Alien Invasion
Plants on the Move

weed curriculum for grades K-12

http://www.weedinvasion.org

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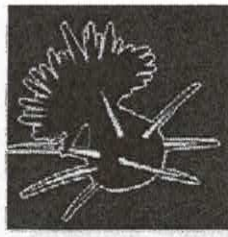

When is a Rose Not a Rose?

Grade: 6 to 8

Length: long term (This lesson may require up to seven hours, depending on the amount of research and discussion.)

Subjects: life science, botany, writing

Topics: defining plants as weeds, weed adaptations, researching and reporting why a weed is a problem

Objectives

Exercises in this lesson help students achieve the following objectives:

- Conduct research to learn about the diversity of invasive plant characteristics and adaptations
- Understand why some plants are considered a weed
- Understand the adaptations and conditions that enable weeds to spread and become established

Introduction

Students will conduct research and report on the history of, problems associated with, characteristics and adaptations of, and control methods for a particular invasive plant species in your area. Students will share the findings from their research with the class. Students will use the information from this report in other lessons within this curriculum. Before teaching this lesson, read the entire lesson and make sure all materials are available.

Background

Plants have evolved over millions of years and developed a wide range of **adaptations** for the ecosystems where we find them today. Plants have developed methods to take advantage of available resources; fend off insects, disease, and animals; and compete with other plants for nutrients, water, and sunlight. Each plant occupies a particular **niche** within the environment.

A **weed** is any plant that is unwanted where it is growing, is difficult to eliminate, has the ability to spread, and grows in an area to which it has not adapted. A rose may be considered a weed if it is growing in a location where it is unwanted. Weeds are a nuisance to humans because weeds degrade the land, lower crop and **range** yields, poison livestock that **forage** on them, and alter water tables.

A plant becomes an invasive species when it grows and reproduces quickly and out-competes the desirable plants for nutrients, water, and sunlight. Invasive weeds disrupt the **biodiversity** of the native plant **community**.

In a healthy **ecosystem**, species that normally live in the ecosystem are in balance with one another. When a new plant enters an ecosystem, the diseases, insects, and animals that normally keep the plant's population in balance or under control are not present. Without these checks and balances to control the plant, it invades the ecosystem. Invasive weed species are plants that have been introduced into an ecosystem in which they normally do not live.

Preparation

Materials

- bouquet of roses – Use live specimens or silk models.

1. At the beginning of class, place a bouquet of roses at the front of the room.
2. Ask students if a rose is a weed. Discuss examples of native plants, ornamental plants

from a nursery, and invasive weeds. Have students identify which plants are weeds.

3 Ask again if a rose is a weed. Encourage students to discuss the definition of a weed; allow students to create their own definition.

Activity

Materials

- list of invasive weed species for your area – County weed boards, extension offices, and state and federal agencies can provide information about invasive weeds in your area.
- copies of the *Invasive Plant Species Report* worksheet – Have available one copy for each student.

1 Using the list of invasive weed species for your area, randomly assign a different plant species to each student. Or depending on the number of invasive species in your area and the number of students, assign a species to a team of students.

2 Give each student a copy of the *Invasive Plant Species Report* worksheet.

Ask students to conduct research on their plant and, using the worksheet as a guide, prepare a rough draft of a report that describes the characteristics and adaptations of the plant.

Tell students that they will share their report with the class.

3 Have students prepare their final report.

Conclusion and Evaluation

- Give each student copies of the *Invasive Plant Species Report* worksheet so they can take notes while listening to oral presentations. Conclude the lesson by having each student make an oral presentation of their final report to the class.
- To evaluate students, test students on the information covered during the oral presentations.

  Use the *Weedy Definitions* and *Solve the Weedy Code* worksheets as an extra exercise (optional).

Independent Practice and Related Activities

- Have students create a poster or display for the plant on which they reported.
- Have students create costumes and prepare a skit that they can present to younger students.
- Have students make an oral presentation of their report in a community outreach program.

Vocabulary

adaptations, biodiversity, community, ecosystem, forage, niche, range, weed

Resources

County weed boards, extension offices, and state and federal agencies can provide information on invasive weed species.

National Plant Database. www.plants.usda.gov

Utah State University Extension, The Weed Web. http://extension.usu.edu/weedweb/ident/ID.htm

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: 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 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, the nature of science

Weed Warrior Worksheet

Invasive Plant Species Report

Common name of your plant_____ Scientific name _____

Prepare a rough draft

Conduct research about your plant. Use this worksheet to write information for the report's rough draft. After you have collected all of the information, write a final report. Include the following information in your report:

1. Origin of the plant _____

2. How the plant was transported or introduced to the United States _____

3. When the plant entered the United States _____

4. Description of the plant, its habitat, and where it is found in your area _____

Invasive Plant Species Report Page 2 of 2

5. Your personal connection with this plant (if any) ______

6. Characteristics (adaptations) and conditions that enabled this plant to become established ______

7. Why this plant is a problem (Describe how the plant affects the environment and the area's economy.)

8. Control methods for this plant ______

9. Conclusion and summary ______

10. Bibliography ______

11. Photos or illustrations of your plant ______

Weed Warrior Worksheet

Weedy Definitions

adaptation – changes an organism makes so it will fit into a different or changing environment

biodiversity – all of the species that are present in a particular area or an ecosystem

community – all the plants and animals that live in the same area and interact with one another

ecosystem – all of the biotic and abiotic things in a particular area that interact with each other

forage – food for animals, especially crops grown to feed horses, cattle, and other livestock

niche – the place or position of an organism within its environment *Each plant occupies a particular niche within the environment.*

range – a large area of open land on which animals can graze

weed – any plant out of place, unwanted where it is growing, difficult to get rid of, with an ability to spread

Weed Warrior Worksheet

Solve the Secret Weedy Code

Match the letters of the alphabet with the numbers and fill in the letters to create these words:

niche **ecosystem** **biodiversity** **weed** **forage**
adaptations **community** **range**

Hint: The code number for "S" is 15.

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
																		15							

__ __ __ __ __ __ __ __ __ __ S
19 8 19 1 18 19 18 17 6 11 15

__ __ __ __ __ __
5 6 20 19 16 10

__ __ __ __ __ __ __ __ S __ __ __
22 17 6 8 17 7 10 20 15 17 18 25

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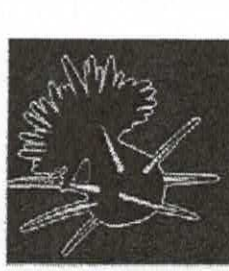


Alien Invasion

Grade: 6 to 8

Length: 1 to 2 sessions

Subjects: life science, composition, math, earth science

Topics: seed dispersal, weed facts, graphing, exponential growth

Objectives

Exercises in this lesson help students achieve the following objectives:

- Investigate the means by which invasive weeds spread and the rate at which they spread
- Calculate the extent of an invasion after seeds have dispersed to gain an understanding of the concept of **exponential growth**
- Create their own story problems that illustrate how humans contribute to the spread of invasive weed species

Introduction

Humans often unintentionally carry invasive weed species to new areas by car, truck, bike, clothing, and pets. With the ease of air and ship travel, we can transport non-native species thousands of miles in just a few hours, and the new habitat might be vulnerable to an invasion. As the human population increases and more people access fields and forests more often, the opportunities for seeds and plants to travel to new areas also increase. Students will learn how their actions and the actions of others can contribute to the spread of invasive weeds. Before teaching this lesson, read the entire lesson and make sure all materials are available.

Background

Our recreational activities are the second most significant factor that contributes to the redistribution of plant species. The first most significant factor is human development. During development, humans remove or disturb native flora and fauna to make way for our needs. Disturbed environments are the most vulnerable to invasion by alien weed species.

Alien weed species have developed **adaptations** that enable them to survive in a wide range of environmental conditions. Alien, invasive weed species are a major cause of reduced **biodiversity** in the United States. Alien species have the ability to easily adjust to and take over in an environment that is new for the species. As we continue to develop and disturb more land, invasive weeds will continue to spread.

