Grade: 6 to 8

Length: about six weeks

Subjects: life science

Topics: control, plant growth, research, experimental design

Objectives

Exercises in this lesson help students achieve the following objectives:

- Investigate means by which plants regenerate, other than by seeds
- Explain chemical, cultural, and biological weed control methods
- Design and conduct an experiment to test a weed-control method

Introduction

Controlling invasive weed species is a significant undertaking in terms of labor and cost. Invasive weed species will continue to spread as long as they can survive in an environment. Altering the conditions that favored the invasion must become part of the solution. Students will become familiar with the process of experimental design as they explore and invent innovative solutions to controlling invasive weed species. Before teaching this lesson, read the entire lesson and make sure all materials are available.

Background

Invasive weed species have few natural enemies and the ability to survive in a wide range of habitat and environmental conditions. A single method of control is rarely effective. For example, weeding the garden is a job that never seems to end. Besides pulling weeds by hand, land managers use chemical, biological, cultural, and mechanical methods to control invasive weeds. (For more information about each of these methods, see the lesson *Once Upon a Town*.)

Land managers frequently use a combination of control methods, especially when the combination reduces the impact to other species. Host-specific control methods are especially desirable.

There are many unanswered questions regarding the best methods to use to control invasive species. Students will have the opportunity to explore and invent potential solutions to control invasive weeds. Perhaps students will create solutions that land managers adopt!

The *Activity* for this lesson is on-going. Allow about one week for students to get started and a minimal amount of time each day thereafter. While conducting their research, students will receive exposure to many life science and botanical topics. Integrate the *Activity* with the regular life-science curriculum by focusing on the concepts and topics students discover, such as plant life cycles (annual, perennial, biannual), botanical terms for stems, leaves, flowers, and reproductive parts, adaptations to particular niches, plant defense, population dynamics, structure and cellular topics, and germination.

Preparation

Materials

- live, potted plant that naturally regenerates from rhizomes, stem sections, and tap roots – An invasive weed species is the best type to use. Or use a common plant, such as bindweed (morning glory) or ivy.
- tray of moist potting soil
- fertilizer and root hormone

- chalkboard or chart paper
- 24-hour gro-lux light

1 Display the potted plant in a prominent location at the beginning of class.

2 Hidden from view, have available a tray of moist potting soil to which a small amount of fertilizer and root hormone, such as B-1 Root Stimulator®, has been added.

3 Ask students to suggest how you might kill the plant and list their appropriate suggestions on the chalkboard.

4 After making the list, jerk the plant out of the pot and ask students if they think you just killed the plant.

5 Break off a few limbs and tear some leaves. Ask students if they think the plant is dead now.

6 Using scissors, snip the limbs and roots into 2-3 centimeter sections, and ask students if they think the plant is dead.

7 Pull out the tray of soil, bury all the plant parts about 1 centimeter deep, mist the surface thoroughly with water, and as you take the tray to the growing station remark, "Well, it might look dead, but I sure don't think it's dead."

8 Keep the soil moist and keep the tray under a 24-hour gro-lux light. In a few days, new sprouts should emerge from the segments of the original plant.

9 Discuss the difficulties involved in killing an invasive weed species.

Activity

Materials

- 24-hour gro-lux light
- live, invasive plants or seed from a variety of invasive plants in your community
- student *Experiment Notebooks*
- one copy of the *Outline for a Student-Based Inquiry* and *Science Experiment Assessment* teacher pages
- copies of the *Experiment Notebook Check-off List* and *Design an Experiment* worksheets – Have available one copy for each student.
- other materials as needed – Students will design their own experiments, so the materials will vary. Complete materials and procedures outlines are essential elements of experimental design. Approve all materials lists and procedures before allowing students to proceed with their experiment.

1 Explain to students that they will develop a hypothesis and design an experiment to kill an invasive weed of their choice. Students may base their experiment on suggestions made during *Preparation* or other ideas. Some suggested methods to kill a weed include the following:

- Apply chemical treatment such as herbicides, fungicides, or pesticides
- Simulate a wildfire
- Destroy the weed by mechanical means, such as chopping or grinding
- Defoliate the plant
- Use biological control methods or Integrated Pest Management (IPM), such as introducing herbivores or parasites
- Allow animals to graze the plant – Have a pet goat at school!
- Bury weeds in a compost pile

2 Discuss how to develop an "I wonder?" question with broad, unconventional ideas, provided the ideas are within reason. For example, ask students, "If a forest fire doesn't kill cheatgrass, I wonder if freezing cheatgrass would work?"

