

BIOLOGICAL CONTROL OF **PURPLE LOOSESTRIFE**



4-H Manual

Illinois-Indiana Sea Grant
IISG-01-10

Michigan Sea Grant
MICHU #01-401

MSUE Pub
4-H 1595

Note: The activities in this manual are intended for high school-aged students. Students in middle school should be able to do many of the exercises as well. With appropriate adult assistance, students of any age can learn from this activity book.

The Biological Control of Purple Loosestrife 4-H program joins students, youth leaders, educators, citizens, and scientists in the biological control of purple loosestrife using its natural insect enemies. This ecologically sound approach allows infested wetland habitat to return to a more natural state.

Editors

Rebecca J. Potratz, Graduate Student, Purdue University

Natalie Carroll, Associate Professor, Purdue University

Michael Klepinger, ANS Program Coordinator, Michigan Sea Grant



NOTE: Most of the information and activities in this manual were adapted from the following publications:

- Klepinger, M., Chapman, D., Corlew, M., Dann, S., Francke, L., Haas, M., Heidemann, M., Hesselsweet, A., Landis, D., Parker, J., Potter, J., Sebolt, D., *The Purple Loosestrife Project Cooperator's Handbook*, Michigan State University.
- Jeffords, M.R.; Post, S.L.; Wiedenmann, R.N.; Voegtlin, D.J., *Biodiversity, Wetlands, and Biological Control: Information and Activities for Young Scientists. Purple Loosestrife: A Case Study*, Teacher Training manual (in progress). Collaborating entities: Illinois Natural History Survey, Chicago Wilderness, U.S. Fish & Wildlife Service, and the Illinois Department of Natural Resources.

Contributors

Dave Voegtlin, Illinois Natural History Survey and University of Illinois

Rob Wiedenmann, Illinois Natural History Survey and University of Illinois

Mike Jeffords, Illinois Natural History Survey and University of Illinois

Patrice Charlebois, Illinois-Indiana Sea Grant, Illinois Natural History Survey, and Department of Natural Resources and Environmental Sciences,

University of Illinois

Doug Jensen, University of Minnesota Sea Grant



Reviewers

Luke Skinner, Minnesota Department of Natural Resources,
Purple Loosestrife Program.

Shari McGorison, University of Minnesota Extension Service 4-H Program,
St. Louis County.

Shari Dann, Michigan State University

Ron Hoyt, Lake County and John Emerson, LaGrange County,
Purdue University Extension Educators

Richard Poor and Cheryl Rhoades, Indiana 4-H Leaders.

Support: The development of this publication was supported by the National Sea Grant College Program of the U.S. Department of Commerce's National Oceanic and Atmospheric Administration under NOAA Grant # A/F-NIS-4 made to members of the Great Lakes Sea Grant Network. The Great Lakes Sea Grant Network is a collaboration of the Illinois-Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania and Wisconsin Sea Grant programs. Sea Grant is a university-based program designed to support greater knowledge and wise use of Great Lakes and ocean resources. Through its network of Extension professionals, researchers, and communication professionals, the Great Lakes Sea Grant Network assists the community in its understanding and management of Great Lakes resources for present and future generations.

Sea Grant College Programs are affirmative action/equal opportunity employers. The views expressed herein do not necessarily reflect the views of Sea Grant.

Design & Layout: Denise Mullikin

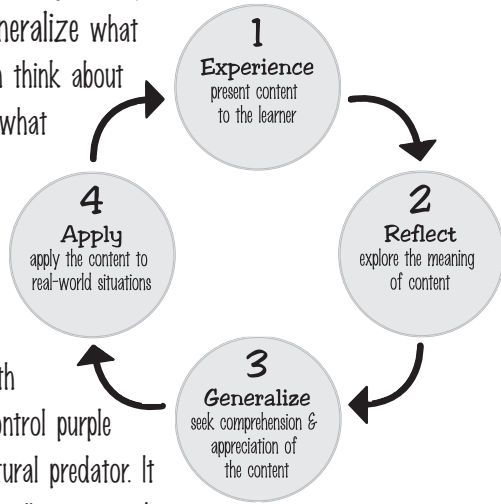
Illustrations: Kathryn Darnell, Christian Oseto

TABLE OF CONTENTS

Eduactional Principles & Websites	4
Overview	5
Frequently Asked Questions	6
Finding a Wetland	9
Activity One: Introduction to Wetlands	10
Activity Two: Aliens Among Us	12
Activity Three: Annual Wetland Plant Diversity Survey	15
Activity Four: Is Purple Loosestrife a Problem in Our County?	20
Activity Five: Controlling Purple Loosestrife	22
Activity Six: Biological Control of Purple Loosestrife	24
Activity Seven: Biological Control Agent: Host-Plant Specificity	30
Activity Eight: Purple Loosestrife & <i>Galerucella</i> Beetle Rearing	32
Activity Nine: Observations & Life Cycles	34
Activity Ten: <i>Galerucella</i> Beetle Release	37
Activity Eleven: Evaluating the Impact of <i>Galerucella</i> on Purple Loosestrife	39

Experiential Learning

Experiential learning distinguishes 4-H youth development education from many formal educational methods. Activities are designed so youth experience a learning activity, reflect on what they did, generalize what they learned, and then think about how they can apply what they learned to other situations.



Objective

This guide was developed to help youth understand how to control purple loosestrife using a natural predator. It provides “learn-by-doing” activities that teach youth about biocontrol of purple loosestrife. Many of the questions in the manual are interpretive, that is, they have no “right” or “wrong” answer.

Answers to the questions in the youth activities are given in the leader’s guide (4-H 918).

Life Skills

Youth will develop the following life skills while working on this endeavor: making decisions, solving problems, relating to others, planning and organizing, communicating with others, leadership, relating to change, and applying science process skills.

Internet Sites for more information

- National Sea Grant Nonindigenous Species
<http://www.sgnis.org>
- University of Illinois
<http://www.inhs.uiuc.edu/cbd/loosestrife/bcpl.html>
- Michigan State University
<http://www.msue.msu.edu/seagrant/pp/>
- Indiana Department of Natural Resources:
www.state.in.us/dnr/entomolo/purple2.htm
- Cornell University:
<http://www.nysaes.cornell.edu/ent/biocontrol/weedfeeders/galerucella.html>
- University of Guelph:
www.uoguelph.ca/~obcp/
www.uoguelph.ca/~obcp/factsheet/loosfa~1.htm
- Sea Grant college Program (exotic species):
www.sgnis.org

Overview

The Plant

Purple loosestrife is a native of Europe and Asia that has spread throughout much of the U.S. 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 showy 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 native 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. Purple loosestrife infestations are a serious problem throughout the Great Lakes region and across North America.