Invasive weed species produce an enormous number of seeds. Seeds that do not germinate immediately remain viable over many years in a wide range of environmental conditions. Environmental factors, such as temperature, moisture, and soil types, and time have little impact on some seeds. When the seeds eventually germinate, the plant invades the area. When humans carry seeds from an alien, invasive weed species to a new area, especially a disturbed area such as a roadside, we contribute to the alien invasion problem.

Preparation

Materials

- magnifying glass

1 Ask students "Who has started an alien invasion?" Ask students if their recreational activities might have started an invasion. Discuss students' ideas on how weeds spread.

2 Walk to the parking lot to examine the tires, bumpers, doors, and undercarriage of vehicles for vegetation and seeds. Remind students to respect other people's property. Students should just **look** for vegetation and seeds. Use a magnifying glass to look for seeds in the tire treads. Look behind the bumper or other places where dirt accumulates.

3 Ask students if they found any vehicles that are helping to spread the invasion.

Activity

Materials

- copies of the *Alien Invasion* worksheet – Have available one copy for each student.
- chalkboard, calculators
- student Weed Journals

1 Have students name the various ways in which they might have started an alien invasion. List their suggestions on the chalkboard.

2 Give each student a copy of the *Alien Invasion* worksheet.

3 Read the following story, *Alien Invasion*, to students. Tell students to listen carefully and record important numbers, because they will have to calculate the extent of the invasion.

To help students visualize the story, draw a map on the chalkboard using the illustration shown on the teacher page as a guide (*optional*).

Alien Invasion

A tract of land was cleared some time ago. The tract is now overgrown with weeds and brush. Spotted knapweed is present on the tract.

This tract of land separates an urban neighborhood from the nearby national forest land. A national park is located a few miles beyond the national forest land. This tract of land is private property, but several trails cross it. People who live nearby use the tract to access the forests beyond.

Members of a local mountain bike club received permission from the owner of the tract to cross the tract to reach the forest trail system. By crossing the tract, bikers do not need to drive their vehicles from town to the trail system. With permission, the bike club organized a 50-mile City To The Park benefit ride to advertise their new club, bring business to their town, and promote mountain biking, a popular recreational activity in the nearby national park.

The event was a success. However, 150 bicyclists cut across the weeded tract of land, and they carried broken bits of seed-bearing knapweed branches that caught in the gears of their bikes and knapweed seed that caught in the deep lugs of their tires. After a few miles of riding along the forest trails, 300 seeds were dislodged. Assume that 50% of the seeds will germinate and grow to maturity. A mature plant can develop 1,000 seeds.

How many plants grew after the event?

How many seeds will be produced for the **seedbank**?

How many plants will appear in the forest the following year?

4 Ask students to record their calculations and answers on the worksheet.

5 Ask students to think about the recreational activities they mentioned at the beginning of this lesson. Divide students into teams of two and ask students to write similar story problems that take the following factors into consideration:

> Recreational activities in which students participate (boating, hiking, biking, riding ATVs and horses, hunting, fishing, picnicking)
>
> Weed seed production numbers of actual weeds in your community – Have students conduct research on local weed species.

The stories may be as complex as students can imagine, but the stories must be based on reality. Students must create story problems that explain how their own recreational activities could lead to an alien invasion in their neighborhood.

Plants that grew after the event:
300 seeds x 50% germination = 150

Seeds for the seedbank:
150 mature plants x 1,000 seeds per plant = 150,000

New knapweed plants:
150,000 seeds x 50% germination = 75,000

Plants that grew in the forest the following year:
75,000 new knapweed plants + 150 mature plants after the race = 75,150

Number of plants for the following year:
75,150 plants x 1,000 seeds per plant x 50% germination = 37,575,000 plants + 75,150 plants from the year prior (spotted knapweed is a perennial) = 37,650,150 plants

The story, *Alien Invasion,* uses a high rate of germination to produce a dramatic effect. Under some conditions, a germination rate of 50% may be possible. The story does not include a factor for seedling survival. Like germination rates, seedlings have survival rates based upon local environmental conditions.

Students may continue the calculations for a five-year period, and plot the results on a graph. Explain that the rapidly rising plot line on the graph represents exponential growth.

See the teacher tips page for a graph that shows exponential growth over a three-year period.

Conclusion and Evaluation

- Conclude the lesson by having students exchange and solve each other's story problems.
- Evaluate students based on whether their story problem is realistic, the complexity of math skills, their ability to work in partnership to create the story, and the completeness of their notes and calculations on the *Alien Invasion* worksheet.

Independent Practice and Related Activities

- Have students obtain lists of plants and seed viability data. This information is available from local weed districts and Web sites, such as http://plants.usda.gov.
- Advanced students may pursue their story lines over a five-year period and graph the exponential growth using a computer software program.
- Use the realistic stories to raise awareness of the invasive weed problem among members of the community.

Vocabulary

adaptations, biodiversity, exponential growth, seedbank

Resources

The U.S. Department of Agriculture Natural Resources Conservation Service Web site contains information about plants, noxious weeds, and invasive weeds. http://plants.usda.gov

County weed boards, extension offices, and state and federal agencies can provide information about invasive weed species.

The Center of Invasive Plant Management Web site contains information about plants, noxious weeds, and invasive weeds. http://www.weedcenter.org/

National Science Education Standards

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

Science as Inquiry – Content Standard A: 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 in Personal and Social Perspectives - Content Standard F: 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

Weed Warrior Worksheet

Alien Invasion

Name____ Date____________

In the box below, write important information from the story and record important numbers. Use this information to answer the questions. Show your calculations.

1 How many plants grew after the event?

2 How many seeds will be produced for the seedbank?

3 How many plants will appear in the forest the following year?

4 There could be over 37 million alien plants in the forest by the end of the second year! How is this possible? Show your calculations.

Weed Warrior Worksheet

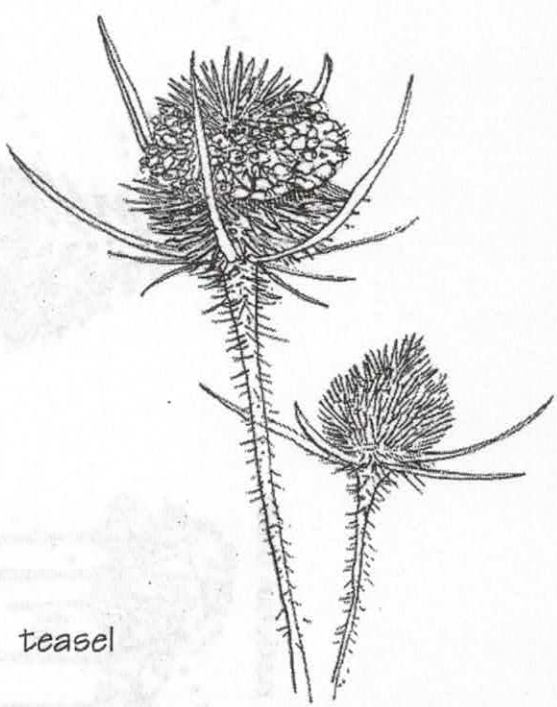
Weedy Definitions

adaptation – changes an organism makes so it will fit into a different or changing environment

biodiversity – all of the species that are present in a particular area or an ecosystem

