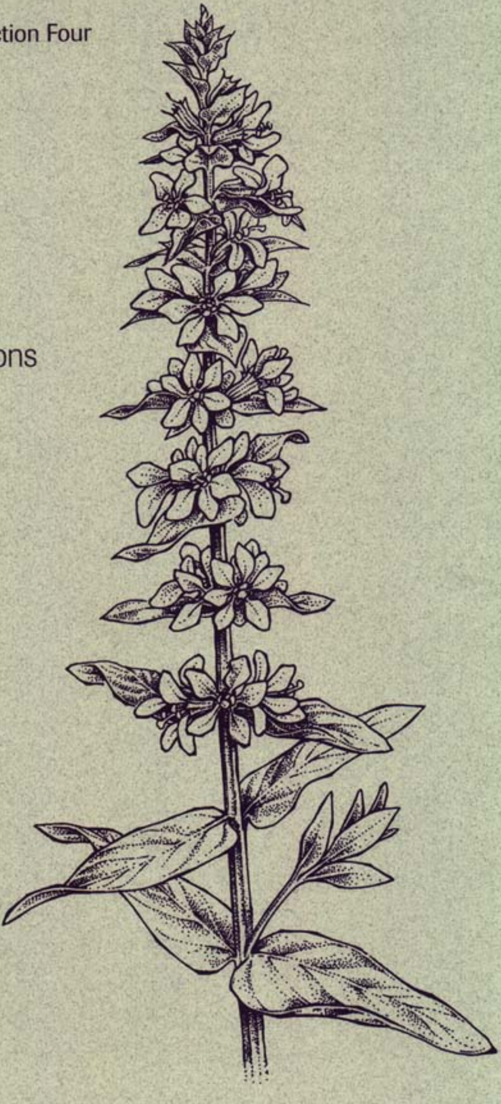
Cooperator's Handbook • Section Four

Upper Elementary Lessons

Teacher's Guide



The Purple Loosestrife Project
Michigan State University
January 1999

The Purple Loosestrife Project *Cooperator's Handbook*
January 1999

MSU-E-2690-4 MSG-99-404	Teacher's Guide
MSU-E-2690-5 MSG-99-405	Student Workbook

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The Purple Loosestrife Project
Cooperator's Handbook

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Upper Elementary Teacher's Guide

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Upper Elementary Lessons

This unit is designed for upper elementary students. It is, however, also written in a format that can be used by middle school teachers, nature center staff members, scout leaders and others involved in youth education. It is designed for use by teachers and other youth leaders with little or no science background as well as those already familiar with the subject.

The unit is divided into three parts. Each part includes a series of lessons, activities and worksheets. Ideally, teachers will conduct the unit sequentially.

Part One
Mission: Life on earth

Understanding basic ecological concepts is important to understanding biological control. In this section, students become a group of scientists from another planet whose mission is to learn about life on Earth. Background information, activities and worksheets will introduce the students to biomes, ecosystems, communities, organisms and relationships. Comparing and learning about the ecology of the marsh ecosystem and the forest ecosystem is the primary focus of this section.

Part Two
Invasion of purple loosestrife

Based on knowledge and skills gained in Part One, students participate in activities that introduce them to native and exotic organisms, the importance of natural enemies and the impact of exotic species on ecosystems. Students grow a purple loosestrife plant in the classroom, learn about its life cycle and compare it with life cycles of other plants.

Part Three
Biological control of purple loosestrife

This final section relies on knowledge and skills gained in previous sections to introduce students to the management of exotic organisms, including biological control. Students will be supplied with a population of leaf beetles that they will place on their purple loosestrife plant. Activities will focus on insect life cycles, selection of biological control agents, and monitoring and evaluating of the beetles' effect on the plant.

Format of the unit

Teacher information is presented here with the information students have in their student workbooks. Information in the *Teacher's Guide* includes:

- A detailed outline of each section showing the sequence of lessons, activities and worksheets.
- Estimated time needed to complete the section.
- Teaching objectives.
- Main ideas and concepts.
- Teacher background information.
- Detailed instructions for teachers.
- Materials (some materials are included and some must be provided by teachers).
- Tips on helping students complete the worksheets.
- Recommended resources (to be provided by teachers).
- Suggested journal entries.
- Extension ideas.
- Glossary.

A note on teaching objectives

The science teaching objectives (Using Scientific Knowledge, Constructing New Scientific Knowledge and Reflecting on Scientific Knowledge) in this unit come directly from the Michigan Essential Goals and Objectives for Science Education (MEGOSE) framework. Objectives from the Michigan Curriculum Framework for social studies, English language arts and mathematics are also included to help teachers integrate the unit in the classroom.

Student Journals

Many of the lessons contain suggestions for student journal entries. In addition to being good writing exercises, these entries are meant to help students explore concepts, integrate other subjects and develop a deeper understanding of the subject. Journals are not provided.

PART ONE - MISSION: LIFE ON EARTH

ESTIMATED TIME TO COMPLETE PART ONE: Field tests in several classrooms suggest that teachers should expect Part One to take from 5 to 7 hours of class time spread over 1 to 3 weeks. This does not include extension or outdoor activities.

Abstracts and Michigan teaching objectives

■ Part One, Lesson 1 Biomes

Michigan Curriculum Framework References

Science: Standard I.1 Constructing New Scientific Knowledge, II.1 Reflecting on Scientific Knowledge, V.1 The Geosphere.

Language Arts: Standards 1,2,3 Meaning and Communication, 11 Inquiry and Research

Social Studies: Standard II.2 Human/Environment Interactions, V.1 Information Processing, V.2 Conducting Investigations

Method

Students will make observations about the differences in the Earth's surface. Students will make inferences about what might cause these differences.

Materials

World atlas, handouts or overhead maps of the world, the US, and the major biomes.

Procedure

1. Students become scientists from another planet who have no information or knowledge about Earth. They will make observations from their "spaceship".
2. An overhead will be shown of the Earth. Students will record observations about the differences they see and record them in their workbooks.
3. They may then draw a picture in the workbook of the differences that are most notable.
4. After making their observations from space, students will take a closer look by sending teams of scientists to explore the Earth's surface. Five teams of scientists will explore five different biomes.
5. Using the resources provided, students will answer questions in the workbook about their five exploration areas such as plants and animals, temperature range, and amount and form of precipitation.

■ Part One, Lesson 2 Ecosystems

Michigan Curriculum Framework References

Science: Standard I.1 Constructing New Scientific Knowledge, II.1 Reflecting on Scientific Knowledge, III.2 Organization of Living Things, III.5 Ecosystems

Social Studies: Standard II.2 Human/Environment Interactions,

Mathematics: Standard I.1 Patterns

Method

Students will continue their exploration of the planet Earth. They will be asked to think about different animals and plants that occur within selected ecosystems. Students will narrow their focus and discover the differences within ecosystems. They will fill-in a matrix of the organisms that occur in selected ecosystems, and work in groups to answer questions and classify their organisms.

Materials

Maps and workbooks provided. World atlas.

Procedure

1. Students will read in the work book about the different ecosystems that occur within a biome. They will speculate about the different organisms that occur within ecosystems and what they indicate, (e.g. cactus=desert, salmon=freshwater ecosystem).
2. Students will be given a matrix to fill out using the species of their choice.
3. Students will then make observations about which organisms in their matrix have similar features.
4. The names of all the organisms will be placed on cards. The cards will be placed into categories of the student's choosing, sorted by color, size, shape, etc.
5. Next, the students will narrow their focus to the temperate deciduous forest biome. The class will be split into two groups, one studying the forest ecosystem, the other studying the marsh ecosystem.
6. They will find information on the living and nonliving factors in their ecosystems.

7. The information on their ecosystems is then shared with the rest of the class.

Part One, Lesson 3 Community Relationships

Michigan Curriculum Framework References

Science: Standard I.1 Constructing New Scientific Knowledge, II.1 Reflecting on Scientific Knowledge, III.2 The Organization of Living Things, III.5 Ecosystems

English: Standards 1,2,3 Meaning and Communication, 7 Skills and Processes

Method

Students will investigate the relationships between different organisms within a community. Students will learn what organisms do within their community, and learn basic interactions of organisms important to the understanding of ecology and biological control.

Materials

Student workbooks provided

Procedure

1. After being introduced to the topic of community relationships, students will read a short story about a forest community.
2. Students will record the relationships they find within the story.
3. They will then answer some questions about the community relationships.

Part One, Lesson 4 Food Chains

Michigan Curriculum Framework References

Science: Standard I.1 Constructing New Scientific Knowledge, II.1 Reflecting on Scientific Knowledge, III.2 Organization of Living Things, III.5 Ecosystems

Social Studies: II.2 Human/ Environment Interactions

Method

Students will use the information gathered from Lesson 3 to try to understand more about how the organisms interact with each other and about relationships in each community.

Materials

Food chain cards provided

Procedure

1. Using the information gathered about the forest and marshland ecosystems in Lessons 2 and 3, students will be introduced to a simple food chain and the vocabulary that applies to it, e.g. producer, herbivore, and predator.
2. The teacher will distribute 24 organisms cards to the students, (marked either forest or marshland).
3. One sun card will be used per ecosystem.
4. There will be eight energy flow cards to go between the different organisms.
5. The students will place themselves, according to their assigned card, where they think they belong in the food chain. The vocabulary that applies to certain members of the food chain can be reviewed.

Part One: Main Ideas and Concepts

- The surface of the Earth is divided into various biomes on the basis of geographic location, climate, topography and other physical features. Some of the major biomes are tundra, desert, tropical forest, ocean, grassland, temperate deciduous forest and savanna.
- Each biome is made up of ecosystems. An ecosystem is a group of interacting organisms and the physical or nonliving factors that affect them. The temperate deciduous forest biome is made up of ecosystems including various forest types, dunes, fields, wetlands, lakes and river ecosystems.
- Each ecosystem has a unique set of living organisms that interact with one another and with the physical or nonliving factors. The living organisms in an ecosystem are called a community.
- The marsh and the forest are two types of ecosystems found within the temperate deciduous forest biome. Each of these ecosystems has a community with a unique set of interacting organisms.
- Every community is similar in that it has organisms that are producers, consumers and decomposers.
- The living organisms in a community interact with one another. These interactions are called relationships. One type of relationship is called a food chain.

Part One: Background Information - Concepts of Ecology

Because of differences in geographic location, climate and topography, the surface of the Earth is covered by biomes such as tundra, desert, ocean, temperate grassland and tropical savanna. Much of the Great Lakes region is within the temperate deciduous forest biome. "Temperate" refers to a moderate climate with distinct seasons; "deciduous" refers to trees that lose all their leaves in the fall.

Each biome is made up of a variety of ecosystems. An ecosystem is defined as a group of interacting organisms and the physical or nonliving factors that affect them. Nonliving factors include such things as water, soil and air. If you were to travel through the temperate deciduous forest biome, you would encounter a variety of ecosystems, including forests, dunes, lakes, ponds, rivers, swamps and marshes. Each of these ecosystems has a unique set of plants and animals that interact with one another and with the nonliving factors. For example, a forest ecosystem is made up of plants (a variety of trees, ferns, wildflowers and many more), animals (red squirrel, scarlet tanager, red-backed salamander and many more) and nonliving factors such as rich soil and lots of shade. A marsh ecosystem is also made up of plants (cattails, sedges and many more), animals (muskrat, red-winged blackbird, fish and many more), and nonliving factors such as standing water, mucky soil and open sunlight.

The interacting living organisms within an ecosystem are called a community. For example, all the living organisms in the marsh ecosystem would be referred to as the marsh community. The living organisms in a community interact with one another. These interactions are called relationships. Organisms have relationships with other individuals of the same species, with individuals of other species and with nonliving factors in the ecosystem. For example, a red-winged blackbird in a marsh ecosystem has many relationships. The blackbird builds a nest of sedges, milkweed and grasses attached to cattails. The blackbird eats many kinds of insects and seeds. The blackbird chases other birds away from its nesting area. The blackbird may be eaten by a hawk or may have parasites on its skin. The blackbird may use a branch as its favorite perch. Each one of these interactions with another organism is a relationship. If you take the hundreds of organisms in a marsh community and think about the great number of relationships each has with other community members and with nonliving factors, you can see that each ecosystem is a complex web of relationships.

Although each community is made up of a different set of living organisms, all communities have some things in common. Every community has producers, consumers and decomposers.

Producers are plants that can make their own food through the process of photosynthesis. Photosynthesis usually takes place in the leaf, where the green pigment chlorophyll is found. Photosynthesis occurs when the leaf takes carbon dioxide (from the air) and water (from the soil) and, with energy from sunlight, produces food and oxygen.

Consumers are animals that cannot make their own food and depend on producers for their food. There are various types of consumers. Herbivores are consumers that eat only plants. Carnivores are consumers that eat only animals. Omnivores are consumers that eat both plants and animals. When a carnivore or an omnivore captures, kills and eats other animals, it is called a predator. The animal that is eaten by the predator is called the prey. The relationship between the two organisms is called a predator-prey relationship. When a carnivore or an omnivore feeds on an animal that is already dead, it is called a scavenger.

Although the material in this unit will focus primarily on producers and consumers, it is important to know that all communities also have organisms called decomposers, which live in or on dead plants or animals and aid in decomposition and nutrient cycling. Decomposers include organisms such as fungi and bacteria.

A food chain is a special way of looking at the relationships between producers and consumers. Producers are always the first link in a food chain because they are the only organisms that can make food. The next link in the food chain is a consumer that eats a producer. A deer eating grass is a simple food chain. The number of links in a food chain depends on how many consumers are involved.

GREEN PLANT → SMALL INSECT → LARGE INSECT → MINNOW → PERCH → LAKE TROUT → HUMAN

is an example of a longer food chain. The arrows between links in the food chain show the direction of energy flow from one organism to another. Most organisms eat more than one thing. For example, the perch may eat several types of insects, small fish, tadpoles and snails. If you connect all the various food chains together, you create a food web.

In summary, the Earth is made up of various biomes. Each biome is made up of a variety of ecosystems, and every ecosystem includes a community of living organisms and nonliving factors, all of which form a complex web of relationships.

You are now ready to begin Part One with students.

PART ONE

Mission: Life on Earth

Lesson One: Biomes

Instructions for teachers

To begin, have the students read the student workbook text (or read it together as a class). Lesson 1 sets the stage and storyline followed throughout Part One. You may not want to mention the name "purple loosestrife" yet because it is the mystery life form that students will be trying to identify throughout this section. It is all right, however, if students already know about purple loosestrife. They will just be able to identify the mystery life form earlier in these lessons.

Student Workbook • Part One

Part One Mission: Life on Earth

Lesson One: Biomes

You are about to begin an exciting adventure with your teacher. You will be reading, working with other students and completing worksheets. There is a glossary in the back of your workbook in case you want to look up the meaning of a word.

You are a group of scientists from Planet ________ (your group should select the name of the planet) traveling through space. Your mission is to locate and study life in other parts of the universe. As you are zipping through the Milky Way galaxy the computerized scanner aboard your spaceship briefly picks up some unusual signals from an unknown source. After decoding the signals, the computer prints out eight clues and a picture of a mysterious object. Is it a life form?

STOP READING and get the picture from your teacher.

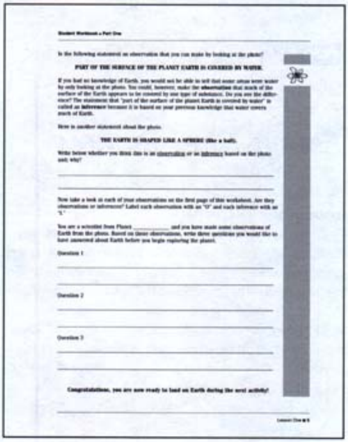
The only clue your spaceship computer recognizes is EARTH, which your computer tells you is the name of a planet in the Milky Way Galaxy. Your team of scientists decides to explore the planet called Earth and to try to learn more about the mystery life form in the picture and the meanings of the other clues. You have no other information about Earth.

As you approach Earth in the spaceship, you begin to make observations.

Stop reading and begin the **View From Space Worksheet.**

Lesson One ■ 5

VIEW FROM SPACE Worksheet



Instructions for teachers

Students should now begin their View From Space worksheet. Teachers must provide a color satellite photo of the Earth for this worksheet. Try these resources:

- Most libraries have atlases with satellite photos of Earth.
- Check the following Web site on the Internet: <www.arcinc.com/globe1.htm>.

Teacher tips on the worksheet

This worksheet helps students learn and practice their observational skills as well as practice formulating questions based on what they observe. Both of these skills are very important in science. Students also learn the difference between an observation and an inference. The observations students make by looking at the photo should not be biased by any previously known information. Two examples are given on the student worksheet. The "Earth is shaped like a sphere" example is also an inference since the photo is flat. You cannot tell that the Earth is a sphere by looking only at the photo. You may need to give students more examples. You also may want to have students read some of their observations to the whole class, then have the class discuss if each one is an observation or an inference. The most important observation (which leads to the next activity) is that the surface of Earth is covered by areas of several colors.

Another observation that the students may not think of is to estimate the percent of the photo covered by the various colors.

Students should now be finished with the **View From Space Worksheet**.

Suggested journal entry

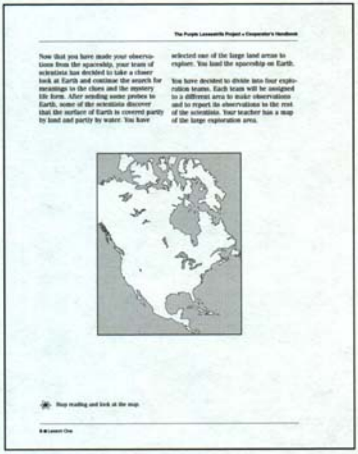
Have the students look closely at the picture of the mystery organism and draw a picture of it in their journals. Along with the drawing, have the students include three observations they can make by looking at the picture.

Extension idea

Another important observational skill is to be able to make quick and accurate observations when needed. When studying animals, you may get only a brief look before the animal disappears from sight. You can help students learn and practice this skill in various ways. One way is to find a picture of an animal in a magazine or book and show it to the students for only a few seconds. Another way is to select a short section of a nature video and let the students view it (if there are only natural sounds in the video, leave the sound on; if there is narration, turn the sound off). What things did the students observe? What are some things that were not observed?

Instructions for teachers

The students can now continue reading the workbook text. For the next activity, you will need to provide the large black and white map of North America as well as the four small black and white maps (provided in



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Now that you have made your observations from the spaceship, your team of scientists has decided to take a closer look at Earth and continue the search for meanings to the clues and the mystery life form. After sending some probes to Earth, some of the scientists discover that the surface of Earth is covered partly by land and partly by water. You have selected one of the large land areas to explore. You land the spaceship on Earth.

You have decided to divide into four exploration teams. Each team will be assigned to a different area to make observations and to report its observations to the rest of the scientists. Your teacher has a map of the large exploration area.

Stop reading and look at the map.

the Materials Section of the unit). You may want to make several copies or an overhead of the map of North America. The students will also need to be divided into four teams. The small maps need to be cut so one map can be given to each of the four teams. You may want to glue or tape each small map to an index card.

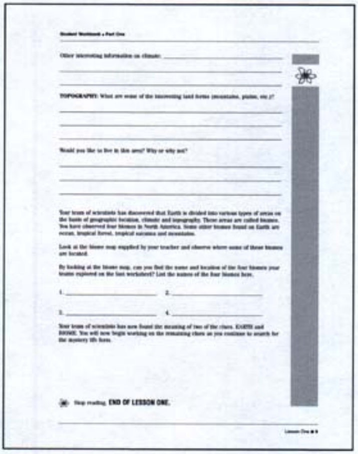
Instructions for teachers

Give one small map to each team. These maps can be matched (even though they may be a different scale) to an area somewhere on the large map of North America. If you need help, there is a key in the teacher's guide with the location of each small map. After all four teams locate their areas on the map of North America, the students are ready to complete the A Closer Look worksheet. This worksheet will require students to look up information about their area and record the information on the worksheet. Teachers will need to provide the resources for this.

Here are some resource ideas:

- Encyclopedias.
- Books on geography, social studies, earth science, ecology or weather.
- A U.S./Canada road atlas.
- Farmer's Almanac.
- A globe.
- Student atlas.
- National Geographic Web site: <http://www.nationalgeographic.com>.
- Biome Information Web site: <http://mbgnet.mobot.org/MGBnet/live/> (go to What's It Like Where You Live, then to Virtual Biomes).

A CLOSER LOOK Worksheet



END OF LESSON ONE.

Key to location of small maps for A Closer Look Worksheet in Lesson 1

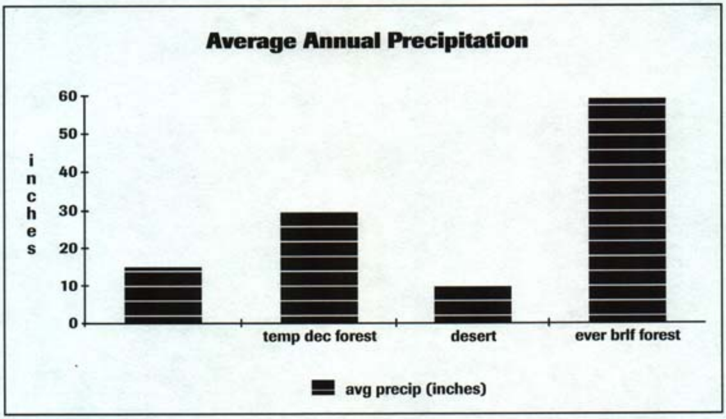
The four small maps come directly from the larger map of North America, though they may be a slightly different scale. Most are easy to match to the North America map. These areas were selected because each is located in a different biome. The locations and biomes are:

- #1 On the west side of Hudson Bay in northern Canada (tundra biome).
- #2 Southwestern U.S./northwestern Mexico – Baja/San Diego area (desert biome).
- #3 Southern tip of Florida (ever green broadleaf forest biome).
- #4 Great Lakes (temperate deciduous forest biome).

Remember that the most important skill in this activity is the ability to locate the small map by matching it to the North America map, and then doing some research to learn about the area. The take-home message is that North America is divided into a variety of biomes.

Here is a sample of the information we found for each area and a sample graph showing one way to display the information. The information the students find for these areas may or may not match this information.

	tundra	temperate deciduous forest	desert	evergreen broadleaf forest
Longitude	100 W	85 W	112 W	81 W
Latitude	62 N	44 N	32 N	26 N
Avg. annual precipitation	15 "	30"	10"	60"
Avg. annual temp. range	-20 to 55 degrees F	10 to 80 degrees F	30 to 95 degrees F	50 to 82 degrees F



Teacher tips on the worksheet

Even though the state boundaries are not shown on the North America map, students will need to figure out what states are in or near their small section to look up information. You will need to provide a road atlas or other map showing the state boundaries for this task. After the worksheet, there is a page with a key to the location of the five sections, most of the information asked for on the worksheet (in case you have a hard time finding the information), as well as an example of a graph. After the four teams have gathered the data on the worksheets, they should share their findings with the other teams. Sharing and reporting information is an important skill for scientists. Teachers can decide the most appropriate way for the students to share and display the information. One suggestion is to compile some of the information in a graph. A great way to share this information is to draw a matrix on the chalkboard (if you are unfamiliar with a matrix, see the Familiar Organisms worksheet in Lesson 2). Across the top of the matrix, you can list the four biomes. Along the side of the matrix, you can list the data categories from the A Closer Look worksheet. Students can then fill in each box of the matrix and discuss the results.

