Purple Loosestrife Project - Cooperators Essentials
Michigan State University
Michigan State University Extension
Cooperators Handbook Section 1
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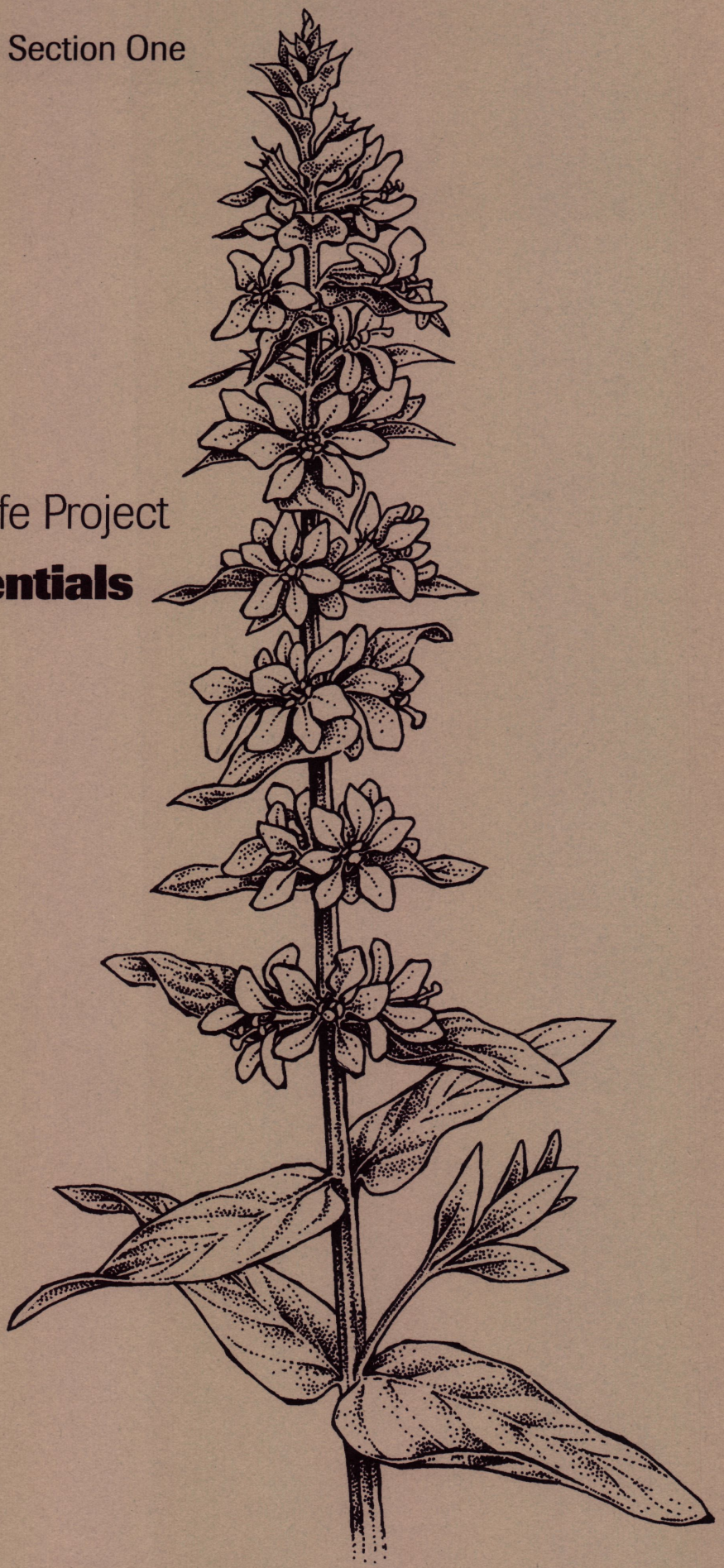
Cooperator's Handbook • Section One

# The Purple Loosestrife Project

# **Cooperator Essentials**



The Purple Loosestrife Project
Michigan State University
January 1999

The Purple Loosestrife Project *Cooperator's Handbook*
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# The Purple Loosestrife Project
# **Cooperator's Handbook**

## Contents

# Introduction

The *Cooperator's Handbook* is a compiled reference for schools, nature centers, youth and community organizations, and land management professionals participating in the Purple Loosestrife Project at Michigan State University or working to control loosestrife in other states. The Purple Loosestrife Project is a statewide biological control program integrating formal and non-formal educational activities. It was initiated in 1997 by faculty at Michigan State University and joined immediately by leaders at the Michigan Department of Natural Resources, U.S. EPA, Michigan Department of Agriculture, public schools, nature centers, and citizen groups from across the state.

The Purple Loosestrife Project borrows from the wisdom of the university-based cooperative extension system model. It is truly a cooperative effort between the university and the hundreds of Michigan communities that are infested with purple loosestrife. Research and successful purple loosestrife education and control methods from the field are brought together in the *Cooperator's Handbook* for you to use. This is a working handbook and reference, compiled so that you can more effectively play the most important role there is in the Purple Loosestrife Project: the role of active partner or, Cooperator.

The *Cooperator's Handbook* is a looseleaf binder with a few important reference sections and plenty of room for Cooperator field notes, found articles, development ideas, and additional reference materials. As the Purple Loosestrife Project grows in cooperating communities over the next few years, the *Handbook* will be refined and tailored to suit community purposes.

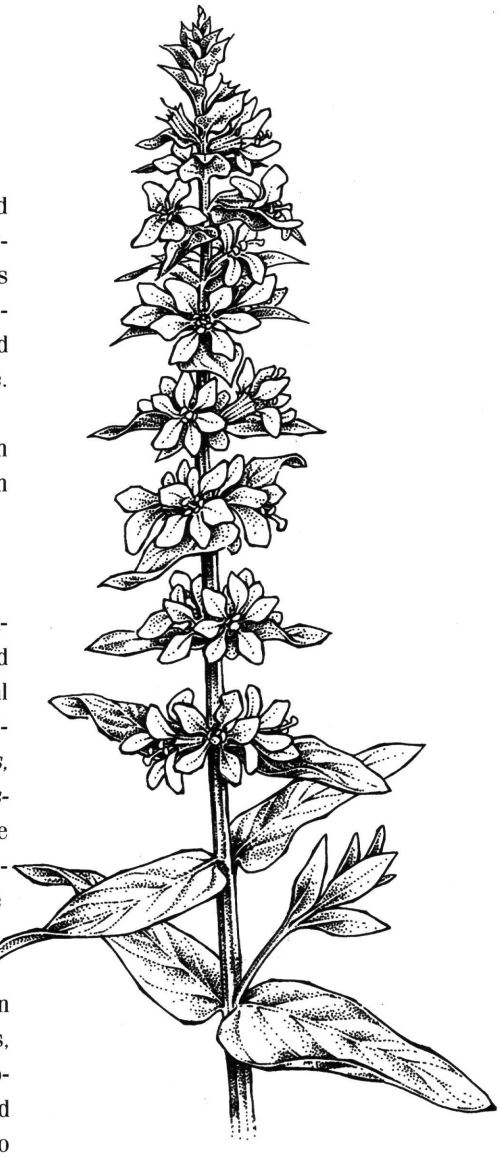
Section One provides an overview of the Purple Loosestrife Project, and answers frequently asked questions. It describes the importance of community action in the control of purple loosestrife and summarizes the role of Purple Loosestrife Project cooperating partners.

Section Two, "Rearing and Releasing Natural Enemies to Control Purple Loosestrife," offers background information and practical methods for rearing and releasing purple loosestrife's natural enemies. Descriptive material on exotic species control options, species population "balance," introducing natural enemies, and the biology and ecology of the *Galerucella* and *Hylobius* beetles are provided. This section contains everything Purple Loosestrife Project Cooperators will need to know for indoor and outdoor rearing of *Galerucella* beetles, as well as field release and monitoring techniques.

The Purple Loosestrife Project educational activities in Sections Three and Four are sorted by learner age group: activities for young children (upper elementary), and activities for adults and young adults. Also in this section, the reader will find a description of how the activities were developed.

Finally, Section Five is a place for Reading Materials and Additional Resources provided with the *Cooperator's Handbook* and/or collected by users over time. To begin your collection, we include an important wetland reference book, courtesy of one of Michigan's premier conservation organizations, Tip of the Mitt Watershed Council. Thanks to Council staff member and author, Wilfred "Wil" Cwikiel, we are fortunate to be able to include the best practical guide to wetlands available anywhere: *Living With Michigan's Wetlands: A Landowner's Guide*. Wetland types, wetland habitats, wetland management, and wetland features are explored in this section. Perhaps most important to wetland stewardship education is the discussion in Cwinkel's book of the value of wetlands in Michigan's natural cycles, and the straightforward call to stewardship presented to landowners (and by extension, to land managers, conservation groups, and community leaders). The Purple Loosestrife Project recommends not only the included *Landowner's Guide*, but also the extensive set of learner activities found in the publication *WOW! The Wonders of Wetlands*. Wetland learning materials can become extensions of teacher-led learning about purple loosestrife biological control.

# The Purple Loosestrife Project



Michigan State University and Michigan Sea Grant College Program initiated the Purple Loosestrife Project to help control the spread of purple loosestrife in a novel way. This innovative project joins students, educators, citizens and scientists in the biological control of purple loosestrife using its natural insect enemies. Biological control of purple loosestrife is an ecologically-sound approach which allows infested wetland habitat to return to a more natural state.