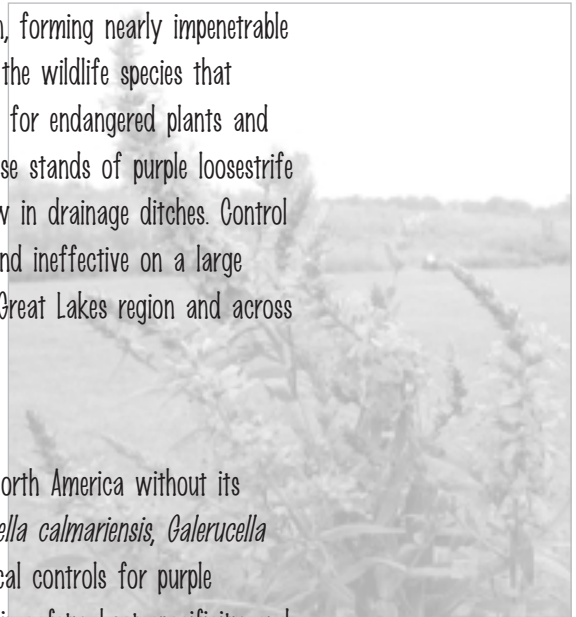


Photo: Pat Charlebois, Illinois-Indiana Sea Grant/Illinois Natural History Survey

A Solution

As often occurs with invasive exotic species, purple loosestrife arrived in North America without its natural enemies. Fortunately, three species of plant-feeding beetles, *Galerucella californiensis*, *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 for importation 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.

Will purple loosestrife disappear?

Those who enjoy purple loosestrife's colorful display need not fear. Experts agree that these natural enemies cannot eliminate purple loosestrife, only reduce its density and harmful effects. Biologists estimate that 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 biological control of purple loosestrife

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

Frequently Asked Questions

- What is purple loosestrife?
- Why should we want to control it?
- Isn't it good for anything?
- So how can we get rid of it?
- What are the control options?
- What is biological control?
- How effective is biological control?
- What natural enemies are approved for use?
- Where can I get the beetles?
- How long will it take for biological control to work?
- How safe is this approach?
- What will the beetles eat when purple loosestrife is gone?
- What can I do?

What is purple loosestrife?

Purple loosestrife (*Lythrum salicaria*) is a perennial plant native to Europe and Asia, which has become widely established in the U.S. 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 purple flower spikes that bloom in the summer and can produce over 2.5 million seeds per year.

Why should we want to control it?

For generations, wetlands were considered wastelands. Throughout the U.S., wetlands were drained until virtually none remained in some areas. It is now widely recognized that wetlands play important many roles. They provide habitats for native plants and wildlife, help to control flooding, enhance water quality, and are used for many types of recreation.

Purple loosestrife is degrading the quality of our precious remaining wetlands. Once it becomes established, purple loosestrife frequently becomes the dominant vegetation by outcompeting native plants. Wildlife species that depend on native plant communities are affected when the native plants decline. Declines in the number of wetland birds (ducks, geese, etc.), muskrats, mink, and some amphibians have all been noted. There is also concern that purple loosestrife may reduce spawning habitat for some fish.

Isn't it good for anything?

Purple loosestrife produces abundant nectar and is attractive to honeybees and other pollinators. Butterflies often obtain nectar from its blossoms. Redwing blackbirds use the stiff, erect stems 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.

So, how can we get rid of it?

For years, people have tried without success to eradicate purple loosestrife. It is now clear that eradication 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.

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 Appendix B for details.

What is biological control?

Biological control is when humans use a pest's natural enemies to reduce its density and the damage that it causes. 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 such as aphids on roses. 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 that 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."

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 U.S., 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.

What natural enemies are approved for use against purple loosestrife?

Three species of plant-feeding beetles, *Galerucella californiensis*, *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 can lead 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.

Where can I get the beetles?

Because some states have restrictions on the importation of certain insects, 4-H Leaders need to work with their local Extension Educator to determine the proper way to obtain the biological control agents. Local Extension Educators should check with their State 4-H Office to see if this effort is being supported. State 4-H Departments should check with the State Entomologist at the Department of Natural Resources to find their preference and current policy regarding the importation of *Galerucella californiensis*, *Galerucella pusilla*, or *Hylobius transversovittatus*, and to see if releases are under way and what documentation by 4-H Leaders will be required.

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 Illinois, Minnesota, and Ontario indicate that *Galerucella* can have 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.

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 to establish that it is free of unwanted diseases or parasites. The *Galerucella* and *Hylobius* beetles were initially 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. An additional 45 plant species were tested after the beetles were imported to North America. *Galerucella* and *Hylobius* beetles are also harmless to human beings and pets.

What will the beetles eat when the purple loosestrife is gone?

First, purple loosestrife will never be gone—biological control does not eradicate a species. There will always be some loosestrife for the beetles to eat. Because normal feeding and growth occurs exclusively on purple loosestrife, the number of the beetles in any area rises and falls in relation to 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. Once established, the beetles will continue to control loosestrife on a permanent basis.

Finding a Wetland

Biological control of purple loosestrife must take place at a wetland site infested with purple loosestrife. Work with appropriate personnel to identify an appropriate wetland site and obtain permission to use that wetland for your study.

Identifying an Appropriate Wetland Site

Who can help?

Most states are trying to keep close watch on the spread of purple loosestrife and efforts to control it. Your 4-H Leader will work with your local Cooperative Extension office to find out what efforts are ongoing in your location and where help is especially needed.

Site selection guidelines

Local authorities (natural resource agencies) can generally help your club find sites for beetle release. Be sure you have spoken with them before you begin to raise the *Galerucella* beetles to be sure there is a place to release them in your area.

Obtaining Permission to Conduct Your Investigations at the Wetland Site

The local authorities that helped you find a wetland to release beetles in can also help your club obtain the necessary permissions for the release. Procedures will vary depending on state regulations and who owns the property.



activity
1

Introduction to Wetlands

Objectives

- Discuss wetlands
- Learn about the value of wetlands
- Learn about local wetlands.