exponential growth – rapidly becoming greater in size

seedbank – comprised of seeds a plant produces for reproduction in the future



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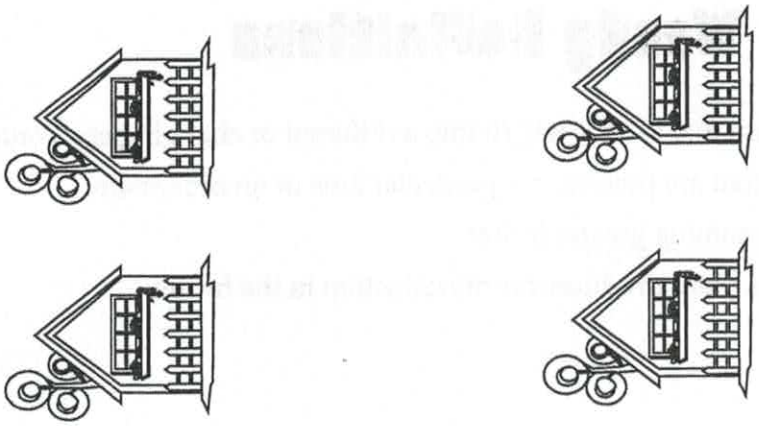
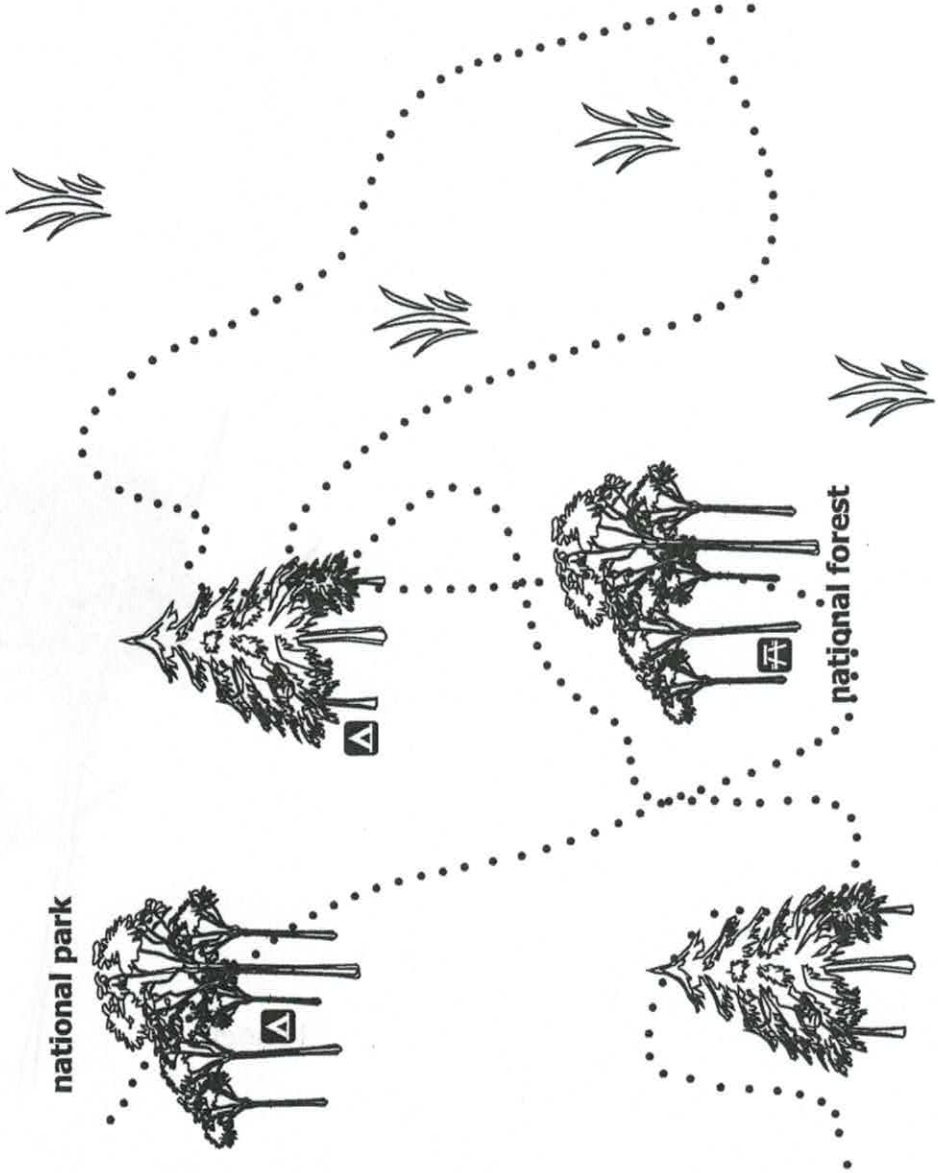
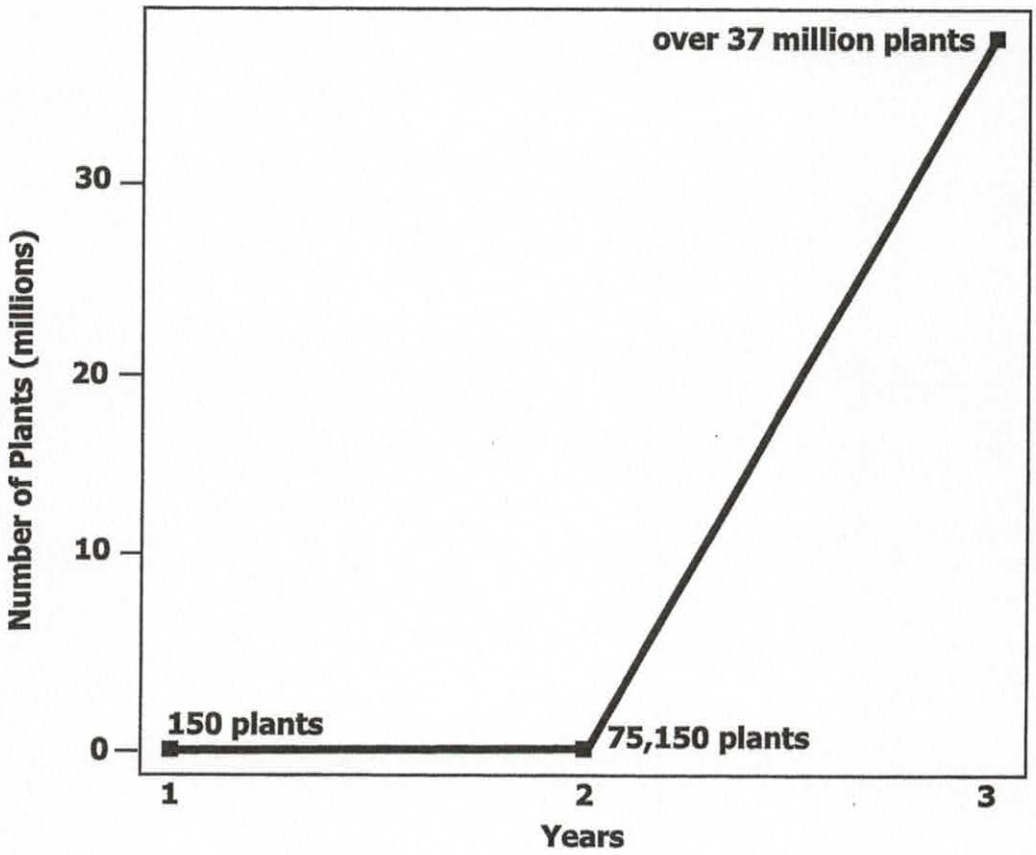
Tips for Teachers







Growth of Spotted Knapweed Plants over a Three-Year Period

Weeds of Mass Destruction

Grade: 9 to 12

Length: two class sessions

Subjects: life science/drawing

Topics: weed facts

Objectives

Exercises in this lesson help students achieve the following objectives:

- Understand how weeds can disrupt life
- Understand how seeds function
- Understand how plants, humans, and animals help disperse seeds
- Demonstrate an understanding of weeds and seed dispersal by designing a weed and its seed

Introduction

Invasive weeds can quickly disrupt an ecosystem. Weeds often have no natural enemies, and many weeds have developed adaptations that enable them to successfully overcome native plant populations. Weed seeds in particular have developed adaptations that enable the seeds to survive a wide range of environmental conditions.

