Natural Inquirer

Spring
2010
Vol. 10
Number 1

The *Natural Inquirer* Student Scientist Edition

Is the Oxbow a good habitat for the great horned owl?

Inside

The *Natural Inquirer*

Student Scientist Edition | Vol. 10 | Number 1
Spring 2010

Written by student scientists at The Henry Ford Academy, The Henry Ford, Dearborn, Michigan

With thanks to:

More Kids in the Woods Initiative | Cynthia Huebner, US Forest Service
Dan Miller, US Forest Service | Randy Davis, US Forest Service
Vicki Saab, US Forest Service | Cindy Chojnacky, US Forest Service
Project Learning Tree | Sharon Lucik, USDA Animal & Plant Health Inspection Service

Welcome to the Student Scientist Edition of the *Natural Inquirer!*

The *Natural Inquirer* is a science education journal, originally created for middle school students. The *Natural Inquirer* presents published science from Forest Service scientists, written in the standard scientific format but for a younger audience. For more information, visit http://www.naturalinquirer.org.

The *Natural Inquirer* Student Scientist Edition was developed as a part of the Forest Service's More Kids In the Woods initiative. Using the *Natural Inquirer* in two high school classrooms, the journals were first used to teach students at the Henry Ford Academy in Dearborn, Michigan to read and write actual scientific papers. The students then developed, conducted, and wrote up their own research. Their research was conducted on a natural area near the school's campus. This area is known as the Oxbow (or the Oxbow Island) because it contains an oxbow lake which is connected on one end to the Rouge River.

This edition of the *Natural Inquirer* contains 5 scientific articles written by the students. It also contains a lesson plan that includes 3 abstracts written from student research papers. The articles can

be used in classrooms from 6th grade through high school. Students can read these articles as they would read a normal *Natural Inquirer*.

These articles were written by high school students using the standard scientific format. Student scientists identified their own research questions, developed their own methodology, collected their own data, and wrote it up using the template of the *Natural Inquirer*.

Before using this journal in the classroom, educators should read the "Educator Resources" section beginning on page 66. This section contains resources to assist educators with using this journal in the classroom.

For more information about the *Natural Inquirer*, visit http://www.naturalinquirer.org

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Visit http://www.naturalinquirer.org
for more information, articles, and resources.

Note to Educators
Before using the *Natural Inquirer* in your classroom, read the Note to Educators section on page 66.

Meet the Student Scientists at the Henry Ford Academy

Advice from these Student Scientists to other Student Scientists who want to create their own *Natural Inquirer*

Keep focused, stay on task and do all your work when you are asked.

Make sure you are organized. Take advantage of asking questions and learning about your topic.

Make sure you completely understand what you are doing in this project. Ask a lot of questions.

Pay a lot of attention and make good observations.

Make accurate results/data, gather accurate research.

I would tell the next class that they shouldn't give up. It gets easier as it goes on. Stay organized.

A lot of work is involved, but it's good for those seriously interested in environmental science.

Do not miss any days.

Pay attention and do all the work. They should also share the work in the group.

Listen very well. Take notes well.

Just to be prepared to work as a team. You should have fun but always remember that you have an assignment at hand.

Pick something that you enjoy. It will make the project easier.

I would tell them that the Oxbow project takes a lot of work and there is no "I" in team.

Have fun!

Editorial Review Board

Janet Johns' 7th grade class, Cass Middle School, Cartersville, Georgia

Great work on this!

Good details!

I like the table because it tells everything about the words.

Be more specific as far as where it [the photo] can be found.

This is a good packet of science. I've never seen anything like it. Thanks for the time.

Make the map and the map key more visible so we can read it.

The Great Horned Owl in the Oxbow

Student Scientists

Esther Harris, Ariel Harvey, Jordan Hendricks, Maggie Johnson, Davon Jones, and Lori Wyroba

Glossary

Natural habitat (**nach** ür ul **ha** buh tat): The natural environment of an organism; place that is natural for the life and growth of an organism.

Nocturnal (**nôk** tür nul): Relating to or occurring at night.