Describe a wetland.

Visit a wetland in your county. What does it look like? What do you hear? What animals and plants do you find? Record your observations. Include some sketches.

Discuss your observations. What characteristics distinguish wetlands from other habitats?



Scientists and resource managers define wetlands in many ways. Generally, all the definitions include three common characteristics of wetlands. What are these three major characteristics?

- 1) _____
- 2) _____
- 3) _____

Why are wetlands important?

What percentage of natural wetlands have you lost in your area? How were they lost? A DNR (Department of Natural Resources) employee or your county Extension Educator may be able to help you with this.



activity
2

Aliens Among Us

Objectives

- Determine the likelihood that an exotic species will survive in a new area.
- Clarify the factors that might limit the survival and population growth of an exotic species.
- Learn about purple loosestrife's limiting factors.

Each organism in an ecosystem survives in relationship to other living organisms (biotic factors) in the ecosystem. The physical non-living environment also affects each organism (abiotic factors). A healthy ecosystem has a dynamic (changing) balance between biotic factors for survival, abiotic factors, and environmental resistance to population growth of the species.

- 1.) Think of an organism in your area. List some factors that could increase the organism's chances of survival.

- 2.) List some factors that affects each organism (environmental resistance).

Examining a Wetland Plant

Choose a plant to study. List the factors that might influence its chances of survival (biotic factors) and limiting factors (environmental resistance) for the plant.

Factors Favoring the Plant	Factors Limiting the Plant

Exotic Species

Exotic species are plants or animals that are not native to an ecosystem. Exotic species that are able to out-compete native species are called invasive. Some native species are also invasive. See if you can complete the chart below by indicating if the plant listed is native to the U.S. or exotic, invasive or non-invasive.

Plant	Native	Exotic	Invasive	Non-invasive
Black locust				
Honeysuckle				
Japanese maple				
Lilac				
Multiflora rose				
Osage orange				
Sugar maple				
Thistle				
Tulip				
Vetch				

Interaction Between Native & Exotic Species

Invasive plant species can interfere with the dynamic balance in an ecosystem.

- 1.) Based on its biotic potential and environmental resistance, how could an exotic plant get into a local wetland ecosystem?



2.) How do you think invasive plant species affect the other plants?

3.) Based on its biotic potential and environmental resistance, how could people control the spread of an exotic plant?

Introducing Purple Loosestrife

Purple loosestrife is an exotic plant species that affects many wetland ecosystems. Read about purple loosestrife and list the biotic factors influencing its chances of survival and environmental resistance to the plant.

Factors Favoring Purple Loosestrife	Factors Limiting Purple Loosestrife



activity
3

Annual Wetland Plant Diversity Survey

Objectives

- Learn how to calculate the species diversity of a plant community.
- Determine if the density of purple loosestrife affects the diversity of the plant community.

Focus Questions

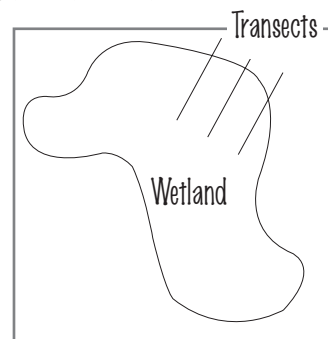
1.) What is diversity?

2.) Why is biological diversity important?

3.) How does plant species diversity affect a wetland?

Procedure for Calculating the Diversity Index

- 1.) Locate the edge of a wetland by noting where the vegetation changes to wetland plants. Establish three 70-foot-long transects (see the marked lines in the drawing) that run from the edge of the wetland into the interior (see the figure at the right). The transects should be parallel to each other and stop before hitting open water. Avoid trampling the plants that will be on your transect. Transects should be at least 32 feet apart. Pound in two PVC pipes as stakes to designate the ends of each transect and tie a stout cord between them. The poles will be left in place so you can easily calculate the Diversity Index in the future by comparing the same place each time.



- 2.) Walk along a transect with another 4-Her and identify each plant that touches the line (or is in the plane of the transect). Identify general plant categories rather than each individual plant, use the following categories: loosestrife (L), grass or sedge (G), cattail (C), and other (O, which would include broadleaf plants and vines). Your data sheet should be made of these letters to indicate the order you found them. For example, LLGLLL would indicate that you saw two loosestrife plants, a grass, a loosestrife plant, a cattail, and two loosestrife plants.
- 3.) Determine the number of 'runs' (changes in species type) on your data sheet. Note that the example given in #2 has 5 runs (loosestrife, grass, loosestrife, cattail, loosestrife).
- 4.) Calculate the General Diversity Index (D_{10}) by using the following equation:

$$D_{10} = \frac{\text{total \# of runs}}{\text{total \# of plants}}$$

The value of D_{10} will vary between 0 (no diversity) and 1 (high diversity). Values around 0.5 indicate that the wetland is relatively diverse. (Note: D_{10} cannot equal 0 because there will be at least one run.)

Note: Keep records of the plant diversity, D_{10} , for your wetland. Increasing the plant diversity is the goal of the Biological Control of Purple Loosestrife 4-H initiative. By increasing plant diversity in your wetland you are allowing native plants to reestablish themselves.

Calculation:

$D_{10} =$



Follow-up discussion

Wetland resource managers say purple loosestrife is a problem because it tends to crowd out other wetland plants and to reduce the diversity of the wetland area. Based on the data your group collected, do you agree or disagree with the wetland resource managers? Defend your answer.

