

Invasive Species of Aquatic Plants and Wild Animals in Minnesota

**Annual
Report
2005**

*for the year
ending December 31*



**Minnesota Department of Natural Resources
Invasive Species Program
500 Lafayette Road
St. Paul, Minnesota 55155-4025**

contributing authors and editors*

Susan Balgie*

Wendy Crowell *

Steve Enger

Gary Montz

Nick Proulx

Jay Rendall

Rich Rezanka

Luke Skinner

Ken Soring

Chip Welling

Heidi Wolf

David Wright

Submitted to

**Environment and Natural Resources Committees
of the Minnesota House and Senate**

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Preface

Each year, by January 15, the Department of Natural Resources (DNR) is required to prepare a report for the Legislature that summarizes the status of management efforts for invasive species (aquatic plants and wild animals) under its jurisdiction. Minnesota Statutes, Chapter 84D.02, Subd. 6, specify the type of information this report must include: expenditures, progress in, and the effectiveness of management activities conducted in the state, including educational efforts and watercraft inspections, information on the participation of others in control efforts, and an assessment of future management needs. Additional sections have been added to this report to provide a thorough account of DNR's Invasive Species Program activities and other activities related to invasive species of aquatic plants and wild animals.

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Invasive Species of Aquatic Plants and Wild Animals in Minnesota: Annual Report for 2005

Summary

Hot topics in 2005

Zebra Mussels Discovered in Lake Mille Lacs and Rice Lake in Central Minnesota

Lake Mille Lacs. DNR fisheries biologists discovered four single zebra mussels attached to rocks in three widely scattered locations in Lake Mille Lacs during routine fisheries dive surveys. No more zebra mussels were discovered despite diving at 40 additional locations, checking water samples, and surveying of boats and docks removed from the lake. Because the mussels were discovered at widely scattered locations, DNR biologists suggest that the adults are a result of zebra mussels successfully spawning in the lake.

In response to the discovery of the mussels, an intensive effort to educate boaters on Lake Mille Lacs was initiated. DNR watercraft inspectors concentrated their efforts at Mille Lacs by conducting 137 hours of inspection in late summer and fall. Fisheries creel clerks working on the lake provided additional information to boaters and anglers. New large signs were installed at public and cooperating private accesses on the lake, informing people that zebra mussels had been found and what recreationists can do to help prevent the movement to other Minnesota waters.

Rice Lake. Zebra mussels were discovered in Rice Lake, a backwater lake on the Mississippi River near Brainerd. The presence of many young-of-year zebra mussels attached to docks and boatlifts suggests that successful reproduction and settlement has occurred in the lake. The presence of reproducing zebra mussels adjacent to or in the Mississippi River creates a source of zebra mussels that can be moved downstream. If zebra mussels establish reproducing populations throughout the Mississippi River from the Brainerd area to St. Paul, many more boaters and connecting waters will be exposed to zebra mussels.

Concern. While Minnesota still has only four inland lakes that contain zebra mussels, the new infestations have the potential for a far greater impact on future spread than previous populations. The high number of visits to Lake Mille Lacs by anglers and other boaters presents a much higher risk of accelerating movement of zebra mussels to other inland lakes within the state. Combined with the occurrence of zebra mussels in Rice Lake, these two new infested waters have significantly increased the potential for accelerated movement to other Minnesota waters (Figure 1).

Public Awareness Efforts Focus on the Brainerd Lake Area

A multi-faceted invasive species public awareness effort was implemented in the Brainerd area throughout the open water season in 2005. With 500 lakes in the greater Brainerd lakes area, this is a popular fishing and boating destination attracting many visitors from Minnesota and other states. Providing information to the public about the actions they can take to help stop the spread of aquatic invasive species was the key message.

The informational campaign included radio and newspaper advertising, new signage at public water accesses, a pilot boat washing program, a new display at the Highway 371 Visitor Center, and additional awareness events in cooperation with local lake associations. More efforts are planned for 2006 as an expansion of the "Stop Aquatic Hitchhikers!" campaign.

Boat Washing Program. The DNR worked with the Minnesota Lakes Association, Minnesota Bass Federation, Minnesota Sea Grant, and other local partners in the Brainerd lakes area to encourage boaters to wash and dry their boats before entering or upon leaving a body of water.

Fifteen car wash owners agreed to participate in the pilot program and to promote their facilities as boat and trailer wash stations. The facilities had to meet specific criteria outlined by the DNR to ensure that they were suitable for washing boat and recreational equipment.

A brochure explaining the program along with step-by-step instructions for removing invasive species from recreational equipment was produced and distributed to local convenience stores, bait shops, travel information centers, and sporting goods retailers. A follow-up survey to assess the initial impacts of the pilot project is planned.

Highway 371 Visitor Center. A permanent invasive species display was installed in the new Highway 371 Visitor Center in May. The Center is a one-of-a-kind facility designed to attract and promote the Brainerd Lakes area as a vacation destination. In addition to the display, visitors can also take with them brochures on preventing the spread of aquatic invasive species. More than 41,000 visitors stopped at the Center in its first five months of operation.

Use of Whole-lake Herbicide Treatments to Control Curly-leaf Pondweed

Curly-leaf pondweed is an invasive aquatic plant that can form dense mats that may interfere with recreation and limit the growth of native submersed plants. In addition, curly-leaf plants usually die back in mid-summer, after which an increase in phosphorus and undesirable algal blooms often occur.

In recent years, there has been an increased interest among lake residents, associations, and other groups in finding better control methods for curly-leaf pondweed. On Lake Benton in Lincoln County, local residents and various groups in the area have been working with the DNR on a pilot project to control of curly-leaf pondweed in this 2,800-acre prairie lake.

In 2005, Lake Benton was subjected to a whole-lake treatment with fluridone herbicide for the first time. The treatment controlled the curly-leaf pondweed quite well. Unfortunately, neither the native submersed plants nor water clarity appeared to increase. Based on these results, it is expected that Lake Benton will be subjected to another treatment with fluridone in 2006.

Though the DNR and its cooperators are making progress in beginning to understand the potential to control curly-leaf pondweed with these treatments, results vary among different types of lakes. Further, it is likely that treatment for three or perhaps more consecutive years will be required to obtain long-term control. Much more work will need to be done in order to fully understand the potential to use herbicides to control curly-leaf and mitigate its effects on native plants, recreation, and water quality.

Status of Invasive Species of Aquatic Plants and Wild Animals in Minnesota: 2005

Aquatic Plants

- **Eurasian watermilfoil** was discovered in 13 additional Minnesota water bodies. There are now 177 Minnesota lakes, rivers, and streams known to contain the invasive submersed aquatic plant.
- **Purple loosestrife** has been documented in more than 2,280 locations statewide. Management efforts are being carried out on nearly half of these locations with biological controls or herbicide applications.
- **Curly-leaf pondweed** is known to occur in 729 Minnesota lakes in 67 counties.
- **Flowering rush** is currently found in 16 lakes. The most problematic area of the state is near Detroit Lakes where the Pelican River Watershed District is leading ongoing management efforts.

Wild Animals

- **Asian carp** (bighead, grass, silver, or black carp). No reports were received from DNR staff, commercial fisherman, or recreational anglers of these species being caught in Minnesota waters. A single bighead carp (*Hypophthalmichthys nobilis*) was caught in Lake Pepin in 2003.
- **Zebra mussels** were discovered in two new Lakes (See Hot topics above). To date, zebra mussels are found in four inland lakes, Lake Superior, the Mississippi River (below the Twin Cities), and the lower St. Croix River.
- **Spiny waterflea** has been documented in Lake Superior and six inland lakes in northern Minnesota.
- ***Daphnia lumholtzi***. One specimen was collected from Lake Pepin. However, in 2003, samples showed clear evidence of reproduction. Cooler water and higher flows may have prevented this sub-tropical invasive species from appearing in higher numbers this season.
- **Round goby**. Annual seining surveys by Wisconsin DNR in the St. Louis River estuary have shown the highest number of round gobies captured in 2005 since their discovery in 1998. The **tubenose goby** was first discovered in 2001 and its population has increased, but at a slower rate than round gobies.

- **Mute swans.** A total of 29 birds were reported in the wild in five counties. These reports were usually accompanied with reports of the birds harassing loons or trumpeter swans at those lakes. Twelve mute swans were captured and removed from Square and Big Carnelian lakes in Washington County.

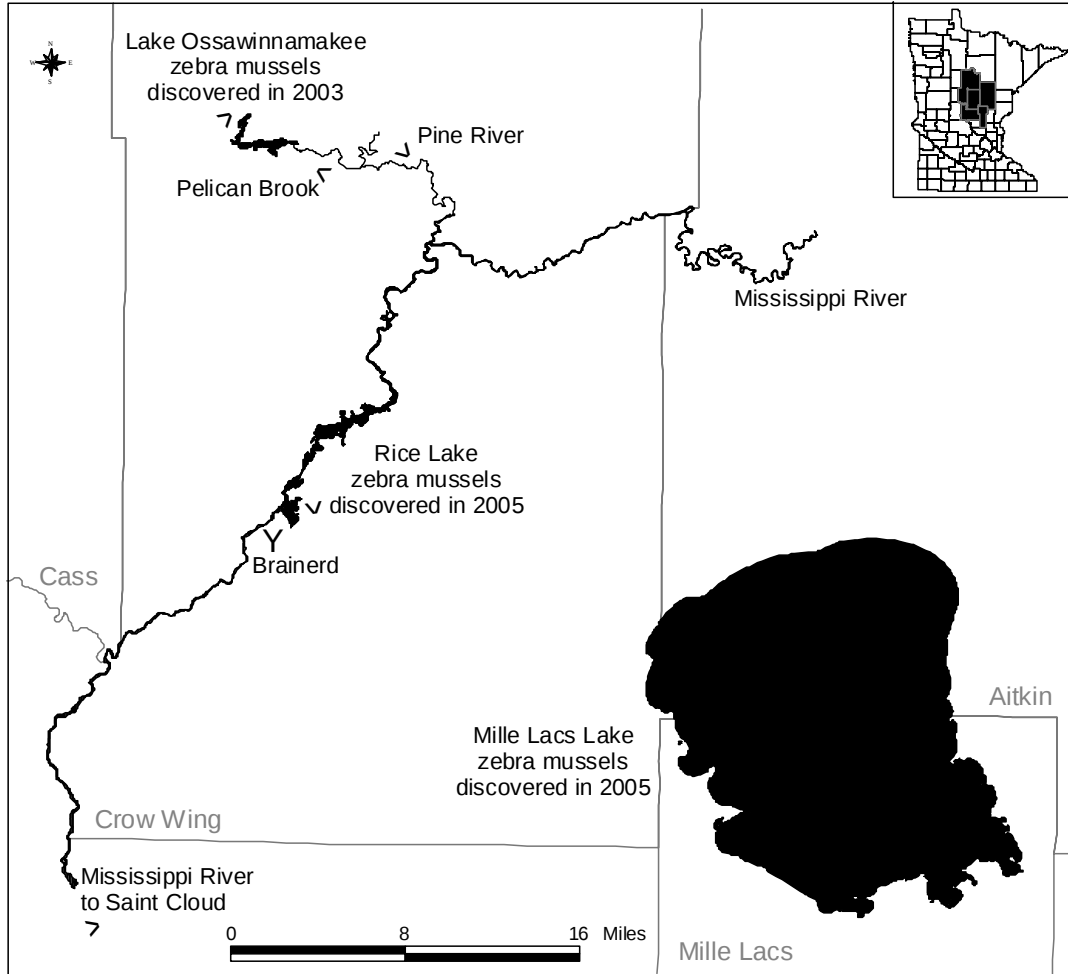


Figure 1. Zebra mussel infestations in central Minnesota.

The Problem

Invasive species have the potential to cause serious problems in Minnesota. Evidence from numerous locations in North America and from around the world demonstrates that these non-native species are a threat to the state's natural resources and local economies that depend on natural resources.

The Response

To address the problems caused by invasive species, the 1991 Minnesota Legislature directed the DNR to establish the Invasive Species Program and to implement actions to monitor and manage invasive species of aquatic plants and wild animals.

The three primary goals of the Invasive Species Program are to:

1. Prevent introductions of new invasive species into Minnesota;
2. Prevent the spread of invasive species within Minnesota;
3. Reduce the impacts caused by invasive species to Minnesota's ecology, society, and economy.

1. Prevent introductions of new invasive species into Minnesota

Risk assessment. Risk assessments are focused on determining whether an invasive species will survive in Minnesota, the problems it might cause, and the pathways through which it might reach our state. Risk assessments of northern snakehead fish (*Channa argus*), New Zealand mudsnail (*Potamopyrgus antipodarum*), tubenose goby (*Proterorhinus marmoratus*), Brazilian waterweed (*Egeria densa*), and Chinese water spinach (*Ipomoea aquatica*) were completed.

Regulations. Regulations help to prevent activities or practices that carry a high risk of introduction. Based on the risk assessments, the DNR will list the most threatening species in Minnesota Rule as regulated or prohibited invasive species.

Education. Education efforts explain the risks posed by invasive species and steps that people and businesses can take to prevent new introductions. The DNR in collaboration with the U.S. Fish and Wildlife Service (USFWS) and the Minnesota Department of Transportation, established a Traveler Information System (TIS) at the Cabela's store in Owatonna. A TIS is a low-frequency radio transmission that allows motorists within approximately a 3- to 5-mile radius of the signal to tune in to AM radio station 1610 for public service announcements about aquatic invasive species. Two roadside signs on Interstate 35 advertise the station and frequency.

2. Prevent the spread of invasive species within Minnesota

Efforts to prevent the spread of invasive species within Minnesota are focused on people and their habits. Once an invasive species becomes established in Minnesota's lakes and rivers, a primary means for its spread is the unintentional transport on boats, trailers, and other water-related recreational equipment.

Watercraft inspections. The DNR hired 40 watercraft inspectors to work at public water accesses, primarily on lakes and rivers already infested with invasive species. They inspect boats, inform owners about the problems invasive species can cause, and demonstrate actions that boaters can take to prevent spread. This year, inspectors worked 19,902 hours and inspected more than 54,000 watercraft during the open water season. Inspections were conducted at 40 fishing tournaments and continued through October to reach waterfowl hunters.

In response to the discovery of zebra mussels on Lake Mille Lacs, additional watercraft inspectors were sent to Lake Mille Lacs during the Labor Day weekend and the two following weekends (See Hot topics).

The DNR also worked cooperatively with four lake associations and citizen groups to increase inspection efforts. These citizen groups funded additional hours of inspection

at specific accesses while the DNR provided training, equipment, and supervision. For example, the Lake Minnetonka Conservation District funded an additional 2,019 hours of inspection on five Lake Minnetonka accesses.

Enforcement. Conservation officers spent 2,809 hours enforcing the invasive species laws and rules statewide. A total of five civil citations, 15 written warnings, and four summons were issued to individuals for violations of invasive species laws and rules.

Education. Providing information to the public about the actions they can take to help stop the spread of aquatic invasive species is a key component of this effort (see Hot topics). New informational signs about the discovery of zebra mussels in Lake Mille Lacs were installed at all public water accesses and at six resorts on the lake. The signs explain what boaters can do to make sure they don't transport any invasive species. The DNR in partnership with the USFWS and Cabela's established a new multimedia exhibit on aquatic invasive species at the Cabela's store in Owatonna.



Developing best management practices. The DNR evaluated the risks posed by DNR Fisheries activities and has proposed additional precautions to prevent the spread of invasive species through those activities.

3. Reduce the impacts caused by invasive species

Current efforts to reduce the harmful effects of invasive species are primarily focused on the management of aquatic plants.

Curly-leaf pondweed. The Invasive Species Program supported efforts to manage curly-leaf pondweed by 1) providing technical assistance to individuals and groups working to manage nuisance curly-leaf growth, including participating in the development of 17 lake vegetation management plans; 2) providing funding for curly-leaf pondweed management pilot projects; and 3) assisting with research of new methods of curly-leaf pondweed management.

Eurasian watermilfoil. To reduce the problems caused by Eurasian watermilfoil (milfoil), the Invasive Species Program worked closely with lakeshore owners, lake associations, local units of government, and others to manage milfoil with herbicides and mechanical harvesting. The amount of funding offered to cooperators for control of milfoil was increased. There was an increase in the total amount of control costs reimbursed by the DNR. Cooperators received \$101,000 to manage milfoil on 27 lakes statewide. The DNR has been conducting research to evaluate the feasibility of using fluridone herbicide to control milfoil in Minnesota lakes. Research completed in 2004 suggests that low rates of fluridone reduce milfoil abundance in nutrient rich lakes, but also cause decreases in beneficial native plants.



Purple loosestrife. Both herbicides and biological control methods (the use of insects that eat purple loosestrife) are being used to manage this invasive plant. Since 1992, more than eight million leaf-eating beetles have been released in 800 of the 2,800 known purple loosestrife infestations. Severe defoliation of purple loosestrife by the beetles was observed on more than 20% of sites monitored in 2005. These efforts have been supported by cooperators from local, county, and state entities to rear and release the beetles statewide.



Coordination and cooperation among groups that manage invasive species

The successes achieved in preventing and managing invasive species result from cooperation among various organizations. Management of curly-leaf pondweed, milfoil, and purple loosestrife involves cooperation with local lake associations and local units of government. Efforts to prevent introductions of new invasive species into Minnesota often involve the participation of DNR staff in state and regional groups such as the Minnesota Invasive Species Advisory Council (MISAC) and the Mississippi River Basin Panel on Aquatic Nuisance Species. Involvement with these groups promotes partnerships, develops uniform messages in educational products, and ensures sharing of information about new and existing invasive species. In 2005, MISAC's members such as DNR, Minnesota Department of Agriculture, and Minnesota Sea Grant lead the development of a statewide invasive species management plan and held a workshop in October to discuss the plan and obtain input from 70 participants representing federal, state, local, and private entities. The plan is expected to be finalized in early 2006.

Revenue and Expenditures

The primary funding source for the Invasive Species Program is a \$5 surcharge on watercraft registered in Minnesota. The surcharge, coupled with additional funding appropriations from the water recreation account in 2003 and 2005, generates approximately \$1.7 million per year. Most of the funding (70%) was spent on education, watercraft inspections, enforcement, and management/control efforts (Figure 2). Additional funding, primarily for research projects, was received from the U.S. Fish and Wildlife Service, the U.S. Environmental Protection Agency, and the Minnesota Legislature as recommended by the Legislative Commission on Minnesota Resources.

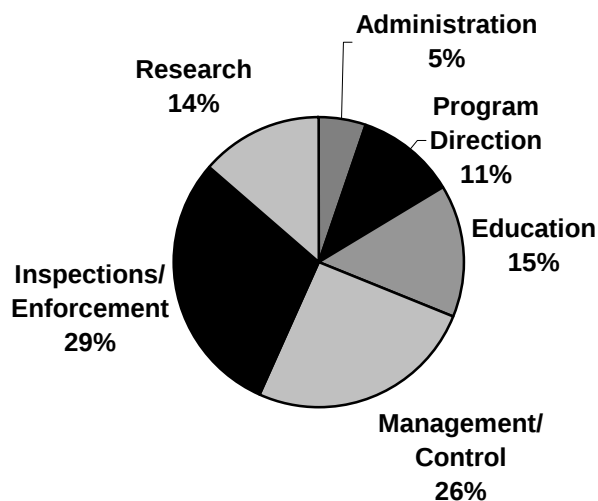


Figure 2. Invasive Species Program spending in FY05 by major categories.

Plans for the future

Continued investment in a comprehensive program to protect Minnesota's natural resources from future damage due to invasive species is paramount. The increase in state funding in 2003 and 2005 has allowed prevention and management efforts to be expanded. The new funding is being used to:

- increase efforts to prevent introductions of new invasive species
- maintain the level of watercraft inspections near 20,000 hours
- develop a grant program for managing milfoil and curly-leaf pondweed
- fund research to improve control approaches and tools

The DNR plans to continue working with other agencies and groups who are members of MISAC to develop and implement comprehensive strategies and actions that will position Minnesota to better address the multitude of invasive species issues.

Introduction

Overview of DNR's Invasive Species Program

Minnesota's Invasive Species Program was established in 1991. The Minnesota Department of Natural Resources (DNR) has responsibility to develop and coordinate a statewide program to prevent the spread of invasive species of wild animals and aquatic plants. Single species programs preceded this comprehensive program. In 1987, the DNR was designated the lead agency for control of purple loosestrife, an invasive plant of particular concern for the state's wetlands. In 1989, the DNR was officially assigned a coordinating role for Eurasian watermilfoil control (Minnesota Statutes 84D.02, Subd. 2).

The Invasive Species Program addresses many invasive species that are present in Minnesota such as Eurasian watermilfoil, purple loosestrife, zebra mussels, and ruffe (see Table 1). The DNR Invasive Species Program also attempts to prevent the introductions of invasive species that have the potential to move into Minnesota such as hydrilla, water chestnut, and Asian carp. To do so, the program identifies potential invasive species in other areas of North America and the world, predicts pathways of spread, and develops and implements solutions that reduce the potential for introduction and spread (see Risk Assessment). Prevention efforts are often undertaken with other states, agencies, and partners with similar concerns.

Most activities of the Invasive Species Program are conducted or directed by staff from DNR's Division of Ecological Services. The Division hires an additional 40 or more students during the summer to inspect boats at public water accesses and help implement management activities. Staff from the DNR Division of Fish and Wildlife, Division of Enforcement, as well as the Bureau of Information and Education also contribute significantly to the implementation and coordination of invasive species activities. In total, the equivalent of over 20 full-time positions are focused on invasive species work.

Within DNR, our goal is to enhance the ability of field staff to effectively manage terrestrial invasive plants on DNR managed lands. Key strategies include: 1) coordinate inventories of public lands for invasive species; 2) gather, maintain, and share knowledge of integrated pest management (chemical, mechanical, and biological control) for invasive terrestrial plants; 3) fund management efforts on state managed lands; and 4) develop or improve management practices through research (i.e., biological control).

Other State Invasive Species Control Programs

The Minnesota Department of Natural Resources (DNR) and the Minnesota Department of Agriculture (MDA) administer prevention and control programs for other invasive species in Minnesota. The DNR's Division of Forestry, working in cooperation with the MDA, is charged with surveying and controlling forest pests, including non-native organisms such as bark beetles. Once an invasive forest pest becomes established in the state, DNR Forestry becomes responsible for management of the species. The DNR's Forest Health Protection Team prepares a separate annual report.

The MDA is the lead regulatory agency to address terrestrial invasive species, i.e., noxious weeds, gypsy moth, emerald ash borer, sudden oak death, under statutory authority in MS 18G,H,J and Chapters 18 and 21. Information about control, prevention, and regulatory programs for several terrestrial invasive species, plant pests, and noxious weeds may be obtained from the MDA. University of Minnesota Sea Grant Extension has an Invasive Species Information Center in Duluth. The Center promotes education and outreach to prevent the spread of aquatic invasive species in the state.

Other DNR Support

Staff from the DNR Division of Fish and Wildlife, Division of Enforcement, as well as the Bureau of Information and Education contribute significantly to the implementation and coordination of invasive species activities.

Table 1. Invasive Species Program efforts that address specific invasive species.

A = public information and education, B = watercraft inspections to prevent spread,
 C = population surveys and monitoring, D = technical assistance for control by others
 E = control to reduce populations, escapes, and nuisance conditions,
 F = research on biology and management, G = regulations

Invasive Species of Aquatic Plants and Wild Animals in Minnesota	Efforts of DNR's Invasive Species Program						
	A	B	C	D	E	F	G
Aquatic Plants							
Flowering rush (<i>Butomus umbellatus</i>)	X	X	X	X	X	X	X
Purple loosestrife (<i>Lythrum salicaria</i>)	X		X	X	X	X	X
Eurasian watermilfoil (<i>Myriophyllum spicatum</i>)	X	X	X	X	X	X	X
Other non-native aquatic plants	X		X	X	X	X	X
Curly-leaf pondweed (<i>Potamogeton crispus</i>)	X	X	X	X		X	X
Animals							
Common carp (<i>Cyprinus carpio</i>)			F		F/W	W	X
Ruffe (<i>Gymnocephalus cernuus</i>)	X	X	F/O		NIF	X	X
Round goby (<i>Neogobius melanostomus</i>)	X	X	F/O		NIF		X
Spiny waterflea (<i>Bythotrephes longimanus</i>)	X	X	F				X
Zebra mussel (<i>Dreissena polymorpha</i>)	X	X	X			X	X
Rusty crayfish (<i>Orconetes nusticus</i>)	X						X
Mute swan (<i>Cygnus olor</i>)			X		X		X

- F - DNR Fisheries monitors this species
 F/O - DNR Fisheries and other agencies monitor this species
 F/W - DNR Fisheries and/or Wildlife occasionally manage this species at priority sites
 NIF - Inland waters will be addressed as outlined in a Nonindigenous Fish (NIF) plan
 W - DNR Wildlife is involved with research on this species

Divisions of Ecological Services and Fish and Wildlife

Pesticide enforcement specialists from Ecological Services and Aquatic Plant Management Specialists in DNR Fisheries assist with the management of various invasive plants including purple loosestrife, Eurasian watermilfoil, and flowering rush. In addition to these staff, other individuals from the Division of Fish and Wildlife and the Division of Ecological Services contribute by providing biological expertise, assisting with control efforts, conducting inventory and public awareness activities, and providing additional avenues for public input.

Division of Enforcement

Conservation officers are responsible for enforcing the state regulations regarding invasive species of aquatic plants and wild animals. A regional enforcement supervisor acts as invasive species enforcement coordinator within the Division of Enforcement to assist in scheduling, executing, and reporting on enforcement activities related to invasive species. A chapter describing enforcement activities is included in this report (see Enforcement).

Bureau of Information and Education

Susan Balgie and other staff from the Bureau of Information and Education provide support for the Invasive Species Program's public awareness activities (see Education and Public Awareness).

Participation in Statewide, Regional, and National Groups

The DNR Invasive Species Program and other agencies in the state participate in statewide groups such as the Minnesota Invasive Species Advisory Council (MISAC), the County Agricultural Inspectors Advisory Committee, and the Weed Integrated Pest Management Group.

The DNR Invasive Species Program and others in the state participate in regional and federal activities regarding harmful invasive species. The increasing number of national and regional entities and activities related to invasive species have made it much more difficult to represent Minnesota's interests at the regional and national level. Minnesota was not active in the Great Lakes Panel on Aquatic Nuisance Species during 2005. A new representative to the panel from Minnesota is being sought for 2006.

Participation on the Mississippi River Basin Panel on aquatic nuisance species helps keep Minnesota informed of regional and federal efforts regarding invasive species and provides a voice for Minnesota interests. Jay Rendall was selected to chair the new panel during its initial year in 2003 and has continued as chair through 2005.

Program staff are also involved with the following statewide or regional groups:

- Gary Montz and Jay Rendall - St. Croix River Zebra Mussel Task Force (see Appendix B);
- Luke Skinner - national garlic mustard biocontrol working group; Midwest Invasive Plant Network;
- Jay Rendall – Council of Great Lakes Governor's Aquatic Invasive Species Task Force; and
- Jay Rendall – national Asian Carp Work group that drafted a national Asian Carp Management and Control Plan in 2005.

Development of a Statewide Invasive Species Management Plan

Throughout 2005, several state, federal, and private entities developed a draft state invasive species plan for aquatic and terrestrial invasive species. Several MISAC members such as DNR, MDA, and Minnesota Sea Grant led the development of a statewide invasive species management plan and held a workshop in October to discuss the plan.

While the MDA and DNR are mandated to have invasive species response plans, several other agencies were interested in creating plans as well. A combined plan will provide a common structure for coordinating and guiding invasive species detection and response efforts, and encourage input from partners. Benefits of a combined plan include increased access to funding, stronger partnerships among interested parties, reduced duplication of effort, and development of a common vocabulary.

A full-day workshop, “A Workshop to Develop a Comprehensive State Plan on Invasive Species for Minnesota,” was held on October 24, 2005. The workshop was funded by Minnesota Sea Grant through a grant from the Great Lakes Commission and was held in collaboration with MISAC, DNR, and MDA. Seventy participants represented businesses and their associations, academia, local, county, state, tribal, and federal government, and non-governmental entities gathered to address invasive species issues in Minnesota.

Workshop participants attended breakout sessions according to their interests and disciplines, and filled out implementation tables indicating how their agencies would address invasive species prevention, early detection, management, and coordination efforts. Information from the tables will be used as input for the comprehensive state plan. The workshop attendance and productivity were evidence of a strong desire for stakeholder connection regarding Minnesota’s response to the increasing number of non-native species on our doorstep.

According to workshop evaluations, the workshop was very successful — 89% of attendees felt the workshop was useful in addressing their organization’s invasive species-related mission, goals, and objectives; 71% thought that the draft plan is on track to become a viable approach; 79% felt it brought together diverse stakeholders; and 78% were more than likely to implement aspects of the plan. A synthesis of workshop outcomes will be presented at a Great Lakes regional summit hosted by the Great Lakes Commission in 2006.

Comments received on the draft plan will be considered during revision by the MISAC team. Once new draft plan is ready, it will be distributed for public comment. The plan is expected to be finalized in early 2006.

Expenditures

Funding Sources

Funding for activities conducted by the Invasive Species Program comes from a variety of state, federal, and local sources.

State Funds

The primary funding source is a \$5 surcharge on the registration of watercraft in Minnesota. "Surcharge" receipts are deposited in the Water Recreation Account and appropriated by the Legislature. Surcharge receipts currently generate sufficient funds to allow an annual appropriation of approximately \$1,200,000 (Table 2). The 2003 Legislature, at the Department's request, expanded funding for the Invasive Species Program by appropriating additional funding from the Water Recreation Account. This funding was from the "regular" watercraft license receipts (Table 2). Funding was increased by \$380,000 in FY04 and \$440,000 in FY05. The 2005 Legislature provided an additional \$154,000 per year of watercraft license funding in FY06 to allow the Department to expand its grant program focused on the management of invasive aquatic plants.

Table 2. State and local funding (in thousands of dollars) received by the Invasive Species Program, fiscal years 2003, 2004, 2005, and 2006.

Fiscal Year	Water Recreation Account		Legislative Commission on Minnesota Resources ¹	Local Contributions	Total
	Surcharge ²	Regular			
2003	1,191	0	45	11	1,247
2004	1,202	380	55	19	1,656
2005	1,201	440	54	17	1,712
2006	1,201	584	100	42	1,927

¹ State appropriations, as recommended by the LCMR, from the Environment and Natural Resources Trust Fund or the Minnesota Resources Fund or both.

² Includes funds appropriated directly to the Division of Enforcement for invasive species work.

Over the last decade, significant support for invasive species research has been appropriated by the Minnesota Legislature from the Environment and Natural Resources Trust Fund and the Minnesota Resources Fund as recommended by the Legislative Commission on Minnesota Resources (LCMR). Recommendations by the LCMR are based on results of a competitive process. During the FY04/05 biennium, funding was provided for a project focused on European buckthorn and spotted knapweed, two high-priority terrestrial invasive plants. This project is a joint effort by DNR and the Minnesota Department of Agriculture (MDA). LCMR recommended additional funding for garlic mustard and buckthorn biocontrol research during the FY06/07 biennium.

Federal Funds

The DNR seeks funding from federal sources for a variety of program activities. Recent projects that have been funded are shown in Table 3. For example, funds from the U.S. Fish and Wildlife Service (USFWS) support the implementation of the St. Croix Interstate Management Plan for aquatic invasive species. A portion of DNR's public awareness efforts and zebra mussel monitoring dives on the St. Croix River are paid from these funds. Two grants have been approved by the U.S. Environmental Protection Agency (USEPA) to support research on the biological control of European buckthorn. Funding from the U.S. Forest Service (USFS) was also obtained to initiate a garlic mustard biological control project. These federally funded projects often operate on timelines that are different from the state's fiscal year.

Table 3. Recent proposals submitted by the Invasive Species Program that received federal funding.

Federal Grant				
Category	Federal Fiscal Year ¹ Grant Awarded	Calendar Year(s) Used	Grant Amount (1000's of \$)	Source
Implement St. Croix management plan for aquatic nuisance species				
	2003	2004	60	USFWS
	2004	2005	71	USFWS
	2005	2006	73	USFWS
Research on biological control of European buckthorn				
	2003	2004-05	50	USEPA
Research on biological control of garlic mustard				
	2003	2004-06	105	USFS
	2004	2004-06	65	USFS
	2005	2005-06	10	USFS
Terrestrial invasive plant management				
	2005	2005-07	200	USFWS

¹ The federal fiscal year begins on October 1 and ends on September 30.

Local Funds

Local groups work with the DNR to manage invasive aquatic species and, in some cases, provide funds to expand planned efforts (Table 2). During 2005, the Bay Lake Association, Pike Lake Association, Big Sandy Lake Association, and Lake Minnetonka Conservation District provided funding so that the number of watercraft inspections on

specific lakes could be increased. See the Watercraft Inspections and Awareness Events chapter for a more detailed account of these cooperative efforts.

Timeframe

This report covers activities in calendar year 2005, which includes the last half of the Minnesota fiscal year 2005 (FY05), Jan. 1-June 30, 2005, and the first half of fiscal year 2006 (FY06), July 1-Dec. 31, 2005. To provide a comprehensive review of expenditures and to meet the report's January 15, 2006 due date, we report on expenditures that were incurred in FY05.

Cost Accounting

The DNR has a detailed cost accounting system that is used to track how funds are spent. All staff time and expenditures are coded. The coding allows us to sort work/expenditures by the type of activity being undertaken (e.g., management activities, public awareness efforts) and/or by what invasive species the work is focused on.

Minnesota Statute (M.S. 84D.02 Subd. 6) identifies five expenditure categories that must be reported. Those categories are Administration, Education/Public Awareness, Management/Control, Inspections/Enforcement, and Research. A sixth category, Program Direction, has been added to cover a variety of program-wide or "big-picture" activities that do not fit easily into the reporting categories required by statute. Expenditures within each category are subdivided to reflect the program activities described in the following chapters.

Administration

Administration includes *Support Costs* assessed by the Division of Ecological Services for general office supplies, office rent, telephones, postage, workers' compensation fees, computer support fees, and the state accounting system fees. *Clerical* costs and *Administrative Support* costs that fund administrative staff who work for the divisions of Fish and Wildlife and Ecological Services are shown separately. Administration also includes a prorated portion of the salary of division staff that serve on regional management teams. Two categories of expenses, "other work" and "staff leave time," listed as an Administrative expense in previous Annual Reports have been changed. "Other work," time staff spent in training, supervising, and providing assistance to other Division or Department projects has been moved to the Program Direction category. "Staff leave time" (time used for holidays, sick leave, and vacation) has been apportioned across all categories based on the proportion of staff time invested in that category. Those costs are listed in Table 4 associated with the "Other" heading.

