IPS EDUCATION KIT

AUTHORS
Krista James, UW-Stout, Biology Dept
Kitrina Carlson, UW-Stout, Biology Dept
Jean D'Angelo, Menomonie High School, Agriscience Dept
Kevin Mason, UW-Stout, Science Education Program
Wendy Sandstrom, UW-Stout, Biology Dept

The Invasive Plant Species Education Lesson Guide was produced under a 2008-2009 grant from the Wisconsin Environmental Education Board (grant number 2008-0018); this guide must not be sold for profit.

Currently available curricula were incorporated into this guide whenever possible. These resources include:

Alien Invasion Plants on the Move, Sonata, Inc
http://www.weedinvasion.org/weed_html.php?page=about

Invaders of the Forest: Educator's Guide to Invasive Plants of Wisconsin's Forests (2005). Funded by the Wisconsin Environmental Education Board (WEEB). Project partners include the Wisconsin Department of Natural Resources and The Park People: Friends of Milwaukee County Parks.

LEAF. Wisconsin K-12 Forestry Lesson Guide. (2004) Stevens Point, WI:Wisconsin Center for Environmental Education and Wisconsin Department of Natural Resources – Division of Forestry.

LEAF. Wisconsin K-12 Urban Forest Lesson Guide. (2007) Stevens Point, WI:Wisconsin Center for Environmental Education and Wisconsin Department of Natural Resources – Division of Forestry.

FORWARD

Dear Educator,

The Invasive Plant Species Education Lesson Guide and Kit has been developed to provide assistance and support to school districts that wish to teach students about caring for the environment and getting involved in their local community through the removal of invasive plant species.

I feel blessed to have been chosen to be the teacher to pilot this outstanding educational training kit and to have my students be the first to try out the lessons. It is my hope that many teachers throughout the state will take advantage of this well written curriculum and will collaborate with their local environmental experts to plan and carry out an invasive species removal project.

You can make a difference! Within just the space of a few decades, the way children understand and experience nature has radically changed. Even as youth become more aware of global threats to the environment, their physical contact with nature is fading. This kit will help teachers address this challenge by creating classroom opportunities for students to explore the outdoors while also learning about forest ecology and invasive plant species.

This kit is designed with the teacher in mind. The lessons are easy to follow; my students enjoyed the variety of activities that are included in the curriculum. As a teacher, you can use the kit as a whole unit or pick certain parts to enhance your already existing teaching plans.

A critical element in this kit is your motivation to make connections with the experts in your local community. These individuals can help you carry out the most important part of these lessons- the actual removal of the invasive species in your area. Don't be afraid to reach out to the environmental experts in your community and learn from them.

Also, encourage your students to connect their classroom experiences to their own neighborhoods to benefit themselves and others. Empower your students to be stewards of the earth. Studies show that adults with a greater environmental awareness had some transcendent experience in nature when they were children. Stewardship of our environment requires knowledge, skills, a positive attitude, and a commitment to making a difference for all who live on our earth. As teachers, we have the power to instill these attributes in our students.

In the end, we will conserve only what we love, we will love only what we understand and we will understand only what we are taught.

Enjoy!

Jean D'Angelo

TABLE OF CONTENTS

Pages

THE FOREST ODYSSEY…… 1 - 8

EXPLORING ECOSYSTEMS…… 9 - 19

RESTORING BIODIVERSITY…… 20 - 24

OUTWIT-OUTPLANT-OUTLAST……..25 - 32

PLANT INVADERS……..33 - 37

PLANT HUNTERS……38 - 41

INTRODUCTION TO GPS AND GIS TECHNOLOGIES……42 - 52

INVASIVE PLANT SPECIES INVENTORY……53 - 60

INVASIVE PLANT SPECIES CONTROL……61 - 69

APPENDIX……70

- USING A COMPASS……..71 - 77
- SUPPLEMETAL GPS ACTIVITIES……..78 - 79

GLOSSARY OF TERMS……80

RESOURCES……81 - 84

AUTHOR BIOS AND THANK YOUS……..85 - 88

THE FOREST ODYSSEY

Source: LEAF, Wisconsin K-12 Forestry *Lesson Guide: 9-12, Wisconsin Department of Natural Resources-Division of Forestry and Wisconsin Center for Environmental Education, Lesson 1: The Forest Odyssey.*

SUMMARY

This lesson will introduce students to basic forest ecology terms and ideas through the reading and discussion of Aldo Leopold's essay *Odyssey*. Students will be able to understand the importance of biodiversity in sustaining life on earth through a group activity.

LEARNING OBJECTIVES

At the end of this unit, students will be able to:

- Define ecosystem and forest ecosystem.
- Find and discuss forest ecology concepts in literature.
- Describe concepts such as change, interconnectivity, and sustainability.

TIME FOR PREPARATION: 15 minutes

It is recommended that teachers pre-read *Odyssey* prior to teaching the lesson for understanding and to lead more in depth discussions.

TIME FOR TEACHING: 2-45 minute sessions

Depending on the size of the class and the students' reading ability, it is possible to separate this lesson into 2 parts: 1) Read and discuss *The Odyssey* and 2) Sketch the flow diagram and complete the Group Odyssey activity using the large X.

SETTING: Indoors/Classroom

MATERIALS:

- Copy of Aldo Leopold's Odyssey – one copy per student
    - Odyssey can also be found in A Sand County Almanac, Part II: Wisconsin, by Aldo Leopold; pages104-108.
- Chalk/marker board
- A cut-out of a large **X** for use in Group Odyssey activity
- *Reading Along with the Odyssey* video clip (optional)
- Paper and pencil for student map/flow chart

OUTLINE FOR THE TEACHING PRESENTATION

After reading the *Odyssey*, atom Y is portrayed as a bad guy through the farmer's use of monoculture. It is recommended that teachers discuss other examples besides monoculture, such as a football field, a grass lawn, an airport, or any other area where one type of vegetation is purposely planted.

Getting Started

1. Explain to the students that the Invasive Species Unit will begin with some background information on basic forest ecology. The background information will start with an essay written by Aldo Leopold. Ask the students to raise their hand if they have heard of Aldo Leopold. Ask them to keep their hand raised if they have read anything else he has written. If there are any students who have read Leopold, have them explain what he writes about. Guide the conversation to the topics of **nature**, **conservation**, and **society** (see vocabulary list for definitions).

2. Tell the class that Aldo Leopold is one of the most famous North American nature writers, and his most acclaimed book, *A Sand County Almanac*, is written about his life on a rural homestead in Wisconsin. Today, they will read a short essay found in *A Sand County Almanac*.

Doing the Activity

1. Explain to students that they will be reading *Odyssey* written by Aldo Leopold. Have students define the word **odyssey** and explain that the story describes the extended journey of an atom through an ecosystem. Review with class the definition of an **atom**.

2. Begin a brainstorming session to define the word **ecosystem**. Further refine the definition to describe a **forest ecosystem**. Use the students' ideas to form a clear definition and write it on the board. (This could be discussed in small groups, have them write it on board, discuss differences and similarities and come up with a class definition.)

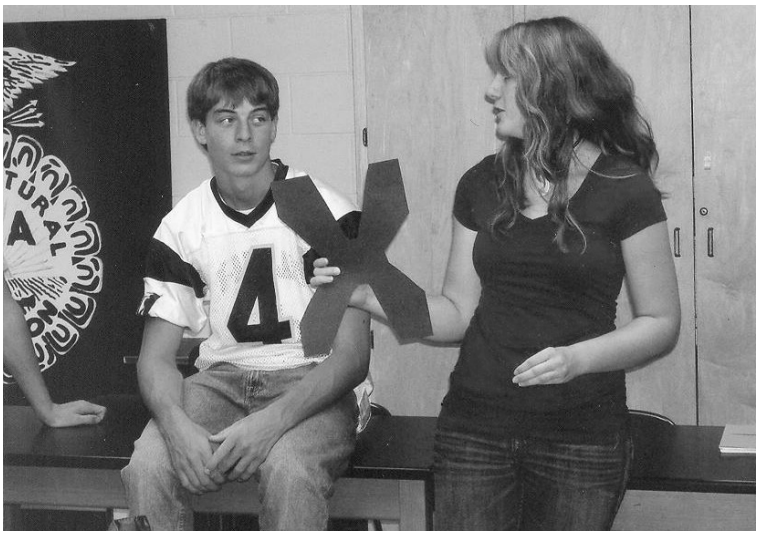
3. Hand out a copy of Aldo Leopold's *Odyssey* to each student in the class. If appropriate, you can use the *Reading Along with the Odyssey* video clip provided with the IPS kit lessons. The video clip can be used in various ways: 1) watch the video instead of reading, 2) watch the video at the same time as the students read along in the book, or 3) allow students to read individually or as a class, and then watch the video.

4. Think-Pair-Share: Give students some time after reading to think about what they just read. Have students pair up with another student to discuss what they thought the essay was about and what path the atoms were taking. Choose a couple of groups to share their ideas with the class.

5. After students have read *Odyssey*, have them work in small groups to map/flow chart the odyssey of atom X and atom Y. One group will be atom X and one group will be atom Y. Have the groups identify in a paragraph or diagram the living and nonliving things in which X resided and describe how the atom transitioned from one location to another. Once the groups have finished, have each group present their paragraph or diagram. (Refer to samples in kit for general idea.)

6. After students have described the odyssey of atom X, lead a discussion on what the students thought about the way Aldo Leopold presented it. You may wish to ask the following questions:
    - What was different about your brief description of the atom's journey and Leopold's?
    - Did you think the essay was interesting?
    - What did the essay make you think about?
    - Did you understand everything?
    - Did it leave any questions unanswered?
    - Do you think the essay is scientifically and historically accurate?
    - Was it too technical to understand?
    - What ecosystem(s) did Leopold write about?
    - How does this story relate to our definition of a forest ecosystem?
    - What concepts or themes are emphasized in the writing?
    - Can you define the concepts of **change, interconnectivity and sustainability** using examples from the writing to illustrate your definition?

7. **Group Odyssey** – Arrange students in a large circle. Explain to the class that just like in Leopold's *Odyssey*, they will be describing the journey of an atom. Each student contributes to the story as the story moves from student to student, eventually completing the full circle. The first person will describe where the atom is (ex. part of a beaver's front teeth), what happens to it (ex. the teeth erode as the beaver uses them to fell trees), and where it ends up (ex. a mushroom grows on the wood chips and assimilates the atom). The next student will need to invent what happens to the atom, and where it ends up. This continues around the circle. The character of the story should change as the atom moves to a different ecosystem. The teacher will play the role of the facilitator by clarifying points and describing natural processes.



Menomonie High School students participating in the group odyssey activity.

EXTENSION ACTIVITIES

1. **Creative Writing** - Have students write their own version of Leopold's *Odyssey* that is plausible and science-based. Share their versions with the class.

ASSESSMENT

Use the discussion and activities listed above to evaluate the students' level of understanding of the concepts of ecosystem, forest ecosystem, interconnectivity, and sustainability.

TEACH THE TEACHER

VOCABULARY

Atom – the smallest unit of an element that retains the chemical properties of that element
Nature - the physical world of living and nonliving things not produced by human kind
Conservation - protecting and preserving nature
Society - a grouping of people with collective characteristics that may impact nature
Ecosystem – an area that contains organisms (e.g. plants, animals, and bacteria) interacting with one another and their nonliving environment (e.g. climate, soil, topography)
Forest Ecosystem – an ecosystem characterized by a dominance of tree cover
Interconnectivity – the relationships that exist between ecosystems
Odyssey – an extended wandering or journey
Sustainability – the ability of natural resources to provide ecologic, economic, and social benefits for present and future generations

FORESTS AS ECOSYSTEMS

A biological community is a group of plants and animals that live and interact with one another in a given area. The term **ecosystem** is used to describe a biological community together with the abiotic (nonliving) components in it. An ecosystem's abiotic components can include physical characteristics (e.g., soils, topography), climatic factors (e.g., sunlight, temperature, moisture), and nutrients, elements and other chemical compounds (e.g., nitrogen, phosphorous, carbon dioxide, water, mercury, pesticides). Ecosystems can vary in size from a large forest to a rotting log.

Forest ecosystems are not isolated from other ecosystems. They are interconnected with other terrestrial ecosystems (such as prairies) and with aquatic ecosystems (such as wetlands). For many of us, the biotic connections are most obvious. For example, many animal and bird species, such as the eagle, osprey, and black bear, find shelter in the forest but get much of their food from adjoining areas. Forest edges receive added sunlight, increasing the habitat for sun-loving plants, and providing important habitat for many birds and animals, including deer, turkey, and grouse. Some organisms (notably amphibians) need a wetland for part of their life cycle but live other parts of their life in terrestrial areas, such as forests.

Forests are also connected to other ecosystems by abiotic factors. Forests retain water and protect surface and groundwater resources. Surface water and groundwater connect forests with lakes, rivers, wetlands, farms, and cities. Fires spread from fields to forests. Erosion from

upland areas can cause siltation of waterways and create soil deposits in lowland areas. Forested areas can act as windbreaks and temperature buffers. All of these are examples of the abiotic connections between forests and surrounding ecosystems.

ALDO LEOPOLD

Aldo Leopold was born in Burlington, Iowa, in 1887. He received a Master of Forestry from Yale University in 1909, and after earning his degree, went on to serve for 19 years in the U.S. Forest Service. Leopold worked in the Southwest until he was transferred in 1924 to the Forest Products Lab in Madison, Wisconsin. In 1933 he was appointed Professor of Game Management in the Agricultural Economics Department at the University of Wisconsin-Madison. Leopold taught at the University of Wisconsin until his death in 1948.

Aldo Leopold is best known as the author of *A Sand County Almanac* (1949), a volume of sketches and essays that helped define an ecological attitude toward people and the land. The notion of a land ethic was rooted in Leopold's perception of the environment. He was an internationally respected scientist and conservationist instrumental in formulating policy, promoting wilderness, and building ecological foundations for forestry and wildlife ecology.

Aldo Leopold died in 1948 but left an amazing legacy. In 1930, he served as chairman of the Game Policy Institute, which developed the American Game Policy. He assisted in the foundation of both the Wilderness Society and the Wildlife Society. Aldo Leopold also left us with one of the most eloquent and definitive collections of environmental writing in American history.

WISCONSIN MODEL ACADEMIC STANDARDS

Grades 9-12 Environmental Education: B.12.2, E.12.1

RESOURCES

A Sand County Almanac by Aldo Leopold. (Oxford University Press, 1949.) Many essays in A Sand County Almanac provide insight into the human aspects and sustainability of Wisconsin ecosystems.

Wisconsin's Forests at the Millennium: an Assessment. (Ann-Marie S. Finan, Editor, Wisconsin Department of Natural Resources, 2000, PUB-FR-161 2000.) This WDNR publication contains ecological, social, and economic information about Wisconsin's forests. It provides a good framework to discuss challenges to forest sustainability.

Natural Communities of Wisconsin www.dnr.state.wi.us/landscapes/community

This DNR website contains links to the natural communities in each of the ecosystem profiles used in this lesson. Information includes natural history, wildlife, statistics, etc.

THE ODYSSEY

Name:_____

1. As you read the essay, *The Odyssey* by Aldo Leopold, write down any words that you don't know or are unsure of.

2. Who is the main character of the story?

3. What do you think about Aldo Leopold's writing style?

4. What do the following lines mean? What do they refer to?
   "The only certain truth is that its creatures must suck hard, live fast, and die often, lest its losses exceed its gains."

   "Black and white buffalo pass in and out of red barns, offering free rides to itinerant atoms."

5. Pick out some lines from the essay that you found interesting and write them below to share with your classmates.

ODYSSEY

An exerpt from A Sand County Almanac by Aldo Leopold

"X had marked time in the limestone ledge since the Paleozoic seas covered the land. Time, to an atom locked in a rock, does not pass.

The break came when a bur-oak root nosed down a crack and began prying and sucking. In the flush of a century the rock decayed, and X was pulled out and up into the world of living things. He helped build a flower, which became an acorn, which fattened a deer, which fed an Indian, all in a single year.

From his berth in the Indian's bones, X joined again in chase and flight, feast and famine, hope and fear. He felt these things as changes in the little chemical pushes and pulls that tug timelessly at every atom. When the Indian took his leave of the prairie, X moldered briefly underground, only to embark on a second trip through the bloodstream of the land.

This time it was a rootlet of bluestem that sucked him up and lodged him in a leaf that rode the green billows of the prairie June, sharing the common task of hoarding sunlight. To this leaf also fell an uncommon task: flicking shadows across a plover's eggs. The ecstatic plover, hovering overhead, poured praises on something perfect: perhaps the eggs, perhaps the shadows, or perhaps the haze of pink phlox that lay on the prairie.

When the departing plovers set wings for the Argentine, all the bluestems waved farewell with tall new tassels. When the first geese came out of the north and all the bluestems glowed wine-red, a forehanded deermouse cut the leaf in which X lay, and buried it in and underground nest, as if to hide a bit of Indian summer from the coming frosts. But a fox detained the mouse, molds and fungi took the nest apart, and X lay in the soil again, foot-loose and fancy-free.

Next he entered a tuft of side-oats grama, a buffalo, a buffalo chip, and again the soil. Next a spiderwort, a rabbit, and an owl. Thence a tuft of sporobolus.

All routines come to an end. This one ended with a prairie fire, which reduced the prairie plants to smoke, gas, and ashes. Phosphorus and potash atoms stayed in the ash, but the nitrogen atoms were gone with the wind. A spectator might, at this point, have predicted an early end of the biotic drama, for with fires exhausting the nitrogen, the soil might well have lost its plants and blown away.

But the prairie had two strings to its bow. Fires thinned its grasses, but they thickened its stand of leguminous herbs; prairie clover, bush clover, wild bean, vetch, lead-plant, trefoil, and Baptista, each carrying its own bacteria house in nodules on its rootlets. Each nodule pumped nitrogen out of the air into the plant, and then ultimately into the soil. This the prairie savings bank took in more nitrogen from its legumes than it paid out to its fires. That the prairie is rich in known to the humblest deermouse; why the prairie is rich is a question seldom asked in all the still lapse of ages.

Between each of his excursions through the biota, X lay in the soil and was carried by the rains, inch by inch, downhill. Living plants retarded the wash by impounding atoms; dead plants by locking them to their decayed tissues. Animals ate the plants and carried them briefly uphill or downhill, depending on whether they died or defecated higher or lower than they fed. No animal was aware that the altitude of his death was more important than his manner of dying. Thus a fox caught a gopher in a meadow, carrying X uphill to his bed on the brow of a ledge, where an eagle laid him low. The dying fox sensed the end of his chapter in foxdom, but not the new beginning in the odyssey of an atom.

An Indian eventually inherited the eagle's plumes, and with them propitiated the Fates, whom he assumed had a special interest in Indians. It did not occur to him that they might be busy casting dice against gravity; that mice and men, soils and songs, might be merely ways to retard the march of atoms to the sea.

One year, while X lay in a cottonwood by the river, he was eaten by a beaver, an animal that always feeds higher than he dies. The beaver starved when his pond dried up during a bitter frost. X rode the carcass down the spring freshet, losing more altitude each hour than heretofore in a century. He ended up in the silt of a backwater bayou, where he fed a crayfish, a coon, and then an Indian, who laid him down to his last sleep in a mound on the riverbank. One spring an oxbow caved the bank, and after one short week of freshet X lay again in his ancient prison, the sea.

An atom at large in the biota is too free to know freedom; an atom back in the seas has forgotten it. For every atom lost to the sea, the prairie pulls another out of the decaying rocks. The only certain truth is that its creatures must suck hard, live fast, and die often, lest its losses exceed its gains.

* * *

It is the nature of roots to nose into cracks. When Y was thus released from the parent ledge, a new animal had arrived and begun redding up the prairie to fit his own notions of law and order. An oxteam turned the prairie sod, and Y began a succession of dizzy annual trips through a new grass called wheat.

The old prairie lived by the diversity of its plants and animals, all of which were useful because the sum total of their co-operations and competitions achieved continuity. But the wheat farmer was a builder of categories; to him only wheat and oxen were useful. He saw the useless pigeons settle in clouds upon his wheat, and shortly cleared the skies of them. He saw the chinch bugs take over the stealing job, and fumed because here was a useless thing too small to kill. He failed to see the downward wash of over-wheated loam, laid bare in spring against the pelting rains. When soil-wash and chinch bugs finally put an end to wheat farming, Y and his like had already traveled far down the watershed.

When the empire of wheat collapsed, the settler took a leaf from the old prairie book: he impounded his fertility in livestock, he augmented it with nitrogen-pumping alfalfa, and he tapped the lower layers of the loam with deep-rooted corn.
But he used his alfalfa, and every other new weapon against wash, not only to hold his old plowings, but also to exploit new ones which, in turn, needed holding.

So, despite alfalfa, the black loam grew gradually thinner. Erosion engineers built dams and terraces to hold it. Army engineers built levees and wing-dams to flush it from the rivers. The rivers would not flush, but raised their beds instead, thus choking navigation. So the engineers built pools like gigantic beaver ponds, and Y landed in one of these, his trip from rock to river completed in one short century.

On first reaching the pool, Y made several trips through water plants, fish, and waterfowl. But engineers build sewers as well as dams, and down them comes the loot of all the far hills and the sea. The atoms that once grew pasque-flowers to greet the returning plovers now lie inert, confused, imprisoned in oily sludge.