Students will learn about how weeds disrupt an ecosystem and the functions of seeds in general. After learning about unique seed adaptations that some invasive weeds have developed, students will apply their knowledge to design a weed and its seed for use as a biological weapon. Before teaching this lesson, read the entire lesson and make sure all materials are available.

If students need more information about weeds and their reproductive potential, teach the lesson *Alien Invasion* before teaching this lesson. Adapt *Alien Invasion* to a higher grade level by including a discussion about topics such as limiting resources, population density, and carrying capacity.

Background

When weeds become so wide-spread that they threaten crops, livestock, or native species, or they pose a threat to humans, they are usually classified as "noxious." The definition of noxious weed varies by state, and each state has its own "state list" of noxious weeds. Each state usually develops its own methodical approach to attack the noxious weeds on the state list.

Noxious weeds are problematic due to physiological and cultural factors. Growth characteristics of weeds contribute to the physiological factors. Cultural factors are problems that arise because of human interactions.

Physiological factors

Noxious weeds are not native to our country; they tend to thrive here because they lack natural enemies. When the insects, diseases, and animals that keep weeds under control in their native countries are absent in a new country, the introduced weeds can out-compete native plants for water, sunlight, and nutrients. Most noxious weeds are not palatable to grazing animals. As noxious weeds overcome native plant populations, cattle, sheep, and wildlife will lose valuable food sources.

Many noxious weeds produce toxins. Some toxins enter the soil and prevent the growth of native plants. Some toxins cause illness or death in hu-

mans or animals that come in contact with them. In some cases, toxins act slowly, and they may cause death in animals months after the animal eats the weed. Some weeds produce chemicals that cause skin and respiratory irritation.

Weeds can help harmful insects and diseases to survive from one growing season to another. An insect might lay its eggs in a weed during the late summer. The weed protects the eggs from winter cold and insecticide sprays. In the spring, eggs hatch, insects emerge from the weeds, and the insects begin decimating crops.

Many noxious weeds cause physical damage. For example, some weed seeds can puncture tires or penetrate the skin of animals, causing discomfort and death. Some weeds cause pavement to fail prematurely by growing through asphalt and concrete.

Many noxious weeds are prolific seed producers; and the seeds can remain viable in the soil for long periods of time. Most noxious weeds **disperse** their seeds very effectively. Some seeds are dispersed by air, others by water. Some seeds pass through an animal's digestive system and disperse through the feces. Seeds are often dispersed when they cling to clothing, animal fur, or vehicle tires.

Some noxious weeds have developed adaptations that enable them to out-compete native species. For example, downy brome or cheat grass is a winter annual. Seeds from the previous generation enter the soil and germinate in the fall. The emerging young plant survives the winter. When moisture from spring rains or snow melt is available, the young plant absorbs the moisture before native plants have a chance to develop.

Weeds can have a detrimental effect on wildlife. In colder climates, wild mammals depend on their fur to insulate and protect them from the elements. Noxious weeds that have developed an ability to cling, such as hound's tongue or burdock, can get into an animal's fur. The seeds cause the fur to mat, the fur loses its insulating value, and the animal can die during periods of extreme cold. Most noxious weeds are deep-rooted and lack surface roots. These weeds often crowd out native, shallow-rooted plants along a stream bank. During periods of snow melt or heavy rain, the noxious weeds are unable to hold back the runoff, and topsoil washes into streams. Fish and other wildlife then die as a result of the excessive amount of topsoil in the stream.

Most noxious weeds are very vigorous. When a fire or human activity, especially construction, disturbs an area, noxious weeds are some of the first plants to grow in the disturbed area. Noxious weeds can thrive in environmental conditions that stress or kill native plants. Many noxious weeds produce large amounts of biomass. When the weeds die and their remains dry, they create the potential for severe brush fires.

Cultural factors

The U.S. economy is a market-based economy; profits are a major driving force. When the costs of controlling weeds drive down a farmer's profits, some farmers ignore the weeds. As the weeds thrive, the productivity of the land decreases, profits dip even lower, and the cycle spirals downward until the land becomes worthless. If one landowner allows weeds to overtake his property, landowners who have property adjacent to the infected property are seriously affected.

Perception or awareness of noxious weeds is often a problem. Many landowners simply do not perceive or understand the damage weeds can cause. It is more costly and time consuming to manage weeds after they overtake property.

Public lands comprise a significant portion of the land in the western United States. Much of this land has marginal value for farming or ranching because it is extremely dry. In areas that were homesteaded, the owners were unable to survive on the land. Public agencies, such as the Bureau of Land Management (BLM) and State Lands, now manage these lands, which often cover vast areas. A small group of government employees oversee the lands. Traditionally, these lands have been used for cattle and sheep grazing, since farming the land is impractical. Today, public agencies lease a large portion of these lands to cattle and sheep ranchers. Noxious weeds pose a serious threat to our public lands for the following reasons:

- Public lands cover a vast area, and it is difficult for the small number of government employees to monitor the lands on a regular basis.
- The costs of managing weeds escalate, while federal and state budgets are reduced.
- Most ranchers who lease public lands are conscientious stewards of the land. However, as weeds invade and profits drop, these ranchers are forced to abandon their leases.
- Some ranchers are poor stewards. These ranchers tend to overgraze land and ignore good grazing practices, which leaves the land susceptible to weed invasion. Once weeds invade an area, they quickly spread to adjacent grazing allotments.
- People are using public land more frequently. Traditionally, public land has been the domain of ranchers or miners. Now backpackers, all-terrain vehicle riders, horse enthusiasts, hunters, and others use the land for recreation. These people often do not understand the impact they have on public land. Recreational use compounds the weed problem on public land. Animal feed, vehicles, and clothing carry and spread seeds over extremely large distances. Most people who recreate on public land do not use the land to generate income, so they have no incentive to protect the land for profit motives.

Noxious weed seeds

When pollen, carried by wind or insects, fertilizes an ovum, **sexual reproduction** occurs and seeds result. A seed generally has an outer protective layer called the **seed coat**, a living component called the **embryo**, and a supply of food for the developing embryo. Under suitable conditions, the seed coat breaks down, and the embryo sends a root toward water and leaves toward the sun. This growth process is called seed **germination**. Each plant has its own set of conditions that must be met before the seed will germinate. A seed remains **dormant** until conditions for germination are suitable. For most plants in temperate climates, seeds need a period of cold followed by a period where temperature and moisture reach certain levels simultaneously. This process is called **stratification**.

Seeds are often dispersed away from the parent plant. Wind, water, and animals are instruments of seed dispersal. In some cases, seeds are dispersed short distances from the parent plant. In other case, seeds can be dispersed miles, even thousands of miles. Seeds must be able to survive the process of dispersal.

Many weeds have developed seed adaptations that enable them to out-compete native plants. One adaptation is the number of seeds a plant produces. Most weeds produce far more seeds than native plants. Another adaptation is viability. Many weed seeds can remain viable for longer periods than seeds of native plants.

Preparation

Materials

- copies of *What About Weeds?* – Have available one copy for each student.

1. Have students read *What About Weeds?* and review information with students.
2. Lead a discussion about weeds. Ask students the following questions:

   If you could be a nasty weed that causes problems for humans and animals, what would you be like?

   What kind of damage would you cause?

   What weeds are a problem in your area and why?

Activity

Materials

- copies of the *Weed Trivia* and *Design a Weed* worksheets – Have available one copy for each student.
- poster board and colored pencils or computer software that allows students to design and illustrate

1. Give each student a copy of the *Weed Trivia* worksheet. Discuss the information.

2 Once students understand adaptations that enable weeds to succeed, ask students to design or engineer their own weed of mass destruction. Make sure students realize that their weed design must explain how the seeds will disperse.

3 Give each student a copy of the *Design a Weed* worksheet. Use the grading rubric included with the worksheet, or develop one of your own.

4 Have students draw their weed, with explanations, on poster board, or design the weed using computer software.

5 After grading the weed designs, have students present their designs to the class.

Conclusion and Evaluation

- Conclude the lesson after students have made their presentation to the class.
- Evaluate students according to the grading rubric on the worksheet.