Program Direction

This category includes a variety of activities and expenditures. *State coordination* includes general program planning, preparation of state plans and reports (including this document), and attendance at public meetings. Program staff met with groups such as the Minnesota Lakes Association and Lake Minnetonka Conservation District to discuss state activities and to coordinate efforts. Program staff are also members of state-level coordinating groups, such as the Minnesota Invasive Species Advisory Council, which are included here. Expenditures primarily represent staff time spent on these activities. *Regional and federal coordination* includes staff time and out-of-state travel expenses to work with regional and federal partners on invasive aquatic species issues. Examples

from 2005 include: a Mississippi River Basin Panel on Aquatic Nuisance Species (ANS) meeting, participation on conference calls associated with the Council of Great Lakes Governors' ANS Initiative, and a regional workshop focused on Promoting Regional ANS Cooperation and Coordination. "Training, supervising, related work" represents a variety of work activities that staff participate in to improve their skills, direct co-workers, or help on other projects. Finally, *Equipment and Services* includes fleet costs not assigned to a specific activity and the cost to purchase and repair boats, trailers, computers, and similar items.

Education/Public Awareness

Expenditures in this category include staff time, in-state travel expenses, fleet charges, mailings, supplies, printing and advertising costs, and radio and TV time to increase public awareness of invasive aquatic species. The costs of developing and producing pamphlets, public service announcements, videos, and similar material are included, as are the costs of developing and maintaining invasive species information on the DNR's Web site.

Management/Control

Expenditures in this category include staff time, in-state travel expenses, fleet charges, commercial applicator contracts, and supplies to survey the distribution of invasive aquatic species in Minnesota and to prepare for, conduct, supervise, and evaluate control activities. When the management activity is focused on a specific invasive aquatic species, e.g., Eurasian watermilfoil, purple loosestrife, or zebra mussels, detailed expenditure information for that species is shown. Funds provided to local government units and organizations to offset the cost of Eurasian watermilfoil management efforts are also included.

Inspections/Enforcement

Expenditures in this category include the costs that conservation officers incur enforcing invasive species rules and laws, the costs of implementing watercraft inspections at public water accesses, and staff time and expenses associated with promulgation of rules, development of legislation, conducting risk assessments, and other efforts to prevent the introduction of additional invasive species into Minnesota.

Research

Expenditures in this category include staff time, travel expenses, fleet charges, supplies, and contracts with the University of Minnesota and other research organizations to conduct research studies. These studies include efforts to develop new or to improve existing control methods, better understanding of the ecology of invasive species, better risk assessment tools, and to evaluate program success. When research is focused on a specific invasive species, such as Eurasian watermilfoil, purple loosestrife, or curly-leaf pondweed, detailed expenditure information for that species is shown.

Fiscal Year 2005 (FY05)

Expenditures on aquatic non-native invasive species activities during FY05 (July 1, 2004-June 30, 2005) totaled \$1,819,000 (Table 4). [Note: An additional \$240,000 was spent on terrestrial non-native invasive plants.] Expenditures from the Water Recreation Account, the largest single source of funding, are listed along with spending

from other accounts. For this report, spending from the “Surcharge” and “Regular” portions of the Water Recreation Account have been combined into a single column. The Invasive Species Program manages other accounts that also support program activities. An example is revenue from the sale of public awareness material. This revenue is deposited in a “Publications Account” and is used to fund future public awareness efforts. Grants received from various state or federal funding sources, such as LCMR recommended appropriations and the USFWS are other examples. As is shown in Table 4, most program activities focused on the management of non-native, invasive terrestrial plants are funded by grants from other organizations.

The final expenditure category reflects work by non-Program staff in the divisions of Ecological Services, Fish and Wildlife, and Enforcement who occasionally do invasive species work as part of their regular DNR jobs. In FY05, major expenditures in this category included \$15,000 of invasive species work coded to the Game and Fish Fund (primarily reflecting the work of aquatic plant management specialists in DNR Fisheries); and \$42,000 to the Division of Enforcement (reflecting enforcement efforts that were not covered by Invasive Species Program funds). This summary may not reflect the contribution of all DNR staff that provide assistance to manage non-native invasive aquatic plant and wild animal species.

The \$1,713,000 of “Water Recreation Account” expenditures by the Invasive Species Program during FY05 (Table 4) exceeded the \$1,642,000 appropriated by the legislature for FY05. Funds from FY04 that remained at the end of that year “rolled over” and were spent during FY05. All funding appropriated for the FY04/05 biennium was spent. Figure 3 provides a broad outline of how the \$1.713 million was spent; a detailed breakdown of spending by category is shown in Table 4.

The Inspections/ Enforcement category (\$510,000) and Management/Control category (\$438,000) represent the two largest segments of the budget; these two categories accounted for 55% of “Water Recreation Account” funds expended in FY05. Never the less, these categories were proportionally smaller than in recent years. More funds were allocated to research efforts (14% in FY05 vs. 9% of FY04 or 11% in FY03) and education efforts (15% in FY05 vs. 12% in FY04 and FY03).

Eurasian watermilfoil remained the invasive species that receives the most focus (based on dollars spent). FY05 spending targeted specifically at this species was \$165,000. Other invasive species that received substantial funding included: zebra mussels (\$141,000), purple loosestrife (\$73,000), and curly-leaf pondweed (\$120,000). Spending on management or research efforts focused on zebra mussels and curly-leaf pondweed has increased substantially in recent years. Individual chapters of this report provide details on the activities accomplished with those funds.

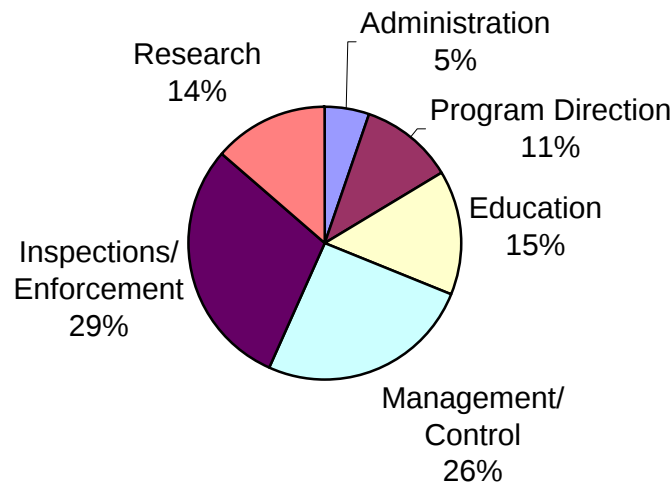


Figure 3. Invasive Species Program spending (Water Recreation Account only) in FY05 by major categories.

The Department sought the increase in watercraft license funding that occurred in FY04 and FY05 to meet specific objectives. Those objectives included:

- 1) expanding grants offered to local groups/communities to offset the cost of managing invasive aquatic plants;
- 2) increasing funding available to the DNR's Division of Enforcement so that 2,000 hours of Enforcement effort is focused on invasive species activities each year;
- 3) allowing the Department to continue to conduct 20,000 hours of watercraft inspection efforts annually even though the number of lakes and the geographical area where inspections occur are expanding;
- 4) expanding the amount of technical assistance provided to lake groups that are managing invasive aquatic plants; and
- 5) expanding funding on research efforts targeted specifically at improving control options.

The increased funding available in FY05 allowed the Program to implement a number of those activities. Specific accomplishments included:

- 1) increasing public awareness efforts while continuing to provide 20,000 hours of watercraft inspections;
- 2) maintaining an additional staff person in Brainerd to provide technical assistance to lake groups;
- 3) continuing an aggressive response to the zebra mussel infestation in Lake Ossawinnemakee in Crow Wing County;

- 4) taking steps to evaluate options designed to slow the movement of Asian carp into Minnesota waters (FY05 funds also helped fund a dispersal barrier to limit Asian carp spread into the Great Lakes);
- 5) increasing research and management efforts targeted at curly-leaf pondweed.

Two of the objectives originally identified when the new funding was proposed were not achieved in FY05. Although the amount of grant funding offered to lake groups that manage Eurasian watermilfoil was increased, the amount of funding actually spent did not rise. The Eurasian watermilfoil chapter in this report provides a more in-depth discussion of this topic. The current grant program will be restructured in FY06 to meet the original objective. In addition, the Department decided that it was not appropriate at this time to reallocate additional revenue to the Division of Enforcement.

Fiscal Year 2006 (FY06)

Since this report is due in the middle of FY06, projected expenditures for this year are not reported. Management/Control expenditures (in the form of grants to local cooperators) will increase because of the additional funding appropriated by the 2005 Legislature (see Table 2). The following chapters describe in detail the activities that were conducted during 2005 with FY05 and FY06 funds.

Table 4. Invasive species related expenditures in fiscal year 2005 (FY05) (in thousands of dollars).

Categories of Expenditures	Water Recreation Account	Other Funding Sources
	FY05	FY05
Administration		
Division Support Costs	39	--
Regional Representation	13	
Clerical	--	
Administrative Support	39	
Subtotal	91	
Program Direction		
State coordination	102	¹ 7
Support regional/federal activities	7	
Training, supervision, related work	46	
Equipment and services	22	
Other	12	
Subtotal	189	7
Education/Public Awareness		
Radio spots, TV, Web site development	242	30
Other	10	30
Subtotal	252	
Management/Control		
General	58	¹ 20
Eurasian watermilfoil	151	¹ 1
Purple loosestrife	62	
Zebra mussel	99	
Curly-leaf pondweed	18	
Flowering rush	3	
Asian carp	--	
Terrestrial invasive plants	--	
Other	46	¹ 134
Subtotal	438	155
Inspections/Enforcement		
Watercraft inspections	342	--
Enforcement - access checks	54	¹ 43
Prevention - laws/risk assessments	91	
Other	23	
Subtotal	510	43
Research		
General	9	¹ 5
Eurasian watermilfoil	14	--
Purple loosestrife	11	--
Zebra mussel	42	--
Curly-leaf pondweed	102	--
Flowering rush	--	--
Other invasive plants	--	--
European buckthorn	--	--
Garlic mustard	--	³ 40
Asian carp	45	^{2, 3} 66
Other	9	--
Subtotal	233	111
Total	1713	346

¹Other DNR funding, ²LCMR funding, ³Federal funding

*Subtotals are rounded to the nearest thousand.

Education and Public Awareness

Introduction

Issue

Public awareness of invasive species is one of the key strategies used to limit their introduction and spread. Since 1992, the DNR's Invasive Species Program has made substantial efforts to create and maintain a high level of public awareness and understanding about invasive species. An annual communications plan is developed by Program staff to identify activities and priorities.

Goals

Public awareness efforts in Minnesota are designed to:

- Make the public and certain businesses aware of the negative environmental impacts caused by some invasives;
- Help these groups identify and report findings of specific invasive species;
- Outline actions that boaters, anglers, seaplane pilots, waterfowl hunters, aquarium owners, water gardeners, riparian landowners, bait dealers, and others must do to reduce the spread of these invasives; and
- Enhance understanding of management options.

Progress in Public Awareness - 2005

Key components of this year's communication efforts included radio and television advertising, public service announcements, printed materials, press releases, media contacts, newspaper ads, information on DNR's Web site, staffing at sports shows and other major events, educational displays and exhibits, informational signs at public water accesses, and training.

Radio

Radio was used in 2005 to reach boaters and anglers in several ways. Paid advertising was used on major stations in the Twin Cities and Brainerd during the weeks preceding the Fishing Opener, Memorial Day, and Fourth of July. The stations were selected for their listener profiles which correspond with those of boat owners. Paid advertising was also used on Minnesota News Network (MNN), reaching additional 73-affiliate stations throughout greater Minnesota in May. In late summer, a special effort was made in the Duluth market, Brainerd Lakes area, and southeastern Minnesota (Rochester and Winona) where zebra mussel infestations occur.

In addition, public service announcements (PSAs) were made available to Minnesota radio stations along with communication encouraging program managers to play these announcements. The PSAs are available in two audio formats from the DNR's Web site making them readily accessible to station managers at any time and eliminating the need to mail tapes each year (www.dnr.state.mn.us/news/psas/index.html).

Television, video, and informational materials

Paid television advertising was used this year in the Duluth market during July and August (WDIO-TV, an ABC-affiliate station) to remind viewers of the continuing concerns about zebra mussels in the area. Two spots aired during morning and

evening newscasts leading into popular outdoors segments including “Sportsman’s Notebook,” “Gone Fishing’,” “Up North,” and “Pro’s Pointers.”

In addition, spots concerning zebra mussels and Eurasian watermilfoil were aired on metro area cable stations to coincide with outdoor programs and Twins baseball coverage.

A newspaper advertising campaign was completed in 2005. The ad design incorporated the “Stop Aquatic Hitchhikers!” national campaign logo and listed four simple steps that boaters and anglers could take to help stop the spread of aquatic invasive species. The ad ran in the outdoor or recreation sections of daily newspapers in targeted areas of the state including Brainerd, Duluth, Rochester, Twin Cities, and Winona during July and August. The ads also ran in several specialty newspapers reaching boaters and tourists. Expanded newspaper coverage was added in the Mille Lacs and Aitkin newspapers following the discovery of zebra mussels in Mille Lacs Lake (see Management of Zebra Mussels).

Distribution of the *Help Stop Aquatic Hitchhikers* brochure continued this year. The publication provides simple steps that recreationists can take to help stop the spread of aquatic hitchhikers. Distribution efforts are ongoing to sport and outdoor shows, special events, information kiosks, and tourist information centers.

The 2005 *Minnesota Fishing Regulations* included a section on invasive aquatic species. Descriptions and illustrations of these invasives were provided along with a summary of invasive species laws, a list of infested waters, and information about how to stop the spread of invasives. More than one million copies of the fishing regulations were printed and distributed.

The *Minnesota Boating Guide* also included a page of information on how to prevent the accidental transport of invasive plants and animals. The guide is updated annually and was distributed this year to more than 300,000 boaters.

Information about invasive species was included in the 2005 edition of the *Explore Minnesota Fishing Guide*, a publication of Explore Minnesota Tourism. The guide targets anglers traveling to Minnesota and is widely distributed throughout the Midwest at major outdoor sports shows including those held in Chicago, Milwaukee, Kansas City, Omaha, Des Moines, Sioux Falls, and Fargo. It is also distributed at travel information centers across Minnesota and some Minnesota outdoor retailers.

An article, “Don’t Let Them Go,” appeared in the *Minnesota Conservation Volunteer* magazine, DNR’s in-house publication that is distributed to 130,000 subscribers annually. The article focused on the problems that occur when non-native plants and animals are released into Minnesota waters.

News releases

News releases alerting the public about invasive species in the state were distributed throughout the year to all major media outlets in Minnesota. In addition, several interviews with Minnesota media resulted in expanded television, radio, and print coverage this year, helping to raise awareness about these issues. Major daily and

weekly newspapers ran articles generated from the news releases and several of these articles were syndicated to other newspapers around the country.

DNR Web site

The DNR's Web site pages covering invasive species issues are updated regularly (www.dnr.state.mn.us/ecological_services/invasives/index.html). The site includes an overview of the Invasive Species Program as well as information on individual programs and staff. A summary of Minnesota's invasive species laws, lists of invasive species and infested waters, as well as field guides to aquatic plants and aquatic invasive plants and animals are available online. The site also provides a list of publications and resource materials in addition to links to related web pages and sites for other partnering agencies.

Shows and fairs

Invasive Species Program staff participated at Minnesota State Fair and other events to distribute literature and information. DNR watercraft inspectors staffed the invasive species display throughout the State Fair providing a venue for visitors to ask specific questions about invasive species while visiting the exhibit. An estimated 750,000 people visit the DNR's exhibits at the Minnesota State Fair each year.

Special exhibits**Highway 371 Visitor Center**

An invasive species exhibit was installed in the new Highway 371 Visitor Center in May as part of its grand opening celebration. The center is a one-of-a-kind facility that attracts and promotes the Brainerd Lakes area as a vacation destination. The backlit transparency display is in a high-traffic area within the center and provides information about how to prevent the spread of invasive species. The center is also distributing brochures on preventing the spread of aquatic invasive species.

More than 41,000 actual visitors stopped at the Center between mid-May and mid-October 2005. The projected number of visitors is 200,000 per year, based on 9% of the vehicles stopping at the facility.

Cabela's

An educational exhibit and supporting Traveler Information System (TIS) was established at the Cabela's store in Owatonna. The DNR worked with the U.S. Fish and Wildlife Service, Pacific States Marine Fisheries Commission, and Minnesota Department of Transportation on this project.

Two major elements comprise the project design: a TIS in the vicinity of the store and an in-store exhibit.

A TIS is a low frequency radio transmission that allows motorists within approximately a 3- to 5-mile radius of the signal to tune in to AM radio station 1610 for public service announcements about aquatic invasive species. The TIS was installed at Cabela's in April and is currently operating. Two roadside signs on Interstate 35 advertise the station and frequency.

An aquatic invasive species exhibit was fabricated and installed in Cabela's in December. The exhibit features three major components: a habitat diorama of aquatic invasive species, including painted depictions or replicate mounts of zebra mussels, silver and bighead carp, snakehead, goby, ruffe, spiny waterflea, sea lamprey on lake trout, Eurasian watermilfoil, curly-leaf pondweed, and water chestnut seeds; a large plasma screen TV displaying DVD footage of invasive species information and imagery; and an interactive computer kiosk with a field guide of aquatic invasive species, what we can do to prevent their spread, and what agencies are doing to address the problems.

Boat washing program

The DNR worked on a collaborative effort with the Minnesota Lakes Association, Minnesota Bass Federation, Minnesota Sea Grant, and other local partners in the Brainerd lakes area. The region is a popular vacation and fishing destination and the risk of spreading aquatic invasive species from one body of water to another is extremely high. Patterned after a similar effort in South Dakota, the project was designed to encourage boaters to wash and dry their boats before entering or upon leaving a body of water.

Area car wash owners were contacted to find out if they would be willing to participate in the pilot program and promote their facilities as boat and trailer wash stations. The facilities also had to meet specific criteria required by the DNR to ensure that they were suitable for washing boats and recreational equipment.

A collateral piece listing the participating car wash facilities along with a location map was produced and distributed to local convenience stores, bait shops, travel information centers, and sporting goods retailers. The publication explained why it is important to wash boats and trailers and provided step-by-step instructions for removing invasive species from recreational equipment. The DNR is working on a follow-up survey to assess the initial impacts of the pilot project.

Public water accesses

DNR watercraft inspectors completed 19,902 hours of inspection (see Watercraft Inspections and Awareness Events) providing boaters with information and tips on ways to reduce the spread of invasive species. The DNR attempts to place "Help Prevent the Spread" and "Stop and Remove" signs at all public water accesses. New informational signs were installed at public water accesses in Brainerd and Mille Lacs, and several northern Minnesota resorts this year (See Watercraft Inspections and Awareness Events). Additionally, "Exotic Species Alert" signs are placed at accesses to infested waters.

Presentations

Presentations were given to a variety of audiences including university classes, high schools, conferences, annual meetings, training sessions, service and professional organizations, and lake associations. In November, one staff member was invited to be the plenary speaker to the Midwest Natural Resources Group (MNRG), a group of senior staff members and technical experts from federal agencies in the Midwest states. The presentation, "Defining the Invasive Species Challenge to the MNRG in the Midwest," started the group's two-day meeting on invasive species.

Effectiveness of Public Awareness Efforts

Background

The DNR and Minnesota Sea Grant have conducted several surveys to help assess the effectiveness of public awareness efforts conducted in Minnesota. In 1994, Minnesota Sea Grant conducted a survey of boaters in Minnesota, Wisconsin, and Ohio to evaluate and compare regional differences in educational and awareness programs. In 1996, the DNR funded a follow-up survey of boaters in the Minneapolis/St. Paul metro area (DNR, 1996). Also in 1998, a survey of boaters in the Brainerd area was conducted (DNR, 1999). Both these surveys indicate that awareness about invasives has continued to increase. In 2005, watercraft inspectors (see Watercraft Inspections and Awareness Events) continued to find high levels of public awareness of invasives by boaters throughout Minnesota. Information from past surveys was used to guide development of annual public awareness efforts and maximize their effectiveness.

Effectiveness and boater survey results

A 2000-2001 mail survey coordinated by Minnesota Sea Grant, with cooperation from the Invasive Species Program and conducted through the University of Minnesota Research Center, was sent to 4,000 boaters in five states: Minnesota, Vermont, Ohio, Kansas, and California. Results from Minnesota show that signs at water accesses, information in fishing and boating regulation booklets, articles in newspapers, and news stories on TV, as well as regulations and enforcement efforts, are the most effective methods to inform boaters and to encourage them to take precautions. The survey results show that messages are translating into action. Ninety percent of Minnesota boaters responding to the question in the survey said they took action (Armson, 2001), an increase over a similar Sea Grant survey in 1994 when 70% of Minnesota boaters said they took action. The survey also showed considerable differences in the percent of boaters who took action in other states: 82% in Vermont; 46% in Ohio; 40% in California; and 30% in Kansas. These differences are proportional to the level of boater public awareness efforts and the variety of methods used in those states.

Comparatively, Minnesota has invested more in public awareness regarding harmful invasive species and results show that this investment is resulting in significant increases in public awareness and preventative actions taken. In another 2000-2001 survey question, 99% of Minnesota boaters said they were very likely or somewhat likely to take precautions.

Participation of Others in Public Awareness Activities

National “Stop Aquatic Hitchhikers!” Campaign

The national Aquatic Nuisance Species (ANS) Task Force, the U.S. Fish and Wildlife Service (USFWS), and the U.S. Coast Guard are the primary sponsors of the “Stop Aquatic Hitchhikers!” campaign. The national campaign was initiated in 2002 and includes a variety of marketing tools such as public service announcements, stickers, posters, magazine and newspaper articles, television, and radio programs to make the public aware of this issue. Most materials and announcements include a Web site address (www.protectyourwaters.net) that directs individuals to visit the site and learn about the steps they can take to stop the transport and spread of aquatic hitchhikers.

Beginning in 2003, the DNR began to use the national “Stop Aquatic Hitchhikers!” brand in its informational materials.

National “Habitattitude” Campaign

Habitattitude™ is a national public education campaign launched in fall 2004 to prevent the release of unwanted aquarium fish and plants into the environment by aquarists and water gardeners. The government-industry-academia coalition is formed in partnership with the Pet Industry Joint Advisory Council, the USFWS, and the National Oceanic and Atmospheric Administration’s Great Lakes Sea Grant Network, led by Minnesota Sea Grant. The campaign’s logo and “don’t release” message are appearing on fish bags, new aquaria, brochures and other print media, news releases, newsletters, and ads in hobbyist magazines across the country. The campaign’s Web site www.habitattitude.net provides resources to campaign partners and consumers. The DNR became a partner on the campaign in late 2005. The Invasive Species Program and MinnAqua Program are two DNR entities that will be involved in campaign efforts in Minnesota. Others, such as Minnesota Sea Grant and Region 3 of the USFWS, will be implementing the campaign in the state. Currently, more than 50 entities from industry to water garden societies and aquarium clubs are partners nationwide.

Minnesota partners

Other agencies and organizations in Minnesota have been cooperatively involved with public awareness activities in the state for more than a decade and continue to conduct public awareness efforts throughout the state.

The Minnesota Invasive Species Advisory Council (MISAC) produced a 2006 invasive species wall calendar highlighting 12 non-native invasive species that are potential threats in Minnesota. The publication contains information about each of the featured species such as keys to identification, means of spread, and impacts. This was the second year MISAC produced the calendar, which was distributed to natural resource, agricultural, highway, and other professionals in the state. The project was a cooperative effort of MISAC members to raise awareness of all types of invasive species and to direct the recipients to the Council’s Web site—www.mda.state.mn.us/misac/ where they can obtain further information about invasive species. The DNR is a member and co-chair of MISAC.

Teachers throughout Minnesota can reserve educational “traveling trunks” that include hands-on activities for classroom instruction. The trunks contain a wide range of tools designed to teach youth about aquatic invasive species (AIS). In addition to the DNR, educators can obtain the trunks from several organizations including the University of Minnesota Sea Grant, Bell Museum of Natural History, Great Lakes Aquarium, and National Park Service. For a more detailed description of the trunks, visit: www.seagrants.umn.edu/education/ttea.html. Staff from DNR’s MinnAqua program added new and replaced original components for the trunks in 2005.

The University of Minnesota Sea Grant Program is a leader in public education campaigns, outreach, and research. The tools and expertise provided by Sea Grant help people learn how to prevent the spread and minimize the impacts of AIS. The Center serves as a liaison between interest groups and business, and local, state, and

federal agencies and task forces. Sea Grant often partners with the DNR to co-develop materials and programs to avoid duplication of effort, save money, resources, and time, and to integrate our expertise to effectively address AIS issues in Minnesota and beyond.

2005 Highlights of Minnesota Sea Grant's educational activities related to aquatic invasive species in Minnesota:

- Sea Grant contributed to the Great Lakes Regional Collaboration, an effort formed after President Bush signed an Executive Order in 2004 to protect and restore the Great Lakes. More than 1,500 representatives from diverse Great Lakes interests developed strategies to address key issues, including AIS. Sea Grant helped lead efforts to write recreational activities as part of the AIS theme area. The team developed 26 actions that organizations can take to protect the Great Lakes from aquatic invaders. More information is available at <http://www.aisstrategyteam.org/index.php>.
- Minnesota Sea Grant had a lead role in the national *Habitattitude*™ public education campaign including pre-campaign surveys. Results of a 2004 pre-campaign mail survey conducted in two communities each in Minnesota and Pennsylvania show that over the last three years consumers released unwanted aquarium fish, plants, crayfish, snails, or turtles a total of 43 times. Only 20% of consumers were aware of laws or regulations concerning release of aquarium or water garden species. Importantly, most aquarists and water gardeners viewed releases as preventable and an environmental problem. Congruent with these attitudes, over 90% agreed that the *Habitattitude* campaign's logo and messages were acceptable, easy to understand, attractive, positive, and clear. A follow-up campaign survey is planned for 2006. Campaign partners will continue to staff booths at trade shows, give presentations at society and club meetings, as well as meet with state, federal, and tribal agencies throughout the Great Lakes and beyond to broaden partnerships. This campaign is supported at the highest levels of government: President Bush's response to the Ocean Commission Report identified *Habitattitude* as a model partnership between industry, government, and academia.
- Sea Grant partnered with the Water Resources Center and the University of Minnesota Extension Service to co-sponsor shoreland volunteer, revegetation, erosion control, aquatic plant identification, and curly-leaf pondweed management workshops across Minnesota.
- Sea Grant was one of the state entities to participate in the development of a state invasive species management plan.
- Sea Grant is working to extend and evaluate the national Stop Aquatic Hitchhikers! campaign along key invasion corridors in Minnesota, Wisconsin, and Iowa. Through a two-year grant from the National Sea Grant College Program (\$218,545), Sea Grant is working in collaboration with the Minnesota, Iowa, and Wisconsin DNRs, Wisconsin Sea Grant, the Minnesota Lakes Association, and

many other partners. This project features the Stop Aquatic Hitchhikers! logo and prevention messages in a multi-media campaign targeting resident and non-resident boaters and anglers along ten highways, which lead to and from infested waters. Efforts will build on previous Sea Grant and DNR efforts to reach boaters and anglers. Campaign methods will include the use of traveler information systems to broadcast prevention messages on AM radio, billboards, road signs, display panels at rest areas/welcome centers, kiosks and posters at retail outlets, water access signs, gas pump toppers, and newspaper advertisements.

- Sea Grant worked with the DNR and MISAC to promote Governor Pawlenty's proclamation of October as Invasive Species Awareness Month in Minnesota. Sea Grant encouraged communities to promote awareness, broaden partnerships, and sponsor local events to prevent and control the spread of invasive species. Activities included two workshops, nine guest lectures or presentations, a poster at a statewide research/management conference, two buckthorn pulls, several news releases and newsletter articles, and three radio interviews in the Duluth area. Community event sponsors were the Great Lakes Aquarium, Lake Superior Zoo, St. Louis River Citizen's Action Committee, University of Minnesota Center for Environmental Education, College of St. Scholastic as well as the Minnesota Lakes Association.
- Sea Grant continues to promote the successful AIS-Hazard Analysis and Critical Control Point Curriculum (AIS-HACCP) Training for aquaculturists, wild baitfish harvesters, hatchery operators, fisheries managers, and conservation officers aimed at preventing the spread of AIS or to provide AIS-free certification. As a Great Lakes Sea Grant Network Project funded by the Great Lakes Protection Fund, Minnesota Sea Grant led production of a new manual and DVD, and duplicated 1,000 copies of the video, *From Net to Sale*. The Network sponsored 15 workshops across the Great Lakes, including one hosted by the Fond du Lac Natural Resources Program, Cloquet. A poster was also presented at the 2005 Minnesota Waters Conference. AIS-HACCP is being adopted by a variety of organizations, tribes, and agencies in Minnesota, the Great Lakes, and beyond. The Great Lakes Regional Collaboration recognized AIS-HACCP as a key tool for training and education in the Aquaculture and Organisms in Trade section of the plan.
- Sea Grant continues to educate youth about AIS by promoting and distributing lesson plans, traveling resource kits, and curricula to teachers and educators. Presentations at "River Quest," a Duluth-Superior youth education environmental stewardship event reached 682 sixth graders in May 2005. Sea Grant also partnered with the Great Lakes Aquarium by sponsoring "Partners in Education," a program that provides training to University of Minnesota-Duluth undergraduate education students. With content based in part on AIS, the program reached 2,100 students from 84 classrooms in 2005 and will continue in 2006.
- Sea Grant provided 89 presentations about AIS at conferences, workshops, meetings, and guest lectures in Minnesota, including a presentation, *What's*

THAT Doing in Our Waters: Plants and Animals Out of Place, to kick off the Great Lakes Aquarium's "Voices from the Lake" Lecture Series in recognition of Invasive Species Awareness Month. As a partnership effort, the Sugarloaf Interpretive Center's "Lakewalk Learning Cart" staff reached more than 400 tourists and residents on AIS issues along Duluth's Lakewalk in August.

- Sea Grant sponsored 20 AIS-related events.
- Sea Grant staff participated on state, regional, and national task forces including the Minnesota Invasive Species Advisory Council Communication and Outreach Committee (chair), Great Lakes Panel on ANS (alternate Minnesota representative), St. Croix River AIS Task Force, and the ANS Task Force's Communication, Outreach and Education Committee.

Future needs for public awareness in Minnesota

- Maintain spending on paid public awareness radio/TV spots to reinforce high awareness of invasive species by watercraft users.
- Continue to make public awareness of zebra mussels in Minnesota near Brainerd, Lake Superior, the Mississippi, Zumbro, and St. Croix rivers a priority.
- Work cooperatively with specific industry groups to develop targeted public awareness efforts such as the aquaculture industry, live bait dealers, water garden and horticulture industry, and aquarium trade.
- Use MISAC and other multi-entity groups to enhance interagency communication on the status and progress of invasive species management efforts.
- Expand public awareness activities that are cooperative ventures with lake communities outside the metro area.
- Increase information about invasive species available through various communication channels such as the DNR Web site, publications, and media outlets.
- Continue to work collaboratively with Minnesota Sea Grant staff to pursue research and outreach funding through National Sea Grant and other sources.

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Enforcement

Introduction

Issue

In 1991, the Legislature directed the DNR Commissioner to establish a two-year program designed to check trailered boats. Road checks were initially designed to inspect boats and trailers for the presence of Eurasian watermilfoil fragments and to educate and inform boaters. As additional invasive species (e.g., zebra mussels) have become established in Minnesota, road checks and boat inspections were expanded to detect illegal transportation of those organisms, as well as other aquatic plants.

The DNR supported changes in statute passed during the 1996 legislative session that prohibited the transport of all aquatic vegetation (rather than Eurasian watermilfoil exclusively). This change in law made enforcement less complicated. Instead of having to identify Eurasian watermilfoil, which can be difficult, officers and watercraft users only had to ensure that all vegetation was removed before transporting boats and equipment.

In 1999, the Division of Enforcement took steps to better focus enforcement efforts. An Invasive Species Enforcement Plan that allocated hours and prioritized invasive species enforcement needs in each district was initiated.

Activities in the statewide Invasive Species Enforcement Plan were included as a specific component of the FY02-FY05 annual work plans for all Enforcement Division activities. These annual work plans describe in detail each enforcement district's responsibilities in meeting various responsibilities, including invasive species, and ensures that appropriate work activities and levels are accomplished.

Goals

One of the Department's goals related to enforcement is to prevent the spread of invasive species within Minnesota. Part of this goal is to lower the percentage of trailered boats transporting prohibited invasive species, aquatic vegetation, and infested water within the state. The second part is to respond quickly when reports are received that invasive non-native wild animals have escaped from captivity.

Progress in Enforcement Efforts - 2005

Several types of enforcement activities have occurred to limit the introduction and spread of invasive species including: educational work and presentations, checks of trailered boats at water accesses, monitoring commercial bait harvest equipment, and follow up on illegally-released exotic animals. In 2005, conservation officers spent 2,809 hours enforcing the invasive species laws and rules. Statewide, there were a total of five civil citations, 15 written warnings, and four summons issued to individuals for violations of invasive species laws and rules. Officers spent many hours educating the public on the regulations and handing out informational pamphlets. Officers also made presentations at resort and lake association meetings.

The following paragraphs summarize some of the key enforcement initiatives that have been used to meet the goals listed above.

Road checks of trailered boats were not conducted in 2005 (for a list of previous road checks, see the 2004 Annual Report). Beginning in mid-summer of 2002, road checks were suspended. The reasons for suspending road checks are described below.

In 1994, the Minnesota Supreme Court decided the case of *Ascher v. Commissioner of Public Safety*. *Ascher* held that the police could not conduct sobriety checkpoints. The Court's reasoning was that these checkpoints constituted an unlawful invasion of privacy. The court held that law enforcement officials must have reasonable suspicion of a violation before stopping a motorist.

In the years between 1994 and 2002, the Division of Enforcement maintained that the needs for resource protection outweighed individual privacy interests in the road-check scenario. Accordingly, we supported the use of game and fish road checks and invasive species road checks.

Developments in our state's appellate courts during 2002 signaled that natural resource enforcement measures must comply with the same constitutional rules that govern general police "searches and seizures." These decisions clearly signal that the *Ascher* case applies to Enforcement's work as well.

The Division of Enforcement discontinued the use of game and fish road checks and invasives road checks as a result. Enforcement is hopeful that further litigation or legislative changes will help resolve this situation for the benefit of our natural resources.

The Division is currently pursuing reinstituting road checks based on current case law.

Enforcement at water accesses

Enforcement near the Mississippi River

Conservation officers conducted invasive species enforcement activities along the Mississippi River, focusing on the transportation of zebra mussels and infested water. Boaters using the Mississippi River south of the Twin Cities must empty bilges, live wells, and bait buckets so that they do not transport zebra mussel infested water from the Mississippi. During the summer of 2005, officers spent time enforcing along the Mississippi and St. Croix rivers (including accesses near Hastings, Red Wing, Lake City, Kellogg, Winona, and LaCrescent).