An important skill learned by completing this worksheet is the problem-solving process of identifying where each small map is located on the North America map and figuring out how to go about finding information about that area. The process is important; the actual information they find is secondary. In other words, don't worry about finding all the information on the worksheet if it becomes difficult or frustrating.

Suggested journal entry

Have students choose a biome and describe what they think they would see if they traveled through the biome.

Students should now be finished with the **A Closer Look Worksheet.**

Instructions for teachers

For students to complete the next activity, you will need the biome map supplied with the unit in the materials section. This biome map will also be needed for students to complete a worksheet in Lesson 2. To continue, students should read the following information in the student workbooks.

Suggested journal entry

Have each student select two biomes from the four they studied and write how the biomes are similar and/or different from each other.

PART ONE

Mission: Life on Earth

Lesson Two: Ecosystems

Instructions for teachers

In Lesson 2 students will build on the biome activities and worksheets of the previous lesson and begin to understand that biomes are composed of various ecosystems and that ecosystems are composed of both living organisms and nonliving factors. The story line of scientists from another planet trying to find the meaning to the remaining clues and the identity of the mystery organism is continued. Begin this lesson by having the students read in their workbooks.

Lesson Two: Ecosystems

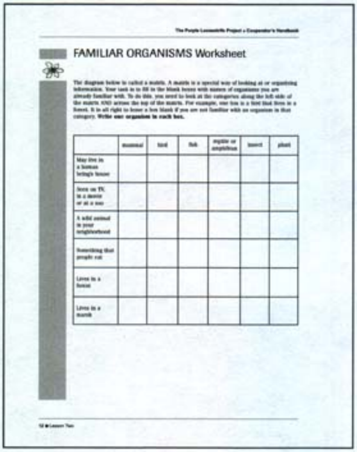
Once you start looking closely at a biome, you will find that each biome includes a variety of different areas. For example, if you were to explore the ocean biome, you would find shorelines, deep-water areas and coral reefs. In the desert biome, you might find sagebrush, open desert and lush riverbeds. In the temperate deciduous forest biome, you would find forests, rivers, dunes, and a variety of wetlands such as swamps, bogs and marshes. You would also find different organisms in each of these areas. All of these areas are called ecosystems. An ecosystem is a group of interacting organisms and the physical or non-living factors that affect them. Physical or non-living factors are things such as water, air and soil. So, within the ocean biome, there are a variety of ecosystems, including the shoreline ecosystem and the coral reef ecosystem. In the temperate deciduous forest biome, ecosystems include forest, marsh, swamp, lake, dune and river ecosystems. The word "temperate" means an area with a moderate climate and distinct seasons. The word deciduous means trees that lose all their leaves in the fall.

WHAT IS AN ORGANISM?

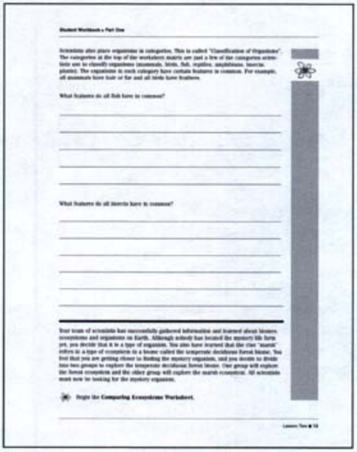
Planet Earth is home to a huge number of living things. Each of these living things is called an organism. It has been estimated that there may be as many as 30 million different kinds of organisms on Earth. About 1.5 million of these have been scientifically identified. You are already familiar with many organisms because they live in the same area that you do. These may include maple trees, grass, dandelions, earthworms, daddy longlegs, bees, ants, robins and squirrels. You may be familiar with other organisms as pets, such as dogs, cats and fish. You are familiar with many organisms because they are things you may eat, such as apples, oranges, mushrooms, carrots, lettuce, peanuts, fish, chickens, cows and pigs. Other organisms you may have never seen but have read about or seen pictures of, such as palm trees, cacti, dolphins, tigers, polar bears, sharks and flamingos. Each kind of organism is known by scientists as a species. For instance, there are many kinds or species of maple trees, including sugar maple, silver maple and red maple. In Michigan alone, there are about 400 species of birds, including American robin, great blue heron and bald eagle. You are also an organism. You belong to the human species.

Have you ever wondered why some species are found only in certain areas on Earth? Why aren't there monkeys in the trees around your school? Why aren't there seals along the Great Lakes shorelines? If you traveled to Arizona, would the organisms be the same or different from those in the Great Lakes region?

Stop reading and begin the **Familiar Organisms Worksheet.**



FAMILIAR ORGANISMS Worksheet



Tips for teachers on worksheet

Now ask students to begin the Familiar Organisms worksheet. The purpose of this worksheet is to get students to think about the organisms that they are already familiar with and to see that organisms can be sorted or classified in various ways. The students will be dealing with organisms throughout the rest of the unit.

Extension idea

Write the organisms the students listed on the Familiar Organisms worksheet matrix on a blank card or piece of paper. Have the students look at the variety of organisms on all the cards and place them in groups according to categories that they invent. For example, put all the organisms with four legs in one category, or separate organisms by size, shape or color. There are no right or wrong categories, so use your imagination.

After students have finished classifying the organisms, ask the following questions:

- What categories did you use to classify the organisms?
- Were any of the organisms hard to fit into your categories?
- How would you change your categories so all the organisms fit?

Students should now be finished with the **Familiar Organisms Worksheet**.

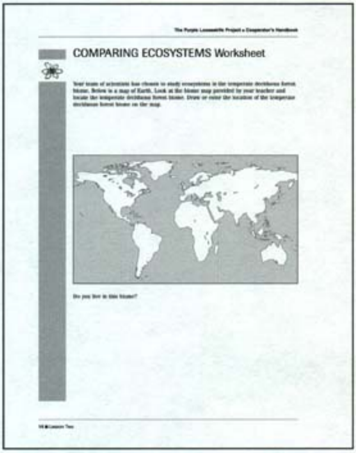
Instructions for teachers

To continue the scientists from space story line, students should read the workbook text.

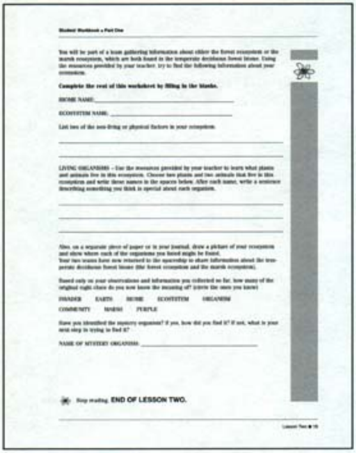
Student workbook information

Your team of scientists has successfully gathered information and learned about biomes, ecosystems and organisms on Earth. Although nobody has located the mystery life form yet, you decide that it is a type of organism. You also have learned that the clue "marsh" refers to a type of ecosystem in a biome called the temperate deciduous forest biome. You feel that you are getting closer to finding the mystery organism and you decide to divide into two groups to explore the temperate deciduous forest biome. One group will explore the forest ecosystem and the other group will explore the marsh ecosystem. All scientists must now be looking for the mystery organism.

Students should now begin their **Comparing Ecosystems Worksheet.**



COMPARING ECOSYSTEMS Worksheet



END OF LESSON TWO.

Tips for teachers on worksheet

The first task on the Comparing Organisms worksheet is for students to locate and draw the temperate deciduous forest biome on the worksheet map. You will need to supply the biome map (supplied with the unit) for students to complete this worksheet. It will be important for students to observe that the temperate deciduous forest biome is found in several areas on Earth, including parts of North America, England, Europe and Asia. This is a major underlying factor that allows organisms from these other regions to live successfully in North America. Purple loosestrife, which is native to Europe, is one such example. Much of Part Two, Invasion of Purple Loosestrife, will build on this concept.

Before students begin page 2 of the Comparing Organisms worksheet, assign each student (or have them choose) to either the forest or the marsh ecosystem. About half the class should be assigned to each. They will write the name of this ecosystem on their worksheet before completing the rest of the worksheet.

You will need to provide some resources for students to create the list of forest or marsh organisms. The best resources are probably field guides and textbooks. The final task for this worksheet is for students to draw a picture of their ecosystem, including the organisms they recorded on the worksheet. This will get them to think about where the organisms would be found within each ecosystem.

Extension idea

All the forest students and all the marsh students could work together on an ecosystem mural where all their organisms would be included. Students could add other things to the mural as new topics are covered.

The students should now be finished with the **Comparing Ecosystems Worksheet**.

Instructions for teachers

To finish Lesson 2, have the students read the remaining student information in Lesson 2 and discuss how many of the clues they have discovered the meaning of. Students should have identified the mystery organism by now. If not, you may want to give them suggestions on figuring it out.

PART ONE

Mission: Life on Earth

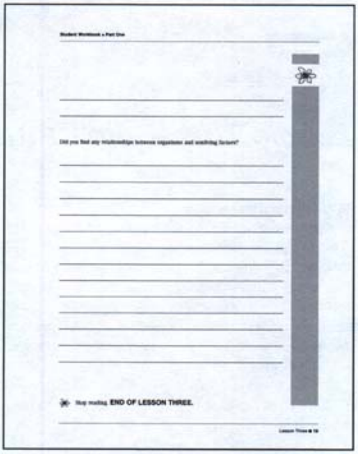
Lesson Three: Community Relationships

Instructions for teachers

The focus of the next two lessons is getting students to begin thinking about organisms in different ways—not just what it is and where it lives, but also what it does where it lives. Learning about the basic interactions of organisms is crucial to understanding ecology and biological control. Students should be able to complete this lesson, including the worksheet, without much help from the teacher.

When you are ready to begin, students can read the text in their workbooks and begin the **Relationships Worksheet**.

RELATIONSHIPS Worksheet



END OF LESSON THREE.

Tips for teachers on the Relationships Worksheet

This worksheet can be done by each student individually or in small groups with a sharing of results when finished.

Extension idea

Human beings also interact with many other organisms and depend on many relationships with other organisms. As a group, make a list of relationships you have with other organisms and how these relationships help you to survive. Below are a few relationships to get you started.

- Think of all the things we use wood for (heat, houses, tools, etc.). These are relationships we have with trees.
- Everything we eat comes from an organism. Each food is a relationship.
- What about plants and animals we use to make clothes?

Suggested journal entry

Have the students write their own relationship story and list the relationships they used.

PART ONE

Mission: Life on Earth

Lesson Four: Food Chains

Instructions for teachers

This is the final lesson in Part One. Before beginning Lesson 4 with students, you will need to prepare the food chain cards. Lesson 4 challenges students to think in more detail about a special type of relationship: food chains. A very important concept to reinforce as you complete this lesson is that ecosystems vary in many ways (e.g., different organisms and different nonliving factors), but all ecosystems also have many things in common (e.g., all have producers and consumers, which form relationships such as food chains). The scientists from another planet story line will end with the completion of this lesson. Instructions on how to prepare the cards are included later in this lesson. If students have not figured out the name of the mystery organism, you should tell them it is a wetland plant called purple loosestrife.

Lesson Four : Food Chains

By now, your team of scientists has learned the meaning of the clue "purple" and have identified the mystery organism as purple loosestrife, a plant that lives in the marsh community. You are now interested in learning more about the marsh and other communities. There are many types of interactions and relationships between organisms in each community. Although each community has a different set of organisms, such as the marsh community and the forest community, all communities have certain relationships in common. We are going to learn more about several special types of relationships that are found in every community.

Every community has producers and consumers.

Producers are plants that contain chlorophyll (the pigment in plants that makes them green). The amazing thing about these plants is that they can make their own food. The chlorophyll traps energy from sunlight, and along with carbon dioxide from the air and water from the soil, these plants make food through a process called photosynthesis. Remember, producers (green plants) are the only things on Earth that can make their own food. Animals are never producers.

Consumers are animals, which cannot make their own food and depend on producers for food. There are different types of consumers. A herbivore is a consumer that eats only plants. A carnivore is a consumer that eats only animals. An omnivore eats both plants and animals. Are you a herbivore, a carnivore or an omnivore?

An example of a herbivore in the forest would be a red squirrel, which eats seeds and a herbivore in the marsh would be a muskrat, which eats cattail roots. An example of a carnivore in the forest would be a scarlet tanager, which eats caterpillars, and a carnivore in a marsh would be a dragonfly, which eats other insects. An example of an omnivore in the forest would be a black-capped chickadee, which eats both insects and seeds, and an omnivore in the marsh would be a painted turtle, which eats both aquatic plants and small animals such as snails and insects.

When carnivores or omnivores capture and kill other animals for food, they are called predators. The animal that is killed and eaten is called the prey. This is called a predator-prey relationship. When carnivores or omnivores eat animals that are already dead, they are called scavengers.

If you eat a hot dog on a bun, which of the following terms would apply to you?

Circle the words which would apply.

Producer **Consumer** **Herbivore**

Omnivore **Carnivore** **Predator**

Prey **Scavenger**

Once you are prepared for the Food Chain Card Activity, you can begin this lesson by having the students read the Student Workbook text.

Food chain card activity instructions for teachers

One copy of the food chain cards is included in the materials section of the unit. You can either cut these cards out or make copies to cut up. There are two sets of cards: one for the forest ecosystem and one for the marsh ecosystem.

Each set includes:

- 24 organism cards. Each organism card includes the name of the ecosystem (either forest or marsh), name of the organism, classification of the organism (insect, bird, mammal, etc.) and what the organism eats.
- One SUN card (only one SUN card should be used for each ecosystem).
- On the same page as the SUN card are blank organism cards for either forest or marsh ecosystems. The use of these is optional but encouraged. Students can use these blank cards to make additional food chain cards by using organisms they identified in Lesson 2 on the Comparing Ecosystems worksheet. These can be used to supplement the other organism cards.
- There is one sheet of ENERGY FLOW cards. One of these eight cards goes between each link in the food chain with the arrow pointing in the direction of energy flow. The energy flows from the sun to producers and then to consumers.

You will need to make enough copies of the energy flow card page so there are about the same number of energy flow cards as there are organism cards.

Once you have all the cards prepared, the procedure is simple. The students who explored the marsh ecosystem in Lesson 2 will work on the marsh ecosystem food chains, and those who did the forest ecosystem in Lesson 2 will work on the forest ecosystem food chains. Each group will need a fairly large surface to work where the group can sit in a circle around the cards and all participate. Divide the cards among the

Can you explain why you circled certain words?

Each time one organism is eaten by another organism, a relationship exists. A food chain is a special way of looking at these relationships. Let's look at a food chain with three links.

GRASS → MOUSE → HAWK

This shows that the grass was eaten by the mouse and the mouse was eaten by the hawk. The hawk is at the top of this food chain, so it is not eaten by anything. Let's look at another example.

ALGAE → SNAIL → WATER BEETLE → MINNOW → PERCH → LAKE TROUT → HUMAN

We can look at each link in the food chain and learn what it eats and what eats it. For example, the minnow eats the water beetle and is eaten by the perch. You may have noticed that the first link in a food chain is always a producer, because producers are the only organisms that can make food. Remember, producers get their energy from the sun. All the other links are consumers. The number of links in a food chain depends on how many consumers are involved. Can you see some of the new terms you learned to describe parts of the food chain? Which organism in the above food chain is a herbivore? Which are carnivores? Are there any predator-prey relationships? As you can see, you can learn a lot about relationships in a community by making and looking at food chains.

All the scientists from Planet ________ have now returned to the spaceship with information on the forest ecosystem and the marsh ecosystem (from Comparing Ecosystems Worksheet in Lesson #2). Your next task is to take the information you gathered in the ecosystems and try to understand more about how the organisms interact with one another and about some of the relationships within each community.

Next do the Food Chain Card activity.

Congratulations! Your mission to explore Earth has been very successful. The only clue that you may not have learned the meaning of is "INVADER." We will learn more about the meaning of this word in the next section. You will now return to Planet ________ and report your exciting discoveries about life on Earth.

Stop reading. **END OF PART ONE.**

students and have them work together to link the cards to make a food chain/web. You may want each student to copy the food web onto a piece of paper or in his/her journal.

All food chains begin with energy from the sun, so start by placing the SUN card. After placing the SUN card, the next card(s) are always producers (plants that use sunlight to make their own food). An energy flow arrow is placed to show the energy going from the sun to the producer. Organisms that eat producers are the next link, and organisms that eat these consumers are next. Some chains may end with the producer; others may have several links. All the information needed to make the links is included on the cards (e.g., the ground beetle eats insects, so it could be linked to any insect card). Since most organisms are eaten by many types of other organisms (e.g., earthworms could be eaten by garter snakes, salamanders and shrews) many of the food chains will not be linear but rather branched. When you have many food chains branched together, you have created a food web! One thing that should be explained to the students is that each card represents a population of organisms, not just one individual (e.g., the earthworm card does not represent just one earthworm but a population of many individuals so you can have several organisms branched from the earthworm card).

A page included with the food chain cards shows examples of ways the food chain cards could be linked together. The most important thing to remember is that there are numerous correct ways to link the cards together, so don't try to copy these samples exactly.

Teacher tips on conducting food chain card activity

After students have successfully organized the food chain cards for the forest and marsh ecosystems, it is important to ask them what they think would happen to either ecosystem if only one kind of producer were present. What is the difference between a natural field ecosystem with many types of plants and a cornfield with only one type of plant? What would happen to a marsh if one plant "took over" and all the other plants, such as cattails, were crowded out? This is exactly what happens when purple loosestrife becomes established in wetlands in North America. Can students predict what effect this would have on the marsh food chain? This will be covered in detail in Part Two.

Food chain card examples

On the following page are two examples of possible ways the food chain cards can be put together. Not all organisms are used in these examples. You also do not have to use every organism card to complete the activity. These examples show only the organism names. The cards also show what each organism eats, so it is easy to make the various chains.

Extension ideas

Get some blank index cards (one for each student) and write the name of a different familiar organism on each card. Without letting the students see what is written on the cards, tape one card to the back of each student so everyone else can see what is on the card. The game is for each student to guess what organism is written on his/her back by asking other students questions. All questions must be answered "yes", "no" or "I don't know." Students can ask another student only one question before moving to the next person.

Outdoor activities

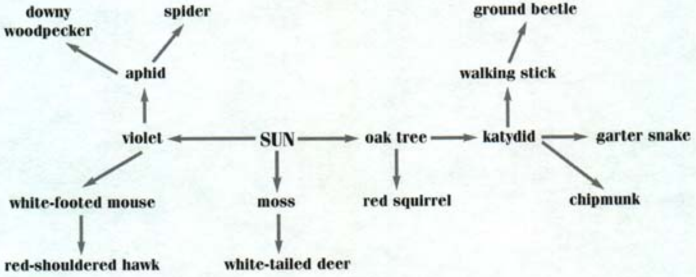
In your school yard (or other natural area if available), take a walk and list as many different organisms as you can. If you don't know the name of the organism, draw a picture of it or describe it. How many different organisms can you find? Can you observe or think of relationships that each organism has with other organisms or with nonliving factors? Can you construct any food chains with the organisms you found?

Wrap-up

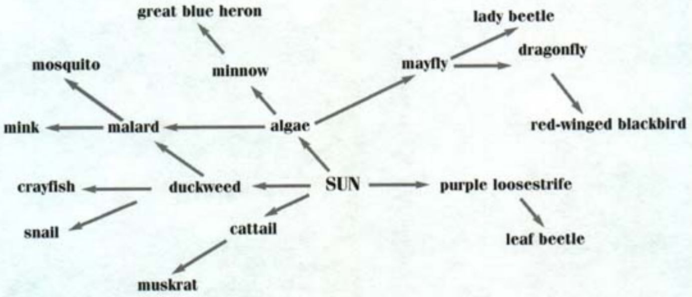
It's time to wrap up Part I at this point. You may want to return to the eight clues and the picture of the mystery organism to review the main ideas and concepts covered in this section. The only clue not covered in Part I is "invasion." Although students will be familiar with this word, they probably have never associated the word with an invasion of an exotic organism. This will be the focus of Part Two.

After completing the Food Chain Card Activity, students should read the remaining student information in the Student Workbook.

Forest Ecosystem Example



Marsh Ecosystem Example



PART TWO - INVASION OF PURPLE LOOSESTRIFE

Timing is critical for Parts Two and Three because students will be growing a purple loosestrife plant in the classroom in Part II and will be releasing beetles on their plant in Part Three. To be successful, it is important that the purple loosestrife root crown is planted early enough to ensure that the plant will have grown enough to provide food for the beetles when they're released. For instructions on planting and care of the root crown and plant, see "Raising Galerucella Beetles Indoors" and "Lighting Requirements for Indoor Rearing of Galerucella Beetles" in the Cooperator's Handbook.

You should be at a point where you are ready to begin Lesson 5 of Part Two about the same time you are potting the purple loosestrife root crown. You will want to begin this section a couple weeks before planting the root crown so Lessons 1- 4 will have been completed before the planting date.

Part Two
Invasion of Purple Loosestrife

ESTIMATED TIME TO COMPLETE PART TWO: Field tests in several classrooms indicate that, teachers should expect Part Two to take 6 to 8 hours of class time spread over about 4 weeks. This time does not include extension or outdoor activities.

Abstracts and Michigan teaching objectives

■ Part Two, Lesson 1
Invasion Discovered

Michigan Curriculum Framework References

Science: Standard I.1 Constructing New Knowledge, II.1 Reflecting on Scientific Knowledge

English: Standards 1,2,3 Meaning and Comprehension, 11 Inquiry and Research

Method

Building on the investigation in Part 1, students will explore the idea of exotic species and how they effect native species. This lesson is a questioning strategy exercise (who, what, where, when, and how).

Materials

Article and worksheet in the student workbook provided

Procedure

1. After reviewing terms from Part 1, students will read the article "Aliens Invade the Midwest".
2. Students will complete the Invading Aliens worksheet.
3. Students will become newspaper reporters who want to find out more about the aliens. Each student will create five questions they would like to ask one of the biologists who discovered the aliens.
4. The class will decide on the five questions that they would like to explore.

Part Two, Lesson 2 Press Conference

Michigan Curriculum Framework References

Science: Standard I.1 Constructing New Scientific Knowledge, II.1 Reflecting on Scientific Knowledge, III.5 Ecosystems

English: Standards 2,3 Meaning and Communication, 11 Inquiry and Research

Method

Students will act as reporters who are responsible for writing an article based on information they get at a press conference.

Materials

Biome map and color photo of purple loosestrife provided

Procedure

1. Students will act as reporters and ask questions from the student workbook.
2. The teacher will play the part of the biologist and respond to the questions raised by the students. Answers are in the teacher's guide.
3. Students should take notes on all the responses that are given by the biologist (teacher).
4. Students will try to answer questions raised in the previous lesson (Lesson 1) with the information they gathered at the press conference.
5. Students will organize their notes from the press conference and write an article from the information they have gathered. They may be instructed to use the questioning strategy of who, what, where, when, why, and how.

Part Two, Lesson 3 A Trip Across The Ocean

Michigan Curriculum Framework References

Science: Standard I.1 Constructing New Scientific Knowledge, II.1 Reflecting On Scientific Knowledge

Social Studies: Standard I.1 Time and Chronology, I.2 Comprehending the Past, II.2 Human/Environment Interaction, II.4 Regions, Patterns, and Processes

Method

Students will explore the history of the invasion of purple loosestrife. They will trace the arrival and spread of purple loosestrife, and identify other major historical events occurring during the time period.