### The Plant

Purple loosestrife is a native of Europe and Asia which has spread throughout much of the United States and Canada. Because the flower is so attractive, purple loosestrife has been sold as an ornamental plant. Recently, many states have banned its sale. Purple loosestrife grows an impressive four to seven feet tall. Its blooms are long spikes of beautiful purple flowers. It grows prolifically in wetlands and other moist areas. Each mature plant produces 30 or more flowering stems and can produce over 2.5 million seeds per year.

### The Problem

A fierce competitor, purple loosestrife eventually overtakes native vegetation, forming nearly impenetrable stands of this single species. As the native plants are reduced, so too are the wildlife species that depend on them. Ecologists are concerned about the loss of habitat for endangered plants and animals, and declines in ducks, muskrats, mink, and some amphibians. Dense stands of purple loosestrife also impair recreational use of wetlands and rivers and impede water flow in drainage ditches. Control by conventional means has proven to be extremely difficult, impractical, and ineffective on a large scale. Sometimes referred to as "the purple plague," purple loosestrife is a serious problem throughout the Great Lakes bioregion and across North America.

### A Solution

As often occurs with introduced exotic species, purple loosestrife arrived in North America without its natural enemies. Three species of plant-feeding beetles, *Galerucella calmariensis, Galerucella pusilla,* and *Hylobius transversovittatus,* show particular promise as biological controls for purple loosestrife. These insects have undergone extensive testing to determine their safety, host specificity and effectiveness, receiving USDA approval in 1992. *Galerucella* beetles feed on buds, leaves, and stem tissue; causing defoliation and prevention of flowering and seed production, eventually leading to plant death.

### No More Purple Loosestrife?

Those who love to see purple loosestrife's beautiful display need not fear. Experts agree that these natural enemies cannot eliminate purple loosestrife, only reduce its density and harmful effects. It is anticipated that the combination of these natural enemies may be capable of reducing the density of purple loosestrife by up to 90% over most of its current range. Remaining plants will serve to maintain a resident population of beetles for the future. Reducing purple loosestrife density will allow the re-establishment of native vegetation.

### Citizen Involvement in the Purple Loosestrife Project

As part of the biological control effort, educators, students, and citizen leaders rear and release *Galerucella* beetles once they have received training from project personnel. The teaching and learning opportunities are numerous, and inoculation of hundreds of infested wetlands is possible within just a few years.

# Frequently Asked Questions



**1. What is purple loosestrife?**

Purple loosestrife (*Lythrum salicaria*) is a perennial plant native to Europe and Asia which has become widely established in the US and Canada. It grows and reproduces prolifically in wetlands and other moist habitats. Each mature 4-to-7-foot-tall plant produces 30 or more beautiful purple flower spikes that bloom in late summer and can produce over 2.5 million seeds per year.

**2. Why should we want to control it?**

For generations, wetlands were considered wastelands. Throughout the U.S., wetlands were drained and filled until in some areas, virtually none remained. Currently, the important roles that wetlands play as habitats for native plants and wildlife, flood control, recreation and enhanced water quality are widely recognized. Purple loosestrife is degrading the quality of our precious remaining wetlands.

While undeniably beautiful, once it becomes established purple loosestrife frequently becomes the dominant vegetation by out-competing native plants. As native plant communities are reduced, so too are wildlife species that depend on them. Declines in ducks, geese and other wetland birds as well as muskrats, mink and some amphibians have all been noted. There is also concern that purple loosestrife may reduce spawning habitat for some fish.

**3. Isn't it good for anything?**

Purple loosestrife produces abundant nectar and is attractive to honeybees and other pollinators. Butterflies can often be seen obtaining nectar at its blossoms. The stiff, erect stems are also used by redwing blackbirds as supports for nest construction. In the past human beings greatly contributed to the spread of purple loosestrife, planting it for its beauty and reported medicinal qualities. Although it is beautiful, we now know better than to let it spread uncontrolled across the countryside.

**4. So how can we get rid of it?**

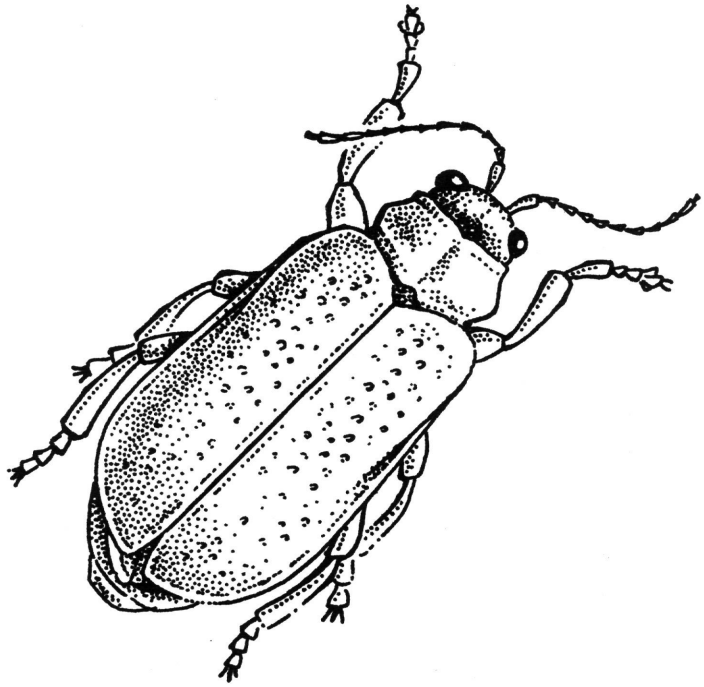
For years, people have tried without success to eradicate purple loosestrife. It is now clear that this is impossible and we must find ways to live with this plant. Current efforts focus on two approaches to controlling but not eradicating purple loosestrife: (1) keeping it out of wetlands where it is not currently established and (2) where it is present, managing its density so that native plants and animals can prosper.

**5. What are the control options?**

There are several, and your choice depends on the particulars of the infested site. The best control strategy is dictated by the density and extent of infestation. See the next section in this *Handbook* for details.

**6. What is biological control?**

Biological control is when human beings use a pest's natural enemies to reduce its density and the damage that it causes. These natural enemies may be predators, parasites or pathogens.



Most people are familiar with the use of predators such as lady beetles to help control insect pests. Fewer are aware that biological control can also be used to help manage plants like purple loosestrife.

When purple loosestrife arrived in North America, it came without the natural enemies that attack it in its native home. Without these natural enemies, loosestrife populations can grow largely unchecked. Scientists know that in its native range, purple loosestrife is a part of wetland ecosystems, but never becomes the dominant vegetation. By careful study, they found several species of insects which feed on purple loosestrife, keeping its population in balance with other vegetation. The process of identifying, studying and establishing these natural enemies where loosestrife has invaded, is known as importation biological control.

**7. How effective is biological control?**

Biological control has been practiced in the U.S. for over 100 years with both successes and failures. In this country, most of the effort has gone into the control of insect pests. Farmers in the midwest are very familiar with the highly successful control of two exotic insect pests, the cereal leaf beetle and the alfalfa weevil, using parasites imported from Europe. The alfalfa weevil project is estimated to save U.S. agricultural producers $10 million per year in reduced pesticide usage and increased yields. Control of Klamath weed, another European invader of rangelands in the western US was also highly successful in just a few years. However, in other cases natural enemies have failed to establish or never built up to sufficient numbers to impact the pest. Fortunately, in the case of purple loosestrife, some of these hurdles have already been overcome.

**8. What natural enemies are approved for use against purple loosestrife?**

Three species of plant feeding beetles, *Galerucella calmariensis*, *Galerucella pusilla* and *Hylobius transversovittatus* show the greatest promise as biological controls for purple loosestrife. The *Galerucella* leaf beetles feed on bud, leaf and stem tissue causing defoliation and prevention of flowering/seed production. Continued defoliation leads to plant death. *Hylobius* is a weevil whose larvae mine in root tissue weakening and ultimately killing the plant. These insects have undergone extensive testing to determine their safety and effectiveness, receiving USDA approval in 1992.

**9. Where can I get the beetles?**

Teachers and others who wish to rear and release *Galerucella* beetles as part of their local purple loosestrife biological control program need to know where they can obtain a breeding stock: a minimum of about twenty beetles. In Michigan, as in other states, one source of beetles is the nearest infested wetland that was inoculated with *Galerucella* in a previous summer. The source of your beetles might be right next door!

If you don't know where to turn for a supply of beetles in Michigan, see the Purple Loosestrife Project website for a Cooperative Biological Control site near you or contact the Purple loosestrife project office on the campus of Michigan State University. If you don't live in Michigan contact your state DNR

or the Purple Loosestrife Project at Michigan State University for a list of agencies and universities we know to be helpful.

You might have to establish your own brood stock with as few as twenty beetles carefully nurtured until their numbers increase. The process will require a minimum of 6 months and a minimum of 15 feet of "bench space" in a greenhouse or on your window sill(s) but you can do it! Follow the instructions in Section II of the *Cooperator's Handbook*, "The Nuts and Bolts of *Galerucella* Rearing and Release." With a little forethought and perseverence, anyone can cultivate a crop of *Galerucella* to help conquer an invading stand of purple loosestrife. Please send us your success story so we can pass it along!

**10. How long will it take for biological control to work?**

Most estimates range from 5 to 15 years for large impacts of these beetles to be realized. However, recent results from Ontario and Minnesota indicate that *Galerucella* can have had a dramatic impact on purple loosestrife infestations in as little as three years. Larger releases and better rearing techniques may help to shorten the time to impact.