Voles (vôlz): Small rodents that typically have a heavy body, a blunt nose, and short ears and inhabit both moist meadows and dry uplands; sometimes doing much damage to crops. They are closely related to muskrats and lemmings but resemble stocky mice or rats.

Prey (pra): An animal, including insects, hunted or seized for food.

Sufficient (suh **fish** ent): Being as much as needed.

Cultivated (**kul** tuh vat ed): Prepared for planting.

Invasive species (in **va** siv **spe** ses): Any plant, animal, or organism that is not native to the ecosystem it is in, and is likely to cause harm to the environment, the economy, or human health.

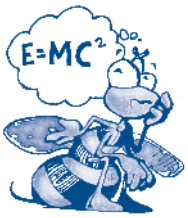
Overabundance (ov ür uh **bun** dens): Too many.

Pronunciation Guide

a	as in ape
ä	as in car
e	as in me
i	as in ice
o	as in go
ô	as in for
u	as in use
ü	as in fur
oo	as in tool
ng	as in sing

Accented syllables are in **bold**.

Thinking About Science



Although environmental scientists usually spend some of their time outdoors, they also spend time doing research in the library and on computers. When conducting an experiment, scientists must spend time reading and writing, as well as time outside collecting data. The student scientists in this research collected data outdoors, as well as from the Internet. They put this information together to answer their research question.

Thinking About the Environment

All organisms need energy to survive. For animals, energy is obtained by eating plants or other animals. In this research, the student scientists were interested in identifying the kinds of animals a particular bird eats to survive. That bird is the great horned owl. When an animal eats a plant or another animal, they are a part of a food chain.

Introduction

Do you remember the last time you saw an owl in its **natural habitat**? Chances are you do not. This is because most owls are **nocturnal** animals and there are not a lot of them out in the open. Owls, like every other animal, have a certain habitat. They generally live alone or with their mate in hollowed out trees. They also live in old stick nests created by hawks. Owls eat rodents such as mice and **voles**. One of the most powerful species of owl is the great horned owl. The great horned owl can be helpful because it **preys** on mice and rats.

Our research question was:

Is the Oxbow a good habitat for the great horned owl (figures 1 and 2)?

Figure 1. Great horned owl.
The great horned owl's body structure is a very important feature that contributes to its survival in its habitat. They have very strong feet and sharp claws to help grasp their prey; they also have a curved beak to tear its prey into bite sized chunks.

Figure 2. The Oxbow is a forested area in Greenfield Village, part of The Henry Ford in Dearborn, Michigan.

Method

The first thing that we did as a class was go into the Oxbow. While in the Oxbow we were able to observe the land and search and identify land areas that would be sustainable habitats for the great horned owl **(figure 3).** Some of the places that were **sufficient** habitats for the great horned owl were dead and hollowed out trees, the fields, and places near the water. One reason that there are so many dead trees in the Oxbow is due to the emerald ash borer. You can read about this **invasive species** in another article of this journal. It is not good to have an invasive insect species in the Oxbow. However, these dead trees are a good habitat for the owls.

Then we researched the food sources of the great horned owl. After we had identified its food sources, we determined whether they were available in the Oxbow.

Figure 3. The class observed various habits in the Oxbow.

Reflection Section

Invasive species are plants or animals that overtake an area and cause harm to the native plants or animals that naturally live there. Do you think that all native plant or animal species are harmed by an invasive species? Why or why not?

How do you think the student scientists researched the food sources of the great horned owl?

Findings

The Oxbow has many good qualities that are suitable for the owl's habitat, such as the open field for the owls to roam and look for food. And, the Oxbow is full of dead trees where the owls can live **(figure 4)**.