Independent Practice and Related Activities

- As students present their weed designs, encourage the class to comment on unique ideas that students have developed.
- Place the posters around the classroom. If students used computer software, have students show the electronic version of their weed design.

Vocabulary

dispersal, dormant, embryo, germination, seed coat, sexual reproduction, stratification

Resources

Kingsbury, J.M. *Poisonous Plants of the United States and Canada*. Pages 396-397. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1964.

Whitson, Tom, ed., Larry C. Burrill, Steven A. Dewey, David W. Cudney, B.E. Nelson, Richard D. Lee, and Robert Parker. *Weeds of the West*. 5th ed., Jackson: Pioneer of Jackson Hole, 1999.

Alien Invasion: What About Weeds? Supplemental material included with the curriculum *Alien Invasion: Plants on the Move*.

Your local Bureau of Land Management weed specialist may have videos, such as *Meet the Menace*, available about noxious weeds.

More information about yellow starthistle and chewing disease is available from:

http://wric.ucdavis.edu/yst/impacts/impacts.html

http://wric.ucdavis.edu/yst/yst_entire_pub.pdf

National Science Education Standards

As a result of activities in grades 9 to 12, students should develop abilities in and an understanding of the following areas:

Life Science - Content Standard C: interdependence of organisms, behavior of organisms

Science in Personal and Social Perspectives - Content Standard F: personal and community health, environmental quality, natural and human-induced hazards

Weed Warrior Worksheet

Weed Trivia

Seeds from the puncturevine can harm animals that eat them, and the seeds puncture tires. Vehicle tires and animals spread the seeds.

puncturevine

Yellow starthistle seeds have thorns up to ¾-inch long. When horses eat this weed, they can develop a neurological disorder of the brain called nigropallidal encephalomalacia or "chewing disease." If the horse continues to eat yellow starthistle, it will develop brain lesions and ulcers in its mouth. There is no known treatment. In most cases, the horse will die due to starvation or dehydration.

Seeds from field bindweed can remain dormant in the soil for up to 50 years.

When seed capsules from leafy spurge dry, the seed capsules explode and eject the seeds up to 15 feet from the parent plant. Leafy spurge has a milky sap that can irritate an animal's mouth, which may result in the animal's death.

All parts of the water hemlock plant are poisonous, including the root. The plant's stem is hollow, and children have been poisoned by using the stems as pea shooters. The plant closely resembles wild parsley. People have been poisoned by water hemlock because they mistook the plant for wild parsley. The toxicity of the plant increases as the growing season progresses.

hound's tongue

Seeds from hound's tongue mat the fur on animals, such as deer and elk. Matting reduces the ability of the animal's fur to provide insulation. During periods of extreme cold, young deer and elk can perish if their fur does not provide adequate insulation against the cold.

Weedy Definitions

dispersal – the natural distribution of plant seeds over a wide area by various methods
dormant – in an inactive state, when growth and development slow or cease, in order to survive adverse environmental conditions
embryo – a plant in its earliest stages of development; in seed-bearing plants, the embryo is contained within the seed
germination – the process of growing from a seed or spore into a new plant
seed coat – outer, protective layer on a seed
sexual reproduction – a natural process by which some plants and animals produce offspring as a result of the production of eggs and the fertilization from another plant or animal
stratification – to store seeds in chilled, moist sand, peat moss, or other material to induce germination or preserve the seeds

Weed Warrior Worksheet

Design a Weed

Use your knowledge of weeds and weed seeds to design a weed and its seed for use as a biological weapon. Draw your weed and seed on poster board, or use computer software to create your weed and seed drawings.

1 Decide what types of problems you want your weed and its seed to create. See the *Weed Trivia* worksheet for some ideas about how weeds can be destructive. Consider the following ways in which weeds can cause problems:

- Disrupt food or water supplies
- Harm humans and animals
- Disrupt transportation

2 Think of **unique** adaptations your weed will have and **unique** ways in which the weed will disperse its seed.

In your drawings, illustrate the unique adaptations of your weed and its seed, and explain the unique manner in which the seed is dispersed. Be creative! Develop new adaptations rather than using adaptations you already know about in other plants.

Grading Guidelines

You will be graded according to the guidelines shown in the table below.

Grade	Ideas	Presentation
A	Weed characteristics are unique and numerous, and the weed design demonstrates that you understand weed issues.	Presentation is clear and well done, and it explains all aspects of the weed design.
B	Weed characteristics are unique, but they are limited in number.	Presentation has minor flaws, and it does not fully explain all aspects of the weed design.
C	Weed characteristics are limited in number, and characteristics are explanations of existing weeds.	Presentation is adequate, but it has numerous flaws and does not fully explain the weed design.

Practicing Protocols

Grade: 6 to 8 (advanced)

Length: one hour in the classroom, plus a half day in the field

Subjects: life science, earth science

Topics: inventory, GPS, mapping

Objectives

Exercises in this lesson help students achieve the following objectives:

- Understand why weed inventories are needed and how they are planned and implemented
- Learn about protocols for data collection
- Plan an inventory
- Collect field data using proper protocols
- Determine what action to take based on inventory results

Introduction

This lesson focuses on how to conduct a **weed inventory**, and the lesson emphasizes protocols. Students will select a local area and devise a plan to inventory the area as a group. Each student will collect field data and check the accuracy of data collected by their peers. Students will decide, as a group, what action to take based on the results of the field work. Before teaching this lesson, read the entire lesson and make sure all materials are available.

Students will use topographic maps and/or GPS receivers during the *Activity*. For information about reading a topographic map, see the lesson *The Marks on This Map are Alien!*. For information about GPS receivers, see the lessons *Introduction to GIS/GPS* and *Intermediate GPS*.

Background

For information about what an inventory is, why weed managers perform inventories, when to perform an inventory, and where to focus efforts, see the lesson *The Right Inventory for the Job*.

Ensuring data is usable: follow protocols

Field work involves long hours of driving or walking in remote locations. It is essential that weed inventory **data** be usable. The staff conducting the inventory must adhere to strict **data-collection standards**. To ensure that data will be usable and can be shared among colleagues, states have developed elaborate **protocols** for data collection. There are protocols for recording the following information when collecting data:

Site location

Location accuracies

Species identification

Change over time (current vs. historic data)

Date infestation was originally discovered

Dates of site re-visitation

Data collection protocols may also require including habitat descriptors, slope (pitch and aspect), light availability, moisture, soil type, **phenology**, and **age class** of plants.

The single most important piece of information in a weed inventory is an accurate recording of location, which is needed to perform follow-up action. Weed managers and their staff may record inventory data using the following methods:

Identifying locations with Global Positioning System (**GPS**) technology

Writing information on a map or photo, for example "yellow star thistle, single plant" "or tansy ragwort, patch"

Recording legal descriptions using **township, range,** and **section**

The individual who conducts the inventory makes a note of the accuracy of the data in feet or acres, depending on the method and capability of the equipment used.

Species are often recorded using abbreviations or codes, such as the naming and code system used by the USDA National Resource Conservation Service (**NRCS**). This system consists of a four-letter code derived from the first two letters of the genus and species of the plant. For example, the scientific name for tansy ragwort is *Senecio jacobaea*. Its NRCS code is SEJA. The code for diffuse knapweed, *Centaurea diffusa*, is CEDI.

Recording methods vary by location. Sometimes field staff will enter data by hand onto a paper form, which might later be entered into a computer database for eventual inclusion in a Global Information System **(GIS) layer** for analysis or mapping. More often, field staff will enter data directly into a GPS **data dictionary** while in the field. The data is then transferred directly into a GIS database.

Preparation

Materials

- two small items or "treasure" – Use any items you wish.
- copies of a hand-drawn map of the classroom or school grounds – Have available one copy for each student.

1 Hide two small items or "treasure" in the classroom or on the school grounds. Place each item in a different location, but approximately the same distance from the starting point.