Efforts also focused on educating the public on the laws relating to transporting water from the St. Croix River in live wells and bait buckets. Zebra mussel awareness cards were handed out to the public again this year. Time was spent educating the public at accesses in Stillwater, Bayport, and Afton.

Efforts were also increased on the upper Mississippi in Crow Wing and Itasca counties regarding watercraft/trailers transporting aquatic plants.

Enforcement during the waterfowl hunting season

Conservation officers conducted invasive species enforcement activities during the waterfowl hunting season to inform hunters about the laws prohibiting transportation of aquatic vegetation. Hunters must remove vegetation from their boats, decoys, and anchors before leaving the water access. There is an exception for the transport of shooting blinds, and emergent vegetation cut above the water line can be transported. Conservation officers contacted hunters during the waterfowl hunting season at accesses statewide that were frequented by waterfowl hunters.

Responding to escaped non-native animals

In 2005, there were two incidents that Enforcement responded to involving escapes of mute swans. There were reports to conservation officers of escapes of non-native deer and other non-native wild animals. In the Twin Cities metro area, conservation officers have visited several ethnic food markets to evaluate the possible trade in invasive species. As a result of the information gathered in these visits, an educational initiative is underway with Invasive Species Program staff and other DNR personnel to provide resource materials to the communities in their respective languages.

Goals for 2006

The DNR believes that enforcement plays a critical role in reducing the spread of invasive species, however, it is only part of the larger prevention effort. In order for the regulations on invasive species to be effective in reducing their spread, there must be: a balanced mix of public education and awareness efforts, voluntary compliance from the general public, and enforcement of the regulations. One measure of the effectiveness of enforcement efforts targeting trailered boats would be a long-term decrease in the percentage of boats carrying aquatic vegetation. Emphasis will be increased in the Mille Lacs/Brainerd area regarding invasive species (specifically zebra mussels and milfoil).

Participation of Others

In the past, the Invasive Species Program has worked to increase the participation of other peace officers to help look for violations and to enforce the state laws related to transport of prohibited invasive species on public roads. Recognition of invasive species, as well as being well versed in the laws that relate to them, aids in the enforcement efforts to stop the spread of invasive species. No training of local peace officers occurred in 2005.

Regulations and Proposed Changes

Introduction

Issue

Minnesota's regulations related to invasive species of aquatic plants and wild animals currently in Minnesota Statutes and Minnesota Rules are generally considered to be comprehensive by entities outside of Minnesota that have reviewed invasive species regulations. The state statutes related to these invasive species are found in Minnesota Statutes, Chapter 84D. The administrative rules related to invasive species are found in Minnesota Rules, Chapter 6216. Current versions of both statutes and rules are available at www.revisor.leg.state.mn.us. Summaries of annual changes in the regulations can be found in past DNR annual reports on invasive (harmful exotic) species.

It is the DNR's responsibility to designate *infested waters* (see M.S. 84D.03). Water bodies are designated infested if they contain specific invasive species such as Eurasian watermilfoil, zebra mussels, ruffe, round goby, white perch, and spiny waterfleas. The current *infested waters* lists are found in Minnesota Rules, Chapter 6216 at www.revisor.leg.state.mn.us/arule/6216.

The DNR is also required to adopt rules (per Minnesota Statutes 84D.12) that place non-native aquatic plant and wild animal species into various regulatory classifications and prescribe how invasive species permits will be issued (per Minnesota Rules 6216.0265). The DNR is authorized to adopt other rules regarding infested waters and invasive species of aquatic plants and wild animals.

Goals

- Continue to support efforts to integrate and improve the comprehensiveness, enforceability, and responsiveness of federal laws regarding noxious weeds, injurious wildlife, and other designations related to invasive species. Specifically seek reauthorization of the National Invasive Species Act (NISA) and designations of injurious wildlife such as the black carp.
- Continue to adopt rules that designate additional prohibited invasive species, regulated invasive species, and unregulated non-native species.

Progress in Regulations - 2005

Federal

At the national level, the following are key regulatory areas: 1) - reauthorization of the National Invasive Species Act (NISA); 2) national ballast water regulations; and 3) potential designation of injurious wildlife. Activity on these areas is described below:

Reauthorization of NISA

Once again this year not much progress has been made to pass the National Aquatic Invasive Species Act of 2005. Bills were introduced in the House and the Senate (S. 770) in 2005 to reauthorize NISA, but never made it to the floor for a vote. Therefore, the National Invasive Species Act of 1996 was not reauthorized in 2005.

National Ballast Water Regulations

A bill titled the “Ballast Water Management Act of 2005” (S. 363) was introduced in the Senate. On July 21, 2005, the U.S. Senate Committee on Commerce, Science, and Transportation voted and approved the Act. If enacted into law, this Act would amend the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (NANPCA). The act includes a provision that federal ballast water laws would preempt state and local laws. Several Great Lakes states were opposed to the bill for several reasons including the preference for Congress to pass a more comprehensive bill such as the National Aquatic Invasive Species Act of 2005 (S.770). In November and December 2005, there were efforts by some congressional members to create a bill that included components for both S. 363 and S. 770.

On August 31, 2005, the U.S. Coast Guard issued a notice of policy that outlines best management practices for vessels declaring No Ballast On Board (NOBOB) when entering the Great Lakes. The policy is intended to reduce the introductions of aquatic invasive species via ballast water residuals carried on board NOBOB vessels that enter the Great Lakes. The policy encourages all vessels, which are equipped with ballast water tanks and that may enter the Great Lakes, to conduct mid-ocean exchanges at 200 nautical miles or more from any shore in waters 2,000 meters or more in depth.

Designation of Injurious Wildlife

The U.S. Fish and Wildlife Service (USFWS) is continuing to review information related to a proposal to designate black carp, silver carp, and bighead carp as an injurious wildlife species under the Lacey Act. A *Federal Register* notice published on October 27, 2005, extended a public comment period on the proposed rule to add all forms (diploid and triploid) of live black carp to the list of injurious species. The public comment period remained open through December 16, 2005. The USFWS had not designated black carp, silver carp, and bighead carp as injurious as of December 31, 2005.

A bill titled the “Asian Carp Prevention and Control Act” (H.R. 3049) was introduced in Congress by Congressman Green of Wisconsin to designate “the black carp of the species *Mylopharyngodon piceus*; the bighead carp of the species *Hypophthalmichthys nobilis*; the silver carp of the species *Hypophthalmichthys molitrix*; the largescale silver carp of the species *Hypophthalmichthys harmandi*” as injurious wildlife. The bill had not passed as of December 31, 2005.

Injurious wildlife can only be imported by permit for scientific, medical, educational, or zoological purposes, or without a permit by federal agencies solely for their own use; permits are also required for the interstate transportation of injurious wildlife currently held in the United States for scientific, medical, educational, or zoological purposes. Designation of injurious wildlife prohibits interstate transportation of those species currently held in the United States for purposes not listed above.

State statute changes

The DNR had proposed minor statutory changes for consideration during the 2005 Legislative Session. The Legislature passed a bill (H.F. 1081) that included the following modifications:

- clarifies statutes on commercial fishing and netting in waters infested with various invasive species.
- requires commercial licensees to remove all aquatic macrophytes from nets and other equipment that are removed from waters of the state.
- requires the DNR to provide commercial licensees with a current listing of designated infested waters at the time a license is issued.
- establishes the water recreation account in the natural resources fund and specifies the money going into the account can be used for “management of aquatic invasive species and implementation of Chapter 84D as it pertains to aquatic invasive species including control, public awareness, law enforcement, assessment and monitoring, management planning, and research.”

Emergency rulemaking

In 2005, DNR adopted emergency rules to designate waters found to have Eurasian watermilfoil and spiny waterfleas as infested waters. The newly designated waters were published in the *State Register* on January 18, 2005.

Permanent rulemaking

New rules were being developed in 2005 to designate infested waters that have been designated in emergency rule, but have not yet been designated in permanent rules. The proposed rules also will designate Northern snakehead fish (*Channa argus*) and New Zealand mudsnail (*Potamopyrgus antipodarum*) as additional prohibited invasive species. Chinese water spinach (*Ipomoea aquatica*) is proposed for re-designation as a *regulated invasive species*. The tubenose goby (*Proterorhinus marmoratus*) and brittle naiad (*Najas minor*) will be proposed for designation as either *regulated invasive species* or *prohibited invasive species*. Brazilian waterweed *Egeria densa*) is proposed for designation as a *regulated invasive species*.

Future needs for Regulations and Proposed Changes

- Propose minor changes to the definition of invasive species and related statutes in 2006.
- Support the reauthorization of NISA and designations of injurious wildlife such as the black carp.
- Use species evaluations and current literature to propose appropriate designations that will protect Minnesota’s environment from the introduction of invasive species.

Watercraft Inspections and Awareness Events

Introduction

Issue

The potential for boaters to accidentally move aquatic invasive species from one lake to another is a clear threat to Minnesota's aquatic ecosystems. For this reason, the 1991 Minnesota Legislature mandated that DNR conservation officers conduct inspections of trailered boats on Minnesota highways. The purpose of these inspections was to look for Eurasian watermilfoil, issue citations to violators, and inform the public about the potential spread of harmful aquatic invasive species.

In 1992, the DNR, Minnesota Lakes Association, and angling groups proposed and supported legislation (adopted as M.S. 18.317, Subd. 3A, and recodified as 84D.02 subd. 4) requiring 10,000 hours of inspections of watercraft leaving infested water bodies containing harmful aquatic invasive species such as Eurasian watermilfoil, spiny waterflea, and zebra mussels. Subsequently, a watercraft inspection program was established by the DNR in 1992 to accomplish this mandate. In 1993, legislation was passed increasing the number of inspection hours to 20,000 starting with the 1994 boating season. In 1999, this statute was amended to allow inspections on both infested and uninfested water bodies to fulfill the 20,000-hour requirement. Effective June 1, 2004, the 20,000-hour requirement was lowered to 10,000 hours.

Goals

Watercraft inspections help to achieve the second goal of the Invasive Species Program: preventing the spread of invasive species within Minnesota. The inspectors also help to:

- Complete up to 20,000 hours of watercraft inspection at public water accesses across the state;
- Increase public awareness about invasive species and the potential for boaters to transport invasive species between water bodies;
- Reduce the percentage of trailered boats carrying invasive species;
- Increase educational efforts with citizen groups.

Progress in Watercraft Inspections - 2005

Complete required hours of watercraft inspection

In 2005, approximately 40 watercraft inspectors worked through the summer providing information to the public on watercraft inspections and invasive species. Inspections began in late April and continued through mid-October. Within this 25-week period, watercraft inspectors logged 19,902 inspection hours. A total of 54,713 watercraft/trailers were inspected.

During the inspection season, inspections were conducted at 40 fishing tournaments and continued through October in order to reach waterfowl hunters. Inspectors distributed more than 8,550 Exotic Alert Tags on vehicles with trailers at access points

on infested waters. Inspectors also worked to clear aquatic plant fragments from the public water accesses (PWAs) at which they were stationed.

Inspection efforts were conducted across the state in rough proportion to the number of PWAs on infested water bodies, (Table 5 and Figure 4). The actual distribution of time reflects both the number of PWAs and the intensity of public use at those accesses. The percent of time that the program is spending in each region has stayed relatively stable from 2001 to 2005 with a slight increase in time in Regions 2 and 3 between 2004 and 2005, (Figure 5). This change could be attributed to the new infestations in greater Minnesota in the past years.

Table 5. Number of watercraft inspections conducted by watercraft inspectors in 2001, 2002, 2003, 2004, and 2005. (Totals are rounded values).

Year	DNR Region				Total
	1	2	3	4	
2001	1,700	4,000	27,200	5,800	39,000
2002	660	3,100	32,300	7,700	44,000
2003	760	5,600	29,700	5,500	42,000
2004	1,200	6,800	35,600	6,800	50,000
2005	1,500	8,300	39,500	5,800	55,000

The watercraft inspection program has primarily focused on water bodies with infestations of aquatic invasive species. This approach was used because there were relatively few infested water bodies and so it was very efficient. While it is important to contact boaters leaving water bodies infested with aquatic invasive species, we feel it is also important to inform boaters on other popular recreation lakes in Minnesota. To allow more flexibility in the program, state statute was amended to include watercraft inspections on uninfested water bodies in order to meet the Department's 20,000-hour mandate (M.S. 84D.02, Subd. 4). During 2005, inspections on uninfested waters represented about 14.52% of the total inspections (7,946 inspections) and approximately 19.57% of the inspection hours (3,894.5 hours).

To determine which uninfested waters to visit, we used three criteria: 1) lakes or areas with a high level of boater activity, 2) lakes identified on program surveys as frequent destinations for boaters leaving infested water bodies, and 3) lakes with lake associations that desired to hold "Invasive Species Awareness Events."

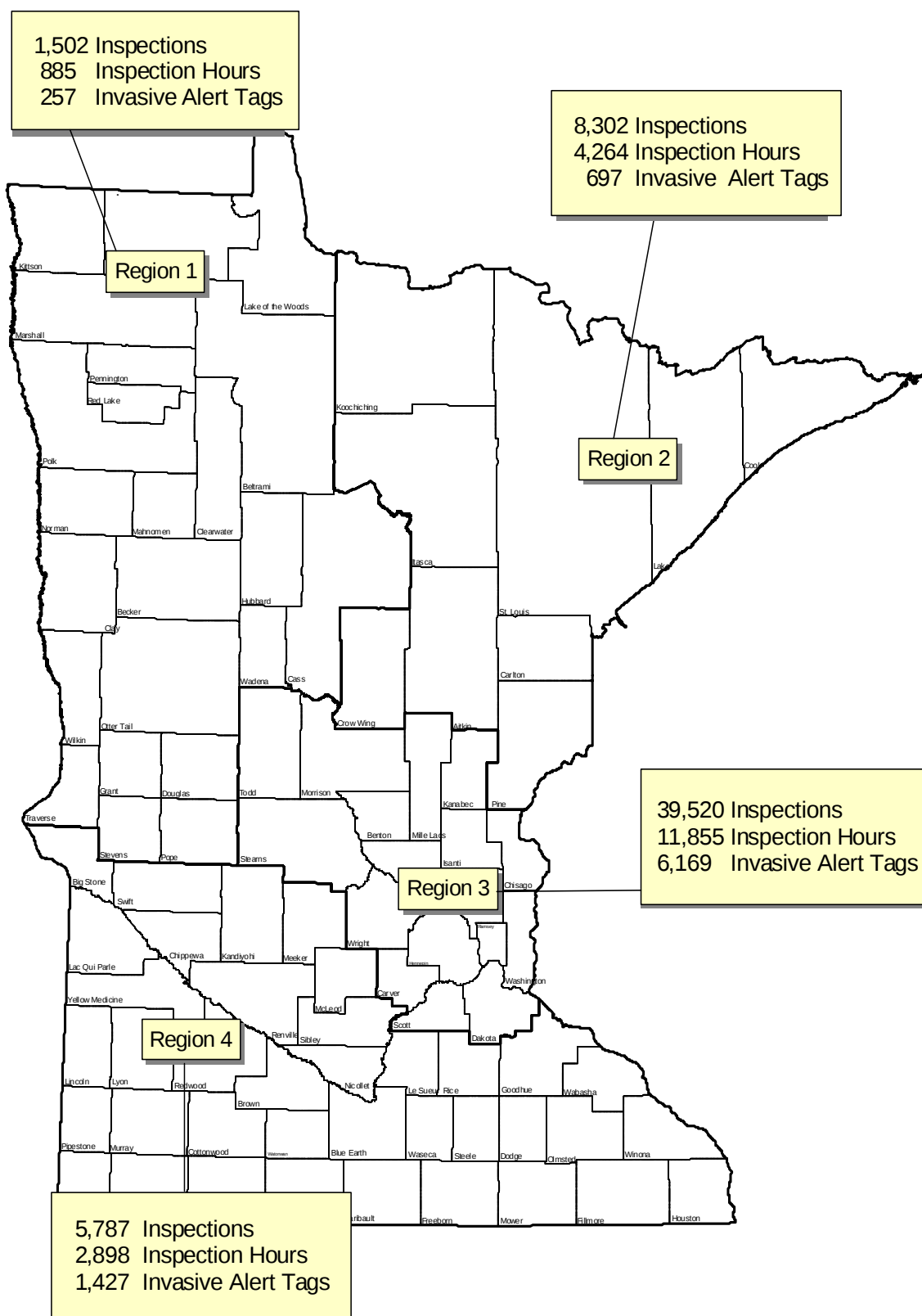


Figure 4. DNR watercraft inspections at public water accesses in 2005.

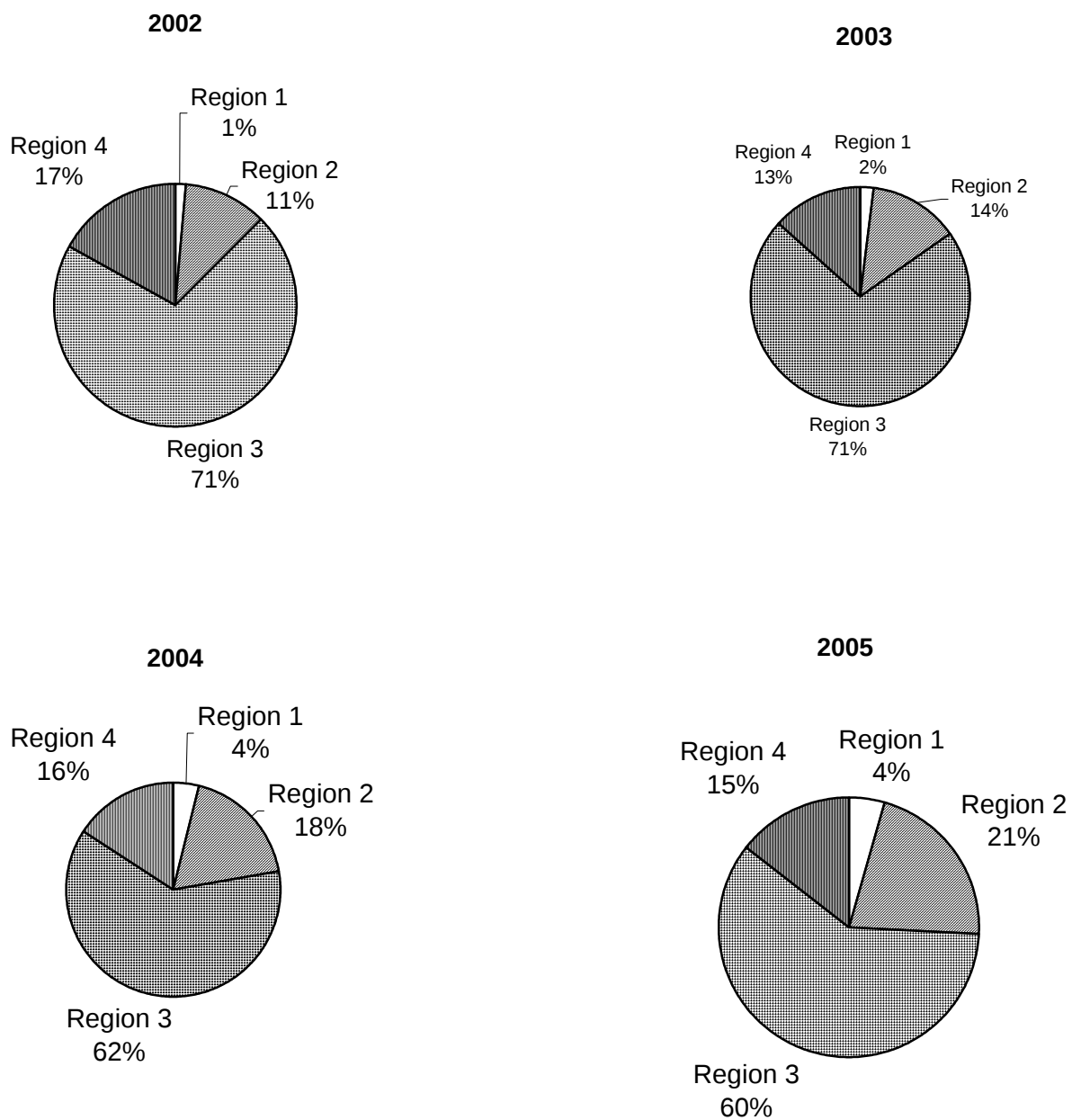


Figure 5. Percent of the state's total watercraft inspection hours spent in each region in 2002, 2003, 2004, and 2005.

Although the program has broadened to include inspections at uninfested waters, the majority of the inspections are still done at infested water bodies. With the population of zebra mussels in Lake Ossawinnamakee increasing since their discovery in 2003 (see Management of Zebra Mussels) it has remained very important to maintain a high level of public awareness effort in the Brainerd area. One of these efforts was to create a new boat wash program that encourages boaters to take their watercraft to participating car washes and clean them using high pressure and hot water.

The DNR has also maintained a high level of watercraft inspection hours in the Brainerd area. In 2005, Lake Ossawinnamakee was visited 78 times and 378 inspections were conducted which is an increase in inspections of 35% (134 inspections) from 2004. The Watercraft Inspection Program increased inspection hours in the Brainerd area in 2004 by 57% (1,063 hours) and inspections by 53% (2,328 inspections) from 2003. In 2005, 2,751 inspection hours were spent in the Brainerd area and 6,921 inspections were conducted.

In August of 2005, four zebra mussels were discovered in Lake Mille Lacs. In response to this discovery additional watercraft inspectors were sent to Lake Mille Lacs during the Labor Day weekend and the two following weekends. During the three weekends, 137 hours were spent at the access and 360 inspections were conducted. New informational signs about the discovery of zebra mussels in Lake Mille Lacs were installed at all public water accesses and at six resorts on the lake. The signs explain what boaters can do to make sure they don't transport any invasive species.

Increase public awareness

Each boater contacted by a watercraft inspector is asked a standard series of questions. These surveys provide important information on the public's awareness of invasive species laws and help identify high-risk areas (i.e., accesses where many watercraft pick up plant fragments). According to survey information collected by watercraft inspectors, awareness of invasive species laws remains very high among Minnesota boaters. The percent of watercraft users who responded "yes" when asked if they were aware of the invasive species laws for the state was 97%. Boaters from other states using Minnesota water bodies had a slightly lower response at 91%. The range of percentages for each Minnesota county where at least 100 inspections had been done varied from 89% (in Lake County) to 100% (in Isanti, Le Sueur and Morrison counties). Of those who said they were not familiar with the laws, slightly less than 3% (24 out of 831) had vegetation on their watercraft when they entered the access. In contrast, slightly more than 1% (327 out of 29,215) of the people who said that they were familiar with the laws entered the access with vegetation.

Decals are given to boaters (see Decal Program for Trailered Watercraft) to signify that they have talked with a watercraft inspector. Of those with no decal, 5.6% said they were not familiar with the invasive species laws. In contrast, of those with a year 2005 decal, 21 out of 18,016 boaters or slightly more than one tenth of a percent said they were not familiar with the laws. This suggests that the Watercraft Inspection Program is successful at educating boaters about Minnesota's invasive species laws.

Reduce the percentage of trailered boats carrying invasive species

The Watercraft Inspection Program has been unable to assist with road checks due to changes in the law that prevents the Department from conducting them (see Enforcement).

Increase educational efforts with citizen groups

In 2005, the Watercraft Inspection Program participated in many public awareness activities and worked with several citizen groups in order to educate the public about aquatic invasive species. Inspectors answered questions both at the invasive species display at the Minnesota State Fair, Celebrate Lake Pepin Day, Whitefish Chain Antique and Classic Wood Boat Rendezvous, and the Festival of Fish. The inspectors also educated citizens at Cannon Valley Trail Days in Welch. The Watercraft Inspection Program was also able to work with several citizen groups throughout the season both through awareness events and participation in lake association meetings. Eight volunteer trainings were conducted during the season; six of those trainings were with individual lake associations and two were in cooperation with the Minnesota Lakes Association and included members of multiple lake associations. Fifty-five lake association members registered with the DNR Volunteer Program and they accomplished 223 hours of inspection time at the access.

The Watercraft Inspection Program also worked cooperatively with four lake associations and citizen groups to increase inspection hours in their areas. These citizen groups funded additional hours of inspection at their accesses while the Watercraft Inspection Program provided training, equipment, and supervision. The Lake Minnetonka Conservation District (LMCD) worked with the Watercraft Inspection Program for the fourth year. Inspectors spent an additional 2,019 hours on five Lake Minnetonka accesses because of the funding provided by the LMCD. Both Bay and Pike lake associations worked cooperatively with the DNR for the second year. Pike Lake Association's cooperative efforts with the Watercraft Inspection Program increased inspection hours on its lake by 242 hours and Bay Lake Association's cooperative efforts increased inspection hours by 197 hours. The 2005 boating season was the first time that the Big Sandy Lake Association had worked cooperatively with the Watercraft Inspection Program. They increased inspection hours by 144 hours on Big Sandy Lake.

Estimate of Risk from Trailered Boats

The percentage of boats/trailers carrying vegetation as they were trailered out of a lake or river varied widely by county (Figure 6). These variations may be caused by several variables including the amount and type of vegetation in the water body, its proximity to the public water access, and the amount of recreational boating traffic. An average of 15% of the watercraft checked by watercraft inspectors were found with vegetation (3,571 watercraft) as they trailered out of the water. This rate demonstrates a clear risk that boaters will transport aquatic vegetation (and invasive species) from lake to lake if boats are not properly cleaned. The percentage of boats and trailers carrying vegetation as they enter public accesses was 1.2%. This is a good indication that the majority of boaters using infested waters are inspecting and cleaning their boats and trailers. Enforcement of invasive species laws continues in an effort to reduce the transportation of vegetation and invasive species (see Enforcement).

Transportation of Other Invasive Species

There were no zebra mussels found on boats being launched into Minnesota waters. One watercraft was found to have attached zebra mussels while exiting the St. Louis River in early October of 2005. This demonstrates a clear risk of zebra mussels being moved on boat hulls or on plants caught on trailers if boats are not properly cleaned. Anglers who “catch” zebra mussels off the bottom and discard them in the bottom of their boats can also move them.

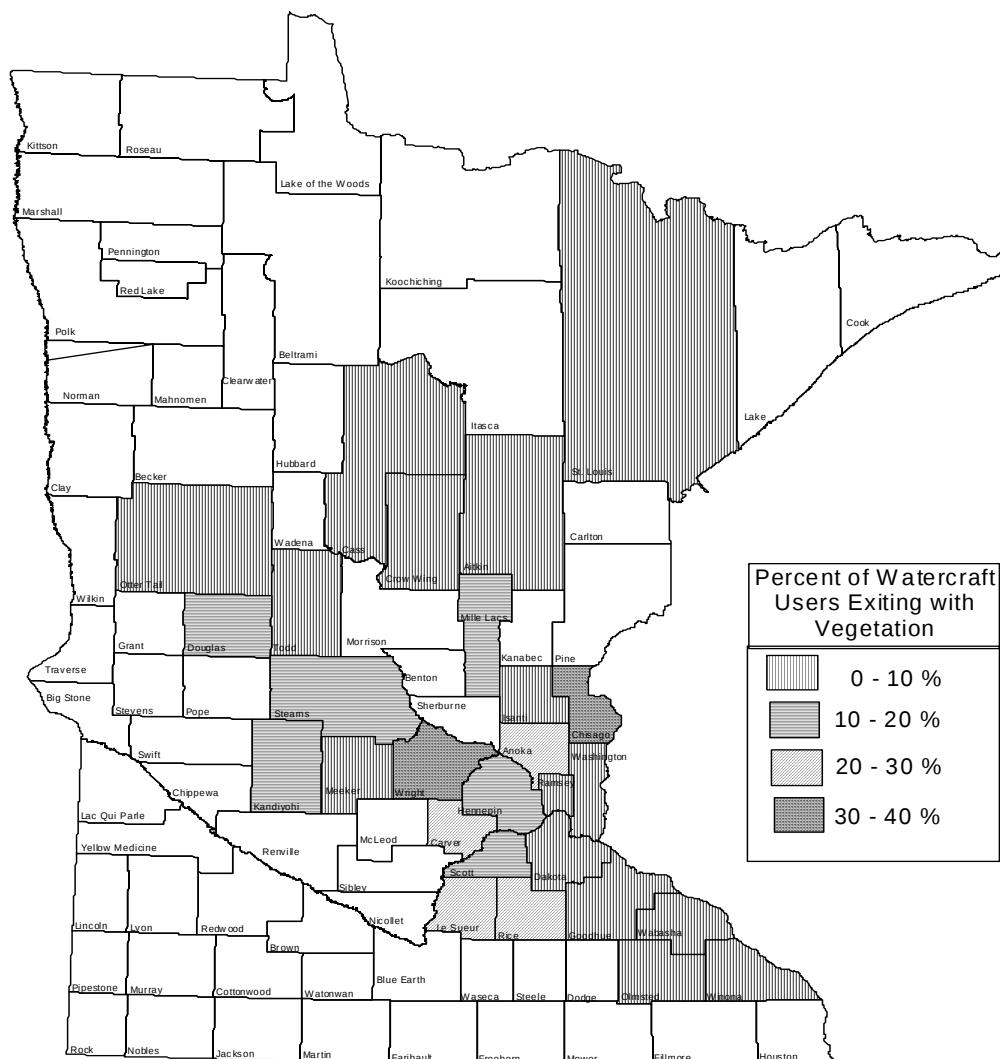


Figure 6. Percentage of exiting watercraft with attached vegetation prior to inspection and cleaning (in counties where more than 100 boats were inspected upon leaving an access).

Decal Program for Trailered Watercraft

During the 1994 boating season, several boaters expressed frustration over being approached by inspectors several times each week throughout the summer. To respond to their concerns and to reduce the duplication of education efforts, a decal was developed and distributed to boaters whose watercraft had been inspected for

invasive species (Figure 7). Boaters are instructed to voluntarily affix the decal to the winch post of their trailer. This allows inspectors to identify the boaters who have already spoken with inspectors during the summer. Boaters with a decal are given a brief reminder to drain water and remove vegetation from their boats. The decals have been used for 11 years now and have been well received by the public. The approximately 33,000 decals distributed during the 2005 boating season also remind boaters to inspect their boats when inspectors are not present.



Figure 7. Decal provided to boaters by DNR watercraft inspectors in 2005.

Future needs and recommendations for watercraft inspections

- Increase cooperation and partnerships with citizen groups that would like to help raise awareness in their areas.
- Expand the number of community events in which we participate in order to educate new audiences about invasive species.

Risk Assessment

2005 Highlights

- Risk assessments of northern snakehead fish (*Channa argus*), New Zealand mudsnail (*Potamopyrgus antipodarum*), tubenose goby (*Proterorhinus marmoratus*), Brazilian waterweed (*Egeria densa*) and Chinese water spinach (*Ipomoea aquatica*) were completed.
- Based on the risk assessments completed in 2005, the DNR began the process to list those species in Minnesota Rule as regulated, prohibited, or unregulated species.
- DNR staff from the divisions of Ecological Services and Fish and Wildlife began an evaluation of the risks posed by DNR Fisheries activities, and proposed additional precautions to prevent the spread of invasive species through those activities.

Introduction

Many invasive species that cause problems in other parts of the United States or in other countries do not yet occur in Minnesota but could become established here. Keeping these species out of Minnesota is a high priority not only for the environment, but also for the state's economy. Failure to interrupt pathways that bring these species to Minnesota, and to address high-risk species can result in introductions that are costly to manage and may become perpetual problems.

Risk assessments are a way to determine how non-native species move into the state and to identify which species pose the greatest threat to Minnesota. Risk assessments need to be updated regularly as new information becomes available. In addition, continuing to gather information about a non-native species in the state can help determine whether to implement new and/or different management strategies.

Risk assessments provide the basis for planning and implementing risk management activities. Risk management activities include, but are not limited to, public education, regulation, and management. The results of a risk assessment can be used to recommend that species be classified as prohibited, regulated, unregulated, or unlisted (M.S. 84D.04-.07). For example, the results of the risk assessment of Eurasian watermilfoil led the DNR Invasive Species Program to propose the species be classified as a *prohibited invasive*, to implement a multi-prong public education effort, to support research on new management methods for milfoil, and to help manage nuisances caused by the milfoil through grants for control work using herbicides and harvesting (See Management of Eurasian Watermilfoil).

Goals

The goals of risk assessment, risk management, and related research are to:

- Identify invasive species that may be harmful to Minnesota resources;
- Identify the pathways by which invasive species come to Minnesota;
- Determine the best options to prevent the release and establishment of potentially invasive species and to implement them.

Risk Assessment of Individual Non-native Species

A risk assessment of a potentially invasive, non-native species includes an assessment of how likely it is to be introduced into the state, the likelihood of its naturalization in the state, the possible adverse effects it may have on native species, outdoor recreation, and other uses of natural resources in Minnesota, and the potential for its control. A history of risk assessment activities done in Minnesota is found in last year's annual report (Invasive Species Program, 2005).

During 2005, DNR staff prepared risk assessments of individual species.

These risk assessments can be used to guide risk management activities and are part of a process for deciding on risk management activities not only for species that were evaluated, but also for ones that will be reviewed in the future.

Risk assessments of individual species answer the following questions:

1. What are its pathways of spread, and what is the probability of it being introduced to Minnesota: high, moderate, or low?
2. What is the probability it can become established in Minnesota: high, moderate, or low?
3. Could it be harmful to Minnesota's economy, environment, or society?
4. How can it be controlled?
5. How severe are the consequences of establishment: high, moderate, or low?

In 2005, Invasive Species Program staff prepared risk assessments of the following species: northern snakehead fish (*Channa argus*), New Zealand mudsnail (*Potamopyrgus antipodarum*), tubenose goby (*Proterorhinus marmoratus*), Brazilian waterweed (*Egeria densa*) and Chinese water spinach (*Ipomoea aquatica*). Table 6 shows a summary of the conclusions from the risk assessments and proposed legal classification in Minnesota Rule. The DNR is still considering whether to propose tubenose goby and brittle naiad as *regulated* or *prohibited* invasive species.

Table 6. Summary of conclusions from risk assessments and proposed legal classifications.

Species	Is it being introduced? (*)	Can it establish? (**)	Harm caused by establishment (***)	Proposed legal classification
Brittle naiad (<i>Najas minor</i>)	moderate	high	moderate	Regulated or prohibited
Brazilian elodea (<i>Egeria densa</i>)	high	low	high	Regulated
Chinese water spinach (<i>Ipomoea aquatica</i>)	moderate	low	moderate	Regulated
New Zealand mudsnail (<i>Potamopyrgus antipodarum</i>)	high	high	high	Prohibited
Northern snakehead fish (<i>Channa argus</i>)	high	high	high	Prohibited
Tubenose goby (<i>Proterorhinus marmoratus</i>)	moderate	high	moderate	Regulated or prohibited

* Is it being introduced? Low means that it is not in the country and that it is not known to be coming to Minnesota in any way

** Can it establish? Low means it is not expected to become established in the state

*** Harm caused by establishment: Low means it is not expected to cause any harm

Many less-detailed risk assessments have been completed on species of potentially invasive, non-native aquatic plants and animals that either have spread to or may spread to Minnesota. A comprehensive list of all species that have been subjected to some level of risk assessment can be found in last year's annual report (Invasive Species Program, 2005).

