Purple Loosestrife Project - Secondary School Activity Set
Michigan State University
Michigan State University Extension
Cooperators Handbook Section 3
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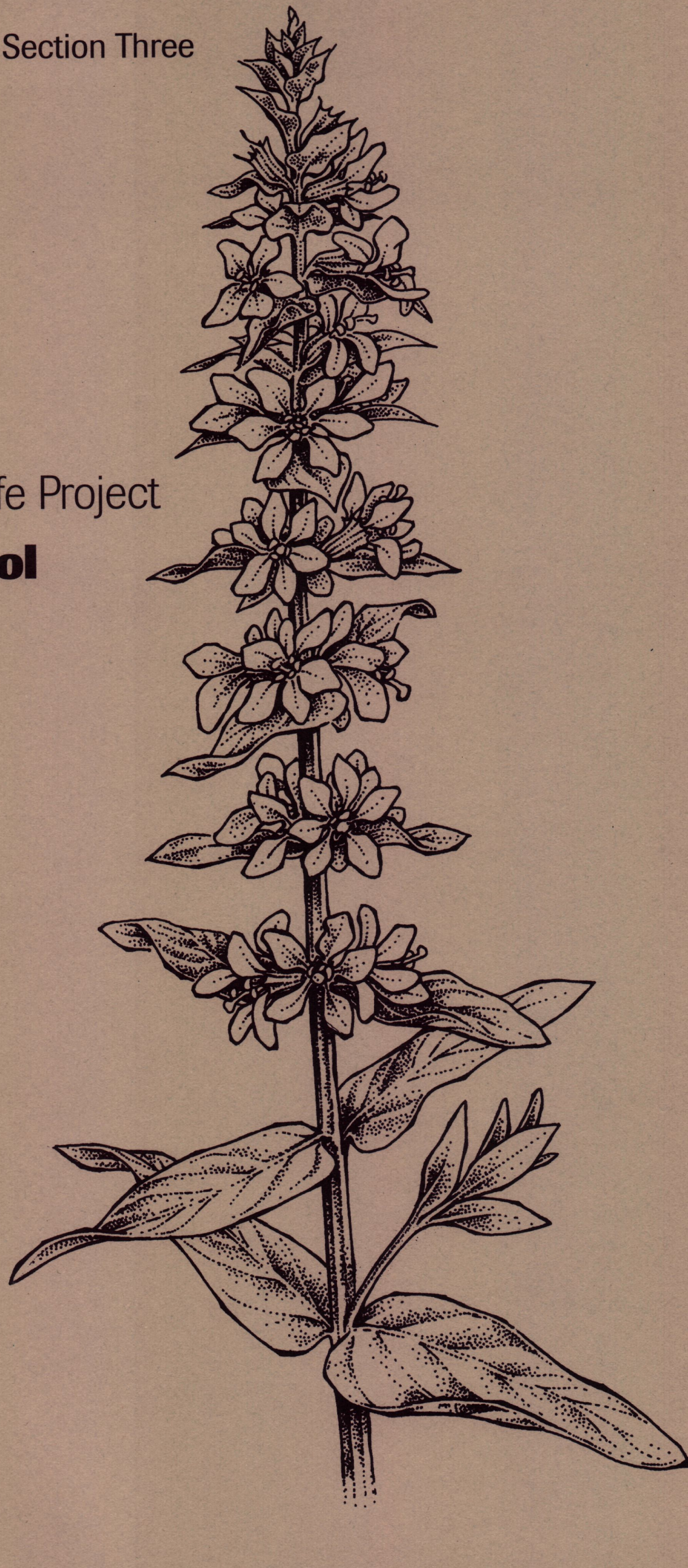
Cooperator's Handbook • Section Three

The Purple Loosestrife Project

Secondary School Activity Set



The Purple Loosestrife Project
Michigan State University
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The Purple Loosestrife Project
Cooperator's Handbook

Contents

Purple Loosestrife Educational Opportunities

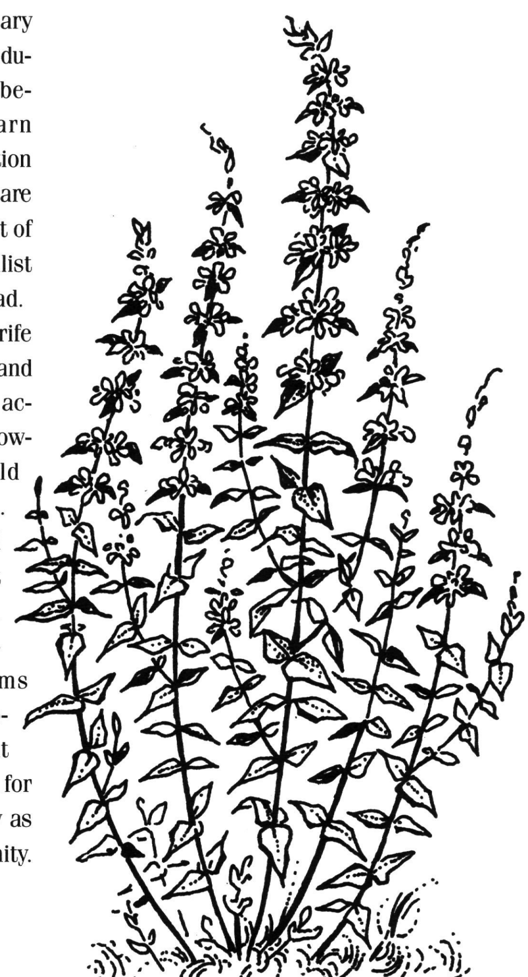
Educators find opportunities in the invasion of North American wetlands by purple loosestrife.

Upper elementary and secondary school teachers provide their students learning opportunities in the "Three R's" as well as in the sciences when they use Purple Loosestrife Project activities. Integrating studies of natural systems and the social context in which communities manage their wetland resources stimulates student inquiry, which leads to improved analytical skill, student decision-making, and increased personal responsibility. These are the elements of any solid environmental education activity, and with a little imagination they can be applied whether the subject area is social studies, mathematics, English or science. The primary key is integration: how does this quantitative exercise we are engaged in relate to the problem of explosive plant population growth? How does our field survey of wetland species relate to protection of biodiversity? Who owns this wetland, and does ownership carry and obligation to manage purple loosestrife so it doesn't spread to neighboring properties?

Purple Loosestrife Project classroom and field activities are correlated to Michigan Department of Education Curriculum Framework learning objectives or content standards so teachers can be sure they are always on the right path as regards their annual teaching goals—even when they are knee-deep in their adopted wetland.

Teachers can use the Purple Loosestrife Project materials in a variety ways. Some will spend only a few hours per year on purple loosestrife, while some will spend a few days per season—depending on their interests. Most of the secondary school activities stand on their own, and they can be used sequentially, but they don't have to be. They can complement broader studies of biology, geography, wetland ecology, biodiversity and exotic species—or they can be used as a primary unit. All Purple Loosestrife Project educational activities are hands-on, because we know students learn stewardship best this way. In addition to important student learning, we are mindful of the fact that there is a lot of loosestrife out there. We want to enlist student help in controlling its spread.

Students find the purple loosestrife project activities to be challenging and fun. They talk about their sense of accomplishment after a field trip, knowing they are making a real-world difference in their local wetland. They can say they are practiced caretakers of the environment, that they have experience with common field equipment, and that they better understand how ecosystems change. We know they have sharpened their thinking skills and that they are just a little better prepared for the stewardship role they will play as responsible adults in their community.



Adapting the Activities

The K–12 purple loosestrife educational activities were formatted so they could be adapted to non-classroom use by nature center and youth group leaders. Each activity follows a recognizable layout, providing; Objectives, Methods, Background, Materials, Procedure, Extensions, and Evaluation for consistency and ease of use. Nature center leaders find the problem of loosestrife offers indoor "rainy-day" opportunities as well as trail-side interpretive lessons. Issues of wetland management, the spread of exotic species, population explosions, and testing the host-specificity of natural enemies provide depth to discussion of bio-diversity, wetland ecology and habitat.

Project Cooperators are developing interpretive display guidelines for Huron-Clinton Metropark facilities. A seasonal display case featuring loosestrife clippings (and/or potted loosestrife) and live *Galerucella* beetles as an introduction point, encourages nature center visitors to do more than observe indoor flatwork. One cooperating Michigan nature center display refers to and describes a trail-side beetle release site so visitors can see first-hand how biological control really works. People are hitting the trails to see *Galerucalla* at work.