Materials

Student workbooks provided

Procedure

1. Students will read historical information about purple loosestrife in their workbooks.
2. Using a cross-section of a tree, students will construct their own tree trunk time line. They will mark the major events in their life on the different rings on the tree.
3. Next, the class will construct a two hundred year old time line and trace the arrival and spread of purple loosestrife using the information read in the student workbook.

Part Two, Lesson 4 Cycles

Michigan Curriculum Framework References

English: Standards 1,2,3 Meaning and Communication, 4 Language

Social Studies: Standard II.2 Human/Environment Interaction

Method

Students will construct a cycle of important events that happen to them. They will use important dates of the year to organize information. This will be helpful in understanding the plant life cycle taught in Lesson 5.

Materials

Dinner-size paper plates, bold markers or crayons

Procedure

1. Students will write down important dates of the year such as their birthday, Christmas, and St. Patrick's day.
2. These events will be recorded on the paper plates next to the month that they occur.
3. Students will answer questions that will help them to understand how the information is organized and the nature of a cycle.
4. Students should save their paper plate cycles to use in Lesson 5.

Part Two, Lesson 5 Life Cycles

Michigan Curriculum Framework References

Science: Standard I.1 Constructing New Scientific Knowledge, II.1 Reflecting on Scientific Knowledge, III.2 Organization of Living Things

English: Standards 1,2,3 Meaning and Communication

Method

Students observe the life cycle of purple loosestrife in this lesson, which has four parts; 1) Roots 2) Stems and leaves 3) Flowers 4) Seeds, and pollination. This lesson should take several days to complete.

Materials

Microscope or magnifying glass, variety of seeds, potted purple loosestrife plant

Procedure

1. After an introduction to the life cycle of flowering plants, students will observe the life stages of purple loosestrife.
2. Students will make observations about the root system of the classroom plant. They will draw what they see in the workbook and then discuss how this particular root system helps the plant survive.
3. As shoots and leaves appear, students will make observations about the stems and leaves, students will make drawings in the workbook.
4. The class will read a passage in the workbook about photosynthesis. Next, they make a diagram showing the movement of energy and food through the stems and leaves.
5. Next students will examine how the flowers help the purple loosestrife plant survive. They will make observations about the plant's flowers and discuss pollination as a factor in its reproduction.
6. Students will complete a worksheet to show how bees and other animals help to pollinate flowers.
7. Students will then investigate how seeds help flowering plants survive.
8. After observing features of a number of seeds, students will classify the seeds based on inferences about dispersal mechanisms.

■ Part Two, Lesson 6 Protecting Wetlands

Michigan Curriculum Framework References

Science: Standard II.1 Reflecting on Scientific Knowledge, III.5 Ecosystems

English: Standards 1,2,3 Meaning and Communication

Method

This last lesson in Part II brings together information learned in Part I and II on purple loosestrife, exotic vs. native organisms and their relationships. Threats to wetland ecosystems are also covered. This lesson introduces the idea of biological control.

Materials

"Hula" hoop or length of yarn, something to represent 300 cattail plants and 300 purple loosestrife plants (e.g. pennies, popcorn, etc.), one die

Procedure

1. After reading some about the threats to wetlands, students will play the wetland relationship game described in the workbook.
2. This game will demonstrate how purple loosestrife can invade a wetland and how an exotic organism can disrupt the natural relationships that occur in wetland ecosystems.
3. After recording the results of the game students will answer some questions in the workbook about what they think will happen to the wetland ecosystem.
4. Next students will read about why wetlands are important to the environment.

Part Two: Main Ideas and Concepts

- The Great Lakes region is not the only place on Earth with a temperate deciduous forest biome. Because of similar geographic location, climate, topography and other physical features, a large part of Europe and part of Asia are also in a temperate deciduous forest biome.
- Because Europe and North America are separated by the Atlantic Ocean, most of the plants and animals that have developed in these two areas are different. The plants and animals that developed in Europe are native to Europe. The plants and animals that developed in North America are native to North America.
- A plant or animal living away from its native environment is called "exotic".
- There are various ways by which plants and animals end up away from their native environment. Some are intentional and some are accidental.
- Purple loosestrife is an example of a plant that is native to European wetlands that was transported across the ocean and now grows in Great Lakes region wetlands. In the Great Lakes region, purple loosestrife is an exotic plant.
- In Europe, where purple loosestrife is native, many natural enemies eat the plant and keep its population under control. In the Great Lakes region, these natural enemies are absent and purple loosestrife populations are growing out of control.
- Without any natural enemies, purple loosestrife easily spreads and grows out of control because of its life cycle.

- Purple loosestrife has spread to many wetland areas throughout the Great Lakes region and is having a negative impact on many native plants and animals.
- Native wetlands are disappearing because of a variety of human-caused factors, including purple loosestrife, development and pollution.
- Native wetlands are important because they provide homes for many plants and animals, protect water quality, reduce flooding and erosion, and provide recreation for humans.

Part Two: Background Information - The Problem of Purple Loosestrife

If you again look at the map of the earth's biomes, you see that the Great Lakes region is not the only place in the world where there is a temperate deciduous forest biome. Because of its similar climate, geographic location and other physical features, a large part of Europe is also part of the temperate deciduous forest biome. But because Europe and North America are separated by the Atlantic Ocean, each has different species of plants and animals, which have developed over millions of years.

Let's use the marsh ecosystem as an example. We already learned that a marsh in the Great Lakes region may have cattails, sedges, muskrats, dragonflies, and many more plants and animals that make up the marsh community. These plants and animals are native to the Great Lakes region. If we were to visit a marsh ecosystem in Europe, at first it may look very similar to a Great Lakes wetland. If we looked closely, however, we would see many plants and animals that are not found in the Great Lakes region. These organisms make up the European marsh community and are native to Europe.

What do you think would happen if you tried to move plants and animals to a different biome? If you moved a saguaro cactus and a roadrunner from the desert biome to the tundra biome, they would not be able to survive because they are not adapted to the climate of the tundra. If you moved a sugar maple and an eastern chipmunk from the temperate deciduous forest biome to the tropical rain forest biome, they also could not survive because they are not adapted to the amount of rainfall, the wet and dry seasons, and other factors of a tropical climate.

What do you think would happen if we moved a plant or animal from the European temperate deciduous forest biome to the temperate deciduous forest biome in the Great Lakes region? Many plants and animals, because the climate and other physical conditions are similar, would be able to survive. What would be missing, however, are all the relationships with other organisms from its native ecosystem. These plants and animals would not be native to the new area. They would be known as alien or exotic plants and animals.

There are many examples of exotic plants and animals in the Great Lakes region that came from the temperate deciduous forest biome in Europe. How did these plants and animals get across the Atlantic Ocean? Most were brought by ships traveling from Europe to North America. Some - such as the European starling, honeybee, gypsy moth and wild carrot - were brought intentionally. Most, however, were transported by accident. Norway rats and the house mouse were stowaways aboard ships. Some, such as the zebra mussel, were transported in the ballast of ships. Ballast is material, usually water or sand, that is loaded onto ships to add weight, which makes the ships more stable. Many ships add ballast in European ports, where they pick up the organisms, and then dump the ballast when they reach North America. Many plants were also accidentally brought to North America as seeds, either mixed in bags of grain or stuck to the hair of farm animals. Because the natural enemies of these exotic organisms - such as predators, herbivores and parasites - were not brought to North America, some species grew out of control.

Let's take a look at one exotic plant species called purple loosestrife. Purple loosestrife is a native wetland plant in Europe. This means that Europe is the location where purple loosestrife originated. Purple loosestrife is thought to have arrived along the east coast of North America in the early 1800s accidentally as seeds in the cargo and ballast of early sailing ships and as seeds stuck to animals such as sheep. Some purple loosestrife was also introduced intentionally by immigrants as a medicinal herb, landscape flower and nectar source for honeybees. Purple loosestrife is still sold today in many gardening catalogs and nurseries, but its sale is now illegal in some Great Lakes states, including Michigan. It has also been found that many of the wildflower seed mixes used by homeowners and road commissions contain seeds of purple loosestrife.

How did purple loosestrife get from the Atlantic shoreline of North America to inland areas such as the Great Lakes region? In their rush to settle the new land, immigrants began building a network of canals to inland areas. These canals were perfect for the invasion of purple loosestrife for two reasons. The first is that these water canals and the ships traveling on them made the transport and dispersal of seeds easy, and second is that building the canals created huge areas of disturbed wetlands for purple loosestrife to invade. One of the largest canal projects was the Erie Canal, completed in 1825, which connected Lake Erie to the Hudson River and other canals in New York. It is easy to see, with a connection to Lake Erie, how purple loosestrife arrived in the Great Lakes region. By 1900, purple loosestrife had spread to many wetlands in the Great Lakes region.

Purple loosestrife is a producer, and there are many native herbivores that eat purple loosestrife in Europe. In fact, scientists have identified at least 120 species of insect herbivores that feed on purple loosestrife in Europe. Some eat flower buds, some eat flowers, some eat leaves, some eat stems, some eat seeds and some eat roots. Because of these herbivores, only a certain number of purple loosestrife plants can survive in the European wetlands. If these herbivores were to disappear, purple loosestrife would grow out of control, and this would have a negative effect on the other plants and animals in the wetland. So the relationships between purple loosestrife and the herbivores that feed on it are important to the health of the European wetland ecosystem. All the other plants and animals in the wetland have similar relationships, which make the wetland a complex web of interrelated plants and animals.

The same is true for the wetlands in the Great Lakes region. Each of the native wetland plants is fed on by a variety of native herbivores, this feeding keeps each plant from growing out of control. There is a natural balance that keeps both the plant and animal populations from becoming too abundant. When purple loosestrife begins growing in a Great Lakes wetland, where it has no natural enemies, it quickly grows out of control and crowds out the native plants and animals.

Purple loosestrife has a life cycle well adapted to living in wetlands. Its seeds are primarily responsible for its spread to other wetlands. Purple loosestrife seeds are very small and extremely numerous. Some seeds travel between wetlands by floating. Others will sink to the bottom of the wetland and then rise to the surface after germination and are dispersed as floating seedlings. Many of the seeds are mixed with the wetland soil, which sticks to animals such as deer or herons, or to tires of off-road vehicles or boots of hunters and so are dispersed in this manner. Scientists have suggested that purple loosestrife seeds may also be dispersed by wind, by sticking to the feathers of birds, or by being eaten by animals and then deposited in other wetlands in their droppings. Because of these many dispersal strategies, purple loosestrife can easily spread from one wetland to another. In addition, seeds are viable up to three years, have an 80 per cent germination rate and can germinate in a wide range of soil conditions.

Once a seed finds a suitable location, it will begin to grow roots, stems and leaves. Eventually (it takes 3-5 years for it to become a mature plant), the plant will develop a large root crown made up of many stems. The root crown survives through the winter and grows new stems and leaves each year. One mature plant can grow over eight feet tall. The plants also grow very close to one another and form a stand so dense that it crowds out the native plants. During the summer, the plants produce abundant and beautiful spikes of purple flowers. These flowers are insect-pollinated. After pollination, the flowers produce tiny seeds, which are stored in small seed capsules. Studies have shown that there are about 1,000 seed capsules per stem and about 90 seeds per seed capsule. This means that one mature plant can produce more than 2 million seeds each year! These seeds fall into the water and on the mud ready to be transported to another wetland.

Another adaptation that allows purple loosestrife to be such a successful invader is that it thrives in disturbed areas. When the root crowns of purple loosestrife are damaged by trampling, machinery or by other means, the injured roots will send up even more new stems. All of these adaptations give purple loosestrife a competitive advantage over native vegetation that allows it to take over entire wetland areas.

Purple loosestrife is called a perennial because each plant can survive for many years. During the winter, the stems, leaves and flowers of purple loosestrife die, but, the root crown remains alive in the wetland soil and will grow again when spring arrives. The seeds also overwinter. Trees are another example of perennials. Some kinds of plants are called annuals because they complete their entire life cycle in one growing season and only the seeds remain alive to grow new plants the following year. Corn is an example of an annual. Other plants are called biennials because they complete their entire life cycle in two years. A carrot, for example, will grow from a seed to a clump of leaves during the first year. The food made by these leaves is stored in the root, which is the only part of the plant which lives through the winter. During the second year, the food stored in the root is used by the plant to grow new leaves and a tall flower stalk. After pollination, seeds are formed and the entire plant, except the seeds, will die. If you ever had a garden with carrots, you probably haven't seen the flowers and seeds. This is because we harvest the carrot taproot after the first year of a two-year cycle so we can eat the food the plant has stored in the taproot. If you were to leave some carrots in your garden for another year, the plant would use the food in the taproot to grow new leaves as well as flowers. The flowers would make seeds and the rest of the plant would then die.

The main physical characteristics used to identify purple loosestrife from other wetland plants are the purple flower spikes, a square stem with opposite or whorled stemless leaves, and, during late fall and winter, the tall, dead stems with the seed capsules.

How does purple loosestrife affect native plants and animals? First, let's think about a native cattail marsh in North America before the invasion of purple loosestrife. Although cattails may be the dominant plant, many other species of wetland plants would also be mixed within the cattails and found along the wetland edge and near open areas of water throughout the marsh. The cattails and other plants provide food, nesting sites, nesting materials and cover for the numerous species of wetland animals, such as muskrats, mink, birds, turtles, frogs, fish, insects and other invertebrates. Animals such as raccoons, foxes, hawks and owls will visit the marsh for food. A complex web of relationships among the native plants and animals keeps the marsh ecosystem diverse.

When purple loosestrife becomes established in a wetland area, it usually forms a dense stand where few other plants can survive. Once purple loosestrife is the dominant plant, many of the relationships between the native plants and animals are disrupted. Native plants cannot compete with the aggressive purple loosestrife, so they disappear from the wetland. Once the native plants are gone, the animals that depended on these plants for food, cover, nesting sites, nesting materials, areas to raise young and other needs have a hard time surviving and either die or leave the wetland area. It has been found that few native animals use purple loosestrife as a nesting site or as food. These marshes are also home to fragile and rare species of plants and animals that cannot survive the invasion of purple loosestrife. Purple loosestrife also changes the structure of the marsh. For example, by eating cattails, muskrats create small areas of open water throughout the marsh. These open areas are used by many species, such as waterfowl, for nesting and feeding. A marsh dominated by purple loosestrife does not have these openings. Many migratory birds also use these wetland areas as resting and feeding areas during their spring and fall migration. Once purple loosestrife is present, the areas may not provide the open mudflats and food required by these migrant species. Some animals, such as red-winged blackbirds and swamp sparrows are able to survive in purple loosestrife stands, but most cannot.

Purple loosestrife is not the only threat to Great Lakes wetlands. Many wetlands suffer from pollution, and many more are destroyed each year by development. Because of these threats, Great Lakes wetlands are disappearing at an alarming rate (see student workbook information for details).

You are now ready to begin this section with students.

PART TWO

Invasion of Purple Loosestrife

Lesson One: Invasion Discovered

Instructions for teachers

Part Two includes a variety of worksheets and activities leading up to the life cycle of purple loosestrife and its impact on wetlands. Part Two builds on ideas and information covered in Part One, so it will be helpful to review with the students the main points of Part One before beginning, including the meanings of the clues from Part One. The clues are EARTH, BIOME, ECOSYSTEM, ORGANISM, COMMUNITY, MARSH and PURPLE. The last clue, INVASION, will be discussed in this section. Begin Lesson 1 by having students read the newspaper article "Aliens Invade he Midwest" in their student workbooks.

Part Two Invasion of Purple Loosestrife

Lesson One : Invasion Discovered

To begin, read the following newspaper article.

Aliens Invade the Midwest

Anytown, USA

Biologists have discovered that millions of aliens have invaded much of North America, including the Great Lakes region, and that this invasion has been going on for over 100 years! The biologists who have seen the aliens also have discovered that large numbers of aliens, some of them 7 feet tall, are living in marshes and swamps, along shorelines and in other wetland areas. Although the aliens appear to be harmless, their numbers are growing out of control. In some wetlands, the aliens have killed many native plants and have forced many of the native animals to leave. What can be done to stop this invasion?

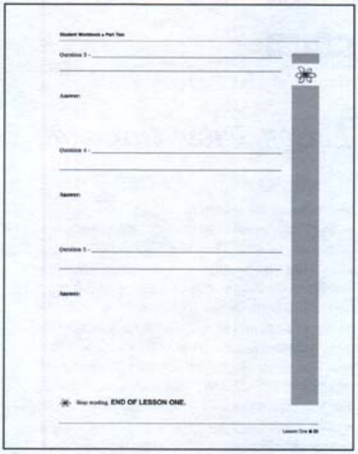
INVADING ALIENS Worksheet

Question 1 -

Answer:

Question 2 -

Answer:



Question 3 -

Answer:

Question 4 -

Answer:

Question 5 -

Answer:

END OF LESSON ONE.

Teacher tips on the Invading Aliens Worksheet

This is designed as a questioning strategy exercise (who, what, where, when, why and how). After students have read the article, divide the class into several small groups. Have each group complete one worksheet. Each group of students will then work together to decide on five questions they would like to ask one of the biologists who discovered the invasion. At this point, students are not expected to know the meaning of the word "invasion" as it applies to exotic organisms. After students decide on their five questions, have all the groups share by making a list of the questions on the chalkboard or on a poster (write the questions in a place where they can be saved and referred to in the future). What do the students think is the most important information to get from the biologist? Can two or more of the questions be merged into one question? Finally, as a group, create five "best questions" that the class would like to ask the biologist. Students will learn the answers to their questions as they complete the following lessons. In the next lesson, students will be asked to revisit this worksheet and to write answers to their questions.

PART TWO

Invasion of Purple Loosestrife

Lesson Two: Press Conference

Instructions for teachers

In Lesson 2, students will begin to learn the answers to their questions by participating in a mock press conference between a group of reporters (the students) and one of the biologists who discovered the invasion (the teacher or another adult).

Before students begin this lesson, you will need to think about how you want to organize the press conference. First, a person playing the role of the biologist must be selected. It may be best for you (or another adult) to be the biologist because many of the biologist's responses are long and contain words the students may not be familiar with. All the students are reporters and they should raise their hands if they want to be selected to ask a question. The students have the reporter questions in their student workbooks but not the biologist's responses. The biologist's responses are only in the teacher's guide. Students should follow along with the questions in their student workbooks during the press conference, and questions should be asked in the order written. To make this easier, questions are numbered.

Lesson Two - Press Conference

The newspaper article "Aliens Invade the Midwest" has caused much concern and raised many questions. To answer these questions, a press conference has been scheduled between a group of reporters and one of the biologists who discovered the invasion. You and the other students are the reporters. A written copy of the questions you will be asking the biologist in the press conference is below. Listen closely to each question and answer. There is space after each question for you to take notes. You will use your notes to write an article about the invasion.

QUESTIONS ASKED BY REPORTERS
(read questions in order given):

Have you seen the aliens?

What do they look like?

How big are they?

This sounds scary! Do we have to worry about being attacked?

Where are these aliens from?

From Earth! I thought aliens were like little green men from Mars.

What does "native" mean?

As part of this lesson, students will act as reporters and will be responsible for writing an article based on the information they get from the press conference. As each question is asked by a reporter and answered by the biologist, all students should take notes on all the responses. There is space after each question in the student workbooks for students to take notes on the biologist's responses. It may be helpful to have the biome map and the color photo of purple loosestrife (both supplied with Part I) to use as resources during the press conference. To begin, have the students read the first paragraph of Lesson 2.

Questions asked by reporters *(read questions in order given)*

1. Have you seen the aliens?
   Biologist: Yes.
2. What do they look like?
   Biologist: They are purple and green.
3. How big are they?
   Biologist: They can be as small as the point of a pencil or 8 feet tall.
4. This sounds scary! Do we have to worry about being attacked?
   Biologist: No. These aliens move very slowly and are not a threat unless you are a plant or animal that lives in wetlands.
5. Where are these aliens from?
   Biologist: The aliens are from Earth.
6. From Earth! I thought aliens were like little green men from Mars.
   Biologist: Sometimes the word "alien" is used to mean life from other planets, but "alien" is also used to describe plants or animals that are living in areas where they are not native.

How can a plant or animal become an alien?

So, how can an alien organism survive?

Can you give me some examples of real aliens?

Does it have something to do with biomes?

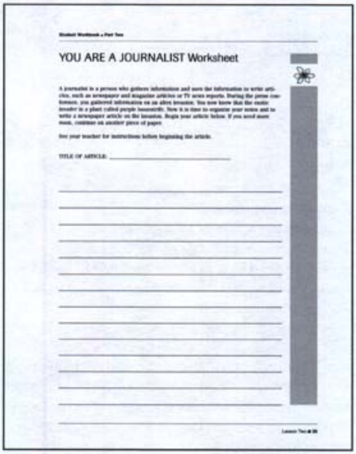
You said that most alien organisms in North America are native to Europe. How did these plants and animals get across the Atlantic Ocean to North America?

You said that the Midwest is being invaded by aliens. What do you mean by "being invaded"?

You have given different meanings to the words "native," "alien" and "invader." Are there any other words we need to know to understand what is going on with this alien invasion?

So, what are these 7 foot-tall, purple and green organisms that are invading the Midwest?

Stop reading and get instructions from the teacher.



YOU ARE A JOURNALIST Worksheet

TITLE OF ARTICLE: ______

7. What does "native" mean?

   Biologist: "Native" is another word that has many meanings. There are many organisms living on Earth, but different organisms live in different areas or biomes. For example, a polar bear lives in the tundra biome and the saguaro cactus lives in the desert biome. So we say that the polar bear is native to the tundra and the saguaro cactus is native to the desert. Every organism has a native area.

8. How can a plant or animal become an alien?

   Biologist: A plant or animal is called an alien when it is living away from its native area. If a polar bear were moved from its native tundra to the desert, it would be called an alien. Of course, because the tundra biome and the desert biome are so different, polar bears would not be able to survive in the desert, just as a saguaro cactus would not be able to survive if it were moved from the desert to the tundra. Most organisms could not survive being moved to a different biome.

9. So, how can some organisms survive as aliens?

   Biologist: Let's use the cactus as an example. The saguaro cactus is native to desert areas only in North America. What if a saguaro cactus seed found its way to a desert area in Asia? It may be possible, since the cactus is still in a desert biome, that the cactus seed could grow and survive. If it did, it would be an alien in the Asian desert.

10. Can you give me some examples of real aliens?

    Biologist: Yes. There are many alien plants and animals in North America. Some you may be familiar with are house mice, European starlings, ring-necked pheasants, honeybees, gypsy moths, zebra mussels, Scotch pine trees, common apple trees, Queen Anne's lace and corn. Most alien organisms in North America are native to Europe. Do you know why?

11. Does it have something to do with biomes?

    Biologist: Right! Much of the eastern part of North America and much of Europe are in the temperate deciduous forest biome. Because the two areas are separated by the Atlantic Ocean, each area has developed different plants and animals. If an organism travels from the temperate deciduous forest of Europe to the temperate deciduous forest of North America, it may be able to survive because the areas are very similar.

12. You said that most alien organisms in North America are native to Europe. How did these plants and animals get across the Atlantic Ocean to North America?

