated species available for sale within close proximity. In the study area, the average distance from a random point to the third nearest store selling aquatic plants was 17 km, so 17 km was used as the distance threshold when counting invasive species. Ponds were considered to be in a high-availability area if there were greater than or equal to nine regulated species sold at stores within 17 km, and in a low-availability area if there were zero, one, or two regulated species sold at stores within 17 km (Figure 14).

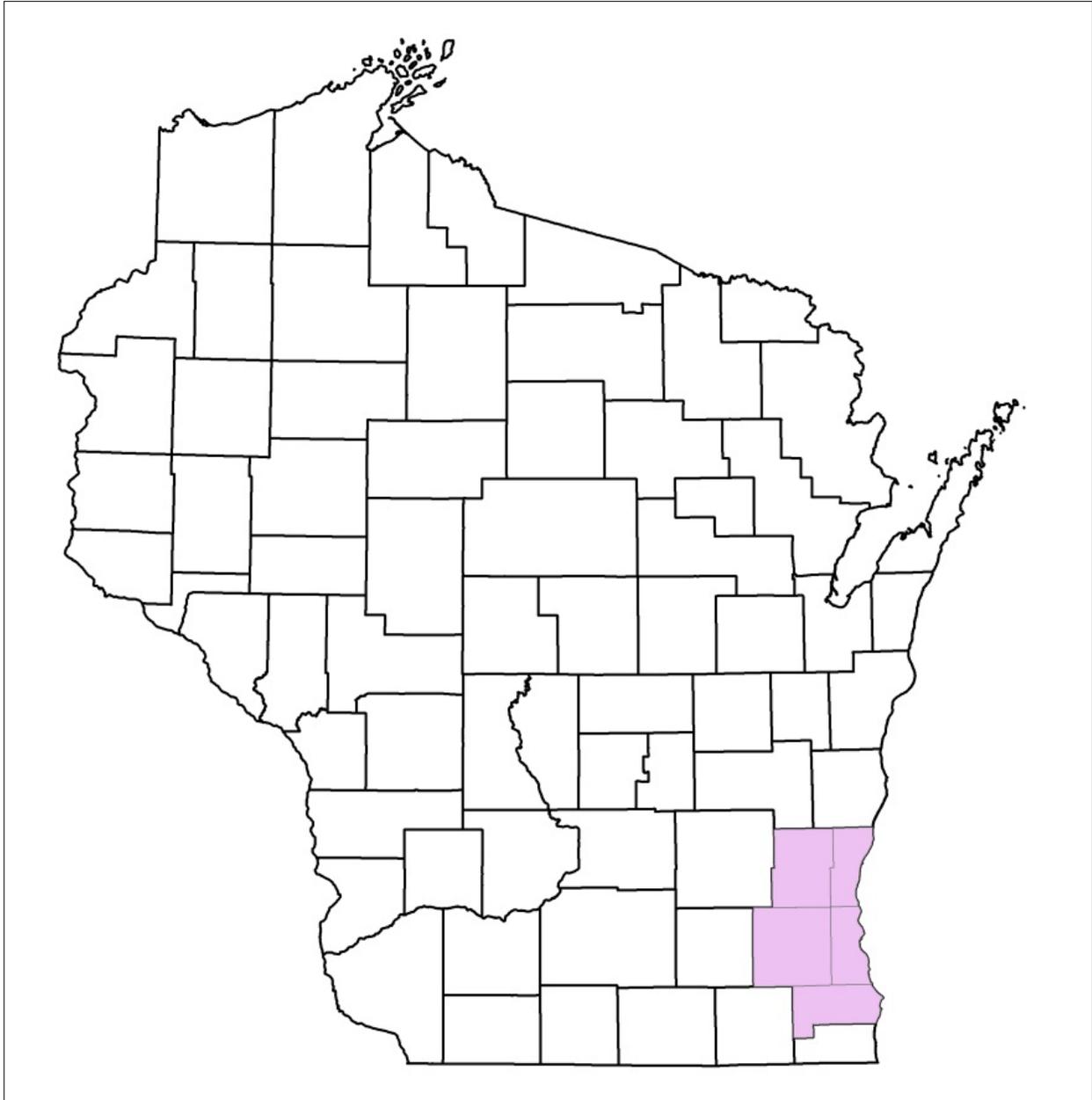


Figure 13. *Five-county study area included in the pond surveys: Washington, Ozaukee, Waukesha, Milwaukee, and Racine counties (west to east, north to south).*

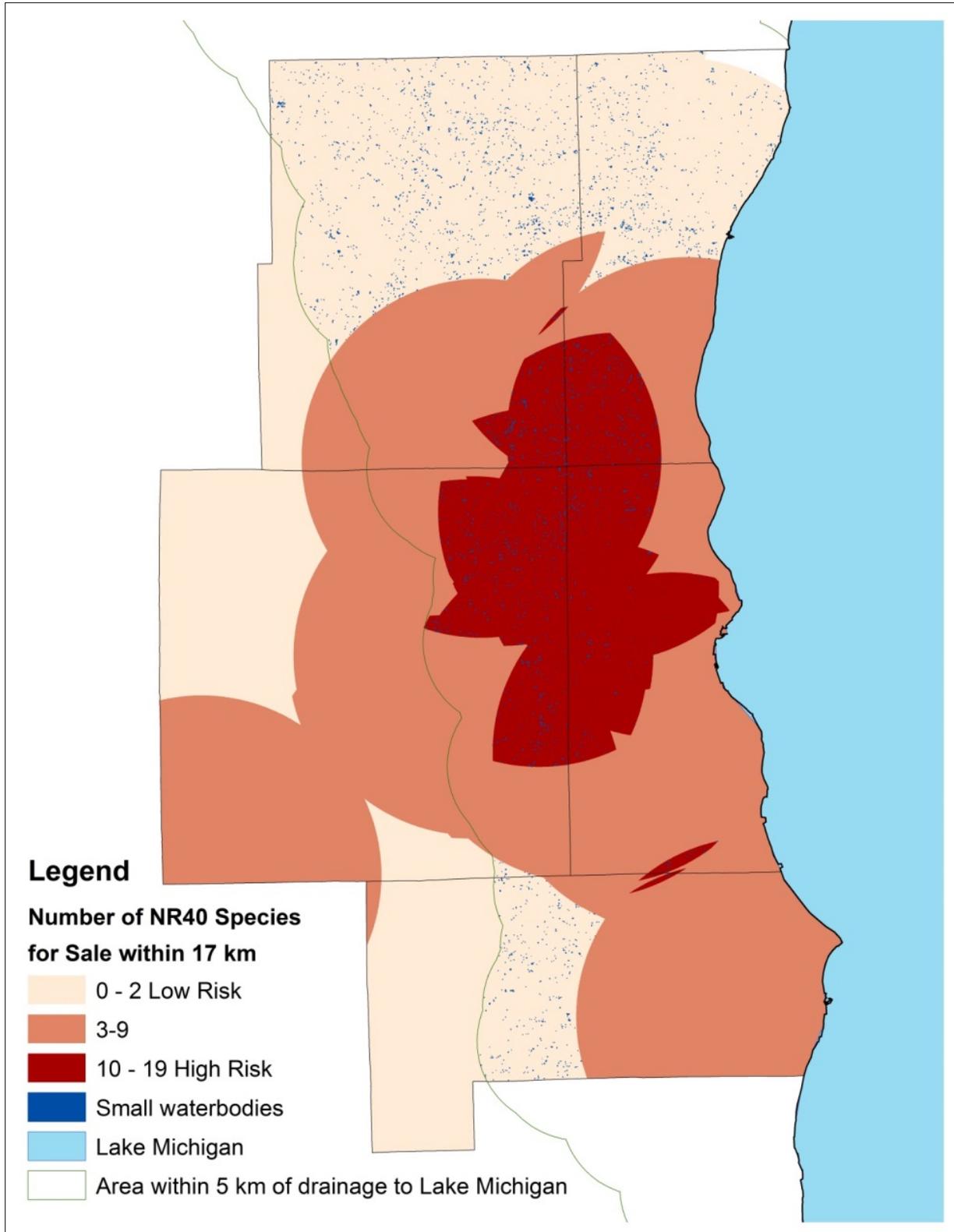


Figure 14. Map of all water bodies in study area. 4,215 water bodies less than 0.02 km² (5 acres) were within 5 km from a drainage to Lake Michigan and in the high or low risk areas based on NR 40-regulated species for sale within 17 km.

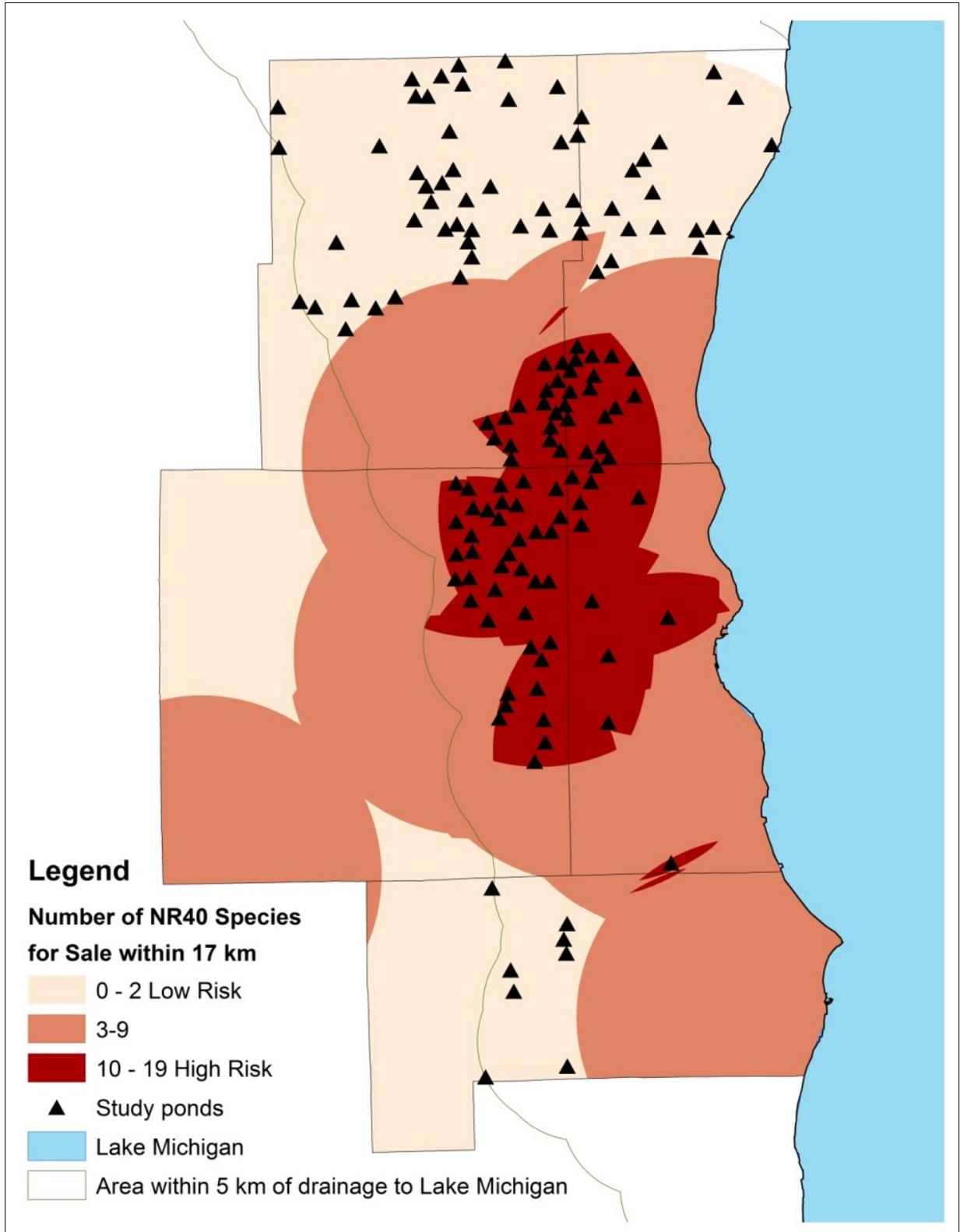


Figure 15. Study area with the locations of the 148 surveyed ponds and the high and low risk categories based on NR 40-regulated species for sale within 17 km.

Ponds were surveyed by a team of two observers (Figure 15) for invasive plants using both a visual search and rake tows with a double-headed rake sampler. The search areas were oriented in equidistant concentric rings from shore 3m apart. The first navigation ring was placed along the edge of the pond, and we searched the water to one side and 1m of shoreline to the other side (Figure 16). Both observers visually searched for invasive aquatic plants submerged, floating, or emersed. Non-wadeable ponds were searched from a canoe. The front observer searched a 3 meter strip perpendicular to the front of the canoe, while the rear observer searched 1 meter on both sides of the canoe. Surveys on shallow ponds were completed using waders and both observers were able to thoroughly search a 3m wide swath. Subsequent rings to the center of the pond were placed 3m apart until no more rings could be made. Random rake tows were used to supplement the visual search. A rake tow consisted of placing the rake on the pond bottom and dragging it for approximately one meter. For drier/dry ponds rings were placed as usual at the edge of the pond (not at the edge of the water) and surveyed visually on foot, with rake tows only in the survey rings with water. At least one rake tow per 405 m² (0.1 acre) was taken for each waterbody, but additional tows were taken in conditions of low visibility (Table 10).

Table 10. Description of the number of random rake tows taken to supplement the visual search.

Visibility	Condition	Target Rake Tows (per 405 m ²)
Clear	Bottom visible	1
Medium	Some plants visible, bottom not visible	5
Zero	No plants visible, bottom not visible	10

This survey methodology yields a probability of detection (POD) of >80% for all visibility conditions for a patch of plants 12 m² or larger. POD was calculated for the visual surveys using the inverse cube function (Koopman 1946, 1980) because we navigated search areas along equidistant, parallel lines. The POD for the rake tows was based upon the proportion of the waterbody raked.

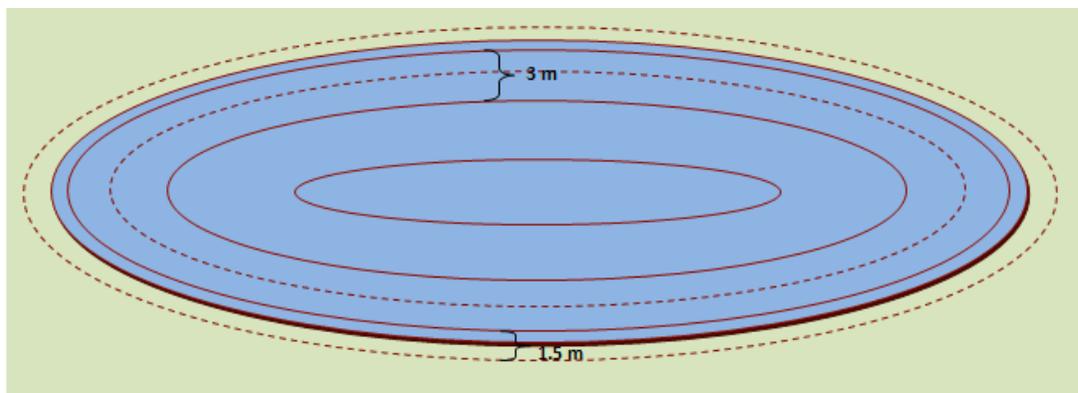


Figure 16. Example search tracks on pond. Solid line=observer path; dashed line=width of search area.

We surveyed 148 ponds between July 5th and Sept 12th, 2012. Due to the weather being very dry in 2012, many of the ponds were low water, and 22 were dry. Dry ponds were surveyed anyway, because many of the plants on our list are emergent plants. Summary statistics referring to submersed and floating species from ponds are only out of the 126 wet ponds. We found no prohibited species in ponds, but 68% of ponds had a restricted species (Table 11). Watch species were found in 70% of ponds including *Eichhornia crassipes* and *Pistia stratiotes*, which very likely had been planted.