Roots still nose among the rocks. Rains still pelt the fields. Deermice still hide their souvenirs of Indian summer. Old men who helped destroy the pigeons still recount the glory of the fluttering hosts. Black and white buffalo pass in and out of red barns, offering free rides to itinerant atoms.”

EXPLORING ECOSYSTEMS

SUMMARY

This lesson will describe the processes that occur within an ecosystem that transport atoms through living and nonliving things. It will also introduce students to a variety of different types of biomes where ecosystems can be found, including forests. This activity will allow students to see and learn about the climate conditions, living organisms, nonliving materials, and interactions that occur within a given ecosystem. Students will also understand why certain things can only survive in certain biomes.

LEARNING OBJECTIVES

At the end of this unit, students will be able to:

- Understand **photosynthesis** and the **carbon cycle** and how these processes transport atoms within an ecosystem.
- Identify a variety of types of **biomes** where ecosystems exist.
- Describe the climate conditions, living organisms, nonliving materials, and interactions in a given biome.

TIME FOR PREPARATION: 15 minutes

TIME FOR TEACHING: 45 minutes

This lesson can be split into two sections. The section on photosynthesis and the carbon cycle can be done first, followed by time on the computer to complete the global biome worksheet.

SETTING: Indoors/Classroom

MATERIALS:

- Copies of *The Movement of Atoms: Photosynthesis and the Carbon Cycle* handout
- Copies of *Biomes and Ecosystems Activity* handout
- Computers with access to online mapping websites such as Google Maps or Yahoo Maps
- Biome posters from kit (can be displayed in classroom during the lesson)
- Video: *Forest Story: Restoring Wisconsin's Treasure* found in the IPS kit

OUTLINE FOR THE TEACHING PRESENTATION

<u>Getting Started</u>

1. An excellent introduction to this lesson is the Wisconsin Division of Forestry video *Forest Story* located on the DVD in the IPS kit. This video describes the history of Wisconsin's forests, foresters, and the forestry program.

2. Review the previous lesson, The Forest Odyssey, by asking the students, the following questions (5 minutes):
    - What is an ecosystem?

- What is a forest ecosystem?
- What things exist in an ecosystem?
- Define ecology.
- Can you give an example of something that is biotic? What about abiotic?
- Do these things interact?
- Based on your reading of Aldo Leopold's essay, *The Odyssey*, what happens to atoms in an ecosystem?
- How do things change? Interconnect? Sustain each other?

You may write down the students' ideas and responses on the board, but keep it brief. You may need to address or clarify any misconceptions or misinformation regarding ecosystems at this time.

3. Preview this lesson by telling students they are going to answer the following questions during today's lesson (5 minutes):
    - How exactly are atoms transported in an ecosystem?
    - Where can you find ecosystems?
    - What are the conditions, organisms, materials, and interactions like in an ecosystem?

    You may allow students to provide their initial thoughts and ideas, but don't give any answers until after the student activities are completed.

Doing the Activity

1. Ask the students, have you ever heard of **photosynthesis** and the **carbon cycle**? What do you know?

2. Hand out *The Movement of Atoms: Photosynthesis and the Carbon Cycle* (10 minutes). The handout provides a diagram of photosynthesis on the front and a diagram of the carbon cycle on the back. In groups, have the students fill in the blanks to complete the diagram of photosynthesis and the carbon cycle. These diagrams should demonstrate how atoms are able to move through an ecosystem. Either collect the worksheet or review the answers as a class.

3. Refer back to the questions asked at the beginning of the lesson. Explain that ecosystems can be found in a variety of different types of **biomes** and the conditions, organisms, materials, and **interactions** will vary based on the location of the ecosystem.

4. Ask the students, have you ever used mapping software such as Google maps? With hands raised, place students into groups with experienced users distributed evenly in the groups. The number of groups will depend on the number of computers available.

5. Handout *Biomes and Ecosystems* and complete the activity (20 minutes). You may use the pictures provided in the IPS kit if computers are not available.

6. Conclude the lesson with a brief discussion of what the students learned (5 minutes). Try to focus the discussion on the living organisms (plants and animals) and their interactions with each other and the nonliving environment. Every living organism has a role and impact on the ecosystem and students need to understand the significance of those impacts. Also, have the students connect these ideas to photosynthesis and the carbon cycle.

EXTENSION ACTIVITIES

1. The water cycle or nitrogen cycle could also be studied in much the same way with students creating diagrams or pictures that help them understand exactly how atoms and molecules can move through and contribute to a healthy ecosystem.

2. The *Biomes and Ecosystems* activity could be a separate lesson if more time is needed and available. Adding more locations, types of biomes, or discussion of biomes could easily make this activity an entire class period.

3. Have students choose two types of biomes and compare and contrast the characteristics of the two biomes. Present your comparison to the class and discuss your findings.

ASSESSMENT

Option 1

Have students choose their favorite biome. Create a poster using magazines/pictures from internet that visually show what that biome looks like. Then, students will choose three living and three non-living things from that biome and complete the carbon cycle and photosynthesis process to show how the non-living and living things depend on each other within that biome.

Option 2

Using the same concept from above, have students create an essay instead of the poster.

TEACH THE TEACHER

VOCABULARY

Photosynthesis – a process or series of steps that converts light energy into chemical energy in living organisms

Carbon Cycle – a process or series of steps by which carbon is transported between the earth, water, atmosphere, and living organisms

Biome – an area with a given set of characteristics such as climate conditions, soil, water, plants, animals, and other organisms

PHOTOSYNTHESIS

Photosynthesis is often studied in greater detail in a high school biology class. More information

on photosynthesis could be found in any biology textbook as well as on the internet.
Steps of Photosynthesis:

1. The chlorophyll in the chloroplast of the plant cell absorbs a photon of light that is stored as chemical energy in adenine triphosphate molecules (ATP).
2. An enzyme captures carbon dioxide molecules (CO_2) from the atmosphere through the stomata of the leaves where it is transported to the chloroplast.
3. Water molecules (H_2O) are absorbed by the roots and transported to the leaves of the plant by the xylem.
4. The chlorophyll uses the energy from the ATP to complete a series of chemical reactions known as the Calvin Cycle. The energy splits the water molecules (H_2O) into hydrogen (H) and oxygen atoms (O).
5. The hydrogen and carbon dioxide are used to make sugars which eventually become the sugar glucose ($C_6H_{12}O_6$). Glucose is transported to other parts of the plant in the phloem where it can be used or stored.
6. The extra oxygen from the water exits through the stomata of the leaves and released into the atmosphere as oxygen molecules (O_2).

The net reaction is represented by the chemical equation:

$$6\ CO_2 + 6\ H_2O + \text{light energy} \rightarrow C_6H_{12}O_6 + 6\ O_2$$

<u>THE CARBON CYCLE</u>

The carbon cycle is often studied in much greater detail in environmental science, ecology, and earth science courses. These textbooks could provide an excellent supplement to find more information and detail on the carbon cycle.
Steps of the Carbon Cycle:

1. Carbon exists in the atmosphere as carbon dioxide gas molecules (CO2) and to a lesser extent in other gases such as methane or chlorofluorocarbons.
2. Carbon exists in the soil often in the form of hydrocarbons, a type of organic compound that contains carbon and hydrogen.
3. Carbon exists in living organisms often in the form of hydrocarbons such as carbohydrates, sugars, lipids, proteins, etc.
4. Carbon exists in oceans, lakes, and rivers as dissolved hydrocarbons as well as living organisms in the water.
5. Carbon dioxide (CO2) is removed from the atmosphere by plants during photosynthesis.
6. Carbon dioxide (CO2) is released into the atmosphere by animals during respiration.
7. Decomposition of dead organisms releases carbon into the atmosphere, soil, or water.
8. Animals release carbon in the form of urine, feces, and gas into the atmosphere, soil, or water. (Some release more gas than others.)
9. Combustion, including the burning of fossil fuels, releases carbon into the atmosphere as carbon dioxide or carbon-based smoke.
10. Evaporation of water releases dissolved carbon dioxide from oceans, lakes, and rivers into the atmosphere.
11. Condensation or rain transfers dissolved carbon dioxide from the atmosphere into oceans, lakes, and rivers.

TYPES OF BIOMES

As you will see in the *Biomes and Ecosystems* activity, the types of biomes include desert, savanna, rainforest, grasslands, wetlands, deciduous forest, coniferous forest, mountains, marine, and tundra. As you read different sources, you will sometimes find other types of biomes identified or slightly different terminology used to describe the same biome. On a very basic level, everyone is familiar with certain biomes like a desert, forest, or rainforest even if they have never seen one in person. However, the characteristics of these biomes and the ecosystems they contain may be less familiar to many people. In addition, most people do not understand or appreciate the countless interactions that occur between living organisms in each ecosystem and between the living organisms and the nonliving environment. More information can be found on biomes and ecosystems in most environmental science, ecology, or earth science textbooks.

The biome posters within the kit serve as great representatives of each biome and also include information about each biome along with pictures.

WISCONSIN MODEL ACADEMIC STANDARDS

Grades 9-12 Environmental Education: B.12.1, B.12.2
Grades 9-12 Life and Environmental Science: F.12.9, F.12.10, F.12.11

RESOURCES

The World's Biomes http://www.ucmp.berkeley.edu/exhibits/biomes/
This University of California website contains information and images of the world's biomes.

Biomes and Ecosystems http://www.windows.ucar.edu/tour/link=/earth/ecosystems.html
This Windows to the Universe website contains educational activities for different learning levels.

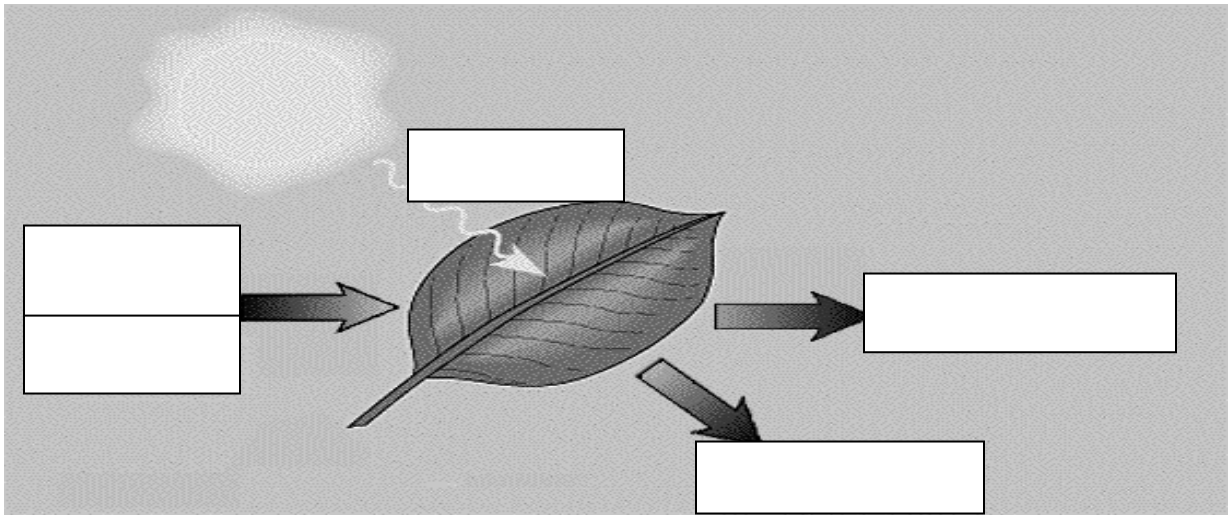
THE MOVEMENT OF ATOMS:
PHOTOSYNTHESIS AND THE CARBON CYCLE

Name_____

Photosynthesis and the carbon cycle are two processes by which atoms are transported through living and nonliving things. These processes demonstrate the scientific basis for Aldo Leopold's *Odyssey* by showing how atoms move through an ecosystem. Photosynthesis and the carbon cycle are certainly not the only biological or chemical processes that involve the movement of atoms and molecules in nature. The nitrogen cycle, water cycle, and many others also move atoms and molecules through an ecosystem.

Photosynthesis is a process or series of steps that converts light energy into chemical energy in the chloroplast of a plant cell.

Directions: Complete the diagram of photosynthesis by filling in the boxes below with the appropriate words and/or chemical symbols.



Source: http://www.phschool.com/science/biology_place/biocoach/photosynth/overview.html

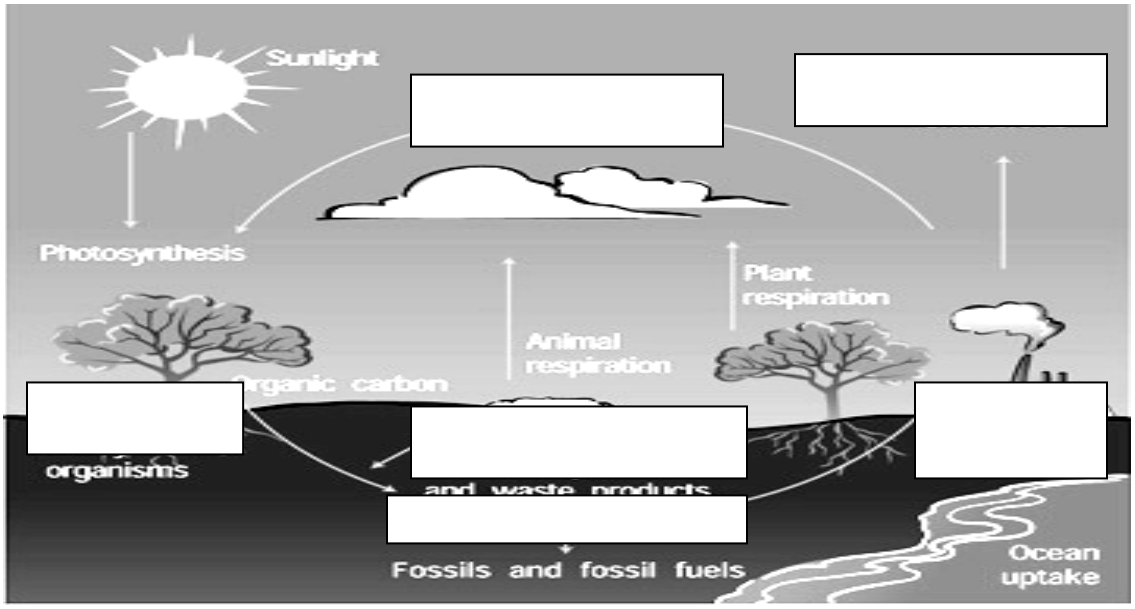
Directions: The net reaction for photosynthesis can be represented by the chemical equation below. Fill in the blanks to identify each reactant and product by **name**.

$6\ CO_2 + 6\ H_2O$ + light energy → $C_6H_{12}O_6 + 6\ O_2$

_____ + _____ + light energy → _____ + _____

The carbon cycle is a process or series of steps by which carbon is transported between the earth, water, atmosphere, and living organisms.

Directions: Complete the diagram of the carbon cycle by filling in the boxes below with the appropriate words and/or chemical symbols for each form of carbon.



Source: http://eo.ucar.edu/kids/green/cycles6.htm

Questions:

1. Where could the carbon atoms in your body have been before they became a part of you?

_____

_____

_____

2. What processes allow carbon to move from one form to another?

_____

_____

_____

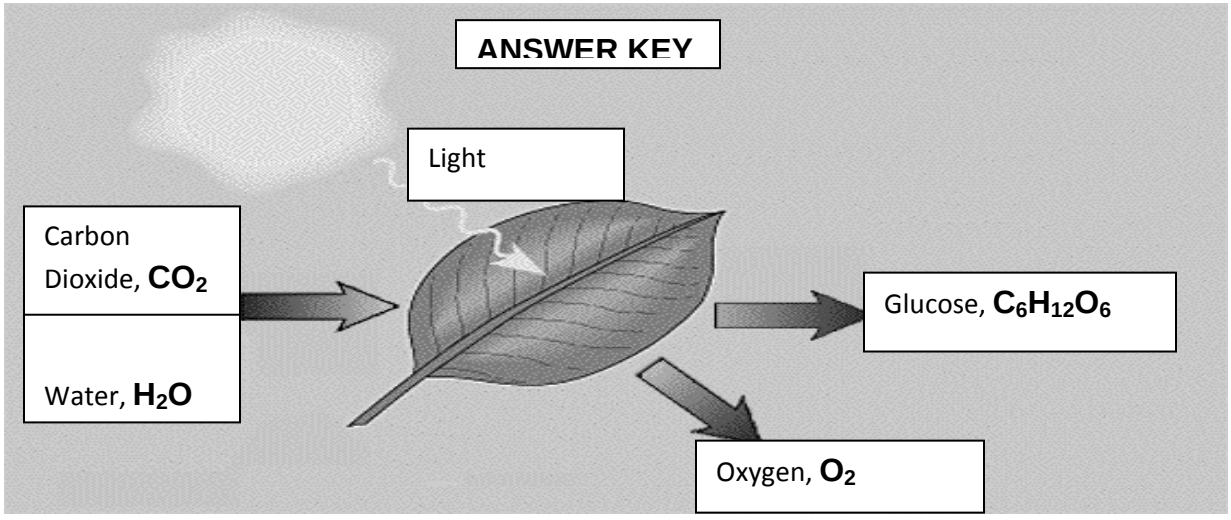
ANSWER KEY

THE MOVEMENT OF ATOMS:
PHOTOSYNTHESIS AND THE CARBON CYCLE

Photosynthesis and the carbon cycle are two processes by which atoms are transported through living and nonliving things. These processes demonstrate the scientific basis for Aldo Leopold's *Odyssey* by showing how atoms move through an ecosystem. Photosynthesis and the carbon cycle are certainly not the only biological or chemical processes that involve the movement of atoms and molecules in nature. The nitrogen cycle, water cycle, and many others also move atoms and molecules through an ecosystem.

Photosynthesis is a process or series of steps that converts light energy into chemical energy in the chloroplast of a plant cell.

Directions: Complete the diagram of photosynthesis by filling in the boxes below with the appropriate words and/or chemical symbols.



Source: http://www.phschool.com/science/biology_place/biocoach/photosynth/overview.html

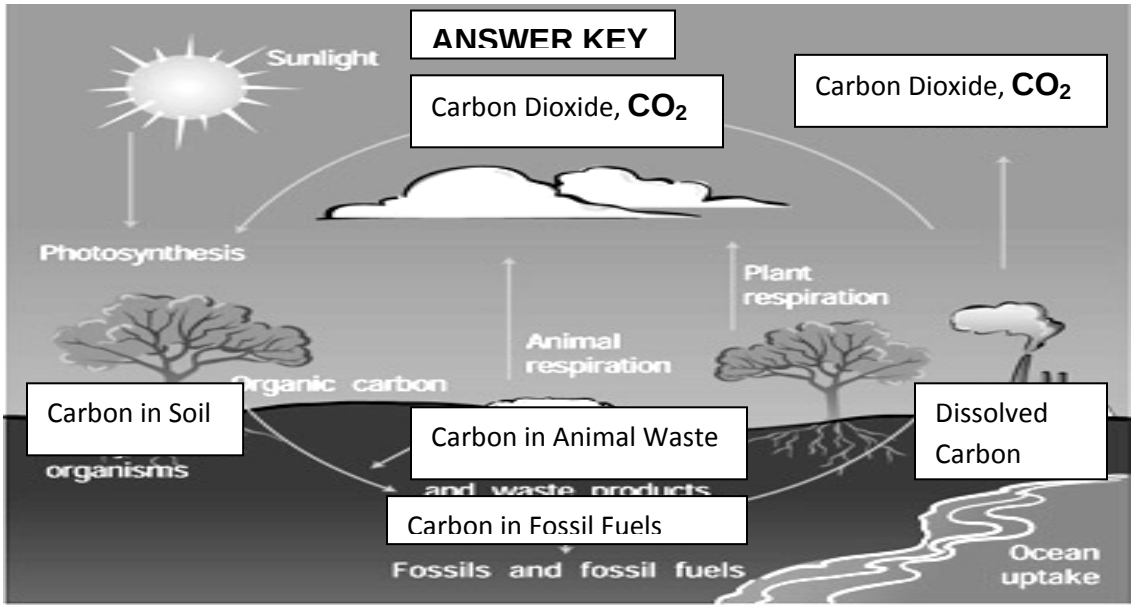
Directions: The net reaction for photosynthesis can be represented by the chemical equation below. Fill in the blanks to identify each reactant and product by name.

$6\ CO_2 + 6\ H_2O$ + light energy → $C_6H_{12}O_6 + 6\ O_2$

Carbon Dioxide + Water + light energy → Glucose + Oxygen

The carbon cycle is a process or series of steps by which carbon is transported between the earth, water, atmosphere, and living organisms.

Directions: Complete the diagram of the carbon cycle below by filling in the blanks with the appropriate words and/or chemical symbols for each form of carbon.