Biologist: That is an excellent question. Most aliens were brought to North America by humans. Some animals, such as the honeybee, were brought on purpose. Many alien plants were brought on purpose from Europe to plant in gardens. Other alien organisms were brought by accident. The house mouse and the Norway rat came accidentally as stowaways aboard ships carrying farm animals and grain to North America from Europe. Many alien plants also came by accident on ships because their seeds were mixed in with bags of grain or stuck to the hair of farm animals.

13. You said that the Midwest is being invaded by aliens. What do you mean by "being invaded"?

    Biologist: The word "invasion" is another word that has multiple meanings. Biologists use the word "invasion" when an alien organism becomes a problem because its population cannot be controlled. We can say that North America has been invaded by the house mouse and the European starling.

14. You have given different meanings to the words "native", "alien" and "invasion". Are there any other words we need to know to understand what is going on with this alien inva-sion?

    Biologist: Well, there is one other word you should know. The word is "exotic". To a biologist, "exotic" means exactly the same as "alien". So, a house mouse is an exotic or alien animal and corn is an exotic or alien plant. Biologists prefer to use the word "exotic" instead of "alien", so from now on we will use the word "exotic".

15. So, what are these 8-foot-tall, purple and green exotics that are invading the Midwest?

    Biologist: The exotic organism we are talking about is a plant called purple loosestrife. Purple loosestrife is native to wetland areas in Europe.

Instructions for teachers

Before starting the next worksheet, have students go back to the Invading Aliens worksheet from Lesson 1. After each question they wrote on this worksheet, there is a space for them to write an answer from information they obtained from the press conference. Have each student finish the worksheet by writing an answer, if known, to each of their questions. Also, discuss as a group the five best questions that the class came up with in Lesson 1. They may not have all the information needed to answer every question, but they will get more information in the following lessons. After completing this task, students can complete the You Are a Journalist worksheet.

After writing answers to your questions on the Invading Aliens Worksheet, you can complete the You Are A Journalist Worksheet.

Teacher tips on the You are a Journalist Worksheet

This worksheet is a writing exercise in which students use their press conference notes and questions/answers from the Invading Aliens worksheet to write a newspaper article. Writing skills are taught in many ways, so you will need to discuss the format and methods used in your classroom with the students before they begin. If you are not a classroom teacher, here is one way you could have your students organize their notes and information:

- List the major points they think are important—who, what, where, when, why, how.
- Place these major points in an order that makes sense for an article.
- Use this outline to write the article.

You may want to limit the length of the article by giving the students a maximum number of words or sentences.

Suggested journal entry

Select a science article from a newspaper or magazine for the students to read (or have each student select an article he/she finds interesting). Have the students make an outline of the main points of the article in their journals and also include what they liked and/or disliked about how the article was written. The Internet is also a good resource for this activity.

Extension idea

From this point through the end of the school year, have students collect newspaper and magazine articles on exotic organisms (or wildlife in general, if you want a broader subject). The articles can be displayed on a bulletin board or kept in a scrapbook.

NOTE TO TEACHERS ON LESSONS 3 AND 4 *Lessons 3 and 4 are recommended but optional, depending on your time limitations and teaching objectives. Lesson 3 is designed to integrate history into this unit. If you will be teaching American history (or other history topics), the worksheet and activity in Lesson 3 will help students understand the invasion of purple loosestrife in the context of your other history lessons. Lesson 4 deals with the concept of cycles and is meant to help students understand life cycles (Lesson 5). If you decide to omit Lesson 3, students should still read the information in their student workbooks before going on. There is no information for students to read for Lesson 4.*

PART TWO

Invasion of Purple Loosestrife

Lesson Three: A Trip Across the Ocean

Teacher tips on the Tree Time Line Worksheet

Before beginning this worksheet, it will be important for students to understand that the drawings on the worksheet and the one they will draw represent a cross-section of a tree showing the annual growth rings. As trees grow, they add a growth ring each year. These annual growth rings can be seen when viewing a cross-section of the tree. For example, if you were to cut down a 50-year-old tree and look at the top of the stump, you would see 50 concentric rings the largest (outermost) ring is the most current growth and the smallest (center) ring is the oldest (the year the tree started growing). So, if this 50-year-old tree was cut down in 1998, each ring would represent one year and the center ring would represent 1948. You may be able to obtain a real cross-section of a tree to use as a demonstration from anyone who works with or cuts wood. If you look at a real cross-section of a tree, you may notice that dark and light rings seem to alternate. The dark areas represent periods of dormancy of the tree (winter) and the light areas represent the growing season. So, one year of growth is represented by a dark ring and a light ring together (don't count them as separate years).

Lesson Three - A Trip Across the Ocean

Purple loosestrife was brought from Europe to the Atlantic coast of North America in the early 1800s. Because purple loosestrife is a wetland plant, it grew near the seaports in Europe where ships would come and go. Some ships would load sand or water from these seaport areas to add weight. This extra weight, called ballast, helped the ships sail better. Since purple loosestrife grew in these seaport areas, the sand and water sometimes contained tiny purple loosestrife seeds. When the ships arrived in North America, they would dump the sand and water ballast and any purple loosestrife seeds that it contained. These seeds could then grow in their new home. Some purple loosestrife plants were brought to North America on purpose by people who used the plant as medicine or as flowers for honeybees. Purple loosestrife was common on the Atlantic coast of North America by 1830. Many people planted it in their gardens because of its pretty purple flowers.

How did purple loosestrife get from the Atlantic coast of North America to the Great Lakes region? You have to remember that in the early 1800s, there was no easy way for people to travel inland from the Atlantic Ocean. People didn't have cars or airplanes. Their main transportation was by non-motorized boats and barges, so they began building canals. A canal is like river but it is made by people. By 1840, there were more than 3,000 miles of canals connecting the Atlantic Ocean and inland areas. The most famous canal was the Erie Canal, which connected Lake Erie with the Hudson River. Boats and barges traveling the canals were used to transport people, farm animals, lumber, coal, grain and other materials needed to make new settlements in the Midwest. They also provided purple loosestrife seeds an easy way to spread, and by 1900, purple loosestrife had spread to many wetlands in the Great Lakes region and beyond.

Stop reading and complete the **Tree Time Line Worksheet**.

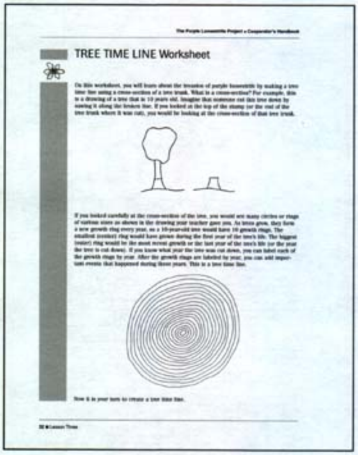
In this lesson each student will use the blank tree time line (showing a cross-section of an 18-year-old tree) on the worksheet to show events that have happened mostly during their lifetimes. You may want to come up with a class list of events for the 18-year period that all students can include on their personal time lines. Then students can personalize their time lines by adding their birth years and other events as noted on the worksheet. This is an excellent homework assignment and opportunity for parent involvement.

Students should now complete the purple loosestrife **Time Line Activity**.

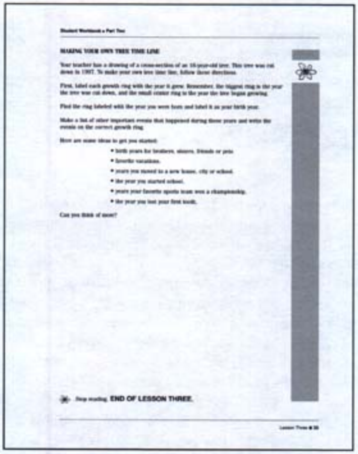
Instructions for teachers

The Tree Time Line worksheet is designed to prepare students for the final task in this lesson. Students, as a group, will create a tree time line going back 200 years. As you can imagine, you will need a very large surface to draw this on (about an 8-foot square if you draw the rings about the same width as those on the student worksheet). One suggestion is to use large pieces of flip-chart paper and tape several pieces together to make one large drawing surface. After the 200 rings are drawn, each ring (or every five or ten rings) should be labeled with the year it represents. An option is to just draw a wedge of the 200-year-old tree (like a piece of a pie). This would still show all 200 years but would take less room (about a 4-foot square) and less time to draw the lines.

Your tree will represent the past 200 years. The next step is for the students to decide which events they would like to place on the time line. You can do this as a class or have each student come up with several ideas. Some historical references, such as an encyclopedia, will be needed for this. Students could also research events and find dates on the Internet. If you have covered history in your classroom, you could integrate the information into this lesson.



TREE TIME LINE Worksheet



END OF LESSON THREE.

Here are some ideas to get you started:

- The years various presidents were born or died.
- The birthdates of other famous people.
- The birthdates of grandparents.
- The year the school was built.
- The years various things were invented (cars, color TV, etc.).

After the list is made, have the students write these events on the tree time line in the appropriate locations. Now it's time to think about the invasion of purple loosestrife. Have the students make a list of the dates mentioned in the student workbook information they read at the beginning of Lesson 3 and place these purple loosestrife-related events on the time line. You may want to highlight the purple loosestrife dates so they are more noticeable than other dates. When finished, discuss other historical events that were happening at approximately the same time as the purple loosestrife-related events.

Extension idea

Find out what other exotic organisms are in the Great Lakes region, including where they came from and how they got here.

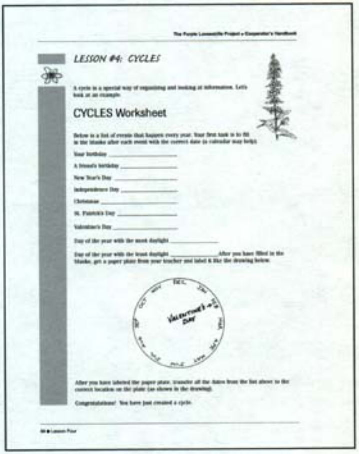
Suggested journal entry

Choose an exotic organism in the Great Lakes region (other than purple loosestrife) and write a short report about it. Include where it is native, how and when it got here, and what problems it is causing (if any). Could the invasion of the exotic organism have been prevented? How?

PART TWO

Invasion of Purple Loosestrife

Lesson Four: Cycles



LESSON #4: CYCLES

CYCLES Worksheet

Your birthday ____

A friend's birthday ____

New Year's Day ____

Independence Day ____

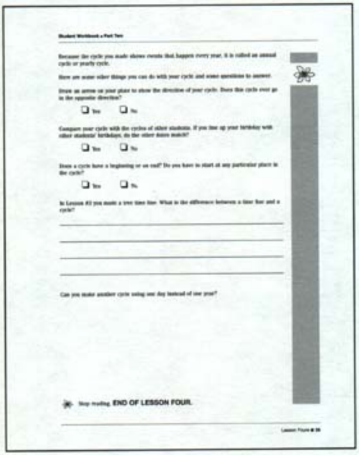
Christmas ____

St. Patrick's Day ____

Valentine's Day ____

Day of the year with the most daylight ____

Day of the year with the least daylight ____



☐ Yes ☐ No

☐ Yes ☐ No

☐ Yes ☐ No

END OF LESSON FOUR.

Instructions for teachers

Lesson 4 will focus on the general concept of cycles. Begin by having students complete the Cycles worksheet. You will need to supply dinner-size paper plates for this worksheet.

Tips for teachers on the Cycles Worksheet

- The day of the year with the most daylight is the summer solstice, which occurs around June 21. The day of the year with the least daylight is the winter solstice, around December 21.
- Does the cycle have a beginning or an end? Although students may think that the cycle starts on their birthday (since we asked them to start there) or on January 1, it is important for them to realize that you can start a cycle at any point and when you return to the starting point, one cycle (or one year, in this case) will have passed. For example, the Chinese calendar starts at a different time of year than ours. The reason for using paper plates is so that students, when finished, can compare their cycles with other students' by turning the plates so the dates match.
- What is the difference in a time line (which they did in Lesson 3) and a cycle? Both the time line and the cycle show a sequence of events. The main difference is that the time line is linear and the events will never repeat themselves. The time line will never go back to the year 1800 and start over. A cycle does, however, repeat itself.
- A daily cycle can easily be made by using the hours of a day instead of months of the year. Students can make a list of things they do or things that happen at the same time every day and make their own daily cycle. You could also try a lunar cycle.

Have the students save their paper plate cycles to use in another activity described in Lesson 5.

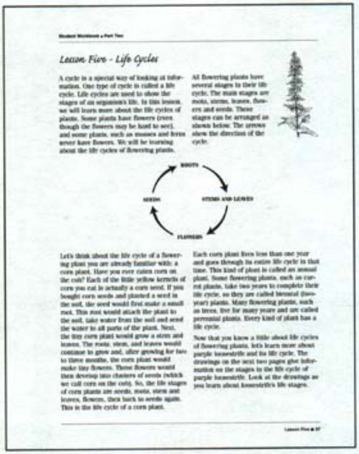
PART TWO

Invasion of Purple Loosestrife

Lesson Five: Life Cycles

Instructions for teachers

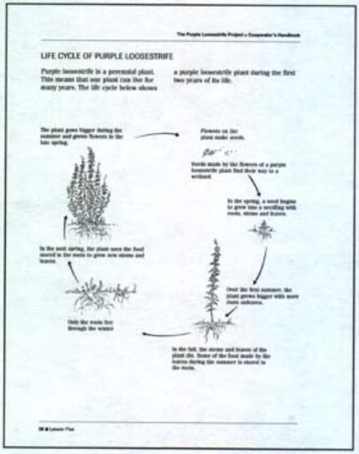
Lesson 5 is the most important lesson in Part Two and will take more time than the other lessons. Students will learn about the life cycle of purple loosestrife by making observations on the growth of the classroom plant, participating in activities, answering questions and completing worksheets on the stages of the life cycle: roots, stems, leaves, flowers and seeds. You should have your potted purple loosestrife root crown in the classroom when you start Lesson 5. As mentioned previously, it is very important that the root crown be planted in early March to ensure enough growth for the beetle release in Part Three. For instructions on planting and care of the root crown and plant, see "Raising Galerucella Beetles Indoors" and "Lighting Requirements for Indoor Rearing of Galerucella Beetles" in the *Cooperator's Handbook*. If your plant is not showing any signs of growth two weeks after planting the root crown, see cooperator's handbook, Section Two.



Extension idea

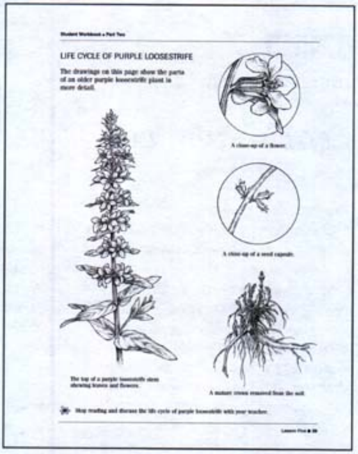
If students completed the annual cycles on paper plates in Lesson 4, have them write the stages of the corn life cycle on their plates (or they could make new plates). These corn life cycles should include the following three things.

1. The months of the year.
2. Arrows showing the direction of the cycle.
3. The stages of the corn plant placed in the proper location on the cycle as follows:
   - Seeds begin to grow – late April through May.
   - Plant grows roots, stems and leaves – late May through mid-July.
   - Peak of flowering – mid-to late July.
   - Seeds fully formed and ready to harvest – late October.
   - Plant spends the winter as seeds —November through late April—And the cycle is now complete.



LIFE CYCLE OF PURPLE LOOSESTRIFE

Purple loosestrife is a perennial plant. This means that one plant can live for many years. The life cycle below shows a purple loosestrife plant during the first two years of its life.



LIFE CYCLE OF PURPLE LOOSESTRIFE

The drawings on this page show the parts of an older purple loosestrife plant in more detail.

Important information on plant observations

As you work through Lesson 5 with the students, it is important for students to apply what they are learning to purple loosestrife by making observations on the classroom purple loosestrife plant. Building observational skills is an important part of this unit. Here are some ideas on making these observations.

Drawings

This is a good way to integrate art into the unit. Have students make a record of plant growth by drawing the purple loosestrife plant once every week. Have them draw the plant in as much detail as possible and have them attempt to draw it to scale. You may want to show them artwork of other plants (in field guides, etc.) to give them examples of how other people draw plants. By doing this, students will have a sequence of drawings showing the growth of the plant over a 6-to-8 week period. This should be continued after the beetles are released on the plant to show the effect of the beetles on the plant. This activity is highly recommended.

Grow other plants

Buy a couple small plants or plant several types of seeds and have students compare the growth of these plants with that of purple loosestrife. How are the roots, stems, leaves, flowers and seeds similar or different? Also, in preparation for Part Three, try planting a couple other kinds of seeds in the same pot with the purple loosestrife. This will be a good test after you place beetles on your plant to see if the beetles eat only the purple loosestrife.

Chart stem growth

Pick and mark (try twist-ties) a couple purple loosestrife stems and keep track of each stem's growth. Pick a day each week to record data such as number of leaves on the stem, the distance along the stem between leaves, stem height and stem width. In the plant care instructions, you are told to cut back or pinch off the stem tips when they reach about 14 inches in height. Try leaving several stems unpinched and compare the growth of these with the stems that are pinched off. These data can then be shown in graph form by showing time along one axis and growth along the other.

Have a stem race

When the stems are just several inches tall (there should be from 10 to 20 stems growing from the root crown), have students select which of the stems they think will be the tallest after a two-week period. The stems will have to be marked (be careful - stems are very fragile when small).

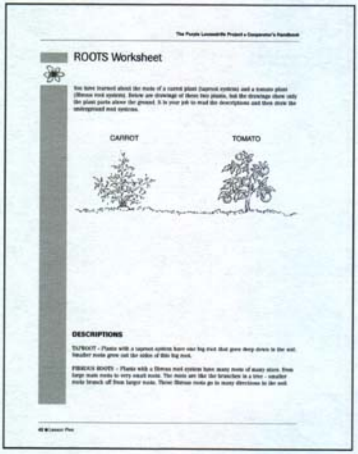
Water use

Record the date and amount of water used each time you add water to the bottom tray of your plant. Can you figure out if the plant uses more, less or the same amount of water as it gets bigger?

Students can now begin Lesson 5 by reading the life cycle information in the student workbooks.

Instructions for teachers

Before continuing this lesson, it would be helpful to discuss the life cycle of purple loosestrife with the class. The information in the student workbook and the worksheets in this lesson are designed to take a closer look at each of the life stages of purple loosestrife - roots, stems, leaves, flowers and seeds. The information for each life stage includes how each stage helps plants survive, what each stage looks like, what this stage in the life cycle of purple loosestrife looks like, and relationships that other plants and animals (including humans) have with the stage. Continue by having students read in their student workbooks.

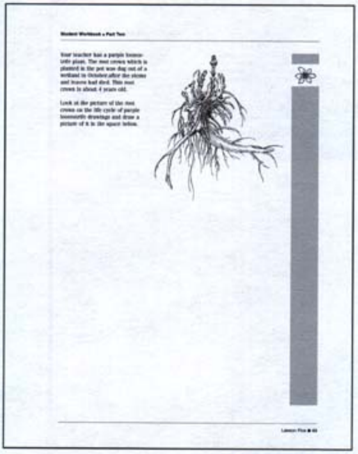


ROOTS Worksheet

CARROT

TOMATO

DESCRIPTIONS



Tips for teachers on Roots Worksheet

The Roots worksheet will help students understand more about the purple loosestrife root crown. The student's drawings of the carrot and tomato root systems will vary, but they should look something like the drawings below.

Extension idea

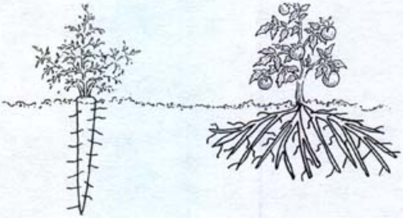
Buy one or two small potted plants from your local nursery (you can buy houseplants in the winter) and have students wash the soil away from the roots to see the root systems. The easiest way to do this without damaging the roots is to remove the plant from the pot and submerge the root ball into a container of water. The soil should rinse away, exposing the roots (you may have to dunk it a few times). Dispose of the muddy water in a proper and safe location.

Extension idea

Buy a carrot from the grocery store (one that is whole and not peeled). Plant the carrot in a pot so only the very top of the carrot (where the leaves were attached) is above the soil. If the carrot is too long for the pot, you can cut off part of the bottom. Water the carrot and see what happens. The carrot is a taproot where food made by the leaves during its first year of growth is stored. The carrot should use this food to grow new leaves. This is a great example of a biennial plant.

Instructions for teachers

This lesson continues with information and a worksheet on stems and leaves. Students can continue by reading the stems and leaves information in their student workbooks.



STEMS

How do stems help flowering plants survive?

- Stems form a strong frame to support the above-ground part of the plant, including leaves, flowers and seeds.
- Stems carry water and minerals from the roots to the leaves, flowers and seeds.
- Stems carry food made by the leaves to flowers, seeds and roots.

What do stems look like?

Stems come in many sizes, shapes and colors. A large oak tree, for instance, has a large stem (the trunk), which supports smaller stems (branches), which support even smaller stems (twigs). If you look at cross-sections of stems, some are round, some are square and some are like a triangle. Some stems are hollow, while others are solid. Some stems are hard and stiff; others are soft and flexible. Some stems even have thorns, which may protect the plant from being eaten by animals.

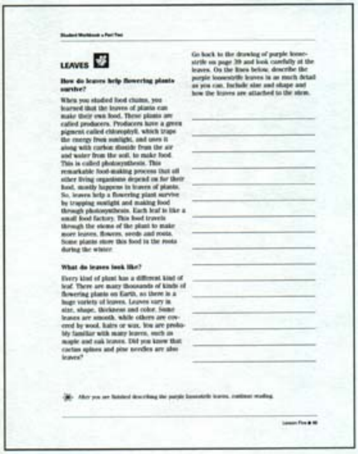
What kind of stems does purple loosestrife have?

In the spring, the root crown of purple loosestrife will begin to grow new stems. These stems can grow to be seven feet tall by the end of summer, and each main stem will have many smaller side stems, leaves, flowers and seeds. The main stems of purple loosestrife are about 1/2 inch wide and square in cross-section. Because these stems grow from a root crown, the stems are clustered together.

Though plants make stems to help them survive, many organisms have learned to use stems in a variety of ways. Here are just a few.

- Many mammals eat stems (deer, mice, voles, beavers, rabbits, some insects).
- People eat stems such as asparagus and rhubarb.
- Some animals, especially insects, will live inside stems. Examples of such insects include the European corn borer (moth) and the pine weevil (beetle).
- Some birds (such as the cardinal) will use stems in nest building. Small stems are used to build the nest and many nests are attached to larger stems.
- Some animals use hollow cavities in large stems (tree trunks) for nests or shelter (woodpeckers, squirrels, owls, raccoons, porcupines).
- People have many things made from wood, such as houses, furniture and toys. All wood comes from stems.

All of these are relationships that organisms have with stems of plants.



LEAVES

How do leaves help flowering plants survive?