Table 11. Species found in pond surveys and their regulatory status at the time of the survey. Percentages are calculated out of just the 126 wet ponds for *Myriophyllum spicatum*, *Potamogeton crispus*, *Eichhornia crassipes*, and *Pistia stratiotes*.

Scientific Name	Common Name	% of Ponds	Regulatory Status
<i>Phalaris arundinacea</i>	Reed canary grass	69.6%	Not regulated
<i>Typha x glauca</i>	Hybrid cattail	54.7%	Restricted
<i>Lythrum salicaria</i>	Purple loosestrife	12.2%	Restricted
<i>Myriophyllum spicatum</i>	Eurasian water-milfoil	11.9%	Restricted
<i>Potamogeton crispus</i>	Curly-leaf pondweed	7.4%	Restricted
<i>Phragmites australis</i>	Common reed	4.1%	Restricted
<i>Typha angustifolia</i>	Narrow-leaf cattail	3.4%	Restricted
<i>Iris pseudacorus</i>	Yellow flag	1.4%	Not regulated
<i>Glyceria maxima</i>	Reed manna grass	1.4%	Prohibited/Restricted
<i>Eichhornia crassipes</i>	Water-hyacinth	0.8%	Not regulated (Caution)
<i>Pistia stratiotes</i>	Water-lettuce	0.8%	Not regulated (Caution)
<i>Lysimachia nummularia</i>	Creeping Jenny	0.7%	Not regulated

We used logistic regression models to test a priori 1) whether individual species sold in the trade are more common at ponds close to stores selling that species or stores selling aquatic plants, 2) whether ponds with NR 40-regulated species are more common near aquatic plant retail locations selling NR 40 species. Post-hoc, we used logistic regression models to describe 3) the locations of planted ponds and 4) the types of ponds in which each NR 40-regulated species was more likely to be found. We conducted all analyses in R (version 2.14.1, function glm in package stats, binomial family, logit link). The post-hoc models were built manually with forward selection; variables added to the model were those that generated the largest improvement in deviance for their respective degrees of freedom (Nicholls 1989). A variable was only added to the model when it produced a significant

change in deviance ($p < 0.05$) over the simpler model and it lowered the Akaike Information Criterion (AIC) by at least two units. We did fit models with one variable even where the response was rare ($m = 5-10$). A small number (< 10) of positive response events per variable (EPV) has been shown to affect the validity of the logistic regression model (Peduzzi et al. 1996), however others suggest this value is more appropriately four EPV or fewer (Vittinghoff and McCulloch 2007). This applied to predictive models of planted ponds ($m=7$), ponds with *Typha angustifolia* ($m=5$) and ponds with *Phragmites australis* ($m=6$).

Explanatory variables considered for input into the models (Table 12) included pond characteristics such as size, type of pond, pond origin, presence of culverts or docks, and accessibility; site characteristics such as ownership, nearby use (within 30 meters), distance to nearest house, and whether or not it was connected to a wetland; regional characteristics such as position in the landscape, land use within 500 m², degree of human activity (housing density and population density), and distance to nearest recorded wild population of a given species; socio-economic characteristics such as income and education level; and horticultural characteristics such as whether the pond was in a high or low availability area (17 km radius) of aquatic invasives or distance to various nursery or aquarium stores (i.e. those selling invasives or a particular species).

Final models were checked for multicollinearity using Variance Inflation Factor (R function VIF) and validated using leave-one-out cross-validation (R function cv.glm from package boot) to estimate the prediction error rate of our models. To further determine each model's ability to discriminate, the Receiver Operating Characteristic curve analysis was used (R function ROC from package Epi). The area under the ROC curve (AUC), also referred to as the c-statistic, indicates the ability of the model to discriminate between the binary outcomes. AUC ranges from 0.5, indicating a model with poor discriminatory power (i.e. less than chance), and 1, which indicates excellent discriminatory power (i.e. perfect).

We tested all seven species found in both store surveys and pond surveys to see if ponds with a given species were closer to stores selling that species than ponds without (Table 13). We also tested for a relationship between the presence of any NR 40-regulated species in ponds and in stores. Although *Lythrum salicaria* was not found to be currently sold, historically it has been offered for sale in the horticultural trade so we also tested the relationship for that species as well, based on distance to any nursery store. *L. salicaria* and aggregated NR 40-regulated species were the only significant tests; in both cases ponds closer to retail outlets were more likely to have *L. salicaria* ($P=0.03$) and NR 40-regulated species on aggregate ($P=0.005$). The other seven species did not show any relationship between pond presence and retail outlet.

Table 12. Variables used in logistic regression models. All variables requiring calculations in mapping software used ArcGIS 10.1 and Geospatial Modeling Environment. WROC=Wisconsin Regional Orthophotography Consortium.

Variable	Type	Unit	Source
Pond			
Size	numeric	m ²	WROC imagery, 6-18" resolution
Pond dry	categorical	2 levels: yes/no	2012 field observation
Stormwater pond	categorical	2 levels: yes/no	2012 field observation
Pond origin	categorical	2 levels: natural/artificial	2012 field observation
Presence of a culvert	categorical	2 levels: yes/no	2012 field observation
Presence of a dock	categorical	2 levels: yes/no	2012 field observation
Accessible to public	categorical	2 levels: yes/no	2012 field observation
Site			
Site use within 30 m	categorical	4 levels: natural/residential/ commercial/urban park	WROC imagery, 6-18" resolution
Ownership	categorical	3 levels: public&nonprofit/ individual/commercial	County Register of Deeds
Golf course	categorical	2 levels: yes/no	2012 field observation
Distance to nearest house	numeric	m	WROC imagery, 6-18" resolution
Adjacent wetland	categorical	2 levels: yes/no	2012 field observation/24k USGS topo map
Regional			
Landscape position	categorical	2 levels: Low position/ other	DNR base hydrography layers following Riera et al. 2000 (Low=score of 1+, other<0)
Majority land use within 500 m	categorical	3 levels: agricultural/ developed/other	2006 National Land Cover Database
Housing density	numeric	n houses per km ²	U.S. Census Bureau; by 2010 census tract
Population density	numeric	n individuals per km ²	U.S. Census Bureau; by 2010 census tract
Distance to urban area	numeric	km	U.S. Census Bureau; 2010 Urbanized Area (>50,000 pop.)
Distance to nearest recorded wild population of a given sp.	numeric	km	DNR SWIMS database, WI State Herbarium, and Great Lakes Early Detection Network

Table 12 continues on next page.

Table 12. Continued. *Variables used in logistic regression models.*

Variable	Type	Unit	Source
Socio-Economic			
Median income	numeric	U.S. dollars	U.S. Census Bureau; by 2010 census tract
Percent high school education	proportion	% of adult population	U.S. Census Bureau; by 2010 census tract
Percent BA/BS	proportion	% of adult population	U.S. Census Bureau; by 2010 census tract
Horticultural			
Availability of aquatic invasives	categorical	2 levels: high/low	Based on n of aquatic invasives sold within 17 km of pond in 2012 surveys
Distance to nearest nursery or aquarium store	numeric	km	2012 surveys
Distance to nearest nursery or aquarium store selling aquatics	numeric	km	2012 surveys
Distance to nearest nursery or aquarium store selling invasives	numeric	km	2012 surveys
Distance to nearest nursery or aquarium store selling a given species	numeric	km	2012 surveys

Table 13. Results from binary logistic regression models describing species presence in ponds due to proximity to retail stores. “NR 40 species” refers to any species listed as prohibited or restricted. DV=dependent variable, IV=independent variable. Wald z-statistic and result of likelihood ratio test (LRT) on the model deviance are shown. Species currently regulated under NR 40 are indicated by *.

DV(presence/absence)	IV (distance to ...)	Estimate	Std. Error	z value	Pr (>z)	LRT
<i>Eichhornia crassipes</i>	store selling EICCRA	-0.3459	0.4242	-0.815	0.415	ns
<i>Glyceria maxima</i> *	store selling GLYMAX	-0.1104	0.1025	-1.077	0.282	ns
<i>Iris pseudacorus</i>	store selling IRIPSE	-0.0079	0.0577	-0.136	0.892	ns
<i>Lysimachia nummularia</i>	store selling LYSNUM	-0.3386	0.4266	-0.794	0.427	ns
<i>Lythrum salicaria</i> *	aquatic nursery store	-0.0585	0.0298	-1.966	0.049	*
<i>Phragmites australis</i> *	store selling PHRAUS	-0.0551	0.0489	-1.127	0.260	ns
<i>Pistia stratiotes</i>	store selling PISSTR	-0.3968	0.4043	-0.981	0.326	ns
<i>Typha angustifolia</i> *	store selling TYPANG	0.0405	0.0297	1.364	0.172	ns
NR 40 Species	store selling NR 40-regulated species	-0.1110	0.0392	-2.834	0.005	**

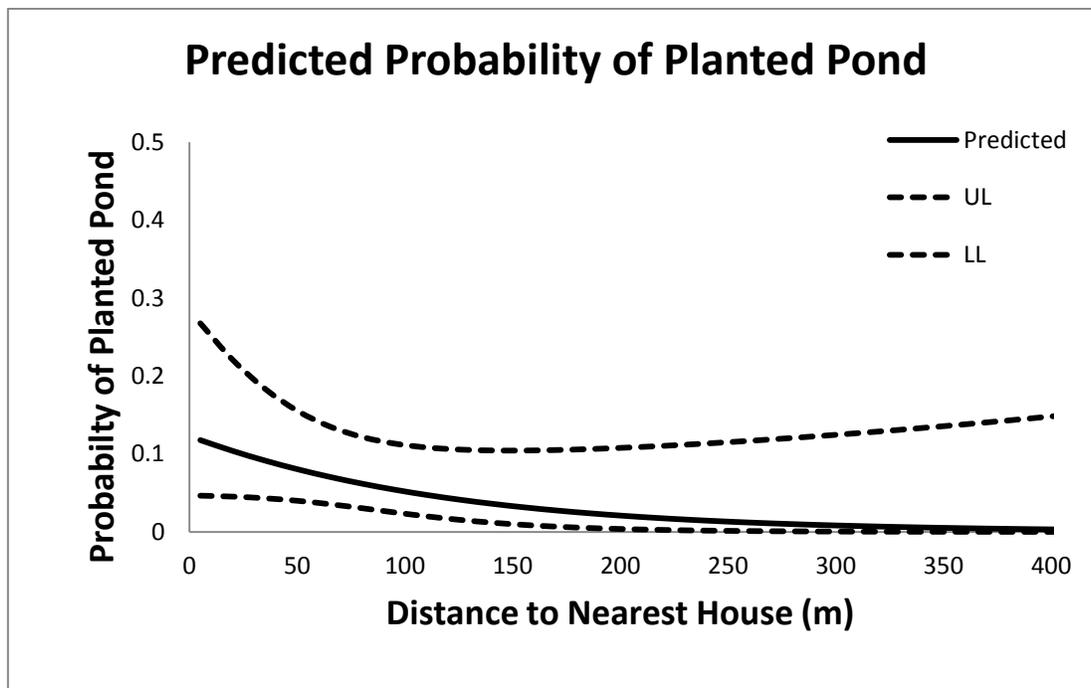


Figure 17. Predicted probability of a planted pond based on distance to nearest house. UL=upper limit (95% confidence) LL=lower limit (95% confidence).

Planted ponds were defined as ponds where we found horticultural varieties of plants (e.g., variegated plants), trade species not yet commonly found in the wild in Wisconsin (*Eicchornia crassipes*, *Pistia stratiotes*), landscaping, plants in buckets, or where we were told by the landowner that the pond had been planted. We found seven ponds out of 148 that fit these criteria (4.7%). The logistic regression model suggested that ponds closest to houses were more likely to be planted ($P=0.03$, cross-validated error 0.054, AUC=0.707, Figure 17). A number of ponds close to houses weren't planted, so the positive predictive value of the model is low (2%), but the negative predictive value is very high (87.8%).

Horticultural variables were important in just two of the seven species for which we created individual species models: *Lythrum salicaria* and *Phalaris arundinacea* were both more common closer to stores (Table 14). The site use immediately buffering the pond (30-m) was also important to the *L. salicaria* model, with both commercial sites and urban parks more likely to have purple loosestrife than a natural site ($P=0.03$, $P=0.04$, respectively), although residential buffer use did not predict presence of *L. salicaria* ($P=0.20$). Stormwater ponds were less likely to have *P. arundinacea* present ($P=0.00001$), but ponds near stores selling NR 40-regulated species ($P=0.02$) and low in the landscape ($P=0.07$) were both more likely to contain *P. arundinacea*. *Phragmites australis* was more common in ponds near urban areas, while *Typha angustifolia* presence was best explained by being near a wetland. However, the *T. angustifolia* model was not significant by the likelihood ratio test, and had poor discriminatory ability (AUC=0.662). This may partially be because occurrences were rare in our dataset (only 5 ponds had *T. angustifolia*). The hybrid cattail model (*T. X glauca*) performed almost as poorly (AUC=0.677), with presence most strongly predicted by presence of *T. latifolia*, the broad-leaved cattail and stormwater ponds. *Myriophyllum spicatum* was most common in larger ponds and ponds closer to other wild populations of *M. spicatum*. Finally, curly-leaf pondweed presence was most likely in ponds occurring on a golf course.

In addition to the logistic regression models, we tested whether or not invasive plants from trade that we found on the landscape were more commonly sold in stores than invasives from trade that were not found on the landscape. We tested this with a non-parametric Mann-Whitney U-test (R function `wilcox.test`). We found that invasives that were present in ponds were more widely available in stores ($W=241.5$, $P=0.02$). Species found in ponds were sold in a mean of 32.4 stores, while species not found in ponds were sold in a mean of only 5.1 stores. This was true when just looking at species sold in the aquarium trade, as well ($W=64$, $P=0.0173$). The presence in stores reflects the popularity of a plant and therefore should be an indication of the relative number of propagules able to disperse onto the landscape through planting. A study of availability of invasives in the horticultural trade in Britain also found that market presence was related to probability of a species escaping (Dehnen-Schmutz et al. 2006).

Finally, we created a risk map of predicted ch. NR 40 species presence in ponds statewide (Figure 18). We based this on the model predicting ch. NR 40 species presence, but modified the ownership term because this information was not readily available for all counties. The next best term was site use in the 30-m buffer around the pond (residential use or not; see Table 15), and this we were able to determine from aerial photographs for all ponds. The risk map indicates that most of southeastern Wisconsin is at higher risk for invasive species, but also that a large section of northwestern Wisconsin around the populated areas of Eau Claire and Hudson (Minneapolis-St. Paul metro area) is at higher risk. In these areas, there are a number of ponds close to houses as well as stores selling regulated species. Based on this map, Lake Michigan has a much higher threat of introduction from horticultural aquatic plants in Wisconsin than does Lake Superior.

Table 14. Results of binary logistic regression models predicting presence/absence of the most common invasive plant species found in the pond surveys. All models use the entire dataset (n=148) except for MYRSPI and MYRCRI, which use ponds that had water only (n=126). DV=dependent variable, IV=independent variable, term Pr is the result of Wald's test, CV=leave one out cross-validation, PV+=positive predictive value, PV-=negative predictive value, AUC=Area under the ROC curve, and LRT=likelihood ratio test. Species codes: LYTSAL=Lythrum salicaria, TYPANG=Typha angustifolia, PHRAUS=Phragmites australis, PHAARU=Phalaris arundinacea, TYPXGLA=Typha X glauca, TYPLAT=Typha latifolia, MYRSPI=Myriophyllum spicatum, POTCRI=Potamogeton crispus.