3 Allow students to develop their own "I wonder?" question. The most difficult aspect of experimental design is refining the question. A broad "I wonder?" question may include many variables that make it difficult to answer the question.

Conducting research on a question often helps to refine the question. For example, the question, "Why is the sky blue?" seems like a simple question. However, a definition is needed for "sky" and "blue." One might conduct research to develop a

better understanding of the layers of atmosphere, particulate matter, reflective properties of particulate matter, physics of light waves, wavelengths emanating from the sun, and other details. After conducting the research, one would be able to design an experiment that simulated a blue sky and answered the "I wonder?" question.

4 Ask students to select a weed for their research. Depending on plant availability and time constraints, have students transplant live weed species from the field or start plants from seed.

5 While caring for their plants until they are ready to begin their experiment, students should record important information, including the following, in their student *Experiment Notebook*:

- Species name
- Date collected or planted
- Drawings of their plant
- Identification of plant parts
- Measurement of plant
- Other observations
- Vocabulary words – During the course of their research and experiments, students should maintain a list of new words and create their own vocabulary list.

6 While plants are maturing, have students conduct research about their plant and the control methods they plan to investigate. To assist students in their research and report writing, give each student a copy of the *Experiment Notebook Check-off List* worksheet.

Many students who are interested in science are eager to apply their scientific knowledge to an actual situation in the field. Students are often unaware that scientists usually conduct years of research to build a foundation for their fieldwork.

7 Give each student a copy of the *Design An Experiment* worksheet. Discuss the worksheet and help students complete it. Defining the following variables is the second most difficult aspect of designing an experiment:

- Independent variable – The factor you manipulate, such as temperature.
- Dependent variable – The factor you believe will respond to the independent variable, such as germination rate.
- Controlled variables – Those factors you control and hold constant, for example, humidity. Controlled variables represent the situation that would exist without manipulating other factors. Compare results of the experiment to results with the controlled variables.

Students must conduct a considerable amount of research before they start imagining the variables. The more time spent helping students to refine their question, the easier it will be to determine and limit the variables. There is less chance for error when an experiment has fewer variables, and the data will be more reliable.

8 After students have made a decision regarding most of the elements of the experiment, ask them to begin writing a detailed procedure for their experiment. This step is the most difficult for students because they must visualize an entire process that they are inventing. Encourage students, and let them know that all scientists continually change or modify their procedures.

9 Approve each student's materials list and procedural outline before allowing them to begin their experiment.

10 Allow students a few days to gather materials and set up their experiments.

After setting up the experiments, students should need a minimal amount of time to monitor the experiments each day. Integrate other lessons. Encourage students to come to class immediately, collect data, and care for their plants. Students should need only 10 to 15 minutes to monitor their experiment. Students are 100% responsible for all aspects of their experiment, including caring for the plants, collecting and recording data, updating their *Experiment Notebooks*, modifying procedures, adding to their research paper, designing data collection forms, and planning ahead for the presentation of their findings to the scientific community or their peers.

Collect the *Experiment Notebooks* each Friday. Use the rubric on the *Science Experiment Assessment* form to evaluate the notebooks. Give each student a weekly progress report and alert them to areas that need improvement.

Conclusion and Evaluation

- Conclude the lesson when students have completed their experiments and presented their findings.
- Evaluate students on their presentation and completeness of their *Experiment Notebooks*. Allow students to grade their peers during oral presentations using the *Science Experiment Assessment* rubric or a modified version of the rubric.

Independent Practice and Related Activities

- Many students may develop highly innovative approaches to controlling invasive weed species. Encourage students to refine, extend, and publish their ideas. Let others in the community know about their ideas through educational programs or practical application of their ideas.

Vocabulary

Have students create their own vocabulary list during the course of their research and experiments. Students should record vocabulary words in their *Experiment Notebook*.