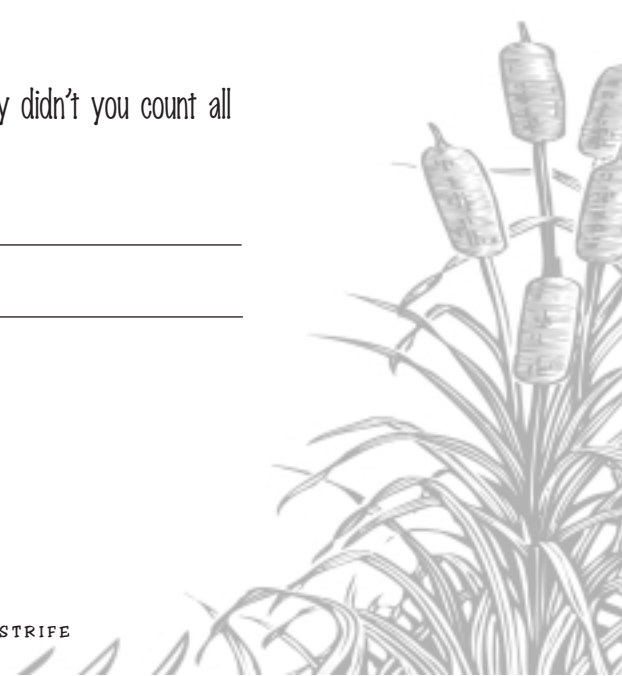
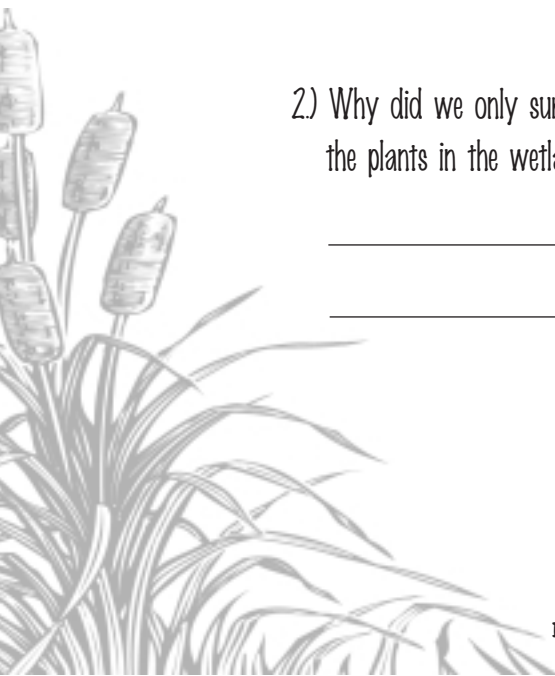
- Is this wetland healthy? Defend your answer.

- What could you do to improve the health of the wetland?

Other Questions to Consider

- 1.) What other factors might affect the diversity of a wetland area? How could you test for or measure those?

- 2.) Why did we only survey a small area within the wetland? Why didn't you count all the plants in the wetland?



3.) You learned how to calculate plant species diversity. Do you think it's an accurate measure? What are some possible errors in the procedure we used?

Extending these calculations

You can calculate a more precise measurement of wetland diversity if you can identify native and exotic species. The calculations, and values calculated using the examples, are given below:

The basic Diversity Index, D_Q , was shown above and is calculated as

$$D_Q = \frac{\text{total \# of runs}}{\text{total \# of plants}}$$

$$D_Q =$$

The Modified Diversity Index, D_M , compares the diversity index of native plants to the total plant population and is calculated as

$$D_M = \frac{\text{total \# of runs of native species}}{\text{total \# of runs}}$$

$$D_M =$$

The Species Diversity Index, D_S , gives the diversity index for different species and is calculated as

$$D_S = \frac{\text{total \# of different species}}{\text{total \# of runs}}$$

$$D_S =$$



The Diversity Index of Exotic species, D_E , is calculated by taking the square root of the basic Diversity Index times the Modified Diversity Index:

$$D_E = \sqrt{(D_B * D_M)}$$

$$D_E =$$

These indices can be used to give an Overall Diversity Index, D_O , which will give a more precise measure of site diversity. It is calculated by taking the cubic root of the basic Diversity Index times the Modified Diversity Index times the Species Diversity Index (or the Diversity Index of Exotic species, if that is your chosen focus):

$$D_O = \sqrt[3]{(D_B * D_M * D_S)} \quad \text{or} \quad D_O = \sqrt[3]{(D_B * D_M * D_E)}$$

$$D_O =$$

If you choose to calculate the Overall Diversity Index perform the calculations for each of three transects separately and then average the three indices to give you the most accurate value.



activity
4

Is Purple Loosestrife a Problem in Our County?

Objectives

- Examine the historical spread of purple loosestrife.
- Collect data on the current distribution of purple loosestrife in the county.
- Predict the impact and future spread of purple loosestrife.

Past: Examining the Historical Record

Gather information about the historical spread of purple loosestrife in the U.S.

- Use reference books, newspapers, or the Internet to learn how and when purple loosestrife arrived in the U.S.. How has it spread? How do you think it got into your county?
- Interview people living in the area where there is a purple loosestrife infestation. What do the wetland neighbors say? Find out what they remember about the plant. How long has it been there? How fast have the numbers increased?



Present: The Current Distribution of Purple Loosestrife

To devise a comprehensive plan for the control of purple loosestrife in wetlands, it is necessary to know the location of local wetlands and loosestrife patches. It is also important to note the extent and density of the purple loosestrife infestation in those wetlands. Different means of control may be used depending on the size of loosestrife patches and their density.

- Use the Loosestrife Locator Cards (Appendix J) to record where you find distinct patches of purple loosestrife within your county. Plot all of the purple loosestrife patches on a map.
- How is purple loosestrife distributed in your county? Do you notice any patterns?

Future: Predicting the Spread and Impact of Purple Loosestrife

The Federal Government is working to reduce the spread of purple loosestrife and other exotic species, by the careful monitoring of ship ballasts and restricting the transfer of the plant. You are helping to control the spread of purple loosestrife by being involved in this 4-H activity. Besides raising and releasing the *Galerucella* beetles (described later in this manual) you can try to predict which ecosystems purple loosestrife will invade next. By working to keep the plant out of local wetlands, you can help reduce the ecological impact purple loosestrife may have in your area.

- Predict the next area(s) that may be invaded by purple loosestrife.

- Predict the impact that purple loosestrife may have on a wetland ecosystem.



activity
5

Controlling Purple Loosestrife

Objectives

- Develop solutions to control the spread of purple loosestrife.
- Discuss benefits and risks associated with each control strategy.

Focus questions

1.) How does purple loosestrife invade wetlands?

2.) Is there any way to control the spread of purple loosestrife?

Sometimes the best control is obtained by using a combination of the strategies mentioned.

3.) How do land managers find an appropriate control strategy? What are some criteria that they use to select the best strategy or strategies?



4.) Discuss the benefits and risks associated with each of the control strategies you listed above.

Solutions	Risks/Drawbacks	Benefits

5.) Which strategy or strategies would you suggest using to control purple loosestrife in your wetland area? Why?



activity 6

Biological Control of Purple Loosestrife

Objectives

- Conduct a benefit and cost analysis of using a biological control agent to manage purple loosestrife.
- Understand biological control and why it is a good solution to the purple loosestrife problem.
- Educate your community about biological control of purple loosestrife.