Risk Assessment and Risk Management of Pathways of Invasive Species Introduction and Spread

Pathway risk assessments are an attempt to predict how invasive, non-native species will enter Minnesota and in what numbers. During 2005, DNR Invasive Species staff worked with DNR Fisheries staff and the aquatic plant industry to help identify pathways of spread and recommend actions to help prevent the spread of invasive species through those pathways.

Assessment of DNR Fisheries Activities

DNR staff from the Divisions of Ecological Services and Fish and Wildlife began an evaluation of the risks posed by DNR Fisheries activities and proposed additional precautions to prevent the spread of invasive species through those activities. This comprehensive review of DNR Fisheries activities ranked the risk of each activity to spread specific invasive aquatic plant and animal species that are known to pose risks to Minnesota. Precautionary actions were proposed for both known infested waters and waters not known to be infested. The proposed additional precautions also included guidance on how and how often waters should be monitored for invasive species. The final recommendations from this project will be available in early 2006.

Prevention of spread of invasive species through aquatic plant sales

Activities such as water gardening, wetland restoration, and shoreline plantings are increasing in popularity. While efforts to restore lakeshores to more natural conditions are recommended, the commercial sale of aquatic plants represents a significant pathway for the introduction of invasive species into Minnesota waters. The risk that invasive species will make their way into natural waters, either by accidental escape of cultivated plants or by deliberate introduction of aquarium or water garden plants, poses a threat to Minnesota lakes, rivers, and wetlands.

During 2005, Minnesota Sea Grant and the University of Minnesota Extension Service continued their initiative to assess the potential for introducing new invasive species through water gardening in Minnesota and to develop an educational campaign to prevent new introductions. Partners on this project included the DNR Invasive Species Program, the Minnesota Water Garden Society, the Minnesota Nursery and Landscape Association, and private nursery and landscape businesses, as well as Michigan Sea Grant and the Wisconsin DNR. Through a series of interviews, focus groups, and questionnaires, they developed key messages and determined what outreach products would be most useful. The key messages were put onto plant tags, plant sticks, and display posters for water gardening centers. These products were produced in May of 2005 and were distributed to 40 interested water gardening centers (Minnesota Sea Grant, 2005). A survey done at the end of the selling season indicated that water gardening centers were happy with the products, and would be willing to pay for them in the future (Barb Liukkonen, Minnesota Sea Grant, personal communication October 2005). Images of the outreach materials can be seen on the Minnesota Sea Grant Web site: http://www.seagrant.umn.edu/exotics/ais_wg_materials.html.

In 2005, Invasive Species Program staff continued to widely distribute two publications aimed at slowing the movement of invasive species through the horticultural trade: *Harmful Exotic Species: What every water gardener and shoreline restorer should know*, and *Harmful Exotic Species: What every aquatic plant seller should know*. These publications give aquatic plant buyers and sellers the information they need to be able to prevent the introduction of invasive species into Minnesota waters.

Future needs for risk assessment, risk management, and related research

Risk Assessment

- Continue to identify non-native species that may be likely to enter or have already entered Minnesota and evaluate their potential to cause problems if they become established in the wild.
- Continue to identify pathways that could bring non-native species into the state.
- Develop a database and maintain files at the DNR of literature about invasive aquatic plant and wild animal species, and pathways of their introduction to guide risk management activities.

Risk Management

- Determine and carry out appropriate actions to deal with species determined to be harmful to Minnesota. Actions will include education, regulations, monitoring and management, and formulation of public policy.

Research

- Encourage, fund, and support research to predict which non-native species are likely to naturalize and be harmful in Minnesota, and to examine the risks associated with particular pathways of introduction of those species.

References Cited

- Invasive Species Program. 2005. Invasive Species of Aquatic Plants and Wild Animals in Minnesota: Annual Report for 2004. Minnesota Department of Natural Resources, St. Paul. MN
- Minnesota Sea Grant 2005. Aquatic Invasive Species and Watergardening. Retrieved from http://www.seagrant.umn.edu/exotics/ais_wg.ppt October 27, 2005.

Management of Curly-leaf Pondweed

2005 Highlights

- DNR staff assisted with several projects to evaluate the management of curly-leaf with endothall herbicide, fluridone herbicide, and winter drawdown.
- The evaluation of fluridone herbicide included the whole-lake treatment of Lake Benton, a 2,800-acre lake in southwest Minnesota.
- The DNR provided funding to the U.S. Army Research and Development Center to determine the lowest rate of fluridone herbicide needed to control curly-leaf pondweed and stop turion production.
- The DNR provided funding to the University of Minnesota to study turion distribution, viability, and longevity.
- DNR staff worked on 17 Lake Vegetation Management Plans for lakes with curly-leaf pondweed.
- Invasive Species Program staff were presenters at three well-attended curly-leaf pondweed symposiums.



Introduction

Issue

Curly-leaf pondweed (*Potamogeton crispus*) is a perennial, rooted, submersed vascular plant that was first noted in Minnesota about 1910 (Moyle and Hotchkiss, 1945). Curly-leaf pondweed is known to occur in 729 Minnesota lakes in 67 of the 87 counties in Minnesota (Figure 8). Unlike most native plants, curly-leaf pondweed plants remain alive, slowly growing even under thick ice and snow cover (Wehrmeister and Stuckey, 1978). Therefore, it is often the first plant to appear after ice-out.

By late spring, curly-leaf pondweed can form dense mats that may interfere with recreation and limit the growth of native aquatic plants (Catling and Dobson, 1985). In mid-summer, curly-leaf plants usually die back, which results in rafts of dying plants piling up on shorelines, and often is followed by an increase in phosphorus (Bolduan et al., 1994) and undesirable algal blooms. A key question underlying management of curly-leaf pondweed is: to what extent do lakes experience algal blooms due to the presence of curly-leaf pondweed, and to what extent do lakes grow large amounts of curly-leaf pondweed due to an abundance of algae and the nutrient regime that supports this condition?

Curly-leaf plants usually die back in early summer in response to increasing water temperatures, but they first form vegetative propagules called turions (hardened stem tips). New plants sprout from turions in the fall (Catling and Dobson, 1985). In order to obtain long-term control of curly-leaf pondweed, the production of turions must be stopped. It is not clear how many years of turion reduction it will take to produce long-term control of curly-leaf.

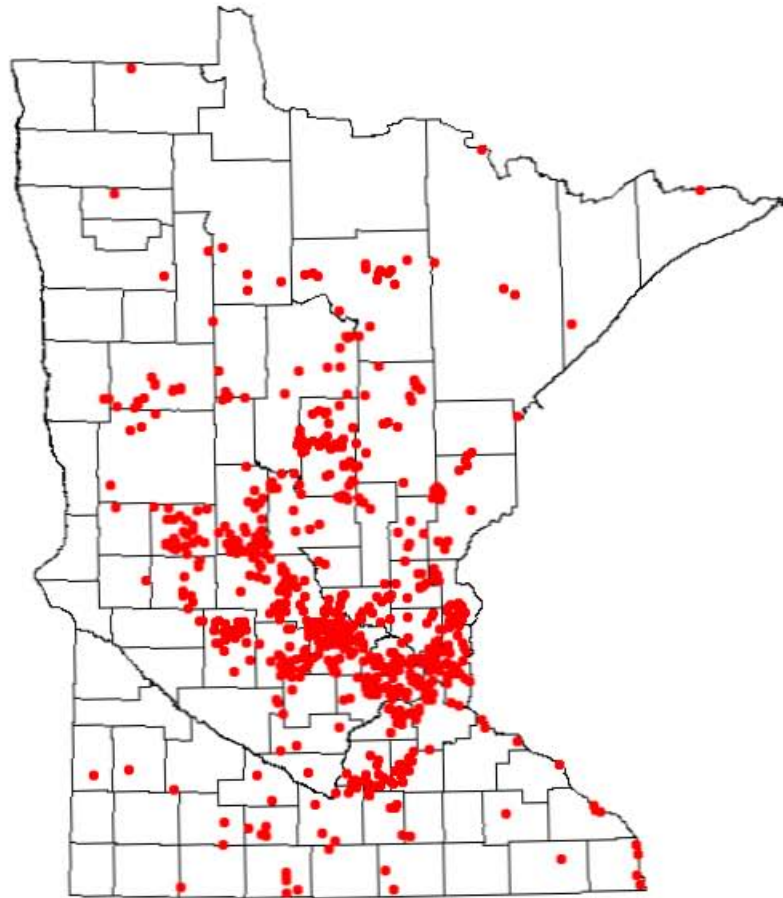


Figure 8. Curly-leaf pondweed locations in Minnesota as of October 2005 (compiled from reports from DNR Fisheries, Wildlife, and Ecological Services staff).

Goals

The DNR has two goals for curly-leaf pondweed management:

- To prevent the spread of curly-leaf pondweed within Minnesota.
- To reduce the impacts caused by curly-leaf pondweed to Minnesota's ecology, society, and economy.

The DNR uses both enforcement and public awareness to achieve the first goal. The DNR has two strategies to achieve the second goal. One is to provide technical assistance to people who are managing curly-leaf pondweed. The other is to support and conduct research to improve the management of curly-leaf pondweed.

Prevention of spread

Invasive Species Program staff worked with the general public, lakeshore residents, and researchers to help prevent the spread of curly-leaf pondweed. The Invasive Species Program continued to use watercraft inspections, informational materials, and public speaking engagements to further our efforts to prevent the accidental spread of curly-

leaf pondweed. In particular, access inspectors spent time at several lakes, which are heavily infested with curly-leaf pondweed (See the Watercraft Inspections and Awareness Events chapter of this report for a description of their activities). DNR conservation officers also helped prevent the spread of curly-leaf pondweed through enforcement of state laws that make it illegal to transfer aquatic plants on public roads (see the Enforcement chapter of this report for a description of these activities).

Progress in Management of Curly-leaf Pondweed - 2005

During the past year, lake residents and lake associations did routine management of curly-leaf pondweed to reduce nuisance areas using both herbicides and mechanical harvesting. In addition, DNR staff, working with lake residents, lake associations, and local units of government, have participated in several pilot projects in which herbicides were used to control curly-leaf pondweed lake-wide.

During 2005, DNR staff have actively supported efforts to manage curly-leaf pondweed. DNR staff have provided technical assistance to individuals and groups working to manage nuisance curly-leaf growth. DNR staff have also assisted with research to evaluate new methods of curly-leaf pondweed management.

The DNR Invasive Species Program is developing a plan to offer funding for curly-leaf pondweed management under a new grant program. Money from this grant program should be available in the spring of 2006. Approximately \$100,000 will be available for curly-leaf pondweed management statewide in 2006.

Technical Assistance

DNR staff continued to provide technical assistance to lake groups working to manage curly-leaf pondweed. Technical assistance included conducting lake vegetation surveys, providing guidance on the best management practices for controlling curly-leaf pondweed, and assistance in writing Lake Vegetation Management Plans (LVMPs).

Lake vegetation surveys

In 2005, DNR staff conducted three types of lake vegetation surveys in support of curly-leaf pondweed management, point-intercept surveys, surveys of buried turions, and boat surveys to map matted areas of curly-leaf. Point-intercept surveys provide an estimate of the distribution and frequency of occurrence of curly-leaf pondweed and native plants. These surveys were used to determine if curly-leaf management activities were effective and to see if curly-leaf management caused any damage to native plant communities. DNR staff conducted point-intercept surveys on 19 lakes with abundant curly-leaf pondweed. Turion surveys were used to determine if successive years of treatment were causing a depletion of curly-leaf pondweed turions in the lake sediments. DNR staff also conducted turion surveys on five lakes. Boat surveys determined where curly-leaf pondweed formed dense mats and how those mats were interfering with recreational use of the lake. These survey efforts served as the basis for evaluation by local residents and the DNR of the extent and severity of the problems caused by curly-leaf pondweed in these lakes, and were used to help determine the best management strategy for the lakes. These evaluations also provided a basis to evaluate the effects of curly-leaf pondweed management efforts.

Best management practices for controlling curly-leaf pondweed

Staff of the Invasive Species Program continued to provide the public with information on the best management practices for curly-leaf pondweed control through individual contacts and participation in public meetings. In 2005, staff presented talks at three curly-leaf pondweed symposiums organized by the Minnesota Lakes Association, Minnesota Sea Grant, and the Initiative Foundation. Staff also attended many lake association meetings, including meetings with the Lake Benton Lake Improvement Association in Lincoln County, the Weaver Lake Association in Hennepin County, the Briggs Rush Julia Association in Sherburne County, the Little Rock Lake Association in Benton County, the Big Swan Lake Association in Todd County, and the Lake Orono Improvement Association in Sherburne County.

DNR staff provided technical assistance to people interested in controlling curly-leaf pondweed with herbicides by providing guidance from CerexAgri, the manufacturer of the endothall based herbicides Aquathol K, Aquathol Super K, and Hydrothol 191. In 2004, CerexAgri provided new recommendations for the use of its products against curly-leaf pondweed. CerexAgri recommends that entire ponds or lakes or large area treatments should be done at 0.75-1.5 ppm, and that lake or pond margin or spot treatments be done at 1.5-2.0 ppm. CerexAgri states that these curly-leaf pondweed treatments may be made when water temperatures reach approximately 50°F. These recommendations were made in part based on the research that has been done in Minnesota on early-season treatments with endothall (see Research section immediately following).

Lake vegetation management plans

DNR staff worked with lake groups and/or local units of government to develop Lake Vegetation Management Plans (LVMPs). LVMPs contain a description of the condition of the lake and plans to address identified problems. The purpose of an LVMP is to develop agreement on goals for the aquatic plant community, identify issues, design methods to reach those goals, and to design methods to evaluate whether the goals are being reached or not. DNR staff worked on 17 LVMPs for lakes with curly-leaf pondweed in 2005. Many of the lake vegetation surveys were conducted to evaluate the results of curly-leaf management allowed by an LVMP or to help with the development of an LVMP.

Research to improve management of curly-leaf pondweed

DNR staff have conducted research and provided technical assistance and financial support to researchers working on curly-leaf pondweed. The principal activity in this area has been lake-wide management with herbicides to control the invasive plant. These treatments have four main goals:

1. Reduce the interference with use of the lake caused by curly-leaf pondweed.
2. Reduce the abundance of curly-leaf pondweed for long periods of time.
3. Increase the abundance of native, submersed aquatic plants.
4. Reduce peaks in concentrations of phosphorous and associated algal blooms.

Operational applications of herbicides to whole lakes that are classified as public waters (Minnesota Statutes (M.S. 103G.005) are not allowed in Minnesota (Minnesota Rules Chapter 6280: Aquatic Plant Management) because this destroys more vegetation than

is necessary to give riparian owners access to lakes. Unnecessary destruction of vegetation in Minnesota waters is not permitted because plants provide many benefits to lake ecosystems (M.S. 103G.615). For these reasons, application of herbicides to control submersed vegetation in Minnesota lakes is limited to treatment of no more than 15% of the littoral zone. A variance from this limit may be issued by the DNR. Variances have been issued for studies of control of curly-leaf pondweed by whole-lake management, where there is a well-developed plan and a commitment to monitor and report the effects of the treatment on the lake.

Repeated whole-lake treatments with endothall to control curly-leaf pondweed

Schwanz and Blackhawk lakes, Dakota County

From 2000 through 2003, the U.S. Army Engineer Research and Development Center (USAERDC) used repeated early spring, whole-lake applications of endothall applied as Aquathol K for control of curly-leaf pondweed in two Dakota County lakes (Invasive Species Program, 2005).

These treatments were discontinued on Schwanz Lake (13 acres) and Blackhawk Lake (37 acres) after 2003. Curly-leaf pondweed was reduced to low levels in spring 2004, and residual turions in the sediment were nearly eliminated. In spring of 2004, a second study was initiated to demonstrate the use of small-scale applications of endothall applied as either Aquathol K or Aquathol Super K to prevent curly-leaf pondweed from returning to nuisance levels. No treatments were conducted on Schwanz Lake in 2004, and 12 acres were treated on Blackhawk Lake using Aquathol K. In April of 2005, two acres on Schwanz Lake and six acres on Blackhawk Lake were treated using a granular endothall herbicide, Aquathol Super K. Low levels of curly-leaf pondweed still occurred in both Schwanz and Blackhawk lakes in June 2005; however, the plants remained below nuisance levels. The USAERDC is planning to continue these small treatments next year to see if it is possible to prevent curly-leaf pondweed from becoming dominant using small treatments after the turion bank has been depleted (John Skogerboe, USAERDC personal communication, October 2005).

The water quality of Schwanz and Blackhawk lakes was monitored by the City of Eagan (Macbeth, 2005). Macbeth reported they saw no evidence that water quality was specifically dependent on curly-leaf pondweed (personal communication). That is, in both Blackhawk and Schwanz, water clarity does not appear to be driven by curly-leaf pondweed.

Based on the USAERDC research so far, the Invasive Species Program recommends that if you wish to use herbicide to control curly-leaf pondweed, you should use an endothall-based herbicide such as Aquathol K when water temperatures are 50 to 60 degrees F in the spring. These treatments should kill curly-leaf pondweed, reduce or eliminate turion production in the treated areas, and will have less of a negative impact on native aquatic plants than treatments done later in the summer. It is not possible to completely eliminate curly-leaf pondweed from a water body using these early-season treatments, but it does appear to be possible to significantly reduce the amount of curly-leaf pondweed present.

Medicine Lake, Hennepin County

Medicine Lake is an 886-acre, eutrophic lake that has both Eurasian watermilfoil and curly-leaf pondweed. The management of curly-leaf pondweed in Medicine Lake was described in a report by Vlach and Barten (2005), which is the basis for this summary. The City of Plymouth developed a Water Resources Management Plan in 2000 that identified Medicine Lake as a high priority resource that requires water quality improvements. A Medicine Lake subcommittee was established to develop and facilitate a comprehensive management plan to pro-actively address the water quality issues. The subcommittee determined that curly-leaf pondweed is a significant factor degrading the in-lake water quality. A primary initiative of the Medicine Lake subcommittee was the formation in October, 2002 of an Aquatic Vegetation Management group (AVM).

The AVM group developed an aquatic plant management plan to control invasive species and promote the growth of native species as an effort to improve water quality conditions for Medicine Lake. The plan proposed to chemically treat the entire littoral area of Medicine Lake with endothall to control curly-leaf pondweed. The DNR approved the project and, in April 2004, granted a three-year variance to the City of Plymouth for chemical control of curly-leaf pondweed in an area greater than 15% of the littoral zone of Medicine Lake. Conditions of the permit required the implementation of an extensive monitoring program to determine whether project goals and objectives will be accomplished.

The first treatment of Medicine Lake with herbicide, Aquathol K, occurred during early May 2004. Post-treatment surveys suggested that the treatment was extremely effective at killing curly-leaf pondweed in Medicine Lake. There was concern that reducing curly-leaf pondweed might shift the plant community towards domination by Eurasian watermilfoil, but this did not happen in 2004.

The primary objective of the long-term approach to control of curly-leaf pondweed is to improve water quality in the lake. Typically, Medicine Lake has an algae bloom following senescence of curly-leaf pondweed at the end of June or beginning of July. In 2004, conditions during the early spring treatment were not conducive for the development of an algae bloom. The water temperatures were also relatively cool for several weeks following the treatment inhibiting the growth of algae. Consequently, algae blooms did not develop until early summer when water temperatures were warmer. Water quality conditions after the algal blooms did not improve significantly during the remaining portion of the summer due to the high amount of nutrients within the lake. It is anticipated that water quality will improve in future years with the continued efforts to reduce curly-leaf pondweed densities and establish a diverse native plant community.

Medicine Lake was subjected to a second lake-wide treatment during 2005 to control curly-leaf pondweed, but results of monitoring done this year are not yet available.

Whole-lake management with low rates of endothall combined with 2,4-D for selective control of curly-leaf pondweed and Eurasian watermilfoil

The USAERDC working in cooperation with Mississippi State University, the DNR, and CerexAgri continued its test of the efficacy of early spring applications of endothall in combination with 2,4-D against curly-leaf pondweed and Eurasian watermilfoil in two Minnesota lakes (Invasive Species Program, 2005). Observations in 2005 indicated that the treatments provided good control of curly-leaf pondweed and Eurasian watermilfoil, and that many native plants were not harmed by the treatments.

Whole-lake treatment with fluridone to control curly-leaf pondweed

The Invasive Species Program supported the initial treatment of two lakes with fluridone herbicide, Weaver in Hennepin County and Benton in Lincoln County. The purpose of these pilot treatments is to determine whether a multi-year series of early-season treatments with fluridone herbicide can control curly-leaf pondweed, deplete the turion bank, and increase native aquatic plant cover without any decline in water clarity and other indicators of water quality. The DNR permitted the first treatments in 2005 with the understanding that permitting of treatments in future years would depend on the success of the initial treatments. Specific criteria to define treatment success were identified, including specific plant community and water quality outcomes. In addition to providing significant technical assistance to these projects, the DNR provided \$10,000 each to the Weaver Lake Association and the Lake Benton Lake Improvement District to help fund the experimental fluridone treatments. The Weaver Lake Association, the Lake Benton Lake Improvement District, the Lake Benton Lake Association, the Lincoln County Environmental Office, the Redwood Cottonwood River Control District, and Southwest State University have also provided significant effort and/or funding to bring these projects forward.

Lake Benton, Lincoln County

Lake Benton is 2,857-acre lake with a maximum depth of nine feet. It is highly eutrophic. Recently curly-leaf pondweed has covered the entire lake during its peak biomass season in May and June. In August 2003, the Lake Benton Lake Improvement Association requested permission to treat the lake with a multi-year series of fluridone herbicide treatments to control curly-leaf pondweed and deplete the turion bank in the lake. The DNR agreed that an initial fluridone treatment could be scheduled for 2005, but that treatments in future years would be dependent on the success of the initial treatment. The DNR and cooperators began collecting pre-treatment data in 2004 (Invasive Species Program, 2005).

In 2005, the Lake Benton Lake Improvement District hired a commercial applicator to treat the lake with fluridone herbicide with a target rate of 4 parts per billion (ppb) of fluridone. The treatment was carried out on April 12, 2005. This is the largest fluridone treatment ever done in the state. The rate of fluridone used was based on research funded by the DNR and completed by the USAERDC (see Evaluation of low rates of fluridone to control the growth and reproduction of curly-leaf pondweed section following). Initial results indicate that the target treatment rate was achieved. Fluridone concentration stayed between 2 ppb and 4 ppb for approximately 90 days after

treatment. The initial rate was higher than desired: at three days after treatment, there was 4.8 ppb of fluridone in the lake.

The DNR Invasive Species Program collected pre-treatment and post-treatment plant community data and assisted the Lincoln County Environmental Office and the Minnesota Pollution Control Agency in collecting water quality data.

The treatment reduced the frequency of occurrence of curly-leaf pondweed. Curly-leaf was 11%, down from 60% in 2004. The treatment also reduced the height of curly-leaf pondweed plants. In June 2004, curly-leaf plants were at the surface in many areas, in June 2005, curly-leaf plants were less than two feet tall. In June 2005, native plants were at least as common and diverse as they were in June 2004. In late July, the occurrence and diversity of native plants were reduced compared to July 2004. In general, native plants occurred at very low levels in Lake Benton in both pre- and post-treatment surveys. The Lincoln County Environmental Office will attempt re-planting of natives.

Water quality measures (total phosphorus, chlorophyll a, total suspended solids, and Secchi depth) were slightly improved in 2005 compared to 2004. In 2004, the average May through September Secchi depth was 1.6 feet. In 2005, it was 1.7 feet. In 2004, the average June-September chlorophyll a was 61 ppb, total phosphorus was 0.14 ppm, and total suspended solids was 27 ppm. In 2005, chlorophyll a was 34 ppb, total phosphorus was 0.11, and total suspended solids was 23 ppm. A full report of the results from 2004 and 2005 plant and water quality data will be available by February 2006.

Weaver Lake, Hennepin County

Various stakeholders suggested that it would be important to have at least one lake in addition to Lake Benton where the DNR would evaluate the effects of application at low rates of fluridone to control curly-leaf pondweed. The DNR chose Weaver Lake because it is mesotrophic, it has several species of native submersed aquatic plants which should increase following a fluridone treatment, there is good pre-treatment water quality and plant community data for the lake, and there is a willingness from the lake association to fund the treatment and continue the monitoring. Weaver Lake is a 150-acre lake with a maximum depth of 57 feet.

Mesotrophic lakes have higher water clarity than eutrophic lakes. The DNR believes it is important to evaluate the effects of fluridone on curly-leaf in a mesotrophic lake because the outcome of fluridone treatments may vary between mesotrophic and eutrophic lakes. In our study of fluridone to control Eurasian watermilfoil (see Eurasian watermilfoil chapter), we found that poor water clarity can make it difficult for native plants to re-establish.

The Weaver Lake Association hired a commercial applicator to treat Weaver Lake with a target rate of 4 ppb fluridone. The treatment was carried out on April 13, 2005. Initial results indicate that the target treatment rate was achieved, although the initial concentration was higher than desired. At one day after treatment, before the product had completely mixed into the water column, the rate was measured at 8.1 ppb. At four

days after treatment, there was 4.6 ppb of fluridone in the lake. Fluridone concentrations stayed between 2 ppb and 4 ppb for about 100 days after treatment.

The treatment reduced the frequency of curly-leaf pondweed from 52% in August of 2003 to 21% in June 2005. The treatment also reduced the height of curly-leaf pondweed plants. In June 2004, curly-leaf plants were at the surface in many areas, in June 2005, curly-leaf plants did not reach the surface in any area. There were increases in the occurrence of six species of native submersed aquatic plants, most notably wild celery and horned pondweed, though there was a decrease in the occurrence of five species of native submersed aquatic plants, most notably coontail. Water clarity, as measured by Secchi disk, was significantly improved compared to previous years. The average May-September Secchi depth for 2004 was 9.1 feet; in 2005, it was 16.4 feet. A full report of the results from 2004 and 2005 plant and water quality data will be available by February 2006.

Winter drawdown to control curly-leaf pondweed

Curly-leaf pondweed turions have been shown to be susceptible to freezing and/or desiccation (Sastroutomo, 1982). Rice Lake (Hennepin County) was drawn down over two consecutive winters to a depth of 5 to 5.5 feet. These drawdowns effectively controlled curly-leaf pondweed for the summers following the drawdowns in the areas where lake sediments were exposed (McComas and Stuckert, 2000a). Although this management strategy may have limited application, the DNR is helping other groups evaluate this management approach. During the winter of 2004-2005, one other Minnesota lake was subjected to winter drawdown in an effort to control curly-leaf pondweed.

Cleary Lake, Scott County

Cleary Lake has been dominated with curly-leaf pondweed and rough fish. During the winter of 2003-2004, the Three Rivers Park District attempted to drain all of the water out of the lake to control curly-leaf pondweed. Because the lake was not completely drained, this effort was not successful (Invasive Species Program, 2005). During the winter of 2004-2005, the Three Rivers Park District again drained the lake. Using pumps they were able to remove all but a small four-acre area in the deepest part of the lake. The only curly-leaf observed in the lake in 2005 was in this small area, which was subsequently treated with Aquathol Super K herbicide. The combination of drawdown and herbicide treatment provided very good control of curly-leaf pondweed in the lake (John Barten, Three Rivers Park District, personal communication, October 2005).

Lake Orono, Sherburne County

In November 2003, the City of Elk River in cooperation with the Lake Orono Improvement Association drew Lake Orono down approximately five feet, which was successful in controlling curly-leaf pondweed in the areas where the sediments were exposed to freezing and drying (Invasive Species Program, 2005).

In 2005, DNR staff surveyed the lake and found a few curly-leaf pondweed plants growing in three areas of the lake. These plants may have grown from turions that had not been killed by the drawdown, or from turions coming from upstream waters that have curly-leaf pondweed. The City of Elk River and the lake association decided not to pursue a lake drawdown during the 2005-2006 winter because of the low amount of

curly-leaf pondweed in the lake. They are considering future use of winter drawdown to control curly-leaf pondweed.

Evaluation of low rates of fluridone to control the growth and reproduction of Curly-leaf pondweed

The DNR provided \$50,000 to the USAERDC to study the effects of fluridone herbicide on curly-leaf pondweed growth and turion production. Two small-scale studies were conducted using low rates of fluridone herbicide in cool water temperatures. The first study evaluated various concentrations and exposure times of fluridone against curly-leaf pondweed to determine the herbicide doses that suppress or inhibit plant growth and prevent turion formation. Results from the first study were received in March of 2005 and were used to determine the rate of fluridone herbicide to use for the pilot studies on Weaver and Benton lakes. The results of the first study indicated that 4 ppb fluridone is the lowest rate that will suppress plant growth and prevent turion formation. Based on these results, the DNR required that the Weaver and Benton lake treatments be done at 4 ppb fluridone. The USAERDC is planning to publish the results of the study sometime in the future. A summary of the results of the first study can be obtained from the DNR Invasive Species Program. The second study evaluated the ability of fluridone treated curly-leaf pondweed to withstand varying levels of turbidity. Results from the second study should be available by January 2006.

Study of turion longevity in curly-leaf pondweed

To obtain long-term control of curly-leaf pondweed, the production of turions must be stopped. Nevertheless, it is unclear how long the “bank” of turions in lake sediments remains viable. There is very little information available on the longevity of curly-leaf turions in lake sediments. A study by Skogerboe and Poovey (unpublished data 2004) found that lakes, which had been treated with endothall to stop turion production, still had good recruitment from turions in the sediments after three consecutive years of treatment. McComas and Stuckert (2000b) found that after three consecutive years of early cutting aimed at stopping turion production in the cut areas, there was still curly-leaf growing in the cut areas.

In 2005, the DNR Invasive Species Program provided \$10,000 in funding to Dr. Newman at the University of Minnesota to evaluate turion distribution, viability, and longevity (Newman and Roley, 2005). This is a continuation of work started by DNR staff and Dr. Newman in 2004 (Invasive Species Program, 2005). The turion distribution study showed significant turion densities to water depths of up to three meters. They found greater than 50% of turions in the top five cm of lake sediments, with 25 to 35% of turions in the 5 to 10 cm layer of sediment. The turion longevity study indicated that up to 50% of turions greater than one year old are able to sprout. Their work also indicated that burial in sediment can inhibit turion sprouting, but that buried turions are viable (Newman and Roley, 2005).

Future needs for management of curly-leaf pondweed

- Review available information on the ecology and management of curly-leaf pondweed to identify possible research projects that might be carried out to improve management of the invasive in Minnesota.
- Continue to provide funding for identified research needs, such as research to determine the distribution, viability, and longevity of curly-leaf turions.
- Continue public awareness efforts focused on containing curly-leaf pondweed. Opportunities include our TV and radio advertising, Watercraft Inspection Program, literature, and public speaking engagements.
- Continue to provide information to the public on the best management practices for curly-leaf pondweed control.
- Continue to support the management of curly-leaf pondweed in the state.

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Management of Eurasian Watermilfoil

2005 Highlights

- Eurasian watermilfoil was discovered in 13 additional Minnesota water bodies during 2005. There are now 177 Minnesota lakes, ponds, rivers, and streams known to contain the invasive submersed aquatic plant.
- In 2005, cooperators on 31 lakes were reimbursed by the DNR.



Issue

Eurasian watermilfoil (*Myriophyllum spicatum*) is an invasive submerged aquatic plant that was inadvertently introduced to Minnesota. Eurasian watermilfoil, hereinafter called milfoil, was first discovered in Lake Minnetonka during the fall of 1987. Milfoil can limit recreational activities on water bodies and alter aquatic ecosystems by displacing native plants. As a result, Minnesota established the Minnesota Department of Natural Resources' (DNR) Invasive Species Program to manage milfoil, as well as certain other invasive species. Milfoil is classified as a *prohibited invasive species*, which means that it may not be bought, sold, or possessed in Minnesota. In this report, we describe the efforts of the Invasive Species Program to manage milfoil and limit its spread in Minnesota during 2005.

Goals

The Invasive Species Program has two primary goals for management of milfoil in Minnesota. They are listed below along with the principal strategies that are pursued to achieve these goals.

- Prevent spread of milfoil in Minnesota
 - Monitor distribution of milfoil in Minnesota
 - Show boaters how to prevent the spread of milfoil (see Watercraft Inspections and Awareness Events)
- Reduce problems caused by milfoil in Minnesota
- Provide funding for maintenance management by cooperators
 - Conduct high-intensity management and control at public water accesses
 - Provide technical assistance
 - Support or conduct research on the ecology and management of milfoil

Spread of Eurasian Watermilfoil in Minnesota during 2005

Milfoil was newly discovered in 13 lakes during 2005 (Table 7 and Figure 9). In addition, milfoil was confirmed to occur in four other basins where the plant was discovered in 2004, but not reported to the Invasive Species Program until 2005. Seven of these lakes are located in the seven-county metropolitan area. Milfoil is now known to occur in 177 water bodies in Minnesota.

The rate of spread of milfoil in Minnesota, as reflected in the annual discovery of new occurrences of the invasive, has changed little over the last three to four years (Table 7). This observation is based on the running three-year average for the number of lakes in which milfoil was discovered.

Table 7. Classification of water bodies in Minnesota with Eurasian watermilfoil during 2005.

Classification	Spring	New in Summer	Fall
Eligible for management with state funds	118	8	126
Ineligible for management with state funds			
Public water but no public access	29	5	34
Not public water	9	0	9
Rivers or streams	8	0	8
Total	164 ¹	13	177

¹ Milfoil was confirmed to occur in four other basins where the plant was discovered in 2004, but not reported to the Invasive Species Program and confirmed until 2005.

Discovery of new occurrences of Eurasian watermilfoil in Minnesota

Characteristics of some newly discovered occurrences of milfoil suggest that there likely are other water bodies in Minnesota with the invasive plant that have not yet been discovered. In some cases, milfoil is discovered years after the time when it became established in a lake. In other lakes, milfoil appears to have been discovered before the invasive became abundant or widespread when it was noticed by a person who was knowledgeable about identification of aquatic plants.

Many false reports of milfoil result when other species of submersed vegetation, often forming mats, attract the attention of users of Minnesota lakes. These individuals suspect that the abundant vegetation is milfoil and report the occurrence to the Invasive Species Program. During 2005, as in previous years, most of these reports were found to be occurrences of various native aquatic plants. It has been extremely useful for citizens to send the DNR samples of suspected Eurasian watermilfoil so the plants can be quickly identified. The DNR encourages the public to report suspected new occurrences of milfoil.