Source: http://eo.ucar.edu/kids/green/cycles6.htm

Questions:

1. Where could the carbon atoms in your body have been before they became a part of you? **The carbon atoms in your body could have been in the atmosphere, soil, fossil fuels, oceans, lakes, rivers, plants, plant waste, animals, or animal waste.**

2. What processes allow carbon to move from one form to another? **Steps Photosynthesis, plant respiration, animal respiration, consumption of living things, digestion of living things, decomposition of living things, reproduction, combustion, evaporation, and condensation.**

BIOMES AND ECOSYSTEMS

Name_____

The terms biome and ecosystem are often mistakenly used interchangeably. Although they are quite similar, a **biome** describes a large geographical region that is characterized by certain climate conditions, plant organisms, animal organisms, and nonliving materials. An **ecosystem** describes an area that contains organisms interacting with each other and their nonliving environment. A biome could contain hundreds or even thousands of ecosystems. An ecosystem could be the size of a national park or the size of a one meter by one meter square. Online mapping websites allow you to view some of the most amazing biomes and ecosystems around the world. There are many different types of biomes including desert, savanna, rainforest, mountains, tundra, grassland, wetland, deciduous forest, and coniferous forest. Each biome hosts a diversity of plants, animals, and other organisms well suited to survive in the climate and environmental conditions of the ecosystem.

Directions: In this activity, you will view a variety of biomes on local and global levels. For each location, identify the type of biome and describe the climate conditions, living organisms, nonliving materials, and the interactions of the living organisms with one another and nonliving things.

Word Bank

Biomes- grassland, desert, coniferous forest, deciduous forest, savannah, rain forest, tundra, wetland
Climate- tropical, wet, dry, cool, hot, humid, etc
Living- deer, fish, frogs, eagles, grass, snakes, fox, lion, cactus, etc
Nonliving- rock, snow, mountain, river, sand, soil, etc
Interactions- birds eat the fruit of the cactus, reptiles warm up on rocks, etc

Local Biomes

Location	Biome Type	Climate	Living	Nonliving	Interactions
Brule Springs, WI					
Lake Wissota, WI					
Horicon, WI (north of the city)					

Global Biomes

Location	Biome Type	Climate	Living	Nonliving	Interactions
Zambezi, Zambia					
Oro Blanco, Arizona					
Tefe, Brazil					
Fairbanks, Alaska					

1. What type of biome is your school in? Why do you think that? What do you see to prove your theory?

_____

_____

_____

_____

2. Have you ever been to a different biome? Where was it located? What living and non-living things did you see? Could these things live in your backyard or your school grounds? Why or why not?

_____

_____

_____

_____

RESTORING BIODIVERSITY

SUMMARY
This lesson will introduce the concept of biodiversity and allow students to observe the biodiversity of species in a local area through a hands-on activity. It will also discuss how restoration projects can be used to restore biodiversity to a local ecosystem. A short creative writing assessment concludes this lesson.

LEARNING OBJECTIVES
At the end of this unit, students will be able to:

- Define and describe **biodiversity**.
- Observe and measure biodiversity near their school.
- Understand how restoration projects can restore biodiversity to an ecosystem.

TIME FOR PREPARATION: 15 minutes

TIME FOR TEACHING: 2 - 45 minutes

SETTING: Indoors/Outdoors

MATERIALS:

- *The Plant Biodiversity Activity* Handout
- Quadrants (PVC pipe squares included in kit)

OUTLINE FOR THE TEACHING PRESENTATION
Getting Started

1. Review the previous lesson, Exploring Ecosystems, by asking and discussing the following questions (5 minutes):

    - What is the difference between a biome and an ecosystem?
    - What types of biomes are common in Wisconsin?
    - What type of biome is your restoration site?
    - What living organisms (plants or animals) live in your restoration site?
    - How should these living organisms interact with each other and the nonliving environment?

    You may need to address or clarify any misconceptions or misinformation regarding biomes and ecosystems.

Doing the Activity

1. Before class begins, divide students into groups and choose an area for each group of students to collect data. Try to choose a variety of sites with high, medium, and low levels of biodiversity with the sites close enough to each other to provide adequate supervision by the teacher. If the restoration site is close to the school, you may want to choose areas in and around the restoration site.

2. Ask the students, what is **biodiversity**, what is **restoration**, and why are they important concepts? Discuss and write a definition on the board (5 minutes).

3. Hand out *The Plant Biodiversity Activity* Handout. Read the introduction and directions for the assignment (5 minutes). Place students into their groups for this assignment and assign one student per group to bring their handout outside to record their group's data. Give students instructions for getting to the site.

   **It is a good idea to give the students their quadrants once they get to their data collection site. The quadrants do not stay together well enough to travel intact with students.

4. Go outside to the collection sites and collect data (15 minutes).

5. Return to the classroom to discuss which locations had the highest/lowest biodiversity and why that is the case. Ask the students, how could we restore biodiversity to an ecosystem? Why is it important to have biodiversity? Discuss student ideas and other ideas for restoration. (e.g. planting, weeding, reduce human use, reduce human pollution, removal of invasive species, control water, control nutrients, monitor pesticides, monitor fertilizers, monitor predator populations, etc)

6. **Creative Writing Assessment:** On a blank piece of paper, write a ½ page essay describing the ecosystem in your backyard or neighborhood. You must use the following terms in your essay: **biome, ecosystem, living organisms, nonliving materials, interaction, biodiversity,** and **restoration** (10 minutes). This assessment can be done in class (if time is available) or as homework.

EXTENSION ACTIVITIES

1. The *Plant Biodiversity Activity* could be repeated at a variety of field locations. The biodiversity index could be calculated near lakes or rivers and next to roads. As a class, discuss the levels of biodiversity found in these various locations.

2. **Family Stories**: Have students share stories about what their family's yard looked like 100 years ago, 50 years ago, or 10 years ago. Has the biodiversity changed? If so, why? How would we go about restoring the yard to what it looked like then?

3. A guest speaker would be a great addition to this lesson to highlight career possibilities or to share historical pictures of your hometown. Contact your local historical society for a possible guest speaker for your class.

Menomonie High School students using quadrants to measure biodiversity

ASSESSMENT

The creative writing assessment described above can be completed in class and used as a quiz or completed at home and used as an assignment.

TEACH THE TEACHER

VOCABULARY

Biodiversity – the variation of living organisms within an ecosystem
Restoration – the return of an ecosystem to its natural or historical condition

BIODIVERSITY

Biodiversity describes the amount of variety of life forms in a given ecosystem. There are a variety of different ways to measure and calculate biodiversity. In this lesson, a very simple formula to calculate biodiversity is used, but other methods can be more mathematically advanced.

RESTORATION

This lesson simply introduces students to the concept of restoration as an approach to restoring the ecosystem to a more natural state. At the end of the lesson, students will discuss their ideas about how to restore an ecosystem. This topic will be addressed in more detail later in the unit prior to beginning the field work on the restoration project.

WISCONSIN MODEL ACADEMIC STANDARDS

Grades 9-12 Environmental Education: A.12.3, A.12.4, B.12.2, B.12.4, B.12.7, D.12.2
Grades 9-12 Science Inquiry: C.12.3

RESOURCES

Saving Nature's Legacy: Protecting and Restoring Biodiversity by Reed F. Noss, Allen Y. Cooperrider, Contributor Allen Y. Cooperrider, Published by Island Press, 1994.
A thorough and readable introduction to issues of land management and conservation biology; it presents a broad, land-based approach to biodiversity conservation in the United States, with the authors succinctly translating principles, techniques, and findings of the ecological sciences into an accessible and practical plan for action.

Living Resources and Biodiversity
http://www.uwsp.edu/cnr/wcee/envsci/Framework/LivingResources/LivingResources7c.htm
The Wisconsin Environmental Science Teacher Network website contains additional resources for exploring the restoration of biodiversity.

Natural Communities of Wisconsin www.dnr.state.wi.us/landscapes/community
This DNR website contains links to the natural communities in each of the ecosystem profiles used in this lesson. Information includes natural history, wildlife, statistics, etc.

PLANT BIODIVERSITY

Name_____

In this activity, you will be measuring the plant biodiversity in a location near your school. A square, called a quadrant, will be constructed from PVC pipe or other materials to define the boundaries of the area you will observe. The plant species biodiversity index will be determined by counting the number of different plant species in a quadrant and estimating the percentage of the quadrant that each species occupies. For example, grass may occupy 80% of your quadrant, dandelions 10%, and a maple tree seedling 10%. The number of species in a quadrant could vary significantly based upon location. For this activity, you will not need to know the names of each plant you encounter. Instead, you simply need to be able to recognize and estimate a percentage of how much of your quadrant that particular plant covers.

Directions: Place your quadrant randomly on the ground in the area assigned by your teacher. Count the number of species in your quadrant and estimate the percent of the quadrant that each species occupies. Record your observations in the data table below. The total percentage of the quadrant (N) that is covered in plants, will not always add up to 100% because of bare spots without any vegetation.

Describe where your quadrant is located: _____

Species (name or detailed description)	Percentage of the Quadrant
	Total Percentage =

OUTWIT-OUTPLANT-OUTLAST

Adapted from: Invaders of the Forest Educator's Guide to Invasive Plants of Wisconsin's Forests

SUMMARY

Lessons from this unit will increase students understanding and awareness of how invasive plants occupy and damage native ecosystems. In a series of activities, students will play the parts of native plants, invasive plants and herbivores.

LEARNING OBJECTIVES

At the end of this unit, students will be able to:

- Experience the vulnerabilities of native species, such as competition, predation, and dependence on nutrients, water and space
- Explain why invasive plants have a competitive advantage over native species
- Chart the advancement of invasive plant species as they spread throughout a natural area

TIME FOR PREPARATION: 20 minutes

TIME FOR TEACHING: One or two 45-minute periods

SETTING: Outdoors or gym

MATERIALS:

- Sidewalk chalk* or paper plates (in IPS kit)
- Water/nutrient tokens (100- in IPS kit)
- Sunshine tokens (100- in IPS kit)
- Cowbell or other noisemaker
- *Outwit-Outplant-Outlast* video clip for set-up and directions for activity (in IPS kit)
- Flagging tape to identify students as native plants, invasive plants or herbivores (2 different colors – in IPS kit)

**A chalk line could also be used*

OUTLINE FOR THE TEACHING PRESENTATION

Getting Started

1. Prepare the playing field by using side-walk chalk to make a "grid" that contains a square for each member of the class (fig 1). Your grid should be large enough to create squares that are approximately 2'X2' each (large enough for a student to stand in). For example, a class with 25 students would require a grid approximately 50' x 50' that was made up of 25 squares. The grid does not need to be exactly squared, but a chalk line can speed the process up if you have an assistant. Alternatively, if you need to play indoors can use paper plates or carpet squares to make the playing field.

2. Find two colors of “tokens” to represent sunshine and water/nutrients. You can use milk caps, poker chips or paper squares. These tokens will be distributed on the playing field.

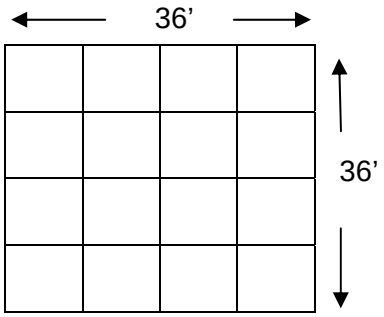


Fig. 1. Example of a playing field grid for 16 students. If you have an uneven number of students, “X” out the extra squares. Playing field squares should be large enough for one student to stand in one square. The squares in this field could be smaller and still work for a class of 20 students. Tokens should be distributed around the playing field randomly.

Doing the Activity

Activity One - Discover how plants invade an empty field

Read the introduction and activity directions to students. This playing field represents a recently plowed field. Each square on the grid has enough space (soil) for one plant. In real life, many different plants and their seeds would invade this bare field. In order to simplify the process and analyze what is happening, we are going to assume that only one seed from an invasive species sprouts in the first year and that no other seeds from other plants can enter the field.

1. Ask students to discuss what plants need to survive. (Sunshine, water, nutrients, soil)

2. Explain the tokens. Show students the water/nutrient tokens (blue) and sunshine tokens (white) leave the tokens distributed around the playing field.

3. Ask one student to represent an invasive plant and to stand in a corner of the grid. This student should wear PINK flagging tape to identify themselves as an invasive plant.

4. Start the activity (read instructions out loud to students). At the sound of the bell, you (the invasive plant) must get three water/nutrient tokens and three sunshine tokens. You will have thirty seconds until I blow the whistle and you must stop trying to gather your tokens. You can’t leave your square to collect tokens; after all, plants have roots! *Note: The student should be able to obtain the necessary tokens easily in this round.*

5. Reproduce. Now that you’ve gathered the necessary tokens for survival, you (the invasive plant) produce many seeds, but only four of them land and sprout inside the grid. Select four of your classmates to be your offspring. These students should stand on squares adjacent to you on the grid.

6. Renew the supply of tokens.

7. Gather water/nutrients and sunlight. At the sound of the whistle all invasive plants will need to gather their necessary tokens. You will have 30 seconds to gather your tokens, but you cannot leave your square! You should gather 3 water and nutrient tokens and 3 sunshine tokens each.

8. Reproduce. All plants that have gathered the appropriate tokens for survival will reproduce producing many seeds, but only four from each plant will survive. Each invasive plant should pick four students to be their "offspring". Seeds should stand adjacent to the "mother plant" on the grid.

9. Instructor Discussion Questions:
    - How many plants can this field support? *(20)*
    - What would happen if two plants tried to live in the same square? (They might both be small and spindly or the weaker one might die. However, if enough water/nutrient and sunshine tokens are present, they might both survive.)
    - If all 25 plants survive and reproduce, how many seeds will sprout the next year? (100)
    - Continue the math for a few more years. What would a graph of this population's growth look like?
    - The playing area is full of plants. What happens to all the extra seeds? (While some might sprout and die, many lie dormant in the soil waiting for the ideal conditions to grow.)
    - What factors did we ignore in this activity? (Most importantly, we ignored the fact that many plants invade at once. In reality, pioneer plants would have covered the field in the first year. Plants don't live forever; some would have died during the activity. Nothing ate the plants. There were no parasites or diseases. There were always plenty of tokens; sometimes plants don't get the things they need to survive.)

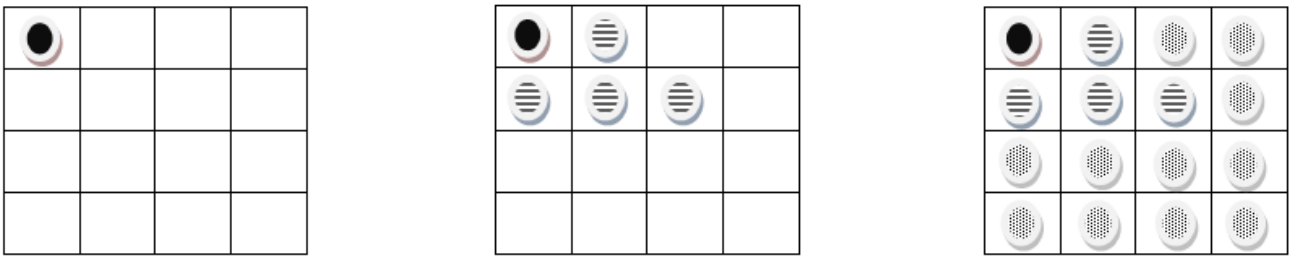


Fig. 2. Distribution of invasive plants, represented by colored circles, after each round of play. Each generation is depicted by a different color.

Activity Two - Discover how native wildflowers occupy a natural area

Read introduction and activity directions to students. It didn't take long for the plants in the first activity to invade the empty field and completely take over. The soil was bare. There was no competition. There was plenty of water/nutrients and sunshine. What do you think happens in a field that is full of native wildflowers and grasses? Let's try it.

1. Instructor: adjust the size of the grid. Using sidewalk chalk, "X" out the unneeded squares so that the playing area contains squares equal to about 1/3 the number of students. For example, a class of 20 would require a grid with about 7 squares. The grid does not have to be perfectly square. Distribute tokens fairly evenly around the playing field.

2. Fill all the squares without an "X" with a student (one student per square). The students who have just been sent into the playing field represent native plants. Students should all wear yellow flagging tape to identify yourselves as native plants and not invasive plants and you stand in a square without an "X".

3. Send in a deer. One student will be selected as an herbivore, deer in this case. Remember, you're plants so you can't avoid the herbivore by moving. (Select one student to be a hungry deer). The deer should eat two of the plants and remove them from the playing field.

4. Gather tokens. All remaining plants need to collect five water/nutrient tokens and five sunshine tokens to survive, you will have thirty seconds. The whistle will blow at the end of thirty seconds.

5. Reproduce. All plants that did not collect enough requirements die and should leave the field. Plants that did get enough are able to reproduce successfully and you remaining plants produce quite a few seeds, but only two seeds per plant land in the playing field. Each remaining native plant should select two of their classmates and represent their native plant seeds. All seeds should wait on the sidelines to find out if they will germinate or not!

6. Send in a mouse. One student will be designated to be the mouse that will eat the seeds. Each year, the mouse will eat half of all seeds produced by the plants. At the signal, the mouse can "eat"/tag half the number of the seeds on the sideline. Seeds who have been eaten should remain outside of the playing field.

7. Germinate. At the signal, the "seeds" will try to take over the empty spaces on the grid. Any unsuccessful seeds return to the sidelines.

8. Count the number of plants on the grid. Compare this to the number at the beginning. If we played another round, how many plants would we probably have at the end of the round? (Talk about what happened. If the students don't understand that the answer

would be the same, play another round to show that while the individual plants may change, the number of wildflowers in the field stays the same).

9. Instructor Discussion Questions:
    - Why did the population end up the same? (Some plants died because they didn't collect enough tokens or because herbivores ate them. The plants that did
    - survive reproduced and filled the empty spaces.)

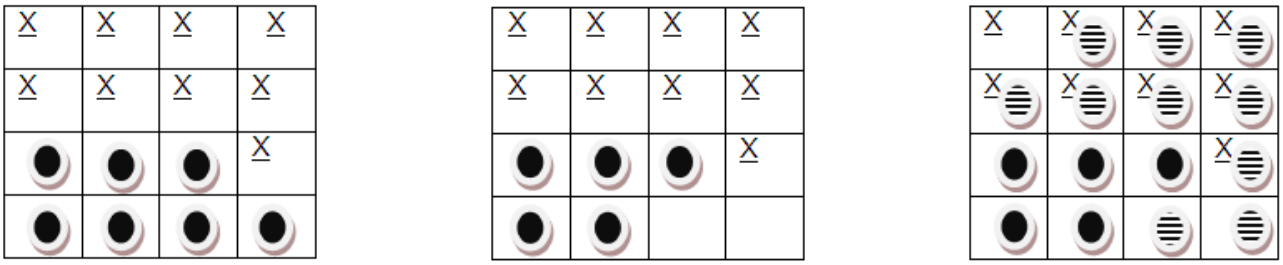


Fig. 3. Distribution of native plants after each round.

Activity Three - Discover how non-natives invade a natural area.
Read introduction and activity directions to students. It was a little harder for an individual wildflower to survive when the field was full of plants. However, the wildflowers as a whole did just fine. When a plant died or was eaten by an herbivore, a seed sprouted in the available space. What would happen if we put the two activities together? What if an invasive plant seed sprouted in one of the empty squares?

1. Place students in the squares without "X"s. Students selected as native plants should wear yellow flagging tape and stand in a square without an "X". One with student will represent an invasive plant and should wear pink flagging tape and stand in a square with an "X".

2. Send in the hungry deer. The deer doesn't recognize the new plant as a food plant, but it does dine on two of the native plants. The native plants who are eaten should leave the playing field.

3. Allow the plants to gather tokens. At the signal, the *invasive* plant will have thirty seconds to collect its requirements. The invasive plant needs three of each kind of token. After the invasive plant collects its tokens, the native plants will try to collect their tokens. Native plants require five of each kind of token. (If the natives protest, explain that invasive plants often turn green earlier in the year and stay green longer in the fall, so they should have more time to collect their tokens. Many invasive plants can also survive on smaller amounts of water, nutrients, and sunshine).

4. Reproduce. All plants that did not collect enough water or sunshine die and should leave the playing field. Plants that did get enough are able to reproduce successfully. The invasive produces many seeds, but only four land on the grid. The natives also produce

quite a few seeds, but only two per plant land in the playing field. Calculate how many seeds the plants produce. Native and Invasive plants should select students to represent their offspring. Offspring should stand on the sidelines and try to germinate!

5. Send in the mouse. The mouse should eat half of all seeds produced by the *native* plants. The mouse doesn't eat the invasive seeds because they are spiky and don't taste good. Designate one student to be the mouse that will eat the seeds. At the signal, the mouse can "eat"/tag the correct number of the native seeds on the sideline. Seeds that have been eaten should sit back down.

6. Germinate. At the signal, the remaining "seeds" can try to take over the empty spaces on the grid (it doesn't matter if there is an "X" in the square or not). Any unsuccessful seeds return to the sidelines.

7. Repeat steps 2 – 8 until invasive plants completely overrun the field. Optional: You could allow two invasives to occupy each square, since invasives often need less space than natives do.

8. Instructor Discussion Questions:
    - What advantages did the invasive species have over the native species? (They produced more seeds. Herbivores didn't eat either the plants or the seeds. They needed fewer tokens to survive. They began collecting tokens before the natives.)
    - Do the native species have a chance in this activity? (No, not really. It's rigged!)
    - Do the native species have a chance in the real world? (No, not in the presence of extremely invasive species. That's rigged too!)
    - In the activity, the deer and mouse continued to eat the plants and seeds of the native wildflowers, no matter how many there were. Is this realistic? (Probably not. As the concentration of natives decreased, the herbivores would probably look other places to find food.)