**11. How safe is this approach?**

Before introduction of any weed biological control agent it must pass several tests to determine its level of host specificity and establish that it is free of unwanted diseases or parasites. The *Galerucella* and *Hylobius* beetles were tested against 47 plant species that are either closely related to purple loosestrife, occur in the same habitat or are important economic species. Based on this testing these species were considered to be host specific to purple loosestrife and approved for release by the USDA. *Galerucella* and *Hylobius* beetles are also harmless to human beings and pets.

**12. What will the beetles eat when the purple loosestrife is gone?**

Because normal feeding and growth occurs exclusively on purple loosestrife the number of the beetles in any area is expected to rise and fall based on the amount of loosestrife present. As the plant becomes less common, the beetles will have a harder time finding food, they will produce fewer offspring, and as a consequence, their population will decline. Experts believe that these natural enemies cannot eliminate purple loosestrife only reduce its density. However, once established, these beetles will continue to control loosestrife on a permanent basis.

**13. What can I do?**

READ ALL YOU CAN: The references cited here are a great start. Also, there is an increasing amount of information available on-line via the Internet and World Wide Web. Begin your internet search with a visit to our Purple Pages: *www.msue.msu.edu/seagrant/pp.*

CONDUCT A SURVEY: Become a Loosestrife Locator. A "windshield survey" of your neighborhood or township can determine if purple loosestrife is present, where it occurs and the level of infestation. Consider enlisting the help of local 4-H, scouts, schools, service organizations, conservation groups, etc., to broaden your coverage.

FORM A MANAGEMENT PLAN: Consider your options for hand digging, cutting flowers or spot spraying. Talk to adjacent landowners about a coordinated effort.

EDUCATE IN YOUR COMMUNITY: Contact The Purple Loosestrife Project office for more information, including suggested activities for kids.

## Get Started!

**PROJECT OVERVIEW**

# The Purple Loosestrife Project at Michigan State University

Linking Ecological Resource Management with Public Education and Community Action

The Purple Loosestrife Project at Michigan State University was initiated in January 1997 with the goals of coupling biological control of purple loosestrife with an innovative outreach and education program.

Purple loosestrife (*Lythrum salicaria*) is a widespread and serious problem, affecting both coastal and inland wetlands, lakes and waterways throughout the Great Lakes region and North America. To date, few viable solutions for managing this invasive weed have emerged.

Three species of plant-feeding beetles, *Galerucella calmariensis*, *G. pusilla* and *Hylobius transversovittatus* show promise as biological controls for purple loosestrife. Native to Europe, these insects have undergone extensive testing to determine their safety and effectiveness, receiving USDA approval in 1992. Since then, these insects have been released in 27 states and all the Canadian provinces. The *Galerucella* leaf beetles feed on bud, leaf and stem tissue causing defoliation and prevention of flowering/seed production. Continued defoliation leads to plant death. *Hylobius* is a weevil whose larvae mine in root tissue weakening and ultimately killing the plant.

Beginning in 1994, the Michigan Department of Natural Resources, Wildlife Division, petitioned the Michigan Department of Agriculture for approval to release insect enemies on several infested state game areas in Michigan. The MDNR's releases of approximately 5,000 *Galerucella* in 1994 established and began to show real impacts by 1996. While these natural enemies cannot eliminate purple loosestrife, experts believe that in combination they are capable of reducing the density of purple loosestrife by 90% over most of its current range. Reducing purple loosestrife density will allow re-establishment of native wetland vegetation.

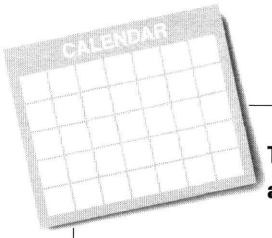
Results from Ontario and Minnesota indicated that the *Gallerucella* beetles can have a dramatic impact on purple loosestrife infestations in as little as three years. Researchers learned that the rearing and release procedures are quite simple but rather labor intensive and that the problem would not be solved quickly or by a handful of scientists. Ongoing research at MSU, and the establishment of a statewide cooperative community network showed promise to speed up the statewide control process.

The challenge was to establish viable populations of these natural enemies wherever purple loosestrife occurs. At first, the Purple Loosestrife Project laboratory at MSU was capable of producing about 150,000 *Galerucella* spp. and managing releases on 10 to 15 sites/year. By training and supporting other groups interested in rearing natural enemies it was possible to greatly multiply the number of beetles reared and the number of release sites impacted in Michigan. Control programs vary state-to-state.

Conservation organizations have been concerned for many years about the dangers of purple loosestrife to wildlife, and environmentalists are well aware of its negative impacts on native species. Park superintendents, lakefront property owners associations, wildlife managers, golf courses, nature reserves, etc., are all attempting to manage purple loosestrife on their properties and in their communities—with limited success. Thus, there exists a significant public awareness of the threat that purple loosestrife poses and great interest in a solution. The possibility that an environmentally friendly approach such as biological control could provide a viable solution is very attractive to a wide segment of society. This situation presents a wonderful opportunity to link various groups at the community level to address their common problem. Because loosestrife has spread to so many locations, it is clear that a few paid professionals cannot accomplish management goals alone. A network of volunteers, in partnership with university and agency professionals, dramatically increases the likelihood of success.

Start-up funding for the Purple Loosestrife Project was provided by Michigan Agricultural Experiment Station, Michigan State University Extension, Michigan State University Department of Entomology, Michigan State University College of Natural Science, Division of Science and Mathematics Education, U.S. Environmental Protection Agency, USDA National Biological Control Institute, Michigan Department of Agriculture, Michigan Department of Natural Resources, Michigan Sea Grant College Program, and cooperating communities.

# Establishing the Purple Loosestrife Project




**Three Phases of the Purple Loosestrife Project at Michigan State University**

Phase I (1997–98)

Developed capability to rear and release large numbers of natural enemies, evaluated their impacts and developed the educational materials necessary to support the community and educational efforts of Phase II. Initiated research to develop improved management techniques.

Phase II (1998–99)

Continue rearing and release of natural enemies in key areas of the state. Support the development of cooperative biological control (CBC) network sites by providing instruction and support to communities. Research on improved management techniques continues in an expanded form. Community-based greenhouse rearing of *Galerucella* begins.

Phase III (2000 )

As the original CBC network cooperators gain experience they take a more central role in supporting additional satellite sites. Cooperating groups come to "own" the project and they develop techniques, expertise and educational materials that they wish to share with other communities. Purple Loosestrife Project leaders at MSU facilitate and encourage this process as well as continue to supply technical support. Research activities in this phase conclude with an impact evaluation of the entire project. *Galerucella* populations are large enough to support "harvesting" and transport from early inoculation sites to new loosestrife infestations by cooperators.

## 1st Objective

*To rear and release purple loosestrife biological control agents for release in all infested Michigan watersheds over the life of the project.*

Using techniques developed at Cornell University, the Illinois Natural History Survey (INHS) and University of Minnesota, the Purple Loosestrife Project conducted a greenhouse rearing program in Michigan capable of producing about 150,000 *Galerucella* beetles per year. This level of production required about 2,000 square feet of greenhouse space and 500 potted *Lythrum salicaria* obtained from wild populations in Michigan. Overwintering beetles were initially obtained from INHS and reared for one generation on fall-collected *L. salicaria*. These first-generation beetles were used for two purposes. Approximately 120,000 were released directly in the spring (timed to natural beetle emergence) in 15 sites. Some of these sites were chosen primarily on scientific criteria regarding site suitability so that the project could develop optimal rearing and release techniques, conduct research and establish nursery sites to provide beetles for future years.

Other sites were chosen by local partners to begin to address their loosestrife control goals. First-year beetles were used to initiate colonies in outdoor rearing programs at CBC network sites. Personnel from each site were personally provided with details on *Galerucella* rearing and trained in these procedures.

## 2nd Objective

*To evaluate the establishment of biological control agents in all release sites and evaluate their impact on purple loosestrife in ten selected sites.*

Standardized evaluation criteria developed by the Cooperative Fish and Wildlife Research Unit at Cornell University are used to evaluate the establishment of the leaf beetles on all release sites. Intensive monitoring will be conducted on ten sites managed by the project for several years to help elucidate site suitability criteria, rate of spread of beetles, impact on individual purple loosestrife plants and recovery of native plant community. Personnel from new cooperating sites are trained in evaluation criteria and encouraged to use them on the sites they manage. A commitment to evaluate at least the establishment of the natural enemies is a requirement for CBC network site participation.

## 3rd Objective

*To use the purple loosestrife biological control program as a forum for youth education in science, environmental stewardship and as a catalyst to link public and private institutions, conservation and environmental advocacy groups, and resource management agencies.*

During the first year of the project MSU personnel coordinated development of the two educational activity sets targeting upper-elementary and high school grade levels found in the *Cooperator's Handbook* (see sections 3 and 4). Concepts of biodiversity, the practice of biological control of invasive species, purple loosestrife biology, ecology and impact on wetlands were used to develop lessons in the physical sciences, social science, and environmental stewardship. This *Cooperator's Handbook*, containing background material and the learning activities, was developed by science educators working in teams with MSU-based Purple Loosestrife Project personnel. The hands-on activities include the rearing and release of insect natural enemies of purple loosestrife. Beetle rearing kits and instructions are made available to individual classes, nature centers, school districts or integrated into a local cooperative control program. *Handbook* materials were tested through selected sites and after revision, made available to project cooperators who are trained in their use. The activities were subsequently linked to standardized Michigan learning objectives.