Monitoring the distribution of Eurasian watermilfoil by other state agencies, local units of government, and interested groups

The participation of other divisions of the DNR and outside agencies, citizens, etc., in reporting new occurrences of milfoil remains critical. This assistance is very important because people in the Invasive Species Program are only able to visit a limited number of lakes each year. Efforts by others to search for milfoil and report suspected occurrences of the invasive greatly increase the likelihood that new occurrences are discovered. The Program investigates likely reports of new infestations as soon as possible for two reasons. First, it is important to determine whether milfoil actually is present in the lake. Second, if the invasive is present, then it is important to minimize the risk of spread to uninfested waters by notifying the users of the lake. It is hoped that once people who use a lake are aware of the presence of milfoil, they will be especially

careful to not transport vegetation from the lake on their boats, trailers, or other equipment.

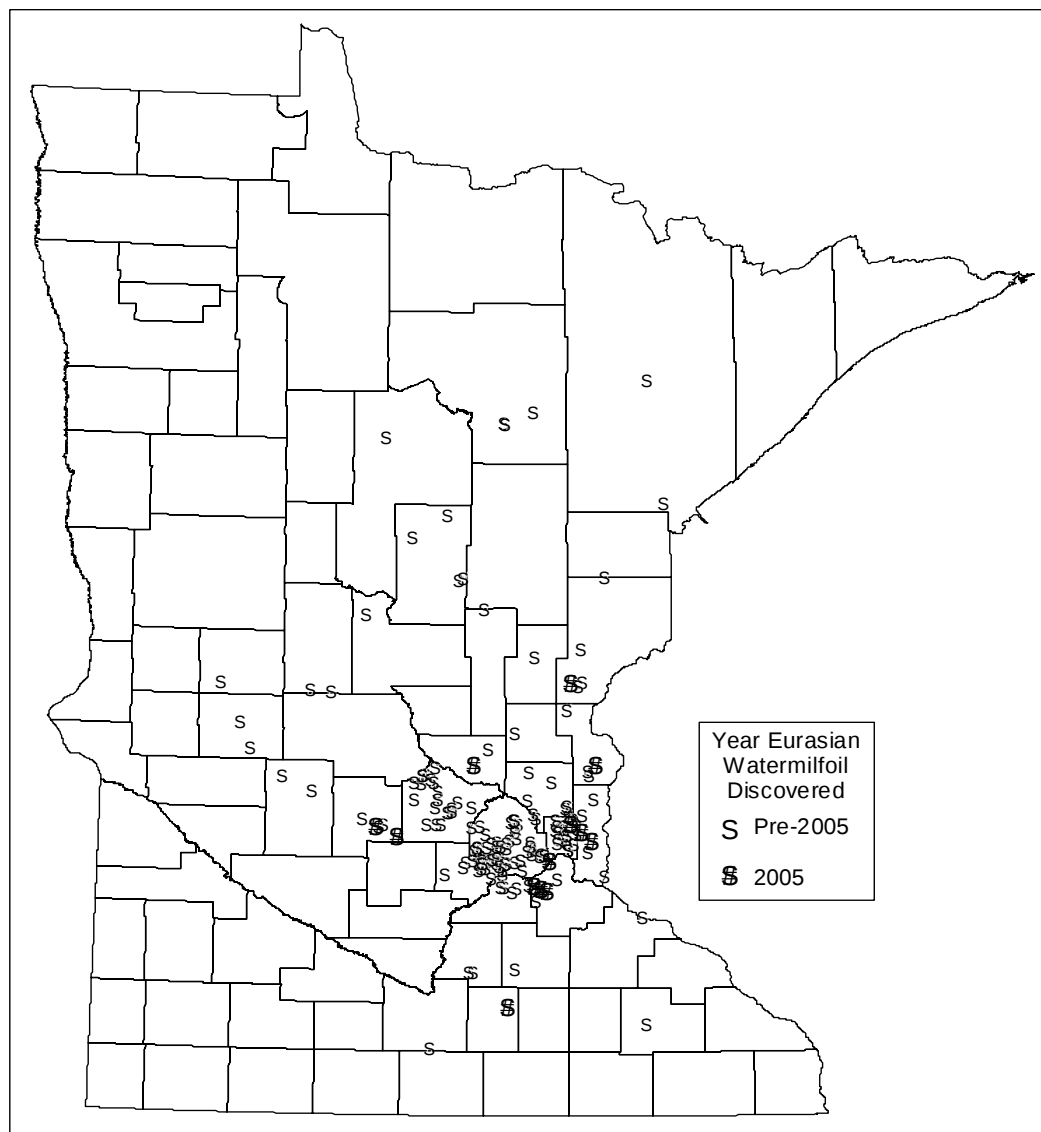


Figure 9. Distribution of water bodies with Eurasian watermilfoil in Minnesota as of November 2005.

Reports of suspected occurrences of milfoil that turn out to be mistaken also have value. In the course of responding to such reports, people in the Invasive Species Program discuss identification of the non-native Eurasian watermilfoil with the observer and so increase the number of people who in the future are likely to be able to distinguish the invasive from native plant species that are similar in appearance.

Management of Eurasian Watermilfoil in Minnesota during 2005

Classification of water bodies for management of Eurasian watermilfoil

In the spring of 2005, the Invasive Species Program classified the 164 bodies of water known to have milfoil (Table 7). One hundred eighteen lakes were determined to be eligible for management with state funds because they have public water accesses and are protected waters that are regulated by the state (Minnesota Statute 103G.005, Subd. 15).

Some lakes were determined to be ineligible for management with state funds because they either do not have public water accesses or are not protected waters. Lastly, flowing waters such as rivers and streams are not usually considered for management of milfoil with state funds because: 1) users of these waters in Minnesota rarely encounter problems caused by milfoil like those found in lakes, and 2) use of herbicides is less reliable in rivers and streams than in lakes.

Eight of the 13 water bodies that were discovered to have milfoil during 2005 were eligible for management with state funds because they have public water accesses (Table 8). Five lakes found to have milfoil in 2005 have no public water access and, consequently, are ineligible for management with state funds.

Management of Eurasian watermilfoil

During 2005, state funding and technical assistance were available from the Invasive Species Program to potential cooperators for management of milfoil. The offer of state funding is described in an announcement that is available to potential local cooperators (DNR 2005a) who are expected to take the lead in control of the milfoil. The offer is briefly summarized here. The most common activity on lakes in the maintenance management class that receive funds from the DNR is application of herbicide, followed by mechanical harvesting and planning. These funds are intended to pay for control during spring or early summer of unavoidable nuisances caused by dense and matted milfoil that will benefit a number of homeowners and the general public who use a lake.

These funds may not be used for control work that would otherwise be done by private individuals. Typically, control undertaken by private individuals is done immediately adjacent to the owner's shoreline or adjacent to structures such as docks. These funds may also be used for control intended to slow the spread of the invasive to other lakes.

The DNR received applications for state funding to control milfoil from potential cooperators on 37 lakes (Table 8). Applications were reviewed by the Invasive Species Program in relation to the standards described in the announcement that is available to potential cooperators (DNR 2005a). Twenty-seven of the applications were approved for funding. Questions about some applications led to inspections of the milfoil in these lakes by staff of the Invasive Species Program. These inspections revealed that some sites proposed to be treated with herbicide either did not have dense and matted milfoil or did not constitute an unavoidable nuisance for users of the lake. The results of these inspections and recommended modifications of proposed control projects were reported to the potential cooperators and staff in the Aquatic Plant Management Program who issue permits for control. On some lakes, proposals were modified by reducing the size

of the area to be treated, and subsequently approved. Applications for reimbursement were not approved for ten lakes.

Table 8. Number of Minnesota lakes where management of Eurasian watermilfoil was supported with state funds in 2002-2005.

Status	Number of Lakes			
	2002	2003	2004	2005
Applications received	32	32	26	37
Applications approved	21	23	18	27
Applications denied or not pursued	11	9	8	10

As a result, the DNR expects to reimburse 20 cooperators on 27 lakes for costs of milfoil management during 2005.

Assessment of Eurasian watermilfoil

In addition to control, the DNR also offers funding to support assessments of the potential for Eurasian watermilfoil to produce dense and matted growth that might interfere with watercraft use, swimming, or other traditional recreational uses of a lake. The offer of state funding is described in an announcement that is available to potential local cooperators (DNR 2005b) who are expected to take the lead in assessment of the milfoil. This requires a survey of milfoil in the lake to be done by a contractor, who will then provide a report to the cooperator. During 2005, the DNR received completed reports on assessments of milfoil for four lakes, which initiated projects in 2004. One assessment was initiated in 2005.

Control of Eurasian watermilfoil by the DNR at DNR Public Water Accesses

The Invasive Species Program initiated treatment of milfoil in the immediate vicinity of public water accesses operated by the DNR on five lakes. The purpose of this type of control is to reduce the risk that users of the lake inadvertently transport milfoil from the lake to other bodies of water.

High-intensity management of Eurasian watermilfoil

The goals of high-intensity management are to: 1) limit the spread of the plant within a lake, 2) reduce the abundance of milfoil within a lake, and 3) slow the spread of the invasive to other lakes. High-intensity management usually involves efforts to find all milfoil in a lake and treat it with herbicide. High-intensity management usually is undertaken by the Invasive Species Program on a very few lakes that either have small, recently discovered populations of milfoil or are located in areas of Minnesota where there are few, if any, other lakes with milfoil. During 2005, the Invasive Species Program did not identify any lakes where it was considered necessary for the agency to conduct high-intensity management of milfoil (Table 9).

Technical assistance to cooperators and other citizens

Technical assistance was provided by the Invasive Species Program to cooperators and other citizens and managers. Staff of the Invasive Species Program attended numerous meetings of lake associations and local units of government to make presentations and participate in discussions of approaches to management of milfoil. During the course of a season, staff of the Invasive Species Program have many conversations with people over the telephone. In addition, staff of the Invasive Species Program exchange correspondence by regular mail and e-mail with people who need assistance in dealing with milfoil.

Effectiveness of management of Eurasian watermilfoil in Minnesota lakes

Though the number of Minnesota lakes known to have milfoil increased in 2005, the number of lakes from which applications for DNR funding for control were received remained much lower than the number of lakes eligible to apply (Tables 8 and 9). The number of lakes where cooperators received DNR funding for control of milfoil during 2005 increased by comparison with the previous year (Table 8).

In 2005, potential cooperators used 70% of the funds that were budgeted by the DNR for reimbursement for control of milfoil (Table 9). Possible explanations for this outcome include: 1) lack of nuisances caused by milfoil that met the criteria for funding by the DNR, and 2) lack of awareness of the program among potential cooperators.

In one particular case, the lake association for Lake Washington in Meeker County obtained a reimbursement of \$17,700 in 2004 for control of milfoil. This involved treatment of 134 acres. In 2005, the members of the lake association reported that matted milfoil did not reappear and no treatment was necessary. It is possible that the treatment done in 2004 provided some carry-over control in 2005. The DNR also suspects that water clarity in the lake may have been significantly lower during 2005 than in 2004, but data to verify or discount this suspicion are not available. It is likely that a combination of factors contributed to the limited amount of milfoil in 2005 compared to 2004.

Table 9. Number of lakes, budgets, and expenditures in different classes of management of Eurasian watermilfoil in Minnesota during 2001-2005.

Year	Number of lakes in class in spring	Funds budgeted in spring	Number of lakes in class where control or assessment was done	Funds spent
Maintenance Management				
Control by Cooperators and Reimbursed by DNR				
2005	118	145,000	25	90,000
Assessment by Cooperators and Reimbursed by DNR				
2005	--	15,000	4 ¹	18,000
Control by DNR at DNR Public Water Access				
2005	--	15,000	5 ²	8,000
High-Intensity Management				
2005	0	10,000	0	0
Totals				
2005	--	185,000	30	116,00

¹Two of these lakes also received funding for maintenance management.

²One of these lakes also received funding for maintenance management and another received funding for and assessment.

Participation in control efforts by other state agencies, local units of government, and interested groups

Cooperation between the Invasive Species Program and organizations outside the DNR such as lake associations and various local units of government was critical to the success achieved in management of milfoil in Minnesota. The Invasive Species Program has also received valuable assistance from staff from DNR Fisheries and the DNR's Aquatic Plant Management Program in the Section of Fisheries and the Division of Ecological Services.

Research on Eurasian Watermilfoil and Potential Approaches to Management in Minnesota

The Invasive Species Program has supported or conducted a number of research projects to improve management of milfoil. In this section, we briefly summarize activities or results of recent efforts by researchers.

Potential for biological control of Eurasian watermilfoil

In 2004, researchers at the University of Minnesota concluded efforts to evaluate the potential for biological control of milfoil that have been supported with funding appropriated by the Minnesota Legislature as recommended by the Legislative Commission on Minnesota Resources since 1992. The research was focused on the milfoil weevil (*Euhrychiopsis lecontei*) and found that its activities can cause declines in

milfoil, but that these declines do not occur in all lakes with the weevil, and that declines may be temporary.

During 2005, Dr. Ray Newman, the principal investigator at the University of Minnesota, and his colleagues continued to work towards publishing results from their research on the milfoil weevil. This research included studies of chemically mediated selection of host plants by the weevil (Marko et al., in press), performance of weevils on different milfoils (Roley and Newman, in press), and predation on weevils by fish (Ward and Newman, in review). Dr. Newman also submitted a manuscript on the Eurasian milfoil weevil to a journal (Newman et al., in review).

Hybrids between the non-native Eurasian and native northern watermilfoil

Previous research had documented hybridization between the non-native Eurasian and native northern watermilfoil (Moody and Les 2002). This has led to questions about potential differences in ecological performance or susceptibility to herbicides between Eurasian watermilfoil and the hybrid. During 2005, the Invasive Species Program committed \$5,000 to support research by Indiana University to develop a library of micro-satellite markers for Eurasian watermilfoil, hybrids, and other species. Though previous studies of genotypic variation among milfoils have used molecular markers, a means for systematic identification of individual genotypes is needed. This need was met by work supported with funds from Minnesota, which were used to develop a library of micro-satellite markers for milfoils (Moody 2005). Future research will refine the use of the micro-satellite markers and set the stage for comprehensive studies of milfoil species and their hybrids.

Potential to use fluridone herbicide to selectively control Eurasian watermilfoil

The potential use of fluridone herbicide, which is formulated as SonarTM and AVAST!TM, to control milfoil has been the subject of much discussion in Minnesota because the product is usually applied to whole bays or lakes (see Welling et al., 1997, Exotic Species Program, 2001). Operational treatment of whole bays or lakes with herbicide is not allowed in Minnesota because this has the potential to destroy more vegetation than is necessary to give users access to the lake.

In 2000, new information was made available from studies in Michigan which suggested that application of fluridone at low rates of 5 to 6 ppb may provide more selective control than had previously been observed in Minnesota (Getsinger et al., 2001; Madsen et al., 2003). To address questions about possible harm to native plants, the DNR is conducting an evaluation of the potential to use fluridone herbicide to selectively control milfoil in Minnesota. As part of this evaluation, three Minnesota lakes were subjected to whole-lake treatments with fluridone in 2002. For the 2002 treatments, the target concentrations were 4.6 to 5 ppb fluridone. The lakes selected for this evaluation were eutrophic lakes, which had average Secchi depths of approximately five to seven feet and few species of submersed plants.

The effect of fluridone on the aquatic plant community was evaluated by examination of the distribution and standing-crop biomass of individual species in the lakes. The distribution of individual species was estimated by determining their frequency, which is the percentage of sampling sites at which the plant was present. Sampling by the DNR

of the three treated lakes and three untreated reference lakes began in 2001 and continued through 2004. Sampling was done on the three treated lakes in 2005. Results from 2001-2004 are described in the DNR Invasive Species Program's 2004 Annual report (Invasive Species Program, 2005). Results from one treated lake (Shutz) and one untreated reference lake (Auburn) are reported in Valley et al. (in review).

The results of these whole-lake treatments suggest that use of fluridone herbicide, even when applied at low rates, to control milfoil in eutrophic lakes with low plant species richness and dominated by tolerant plant species such as coontail is likely to do more harm than good due to decreases in native plant. In addition, these types of treatments do not appear to permanently eliminate milfoil from the treated lake. In 2005, milfoil was found in two of the treated lakes, Crooked and Shutz, which were inspected (Invasive Species Program, unpublished data). During 2005, inspection of the third lake treated in 2002 did not discover milfoil.

Additional information from similar treatments made in mesotrophic lakes, where average Secchi depths are greater than three meters and which often have more plant species than are found in eutrophic lakes, suggests that selective control of milfoil with an increase in native plants maybe attainable. More research on the effects of fluridone in mesotrophic lakes would appear to be useful. At this time, the DNR is considering allowing additional whole-lake treatments with this herbicide to control milfoil in 2006, assuming that pre-treatment data is available from 2005.

Lac Lavon, in Dakota County, was surveyed in August 2005. Lac Lavon is a mesotrophic lake, which formed from an abandoned gravel pit. It has been treated with fluridone three times over the past nine years: in 1996, 1998, and 2002 (Crowell and Proulx 2005). Prior to the 1996 treatment, Lac Lavon averaged 2.3 native taxa per sampling site (May 1996) and in June 2004, the average increased to 3.5 native taxa per site (Invasive Species Program, unpublished data). Milfoil has been increasing in abundance since 2003. By 2005, the frequency of milfoil had reached 92% (Invasive Species Program, unpublished data). Residents and local government officials are considering the possibility of treating Lac Lavon with fluridone in 2006.

McKinney and Ice lakes in Grand Rapids were surveyed in early July 2005. These lakes were treated with fluridone in 1999. In McKinney Lake, milfoil returned to well over half (69%) of the sampling sites, while the average number of native taxa per sampling site continued to increase. Given past experience with milfoil on this lake, the expectation is a further increase in milfoil, and given past experience with Lac Lavon the expectation is that the native plant community will decrease in frequency and abundance. To what extent will depend on growing conditions in the next few years.

Potential to apply two herbicides at low rates to control both Eurasian watermilfoil and curly-leaf pondweed

In 2005, the U.S. Army Corps of Engineers continued a study in Minnesota to determine whether early spring treatment with low rates of endothall and 2,4-D herbicides will control both milfoil and curly-leaf pondweed. The researchers also want to determine whether reductions in milfoil and curly-leaf will produce a more diverse and abundant native plant community. Lastly, the project is intended to determine whether the

expected shift in vegetation will affect the fish community. The study is being conducted in cooperation with Mississippi State University and the DNR. CerexAgri, an herbicide manufacturer, is providing financial and technical support. Herbicides were applied in spring and monitoring was done during the open water season of 2005. Results on progress were reported to the DNR through oral presentations during 2005. Written results are expected to be reported to the DNR in the future.

Susceptibility of selected species and hybrids of milfoil to aquatic herbicides

Recent documentation of hybridization of Eurasian (*Myriophyllum spicatum*) and northern watermilfoil (*Myriophyllum sibiricum*) has implications for various management strategies including herbicides and biological control (Moody and Les, 2002). In conjunction with the discovery of hybrid milfoils, there have also been numerous anecdotal reports of reduced activity of the herbicides 2,4-D and fluridone in the upper Midwest. Reports of reduced efficacy are often noted at sites that have been managed over time. While this could simply be a matter of yearly variations in initial plant vigor and environmental conditions on the date of treatment, the number of reports from different locations suggests the potential for the development of increased herbicide tolerance by a milfoil biotype.

In 2005, the DNR provided funding to the U.S. Army Engineer Research and Development Center (USAERDC) to support a study of potential variation among different species and genotypes of milfoils in susceptibility to herbicides. To date, three experiments have been completed and two more are in progress. Two of the completed experiments included Eurasian watermilfoil and the hybrid (*M. spicatum* X *M. sibiricum*), which were exposed to various levels of 2,4-D and triclopyr herbicides. Preliminary results do not indicate that there is a large difference in susceptibility to these two herbicides between Eurasian watermilfoil and the hybrid.

The third completed experiment included Eurasian watermilfoil, northern watermilfoil, and the hybrid, which were exposed to various levels of fluridone herbicide. Preliminary results do not indicate that there is a difference in susceptibility to fluridone among the three watermilfoils tested.

At the time of this writing, two additional experiments are in progress. The first includes Eurasian watermilfoil, northern watermilfoil, the hybrid between the two preceding species, whorled watermilfoil (*Myriophyllum verticillatum*), and variable watermilfoil (*Myriophyllum heterophyllum*). These plants will be exposed to a series of levels of four different herbicides: diquat, 2,4-D DiMethy-Amine, 2,4-D Butoxyl Ethyl Ester, and triclopyr. The second experiment includes Eurasian watermilfoil and the hybrid, which will be exposed to various levels of two new acetolactate synthase (ALS) inhibitors, Penoxsulam and Imazamox and 20 ppb against hybrid milfoil and *M. spicatum* under continuous exposure regimes. These treatments are being compared to fluridone at 5 and 10 ppb.

Complete results of this study and recommendations will be conveyed in a final report from the USAERDC to the DNR.

Future plans and needs for management of Eurasian watermilfoil

Priorities for management of milfoil include:

- Keep the public informed about milfoil and the problems it can cause.
- Reduce the plant's spread by targeting watercraft inspection and enforcement efforts in areas of the state where milfoil is present.
- Monitor the distribution of milfoil in the state with emphasis on verification of reports of new occurrences of milfoil.
- Continue to improve our understanding of the ecology and management of milfoil.

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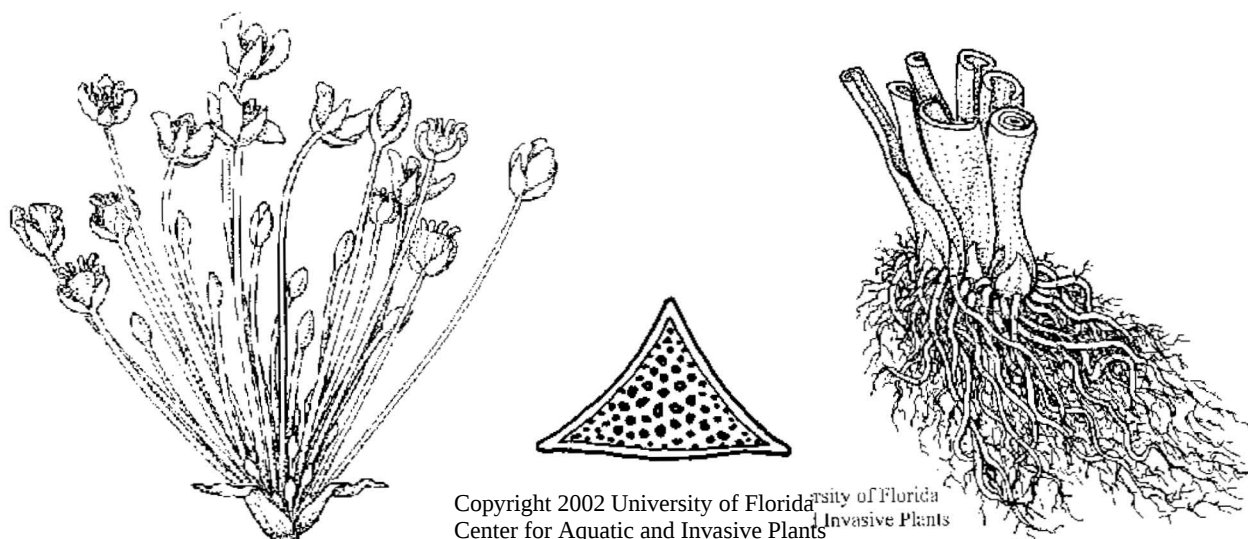
Management of Flowering Rush

Introduction

Issue

Flowering rush (*Butomus umbellatus* L.) is a perennial aquatic plant, native to Europe and Asia. It grows along lake and river shores as an emergent plant with three-angled fleshy leaves and may produce an umbel-shaped cluster of pink flowers (Figure 10). Flowering rush may also grow as a non-flowering submersed plant with limp, ribbon-like leaves.

The plant spreads primarily vegetatively from thick rhizomes (Figure 10) from small tubers that break off the rhizome, and from small bulblets that form in the inflorescence. Water currents, ice movement (Haber, 1997), and muskrats (Gaiser, 1949) can easily move these reproductive structures to new locations within a water body.



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Figure 10. Flowering rush umbel, cross-section of a leaf, and rhizomes.

Flowering rush was likely brought to North America in the late 1800s in ship ballast and has also been repeatedly introduced as an ornamental plant. As early as 1973, resource managers and researchers have expressed concern that flowering rush may grow more aggressively in North America than in its native Europe and may become an aggressive competitor with native wetland vegetation (Anderson et al., 1974; Staniforth and Frego, 1980). Given the invasive characteristics of flowering rush, it is classified as a *prohibited* invasive species in Minnesota. A prohibited invasive species is illegal to possess, sell, transport, or release into the wild.

Distribution

Flowering rush was first recorded in Anoka County in 1968 (Moyle, 1968) and has since been located in six other counties. Despite its 30-year presence in the state, the distribution of flowering rush is widely scattered and uncommon (Figure 11). New

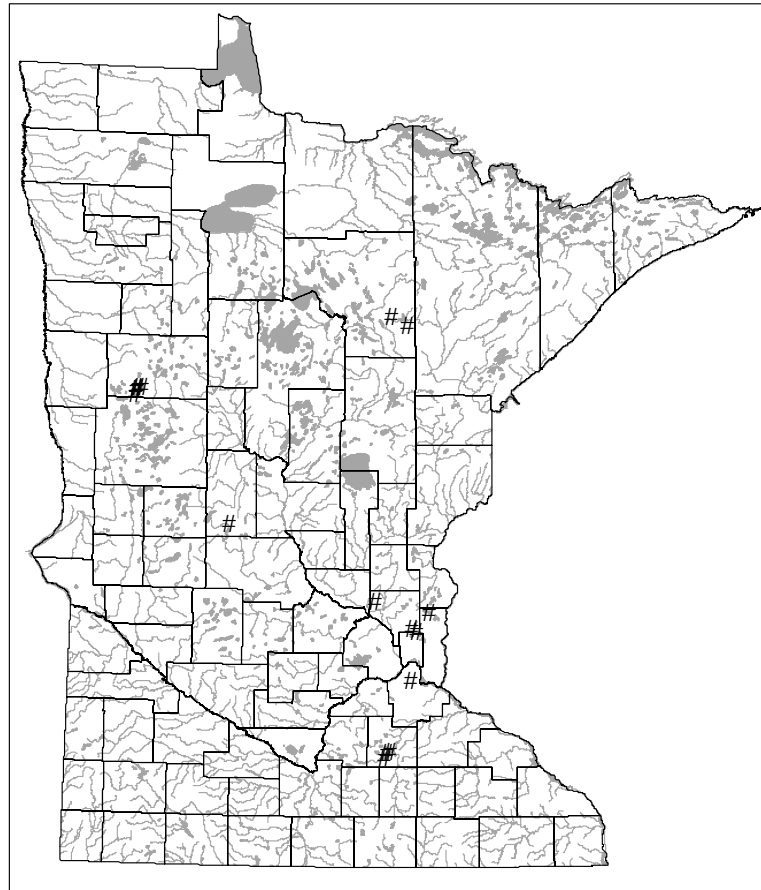


Figure 11. Minnesota flowering rush locations as of December 2005.

introductions are likely the result of intentional planting from horticultural sales. More information about the distribution of flowering rush in the state can be found in the 2000 Exotic Species Annual Report (Exotic Species Program, 2001). There were no new discoveries of flowering rush locations in 2005.

Goals

The DNR has two goals that apply to flowering rush management: 1) To prevent the spread of flowering rush within Minnesota; and 2) To reduce the impacts caused by invasive species to Minnesota's ecology, society, and economy. To attain these goals, the following strategies are used:

- Prohibit the sale of flowering rush in Minnesota.
- Monitor current distribution and assess changes.
- Support research to develop and implement better management methods.
- Provide information to those interested in how to best manage flowering rush.

Progress in Management of Flowering Rush - 2005

Prohibit the sale of flowering rush

Flowering rush is a prohibited invasive plant in Minnesota, which means that it is unlawful to possess, purchase, or sell this invasive in Minnesota. Nevertheless, horticultural sales are the most likely means of introducing this plant into a new area. Flowering rush is advertised for sale in catalogs and Internet companies as a hardy, desirable ornamental water garden plant. An effort to inform aquatic plant sellers and buyers about the potential negative impacts of releasing non-native plants into the wild will continue, utilizing various public education materials and personal contacts.

Monitor current distribution and assess changes

In 2005, Invasive Species Program staff surveyed flowering rush distribution during peak biomass on Detroit (Curfman Bay, Becker County), North Twin (Itasca County), and Hart lakes (Itasca County). These surveys were modified from past techniques in order to obtain additional information on distribution and abundance of flowering rush with the goal of documenting spread and monitoring results of management. Two of these lakes (Hart and North Twin), have limited aquatic plant management, while Detroit Lake implements a comprehensive aquatic plant management program.

Table 10 shows year of discovery, abundance, and quantity of flowering rush. Curfman Bay (Detroit Lakes) has had flowering rush since 1976 and is currently being managed primarily by mechanical harvesting. Large stands of hardstem bulrush still occupy the southern portion of the bay with flowering rush doing well near the developed portions of the shoreline (Figure 12). From 2002 to 2004, point intercept plant surveys have been completed on Detroit Lake for flowering rush presence. A point intercept survey is performed by placing sample points equally spaced over the area of interest. Table 11 summarizes the three years of surveys. For details and additional results of these surveys see the Invasive Species 2004 Annual Report.

Table 10. Detroit, North Twin, and Hart lakes flowering rush abundance and year discovered.

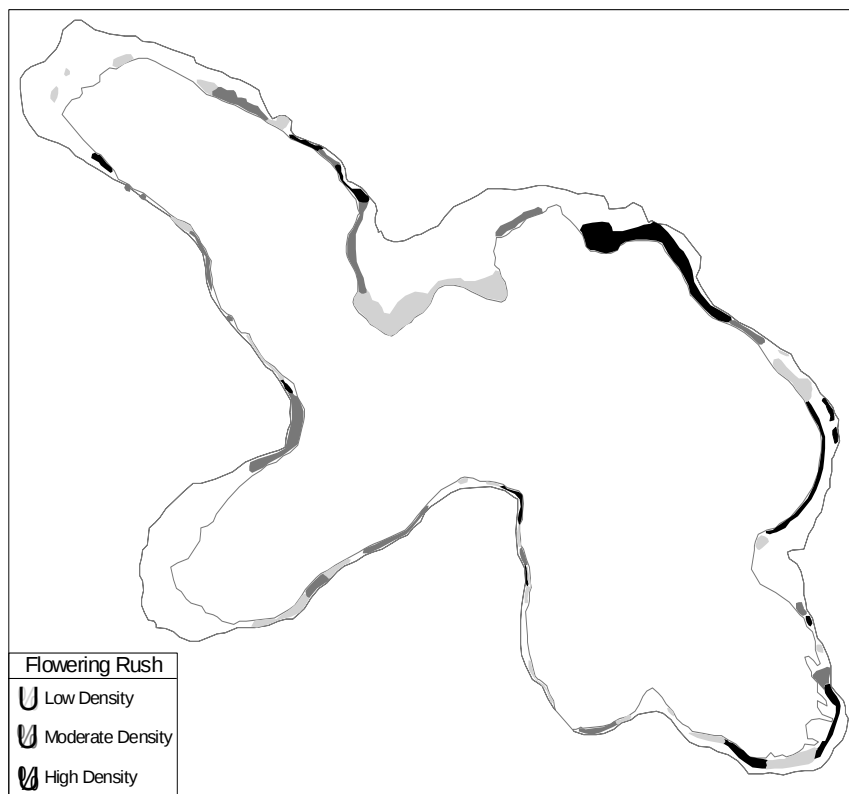
	Detroit Lakes (Curfman Bay)	North Twin Lake (Invasives Program 2005)	North Twin Lake (Fisheries 1999)	Hart Lake
Year Discovered	1976	1995	1995	2001
Total	111 acres	250 acres	250 acres	325 acres
Total littoral	66 acres	73 acres	73 acres	75 acres
Total emergents	46 acres	50 acres	34 acres	47 acres
Total flowering rush	22 acres	13 acres	4 acres	3 acres
Dense flowering rush	6 acres	4 acres	n/a	1 acre
Moderate flowering rush	9 acres	4 acres	n/a	1 acre
Light flowering rush	7 acres	5 acres	n/a	1 acre

**Figure 12. Curfman Bay flowering rush locations and relative abundance in 2005.**

Table 11. Flowering rush frequency on Detroit Lake.

Year of Survey Performed By	Number of Sample Sites	Frequency of Flowering Rush
Spring 2002 – Exotics Program	241	6%
Fall 2002 – Exotics Program	260	7%
Summer 2003 – Invasives Program	190	18%
Summer 2004 – Invasives Program	278	17%

The flowering rush in North Twin Lake was discovered in 1995. Since then, the only management occurring is within and near the beach and public water access area. During the late 1990s and up until 2003, the area has been hand cut with limited long-term success. In an effort to reduce the amount of flowering rush in the beach area in 2006, Habitat herbicide (imazapyr) was used in late summer of 2005. Flowering rush has become more widespread since its discovery and seems to be doing well near developed and undeveloped shoreline (Figure 13). In 1999, DNR Fisheries completed a detailed survey of all emergent and floating leaf aquatic vegetation, including flowering rush (Figure 14). When compared to the 2005 survey, it demonstrates the expansion of flowering rush during the last six years (Figures 13, 14).

**Figure 13. North Twin Lake flowering rush locations and relative abundance in 2005.**

Finally, Hart Lake's flowering rush was recently discovered in 2001. It can be found primarily along developed shoreline, including near the public water access. This lake has very large expanses of hardstem bulrush and, unlike the other two lakes, flowering rush for the most part has not moved into these areas. It will be beneficial to repeat these surveys in the future to measure general population movements.

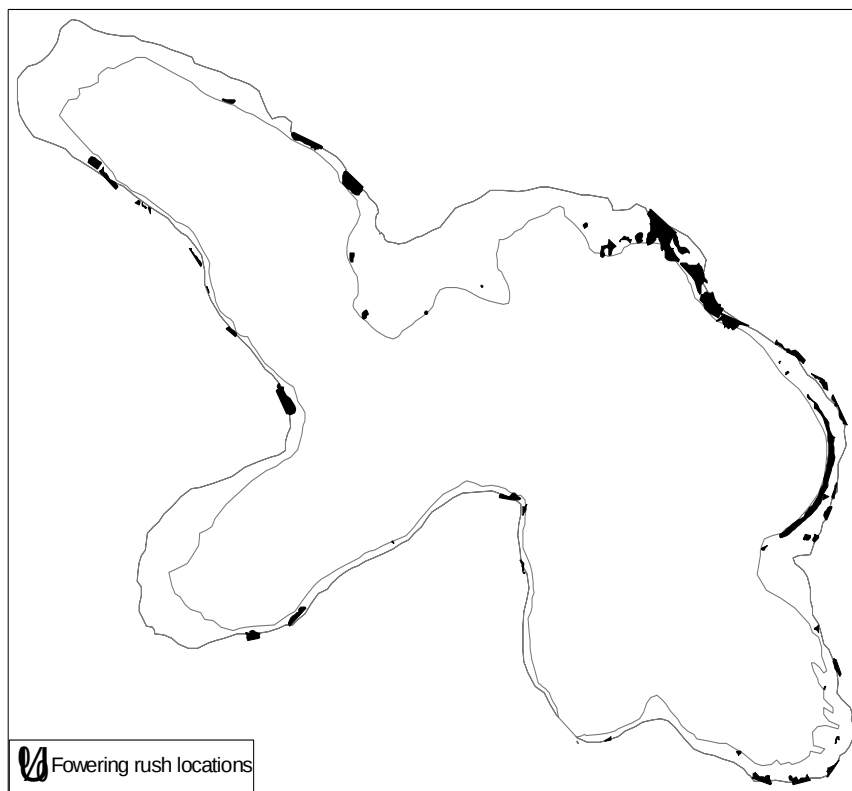


Figure 14. Flowering rush on North Twin Lake (1999 DNR Fisheries).