Resources

For background information students will need for their research:

U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory, Fire Effects Information System. **http://www.fs.fed.us/database/feis/**

U.S. Department of Agriculture, National Plant Data Center. **http://plants.usda.gov/**

National Science Education Standards

As a result of their activities in grades 5 to 8, students should develop abilities in and an understanding of the following areas:

Science as Inquiry – Content Standard A: abilities necessary to do scientific inquiry, understandings about scientific inquiry

Life Science – Content Standard C: structure and function in living systems, reproduction and heredity, regulation and behavior, populations and ecosystems, diversity and adaptations of organisms

Science and Technology – Content Standard E: abilities of technological design, understandings about science and technology

Science in Personal and Social Perspectives – Content Standard F: personal health; populations, resources, and environments; natural hazards; risks and benefits; science and technology in society

History and Nature of Science – Content Standard G: science as a human endeavor, nature of science, history of science

Tips for Teachers

Outline for a Student-Based Inquiry

Develop an "I wonder?" question

Time: one day

1 Ask students to think about and write an "I wonder?" question for effective control of the invasive weed species they have selected.

2 Group the "I wonder?" questions into similar themes based on control methods (chemical, biological, mechanical, cultural).

3 Create scientific teams based on the various themes. (Or have students work individually.) Help students design experiments that address each theme, and assign an experiment to every team.

Provide instruction on experimental design

Time: one day

1 Provide students with information about the elements of experimentation, including, but not limited to, the following:

- Defining independent and dependent variables
- Setting up controls
- Developing a hypothesis
- Collecting data
- Defining the length of time and materials needed

2 Have the scientific teams identify the elements for the experiment that they designed. Give each student a copy of the *Design An Experiment* worksheet and help students complete the worksheet.

Review literature

Time: 3 to 5 class sessions plus homework

1 Based on the nature of their experiment, have students conduct research to find and review literature regarding the topic they are investigating.

2 Have students prepare a report of the literature they found. Students must include copies of their sources of information—not a reference list, but the actual articles. (When evaluating reports, having copies of the source material aids in helping students understand the difference between plagiarism and paraphrasing.)

Conduct the experiment

Time: 6 to 8 weeks

After one or two weeks, students will need only 10-15 minutes each day to record data. Based on information recorded on the *Design an Experiment* worksheet, have students assemble the materials for their experiment, provide a detailed description of the procedure for the experiment, conduct the experiment, and collect data.

Report the results

Time: ongoing until the experiment ends – Review and refine details of the experiment as needed, on a weekly basis or more often if necessary.

1 Have students write a "scientific paper" to report the results of their experiment to the "scientific community" (the class). The paper should include the following sections:

- Title page – Includes the name of the experiment, student's name, and the date.
- Discovery – Describes what students learned from the research they conducted. Students

Outline for a Student-Based Inquiry

may paraphrase scientific facts and details they learned while conducting the research.

- Literature – Lists the literature and resources students used. Includes copies of all literature.
- Description – Describes details about the experiment that the student conducted. Students must include information about the independent and dependent variables, control, problems encountered (sources of error), and the hypothesis they were testing.
- Interpretation – Describes the student's interpretation of the data collected from their experiment. Students must explain how they collected the data; show the data graphically using charts, transparencies, or other methods; describe what the data means; and state whether the data supports their hypothesis.
- Implications – Describes implications of the experiment, states new questions that arose, and explains how to use the information gained from the experiment to learn more.
- Graphics – Includes photos or drawings that help illustrate what the student did.

2. Have students give an oral presentation based on their "scientific paper."

Weed Warrior Worksheet

Experiment Notebook Check-off List

Name: _____ Area of Research _____

Listed below are the items that should be in your Experiment Notebook. Check off each item as you complete it.

☐ **Your original "I wonder?" question.**

☐ **Report of the research** and review of the literature behind your experiment. Include the following sections in your report:

- **Title page –** Include the name of the experiment, your name, and the date.
- **Discovery –** Describes what you learned from the research you conducted. Paraphrase scientific facts and details you learned while conducting the research.
- **Resources –** List the literature and resources you used. Include copies of all resources.

Your report should address the botanical description, life cycle, scientific classification, adaptations, and known control methods for the invasive weed species that is the subject of your research.

You may have already written an initial report about your invasive plant. However, as you become involved with your experiment, you will find you must learn new skills or details that will require more research. Add these new skills and details to the original research paper.

☐ **Description of the experiment you conducted.** Include the following information:

- Definition of the independent and dependent variables
- Description of the control
- Problems with the experiment (sources of error)
- Hypothesis you were testing
- Description of detailed procedures. Write detailed instructions. Include a step-by-step outline of everything you have done or will be doing. Include a materials list. This part of the project will change as your experiment progresses. Update the description on a regular basis, as you encounter problems, or as you make changes to your experiment.
- Examples of data collection sheet. If a computer is available, use computer software to create the data collection sheet.