Many of our finest nature centers are situated in or near wetlands which are now being overrun by purple loosestrife. Becoming a Purple Loosestrife Project cooperator not only offers educational and interpretive program benefits, it can maintain or improve nature site biodiversity as well.

A nature center display about Purple Loosestrife and the *Galerucella* beetle.

Youth groups provide Purple Loosestrife Program cooperators a venue for offering extended learning experiences for learners. After-school clubs, science clubs, ecology clubs, 4-H or scout clubs and other youth groups can carry out long-term Purple Loosestrife Project stewardship projects (throughout the year and at times when school is not in session). Volunteers who work with such youth groups provide a great source of energy and enthusiasm for purple loosestrife projects. Dedicated volunteers provide continuity over the seasons.

Forming a local partnership with youth-serving clubs and organizations will help your Purple Loosestrife Project in many ways. These organizations provide such benefits for kids as: awards programs, other recognition (through badges, medals, etc.), leadership training experiences, scholarships, opportunities to attend camps or other special state/national/international programs, and the chance to share their learning through science fairs, county fairs, collections, community service projects, and local environmental or public policy arenas. Many groups, such as 4-H and Scouts, provide volunteer training opportunities for parents and resource people working with youth.

In Michigan, the 4-H Natural Resources and Environmental Education Program connects youth ages 5–19 with volunteers and teachers interested in programs like the Purple Loosestrife Program. Through the 4-H NREE Program, cooperators can access: materials (extension bulletins, curriculum materials, posters, etc.), leader/teacher training workshops, and support from county extension staff in working with youth groups. 4-H youth materials, volunteer training, and community events help counties develop stronger youth environmental science and stewardship education programs. 4-H encourages networks of teens and adults representing many organizations to work together to conduct land and water stewardship projects important at the local level—a vision shared by the Purple Loosestrife Project.

K–12 Activity Writing Teams

Purple Loosestrife Project leaders determined that a need-based team approach to development of the educational opportunities for school children was preferred over creating activity sets at the university and then packaging them for the community to accept (or reject!). Leaders in Michigan's environmental and outdoor education profession were informally polled for writing team nominations, initial inquiries were made of prospective team members, and individuals were interviewed by Purple Loosestrife Project staff prior to being invited to join. Teacher-authors were chosen who were experienced team players with a solid foundation in environmental education curriculum development and a genuine enthusiasm for the Purple Loosestrife Project. After a grounding in biological control of purple loosestrife and the vision of Purple Loosestrife Project leadership, team members brainstormed and refined ideas for educational activities. Two teams were asked to draft and field test materials prior to publication of the draft March, 1998 *Cooperator's Handbook* with the understanding that their work would be scrutinized, adopted and adapted by a larger group of teaching professionals throughout the spring and summer of 1998. To assure broad acceptance and utility, all Purple Loosestrife Project teaching materials are field tested and improved prior to publication for distribution.

The Primary School Writing Team chose to develop a unit with lessons grouped in three sections: Mission; Life on Earth, Invasion of Purple Loosestrife, and Biological Control of Purple Loosestrife. This approach appeals to elementary school teachers, who as generalists, appreciate bundling of essential elements.

The Secondary School Team chose to develop discrete activities that, along with selected background materials provided in the *Handbook* and/or collected locally, could be used by classroom teachers as lessons.

Abstracts of Activities for Young Adults (Grades 6–12)

See the complete activity text for Methods, Objectives, Materials, Procedure, Extensions, Evaluation, and Correlation to the Michigan Department of Education Curriculum Framework.

1 Aliens Among Us

■ GRADE LEVEL/SUBJECT

High school/science

■ INVESTIGATION

Each organism in an ecosystem survives in relationship to other organisms (biotics) and physical nonliving environment (abiotics). How does introduction of a nonindigenous species affect the dynamic balance of native ecosystems? What is the biotic potential of a species? What biotic and abiotic factors influence species survival?

■ PROCEDURE

Students investigate plant species in the schoolyard, chart abiotic and biotic limits to population growth, create an imaginary exotic species to compete with chosen schoolyard plants and relate discoveries to the problem of purple loosestrife.

2 Annual Wetland Plant Diversity Survey

■ GRADE LEVEL/SUBJECT

High school/science, mathematics

■ INVESTIGATION

Changes in plant community diversity prior to and during a biological control project are used to evaluate the control method. How do scientists measure plant communities? Is biodiversity increased after purple loosestrife's natural enemies are introduced? What is a diversity index, and how does it change over time? What changes in habitat result with biocontrol?

■ PROCEDURE

Students randomly locate and establish one meter quadrats in a purple loosestrife infested wetland, count plant stems, calculate percent of species coverage, and extrapolate for the entire wetland. A diversity index is created prior to beetle release, and each spring thereafter.

3 An Insect Life Cycle

■ GRADE LEVEL/SUBJECT

High school/science

■ INVESTIGATION

Insects pass through a series of stages in development from egg to adult. What are these stages and how is the life cycle of *Galerucella sp.* similar to and different from some common insects such as the common fruit fly (*Drosophila melanogaster*)?

PROCEDURE

Students will trap adult fruit flies and describe the development from egg to adult, comparing it to that of beetles. In doing so, they will learn standard methods for handling fruit flies and develop a colony for later study of population growth. Students may also raise mealworms (*Tenebrio sp.*, available from many pet shops and easily grown in bran meal) to compare the life cycle with that of *Galerucella sp.* Allow approximately 20 minutes, two days per week, for four weeks.

4 Is Purple Loosestrife a Problem Near Our School?

■ GRADE LEVEL/SUBJECT

High school/science, social studies

■ INVESTIGATION

Do we have a purple loosestrife problem in our community? Where is it? Since the scale of the problem dictates which control method is best, what choices do we recommend? Is biological control, pulling, flooding, or some other control method called for to protect the community's wetlands from invasion? How does the picture look this year, compared to last year, or the year before?

■ PROCEDURE

Students learn to identify purple loosestrife and log their observations around the community. Aerial photographs, walking, bicycling, private automobiles and class outings are used to survey the community. Logs are transferred to local maps, which can be used while making control recommendations to public officials.

5 What's Wetland Allelopathy?

■ GRADE LEVEL/SUBJECT

High school/science

■ INVESTIGATION

Allelopathy is the production of phytotoxic substances by plants. How do neighboring plant extracts affect each other? Are there native wetland plants that disperse chemical substances which inhibit or increase growth of purple loosestrife? Does purple loosestrife work its magic on neighboring plants?

■ PROCEDURE

Students collect leaves of purple loosestrife and neighboring wetland plants, create a slurry extract and apply to competing plant seedlings.

6 What's in the Water?

■ GRADE LEVEL/SUBJECT

High school/science

■ INVESTIGATION

Water chemistry and aquatic organisms are indicators of wetland water quality. How do we define water quality? What are the chemical and biological characteristics of the water in this wetland? How do these factors influence plant growth? Are there correlations between water chemistry/aquatic organism content and purple loosestrife infestation? Are there differences in the water of purple loosestrife infested/noninfested wetlands?

■ PROCEDURE

Students collect and test for pH, nitrates, oxygen, phosphates, other chemistry and macro-invertebrates.

7 Beetle Collection and Release

■ GRADE LEVEL/SUBJECT

High school/science

■ INVESTIGATION

Native plants have native predators that tend to limit every plant's population. Purple loosestrife's natural enemies are not native to this area, but once introduced they can successfully reproduce and impact the population of purple loosestrife. Is there an observable difference in insect plant predation (herbivory) between nonnative purple loosestrife and other native species? How do scientists and resource managers inoculate infested areas with biological control agents? What difference does this inoculation make?

■ PROCEDURE

Students observe and collect native plants and purple loosestrife for herbivory observation. This observation will be the baseline data. Students release approximately 5,000 adult *Galerucella* beetles in the observation area for continued observation.

8 Beetle Rearing

■ GRADE LEVEL/SUBJECT

High school/science

■ INVESTIGATION

Galerucella beetle populations can be substantially increased in a few months if provided nutrition and protection from predators. How do scientists and resource managers breed natural enemies of purple loosestrife? What special care must be taken with purple loosestrife's natural enemies if we wish to nurture them?