X**N**	X**N**	X**N**	X**N**
X**N**	X**N**	X**N**	X**N**
I			X**N**

Fig. 4. Distribution of native plants (N) and invasive plants (I) at beginning of game play

EXTENSION ACTIVITIES

1. **Play Activity Three again.** This time try to control the spread of the invasive plants at varying times. What if someone removes the first plant before it makes seeds? What if people don't begin to control the plant until after it produces seeds? Ask students to find out how many seeds invasive plants actually produce. Find out how long the seeds remain viable in the soil. This activity makes a strong case for early intervention and rapid response to a plant invasion!

2. **Write it out/Act it out.** After completing the activities, bring students together in groups to write out the situations they found in the game. Students could also act it out and present it to the class.

ASSESSMENT

Ask students to chart and graph the predicted plant populations in each of the three activities and to work in teams to complete the "student worksheet". Students should complete the questions after each activity is finished and the teacher should lead the students in a discussion based on the worksheet question.

TEACH THE TEACHER

VOCABULARY

Invasive - a non-indigenous species or strain that becomes established in natural plant communities and wild areas, replacing native vegetation
Native - a plant that occurs naturally, having never been introduced by an outside source
Herbivore - an animal that obtains its energy from eating plants, and only plants
Competition - a rivalry between individuals or groups of plants or animals for territory and resources
Predation - an interaction between species in which one species uses another species as food
Nutrient – a food or chemical that an organism needs to live and grow.

WISCONSIN MODEL ACADEMIC STANDARDS

Grades 9-12
Environmental Education: B.12.3, B.12.4, B.12.6
Science: F.12.7, F.12.8

RESOURCES

Alien Plant Invaders of Natural Areas. Plant Conservation Alliance. 2005.
www.nps.gov/plants/alien/factmain.htm
Illustrated, easy-to-read fact sheets on invasive alien plants with native ranges, plant descriptions, ecological threats, U.S. distributions and habitats.

Invasive Plants Weeds of the Week. United States Forest Service: Northeastern Area. 2005.
http://na.fs.fed.us/fhp/invasive_plants/weeds/index.shtm
These fact sheets are designed to distribute information about specific invasive plants that exist in the Northeastern United States.

OUTWIT-OUTPLANT-OUTLAST

Name_____

1. Consider the playing field that represented habitat for the native and invasive plants. What would happen if two plants tried to live in the same square?

2. The playing area is full of plants that reproduce, but only some of the seedlings germinate on the playing field. What happens to all the extra seeds?

3. What advantages did the invasive species have over the native species?

4. Do the native species have a chance in the real world?

5. In the activity, the deer and mouse continued to eat the plants and seeds of the native wildflowers, no matter how many there were. Is this realistic?

PLANT INVADERS

Adapted from: Alien Invasion: Plants on the Move pages 71-73 and The Invasive plant Association of Wisconsin website, www.IPAW.org.

SUMMARY

Lessons from this unit will increase students awareness of the invasive plants found in Wisconsin and enhance their understanding of how invasive plants move into a new environment.

LEARNING OBJECTIVES

At the end of this unit, students will be able to:

- Learn how introduced invasive plant species spread
- Conduct research on the origin of an invasive plant common to Wisconsin
- Create poster detailing the native plant and how it arrived in Wisconsin

TIME FOR PREPARATION: 20 minutes

TIME FOR TEACHING: two 45-minute class periods

SETTING: Classroom or computer lab

MATERIALS:

- Computers/internet
- *Invasive Plant Invaders* worksheet
- *Invasive Plant Cards* from the WDNR (in IPS kit)
- *Invasive Plants of the Upper Midwest* by Elizabeth J. Czarapata (in IPS kit)
- Poster paper, art supplies (students could also create their posters digitally)

OUTLINE FOR THE TEACHING PRESENTATION

Botanists have traced the migration of invasive plants as they spread across the country. However, much of the information about invasive plant migration is incomplete and lacking in detail. By conducting research on invasive plants in their area, students will understand how they spread and why they can be a problematic. Students will create a poster that describes how the invasive plant arrived in Wisconsin.

<u>Getting Started</u>

1. Briefly discuss with students some ways invasive plants may have entered the United States. Ask students to briefly brainstorm some ways they think invasives may have gained entry.

Doing the Activity

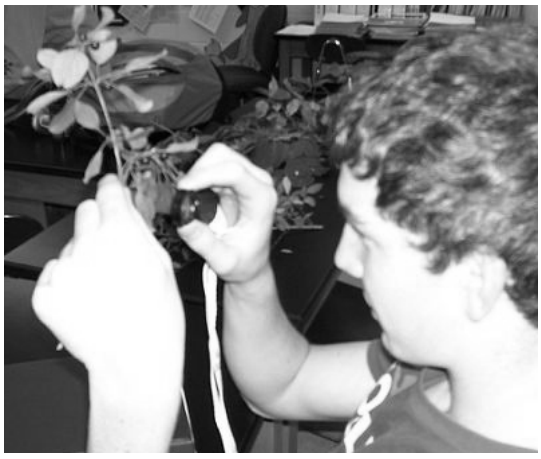
1. Give each student a copy of the *Invasive Plant Invaders* worksheet, which explains their assignment.

2. Place the invasive plant cards into a hat and ask students to select one card. This ensures that a variety of plants are covered in the class research. Students will write or create a poster about the plant they selected from the hat.

3. Provide students with *Invasive Plants of the Upper Midwest* book and the Invasive plant card they selected. Ask students to conduct research about the plant they selected using the Internet. Their research should include how botanists believe the plant entered the United States and how we can prevent the further spread of the plant (see worksheet and rubric for details).

4. After students have collected detailed information about their invasive plant, have them begin creating their short story or poster.

5. During the next class period, provide students with opportunities to share their stories with peers, parents, and members of the community.



Menomonie High School student identifying plants

EXTENSION ACTIVITIES

Encourage students to convert their work to an "invasive plant coloring book" for younger children. Distribute the invasive plant coloring book throughout the school and community.

ASSESSMENT

Evaluate students using the grading rubric on the "Invasive Plant Invaders" worksheet

TEACH THE TEACHER

VOCABULARY

Invasive Plants - non-indigenous species or strains that become established in natural plant communities and wild areas, replacing native vegetation

Potentially Invasive Plants(for Wisconsin) - species that are invasive in parts of North America having similar climates and plant communities, and that are thought to have the potential to colonize and become invasive in Wisconsin

Sometimes Invasive Natives - native plants that can become overly abundant in a plant community to which they are indigenous, often in response to a change in the disturbance regime

Indigenous - means occurring naturally in a specific area or plant community; not introduced

INVASIVE PLANTS

An invasive plant is defined as any plant that is out of place or unwanted where it is growing. Grass is desirable when confined to your lawn, but when grass invades your flower beds, it is an invasive plant. Some plants are always a nuisance or of little use to humans. These plants have been permanently classified as invasive plants. For example, the dandelions are classified as a weed everywhere in the United States. Both a weed and an invasive plant are "plants out of place," but an invasive plant encroaches into forests, roadsides, and prairies where it is unchecked by the devotions of an obsessive backyard gardener. The ramifications of invasive plants are so much more ominous than that of weeds because they can and do destroy the natural diversity of native vegetation.

Ironically, many invasive plants get their foothold through well-meaning gardeners who introduce the species as part of their garden. However, many of these plants come from foreign lands and do not have the natural controls that a native plant has. Soon the nonnative plant takes over – first the garden and then, by propagating via the wind, through deep-set runners and by the cooperation of willing birds carrying the seeds, more distant places. (IPAW website).

Some invasive plants came to our country with the earliest settlers and pioneers. Most of our invasive plants originated in Europe or Southern Asia. These invasives entered our country as seeds mixed in bags of wheat or other grains. Other invasives arrived as seeds hiding in the hay or grass used to feed animals on the ocean voyage to this country. Some seeds were hitchhikers in the fur of domestic animals brought to the New World or in the clothing and bedding of the settlers themselves. Often, seeds were mixed in with the soil that was used for the ship's ballast. These invasives were brought to our country unintentionally or inadvertently.

Once in our country, the invasives established themselves at their point of arrival or point of embarkation, usually along the East Coast of America. As people pushed west, canals and rivers transported men and animals, railroads expended, and the invasive plants spread. Accidental spilling of contaminated seed or using gravel contaminated with invasive seed contributed to the spread of invasives along roads and railroads. As invasive seeds entered the rivers, they spread to wherever the rivers flowed.

All invasive plants species were not brought to the United States inadvertently. Some were brought here intentionally because of their beauty or some other perceived benefit. For example, Purple Loosestrife was brought to the United States as a flowering ornamental

because of its beautiful purple flowers. The plant became established in private gardens and some of its seeds escaped into the wild; Purple Loosestrife has since become one of the most significant invasive plants in Wisconsin.

The Melaleuca tree, which is found in Florida, was brought to America because of its unique physiology. Melaleuca trees were introduced to help dry up the Everglades because these trees have very high rates of evapotranspiration. A Florida developer scattered the seed from these trees over vast parts of the Everglades, hoping the plants would turn the swamps into dry land. The trees did dry up vast parts of the Everglades, which endangered a very valuable ecosystem. Introducing this invasive plant dramatically altered the habitat for large numbers of native plants and animals throughout the entire state.

Whether invasive plants came to America inadvertently or were intentionally introduced into our country, these plants have permanently altered our landscape and ecosystems.

WISCONSIN MODEL ACADEMIC STANDARDS

Grades 9-12
Environmental Education: B.12.3, B.12.4, B.12.6
Science: F.12.7, F.12.8

RESOURCES

Invasive Plants of the Upper Midwest An Illustrated Guide to Their Identification and Control. By Elizabeth Czarapata. The University of Wisconsin Press, 2005.

The Invasive Plant Association of Wisconsin www.ipaw.org
This association promotes better stewardship of the natural resources of Wisconsin by advancing the understanding of invasive plants and encouraging the control of their spread.

Invasive and Exotic Species Information www.invasive.org
The overall objective of Invasive.org is to provide an accessible and easily used archive of high quality images related to invasive and exotic species, with particular emphasis on educational applications.

Wild Ones: Invasive Plants http://www.for-wild.org/download/invasive.html
A collection of web sites with information on invasive plants.

Wisconsin DNR, Wildcards http://dnr.wi.gov/forestry/Publications/wildcards.html
Source for printing and/or purchasing Wisconsin Wildcards

INVASIVE PLANT INVADERS POSTER

Name_____

- Common name, spelled and used appropriately
- Scientific name, spelled and used appropriately
- Image (e.g., photo or line drawing) Extra credit: Find the plant and take your own photo!
- Distinguishing features (e.g., flowers, leaves, or fruits that identify the plant)
- Reproductive strategies (e.g., seeds, suckers, or fragments)
- Ecological damage it causes to environment (e.g., shading out, strangling, or stealing resources from native plants).
- Information detailing how it moved to Wisconsin
- What we can do to control the plant
- Where is your plant located within the state of Wisconsin?
- Reference List, you should use at least three sources on your poster, all sources should be included in a reference list included on the poster

Poster Requirement	**Exceeds Expectations**	**Meets Expectations**	**Does Not Meet Expectations**
Common name			
Scientific name			
Image			
Distinguishing features			
Reproductive Strategies			
Ecological Damage			
How it arrived in State			
Control			
Location			
References			

THE PLANT HUNTERS

Extension activities adapted from: Invaders of the Forest Educator's Guide to Invasive Plants of Wisconsin's Forests pages 39-44

SUMMARY

Students will learn how to identify local invasive plants, native wildflowers, and common trees.

LEARNING OBJECTIVES

At the end of this unit, students will be able to:

- Learn basic plant identification techniques
- Understand that reasons for and techniques used in "hunting plants" has gone through changes over time

TIME FOR PREPARATION: 30 minutes

TIME FOR TEACHING: Two 45-minute periods, could be an ongoing project

SETTING: Outdoors and classroom

MATERIALS:

- *Newcomb's Field Guide to Wildflowers* (in IPS kit)
- *Illustrated Guide to Trees and Shrubs* (in IPS kit)
- Plants in botanical mounts (in IPS kit)
- 10X hand lens (in IPS kit)
- Access to the internet

OUTLINE FOR THE TEACHING PRESENTATION

Getting Started

1. Bring in several different local weeds, wildflowers and leaves from local trees that students have probably seen before. As a class, ask them to call out the *names of the plants, if they know them. *Pictures of plants can be used if the weather is inclement*

2. When students recognize plants, ask them what characteristics about the plant allowed them to distinguish the plant. Ask the students to create a list of distinguishing characteristics in plants (such as flower shape, color, type and shape of leaf, habit of plant, bark on tree, branching, etc.)

3. Explain to students they will be using these types of characteristics to identify local **invasive plants**, **native plants** and trees. Tell them it's important for them to be able to distinguish native plants from invasive plants so the appropriate prevention and control strategies can be implemented.

Doing the Activity

1. Visit the Online Wisconsin State Herbarium. Handout the "Plant Hunters" worksheet" and take a virtual field trip to Wisconsin's online **herbarium**. Ask students to look up the plants listed on the worksheet and determine whether the plant is native to their area or an invasive. http://www.botany.wisc.edu/wisflora/

2. Introduce students to the *Newcomb's Field Guide to Wildflowers* and the *Illustrated Guide to Trees and Shrubs.* Move the students into groups of two or three and pass out copies of each field guide. Discuss the methods each key uses for identification.
    - *Newcomb's* requires users to answer a series of questions about a plant to determine a three-number-key that directs students to the correct plant. *Direct students to the pages in Newcomb's that explains the simple step-by-step identification process*.
    - The *Illustrated Guide to Trees and Shrubs* requires users to answer a series of questions about the type, shape and arrangement of leaves on tree branches for identification. *Direct students to pages that explain the key.*

3. Pass out the botanical mount plant unknowns from the IPS kit to students and ask them to identify the plant using any of the materials they have at their disposal. Each group should work on one mounted **specimen** at a time and each group should try to identify every plant in the collection.

4. When all groups have completed this task, reveal the names of the unknown plants. Ask students who answered correctly to explain the process they used to identify their plants. You may find students used a variety of techniques for plant identification, but explain that the basis of all their techniques was careful observation of distinguishing plant characteristics.

5. Ask the students to go back to the botanical mounts (now that they know the names of each plant) and work backwards with their field guides. This will help them to develop a better understanding of how the key system works in each guide.

6. Ask students to go outdoors and identify as many plants as possible. They should try to find and identify 10 trees and 10 herbaceous plants.

EXTENSION ACTIVITIES

1. Alternatively, instructors can visit the outdoor area and prepare a scavenger hunt for students. For the scavenger hunt instructors should identify 10 to 15 plants in the area (with a special focus on invasive plants if they are present) and ask students to work in their teams to find each plant on their list. Instructors with access to digital cameras can ask students to take pictures of the plants they've found.
2. Claim some fame! The Wisconsin State Herbarium keeps plant specimens from all around the state. If your students are the first to send a particular plant specimen from your county, their names will be listed permanently on that specimen and on the

WISFLORA Web site. Check the web site to see which invasives have not been collected in your part of the state. www.botany.wisc.edu/wisflora. You can find detailed directions for sending in specimens and an Invasive Plant Report Form on the WDNR's Web site www.dnr.wi.gov/invasives/futureplants/index.htm.

MHS students dentifying plants using the resources in the IPS Education Kit

ASSESSMENT

Quiz students on their ability to identify common plants using *Newcomb's Field Guide.* Bring in common Wildflowers and require students to use *Newcomb's* to identify specimens.

TEACH THE TEACHER

VOCABULARY

Invasive Plants - non-indigenous species or strains that become established in natural plant communities and wild areas, replacing native vegetation.

Herbarium – a collection of dried plants that are labeled with the plant species name, collection date, location site. Collection curators maintain the herbarium and provide access to plant material.

Native Plant – a plant that has been found in a given area long enough to have co-evolved with existing organisms to become an integral part of the plant community and surrounding ecosystem.

Plant Community – all the plant species that grow together within a specific area

Specimen – a plant submitted to a herbarium to be used as a representative example of a plant species found within a specific area.

WISCONSIN MODEL ACADEMIC STANDARDS

Grades 9-12 Science: B.12.4, C.12.3 F.12.5

RESOURCES

Illustrated Guide to Trees and Shrubs: A Handbook for the Woody Plants of the Northeastern United States and Adjacent Canada. By Arthur Graves. 1992. This book is an excellent

resource for identifying trees and shrubs in Wisconsin.

Newcomb's Wildflower Guide. By Lawrence Newcomb,1989. Published by Little, Brown and Co. This is an outstanding guide for identifying herbaceous plants in Wisconsin.

Invasive Plant Species: http://www.dnr.wi.gov/invasives/plants.asp
A Wisconsin DNR website with a species list for plants in Wisconsin which are known to be invasive in Wisconsin or may be potentially invasive.

Invasive Plants of the Future http://www.dnr.wi.gov/invasives/futureplants/index.htm
This Wisconsin DNR website is an online field guide for identifying and reporting the first set of target plants of the Early Detection Project. The target list will continue to be updated and expanded as new invasive plants threaten the state.

WISFLORA: Wisconsin State Herbarium. University of Wisconsin – Madison. 2005. Online listing of plants by common name, scientific name, habitat, status, and county. www.botany.wisc.edu/wisflora/

PLANTS Database http://plants.usda.gov/
Provides standardized information about the vascular plants, mosses, liverworts, hornworts, and lichens of the U.S. and its territories.

INTRODUCTION TO GEOGRAPHICAL INFORMATION SYSTEM (GIS) & GLOBAL POSITIONING SYSTEM (GPS) TECHNOLOGIES

Source: Alien Invasion: Plants on the Move; Bureau of Land Management, Weed Facts at http://weedinvasion.org Pages 227-272

SUMMARY

In this lesson, students will learn the basics of **GIS** and **GPS** technology. In an outside activity, students will learn how to use a GPS receiver and will apply their previously learned plant identification skills. These combined skills will be used in the next lesson, *Invasive Plant Inventories,* in which students will monitor the presence and density of invasive plant species in a nearby natural area.

LEARNING OBJECTIVES

At the end of this unit, students will be able to:

- Understand uses for GPS data
- Understand GPS terminology
- Operate a GPS receiver for marking the location of invasive plants

TIME FOR PREPARATION: 60 minutes

TIME FOR TEACHING: Two 45 minute periods

SETTING: Indoors and Outdoors

MATERIALS:

- *NASA: Destination Tomorrow?* DVD (in the IPS kit)
- *Introduction to GIS and GPS Technology*- one copy per student
- *Introduction to GPS Receivers*- one copy per student
- *Using the Garmin Legend GPS Receiver*- one copy per student
- GPS receivers (in the IPS kit)
- Garmin eTrex Series instructional video (*item in the IPS education kit*)
- *Newcomb's Wildflower Guide* (in the IPS kit)
- *Illustrated Guide to Trees and Shrubs* (in the IPS kit)
- *Invasive Plants of the Upper Midwest* (in the IPS kit)
- Flagging tape or wire flag markers (in the IPS kit)

OUTLINE FOR THE TEACHING PRESENTATION

Getting Started

Before class starts:

1. Install freshly charged AA batteries into the GPS receivers before starting the activity.

2. Spend time familiarizing yourself with the Garmin eTrex Legend GPS receiver. The Garmin owner's manual and instructional video are included with the IPS education kit. The Teacher's Resource CD contains supplemental information about GPS, including a

GPS PowerPoint presentation and additional class activities.

3. For each receiver, turn on, go to the Main Page, click on “Setup”, click on “Units”, and set “Position Format” to “hddd^{o} mm’ ss.s” (degrees, minutes, seconds); directions are on page 44 in the eTrex Legend owner’s manual. Also, follow the directions on page 20 of the manual to reset settings for each receiver before starting the lesson (this will not change the “Position Format”.

4. Visit a natural area close to your school and mark the location of at least ten different invasive plant species with flagging tape or wire flag markers. Make sure the area is large enough so that 200 feet separates the different flagged plants. Be sure to record the names of the plants and their **GPS** (Global Positioning System) coordinates to create a key for *The Hunt is On* student page.

Doing the Activity

Day One

1. Show students the *NASA: Destination Tomorrow* DVD. This movie is only 5 minutes long and is a nice introduction to Global Positioning System (GPS). Discuss the movie with the class and explain how they will be trained to use the eTrex Legend GPS receivers to conduct an Invasive Plant Species Inventory in a future lesson.

2. Explain to students that invasive plant 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 invasive plant species is one method scientists use to track the spread of invasive plants. Almost every management district in the country uses GIS and GPS technology to map the location of invasive plants.

3. Give each student a copy of the *Introduction to GIS and GPS Technology* and *Introduction to GPS Receivers* student pages.

4. Have students read the information and complete the word puzzle.

5. Pass out the GPS receivers (1 per 2 people) and have the students watch the first 10 minutes of the eTrex Series instructional video. Students can practice using the receivers while watching the instructional video.

6. After viewing the video, give each student a copy of *Using the Garmin Legend GPS Receiver* (Student page) and have them go outside and practice using the GPS receivers using these directions. The Teacher Resource CD contains additional GPS activities that you might want to incorporate if time allows.

Day Two

1. After students feel confident finding their location on the receiver, have them start *The Hunt is On* activity. Show students the boundaries of the study area and ask them to stay within those boundaries for this activity. (*Hint: It would be a good idea to choose one site to practice with the students before letting them do the activity on their own to answer any questions the students might have.*)

2. Ask students to find the “flagged” plants. When they locate a plant, they should write the name of the plant and its coordinates on *The Hunt is On* worksheet.