☐ **Interpretation of the data collected.** Include the following information:

- Describe how you collected the data.
- Display the data using charts, transparencies, or other methods.
- Explain what the data means.
- Explain whether the experiment supported your hypothesis.
- Describe implications of the experiment. What new questions arose? How can you use the information gained from the experiment to learn more?
- Include photos or drawings that help illustrate what you did

☐ **Daily journal.** Describe what you did each day, things you learned, problems you encountered, how you resolved the problems, and changes to the design and procedures. Describe your feelings about the experiment. Include your frustrations, confusing moments, feelings of success or breakthrough, and more. Write in your journal for 10-15 minutes during class each day. Follow up at home and on weekends.

Experiment Notebook Check-off List

- ☐ **Final report.** Place all of the components listed above in a 3-ring notebook. Design a front cover, table of contents, and other pages. The final version must be typewritten. Include your preliminary rough drafts, hand-written notes, copies or printouts of resources, and other information.
- ☐ **Rubrics.** The original rubrics that were scored each time you turned in a draft copy.
- ☐ **Check-off list.** Include this check-off list with your notebook.

The next check of the Notebook will be on this date:

_____

_____

_____

Your score will be based on this updated check-off list, so you know in advance what is needed!

Weed Warrior Worksheet

Design an Experiment

Name: _____ Date: _____

Describe your research topic in as much detail as possible.: _____

_____

_____

_____

1 Identify the independent (manipulated) variable. _____

_____

2 Identify the dependent (responding) variable.

_____

_____

3 State your research question ("I wonder?" question). _____

_____

_____

4 State your hypothesis. _____

_____

_____

5 Describe the materials you will need to do the experiment. _____

_____

_____

6 On a separate sheet of paper, write a procedure to test your hypothesis. Remember to include safety considerations and details about how you will set up the experiment.

7 Identify the control. _____

_____

_____

8 Describe the variables that you will hold constant. _____

_____

_____

9 On a separate sheet of paper, design a data table to collect and display your results.

10 What kind of graph or chart will you use to present your data?

(Circle one.) line bar pie

11 Be prepared to plot your data on graph paper. Include a title, labels, and units for the vertical and horizontal axis.

12 Describe the results of your experiment. Did it answer your research question? Did it support or disprove your hypothesis? Do you need to re-design the experiment and try again?

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_____

Tips for Teachers

Name: _____ Experiment Topic: _____ Date: _____

SKILLS Rate each skill on a scale of 1-5. Assign a score of "5" if you observe all applicable criteria in the student's project.

Basic Process		Score
Observation	Uses five senses to observe; observes using tools (lens, etc.); identifies properties of an object; uses numbers to describe observations; notes changes in objects; realizes that observation enhances understanding.	
Classification	Identifies similarities and differences in properties; identifies properties for sorting; classifies objects or attributes into groups; forms subgroups; has logical rationale for sorting; understands characteristics define sorting systems.	
Communication	Describes accurately using appropriate vocabulary; asks relevant questions; verbalizes thinking; shares views with others; constructs other means to communicate (reports, media, graphs, etc.).	
Measurement	Uses non-standard ways as well as traditional ways to measure; selects appropriate measuring tools; uses tools with precision (i.e., to 10ths in metric); compares and orders objects by weight, length, volume and/or time.	
Prediction	Performs simple predictions based on inferences; recognizes and extends patterns; shows reasoning in defending predictions; able to blend events, patterns, and data to form ideas of what may happen in the future.	
Integrated Processes		
Interpreting Data	Able to find meaning or patterns with accuracy between sets of information and use that meaning to construct inferences, predictions, and hypothesis; able to identify a single pattern among objects within an experiment.	
Controlling Variables	Able to identify variables within an experiment that are to be held constant and those that are to be manipulated; understands the difference between single and multiple variable manipulation.	
Designing Experiments	Able to visualize the procedures that may be necessary to answer the question and plans the appropriate data collection operation; includes a plan to organize data; uses organized, sequential plans to test a hypothesis.	
Inferring	Uses all appropriate information to form inferences and is able to distinguish non-essential information; develops inferences (ideas) based on observations; able to defend inferences reasonably and logically.	
Defining Operationally	Able to explain relationships between observed actions to explain phenomena; uses events to describe how something works or doesn't work; is able to find alternative actions from evaluating what doesn't work.	