Biological Control

Biological control means using living organisms to control other organisms. The organism used to control another organism is called the biological control agent. The organism being controlled is called the target organism.

What is the target organism in our wetland system?

Benefit/Cost Analysis

Before a biological control effort can be recommended, the costs, risks, and benefits of the program must be studied. Complete the following problems to assess the benefits and costs of using a biological control on purple loosestrife. The scenarios in this activity are based on actual estimates.

Potential Gains From Biological Control

A.) It is estimated that 1,233,000 acres of wetlands are at risk of purple loosestrife infestation in the central and eastern U.S. Assume that these wetlands have an average value of \$300/acre and that 5% of them are damaged by purple loosestrife each year so that they are worth nothing. What would be the land value of the wetlands lost to purple loosestrife in a year? What would be the cost of the loss of wetlands after 20 years?

B.) Muskrats provide fur for the market at a rate of 5,204,461 pelts/year. Each pelt is worth an average of \$2.69. Muskrats need cattails for food and cover, but cattails are generally out-competed by purple loosestrife. If purple loosestrife replaces the cattail population in the U.S., what is the potential yearly loss of pelt revenue (to the nearest dollar)?

C.) The money people spend in recreational pursuits is one way to determine the value of a resource. Consider the following two uses of wildlife:

1.) Consumptive Wildlife Use

Assume that there are 500,000 migratory bird hunters, and each hunter spends an average of \$120/year. Half of the money spent by hunters involves hunting birds that utilize wetlands. What would the potential loss of revenue from bird hunters be if all wetlands were invaded by purple loosestrife, which caused a loss of habitat and, consequently, a loss of half the game birds after 20 years (as in part A)? Assume that the loss of game birds result in a decrease in hunting (by half). What would the average annual loss be?

2.) Non-Consumptive Wildlife Use:

During any given year, an estimated 12.6 million people visit wild places to photograph, bird watch, or just “get away from it all.” Assume that each visitor spends an average of \$129.86/year, and approximately 10% of the visits are to a marsh or other wetland. What is the potential annual lost revenue, assuming that visitors do not want to see only purple loosestrife and 10% stop going to the marshes and wetlands?



D.) Find the potential annual resource value lost.

1) Add the values that you calculated for sections A, B, and C for wetlands that decline due to purple loosestrife infestation.

2) If the purple loosestrife biological control program can save 20% of this annual resource value, then how much money will be saved?

Potential Losses From Biological Control

E.) The cost of developing and running the purple loosestrife biological control program to date has been approximately \$1,200,000. This includes research in Europe looking for appropriate biological control insects, research on the insects found, and rearing and release of biological control organisms. Assuming that this research began in 1990, what is the average yearly cost in the year 2000 (to the nearest dollar)?

F.) Purple loosestrife is an excellent source of nectar, so bees use it regularly during the blooming season. Annual sales of honey amount to \$12,820,000. If purple loosestrife did not exist in wetlands, an estimated 10% of this revenue would be lost. What is the potential total honey revenue lost?

G.) Purple loosestrife is also a sought-after ornamental. While it has been declared a noxious weed in many states, it is still available on the market as a “sterile cultivar.” If this cultivar also became illegal, as some people recommend, then \$300,000 in sales would be lost each year.

H.) Find the total annual cost ($E + F + G$) of losing purple loosestrife.

I.) Find the yearly benefit-cost ratio (benefits, $D-2$, divided by costs, H) to the nearest decimal point.

Selecting a Biological Control Agent

When selecting biological control agents, scientists choose a natural enemy of the organism needing to be controlled. For purple loosestrife, scientists traveled to Europe where purple loosestrife is a native plant, to search for possible biological control agents. They identified more than 120 kinds of insects that are natural enemies of purple loosestrife in Europe. They tested many of these insects while considering the following questions:

- Does the *Galericuella* beetle live only on purple loosestrife and not any other native plants?
- Is it harmful to humans or other organisms (i.e. are they safe)?
- Can it survive year round in the new environment?
- Can it be easily and cheaply raised?

1.) Why are these questions important when selecting a biological control agent?

2.) Visit the websites listed below to learn more about purple loosestrife, biological control, and the *Galerucella* beetle. These sites will help you answer the questions below.

www.state.in.us/dnr/entomolo/purple2.htm

www.inhs.uiuc.edu/cbd/loosestrife/bcpl.html

www.msue.msu.edu/seagrant/pp/

www.nysaes.cornell.edu/ent/biocontrol/weedfeeders/galerucella.html

www.uoguelph.ca/~obcp/

www.sgnis.org

- Does the *Galerucella* beetle live only on purple loosestrife and not any other native plants?

- Is it harmful to humans or other organisms (i.e. are they safe)?

- Can it survive year-round in the new environment?



- Can it be easily and cheaply raised?

3.) Do you think the *Galerucella* beetle was a good choice as a biological control agent for purple loosestrife?

Educating the Public

Now that you have learned so much about the purple loosestrife invasion of wetlands and the costs and reasons for control you should begin thinking about sharing your knowledge with your community. Most citizens are probably not aware of the purple loosestrife problem. They need to understand why people are using biological control with *Galerucella* beetles. What questions might members of your community have? How would you answer those questions?



activity 7

Biological Control Agent: Host-Plant Specificity

Objectives

- Test whether a biological control agent will feed on plants other than purple loosestrife.
- Assess the chances that the biological control agents will eat native species of plants.

Identifying the Problem

Assume that you are working for the Plant Protection and Quarantine Service of the U.S. Department of Agriculture. You have been sent a new species of beetles, *Galerucella californiensis*, which are to be tested before potential release as a biological control agent against purple loosestrife. Before any release can be made, the specificity of the agents must be assessed and then a decision made as to the safety of the agent. "Specificity" refers to whether the beetle will eat a wide range of plants or whether it eats only specific plants.

Does the beetle being proposed as biological control agent for release against purple loosestrife show host specificity (choose to eat only purple loosestrife)? How safe will it be when released into your wetland? Will the beetle eat native plants? To determine the answers to these questions, you will conduct a choice test. In a choice test, the biological control agent (*Galerucella*) is tested using the target plant (purple loosestrife) and several other plant species. Biological control agents with a broad host range (those that eat many species related to the target) may have a deleterious impact on non-target species. In contrast, those with a fairly narrow host range will probably have few, if any impacts on non-targets. You will need to determine if *Galerucella* beetles have a narrow or broad host range. This will help you decide if the beetles should be released in our wetlands.