Model Variables (level)	DV~ IV	Estimate	Std. Error	Pr (> z)	CV Error	PV+ (%)	PV- (%)	AUC	LRT
LYTSAL~									
km to aquatic plant store		-0.2463	0.1155	*					
30-m buffer use (comm)		2.3681	1.0962	*	0.129	4.2	73.1	0.79	***
30-m buffer use (park)		2.8236	1.3860	*					
30-m buffer use (resid)		1.4259	1.1133	ns					
TYPANG~									
Adjacent wetland		2.0794	0.9653	*	0.034	2.2	84.6	0.662	ns
PHRAUS~									
km to urban area		-1.9566	1.7283	ns	0.041	0.0	91.4	0.732	**
PHAARU~									
Stormwater pond		-1.5460	0.4189	***					
km to store selling NR 40		-0.1026	0.0435	*	0.297	52.6	11.4	0.742	***
Low landscape position		1.9717	1.0960	ns					
TYPXGLA~									
TYPLAT		1.9102	0.5829	**	0.351	40.0	30.1	0.677	***
Stormwater		0.8256	0.3682	*					
MYRSPI~									
Size (m ²)		0.0002	0.0001	**	0.127	4.7	72.5	0.747	***
km to wild MYRSPI		-0.2089	0.0974	*					
POTCRI~									
Golf course pond		3.4380	0.842	***	0.071	5.1	37.5	0.714	***

Table 15. Results of the binary logistic regression model predicting presence/absence of ch. NR 40 species used for the risk map. DV=dependent variable, IV=independent variable, term Pr is the result of Wald's test, CV=leave one out cross-validation, PV+=positive predictive value, PV-=negative predictive value, AUC=Area under the ROC curve, and LRT=likelihood ratio test.

Model Variables (level)	DV~ IV	Estimate	Std. Error	Pr (> z)	CV Error	PV+ (%)	PV- (%)	AUC	LRT
NR40~					0.298	30.6	19.6	0.741	***
30-m buffer use (resid)		-1.4389	0.470	**					
km to nearest house		-0.0037	0.001	**					
Size		0.0002	0.000	*					
km to store selling NR40		-0.1066	0.042	*					

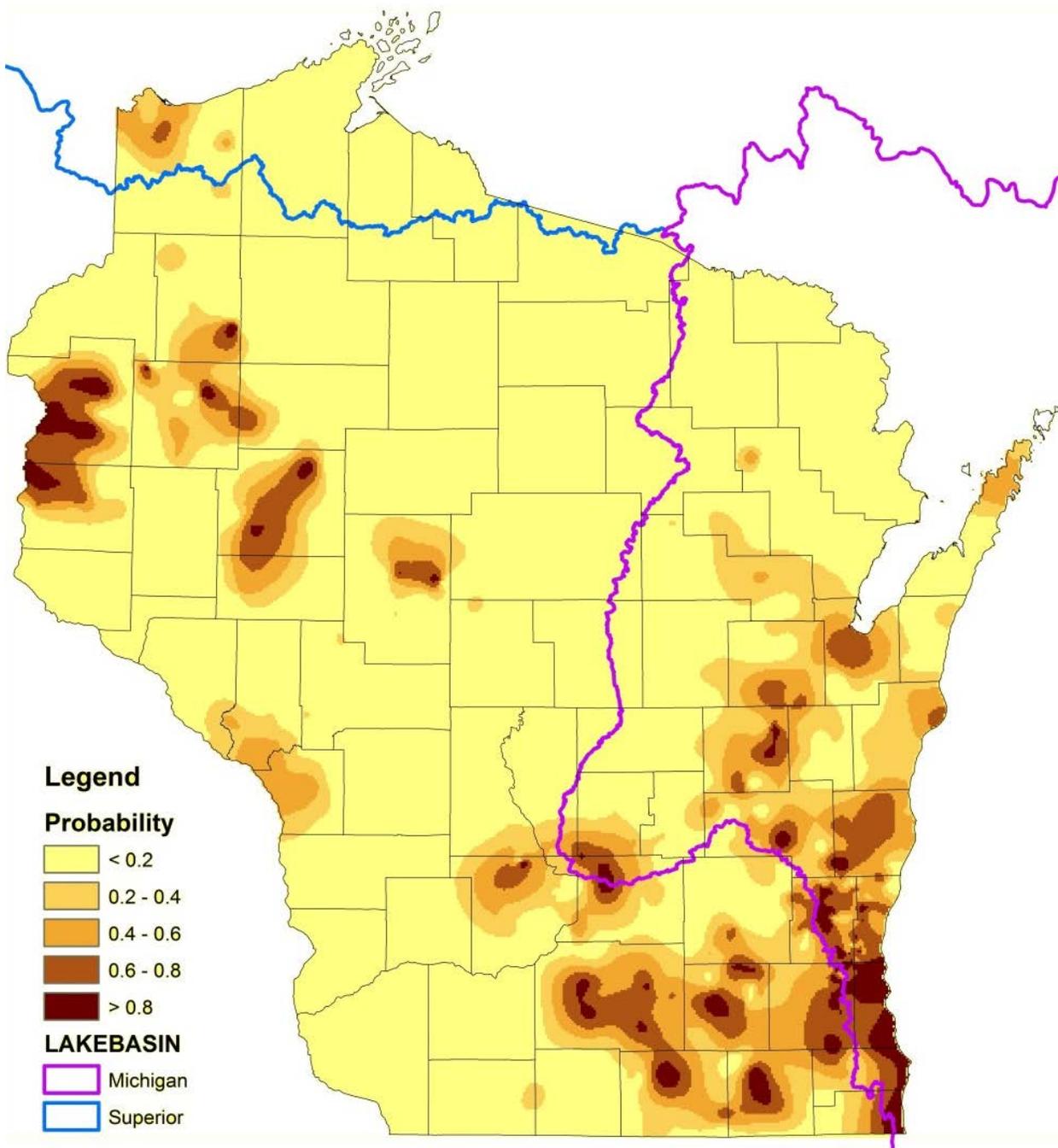


Figure 18. Risk map showing predicted probability of a pond having a ch. NR 40-listed species, based on the logistic regression model shown in Table 15.

Technology Transfer

Presentations and Displays Resulting from Work

- Webinar meeting participation: *Protecting the Great Lakes from the Internet Trade of Aquatic Invasive Species*. Great Lakes Commission webinar on January 14, 2013.
- Oral presentation: "Invasive species regulation revision and GLRI aquatic plants in trade project," DATCP Nursery Inspectors Meeting in Madison, WI, on February 12, 2013.
- Oral presentation: "Invasive Species in Trade -- Coming to a Wetland Near You?" Wisconsin Wetlands Association 18th Annual Conference in Sheboygan, WI, on February 13, 2013.
- Oral presentation: "Live Plants in Trade," Wisconsin Lakes Partnership Meeting in Boulder Junction, WI, on February 20, 2013.
- Oral and webcast presentation: "Working with Live Plant Retailers to Reduce the Availability of Aquatic Invasive Plants in Wisconsin," DNR Science Services Seminar Series in Madison, WI, on February 22, 2013.
- Poster presentation: "Landscape Risk Assessment of Invasive Aquatic Plants in Southeast Wisconsin Ponds", Wisconsin DNR Science Open House, Madison, WI, on March 1, 2013. (Poster - see Appendix P)
- Educational display: *The use of aquatic invasive plants in the classroom*, Wisconsin Society of Science Teachers Annual Conference in Wausau, WI, on March 14 -16, 2013.
- Oral presentation: "Invasive Aquatic Plants in Trade: Quantifying Availability and Risk to Wisconsin Waters," Wisconsin Lakes Partnership Convention in Green Bay, WI, on April 10, 2013.
- Regional meeting participation: Invasive Ornamental Working Group Symposium at the Chicago Botanical Gardens on October 3, 2013.
- Oral presentation: Aquatic Invasive Species Coordinators Annual Fall Meeting in Stevens Point, WI, on October 29, 2013.
- Regional meeting participation: *Protecting the Great Lakes from the Internet Trade of Aquatic Invasive Species*. Great Lakes Commission in Detroit, MI on November 20, 2013. (participated remotely)
- Poster presentation: Final results of project. Wisconsin Lakes Convention in Stevens Point on April 24-26, 2014.

Publications Resulting from Work

Species Lists and Resources for Pet and Aquarium Stores – Appendix D

Invasive Aquatic Plants and Their Other Names – Appendix G

Are your snails okay? – Appendix H

Crayfish and the Invasive Species Rule – Appendix I

Chapter NR 40 *Regulated Plants* – Appendix J (revision only)

Brochure: *Protect Your Pond or Water Garden* – Appendix K

Brochure: *Make the Right Choice about Elodea* – Appendix L

Information and Education Products

Outreach letter for Pet and Aquarium Stores – Appendix E
Outreach letter for Aquatic Plant Nurseries – Appendix F
Teacher mailing cover letter – Appendix M
Pond retailer mailing cover letter – Appendix N
Pond owner mailing cover letter – Appendix O

Peer-reviewed Journal Articles

We have three journal articles that are currently in preparation to be submitted to peer-reviewed journals:

- The impacts of educational efforts as demonstrated in retailer response to mailed social survey
- Availability of aquatic invasive plants in the live plant trade before and after education on invasive species regulations
- Patterns of invasive species occurrence and relationship to the aquatic plant trade in small water bodies across an urbanized landscape in Wisconsin

Lessons Learned, Recommendations, and Future Work

Retailer Awareness of Invasive Species & Understanding of Laws

Through this study we sought to increase retailer awareness of invasive species and understanding of Wisconsin's invasive species laws. We sought to measure the change in awareness and understanding through direct questions in the social surveys and through observed behaviors in the retailer stock surveys. Our survey results highlight part of the picture, but our in-person experiences with retailers, and our involvement with regional industry discussions and meetings provided additional pieces of information to synthesize. With all of these pieces in mind, we can paint a fairly complete picture of retailer awareness of invasive species and understanding of the associated laws. This study provided additional information that will be used by Wisconsin DNR staff to inform current partnerships and future interactions with the plant industry. Above all, this effort provided ten Wisconsin DNR with an opportunity to engage with the industry out on the landscape in a new way, which has helped to establish better working relationships and general good will between the regulators (Wisconsin DNR) and the regulated industry. During several site visits, retailers expressed their gratitude for the individual attention and the education-first approach towards enforcement. Some retailers engaged with Wisconsin DNR staff beyond the formal visits, such as through the collaborative Sea Grant workshop and additional communications when seeking to have questions answered. In an email correspondence after receiving additional educational materials in 2013, one such retailer commented,

"I wanted to say thank you for the 'Protect Your Pond or Water Garden' brochures and the 'Know Your Plants - Know the Rules' publication that you sent. They are very helpful to me and my staff, as well as our customers in making sure we are doing the right things for the Wisconsin environment. As always, I appreciate the positive, cooperative, proactive approach that you and the DNR are taking in trying to prevent the introduction of invasive aquatic species in or state. I commend your efforts and look forward to helping in any way that I can."

Comments such as this are encouraging, even though they do not quantitatively demonstrate our success. They do, however, reinforce our measures and provide a qualitative element that is invaluable.

While we saw a general increase in awareness and knowledge, some disappointments remained. Following the 2013 round of the social survey, a small number of retailers still reported planning to sell regulated invasive species (4.7% of respondents reported that they planned to sell parrot feather, *Myriophyllum aquaticum*). This percentage was down considerably from the 8.0% that planned to sell *M. aquaticum* in 2012, but our aim was to get that percentage down to 0%. Why would retailers still plan to sell a regulated plant after learning that it is prohibited? Parrot feather has been a widely popular landscaping plant in the past. It is possible that retailers plan to continue its sale despite knowing of its prohibition. However, it is also possible that the few retailers that planned to continue its sale did not realize that that specific plant was regulated. On two occasions following up with retailers that continued to sell regulated species after being educated through several venues, the retailer claimed to have not realized that the plant was regulated, and quickly pulled the plant from sale upon learning of its status. This situation could be a direct reflection of the plant familiarity and naming challenges described in the "Effectiveness of Outreach & Educational Efforts" discussion which follows. The retailers could be generally familiar with the regulations, have reviewed the regulated plant lists, and have missed a few of the regulated plants.

Conversely, it is possible that retailers were aware of the prohibition and continued its sale because there was little perceived threat of repercussion for continuing the sale. In the coming years, consistent enforcement of the regulations across the state will be vital to ensure that this does not become a common practice.

Following the 2013 round of the social survey, 25.5% of respondents still felt that they were “not at all knowledgeable” about Wisconsin’s invasive species regulations. Perhaps these respondents never opened the outreach packet that arrived in the mail, or perhaps the information delivery method was inadequate to reach them. It is hard to say. It would be worthwhile to follow-up directly with these retailers to determine what form of education would work for them initially.

At the same time, 28% of respondents felt they were just “a little knowledgeable” and 43.2% of respondents felt they were either “somewhat,” “very,” or “extremely” knowledgeable about invasive species regulations. Both of these numbers slightly increased from 2012 when 27.1% were “a little knowledgeable” and 35.6% either “somewhat,” “very,” or “extremely” knowledgeable. For the majority of the respondents, the educational efforts we delivered at a minimum provided a foundation for increasing their understanding. Over time, with increased educational efforts we would expect to see this trend continue.

Availability of Regulated Species in Trade

Although we did not find any evidence that the informational mailer reduced the prevalence of invasive species in stores, the educational outreach visit to retailers did. Across all stores, we detected 2012 to 2013 decreases in the most common regulated species, as well as an improvement in the number of stores compliant with the regulations. This is encouraging that many retailers responded quickly to become compliant with the invasive species regulations.

There is additional work to be done: 23.6% of stores were still noncompliant in 2013. Not all regulated species decreased. *Nymphoides peltata*, *Butomus umbellatus*, *Phragmites australis*, and *Typha angustifolia* were still being sold and did not show any reductions from 2012 to 2013 stock surveys. However, all of these species were relatively uncommon in the 2012 surveys to begin with; the most common species was only present in 3% of stores. It is possible that these species were more widely recognized as invasive (either by customers or retailers) due to their presence and impacts in the wild in Wisconsin. Other invasive species present or widespread in the state that reportedly were sold in the live plant trade, but not found in our surveys, include *Myriophyllum spicatum* and *Lythrum salicaria*. If this is a contributing factor to the baseline presence of the restricted species, then education about up-and-coming (prohibited) invasive plants targeting water gardeners, pond owners, and aquarists may help reduce further the demand for prohibited species and help prevent their introduction to the state.

Our analysis shows that although mislabeling is rare in the live plant trade overall, several species continue to be mislabeled. Those identified previously include *Myriophyllum* spp. and *Egeria densa* (Thum et al. 2012). However, we also found *Cabomba caroliniana* to be mislabeled. *Egeria densa*'s mislabeling issues appear to arise from historical name changes as well as cryptic with other closely related species (*Egeria najas*, *Elodea canadensis*, *Hydrilla verticillata*). The mislabeling issues we observed with *Myriophyllum aquaticum* and *Cabomba caroliniana* appear to also be due to breeding and changes occurring with the species in the trade: hybridization and development of varieties. These are not well identified and pose a considerable hurdle for regulatory agencies to enforce regulations prohibiting these two

species. Furthermore, a plant unidentifiable morphologically and genetically was found in our surveys (*Myriophyllum* sp. 'propium'), despite the *Myriophyllum* genus being relatively well-sequenced (Aiken 1981, Moody and Les 2010, Thum et al. 2012).

Although hitchhiking species are concerning as an invasion pathway, we did not commonly find them on purchases in our study. Other studies of hitchhikers on aquatic plants have found much higher rates of unwanted taxa (>90%; Maki and Galatowitsch 2004, Keller and Lodge 2007); however, these included non-vegetative propagules whereas our study did not. This is not to say that unwanted taxa purchased on plants pose little risk: hitchhiking hydrilla (*Hydrilla verticillata*) was responsible for the only known population of hydrilla found to date in Wisconsin. Multiple stores in our study had the regulated parrot feather (*Myriophyllum aquaticum*) hitchhiking in unregulated emergent plants that were not purchased as vouchers. We did not observe any changes in the prevalence of unwanted taxa between 2012 and 2013. Had stores incorporated recommended best management practices to remove contaminant plants and animals prior to sale, we would have expected to see a decrease in the presence of hitchhikers. The biological results as well as the social survey results indicate that most stores did not implement preventative procedures to remove hitchhiking organisms.