From 1999 to 2004, informal flowering rush surveys were performed on Forest Lake (Washington County). During those four years, flowering rush has increased in distribution, but has remained within the “third” or east basin (Figure 15). In 2004, no visible increase in distribution was noted. Although no surveys were completed in 2005, future surveys are planned for Forest Lake.

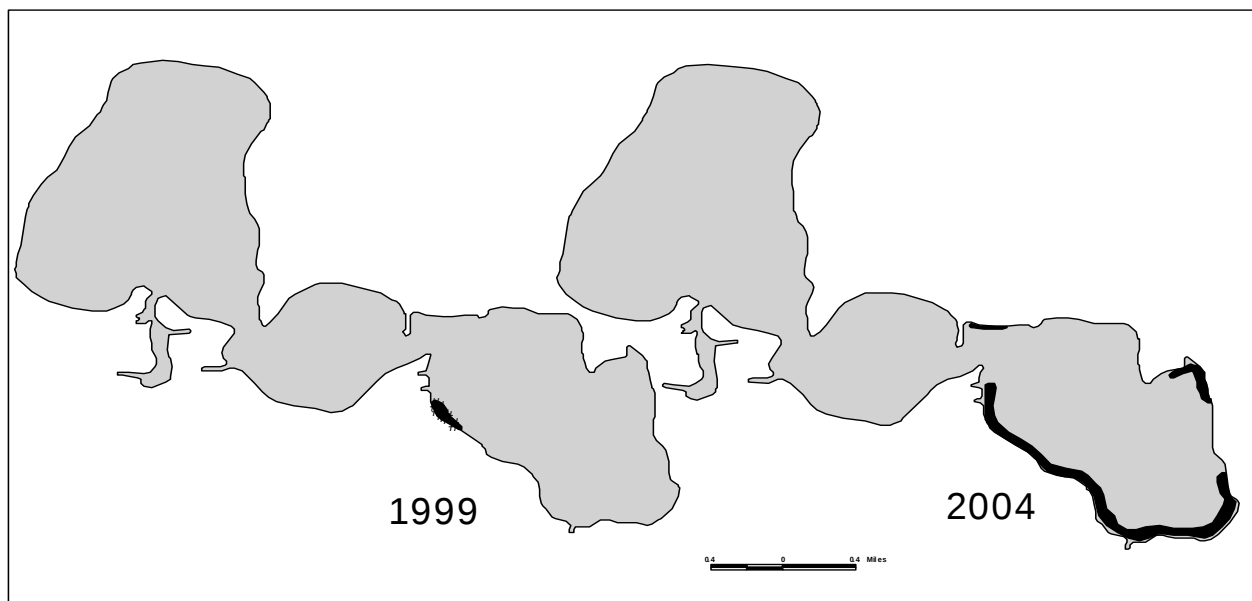


Figure 15. Flowering rush locations in Forest Lake in 1999 and 2004.

Support research to develop and implement better management methods

In 2003 through 2005, the Pelican River Watershed District (PRWD) contracted with a private herbicide applicator to test different aquatically registered herbicides on small plots of flowering rush. In 2003, six sites were sprayed with different herbicides and rates including glyphosate, 2, 4-D (granular and liquid), diquat, and various adjuvants. Two glyphosate sprayed plots showed roughly 50% reduction in flowering rush density in the year after treatment. The remaining plots did not show any visible reduction. One potential complicating factor was the unseasonably cool water temperatures in late August 2003, which may have played a part in the early senescence of flowering rush (Dick Hecock, PRWD, March 9, 2005). As a result, in 2004, the treatments were moved up a month. Preliminary results suggest most of the treatments knocked back flowering rush in the year of treatment. In 2005, the year after treatment surveys showed that the imazapyr and glyphosate plots reduced the flowering rush significantly. As a result, the 2005 treatments were limited to using imazapyr and glyphosate and not treating the 2004 imazapyr treated plots. By not re-treating those plots, it may be possible to determine the length of time control might last.

In an effort to replicate those results, imazapyr was applied to three acres of flowering rush on North Twin (Itasca County) along the boat landing and beach area. This is the same area that manual cutting has been used in the past with limited long-term success. Detailed pre-treatment aquatic vegetation sampling was completed and will

be repeated in 2006. The purpose of this survey is to document non-target impacts of this herbicide.

Provide information to those interested in how to best manage flowering rush

The PRWD annually meets with DNR staff including representatives from the Invasive Species Program to discuss concerns regarding the expansion of flowering rush within and into lakes in the Detroit Lakes area. Currently, the PRWD mechanically harvests flowering rush and other aquatic plants to reduce the nuisances for lake residents and users. During the past three years, the PRWD has been engaged in testing various herbicides on flowering rush. Support of this project, including technical assistance will continue.

Hand-cutting has been successful at seasonally reducing dense stands of emergent flowering rush. In the past, the Invasive Species Program coordinated and assisted with a flowering rush hand-cutting project at a public swimming beach in Twin Lakes (Itasca County). Due to the limited long-term control of cutting and recent herbicide treatment results, the beach and public water access area have been treated with herbicide for the past two years. In 2004, hydrothol 191 and 2, 4-D were applied with no visible reduction in flowering rush. In 2005, imazapyr was applied and results will be summarized in 2006.

Effectiveness of Management

Flowering rush often grows in stands with native vegetation, making it difficult to control this invasive without harming the native plants. Mechanical control by cutting appears to be an effective method of reducing dense stands of flowering rush seasonally. Cutting is most effective if done early and repeated several times during the growing season (Hroudova, 1989). The disadvantages of cutting are that it lacks selectivity, it is labor intensive, and it does not eliminate the invasive. Digging flowering rush may increase its spread if the entire rhizome is not removed, but can be effective at removing small infestations of flowering rush. Recent herbicide work, contracted by the PRWD, is showing some promise in more long-term control of flowering rush. As that information becomes available, the Invasive Species Program staff will continue to evaluate the utility of these treatments.

Participation by Other Groups

Others involved in flowering rush management in Minnesota in 2004 include: DNR's Division of Fish and Wildlife, PRWD, and Greenway Township in Itasca County.

Future needs for management of flowering rush

- Continue efforts to prevent introductions of flowering rush in Minnesota. Inform the public, nursery industry, and other businesses selling flowering rush of the problems associated with this plant and the existing laws against its possession and sale in Minnesota.
- Encourage research on the distribution, reproductive biology, and potential impacts of flowering rush in Minnesota.
- Continue to investigate new methods of controlling flowering rush and to evaluate the results of ongoing flowering rush management within the state.

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Management of Purple Loosestrife

Background

Purple loosestrife (*Lythrum salicaria*, *L. virgatum* and their hybrids) is a wetland plant from Europe and Asia that invades marshes and lakeshores, replacing cattails and other wetland plants. The DNR and other agencies manage purple loosestrife because it harms ecosystems and reduces biodiversity by displacing native plants and habitat for wildlife (Blossey et al., 2001). The Purple Loosestrife Program was established in the DNR in 1987. State statutes direct the DNR to coordinate a control program to curb the growth of purple loosestrife (M.S. 84D.02, Subd. 2) and a significant amount of progress has been made toward the development of a sound approach to manage this invasive.

This management program integrates chemical and biological control approaches and cooperates closely with federal and state agencies, local units of government, and other stakeholder groups involved in purple loosestrife management. The goal of the program is to reduce the impact purple loosestrife is having on our environment. Management efforts include both biological and chemical control methods, monitoring management efforts, and supporting further research.

Statewide Inventory of Purple Loosestrife

In 1987, the DNR began to inventory sites in Minnesota where purple loosestrife was established. DNR area wildlife managers, county agricultural inspectors, local weed inspectors, personnel of the Minnesota Department of Transportation, and the general public report purple loosestrife sites to the DNR. The DNR maintains a computerized list or database of sites that includes the location, type of site, and number of loosestrife plants present (see Figure 16). In 2005, 69 new purple loosestrife infestations were identified in Minnesota. There are now over 2,200 purple loosestrife infestations recorded statewide (Table 12). Of those sites, the majority (70%) are lakes, rivers, or wetlands. Inventory totals indicate that Minnesota presently has over 63,000 acres infested with purple loosestrife.

Progress in Management of Purple Loosestrife - 2005

Chemical control of purple loosestrife

Initial attempts by the DNR to control purple loosestrife relied mainly on the use of herbicides. The most effective herbicide is Rodeo™, a formulation of glyphosate, which is a broad-spectrum herbicide that can kill desirable native plants. To allow maximum survival of native plants, Rodeo™ is applied by backpack sprayer as a “spot-treatment” to individual loosestrife plants.

Beginning in 1991, a prioritization plan was developed for selecting control sites in public waters and wetlands where herbicide would be used for purple loosestrife control. This was done because there are insufficient resources to apply herbicides to all known purple loosestrife sites in Minnesota. In addition, DNR personnel observed that herbicide treatments do not result in long lasting reductions of loosestrife when applied

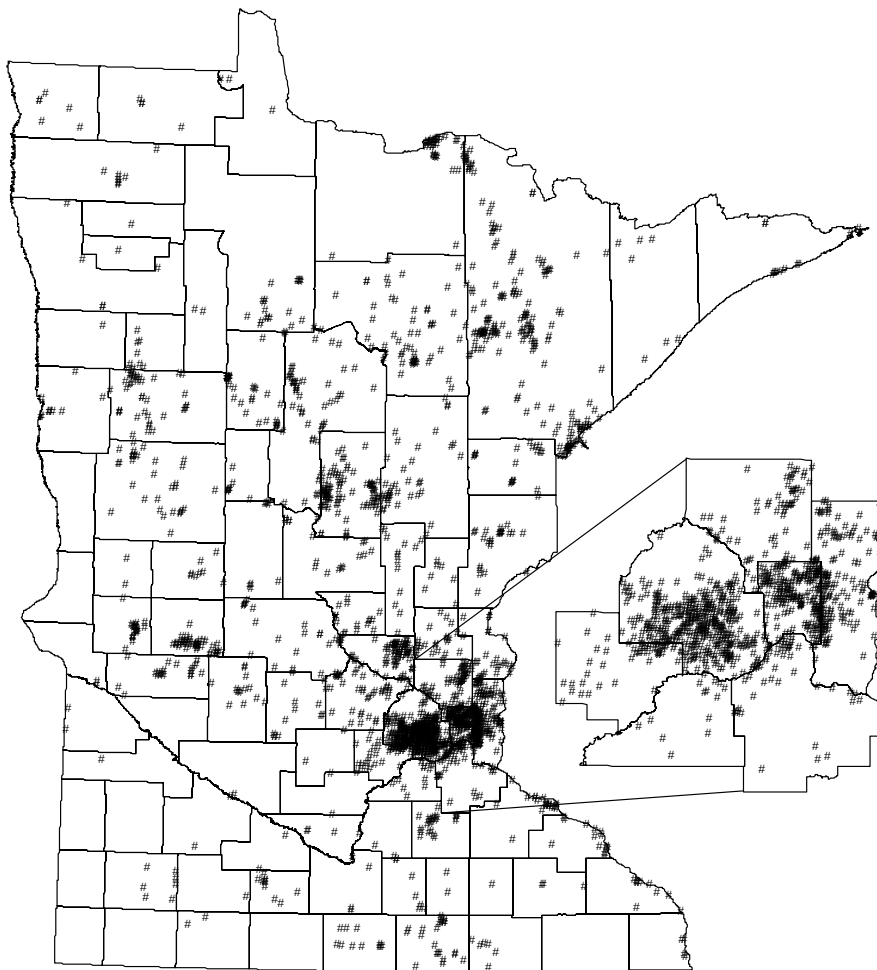


Figure 16. Purple loosestrife infestations in Minnesota as of December 2005.

Table 12. Purple loosestrife infestations in Minnesota recorded by the Minnesota Department of Natural Resources in 2004 and 2005.

Site Type	Total sites 2004	New sites 2005	Total sites 2005
Lake	667	17	684
River	203	10	213
Wetland	693	29	722
Roadsides and ditches	487	10	497
Other ¹	162	3	165
Total	2212	69	2281

¹Includes gardens and other miscellaneous sites.

to large populations that have been established for a number of years. This is due in part to the plant's ability to re-establish from an extensive purple loosestrife seed bank.

Research by the University of Minnesota, under contract to the DNR, demonstrated that long-established stands of loosestrife develop very large and persistent seed banks (Welling and Becker, 1990). Herbicide treatments kill the existing loosestrife population only, creating space for additional seeds to sprout. Consequently, small and recently established populations of loosestrife, which are likely to have small seed banks, are given the highest priority for treatment. In addition, because seeds of this species are dispersed by water movements, the DNR tries to keep loosestrife from infesting downstream lakes. Sites located in the upper reaches of watersheds with small loosestrife infestations are treated before those located in watersheds with large amounts of loosestrife. Implementation of the prioritization scheme in 1991 resulted in fewer large sites (> 1,000 plants) being treated.

Between 1989 and 2005, the number of sites, number of plants, and total cost of treating purple loosestrife with herbicide has decreased (Table 13). This summary includes applications made by DNR personnel, commercial applicators working under contract to DNR, and various cooperators; it is not a complete listing of all herbicide applications made in Minnesota. In 2005, only DNR staff were used to treat purple loosestrife stands statewide. DNR staff visited 62 purple loosestrife stands for herbicide control work (Figure 17, Table 13). At five sites, workers found no loosestrife plants to treat. A total of 57 sites were treated with herbicides. Most of the sites were very small: 80% had fewer than 100 plants. At one location, seven purple loosestrife plants were hand-pulled. This work took a total of 296 worker hours, and only 0.40 gallons of RodeoTM. Total cost for this effort was \$9,000.

Effectiveness of chemical control

Effectiveness of control efforts will be based on short-term and long-term objectives. Control or eradication of small infestations statewide with herbicides is the primary short-term objective. Each year, a small number of purple loosestrife infestations (five in 2004) are controlled for at least one year beyond the year of treatment with herbicides. This is critical because these infestations are in watersheds that have very few infestations of loosestrife. This effort helps prevent the spread of purple loosestrife into uninfested wetlands and lakeshores.

Table 13. Historical herbicide applications performed by DNR and applicators contracted by DNR in Minnesota (1989-2005).

Year	Sites visited	Sites with <100 plants treated	Sites with >100 plants treated	No plants located	Total worker hours	Herbicide quantity used	Total treatment costs
1989	166				3,045	471	\$102,000
1990	194	74	120	0	3,290	-	\$74,900
1991	200	109	58	33	3,420	-	\$77,900
1992	227	110	77	40	-	-	-
1993	194	96	79	19	2,300	48	\$65,000
1994	188	81	81	26	1,850	30	\$52,000
1995	203	102	63	38	2,261	35	\$63,000
1996	153	74	56	23	1,396	14	\$45,000
1997	132	55	55	22	965	7	\$36,000
1998	144	66	51	27	1,193	11	\$40,000
1999	131	65	38	28	791	9.5	\$26,000
2000	111	38	28	45	518	2.4	\$22,800
2001	87	55	17	15	359	1	\$19,700
2002	55	32	7	16	305	2.3	\$18,800
2003	54	30	7	17	243	0.87	\$8,180
2004	60	30	9	20	370	0.58	\$9,400
2005	62	48	9	5	296	0.40	\$9,000

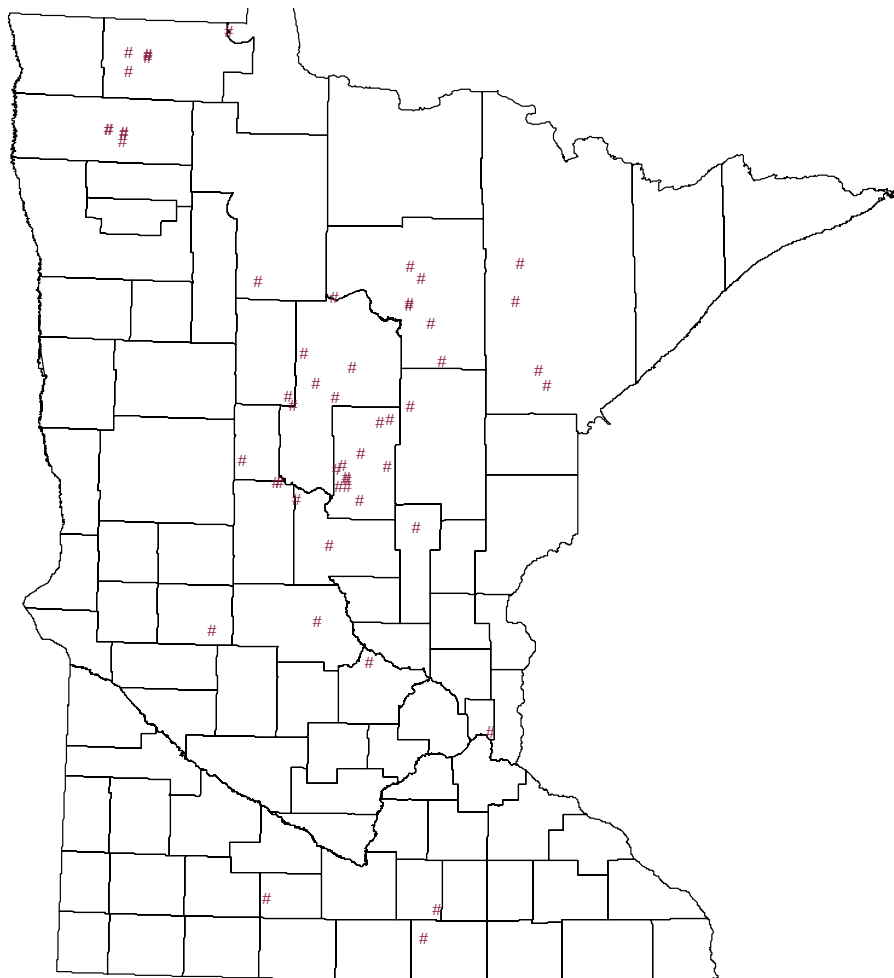


Figure 17. Locations where DNR staff used herbicides to control purple loosestrife in 2005.

Biological control of purple loosestrife

Insects for biological control of purple loosestrife were first released at one site by DNR staff in 1992. This initial release occurred after years of testing to make sure the insects were specific to purple loosestrife and would not damage native plants or agricultural crops and after the insects were approved for release by the United States Department of Agriculture (USDA). To date, four species of insects, two leaf-eating beetles, *Galerucella californiensis* and *G. pusilla*; a root-boring weevil, *Hylobius transversovittatus*; and a flower-feeding weevil, *Nanophyes marmoratus*, have been released as potential biological controls for loosestrife in Minnesota.

Leaf-Eating Beetles: In 1997, the DNR initiated an insect rearing program by providing county agricultural inspectors, MDA field staff, DNR area wildlife managers, MN Sea Grant, nature centers, lake associations, schools, 4-H and garden clubs with a “starter kit” for rearing their own leaf-eating beetles. A starter kit is composed of pots, potting soil, insect cages, leaf-eating beetles, and other materials necessary to rear 20,000

leaf-eating beetles (*Galerucella* spp.). The insects were then released on high-priority areas. All insect rearing was completed outdoors for ease of production and to produce hardier insects. From 1997 to 2005, this cooperative effort has had a significant effect on total number of insects released (Figure 18).

With the success of insect establishment in the field, organized rearing efforts have come to an end in 2004. Resource managers are able to collect insects from established release sites and redistribute them to new infestations. Current research suggests that these insects will move up to five kilometers on their own if purple loosestrife is present (McCornack et al., 2004). The “collect and move” method has reduced the effort needed to further distribute leaf-eating beetles in Minnesota. In 2005, an estimated 134,350 leaf-eating beetles were collected and released on 34 sites. To date, the leaf-eating beetles have been released at more than 781 sites statewide (see Figure 19, Table 14).

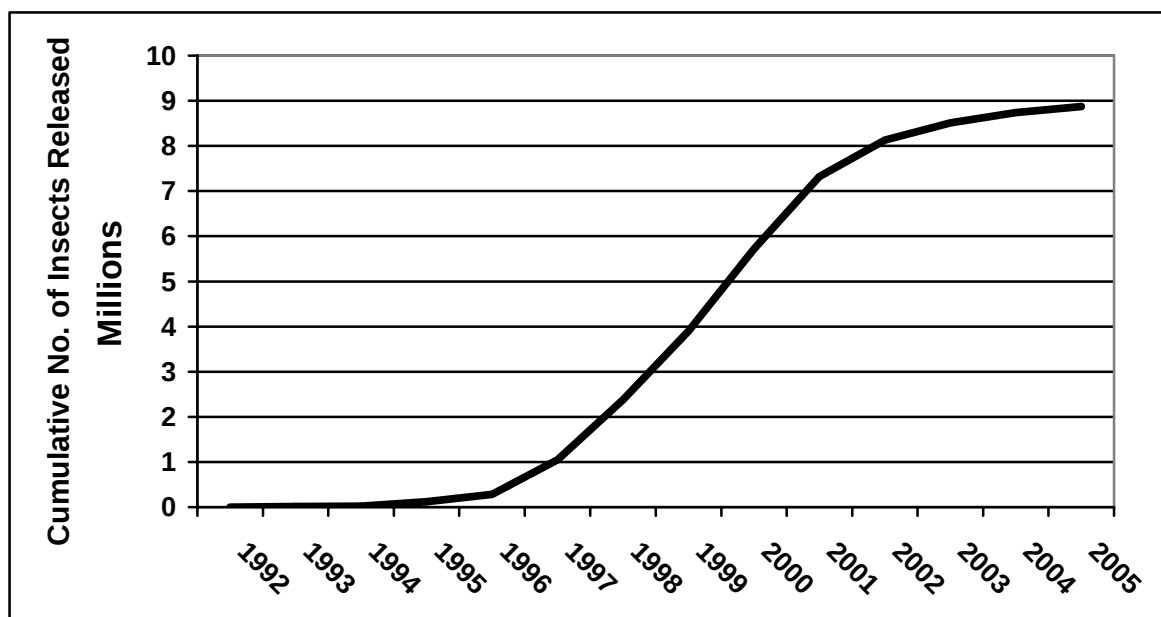


Figure 18. Cumulative number of insects released to control purple loosestrife by year.

Table 14. Summary of number of insects released in each region to control purple loosestrife (1992-2005).

Minnesota DNR Regions	Number of Release Sites	Number of Insects Released
1 – Northwest	123	1,361,550
2 – Northeast	201	1,622,490
3 – Central	400	5,187,820
4 – South	57	703,300
Totals	781	8,875,160

Biological control insects released between 1992 and 2005 have established reproducing populations at more than 80% of the sites visited. Insect populations increased significantly at many locations with pronounced damage to loosestrife plants. In the summer of 2005, 320 insect release sites were visited to assess the insect establishment and level of control achieved. At 31% (99 sites) of the sites surveyed, the insect populations are rapidly increasing causing damage to the loosestrife infestations. At 11% (35 sites) of all visited sites, the loosestrife was severely defoliated (90-100%) (Figure 20).

Effectiveness of biological control

A long-term objective is to utilize biological controls to reduce the abundance/impacts of loosestrife in wetland habitats throughout Minnesota. Biological control, if effective, will reduce the impact loosestrife has on wetland flora and fauna. The DNR's goal is to reduce the abundance of loosestrife in wetlands where it is the dominant plant by at least 70% within 15-20 years. Purple loosestrife will not be eradicated from most wetlands where it presently occurs, but its abundance can be significantly reduced so that it is only a small component of the plant community, and not a dominant one. Assessment efforts in 2005 demonstrated that *Galerucella* introductions have caused moderate to severe defoliation of loosestrife populations on 44% of sites visited (Figure 20). The DNR will continue to track these wetlands to assess how loosestrife abundance changes over time and to determine what combinations of biological control agents provided the desired level of control.

Research on Insects as Biological Control Agents

Post-release monitoring in Minnesota wetlands may provide insight into factors that effect the establishment of each *Galerucella* spp. In 2004 and 2005, approximately 60 and 75 wetlands respectively, were sampled for *G. californiensis* and *G. pusilla*. Multiple sampling techniques, such as hand collection and pheromone traps, were used to collect insects within each wetland. Factors such as location, year of initial release, years a site was defoliated by beetles, wetland type, density of purple loosestrife, size of purple loosestrife infested area, and water level were used in a categorical analysis to determine if any of these factors are predictive of species composition.

Overall species composition for all sites sampled in 2004 and 2005 was 41% *G. californiensis* and 59% *G. pusilla*, even though the insectaries used for releases have an 85%/15% *G. californiensis*/*G. pusilla* composition. Species composition sampling from Minnesota wetlands in 2004 indicated that 49% of wetlands sampled contained 90% or greater *G. pusilla*). *Galerucella pusilla*-dominated wetlands were associated with continuous patches of purple loosestrife and permanently flooded wetlands in the southern portion of the state. Pheromone traps and hand collecting resulted in significantly different species compositions. Pheromone samples contained 25% more *G. californiensis* than hand collected samples. Samples collected on the pheromone traps are biased towards *G. californiensis*. More testing is needed to determine accuracy of sampling techniques. Factors that may affect results include: temperature, weather conditions, beetle behaviors, and actual species composition in wetlands.

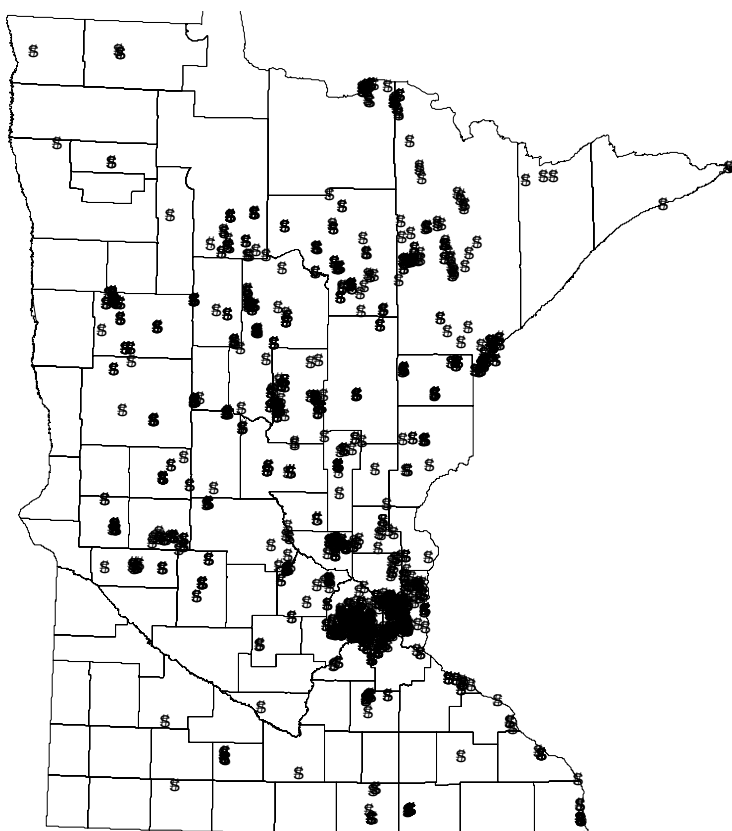
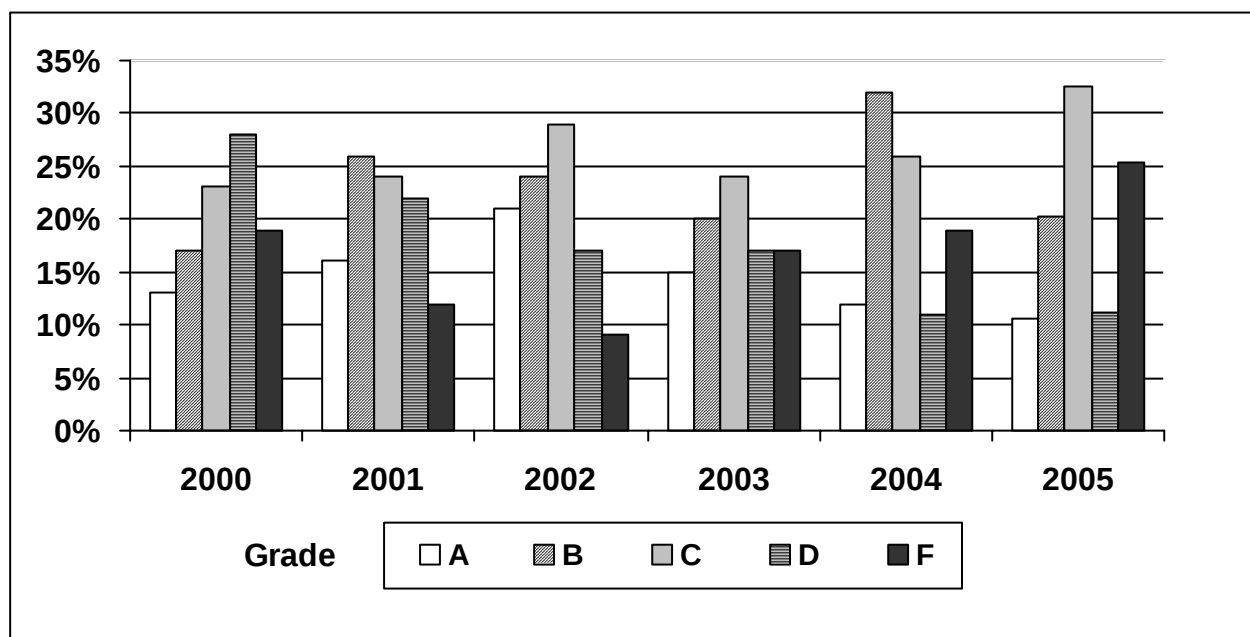


Figure 19. Locations of insects released to control purple loosestrife in Minnesota through 2005.



A = 90-100% defoliation, B = 50-89% defoliation, C = damage near release point with insects visible, D = no damage, few insects visible, F = no insects or damage present.

Figure 20. Sites graded for insect establishment and control.

Future needs for management of purple loosestrife

- Continue implementation and evaluation of biological control of purple loosestrife.
- Continue DNR funding of herbicide control efforts on small, high-priority infestations.
- Continue to assess effectiveness of overall management strategies.
- Continue to collaborate with county agriculture inspectors, MnDOT, DNR area wildlife managers, nature centers, etc., to expand management efforts.

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Other Invasive Aquatic Plant Species in Minnesota

Introduction

Numerous invasive species of aquatic plants exist in the state. The previous chapters described species for which there were ongoing efforts. The species listed in Table 15 exist in the state, but there are no ongoing efforts by the DNR to manage them in the wild. They are included because they are or have been of interest within the state, and have been described in previous annual reports.

Table 15. Other Invasive Aquatic Plant Species in Minnesota.

Species	Status	Legal Status	Last annual report to include info on this species
Yellow iris (<i>Iris pseudacorus</i>)	Commonly sold; public education has focused on preventing people from planting it in natural water bodies	Regulated	2002
Brittle naiad (<i>Najas minor</i>)	One known population in Lac Lavon in Dakota County	Proposed to be listed as Regulated	2004
Hardy hybrid water lily (<i>Nymphaea</i> spp. hybrid)	Three known wild populations in Minnesota	Regulated	2004
Water lettuce (<i>Pistia stratiotes</i>)	No new infestations found since 2001	Unlisted	2001
Reed canary-grass (<i>Phalaris arundinacea</i>)	Widespread in Minnesota	Unlisted	2004
Salt cedar (<i>Tamarix ramosissima</i>)	One known population that was treated with herbicide and by mechanical methods in 2003-2004. It is believed to have been eradicated from the site.	Unlisted	2004
Introduced genotypes of common reed (<i>Phragmites australis</i>)	Only a few known populations in the state; distribution information is lacking.	Unlisted	

Terrestrial Invasive Plant Management

Overview

The Invasive Species Program is playing a key role to improve the management of terrestrial invasive plants in natural areas, including DNR managed lands. A major focus was placed on providing support and technical expertise to DNR land managers statewide and developing new control methods such as biological control for common buckthorn and garlic mustard. This work is being funded by a combination of sources that includes state funding (Legislative Commission on Minnesota Resources and Heritage Enhancement), and federal funding (U.S. Forest Service, and U.S. Environmental Protection Agency-Great Lakes National Program Office).

Heritage Enhancement Collaborative Projects

The Division of Ecological Services is leading a collaborative effort with the Divisions of Parks and Recreation, Fish and Wildlife, and Trails and Waterways to enhance DNR's ability to effectively manage terrestrial invasive plants. Started in FY04 using Heritage Enhancement Funds, this effort has expanded work in four high-priority areas. Those areas are: 1) terrestrial invasive plants inventory, 2) research on control methods, 3) invasive species management, and 4) information/education.

Inventory

Using standardized protocols developed by the DNR and MDA, more than 8,000 locations of invasive plant species on state-managed lands have already been mapped using GPS/GIS technologies. This includes surveys conducted in 20 state parks, 120 wildlife management areas, and along 160 miles of state trails. Managers are now using this information to target and monitor results of control efforts on these populations.

Management

Best management practices (BMPs) are being developed to reduce the movement of invasive plants during DNR management or development projects. A first draft has been completed and will now be circulated to other Divisions for comment.

Funding was provided for a demonstration project to manage invasive plants in a public/private effort across ownership boundaries in western Minnesota. This "partnering on terrestrial control" pilot project took place at Glacial Lakes State Park. Park staff worked with adjacent landowners to manage buckthorn. More than 32 acres of buckthorn were controlled with the cooperation of two landowners. Projects like this engage the public and provide a buffer to state lands where invasive control is occurring.

Information and Education

A new buckthorn brochure was developed in conjunction with the Division of Forestry to fulfill the growing demand from the public for information on buckthorn management. Fifty-thousand copies of the brochure were printed and approximately half have been distributed already.

BMP fact sheets were developed for reed canary-grass, Canada thistle, garlic mustard, and spotted knapweed. The fact sheets were created in a digital format so that they can easily be updated for posting on DNR's Web site.