A spring project conference held during MSU's Agriculture and Natural Resources Week is the starting point for most cooperators. The morning program, which is open to the general public, is a forum to review aspects of purple loosestrife biology ecology and management and provide an overview of The Purple Loosestrife Project at MSU. The afternoon consists of two breakout sessions and is limited to individuals and groups directly participating in the project. One breakout session is for educators who will be using the activity sets in their classrooms or non-formal learning environments in the coming year. A second session is for persons from cooperative satellite sites (CBC network sites) who will be conducting outdoor beetle rearing and making releases of natural enemies. The spring project conferences draw heavily on cooperators by encouraging them to review their results and share their plans for the upcoming year.

The third educational initiative places individual citizens and citizen groups on the hunt for large purple loosestrife infestations. In 1998, the public was asked to help complete a statewide survey of the largest infested sites containing "1000 loosestrife plants within 100 yards." Several thousand "loosestrife locator cards" were designed, printed, and distributed as part of the Loosestrife Locator Survey so that citizens could report large infestations for our consideration as beetle release sites. In addition, where citizen leaders organized the necessary effort, systematic surveys began at the level of the township.

## 4th Objective

*To improve biological control of purple loosestrife through research aimed at elucidating opportunities and limitations in the system.*

Two areas of research interest emerged in the first phase of the Purple Loosestrife Project.

Once released in the field, *Galerucella* are exposed to indigenous predators. Other researchers have proposed that predation could influence the successful establishment and population increase of *Galerucella*. In greenhouse tests, Purple Loosestrife Project researchers have documented that several indigenous predators can significantly reduce the survival of *Galerucella* immatures and can limit population growth to near zero. Researchers hope to determine under what conditions predators can impact the successful establishment and spread of these natural enemies under both controlled and natural conditions.

There is potential for continued advancement in improving the rearing of *Hylobius* beetles, and in the use of two additional flower feeding beetles planned for future release. Research examining the optimal integration of these natural enemies into the purple loosestrife biological control program will be required. As other natural enemies or control techniques become available they will be integrated into the research program.

**Anticipated Outcomes**

It is anticipated that by the end of five years, we will have been able to establish viable populations of the *Galerucella* beetles in every purple loosestrife–infested watershed in Michigan and initiated evaluation of the impacts of these releases. In addition, we will have monitored the establishment process to such a degree that the reasons for success or failure will be clear. Perhaps more importantly we will have involved local stakeholder groups in a meaningful way, resulting in the formation of partnerships among various interest groups involved in wetland management, use and conservation. These partners will take the lead in the process of educating youth and the public on the project, resulting in greater understanding of biological control and the desirability of its use. As Michigan faces continued challenges from exotic species and loss of effective conventional control tactics, a public which is knowledgeable and supportive of biological control techniques will be a great asset. Local leadership development and support satisfies one of the core purposes of the pioneer land grant university.

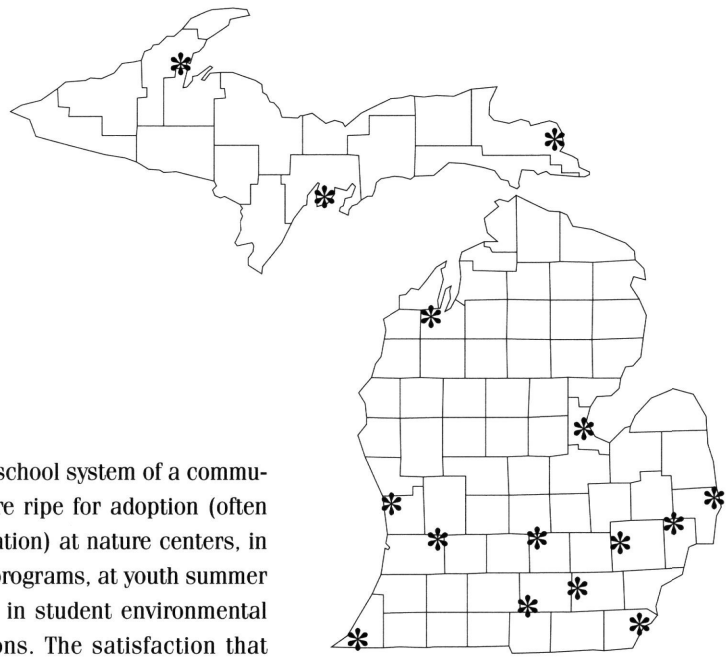
# The Role of Project Cooperators

### Students and Teachers

K–12 students and teachers provide invaluable "horsepower" to the Purple Loosestrife Project, and they make it all worthwhile. There are thousands of teachers and tens of thousands of students in Michigan as there are in every loosestrife-infested state. Because the problem of purple loosestrife is dispersed in nearly every community and often hidden in isolated areas, any purple loosestrife biological control project that does *not* have the benefit of local teacher and student involvement is sure to take a long, long time. Enlistment of thinking people who see the great value in actively caring for wetland habitats will dramatically increase the rate of biological control over the next few years. The Purple Loosestrife Project is designed to show (relatively) rapid impact with biological control.

The Project also nurtures symbiosis between resource managers and community change agents. Teachers and students are looking for hands-on, outdoor education activities with a purpose. Habitat resource managers need caring people to help control purple loosestrife in more locations than they can possibly reach in a generation's time. The Purple Loosestrife Project facilitates interaction of resource managers and the K–12 educational community, and both groups benefit.

Beyond the classroom, participating K–12 teachers and their students provide nonformal educators and learners with exciting ideas and experience. Once K–12 activities are accepted in the formal school system of a community they are ripe for adoption (often with adaptation) at nature centers, in 4-H youth programs, at youth summer camps and in student environmental organizations. The satisfaction that grows out of making a real-world difference in habitat management makes young adults proud ambassadors of biological control, increasing its use and reducing the use of less earth-friendly controls throughout the community.



Michigan's Cooperative Biological Control Network 1998 Regional Support Sites

### Community Action

Although biological control of purple loosestrife is not overly complicated, it is quite labor-intensive. Rather than recruiting, training and hiring a small army of field workers, the Purple Loosestrife Project is structured to facilitate action by the greatest number of community-based volunteers. Condominium associations, lakefront property owner groups, garden clubs, neighborhood associations and conservation groups are encouraged to form cooperative biological control programs. Public property managers, utility companies, municipal golf course managers, municipal officials, and private citizens are all welcome participants.

The Purple Loosestrife Project not only works for those who are motivated by the need for an educational experience; it also works for those who are interested exclusively in loosestrife control. Empowering volunteers serves important long-term purposes: it leverages scarce public resources, increases adoption of biological controls, and places responsibility for landscape stewardship where it must ultimately rest: in the hands of community leaders.

# How to Organize a Cooperative Biological Control Site

One of the most important goals of the Purple Loosestrife Project at Michigan State University is coupling biological control of purple loosestrife with an innovative outreach and education program. The project aims to restore the biological diversity, integrity and ecological function of wetlands degraded by purple loosestrife, and offers a unique opportunity for youth science and environmental education. Engaging local communities in the process of biological control increases the likelihood of success. There will never be enough "experts from Lansing" to get the job done. In Michigan, volunteerism and community action will be critical to control of purple loosestrife.

One mechanism for community involvement is through the development and support of satellite cooperative biological control (CBC) sites. A CBC site is intended to provide a focal point for people who come together to address the problem of purple loosestrife in their community. Property owners and lake associations, golf courses and parks are partnering with nature centers, local schools and other youth organizations to form them. We hope to facilitate many types of satellite CBC sites with the common features being an infested site, the ability to rear and release the natural enemies, and a willingness to actively involve youth in the process. The network of CBC sites will carry the program forward.

Tests during 1997 and 1998 indicated that with easily obtained materials (including three-gallon pots, tomato cages, wading pools) and some instruction, interested groups should be able to rear between 5,000 to 15,000 *Galerucella* leaf beetles for release in one to two local purple loosestrife infestations. The plants and insects are very cooperative and nearly anyone with a knack for growing a garden or caring for pets should feel comfortable with the rearing procedures. Groups may also consider enlisting the assistance of biology teachers, nature center staff, master gardeners, or university Extension staff in planning and conducting the rearing.

**Criteria for Establishing a CBC Site**

1. Access to a purple loosestrife infestation site that meets minimum criteria, see: "Site Selection Guidelines for Release of *Galerucella* Beetles" on page 21.
2. A site to conduct beetle rearing and persons willing to devote about an hour daily to plant watering and rearing during the approximately six-week rearing cycle in June-July.
3. Commitment to evaluate the establishment and impact of the natural enemies over a three-year period. Spring and fall evaluations require about one day each.
4. Willingness to share your expertise, experiences, and in the future, beetles from your site, with other groups in your area interested in developing a beetle rearing or purple loosestrife education program of their own.

# Timeline for PLP Biological Control Cooperators

The following timeline applies to both CBC network members and individuals.

**October–November**

Determine interest in your community regarding participation in the project. Discuss the concept with community associations, township boards, county parks and recreation departments, nature centers, etc. to determine support. Meet with landowners and local officials to enlist their support and obtain any needed permission to proceed. (Note: PLP has obtained appropriate state and national permits).

**December**

Submit a letter to the project office detailing your interest and capabilities to participate. CBC network applicants should develop a budget and begin to secure resources needed to rear and release beetles.

**March**

Attend the Agriculture and Natural Resources Week PLP program. The program agenda is posted on our website (*http://www.msue.msu.edu/seagrant/pp*) and will be held on the campus of MSU in East Lansing. Cooperators will be invited to receive hands-on training in beetle rearing procedures, beetle release, and field evaluation process. An educator's workshop will run concurrently.

**April–May**

Dig and pot up purple loosestrife rootstocks; prepare wading pools and cages for rearing. Conduct a pre-release survey in the selected wetland(s).

**Late May–June**

Receive *Galerucella* beetles and initiate the rearing cycle.