However, we found that there is an opportunity to improve the habitat for the great horned owl in the Oxbow. One of the easiest things to do that will enhance the Oxbow for owls is to plant a field of

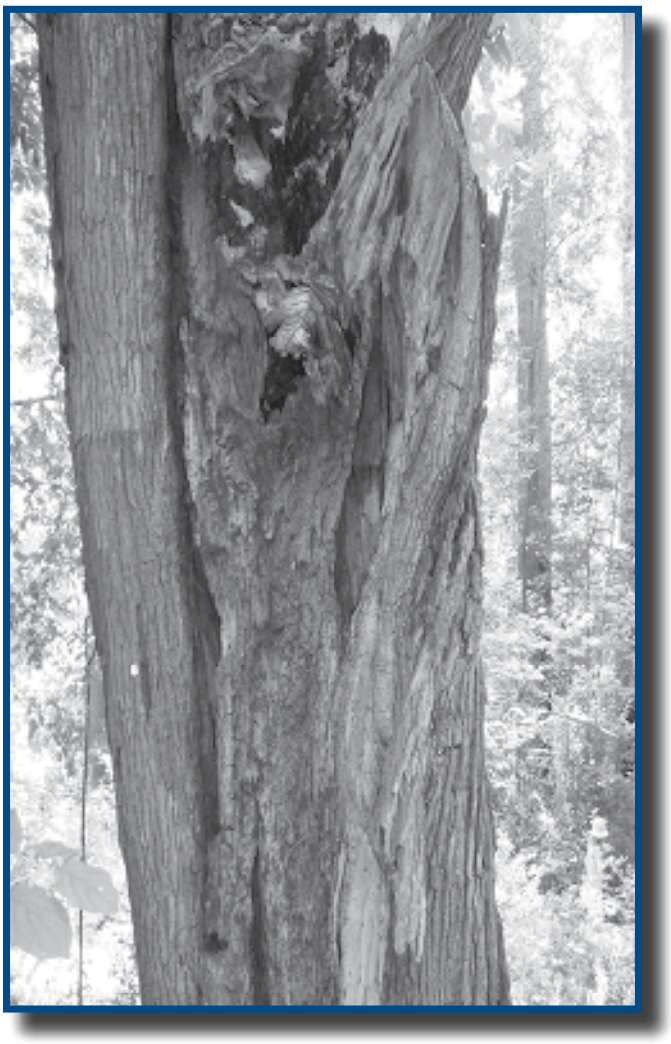


Figure 4. There are many dead trees in the Oxbow.

wheat. Behind the Oxbow is a horse pasture that is perfect for the field of wheat **(figure 5)**. When it is warm enough, the horses can be moved to another part of Greenfield Village. This will enable the field to be **cultivated** and the wheat field to be planted. When the field is planted the voles will be attracted to their new habitat. Voles are one of the great horned owl's biggest food sources. The owls also eat many types of smaller animals and small food such as squirrels, rabbits, skunks, bats, frogs, grasshoppers, and berries **(figure 6)**. Great horned owls will also occasionally eat ducks and geese.

Figure 5. The horse pasture would be a perfect place to plant wheat.

Voles and mice	Mice are in the Oxbow already, and voles could survive there quite well if more grain was planted for them to eat.
Squirrels	Squirrels are currently present in the Oxbow and in the surrounding areas.
Rabbits	Rabbits are present in the Oxbow and can survive off the vegetation and grass.
Skunks	Skunks are already in the Oxbow and eat weeds, which there is plenty of in the area. They also eat rodents, lizards, salamanders, and other animals.
Berries	Berries are currently in the Oxbow, and more can be planted.
Grasshoppers	Grasshoppers are found everywhere in Michigan, and they eat other insects, so there is great availability.
Bats	Bats are in the Oxbow, and there is a good habitat for them already, including bat houses.
Frogs	Frogs are in the water near the Oxbow. They eat the insects in and near the water, and there are plenty of them.
Geese	Near the Oxbow, there is an abundance of geese. Great horned owls occasionally prey on the young of ducks and geese.

Figure 6. Some food sources of the great horned owl and their availability in the Oxbow.