Symposium on the biology, ecology, and management of garlic mustard and buckthorn

On March 17-18, 2005, the DNR, in conjunction with USDA Forest Service and the University of Minnesota, hosted a two-day workshop on garlic mustard and buckthorn. The purpose of this symposium was to get researchers and resource managers together for discussions of biology, ecology, and management of garlic mustard and invasive buckthorn with an emphasis on using classical biological control as a long-term management strategy. One day of talks and discussion was devoted to each species. Our goal was to provide a forum where the presentations by subject experts were designed to introduce topics, give a general overview, and end with the most current understanding of the problems. Each day, nearly three hours were set aside for discussion of issues related to management and future research needs for each species.

Presenters for this symposium were chosen because of their current involvement in research or management of garlic mustard and buckthorn. Three speakers came from CABI Bioscience Center in Switzerland, where overseas work is focused on biological control for garlic mustard and buckthorn, while the remaining speakers came from various universities and government agencies. More than 80 people from 11 different states attended the symposium with participants from local, state, and federal agencies, universities, and private organizations.

The garlic mustard presentations were primarily focused on issues related to the development of biological control, including host specificity testing and developing protocols for monitoring future biological control releases, plus a presentation on ecosystem impacts. The buckthorn presentations were evenly split between talks on the biology and impacts of buckthorn and management strategies, including the development of biological controls.

Symposium speakers were asked to provide summaries or short papers of their presentations and discussion points. Although the summaries may be brief, they provide state-of-the art information related to impacts and management of garlic mustard and buckthorn. A proceedings was produced and made available in October 2005 and is a valuable reference on the biology and management and the potential for biological control of garlic mustard and common and glossy buckthorn.

Logger and forester training

A one-day workshop entitled "Invasive Plants of Minnesota Forests" was held two consecutive days in October, 2005, in Grand Rapids, Minnesota. The purpose of the workshop was to educate loggers, foresters, and resource managers on how to identify, monitor, prevent the spread, and control the most troublesome invaders of Minnesota's woodlands. These non-native invasive species have ecological implications for forest communities, disrupt tree regeneration, and create problems during and after timber harvests. Highlights of the workshop included 1) developing basic "four-season" identification skills and understanding the life history of each species, especially as it pertains to eradication and control methods; 2) learning to distinguish between non-

native (exotic) invasive species and “native but sometimes nuisance” species such as prickly ash, sumac, alder, willow, hazel, etc.; 3) developing an ability to assess a site and determine appropriate management practices; and 4) getting feedback for participants to help shape future invasive species policy in Minnesota by giving input as to what are realistic, efficient, and affordable approaches that can be adopted by woods workers. The workshop focused on the most common woodland invasives: common and glossy buckthorn, exotic honeysuckles, and garlic mustard.

The workshops were funded by a Minnesota DNR Forest Stewardship grant to the Institute of Agriculture and Trade Policy (IATP). The workshops were planned and carried out in conjunction with the Minnesota DNR Invasive Species Program. The lead instructor, Gigi La Budde of IATP’s Community Forestry Resource Center, lead the all-day session with both classroom and field components with support from the DNR’s Invasive Species Program.

Research

Funds are being provided to support research on biological control methods for garlic mustard and buckthorn. Research is also underway to refine methods of controlling Canada thistle in the Talcot area, where Canada thistle dominates many of the wildlife management areas. The goal of the research is to improve control of Canada thistle, reduce herbicide use, and reduce impacts to native plants.

Canada Thistle Research

Research on BMPs for Canada thistle management was carried out under contract with the University of Minnesota. University scientists conducted the research in cooperation with DNR Wildlife staff from the Talcot Area office. Sites used for testing the BMPs included the West Graham Wildlife Management Area and Timber Lake U.S. Fish and Wildlife Service Waterfowl Protection Area. These BMPs are designed to balance the needs of managing wildlife habitat, to benefit desired native prairie species, and to decrease or eliminate the presence of Canada thistle. Clopyralid (Transline formulated product) is used because clopyralid is the most effective product on Canada thistle and offers non-target forb tolerance. To date, data indicate that spot treatment may not be feasible, and mowing two times per season would also likely result in inadequate control of Canada thistle. Clopyralid application at labeled rates in the pre-bud stage provided good control. However, early season herbicide applications may harm nesting and survival of desired waterfowl. Waiting until after July 15 resulted in higher levels of Canada thistle. Below label rates of clopyralid, that would provide a greater margin of safety for sensitive forbs, did not control Canada thistle. Biomass, percent cover, and species presence/absence data have yet to be analyzed and will be included in future reports. Data will be collected again in 2006.

Clopyralid (Transline) small plot studies were conducted to assess recommendations for use in Canada thistle control in native prairies. One year after treatment, spring applications of clopyralid resulted in similar or reduced control compared to fall applications. The below label, 8 oz. rate of clopyralid and even the low end of the labeled rate (12 oz./A), appear likely to result in higher risks of nonperformance. It appears that the labeled rates are on target for clopyralid. Less than labeled 8 oz. of clopyralid may on occasion provide adequate control, but the question if this improves the margin of safety for non-target organisms is yet to be determined considering the

increased risk of needing to respray. There was no benefit from increasing application rates above 10 to 20 gallons per acre, countering the notion that high levels of plant residue common in CRP or prairies require higher volumes to get good coverage. The use of additives did not enhance the performance of clopyralid over use of the product alone. Finally, imazapyr and chlorimuron (Plateau and Telar) provided significantly lower levels of Canada thistle control than clopyralid. Thus, clopyralid still appears to be the product of choice for use on native prairie wildlife management areas. A new product that just received labeling this year, aminopyralid (Milestone formulated product) was studied in a native CRP planting north of Waseca, Minnesota, and may offer another option for prairie use.

Studies are being conducted at the University of Minnesota's research facilities at Rosemount and at Lamberton to define the potential of functional groups of native plants (i.e., warm and cool season grasses and forbs) to be resistant to Canada thistle invasion. Certain select planting strategies within functional groups may prevent Canada thistle establishment during the restoration of native prairies. To date, frost seeded cool season functional groups clearly showed an inverse relationship with Canada thistle establishment. The least successful was that of the warm season only functional group. The mixed species group provided intermediate, or similar, levels of thistle suppression to that of the warm season functional groups. It was expected that the use of cool season functional groups would be most competitive with Canada thistle when frost seeded since Canada thistle as a cool season species, would emerge at similar times the following spring. Plateau pre-emergence did provide some suppression of the establishment of Canada thistle seedlings. The basis for long-term studies from which to improve BMPs for Canada thistle management in prairies are being developed with this funding.

Buckthorn Biological Control Research

Research in Europe. The DNR has initiated a research project on biological control of European buckthorn, conducted by the Center for Applied Bioscience International in Switzerland (CABI). The research is funded by the United States Environmental Protection Agency-Great Lake National Program Office and by the Minnesota legislature as recommended by the Legislative Commission on Minnesota Resources, from the Environmental Trust Fund to continue this research.

Initial research results suggest that a dozen species of insects show some potential as control agents. Researchers carried out field surveys for potential control agents in 2002 through 2004. Surveys and collection trips were carried out by CABI researchers in Germany, Italy, Switzerland, Austria, and Yugoslavia. In total, more than 60 buckthorn sites were discovered and sampled. To date, some 270 arthropod samples have been collected, 184 on *Rhamnus cathartica* and 70 on *R. frangula*.

Several insect species have been selected for detailed host specificity studies based on their food niche, period of attack, potential availability, and likely specificity. Most of these species are targeted for *Rhamnus cathartica*. Researchers are currently rearing potential control agents and testing whether they feed and/or reproduce on non-target native plants that are closely related to buckthorn. Currently, two North American and three European buckthorn species are being cultivated at the research facility in Switzerland for host specificity testing. More native plant species will be collected and

shipped to Switzerland from the United States this summer as the host specificity testing continues.

Emphasis will be put on field surveys of flower- and fruit/seed-feeding insects as well as on *Oberea pedemontana*, a stem-mining beetle. Flower- and fruit/seed-feeding insects had not been prioritized in the initial phase of the project because test plants would need to be synchronized at the flowering stage. Now that a smaller subset of potential agents are proposed for further consideration and a few plant species are growing well in the Center's garden, it has been decided to include flower- and fruit/seed-feeding insects in the study for the next two years. Finally, priority will be given to the biological control of *R. cathartica*, and no detailed work will be planned for biological control of *F. alnus* at this time.

This research is expected to take eight to ten years to complete. If a successful biocontrol agent is discovered, we expect buckthorn populations will be suppressed by: 1) killing buckthorn shrubs outright, 2) stressing or weakening buckthorn plants so that native plant and shrub species can gain a competitive advantage, and/or 3) reducing seed production. In many cases, control or suppression of the pest plant can be long-term.

Research in Minnesota. As part of developing biological controls for buckthorn, it is important to know what insect species are currently utilizing buckthorn in Minnesota. A contract with the University of Minnesota is in place to conduct surveys for insects on buckthorn in Minnesota. Surveys began in late May 2004. Seven locations in Minnesota are being surveyed systematically throughout the growing season to capture insects utilizing buckthorn. The research was continued in 2005, where buckthorn stands were sampled for insect fauna. Over 450 insect specimens have been collected on buckthorn in 2005. This information will help us understand the diversity and abundance of insects collected in the buckthorn survey. Funding for this effort was recommended by the Legislative Commission on Minnesota Resources from the Minnesota Environment and Natural Resources Trust Fund.

Garlic Mustard Biological Control Research

Garlic mustard, *Alliaria petiolata*, is currently one of the most serious invaders of forested areas in southern Ontario and the northeastern and mid-western United States. This biennial non-native plant can cover large areas where it displaces the native woodland ground flora such as spring ephemerals. Garlic mustard is a prohibited noxious weed in Minnesota, making it illegal to import, sell, and transport, which requires control. Few infested sites were known to exist in the state until recently. In 2001 and 2002, the numbers and sizes of infestations increased significantly. It has become an increasing problem in Minnesota during the past two years. University of Minnesota herbarium records, and reports from citizens and biologists received during 2002, indicate that infestations exist in at least 15 counties: Anoka, Brown, Carver, Cass, Clay, Dakota, Hennepin, Kandiyohi, Nicollet, Otter Tail, Pine, Ramsey, Scott, Washington, and Wright counties. Distribution of garlic mustard is likely more widespread than currently known.

Control of large infestations is difficult and land managers are seeking better control tools. In 1998, a project to search for natural enemies of garlic mustard was initiated at

Cornell University. Funding has been provided by the Departments of Natural Resources in Minnesota, Illinois, Indiana, and Kentucky; Hoosier National Forest; Native Plant Societies of Illinois and Indiana; U.S. Department of Defense and others. In 2002, the DNR and the United States Forest Service-Forest Health Technology Enterprise Team, in cooperation with representatives from many of the initial funding agencies organized an informal working group to develop a 3-5 year plan for continuing the project to develop a biological control program for garlic mustard. In 2002-2005, the consortium has cooperatively provided technical and financial assistance to continue the host range testing in Europe, established laboratory colonies of promising agents in a quarantine facility in the U.S., and established permanent evaluation plots in several states. This effort will pave the way for the introduction of garlic mustard biocontrol agents in the near future. To date, several species of insects show promise as control agents against garlic mustard.

Host specificity testing. To complete host specificity testing of potential control agents, the United States Forest Service-Forest Health Technology Enterprise Team has provided funding to the DNR to help complete testing in quarantine at the University of Minnesota. Testing is currently being carried out to make sure the potential control agents do not feed on native plant species.

In Minnesota, all host range testing is conducted under quarantine conditions in the High Containment Security Facility on the University of Minnesota campus. Three species of garlic mustard weevils, *Ceutorhynchus scrobicollis*, *C. roberti* and *C. alliariae*, are now in quarantine at the University of Minnesota campus and host range testing has been conducted with *C. scrobicollis*. A shipment of the shoot-mining weevils, *C. roberti* and *C. alliariae*, was received in April 2005. Both species were tested for oviposition on flowering garlic mustard plants. No eggs were found on plants and it is thought that the trip from Switzerland to Minnesota may have disrupted oviposition in these two species. Adults are now progressing through simulated seasons in the quarantine lab to see whether they can be induced to lay eggs.

Thus far in our host range tests, *C. scrobicollis* has not successfully completed development on any plant species other than garlic mustard. These results are encouraging, but more testing needs to be carried out. We anticipate completing the host specificity tests for *C. scrobicollis* in 2006. Once all the testing is completed, the results will be evaluated and a decision will be made whether to petition the federal government for permission to release the control agents into the United States.

Garlic mustard biological control implementation in Minnesota. A second garlic mustard project was initiated in 2005 to establish permanent plots to monitor garlic mustard populations in anticipation of biological control insect release. To find potential sites, it was necessary to locate garlic mustard populations of the appropriate size in areas where management would not be applied. The established plots then have their species composition and garlic mustard abundance recorded in June and October. Garlic mustard monitoring plots were established in 12 sites. The sites include:

1. Prairie Creek SNA in Big Woods State Park (Nerstrand),
2. Pine Bend Bluffs SNA (Inver Grove Heights),
3. Fort Snelling State Park (St. Paul),
4. Baker Park Preserve (Three Rivers Park District, Maple Plain),
5. Warner Nature Center (Science Museum of Minnesota, Marine-on-St. Croix),
6. Luce Line Trail (Long Lake),
7. Hilloway Park

(Minnetonka), 8. Westwood Hills Nature Center (St. Louis Park), 9. Coon Rapids Dam Regional Park (Coon Rapids), 10. Cottage Grove Ravine Regional Park (Cottage Grove), 11. Plainview (Otter Tail County), and 12. Willmar (Kandiyohi County).

In addition to setting up monitoring sites, a research plan for garlic mustard was developed. Current research on garlic mustard was reviewed and research objectives and experiments related to impacts and control of garlic mustard were developed. Garlic mustard seeds were collected from Fort Snelling State Park, Baker Park Preserve, and the Warner Nature Center for use in competition studies to be carried out in the greenhouse this winter. In order to study the soil seed bank of the monitoring sites, soil samples were collected in September from seven sites (the Westwood Hills site was not established at the time). The contents of the soil seed bank will be examined in the greenhouse this winter. Funding for this effort was recommended by the Legislative Commission on Minnesota Resources from the Minnesota Environment and Natural Resources Trust Fund.

Management of Asian Carp

Introduction

Four non-native species of carp, collectively known as Asian carp, have been imported for commercial aquaculture use in the Mississippi River basin and appear to have significant potential to harm aquatic ecosystems in Minnesota. The species are: bighead carp (*Hypophthalmichthys nobilis*), silver carp (*Hypophthalmichthys molitrix*), grass carp (*Ctenopharyngodon idella*), and black carp (*Mylopharyngodon piceus*). All four species have escaped from captivity and all but the black carp are known to have established populations in the Upper Mississippi River Basin (UMRB). Monitoring has documented that these populations are expanding their geographic range and are moving up the Mississippi River towards Minnesota (a single bighead carp was caught in Lake Pepin in 2003). There is also concern that these fish could enter the Great Lakes through the Illinois waterways that connect the Mississippi River basin with the Great Lake Basin.

Resource managers throughout the UMRB are concerned about Asian carp and their associated impacts on natural resources and human safety. The distribution of these fish species in Asia and risk assessments suggest that they will thrive in the UMRB. Asian carp are already the most abundant large fish in parts of the Missouri River and are present in large numbers in parts of the Mississippi River and its tributaries. Each of these species has unique characteristics and poses different threats to fish and other aquatic species. Taken together they appear capable of having profound effects on aquatic resources and recreational opportunities.

At present, no populations of Asian carp are known to have established in Minnesota. No Asian carp were reported caught in the state in 2005. The closest known populations are in Iowa waters of the Mississippi River and its tributaries. Monitoring has documented that these populations continue to move upstream. Asian carp can move up to seven miles a day (Anderson, 2004) and 150 miles in a season (Chapman, 2004), so there appears to be a short window of opportunity to limit the spread of these species throughout the UMRB.

Bighead carp

The bighead carp are a planktivorous fish (they eat microscopic organisms) and are native to China. They prefer zooplankton (microscopic animals), but will supplement their diet with phytoplankton (microscopic plants) and detritus. They can get quite large, with individuals reaching over 30 inches in length and weighing over 60 pounds. A unique feature that distinguishes the bighead carp from our native fishes is the placement of the eyes, which are located below the mouth. Bighead carp feed on the same food items as many of our native species and they will directly compete with the commercially-harvested bigmouth buffalo, the threatened paddlefish, young-of-the-year of many fish species, and freshwater mussels.

Silver carp

Silver carp are native to eastern Asia. They were imported into the U.S. and stocked in private waters in other states to control algae/phytoplankton. The fish was first found in natural waters in Arkansas around 1980, likely the result of escapes from private

aquaculture facilities. This fish has the potential to cause considerable damage to native species because it feeds on plankton required by larval fish, gizzard shad and other plankton eating fish, and native mussels. The silver carp has also attracted attention because of its habit of jumping out of the water in response to passing boats (Figure 21). Because of their size and the height the fish reach, this behavior creates a serious hazard to boaters. Silver carp have not yet been documented in Minnesota waters.



Figure 21. Numerous silver carp jumping near a dam in Illinois.

Grass carp

Grass carp are native to eastern Asia. Wild populations are now present in many natural waters in the United States. These fish have been and continue to be widely stocked to control aquatic vegetation. According to fisheries biologists in Midwest states, reproducing populations of grass carp are found in tributaries of the Mississippi River south of Minnesota. Grass carp have not become established in Minnesota waters, but individual fish have been caught in state border waters (Mississippi River below the Twin Cities and Okamanpeedan Lake on the Minnesota-Iowa border). They have been sampled periodically in the Mississippi River with the northern-most record at Wabasha, Minnesota, in 1994, and the earliest record in Lake Winona in 1977.

Black carp

Black carp are native to eastern Asia. This species was first brought into the United States in the early 1970s as a "contaminant" in imported grass carp stocks for a private fish farm in Arkansas. In the early 1980s, black carp were imported as a food fish and to control the spread of yellow grub *Clinostomum margaritum* in aquaculture ponds (Source: <http://nas.er.usgs.gov/queries/SpSimpleSearch.asp>). Their establishment in the wild would pose a significant risk to the mollusk and fisheries resources throughout the Mississippi River and its tributaries.

A new risk assessment on black carp (Nico, 2005) reports that black carp have been found in the wild in other states more than previously reported. On several separate occasions black carp have been captured in open waters of the nation: Illinois (2003 and 2004), Louisiana (2004), and Arkansas (2005). Despite these occurrences, it is not known with certainty if they are reproducing in the wild. There are no reports of larval or juvenile black carp, but it is possible they have reproduced and may have been misidentified or overlooked. Nico (2005) states, "the continued captures of adult black carp in Louisiana and other parts of the Mississippi River basin provide strong evidence that the species is reproducing and is already firmly established."

Nico (2005) reports that in terms of overall habitat suitability, the Mississippi River is suitable for black carp populations, perhaps even better than some rivers in its native range. The upper Mississippi is less suitable because of the existence of many navigation locks and dams that restrict fish movement. He points out that habitat restoration and increasing connectivity, which benefit native fishes, also favors black carp survival.

Management Goals and Options

There are three general options to manage wild populations of Asian carp:

- 1) no action;
- 2) attempt to prevent further geographical spread; and
- 3) attempt population control after colonization.

Based on results in areas where Asian carp have already become established, it is clear that, if no actions are taken, Asian carp will eventually jeopardize aquatic resources and use of those resources in much of the UMRB. Currently there are no effective measures that would selectively control these species. The Minnesota DNR's goal is to prevent or slow the introduction of Asian carp into state waters and continue to support research efforts to develop new control techniques. To accomplish this goal, states, federal agencies, and Congress will need to act promptly, ideally during 2006, to limit the northern spread of Asian carp in the UMRB.

Progress in Management of Asian Carp - 2005

Actions

- Minnesota and the other Great Lakes states worked actively with the Council of Great Lakes Governors, the Great Lakes Fishery Commission, and other groups to fund and install a new dispersal barrier in the Illinois waterways. The Department of the Army will contribute \$6,825,000 of federal funds, the Illinois Department of Natural Resources contributed \$1.8 million, and the states of Minnesota, Indiana, Michigan, Ohio, New York, Wisconsin, and Pennsylvania each contributed \$67,857 toward the non-federal cost share in 2005. DNR's Invasive Species Program provided the funds for Minnesota.
- The DNR also worked with the Minnesota Congressional Delegation to pursue \$7 million of federal funding to implement recommendations from an earlier feasibility study (FishPro, 2004) to slow Asian carp movement up the Mississippi River. The DNR desires to have fish barriers installed in conjunction with two

Mississippi River locks and dams (L&D) such as L&D 11 and L&D 14 or 15, ideally by spring 2006 (Figure 22). The costs to build two fish barriers will depend on the sites and types of technologies:

- o Sound and bubble diversions (Bio Acoustic Fish Fence) placed at the lock chambers are estimated to cost approximately \$1.2-\$1.6 million each.
- o Costs of \$.5-\$3 million are estimated for creating a harvesting area for carp that congregate below each lock.
- o The need and feasibility of adding additional barrier technology along the spillway of the dam that will not compromise other river management concerns is still being examined and, if pursued, could cost an additional \$8- to \$10-million per dam.



Figure 22. Locations of selected locks and dams on the Mississippi River.

Participation of Others

Federal Regulations

The USFWS began a process in 2002 to determine if it will list black carp as an injurious wildlife species. A similar process was initiated in 2003 to determine if bighead and silver carp should be listed as injurious wildlife species. In 2005, a bill was introduced in Congress to designate several Asian carp as injurious wildlife (see Regulations and Proposed Changes). If listed, it would be illegal to import these species into the country or to ship them between states. As of December 2005, the USFWS has not designated any of the three species as injurious wildlife.

National Asian Carp Management and Control Plan

The USFWS formed an Asian Carp Work Group (ACWG) to develop a national Asian Carp Management and Control Plan that will cover bighead, silver, and black carp. Jay Rendall, Minnesota's Invasive Species Program Coordinator, was a member of that group which developed a draft of the plan. In December 2005, the ACWG sent the draft plan to the national Aquatic Nuisance Species Task Force.

The draft plan has the following goals:

1. Prevent unauthorized introductions of bighead, black, grass, and silver carps in the United States.
2. Contain and control the expansion of feral populations of bighead, black, grass, and silver carps in the United States.
3. Reduce feral populations of bighead, black, grass, and silver carps in the United States.
4. Minimize potential negative effects of feral bighead, black, grass, and silver carps in the United States.
5. Inform the public, private industries, and government agencies about bighead, black, grass, and silver carps, their potential effects, and how to prevent unauthorized introductions, control the spread of feral populations, and minimize potential negative effects resulting from introductions in the United States.
6. Conduct research to provide accurate and scientifically valid information necessary for the effective management and control of bighead, black, grass, and silver carps in the United States.
7. Effectively plan, implement, and evaluate management and control efforts for bighead, black, grass, and silver carps in the United States.

The complete draft plan will be available in early 2006.

Illinois Barriers I and II

The original demonstration barrier (Barrier I) in the Chicago area, which became operational in 2002, continues to function though its electrodes continue to corrode. Barrier I lost about 75% power at one point in August due to a lightning strike that caused some equipment to short out. The Army Corps will keep Barrier I operating until Barrier IIB is running, then will shut off Barrier I.

Construction of the second barriers (Barrier II) continued through 2005. Barrier IIA was completed in late August. The funding for IIB is in place. Both parts of Barrier II are expected to be complete in fall of 2005 with power-up in late 2005 or early 2006. The

electrical components for the second array have been developed. In October 2005, issues between one of the contractors and Army Corps of Engineers were delaying the project (Phil Moy, Wisconsin Sea Grant, 31 October 2005).

Reports of Asian carp in the Chicago area in 2005 have been unconfirmed. No Asian carp have been captured or seen by the monitoring crews. The Illinois DNR sampled the South Branch of the Chicago River in response to reports of Asian carp in this area. Three shocking boats working for several hours in the vicinity failed to collect any Asian carp. Reports of anglers catching Asian carp in Wolf Lake have thus far been unconfirmed. Sampling by the Indiana DNR this summer on Wolf Lake revealed no Asian carp.

Future needs for management of Asian carp

- Support efforts to maintain two effective barriers to prevent Asian carp passage in the Illinois waterways.
- Seek funding for one or more dispersal barriers in the Mississippi River to prevent Asian carp from moving into Minnesota waters.
- Evaluate potential to re-establish St. Anthony Falls as a natural barrier.
- Evaluate potential to prevent spread of Asian carp in Minnesota's major tributaries to the Mississippi River including the St. Croix, Minnesota, Zumbro, Cannon, and Root rivers.
- Evaluate non-target impacts for proposed dispersal barriers in the Mississippi River.

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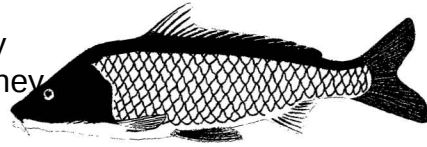
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Management of Common Carp

Introduction

Issue

Common carp (*Cyprinus carpio*) were intentionally introduced into Minnesota waters before 1900. They remained relatively unnoticed as a threat to environmental quality until after the drought of the 1930s. The drought caused many wetlands and wetland areas around lakes to dry up and set the stage for an explosion of aquatic vegetation and invertebrates. The early wetland drainage efforts also provided connections into many wetlands and shallow lakes previously inaccessible to fish. With the recovery of precipitation and subsequent increase in water levels in wetlands, lakes, and streams, the common carp found an abundance of food and spawning habitat. As early as the 1940s, carp had noticeably damaged aquatic habitat in famous waterfowl lakes such as Heron Lake in southwestern Minnesota. By the 1960s, common carp were recognized as a major factor in the deterioration of aquatic habitat across southern Minnesota.



The role of common carp in causing habitat deterioration is primarily related to their search for invertebrates in aquatic vegetation and bottom sediments. Their feeding activity disrupts shallowly rooted plants and suspends bottom sediments in the water column. The sediments release phosphorus that increases the growth of phytoplankton. As water clarity is reduced, remaining aquatic plants find it difficult to survive. As the rooted plants disappear, more bottom soils are exposed to wave action and further suspension. The cycle continues until the water body is devoid of rooted aquatic plants and phytoplankton thrives in the suspended nutrients. Habitat for most native game fish and aquatic wildlife such as waterfowl is devastated. Since carp do not require clear water to feed and reproduce, they eliminate competition from fish that do, including those that would prey on young carp.

Common carp are a carrier of a new disease in the state, spring viremia of carp. All *Cyprinids* (minnows) and northern pike are susceptible to the disease.

Goals

The DNR has two goals related to management of common carp:

- Prevent the spread of carp into waters within Minnesota where they do not currently exist or have been successfully removed.
- Remove common carp from high-priority waterfowl waters, such as shallow lakes and wetlands where they are present.

Distribution

Carp currently occur in the majority of waters across the southern half of Minnesota (see Figure 23).

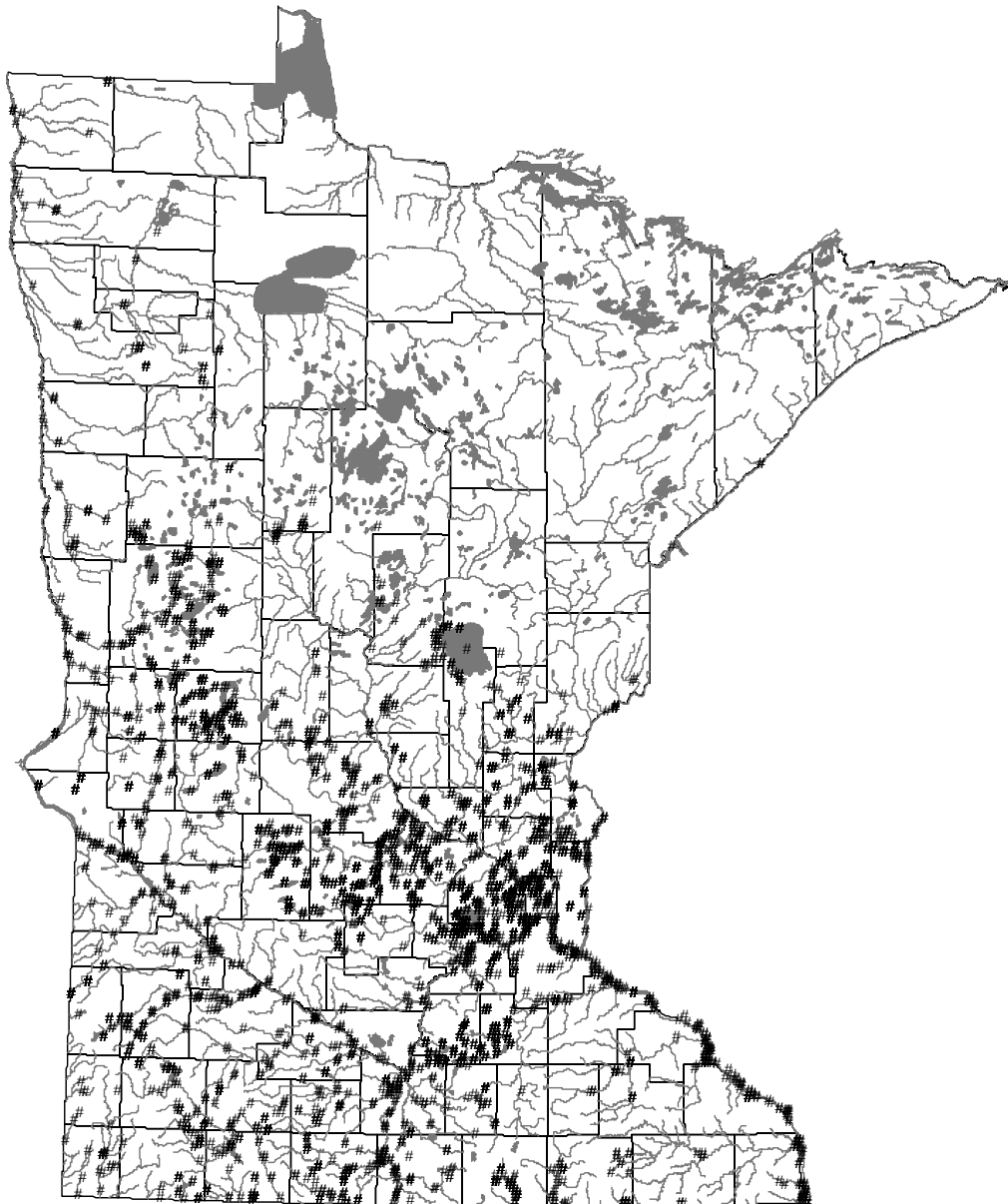


Figure 23. Distribution of common carp in Minnesota as of December 2005.

Progress in Management of Common Carp - 2005

Several activities occur to inventory common carp infested waters, limit their spread, and remove carp from waters where they exist. Those activities (described below) are primarily conducted by staff of the Division of Fish and Wildlife.

Evaluation of habitat conditions on shallow lakes

Habitat evaluation surveys were conducted on about 360 shallow lakes by DNR Wildlife staff in 2005. These surveys evaluate water clarity, chemistry, and depth along with occurrence and density of rooted aquatic plants.

Evaluation of fish populations

Fish population surveys were proposed at 600 managed fishing lakes by DNR Fisheries. The results of those surveys will be available in June 2006.

Establish and maintain fish barriers

Fish barriers are used to limit the movement of common carp between connected waters. Six electric fish barriers are currently - operated under contracts with Smith-Root. A seventh electrical fish barrier will be installed in 2006. Other fish barriers continued to be constructed, repaired, and maintained by DNR Wildlife in 2005.

Remove carp from priority lakes

A large project was conducted by DNR Wildlife at Howard and Mud lakes, shallow lakes near Carlos Avery Wildlife Management Area, to remove common carp, bullheads, and other zooplankton-eating fish in October 2004. The project yielded excellent results on bullheads and carp. In 2005, the result was extremely clear water as intended. DNR Wildlife also repaired the electric fish weir in November.

A similar treatment was conducted in Lake Christina in 2003. The lake has continued to improve in 2005 and water chemistry analysis is being conducted.

Drawdowns of water levels were conducted by DNR Wildlife on about 20 shallow lakes in 2005 to eliminate carp and restore aquatic vegetation. A major effort was initiated at Swan Lake in Nicollet County during 2005 to eliminate carp. The presence of carp in this premier waterfowl lake was confirmed in late November. In early December, the DNR began to drawdown the water in the lake to eliminate the carp or at least the majority of them. Any remaining carp could be eliminated by reverse aeration or Rotenone.

Research

Research to identify pheromones to attract or repel carp is being conducted at the University of Minnesota, with Dr. Peter Sorensen as the project leader, in cooperation with DNR Division of Fish and Wildlife. A project entitled "Developing Pheromones for Use in Carp Control" that was recommended by the Legislative Commission on Minnesota Resources (LCMR) and was subsequently funded by the Legislature continued this research at the University of Minnesota in FY 04-05. It is hoped that the findings from the pheromone research will allow development of an integrated approach to carp management.

In 2005, the LCMR recommended and the legislature provided additional funding of \$550,000 for a project titled "Integrated and Pheromonal Control of Common Carp." This funding will allow Dr. Sorensen to continue research on common carp management during FY 06-09. The DNR is a partner on the proposed project and will contribute staff and equipment from DNR Fisheries and \$60,000 from the Invasive Species Program. This project has three objectives: 1) to develop sensory attractants for female common carp so that efforts might focus on their removal via trapping; 2) to elucidate spawning habitat preferences of wild common carp in Minnesota so that their spawning habitats, and young, might also be targeted for removal; and 3) to develop a population dynamics model to explore how best to control local populations of common carp (Personal Communication, Peter Sorensen, April 5, 2005).

Effectiveness of carp management

Common carp management has been only moderately effective in all types of waters within Minnesota. Nevertheless, in shallow waters where removal of carp has been successful, the aquatic habitat has responded immediately the next spring with improved water clarity and abundant native rooted aquatic plants.

Participation of Others

Participation of others varies depending on the individual management project for common carp. Participation on common carp management projects often included Ducks Unlimited, Minnesota Waterfowl Association, USFWS, DNR Fisheries, and local lake associations.

Future needs for management of common carp

- Continue support for funding of research related to the application of pheromones, induce winterkill to remove carp, develop and evaluate new fish barrier designs, and make additional refinements of chemical applications to remove common carp.
- Continue to seek and provide funding for management to accelerate the removal of common carp from high-priority affected waters and/or the construction of barriers to limit natural dispersal.
- Monitor the new disease, spring viremia of carp, to determine how widespread it is in Minnesota and consider new limitations on live carp shipments.

Reference Cited

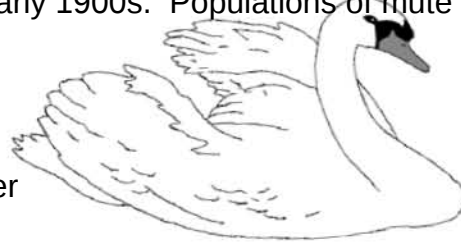
Sorensen, P.W. 2004. Integrated and pheromonal control of carp. Unpublished proposal submitted by the Department of Fisheries, Wildlife, and Conservation Biology, University of Minnesota, St. Paul, MN 55108 to the Legislative Commission on Minnesota Resources, State Office Building, Saint Paul, MN 55155.