**July**

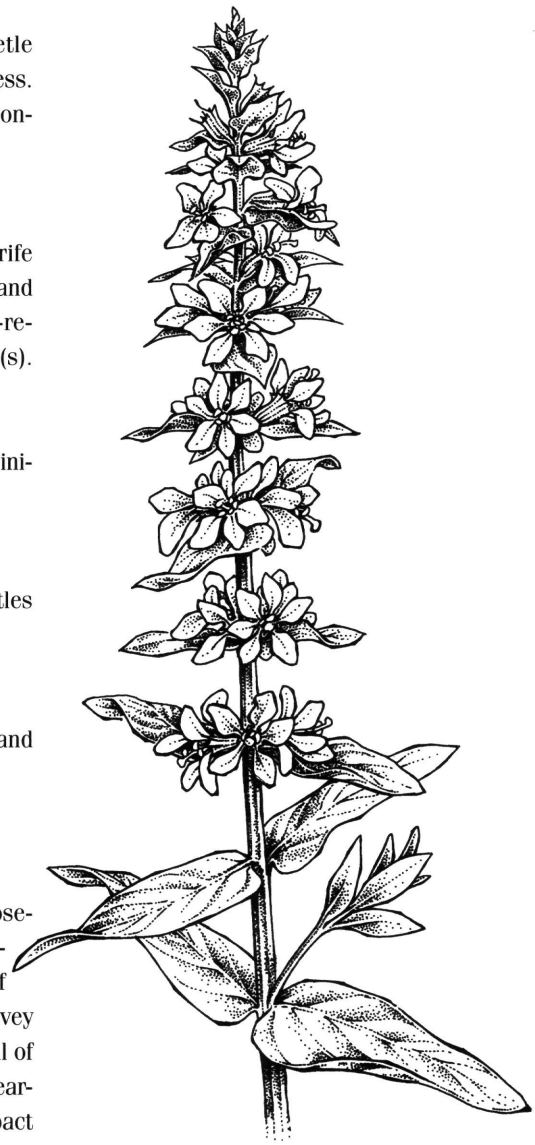
Collect, count and release beetles in your selected wetland(s).

**August–September**

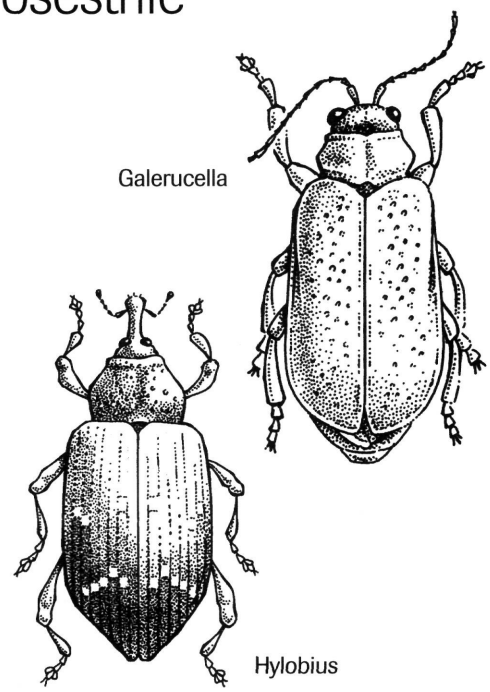
Conduct fall impact sampling and report your results.

**Spring and Summer of Following Years**

Attend the ANR Week purple loosestrife workshop to present your results and learn from the activities of other groups. Conduct a spring survey to determine overwintering survival of the beetles. Conduct an additional rearing and release cycle. Complete impact sampling in the late summer.



# Natural Enemies to Control Purple Loosestrife




In nature, all organisms live in a dynamic balance with the other organisms in their environment. Population levels rise and fall over time but typically revert to a long-term level that can be supported by the habitat. The maintenance of this dynamic balance is a fundamental part of the ecology of natural systems and helps to preserve their integrity and function. For example, while the rabbit population may temporarily expand to the detriment of a flower or vegetable garden, eventually the local foxes, owls and cats take their individual toll, reducing the rabbit population back to a level typical for the neighborhood. If this did not occur, rabbit disease or starvation would likely ensue, accomplishing a similar result. This process of natural control is often referred to as the "balance of nature." Primary actors in this play are the "natural enemies": predators, parasites and diseases, which every organism has evolved with and which serve to help keep its population in check.

Occasionally, something occurs which disrupts these natural controls. The presence of an overgrown field may provide the rabbits increased protection from predators. Or, an excellent food source may increase their general health and allow them to better resist some common diseases. However, as long as all the natural enemies are still present, eventually a balance will be restored. But, what would happen if the natural enemies were to suddenly disappear altogether? In a sense, this is what has happened when purple loosestrife arrived in North America. Because of human activity, purple loosestrife arrived here without its natural enemies. It is now an established nonindigenous aquatic nuisance species.

In its native Europe, purple loosestrife lives in balance with the other plants and animals that share its wetland habitat. While it is a part of wetland ecosystems it never becomes the dominant component as it does here in North America. The reason is that in its native home, purple loosestrife is attacked by a long list of natural enemies that keep its population in check. Over 120 insects and several diseases have been documented to attack purple loosestrife, of these, the insects are probably the most important natural controls. Should a purple loosestrife population arise in a given wetland these insects soon find it. Some feed on the flower buds and developing seeds, reducing seed production. Others feed on the leaves, killing the tips of the plant and stunting it while reducing the amount of photosynthetic energy it can produce. Finally, others tunnel in the root system, weakening it and eventually killing the plant.

In part because of its long evolutionary battle with these natural enemies, purple loosestrife has developed some impressive characteristics of its own. As a perennial plant it is able to persist in the same location for many years, storing up energy in its root system in one season that is then used for growth in the following spring. Using these reserves, loosestrife can grow very rapidly, shading out slower growing plants nearby. It is a very tall plant producing multiple stems (often 30 to 50) from each root crown. Stems frequently exceed seven feet in height and produce multiple flowering stalks. If a stem should happen to break off, it can easily sprout roots and establish a new plant. In addition to this vegetative reproduction, loosestrife is also a prolific producer of seed. One mature loosestrife plant can produce over 2.5 million seeds per year. These tiny seeds can float on the water, blow across frozen marshes or even be carried on the fur or feathers of wetland animals, to some distant location. It is these traits which make purple loosestrife such a threat to wetland biodiversity in North America.

Without natural enemies, North

American loosestrife populations can expand unchecked to the point that they frequently come to dominate individual wetlands. As native plants are crowded out, the other organisms that depend on them disappear as well. For example, in some marshes cattail has been replaced by a solid (monotypic) stand of loosestrife. Muskrats, which depend on cattail but do not eat loosestrife, are soon displaced as well. As importantly, the role that muskrats formerly played in the marsh's ecology is lost. For example, muskrat houses are no longer available as nesting platforms for geese. In addition, the mosaic of cattail and open water created by muskrat feeding, and the resulting habitat which is favored by many types of waterfowl, is replaced by solid stands of loosestrife.

Scientists know that in its native range, purple loosestrife is a part of wetland ecosystems, but never becomes the dominant vegetation. By careful study, they found several species of insects that feed only on purple loosestrife and are largely responsible for keeping its population in balance. The process of identifying, studying and importing these natural enemies is known as importation biological control. Biological control is when humans use a pest's natural enemies to reduce its density and the damage that it causes. These natural enemies may be predators, parasites or pathogens. Most people are familiar with the use of predators such as lady beetles to help control insect pests in a garden. Fewer are aware that biological control can also be used to help manage wetland plants like purple loosestrife.

Biological control has been practiced in the U.S. for over 100 years. In this country, most of the effort has gone into the control of insect pests. Farmers in Michigan are very familiar with the highly successful control of two exotic insect pests, the cereal leaf beetle and the alfalfa weevil, using parasites imported from Europe. The alfalfa weevil project is estimated to save U.S. agricultural producers $10 million every year in reduced pesticide usage and increased yields. Because these natural enemies are self-sustaining, these benefits will continue long into the future. Control of Klamath weed, a European plant that invades rangelands in the western U.S. was also highly successful in just a few years. In other cases, natural enemies have failed to establish or never built-up to sufficient numbers to impact the pest. Fortunately, in the case of purple loosestrife, some of these hurdles have already been overcome and the prospects for successful control are quite good.

Three species of plant-feeding beetles, *Galerucella calmariensis, Galerucella pusilla* and *Hylobius transversovittatus* show the greatest promise as biological controls for purple loosestrife. The *Galerucella* leaf beetles feed on bud, leaf and stem tissue causing defoliation and prevention of flowering and seed production. Continued defoliation leads to plant death. *Hylobius* is a weevil who's larvae mine in root tissue weakening and ultimately killing the plant. These insects have undergone extensive testing to determine their safety and effectiveness, receiving USDA approval in 1992. Results of 1996 releases of *Hylobius* are still uncertain, with most experts estimating that 5–15 years may be required for the full impact of these beetles to be realized. However, *Galerucella* can impact purple loosestrife infestations is as little as three years.

Following the methods described here, cooperators will raise *Galerucella* beetles indoors (for small local demonstrations) or outdoors (rearing enough beetles to share for release in an infested wetland). Cooperators cannot be guaranteed success in their efforts but they can expect to shepherd a fascinating natural process.