It is somewhat surprising that we did not observe any increases in unregulated species to compensate for the decreases in regulated plants. Stores would be expected to find alternatives to the regulated plants in order to continue to offer their customers a variety of plants for their water gardens or aquaria. It is possible that they did not find alternatives as quickly as they were able to pull regulated stock from their shelves, and this might change if annual surveys were continued. Alternatively, the replacements selected may have been non-invasive plants already available in the trade or native species and therefore not tracked in this study. The introduction of new species into the live plant trade from new climates and regions of the world has been identified as a major contributor to future waves of horticultural-mediated invasions (Bradley et al. 2012). Continued vigilance and periodic assessment of species introduced into trade will be required to ensure that species adopted do not pose an invasion risk in Wisconsin or the Great Lakes region. Table 16 lists several species observed frequently in our surveys but not tracked formally. Future studies could evaluate these species for invasiveness in the Great Lakes region using available risk assessment tools, or alternatively screen them for a "green" list (Dehnen-Schmutz 2011).

Effectiveness of Outreach and Educational Efforts

We measured the overall effectiveness of our educational efforts by the self-reported information in the completed social surveys as well as by in-store stock surveys completed before and after the educational efforts. Overall, our results showed an increase in compliance for both the visited and unvisited groups, suggesting that the educational approach of sending informational mailings was successful. However, no significant difference was found between the magnitude of change in the visited versus the unvisited groups.

Initially, this may be a good sign for regulators and land managers – the impact of mailed outreach materials was not significantly different than the impact of in-person educational visits. It is considerably less resource-intensive to mail or email materials than it is to physically visit someone in person. However, when it comes to implementing a truly effective educational approach for behavior change, the real lesson here may not be that publications and in-person learning are equally valuable – rather the lesson may be that one visit is not enough.

Changing behavior is a complex task that has received attention in diverse fields ranging from environmental education, to healthcare, to resource management, and social marketing. Research from the field of environmental education has demonstrated that one-time visits are valuable, but that repeated and ongoing environmental experiences are most effective (Falk & Falling, 1980; Knapp, 2000; Koran, et al, 1989). Our educational approach acknowledged this in that the “visited” group had at least two incidents of contact, versus one incident of contact for the unvisited group. However, insights from this field suggest that additional visits, repeated points of contact, would be needed to see a significant difference between the two groups. Even one more educational contact may have been enough to tip the scales between the visited and unvisited groups. Additional studies would be needed to affirm this.

What we learned both quantitatively and qualitatively throughout this project has helped us form recommendations for future outreach and enforcement. Through our efforts we have developed a useful outreach approach and recognized several major gaps that needed to be addressed with this particular regulated community.

Each in-person visit was tailored to the needs of the retailer to the extent feasible. However the nature of the visits had some limitations. Each visit was unannounced and varied per the time the owner or manager had available. The basics of the regulations were explained and the educational packet included resources to help the retailers understand the regulations completely. Wisconsin’s invasive species regulations are complex and a full understanding of them requires further study than a twenty minute tutorial. Those retailers that attended supplemental workshops or did their own personal study would have developed a much better familiarity with the regulations than those that did not go beyond what was provided. To address the needs of this regulated community in the future, it would prove valuable to make multiple educational opportunities available such as providing workshops in coordination with trade organizations, online resources and tutorials, and in-person visits where appropriate.

Two other issues that became clear during this project were retailers lack of familiarity with certain plants and differences in naming conventions. Addressing these issues will be vital in all future outreach efforts. Every retailer has a different level of knowledge related to plants – some are trained botanists, some have training through working in the industry, and some have a mix of other related training from a variety of sources. For pet stores in particular, some retailers may have no training in plant identification at all. This range of knowledge means that not all retailers will be familiar with all of the listed regulated plants. While Wisconsin’s regulations list only about sixteen purely aquatic plant species, the regulations cover over seventy-five individual plant species. The learning curves related to becoming familiar with all regulated plant species varies widely for Wisconsin retailers.

In addition to basic familiarity with plants, retailers in the plant industry face another challenge in regards to the naming of plants. It is well understood within the biological fields that species may have many different common names which vary by region or due to other factors. For this reason, the scientific community relies upon the scientific or Latin names of species to ensure that communication can happen about species consistently across regional or national boundaries. Within the plant industry species are often only known by a common name, or may additionally be known by a specific trade name. This means retailers may not be familiar with the current scientific names regulated species are listed under. In an effort to address this issue, Wisconsin has available a master list of known synonyms for regulated species (common, scientific, and trade names). This is a resource that has been valuable for Wisconsin retailers, but we found additional resources were needed to address this issue for aquatic plant retailers. This was the primary reason that the resource *Invasive Aquatic Plants and Their Other Names* (Appendix G) was created during this project. This resource focused in on the top eight aquatic plants that retailers were most likely to encounter to help focus awareness. This

resource is now available electronically to all audiences on the DNR’s website. Additional focused resources such as this would prove valuable to help other business audiences best understand how Wisconsin’s invasive species regulations affect their industries.

Table 16. *Non-native, unregulated plants for sale in Wisconsin live plant trade. This list is not exhaustive. Inclusion on this list does not mean the plant is invasive, only that it was commonly offered for sale.*

Scientific Name	Common Name	Plant Type
<i>Alternanthera reineckii</i>	Scarlet temple plant	Aquarium
<i>Anubias barteri</i>		Aquarium
<i>Aponogeton madagascariensis</i>	Madagascar lace	Aquarium
<i>Bacopa caroliniana</i>		Aquarium
<i>Bacopa monnieri</i>	Moneywort	Aquarium
<i>Cryptocoryne wendtii</i>		Aquarium
<i>Echinodorus spp.</i>	Sword plant	Aquarium
<i>Egeria najas</i>	Narrow-leaf anacharis	Aquarium
<i>Glossostigma elatinoides</i>	Glosso	Aquarium
<i>Hemianthus callitrichoides</i>	Dwarf baby tears	Aquarium
<i>Hygrophila corymbosa</i>	Temple plant	Aquarium
<i>Hygrophila difformis</i>	Water wisteria	Aquarium
<i>Lilaeopsis brasiliensis</i>	Micro sword	Aquarium
<i>Ludwigia arcuata</i>		Aquarium
<i>Ludwigia glandulosa</i>		Aquarium
<i>Ludwigia repens</i>	Red ludwigia	Aquarium
<i>Microsorium pteropus</i>	Java fern	Aquarium
<i>Myriophyllum crispatum</i>	Upright watermilfoil	Aquarium
<i>Nymphoides aquatica</i>	Banana plant	Aquarium
<i>Rotala indica</i>		Aquarium
<i>Sagittaria subulata</i>	Dwarf sagittaria	Aquarium
<i>Vallisneria spiralis</i>	Italian or corkscrew Val	Aquarium
<i>Aponogeton distachyos</i>	Water hawthorn	Aquarium/Pond
<i>Cyperus alternifolius</i>	Umbrella palm	Pond
<i>Glyceria striata</i>	Manna grass	Pond
<i>Houttuynia cordata</i>	Chameleon plant	Pond
<i>Hydrocleys nymphoides</i>	Water poppy	Pond
<i>Iris ensata</i>	Japanese iris	Pond
<i>Iris fulva</i>	Louisiana iris	Pond
<i>Saururus cernuus</i>	Lizard tail	Pond
<i>Tulbaghia violacea</i>	Water garlic	Pond

Distribution of Invasive Species Relative to Retail Sources

Our work on assessing the landscape level risk of horticultural sources of aquatic plants shows that there are links between species sold and species present on the landscape. Invasive aquatic plants that were present in ponds in our surveys were the species most commonly sold in stores. This effect could be due to escape of propagules directly from plants grown at the nursery, customers purchasing and planting the plant on the landscape, and/or secondary spread following planting in a new location. This finding is consistent with Dehnen-Schmutz et al. (2006), who found that species that had escaped from cultivation were offered more commonly in 19th century nursery catalogs than species that had not escaped, and over half were no longer on sale.

For *L. salicaria*, and for all NR 40-regulated species together, there was a spatial relationship between retail source and landscape presence as reflected by the results of our distance to store models. In addition, this relationship may persist after the plant is removed from sale: although *L. salicaria* was not sold in any retail stores in our survey in 2012, the pond populations we observed were geographically closer to aquatic plant stores. This spatial relationship was not replicated at the scale we made observations, so it is difficult to say what characteristics of *L. salicaria* contributed to the observed pattern. Other species may exhibit a similar relationship at a broader scale, or this may be an isolated pattern due to the extreme popularity of this plant.

Planted ponds were much more likely near houses than away from them. While it makes sense that people would beautify the ponds closest to their houses, we cannot rule out the possibility of our data showing a spurious connection because we were more likely to have known that a pond was planted if the landowner talked to us while we did the survey. While we used other indicators, this transfer of information did not occur with ponds out of view of houses, and certainly, people do plant ponds to benefit wildlife, rather than just for aesthetic reasons. Despite the intuition that planted ponds would be more likely to have invasives from the plant trade, as well, our data did not support this. This may be due to the small number (only 7 ponds) of water bodies we discovered that had been planted. With these caveats in mind, our data does show that there are a number of waterbodies that would not be likely to be intentionally planted (those over ~150m from a house).

The individual species distribution models we ran indicate that although some horticultural variables may affect the presence of certain species, their relative importance to other variables is low. There were some interesting relationships elucidated by our data, including *Potamogeton crispus* being more prevalent on golf courses, *Myriophyllum spicatum* being more common in larger ponds near other infestations, and *Typha X glauca* being more common in ponds where the native *T. latifolia* is present, however these relationships are tangential to the focus of our study and will not be further discussed here.

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Appendix A. Education and Outreach Plan

Introduction

General approach: In developing an educational plan, it is critical to ensure that the methodology and materials are valued, relevant and accessible to the audience at hand. In essence, this requires that the educational approach starts “where they’re at” and builds from there. Successful implementation requires understanding the audience, which includes knowing what the audience knows already, what challenges they face, and what support they would like to receive. To better understand these audiences, I reviewed business and association websites, professional newsletters and catalogues. Personal communication and past partnerships within the industry were also considered. Finally, I reviewed Sea Grant’s efforts with aquatic retailers. Personal contact with each retailer will ultimately form the best understanding, as it will be relationally based. Businesses have many goals in regards to how they operate. In determining the best way to approach aquatic plant retailers, I have included considerations of the following business desires:

- *to be economically successful*
- *to please customers*
- *civic duty to contribute to the community or “do right”*

Educational Goals:

- | | |
|---|--------------------------------------|
| 1) Inform retailers of the invasive species regulations | Material Tool
(O5a) |
| 2) Increase retailer knowledge of NR40 regulations | (O5a) |
| 3) Help retailers identify prohibited and restricted species | (O5a, samples) |
| 4) Increase awareness of the threats posed by AIS | (O5b, case study) |
| 5) Increase understanding of the ecological risks aquatic invasive species present | (O5b) |
| 6) Increase the number of plant nurseries, water garden and aquarium retailers that use best management practices | (O5b, demos) |
| 7) Increase retailer awareness of native plant alternatives | (O5b, O5c) |

Outputs:

- 1) Education & Outreach Plan for aquatic plant retailers
- 2) Best management practices (For aquatic retailers & aquaculture)
 - a. Background research
 - b. Agreed-upon
- 3) Background research on behavioral change
- 4) Data : Self-reported data on awareness, preventive measures, and aquatic plant sales
- 5) Supporting educational materials
 - a. What they need to know (Regulations & ID) -- **Regulated AIS 2012 handout**
 - b. Actions they need to take (Risk & BMPs) -- **Handout**
 - c. Resources for their customers (Native plants, Regs & BMPs, pond, water garden, aquarium specific resources) -- **Brochure, posters, Habitatitude & Sea Grant Materials**
 - d. Outreach letter -- **letter**

Methodology

- 1) Personal contact
 - 1) phone call
 - 2) survey
 - 3) any follow-up
 - 4) letter
 - 5) phone/email
 - 6) visit
 - 7) follow-up
- 2) Educational materials (a. Regs & ID, b. BMPs, c. Customer resources, d. outreach letter)
- 3) Visit: Explanation of NR40 & ID help (script, plant samples, other tools) ; material distribution

Audiences

Aquatic Plant Retailers in Wisconsin

1) NURSERIES

Survey Categories: **A.** Garden Center, Greenhouse or Nursery;
B. Water Garden or Pond Store; **C.** Home Improvement or Hardware store

Codes: 1000s: "licensed/reported", "licensed/considering" & "licensed/past, future"
2000s: "licensed/unknown"; 3000s: "unlicensed/reported"; 4000s: "unlicensed/unknown"

2) PET STORES/ AQUARIUMS

Survey Categories: **D.** Aquarium or Pet store

Codes: 5000s aquarium and pet stores

Education & Outreach Plan

Actions:

1. Develop material packets: Regulations, BMPs, other resources
 - a. Regulations
 - Summary
 - List of what not to sell
 - Info on other species (terrestrial plants, fish, inverts, etc)
 - b. BMPs
 - c. Resources
 - List of native alternatives
 1. List of where to get plants
 - Materials for customers
 1. water gardeners, rain gardeners, wetland users, lake owners
 2. aquarium keepers, pet owners
 3. Habitatitude
 - d. Variety for different types of businesses
2. Write letter as follow-up to survey; introduction; thank you
3. Contact and arrange visits
4. Visit
 - a. Provide materials
5. Follow-up
 - a. Via phone, email, or letter (preferred option of business)
6. Contact outreach associations/ groups (See outreach contacts in Pond excel)
 - a. Write article for trade organizations
 - b. Present at tradeshow
 - c. Provide workshops
 - Bruce company provides seminars: <http://www.brucecompany.com/pages/wholesale/Ponds-Water-Features.php>
 - Hobbyist groups, etc.
7. Create long-term update/ outreach contact plan - integrate into overall outreach

Resources:

General Outreach Outlets: See "Internet_Outreach" excel file in GLRI folder

Timeline

<p>Winter 2012</p> <ul style="list-style-type: none"> - Develop social survey <p>March 2012</p> <ul style="list-style-type: none"> - Send out social surveys - Develop educational materials <p>April 2012</p> <ul style="list-style-type: none"> - develop educational materials <p>May 2012</p> <ul style="list-style-type: none"> - review with partners (SG, UWEx) - develop letters - Finalize educational materials - Update AIS coordinators <p>June 2012</p> <ul style="list-style-type: none"> - Send letters - Visit preparation - Survey analysis - Habitatitude meeting <p>July / August/ September 2012</p> <ul style="list-style-type: none"> - review social survey data - Site visits - Complete targeted Outreach Campaign to "non-compliant" retailers <p>October 2012</p> <ul style="list-style-type: none"> - Analyze social survey data - Meet with groups 	<p>November 2012</p> <ul style="list-style-type: none"> - Analyze social survey data - Meet with groups <p>Winter 2013</p> <ul style="list-style-type: none"> - revise social survey - meet with groups <p>February 2013</p> <ul style="list-style-type: none"> - Send follow-up social survey (assess change due to education and outreach) <p>Summer 2013</p> <ul style="list-style-type: none"> - Assess education and outreach efficacy - Analyze data - Use results to guide the educational approach for the future - Plan for conference presentations <p>Fall 2013 & Winter/Spring 2014</p> <ul style="list-style-type: none"> - Share results <ul style="list-style-type: none"> o Lakes Convention o AIS Coordinators meeting o others - Publish findings
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Background from Grant Proposal

We should conduct an education campaign so that a greater number of retailers and consumers understand the new regulations.