3. Optional: to make the exercise more competitive, record the time it takes for students to complete the activity.

IPS Education Kit team members practicing using the GPS unit

EXTENSION ACTIVITES

1. A guest speaker would be a great addition to this lesson. Contact local agencies to find someone who does this for a living to bring in a real world connection.

ASSESSMENT

Use *The Hunt is On* activity to evaluate students on their ability to identify invasive plants and use GPS receivers to determine UTM coordinates.

TEACH THE TEACHER

VOCABULARY

GPS – global Positioning System is a satellite-based navigation system
GIS – geographical Information System is a digital map with a database connected to it.

GLOBAL POSITIONING SYSTEM

GPS technology was originally developed by the U.S. Department of Defense for use by the military. The U.S. government operates and maintains the satellites that comprise the GPS.

A GPS receiver helps you find your location and other locations on the earth. With a GPS receiver, you can navigate to a specific location. GPS receivers are available, at relatively low

cost, from several manufacturers. Easy access to receivers has contributed to an increase in their use. Here are some of the ways in which people use GPS receivers:

- Outdoor activities - Recreationists use GPS receivers to Goto and mark locations of interest while skiing, hiking, and fishing.
- Travel - Some cars have built-in GPS receivers to help drivers navigate to a specific location.
- Search and rescue - GPS technology helps search and rescue personnel locate victims and plan rescue routes.
- Professional - Land managers, biologists, foresters, and other professionals use GPS technology to mark and map the locations of plants, animals, landmarks, and important sites.
- Safety personnel - Using GPS technology, fire fighters and ambulance drivers can locate the nearest fire hydrants and plot the fastest route to a location.
- Fun - Many people use GPS receivers to navigate during road rallies and for the growing hobby of geocaching.

The accuracy, features, and functions of a GPS receiver vary by manufacturer. For example, some receivers can display maps of the earth. With some receivers, you can transfer data between the receiver and a computer. Every GPS receiver has functions that enable you to enter the coordinates of a specific location and then navigate to those coordinates.

WISCONSIN MODEL ACADEMIC STANDARDS

Grades 9-12
Environmental Education: E.12.3
Nature of Science: B.12.4
Life and Environmental Science: F.12.7, F.12.8
Science Performance Standards: H.12.6

RESOURCES

Garmin website http://www.garmin.com/garmin/cms/site/us
For additional resources for using the Garmin Legend GPS units.

GPS and Geocaching Lesson Plans: http://lovinfifth.com/gps/GPS-activities.htm
Great website for additional GPS activities and lesson plans, including geocaching.

The Science Spot: http://www.sciencespot.net/Pages/classgpslsn.html
GPS and GIS lesson plans and links.

GPS in Education http://education.usgs.gov/common/lessons/gps.html
U.S. Geological Survey (USGS) website listing examples of how GPS can be used in education.

What is GIS? http://www.gis.com/whatisgis/
This ESRI supported website provides introductory information on the applications of GIS.

Introduction to GIS and GPS Technology

About Geographical Information System (GIS) Technology

Have you ever used a map? Perhaps you have used one to follow a series of highways and freeways while driving to a distant town. Maybe you have used a map to find your way to the top of a remote mountain while hiking. Or maybe you located the restaurant nearest your hotel using a map. Maps are very useful.

Have you ever wished that a map had more information or that the map could perform calculations? Imagine a road map that specifies the number of miles between a rest stop and the next exit and calculates the time needed to drive the distance. Or imagine a **topographic** map that indicates the number of miles to the top of a mountain, calculates how far you can see from the mountaintop, and alerts you to obstructions that might block your line of sight. A map that shows the number of fast-food restaurants within the city limits and calculates the number that are within one mile of your hotel could be very helpful. By using a GIS, all of this information and more is available to you with a click of your mouse.

In its most basic form, a **GIS** is a digital map with a **database** connected to it. Standard information appears on the digital map. However, you may see additional information about any specific item on the map by clicking the map. The transportation systems in a city, number of hotels in a town, or facilities available at a county park are all useful facts that usually cannot fit on a paper map. In a GIS, this additional information is stored in a database that is linked to a map. By using the database and certain functions within GIS software, you may locate additional information and perform calculations.

About Global Positioning System (GPS) Technology

If you have ever spent an evening staring at the stars, you may have seen a slow-moving object. The object might have been a satellite. There are many **satellites** in space. They are used for satellite TV, cellular phones, military purposes, and other applications. GPS receivers also use satellites.

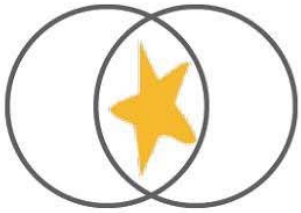
Finding your way in a shopping mall or large department store can be confusing. Perhaps you have used a mall directory with a star labeled *you are here*. The star suddenly gives you a sense of place so you can find your location. A GPS receiver is similar to that star, but on a much larger scale.

GPS receivers communicate with moving satellites to pinpoint a specific location. When you use a GPS receiver, it creates a *you are here* star for you on a global map.

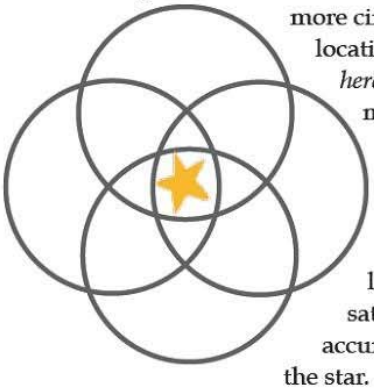
Suppose one satellite transmits a signal to a GPS receiver. Satellites are in a locked (known) orbit, so the GPS receiver is able to calculate where it is in relation to the satellite. If the GPS receiver communicates with only one satellite, it can create only one very large *you are here* star.

Introduction to GIS and GPS Technology

If another satellite transmits a signal, the GPS receiver can create two large circles. The *you are here* star fits in the area where the two circles overlap.



If three or four satellites transmit a signal, the GPS receiver can create more circles, and the location of the *you are here* star becomes more accurate.



A GPS receiver usually needs to receive a transmission from at least four different satellites to ensure accurate placement of the star. If every satellite in the sky communicated with your GPS receiver, a circle would still surround your star, plus or minus five meters. Some GPS receivers are able to limit the size of their circles to one centimeter! The GeoExplorer 3 is one brand of GPS receiver. This receiver is able to pinpoint a location to within about five meters.

Place a pencil in a clear glass of water. Notice that the pencil appears to bend where it touches the water. If you're not convinced that the pencil is straight, pull out the pencil to make sure it is. The pencil appears to bend when it's in the water because when lightwaves make contact with the water, the lightwaves **refract** or bend, which makes the pencil appear bent.

Satellite signals sometimes behave in a manner similar to light. Sometimes satellite signals do not follow a straight line. When satellite signals encounter interference, for example air patterns in the atmosphere or uneven geography, the signals sometimes bend, just like the lightwaves. Sometimes the signals bounce off objects before the signals reach a GPS receiver. This interference makes the signal less accurate, and gives it a high Positional Dilution of Precision (**PDOP**).

A high PDOP equates to less accuracy. A low PDOP equates to more accuracy. You may set the GeoExplorer 3 to collect signals at a high or low PDOP. Remember, the higher the PDOP, the less accurate the signals, and the less accurate the placement of the star.

High PDOP = less accuracy
Low PDOP = more accuracy

How to Use GPS technology

Now you know what a GPS receiver is, how it works, and how you can make it more accurate. You may wonder about the purpose of a GPS receiver and why it is important to place the *you are here* star in an accurate location. There are many uses for the geographical information that you can collect using a GPS receiver. Every day, people think of more ways to use the information. The following examples are just a few of the possible uses for GPS technology:

- With GPS information, ambulance drivers can quickly locate the *you are here* star of whomever makes the call.
- Firefighters can use a GPS receiver to locate the sites of all hydrants. When a fire occurs in a building, firefighters can look at a map to determine where to park for the best access to a hydrant.
- Mapmakers can use GPS technology to create better maps. Satellite communications are more accurate for pinpointing roads and landmarks than drawing maps by hand.

Why you should learn about GPS Technology

GPS technology offers more opportunities each day, as people think of new ways to use the technology. A variety of job opportunities are available to those who understand GPS technology.

Introduction to GPS Receivers

GPS receivers come in many different shapes, sizes, and colors. The features and functions that are available vary by manufacturer and model. The table below shows the basic functions that are generally available on every GPS receiver and some of the terminology used.

Feature	Function
Bearing	A direct line of travel between your starting point and your destination. The bearing is a compass direction.
"Bread crumb trail"	A simple map of your trail—where you are going or where you have been. You enter waypoints along the trail.
Coordinate	A set of numbers and letters that define a location. Coordinates may be in latitude/longitude or Universal Transverse Mercator (UTM). Set your GPS receiver to match the coordinate system you are using.
Goto	Use the Goto function to guide you to your destination.
Ground Speed	The speed at which you are traveling.
Map Datum	A reference point for drawing a map. Every map lists map datum, usually near the title for the map. There are several types of map datum in use. Set your GPS receiver to match the map datum listed on the paper map you are using.
Mark	When a GPS receiver is ready to navigate, use this function to define your location as a waypoint.
North Reference	A compass needle points to the earth's magnetic north. True North (geographic north) is a fixed point at the end of the axis on which the earth spins. Grid north corresponds to the grid lines drawn on a map. Set your GPS receiver for the north reference you want to use. Usually, the GPS receiver will correspond to your compass if the receiver is set to magnetic north.
Units of measure	Units of measure are used to record your distance and speed. Three units commonly used are statute (miles and miles/hour), nautical (nautical miles and knots), and metric (kilometers and kilometers /hour). Set your GPS receiver to the units of measure you want to use.
Waypoint	A set of coordinates for a specific location, landform, or object. Use waypoints to guide you to your destination. You can enter waypoints manually into a GPS receiver by reading coordinates from a map, and you can use a GPS receiver to determine and record the waypoints for your current location.
Satellite information	The receiver shows the number of satellites with which it has contact. When the GPS receiver is in contact with enough satellites, a "ready to navigate" message is often displayed.

Name_____

Introduction to GPS Receivers

1 The direction in which a compass needle points.
n h o h m n c i a t r r t e s g t a e

2 A set of coordinates for a specific location.
t i y o a p w n

3 A direct line of travel between your starting point and your destination.
r a g n e b i

4 Use this function to guide you to your destination.
o o t g

5 A type of coordinate.
t u n s s r r e l a n a s v i t m e c a r r o v e r e

6 A GPS receiver is ready to navigate when it is in contact with these.
t e l s l e s t i a

USING THE GARMIN LEGEND GPS RECEIVER

Since most GPS receivers won't work indoors, the first step is to go outside in a relatively clear area and turn on the receiver. Receivers should work fine in any weather condition or any time of the day.

1. Turn on the eTrex Legend by pressing and holding the *Power* button.

2. The first screen you will see will be the Satellite page. Wait and observe the number and position of satellites the unit is receiving. The Skyview graphic on this page represents a view looking up at the sky from your current location showing satellites and their assigned numbers. The outer ring represents the horizon, while the inner ring represents an overhead view of the sky at 45 degrees from the vertical. The black bars along the bottom of the screen represent satellite signal strength. The satellites you are receiving will be represented by black bars. Also notice that the latitude, longitude, and elevation are also shown.

3. When sufficient satellites are received, ***Ready to Navigate*** will display at the top of the screen.

4. Look at the bottom of the Satellite Page to see your location coordinates.

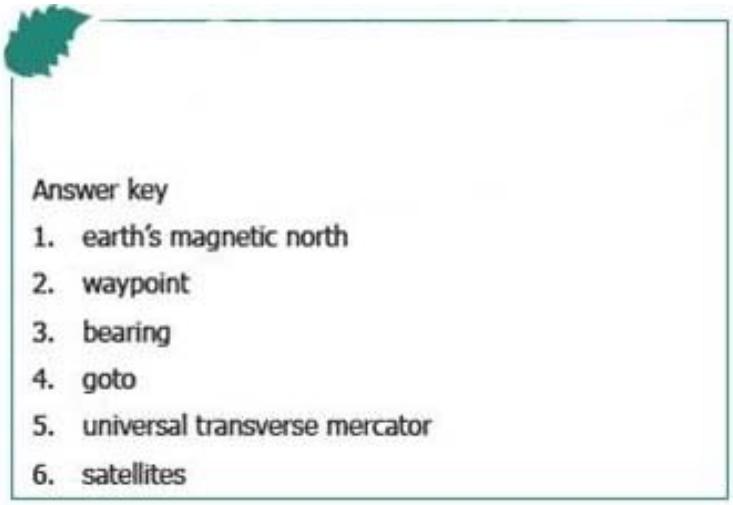
The Hunt is On

Name_____

Your teacher has "flagged" the location of different invasive plants. You need to find those plants and complete the table below using a GPS receiver and plant identification guides.

Name of Invasive Plant (Common and Scientific)	Description of the Location	GPS Coordinates Degrees, Minutes, Seconds	
		Latitude	Longitude

Answer key for the GPS word puzzle



Make Your Answer Key

The Hunt is On

Your teacher has "flagged" the location of different invasive plants. You need to find those plants and complete the table below using a GPS receiver and plant identification guides.

Name of Invasive Plant	Description of the Location	GPS Coordinates Degrees, Minutes, Seconds	
		Latitude	Longitude

INVASIVE PLANT SPECIES INVENTORY

Source: Alien Invasion: Plants on the Move; Bureau of Land Management, Weed Facts at http://weedinvasion.org Pages 219-226

SUMMARY

After learning about the impact of invasive plant species, students often want to know how they can make a positive contribution. This lesson provides one example of how students may help. Students will apply skills learned in previous lessons to conduct an Invasive Plant Species Inventory in a forested area with restoration potential. Students should know how to identify plants. Ideally, the inventory should be conducted in the natural area where the invasive plant species removal project will be conducted.

LEARNING OBJECTIVES

At the end of this unit, students will be able to:

- Understand the importance of invasive plant inventories
- Conduct an invasive plant inventory

TIME FOR PREPARATION: 30 minutes

TIME FOR TEACHING: 45 minutes

SETTING: Indoors and outdoors

MATERIALS:

- *Invasive Plant Inventory Protocol*- one copy for each student
- 30-meter measuring tape for establishing transect lines
- Compasses: 1 per Bearing Team (in the IPS kit)
- Plastic tent stakes: 3 per Transect Team (in the IPS kit)
- Plot frame (1m x 1m): 1 per Bearing Team (in the IPS kit)
- *Newcomb's Field Guide to Wildflowers* (in the IPS kit)
- *Invasive Plants of the Upper Midwest* (in the IPS kit)

OUTLINE FOR THE TEACHING PRESENTATION

Getting Started

1. It is assumed that students have used compasses before. However, if that is not the case, the *Using A Compass* lesson is included in the IPS Teacher Resource CD under "Supplemental Activities". These activities will require an additional teaching day.

2. Explain to students that land managers are individuals who are trained to manage private and public lands. The National Park Service, Bureau of Land Management, Natural Resource Conservation Service, Wisconsin Department of Natural Resources, state extension services, and city and county park departments are examples of

governmental agencies that employ land managers. Preventing and controlling the spread of invasive plant species is a high priority for most land managers. They need to know the locations of specific invasive plant species, whether they are spreading, and the effectiveness of management practices. Inventories help provide this information.

3. Review information about inventories with students. Students should understand that invasive plant inventories are used to monitor the presence/absence and density of invasive plant species on private and public lands. Conducting inventories before an invasive species removal project provides important baseline data, a benchmark against which change that occurs during the project period can be assessed. Ideally, the inventory should be conducted annually for at least 3-5 years after the project to determine the effectiveness of specific management plans.

4. Discuss **transect lines** and **plant stem counts**. Explain that students will set up a transect line outdoors, count the number of live invasive plant stems in plots along the transect line, and estimate the population of invasive plant species, based on their stem counts.

Doing the Activity

1. Give each student a copy of the *Invasive Plant Inventory Protocol*.

2. Divide students into Transect Teams, with at least 9 students per team.

3. Each Transect Team of 9 students will be sub-divided into 3 Bearing Teams of 3 students each. Assign each 3 person Bearing Team one of the following transect bearings: 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 invasive plant species stems.

EXTENSION ACTIVITES

1. After conducting the Invasive Plant Species Inventory, calculate the density of each invasive plant species: 1) Calculate the total area of all plots: multiply the total area of one plot ($1m^2$) by the number of plots sampled; 2) Divide the total number of stems for each species by the total area of all plots to get the density for that species. Repeat for each invasive plant species; 3) Total density of all invasive plant species can be found by adding the totals for each species together, and dividing by the total area sampled.

2. While conducting the Invasive Plant Species Inventory, have students also identify and record the number of stems of native plant species for each plot.

3. Arrange to have students conduct plant inventories in the same area at a later date to determine if the invasive plants are spreading.

ASSESSMENT
Evaluate students by observing them as they complete the field work and determining if they estimated the population density correctly.

TEACH THE TEACHER
VOCABULARY
Transect – a line, made with a tape measure, so that measurements may be taken at regular intervals
Plant stem counts – a quantitative method for determining the density of invasive plant species in a land area

LAND MANAGEMENT FOR CONTROLING INVASIVE PLANT SPECIES
After managers have identified invasive plant species and understand why and how the species have become a problem in an area, they need to know how far the invasive plants have spread. Managers can devise strategies to quantify and then control an invasion when they understand the plant biology, ecosystem dynamics, and extent of the problem. Invasive plant inventories are an important tool for managers because they provide data that is important to developing effective control strategies.

To manage invasive plant species effectively, a manager must answer the following questions:

- Does the plant grow in this area? If so, where is it located?
- How serious is the infestation?
- How quickly is the infestation spreading?
- What are the characteristics of this invasive plant?

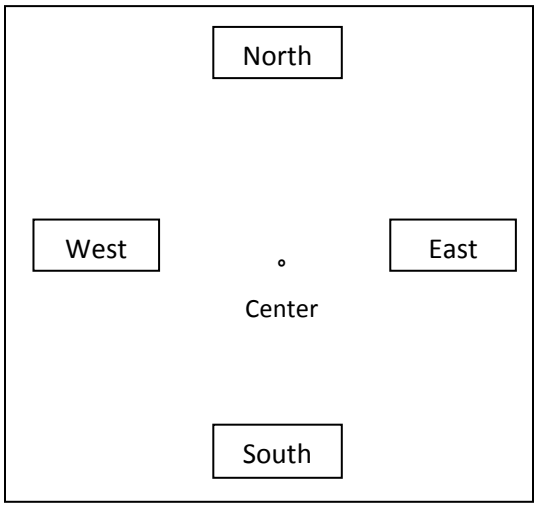
Land managers can use the data from the invasive plant species inventory to develop an invasive plant species management program. Later, the manager might conduct another inventory to determine the effectiveness of the management practices. This second inventory would show an increase or decrease in the size of the infestation over a period of several years.

PLANT INVENTORIES
In actual invasive plant inventories, timing is critical for accuracy. Timing varies with the targeted species and the plant identification skills of the field staff. Inventories usually occur when the target species are in full bloom, because the plants are most obvious to observers when in this state. To ensure the reliability of information, managers follow strict protocols or procedures when collecting information during inventories. This lesson focuses on the following protocols:

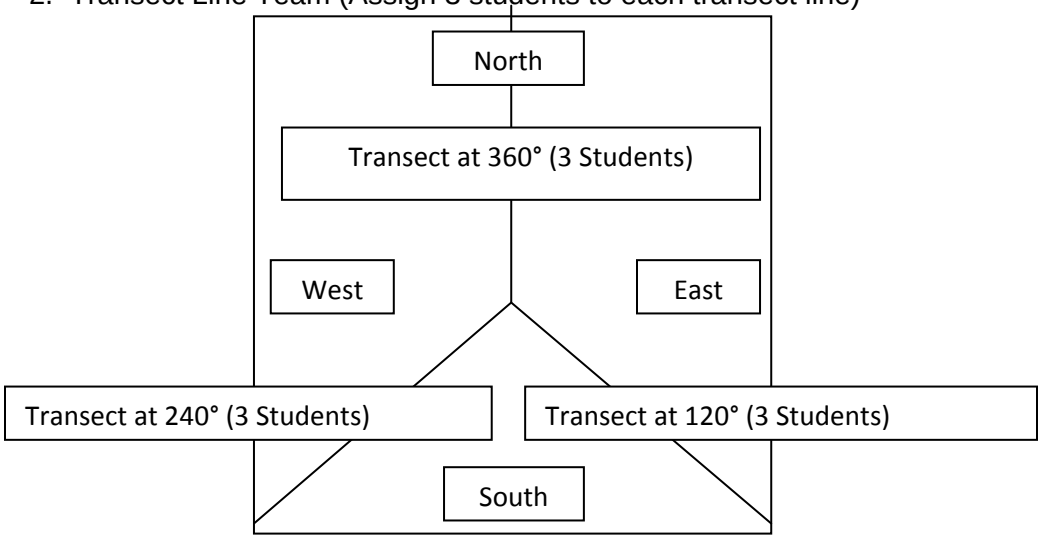
SETTING UP A TRANSECT LINE
A transect line is a straight line laid out randomly or systematically within a study area. One or more transect lines may be set up within a study area. Managers often divide the area along the transect line into small plots and observe and record plants that occur within the plots.