■ PROCEDURE

Students place about 200 *Galerucella* beetles into caged purple loosestrife environment to establish a summer rearing project.

9 The Abiotic Limits to Purple Loosestrife Growth

■ GRADE LEVEL/SUBJECT

High school/science

■ INVESTIGATION

All plants, including purple loosestrife, survive and thrive where soil, water, and solar energy amounts are within the limits necessary for the particular species. How do soil temperature, water availability and photoperiod effect purple loosestrife growth? Are there combinations of these conditions that slow or accelerate growth?

■ PROCEDURE

Students conduct indoor research on the effects of soil temperature, water availability, and photo period.

10 How Do We Know These Insects Are Safe to Use?

■ GRADE LEVEL/SUBJECT

High school/science

■ INVESTIGATION

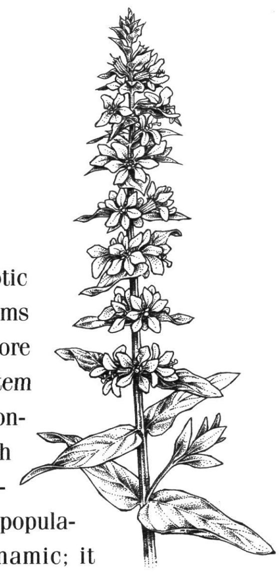
Importation of insect natural enemies for biological control of weed plants is subject to government approval after testing for host specificity to reduce the risk that the insect might create more problems than it solves. What tests were done for purple loosestrife's natural enemies? Which native plants and animals were tested? What interrelationships were considered? Does *Galerucella* feed on plants we are concerned about? What damage is caused?

■ PROCEDURE

Students tent purple loosestrife with other plants, nurture both species to health, and then introduce *Galerucella* to the tent. Impacts are recorded on a number of species, before, during and after substantial purple loosestrife defoliation.

ACTIVITY ONE

Aliens Among Us



Objectives

Students will become familiar with the impact of exotic species on ecosystems (with application to purple loosestrife) by investigating a local school yard plant's biotic potential and environmental resistance, creating an imaginary exotic plant to compete for the local plant's niche and evaluating the possible results.

State Curriculum Framework Connections

Science: I.1.1, I.1.7, I.2.5, II.1.1, III.2.4, III.5.3, III.5.4, III.5.6

Social Studies: II.2.2, II.4.3, II5.2, V.1.1

Method

In groups of two, students will discover and apply information about a schoolyard plant's biotic potential and environmental resistance. Students will chart the information and predict results of the introduction of an imaginary invader species and apply this learning to the problem of purple loosestrife.

Terms

Biotic, abiotic, biotic potential, environmental resistance, indigenous species, nonindigenous species, exotic species.

Background

Each organism in an ecosystem survives in relationship to other organisms (biotics) in the ecosystem. Each organism is also effected by its physical non-living environment (abiotics). The organism's push toward growth is its biotic potential. Some of the factors that increase the organism's biotic potential (increasing likelihood of survival) are its reproductive and growth rate, its ability to migrate and invade new habitats, defense mechanisms, heartiness and ability to cope with adverse conditions. Factors that offer environmental resistance (limiting factors decreasing likelihood of survival) are insufficient water, nutrients, suitable habitat, adverse weather conditions, predators, disease, and competition for environmental features. At all times, the biotic and abiotic factors in the environment limit growth of the individual organism, and its kin—its total population—is under the influence of biotic and abiotic features in the environment. As ecosystems evolve and become more diverse and more stable, the organisms within the ecosystem achieve a dynamic balance—each is connected and dependent on the others. Each organism's biotic potential and environmental resistance interact to keep the populations balanced. This balance is dynamic; it changes over time. If some of the interaction between species is lost, if the balance is upset, the web of connections may begin to unravel. As people have traveled from place to place, they have altered the environment and carried along (sometimes purposefully and sometimes accidentally) species of plants and animals not indigenous to the area. Those which are introduced and begin to thrive are called nonindigenous species. Many introduced species never become established and their populations simply collapse within a generation or two. Successful invaders have upset the balance of native ecosystems by permanently altering the biotic potential and environmental resistance. When an exotic species invades an ecosystem, it often has a much greater native biotic potential and little environmental resistance compared to native species. If it is able to outcompete the indigenous organisms for space, nutrients, water, etc. It may be able to out-reproduce the local species. To maintain the health of native ecosystems, to make informed personal and community choices, it is important to be aware of the impact of exotic species such as purple loosestrife, zebra mussels, sea lamprey, spotted knapweed and the goby fish to name a few.

Materials

Plant identification books, clipboards, plain paper (for extension: soil moisture, pH, weather data, more).

Procedure

1. In the classroom, introduce the concept of dynamic balance between biotic potential and environmental resistance relative to population growth. Take a mini field trip outside in the school yard. Ask students, in groups of two,

to identify plants growing in the school yard and choose one for further investigation.

2. Create a chart to list the biotic potential and environmental resistance for the chosen schoolyard plant using plant books, encyclopedias, the Internet, and field observation.

Example: *Quackgrass*

BIOTIC POTENTIAL	ENVIRONMENTAL RESISTANCE
REPRODUCTION: grows by runners and seeds	COMPETITORS: dandelions, crabgrass, etc.
GROWTH: rapid	WATER: tolerant of wide variation
MIGRATION: man spreads it	PREDATORS: few visible signs of predation. Mowed by people.
COPING: hardy, thrives in most soil	DISEASE: few signs of disease

3. Discuss limiting factors and predict the chosen plant's population growth in the schoolyard.

4. Ask the same groups of two students to create an imaginary exotic plant species; chart biotic and abiotic limits to growth, biotic potential and environmental resistance. Draw a picture of the exotic plant. Draw a web for the chosen plant with other organisms observed in its ecosystem. Predict the population growth of the chosen plant relative to other organisms in the web.

5. Describe how the imaginary species would get into the chosen plant's ecosystem, and based on its biotic potential and environmental resistance, discuss ways people could control its spread.

6. Hand out a reading on purple loosestrife. Read and discuss how it arrived and spread. Create a class chart for purple loosestrife.

7. Create several hypotheses about the impact of purple loosestrife on an ecosystem. Defend the hypotheses with information about biotic potential and environmental resistance. Compare to the scenarios developed by the class for school yard plants.

Extensions

As a scientist, if you were to observe an increase in purple loosestrife over the next several years, what inferences could you make? Using the Internet, gather information on the spread of purple loosestrife over the last 100 years. Describe how your inferences compare to the historical record.

Interview people living in the area where there is a purple loosestrife infestation. Find out what they remember about the plant. How long has it been there? How fast have the numbers increased?

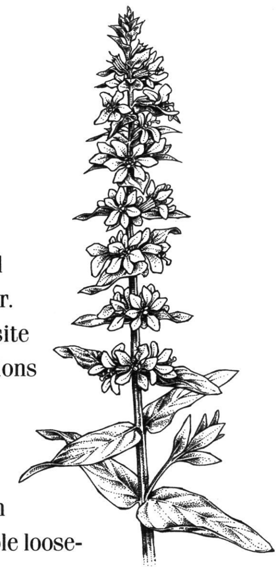
Evaluation

Student presentations to class of their research on a local plant and imaginary exotic species including prediction of population growth of both in relationship to each other. Teacher observation of understanding of concepts of biotic potential and environmental resistance and the effects on the populations.

ACTIVITY TWO

Annual Wetland Plant Diversity Survey

Relating wetland plant species diversity to the degree of infestation by purple loosestrife



Objectives

The student will use a standard method for calculating the diversity of a plant community and determine whether purple loosestrife population density is correlated to the diversity of the community.

State Curriculum Framework Connections

Science: I.1.1, I.1.3, III.5.1, III.5.3

Social Studies: II.2.4, II.4.3, V.1.2

Method

One square meter quadrats will be selected randomly in a wetland containing areas of differing levels of loosestrife invasion. The numbers and areas covered by each species of plants will be recorded and used to calculate a diversity index using the formula

$$\text{diversity} = -\sum p_i \cdot \ln(p_i)$$

where p_i is the number of individuals of one species divided by the total number of individuals in the sample. The diversity values obtained will be plotted in a scatter plot versus the percentage of the total plant population represented by loosestrife.