When you studied food chains, you learned that the leaves of plants can make their own food. These plants are called producers. Producers have a green pigment called chlorophyll, which traps the energy from sunlight, and uses it along with carbon dioxide from the air and water from the soil, to make food. This is called photosynthesis. This remarkable food-making process that all other living organisms depend on for their food, mostly happens in leaves of plants. So, leaves help a flowering plant survive by trapping sunlight and making food through photosynthesis. Each leaf is like a small food factory. This food travels through the stems of the plant to make more leaves, flowers, seeds and roots. Some plants store this food in the roots during the winter.

What do leaves look like?

Every kind of plant has a different kind of leaf. There are many thousands of kinds of flowering plants on Earth, so there is a huge variety of leaves. Leaves vary in size, shape, thickness and color. Some leaves are smooth, while others are covered by wool, hairs or wax. You are probably familiar with many leaves, such as maple and oak leaves. Did you know that cactus spines and pine needles are also leaves?

Go back to the drawing of purple loosestrife on page 39 and look carefully at the leaves. On the lines below, describe the purple loosestrife leaves in as much detail as you can. Include size and shape and how the leaves are attached to the stem.

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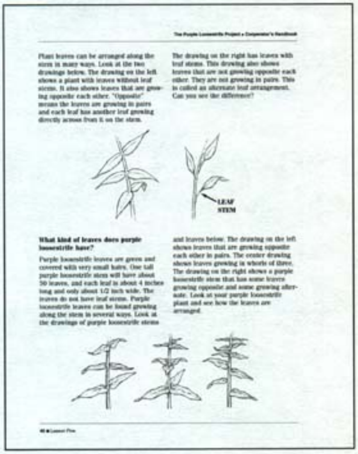
After you are finished describing the purple loosestrife leaves, continue reading.



Plant leaves can be arranged along the stem in many ways. Look at the two drawings below. The drawing on the left shows a plant with leaves without leaf stems. It also shows leaves that are growing opposite each other. "Opposite" means the leaves are growing in pairs and each leaf has another leaf growing directly across from it on the stem.

The drawing on the right has leaves with leaf stems. This drawing also shows leaves that are not growing opposite each other. They are not growing in pairs. This is called an alternate leaf arrangement. Can you see the difference?

LEAF STEM

What kind of leaves does purple loosestrife have?

Purple loosestrife leaves are green and covered with very small hairs. One tall purple loosestrife stem will have about 50 leaves, and each leaf is about 4 inches long and only about 1/2 inch wide. The leaves do not have leaf stems. Purple loosestrife leaves can be found growing along the stem in several ways. Look at the drawings of purple loosestrife stems and leaves below. The drawing on the left shows leaves that are growing opposite each other in pairs. The center drawing shows leaves growing in whorls of three. The drawing on the right shows a purple loosestrife stem that has some leaves growing opposite and some growing alternate. Look at your purple loosestrife plant and see how the leaves are arranged.

Plants make leaves to help them survive, but many organisms have learned to use leaves in a variety of ways. You have already learned how other organisms use roots and stems. Can you list three relationships that organisms have with leaves?

1. ______________________________

2. ______________________________

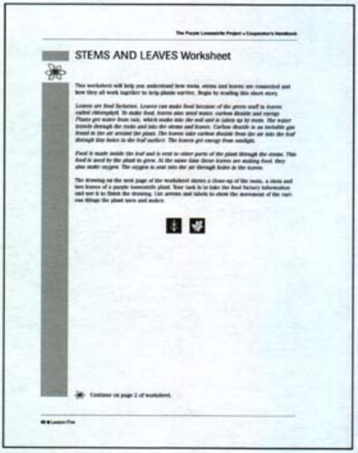
3. ______________________________

There are many relationships that organisms have with leaves.

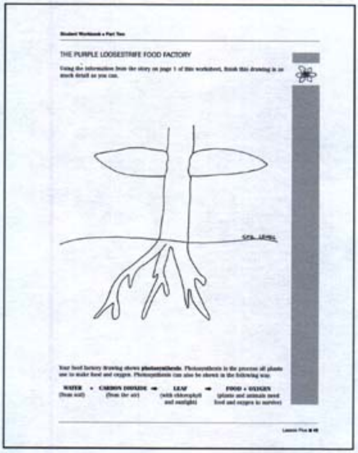
- Many animals eat leaves. In fact, there are leaf eaters in most groups of animals. There are many mammals (deer, elephants, giraffes, mice, woodchucks, rabbits), some birds (grouse, geese) and reptiles (turtles). A huge number of insects eat leaves. Some chew the leaves (leaf beetles, moth and butterfly caterpillars), while others suck the juices from leaves (plant bugs, aphids).
- People also eat leaves such as spinach, lettuce and cabbage.
- Some insects live inside leaves. They either burrow inside the leaf, like the birch leaf miner (a moth), or some will curl the leaf around them, like the apple leafroller (a moth).
- Many animals - such as squirrels, chipmunks, voles and many birds - will use leaves to build nests.
- Leaves provide shade and shelter that some animals and plants need.
- Dead leaves add humus to the soil, making it more fertile for new plants to grow.
- Many organisms (worms, insects, fungi) also live on this humus.

All of these are relationships that organisms have with leaves of plants.

Stop reading and complete the **Stems and Leaves Worksheet.**



STEMS AND LEAVES Worksheet



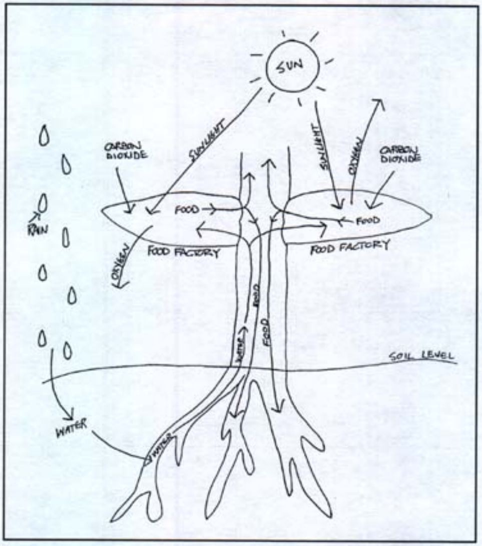
THE PURPLE LOOSESTRIFE FOOD FACTORY

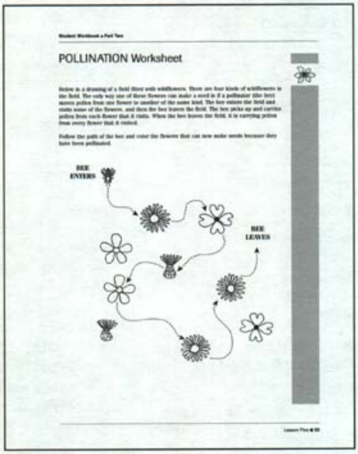
Tips for teachers on Stems and Leaves Worksheet

This worksheet will show students how the stems, leaves and roots of a plant work together to help a plant survive. Students read a story and use the information to complete a drawing of a close-up of a purple loosestrife root, stem and leaves. Included is a finished drawing as a model. You may want to make an overhead of this drawing to help students get started. Students may want to use colored pencils or crayons to show the movement of the water, food, etc. Students are also introduced to photosynthesis. After students complete the worksheet, it may be helpful to review the process by making a drawing on the chalkboard or on a poster with the whole class.

Instructions for teachers

The next section and worksheet in this lesson cover flowers. Students can continue by reading the flower information in their student workbooks.





Tips for teachers on the Pollination Worksheet

This worksheet is designed to help you explore the basic concept of flower pollination. There are four kinds of plants on the worksheet, each with a different shaped flower. The pollinator (a bee) visits six of the flowers as shown by the lines and arrows. As the bee visits each flower, it carries with it pollen from every previously visited flower. The students are to color the flowers that can now make seeds. For any flower to make a seed, the pollinator must transfer pollen from one flower to another of the same kind. On the worksheet, this happens only with the last two flowers that the bee visits, so these are the only flowers that can make seeds.

Instructions for teachers

The final part of this lesson deals with seeds and includes information, questions and an activity. Students can continue by reading the following information in their student workbooks

Seed Dispersal Activity

Instructions for teachers

In this activity, students will compare a variety of seeds and fruits and classify each by its method of dispersal.

Materials needed

- seed and fruit samples
- hand magnifiers
- a dissecting scope (optional)
- an old sock (white is best)
- gardening books with pictures of flowers
- wildflower field guide

STEP 1. A variety of seeds (including fruits and vegetables) should be collected. Some can be brought or collected by students from their homes/yards. Some can be collected as a group activity around the school yard. One method of collecting seeds is for the teacher to place an old sock over his/her shoe and walk through an old field or any area that has wild plants. You can then pick seeds off the sock.

STEP 2. After a variety of seeds are collected, students should observe each seed with the magnifiers and scope (if available) and try to determine how each seed is dispersed. The most common dispersal strategies are described in the seeds section of Lesson 5 in the student workbooks. Students should develop simple experiments to help them determine the dispersal strategies for the various seeds - e.g., does the seed stick to things, does it float in water, does it float in the air? Do any of the seeds have more than one dispersal strategy?

STEP 3. Students should classify the seeds according to method of seed dispersal.

STEP 4. An optional part of this activity is for the students to try to find pictures of some of the flowers that match the collected seeds.

Extension idea

To integrate math into this lesson present this math problem for students to solve individually or in groups.

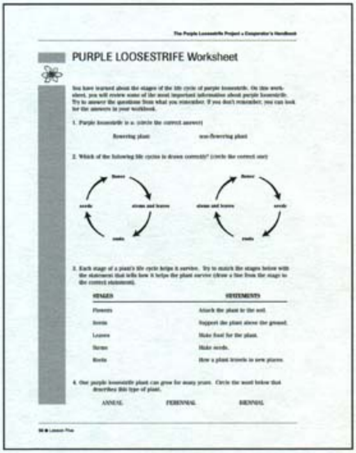
There is a wetland with 200 purple loosestrife plants growing in it. Each purple loosestrife plant has four stems. Each of these stems has 75 seed capsules, and each seed capsule has 100 seeds in it. What is the total number of purple loosestrife seeds in this wetland?

ANSWER: 6,000,000 seeds (200 x 4 x 75 x 100 = 6,000,000)

In addition to integrating math into the lesson, this also demonstrates the enormous number of seeds that can be produced by purple loosestrife in a small wetland.

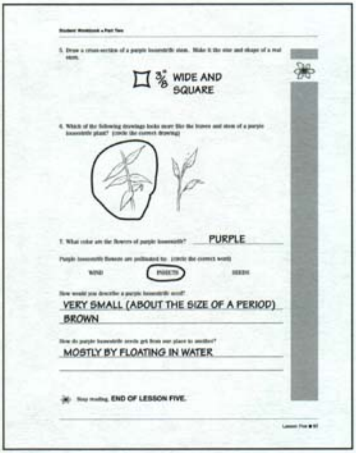
Tips for teachers on worksheet

The Purple Loosestrife worksheet is included as a review for students of the material covered in Lesson 5. If desired, teachers may also use this as an assessment tool. A copy of the worksheet with answers is included.



PURPLE LOOSESTRIFE Worksheet

ANNUAL PERENNIAL BIENNIAL



3/8" WIDE AND SQUARE

PURPLE

VERY SMALL (ABOUT THE SIZE OF A PERIOD)
BROWN

MOSTLY BY FLOATING IN WATER

END OF LESSON FIVE.

PART TWO

Invasion of Purple Loosestrife

Lesson Six: Protecting Wetlands

Instructions for teachers

This last lesson in Part Two brings together information that students have learned in Part One and Two on purple loosestrife, exotic vs. native organisms and relationships. The importance of and threats to wetland ecosystems are also covered. This lesson also serves as an introduction to Part Three of this unit by stating that scientists are challenged to come up with a plan to control purple loosestrife while at the same time protecting native wetland plants and animals. Meeting this challenge through biological control is the focus of Part Three. Students can continue by reading the following information in their student workbooks

Lesson Six - Protecting Wetlands

Wetland Relationship Game

Instructions for teachers

The Wetland Relationship Game is meant to help students understand how purple loosestrife crowds out native plants and animals in a wetland ecosystem.

MATERIALS NEEDED

- Something to define the wetland boundary (a hula hoop or piece of yarn).
- 300 "cattail plants".
- 300 "purple loosestrife plants". (You will need to select two distinct items to represent cattails and loosestrife plants, such as pennies, popcorn, beans, etc.).
- One die.

GAME DIRECTIONS

1. Place 200 cattail plants and 20 purple loosestrife plants in the wetland and randomly spread them out. This represents a wetland where purple loosestrife is just beginning to grow. Students should understand that cattails are native and purple loosestrife is exotic.
2. Use the following criteria to figure out how many muskrats, ducks and mink can live in the wetland and record the information on a piece of paper:
   - It takes 20 cattails for 1 muskrat to live (muskrats eat cattails).
   - It takes 4 muskrats to make a clearing big enough for 1 duck to live.
   - It takes 2 ducks for 1 mink to live (mink eat ducks).

   Students should come up with the following: a marsh with 200 cattails can support 10 muskrats; 10 muskrats can support 2 ducks; 2 ducks can support 1 mink.
3. Have students take turns rolling the die and adding and/or removing plants from the wetland as described below. You may want to write this information on the chalkboard so each student can read and follow the directions.

   Roll of 1 - New cattails are growing from seeds.
   ADD 2 cattail plants.

   Roll of 2 – Cattails are living but not making seeds because purple loosestrife is taking up more space.
   ADD 2 purple loosestrife plants.

Many wetlands have been destroyed by people. There used to be many more wetlands. It is estimated that, in the 1700s, there were more than 10 million acres of wetlands in the Great Lakes region. By 1990, over half of these wetlands were gone, and another 6,500 acres of wetlands are still being destroyed each year. Scientists estimate we have lost more than 120 million wetland acres in the United States since Europeans arrived and that we still lose about 100,000 acres each year to development. Most of these wetlands are destroyed because of human activities. Many wetland areas have been drained and filled so they could be used as building sites. Others have become so polluted that organisms cannot live there. If more people understood the value of wetlands, they would want to protect them instead of destroying them. There are laws to help protect some wetlands from being destroyed, but these laws cannot keep purple loosestrife from spreading. The challenge for scientists is to come up with a plan to control purple loosestrife while at the same time protecting the native plants and animals in the wetlands.

Stop reading END OF PART TWO.

Roll of 3 – Purple loosestrife seeds are growing but the plants are still small.
ADD 3 purple loosestrife plants.

Roll of 4 – Purple loosestrife plants are getting bigger and taking space away from cattails.
REMOVE 4 cattails.

Roll of 5 – Purple loosestrife plants are growing bigger and are making lots of seeds.
REMOVE 6 cattails and ADD 3 purple loosestrife plants.

Roll of 6 – Purple loosestrife is spreading rapidly and taking up lots of space.
REMOVE 8 cattails and ADD 4 purple loosestrife.

4. If you have a class of about 30 students, have each student take one turn. After this first round, stop and count the number of cattails left in the marsh. Using the same criteria used before, have the students figure out how many muskrats, ducks and mink can now live in the wetland. For example, if only 100 cattails are left, this would support 5 muskrats, 1 duck and 0 mink. Also count the number of purple loosestrife plants that are now in the wetland. Record this information with the previous numbers for comparison.
5. Have the students play another round (or play until most or all of the cattails are gone). After this round, again figure how many muskrats, ducks and mink could live on the number of cattails left in the wetland and count the number of purple loosestrife plants now in the wetland. Record this with the previous numbers and compare.
6. Finally, have each student write two things he/she learned about purple loosestrife by playing the game. Here are some of the main take-home messages:
   - Purple loosestrife crowds out the native plants by growing from seeds and by growing bigger and more densely.
   - As the native plants disappear, the animals that depend on the plants also disappear.
   - Because purple loosestrife is an exotic, a marsh filled with purple loosestrife doesn't provide food, space or other resources needed by many native animals.

Instructions for teachers

After completing the Wetland Relationship Game, students can continue by reading the remaining information in their student workbooks.

Extension idea

Are there any endangered or threatened species of plants or animals that live in wetlands and may be harmed by the invasion of purple loosestrife? Get a copy of the endangered and threatened species list for your area and learn which ones live in wetlands.

PART THREE - BIOLOGICAL CONTROL OF PURPLE LOOSESTRIFE

This final section of the unit relies on ideas and concepts that students learned in Parts One and Two. Timing is important for Part Three because you will be receiving and placing leaf beetles on the purple loosestrife plant you are growing in the classroom. To be successful, beetles need to be placed on the classroom purple loosestrife plant in mid-April in Michigan. This will ensure that the leaf beetles will complete their life cycle on the classroom plant before they are taken to a wetland area for release at the end of the school year. It is best to complete Lesson 1 in advance of receiving beetles, so you will want to begin Part Three about a week before the beetles are shipped to you.

For instructions and information on infesting your classroom purple loosestrife plant with beetles and making a beetle release in a wetland, refer to "Raising Galerucella Beetles Indoors" and "Lighting Requirements for Indoor Rearing of Galerucella Beetles" in the *Cooperator's Handbook*.

Even though you may finish all the lessons before the end of the school year, it will be important to care for the plant and the beetles until the release.

Part Three: Biological Control of Purple Loosestrife

ESTIMATED TIME TO COMPLETE PART THREE: Field tests in several classrooms indicate that, teachers should expect Part III to take a total of 4 to 6 hours of class time spread over about 4 weeks. This time does not include extensions or outdoor activities.

Abstracts and Michigan teaching objectives

■ Part Three, Lesson 1 Controlling Purple Loosestrife

Michigan Curriculum Framework References

Science: Standard I.1 Constructing New Scientific Knowledge, II.2 Reflecting on Scientific Knowledge, III.5 Ecosystems

Social Studies: Standard II.2 Human\Environment Interaction

English: Standard 1,2,3 Meaning and Communication, 4 Language

Method

Students will be challenged to think about some solutions to problems caused by the invasion of purple loosestrife and the risks involved in different control strategies.

Materials

Student workbook.

Procedure

1. Students will begin by reading some background information in their workbooks.
2. They will then be challenged to think of ways to control purple loosestrife without harming the native wetland plants and animals or the wetland ecosystem.
3. Students will then move to the solutions worksheet where they are given a list of four different solutions to controlling the spread of purple loosestrife.

4. After reading the solutions they will write why they would or would not choose the solution to solve the problem.
5. At the end of the lesson, students will be introduced to the idea of biological control.

Part Three, Lesson 2 Biological Control

Michigan Curriculum Framework References

Science: Standard I.1 Constructing New Scientific Knowledge, II.2 Reflecting on Scientific Knowledge

Social Studies: Standard II.2 Human\Environment Interactions

English: Standards 1,2,3 Meaning and Communication, 4 Language

Method

This lesson introduces students to biological control. This is also when students will receive and place leaf beetles on the purple loosestrife plant they have grown in the classroom.

Materials

Student workbook, leaf beetles.

Procedure

1. Students will begin by reading information in their workbooks. They will read three example of how biological control is used.
2. After reading the examples, students will answer questions about the different aspects of biological control like who is the target organism and which is the control agent.
3. After becoming familiar with biological control, students will place their beetles on their plants.
4. Next, they will make observations of the beetles on the plants, such as stages of the beetle's life cycle, amount of plant eaten, and how these relate to biological control.
5. Then the students will be asked to make predictions in their journals of what they think will happen.

Part Three, Lesson 3 Life Cycle of Leaf Beetles

Michigan Curriculum Framework References

Science: Standard I.1 Constructing New Scientific Knowledge, II.1 Reflecting on Scientific Knowledge, III.2 The Organization of Living Things

Method

The main focus of this lesson is on the life cycle of insects. Students will become familiar with both the simple and complete metamorphosis of insects and how these relate to the leaf beetle and biological control.

Materials

Provided in student workbook.

Procedure

1. Students will study diagrams of insects who have both a simple and a complete metamorphosis.
2. They will be asked to compare the different life cycles of each typ of metamorphosis.
3. Then, they will look at the life cycle of the leaf beetle and compare it to what they already know.
4. Students will then learn about the different body parts of the leaf beetle and how these parts are used.
5. Finally, the students will be asked to draw a picture of the leaf beetle's life cycle in their journals.

Part Three, Lesson 4 Leaf Beetles & Purple Loosestrife Together

Michigan Curriculum Framework References

Science: Standard I.1 Constructing New Scientific Knowledge, II.1 Reflecting on Scientific Knowledge, III.2 The Organization of Living Things

Method

Now that students have learned about the life cycles of both purple loosestrife (Part II) and leaf beetles, this lesson will focus on how these two life cycles fit together and how the leaf beetles affect the growth of purple loosestrife.

Materials

Student workbooks, blank paper, pencils or crayons.

Procedure

1. Students will follow a group of leaf beetles in a Michigan wetland to see what they are doing during different seasons of one year.
2. As they read the information , students will draw a different picture for each of the seasons.
3. Included in each of the drawings will ne the purple loosestrife and the leaf beetles. They will show where the leaf beetles are located and what stage of their life cycle they are in.

Part Three, Lesson 5 Selecting Natural Enemies for Biological Control

Michigan Curriculum Framework References

Science: Standard I.1 Constructing New Scientific Knowledge, II.1 Reflecting on Scientific Knowledge, III.2 The Organization of Living Things

Method

This lesson will help students understand some of the basic questions that are asked by scientists when selecting a natural enemy to be used as a biological control agent. By using the criteria given, students will evaluate each natural enemy and select the one that they feel is best.

Materials

Provided in student workbook.

Procedure

1. Students will read The Problem paragraph and list the four main things used to make a decision.
2. Divide the class into six groups and assign one natural enemy to each group.
3. Each group will read about their natural enemy, and by using the four criteria, decide whether or not it would be a good natural enemy to control water choke weed.
4. Each group will then report their decision and discuss why they made their decision to the rest of the class.

■ Part III, Lesson 6 Biological Control Of Purple Loosestrife

Michigan Curriculum Framework References

Science: Standard I.1 Constructing New Scientific Knowledge, II.1 Reflecting on Scientific Knowledge, III.5 Ecosystems

Method

This final lesson of the unit will focus on the biological control of purple loosestrife. Students will read about why leaf beetles were selected as biological control agents for the control of purple loosestrife and will use their observations of beetles in the classroom to complete a worksheet.

Materials

Provided in student workbook.

Procedure

1. Students will begin by reading information about why scientists chose leaf beetles to be used as the natural enemy to control purple loosestrife.
2. Students will complete the biological control worksheet.
3. In the worksheet, students will record information they observed about the effects of the leaf beetles on the purple loosestrife.

Part Three: Main Ideas and Concepts

- Because purple loosestrife has invaded many wetlands in North America and is having a negative impact on native plants and animals, land managers and scientists are working on ways to control purple loosestrife to protect wetlands.
- Several mechanical control methods have been tried, including hand pulling plants, burning and spraying herbicides. All of these methods have negative effects on the wetland and are not effective on a large scale.
- Another method of controlling exotic organisms is called biological control. Biological control has been successful in controlling a variety of exotic plants and animals. Using biological control on purple loosestrife is a main focus of scientists and land managers.
- It is important to understand the life cycle of both the natural enemy (biological control agent) and the exotic organism (target organism) when developing a biological control program.
- Many factors are involved in selecting the proper natural enemies for biological control, including feeding behavior (generalist vs. specialist), ability to raise the natural enemy in large numbers and cost.
- Scientists decided that leaf beetles would be the best natural enemy to be raised as a biological control agent for purple loosestrife because their life cycle is closely tied to the life cycle of purple loosestrife.
- Scientists predict that releasing leaf beetles into area wetlands will cause purple loosestrife populations to decline to a point where they are no longer having a negative impact on native plants and animals.
- To test this prediction, scientists must evaluate and monitor the activities of the leaf beetles and purple loosestrife in a wetland ecosystem. They must also evaluate the risks and benefits of a biological control program.