We will assess the impact of education and outreach activities on vendor behavior by repeating this retailer survey in the field season of 2013, a year after the implementation of educational programs. **Whereas changes in general knowledge may be more easily achieved through education and outreach, it is of interest to us to determine whether education leads to actual behavioral change.**

During the first year of the project, we will administer a social survey to retailers*, landscapers, and growers in order to identify preventive procedures already in place and assess retailers' knowledge of aquatic invasive species issues and new statewide regulations. **Past social marketing research targeting boaters and anglers has shown personal contact to be more effective than written notices, advertizing**

or other forms of contact, and we will be including this as part of a multi-faceted educational approach (Shaw, personal communication). Our educational goals include informing vendors of new regulations, helping them identify prohibited and restricted species, and increasing their awareness of threats posed by AIS.

We will implement this focused educational program during the first full summer field season of 2012 by targeting non-compliant vendors identified during the spring biological vendor survey. We then plan to use the results collected during the 2013 biological vendor follow-up surveys to guide the educational approach for the future beyond the timeframe of this project. This targeted, strategic outreach effort that focuses on the urban areas that pose the highest risk for the establishment of new invasive plants **will leverage both efforts by the local Sea Grant offices to increase the visibility of the Habitatitude campaign that encourages responsible care for pond and aquarium organisms and new state efforts to increase awareness and compliance with invasive species laws.** By collecting information on the threats of AIS via the live organism trade both in 2012, before the educational campaign and in 2013, following the targeted campaign, we can assess our impact, facilitate EPA oversight, and allow our educational effort to progress in as cost-effective and beneficial a manner as is possible.

Time	Objective	Steps	Achievements
Spring 2012	<ul style="list-style-type: none"> Develop social survey Develop education and outreach materials 	<ul style="list-style-type: none"> Develop and send simple social survey to aquatics retailers Create educational plan, identify best management practices for aquatics retailers 	<ul style="list-style-type: none"> Education plan and support materials
Summer 2012	<ul style="list-style-type: none"> Education and outreach to aquatics retailers 	<ul style="list-style-type: none"> Site visits to aquatics retailers identified during aquatics retailer surveys 	<ul style="list-style-type: none"> Education and outreach
Fall 2012	<ul style="list-style-type: none"> Synthesize social survey results 	<ul style="list-style-type: none"> Analyze social survey data 	<ul style="list-style-type: none"> Self-reported data on awareness and preventive measures of aquatics retailers in Wisconsin
Winter 2013	<ul style="list-style-type: none"> Assess change in beliefs due to education and outreach 	<ul style="list-style-type: none"> Send follow-up social survey 	
Summer 2013	<ul style="list-style-type: none"> Assessment of efficacy of education and outreach 	<ul style="list-style-type: none"> Quantify aquatics retailers' awareness of invasive species issues after education 	<ul style="list-style-type: none"> Peer-reviewed paper written and submitted

Fall 2013	<ul style="list-style-type: none"> • Build cooperation among states and increase impact of study 	<ul style="list-style-type: none"> • Participate in state and regional events to share outcomes and strategies to regulate live organism trade • (into Winter/Spring 2014) 	<ul style="list-style-type: none"> • Interstate collaboration and increased potential to prevent AIS introductions
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Overall GOALS

- The number of plant nurseries, water garden and aquarium retailers that use best management practices for aquaculture will increase
- Retailers’ beliefs about AIS will more often include an understanding of the ecological risk they present.
- Retailers’ awareness of the use of native plant alternatives will increase
- Retailers’ knowledge of Wisconsin’s Chapter NR 40 Invasive Species Identification, Classification and Control Rule will increase

As a part of this project, **UW-Extension and DNR will work together to build an educational approach strategically targeted to in-state retailers of regulated species.** The DNR will personally contact all licensed retailers of aquatic and wetland plants and present educational materials, information on best management practices, as well as an explanation of the new NR40 Invasive Species Identification, Classification, and Control Rule. In addition, results from the initial and final social and biological surveys of retailers will be presented at the annual Wisconsin Lakes Convention and the Wisconsin AIS Coordinators Meeting in order to communicate findings to lakeshore owners and county AIS coordinators. These groups of people have a proven capability of spreading information about AIS statewide; communicating our study results will greatly expand our message about prevention of AIS via the live organism trade. Surveying non-compliant retailers a second time will help quantify the efficacy of our educational program and help guide and target future education and enforcement actions.

Note: Surveys were sent to self-identified aquatic plant retailers, and DATCP identified aquatic plant growers. Landscapers were omitted if they did not have a retail location. They will receive outreach and education outside of this project.

Appendix B. 2012 Social Survey Response Data

2012 DNR Aquatic Plant Study Final Response Rate Report

Project Summary

The UWSC was contacted in December of 2011 by the Wisconsin Department of Natural Resources to conduct a project evaluating the availability of aquatic plants at various retail and wholesale outlets throughout the state. The primary goal of the project was to measure the types of plants available and to assess the overall knowledge and attitudes of personnel involved selling and distributing aquatic plants.

The UWSC is a department in the College of Letters and Science at the University of Wisconsin-Madison. Funding for the UWSC comes from funds provided by the College and from revenue generated by contractual work. The UWSC serves the survey research needs of the University of Wisconsin, government agencies, and non-profit organizations. The mission of the UWSC is to assist researchers by providing a complete range of high quality survey research services. Professor Nora Cate Schaeffer is the Faculty Director, and John Stevenson is Associate Director, of the UWSC. Christopher Huard acted as the Project Director for this study.

Sample Design

This project consisted of a sample that was broken down into 5 groups. The breakdown of respondents per sample group is displayed in the table below. The sample file was provided by the client.

Sample Group	ID Range	Number of Respondents within Group
Licensed/Reported	1000s	170
Licensed/Unknown	2000s	244
Unlicensed/Reported	3000s	33
Unlicensed/Unknown	4000s	26
Pet stores	5000s	110
TOTAL	n/a	583

This was a 3 wave mail study with a reminder postcard. The 1st mailing included a cover letter, survey, a pre-paid return envelope and a \$2 bill incentive. The 2nd mailing was a reminder follow-up postcard. And the 3rd and 4th mailings mirrored the 1st but they were only sent out to participants who had not yet responded and there was no monetary incentive included. There was a 1 week waiting period between mailing 1 and mailing 2 (reminder postcard). There was approximately 2-3 weeks between mailing 2 and mailing 3 and another 2-3 weeks between mailings 3 and 4. The field period for this project ended on 7/1/12. Below is breakdown of the 4 mailings including mail dates and number of surveys sent.

Mailing	Date Sent	Number Sent
1 (included \$2 incentive)	3/22/2012	583
2 (postcard)	3/28/2012	580
3	4/18/2012	283
4	5/9/2012	204

Response Rate

Below are tables summarizing the outcome of each survey group.

Licensed/Reported

Sample Disposition	Total Cases
Completed Survey	102
Refusal	1
Ineligible	8
Undeliverable	4
No Reponse	55
Total	170
Response Rate	63.9%

Licensed/Unknown

Sample Disposition	Total Cases
Completed Survey/Partial	146
Refusal	2
Ineligible	27
Undeliverable	7
No Reponse	62
Total	244
Response Rate	68.6%

Unlicensed/Reported

Sample Disposition	Total Cases
Completed Survey/Partial	20
Refusal	0
Ineligible	3
Undeliverable	1
No Reponse	9
Total	33
Response Rate	70.0%

Unlicensed/Unknown

Sample Disposition	Total Cases
Completed Survey/Partial	7
Refusal	0
Ineligible	4
Undeliverable	4
No Reponse	11
Total	26
Response Rate	38.9%

Pet Stores

Sample Disposition	Total Cases
Completed Survey/Partial	46
Refusal	0
Ineligible	13
Undeliverable	19
No Reponse	32
Total	110
Response Rate	59.0%

Summary

TOTAL

Sample Disposition	Total Cases
Completed Survey*	323
Refusal	3
Ineligible	55
Undeliverable	35
No Reponse	167
Total	583
Response Rate	64.9%

*2 surveys were returned with no ID labels thus could not be included in one of the previous tables but are included here

Simple Response Rate

$$\begin{aligned}
 & \text{\# of completed interviews - refusals} \\
 = & \frac{323 - 3}{583 - 55 - 35} \\
 = & \frac{320}{473} \\
 = & \mathbf{64.9\%}
 \end{aligned}$$

Appendix C. 2013 Social Survey Response Data



**SAMPLE DESCRIPTION AND RESPONSE RATE REPORT FOR
The Aquatic Plant Survey (follow-up)
P9977**

JUNE 18, 2013

Project Summary

The UWSC was re-contacted in December 2012 by the Wisconsin Department of Natural Resources to conduct a follow-up project evaluating the availability of aquatic plants at various retail and wholesale outlets throughout the state. The primary goal of the project was to measure the types of plants available and to assess the overall knowledge and attitudes of personnel involved in selling and distributing aquatic plants. The follow-up project also aimed to gauge the impact of the outreach efforts made by the Wisconsin DNR after the initial survey in March 2012.

The UW Survey Center (UWSC) is a department of the College of Letters and Science at the University of Wisconsin-Madison, and is supported by the College and revenue generated from contractual work. The UWSC serves the survey research needs of University of Wisconsin faculty, staff, and administration; faculty at other universities, federal, state, and local governmental agencies and not-for-profit organizations. The mission of the Survey Center is to assist researchers by providing the highest quality survey research services and as such, the Survey Center provides the complete range of survey research capabilities. Professor Nora Cate Schaeffer is the Faculty Director of the UW Survey Center. Christopher Huard served as Project Director on this project.

Sample Design

The project consisted of a sample that was broken down into 5 groups. The breakdown of the respondents per sample group is displayed in the table below. The sample file was provided by the client.

Sample Group	ID Range	Number of Outlets in Group
Licensed/Reported	1000s	156
Licensed/Unknown	2000s	233
Unlicensed/Reported	3000s	30
Unlicensed/Unknown	4000s	21
Pet Stores	5000s	85
TOTAL	N/A	525

This was a 3 wave mail study with a reminder postcard. The 1st mailing included a cover letter, survey, a pre-paid return envelope and a \$2 bill incentive. The 2nd mailing was a reminder follow-up postcard. And the 3rd and 4th mailings mirrored the 1st but they were only sent out to participants who had not yet responded and there was no monetary incentive included. There was a 1 week waiting period between mailing 1 and mailing 2 (reminder postcard). There was approximately 2-3 weeks between mailing 2 and mailing 3 and another 2-3 weeks between mailings 3 and 4. The field period for this project ended on 6/10/13. Below is a table which breakdowns the 4 mailings including mail dates and number of surveys sent.

Mailing	Date Sent	Number Sent
SAQ 1 (with \$2 incentive)	4/1/2013	525
Reminder Postcard	4/8/2013	525
SAQ 2	4/22/2013	351
SAQ 3	5/9/2013	245

Response Rate

Below are the outcomes broken down by each sample group.

Licensed/Reported – Outcomes	Number of Cases
Complete	92
Refusal	1
Undeliverable	2
Ineligible	5
No Response	56
Total	156

Licensed/Unknown – Outcomes	Number of Cases
Complete	125
Refusal	1
Undeliverable	6
Ineligible	36
No Response	65
Total	233

Unlicensed/Reported – Outcomes	Number of Cases
Complete	16
Refusal	0
Undeliverable	2
Ineligible	0
No Response	12
Total	30

Unlicensed/Unknown – Outcomes	Number of Cases
Complete	6
Refusal	0
Undeliverable	1
Ineligible	5
No Response	9
Total	21

Pet Stores – Outcomes	Number of Cases
Complete	34
Refusal	0
Undeliverable	5
Ineligible	3
No Response	43
Total	85

TOTAL (all outlets) Outcomes	Number of Cases
Complete	275*
Refusal	2
Undeliverable	16
Ineligible	49
No Response	185
Total	525*

*2 respondents ripped off the ID label upon completing/returning so we do not know which sample group they came from

Simple Response Rate

$$\begin{aligned}
 &= \frac{\text{completed questionnaires}}{\text{TOTAL N} - (\text{undeliverables} + \text{ineligibles})} \\
 &= \frac{275}{525 - (49+16)} \\
 &= \mathbf{59.8\%}
 \end{aligned}$$

Appendix D. Species Lists and Resources for Pet and Aquarium Stores

Wisconsin's Invasive Species Rule: Chapter NR 40

Species Lists and Resources for Pet & Aquarium Stores

Invasive species are non-native plants, animals and pathogens that cause harm to the economy, environment or human health. The DNR works to reduce the damage invasive species may cause and supports local partnerships to slow the spread of invasive species throughout the state. Since many types of organisms can be invasive, Wisconsin's regulations include invasive plants, fish, invertebrates, mammals, birds, pests and pathogens.

The Invasive Species Rule

The Invasive Species Identification, Classification, and Control Rule (Chapter NR 40, Wis. Adm. Code) classifies invasive species in Wisconsin as **Prohibited** or **Restricted** and regulates the **transportation, possession, transfer** and **introduction** of those species. This rule also establishes "Preventive Measures" to show actions we can take to slow the spread of invasive species. The Invasive Species Rule covers over 128 species and affects everyone in Wisconsin.

Prohibited Invasive Species

- Not yet in the state or only in a few places
- Likely to cause environmental or economic harm
- Eradication and prevention is feasible

Regulations: Cannot transport, possess, transfer or introduce without a permit. Control is required. DNR may order or conduct a control effort.

Restricted Invasive Species

- Already widely established in the state
- High environmental or economic impacts
- Complete eradication is unlikely

Regulations: Cannot transport, transfer or introduce without a permit. Possession is allowed except for fish or crayfish. Control is encouraged but not required.

Under the Invasive Species Rule, any viable part of the species is covered. Certain exemptions do exist with these regulations. Please consult the [website](#) or staff for clarifications.

Go to: dnr.wi.gov type keyword: **invasives**

Invasive Species in the Pet & Aquarium Trade

The scope of your business will largely determine how much you need to know about the Invasive Species Rule. The sections below describe some considerations for species groups that you are likely to encounter in the pet and aquarium trade. This listing is not comprehensive. A complete list of all regulated invasive species in Wisconsin can be found at: <http://dnr.wi.gov/topic/Invasives/documents/NR40ListsSep292010.pdf>.

Vertebrates (except fish)

The Invasive Species Rule only lists four vertebrate species other than fish. The monk or Quaker parakeet and the red-eared slider are two regulated vertebrate species known to have occurred in the pet trade. Pet stores **may not sell** monk parakeets or red-eared sliders with a carapace length less than 4 inches in Wisconsin. It is also important to be aware that these species may not be introduced to the wild.

Fish

All non-native fish are regulated under the Invasive Species Rule. Non-native fish species that are nonviable in Wisconsin, however, can still be sold in the aquarium trade. This means all salt water fish species and fish species that cannot survive in water colder than 38°F can still be sold. Additionally, the following viable nonnative fish **may be sold** in the aquarium trade:

- | | | |
|------------|-----------------|-------------------------------|
| • Koi carp | • Bitterling | • Chinese hi-fin banded shark |
| • Goldfish | • Ide | |
| • Sterlet | • Weather loach | |

Regulated fish may only be kept in safe, contained facilities. They should never be released. For more information, please visit our [website](#) or view the publication "Not in Our Backyard" PUB – FH-716.

Crayfish

All non-native crayfish are regulated under the Invasive Species Rule. The rusty crayfish, *Orconectes rusticus*, may only be sold under certain circumstances. **The sale or transfer of all other non-native crayfish is prohibited.**

Invertebrates (except crayfish)

The following invertebrates are regulated invasive species. These species **may not be sold** in Wisconsin, and it is important to be aware that they may not be introduced into the wild. Make sure these invertebrates don't hitch a ride with other organisms or on plants that you sell.