Background

One of the major problems with the presence of loosestrife often cited by researchers and resource managers is that it tends to crowd out other wetland plants and reduce the diversity. This reduces the variety of available foods for herbivores, space for nesting of wetland birds, and turns the infested area into a "biological desert". If this is true, students should see a very strong negative effect of loosestrife density on the diversity index. If the expected relationship does not appear, this will provide a chance for further research or refinement of techniques.

Materials

Six clipboards, one ten meter tape measure, five quadrat markers made of 1" plastic pipe or meter sticks taped together at the corners, four corner stakes (60" each), hip boots or old sneakers, tally sheets and site maps, calculator and graph paper. [Optional: aerial photos of the study site and/or maps, camera to record operations and allow later checking for accuracy]

Procedure

Locate an area of marsh in which some areas are heavily infested with purple loosestrife, other areas have some plants and some areas are not yet infested. Otherwise conditions in the areas should be as similar as possible with regard to wetness, soil type, drainage, etc. Show the students the quadrat markers and ask for volunteers to place them and record notes. Locate a ten meter quadrat in each of the areas described and stake the corners. Measure diagonals to ensure a square. Position one student in the center and one in each corner and have them carefully position the quadrat markers in the center and four corners. Have the students draw a picture of the plot and their location labeled "1," "2," "3," "4" in any order around the perimeter. Complete the field notes forms with a count of the number of stems per square meter for each plant species found. Rotate the quadrat by 45 degrees and repeat using a different group of students. Combine the field notes to calculate the percentage of stems of loosestrife in the plot. Also use the data to calculate the diversity index for each plot. On a piece of graph paper, plot the diversity index for each quadrat as a function of the density of purple loosestrife in the one meter squares.

Extensions

Using standard references, find and use different diversity indices to compare the plots. Remove all loosestrife plants from the same ten meter square plot as soon as growing plants can be identified in the spring and keep the loosestrife plants from growing by periodic weeding during the summer. Calculate the diversity index for the same plot the following September.

Evaluation

Student performance in this activity may be evaluated by:

- Observation during the activity.
- Informal questioning and discussion before, during and after the activity.
- Ask the students to discuss in written form the reason for doing this activity, the expected result, and what was actually observed.
- Ask the students to predict the results of releasing *Galerucella spp.* in the study plots and justify the prediction.
- Have each student write up the activity as a formal scientific report and evaluate using the standards used for other lab write-ups.
- Have groups do a poster or presentation on the investigation and its results.
- Ask students and/or groups to suggest further investigations based on the results of this one.

ACTIVITY THREE

An Insect Life Cycle

Development of *Drosophila melanogaster* (common fruit fly)

Objectives

Students will observe the development of a common insect *(Drosophila melanogaster)* through all of its life stages and compare it to the life cycle of beetles (*Galerucella spp.*) and other common insects. Mealworms (*Tenebrio spp.*) may be substituted because their life cycle is more similar to that of *Galerucella spp.*)

State Curriculum Framework Connections

Science: I.1.1, I.1.3

Methods

Students will trap adult fruit flies and describe the development from egg to adult, comparing it to that of beetles. In doing so, they will learn standard methods for handling fruit flies and develop a colony for later study of population growth. Students may also raise mealworms (*Tenebrio spp.*, available from many pet shops and easily grown in bran meal) to compare the life cycle with that of *Galerucella spp.* Allow approximately 20 minutes, two days per week for four weeks.

Background

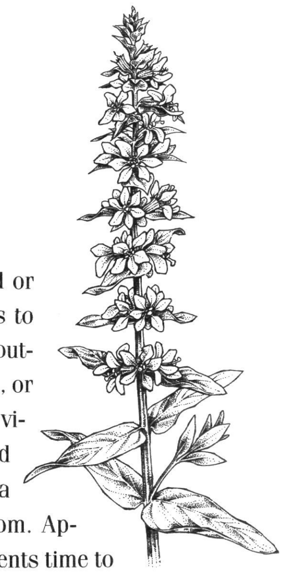
In order to understand interactions between Purple Loosestrife and *Galerucella spp.* It is necessary for students to become acquainted with its life cycle and development. Fruit flies and mealworms provide model populations that have a shorter life cycle and are much easier to obtain and maintain. In the process it will also be easier for students to understand the concept of exponential growth and limiting factors.

Materials

Two or three baby food jars or wide mouthed glass vials per group, small piece of ripe banana, cotton batting and cheesecloth for stoppers, hand lense or stereo microscope.

Procedure

Have students label the vials or jars with their name and date and place a 1-inch section of a ripe banana in the bottom. Insert a small strip of index card or heavy paper into the banana for adults to rest on and pupae to be attached. Place outside in a shaded location for 1 to 2 days, or until adult fruit flies are seen inside the vials. Stopper with a cotton ball wrapped in cheesecloth and place the vial in a warm shaded location of the classroom. Approximately every other day, allow students time to observe the development of eggs and larvae using a hand lense or stereo microscope.



These may be removed for study with a cotton swab or wooden splint. Students should make careful drawings of all stages seen together with written descriptions of changes and behavior. When adults appear, some may be transferred into another vial and inactivated for study by placing the vial in an ice bath until chilled to inactivity. As time progresses present pictures of the life cycles of other insects, including beetles and *Galerucella spp.* Proper terminology should be taught at this time.

Extensions

Depending on the season, it may be possible to observe some of the stages of development of *Galerucella spp.* on Purple loosestrife plants or of other insects on other host plants. A record of the population size of the fruit flies may also be kept. It will be necessary to transfer colonies to new medium if the old medium becomes moldy. If photographic or video equipment is available, students may document the stages of development with still or video pictures and present the results to the class. In addition to or at the same time as the above investigation, students may set up and observe a colony of the common mealworm (*Tenebrio spp.*). These may be obtained from most pet shops and easily maintained in plastic or glass containers of bran cereal. These are much larger than *Drosophila spp.* and may be handled with forceps and viewed with a magnifying glass or stereo microscope.

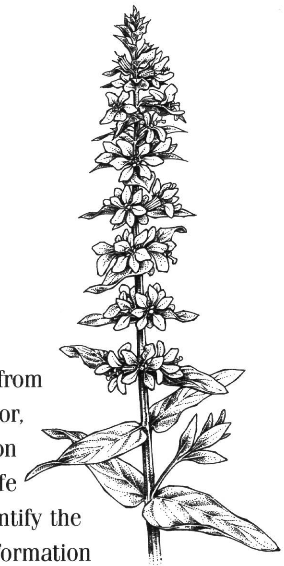
Evaluation

The following factors may be taken into account in evaluation of student progress:

- Lab book with drawings and observations is evaluated as the project goes on. Grade will be based on accuracy of drawings, number and quality of written observations.
- Students should be observed as the project proceeds and graded on the basis of technique, involvement, cooperation and interaction with group members.
- Students may be quizzed on the details and terminology of insect development as information is presented.
- Groups may be graded on the quality of a presentation such as a poster, multimedia presentation, or video.

ACTIVITY FOUR

Is Purple Loosestrife a Problem Near Our School?



Objectives

Students will cooperate to prepare a comprehensive map showing the distribution of Purple loosestrife in the school district area and collect other data relevant to its distribution and control.

State Curriculum Framework Connections

Science: I.1.1, I.1.7

Social Studies: V.1.2

Methods

Each student will locate as many patches of purple loosestrife as possible in the area surrounding his/her residence and fill out a standard form which can be used to plot the distribution and density of the species for the school district area. The location of loosestrife stands are marked on a large road map of the district with the color of the push pins representing the percentage of ground covered by the plants.

Background

In order to devise a comprehensive plan for the control of purple loosestrife in wetlands, it is necessary to know the location of stands, their extent and density. Different means of control may be used depending on the size of stands and their density. In very small stands with low densities of plants, control may be a matter of pulling the plants before they set seed for several years in a row. In other situations, weed-killing chemicals may slow the spread. In the thickest of stands, biological controls may be the best method.

Materials

Large school district map, such as that used by the school bus system showing street names, roads and water bodies. A box of push pins with heads of at least four colors. Standard forms to record information on loosestrife stands. One or more USGS topographic maps covering the same area as the road map on which to compile and accurately locate the distribution of the plants.