Part Three: Background Information - Management of Purple Loosestrife

Are there any solutions to the purple loosestrife problem? Land managers and scientists have tried a variety of methods in an attempt to control or eradicate purple loosestrife from Great Lakes wetlands. One method is the use of herbicides. Although there are herbicides that kill purple loosestrife, they also kill many of the native plants. This is, in turn, harmful to many wetland animals. Other control methods that have been tried include water manipulation (flooding and/or removal of water from the site), tilling, hand pulling of plants and burning. Though some of these control methods may work on a small scale or in certain situations, they are not good solutions for controlling purple loosestrife on a large scale while at the same time protecting or restoring the native plants and animals in a wetland. Besides protecting the native wildlife, other important factors when choosing a control method include cost and whether it is a long-term solution.

Scientists and land managers have turned their attention to a control method called biological control. Biological control involves finding the exotic pest's natural enemies in its native range and introducing the natural enemies into the area where the pest is a problem. This type of biological control is called classical or importation biological control. The goal of classical biological control is not exterminating the pest species but reducing the pest population to an acceptable level. Examples of classical biological control are given in Lesson 2.

Can biological control be used to control purple loosestrife? In the late 1980s, a team of scientists traveled to Europe to locate potential natural enemies in the native range of purple loosestrife. Through research and field observations, they identified 120 species of insects that eat purple loosestrife. After studying the habits and life cycles of these insects, three species were selected as the most promising natural enemies for the biological control of purple loosestrife. Two of the selected insects are small leaf beetles, *Galerucella calmariensis* and *G. pusilla*, which feed on the leaves and stems of purple loosestrife. The third insect is a weevil (another type of beetle), *Hylobius transversovittatus*, which lives and feeds on the roots of purple loosestrife.

How and why did the scientists choose these three insects out of the 120 identified?

After studying the feeding habits and life cycles of the insects, scientists decided which ones would be best on the basis of a variety of factors, including:

- Is the insect host-specific? That is, does the insect eat only purple loosestrife, or does it eat other plants as well?
- Can the natural enemy be easily raised in large numbers at an acceptable cost?
- Is it likely that the insect will be able to survive and thrive in its new environment?
- Is the insect likely to have a large enough population when established to have an impact on purple loosestrife?

It has been found that the two leaf beetles are easier to raise than the weevil for biological control, so we will concentrate on the leaf beetles. Galerucella calmariensis and G. pusilla are both 3 to 5 mm long and half as wide. They are light brown with a dark stripe on the thorax. Both have similar life cycles and ways of feeding on purple loosestrife. DNA analysis and behavioral studies have shown that they are, however, distinct species. Both species share the following life cycle. Overwintering (hibernating) adult beetles emerge in spring from the soil litter beneath the host plants or from the dead hollow stems. They are very mobile as they seek out new stands of purple loosestrife and feed on newly emerging leaves. These adults soon mate and the females lay small clusters of eggs on the stems and leaves of purple loosestrife. Each female lays 300 to 400 eggs. Several weeks after mating and egg laying, all these adults die.

When the eggs hatch, the young larvae feed on leaf and flower buds at the tips of the purple loosestrife stems. These small larvae are difficult to see because many are hidden between the new leaves. The older and bigger larvae feed on all parts of the host plant and are easier to find. After molting several times, the larvae will crawl into the soil at the base of the purple loosestrife plant and pupate. New adult beetles emerge from these pupae in mid summer and dig out of the soil to feed on the purple loosestrife plants. These adults overwinter.

Entomologists in several states have successfully reared large numbers of these beetles. Releases of 4,000 to 6,000 beetles per site have resulted in dramatic reductions in purple loosestrife populations. If the beetle population is high enough, purple loosestrife plants can become defoliated, this kills plants and reduces seed production. With these promising results and with ongoing research and release programs, it is hoped that this invasive plant can be controlled and that native flora and fauna will reestablish in these wetland areas.

Once leaf beetles are released into a wetland, a long-term monitoring and evaluation program begins. Data are collected on changes in the population of purple loosestrife, success of the leaf beetles (feeding and reproduction) and changes in the plant community. This information is standardized and stored in a central database so researchers and land managers anywhere can make use of the information.

Whenever a biological control program is implemented, there are always many questions and concerns. Evaluating and weighing potential risks and benefits is an important part of any successful biological control program. Biological control of purple loosestrife is no exception. As mentioned earlier, there are many risks and few benefits to other control methods such as spraying herbicides, handpulling, tilling and burning. The challenge is to control purple loosestrife while at the same time protecting native plants and animals. These methods may control purple loosestrife to some degree, but they are either harmful to native wildlife or not practical on a large scale. There is also a risk in doing nothing. Purple loosestrife is not going to go away by itself, and doing nothing means it is only a matter of time before it spreads and has a negative impact on many wetland areas. Taking appropriate action before purple loosestrife dominates a wetland is the key to successful control.

Is biological control safe? How do you know that the leaf beetles won't become pests by eating native plants or crops? These are commonly asked questions about biological control. Before leaf beetles (or any biological control agent) can be released in a biological control program, they must undergo and pass several tests. This testing is regulated by the U.S. Department of Agriculture (USDA). Many of the tests determine which plants the leaf beetles will feed on, both as adults and larvae. It is very important to select a natural enemy that is a specialist feeder - feeds only on the target organism - and not a generalist feeder - feeds on many plants. It was found that the leaf beetles would feed and lay eggs only on purple loosestrife and not on native wetland plants, closely related plants or crops. The leaf beetles were also tested to make sure they were free of disease or parasites that might affect other organisms. After extensive testing, the USDA approved the use of the leaf beetles for biological control of purple loosestrife in 1992.

You are now ready to begin this section with students.

PART THREE

Biological Control of Purple Loosestrife

Lesson One: Controlling Purple Loosestrife

Instructions for teachers

In Lesson 1, students will be challenged to think about some solutions to problems caused by the invasion of purple loosestrife and the risks involved in various control strategies. The lesson begins with a brief review of the problem followed by a worksheet dealing with possible solutions. Begin by having students read the following information in the student workbooks.

Part Three Biological Control of Purple Loosestrife

Lesson One - Controlling Purple Loosestrife

As you know, the invasion of purple loosestrife is causing problems in North American wetlands. Are there solutions to these problems? It is important to understand ecology and life cycles of organisms if you are going to try to find solutions to problems such as the invasion of purple loosestrife.

Let's review some of the problems caused by the invasion of purple loosestrife. If you need more review, go back and read the information in Section I and Section II in your workbook.

Purple loosestrife is a flowering plant that is native to wetlands in Europe. In Europe, purple loosestrife is an important part of the wetland ecosystem. Purple loosestrife has many relationships with other wetland plants and animals in this wetland community. One very important relationship is that purple loosestrife provides food for some of the animals, especially insects. Some insects eat the roots, some eat the leaves and stems, some eat the flowers and some eat the seeds of purple loosestrife. These relationships control the number of purple loosestrife plants that grow in these European wetlands. If these insects were not in the wetland eating the purple loosestrife, there would be too many purple loosestrife plants. If there were too many purple loosestrife plants, there wouldn't be enough room for the other plants and animals to live. So you can see that the relationships between purple loosestrife and the insects that eat it are very important to the ecology of the European wetlands. These insects that eat purple loosestrife are called the natural enemies of purple loosestrife.

Before the year 1800, purple loosestrife did not grow in North America. North America and Europe are separated by the Atlantic Ocean, so it would have been hard for purple loosestrife to get to North America. As more and more people traveled across the ocean on ships, however, purple loosestrife seeds were also transported on these ships in ballast water, mixed in bags of grain or stuck to the hair of farm animals. By 1900, purple loosestrife was growing in many wetlands in the Great Lakes region.

Because purple loosestrife is an exotic plant (not native) in North America, it has no natural enemies in North American wetlands. All its natural enemies are in Europe. Without natural enemies in North America, purple loosestrife grows out of control. In wetlands where there are too many purple loosestrife plants, there isn't enough room for native plants and animals to live. This harms the native wetland plants and animals in North America.

The Purple Loosestrife Project • Cooperator's Handbook

This is why purple loosestrife is a problem in North America.

Because of its life cycle, purple loosestrife can spread rapidly when there are no natural enemies to control it. Purple loosestrife can spread in two ways: by roots and by seeds. Purple loosestrife roots get bigger each year. As the roots get bigger, they make more stems, leaves, flowers and seeds. These bigger plants take up more room than smaller plants. One purple loosestrife plant can make over 2 million seeds. These seeds travel to other wetlands by floating in the water or by mixing with the wetland mud, which then sticks to animals that walk through the wetland. It may take years before there are lots of purple loosestrife plants growing in a wetland. Once this happens, however, the purple loosestrife plants can spread rapidly, and it may take only a few years for it to take over the entire wetland.

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

Many people are trying to find a solution to this problem. Everyone agrees that, because purple loosestrife is already growing in North America, there is no way to get rid of it completely. But are there other solutions? The challenge is to control purple loosestrife without harming the native wetland plants and animals or the wetland ecosystem.

Tips for teachers on the Solutions Worksheet

Students can complete all four of the worksheets individually, or you may want to divide the class into four groups and assign one of the solutions to each group. The groups can then share their comments with the whole class. Discuss the risks and benefits of each solution. You may want first to make a list on the chalkboard or an overhead of the questions a land manager might ask to make this decision. These questions may include:

Does the solution control the purple loosestrife?

Does it harm other plants and animals?

Does it cost too much money?

Does it take too much time?

Does it have to be done annually and indefinitely?

Is it a long-term solution?

Do I need more information to make a decision?

Students should be encouraged to examine each solution carefully and to think about the risks and benefits of each. Here are some thoughts on each solution.

Solution 1 - Burning the wetland would kill or stunt existing purple loosestrife plants, but it would not kill the root crowns or seeds in the soil. Burning would also harm other plants and animals. Burning is not a long-term solution because purple loosestrife would grow back along with the other plants. This solution does not cost much and doesn't take much time.

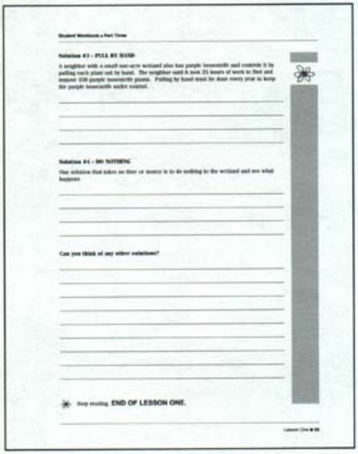
Solution 2 - Spraying herbicides would slow the spread of purple loosestrife, but it would also kill other wetland plants. Even though it does not directly kill animals, all the animals depend on plants for food, shelter and nesting sites, so this would also be harmful to the animals. If you were to spot spray only the purple loosestrife plants, you would use less herbicide and would protect most of the other plants from being sprayed. The problem with spot spraying is that you would miss many of the small purple loosestrife plants and, no matter how careful you are, some of the herbicide would be sprayed on other plants or into the water. Once a toxic chemical is in the ecosystem, it may find its way into food chains where it could be harmful to other organisms. This also is not a long-term solution because spraying would have to be done each year. Spraying could be costly.

Solution 3 - Pulling by hand seems to be a good solution. It doesn't cost much and there are no toxic chemicals. It also does no harm to most of the other plants and animals (just the ones you step on while you are walking through the wetland). This is a good solution for a small wetland that is not heavily infested with purple loosestrife, but it is impractical on a large scale. If you use the figures given, you can prove this point. The neighbor spent 25 hours finding and pulling 100 plants. That's 15 minutes per plant. The land manager has 500 acres with 50 plants per acre. That is a total of 25,000 plants. At 15 minutes per plant, it would take 6,250 hours to hand pull the plants. If one person pulled plants 40 hours every week, it would take over 150 weeks. The only way to do this would be to have lots of people to help pull plants and that would cost too much.

Solution 4 - Doing nothing is not a good solution to the problem. Though it wouldn't take any time or cost anything, the purple loosestrife would not be controlled. Once the purple loosestrife took over the wetland, the other plants and animals wouldn't have enough space to live.

Did any students come up with the idea of trying to find an animal (a natural enemy) to eat purple loosestrife as a control solution? If so, tell

SOLUTIONS Worksheet



END OF LESSON ONE.

them that what they are suggesting is called biological control. Students will begin to learn about biological control in Lesson 2. They will also learn that a natural enemy must be a specialist feeder (feeding only on the target organism) rather than a generalist feeder (feeding on many organisms) to be an effective biological control agent. Lesson 5 focuses on this.

Extension idea

One way to organize the information from the student's worksheets is to make a matrix on the chalkboard or a poster. One side of the matrix would be the solutions and the other would be the questions listed above. The class could then add a "yes" or "no" to each of the boxes in the matrix.

PART THREE

Biological Control of Purple Loosestrife

Lesson Two: Biological Control

Instructions for teachers

Lesson 2 introduces students to biological control. This is also when students will receive and place leaf beetles on the purple loosestrife plant they have grown in the classroom. There is no worksheet with this lesson, but the students are asked to answer several questions as they read the information in their workbooks. Begin this lesson by having students read the following information in their student workbooks.

IMPORTANT!

This is the point when leaf beetles should be placed on your purple loosestrife plant. See "Raising *Galerucella* Beetles Indoors" and "Lighting Requirements for Indoor Rearing of Galerucella Beetles" in the *Cooperator's Handbook* for instructions and information.

Student Workbook • Part Three

Lesson Two - Biological Control

Now that you have finished the Solutions Worksheet, you know that it is hard to find a good solution to the problems caused by the invasion of purple loosestrife. There are many ways to control or kill the purple loosestrife as it grows back each year, but these ways also harm the native plants and animals. There is another way to control exotic organisms such as purple loosestrife. It is called biological control.

What is Biological Control?

The science called biology is the study of living organisms. A person who studies living organisms is called a biologist. Biological control means using living organisms to control other organisms. Let's learn about biological control by looking at some examples.

EXAMPLE #1

Most farms have barns to store bags of seeds that the farmers will plant in the fields and also to store bags of food to feed the farm animals. Because of all the seeds and animal food, barns are great places for mice to live. In fact, sometimes barns have so many mice that they eat or spoil too much of the farmer's seeds and animal food. This is a problem for the farmer. How can the farmer control the mouse population? Mousetraps won't work because there are too many mice and it would take too much time to set and check the many traps. Mouse poison is not a good solution because the poison could get into the food chain and harm other animals. For example, a fox might eat a poisoned mouse and this would harm the fox. Poison and traps can also be expensive. Another solution would be to find a predator (a predator is an animal that eats other animals) that eats mice and let it live in the barn. One example of a mouse predator is a barn owl. Barn owls make their nests in barns and catch lots of mice to eat and to feed the young owls. The owls control the number of mice by eating them. Another mouse predator that farmers could use is a cat. Cats and barn owls eat mice, so they are called natural enemies of mice. This is an example of biological control: using a living organism (the cat or owl) to control the numbers of another living organism (mice). Not all the mice are eaten, but enough are eaten so they are no longer such a problem.

Here are two more new terms for you to learn about biological control. The organism used to control another organism is called the biological control agent. The organism being controlled is called the target organism. In example #1, the biological control agent is the owl or the cat. The target organism is the mouse.

EXAMPLE #2

Alfalfa is a very important crop in the United States and is grown on millions of acres of farmland. Farmers use alfalfa to feed animals such as cattle, sheep and horses. The alfalfa weevil, a native of Europe, invaded the United States, and the weevils were eating too much of the alfalfa crop. They were a big problem because they had no natural enemies in the United States and their numbers grew out of control. At first, the only way farm-

Lesson Two ■ 57

Tips for teachers on making observations after placement of the leaf beetles

As soon as the leaf beetles have been placed inside the sleeve cage, students should begin making observations. The primary objectives of making observations are for students to find and identify the stages of the beetle's life cycle (except the pupa, which is not visible because it is under the soil) and to observe how each stage behaves. It is also important that students continually relate these observations to the biological control of purple loosestrife. Teachers will need to be sure the focus of biological control is not lost in the excitement of raising beetles and making observations. Here are some important tips on making observations:

- You should plan to make observations on a regular basis beginning when the beetles are placed on the plant and continuing until the beetles are taken to be released in a wetland. This will be about a 6-week period and will give students the opportunity to observe the entire life cycle of the leaf beetles. You should make observations at least once each week.
- It is very difficult to see the beetle stages (especially eggs and larvae) by looking through the sleeve cage. To make these observations, the sleeve cage will have to be loosened and partially slipped over the tomato cage so some of the leaves and stems are visible to the students. The adult beetles are the only stage that might escape when the plant is exposed. If you are careful, this should not be a problem. If an adult does escape (and you can find it), try to get it to walk onto a piece of paper and then transfer it back on the plant. Adult beetles are fairly easy to see through the sleeve cage, so it is recommended to wait about 3 weeks after the beetles are placed on your plant

ers could kill the weevils was by spraying the fields with pesticides. To find another solution, scientists went to Europe, where the weevils are native, and found out that animals were the natural enemies of the weevils in Europe. They collected some of these natural enemies and brought them to the United States, where they were raised and released in alfalfa fields. These natural enemies were tiny wasps that would lay their eggs inside the weevil's body. When the eggs hatched, the wasp larvae would live and feed inside the weevils and the weevils would be killed. After several years, there were so many wasps in the alfalfa fields that the number of weevils was under control. This saved the farmers lots of time and money because they didn't have to spray the fields. This also protects native plants and animals that may be harmed by pesticides. This is another example of biological control.

In example #2, which organism is the biological control agent?

the wasp

Which organism is the target organism?

the alfalfa weevil

EXAMPLE #3

In the first two examples, the target organism was an animal: the mouse in example #1 and the weevil in example #2. Biological control can also be used to control plants. Here is an example. In about 1900, a plant called the Klamath weed invaded California. Klamath weed is native to Europe and is an exotic invader in North America. By 1940, Klamath weed had grown out of control and had taken over millions of acres of grassland ecosystems in California and other western states. The Klamath weed was taking up so much space that many of the native plants and animals couldn't live there anymore. Klamath weed was also poisonous to some animals that tried to eat it. People tried to control the Klamath weed with herbicides, but it was expensive and didn't work very well. In the 1940s, scientists went to Europe, where Klamath weed is native, and found several kinds of beetles that eat Klamath weed. These natural enemies of Klamath weed were brought to California and released in the grasslands. These natural enemies became very common in the grasslands and have eaten almost all of the Klamath weed. Once the Klamath weed was gone, the native plants and animals returned to live in the grasslands. This is another example of biological control.

Which of the organisms in example #3 is the natural enemy?

the beetles

Which is the target organism?

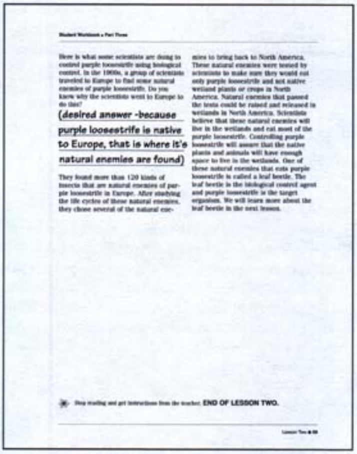
Klamath weed

Which is the biological control agent?

the beetles

Let's think about purple loosestrife and biological control. As you know, purple loosestrife is native to Europe but now grows in North America. Because it doesn't have any natural enemies in North America, it grows out of control. What would you do to control purple loosestrife?

(desired answer -find some natural enemies that will eat purple loosestrife)



Here is what some scientists are doing to control purple loosestrife using biological control. In the 1980s, a group of scientists traveled to Europe to find some natural enemies of purple loosestrife. Do you know why the scientists went to Europe to do this?

(desired answer -because purple loosestrife is native to Europe, that is where it's natural enemies are found)

They found more than 120 kinds of insects that are natural enemies of purple loosestrife in Europe. After studying the life cycles of these natural enemies, they chose several of the natural enemies to bring back to North America. These natural enemies were tested by scientists to make sure they would eat only purple loosestrife and not native wetland plants or crops in North America. Natural enemies that passed the tests could be raised and released in wetlands in North America. Scientists believe that these natural enemies will live in the wetlands and eat most of the purple loosestrife. Controlling purple loosestrife will assure that the native plants and animals will have enough space to live in the wetlands. One of these natural enemies that eats purple loosestrife is called a leaf beetle. The leaf beetle is the biological control agent and purple loosestrife is the target organism. We will learn more about the leaf beetle in the next lesson.

Stop reading and get instructions from the teacher. **END OF LESSON TWO.**

before you partially remove the sleeve cage. This will give the adults the opportunity to mate and lay eggs. After this 3-week period, there should be egg clusters on the plant.

- Color photographs (enlarged) of an egg cluster, larvae and an adult are supplied in the materials section of the unit to help with your observations. Lesson 3 focuses on the leaf beetle's life cycle. Completing this lesson soon after the placement of beetles on your plant will help students make better observations and aid in their understanding of what is going on.
- Students should design their own observation form (either on paper, a poster or the chalkboard). The observation form should include the following columns:
  - Date of placement of beetles on the plant.
  - Date of observations.
  - Stages of beetle's life cycle observed.
  - Location and behavior of the stages observed.
  - Amount of purple loosestrife foliage eaten.
  - How observations relate to bio logical control.

Students may have other ideas on other observations to make. Taking photographs and making drawings should also be encouraged.

Teacher information to help students make observations on the leaf beetle's life cycle

It is hoped that students, through making careful observations and by completing the other lessons, will construct much of this information on their own as they make their observations over a period of 4 to 6 weeks.

ADULTS – You will start out with about 20 adult leaf beetles (the ones you place on the purple loosestrife plant). The adults are usually light brown (color may vary). These adults spent last winter buried in the soil. During the first week after being placed on the plant, these adults can be observed feeding on leaves, walking around on the plant and mating. After mating, the female adults will lay eggs. These adults will continue to feed and live on the plant for about 4 to 6 weeks and then will die. You may notice a steady decline in the number of living adults as time passes. When observing adults, have students describe how the adult uses its legs and antennae as it feeds and moves about. Can the adults walk upside-down? If yes, why? Do they ever fly? Do they ever stretch their wings? Are the adults always moving or do they rest? Are they usually alone or in groups?

EGG CLUSTERS – Look at the photo of the egg cluster. It may take up to two weeks from the day they are placed on the plant before the females lay eggs. Leaf beetles lay their tiny cream-colored eggs in clusters of up to 18 eggs per cluster. One cluster may be only about 1 mm across. A thin black string of fecal material is deposited over the egg cluster by the female. Look for egg clusters on stems and leaves, especially in the leaf axils (the point where the leaf is attached to the stem). When an egg cluster is found, record its location on the observation sheet (e.g., in the leaf axil about 20 cm above soil level). How many egg clusters can the students find? You may want to mark the location of a couple egg clusters (place a twist-tie a couple inches away on the stem so you can easily find the same clusters again) and watch what happens. If you have a magnifier, you may be able to tell if eggs have hatched or not. Egg clusters are almost impossible to find by looking through the sleeve cage. Partially remove the sleeve cage (as described previously) to look for egg clusters.