Management of Mute Swans

Introduction

Issue

Mute swans (*Cygnus olor*) are native to Europe and Asia and were brought to the United States from the mid-1800s through the early 1900s. Populations of mute swans have established in numerous states. These populations have originated from release or escape of individuals from captive flocks. The current population growth in the Great Lakes states is estimated at 10-20 percent or higher per year (Scott Petrie, Bird Studies Canada, Port Rowan Ontario, presentation to Mississippi River Basin Panel, 8 September 2005). The birds can consume 8 pounds of submersed vegetation and uproot 20 pounds per day causing significant harmful impacts on lake ecosystems.



Mute swans are currently regulated in part by the Minnesota game farm statutes in Minnesota Statutes 97A.105 and they are designated as a *regulated invasive species* in Minnesota Rules 6216.0260. It is illegal to release mute swans into the wild in Minnesota under the game farm and regulated invasive species statutes.

In 2004 and 2005, the DNR has received comments from riparian landowners who are concerned about the presence and increase of mute swans on the lakes where they reside. They are concerned about mute swans interfering with loon nesting that has previously occurred on those lakes. One individual reported seeing the mute swans harassing trumpeter swans. Three individuals and one lake association requested the DNR to remove the mute swans from lakes where there were birds in the wild.

Goal

The DNR's goal for mute swan management is to avoid the establishment of naturalized populations of mute swans in Minnesota.

Distribution

Several unconfined mute swans were reported in Minnesota in 2005 and in previous years. Monitoring mute swans in the wild is a strategy necessary to help DNR respond to birds that may establish naturalized populations. During 2005, the DNR recorded reports of wild or escaped mute swans at seven locations in the state. A total of 29 birds were reported in the wild in three counties (Table 16). Sources of the reports include: conservation officers, birders, the public, and other DNR staff who observed unconfined birds. In 2005, pairs of mute swans successfully nested at Square Lake (3 cygnets), Big Carnelian (3 cygnets), and Little Carnelian (3 cygnets) lakes in Washington County.

Progress in Management of Mute Swans - 2005

Recent federal court decisions, which required the United States Fish and Wildlife Service to protect mute swans under the Migratory Bird Treaty Act (MBTA), prevented

the DNR from controlling mute swans in recent years. This limitation was removed in 2005.

On March 15, 2005, the Secretary of Interior published a final list in the *Federal Register* of the non-native bird species that have been introduced by humans into the United States or its territories and to which the MBTA does not apply. This action was required by the Migratory Bird Treaty Reform Act (MBTRA) that was passed by Congress in 2004. The MBTRA amends the MBTA by stating that it applies only to migratory bird species that are native to the United States or its territories, and that a native migratory bird is one that is present as a result of natural biological or ecological processes. Mute swans were included on that list. Therefore, under state and federal laws, mute swans are once again unprotected species in Minnesota.

During October 2005, DNR staff captured and removed 12 mute swans from the wild at Square and Big Carnelian lakes in Washington County.

Table 16. Unconfined mute swans reported in Minnesota counties during 2005.

County	Number of Mute Swans Reported	Months Reported
Anoka	1 to 3 - Lake Amelia	April, November
Nobles	2 - near Lake Okabena	May
LeSueur	1 - Diamond Lake WMA and waters near Waterville	Spring through Fall
Wright	4 - near Crow River and Co Rd 4	October
Washington	2 to 6 - Square Lake 4 to 8 - Big Carnelian Lake 5 - Little Carnelian Lake	July through October July through October July through October
Total for all counties	29	

Future needs for management of mute swans

In the future, the DNR has the following needs for management of mute swans:

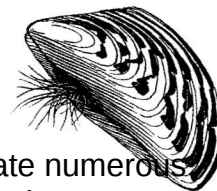
- Encourage reporting and verify occurrences of mute swans in the state.
- Take appropriate actions to have the birds confined under game farm licenses or remove the birds from the wild.
- Develop and distribute informational materials about mute swans and related state and federal laws.

Management of Zebra Mussels

Introduction

Issue

The zebra mussel (*Dreissena polymorpha*) is a small striped invasive mussel that was brought to North America in the ballast waters of trans-Atlantic freighters in the late 1980s. Unlike our native mussels, zebra mussels secrete sticky threads that are used to firmly attach to any hard surface in the water. The ability of these mussels to attach in large clumps can create numerous problems, such as clogging intake pipes for industry or killing native mussels. Attachment of the adults to recreational boats or aquatic vegetation (which may be transported by boaters) can serve to move zebra mussels to other waters.



Zebra mussels have a microscopic free-living larval stage (veliger), which may float in the water for two to three weeks. This larval stage ensures widespread distribution in lakes, and downstream of any established zebra mussel populations in rivers. Additionally, this microscopic life stage may also be moved to other water bodies in any water (such as bait buckets) transported over land. The high reproductive capacity and free-living veligers of the zebra mussel allows for rapid dispersal within a water body.

Zebra mussels feed by filtering algae and other small particles out of the water. These same small food particles are the food base for zooplankton and larval fish in our lakes and rivers. Hundreds of thousands of zebra mussels may filter so much of this food that it could interfere in the aquatic food chain, reducing the food availability for larval fish and impacting fish populations.

Goal

- Prevent the spread of zebra mussels to uninfested waters within Minnesota.

Distribution

Mississippi River from St. Paul and downstream
St. Croix River (downstream of river mile 25.4)
Duluth Harbor
Lake Zumbro
Zumbro River (downstream of Lake Zumbro)
Lake Ossawinnamee
Pelican Brook (downstream of Lake Ossawinnamee)
Lake Mille Lacs
Rice Lake (Crow Wing County)

Management of Zebra Mussels - 2005

Monitoring

Increasing numbers of veligers were collected in sampling in Lake Ossawinnamee compared to the previous season, providing evidence of higher levels of reproduction. Diving surveys in the lake found many zebra mussels of different size classes attached

to rocks and wood on the lake bottom. Substrate samplers and aquatic vegetation sampling indicated increased numbers of zebra mussels in the northern and western parts of the lake. Diving and sampling in Kimball Lake, upstream of and connected to Lake Ossawinnamakee by a small creek, found no evidence of zebra mussels. Zebra mussel populations in Lake Zumbro still remain at high levels and evidence of extensive reproduction and settlement was seen in shallow areas.

While diving during routine fisheries survey work in Lake Mille Lacs, fisheries biologists found four single zebra mussels attached to rocks in three widely separated sites. Veliger sampling at the mouth of the Rum River (outlet from the lake) found no veligers present; however, the single sample late in the summer cannot be considered conclusive. Initial surveys have found no zebra mussels on a sampling of docks or boats removed from the lake in the fall. The size of Lake Mille Lacs may prevent finding clusters of reproducing zebra mussels. DNR staff are meeting with concerned groups (resort owners, bait dealers) about this new discovery and what it may mean for the lake.

Acting on a report from a lakeshore property owner, biologists from Brainerd confirmed the presence of multiple small zebra mussels attached to two separate dock/boat lifts in Rice Lake, on the northern edge of Brainerd. This lake is a backwater on the Mississippi River. The presence of many young-of-year settled zebra mussels suggests that successful reproduction and settlement has occurred in the lake, or reproduction has occurred in the river with the veligers carried into the lake.

The Volunteer Zebra Mussel Monitoring Program continued with mailing of report forms and results from the previous year to all lakeshore residents who had participated last year. Reports to date from volunteers monitoring their lakeshore areas have not found any zebra mussels in any other waters of the state.

The National Park Service monitors for zebra mussels using slides on settling plate samplers and veliger samples in the federal zone of the St. Croix River, above the infested section of the river. Samples taken by the National Park Service were analyzed in the aquatic invertebrate office by DNR biologists. No zebra mussels were found on the slides or veliger samples examined for 2005, suggesting that this invasive has not been moved upstream within these waters.

Prevention of spread

Increased public awareness and education efforts continued in the Brainerd lakes area, in response to the increasing zebra mussel population in Lake Ossawinnamakee. The number of hours of watercraft inspections directly at the lake increased, as well as inspection time spent in the Brainerd lakes area. A new sign was developed and placed at the access of Lake Ossawinnamakee. The sign is larger than existing advisory signs and the text and pictures emphasize what boaters should do to help prevent the spread of this invasive. Similar signs were developed and posted at Lake Mille Lacs access sites. A pilot program was initiated with cooperators to guide people to private car wash facilities to wash their boats after use in Lake Ossawinnamakee. Brochures and maps were provided at the access as well as other cooperating locations.

Efforts continued to try to prevent downstream spread of the veligers from Lake Ossawinnamakee through Pelican Brook. This season the DNR again contracted to have copper sulfate applied weekly during the summer to the bay (Muskie Bay) feeding the outlet stream. As in last season, fall sampling in Pelican Brook failed to collect any adult zebra mussels on rocks or wood in the outlet area. While this treatment was effective as a short-term control measure, toxicity to other aquatic life and metal accumulation in sediments would prevent this from being used as an annual operational control option. However, the late-season discovery of zebra mussels in Rice Lake, downstream of the confluence of the river connections from Lake Ossawinnamakee to the Mississippi (Figure 24) has halted further investigations for prevention in this area.

The discovery of isolated zebra mussels in Lake Mille Lacs provided an increase in public awareness in this area through increased media attention. A news release was sent out, followed by interviews with various media outlets (newspaper and radio). Increased public education efforts were made in this local area to bring attention to the discovery, and watercraft inspection efforts were increased. Information was also provided to fisheries creel census staff on the lake, to assist them in answering questions that might arise from the public.

Research

A final report was received from an environmental consulting company examining the feasibility of preventing the spread of zebra mussel veligers out of Lake Ossawinnamakee into the outlet stream (Pelican Brook). The report looked at various treatment methodologies and examined their potential for use in the brook. In response to the report recommendations, the DNR began work to determine if a physical barrier could be placed in the lake or stream to prevent downstream veliger movement. The discovery of zebra mussels in a backwater lake of the Mississippi River (Rice Lake) downstream of these connections has halted further research for Pelican Brook.

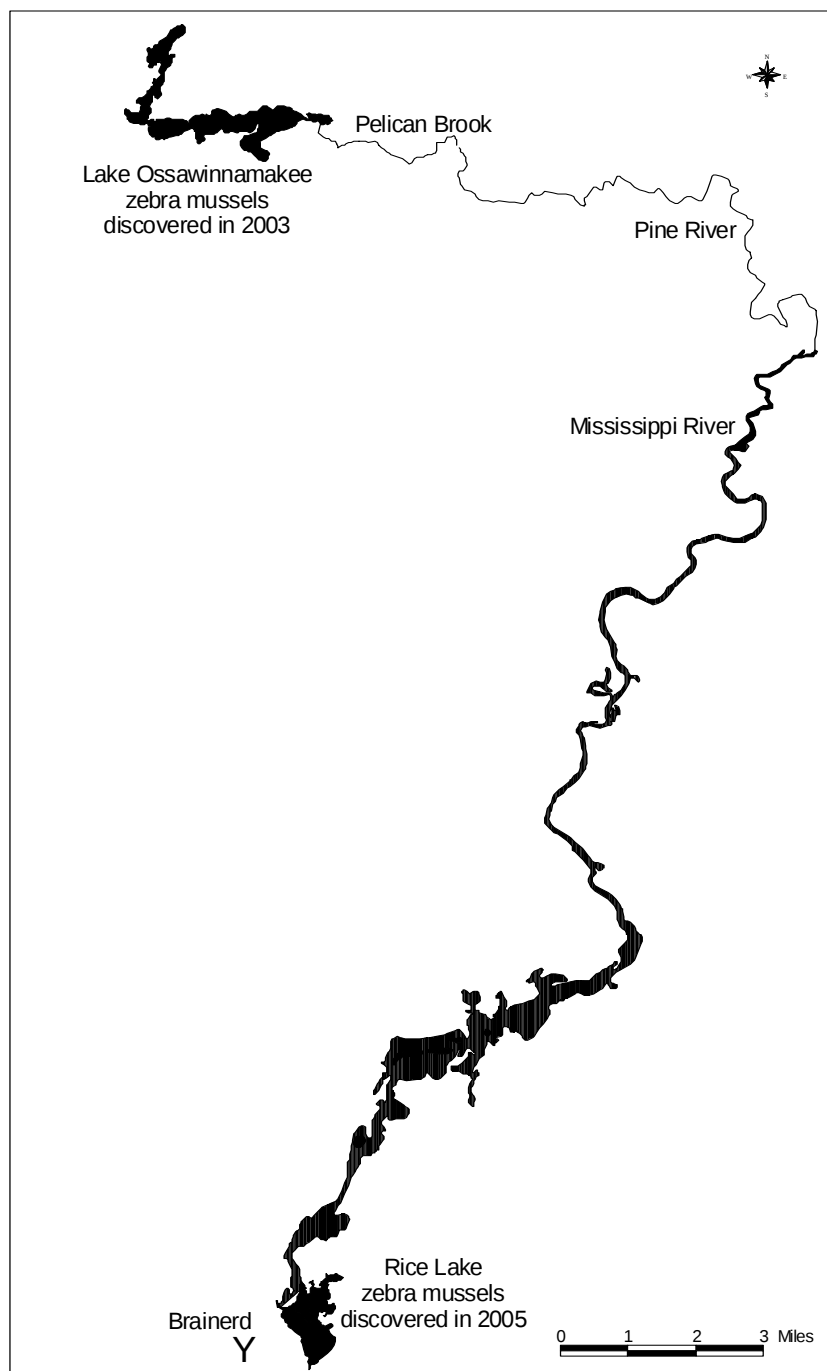


Figure 24. Lake Ossawinnamakee with connection to Rice Lake via Pelican Brook and Pine River to the Mississippi River.

Effectiveness of Management

Minnesota has only four inland lakes that contain this invasive. However, the discovery of zebra mussels in Lake Mille Lacs places this species in a lake supporting an extremely high level of boating recreation. The number of visits to this lake by anglers and other boaters presents a much higher risk of accelerating movement of zebra mussels to other inland lakes within the state. Equally of concern is the presence of zebra mussels in Rice Lake, a backwater lake connected to the Mississippi River on the northern edge of Brainerd. This presents the opportunity for zebra mussel veligers to be carried downstream through the river. If zebra mussels establish reproducing populations throughout the river from the Brainerd area to St. Paul, many more boaters and connecting waters can be exposed to this invasive.

Participation of Others

Funding for an interstate management plan for coordinated actions against the zebra mussel for the St. Croix River was continued by U.S. Fish and Wildlife Service. The Minnesota DNR, Wisconsin DNR, and the Great Lakes Indian Fish and Wildlife Commission received funding assistance for zebra mussel activities on the St. Croix River outlined in the management plan.

Monitoring efforts for zebra mussels continued by lakeshore residents throughout Minnesota. Approximately 225 people annually have participated in the Volunteer Zebra Mussel Monitoring Program, checking lakes across the state for zebra mussels. These efforts provide a much more extensive examination of Minnesota waters for this invasive than could be conducted by the Invasive Species Program alone. Inland lake infestations in Minnesota (Zumbro, Ossawinnamakee, Rice) were reported by members of the public indicating the importance and value of this volunteer effort.

The Minnesota Lakes Association and Minnesota Bass Federation cooperated in the development of a pilot boat wash program promoting the use of car wash facilities and helped to develop and distribute brochures detailing this program. This program was modeled after one in South Dakota and is another component of helping boaters understand how to prevent spread of invasives.

The zebra mussel coordinator attended a meeting of western state and federal biologists working to create a zebra mussel prevention plan for the Columbia River basin to provide input based on the experience Minnesota has gained from the three inland lakes with zebra mussel populations. Information was provided to participants on the efforts to prevent spread of zebra mussels from Lake Ossawinnamakee.

Future needs for management of zebra mussels

- Continue monitoring zebra mussel populations in various Minnesota waters.
- Continue the Volunteer Zebra Mussel Monitoring Program.

Other Invasive Animal Species in Minnesota

Introduction

Numerous invasive wild animals exist in the state. The previous chapters described species for which there were ongoing efforts. The species described in this chapter exist in the state, but there are no ongoing efforts by the DNR to manage them in the wild. They are included because they are or have been of interest within the state. In addition to the information presented on rusty crayfish, spiny waterflea, *Daphnia lumholtzi*, round and tubenose goby, and Eurasian collard-dove, in this chapter, Table 17 presents a summary of other invasive animal species in Minnesota.

Examples of Releases of Non-native Species in 2005

Local examples of aquarium or water garden types of releases continue to appear in the state. During 2005, a Lima shovelnose catfish (*Sorubim lima*) native to South America was discovered alive during July in Caribou Lake near Duluth. DNR Fisheries personnel netted it during a routine fisheries census. An angler caught one of several koi, an ornamental variety of carp used in captive ponds, he had observed in Lake George near St. Cloud during the summer of 2005.

Black-tailed Prairie Dog

In 2005, black-tailed prairie dogs (*Cynomys ludovicianus*) were observed in the state at two locations. This species is not native to Minnesota. Its range exists just southwest of the state and it is usually found in short grass to mid-grass prairies. The colonies found this year are located north of Mankato in Blue Earth County, and near Holland in Pipestone County. At the Mankato site, there were about 10-12 burrows and approximately two dozen prairie dogs in a horse pasture. The landowner said the animals had reportedly been released by an individual who brought them into the state from Montana. The animals were poisoned by the landowner to protect his horses which were at risk of breaking their legs in burrows. In Pipestone County, there was one prairie dog observed. The establishment of this non-native species will be reviewed in 2006 by the Invasive Species Program, Nongame Wildlife, and DNR Wildlife to determine its potential to be invasive.

Eurasian Collared-dove

The Eurasian collared-dove (*Streptopelia decaocto*), a bird native to the Indian subcontinent and Turkey, was first described as a new, non-native bird species in the state in the annual report for 1999. The bird has been observed in 20 Minnesota counties from 1999 to 2004: Big Stone, Blue Earth, Brown, Carver, Chippewa, Dakota, Freeborn, Houston, Lac qui Parle, Lyon, Kandiyohi, Martin, Pennington, Pipestone, Renville, Rock, Roseau, Stearns, Swift, and Yellow Medicine.

In 2005, Eurasian collared-doves were reported for the first time in the towns of Heron Lake in Jackson County, Courtland in Nicollet County, Ottertail in Otter Tail County, Plainview in Wabasha County, and Winona in Winona County. They were reported again in Lyon and Swift counties. The birds are likely to be in other Minnesota counties and to continue spreading throughout the state.

Eurasian collared-dove was included on the list published in the March 15, 2005 issue of the *Federal Register* that identified the non-native bird species that have been introduced by humans into the United States or its territories and to which the Migratory Bird Treaty Act does not apply. This means that Eurasian collared-doves are not protected under federal laws.

The DNR is not attempting to eliminate or control the population of Eurasian collared-doves in Minnesota. There are several reasons: it would be difficult to prevent their continued introduction from adjoining states; the birds look similar to mourning doves; and there is not a regional or national effort to stop their spread.

Rusty Crayfish

The rusty crayfish (*Orconectes rusticus*) is an invasive species that is native to the eastern and mid-eastern United States. It has been spread across the Midwest through human activities, likely through release of bait by anglers. This invasive can out-compete native crayfish and may interbreed with our native species. It can displace native crayfish, reduce or eliminate aquatic vegetation, and may interfere with some fish populations in certain lakes. There are currently no selective and effective control methods once the rusty crayfish become established in lakes or rivers. A report on crayfish control (*Investigation of Crayfish Control Technology*, M. W. Hyatt, Arizona Game and Fish Department) looked at varying methods of control and came to the conclusion that non-specific biocides might work in very limited circumstances, but no other control method (manual removal, trapping, predator management) would eliminate crayfish. With the lack of any selective or even effective control methods, the Invasive Species Program does not conduct any active management of rusty crayfish.

These crayfish have been reported from more than 40 lakes and eight rivers in the state, scattered from northeast to south-central Minnesota. DNR Fisheries staff encounter rusty crayfish in their lake sampling gear and report findings to the Division of Ecological Services. Judging from the widespread reported distribution, it is highly likely that rusty crayfish are present, but unrecorded in more waters in the state.

Spiny Waterflea

The spiny waterflea (*Bythotrephes longimanus*) is an invasive cladoceran zooplankter native to Europe. It was brought over to North America in ballast water in the late 1980s and first appeared in the Great Lakes. This zooplankter is a predaceous cladoceran, feeding on other smaller zooplankton. The long, barbed tail spine on this invasive can prevent predation by small larval fish as well as other aquatic animals. Some species of larger fish have been shown to feed heavily on the spiny waterflea. This invasive may interfere with lake food webs by preying heavily on and reducing the number of other zooplankton. Some research suggests that the most significant impacts will occur in larger, oligotrophic (lacking plant nutrients) lakes with simpler fish communities. The spiny waterflea produces resting eggs similar to those of native Cladocera, which can resist desiccation and freezing, providing a long-range dispersal method for overland spread. Adults may become entangled in fishing gear and moved to other water bodies.

The spiny waterflea was discovered in Lake Superior in the late 1980s, and shortly after that was found in two nearby lakes (Fish and Island lakes, near Duluth). Monitoring by area DNR Fisheries staff reported that it disappeared from Fish Lake, while remaining in

Island Lake. The recent occurrence of this invasive in the northeastern part of the state suggests that it is likely that the spread to other lakes may occur (or has already occurred) through natural movement via connections between water bodies in this area. The resting eggs or viable adults can be carried through such connections into other water bodies.

Fisheries staff in the Duluth area are currently working on completing a research study examining *B. longimanus* populations in Island Lake. The DNR Aquatic Invertebrate Biology staff is assisting in laboratory work for this study.

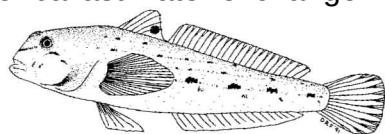
Daphnia lumholtzi

Daphnia lumholtzi is an invasive cladoceran native to the subtropical regions of Africa, Asia, and Australia. This species was first reported in North America in 1990 from a small reservoir in eastern Texas and shortly thereafter from a reservoir in southwest Missouri. Since its first sightings, it has spread rapidly throughout the southern and mid-western states. *D. lumholtzi* can be easily distinguished from native daphnia by its large pointed helmet, long tail spine, and numerous smaller spines along its carapace. Because of its armored body, *D. lumholtzi* may be less susceptible to predation than native daphnia and could compete with native daphnia, which are very important in the diet of juvenile fishes.

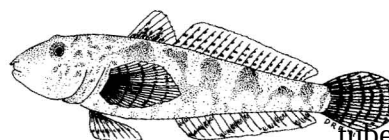
Zooplankton samples have been collected from Lake Pepin since the early 1990s as part of the Long Term River Monitoring Program. *D. lumholtzi* were first found in reproductive densities in Lake Pepin in 2003. Samples from 2005 found a single specimen from the main channel in mid-September. No other *D. lumholtzi* were found in other samples collected from August and September. Similar to native cladocerans, *D. lumholtzi* survives the winter by producing resting eggs that can resist freezing and desiccation, and hatches the following summer when optimum temperatures return (25-31° C). These resting eggs can also be a means of dispersal for the species as they can be transported across land by migrating birds and human activities. Because *D. lumholtzi* is a subtropical species requiring warmer water temperatures than native daphnia, it generally does not appear until late summer and is often restricted to warmer shallow water. Lake Pepin is the furthest north *D. lumholtzi* has been found so far. Water temperature may present a major physical constraint on its long-term success in northern latitudes, but this has yet to be determined.

Round and Tubenose Goby

The round (*Neogobius melanostomus*) and tubenose (*Proterochinus marmoratus*) gobies (Figure 25) are bottom dwelling fish from Europe and native to the Black and Caspian seas. The gobies were discovered in Michigan waters in 1990, likely the result of ballast water exchange from transoceanic vessels.



round goby



tubenose goby

Figure 25. The round and tubenose goby.

In 1995, the round goby was discovered in the Duluth/Superior Harbor. Since then, the population has steadily increased and spread within the Harbor. In North America, the round goby has expanded its range throughout the Great Lakes, Detroit River, Lake Superior watershed, and the Illinois Waterway. The round goby has documented negative impacts on mottled sculpin reproduction (Janssen and Jude, 2001) and suspected impacts on other native bottom dwelling fish, such as darters and sturgeon.

The tubenose goby was first discovered in the St. Louis River estuary in 2001. It has also been documented in several other lakes and rivers within the Great Lakes Basin. Very little is known about its ecological impacts, but some insight can be gained from work done by French and Jude (2001). They demonstrate the overlap of diets between the tubenose goby and other benthic species, but cannot show direct competition.

The Wisconsin DNR and U.S. Geological Survey do annual fish surveys using seines and bottom trawls to estimate fish populations. Both agencies note an increase in tubenose and round gobies species over the last seven years. Round gobies remain far more abundant and have increased at a higher rate than the tubenose goby. Figure 26 shows the total number of tubenose and round gobies captured by the Wisconsin DNR using a seine at nine designated areas within the Harbor.

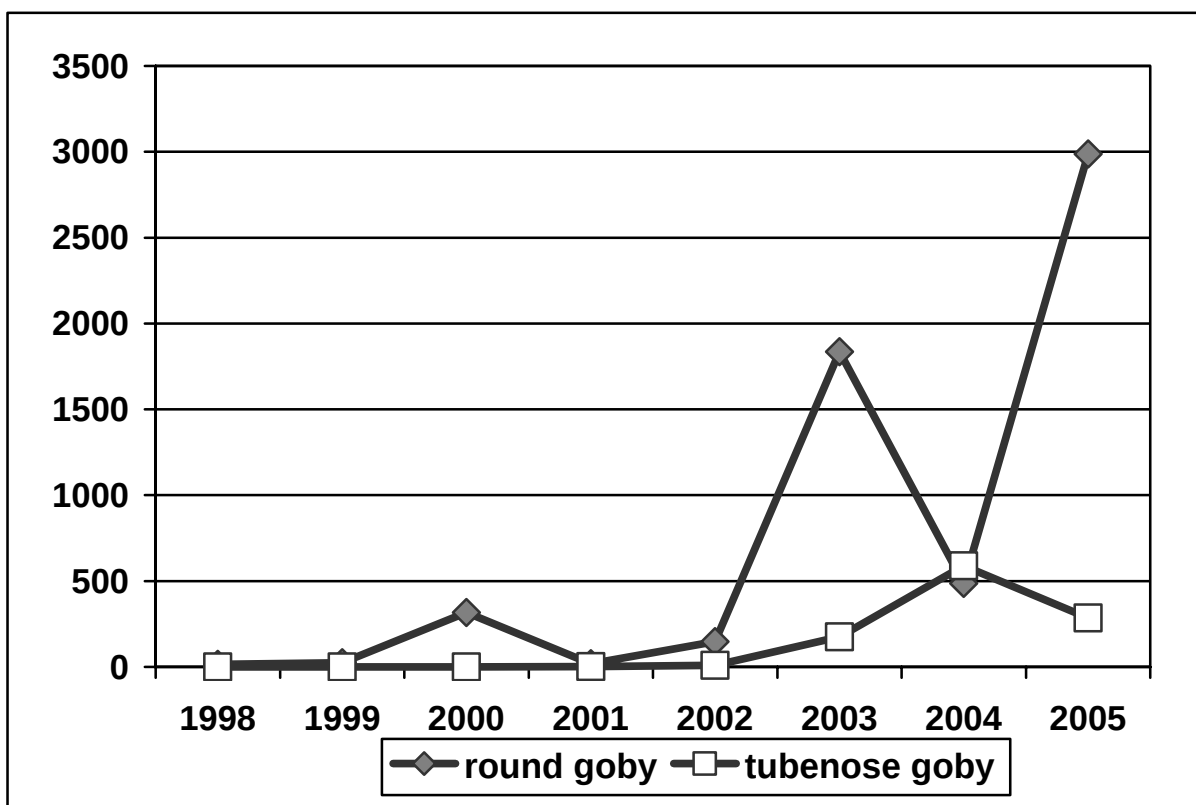


Figure 26. Number of round and tubenose gobies captured using a seine at nine sites (Dennis Pratt, Wisconsin DNR, October 6, 2005).

According to the recent Invasive Species Program risk assessment for the tubenose goby within Minnesota, no selective control methods exist for either species. Piscicides and physical barriers may provide options if selectivity is not a concern.

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- Janssen, J. and D.J. Jude. 2001. Recruitment Failure of Mottled Sculpin *Cottus bairdi* in Calumet Harbor, Southern Lake Michigan, Induced by the Newly Introduced Round Goby *Neogobius melanostomus*. J. Great Lakes Res. 27(3):319-328.

Table 17. Other invasive and non-native species that have been found in the wild in Minnesota.

Species	Status	Legal Status	Last annual report to include info on this species
Earthworms (various genera)	Continued public education has focused on preventing the release of earthworms.	Unlisted	2003
Eurasian swine (<i>Sus scrofa</i>)	No new reports of escaped Eurasian swine in 2005.	Prohibited	2002
Three spine and four spine stickleback (<i>Gasterosteus aculeatus</i> and <i>Apeltes quadracus</i>)	In Lake Superior.	Unlisted	2000
Red deer (<i>Cervus elaphus</i>)	Reports to DNR of six escaped in 2005. They were dispatched by DNR.	Unlisted	1999
Sika deer (<i>Cervus nippon</i>)	Several escapes in past years. Reports to DNR of four escaped in 2005. They were returned to a fenced farm. Another was reported shot by a deer hunter in 2005.	Unlisted	2001
Fallow deer (<i>Dama dama</i>)	Several escapes in past years. Reports to DNR of eight escaped in 2005. They were returned to a fenced farm.	Unlisted	2001
Ruffe (<i>Gymnocephalus cernua</i>)	No new water bodies since 1988.	Prohibited	2002

Appendix A - Invasive Species Program Staff

Title / Area of Responsibility	Name	Phone	E-mail
Invasive Species Program Coordinator - rulemaking, legislation, state representative on regional aquatic invasive species committees or panels and federal invasive species issues, education and public awareness	Jay Rendall	651-259-5131	jay.rendall@dnr.state.mn.us
Purple Loosestrife Coordinator - technical assistance for management of purple loosestrife, and biological control of other invasive species	Luke Skinner	651-259-5140	luke.skinner@dnr.state.mn.us
Eurasian Watermilfoil Coordinator - technical and financial assistance for management of milfoil, and technical assistance for other invasive aquatic plants	Chip Welling	651-259-5149	chip.welling@dnr.state.mn.us
Invasive Species Biologist - technical assistance for management of milfoil, curly-leaf pondweed, and other invasive aquatic plants	Wendy Crowell	651-259-5085	wendy.crowell@dnr.state.mn.us
Invasive Species Biologist - technical assistance for management of milfoil, flowering rush, and other invasive aquatic plants	Nick Proulx	651-259-5129	nick.proulx@dnr.state.mn.us
Invasive Species Biologist - invasive species issues in northern portions of the state	Dan Swanson	218-833-8645	dan.swanson@dnr.state.mn.us
Invasive Species Ecologist - invasive species issues in northern portions of the state; purple loosestrife database management	Rich Rezanka	218-833-8646	richard.rezanka@dnr.state.mn.us
Watercraft Inspection Program Coordinator - supervises watercraft inspection interns; awareness events at water accesses	Heidi Wolf	651-259-5152	heidi.wolf@dnr.state.mn.us
Watercraft Inspection Program Assistant - awareness events at water accesses	Vacant	651-259-5146	
Aquatic Invertebrate Biologist - zebra mussels, rusty crayfish, and other invasive aquatic invertebrates	Gary Montz	651-259-5121	gary.montz@dnr.state.mn.us
Conservation Officer - statewide enforcement of invasive species regulations for aquatic plants and wild animals	Ken Soring	218-999-7809	ken.soring@dnr.state.mn.us
General Information		651-259-5100	

Appendix B - Other State Contacts for Invasive Species Prevention and Control Programs and Interagency Groups

Department of Natural Resources - Forest Pest Program

DNR's Division of Forestry, working in cooperation with the MDA, is charged with surveying and controlling forest pests, including invasive organisms such as gypsy moth and several bark beetles (an annual report is prepared by the DNR Forest Health Protection Team on those issues).

Forestry Division Contacts

Metro Forest Health Specialist	Susan Burks	651-772-7927
Southern Forest Health Specialist	Ed Hayes	507-285-7431
Northeast Forest Health Specialist	Mike Albers	218-327-4115
Northwest Forest Health Specialist	Jana Albers	218-327-4234
Forest Development Health and Use Supervisor	Al Jones	651-259-5271

U of Minnesota Sea Grant - Aquatic Invasive Species Information Center

The Aquatic Invasive Species Information Center at the University of Minnesota Sea Grant Program provides research, outreach, and education in collaboration with the DNR's Invasive Species Program. The Center has served as an important resource on aquatic nuisance species (ANS) and provides information to the public to prevent and slow their spread.

Center Coordinator - Duluth	Doug Jensen	218-726-8712
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Minnesota Department of Agriculture - Invasive Species Programs

The MDA is responsible for the state's noxious weeds, plant pests, and invasive species of terrestrial plants and insects. MDA's Invasive Species Program addresses species such as Japanese beetle, gypsy moth, long-horned beetle, Grecian foxglove, and Eurasian buckthorn. MDA prepares an annual report for these programs.

Agronomy and Plant Protection Division Contacts

Invasive Species Unit	Teresa McDill	651-201-6448
Terrestrial Invasive Species Program	Val Cervenka	651-201-6590

Agricultural Resources Management Division Contacts

Weed IPM Program Coordinator	Anthony Cortilet	651-201-6608
Weed Biological Control Project	Monika Chandler	651-201-6468

Interagency Invasive Species Groups

There are several invasive species committees or work groups that facilitate coordination between the involved agencies.

Minnesota Noxious Weed Potential Evaluation Committee - Val Cervenka, Chair, MDA - Weed and Seed Unit, Agronomy and Plant Protection Division, 651-201-6590.

Weed Integrated Pest Management Committee - Jean Ciborowski, MDA - Integrated Pest Management Coordinator, Ag Development Division, 651-201-6217.

Gypsy Moth Program Advisory Committee - Kimberly Thielen Cremers, MDA - Invasive Species Unit, Agronomy and Plant Protection Division, 651-201-6692.

St. Croix River Zebra Mussel Task Force - Includes these primary members and other less active members: Minnesota Department of Natural Resources, Wisconsin Department of Natural Resources, Great Lakes Indian Fish and Wildlife Commission, U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, and the National Park Service.

Minnesota Invasive Species Advisory Council - Co-chairs: Teresa McDill, MDA - Invasive Species Unit, Agronomy and Plant Protection Division, 651-201-6448 and Jay Rendall, DNR Invasive Species Program, Ecological Services Division, 651-259-5131.