- **Crazy worm** (*Amyntas spp.*, *Amyntus spp.*)
- **Faucet snail** (*Bithynia tentaculata*)
- **Chinese mitten crabs** (*Eriocheir sinensi*)
- **Bloody shrimp** (*Hemimysis anomala*)
- **New Zealand mudsnail** (*Potamopyrgus antipodarum*)
- **Chinese mystery snail** (*Cipangopaludina chinensis* or *Viviparus malleatus*)
- **Asian clam** (*Corbicula fluminea*)
- **Quagga mussels** (*Dreissena bugensis*)
- **Zebra mussel** (*Dreissena polymorpha*)

Aquatic Plants

The following aquatic plants are regulated invasive species and **may not be sold** without a permit.

- **Cabomba or Fanwort** (*Cabomba caroliniana*)
- **Parrot feather** (*Myriophyllum aquaticum*)
- **Brazilian waterweed** (*Egeria densa*)
sold as: anacharis, wide-leaf anacharis, elodea
- **European frogbit** (*Hydrocharis morsus-ranae*)
- **Hydrilla** (*Hydrilla verticillata*)
- **Yellow floating heart** (*Nymphoides peltata*)
- **Curly-leaf pondweed** (*Potamogeton crispus*)

Aquatic plants must not be released or dumped into waters of the state. These are the aquatic plants that are most likely to be seen in the pet and aquarium trade, but this is not a complete list of regulated invasive plants. A complete list of regulated plants can be found at: <http://dnr.wi.gov/topic/Invasives/documents/NR4Oplantlist.pdf>.

What Can You Do?

- Get to know the regulations, and make sure that your store does not sell regulated invasive species.
- Learn to identify invasive aquatic plants and animals.
- Help your customers learn about the importance of keeping pets and plants contained.
- Check your orders for unwanted hitchhikers like snails or invasive plants.
- Use and promote beautiful non-invasive alternatives.
- **Do not release *any* aquarium plants, fish or invertebrates.**

Additional Resources

The pet and aquarium trade is one industry among many that is helping Wisconsin win the fight against invasive species. The Department of Natural Resources is working with businesses, community groups and agencies across the state. We are working with boaters and anglers to stop aquatic hitchhikers from entering our waterways, and we are working with landowners to slow the spread of invasives across the landscape. Visit our website to learn more about efforts across the state and to learn more about individual invasive species. Go to: dnr.wi.gov keyword: **invasives**.

For more information, contact:
Chrystal Schreck, Bureau of Science Services
telephone: 608-264-8590
email: chrystal.schreck@wi.gov



Bureau of Science Services
Wisconsin Department of Natural Resources
P.O. Box 7921
Madison, WI 53707-7921
Miscellaneous Publication SS-1094 2012

The Wisconsin Department of Natural Resources provides equal opportunity in its employment, programs, services, and functions under an Affirmative Action Plan. If you have any questions regarding this plan, please write to Equal Opportunity Office, Department of Interior, Washington, D.C. 20240.

This publication is available in alternative format (large print, Braille, audio tape, etc.) upon request. Please call (608) 266-0531 for more information. v. 8.9.2012



Appendix E. Outreach Letter for Pet and Aquarium Stores

State of Wisconsin
DEPARTMENT OF NATURAL RESOURCES
101 S. Webster Street
Box 7921
Madison WI 53707-7921

Scott Walker, Governor
Cathy Stepp, Secretary

Telephone 608-266-2621
Toll Free 1-888-936-7463
TTY Access via relay - 711



July 3, 2012

Dear Pet or Plant Department Manager,

During the past few months, your corporate office received a survey about **aquatic plants** from the Department of Natural Resources (DNR) and the University of Wisconsin's Survey Center. The survey responses from businesses provided valuable information that will help the DNR both understand and decrease the threat of aquatic invasive plants. I want to take this opportunity to provide some additional information about invasive species and how they may relate to your business at the local level.

The DNR is working to prevent the spread of invasive species in Wisconsin through partnerships with businesses, landowners and the public. In 2009, the Wisconsin Legislature passed the Wisconsin Administrative Code Chapter NR 40 -- *Wisconsin's Invasive Species Identification, Classification, and Control Rule*. This Rule mandates consistent statewide regulation of a list of potentially harmful invasive species in order to prevent their introduction and spread. With few exceptions, the Invasive Species Rule makes illegal the sale, transportation and introduction of listed invasive species. For more information, please review the enclosed materials and visit <http://dnr.wi.gov>, **keyword: invasives**.

Please familiarize yourself with the regulations and take particular note of the species that are now illegal to sell. I will work to answer any questions that you may have about the new regulations. I am also happy to provide outreach materials to help your customers make informed decisions about invasive species. Please contact me if you have questions or would like more information.

Enclosed with this letter is a summary of the Invasive Species Rule as it relates to pet and aquarium stores, pictures of the regulated plants and a brochure which describes how the regulations relate to fish species. I will be in touch later this year to provide additional resources.

Again, please do not hesitate to contact me. Thank you for your time.

Sincerely,

A handwritten signature in cursive script that reads 'Chrystal Schreck'.

Chrystal Schreck
Invasive Species Outreach and Education Specialist
Bureau of Science Services
phone: (608) 264 - 8590
e-mail: Chrystal.Schreck@Wisconsin.gov
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dnr.wi.gov
wisconsin.gov

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Appendix F. Outreach Letter for Aquatic Plant Nurseries

State of Wisconsin
DEPARTMENT OF NATURAL RESOURCES
101 S. Webster Street
Box 7921
Madison WI 53707-7921

Scott Walker, Governor
Cathy Stepp, Secretary

Telephone 608-266-2621
Toll Free 1-888-936-7463
TTY Access via relay - 711



July 9, 2012

Dear Manager or Owner,

During the past few months, you should have received a survey about aquatic plants from the Department of Natural Resources (DNR) and the University of Wisconsin's Survey Center. Thank you for taking the time to read the information. The survey responses from local businesses provided valuable information that will help the DNR both understand and decrease the threat of aquatic invasive plants. I want to take this opportunity to provide some additional information about invasive species and how they may relate to your business.

The DNR is working to prevent the spread of invasive species in Wisconsin through partnerships with businesses, landowners, other agencies and the public. In 2009, the Wisconsin Legislature passed the Wisconsin Administrative Code Chapter NR 40 -- *Wisconsin's Invasive Species Identification, Classification, and Control Rule*. This rule mandates consistent statewide regulation of a list of potentially harmful invasive species in order to prevent their introduction and spread. With few exceptions, the Invasive Species Rule makes it illegal to sell, transport or introduce regulated invasive species. For more information, please review the enclosed materials and visit <http://dnr.wi.gov>, **keyword: invasives**.

Since the Department of Agriculture, Trade and Consumer Protection (DATCP) is the agency that licenses plant nurseries, we are working together to raise awareness about invasive species. DATCP sent an Invasive Species Rule notification letter to all licensed nurseries in January of 2011, and the DNR is continuing to work with DATCP to provide educational materials to nurseries about invasive species and the regulations. The DATCP Nursery Inspectors enforce the Invasive Species Rule at the businesses they work with.

Please familiarize yourself with the regulations and note that it is now illegal to sell restricted or prohibited plants. I will work to answer any questions that you may have about the regulations. I am also happy to provide outreach materials to help your customers make informed decisions about species they choose to plant.

Enclosed with this letter are a summary of the Invasive Species Rule, pictures of both aquatic and terrestrial regulated plants and a text list of the regulated plants. A synonym list for the regulated plants is available at: http://dnr.wi.gov/topic/Invasives/documents/Nursery_plantlist.pdf. I will be in touch later this year to provide additional resources, but please contact me if you have questions or would like additional information.

Thank you for your time.

Sincerely,

A handwritten signature in cursive script that reads "Chrystal Schreck".

Chrystal Schreck
Invasive Species Outreach and Education Specialist
Bureau of Science Services
phone: (608) 264 - 8590
e-mail: Chrystal.Schreck@Wisconsin.gov
Find us on Facebook: www.facebook.com/WIDNR

dnr.wi.gov
wisconsin.gov

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Appendix G. Factsheet: *Invasive Aquatic Plants and Their Other Names*

INVASIVE AQUATIC PLANTS & THEIR OTHER NAMES WISCONSIN REGULATED SPECIES

This document highlights some of the alternate names (synonyms and misnomers) that have been used for some of the more common invasive aquatic plants. These species are PROHIBITED invasive species under the Invasive Species Rule, Wisc. Adm. Code Ch. NR 40. These plants may not be transferred (bought or sold), transported, possessed or introduced without an invasive species permit from the Wisconsin DNR. Visit: dnr.wis.gov, keyword: "invasives" for more information.

DO NOT SELL THESE SPECIES

Cabomba, *Cabomba caroliniana*

Photo by Ann Murray

<i>Cabomba aquatica</i>	Carolina fanwort
<i>Cabomba australis</i>	Carolina water-shield
<i>Cabomba caroliniana</i> var. <i>caroliniana</i>	Fish-grass
<i>Cabomba caroliniana</i> var. <i>flavida</i>	Green cabomba
<i>Cabomba caroliniana</i> var. <i>pulcherrima</i>	Purple cabomba
<i>Cabomba pulcherrima</i>	Silver-green cabomba
<i>Cabomba viridifolium</i>	Washington grass
<i>Nectris caroliniana</i>	Washington plant



Opposite, fan-like leaves

Parrot feather, *Myriophyllum aquaticum*

Photo by Courtney Ripp

<i>Enydria aquatica</i>	Brazilian water-milfoil
<i>Myriophyllum brasiliense</i>	Red-stemmed parrots
<i>Myriophyllum brasiliensis</i>	feather
<i>Myriophyllum brasiliensis</i> var. <i>spiralis</i>	Thread-of-life
<i>Myriophyllum proserpinacooides</i>	Water-feather



Whorls 4-6, 6-30 segments on each leaf

Brazilian waterweed, *Egeria densa*

Photo by Ann Murray

<i>Anacharis densa</i>	Anacharis
<i>Elodea densa</i>	Brazilian elodea
<i>Elodea densa</i> var. <i>longifolia</i>	Common waterweed
<i>Philotria densa</i>	Elodea
	South American
	waterweed
	Wide-leaf anacharis



Whorls of 4-8, Serrate margins

Photos: Vic Ramey and Ann Murray, University of Florida/ Center for Aquatic and Invasive Plants; Courtney Ripp, Wisconsin DNR; Glenn Miller, Oregon Department of Agriculture; Christian Fischer.

Oxygen-weed, *Lagarosiphon major*

Anacharis crispata
Anacharis crispus
Elodea crispata
Elodea crispus
Lagarosiphon muscoides

African elodea
 African waterweed
 Curly waterweed
 Lagarosiphon

Photo by Vic Ramey



Alternate curled leaves

Hydrilla, *Hydrilla verticillata*

Hydrilla asiatica
Hydrilla japonica
Hydrilla lithuanica
Hydrilla ovalifolia
Hydrilla verticillata var. *brevifolia*
Hydrilla verticillata var. *crispata*
Hydrilla verticillata var. *roxburghii*
Hydrilla verticillata var. *tenuis*

Esthwaite waterweed
 Florida elodea
 Oxygen weed
 Waterthyme

Photo by Vic Ramey



Whorls of 5, toothed lower midrib

Yellow floating heart, *Nymphoides peltata*

Limnanthemum peltatum
Menyanthes nymphoides
Nymphoides flava
Nymphoides natans
Nymphoides nymphaeoides
Villarsia nymphoides

Entire marshwort
 Floating heart
 Fringed water lily

Photo by Glenn Miller



Wavy margin, 5 petals

European frogbit, *Hydrocharis morsus-ranae*

Hydrocharis morsus-ranae var. *asiatica*
Hydrocharis morsus-ranae f. *terrestris*

Common frogbit
 Frog's-bit

Photo by Christian Fischer



Leaves 1-2 in. wide, 3 petals



Bureau of Science Services
 Wisconsin Department of Natural Resources
 P.O. Box 7921
 Madison, WI 53707-7921
 Miscellaneous Publication PUB-SS-1095 2013

For more information, contact:

Chrystal Schreck, Bureau of Science Services
 telephone: 608-264-8590
 email: chrystal.schreck@wi.gov



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 v_7.17.2013

Appendix H. Factsheet: *Are Your Snails Okay?*

Are Your Snails Okay?

Invasive Snails

Chinese Mystery Snail or **Japanese Trapdoor Snail** (Restricted Invasive Species in Wisconsin)
Cipangopaludina chinensis, *Bellamya chinensis* or *Viviparus malleatus*

- Produces live young



DO NOT SELL



Photo: Amy Benson - USGS

Banded Mystery Snail

Viviparus georgianus
(not yet regulated)

- Wide bands
- Round shoulder
- live birth



CAUTION

Non-invasive Snail

Mystery Snail, Spike-topped Apple Snail or Apple Snail

Pomacea bridgesii or *Pomacea densa*
(not regulated in Wisconsin)

- Lays eggs
- Narrow bands
- Square shoulder



S. Chaequiano

OKAY to SELL



Apple snail mages from <http://www.applesnail.net>

DRAFT v_8.13.12

Appendix I. Factsheet: *Crayfish and the Invasive Species Rule*

CRAYFISH AND THE INVASIVE SPECIES RULE

What is a Crayfish?

Crayfish are decapod crustaceans in the following families:
Astacidae, *Cambaridae* and *Parastacidae*

Cambaridae: Includes over 400 species, found mostly east of the Great Divide in North America.

Astacidae: Includes twelve species in three genera. These are native to Europe and western North America.

Parastacidae: Includes fifteen genera, all of which are native to the Southern hemisphere.

Non-native crayfish can be incredibly invasive in natural ecosystems. Under Wis. Adm. Code s. NR 40.04(2)(c)(12), all non-native crayfish are prohibited species in Wisconsin. There is one exception, the rusty crayfish, which is classified as a restricted species and considered an "established non-native crayfish." Rusty crayfish are restricted under NR 40, and are the only non-native crayfish that may be possessed live without a permit or for personal use.

All other live non-native crayfish **may not be transported, transferred (bought or sold) or introduced in Wisconsin**. Additionally, they may not be possessed unless an invasive species permit is issued by the DNR for research or public display purposes.

Native Crayfish Species

Wild crayfish can be captured according to the rules as described in NR 19.27, which covers seasons, methods of harvest, and bag limits. If the crayfish is a prohibited non-native species, it must be immediately killed before a person can keep it. A fishing license or small game license is required to collect or harvest crayfish from the wild by any person age 16 or older. A bait dealer license is required to sell crayfish (live or dead) as bait for fishing. It is not legal to possess hook & line fishing gear while in possession of live crayfish on any inland waters, except for the Mississippi River. The following list includes **Wisconsin native crayfish** which may be possessed, transported, purchased and sold in the state.

<i>Cambarus diogenes</i> -	Devil Crayfish
<i>Fallicambarus fodiens</i> -	Digger or Chimney Crayfish
<i>Procambarus acutus</i> -	White River Crayfish
<i>Procambarus gracilis</i> -	Prairie Crayfish
<i>Orconectes propinquus</i> -	Northern Clearwater Crayfish
<i>Orconectes virilis</i> -	Virile Crayfish
<i>Orconectes immunis</i> -	Calico Crayfish

More information at: <http://www.mpm.edu/downloads/collections/pubs/invertebrates/wicrayfish/crayfish.pdf>

Best Practices for Aquarium & Water Garden Users

- Learn to identify invasive aquatic plants and animals.
- Do not use invasive plants, fish or invertebrates such as crayfish in your aquarium.
- Use and promote beautiful non-invasive alternatives.
- Check your plant/ animal orders for unwanted invasive hitchhikers.
- Do not release *any* aquarium plants, fish, or invertebrates into natural waters.
- Understand the laws, get to know the species and spread the word!