Detailed Diagrams for Setting up the Transects

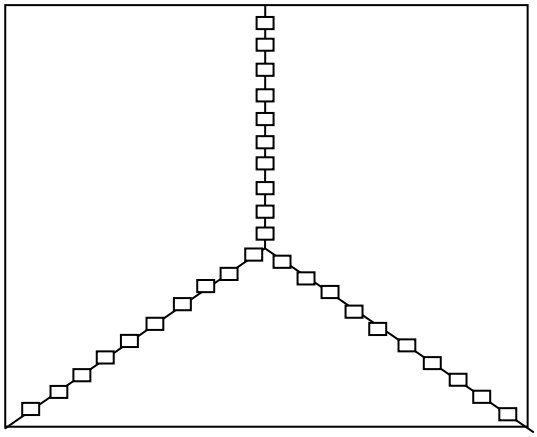
1. Site Location (Assign 9 students to each site location)



2. Transect Line Team (Assign 3 students to each transect line)



3. Plots (Every 10 feet, lay down the plot frame and count plant stems)



CONDUCTING INVASIVE PLANT STEM COUNTS

By counting the number of live invasive plant stems within a plot, managers can estimate the density of these plants in a study area.

WISCONSIN MODEL ACADEMIC STANDARDS

Grades 9-12

Environmental Education: D.12.5

Science: C.12.3

RESOURCES

Invasive Plants of Wisconsin

http://www.uwgb.edu/biodiversity/herbarium/invasive_species/invasive_plants01.htm

Lists plants that are the most serious invasive species in northeastern Wisconsin.There are numerous sites on the web with good information on these species, including control methods.

Monitoring Ecological Effects Handbook, http://www.fs.fed.us/r3/spf/cfrp/monitoring/pdf/mm4.pdf

This multiparty monitoring handbook is part of a series of guides to monitoring collaborative forest restoration projects. The series was written specifically for projects funded through the USDA Forest Service's Collaborative Forest Restoration Program (CFRP)

Volunteer and Invasives Program http://www.refugenet.org/New-invasives/vimp.html

In collaboration with the Center for Invasive Plant Management (www.weedcenter.org), the National Wildlife Refuge System (NWRS) has developed an invasive plant online training program for volunteers.

Wisconsin Weed Watcher http://dnr.wi.gov/invasives/futureplants/weedwatcher.htm

This Wisconsin Invasive Plants Reporting and Prevention Project is an early detection and strategic response initiative co-sponsored by the Wisconsin DNR and the Wisconsin State Herbarium.

Global Garlic Mustard Field Survey

http://invasionsrcn.org/portal/activities/alliaria-sampling/AlliariaProject_Feb2009.pdf/view

This pdf file includes detailed instruction on how to collect the data, and a sample data sheet that can be used for recording the data. This website is supported by the Global Invasions Research Coordination network, an international network of scientists supported by the U.S. National Science Foundation, and provides a resource for scientists working on invasions to find colleagues located in geographic regions of interest to aid in sampling and experimental work.

INVASIVE PLANT INVENTORY PROTOCOL

Set Up a Transect Line

Scientists cannot count, measure, and record attributes for every plant in a forest. Monitoring every plant would be very time consuming. Instead, scientists study small plots that represent the whole area.

Scientists often use a transect line to collect scientific 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 invasive plant stems present, scientists can determine the density of invasive plant species.

1. Your Site Team will be assigned a specific study area to conduct the inventory.

2. Mark the center of the study area with a rock or other object. Use the compass to find North. This bearing represents 360 degrees. Have someone stand over the center of the study area with a compass.

3. 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.

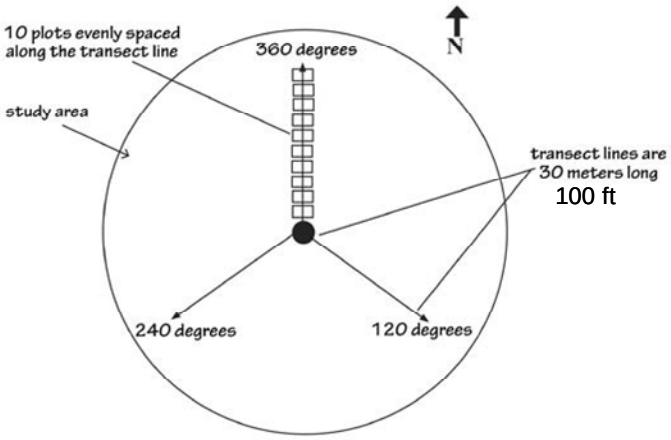
4. Have the person in the center push the tent stake attached to one end of the transect line into the center point.

5. Have a second student take the transect line 100 feet away, in the direction of their team's compass heading.

6. Align the transect line with the angle determined by the compass. Pull the line taut, and firmly plant the transect stake into the ground.

7. Repeat steps 5 through 9 to set up the transect line for each Transect Line Team (120, 240 or 360 degrees).

8. Once the transect lines are in place, each team may begin the plant stem count.



Conduct Stem Count

Names: _____ Date: _____

Directions

1. Starting at the beginning of the transect line and go to the first 10 feet. Place the plot frame at the center of this point. For each invasive plant species, count the number of live stems inside the plot frame; record this number on the chart below. Record the GPS coordinates (location) for each plot frame.

2. Repeat for every 10 feet until 10 plot frames have been recorded.

Location of Study Site: _____

Circle your Bearing Team's transect line location: 120° 240° 360°

Plot Frame #	GPS Coordinates Degrees, Minutes, Seconds		For each frame, list the different invasive plant species and count the number of stems for each species.	
	Latitude	Longitude	Invasive Plant Species	Stem Count
1				
2				
3				
4				
5				
6				

7				
8				
9				
10				

Determine the density of each invasive plant species by adding the total number of stems for each species and dividing by the total area sampled (10 plots x $1m^2$ each = **$10m^2$**).

Plant Species	Total Number of Stems	Density (Total number of stems divided by 10)

INVASIVE PLANT SPECIES CONTROL

Sources: Invaders of the Forest © 2005 WEEB, WDNR, Park People of Milwaukee County; Pages 113-123 and Alien Invasion: Plants on the Move; Bureau of Land Management, Weed Facts at http://weedinvasion.org Pages 273-302.

SUMMARY

Students will list the different ways invasive plants are controlled and find out more about mechanical controls that they can do. If resources and support are available, students will work in cooperation with a government agency to complete an invasive plant species removal project in a nearby natural area.

LEARNING OBJECTIVES

At the end of this unit, students will be able to:

- Understand the importance of managing invasive plant species
- Differentiate between control and eradication of invasive plants
- Discuss the seven methods of invasive plant control and the advantages and disadvantages of each method.
- Manage invasive plants by physically removing them from a specified area

TIME FOR PREPARATION: varies depending on the project

TIME FOR TEACHING: varies depending on the project

SETTING: Indoors and Outdoors

MATERIALS:

- *Wisconsin Wildcards* (in IPS kit)
- *How to Control Invasive Plants*- one copy per student
- *Invasive Plants of the Upper Midwest* (in IPS kit)
- Teacher's copy of the book *Invasive Plants: Weeds of the Global Garden*; the chapter titled "Tools & Techniques: Chemical-free Weed Controls" is a great resource for this lesson (in IPS kit)

OUTLINE FOR THE TEACHING PRESENTATION

Getting Started

This is the capstone activity! You've tracked down and identified invasive plants. Now it's time for you and your students to take action and make a difference for the environment!

1. Establish a partnership with an expert from a local government agency involved in the control of invasive plants. This person can help identify strategically important sites, provide guidelines to ensure that students make a positive contribution, and provide background information so students learn about their local environments. If possible, ask them to give a classroom presentation and walking tour of the natural area, describing how management plans are used to control invasive plant species. Try to choose a person who is aware of conditions in the area and enjoys working with students. With this expert, plan a course of action that will be meaningful to students and beneficial to invasive plant control efforts.

2. Decide if your project will be **site-specific** or **species-specific**. In other words, you can choose to try to eliminate all the invasives in an area or to eliminate all the plants of a

particular species. If this is your first project of this kind, you should probably concentrate on one species. With help from the local expert, decide which control method to use, what materials or tools you need, what time of year to conduct the control, and how often you should repeat the control measures. Don't be afraid to ask for help at this stage! Lists of experts in Wisconsin who are willing to help are included on the IPS Teachers Resource CD.

3. Work with your school grounds department and other local government agencies (e.g. Department of Natural Resources, city and county parks departments) to obtain supplies for your restoration project. Work gloves and protective goggles/glasses are the minimum requirement for an invasive plant species removal project. Shovels and hand saws should be available to remove larger woody plants, such as buckthorn and honeysuckle. Local businesses are often willing to donate items that benefit the community.

4. As you plan a control project, consider these things:
    - Age and abilities of the students
    - Availability of appropriate tools
    - Plant sensitivities. Be sure the plants you intend to control are safe (i.e., avoid plants that can cause rashes)
    - Safety of the site. Check out the site ahead of time to be sure there aren't any safety hazards (e.g., broken glass, garbage, poison ivy, hornet nests, etc.)
    - Preparedness of the students. Review how to dress for success (i.e., long pants, long sleeves, sturdy shoes, water bottles, sunscreen, mosquito repellent)
    - Tool/equipment safety. If you are using tools, be sure students know how to use them safely, when to wear safety glasses, and where to place tools when done
    - Follow-up treatment. If an herbicide application is needed after cutting trees and shrubs, make arrangements for certified adults to accomplish the task within the recommended time limits.

5. Before class starts make sure all supplies are organized. Work gloves and safety goggles should be available for all students.

<u>Doing the Activity</u>

1. Have students brainstorm a list of invasive plant species control methods. List all the ideas on the board.

2. Pass out *Alien Invaders Wildcards*. Allow time for students to read the cards. Look for control methods on the back of each card listed under "Management." Ask students if their cards list one or more control methods.

3. Have students read the student page *How to Control Invasive Plants.*

4. Look back at the list of control methods that you listed in step 1. Circle the manual control methods that students can do. Depending on their age, students could control invasives by:

- Pulling by hand.
- Pulling with tools (shovels)
- Cutting (saws or pruners)
- Beheading (scissors or pruner)
- Severing roots (shovel)

5. Have students carry out the invasive plant species removal project. Students might need a little fun thrown into their invasive control project. Consider some of these ideas:
    - Divide into teams. Lay down a large tarp for each team. Which team has the biggest pile of invasives after 10 or 20 minutes of pulling? If laying down a tarp would damage desirable vegetation, count the number of full garbage bags per team.
    - When pulling plants with taproots, have a contest to see who can pull out the longest intact root. Brainstorm other possible challenges (e.g., plant with the most flowers/seeds or tallest plant).Gather pledges for each stem, pound, or bag of invasive plants pulled. Use the pledge money to revegetate an area with native plants.

6. Follow through. Monitor the area as long as possible and schedule additional work days if necessary.

7. Record your project and lessons-learned in the IPS kit journal (included in the IPS education kit). This journal will stay with the kit as a feedback mechanism for tracking kit use and project success.

EXTENSION ACTIVITIES

1. Ask students to work individually or in small groups to research control methods for an invasive plant. Try to select plants that you know are problems in your area or your school forest. Students should use print and Internet sources. Instruct them to note if one or more control methods are recommended and if those methods are to be used together, consecutively, or in rotation. Remind them to consider the plant's life cycle when determining the most effective time to implement control methods. Ask students to present their information. Discuss whether all the sources agree on all aspects of control. Why would different sources recommend different practices? When using the Internet, be sure students record the source of information. Is the source reliable? Is the source local?

2. To help increase invasive plant species awareness, have students make a presentation about their control efforts to their peers or the community.

3. Get the community involved in the project. Ask for support from parents, other teachers, your principal and community DNR supporters.

4. If funds are available, work with local officials and businesses to create and install a sign next to your restored area. This is a great way to advertise your financial donors' support and educate the wider community about the importance of controlling invasive plant species.

ASSESSMENT
When students have completed the project, ask students to reflect on their accomplishment by writing an essay (300 words or more) describing what they learned about invasive plant species and the importance of managing these plant populations.

TEACH THE TEACHER
VOCABULARY
Site Specific – focus on removing all invasive plant species within a specific natural area
Species Specific – focus on removing one specific invasive plant species from a natural area

CONTROL OF INVASIVE PLANT SPECIES
It is impractical to believe that we can eradicate invasive plants. Invasive plants have developed adaptations that enable them to survive in a wide range of environmental conditions. Seeds of invasive plants can often remain dormant in the soil for many years. According to most experts, it is more realistic to control or manage invasives so native plants can compete successfully.

Managers control invasive plants using the seven methods described below. Each method has advantages and disadvantages. Managers have achieved the most success when they use a combination of methods.

PREVENTION
This method, which is the most effective and least costly, focuses on preventing invasive plants from entering an area. Prevention requires following certain procedures. Farmers, growers, and anyone who purchases seed must use only certified “weed free” seed. Plants purchased from nurseries must be inspected to ensure the plants are free from invasive plant seed, stolons, and roots. Plants must be tested before they enter this country from other countries, regardless of how attractive or functional the plant may appear to be.

CHEMICAL
Chemical control methods involve using herbicides. Herbicides are classified according to types of chemicals, time of application, and their effect on plants. (Some herbicides kill all plants; others are species-specific.) Chemical control is generally used to kill invasive plants quickly. It is also used for very large or small areas of infestation. The disadvantages of chemical methods include cost, damage, and danger. Many chemical sprays are very expensive to purchase and apply. Chemicals can damage or kill other plants, animals, and fish. Runoff from chemicals can spread through waterways and cause damage to plants and animals far from where the chemical was applied. Chemicals can harm people too. Land managers must exercise caution when mixing and applying chemicals.

BIOLOGICAL
Biological methods use insect or disease agents to kill specific invasive plants. Natural predators from the plant’s native country are often identified, tested to ensure they won’t harm native plants, and then released in our country. This method can be safe for the environment. However, it is usually very time consuming to develop a biological control. It takes years to test biological control agents, and it usually takes years before a biological control agent makes a significant impact in infested areas.

CULTURAL
Cultural methods include rotating crops, selecting plants that compete successfully with invasive plants, using drip irrigation methods, and introducing animals to eat invasive plants. Generally,

these methods are safe for the environment, but they are time consuming and require more labor than chemical or biological methods.

MULCHES

Homeowners are using mulches more frequently. This method includes placing 2-4 inches of grass clippings, wood chips, or other organic matter around desired plants. The mulch effectively prevents invasive plants from sprouting. Plastic groundcovers raise the soil temperature to a level that kills seeds. The disadvantage of mulch is the time and labor involved in obtaining and applying the mulch and maintaining mulched areas.

MECHANICAL

Mechanical methods employ plowing fields and digging or pulling invasive plants by hand. Fire is also a mechanical method. Mechanical methods generally have a low impact on the environment. They are time consuming to implement, and can be very expensive in terms of labor costs.

INTEGRATED MANAGEMENT PROGRAMS

The most effective management efforts integrate or combine several, if not all, of the above methods. For example, a manager may spray an area to kill invasive plant seeds, then release beetles and bring in goats for long-term suppression, while introducing plants that can out-compete the invasives. Managers also time their control efforts to when the plant is most vulnerable. For example, the best time of the year to control buckthorn is late fall when native plants are dormant and the buckthorn sap is flowing downward. At this time, cutting the shrub and painting the cut stump with herbicide can be very effective.

Many of the regional and national management and control methods for invasive plants require significant amounts of time, equipment, and money. At the local level, students can participate in meaningful activities that require small expenditures of time and money. Chemical, biological, and cultural controls are usually the most effective methods to control large invasive plant infestations. Students can perform a valuable service by physically removing invasive plants from small, strategically important sites, such as the following:

- Streams, campgrounds, trail heads, ATV loading sites, and other locations where invasive plants can easily spread
- Riparian zones and sensitive locations that cannot be sprayed
- Locations that require immediate control before invasive plants spread

If students intend to visit a site that is heavily infested with invasive plants and physically remove the plants, plan carefully to ensure that the exercise has a meaningful and significant impact on students and the environment. Lack of planning can result in a disorganized, insignificant, and environmentally worthless project.

EXAMPLES

The following two examples show how students performed valuable services by identifying a potentially serious invasive plant infestation, alerting managers, and physically removing invasive plants from a critical habitat area. Both examples required a minimal amount of planning and expensive equipment.

Example 1

While students were conducting an invasive plant inventory project, they located a potentially serious infestation near a popular, yet remote campground site. The county weed

superintendent realized that the site was used frequently by backpackers, hikers, mountain bikers, and horseback riders, so the invasive plants could easily spread. He also realized that he could not safely spray the site because of its close proximity to water. The chemical spray could also pose a potential health hazard to campers and picnickers. He decided to solve the problem by teaching community groups about the seriousness of invasive plant species issues and enlisting their support to physically remove the plants. Students performed a valuable service by identifying the invasive plants during their inventory project. Students could have been involved in the eradication efforts too.

Example 2
State Fish and Wildlife officials, who were responsible for managing an elk winter refuge, became alarmed at the increase in hitchhiker invasive plants along streams where elk bed down during the winter months. The seeds from these plants, specifically burdock and hounds tongue, stick to animal fur. The seeds mat the animal's fur, which prevents the fur from providing insulation against the cold.
Fish and Wildlife officials were concerned that elk calves would freeze to death during severe cold temperatures if the seeds became embedded in their fur.
Fish and Wildlife officials identified the infestations just prior to the onset of winter; the invasive plants had to be removed quickly. It was not safe to use chemical sprays in the area, so Fish and Wildlife officials asked students to help. Students spent a day at the elk refuge pulling invasive plants. Under the direction of Fish and Wildlife officials, students learned about the problem and how to remove the plants effectively. Fish and Wildlife officials provided all materials and handled final disposal of the plants that students removed. Students performed a valuable service by removing the invasive plants before they spread.

<u>PLANNING AND IMPLEMENTING AN INVASIVE PLANT SPECIES REMOVAL PROJECT</u>
Work with an invasive plant species specialist (ex: Department of Natural Resources (DNR), Natural Resource Conservation Service (NRCS), City Park Service, or County Land Manager) to develop a restoration plan for your natural area. There are many techniques available but the one you decide to use will depend on the species you are trying to control and the extent of the infestation.

To plan a success restoration project:

- Determine the invasive plant species at your site
- Find out which methods are available to control the invasive plants.
- Understand how the method you choose will affect plants, animals and ecosystem.
- Consider environmental impacts like erosion, trampling native vegetation, contamination, and soil compaction.
- List all required equipment, personnel, quantities and costs to achieve your goals
- Develop a project timeline to help you plan ahead and organize your restoration project. Include: Date and Task Description
- Practice your method before tackling the plant invaders at full force.
- When removing invasive plants manually, dispose of them properly. If they will be left on-site, ensure that they won't take root and re-sprout.
- Consider replanting the site with vigorous native plants adapted to that site soon after removing the invasive plants.
- Observe and evaluate the impacts of your project towards achieving your goals (Invasive Plant Species Inventory, photographs).
- Re-evaluate, modify your restoration plan if necessary and start the cycle again.

Most invasive plants are very persistent, re-sprout vigorously when cut or from stem or roots fragments left in or on soil, and produce a lot of seed that can survive in the soil for many years. Getting rid of invasive plants can be a long-term process. Keep this in mind when planning your restoration project.

MEASURING SUCCESS

Since your restoration project brings about changes to a landscape, monitoring those changes over time is necessary to evaluate the impacts of your activities. Observations may tell you to change the methods or timing of successive restoration events. Photo-monitoring is one of the easiest methods to measure change over time. It is important to take a photo from an established point somewhere at your restoration site before any work starts. About halfway through your project, take another photograph from the same point. This is a good way to document the progress of your project. And finally, after you have finished, take a final shot from the same point. Now, you have at least before and after photographs of your restoration site.

WISCONSIN MODEL ACADEMIC STANDARDS

Grades 9-12
English Language Arts: F.12.1
Environmental Education: D.12.3, D.12.5
Science: F.12.8, H.12.5, H.12.6

RESOURCES

Invasive Plants: Guide to Identification and the Impacts and Control of Common North American Species. By Sylvan Kaufman and Wallace Kaufman, Stackpole Books, 2007.
This guide will help with plant identification; manual, mechanical, biological, and chemical control techniques; information and advice about herbicides; and suggestions for related ecological restoration and community education efforts.

Invasive Plants: Weeds of the Global Garden by John M. Randall, Janet Marinelli, 1996.
Published by the Brooklyn Botanical Garen. This book tells you which plant invaders are problems in your area and how to control them.

Invasive Exotic Plant Management Tutorial for Natural Lands Managers
http://www.dcnr.state.pa.us/Forestry/invasivetutorial/index.htm
Excellent resource for exploring options for invasive plant species control and management.

Meeting the Challenge: Invasive Plants in PNW Ecosystems
http://www.ruraltech.org/video/2006/invasive_plants/#sv
Streaming videos about invasive plant species and community/education cooperative projects.

How to Control Invasive Plants

Cultural Controls

Cultural controls involve changing the environment to eliminate the opportunity for non-native species to dominate an ecosystem or to give native species an advantage over non-natives. Cultural controls include:

- Educating people.
- Encouraging actions that minimize the spread of invasive species.
- Changing the environment so that it is not suitable for the invader.
- Manipulating water or soil chemistry to favor the growth of native species.
- Using fire to suppress invasive plants or encourage native plants.