Procedure

Obtain a large school district map from the bus garage, transportation supervisor, school district office, or county extension office. After discussing the loosestrife problem and teaching students to identify the plant, distribute cards for recording information about stands of loosestrife. Students will take these home and attempt to locate all of the existing stands of purple loosestrife within a 1 km radius of their home. The student will fill out one card for each distinct stand of the plant, listing the location of the stand, approximate number of plants, density of plants and other information obtained. A small sketch map on the reverse side of the card may be useful in precisely locating the stand and its size. Data from the record cards is then plotted on the wall map and a master topographic map of the school area. Additional information extracted from the cards can be charted or used to construct tables and graphs.

Extensions

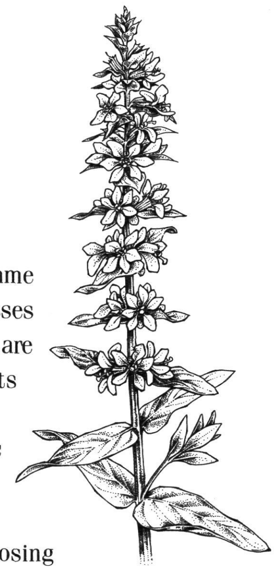
Other wetland species, such as cattails, sedges, willows, etc. could be mapped at the same time on the same map by using other colors of push pins or different head sizes. Or each species could be mapped on separate acetate overlays to fit over the map. The distribution of species could be compared to a soils map of the same area, obtainable from the county extension office. Photos of areas mapped could be placed around the map and connected to their location by colored strings.

Evaluation

Students may be asked to generate testable hypotheses relating to the distribution shown by the maps. They may be asked to make predictions about areas that might be the next ones to be invaded by loosestrife. The number and quality of record cards submitted could be used in assigning extra credit or contributing to the marking period grade.

ACTIVITY FIVE

What's Wetland Allelopathy?



Objectives

Students will construct an experiment of allelopathic interactions between wetland plants, including purple loosestrife and evaluate results. Students will develop questions, hypothesis, experiment and analyze results beginning in the field and concluding the experiment in the classroom.

State Curriculum Framework Connections

Science: I.1.1, I.1.2, I.1.3, II.1.1, II.1.5, III.5.1, III.5.3

Methods

Students will make plant extracts from chosen wetland plants and test their allelopathic effects on the germination rate, radicle and hypocotyl growth of test seeds. The experiment can take from 2 to 4 or more weeks depending on the germination time of the test seeds chosen as bio-indicators.

Terms

Allelopathy, competition, wetland, exotic species, radicle, hypocotyl, germinate, biotic potential, environmental resistance, succession.

Background

Plants need sunlight, nutrients, water, air and protection from harm in order to thrive and survive. When plants are overcrowded and do not have enough space, they cannot meet their needs. Plants, like animals compete with other plants for the same spot in the soil to put down their roots, take in nutrients, water and sun. For some plants, crowding invites predation and the threat of spreading fire. It may benefit a plant to make sure other plants of the same species or different species do not grow too close. Many plants produce chemical substances that are phytotoxic (harmful to other plants). In this way, the plants keep other plants out their space. This chemical process is called *allelopathy*.

There are several kinds of chemical allelopathy. In one kind, a plant releases protective chemicals into the soil from it's roots. Other plants growing next to the allelopathic plant or seeds germinating near by absorb these chemicals and die. Another way allelopathic plants keep other plants from growing too close is the leaching of chemicals from decomposing leaves into the soil with the same results. Some plants even release gasses through their stomata into the air that are "breathed" by neighboring plants inhibiting their growth.

An example of an allelopathic plant easily observed is the pine tree. Few plants grow where a pine tree has shed it's needles. The decomposing needles contain acid which leaches into the soil stifling the germination of other plants. Weedy field plants and some trees competing in the intermediate stages of succession such as pines, tree of heaven, some ferns and sagebrush are more likely to produce these chemicals. Even large trees like the black walnut are allelopathic.

The exotic species, purple loosestrife, is rapidly colonizing the wetlands of North America. It easily invades an area that is disturbed and quickly out populates the indigenous wetland species such as cattail, sedges and rushes. For this introduced species, there is little environmental resistance from predators and high biotic potential from reproduction as each plant produces up to two million seeds each year. Could there be other factors that add to its success such as allelopathy? Might there be other plants that are allelopathic to purple loosestrife that might serve as a control to it's aggressive colonizing of wetlands?

The major purpose of this activity is for the student to evaluate a wetland site and create their own experiments using available wetland plants, including purple loosestrife, to test for alleleopathic interactions. There is little if any research available in this area. Findings could contribute to a growing body of knowledge about purple loosestrife and it's control in North America.

Materials

Scissors or plant clippers, plastic bags, access to a wetland, triple beam balance or other scale, medium size jars with lids, distilled H_2O, beaker or other liquid measuring device, seeds, petri dishes, absorbent paper towels, small cm rulers for groups.

Procedure

1. Classroom discussion of plant competition, succession and possible uses of chemical by plants for their protection. How do chemicals contribute to the plants survival? What role do they play in succession? Discuss allelopathy and the role it might play in competition and succession. Begin journal for allelopathy and record discussion information.

2. Visit a wetland populated with some purple loosestrife as well as other species. Identify the more dominate species. Students ask questions about possible allelopathic interactions between the identified plants. Choose several plants to test for possible allelopathy. Decide which seed or seeds will be bio-indicators. Record in journal. Collect 10 or more leaves for each chosen plant. Place leaves in labeled plastic bags. Try to guess which plants might be allelopathic from observing the plants in their natural setting. Record field observations. Refrigerate leaves if next step is not immediate.

3. Weigh 10 or more grams of leaves. Tear the leaves into small pieces and place in a labeled jar. Add 100 ml of distilled water and crush leaves with a spoon, stirring to mix. The amount does not matter, just keep the procedure the same for all. The leaf liquid should be very dense, pasty. Swirl several times a day for 3 or 4 days. If not used at this time, refrigerate up to a month.

4. As a class or in cooperative groups generate a hypothesis. List the plant extracts plus a plain water control. Students rank each plant they choose based on field observations. Choose seed for bio-indicator. These could be seeds from one or more wetland plants or a quick growing seed like a radish.

5. Label petri dishes. Place several seeds (4 or 5) in folded paper towel in bottom of petri dish. Measure enough plant extract water onto the paper towel to soak it. Be sure the plant extract used on the seeds matches the label on the petri dish. Place lid on dish and place in the dark. Check periodically, and rewater with extract. Keep the amounts the same for all petri dishes.

6. Record germination date. Record the radicle and hypocotyl growth daily for approximately five days. Record qualitative information about the seeds. Chart qualitative results.

7. Calculate means, graph, chart quantitative results. Discuss your results and draw conclusions.

Extensions

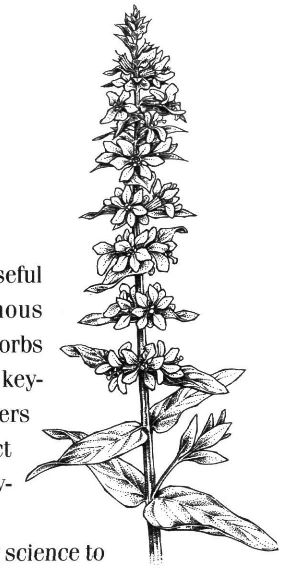
- Try other allelopathic interactions.
- Try using extract to water mature plants.
- Go on line and find the results of other scientists investigation into allelopathic interactions.
- Create a visual representation of your findings.

Evaluation

Create a written summary of results and their implications for wetlands and purple loosestrife. Combine allelopathic information with other biotic potential for the purple loosestrife. Measure that against any known environmental resistance. Suggest what can be done.

ACTIVITY SIX

What's in This Water?



Objectives

Students will seek to answer the questions; What are the chemical and biological characteristics of water in which purple loosestrife occurs? Do these characteristics differ in wetland water dominated by indigenous wetland plants (cattails, rushes, sedges, etc.)?

State Curriculum Framework Connections

Science: I.1.1, I.1.2, I.1.3, I.1.6, II.1.1, III.5.4, III.5.5, III.5.6, V.2.3

Social Studies: II.2.4, V.1.2, V.2.4

Methods

Students will locate two wetlands one with and one without a medium to high density of purple loosestrife. Using water quality measuring kits (Hach kits are inexpensive and work well for classroom use), nets and containers, students will sample and test the water for temperature, pH, nitrate nitrogen, oxygen, phosphates and macro-invertebrate indicators (all or part of these tests may be used).