Reflection Section

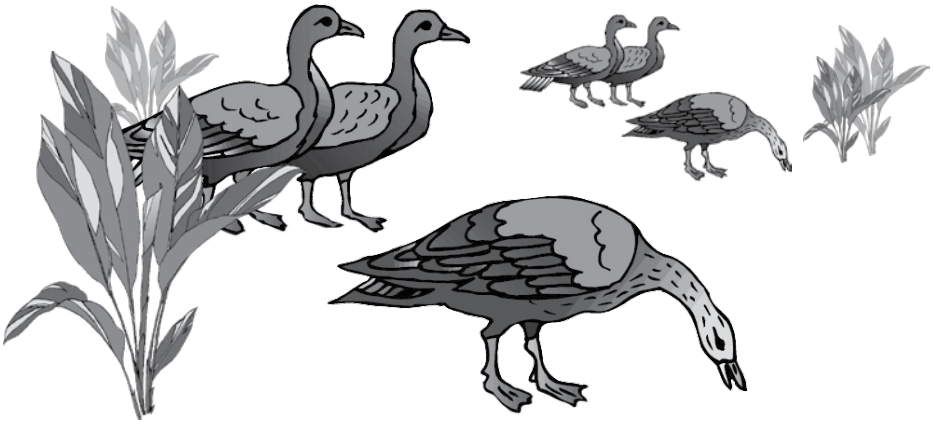
When you improve the habitat for the great horned owl, do you think other animals benefit from the improvement also? Why or why not?

What are some benefits of attracting more great horned owls to the Oxbow?

Discussion

A favorable habitat can have many benefits. Native bird species may need help so that their native habitats can be restored. The great horned owl is a bird that may be able to control an undesirable species in the area. One problem species present in the Metro Detroit area and the Oxbow is the Canada Goose. There is an **overabundance** of these animals and they have become a nuisance over the years. The great horned owl would be able to help with this problem because the owls can use geese as one of their food sources. This would help keep the Canada Geese in the Oxbow under control instead of being a problem.

One thing that could be done in the Oxbow is to add a wheat field. The field will help to accommodate the mouse-like creature called a vole. A vole's main food source is wheat. This is important because the great horned owl also eats the vole. All of these animals and plants will help make an ecosystem strong so it will not fail. In other words, the wheat, the voles, and the great horned owls would possibly balance out the ecosystem.*



Through all of our research findings, we have concluded that the great horned owl should survive and do well in the Oxbow. We found that the great horned owl's habitat is similar to the habitat found in the Oxbow. The great horned owl eats many different types of animals and many of these animals are abundant in the Oxbow. For example, Canada Geese, mice, and other small animals are available in the Oxbow.

There would be an even greater abundance of rodents if there were more wheat fields. These fields could easily be planted. Everything that is needed for the great horned owl's existence is provided in the Oxbow. With the great horned owl living in the Oxbow, it will attract more tourists, aid in the learning of others, and will support the food chain and ecosystem.

*After Forest Service scientist review, we want to note that it is difficult for humans to judge balance in an ecosystem that is already altered by humans. In this example, humans are further altering the system through agricultural practices.

Reflection Section

Do you think it is a good idea to enhance the great horned owl's habitat in the Oxbow? Why or why not?

Let's say the student scientists were able to plant a wheat field where the horse pasture is now. How might the student scientists find out if planting the wheat field had any impact on the number of great horned owls living in the Oxbow?

FACTivity

In this FACTivity, you will do a similar study to the student scientists in this research.

Using your school library, the Internet, and other resources, identify five birds that should live in the natural area around your school. Divide your class into five groups. Each group will do research about a different bird. The question each group will answer is: Is the natural area around our school a good habitat for the bird we are researching?

To answer your question, you will need to develop a method similar to the student scientists in this research. You will need to find out what kind of resting and nesting areas your bird needs. You will also need to identify what kind of food your bird eats to survive. When you have completed your research, write up your results using the same format as the student scientists. You may want to include photos, drawings, and other illustrations in your report.

PLT

If you are a PLT-trained educator, you may use #22 "Trees as Habitats" as an additional resource.