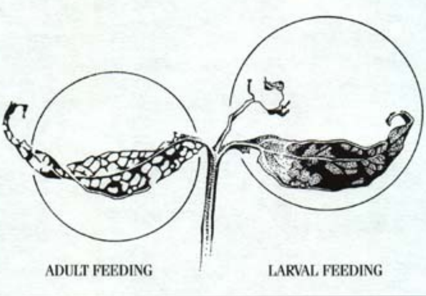
LARVAE - (Note: "larva" is singular, "larvae" is plural and "larval" is an adjective (the larval stage). Look at the photo of the leaf beetle larvae. Leaf beetle larvae are yellow to orange with black stripes that run side-to-side across the body. Larvae molt several times. Each time they molt, they get a little bigger. You may not be able to find the early stages of the larvae because they are very small and they usually crawl to the tips of the stems where they are hidden between the newly-growing leaves. So don't be alarmed if you can't find any of the early larval stages. It takes about three weeks after hatching from an egg for larvae to be full-grown. A full-grown larva may be found anywhere on the plant or crawling on the sleeve cage and will be about 7 mm long (1/4 inch). These full-grown larvae should be easy to find on the plant. Larvae feed in all stages. As larvae get bigger, you may notice small black spots on the leaves. This is the fecal material (frass) from the larvae. Have students make and record observations of when and where they see larvae and what the larvae doing. Also record the size of larvae. If you find a larva on a leaf, try removing the entire leaf from the plant and placing the leaf and larva in a petri dish or other clear container. You may want to place a couple other leaves in the container also. Students can then make close observations of the larva (use a magnifier or microscope if available). Return the larva to the plant before the leaf dries out (after a couple hours). Though it would be difficult to count larvae accurately, students may be able to make observations about whether the larvae seem to be increasing or decreasing in numbers or in size each time they make observations.

PUPAE - (Note: "pupa" is singular, "pupae" is plural and "pupal" is an adjective (the pupal stage). Just before a full-grown larva molts into a pupa, it will crawl down the plant and bury itself in the soil, where it will remain for about two weeks. Students will not be able to see the pupal stage.

NEW-GENERATION ADULTS - A new generation of adults will emerge underground from the pupae, dig out of the soil and begin feeding on the purple loosestrife. These adults will be lighter in color than the adults that were placed into the sleeve cage and usually will gather near the top of the sleeve cage. Though most of the adults that were placed into the sleeve cage will be dead, a few may still be alive. This means that there may be a slight overlap period when adults from both generations will be present. Students should make observations on the general number of adults they see on the plant and what they are doing. There should be a decrease in numbers of adults as the original adults die and then a sudden increase when the next generation begins emerging.

From the time the beetles are placed into the sleeve cage to the time the new generation of adults emerge is about 6 to 8 weeks. Once you start to see the new generation of adults, it is time for the beetles to be released into a wetland. Your one plant may produce from 500 to 1,000 new adult beetles, so it is important to release the beetles into a wetland before too many emerge. Your plant will not be able to provide enough food for these beetles.

AMOUNT OF FOLIAGE EATEN - This is where students will make observations related to the effectiveness of the leaf beetles as biological control agents. Are the beetles eating the purple loosestrife, how much are they eating and what stages are eating the most leaves? Having the students figure out a process for


ADULT FEEDING LARVAL FEEDING

estimating the amount of foliage eaten would be a good activity in itself.

Students should also make observations on feeding patterns. Do different stages feed on different parts of the plant and in different ways? Here are some thoughts on feeding pattern observations. Adults usually feed by making small holes through the leaves but not eating the leaf veins. Larvae usually eat the upper layer of the leaf surface, leaving the lower layer behind. These areas will appear as small "windows" in the leaves. Larvae usually begin feeding near the top of the stems and then progress downward. The drawing shows both adult and larval feeding patterns.

Be sure there are enough leaves left on the plant for the remaining larvae and/or adults to eat, or provide fresh clippings from the field.

MAKING PREDICTIONS (journal entry) - After placing the beetles on your purple loosestrife plant, have students make predictions in their journals of what they think will happen. What will happen to the beetles? What will happen to the plant? Keep these predictions handy and revisit them periodically to see how accurate they are. Do students want to change their predictions as they observe and learn more about the beetle's life cycle? Students will be asked to revisit these predictions in Lesson 6.

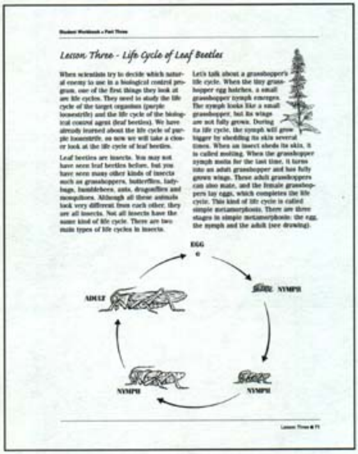
PART THREE

Biological Control of Purple Loosestrife

Lesson Three: Life Cycles of Leaf Beetles

Instructions for teachers

Now that you have placed the leaf beetles on the purple loosestrife plant in the classroom, students will begin to learn more about the leaf beetles. The main focus of this lesson is life cycles of insects. Begin by having students read in their student workbooks.



Student Workbook • Part Three

Lesson Three - Life Cycle of Leaf Beetles

When scientists try to decide which natural enemy to use in a biological control program, one of the first things they look at are life cycles. They need to study the life cycle of the target organism (purple loosestrife) and the life cycle of the biological control agent (leaf beetles). We have already learned about the life cycle of purple loosestrife, so now we will take a closer look at the life cycle of leaf beetles.

Leaf beetles are insects. You may not have seen leaf beetles before, but you have seen many other kinds of insects such as grasshoppers, butterflies, ladybugs, bumblebees, ants, dragonflies and mosquitoes. Although all these animals look very different from each other, they are all insects. Not all insects have the same kind of life cycle. There are two main types of life cycles in insects.

Let's talk about a grasshopper's life cycle. When the tiny grasshopper egg hatches, a small grasshopper nymph emerges. The nymph looks like a small grasshopper, but its wings are not fully grown. During its life cycle, the nymph will grow bigger by shedding its skin several times. When an insect sheds its skin, it is called molting. When the grasshopper nymph molts for the last time, it turns into an adult grasshopper and has fully grown wings. These adult grasshoppers can also mate, and the female grasshoppers lay eggs, which completes the life cycle. This kind of life cycle is called simple metamorphosis. There are three stages in simple metamorphosis: the egg, the nymph and the adult (see drawing).

Lesson Three ■ 71

Tips for teachers on Beetle Life Cycle Worksheet

Students should be able to complete this worksheet after reading the information in their student workbooks.

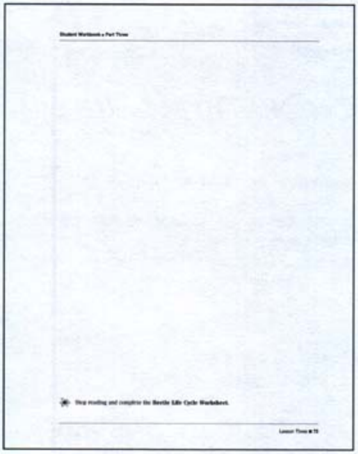
1. The leaf beetle has complete metamorphosis (like the butterfly). Students should be able to see that the larva and pupa look different from the adult. If this were simple metamorphosis (like the grasshopper), the stages (except the egg) would all resemble the adult. The term "nymph" is used only for stages in simple metamorphosis. The terms "larva" and "pupa" are used only for stages of complete metamorphosis.
2. The blank spaces should be filled in with egg, larva, pupa and adult (in that order).
3. This question isn't as obvious, but the information is given in the student workbook information. The egg stage does not feed. The larva stage is a feeding stage. As the larva gets bigger, it eats more. The pupa does not feed. The adult stage is also a feeding stage. So it is the larva and adult stages that eat and help control purple loosestrife.
4. It is hard to see all the parts of an insect in one drawing or photo. You may be able to find other drawings of other beetles to use as a comparison. If you have a dead leaf beetle (or other type of beetle such as a ladybug) you can dissect it to see the hard front wings, fragile back wings and other parts.

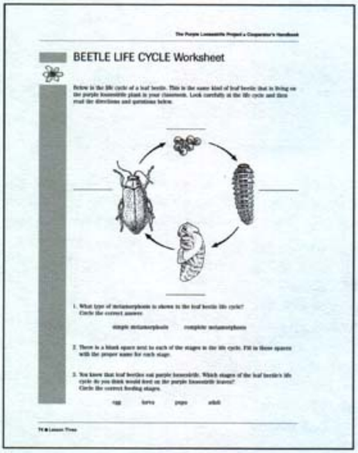
Journal entry

Have students draw a picture of the life cycle of the leaf beetle and color the drawings to reflect the true colors of each stage. Use the descriptions in Lesson 2 and/or the photos to find out what colors to use.

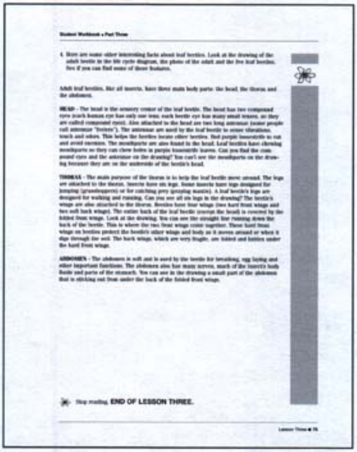
Extension idea

Have students learn about the life cycle of another insect they are familiar with and construct/draw its life cycle.





BEETLE LIFE CYCLE Worksheet



END OF LESSON THREE.

PART THREE

Biological Control of Purple Loosestrife

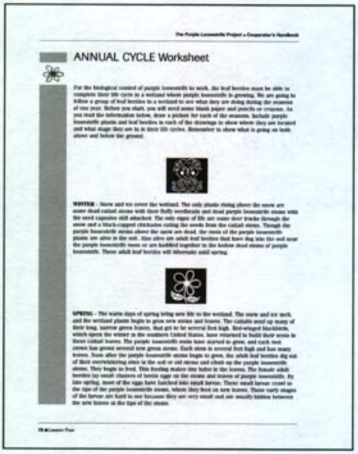
Lesson Four: Beetles and Loosestrife Together

Instructions for teachers

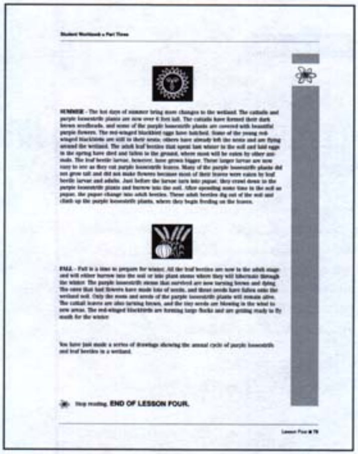
Now that students have learned about the life cycles of both purple loosestrife (Part Two) and leaf beetles, this lesson will focus on how these two life cycles fit together and how the leaf beetles affect the growth of purple loosestrife. Begin by having students read the following information in their student workbooks.

Lesson Four – Leaf Beetles and Purple Loosestrife Together

You have learned about the life cycle of purple loosestrife, the life cycle of the leaf beetle and biological control. As you know, the problem with purple loosestrife in North American wetlands is that it has no natural enemies here. When leaf beetles (the biological control agent) are released into these wetlands, they eat purple loosestrife (the target organism) and help control the number of purple loosestrife plants that are growing in the wetland.



ANNUAL CYCLE Worksheet



END OF LESSON FOUR.

Tips for teachers on the Annual Cycle Worksheet

The main objective of this worksheet is to set the students to focus on how the life cycles of the leaf beetles and purple loosestrife are connected and what each organism is doing during the various seasons. A lot of information is given and it may be difficult to grasp (especially the annual cycle of the leaf beetles) at first. After the students have finished their drawings, it may be helpful to read through each of the seasons again to review what the organisms are doing. Observing the activities and stages of the leaf beetles in your classroom will also help reinforce the ideas.

Extension idea

Have students create a mural of a wetland where purple loosestrife and leaf beetles live.

Suggested journal entry

Have students select other plants and animals that live in the wetland (possibly from their lists from Part One) and write a story about their annual cycles. Some suggestions include the marsh wren, leopard frog, muskrat or painted turtle.

PART THREE

Biological Control of Purple Loosestrife

Lesson Five: Selecting Natural Enemies

Instructions for teachers

Up to this point, students know that leaf beetles are used as a biological control agent for purple loosestrife. Lesson 5 will help students understand some of the basic questions that scientists ask when selecting a natural enemy to be used as a biological control agent. What are the risks and benefits of releasing a particular natural enemy? In the activity, the students are given a hypothetical situation and a list of hypothetical natural enemies. By using the criteria given, students will evaluate each natural enemy and select the one that they feel is best. You may want to complete the following extension idea before beginning.

Extension idea

Scientists must make many decisions must be made when selecting a natural enemy for biological control. What are some of the criteria students use to make decisions in their lives? Divide the students into four groups. Have students pretend that a $10 bill has been given to each student. Members of each group must pool their money and agree on how they would spend it. Whatever they buy must be useful and agreeable to everyone in their group. After they have made their decision, have each group write down the criteria they used to make their decision. This information can then be shared with the entire class.

Students can begin by reading in their student workbooks.

Instructions for teachers

To begin, students should read "The Problem" paragraph and the list of four main things used to make a decision. You may want to go over this material with the whole class to be sure everyone understands the activity. It is also important that students understand that this is hypothetical. There are six potential water choke-weed natural enemies. Divide the class into six groups and assign one of the natural enemies to each group. Each group will read about its natural enemy and by using the four criteria, decide whether it would be a good natural enemy to control water choke-weed. Each group will then report its decision and explain to the class why members made their decision.

Another, more time-consuming way to conduct the activity is for each small group to evaluate all six natural enemies and decide which is best. Each group can then share its findings and reasoning.

2. The natural enemy would have to be able to survive year round in Michigan ponds and lakes.
3. The natural enemy would have to eat lots of water choke-weed but not eat any native plants or crops.
4. The natural enemy cannot be harmful to humans or other organisms.

WATER CHOKE-WEED NATURAL ENEMY #1

Students stop reading and get instructions from the teacher

This natural enemy is a small fish called the weed minnow. In indoor experiments, it was found to eat only water choke-weed and to pose no threat to humans or any other organisms. The weed minnow is very easy to raise in indoor water tanks and it doesn't cost much to raise them by the thousands. Each small fish eats several water choke-weed leaves every hour. The weed minnow is native to wetlands in tropical areas of Asia, where it does a great job controlling the growth of water choke-weed. The weed minnow cannot survive if the water temperature goes below 50 degrees Fahrenheit.

WATER CHOKE-WEED NATURAL ENEMY #2
This natural enemy is a small mammal called the water rat. Water rats are native to lakes in the temperate deciduous forest biome of Europe, where they eat huge amounts of water choke-weed. They won't eat any other kind of plant. They also make their nests in the water choke-weed. During the nesting season, water rats are very aggressive and will bite and chase away any other mammals or birds within sight. Water rats can be easily and cheaply raised by the thousands in the laboratory and can survive even the coldest winters.

WATER CHOKE-WEED NATURAL ENEMY #3
This natural enemy is an insect called the green water beetle and is native to lakes in the temperate deciduous forest biome of Europe. In Europe, it is found only in lakes with lots of water choke-weed. After studying its life cycle, scientists discovered that it is a predator and it eats only other insects that eat water choke-weed. During the winter, it survives by burrowing into the lake bottom. Green water beetles are cheap and easy to raise in laboratories and are not harmful to any native plants or animals.

WATER CHOKE-WEED NATURAL ENEMY #4
This natural enemy is called the pond fly and is native to the temperate deciduous forest biome in Europe. The adult pond flies do not feed or bite and live only a few days. The female adult pond flies lay their eggs only on water choke-weed leaves. When the eggs hatch, the pond fly larvae burrow into the water choke-weed stems and eat their way all the way to the roots. One larva can kill an entire water choke-weed plant. The fly spends the winter as a pupa in the roots and then, in the spring, the pupa floats to the water surface where the adult pond fly emerges. The larvae will burrow into and eat only water choke-weed. The pond flies are easy and cheap to raise and don't harm or bother any other organisms.

WATER CHOKE-WEED NATURAL ENEMY #5
This natural enemy is called the water leaf beetle. These insects can't seem to get enough water choke-weed and will eat it until it is gone. Scientists found they could easily and cheaply raise thousands

of water leaf beetles by keeping them in cages and feeding them corn and cattail leaves. Because they are from the temperate deciduous forest biome in Europe, the water leaf beetles can easily survive the winters in the Great Lakes Basin.

WATER CHOKE-WEED NATURAL ENEMY # 6
This natural enemy is called the purple stem weevil (a kind of beetle). The purple stem weevil is native to the temperate deciduous forest biome in Europe and easily survives the winter in the Great Lakes Basin. It is truly a water choke-weed specialist and lives its entire life cycle on the plant. The adult weevils eat the seeds so there are fewer new water choke-weed plants. The larvae eat lots of stems and leaves of water choke-weed. The purple stem weevil will not eat anything else and is not harmful to any other organisms. Scientists have found that it takes three years using expensive growth chambers to raise about 100 weevils in the laboratory.

Stop reading. END OF LESSON FIVE.

Tips for teachers on the Which Natural Enemy is Best activity

Here is information on why only one of the natural enemies (#4) is the best selection for a biological control agent of water choke-weed. These explanations follow the four criteria listed in the activity.

NATURAL ENEMY #1
WEED MINNOW

1. Can it be easily and cheaply raised in a laboratory? YES
2. Can it survive year round in Michigan? NO

   Because it is native to tropical areas, it cannot survive if the water temperature goes below 50 degrees Fahrenheit. Water temperatures go well below 50 degrees during Michigan winters. Because of this, it is not the best natural enemy.
3. Does it eat only water choke-weed and not any other plants? YES
4. Is it harmful to humans or other organisms? NO

NATURAL ENEMY #2
WATER RAT

1. Can it be easily and cheaply raised in a laboratory? YES
2. Can it survive year round in Michigan? YES
3. Does it eat only water choke-weed and not any other plants? YES
4. Is it harmful to humans or other organisms? YES

If water rats are aggressive during the nesting season, this would have a negative effect on the native animals that also use the pond or lake for nesting and feeding. It also would restrict recreational swimming. Because of this, water rats are not the best natural enemy

NATURAL ENEMY #3
GREEN WATER BEETLE

1. Can it be easily and cheaply raised in a laboratory? YES
2. Can it survive year round in Michigan? YES
3. Does it eat only water choke-weed and not any other plants? NO

   It was found that green water beetles are predators of other insects that eat water choke-weed. If there are fewer insects eating water choke-weed (because they are being eaten by the green water beetles), there would be more water choke-weed. Because of this, green water beetles are not the best natural enemy.
4. Is it harmful to humans or other organisms? NO

NATUAL ENEMY #4
POND FLY

1. Can it be easily and cheaply raised in a laboratory? YES
2. Can it survive year round in Michigan? YES
3. Does it eat only water choke-weed and not any other plants? YES

4. Is it harmful to humans or other organisms? NO

   The pond fly meets all of the selection criteria and is the best natural enemy to control water choke-weed.

NATURAL ENEMY #5
WATER LEAF BEETLE

1. Can it be easily and cheaply raised in a laboratory? YES
2. Can it survive year round in Michigan? YES
3. Does it eat only water choke-weed and not any other plants? NO

   Water leaf beetles will eat lots of water choke-weed, but they will also eat other plants, such as corn and cattails. This would not be good.
4. Is it harmful to humans or other organisms? YES

   If these insects became a pest of corn and cattails, it would affect both humans and any animals that depend on cattails for food, cover or nesting sites. For these reasons, water leaf beetles are not the best natural enemy.

NATURAL ENEMY #6
PURPLE STEM WEEVIL

1. Can it be easily and cheaply raised in a laboratory? NO

   Taking 3 years to raise only 100 beetles would not be practical or effective. Also, the growth chambers are expensive. For these reasons, the purple stem weevil is not the best natural enemy.
2. Can it survive year round in Michigan? YES
3. Does it eat only water choke-weed and not any other plants? YES
4. Is it harmful to humans or other organisms? NO

PART THREE

Biological Control of Purple Loosestrife

Lesson Six: Biocontrol of Purple Loosestrife

Instructions for teachers

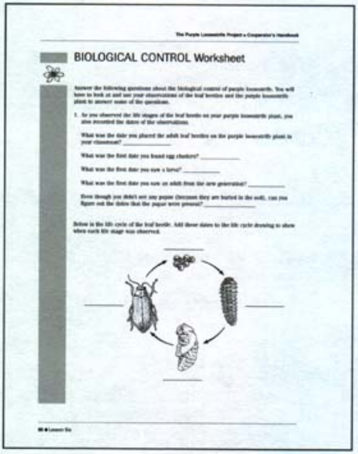
This final lesson of the unit will focus on the biological control of purple loosestrife. Students will read about why leaf beetles were selected as biological control agents for the control of purple loosestrife and will use their observations of beetles in the classroom to complete a worksheet. This worksheet can also be used to assess student understanding of the biological control of purple loosestrife. Because the worksheet is based on student observations, it should be completed toward the end of the school year (so that students have observations of the entire beetle life cycle). Begin by having students read the following information in their student workbooks.

Lesson Six - Biological Control of Purple Loosestrife

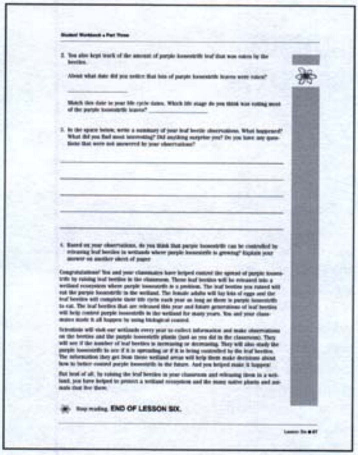
Now that you know how scientists choose a natural enemy for use in biological control, let's learn some of the reasons that leaf beetles were chosen to control purple loosestrife. As you read before, scientists traveled to Europe (where purple loosestrife is native) and identified more than 120 kinds of insects that are natural enemies of purple loosestrife in Europe. Here are some of the main reasons that the leaf beetle was chosen to be used in a biological control program for purple loosestrife.

1. It was found that many of the natural enemies of purple loosestrife are difficult or expensive to raise in large numbers. Leaf beetles can be easily raised in laboratories, greenhouses and classrooms by growing purple loosestrife plants in pots and then letting the leaf beetles live on the plants. The leaf beetles can't escape because a screen bag is placed over the potted plant. The leaf beetles will complete their entire life cycle on these potted plants and then can be released into wetlands where purple loosestrife is growing.
2. Because the leaf beetles are native to the temperate deciduous forest biome of Europe (where the climate is similar to that in the Great Lakes region), they can survive year round after they are released into the wetlands. Once they are released into a wetland where purple loosestrife grows, the leaf beetles can go through their life cycle every year and continue to eat purple loosestrife for many years.
3. Leaf beetles eat lots of purple loosestrife. Both the adults and the larvae of leaf beetles eat purple loosestrife. By eating many of the leaves, the leaf beetles keep purple loosestrife from growing out of control. Also, if a plant has too many of its leaves eaten, it won't make enough food to make flowers. If it doesn't make flowers, it can't make seeds. With fewer seeds, there are fewer new purple loosestrife plants. When there are fewer purple loosestrife plants, there is more room for the native plants and animals to live.
4. Scientists tested the leaf beetles and found that they would not eat anything except purple loosestrife and would lay their eggs only on purple loosestrife. They placed hungry adults and larvae of leaf beetles inside cages and tried to get them to eat other plants. The only plant they would eat was purple loosestrife. This is very important when choosing a natural enemy. An animal that eats only one kind of organism, such as the leaf beetle that eats only purple loosestrife, is called a specialist. An animal that eats many kinds of other organisms (such as a rabbit, which eats many kinds of plants) is called a generalist. Most animals used in biological control programs are specialists. Do you think human beings are specialist or generalist feeders?
5. Because the leaf beetles eat only purple loosestrife, they are not harmful to human being or other organisms.