Background

A wide variety of information is valuable in understanding the impact on and spread of purple loosestrife. Scientist are in the process of gathering data on this widely spreading plant. In Canada, scientists mapping the location of purple loosestrife noticed that it has not taken hold and spread in more acidic waters and soils of the Canadian Shield but is found widespread in the more basic water and soils south of the Canadian Shield. Could the type of water and soil predict the spread of purple loosestrife?

Cattails and other keystone wetland species are known to cleanse water of pollutants such as nitrates, phosphates, chlorines and other more dangerous pollutants originating in waste water, runoff, industrial discharges and farm runoff. These herbaceous, absorbent plants help capture and hold, use and change, pollutants—and provide a barrier to sediment runoff as well as a sponge for excess water. Indigenous plants provide a breeding place for organisms of all sizes and types.

Purple loosestrife forms dense stands of vegetation crowding out other species. It is not useful for shelter and food as are indigenous plants. There is no indication that it absorbs and alters pollutants as do the major keystone wetland species. It definitely alters the ecosystem. Might this change effect the water and invertebrate organisms living in it?

It is important for students studying science to do real science and to do something useful with their findings. Exploring questions, using the scientific method, and communicating data to others builds true scientific literacy.

Materials

Hach kits for water quality tests chosen, thermometers, D nets or even small, department store fish nets, plastic jars for dipping, containers to transport biological samples, trays for observing biological samples, eye droppers and tweezers to place organisms on slides, dissection scopes or Brock optical magiscopes, biological indicator chart, and data sheets.

Procedure

1. Using a USGS map, school district map, or county map, locate accessible local wetlands and ask students to assess them independently for stands of purple loosestrife. Choose one with and one without a medium to high density of purple loosestrife. The sites should be similar in as many ways as possible to control for intervening variables such as impact of nearby human activity or amount of water and depth. Obtain permission to use the site for sampling.

2. Create data sheets to record chosen water quality tests in several locations at each site.

3. Assign groups of students to each location at both sites. Groups assign each student tasks to perform during the sampling. Set parameters for sampling so that each group uses the same techniques. Do some research on the meaning of results for each water test.

4. Visit site. Record qualitative observations of the site including kind of vegetation (algae, submerged plants and

emergent plants), human use of site and surrounding area, visible animal life, overall impressions of the site. Record also an estimate of the amount of different kinds of vegetation, animals etc. If it is not possible for the class to visit the site, individual students could visit the site outside of class and bring observations and samples in for analysis.

5. Collect water samples and biological samples for testing. Running the tests and observing for invertebrates can be done on site or back in the classroom.

6. Complete water chemistry tests as soon as possible. If water is held overnight, hold it in a closed container and refrigerate. Observe and record amount and kind of invertebrates sampled. Use pollution tolerance index for invertebrates. Complete data sheets for each site.

7. Repeat for the other site.

8. Compare the two sites using charts, graphs (visual representation), written description and group discussion. Did you notice any differences? Can you account for the differences based on what you observed on or near the site? Might the purple loosestrife account for the differences? If there are no differences, what do you conclude?

8. Contribute your data to the state Purple Loosestrife Project. Publish it in your local press with an explanation.

Extensions

Find other schools that could do the same experiment and compare data. Discuss similarities and differences.

Compare water quality data to open water, ponds, lakes or streams in your area. Explain your findings.

Evaluation

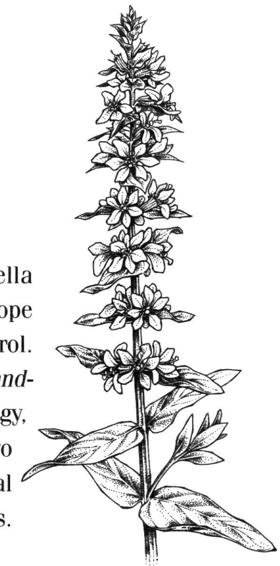
1. A completed scientific investigation including student created question, hypothesis, experimental design, data collection, analysis and justification of conclusions based on data.

2. Observation of student use of water quality testing equipment and methods.

3. Presentation to class with graphics and explanation.

ACTIVITY SEVEN

Beetle Collection and Release



Objectives

Students will observe and investigate natural enemies of indigenous wetland plants or indigenous on-site school plants and compare them to the observable enemies of purple loosestrife. This activity may be done as a field observation, hands-on classroom activity or research activity. Students will then release *Galerucella* beetles (a purple loosestrife natural enemy) in a local loosestrife infested area.

State Curriculum Framework Connections

Science: I.1.1, I.1.2, I.1.3, II.1.1, II.1.3, II.1.5, III.5.1(Middle School-M), III.5.2(M), III.5.3(High School-H), III.5.4(H), III.5.6(H)

Methods

Students will locate an infested wetland for on-site purple loosestrife and indigenous plant herbivory observation and/ or teacher/student will bring in samples of loosestrife and indigenous plants to classroom for observation. Students will either shake down the plants for possible natural enemies and/or record signs of herbivory in the classroom and compare the natural enemies of indigenous plants to local purple loosestrife. Students will then predict possible impacts on plant populations based on observed evidence. After learning about purple loosestrife and *Galerucella* beetles, students will release these natural enemies in the wetland.

Terms

Herbivory, predators, indigenous and nonindigenous species.

Background

Ecosystems evolve a dynamic balance between their many species. Predation is a part of that natural balance. Indigenous plant and animal populations are kept in check by indigenous predators. Nonindigenous species threaten ecosystems because invaders frequently do not have predators, so the invaders often have the ability to disrupt the existing ecological balance, dominate an area and have adverse unforeseen consequences. Purple loosestrife is an invading species with few if any local natural predators. The USDA has approved the Galerucella beetle, a natural predator from Europe for use in purple loosestrife control. Section Two of the *Cooperator's Handbook* provides details on the biology, ecology and management of these two organisms, and includes additional references for teachers and students.

Materials

White bedsheets, scissors or plant clippers, small sealable plastic bags, and large plastic bags, tweezers, magnifying glasses, insect identification books, microsopces (dissection, field or Brock optical scopes), a source for Galerucella beetles and a wetlands location with purple loosestrife.

Procedure

1. Locate a site with a fairly large, medium to heavy infestation of purple loosestrife. (Much of this activity can still be done if a site with just a few loosestrife is the only available site.) Arrange a field trip to the site or find someone to collect at the site. Obtain landowner permission.

2. While on site, students individually or in groups of two, map and record site observations such as surrounding human activity, plant and animal life, water amount and flow etc. Students draw map noting surrounding roads and locating observed plants and animals, water, etc. On map, note time of day, year, and weather observations. This may impact findings.

3. Divide students into groups of 3–4 for collection. To collect data in the field, students choose several indigenous plants on the site to compare to the purpleloose strife found there. Sit or stand quietly and observe the plants for visitors that might be feeding. Record any observed insects or birds feeding on the plants. Collect predator data by shaking the plants over a sheet and putting contents of sheet into individually marked small sealable bags for later identification. Using the same plants record the observable signs of herbivory, holes and chewing on leaves, and stems. Use the same number of each plant and randomly observe

the same number of leaves and stems for herbivory on each plant. Cut a sample or two of each plant to bring back to the classroom for further observation.To do data collection solely in the classroom, samples must be cut in the field and brought into the classroom for herbivory observation. Each specimen should be carefully bagged in the field to preserve any resident feeding insects. Each plant should be cut off at ground level.

4. In the classroom, observe, identify and record different kinds and numbers of organisms found on the plants, including fungus. Using identification books try to identify organisms associated with the plant. Covering the desks or tables with sheets of white paper facilitates observation. Observe and record signs of herbivory on selected leaves and stems. The book *Eco.Inquiry*, published by Kendall Hunt, is recommended for graphic examples of herbivory, in addition to the materials found in Section Two of the *Handbook*. Chart and compare data. Is there any difference between predation on indigenous plants and on the purple loose strife? Student may also do print material or internet research on their chosen plants about possible predators and other limits to growth.

5. Present group findings to class with predictions for future population growth of the chosen plants compared to the purple loosestrife based on data collected.