Student Article Citations

"Great Horned Owl." All About Birds. 06 Jan 2008. http://www.birds.cornell.edu/AllAboutBirds/BirdGuide/Great_Horned_Owl_dtl.html

"Great Horned Owl." Desert USA. Digital West Media Inc. 06 Jan 2008. http://www.desertusa.com/mag00/jan/papr/ghowl.html

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Axley, E. 2001. **"Bubo virginianus."** (On-line), Animal Diveristy Web. Accessed January 10, 2008 at http://animaldiversity.ummz.umich.edu/site/accounts/information/Bubo_virginianus.html

Oxbow
Soil Vitality:
Is it healthy?

Student Scientists

Peter Beard, Sabelia Gaston, Katie Petrlich, Stuart Husky, and Jasmine Cook

Glossary

Industrial waste (in **dus** tre ul wast): Waste created in the process of manufacturing products.

Agricultural chemicals (**ag** ruh kul chür ul **kem** uh külz): Chemicals used in agriculture. These chemicals can come from a variety of sources such as pesticides, fertilizers, and veterinary medicines.

Chemical property (**kem** uh kül **prôp** ür te): A characteristic of a substance that becomes evident during a chemical reaction. An example is the formation of rust.

∑: This is a symbol that means "the sum".

Physical property (**fiz** ul kül **prôp** ür te): A characteristic of a substance that can be observed, such as color, taste, texture, and density.

Oxbow (**ox** bo): A U-shaped bend in a river or stream.

Nitrogen (**nit** ro jen): Nitrogen is an element that is necessary for plant and animal growth. For example, nitrogen is a part of chlorophyll that plants need for photosynthesis.

Potassium (po **täs** e um): Potassium is an essential mineral that helps with photosynthesis, the quality of fruit, and disease reduction.

Phosphorous (**fôs** fôr us): Phosphorous is an essential nutrient for plant growth. It helps plants with photosynthesis, plant structure, and energy.

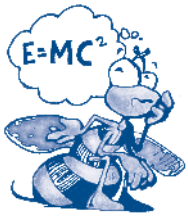
Density (**den** su te): The amount of matter in a given space.

Pronunciation Guide

a	as in ape
ä	as in car
e	as in me
i	as in ice
o	as in go
ô	as in for
u	as in use
ü	as in fur
oo	as in tool
ng	as in sing

Accented syllables are in **bold**.

Thinking About Science



Scientists sometimes develop an index to help them describe and compare a particular thing. An index contains a lot of information summarized into one number or quality. In this research, the student scientists adapted an index created by the Forest Service to describe soil quality. The Forest Service index contains many separate measurements of different soil qualities. The different measures are added together into one number, which represents the quality of a particular soil. Another index you might know about is a credit score. This is one score that represents many measures of a person's payment record on a variety of loans, such as car loans. One advantage of an index is that it allows scientists to compare one person or thing with another.