Stop reading and complete the **Biological Control Worksheet.**



BIOLOGICAL CONTROL Worksheet



END OF LESSON SIX.

Tips for teachers on Biological Control Worksheet

This worksheet is designed for students to use to make sense of their observations. It may be best to construct the life cycle and dates together and then have students use the life cycle and other observations to answer the questions. The pupae would have been present between the time students first saw large larvae and the time they first saw new-generation adults.

Extension idea

Have students use the dates and observations they made to create a time line. Students could add observations they found interesting, life stage information and other facts to the time line.

Extension idea

Using your observations, write a class report of your results and send it to the Purple Loosestrife Project at Michigan State University, 334 Natural Resources Building, East Lansing, MI 48824.

Instructions for teachers

In Lesson 2, students made predictions of what they thought would happen after the leaf beetles were placed on the plant. Revisit these predictions with the students and discuss, based on their observations, why their predictions were or were not accurate. To finish this section, have the students read the following information in their student workbooks.

Student Glossary

ABDOMEN – One of the three main body parts of an adult insect.

ADULT – The stage in the life cycle of an insect that may have fully grown wings (some insect adults don't have wings – for example fleas) and can mate and lay eggs.

ALIEN – A plant or animal that is living in an area that it is not native to. "Alien" means the same as "exotic."

ANTENNAE – Sensory structures on the heads of insects (also called "feelers").

ANNUAL – A plant that completes its life cycle in one year.

BIENNIAL – A plant that takes two years to complete its life cycle.

BIOLOGICAL CONTROL – Using an organism (the biological control agent or natural enemy) to control another organism (the target organism).

BIOLOGICAL CONTROL AGENT – An organism that is used in a biological control program to control another (target) organism.

BIOME – A large area of the Earth shaped by geographic location, climate, topography and other physical features. Examples of biomes include tropical rain forest, tundra, ocean, grassland and temperate deciduous forest.

COMMUNITY – All the interacting organisms within an ecosystem. For example, all the living organisms in a marsh ecosystem make up the marsh community.

COMPOUND EYES – Eyes, as in adult insects, that are made up of many tiny lenses. Each human eye has only one lens.

CARBON DIOXIDE – An invisible gas in the air that green plants use to make food and oxygen through the process of photosynthesis.

CARNIVORE – An animal that eats only other animals.

CHLOROPHYLL – The green pigment in plants that captures energy from the sun in the process of photosynthesis.

CONSUMER – Any organism that cannot make its own food and must eat other organisms to get energy.

DECIDUOUS – Refers to trees and shrubs that lose all their leaves in the fall.

DISPERSAL – The various ways that seeds travel from place to place.

ECOLOGY – The study of living organisms and their relationships.

ECOSYSTEM - A group of interacting organisms (community) and the non-living or physical factors that affect them.

EGG – One stage of an insect's life cycle. Eggs are laid by adult females.

EXOTIC – A plant or animal that is living in an area to which it is not native. "Exotic" means the same thing as "alien".

FOOD CHAIN – A sequence of organisms in a community that shows which each one eats and what eats it and the direction of energy flow.

GENERALIST – An animal that feeds on many types of plants and/or animals.

GREAT LAKES REGION – The states and provinces in North America that surround the five Great Lakes.

HERBICIDE – A chemical that is used to kill plants.

HERBIVORE – An animal that eats only plants.

INVASION – When an exotic plant or animal begins living in an area where it didn't live before.

LARVA (larvae [plural]) – A stage in the life cycle of an insect that undergoes complete metamorphosis. It is the stage after the egg and before the pupa.

LATITUDE – Imaginary lines on the Earth used to measure distance north and south of the equator.

LIFE CYCLE – A way to show the different stages of an organism's life.

LONGITUDE – Imaginary lines used to measure distance east and west around the Earth.

METAMORPHOSIS – The changes that insects go through as they complete their life cycle. Some insects undergo simple metamorphosis which has three life stages: egg, nymph and adult. Some insects undergo complete metamorphosis, which has four life stages: egg, larva, pupa and adult.

MOLTING – The shedding of skin by a nymph or larva that allows it to grow bigger or to change into a different life stage.

NATIVE – A plant or animal that is living in the area where it originally developed.

NATURAL ENEMY – An organism that controls the numbers of other organisms. Predators and herbivores are examples.

NECTAR – The sweet liquid made by flowers to attract pollinators.

NYMPH – A life stage of an insect that undergoes simple metamorphosis. It is the stage after the egg and before the adult.

OMNIVORE – An animal that eats both plants and animals.

ORGANISM – An individual of any living thing.

OXYGEN – An invisible gas made by green leaves through the process of photosynthesis..

PESTICIDE – A chemical that is used to kill organisms that humans consider pests.

PHOTOSYNTHESIS – The process by which green leaves (with chlorophyll) capture energy from sunlight and use carbon dioxide and water to make food and oxygen.

POLLEN – Small particles made by the male parts of flowers.

POLLINATION – The transfer of pollen from flower to the flower so the flowers can make seeds. Pollen is usually transferred between plants by the wind or by pollinators.

POLLINATOR – An animal, usually an insect, that transfers pollen from oneflower to another flower.

PRECIPITATION – Rain, snow, hail and sleet.

PREDATOR – An organism that captures, kills and eats other animals.

PREY – An organism captured, killed and eaten by a predator.

PRODUCER – Organisms (mostly green plants) that make their own food using the energy from sunlight.

PUPA or pupae (plural) – A stage in the life cycle of an insect that undergoes complete metamorphosis. It is the stage after the larva and before the adult.

RELATIONSHIP – Any interaction between individual organisms or between an organism and non-living factors. Relationships are sometimes called interrelationships.

SPECIALIST – An animal that feeds on only one kind of plant or animal.

SPECIES – A specific kind of organism.

TARGET ORGANISM – The organism that is being controlled in a biological control program.

TEMPERATE – Refers to areas with a moderate climate and distinct seasons.

THORAX – One of the three main body parts of an adult insect. The legs and wings are attached to the thorax.

TOPOGRAPHY – The surface features of land, such as mountains, valleys, plains, rivers and lakes.

WETLAND – An area that usually has standing water for at least part of the year. Some wetland types are marshes, swamps and bogs.

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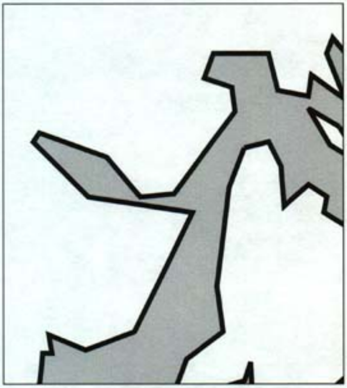
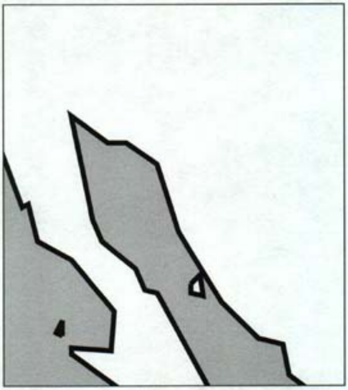
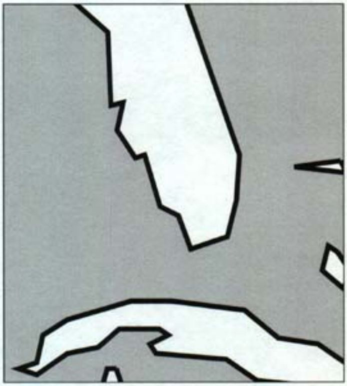
Teacher Classroom Materials



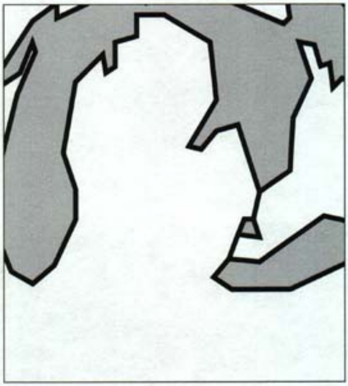
MAP #1



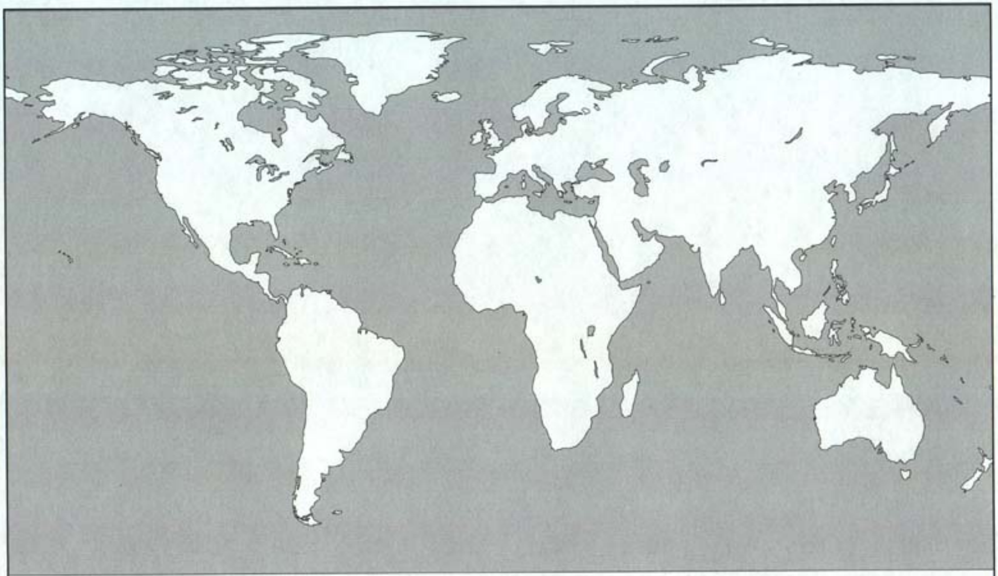
MAP #2



MAP #3



MAP #4



BIOMES of the WORLD

☐ ocean/lakes

☐ tundra

☐ desert

☐ semidesert, arid grassland

☐ evergreen coniferous forest

☐ temperate deciduous forest

☐ temperate grassland

☐ dry woodlands and shrublands

☐ tropical scrub forest

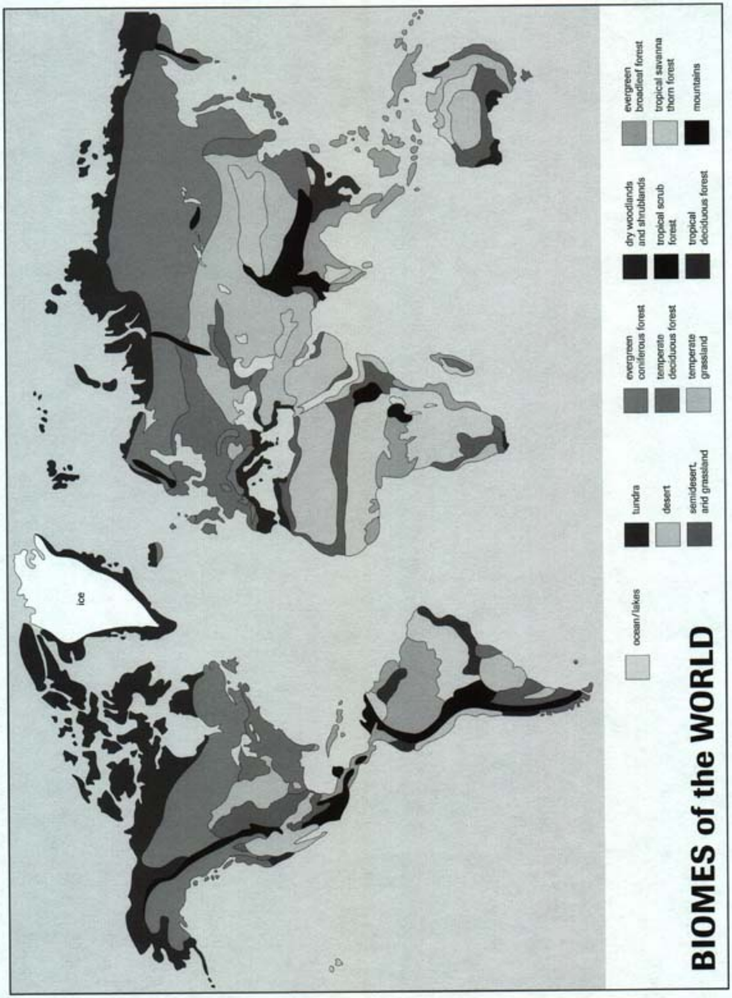
☐ tropical deciduous forest

☐ evergreen broadleaf forest

☐ tropical savanna thorn forest

☐ mountains

BIOMES of the WORLD



FOREST ECOSYSTEM

FOOD CHAIN CARDS

SUN

Gives plants the energy to make their own food

ECOSYSTEM: FOREST

ORGANISM: ____________________

CLASSIFICATION: ____________________

FOOD: ____________________

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ECOSYSTEM: FOREST

ORGANISM: ____________________

CLASSIFICATION: ____________________

FOOD: ____________________

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ECOSYSTEM: FOREST

ORGANISM: ____________________

CLASSIFICATION: ____________________

FOOD: ____________________

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ECOSYSTEM: FOREST

ORGANISM: ____________________

CLASSIFICATION: ____________________

FOOD: ____________________

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ECOSYSTEM: FOREST

ORGANISM: ____________________

CLASSIFICATION: ____________________

FOOD: ____________________

____

ECOSYSTEM: FOREST

ORGANISM: ____________________

CLASSIFICATION: ____________________

FOOD: ____________________

____

ECOSYSTEM: FOREST

ORGANISM: short-tailed shrew

CLASSIFICATION: mammal

FOOD: insects and earthworms

ECOSYSTEM: FOREST

ORGANISM: centipede

CLASSIFICATION: centipede

FOOD: insects

ECOSYSTEM: FOREST

ORGANISM: ground beetle

CLASSIFICATION: insect

FOOD: insects

ECOSYSTEM: FOREST

ORGANISM: walkingstick

CLASSIFICATION: insect

FOOD: plants

ECOSYSTEM: FOREST

ORGANISM: white-footed mouse

CLASSIFICATION: mammal

FOOD: plant seeds and insects

ECOSYSTEM: FOREST

ORGANISM: moss

CLASSIFICATION: plant

FOOD: uses sunlight to make its own food

ECOSYSTEM: FOREST

ORGANISM: fern

CLASSIFICATION: plant

FOOD: uses sunlight to make its own food

ECOSYSTEM: FOREST

ORGANISM: downy woodpecker

CLASSIFICATION: bird

FOOD: insects

ECOSYSTEM: FOREST

ORGANISM: oak tree

CLASSIFICATION: plant

FOOD: uses sunlight to make its own food

ECOSYSTEM: FOREST

ORGANISM: katydid

CLASSIFICATION: insect

FOOD: plants

ECOSYSTEM: FOREST

ORGANISM: red squirrel

CLASSIFICATION: mammal

FOOD: tree seeds

ECOSYSTEM: FOREST

ORGANISM: red-shouldered hawk

CLASSIFICATION: bird

FOOD: mammals

ECOSYSTEM: FOREST

ORGANISM: black-capped chickadee

CLASSIFICATION: bird

FOOD: plant seeds and insects

ECOSYSTEM: FOREST

ORGANISM: ant

CLASSIFICATION: insect

FOOD: insects

ECOSYSTEM: FOREST

ORGANISM: American toad

CLASSIFICATION: amphibian

FOOD: insects

ECOSYSTEM: FOREST

ORGANISM: spider

CLASSIFICATION: arachnid

FOOD: insects

ECOSYSTEM: FOREST

ORGANISM: aphid

CLASSIFICATION: insect

FOOD: plant juices

ECOSYSTEM: FOREST

ORGANISM: maple tree

CLASSIFICATION: plant

FOOD: uses sunlight to make its own food

ECOSYSTEM: FOREST

ORGANISM: chipmunk

CLASSIFICATION: mammal

FOOD: tree seeds and insects

ECOSYSTEM: FOREST

ORGANISM: red-backed salamander

CLASSIFICATION: amphibian

FOOD: earthworms and insects

ECOSYSTEM: FOREST

ORGANISM: earthworm

CLASSIFICATION: segmented worm

FOOD: dead plants

ECOSYSTEM: FOREST

ORGANISM: garter snake

CLASSIFICATION: reptile

FOOD: toads, earthworms and insects

ECOSYSTEM: FOREST

ORGANISM: violet

CLASSIFICATION: plant

FOOD: uses sunlight to make its own food

ECOSYSTEM: FOREST

ORGANISM: white-tailed deer

CLASSIFICATION: mammal

FOOD: plants

MARSH ECOSYSTEM

FOOD CHAIN CARDS

SUN

Gives plants the energy to make their own food

ECOSYSTEM: MARSH

ORGANISM: ____________________

CLASSIFICATION: ____________________

FOOD: ____________________

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ECOSYSTEM: MARSH

ORGANISM: ____________________

CLASSIFICATION: ____________________

FOOD: ____________________

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ECOSYSTEM: MARSH

ORGANISM: ____________________

CLASSIFICATION: ____________________

FOOD: ____________________

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ECOSYSTEM: MARSH

ORGANISM: ____________________

CLASSIFICATION: ____________________

FOOD: ____________________

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ECOSYSTEM: MARSH

ORGANISM: ____________________

CLASSIFICATION: ____________________

FOOD: ____________________

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ECOSYSTEM: MARSH

ORGANISM: ____________________

CLASSIFICATION: ____________________

FOOD: ____________________

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ECOSYSTEM: MARSH

ORGANISM: red-winged blackbird

CLASSIFICATION: bird

FOOD: plant seeds and insects

ECOSYSTEM: MARSH

ORGANISM: loosestrife leaf beetle

CLASSIFICATION: insect

FOOD: purple loosestrife

ECOSYSTEM: MARSH

ORGANISM: lady beetle

CLASSIFICATION: insect

FOOD: insects

ECOSYSTEM: MARSH

ORGANISM: sedge

CLASSIFICATION: plant

FOOD: uses sunlight to make its own food

ECOSYSTEM: MARSH

ORGANISM: mayfly

CLASSIFICATION: insect

FOOD: young mayflies eat plants

ECOSYSTEM: MARSH

ORGANISM: minnow

CLASSIFICATION: fish

FOOD: algae and insects

ECOSYSTEM: MARSH

ORGANISM: duckweed

CLASSIFICATION: plant

FOOD: uses sunlight to make its own food

ECOSYSTEM: MARSH

ORGANISM: green frog

CLASSIFICATION: amphibian

FOOD: insects

ECOSYSTEM: MARSH

ORGANISM: snail

CLASSIFICATION: mollusk

FOOD: plants

ECOSYSTEM: MARSH

ORGANISM: crayfish

CLASSIFICATION: crustacean

FOOD: plants

ECOSYSTEM: MARSH

ORGANISM: leech

CLASSIFICATION: segmented worm

FOOD: blood of turtles, fish and frogs

ECOSYSTEM: MARSH

ORGANISM: algae

CLASSIFICATION: plant

FOOD: uses sunlight to make its own food

ECOSYSTEM: MARSH

ORGANISM: dragonfly

CLASSIFICATION: insect

FOOD: mosquitoes and other insects

ECOSYSTEM: MARSH

ORGANISM: mallard

CLASSIFICATION: bird

FOOD: duckweed and other plants

ECOSYSTEM: MARSH

ORGANISM: purple loosestrife

CLASSIFICATION: plant

FOOD: uses sunlight to make its own food

ECOSYSTEM: MARSH

ORGANISM: mosquito

CLASSIFICATION: insect

FOOD: blood of mammals and birds and plant juices

ECOSYSTEM: MARSH

ORGANISM: diving beetle

CLASSIFICATION: insect

FOOD: insects and snails

ECOSYSTEM: MARSH

ORGANISM: snapping turtle

CLASSIFICATION: reptile

FOOD: plants and animals

ECOSYSTEM: MARSH

ORGANISM: muskrat

CLASSIFICATION: mammal

FOOD: cattails

ECOSYSTEM: MARSH

ORGANISM: cattail

CLASSIFICATION: plant

FOOD: uses sunlight to make its own food

ECOSYSTEM: MARSH

ORGANISM: water snake

CLASSIFICATION: reptile

FOOD: frogs, crayfish and fish

ECOSYSTEM: MARSH

ORGANISM: mink

CLASSIFICATION: mammal

FOOD: crayfish, fish and birds

ECOSYSTEM: MARSH

ORGANISM: great blue heron

CLASSIFICATION: bird

FOOD: frogs, fish and snakes

ECOSYSTEM: MARSH

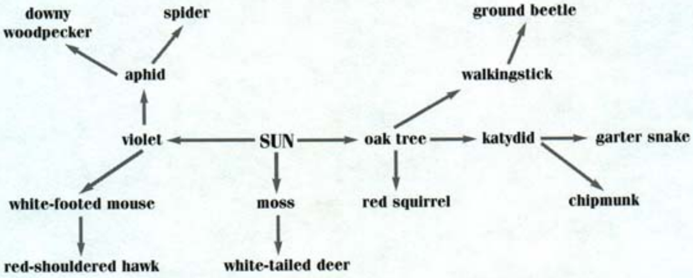
ORGANISM: giant water bug

CLASSIFICATION: insect

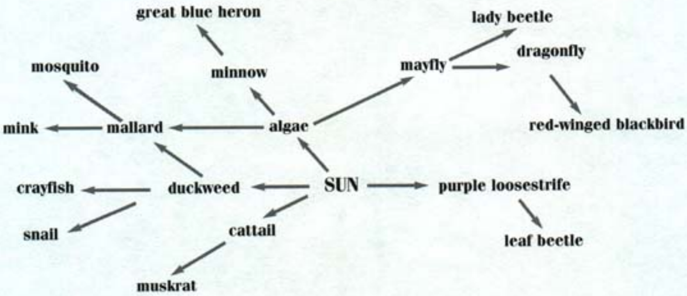
FOOD: insects and fish

ENERGY ➡ ➡ ➡ **FLOW**	**ENERGY** ➡ ➡ ➡ **FLOW**
ENERGY ➡ ➡ ➡ **FLOW**	**ENERGY** ➡ ➡ ➡ **FLOW**
ENERGY ➡ ➡ ➡ **FLOW**	**ENERGY** ➡ ➡ ➡ **FLOW**
ENERGY ⬅ ⬅ ⬅ **FLOW**	**ENERGY** ⬅ ⬅ ⬅ **FLOW**

Forest Ecosystem Example



Marsh Ecosystem Example



TREE TIMELINE