2 Draw two maps of the classroom or school grounds. On one map, use an "X" to accurately mark the location of the item on the map. On the other map, use an "X" to mark the location of the item, but don't mark the location accurately; the item should be in the vicinity of the "X." Do not tell students about the incorrect map. The group of students who use the incorrect map will likely need more time to locate the treasure, and you might need to adjust or correct their map.

3 Divide the class into two teams. Tell students that you hid a "treasure" for each team someplace in the classroom or on the school grounds, depending on where you choose to conduct this exercise. However, you are not going to tell them the location of the treasure. They will have to find the treasure by reading a map. The treasure for each team will be in a different location, but each team will travel approximately the same distance to find the treasure.

4 Explain that students should work together to find the treasure in the shortest time possible. Once they have found the treasure, students should return to the classroom.

5 Give a copy of the maps to every student on each team. Allow the teams a two-minute planning session. During this time, teams should look at their maps together and plan their strategy. To increase students' anticipation, ask, "Which group will find their treasure and get back first?"

6 After teams have found their items, ask students if this exercise was easy or difficult and why.

7 Explain that maps are an important tool for weed inventories. Review the purpose of a weed inventory and its components. Discuss why an accurate recording of a weed's location is probably the single most essential piece of data for an inventory. An accurate recording of location allows weed mangers to return to the same location in the future to control or monitor the weed.

Activity

Materials

- **topographic** or legal maps showing township, range, and section for the area students will inventory, or use GPS receivers
- copies of the *Noxious Weed Sighting Report Form* worksheet – Have available one copy for each student. Or contact a local weed manager and obtain a copy of a weed sighting report form specific to your area.

1 Before beginning this exercise, make sure you understand how to read the topographic maps or use the GPS receivers students will use to record the location of weeds.

2 With the help of your students, choose a location to conduct a weed inventory. When choosing the location, consider the following criteria:

- A nearby road or trail is best.
- Choose a location that receives little traffic during the time of day or season you conduct the inventory.
- The location should have one or more weed species, in bloom or easily identifiable by students, that you will target for this inventory.

3 Obtain topographic or legal maps of the area. Make sure the maps show township, range, and section.

4 Review identification of targeted species, amount of time students will be in the field, and the distance students will walk.

5 Give each student a copy of the *Noxious Weed Sighting Report Form* and review the form with students. If using topographic maps, explain how to read the maps and record the data. If using GPS receivers, explain how to use them.

6 Tell students they will conduct the inventory in two teams; each team will work toward the center from opposite ends of the site. Divide students into two teams and conduct the inventory.

7 When the teams meet in the center, have them exchange data, check each others' work, and correct inaccuracies.

8 Reconvene as an entire class. Ask each team to comment on the accuracy of their work.

9 Ask students how they might follow-up on the inventory. Students may give the results of their survey to a local weed manager, get involved in weed control themselves, implement an education plan for the area, or take some other action.

Conclusion and Evaluation

- Conclude the lesson by having students discuss what they learned from the *Activity*. Emphasize the importance of collecting accurate data and following protocols.
- Evaluate students on the thoroughness and accuracy of the data they collected, their behavior in a field setting, and their participation in group discussions.

Independent Practice and Related Activities

- Repeat this exercise in different locations to help students improve their skills.
- Work with a local weed manager; involve students in the weed inventory process on a larger or more practical scale.
- Provide practice with a variety of data collection tools, especially GPS if possible.
- Use this lesson as a motivator for your students to become involved in invasive plant prevention, control, and education in your community.

Vocabulary

age class, data, data dictionary, GIS layer, GPS, NRCS, protocols, phenology, range, section, standards, topographic, township, weed inventory

Resources

Weed managers from various local government agencies can often provide maps, data collection forms, and information about weeds and weed inventories.

National Science Education Standards

As a result of their activities in grades 6 to 8, students should develop abilities in and an understanding of the following areas:

Life Science – Content Standard C: characteristics of organisms, life cycles of organisms, organisms and environments

Science in Personal and Social Perspectives

– **Content Standard F:** characteristics and changes in populations, changes in environments

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

Weed Warrior Worksheet

Noxious Weed Sighting Report Form

Observer_____ Date_____

1 Choose one species code from the table on the next page.
Code_____ Common name_____

2 Record the relative frequency. (Circle one.) Spot Scattered Patch

3 Record information about the location. It is important to provide location information that is as detailed as possible.

If you are using a map, record the following information:

TWP_____ RGE_____ Section_____ QTRQTR_____

30 minute quad_____ Topo name_____

Site type_____ Road name _____

Road miles_____

If you are using a GPS receiver, record the UTM coordinates: _____

4 Record other vegetation in the vicinity. _____

5 Record general location information. (Circle one.) Roadside Ditch Rangeland Riparian

6 Record information about the growth form. (Circle one.) Basal rosette Upright growth

7 Record information about the growth stage. (Circle one.) Pre-flower Flowering Seeded

8 Record land ownership information. (Circle one.) BLM USFS Private State

9 Record other information that is pertinent. _____
_____

Noxious Weed Sighting Report Form

Sample list of species and NRCS codes*

Common Name	Scientific Name	Code
African rue	Peganum harmala	PEHA
black henbane	Hyoscyamus niger	HYNI
bull thistle	Cirsium vulgare	CIVU
bur buttercup	Ranunculus testiculatus	RATE
Canada thistle	Cirsium arvense	CIAR4
Dalmatian toadflax	Linaria dalmatica	LIDA
diffuse knapweed	Centaurea diffusa	CEDI3
dyer's woad	Isatis tinctoria	ISTI
field bindweed	Convolvulus arvensis	COAR4
halogeton	Halogeton glomeratus	HAGL
hound's tongue	Cynoglossum officinale	CYOF
Klamath weed	Hypericum perforatum	HYPE
leafy spurge	Euphorbia esula	EUES
Mediterranean sage	Salvia aethiopis	SAAE
Medusahead rye	Taeniatherum caput-medusa	TACA8
musk thistle	Cardus nutans	CANU4
perennial pepperweed	Lepidium latifolium	LELA2
poison hemlock	Conium maculatum	COMA2
puncturevine	Tribulus terrestris	TRTE
skeleton weed	Chondrilla juncea	CHJU
Russian knapweed	Acroptilon repens	ACRE3
sacred datura	Datura innoxia	DAIN5
St. Johnswort	Hypericum perforatum	HYPE
Scotch thistle	Onopordum acanthium	ONAC
spotted knapweed	Centaurea maculosa	CEMA4
tamarisk	Tamarix ramosissima	TAPA4
tansy ragwort	Senecio jacobaea	SEJA
whitetop	Cardaria draba	CADR
yellow starthistle	Centaurea solstitialis	CESO3
yellow toadflax	Linaria vulgaris	LIVU2

* The species included on this list may not be found in your area. For a list of species specific to your area, see a weed manager from a local government agency.

Weed Warrior Worksheet

Weedy Definitions

age class – all of the plants that are of a particular age

data – information or facts from which conclusions can be drawn

geographical information system (GIS) layer – one layer in a stack of layers that show geographical features used when creating digital maps

geographical positioning system (GPS) data dictionary – database that contains information about the geographic location of objects for eventual use in mapping and analysis

National Resource Conservation Service (NRCS) – provides products and services that enable people to be good stewards of the Nation's soil, water, and related natural resources on non-Federal lands

protocol – a specific procedure to follow, *When you conduct a weed inventory, you must follow a protocol.*

phenology – the study of regularly recurring biological phenomena, such as animal migrations or plant budding, especially as influenced by climatic conditions

range – a division of land, a strip of land between two meridian lines six miles apart

section – a division of land that is one mile square (contains 640 acres)

standards – rules that define how good something is, *Weed managers must follow strict data-collection standards when they conduct a weed inventory.*

topography – detailed description of the physical features of an area, including rivers, mountains, valleys

township – a division of land, one township is equal to 36 square miles

weed inventory – to collect data about plants in an area, *Weed inventory data must be accurate.*

Sample Inventory Protocol

Grade: 9 to 12

Length: variable

Subjects: life science

Topics: inventory

Objectives

Exercises in this lesson help students achieve the following objectives:

- Understand how to conduct weed inventories using a transect line
- Understand the importance of following a protocol

Introduction

Established protocols help ensure that weed managers collect accurate and consistent data when conducting a weed inventory. Students will learn how to follow a protocol properly and collect accurate data by setting up a transect line. This lesson is ideal for students who wish to collect specific weed location information without using a GPS receiver. Before teaching this lesson, read the entire lesson and make sure all materials are available.