Visit dnr.wi.gov and search "invasives" or email invasive.species@wi.gov

DRAFT - 8/17/2012, WDNR

Appendix J. Factsheet: Chapter NR 40 Regulated Plants

Chapter NR 40 Regulated Plants

Prohibited Statewide

* aquatic species

Common Name	Scientific Name	Notes
Australian swamp crop or New Zealand pygmyweed*	<i>Crassula helmsii</i>	
Brazilian waterweed*	<i>Egeria densa</i>	
Brittle naiad, or Lesser, Bushy, Slender, Spiny, or Minor naiad or Waternymph*	<i>Najas minor</i>	
Chinese yam	<i>Dioscorea oppositifolia</i>	
European Frogbit*	<i>Hydrocharis morsus-ranae</i>	
Fanwort *	<i>Cabomba caroliniana</i>	
Giant hogweed	<i>Heracleum mantegazzianum</i>	
Giant knotweed	<i>Polygonum sachalinense</i>	Includes hybrids
Hydrilla*	<i>Hydrilla verticillata</i>	
Japanese honeysuckle	<i>Lonicera japonica</i>	
Japanese stilt grass	<i>Microstegium vimineum</i>	
Kudzu	<i>Pueraria montana</i>	Also known as Pueraria lobata
Mile-a-minute vine	<i>Polygonum perforatum</i>	
Oxygen-weed, African elodea, or African waterweed*	<i>Lagarosiphon major</i>	
Pale or European swallowwort	<i>Vincetoxicum rossicum</i> = <i>Cynanchum rossicum</i>	
Parrot feather*	<i>Myriophyllum aquaticum</i>	
Perennial or broad-leaved pepper-weed	<i>Lepidium latifolium</i>	
Porcelain berry	<i>Ampelopsis brevipedunculata</i>	Includes the variegated cultivar
Princess tree	<i>Paulownia tomentosa</i>	
Sawtooth oak	<i>Quercus acutissima</i>	
Scotch broom	<i>Cytisus scoparius</i>	
Sericea or Chinese lespedeza	<i>Lespedeza cuneata</i> = <i>Lespedeza sericea</i>	
Spreading hedgeparsley	<i>Torilis arvensis</i>	
Water chestnut*	<i>Trapa natans</i>	
Wineberry or Wine raspberry	<i>Rubus phoenicolasius</i>	
Yellow floating heart *	<i>Nymphaoides peltata</i>	
Yellow star thistle	<i>Centaurea solstitialis</i>	

Restricted Statewide

Common Name	Scientific Name	Notes
Autumn olive	<i>Elaeagnus umbellata</i>	
Canada thistle	<i>Cirsium arvense</i>	
Common buckthorn	<i>Rhamnus cathartica</i>	
Common teasel	<i>Dipsacus sylvestris</i> = <i>Dipsacus fullonum</i>	
Creeping bellflower	<i>Campanula rapunculoides</i>	
Curly-leaf pondweed*	<i>Potamogeton crispus</i>	
Cut-leaved teasel	<i>Dipsacus laciniatus</i>	
Cypress spurge	<i>Euphorbia cyparissias</i>	
Dame's rocket	<i>Hesperis matronalis</i>	
Eurasian watermilfoil*	<i>Myriophyllum spicatum</i>	Includes hybrids
Flowering rush *	<i>Butomus umbellatus</i>	
Garlic mustard	<i>Alliaria petiolata</i>	
Glossy buckthorn	<i>Rhamnus frangula</i> = <i>Frangula alnus</i>	Includes cultivar Columnaris (tall hedge). Excludes cultivars Asplenifolia and Fineline (Ron Williams)

Restricted Statewide continued

Common Name	Scientific Name	Notes
Helliborine orchid	<i>Epipactis helleborine</i>	
Hemp nettle	<i>Galeopsis tetrahit</i>	
Hound's tongue	<i>Cynoglossum officinale</i>	
Hybrid cattail	<i>Typha x glauca</i>	
Japanese knotweed	<i>Polygonum cuspidatum = Fallopia japonica</i>	Includes hybrids
Leafy spurge	<i>Euphorbia esula</i>	
Morrow's honeysuckle	<i>Lonicera morrowii</i>	
Multiflora rose	<i>Rosa multiflora</i>	
Musk or nodding thistle	<i>Carduus nutans</i>	
Narrow-leaf cattail	<i>Typha angustifolia</i>	
Oriental or Round-leaf bittersweet	<i>Celastrus orbiculatus = Celastrus orbiculata</i>	
Phragmites, or Common reed	<i>Phragmites australis</i>	Non-native ecotype only
Plumeless thistle	<i>Carduus acanthoides</i>	
Purple loosestrife	<i>Lythrum salicaria</i>	
Russian olive	<i>Elaeagnus angustifolia</i>	
Showy bush or Bell's honeysuckle	<i>Lonicera x bella</i>	
Spotted knapweed	<i>Centaurea biebersteinii = Centaurea stoebe</i>	= <i>Centaurea maculosa</i>
Tansy	<i>Tanacetum vulgare</i>	Excludes cultivars Aureum and Compactum
Tatarian honeysuckle	<i>Lonicera tatarica</i>	
Tree of heaven	<i>Ailanthus altissima</i>	
Wild parsnip	<i>Pastinaca sativa</i>	Except the garden vegetable form

Split-listed Plants: Prohibited in some counties / Restricted in others

Common Name	Scientific Name	Notes
Amur honeysuckle	<i>Lonicera m. maackii</i>	Restricted in Adams, Brown, Calumet, Columbia, Crawford, Dane, Dodge, Fond du Lac, Grant, Green, Green Lake, Iowa, Jefferson, Juneau, Kenosha, Kewaunee, La Crosse, Lafayette, Manitowoc, Marquette, Milwaukee, Monroe, Outagamie, Ozaukee, Racine, Richland, Rock, Sauk, Sheboygan, Vernon, Walworth, Washington, Waukesha, Waupaca, Waushara and Winnebago counties, prohibited elsewhere
Black or Louise's swallowwort	<i>Vincetoxicum nigrum = Cynanchum louiseae</i>	Restricted in Columbia, Crawford, Dane, Grant, Green, Iowa, Jefferson, Juneau, Kenosha, La Crosse, Lafayette, Milwaukee, Monroe, Racine, Richland, Rock, Sauk, Vernon, Walworth and Waukesha counties, prohibited elsewhere
Celandine	<i>Chelidonium majus</i>	Prohibited in Ashland, Barron, Bayfield, Burnett, Chippewa, Douglas, Dunn, Florence, Forest, Iron, Langlade, Lincoln, Marinette, Oconto, Oneida, Polk, Price, Rusk, St. Croix, Sawyer, Taylor, Vilas and Washburn counties. Restricted elsewhere
European marsh thistle	<i>Cirsium palustre</i>	Restricted in Ashland, Bayfield, Chippewa, Door, Florence, Forest, Iron, Langlade, Lincoln, Marathon, Marinette, Menominee, Oconto, Oneida, Price, Rusk, Sawyer, Shawano, Taylor and Vilas counties, prohibited elsewhere
Hairy willow herb	<i>Epilobium hirsutum</i>	Restricted in Kenosha County, prohibited elsewhere
Hill mustard	<i>Bunias orientalis</i>	Restricted in Green and Lafayette counties, prohibited elsewhere
Japanese hops	<i>Humulus japonicus</i>	Restricted in Grant and Crawford counties, prohibited elsewhere
Japanese or Erect hedgeparsley	<i>Toxilis japonica</i>	Prohibited in Ashland, Barron, Bayfield, Buffalo, Burnett, Chippewa, Clark, Douglas, Dunn, Eau Claire, Florence, Forest, Iron, Jackson, Lincoln, Oneida, Pepin, Pierce, Polk, Price, Rusk, St. Croix, Sawyer, Trempealeau, Taylor, Washburn, Vilas and Wood counties, restricted elsewhere
Lyme grass or Sand ryegrass	<i>Leymus arenarius = Elymus arenarius</i>	Restricted in Door, Kewaunee, Manitowoc, Sheboygan, and Racine counties, prohibited elsewhere
Poison hemlock	<i>Conium maculatum</i>	Restricted in Crawford, Dane, Grant, Green, Iowa, Lafayette, Richland, Rock, and Sauk counties, prohibited elsewhere
Tall or Reed manna grass	<i>Glyceria maxima</i>	Restricted in Brown, Calumet, Dodge, Door, Fond du Lac, Jefferson, Kenosha, Kewaunee, Manitowoc, Milwaukee, Outagamie, Ozaukee, Racine, Sheboygan, Walworth, Washington, Waukesha and Winnebago counties, prohibited elsewhere
Wild chervil	<i>Anthriscus sylvestris</i>	Restricted in Barron, Columbia, Dane, Milwaukee, Polk and Walworth counties, prohibited elsewhere

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Appendix K. Brochure: *Protect Your Pond or Water Garden*

For a complete list of regulated species in Wisconsin, go to: dnr.wi.gov keyword: "NR 40"

REGULATED AQUATIC INVASIVE PLANTS

P

Prohibited Invasive Species cannot be possessed, transferred, transported or introduced.

Prohibited Aquatic Plants

- Australian swamp crop, *Crassula helmsii*
- Brazilian waterweed, *Egeria densa*
- Brittle naiad, *Najas minor*
- European Frogbit, *Hydrocharis morsus-ranae*
- Fanwort, *Cabomba caroliniana*
- Hydrilla, *Hydrilla verticillata*
- Oxygen-weed, *Lagarosiphon major*
- Parrot feather, *Myriophyllum aquaticum*
- Water chestnut, *Trapa natans*
- Yellow floating heart, *Nymphoides peltata*

R

Restricted Invasive Species cannot be transferred, transported or introduced.

Restricted Aquatic Plants

- Curly-leaf pondweed, *Potamogeton crispus*
- Eurasian watermilfoil, *Myriophyllum spicatum*
- Flowering rush, *Butomus umbellatus*
- Narrow-leaf cattail, *Typha angustifolia*
- Purple loosestrife, *Lythrum salicaria*

For assistance on control efforts for any of these invasive aquatic plants contact the aquatic plants management specialist for your region. Find them at dnr.wi.gov keyword: "APM contacts"

To report a regulated invasive species or for additional information, contact the DNR at Invasive.Species@wi.gov

Or visit our website: dnr.wi.gov keyword: "invasives"



Bureau of Science Services
Wisconsin Department of Natural Resources
P.O. Box 7921
Madison, WI 53707-7921
Miscellaneous Publication SS-1115 2013

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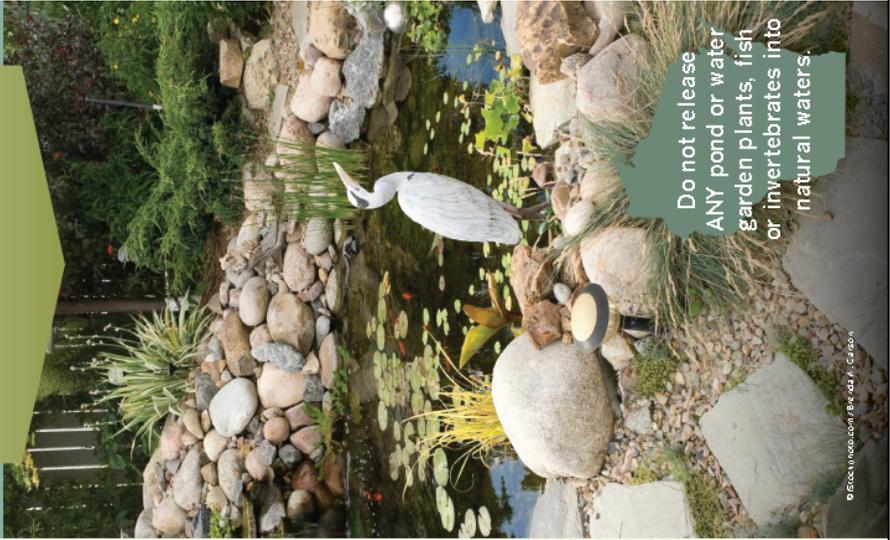
The Wisconsin Department of Natural Resources provides equal opportunity in its employment, programs, services, and functions under an Affirmative Action Plan. If you have any questions regarding this plan, please write to Equal Opportunity Office, Department of Interior, Washington, DC 20240.

This publication is available in alternative form at (large print, Braille, audio tape, etc.) upon request. Please call (608) 266-0551 for more information.



PROTECT YOUR POND OR WATER GARDEN

Learn what you can do to keep invasive species out of your backyard and out of Wisconsin waters



Do not release ANY pond or water garden plants, fish or invertebrates into natural waters.

© iStock.com/184 041 0 02 05 9

YOU CAN HELP PROTECT WISCONSIN'S WATERS & LANDS

Are Your Ponds at Risk?

Ponds, fountains and water gardens can provide tranquil settings for humans while adding extra benefits for native wildlife visitors.

Unfortunately, these aquascapes can put native ecosystems at risk unless certain precautions are taken to avoid invasive species.

Invasive species are non-native species that spread rapidly and take over native ecosystems, causing environmental or economic harm or posing threats to human health.

HOW YOU CAN HELP:

- Build your aquascapes away from natural waterways and flood zones.
- Learn to recognize invasive species.
- Purchase and plant non-invasive and native plants.
- Check plant orders for unwanted invasive hitchhikers.
- Do not use invasive plants, fish, crayfish or snails in your garden.
- Do not release any plants, fish or invertebrates into natural waters.

When invasive plants like watercress escape from their original planting sites, they can drastically alter native ecosystems. Such changes can impact native wildlife as well as recreational opportunities.



DNR Images
Watercress taking over a stream edge



DNR Images
While not currently regulated in Wisconsin, water hyacinth and water lettuce are two examples of plants that can be incredibly invasive. Take precautions to not let these or any other plants escape your garden.

Wisconsin Laws
Wisconsin's Invasive Species Rule (Wis. Adm. Code ch. NR 40) classifies and regulates the invasive species that threaten Wisconsin most. The rule is aimed at helping citizens learn to identify and minimize the spread of invasive plants, animals and diseases that can invade our lands and waters and cause significant damage. It is important to avoid these species in water gardens and elsewhere.

The rule classifies species as either "Prohibited" or "Restricted" in Wisconsin and regulates their transportation, possession, transfer and introduction.

To learn more about the rule, visit the DNR's invasives site at: dnr.wi.gov keyword: "NR 40."



Understand the laws, get to know the species and spread the word!

Watch out for these invaders!
These invasive aquatic plants are prohibited in Wisconsin.



Hydrilla
Hydrilla verticillata



Anacharis
Egeria densa



Parrot feather
Myriophyllum aquaticum



Yellow floating heart
Nymphoides peltata



European frogbit
Hydrocharis morsus-ranae

Appendix L. Brochure: *Make the Right Choice about Elodea*

KNOW YOUR PLANTS — KNOW THE RULES

MAKE THE RIGHT CHOICE ABOUT ELODEA

BEST

ELODEA CANADENSIS

use for cell study, ponds, and aquaria

Also known as:
 Elodea
 Canadian waterweed
 Common waterweed
Anacharis canadensis
Elodea brandegeae
Elodea ioensis
Elodea latifolia



Considerations: This plant is native to Wisconsin and can be ordered locally.
 Characteristics: Leaves in whorls of 3, edges appear smooth to the naked eye

ALLOWED

EGERIA NAJAS

use with caution

Also known as:
 Elodea
 Narrow-leaf anacharis
Anacharis hirtiana
Anacharis najas
Elodea guyanensis f. *longifolia*
Elodea hochii
Elodea najas
Elodea paraguayensis



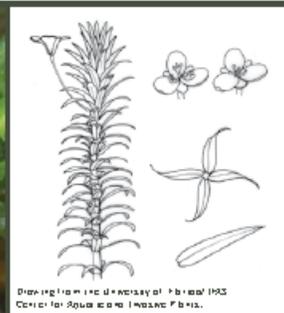
Considerations: This plant is not native in Wisconsin, but is not a regulated invasive species.
 Characteristics: Leaves in whorls of 5, obvious serrated edges, smooth midrib (under leaf)

PROHIBITED

EGERIA DENSA

do not use

Also known as:
 Elodea
 Wide-leaf anacharis
 Brazilian elodea
 Brazilian waterweed
 South American waterweed
Anacharis densa
Elodea densa
Elodea densa var. *longifolia*
Philotria densa



Considerations: This plant is a prohibited invasive species. It cannot be bought, sold, transported, transferred, or introduced in Wisconsin.
 Characteristics: Leaves in whorls of 4 – 8, edges appear smooth to the naked eye

View the complete list of prohibited plants at dnr.wi.gov keyword: "NR 40"

KNOW YOUR PLANTS — KNOW THE RULES

Invasive species are non-native plants, animals and pathogens that cause harm to the economy, environment or human health. The DNR works to reduce the damage invasive species may cause and supports local partnerships to slow the spread of invasive species throughout the state. Since many types of organisms can be invasive, Wisconsin's regulations include invasive plants, fish, invertebrates, mammals, birds, pests and pathogens. *Egeria densa* is just one example of a prohibited invasive plant in Wisconsin covered by the Invasive Species Rule.