Scientists generally conduct no-choice tests as well as choice tests. In a no-choice test, the biological control agent is given just one plant to see if it will eat the plant when there are no other choices.

Procedure

- 1.) Place about one square inch pieces of 5-10 leaves of different plants in a Petri dish (Be sure that one leaf piece is purple loosestrife.)
- 2.) Place filter paper in the bottom of the Petri dish. Arrange the leaf pieces around the Petri dish, at least 1 cm from the outside edge. Label the leaves in the dish.
- 3.) Slightly wet the filter paper to keep the leaves from drying out. Wet the paper each day by raising one side of the dish lid and adding very little water.
- 4.) Place 5-10 beetles in the center of the dish and cover with the lid. Keep in a warm place (room temperature or above) but not in direct sunlight.
- 5.) After a few days, remove the lid and assess the feeding. *Galerucella* beetles feed by chewing holes in leaves, so you will estimate the percent of damage. Record your observations in a data table.



Photo: Pat Charlebois, Illinois-Indiana Sea Grant/Illinois Natural History Survey

Data Table

Plant Species	Percent (%) of Feeding Damage



Purple Loosestrife & *Galerucella* Beetle Rearing

Objectives

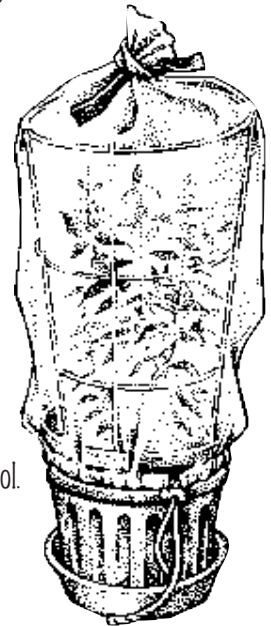
- Learn techniques for rearing purple loosestrife plants and *Galerucella* beetles.
- Raise beetles for release into wetland areas. This takes about two to three months (one month to grow purple loosestrife and one or two months to raise the beetles).

Note: In the Midwest you should time your beetle rearing so they are ready to be introduced to the designated wetland in June-August.

Growing Your Plant

A.) Potting the Root Crown

- 1.) Put a 4-gallon pot into the kiddie wading pool. The pot should have holes in it so the plant can be watered from below. (Note - one 4-H leader made her own pots with 5 gallon plastic buckets. She drilled 6 holes on the bottom and 4 holes on the sides, 2 inches above the bottom for water uptake.)
- 2.) Fill the pot half full with a non-soil potting mix.
- 3.) Sprinkle a tablespoon of slow-release fertilizer and mix into the soil.
- 4.) Place the root crown into the soil. Make sure the stems are pointed upwards.
- 5.) Fill the remainder of the pot with potting soil.
- 6.) Tap the pot to settle the soil, but do not pack it down.
- 7.) Water the plant thoroughly ONCE from the top and put 2-3 inches of water in the pool.



B.) Setting up the Plant Cage

- 1.) Place a tomato cage into the pot and press down firmly to seat it.
- 2.) Tape the sharp edges and joints of the tomato cage so they won't tear the fabric (sleeve).
- 3.) Place a fine mesh sleeve over the cage. Secure the top and bottom with twine, tape, or a heavy rubber band. (Note - one 4-H leader used a truck tire inner tube (cut cross-ways into 1/2 inch circles) as the 'rubber band' to hold the net on the bucket.
- 4.) Place the plant where it will receive the most sunlight.

Sample Data Sheet

Date	Temperature (°C)	Humidity	Rainfall (cm)	Height of Plant (cm)

Notes



activity 9

Observations & Life Cycles

Objectives

- Observe the growth of purple loosestrife and the life cycle of *Galerucella* beetles.
- Collect and organize data based on your observations.
- Formulate questions about the purple loosestrife plants and the beetles.

Data Collection

When you raise plants and animals, it is important to monitor their growing conditions. Good observations will help you determine the optimum growing conditions for the plants and animals.

A.) Abiotic Conditions

Abiotic factors are the non-living components of the environment, such as temperature, cloudiness, humidity, amount of light, etc. Abiotic factors can impact the growth of plants and the behavior of animals. Your group should determine which abiotic factors you want to record. An example of a data table is given in Activity Eight.



Purple Loosestrife Growth

B.) Purple Loosestrife

Sketch the purple loosestrife plant as it looked when you started, and when you introduced the beetles. Measure the growth (height) of the purple loosestrife plants. Include this data in your data table from Part A. Also, note the appearance of the plants and their leaves over time. Create a data table to record your observations.

C.) Use the following data chart (or make your own) to record the plant growth and abiotic conditions:

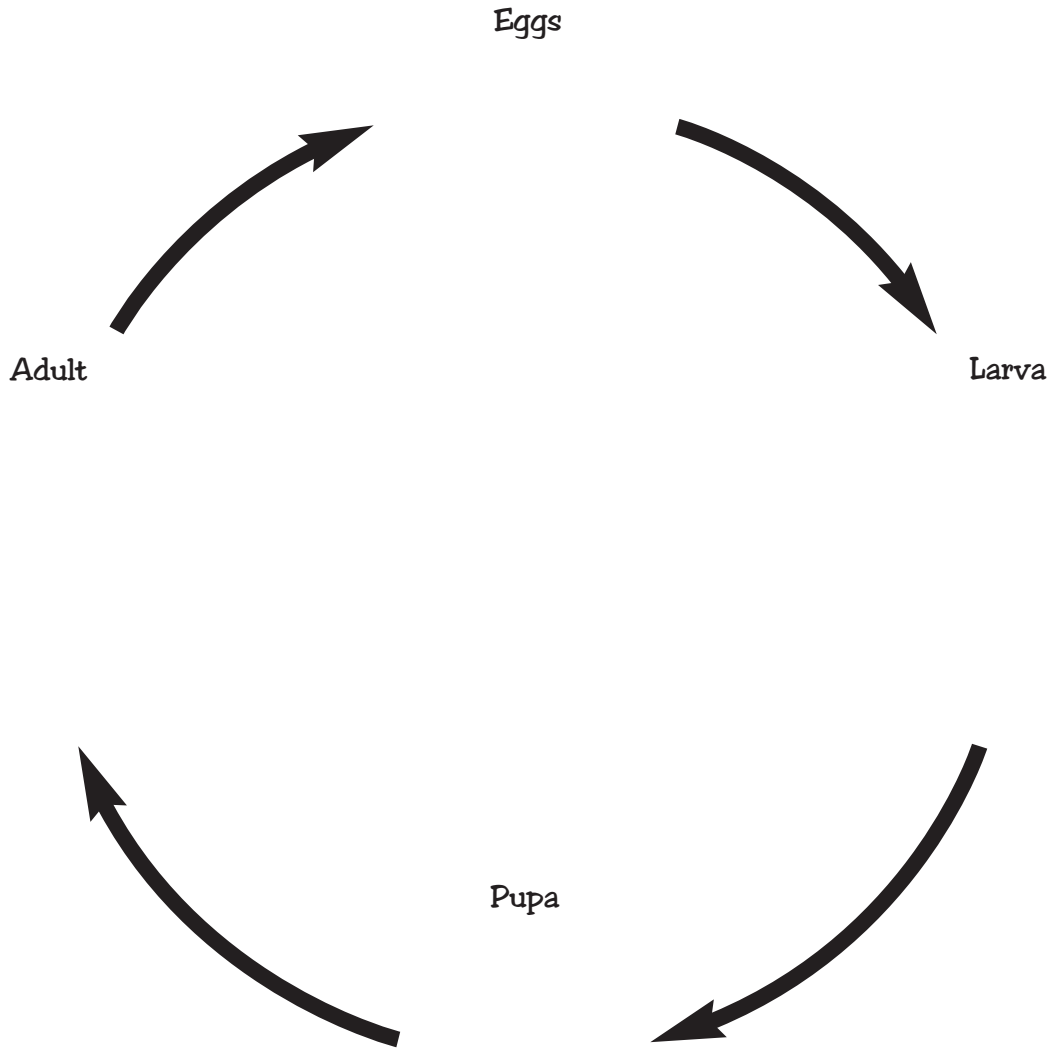
Example

Date	Plant growth (can include any/all of the following: plant height, temperature, humidity, hours of darkness, soil temperature, etc.)

Notes: *Other abiotic conditions that you might want to record (in addition to or in place of those given above) could include: amount of water offered, amount of fertilizer added, hours of artificial light and hours of daylight. Also, if the plants are grown in a greenhouse a hand lens should be used weekly to check for unwanted insects and diseases and the plants will need to be shaded from June to September.*

D.) *Galerucella* Beetles

Observe the stages of the *Galerucella* beetle life cycle. Make a sketch of each life stage. Compare the *Galerucella* beetle life cycle with the purple loosestrife life cycle.



E.) Data Analysis

Create a graph to represent some of the data your group collected. Interpret the graph. What does it tell you about purple loosestrife or the beetles?

F.) Focus Questions

Watching the purple loosestrife plants and beetles grow may cause you to ask many questions, like those given below. Try to think of questions that you can share with your group.

- What is the impact of the beetles on the purple loosestrife plants?
- How do the abiotic factors impact the growth of purple loosestrife?
- How long did it take before the new adult (second generation) beetles appeared? What was the average daily soil temperature during this time?



activity 10

Galerucella Beetle Release

Objectives

- Release your *Galerucella* beetles in a wetland infested with purple loosestrife.
- Establish the monitoring program to study the effects of the beetles on the wetland.

Setting up the Sampling Area

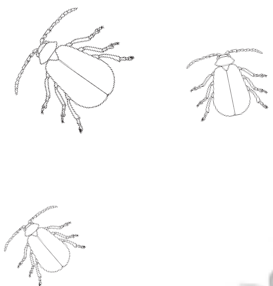
- 1.) Measure the plant diversity as described in Activity Three.
- 2.) Draw a map of the area. Provide enough detail so that you can find your release location the next time you survey the area even if someone removes your field markers. The survey work you completed in Activity Three will provide baseline information about the wetland area where we released the beetles. This can be done at the same time you release your beetles. You will be able to evaluate how well the population is doing by comparing future Diversity Index data.

Release Sampling

- 1.) Record the location, date, time, temperature and other weather conditions, and the name(s) of the evaluators at the top of the data sheet.
- 2.) Plant Data
Calculate and record the plant Diversity Index (or indices, if you prefer) as described in Activity 3.
- 3.) Release your beetles as described below. Keep the data that you took for comparisons to future data you collect.

Beetle Release

- 1.) Beetles should be released when new adults are visible and the potted purple loosestrife plants are nearly defoliated.
- 2.) Choose a release area with a thick growth of purple loosestrife that is in open sunlight.
- 3.) Move the entire plant and pot to the release site.
- 4.) Remove the mesh sleeve.
- 5.) Shake out any beetles still in the mesh bag (turn the mesh bag inside out).
- 6.) Remove the tomato cage and leave the potted root crown in place for one year. Record the spot of release on a map. Mark the location with 10' PVC pipe. Push the pipe into the wetland as far as you can.



Wetland Plant Diversity Sheet

Galerucella beetle release

Location: _____

Date: _____

Time: _____

Temperature: _____

Weather Conditions: _____

Evaluator(s): _____

Plant Diversity: _____

Species along the transects: (L - loosestrife, G - grass, C - cattail, O - other)

Transect 1 _____

Transect 2 _____

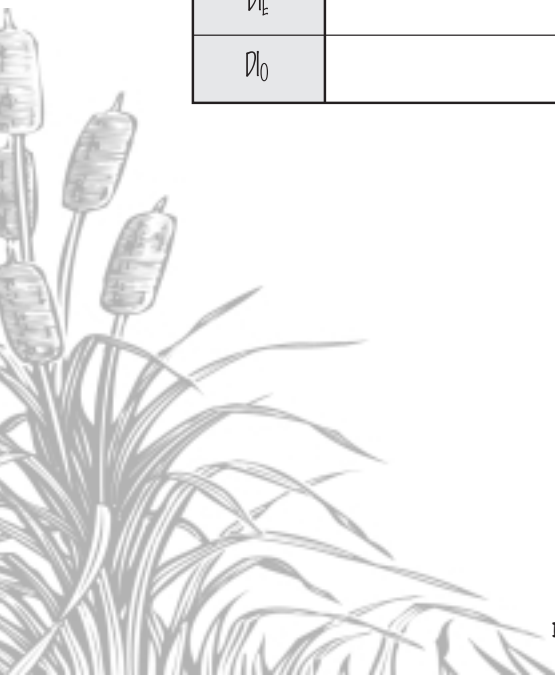
Transect 3 _____

Calculate the Diversity Index, DIG , for each transect:

Transect	1	2	3
DIG			

Optional Calculations:

Transect	1	2	3
DIM			
DIG			
DIE			
DIO			



activity 11

Evaluating the Impact of *Galerucella* on Purple Loosestrife

Objectives

- Monitor the purple loosestrife and beetle populations in the wetland area where you released the beetles.
- Report on the success of biological control in your wetland area and predict the future impact.