To complete this lesson successfully, students must already have the ability to identify noxious weeds in their study area.

If students need more information about inventories, conduct the lesson *The Right Inventory for the Job* before teaching this lesson.

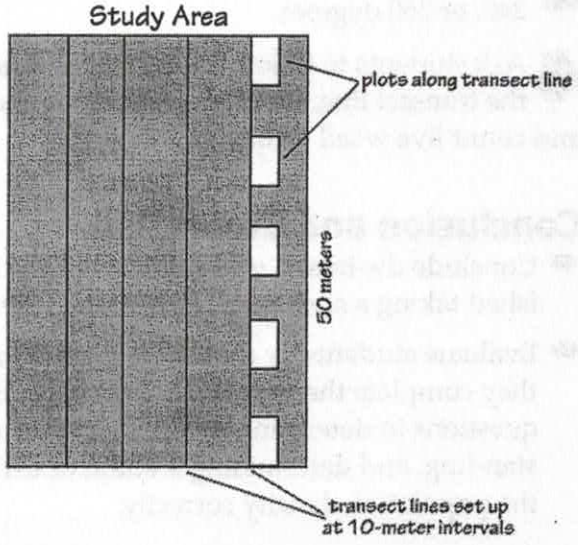
Background

Weed managers need to know the locations of specific weeds, whether the weeds are spreading, and the effectiveness of weed management practices. Inventories help provide this information.

There are different types of inventories. Sometimes, an **inventory** covers a large area in a broad sweep. Other inventories provide detailed information about a small area. Regardless of the type of inventory, it is imperative that information collected during the inventory be accurate and reliable.

To ensure the reliability of information, weed managers follow strict **protocols** or procedures when collecting information during inventories. (For more information about protocols, see the lesson *Practicing Protocols*.) This lesson focuses on the following protocols:

Setting up a transect line – A **transect** line is a straight line laid out randomly or systematically within a study area. One or more transect lines may be set up within a study area. Before setting up a transect line, determine the length of the line. The line length often depends on the size of the study area. Weed managers often divide the area along the transect line into small plots and observe and record plants that occur within the plots. The illustration below shows an example of several transect lines set up at equal intervals with plots along each transect line.



Transect Lines in Study Area

Conducting weed stem counts – By counting the number of live weed stems within a plot, weed managers can estimate the density of weeds in a study area.

Preparation

1. If necessary, help students learn to identify weeds. (Before beginning the *Activity*, students should have the ability to identify **noxious weeds** in their study area.)
2. Discuss the importance of following protocols when conducting a weed inventory.
3. Discuss transect lines and weed stem counts. Explain that students will set up a transect line outdoors, count the number of live weed stems in plots along the transect line, and estimate the population of weeds, based on their stem counts.

Activity

Materials

- copies of the *Inventory Protocol* worksheets – Have available one copy for each student.
- materials listed under *Setting Up a Transect Line* on the worksheet

1. Give each student a copy of the *Inventory Protocol* worksheet.
2. Divide students into teams, with at least three students per team.
3. Assign each team a transect bearing of 120, 240, or 360 degrees.
4. Ask students to follow the instructions, set up the transect line, establish plots along the line, and count live weed stems.

Conclusion and Evaluation

- Conclude the lesson when students have finished taking a stem count of noxious weeds.
- Evaluate students by observing students as they complete the field work, asking pertinent questions to determine students' level of understanding, and determining if students estimated the population density correctly.

Independent Practice and Related Activities

- Have students conduct other types of inventories using different protocols.
- Have students set up a transect line in a pattern that is not circular. Conduct stem counts and compare the results with the results of the first count.

Resources

Hankins, Juley, and Karen Launchbaugh. *Rangeland Vegetation Inventory Field Lab Manual.* University of Idaho Department of Rangeland Ecology and Management.

Vocabulary

inventory, noxious weed, protocol, transect

National Science Education Standards

As a result of their activities in grades 9 to 12, 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

Science in Personal and Social Perspectives – Content Standard F: environmental quality; science and technology in local, national, and global challenges

This lesson adapted from *Rangeland Vegetation Inventory Field Lab Manual*, by Juley Hankins and Karen Launchbaugh, University of Idaho Department of Rangeland Ecology and Management, Moscow, Idaho 83844-1135. http://www.idrange.org/educators/FieldLabManual.pdf

Weed Warrior Worksheet

Inventory Protocol

Set Up a Transect Line

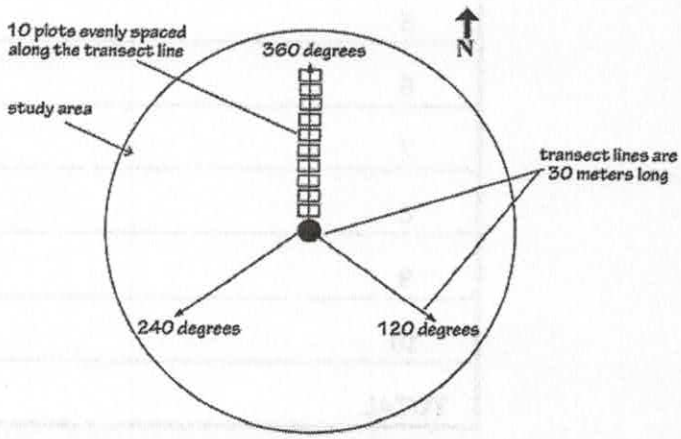
Rangeland scientists cannot count, measure, and record attributes for every plant on rangeland. Monitoring every plant would be very time consuming. Instead, scientists study small plots of rangeland that represent the whole area.

Scientists often use a transect line to collect scientific rangeland vegetation data. A transect line is a straight line through the study area. Study plots are relatively small areas located along the transect line. To represent conditions across an entire study area, scientists monitor the vegetation in several small study plots and average the results of the data. By counting the number of live weed stems present, scientists can determine the density of weeds.

Materials

- one 30-meter measuring tape or transect line
- one compass
- one hammer to pound in stakes
- 90 meters of line
- four plastic tent stakes

1. Select a study area. The area should be at least two acres in size.
2. Mark the center of the study area with a rock, stake, or other object.
3. Use the compass to find North. This bearing represents 360 degrees.
4. Have someone stand over the center stake with a compass.
5. Starting at 360 degrees, the person in the center holds the compass and turns counterclockwise until the needle points to the next transect heading, which will be 120 degrees or 240 degrees. To obtain the most accurate reading, keep the compass parallel to the ground surface.
6. Have the person in the center push the tent stake attached to one end of the transect line into the center point.
7. Have a second student take the transect line 30 meters away, in the direction of their team's compass heading.
8. Align the transect line with the angle determined by the compass. Pull the line taut, and firmly plant the transect stake into the ground.
9. Repeat steps 5 through 9 to set up the transect line for each team.
10. Once the transect lines are in place, each team may begin the weed stem count.



Inventory Protocol

Name _____ Date _____

Conduct Stem Count

Materials

- transect line
- 45 centimeter x 45 centimeter plot frame, constructed from ½-inch PVC pipe

1. Choose ten, evenly-spaced points along a transect line.
2. Place the plot frame at each of these points and count the number of live, noxious weed stems inside the frame; record this number on the chart below.
3. If there is more than one noxious weed species present, record the species.
4. Repeat the procedure for each transect line.