Thinking about the Environment

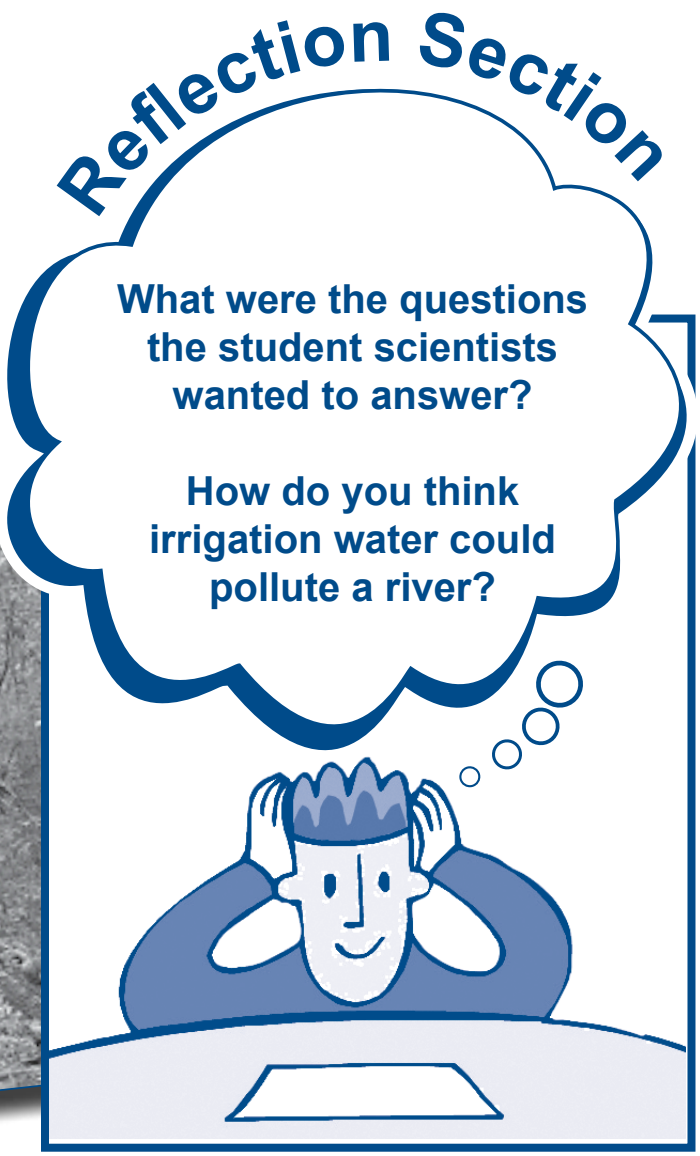
The importance of soil quality is often overlooked when people think about the environment. Soil, however, is the place where plants such as trees, flowers, and crops, get their nutrients. The soil can be depleted of nutrients by years of agriculture. Healthy soil can be washed into streams and rivers. Soil can be polluted by **industrial waste** or **agricultural chemicals**. The student scientists in this study decided to investigate the soil quality in an area near their school. They heard that the soil was polluted by irrigation water. They decided to find out for themselves how healthy the soil was in that area.

Introduction

The Forest Service's Forest Inventory and Analysis (FIA) program uses a number of **chemical** and **physical properties** to measure the health and/or quality of soil. A new index was developed that integrates nineteen different measured chemical and physical properties that can be found in soil. The index combines the properties into one single number that serves as the soil's "vital sign." This new index is called the Soil Quality Index (SQI). The SQI is a measure that can be used to describe the **Oxbow's** soil health.

The Oxbow is a 20–acre tract of undeveloped land, bound on three sides by an oxbow of the Rouge River in Dearborn, Michigan **(figure 1)**. The Oxbow has been contaminated and ruined over time. The water is (partially) polluted by irrigation. Our job, as the soil team, was to find out how the soil has been affected by irrigation water and determine the overall status of the soil's health in the Oxbow.

Figure 1. The Oxbow, Dearborn, Michigan.



Method

Our student team used a modification of the SQI to measure the health of soil in the Oxbow. Soil properties were measured in the Oxbow area of Greenfield Village during the week of November 28, 2007. The Oxbow has many different trees from hackberries to white oaks. Our team chose three trees to be the main independent variables in our research **(figure 2)**. These three trees are the ash, hackberry, and cottonwood. We chose these trees because they are dominant in the Oxbow.

Our team hypothesized the following:
"If the tree is healthy, then the SQI value will be higher; and if the tree is unhealthy, then the SQI value will be lower."

Since we are student scientists, we could not use all of the exact chemical and physical properties that are used to find SQI. We had to create our own SQI value using the same methods with different measured chemical and physical properties. We called our SQI the Student SQI, or SSQI. The original properties that are used to find a SQI are density, soil pH, organic carbon (in minerals) percentage, total nitrogen, sodium, potassium, magnesium, iron, nickel, copper, zinc, cadmium, lead, sulfur, and Bray 1 or Olsen extractable phosphorous.

The only physical and chemical properties that we used were **density** (of gathered soil in percentage), total **nitrogen** (percentage), **potassium**, **phosphorous**, and soil pH. The maximum value of the total SSQI is 9 and the minimum value is -2, if all the 5 properties are measured to their highest and/or lowest level. The SSQI value is then expressed as a percentage. The method that will be used to find the SSQI value is shown in figure 3 and 4.