Because they are host-specific, the number of *Galerucella* beetles in any area is expected to rise and fall based on the amount of purple loosestrife present. At first, with an almost unlimited food supply, many beetles will be produced. As purple loosestrife becomes less common, the beetles will have a harder time finding food, they will produce fewer offspring, and as a consequence, their population will decline. Over time, a new balance will occur as purple loosestrife and its natural enemies again resume a stable interaction. Biological control experts do not expect *Galerucella* beetles to eliminate purple loosestrife but, rather, it is believed they may be able to reduce its density by about 90%. And, once established, the beetles will continue to control loosestrife on a long-term self-sustaining basis.

| | SIZE OF INFESTED AREA | | |
|---|---|---|---|
| | A FEW SQUARE YARDS | LESS THAN AN ACRE BUT MORE THAN A FEW SQUARE YARDS | MORE THAN AN ACRE |
| **LOW DENSITY** | **DIG**  | **DIG,** SPRAY[1], SNIP[2]  | **BUGS,** DIG, SPRAY[1]  |
| **HIGH DENSITY** | **DIG,** SPRAY[1], SNIP[2]  | **BUGS,** SPRAY[1], SNIP[2]  | **BUGS,** SNIP[2]  |

1. Always follow label directions. 2. This is usually a "holding action" until other measures can be taken.

### Control Options

How does one know which control method is best? Snipping, burning, spraying, pulling—or what? The answer really depends on local circumstances. You should contact a local CBC site or the Project office if the following instructions don't work for you.

### New or Localized Infestations

In habitats where just a few isolated plants exist or the infestation is localized in a very small area (less than one acre), it is best to dig them up. Be sure to get all the roots, but try not to overly disturb the surrounding soil or vegetation. Plant cover is vital to keep loosestrife from re-invading. All plant material should be dried and burned, or placed in a closed black plastic bag in the sun for several days where the high heat will kill the plant and seeds. Any plant material left in the field can easily re-sprout. See "Handpulling" on the following page to learn more about removing loosestrife by hand.

Where permitted, plants may be treated with an approved herbicide. Rodeo™ is an effective herbicide registered for use in wetland habitats. However, it is nonselective and will kill most vegetation it contacts. Spot sprays directed at the at the early flowering stage are most effective. Broadcast sprays are not recommended.

Cutting of plants can be used as a holding action until other measures can be taken. Flowering stalks can be cut to prevent seed formation and old flower heads removed as these may still contain viable seed.

### Established Infestations

Where hundreds of mature plants exist, or the infestation is spread over several acres digging may be impractical, however, use of herbicides and cutting are still options to consider. In established infestations where millions of purple loosestrife seeds are present in the soil, care must be taken not to spread them on muddy boots or equipment. Disturbance of the soil and vegetation should be minimized so as not to open up new areas for loosestrife seedling establishment.

Learn to recognize purple loosestrife throughout the year. Record areas where you see vegetative growth in the spring, the flowering plants in late summer, or the dry, erect stems in the winter. Plan ahead. In most instances where more than 500 mature plants occur, biological control is likely to be the only practical long-term management option.

# Removing Purple Loosestrife by Hand

*Adapted from "A universal manual for purple loosestrife control." C. Keddy. Ontario Federation of Anglers and Hunters, 1993*

*Sometimes it is necessary to dig and pull purple loosestrife. How is this done? We are fortunate to have the benefit of the Ontario Federation of Anglers and Hunters' several years experience with hand removal, and to be allowed to paraphrase from their fine field manual. The following description is reproduced here nearly verbatim, but without a few of the references cited in the original work, for the sake of clarity and brevity.*

Pulling plants out of the ground by hand is most effective in eliminating young (1-2 year old) plants. Young plants can be distinguished as follows: both the current flowering shoot and the remains of the first year flowering shoot will be attached to the crown of two year old plants, while only the current flowering stalk will be present on one year old plants. The flowering stalks of older plants tend to pull loose from the well established root crown which will flower in subsequent seasons. This shoot removal, however, does eliminate seed production for the season.

Hand pulling is most effective when the soil is wet (e.g. after a rain, when water levels are high). All the stalks arising from a single root crown should be grasped firmly near the base with both hands and pulled evenly and slowly to avoid detachment from the crown. Gently rocking the stem back and forth while pulling may also help.

Flowering plants should either be dried and burned, or put in garbage bags and disposed of where there is no chance of the seeds or fragments establishing. Prior to flowering, pulled plants may be safely dried in open sunny areas where there is no chance of plants rooting or washing away.

Digging plants up would help to ensure that a sufficient portion of the root system was removed to prevent resprouting, but could also disturb the soil significantly more. If herbicides cannot be used and hand pulling did not remove the root crown, digging would be appropriate for isolated plants and low density infestations. Garden forks can be useful for loosening large root crowns prior to hand pulling.

Hand pulling is labour intensive. In 1990, a total of 1,200 plants were pulled at a rate of 600 plants/worker hour in an area of intermediate density in Presqu'ile Provincial Park [Ontario]. The entire root stalk was removed in the majority of cases, but success varied because the plants ranged in age and root crown size. In 1991, only 123 plants were found and pulled in the same area. In a low density [area], plants were pulled at a rate of 400/worker hour. Under these conditions, more time is spent moving from plant to plant. Handpulling is practical on a small scale or where labour is not limited.

O.F.A.H. "Project Purple" workers found hand pulling rates could vary between 400 and over 3,000/worker day, depending upon the age and density of the plants, and the moisture content of the soil.

The advantages of this technique are that potentially harmful herbicides are not added to the environment and it is effective on young plants (<2 years). It is also a technique that volunteers can easily employ. The drawbacks of this method are that soil surface disturbance may promote further purple loosestrife seed germination or the establishment of other alien plant species, micro topography (possible effecting seed germination of desirable species) is altered, effectiveness varies with plant age, plants pulled must be removed to prevent establishment from fragments, and it is very labour intensive.

After one year of hand pulling in Presqu'ile Provincial Park, ther e were no seedling clusters obviously associated with places from which plants had been pulled and, despite the variance in age of the plants (root crowns could not be completely removed in all cases), there was a great reduction in the number of plants the year following pulling.

# Site Selection Guidelines for Release of *Galerucella* Beetles

A number of factors are important in creating the greatest the potential for successful establishment of *Galerucella* spp. against purple loosestrife. Avoidance of sites with known adverse characteristics is most critical. Sites which have the most favorable combination of criteria should be favored as release sites.

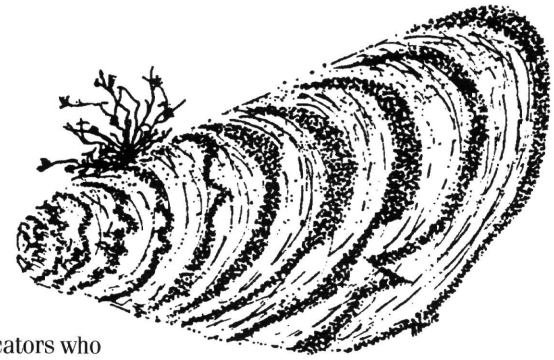
### Unacceptable Conditions

1. Sites should not be subject to direct disturbances which remove purple loosestrife or kill beetles. Sites which may be developed, mowed, dredged or receive herbicide applications against purple loosestrife are not suitable.
2. Sites which will be sprayed with insecticides against adult mosquitos are not suitable.
3. Sites with permanent flooding are not suitable. Occasional flooding, particularly in spring, can be tolerated by the beetles but overwintering success will be enhanced on sites without permanent standing water.
4. As a precaution, sites containing mixtures of purple loosestrife and the native winged loosestrife, *Lythrum alatum* or swamp loosestrife, *Decodon verticillatus*, should be avoided. While these beetles are considered to be host specific and unlikely to cause serious damage to nontargets, avoiding opportunities for incidental feeding on related plants is desirable. Alternative means of purple loosestrife control should be considered where populations of these plants occur.

### Favorable Attributes

1. Sites should be accessible for release and continued monitoring of beetles. Physical access (a nearby road or lane) is required to transport beetles to the site. Legal access (landowner permission) is required for initial release and subsequent monitoring.
2. Sites should contain at least 500 purple loosestrife plants in a 100 yard radius.
3. Sites that are open to sunshine and not shaded are more easily established.
4. Releases in mixed plant communities are encouraged as it is expected that competition from other plants will accelerate control. Sites containing other invasive species such as Phragmites or reed canary grass should receive low priority.
5. Establishment may be more reliable on sites that contain a mixture of young and old purple loosestrife plants

**Reading Materials and Additional Resources**



# Aquatic Exotics

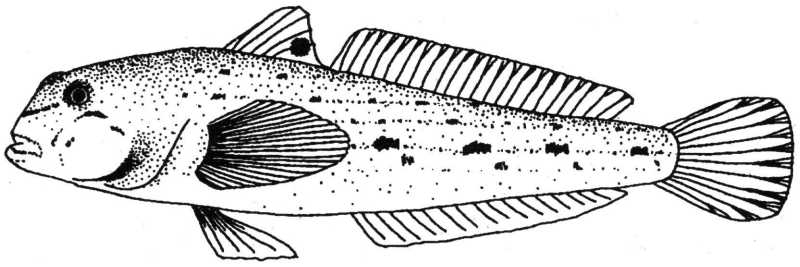
North American ecosystems are now home to dozens of nonindigenous aquatic species. These exotic organisms, which were introduced by human activity from their native ranges, are now part of the fabric of our environment. We are learning to live with them. They are the result of biological pollution, a type of pollution that is, for the next few generations at least, permanent. Unlike the phosphate pollution of the 1960s, biological pollution cannot be diluted, washed away by the rains, or cleaned up. This type of pollution can be avoided, mitigated, and accommodated, but once introduced it will never be removed. Nonindigenous species compete with native species for space and nutrition. They often outcompete native species, which have evolved within biotic and abiotic limits, and they become aquatic nuisance species. Nonindigenous population explosions and crashes have caused immediate and tangible ecological and economic difficulties, and the incremental, long-term loss of biodiversity casts an increasingly foreboding shadow on the future. Preventing biological pollution is now recognized as one of the great challenges facing the North American environment.