The Invasive Species Rule

The Invasive Species Identification, Classification and Control Rule (Wis. Adm. Code ch. NR 40) classifies invasive species in Wisconsin as Prohibited or Restricted and regulates the transportation, possession, transfer and introduction of those species. This rule also establishes "Preventive Measures" to show actions we can take to slow the spread of invasive species. The Invasive Species Rule covers over 128 species and affects everyone in Wisconsin.

Prohibited Invasive Species

- Not yet in the state or only in a few places
- Likely to cause environmental or economic harm
- Eradication and prevention is feasible

Regulations: Cannot transport, possess, transfer or introduce without a permit. Control is required. DNR may order or conduct a control effort.

Restricted Invasive Species

- Already widely established in the state
- High environmental or economic impacts
- Complete eradication is unlikely

Regulations: Cannot transport, transfer or introduce without a permit. Possession is allowed except for fish or crayfish. Control is encouraged but not required.

Under the Invasive Species Rule, any viable part of the species is regulated. Certain exemptions do exist with these regulations. Please consult the website or staff for clarifications.

WHAT CAN YOU DO?

- Get to know the regulations, and make sure that you do not buy, sell or use regulated invasive species.
- Learn to identify invasive plants and animals.
- Educate others about the importance of keeping pets and plants contained.
- Use and promote non-invasive alternatives.
- Do not release any aquarium plants, fish or invertebrates.

For more information, contact:

Chrystal Schreck, Bureau of Science Services
Telephone: 608-264-8990
Email: chrystal.schreck@wi.gov

Bureau of Science Services
Wisconsin Department of
Natural Resources
P.O. Box 7921
Madison, WI 53707-7921
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Visit: dnr.wi.gov keyword: "invasives"

The Wisconsin Department of Natural Resources provides equal opportunity in its employment, programs, services, and functions under an Affirmative Action Plan. If you have any questions regarding this plan, please write to Equal Opportunity Office, Department of Interior, Washington, DC 20240. This publication is available in alternative format (large print, Braille, audio tape, etc.) upon request. Please call (608) 266-0531 for more information.



Appendix M. Teacher Mailing Cover Letter

State of Wisconsin
DEPARTMENT OF NATURAL RESOURCES
 101 S. Webster Street
 Box 7921
 Madison WI 53707-7921

Scott Walker, Governor
Cathy Stepp, Secretary
 Telephone 608-266-2621
 Toll Free 1-888-936-7463
 TTY Access via relay - 711



September 23, 2013

Dear biology and botany teachers,

In 2009 the Department of Natural Resources enacted a comprehensive invasive species rule (ch. NR 40, Wis. Adm. Code) to address some of the most threatening invasives. This rule impacts everyone in the state, and this letter explains how the rule might impact biology or botany classrooms.

The invasive species rule classifies species as *Prohibited* or *Restricted* and regulates them in order to prevent their introduction or spread. Prohibited or restricted invasive species cannot be transferred, transported, or introduced without a permit. Additionally, prohibited invasive species cannot be possessed without a permit. Please review the regulated invasive species list on the invasives website (link below) and ensure that you are following the regulations when it comes to any live organisms you consider using in the classroom.

One invasive plant of note is *Egeria densa* (also known as "elodea" or "anacharis"). Due to its ability to invade both still and flowing water ecosystems including lakes, ponds, ditches, and rivers, *E. densa* is listed as a prohibited invasive plant. It can form dense stands that crowd out native vegetation and reduce an area's value as a fish habitat; it can also interfere with recreational activities such as fishing and swimming.

Thankfully, there are currently no known populations of *E. densa* in the state. One over-wintering population was found in 2009, but it was eradicated. While *E. densa* has been a prohibited species since 2009, many retailers have only recently learned that they cannot sell this plant in Wisconsin, so the change may seem new to teachers that have used *Egeria densa* for studying cell structure and cytoplasmic streaming in the past.

Luckily, there are alternative plants that biology teachers can use in their labs. *Elodea canadensis* is one native alternative to study. Another alternative is *Egeria najas*, also known as narrow-leaf anacharis. Both of these species are suitable for the general labs that *E. densa* has been used for in the past. Attached with this letter is a publication to help you learn the difference between these three plants. This publication is also available online at: <http://dnr.wi.gov/topic/invasives/documents/SS1116ElodeaGuide.pdf>

Thank you in advance for your cooperation. If you have questions about this issue or invasive species in general, please feel free to contact me at 608-264-8590 or via email at Chrystal.Schreck@wisconsin.gov. You can learn more about invasive species on our website at <http://dnr.wi.gov> keyword "invasives."

Sincerely,

Chrystal Schreck
 Invasive Species Outreach and Education Specialist
 Bureau of Science Services

CHECK OUT DNR'S EDUCATION RESOURCES!

There are lots of great resources for teachers and students on DNR's website at <http://dnr.wi.gov> keyword "education"

Including:

Project WET (Water Education for Teachers)
 Get your feet wet and use fun K-12 hands-on science lessons to teach about Wisconsin's water resources. Schedule a workshop for your district inservice training today on the DNR website, keyword "Project WET"

dnr.wi.gov
wisconsin.gov

Naturally **WISCONSIN**



Appendix N. Pond Retailer Mailing Cover Letter

State of Wisconsin
DEPARTMENT OF NATURAL RESOURCES
101 S. Webster Street
Box 7921
Madison WI 53707-7921

Scott Walker, Governor
Cathy Stepp, Secretary
Telephone 608-266-2621
Toll Free 1-888-936-7463
TTY Access via relay - 711



July 30, 2013

Dear Owner or Manager,

When it comes to buying aquatic plants, many consumers look to their local retailers for expertise and advice. The Department of Natural Resources is providing aquatic plant retailers around Wisconsin with two new educational materials to help provide customers additional information about invasive species and aquatic plants.

Enclosed is a pack of brochures titled "Protect Your Pond or Water Garden." Please consider placing these brochures near your aquatic plant selection to help consumers understand what they can do to be responsible pond owners or water gardeners. If you only sell aquatic plants for aquariums, please keep these on hand for customers that may have questions about using your plants outdoors.

If you have an area of your store where you provide resources for your customers, consider including this brochure here. If you run out of these brochures before next season, please contact me to order more. There is no charge for these or most other DNR publications.

Also enclosed is the publication "Know Your Plants – Know the Rules." This publication is designed to help retailers and customers tell the difference between 3 different plants that are all often referred to as "elodea" or "anacharis." One copy is provided here for your use. If you would like to make this publication available to your customers, I can gladly send you more copies.

Thank you in advance for helping to prevent the spread of invasive species in Wisconsin. If you have questions about these publications or invasive species in general, please feel free to contact me at 608-264-8590 or via email at Chrystal.Schreck@wisconsin.gov.

Sincerely,

Chrystal Schreck
Invasive Species Outreach and Education Specialist
Bureau of Science Services

Appendix O. Pond Owner Mailing Cover Letter

State of Wisconsin
DEPARTMENT OF NATURAL RESOURCES
101 S. Webster Street
Box 7921
Madison WI 53707-7921

Scott Walker, Governor
Cathy Stepp, Secretary

Telephone 608-266-2621
Toll Free 1-888-936-7463
TTY Access via relay - 711



December 2013

Dear Sir or Madam,

Have you thought recently about the ponds and/or landscaping on your property? Over the winter months, many people start planning for spring. The Department of Natural Resources would like to take this opportunity to provide you with some important resources about invasive species to help you protect your property and our state's natural areas.

Many non-native invasive species such as zebra mussels and Eurasian water milfoil have found their way into Wisconsin's waterways. Their presence can cause severe damage to local ecosystems, industry and tourism. Unfortunately, new invaders may spread from private property if landowners are not aware of potential invasive species and how to contain them.

Enclosed is a brochure titled **Protect Your Pond or Water Garden**. If you have a pond or water garden on or neighboring your property, this guide can help you make good decisions about what plants and practices to use. These practices can help protect your property and the natural areas around you from invasive species.

The enclosed **Regulated Aquatic Invasive Plants in WI** guide includes photographs of the aquatic invasive plants that you might find. These species are currently regulated in Wisconsin under the Invasive Species Rule (Chapter NR 40, Wis. Adm. Code) and may not be bought, sold, transported, or introduced in the state. Additionally, any plant listed as prohibited cannot be possessed. If you do not have a water body on your property, you might want to learn more about the terrestrial invasive plants that could impact your property, such as common buckthorn and garlic mustard. You can view a complete list of regulated invasive species and learn more about identification and control options by using the keyword "**invasives**" on the department's webpage (dnr.wi.gov).

Please take some time to read through these materials and familiarize yourself with the regulated invasive species. If you find any of these species on your property, please let us know so we can help contain the population and prevent its spread. Always dispose of unwanted plants properly, and remember to never release aquatic plants, fish, or other organisms into public waters.

Thank you in advance for helping to prevent the spread of invasive species in Wisconsin. If you have questions about these publications or invasive species in general, feel free to contact me at 608-264-8590 or via email at Invasive.Species@wisconsin.gov.

Sincerely,

A handwritten signature in cursive script that reads "Chrystal Seeley-Schreck".

Chrystal Seeley-Schreck
Invasive Species Outreach and Education Specialist
Bureau of Science Services

dnr.wi.gov
wisconsin.gov

Naturally **WISCONSIN**



Appendix P. Poster: "Landscape Risk Assessment of Invasive Aquatic Plants in Southeast Wisconsin Ponds"

Landscape Risk Assessment of Invasive Aquatic Plants in Southeast Wisconsin Ponds



Kelly I. Wagner¹, Elizabeth A. Haber¹, Alison Mikulyuk^{1,2}

¹Wisconsin Department of Natural Resources, ²UW-Madison Center for Limnology



Figure 1: Invasives along the shore of a pond in Ozaukee Co.



Figure 2: Photos of various aquatic plants in a pond. Clockwise from top left: (a) *Hydrilla verticillata*, (b) *Elodea canadensis*, (c) *Hydrilla verticillata*, (d) *Hydrilla verticillata*, (e) *Hydrilla verticillata*, (f) *Hydrilla verticillata*, (g) *Hydrilla verticillata*.

Introduction

Many aquatic invasive plants are intentionally introduced into ponds as horticultural plantings. Ponds may thus support source populations of new aquatic invaders and act as reservoirs for established invasive plants. We surveyed 146 ponds in southeast Wisconsin with the aim of addressing the following questions:

- 1) What landscape factors affect the distribution of aquatic invasive plants in SE WI?
- 2) Does proximity to a store selling aquatic plants affect the presence of ornamental invasives on the landscape?
- 3) Are there any previously undocumented introductions of aquatic invasive plants to Wisconsin?

Results and Discussion

Presence of regulated invasive plants in ponds is more likely on public or commercial property, more likely near a house, more likely on larger ponds, and more likely close to stores selling regulated invasives.

Presence of horticultural plantings in ponds (whether invasive plants or not) is best predicted by the distance to the nearest house. All planted ponds are less than 55 m from a house. Distance to nearest store and housing density predict purple loosestrife presence in ponds. Purple loosestrife has a long history of use as an ornamental perennial in Wisconsin, which could explain why the distribution of this species shows an association with nurseries and housing density.

No invasives previously unobserved in Wisconsin were found in pond surveys, but restricted species were found in 70% of ponds (see Table 1).

Identifying where plants are located on the landscape will help improve monitoring and early detection efforts for invasive species.

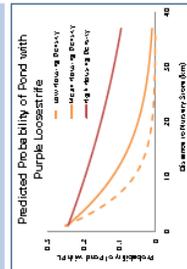
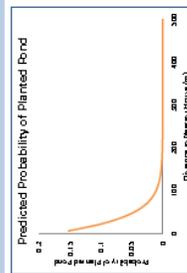


Figure 3: Study area (pink) highlighting counties of Ozaukee, Outagamie, Waubesa, Waubesa, and Waubesa counties.

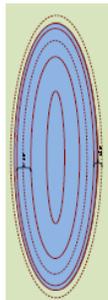


Figure 4: Buffer radius around pond. Solid line = 100m buffer, dashed line = 200m buffer.

Species	Variable (Relationship)	Significance
Curly-leaved pondweed (<i>Potamogeton amplifolius</i>)	Distance to H	P < 0.0001
European water milfoil (<i>Myriophyllum spicatum</i>)	Housing density, H	P = 0.0002
Hybrid cattail	Average housing density, H	P < 0.0001
Hybrid spikerush (<i>Sparganium angustifolium</i>)	Presence of water control, H	P = 0.006
Narrow-leaved cattail (<i>Sparganium angustifolium</i>)	Distance to nearest house, H	P < 0.0001
Red smartweed (<i>Aster spicatus</i>)	Distance to nearest house, H	P < 0.0001
Water hyacinth (<i>Eichhornia crassipes</i>)	Distance to nearest house, H	P < 0.0001
Water lettuce (<i>Pistia stratiotes</i>)	Distance to nearest house, H	P < 0.0001

Table 2: Results of logistic regression for individual species.

Acknowledgements

Special thanks to Diane Meusz for GIS support and numerous property owners for allowing access to their private ponds. We would also like to thank Michelle Nault, Scott Van Egeren, Martha Barton, and Erin Vennie-Vollrath for their assistance with data collection. Funding for this project was provided by an EPA Great Lakes Restoration Initiative grant.

For further information

Please contact Kelly.Wagner@wisconsin.gov. More information about Wisconsin's aquatic, wetland, and terrestrial invasive species is available at: www.dnr.wis.gov; keyword: "invasives".

Methods

Ponds were identified and digitized from 6- to 18-inch aerial imagery from spring 2010. Ponds within the Lake Michigan basin in the 5-county study area (see Figure 3) were selected randomly from the following strata:

- Availability of invasives from nearby stores: High/Low Surrounding land use: Agricultural/Urban/Other.

Sampling effort was a combination of visual search in concentric 3-meter rings following the pond shore (including one meter on shore) and random rake tows based on pond area and water clarity (see Figure 4).

Logistic regression models were used to test hypotheses about invasive plant distribution. Forward model selection was performed using likelihood ratio tests.

Notes

Notes

Science Services

**Center for Excellence –
providing expertise for science-based decision-making**

We develop and deliver science-based information, technologies, and applications to help others make well-informed decisions about natural resource management, conservation, and environmental protection.

Our Mission: The Bureau of Science Services supports the Wisconsin Department of Natural Resources and its partners by:

- conducting applied research and acquiring original knowledge.
 - analyzing new information and emerging technologies.
 - synthesizing information for policy and management decisions.
 - applying the scientific method to the solution of environmental and natural resources problems.
 - providing science-based support services for management programs department-wide.
 - collaborating with local, state, regional, and federal agencies and academic institutions in Wisconsin and around the world.
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