Advantages

- Prevention is by far the most cost-effective way to control invasive plants.
- Everyone can participate in preventing the spread of invasive plants.

Disadvantages

- Changes in the environment (e.g., floods, drought, and fires) can create extreme conditions that kill both native and invasive plants.
- Cultural controls occasionally accelerate the invasion, rather than eliminate it.

Biological Controls

Biological controls involve the encouragement or introduction of control agents specifically tested to control an invasive species. Biological controls include:

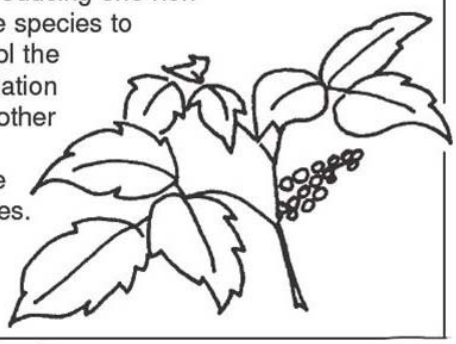
- Introducing animals (usually insects) that will feed on the plant.
- Introducing parasites to weaken a plant.
- Introducing disease organisms (i.e., bacteria, viruses, or fungi).
- Encouraging the populations of biocontrol agents already present in an area (e.g., encourage populations of native insects).
- Encouraging succession (the normal process in which dominant plant species change as an ecosystem matures), so that native vegetation has a better chance of outcompeting non-native vegetation.

Advantages

- Biological control is perceived as progressive and environmentally friendly.
- Once the protocol is in place, biocontrols are relatively cheap and easy to implement.
- No chemicals are introduced into the environment.
- Widespread control is possible.
- Control is essentially permanent.

Disadvantages

- Biological control is a slow process. It can be years before the density of the biocontrol agent reaches the point where it makes a significant change in the invasive plant population.
- Testing of biocontrol agents is expensive and can take many years.
- Biological control can slow the spread of an invasive, but generally cannot eradicate the infestation.
- Even though biocontrol agents go through extensive testing, there is a risk in introducing one non-native species to control the population of another non-native species.



Mechanical Controls

Manual or mechanical controls result in physical damage to invasive plants. Mechanical controls include:

- Pulling invasives by hand.
- Removing invasives with chain saws, pruners, or loppers.
- Mowing (both rotary and flailing).
- Discing or tilling with heavy equipment.

Advantages

- Removal can be very selective, affecting only the target species.
- Timed correctly, mechanical control can be very effective against some plants.
- People of all ages can be involved in management projects.
- Control can be very cost-effective if volunteers participate.
- Combined with chemical control, this method can be very effective. For example, cutting down invasive trees and treating the stumps with herbicide is more effective than either control method used alone.

Disadvantages

- Removing plants from large areas is labor-intensive. Without volunteers, the costs can be prohibitive.
- Native plants can be trampled during the removal process.
- Soil can be disturbed during the process, allowing opportunities for the establishment of the same or different invasive plants.
- Often control methods need to be repeated several times before plants are killed or eliminated.
- Mechanical control stimulates growth of some invasive plants.
- Equipment must be cleaned between sites to prevent moving invasive plant seeds and other plant parts into new areas.
- Mechanical control must be timed to the plant's life cycle. Sometimes the best time to control a plant is a narrow window.
- Pulling weeds may slow the *spread* of weeds, but it does not alter the conditions that first favored the invasion.
- Many of these methods are not specific to the invasive weed. For example, machinery typically cuts, chips, and grinds everything in its path, including native plants, insects, small mammals, birds, and reptiles and amphibians.

Chemical Controls

Chemical controls use herbicides to kill target plants. Chemical controls include:

- Using herbicidal sprays on leaves.
- Painting the stumps of cut trees and shrubs with herbicides.
- Injecting herbicides into trunks and stems.

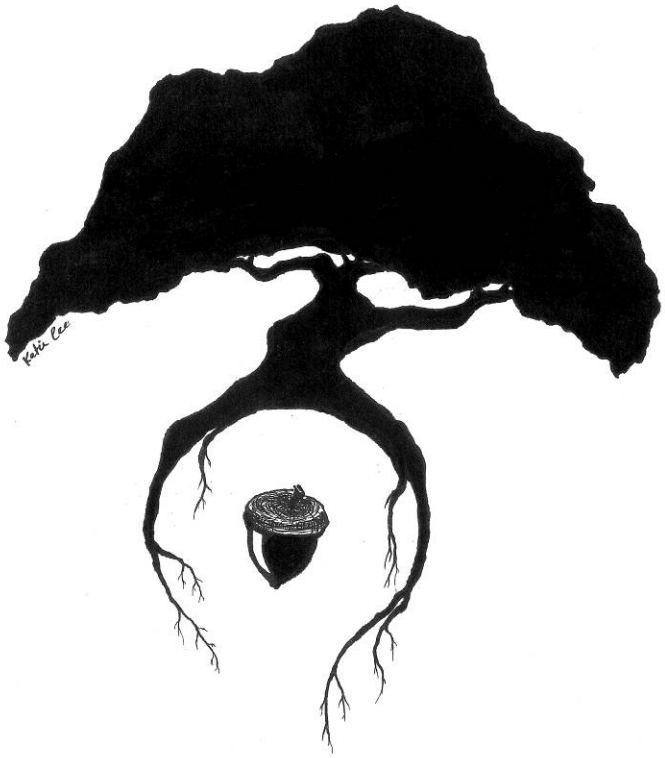
Advantages

- Herbicides usually kill the target plants with one treatment.
- Herbicides are readily available.
- Herbicides can quickly be applied to target plants.
- Applying herbicides requires less labor than manual control methods.

Disadvantages

- Nearby desirable plants may be killed too.
- Herbicides and herbicide application can be expensive.
- Applicators must be certified and licensed to apply herbicides in some areas.
- Some herbicides could harm wildlife and/or contaminate water sources.
- Some herbicides can persist and accumulate in the environment.

APPENDIX



USING A COMPASS

Source: Iowa Department of Natural Resources website: http://www.iowadnr.gov/education/files/mapcomp.pdf

SUMMARY

Compass skills are important in conducting invasive plant species inventories. Many students will probably already know how to use a compass, but others may not. This lesson will provide an introduction and /or review of the fundamentals of compass use. It can be performed indoors or outdoors, depending on weather conditions.

LEARNING OBJECTIVES

At the end of this unit, students will be able to:

- Use a compass to conduct the Invasive Plant Species Inventory

TIME FOR PREPARATION: 30 minutes

TIME FOR TEACHING: 45 minutes

SETTING: Indoors or outdoors

MATERIALS:

- *Compass Matching*- one copy for each student
- *Get Your Bearings*- one copy for each student
- *X Marks the Spot*- one copy for each student
- *Walking Circles*- one copy for each student
- Compasses: 1 per 3 students (in IPS kit)
- Wire flags for *Walking Circles*

OUTLINE FOR THE TEACHING PRESENTATION

Getting Started

1. Read the compass users manual that is included with the IPS Kit. Practice using the compass indoors and outdoors.

Doing the Activity

1. Demonstrate the use of the compass in front of the class.

2. Have students complete *Compass Matching*.

3. Show students how the magnetic needle always points north. Have students align the orienting arrow and magnetic needle then use the compass to complete *Get Your Bearings* and *X Marks the Spot* activities.

4. If time allows, have students go outside and work in teams to complete *Walking Circles*. Students will need 10 wire flags per team.

EXTENSION ACTIVITES

1. If time allows, have students go outside and practice the transect protocol on the Invasive Plant Species Inventory lesson.

ASSESSMENT

After completing this lesson, students should be able to correctly use a compass to determine bearings from one point to another.

TEACH THE TEACHER

VOCABULARY

Compass Housing - center part of the compass that is sealed; contains the magnetic needle in a liquid so it can move freely

Compass Base - bottom of the compass; part you hold in your hand; shows direction-of-travel arrow and millimeter and inch scales for computing distances on a map

Direction of Travel Arrow - points the direction you need to travel after the bearing has been set magnetic needle: red and white needle; moves inside the compass housing; the red end of the needle always points north when at rest

Degree Readings - the numbers on a compass; angular difference, measured in degrees, between any point and north; given either as a magnetic (compass) bearing or a true (map) bearing; a compass has 360^{O}; 90^{O} = east, 180^{O} = south; 270^{O} = west.; 0^{O} or 360^{O} = north

Orienting Lines - parallel lines inside or on the compass housing

Orienting Arrow - stationary arrow inside the compass housing

Declination Scale - used to determine the angle difference between true north (from your map reading) and magnetic north (reading from your compass) (Note: Declination must be added or subtracted to compass bearings.)

TAKING A BEARING

For the Invasive Plant Species Inventory students will need to use a compass to take a bearing for establishing transect lines. A bearing is a 3 digit angle measured clockwise from north. It is a way of indicating direction without ambiguity. We usually speak of taking a bearing between 2 points. When following a bearing (i.e. attempting to walk in the direction indicated by the compass), it is important to notice a landscape feature that lays along that path. Then make your way to that feature. Take regular sightings of the feature in case you lose sight of it during your 'detours'. When you reach the feature, simply take the same bearing again, (i.e. sight along the compass again) and repeat, looking for a prominent feature.

WISCONSIN MODEL ACADEMIC STANDARDS

9-12 Grade Science Inquiry Performance Standards: C.12.4

RESOURCES

Using a Compass to Find Your Way, Teachers' Domain Web site:
http://www.teachersdomain.org/resources/phy03/sci/phys/matter/zorient/index.html

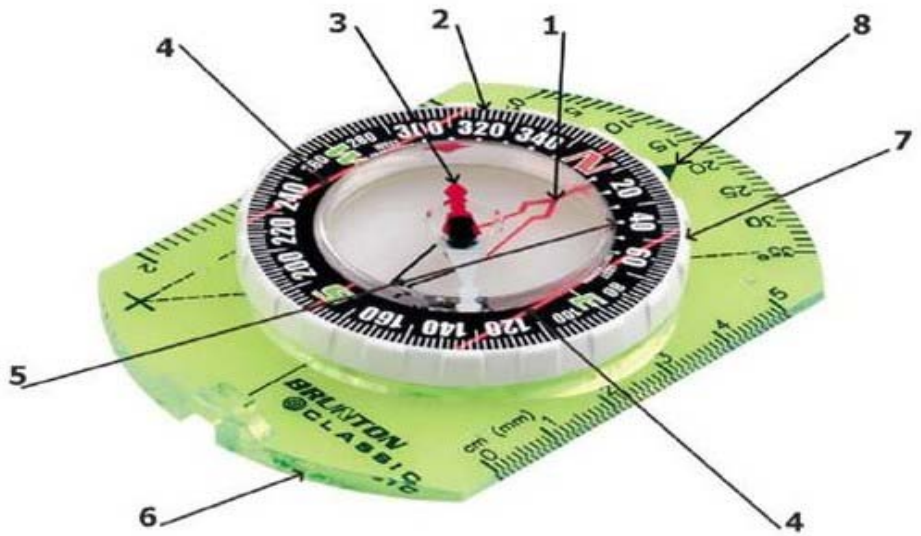
Working in the Woods, University of California Web site:
http://www.cnr.berkeley.edu/departments/espm/extension/COMPASS.HTM

USGS Education Web site:
http://education.usgs.gov/common/lessons/how_to_use_a_compass_with_a_usgs_topographic_map.html

COMPASS MATCHING

Name_____

Match the definitions at the bottom of the page to the correct number on the compass diagram below.



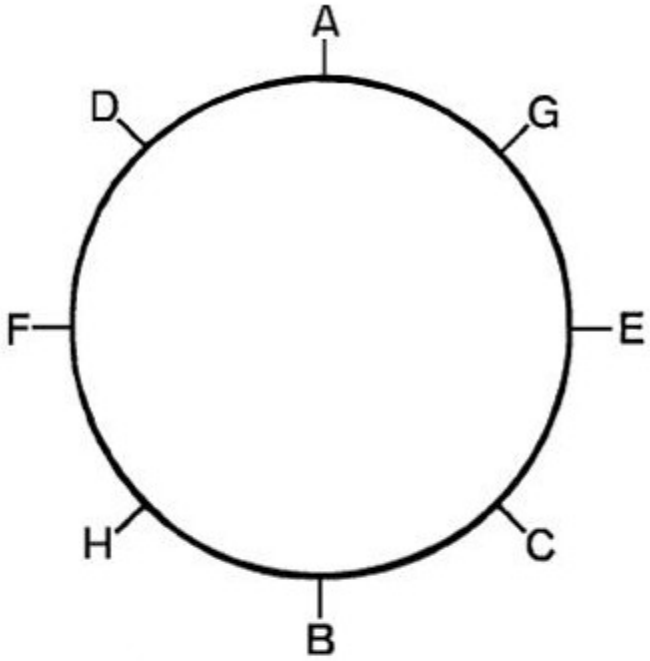
1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____

Compass Housing - center part of the compass that is sealed; contains the magnetic needle in a liquid so it can move freely
Compass Base - bottom of the compass; part you hold in your hand; shows direction-of-travel arrow and millimeter and inch scales for computing distances on a map
Direction of Travel Arrow - points the direction you need to travel after the bearing has been set
magnetic needle: red and white needle; moves inside the compass housing; the red end of the needle always points north when at rest
Degree Readings - the numbers on a compass; angular difference, measured in degrees, between any point and north; given either as a magnetic (compass) bearing or a true (map) bearing; a compass has 360^{O}; 90 ^{O} = east, 180 ^{O} = south; 270 ^{O} = west.; 0 ^{O} or 360 ^{O} = north
Orienting Lines - parallel lines inside or on the compass housing
Orienting Arrow - stationary arrow inside the compass housing
Declination Scale - used to determine the angle difference between true north (from your map reading) and magnetic north (reading from your compass)

GET YOUR BEARINGS

Name_____

It is important to know what direction various compass bearings represent. Assume that “A” is zero degrees on a compass. List the direction and degree reading for each point below.



	Bearing/Degree Reading	Direction
A.	_____	_____
B.	_____	_____
C.	_____	_____
D.	_____	_____
E.	_____	_____
F.	_____	_____
G.	_____	_____
H.	_____	_____

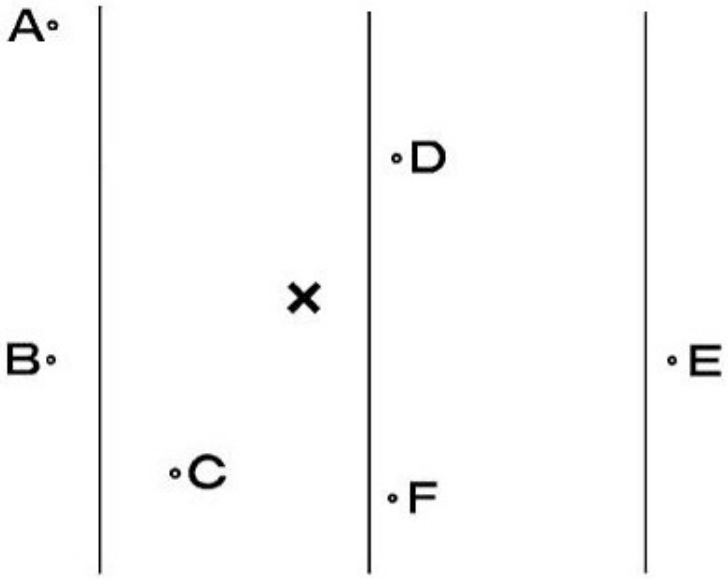
X MARKS THE SPOT

Name_____

Your location is noted by the “X” below. Set the declination of your compass at 0o. Determine the compass bearing from the center of “X” to the dot next to each letter. Select the correct reading from the list of possible answers below and write it in the appropriate space.

Possible Answers:

1) 34° 2) 316° 3) 10° 4) 216° 5) 100° 6) 188° 7) 156° 8) 256°



_____ X to A
_____ X to B
_____ X to C

_____ X to D
_____ X to E
_____ X to F

Hint: The “N” on the compass should point toward the top of the map or be parallel to the “N” lines on your map.

WALKING CIRCLES

Name_____

Practice taking compass bearings by following the directions below.

1. Find an area where there are no obstacles at least 50 feet in either direction. Place a flag in the ground to mark the starting point.

2. Determine the number of paces you must take to travel 50 feet.
   Number of paces to travel 50 feet= _____

3. Stand next to the flag marking your starting point. Set any bearing you wish on your compass and travel 50 feet.

4. When you have traveled 50 feet, STOP. Place a flag to mark your new location.

5. Add 90o to the bearing on your compass.

6. Travel 50 feet in the new direction, STOP and mark the new location.

7. Repeat this procedure twice.

8. You should end up at your original location. If not, how far are you from your starting point?
   _____

Answer Key for *Compass Matching*

1) Orienting Arrow
2) Degree Reading (bearing)
3) Magnetic Needle
4) Orienting Lines
5) Declination Scale
6) Compass Base
7) Compass Housing
8) Direction of Travel Arrow

Answer Key for *Get Your Bearings*

A) 0^{o} or 360^{o}, north
B) 180^{o}, south
C) 135^{o}, southeast
D) 315^{o}, northwest
E) 90^{o}, east
F) 270^{o}, west
G) 45^{o}, northeast
H) 225^{o}, southwest

Answer Key for *X Marks the Spot*

X to A = 2) 316^{o}
X to B = 8) 256^{o}
X to C = 4) 216^{o}
X to D = 1) 34^{o}
X to E = 5) 100^{o}
X to F = 7) 156^{o}

SUPPLEMENTAL GPS ACTIVITIES

Source: GPS in South Dakota's State Parks http://www.sdgfp.info/parks/Recreation/GPS.htm

Mark & Find:

- A small group can be taught to "mark" and "find" waypoints in just a few minutes.
- Clear all waypoints from GPS memory before class. Hand out of GPS units. Don't turn the GPS units on until you are outside, under an open sky. Explain briefly how the GPS unit acquires satellites using the satellite screen on the GPS unit. When the GPS unit has acquired at least four satellites show the group how to mark a waypoint. Keep it simple! (Press the mark button then press enter).
- Select a spot about 200 yards away and send the whole group to that point. While they are walking (kids will run, which is cool because they can check their speed on the GPS while they run). Have the group look at their trip computer screen while walking to see how the GPS tracks data about the user.
- Again mark a waypoint for this second point.
- Now show the group how to use the "find" or "GoTo" button to display the waypoints in the GPS. Each person with a GPS should "find" and select the waypoint they marked at the first spot. Page to the compass page and follow the compass arrow back to the original spot.
- Note the distance going down as you head toward the first point you marked. As your distance get closer and closer to zero start looking around for the spot you marked. See how close the GPS will take you to the same spot. REMEMBER: GPS units report an approximate position only. If you are within fifteen feet of the spot you want, that is pretty close for sport grade GPS.
- Now try and "find" or "GoTo" the other point you marked. If this works for you then you are ready to do simple GPS navigation.

GPS Trail

- This is a zero prep activity for small or large groups. Two people can play against each other. 20 people can play as two groups of 10, etc. Most groups will complete the activity within 40 minutes.
- You will need: at least 2 handheld GPS units, one per group; 10 tent stakes, tie a small piece of ribbon to each; instructions for using the GPS if you are not familiar with the unit; and step by step directions to *GPS Trail*.
- Divide into 2 groups. Each group should have the same number of GPS units.
- Meet at a designated starting point.
- Turn the GPS on. Make sure the GPS locks on at least 4 satellites.
- Check your battery level. If it is less than 1/4, change batteries.
- Review with how to MARK and Find or GoTo waypoints
- Clear memory in your GPS before beginning
- Each group gets 5 stakes
- You will have 20 MINUTES to hide and mark all 5 stakes.
- First group goes to an area directed by staff. The second group goes to a separate area (opposite sides of a building works well - out of sight of each other).
- Each group hides its tent stakes one at a time. Be creative here. Don't make it too easy! Hide each stake as far apart from the other stakes as possible. The ribbons on each stake MUST be visible from 5 feet away, but you can still camouflage them in a bush, or stick it in the crook of a tree, etc.

- Carefully hold each GPS over the hidden tent stake and MARK that spot. Be sure and save the marked waypoint for each tent stake on each GPS!
- Repeat for all five tent stakes.
- When you have hidden, MARKed and Saved the location of each tent stake on each GPS, return to the starting point.
- The two groups then trade GPS units.
- Review with the groups how to FIND or GO TO, SELECT a WAYPOINT, and navigate to that spot. Note: You must "move" before the GPS will give you an accurate direction of travel. START WALKING, THEN LOOK AT THE GPS!
- Most people like to navigate using the COMPASS page. Press the PAGE or NAV button till you get to this page. Follow the dark arrow on the compass dial and count down the distance. When you get within 15 feet of your destination, start looking around!
- Each group goes back out to the area where the other group hid their tent stakes and follows the FIND or GoTo on the GPS to find the hidden stakes one at a time.
- Pick up each tent stake as the group finds it (Hint: How about picking up "other" litter as you search for tent stakes?)
- When all the tent stakes your group can find have been picked up, return to the starting point. Report to the staff at the start how the *GPS Trail* went.
- Turn in your GPS and recovered tent stakes, and you are done!