Many scientists and educators who study and teach about aquatic exotics begin with the story of the sea lamprey (*Petromyzon marinus*). The lamprey, which symbolizes a management success story for some, arrived in the Great Lakes from the Atlantic coast and was largely responsible for the crash of ecologically and economically important fisheries in the middle of this century. Anyone who visited the Great Lakes shore in the heyday of the alewife/lamprey population boom and bust cycles got a very real lesson in the value of preventing biological pollution because of the decomposing alewives there. The composition of native systems was changed forever, and chemical control of this fish now costs Great Lakes taxpayers several million dollars per year.

Most recently the zebra mussel (*Dreissena polymorpha*) has captured the exotic species spotlight. Its population explosion has clogged municipal and industrial water intakes so thoroughly as to shut down entire facilities. Zebra mussels foul boat motors and hulls, create razor-sharp docks and rocks, pile-up on public beaches to decompose, decimate native clams and contribute to algal blooms that cause drinking water taste and odor problems. This phenomenal filterer has changed the most basic structure of the aquatic food web. The zebra mussel is the poster-child of aquatic exotics; nearly everyone knows about this nuisance.

Not all aquatic invaders come into the public spotlight. In the years between the sea lamprey and the zebra mussel, there were many exotic newcomers, but few have done as much as these two pests to raise public awareness and understanding of aquatic nuisance species. Scientists recorded 130 nonindigenous species introductions between 1885 and 1990. In the Great Lakes basin, round and tubenosed gobies (*Neogobius spp.*), ruffe (*Gymnocephalus cernuus*), spiny water flea (*Bythotrephes cedarstroemi*), rusty crayfish (*Orconectes rusticus*), eurasian watermilfoil (*Myriophyllum spicatum*), are among the most notorious to establish themselves. Their stories are told in the reference materials that follow.

These materials are the most prominent available, but this collection is not complete. The Purple Loosestrife Project *Cooperator's Handbook* can be a beginning point for further in-depth investigation of the substantial and growing body of aquatic exotics literature.



# Selected Aquatic Nuisance Species Materials: 1999

## ZEBRA MUSSEL

*Boaters: Take Action Against Zebra Mussels*

Ohio Sea Grant College Program, The Ohio State University, 1314 Kinnear Road, Columbus, OH 43212-1194; ph: 614/292-8949; fax: 614/292-4364; *banicki.1@osu.edu* [1996; 2 pages]

*Zebra Mussel Distribution Along Michigan's Great Lakes Coastline*

Michigan Sea Grant College Program, University of Michigan, 2200 Bonisteel Blvd., Ann Arbor, MI 48109-2099; ph: 734/764-1118; fax: 734/647-0768; *msgpubs@engin.umich.edu* [1995; 1 page]

*Safe Use of Zebra Mussel in Classroom and Laboratories*

Michigan and Ohio Sea Grant College Programs, University of Michigan, 4116 I.S.T. Building, 2200 Bonisteel Blvd., Ann Arbor, MI 48109-2099; ph: 734/764-1118; fax: 734/647-0768 [1993; 2 pages]

*Zebra Mussel Distribution in the Inland Waters of Michigan*

Michigan Sea Grant College Program, University of Michigan, 2200 Bonisteel Blvd., Ann Arbor, MI 48109-2099; ph: 734/764-1118; fax: 734/647-0768; *msgpubs@engin.umich.edu* [Updated regularly]

*Standard Protocols for Monitoring and Sampling Zebra Mussels*

Illinois Natural History Survey, Lake Michigan Biological Station, 400 17th St., Zion, IL 60099; ph: 847/872-8676; fax: 847/872-8679; *jmarsden@uiuc.edu* [1992; 40 pages]

*Detecting Zebra Mussels: A Monitoring Program for Citizens*

Michigan Sea Grant College Program, University of Michigan, 2200 Bonisteel Blvd., Ann Arbor, MI 48109-2099; ph: 734/764-1118; fax: 734/647-0768; *msgpubs@engin.umich.edu* [1996; brochure describing loanable equipment and instructions]

*Control of Zebra Mussels in Residential Water Systems*

New York Sea Grant, Zebra Mussel Information Clearinghouse, Morgan III, State University College, Brockport, NY 14420-2928; ph: 1-800-285-2285 or 716/395-2516; fax: 716/395-2729; *zmussel@cce.cornell.edu* [1996; 10 pages]

*The Zebra Mussel (Dreissena polymorpha): An Unwelcome North American Invader*

New York Sea Grant, Zebra Mussel Information Clearinghouse, Morgan III, State University College, Brockport, NY 14420-2928; ph: 1-800-285-2285 or 716/395-2516; fax: 716/395-2729,; *zmussel@cce.cornell.edu* [1991; 12 pages]

*Present and Expected Economic Costs of Zebra Mussel Damages to Water Users with Great Lakes Water Intakes*

Ohio Sea Grant College Program, The Ohio State University, 1314 Kinnear Road, Columbus, OH 43212-1194; ph: 614/292-8949; fax: 614/292-4364; *banicki.1@osu.edu* [1995; 2 pages]

*Aquatic Exotics: Sea Grant Resources on Zebra Mussels*

University of Wisconsin Sea Grant Institute, 1800 University Ave., Madison, WI 53705-4094; ph: 608/263-3259; fax: 608/263-2063; *lecampbe@seagrant.wisc.edu* [1995; 23 pages]

*The Spread of Zebra Mussels to Inland Lakes-Implications and Actions*

Michigan Sea Grant College Program, University of Michigan, 4116 I.S.T. Building 2200 Bonisteel Blvd., Ann Arbor, MI 48109-2099; ph: 734/764-1118; fax: 734/647-0768; *msgpubs@engin.umich.edu* [1994; 66 slides and 10-page script; approximate duration 30–40 min]

*Zebra Mussel Expert System*

U.S. Army Corps of Engineers, Zebra Mussel Research Program, Waterways Experiment Station, 3909 Halls Ferry Rd., Vicksburg, MS 39180-6199 Halls Ferry Rd., Vicksburg, MS 39180-6199; ph: 601/634-2976; fax: 601/634-2398; *sander1@ex1.wes.army.mil* [1996; CD-ROM]

*Zebra Mussels, The Silent Invader*

Electric Power Research Institute, Distribution Center, 207 Coggins Dr., Pleasant Hill, CA 94523; ph: 510/934-4212; fax: 510/944-0510; *ic@eprinet.epri.com* [1991; 16-minute video on large power-generating facilities, for grade levels 7 and up]

*Dreissena!*

Zebra Mussel Information Clearinghouse, New York Sea Grant Extension, Morgan III, State University College at Brockport, Brockport, NY 14420-2928; ph: 1-800-285-2285 or 716/395-2516; fax: 716/395-2729; *zmussel@cce.cornell.edu* [Published bi-monthly; 8–16 pages]

*Invasion of an Exotic Species: Stop the Zebra Mussel!*

Virginia Sea Grant communications, Virginia Institute of Marine Science, P.O. Box 1346, College of William & Mary, Glouster Point, VA 23062; ph: 804/642-7170; fax: 804/642-7161; *vclark@vims.edu* [1994; Fact sheets and classroom activities for grades 8–12. Written for Virginia]

*Alien Invaders: A Zebra Mussel Issue Investigation*

The Rivers Project, Southern Illinois University, Box 2222, Edwardsville, IL 62026; ph: 618/692-3788; fax: 618/692-3359; *rivers@siue.edu* [1994; 100 pages; Curriculum unit for middle school students]

*Zebra Mussel Mania Traveling Trunk*

Illinois-Indiana Sea Grant Program, University of Illinois, 65 Mumford Hall, 1301 West Gregory Dr., Urbana, IL 61801; ph: 217/333-9448; fax: 217/333-2614; *rgoettel@uiuc.edu* [1996; Science kit and curriculum to teach children ages 8–14]

*Mussel Menace! Zebra Mussels and You; Instructor's Training Package*

Minnesota Sea Grant Exotic Species Information Center, University of Minnesota-Duluth, 2305 East Fifth St., Duluth, MN 55812-1445; ph: 218/726-8712; fax: 218/726-6556; *djensen@mes.umn.edu* [1996; Training package, includes a training manual, fact sheets, and other educational materials]

## EURASIAN WATERMILFOIL

*How to Identify and Search for Eurasian Watermilfoil*

Vermont Department of Environmental conservation, Water Quality Division, 103 South Main St., Building 10-North, Waterbury, VT 05671-0408; ph: 802/241-3777; fax: 802/241-3287; *mikeH@waterq.anr.state.vt.us* [1996; 8 pages]

*Eurasian Watermilfoil Pressed Dried Specimens*

Vermont Department of Environmental Conservation, Water Quality Division, 103 South Main St., Building 10-North, Waterbury, VT 05671-0408; ph: 802/241-3777; fax: 802/241-3287; *mikeH@waterq.anr.state.vt.us* [Mounted on heavy paper and encased in a waterproof covering]

*Ovposition Specificity and Behavior of the Watermilfoil Specialist Euhrychiopsis lecontei*

Minnesota Sea Grant Exotic Species Information Center, University of Minnesota- Duluth, 2305 East Fifth St., Duluth, MN 55812-1445; ph: 218/726-8712; fax: 218/726-6556; *djensen@d.umn.edu* [1996; 8 pages]