Figure 2. Experimental Factors in the Oxbow SQI Experiment.

Independent Variable	Factor that changes	Tree Soil
Dependent Variable	Factor that changes due to independent variable	SQI Value
Control	The experiment is compared to this	Average Healthy Soil SQI Value
Constants	Remains the same	5 physical and chemical properties

Figure 3. The properties measured and method used to calculate SSQI.

Property	Level	Interpretation	Value
Density (g/cm^3)	>1.5	Possible adverse effects.	0
	≤1.5	Adverse effects unlikely.	1
Soil pH	<3.0	Severely acid-almost no plants can grow in this environment.	-1
	3.01 to 4.0	Strongly acid-only the most acid tolerant plants can grow in this pH range.	0
	4.01 to 5.5	Moderately acid-growth of acid intolerant plants is affected depending on levels of acid.	1
	5.51 to 6.8	Slightly acid-optimum for many plant species, particularly more acid tolerant species.	2
	6.81 to 7.2	Near neutral-optimum for many plant species except for those who prefer acid soils.	2
	7.21 to 7.5	Slightly alkaline-optimum for many plant species except those that prefers acid soils.	1
	7.51 to 8.5	Moderately alkaline-preferred by plants adapted to this pH range.	1
	>8.5	Strongly alkaline-preferred by plants adapted to this pH range.	0

Nitrogen (percent)	>0.5	High-excellent buildup of organic carbon with all associated benefits.	2
	0.1 to 0.5	Moderate-adequate levels.	1
	<0.1	Low-could indicate loss of organic nitrogen.	0
Potassium (mg/kg)	>500	High-excellent reserve.	2
	100 to 500	Moderate-adequate levels for most plants.	1
	<100	Low-possible deficiencies.	0
Phosphorus (mg/kg)	>1000	High-excellent reserve, probably calcareous soil.	2
	101 to 1000	Moderate-adequate levels for most plants.	1
	10 to 100	Low-possible deficiencies.	0
	<10	Very Low-severe Ca depletion, adverse effects more likely.	-1

Figure 4. Equations used by the student scientists.

$$\text{Total SSQI} = \Sigma \text{ individual soil property values}$$

$$\text{SSQI} = (\text{Total SSQI} / \text{Maximum possible total SSQI for properties measured}) \times 100$$

The team gathered six different samples from the three different trees chosen **(figure 5)**. Although we decided to use only three trees, we wanted to have multiple samples from each tree. We took two different samples for each tree. Two samples were taken from two different ash, hackberry, and cottonwood trees. The next step was to find the properties listed above. After finding these properties we were able to conclude the SSQI value of each sample of the soil. We were hopeful that we would come up with an average SSQI value of the entire Oxbow, or portion of the area.

Figure 5. The team gathered different soil samples from under three different tree species.

Reflection Section

Why did the student scientists have to modify the SQI?

Why did the student scientists focus on ash, hackberry, and cottonwood trees?

Findings

The results of our soil analysis varied depending on the area from which the soil was taken. We assumed the soil was healthy since it was taken from around tree roots. In some areas, the soil was higher in certain nutrients (chemical properties) and low in others. Our data states the SSQI value of each area of the Oxbow, and an average SSQI value for the entire region of the Oxbow. The physical properties of our soil samples consisted of measures of potassium, phosphorous, nitrogen, and soil pH **(figure 6)**.

From the results of our experiment, we estimated that the soil quality of the Oxbow is measured to a value of 5. The total SSQI range is from 3-6. The average is 4.5. The SSQI value ranges from 33.33-66.67 and averages 50.00.

This says a lot about the soil vitality of the Oxbow. It is not necessarily healthy, but it also isn't dangerous. The pH levels show that the Oxbow is suitable for plants to live there, and plants actually prefer the soil pH of the Oxbow. However, the Oxbow is low in nitrogen and high in potassium. Plants that need potassium would prefer to live here as well. Though the soil is low in nitrogen with high nutrients in other chemical properties it shows that trees and other plants are very likely to live in the Oxbow.