6. Read and discuss the use of *Galerucella* beetles as predators for purple loose strife control.

7. Obtain *Galerucella* beetles. If you are uncertain where to acquire beetles, contact the Purple Loosestrife Project office. Arrange another field trip to set up the beetle release and observation site. Follow the Purple Loosestrife Project protocol for beetle release, (See *Handbook* Section Two), and release the beetles to prey upon the plants.

8. Keep a running biannual observation log (spring and fall) of the beetle release site and how the hervivory relationship between purple loosestrife and other indigenous plants changes over time. This activity will become richer over the years. The same herbivory observation can be done year after year in the same place. It should be interesting to trace the impact of the beetles on the purple loose strife and observe if the beetles impact any other plants in the area.

Extensions

A practice trial of this activity could be done with any plants in your local school yard.

Students of different school districts will compare information via the Purple Pages website when available. Meanwhile, use e-mail, fax, or the postal service to provide information to the Purple Loosestrife Project office, using input forms provided. See the Purple Pages at *www.msue.msu.edu/seagrant/pp* or contact the project office for details.

Evaluation

Evaluation can be based on observation of students careful methodology with data collection, written record of observations and communication to class of predictions.

ACTIVITY EIGHT

Outdoor Beetle Rearing

Objectives

Students will learn techniques for rearing wetland plants using inexpensive materials available locally, keep accurate records of plant growth and development, raise beetles to release for purple loosestrife control or to provide to other cooperating schools and groups, observe the life cycle of *Galerucella spp.* over an extended period, learn about several abiotic and biotic factors affecting the growth of purple loosestrife and *Galerucella spp.*

State Curriculum Framework Connections

Science: I.1.1, I.1.3, III.5.1, III.5.3, III.5.4

Methods

In small groups, students will collect root crowns, prepare pots, plant the root crowns, and care for the potted plants. When the plants reach the right size, beetles will be released onto mesh cages surrounding the plants and pots and their growth and development monitored. At the appearance of the new generation of adults, the beetles will be released at several heavily infested sites and their progress and effects on the loosestrife plants monitored through the summer into the fall. Following is a typical timeline for rearing and releasing *Galerucella* beetles: (1) pot root crowns, April 5; (2) place beetles into cages, May 10; and (3) release beetles, June 15–30. (Times will depend on local conditions.)

Background

In order to have an adequate supply of beetles to release for loosestrife control, it is necessary that the beetles be cultured in large numbers. This cannot be easily done in the indoor facilities of most schools, but many schools have courtyards or other outdoor areas protected from vandal or animal damage in which large numbers of loosestrife plants can be maintained. This not only helps with the supply of beetles needed, but it gives students knowledge and skills useful in growing and propagating other flowering plants. It also provides an opportunity for students to design and carry out other experiments or observations on the plants not used to grow beetles.

Materials: Outdoor Beetle Rearing Kit

Many of these materials may be obtained by soliciting local businesses for donations of materials.

ITEM	COST	QUANTITY
Wading pool (6 ft. diameter)	$15.00	1 ea.
Wire tomato cage (42 inches)	$2.50	15 ea.
Soilless mix (Baccto High-Porosity Professional Planting Mix, 40 qt., or similar product)	$4.00	2 ea.
Osmocote fertilizer 14-14-14 NPK	$12.00	2½ lb.
Four-gallon pot	$1.00	15 ea.
Six-foot metal fence posts (T-Post)	$2.00	4 ea.
Heavy-duty string	$1.50	1 ea.
Sleeve cage (Provided by MSU)	—	12 ea.
Aspirator (Provided by MSU)	—	1 ea.
PVC pipe (8 ft.)	50¢/ft.	5 ea.

Procedure

Locate a wetland area near school with a large population of overwintering purple loosestrife plants and collect approximately 20 root crowns with 5–6 stems. If this is done in the fall after the plants have become dormant, the root crowns may be stored under a tarp or other cover till spring. Alternatively the root crowns may be dug in March before they are actively sprouting and potted immediately. A plastic wading pool about 6 feet in diameter is used to supply water to the potted plants during growth.

Fifteen four-gallon pots are half filled with a non-soil potting mix, a tablespoon of slow release fertilizer such as Osmocote is sprinkled on the soil surface and the root crown is placed into the soil. The remainder of the pot is then filled with further potting soil. The soil should not be packed down, but may be tapped to help it settle. The pots are then placed into the wading pool in water about 2–3 inches deep and watered once from the top. From then on, all watering should be done by adding water to the wading pool.

A tomato cage is placed into each pot and pressed down firmly to seat it. The sharp edges and joints of the tomato cages should be taped to prevent damage to the mesh cage sleeves when they are put over the cages and pots. Since the plants will be outside, the mesh sleeves should be placed over the cages immediately and secured top and bottom with twine, tape or a heavy rubber band to prevent entry of aphids, predators or other pests that might interfere with the plant or beetle growth.

Place the wading pool in a protected area away from possible vandals, animals or strong winds. Space 15 of the pots evenly in the pool so that each receives plenty of light and air can circulate freely. Fill the pool up to 3" with water and check and refill as needed daily throughout the growing period. An overflow hole should be cut into the side of the pool about 5" from the ground to allow heavy rain to escape. When the stems reach about 14 inches, pinch off about ½ inch of the tip of each stem to encourage lateral stem growth and provide plenty of food for the beetles.

After 4–5 weeks of growth, the plants should be around 24" tall and be ready to infest with the beetles. Choose the healthiest plants for infestation with the beetles. At this time notify your supplier that you are ready to receive the beetles. They will arrive by overnight delivery and should be put on the plants immediately. Be sure not to keep the container in an area where it may become overheated by direct sunlight.

Use the aspirator supplied with the beetles to put 20–25 beetles into each cage, making sure that none escape from the shipping container or from the cages. Securely tie the top and the bottom of the mesh cage to prevent loss of the beetles. The *Galerucella* adults should begin feeding immediately and after 1–2 weeks begin laying eggs on the plants. The eggs are layed in small groups on either stems or leaves and are round, pinhead-sized eggs with a black stringy deposit across the top of the egg mass. Eggs hatch within 2 weeks. The larvae are yellow to orange with black stripes across the body. They have several growth stages called instars and feed on the fresh leaf tips and flower buds. They will be hard to see at first, but they eat the upper layer of the leaves producing "window-paning" starting at the top of the plant and moving downward.

The larvae take about 3 weeks to become full grown and then burrow into the soil to become pupae. Pupae do not feed or move around and after about two weeks, the adult beetles begin to appear and collect near the top of the plant. When these are visible and the plants are nearly defoliated, it is time to release the beetles or collect the adults for distribution to other schools.

Choose a release area with a thick growth of loosestrife, but in open sunlight. The release site should be out of easy sight by possible vandals. The entire plant and pot should be moved to the release site and the mesh and cage removed next to a fresh supply of wild plants. Shake any beetles still in the bag out and remove the tomato cage. The spot of release should be recorded carefully on a map and marked with four white PVC pipes stuck in the ground. It is important that the site can be located by more than one method (pipes, measurements, etc.) because vandals, ice and plant growth may obliterate or move your markers over several years.

Extensions

Students may record abiotic conditions, such as temperature, cloudiness, length of day, etc. as well as plant measurements and appearance over the time of the project. Problems may arise with either the plant growth or the beetle population growth that may lead to discussion and attempted solutions. Students may use stereo microscope, magnifiers and measuring devices to record the stages in the *Galerucella* life cycle. Some larvae and adults may be used for observations and experiments relating to behavior and food selection. Information may be shared about the project with other cooperating schools by Internet, mail or telephone. The project may be continued during the summer by volunteer groups of students or other interested groups may be enlisted and trained to do so (such as summer school classes, scouts, 4-H or other groups. Class activities may be recorded by videotape, school newspaper, and local media to keep the community informed of the progress of the project.

Evaluation

Evaluation can be based on informal observations of students and groups during the project, lab notebook records, observation of group problem solving meetings, student presentations to the class or community organizations.

ACTIVITY NINE

Abiotic Limits to Loosestrife Growth

Objectives

The students will design and conduct a controlled experiment to determine the effects of an abiotic variable on the growth of purple loosestrife.

State Curriculum Framework Connections

Science: I.1.1, I.1.2, I.1.4(M), I.1.3(H), II.1.1

Methods

Students conduct indoor research on the effects of soil temperature, water availability, photo period, or another abiotic variable they believe might have an effect on the growth of purple loosestrife.