*Investigations on the Potential Use of an Aquatic Weevil to Control Eurasian Watermilfoil*

Michigan Sea Grant College Program, University of Michigan, 2200 Bonisteel Blvd., Ann Arbor, MI 48109-2099; ph: 734/764-1118; fax: 734/647-0768; *msgpubs@engin.umich.edu* [1997; 10 pages]

## SEA LAMPREY

*The Five Lamprey of the Great Lakes*

Michigan Sea Grant College Program, University of Michigan, 2200 Bonisteel Blvd., Ann Arbor, MI 48109-2099; ph: 734/764-1118; fax: 734/647-0768; *msgpubs@engin.umich.edu* [1997; 10 pages]

*Great Lakes Fishery Commission Fact Sheet Series*

Great Lakes Fishery Commission, 2100 Commonwealth Blvd., Suite 209, Ann Arbor, MI 48105; ph: 313/662-3209; fax: 313/741-2010; *mgaden@great-lakes.net* [1996; 8 pages]

*Sea Lamprey Anniversary Coloring Book*

Department of Fisheries & Oceans, Bayfield Institute, 867 Lakeshore Rd., P.O. Box 5050, Burlington, Ontario L7R 4A6; ph: 905/336-6240; fax: 905/336-4819; *Colleen.OMeara@c-a.dfo.dfo-mpo.x400gc.ca* [1996]

*Great Lakes Invader*

Great Lakes Fishery Commission, 2100 Commonwealth Blvd., Suite 209, Ann Arbor, MI 48105; ph: 313/662-3209; fax: 313/741-2010; *mgaden@great-lakes.net* [1984]

*Great Lakes Invader: The Sea Lamprey Battle Continues*

Great Lakes Fishery Commission, 2100 Commonwealth Blvd., Suite 209, Ann Arbor, Mi 48105; ph: 313/662-3209; fax: 313/741-2010; *mgaden@great-lakes.net* [1993; 25-minute video]

## EURASIAN RUFFE

*Ruffe : A New Threat to Our Fisheries*

Minnesota Sea Grant Exotic Species Information Center, University of Minnesota-Duluth, 2305 East fifth St., Duluth, MN 55812-1445; ph: 218/726-8712; fax: 218/726-6556; *djensen@d.umn.edu* [1997; 4 pages]

*International Symposium on the Biology and Management of Ruffe*

Minnesota Sea Grant Exotic Species Information Center, University of Minnesota-Duluth, 2305 East fifth St., Duluth, MN 55812-1445; ph: 218/726-8712; fax: 218/726-6556; *djensen@d.umn.edu* [1997; 76 pages (Proceedings)]

*The Ruffe: A Small Fish - Big Problems*

Minnesota Sea Grant Exotic Species Information Center, University of Minnesota- Duluth, 2305 East Fifth St., Duluth, MN 55812-1445; ph: 218/726-8712; fax: 218/726-6556; *djensen@d.umn.edu* [1993; 17-minute video]

## ROUND GOBY

*Round Gobies Invade North America*

Illinois-Indiana Sea Grant Program, University of Illinois, 65 Mumford Hall, 1301 W. Gregory Dr., Urbana, IL 61801; ph: 217/333-9448; fax: 217/333-2614; *r-goettel@uiuc.edu* [1995; 2 pages]

*Gobies in the Great Lakes*

Ontario Ministry of Natural Resources, Natural Resources Information Center, Box 7000, 300 Water St., Peterborough, Ontario K9J 8M5; ph: 1-800-563-7711 in Ontario or 705/755-1950; for requests in French 705/755-1674; fax: 705/755-1201; *dextraal@epo.gov.on.ca* [1996; 2 pages]

*Gobies: Cyberfish of the '90s*

Michigan Sea Grant College Program and the Center for Great Lakes and Aquatic Sciences, University of Michigan, 4116 I.S.T. Building, 2200 Bonisteel Blvd., Ann Arbor, MI 48109-2099; ph: 734/764-1118; fax: 734/647-0768; *msgpubs@engin.umich.edu* [1996; 4-page fact sheet about impact on native benthic fish]

*The Round Goby Neogobius Melanostomus (Pallas): A Review of European and North American Literature*

Illinois-Indiana Sea Grant Program, University of Illinois, 65 Mumford Hall, 1301 West Gregory Dr., Urbana, IL 61801; ph: 217/333-9448; fax: 217/333-2614; *r-goettel@uiuc.edu* [1997; 76 pages]

## SPINY WATER FLEA

*Effects of Spiny Tailed Bythotrephes on Great Lakes Fish*

Michigan Sea Grant College Program, University of Michigan, 4116 I.S.T. Building, 2200 Bonisteel Blvd., Ann Arbor, MI 48109-2099; ph: 313/764-1118; fax: 614/292-4364 [1997; 2 pages]

*The Spiny Water Flea, Byrhotrephes cederstroemi: Another Unwelcome Newcomer to the Great Lakes*

Ohio Sea Grant College Program, The Ohio State University, 1314 Kinnear Road, Columbus, OH 43212-1194; ph: 614/292-8949; fax: 614/292-4364; *banicki.1@osu.edu* [1997; 2 pages]

*Spiny Water Flea Distribution*

Ontario Ministry of Natural Resources, Natural Resources Information Center, Box 7000, 300 Water St. Peterborough, Ontario K9J 8M5; ph: 1-800-563-7711 in Ontario or 705/755-1950; for requests in French 705/755-1674; fax: 705/755-1201; *dextraa1@epo.gov.on.ca* [1995; updated annually]

## OTHER AQUATIC NUISANCE SPECIES, GENERAL MATERIALS

*Great Lakes Sea Grant Network Exotic Species Graphics Library Catalogue*

Michigan Sea Grant College Program, University of Michigan, 4116 I.S.T. Building, 2200 Bonisteel Blvd., Ann Arbor, MI 48109-2099; ph: 734/764-1118; fax: 734/647-068; *msgpubs@engin.umich.edu* [1993]

*A Field Guide to Aquatic Exotic Plants and Animals*

Minnesota Department of Natural Resources, Exotic Species Program, 500 Lafayette Rd., Ste. Paul, MN 55155-4025; ph: 612/296-2835; fax: 612/296-1811; *debbie.hunt@dnr.state.mn.us* [1992; 12 pages]

*Biological Invasions; How Aquatic Nuisance Species Are Entering North American Waters, the Harm They Cause and What Can Be Done to Solve the Problem*

Great Lakes Panel on Aquatic Nuisance Species, c/o Great Lakes Commission, The Argus II Building, 400 Fourth St., Ann Arbor, MI 48102-4816; ph: 313/665-9135; fax: 313/665-4370; *glc@great-lakes.net* [1997; 8 pages]

*Rusty Crayfish: A Nasty Invader*

Minnesota Sea Grant Exotic Species Information Center, University of Minnesota- Duluth, 2305 East Fifth St., Duluth, MN 55812-1445; ph: 218/726-8712; fax: 218/726-6556; *djensen@d.umn.edu* [1995; 8 pages]

*Aquatic Nuisance Species Information and Education Materials Relevant to the Great Lakes Basin: Recommendations and Descriptive Inventory*

Great Lakes aPanel on Aquatic Nuisance Species, c/o Great Lakes Commission, 400 Fourth Street, Ann Arbor, MI 48103; ph: 734/665-9135; fax: 734/665-4370 [1997; 70 pages plus appendices]

*Aquatic Exotics*

Minnesota Department of Natural Resources, Exotic Species Program, 500 Lafayette Rd., St. Paul, MN 55155-4025; ph: 612/296-2835; fax: 612/296-1811; *debbie.hunt@dnr.state.mn.us* [1996; 22-minute video]

*Exotic Aquatics Traveling Trunk*

Minnesota Sea Grant Exotic Species Information Center, University of Minnesota-Duluth, 2305 East Fifth St., Duluth, MN 55812-1445; ph: 218/726-8712; fax: 218/726-6556; *djensen@d.umn.edu* [1996; Science kit and curriculum]

*ANS Digest*

Freshwater Foundation, 2500 Shadywood Road, Navarre, MN 55331; ph: 612/471-9773; fax: 612/471-7685; *nhalker@freshwater.org* [Published quarterly]

*Fishways - Primary/Junior*

Ontario Ministry of Natural Resources, Natural Resources Information Center, Box 7000, 300 Water St., Peterborough, Ontario K9J 8M5; ph: 1-800-563-7711 in Ontario or 705/755-1950; for requests in French 705/755-1674; fax: 705/755-1201; *dextraal@epo.gov.on.ca* [1991; Aquatic ecosystem curriculum]

*Great Lakes Exotic Species (Great Lakes Research Review, Volume 3, Numbers 1 and 2, April and December 1997)*

University of Buffalo, Great Lakes Program, 202 Jarvis Hall, Buffalo, NY 14260- 4400; ph: 716/645-2088; fax: 716/645-3667; *hdomske@cce.cornell.edu* [1997; 44-page collection of peer-reviewed articles]

## BALLAST WATER

*Ballast Water: Canadian Coast Guard*

Transport Canada, Ship Safety, 201 N. Front St., Sarnia, Ontario N7S 5S6; ph: 519/383-1837; fax: 519/383-1997; *wileycj@tc.gc.ca* [1995; 2 pages]

*No Room at the Intake: Review of the Great Lakes Ballast Water Management Plan*

Lake Carriers' Association, 614 Superior Ave., West, 915 Rockefeller Building, Cleveland, OH 44113-1383; ph: 216/621-1107; fax: 216/241-8262 [1993; 20-minute video]