Note: This activity must be completed after the beetles have had a chance to have an effect on the purple loosestrife. Please be aware that you may not see a decrease in the amount of the plant for two or three years.

Procedures

Using some of the same techniques as when you first released the beetles and collected data, your group will monitor the wetland area each spring and fall to determine the impact of *Galerucella* beetles on purple loosestrife in your release area.

Spring Sampling

Sampling in the spring should take place after the beetles have emerged from their over-wintering locations and resumed normal activity. At this time the loosestrife plants will be one to two feet tall. (If plants are more than three feet tall, it will be difficult to find the beetles or their damage.) In the Midwest this is likely to occur in the second half of May.

- 1.) Record the location, date, time, temperature and other weather conditions, and the name(s) of the evaluators at the top of the data sheet.
- 2.) Approach the sample area slowly to avoid disturbing any adult beetles.
 - a.) Count and record the number of adults you see in a one-minute interval. Note that adults may be found anywhere on the plant but will most often be found feeding at the shoot tip.
 - b.) Count and record the number of larvae you see in a one-minute interval. Note that larvae may be found anywhere on the plant.
 - c.) Count and record the number of eggs you see in a one-minute interval. Note that eggs may be found anywhere on the plant, including the undersides of leaves.



Fall Sampling

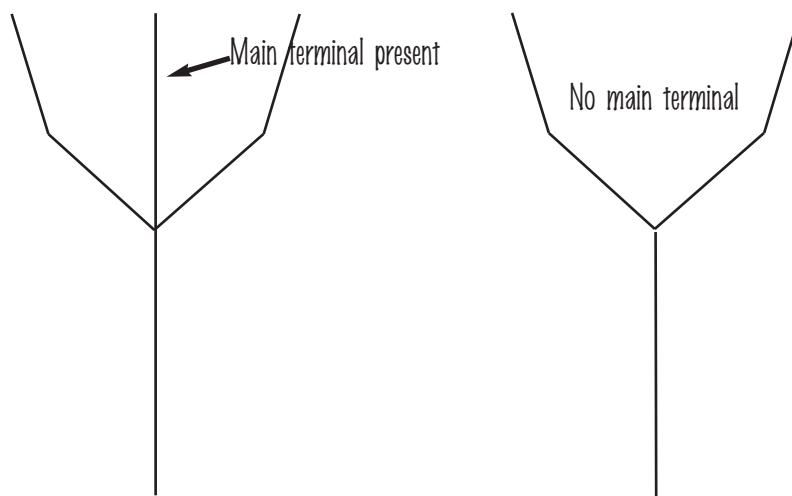
Fall data collection occurs after plants have matured. The *Galerucella* beetles are not active in the fall; so all data collected involve only the purple loosestrife plants.

Plant Data

- a.) Record the location, date, time, temperature and other weather conditions, and the name(s) of the evaluators at the top of the data sheet.
- b.) Calculate and record the plant Diversity Index (or indices) as described in Activity 3.
- c.) Measure and record the height of the five tallest loosestrife stems along each transect (from root crown to tip of plant).
- d.) For each stem you measured, count and record the number of inflorescences. The inflorescence is the part of the stem containing flower buds.
- e.) For each stem you measured, measure and record the length (inches) of the five upper inflorescences.
- f.) Record if the main terminal is present or not (see picture).

Data Analysis

- 1.) Prepare graphs that compare the data you've collected on your data sheets.
- 2.) Write a short essay about the success of your biological control efforts at the wetland. Predict the future impact of the *Galerucella* beetle on the purple loosestrife in the wetland. How will the wetland area change in one year? Five years? Ten years?
- 3.) You may want to contact your local newspaper to see if they would print your group's report on the biological control of purple loosestrife.



Biological Control of Purple Loosestrife

Fall Sampling Sheet

Location: _____

Date: _____

Time: _____

Temperature: _____

Weather Conditions: _____

Evaluator(s): _____

Plant Diversity: _____

Species along the transects: (L - loosestrife, G - grass, C - cattail, O - other)

Transect 1 _____

Transect 2 _____

Transect 3 _____

Calculate the Diversity Index, D_{IG} , for each transect:

Transect	1	2	3
D_{IG}			

Optional Calculations:

Transect	1	2	3
D_M			
D_S			
D_E			
D_O			

Additional plant information:

Transect	1	2	3
Height of 5 tallest stems			
Number of inflorescences on the 5 tallest stems			
Length of each of the 5 inflorescences you measured			
Number of main terminals present on the 5 tallest stems (0-5)			

Biological Control of Purple Loosestrife

Spring Sampling Sheet

Location: _____

Date: _____

Time: _____

Temperature: _____

Weather Conditions: _____

Evaluator(s): _____

Beetle Information:

Number of *Galerucella* beetles counted in five minutes: _____

Number of *Galerucella* beetle larvae counted in five minutes: _____

Number of *Galerucella* beetle eggs counted in five minutes: _____



Notes



Notes







Protected under
18 USC 707

It is the policy of Purdue University Cooperative Extension Service, David C. Petritz, Director, that all persons shall have equal opportunity and access to its programs and facilities without regard to race, color, sex, religion, national origin, age, marital status, parental status, sexual orientation or disability.

Purdue University is an Affirmative Action employer.
This material may be available in alternative formats.

1-888-EXT-INFO, <http://www.agcom.purdue.edu/AgCom/Pubs/menu.htm>

Special thanks to The Sea Grant College Program for their support of this endeavor and to all the 4-Hers and their leaders who pilot tested the Purple Loosestrife Activity in Indiana, Illinois, Michigan, and Minnesota.