Location: _____

Noxious Weed Species present: _____

Frame	Weed Stem Count
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
TOTAL	

Weed Mapping

Alien weed species can take advantage of a wide range of habitats. They can cause problems on a small scale, such as on school property, and within a much larger environment. Mapping the location and number of alien weed species is one method scientists use to track the spread of invasive plants.

To determine the effectiveness of weed management practices, scientists must know the location of weeds. Almost every weed management district in the country uses Geographical Information System (GIS) and Global Positioning System (GPS) technology to map the location of weeds. Students may often assist in the weed-mapping process if they understand how to use and apply these technologies.

About the Weed Mapping Unit

There are many opportunities available in the fields of GIS and GPS technology. There is a tremendous worldwide need to transfer geographical data from databases to computer-mapping software, and there is also a tremendous need to determine the best uses for the visual data after it has been created.

Lessons in this unit expose students to basic concepts in the following areas:

- map making
- map reading
- GIS
- GPS technology

For teachers who wish to delve deeper into mapping and involve students in a statewide or national mapping project, see *Resources* near the end of each lesson for more information.

Lessons

This unit includes the following lessons:

Elementary school

Drawing Sequence Maps – Introduces the abstract concept of mapmaking. Students will draw a pictorial map and learn to follow a route using a simple map.

Map Journeys – Expands students' map skills. Students will learn to draw and use maps to locate objects.

Middle school

Tracking Aliens in the Schoolyard – Helps students to refine their mapmaking skills and develop a sense of scale and heading by drawing a simple map of the schoolyard. Students will mark the locations of weeds on their maps.

The Marks on this Map are Alien! – Explains how to read topographic maps and examines three methods for determining the location of a site: township, range, and section; latitude and longitude; and UTM coordinates.

High school

Introduction to GIS/GPS – Introduces the rudiments of GIS and GPS technology and explains the relationship between the two. Students will learn how to apply each technology to various situations.

Intermediate GIS – Familiarizes students with basic features and functions of ArcView GIS software. Students will learn about using ArcView to map weed data.

Intermediate GPS – Familiarizes students with basic features and functions of GPS receivers. Students will learn about uses for GPS data and GPS terminology.

Weed Mapping – Allows students to apply their weed identification, GIS, and GPS skills to an actual weed-mapping project. Students will partner with a government agency.

Books

Aczel, Amir D. *The Riddle of the Compass: The Invention That Changed the World*. New York: Hartcourt, Inc., 2001.

Alder, Ken. *The Measure of All Things: The Seven-Year Odyssey and Hidden Error That Transformed the World*. New York: The Free Press, 2002.

Blaise, Clark. *Time Lord: Sir Sandford Fleming and the Creation of Standard Time*. New York: Pantheon Press, 2000.

Calquhoun, Jed. *Pacific Northwest's Least Wanted List: Invasive Weed Identification and Management*. Corvallis: Oregon State University Extension Service and State Communications (in-house publication), 2003.

Gorst, Martin. *Measuring Eternity: The Search for the Beginning of Time*. New York: Broadway Books, 2001.

Hankins, Juley, and Karen Launchbaugh. *Rangeland Vegetation Inventory Field Lab Manual*. University of Idaho Department of Rangeland Ecology and Management.

Hunken, Jorie. *Botany for All Ages: Discovering Nature Through Activities for Children and Adults*. Globe Pequot Press, 1993.

Malone, Lyn, Palmer, Anita M., and Voigt, Christine L. *Community Geography: GIS in Action Teacher's Guide*. Redlands, CA: ESRI Press, 2003.

Peterson, Roger Tory and Margaret McKenny. *A Field Guide to Wildflowers of Northeastern and North-central North America*. Boston: Houghton Mifflin Company, 1968.

Proctor, John, and Susan Proctor. *Color in Plants and Flowers*. New York: Everest House, 1978.

Sheley, Roger L., and Janet K. Petroff, eds. *Biology and Management of Noxious Rangeland Weeds*. Corvallis: Oregon State University Press, 1999.

Spellenberg, Richard. *National Audubon Society Field Guide to North American Wildflowers, Western Region*. 2nd ed. New York: Knopf, 2001.

Whitson, Tom, ed., Larry C. Burrill, Steven A. Dewey, David W. Cudney, B.E. Nelson, Richard D. Lee, and Robert Parker. *Weeds of the West*. 5th ed., Jackson: Pioneer of Jackson Hole, 1999.

Winchester, Simon. *The Map That Changed the World: William Smith and the Birth of Modern Geology*. New York: Harper Collins Books, 2001.

Zanelli English, Kim and Laura S. Feaster. *Community Geography: GIS in Action*. Redlands, CA: ESRI Press, 2003.

Publications

Alien Invasion: An Oregon Weed Primer, supplemental material that is part of the curriculum *Alien Invasion: Plants on the Move.*

Alien Invasion: An Oregon Weed Primer and *Alien Invasion: What About Weeds?*, supplemental material that is part of the curriculum *Alien Invasion: Plants on the Move.*

Interpreting Indicators of Rangeland Health, Version 3 (2000); U.S. Department of the Interior, U.S. Department of Agriculture Technical Reference 1734-6.

Other

County weed boards, extension offices, and state and federal agencies can provide information about invasive weed species and weed identification guides.

Forestry Suppliers sells paper for plant collections. **http://www.forestry-suppliers.com**

Idaho Rangeland Resource Commission, University of Idaho, Moscow, ID 83844-1135.

Local seed companies or co-ops.

For three-dimensional models of weed specimens, contact the Center for Invasive Plant Management, 733 Leon Johnson Hall, MSU Bozeman, P.O. Box 173120, Bozeman, MT 59717-3120; 406-994-6832. **cipm@montana.edu, www.weedcenter.org**

For a lesson plan about plant classification developed by Professor Jim Wilson, contact Plant Science Instructor, College of Southern Idaho, Ag Science Department, Evergreen Building, P.O. Box 1238, 315 Falls, Twin Falls, ID 83303.

For Weed Seed Library Images, contact Doug Pals, secondary ag instructor from Culdesac, Idaho and Terry Crawford, Department of Agriculture and Extension Education, University of Idaho.

Weed Story, a noxious weed PowerPoint presentation. S.M. Stoller Corporation, 1780 First Street, Idaho, Falls, ID 83401.

Web Sites

Comprehensive, CD-based plant identification system by XID Services, Inc. **http://www.xidservices.com**

National Botanical Association. **http://www.mcintosh.botany.org/bsa/misc/mcintosh**

National Plant Database. **www.plants.usda.gov**

Rocky Mountain Research Station, Fire Sciences Laboratory, Fire Effects Information System. **http://www.fs.fed.us/database/feis/**

12 authors: (Chapman et al., 1999). *The Purple Loosestrife Project*. Michigan State University (in house-publication). **www.miseagrant.umich.edu//pp/**

The U.S. Department of Agriculture Natural Resources Conservation Service Web site contains information about assessing an ecological site. **http://esis.sc.egov.usda.gov/About.aspx**

The U.S. Department of Agriculture Natural Resources Conservation Service Web site contains information about plants, noxious weeds, and invasive weeds. **http://plants.usda.gov**

The U.S. Department of Agriculture Natural Resources Conservation Service Web site contains information about plants, noxious weeds, and invasive weeds. **http://plants.usda.gov**

For information about topographic maps and to order maps, see the USGS Web site. **http://www.topomaps.usgs.gov/**

For access to USGS topographic and digital aerial maps, see the TerraServer USA Web site. **http://terraserver-usa.com**

Tree of Life Web Project. **http://tolweb.org/tree/phylogeny.html**

For general information about using a GPS receiver, using a receiver with a map, and additional resources, see the Web sites for various manufacturers. **www.garmin.com, www.geocaching.com, www.gypsy.com, www.lowrance.com, www.magellangps.com, www.onstar.com, www.trimble.com**