Background

All plants, including purple loosestrife, survive and thrive where soil, water, and solar energy amounts are within the limits necessary for the particular species. Other abiotic factors may also affect the plants growth. Often plant growth decreases when such factors are very high and very low. Beyond some level the plant can't grow at all. How do such abiotic factors effect purple loosestrife? Are there combinations of these conditions that slow or accelerate growth?

Materials

Two or more purple loosestrife plants growing in pots according to the directions given in the activity "Raising *Galerucella* Beetles Indoors" (Section 2, page @). Young plants best.

Ruler for measuring growth, appropriate lighting, beaker or liquid measuring container.

Other materials will vary depending on which abiotic variable the students choose to test.

If photo period is being tested, then two timers on two light sources are needed.

If soil temperature is tested, then a soil thermometer is needed.

Procedure

1. Start two or more plants growing in pots. (See directions in activity "Raising *Galerucella* Beetles Indoors," Section 2, page @)

2. Lead discussion with students about what abiotic conditions are, and what conditions they think might affect the growth of purple loosestrife. Based on this discussion, students select which abiotic variable they want to test.

3. Students then must alter the growing conditions for one of the plants so that the variable selected can be tested. All other conditions must be the same for the two plants (or two groups of plants). (A) If amount of water is to be tested, then all plants must be grown in the same soil, the same light routine, the same temperature, etc. But the amount of water each plant is given needs to be selected, and that amount carefully measured when it is given. Students need to determine if they are interested in the amount of water added, the frequency of water added, or the level of standing water in which the plants are growing. (B) If photo period is to be tested, then the control plant and the experimental plants must have separate (but identical) light sources. Each plant (or group of plants) must be isolated from other light sources. The light source of the experimental and controls groups must have timers with different settings so that one group gets light for a different length of time then the other. (C) If soil temperature is to be tested, the students must devise some method to heat or cool the pots of soil, while maintaining all the other conditions (such as lighting) exactly the same. This might involve putting the pots inside larger pots in which student maintain ice or ice water. Or it could involve some sort of heating device like aquarium heaters or heater "rocks" found in pet shops for reptiles.

Encourage students to design the experiments themselves. Make sure they control for all variables except the one to be tested. Their design should have an experimental group and a control group. These "groups" may have only one plant in each, although it would be more scientifically valid if more plants were used.

4. As the plants are grown according to the experimental plan, observations must be made about the growth and health of the plants. Growth can be determined by measuring the height of the plant each day or every other day. Since some extremes of abiotic conditions actually start to kill the plant, it is also valuable to observe such things as yellowing of the leaves, wilting, sections of dead tissue, and dropping of leaves.

5. After an appropriate amount of time, compare the control and experimental plants. (Graphs of height versus time could be used.) Students decide if the variable made a significant difference and write a justification for their conclusions.

6. Because we don't want to add to the spread of purple loosestrife, the plants that were grown should be destroyed. Make sure seeds and live root sections are not introduced into the outdoor environment.

Extensions

Once the effects of one variable are determined, additional experiments could be done to determine what combination of conditions slow or accelerate growth.

The experiment could also be done with several incremental changes in the variable. For example, one plant could be grown at room temperature, while other plants are grown 5, 10, and 15 degrees below room temperature.

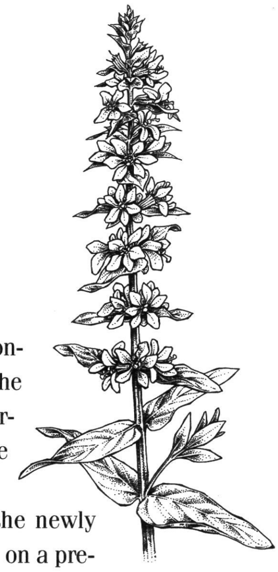
Ask students to suggest the implications of what they have learned from their experiment. Can their results explain historical patterns about where purple loosestrife has and has not appeared in North America? Can they suggest an application of this knowledge to reducing purple loosestrife's impact on a wetland?

Evaluation

Students are to prepare a written report of their experiment which includes a statement of their hypothesis, careful description of procedures, all observations, and a conclusion with clear justification of those conclusions based on the observations.

ACTIVITY TEN

How Do We Know These Insects Are Safe to Use?



Objectives

Students will critically investigate the type of testing procedure used by the USDA when it determines that a new species of natural enemy may be imported for biological control of weeds.

Method

In small groups, students will decide which ornamental and native or naturalized plants they want to expose to *Galerucella spp.* leaf-feeding beetles, a European natural enemy of purple loosestrife recently approved for release by the US Department of Agriculture. Simulating the host-specificity testing procedures used by USDA in the classroom, students will place *Galerucella* on caged plants and then observe, catalogue, and discuss insect and plant interaction during their life cycles.

Background

Biological control of invasive weeds carries some risk, just as other methods of weed management, such as the application of herbicides, carry risks. Biological control scientists carefully apply procedures designed to minimize the risk of importing a weed's natural enemy that itself becomes a nuisance. What if the insect feeds on our preferred plants? Is this insect host-specific: will it feed only on the host weed, purple loosestrife? Given the large variety of plants found in our gardens, meadows, and wetlands, it was not practical for every preferred plant species to be tested before finally deciding to import a natural enemy to control invasive purple loosestrife, so scientists established a panel of experts to decide how to proceed. Under laboratory quarantine, three categories of plants were exposed to one of purple loosestrife's European natural enemies, *Galerucella spp.*, to see if it was host-specific: (1) North American plants taxonomically related to purple loosestrife; (2) plants that live in the same wetland ecosystems as purple loosestrife, and; (3) selected crop and garden ornamental plants.

A close look at the life cycle of *Galerucella* reveals three critical observation points that can be used to predict the potential for negative impacts on non-target (preferred) plant species. The first is whether any amount of herbivory or defoliation occurs. Is there damage done? A second critical observation point is the ability of the newly emerged adults to feed and survive on a preferred plant. The third critical observation to make is the question of whether female *Galerucella* beetles can lay and mature eggs on the preferred plant. Two thresholds should be investigated: (1) can *Galerucella* eat the preferred plant enough to cause plant damage and (2) can *Galerucella* survive on the preferred plant? Observing the two organisms throughout their life cycle together provides evidence to help answer these important questions.

Now that European *Galerucella spp.* beetles are approved for use and have been released in this country we can only hope that our USDA panel of scientists made the right decisions about the risks presented by purple loosestrife and its insect enemy. Investigating and understanding the USDA host-specificity testing procedure, and extending this understanding to the student's selection of plants will lead to more informed decision-making when looking for ways to biologically control the next invasive species.

Materials

A minimum of one purple loosestrife specimen plant and it's natural enemies (described in Section 2 of the *Cooperator's Handbook*). Each small group will need one caged two-gallon plastic pot, approximately 2 square feet of adequately lit bench space, and 10 adult *Galerucella* beetles for each preferred plant it wishes to test.

Procedure

"No-choice" testing of the student's preferred garden or wetland plants will require teacher coordination of beetle and plant life cycles so that beetles have foliage to accept or reject as food when they are placed in the cage. Timing of plant and beetle growth can be influenced by your control of temperature and photoperiod as described more fully in Section 2 of the *Cooperator's Handbook.*

A list of plants which have previously been selected for host-specificity testing is available from USDA and the PLP at MSU. Students may wish to repeat tests on these plants or select their own untested favorite plants without effecting your attainment of the objectives for this activity. Preferred plants can be obtained in stores, in family gardens, in the schoolyard, or in the wild. Student selection of plants will be limited by seasonal availability.

Remove any damaged foliage from the student's preferred target plant. Place ten newly emerged adult beetles in each cage with the preferred plant and after seven days remove the cage so the plant can be carefully examined for feeding damage or egg masses. Compare a representative leaf with any leaf found to be damaged by placing them on a 10×10 grid of 2.5 cm graph paper and recording the number of squares eaten. Count and record egg masses and the average number of eggs in each mass. Count and record the number of live adult beetles. Repeat this weekly until results stabilize.

Extensions

Additional preferred plant species can be tested throughout the year. Student research and reporting on plant/animal interaction, wetland ecology, the history of importation biological control, and risk management studies extend this activity.