Puzzle-Points:

- The "point" is to complete the puzzle by having each GPS team (Team organization is up to you) find each of 6 – 10 geographic coordinate sites, pick up a puzzle piece at each site, and combine them when they get to "Home" base.
- Puzzles could be selected from a children's jig-saw puzzle with the number of puzzle pieces equal to the number of GPS teams times the number of waypoints (hardest). Or use a children's puzzle for each GPS team and have the number of pieces match the number of waypoints in the course. Or use Lego or Duplo or Connex figures made out of the same number of pieces as the number of waypoints. Have enough pieces at each point on the course so every team gets one.
- Instructor previews the area of the course, marks waypoints as wanted, saves as waypoint list or saves to route. Route can be uploaded to GPS units or students can hand enter (I prefer this if time permits). This is a great activity to turn any age student loose on even when they have no experience. THEY WILL FIGURE IT OUT QUICKLY!
- With waypoints entered and route active, students begin together but do not have to go to waypoints in order.
- They will quickly learn this, but you can speed things up by reminding them they can select any waypoint to "Find" or "Goto."
- Use as big a field as you can find. The size of four football fields with dips and depressions to hide puzzle piece containers in is usually minimum for a class size group (25).
- This takes about ½ hour to 45 minutes usually for student groups to complete. Set up and waypoint entry (and GPS instruction) is extra.
- The favorite containers for puzzle parts are small ammo cans. They are water-proof, tough, and if you want to make them more permanent, you can chain them in place.

GLOSSARY OF TERMS

Atom – the smallest unit of an element that retains the chemical properties of that element
Biodiversity – the variation of living organisms within an ecosystem
Biome – an area with a given set of characteristics such as climate conditions, soil, water, plants, animals, and other organisms
Carbon Cycle – a process oby which carbon is transported between the earth, water, atmosphere, and living organisms
Competition – a rivalry between individuals or groups of plants or animals for territory and resources
Conservation - protecting and preserving nature
Ecosystem – an area that contains organisms (e.g. plants, animals, and bacteria) interacting with one another and their nonliving environment (e.g. climate, soil, topography)
Forest Ecosystem – an ecosystem characterized by a dominance of tree cover
GIS – Geographical Information System is a digital map with a database connected to it
GPS – Global Positioning System is a satellite-based navigation system.
Herbarium – a collection of dried plants labeled with the species name, collection date, location
Herbivore – an animal that obtains its energy from eating plants, and only plants
Indigenous – occurring naturally in a specific area or plant community
Interconnectivity – the relationships that exist between ecosystems
Invasive plant – a non-indigenous species or strain that becomes established in natural plant communities and wild areas, replacing native vegetation
Native plant – a plant that occurs naturally, never introduced by an outside source
Nature - the physical world of living and nonliving things not produced by human kind
Nutrient – a food or chemical that an organism needs to live and grow
Odyssey – an extended wandering or journey
Photosynthesis – a process that converts light energy into chemical energy in living organisms
Plant Community – all the plant species that grow together within a specific area
Plant stem counts – a quantitative method for determining the density of invasive plant species in a land area
Potentially Invasive Plants(for Wisconsin) - species that are invasive in parts of North America having similar climates and plant communities, and potential to become invasive in Wisconsin
Predation – an interaction between species in which one species uses another species as food
Restoration – the return of an ecosystem to its natural or historical condition
Site Specific – focus on removing all invasive plant species within a specific natural area
Society - a grouping of people with collective characteristics that may impact nature
Sometimes Invasive Natives - native plants that can become overly abundant in a plant community to which they are indigenous, often in response to a change
Species Specific – focus on removing one specific invasive plant species from a natural area
Specimen – a plant submitted to a herbarium to be used as a representative example of a plant species found within a specific area
Sustainability – the ability of natural resources to provide ecologic, economic, and social benefits for present and future generations
Transect – a line, made with a tape measure, so that data may be taken at regular intervals

RESOURCES

The Forest Odyssey

A Sand County Almanac by Aldo Leopold. (Oxford University Press, 1949.) Many essays in A Sand County Almanac provide insight into the human aspects and sustainability of Wisconsin ecosystems.

Wisconsin's Forests at the Millennium: an Assessment. (Ann-Marie S. Finan, Editor, Wisconsin Department of Natural Resources, 2000, PUB-FR-161 2000.) This WDNR publication contains ecological, social, and economic information about Wisconsin's forests. It provides a good framework to discuss challenges to forest sustainability.

Natural Communities of Wisconsin www.dnr.state.wi.us/landscapes/community
This DNR website contains links to the natural communities in each of the ecosystem profiles used in this lesson. Information includes natural history, wildlife, statistics, etc.

Exploring Ecosystems

The World's Biomes http://www.ucmp.berkeley.edu/exhibits/biomes/
This University of California website contains information and images of the world's biomes.

Biomes and Ecosystems http://www.windows.ucar.edu/tour/link=/earth/ecosystems.html
This Windows to the Universe website contains educational activities for different learning levels.

Restoring Biodiversity

Saving Nature's Legacy: Protecting and Restoring Biodiversity by Reed F. Noss, Allen Y. Cooperrider, Contributor Allen Y. Cooperrider, Published by Island Press, 1994.
A thorough and readable introduction to issues of land management and conservation biology; it presents a broad, land-based approach to biodiversity conservation in the United States, with the authors succinctly translating principles, techniques, and findings of the ecological sciences into an accessible and practical plan for action.

Living Resources and Biodiversity
http://www.uwsp.edu/cnr/wcee/envsci/Framework/LivingResources/LivingResources7c.htm
The Wisconsin Environmental Science Teacher Network website contains additional resources for exploring the restoration of biodiversity.

Natural Communities of Wisconsin www.dnr.state.wi.us/landscapes/community
This DNR website contains links to the natural communities in each of the ecosystem profiles used in this lesson. Information includes natural history, wildlife, statistics, etc.

Outwit-Outplant-Outlast

Alien Plant Invaders of Natural Areas. Plant Conservation Alliance. 2005.
www.nps.gov/plants/alien/factmain.htm
Illustrated, easy-to-read fact sheets on invasive alien plants with native ranges, plant descriptions, ecological threats, U.S. distributions and habitats.

Invasive Plants Weeds of the Week. United States Forest Service: Northeastern Area. 2005.
http://na.fs.fed.us/fhp/invasive_plants/weeds/index.shtm
These fact sheets are designed to distribute information about specific invasive plants that exist in the Northeastern United States.

Plant Invaders

Invasive Plants of the Upper Midwest An Illustrated Guide to Their Identification and Control. By Elizabeth Czarapata. The University of Wisconsin Press, 2005.

The Invasive Plant Association of Wisconsin www.ipaw.org
This association promotes better stewardship of the natural resources of Wisconsin by advancing the understanding of invasive plants and encouraging the control of their spread.

Invasive and Exotic Species Information www.invasive.org
The overall objective of Invasive.org is to provide an accessible and easily used archive of high quality images related to invasive and exotic species, with particular emphasis on educational applications.

Wild Ones: Invasive Plants http://www.for-wild.org/download/invasive.html
A collection of web sites with information on invasive plants.

Wisconsin DNR, Wildcards http://dnr.wi.gov/forestry/Publications/wildcards.html
Source for printing and/or purchasing Wisconsin Wildcards

The Plant Hunters

Illustrated Guide to Trees and Shrubs: A Handbook for the Woody Plants of the Northeastern United States and Adjacent Canada. By Arthur Graves. 1992. This book is an excellent resource for identifying trees and shrubs in Wisconsin.

Newcomb's Wildflower Guide. By Lawrence Newcomb,1989. Published by Little, Brown and Co.
This is an outstanding guide for identifying herbaceous plants in Wisconsin.

Invasive Plant Species: http://www.dnr.wi.gov/invasives/plants.asp
A Wisconsin DNR website with a species list for plants in Wisconsin which are known to be invasive in Wisconsin or may be potentially invasive.

Invasive Plants of the Future http://www.dnr.wi.gov/invasives/futureplants/index.htm
This Wisconsin DNR website is an online field guide for identifying and reporting the first set of

target plants of the Early Detection Project. The target list will continue to be updated and expanded as new invasive plants threaten the state.

WISFLORA: Wisconsin State Herbarium. University of Wisconsin – Madison. 2005. Online listing of plants by common name, scientific name, habitat, status, and county. www.botany.wisc.edu/wisflora/

PLANTS Database http://plants.usda.gov/
Provides standardized information about the vascular plants, mosses, liverworts, hornworts, and lichens of the U.S. and its territories.

Introduction to GPS and GIS Technologies
Garmin website http://www.garmin.com/garmin/cms/site/us
For additional resources for using the Garmin Legend GPS units.

GPS and Geocaching Lesson Plans: http://lovinfifth.com/gps/GPS-activities.htm
Great website for additional GPS activities and lesson plans, including geocaching.

The Science Spot: http://www.sciencespot.net/Pages/classgpslsn.html
GPS and GIS lesson plans and links.

GPS in Education http://education.usgs.gov/common/lessons/gps.html
U.S. Geological Survey (USGS) website listing examples of how GPS can be used in education.

What is GIS? http://www.gis.com/whatisgis/
This ESRI supported website provides introductory information on the applications of GIS.

Invasive Plant Species Inventory
Invasive Plants: Guide to Identification and the Impacts and Control of Common North American Species. By Sylvan Kaufman and Wallace Kaufman, Stackpole Books, 2007.
This guide will help with plant identification; manual, mechanical, biological, and chemical control techniques; information and advice about herbicides; and suggestions for related ecological restoration and community education efforts.

Invasive Exotic Plant Management Tutorial for Natural Lands Managers
http://www.dcnr.state.pa.us/Forestry/invasivetutorial/index.htm
Excellent resource for exploring options for invasive plant species control and management.

Invasive Plants of Wisconsin
http://www.uwgb.edu/biodiversity/herbarium/invasive_species/invasive_plants01.htm
Lists plants that are the most serious invasive species in northeastern Wisconsin.There are numerous sites on the web with good information on these species, including control methods.

Monitoring Ecological Effects Handbook, http://www.fs.fed.us/r3/spf/cfrp/monitoring/pdf/mm4.pdf
This multiparty monitoring handbook is part of a series of guides to monitoring collaborative forest restoration projects. The series was written specifically for projects funded through the USDA Forest Service's Collaborative Forest Restoration Program (CFRP)

Volunteer and Invasives Program http://www.refugenet.org/New-invasives/vimp.html
In collaboration with the Center for Invasive Plant Management (www.weedcenter.org), the National Wildlife Refuge System (NWRS) has developed an invasive plant online training program for volunteers.

Wisconsin Weed Watcher http://dnr.wi.gov/invasives/futureplants/weedwatcher.htm
This Wisconsin Invasive Plants Reporting and Prevention Project is an early detection and strategic response initiative co-sponsored by the Wisconsin DNR and the Wisconsin State Herbarium.

Global Garlic Mustard Field Survey
http://invasionsrcn.org/portal/activities/alliaria-sampling/AlliariaProject_Feb2009.pdf/view
This pdf file includes detailed instruction on how to collect the data, and a sample data sheet that can be used for recording the data. This website is supported by the Global Invasions Research Coordination network, an international network of scientists supported by the U.S. National Science Foundation, and provides a resource for scientists working on invasions to find colleagues located in geographic regions of interest to aid in sampling and experimental work.

Invasive Plant Species Control
Invasive Plants: Guide to Identification and the Impacts and Control of Common North American Species. By Sylvan Kaufman and Wallace Kaufman, Stackpole Books, 2007.
This guide will help with plant identification; manual, mechanical, biological, and chemical control techniques; information and advice about herbicides; and suggestions for related ecological restoration and community education efforts.

Invasive Plants: Weeds of the Global Garden by John M. Randall, Janet Marinelli, 1996.
Published by the Brooklyn Botanical Garen. This book tells you which plant invaders are problems in your area and how to control them.

Invasive Exotic Plant Management Tutorial for Natural Lands Managers
http://www.dcnr.state.pa.us/Forestry/invasivetutorial/index.htm
Excellent resource for exploring options for invasive plant species control and management.

Meeting the Challenge: Invasive Plants in PNW Ecosystems
http://www.ruraltech.org/video/2006/invasive_plants/#sv
Streaming videos about invasive plant species and community/education cooperative projects.

The Invasive Plant Species Curriculum and Kit has been made possible through the contributions of the following individuals:

Krista C. James is an environmental educator and senior lecturer in the Biology Department at UW-Stout. In 2008, she received funding through the Wisconsin Environmental Education Board (WEEB) Forestry Education grant program to develop, test and disseminate an Invasive Plant Species (IPS) Education Kit for middle school and high school teachers. It is her expectation that teachers and students using the kit will develop a deeper awareness of basic forest ecology and will be able to apply that knowledge to understanding how invasive plant species alter the natural forest environment. She plans to work with CESA #11 and other collaborators to disseminate and monitor the use of the IPS kit and incorporate ideas and feedback to improve the effectiveness of the citizen action aspect of the project. Krista can be contacted by email at jamesk@uwstout.edu or by phone at 715-232-1557.

Dr. Kitrina M. Carlson is an Associate Professor of biology at UW-Stout. Her expertise and research interests are broadly focused in the plant sciences, including plant medicine, plant pathology, and research into sustainable agricultural practices. A project she currently has underway involves researching the history of the weeds of Wisconsin, including how they got here and if they have any useful properties, particularly useful medicinal properties.

She was very excited to work on the IPS project because it involved developing curricula for high-school students. One of her largest collaborative research initiatives is focused on developing collaborative research experiences between high school science teachers and college professors in order to engage a new population of students in the sciences. The IPS project was an excellent opportunity to build on this concept and produce a lab manual and set of supplies that will be available to educators across the state. She developed three labs for the project that are based on the concerns surrounding invasive plants and plant identification. As a plant scientist, she's available to answer any questions regarding invasive plant background and identification. Kitrina can be contacted by email at carlsonki@uwstout.edu.

Jean D'Angelo grew up in Milwaukee and always had a love for animals, plants, and the environment. Receiving her Bachelor of Science degree from the University of Wisconsin Madison in Agricultural Education allowed her to teach students about her strongest interests. Completing her degree in 1987 she started teaching in a small rural community in southern Wisconsin and then moved to Menomonie in 1989. She has taught at Menomonie High School for the past 19 years in courses of Horticulture, Plant & Land Management, Animal Science, Dairy Science, Veterinary Science, Natural Resources, Environmental Conservation, and

Agricultural Internship. In addition she completed her Masters in Ag Ed at the University of Wisconsin River Falls in 1999. Having had the opportunity to travel to several countries on education tours and studies, Jean has learned the importance of teaching her students about caring for the environment on a global perspective. Jean served as editor for the curriculum in this kit and made suggestions for improving the activities. Her students were the first group to try out the lessons and together they made the curriculum as user friendly as possible. Jean can be contacted by email at jean_dangelo@msd.k12.wi.us or phone at 715-232-2609 ext. 40125.

Kevin Mason became the program director for science education at UW-Stout in 2006. He is a 1992 graduate of Chippewa Falls High School in nearby Chippewa Falls, Wis. He received a Bachelor of Science degree in chemistry from the University of Minnesota in 1996. After graduating, he enrolled in the Master of Education degree program at the University of Minnesota where he became certified to teach middle school and high school science in Minnesota and Wisconsin. Kevin then returned to Chippewa Falls High School where he taught chemistry and physics from 1997–2001. In 2003–2004, Kevin returned to school to pursue his Doctorate of Philosophy degree in curriculum and instruction at UW-Madison. He is currently conducting his dissertation research on the involvement of practicing teachers in teacher education. Kevin got involved with the IPS Education Curriculum and Kit because science education is extremely important to him and science curriculum that is current, relevant, and meaningful is extremely important to students. Kevin is very proud to have helped developed the unit and daily lesson plans and hopes teachers find them easy to implement and adapt in their own classrooms. Kevin can be contacted by email at masonk@uwstout.edu.

Wendy Sandstrom grew up in Stillwater, Minnesota, where she found a love of nature and the outdoors through camping, fishing and hiking with her family. Wendy graduated from the University of Wisconsin-River Falls in 2003 with a degree in Elementary Education and an emphasis in Science. After graduating, she taught summer school classes and after school enrichment courses in Physics, Rocketry and general Science topics. Wendy returned to school in spring of 2008 at the University of Wisconsin-Stout to pursue a degree in Secondary Science Education. She joined the Invasive Plant Species team in order to further her teaching experience and gain a better understanding of the effect invasive species have on the environment. Wendy helped to develop lessons within the kit pertaining to forest ecology and was also the lead teacher, helping Jean D'Angelo test the curriculum with her students at Menomonie High School. Wendy can be reached by email at wendysandstrom_41@hotmail.com.

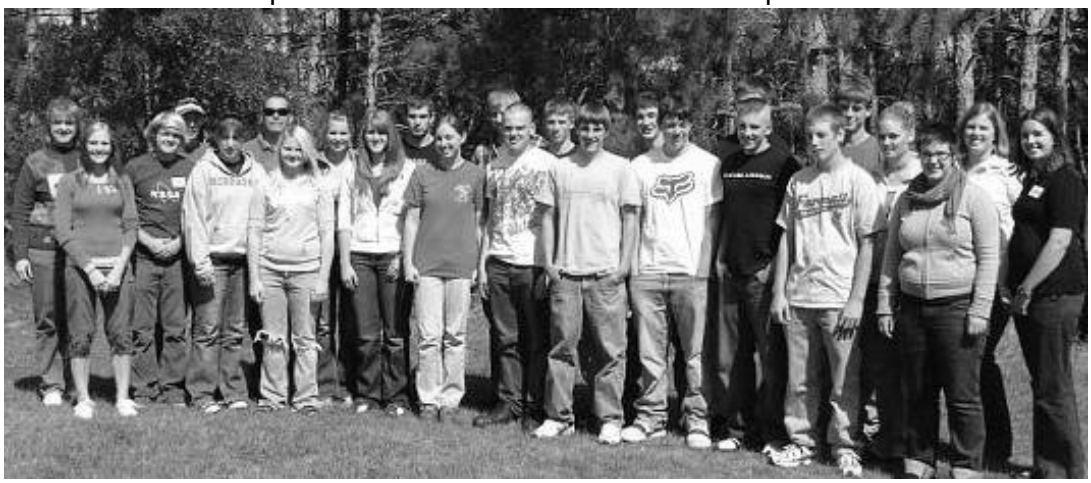
Brittany E. Johnson graduated from Elk Mound High School and decided to continue her education at the University of Wisconsin-Stout. She is currently working on a bachelor's degree for science education. Her goal is to become a biology and chemistry High School teacher. Her love for science brought her to become involved in the IPS project, and the teaching experience was an added bonus. Alongside Wendy Sandstrom, she helped teach the curriculum designed for the IPS kit. Brittany can be contacted by email at johnsonbrittany@uwstout.edu.

Mark Baumgartner is a sophomore at UW-Stout. He was born and raised in Eau Claire, WI. His early pastimes consisted of chasing and catching western Wisconsin's wild reptiles and amphibians. This love for the outdoors was nurtured in elementary school when he joined the Boy Scouts of America. He was an active member, participating in monthly campouts, up until the he obtained the rank of Eagle Scout his senior year of high school. High school provided new opportunities for a young man interested in the environment. Mark joined FFA his junior year, competing in the forestry competition and making it to the state level in Madison, WI. With his acceptance into to University of Wisconsin Stout, Mark was able to take his love for the outdoors to a new level. Mark immediately joined the Applied Science program and was one of the first to jump on board with the brand new Environmental Science Concentration. Mark was excited to get the opportunity to teach high school students about the threats of invasive plants and to head an invasive eradication and restoration project. Mark helped edit and test the IPS curriculum, as well run organize the restoration project. Mark can be reached by email at baumgartnerm@uwstout.edu.

Nina Borchowiec is a senior at UW-Stout. She is currently in the Applied Science program with a concentration in environmental science. The IPS project was right up her alley. Nina got involved because she feels that one person can really change the world and wanted to help educate students on invasive plants. Over the summer, Mark and Nina worked on the restoration part of the project and took an inventory of the forest. Mark and Nina got to know the restoration site inside and out and learned about all of the plants that were in it so they could help the students when it can time to pull the invasive plants. Nina helped as an assistant teacher to Wendy, who was the main teacher in this project. With her background in the IPS project, Nina believes she can help other teachers with this curriculum. Nina can be contacted at the following e-mail address: borchowiecn@uwstout.edu .

Thank you to Clare James, a student at Menomonie High School, for providing filming/technical support for use in the Invasive Plant Species kit.

A special thanks to the students in Jean D'Angelo's Agriscience class at Menomonie High School who helped test out the initial Invasive Plant Species curriculum.



Front Row (left to right: Brittany Johnson, Mark Baumgartner, Jenny Finder, Ashleigh Hendricks, Danielle Keyes, Jessica Alf, Ben Berger, Keith Kadinger, Trevin Jensen, Tucker Taylor, Kyle Govin, Nina Borchowiec; Back Row (left to right): Jean D'Angelo, Rob Strand, Richard Henning, Amanda Howe, Ethan Scheffler, Taylor Kraft, Aaron Tischman, Mike Reitz, Aaron Lausted, Nick Jacobson, Lindsay Wolf, Kitrina Carlson, Wendy Sandstrom

Thank you to Rob Strand (left) from the Wisconsin DNR for providing his professional expertise and Jenny Elliot (right) for her assistance in making the "Reading Along with The Odyssey."