Figure 6. The results of the soil analysis.

Hack= Hackberry CW= Cottonwood.

SSQI Factor	Ash Tree 1	Ash Tree 2	Hack Tree 1	Hack Tree 2	CW Tree 1	CW Tree 2
Density	1	1	1	1	1	1
Potassium	Medium 1	Medium 1	Medium 1	High 2	Medium 1	Medium 1
Phosphorous	Low 0	Medium 1	Low 0	Medium 1	Low 0	Medium 1
Nitrogen	Low 0	Low 0	Low 0	Low 0	Low 0	Low 0
Soil pH/ SSQI	8 1	7 2	6 2	7 2	7 2	6 2
Total SSQI	3	5	4	6	4	5
SSQI Value	33.33	55.56	44.44	66.67	44.44	55.56

Reflection Section

In your own words, summarize what the student scientists found through their study.

The SSQI value ranges from 33.33-66.67. The average is 50.00. Based on these findings do you agree with the students' assessment of their findings? Why or why not?

Discussion

After doing our research and doing an analysis, we came to the conclusion that the soil was in pretty good shape. Therefore, we concluded that the soil was not being affected too much by irrigation water. The soil in some areas had highs and lows but overall the soil in the Oxbow was moderate. This means that some plants can live in the soil. Of course, it would have been good to be able to measure more chemicals.

With all of the work being done to the Oxbow, it is surely on its way from being a dump site to being an attraction for people to come learn about plants and animals alike. The Oxbow has sure seen its bad days, but the light is starting to shine on the forgotten Oxbow.

Reflection Section

The student scientists wished they could have measured more chemicals. If they had been able to do so, do you think they might have come to a different conclusion? Why or why not?

The SSQI used 5 different measures to come up with an overall value. Think of a similar situation in your life where many different measures are combined in some way to produce one overall value. Explore this process of evaluation in a class discussion. What are its advantages and disadvantages?

FACTivity

In this FACTivity, you will do something similar to the student scientists in this study. The question you will answer in this FACTivity is: How do different areas in our school yard compare as wildlife habitats?

The method you will use to answer your question is:

Divide your class into 6 groups. Select three separate areas in your school yard. Depending on the size of your school yard, each area could be rather small. Two groups will work in each area.

Use the Student Wildlife Habitat Quality Index (SWHQI) below.

The range of this index is –2 to 6. Six would indicate an excellent wildlife habitat and –2 would indicate a poor wildlife habitat.

After the groups gather data on different areas in the school yard, compare what you found. What is the wildlife habitat quality overall? What could you do to improve the wildlife habitat? Where some areas of the school yard better than other areas? If so, why?

Discuss the value of using an index to compare wildlife habitats. Is it easier to use one number than comparing five qualities? Why or why not?

PLT

If you are a PLT-trained educator, you may use #70 "Soil Stories" as an additional resource.

Does the area have natural ground cover, such as leaves and small bushes?	**No coverage (less than 10 percent)= -1 Some coverage (less than 25 percent) =0 Fifty percent coverage and above=1**
Are there are variety of plants in the area?	**No variety= 0 Some variety=1 Wide variety=2**
Are there some plants that produce berries or other fruits?	**No plants=-1 Less than 25 percent = 0 Fifty percent and above= 1**
Is there some source of fresh water available?	**No =0 Yes=1**
Is there enough space for things to grow and live?	**No=0 Yes=1**

The Emerald Ash Borer

An Ash Tree's Worst Enemy!

Student Scientists
Isaiah Spriggs, Timothy Pugh, Sam Simpkins,
Erika Gutierrez, Ben Mueller, Delianise Olivo

Photo: Eric R. Day, Virginia Polytechnic Institute and State University, Bugwood.org

Glossary

Infestation (in **fes** ta shun): To swarm or spread in and over in a troublesome manner.

Oxbow (**ox** bo): A U-shaped bend in a river.

Distilled water (dis **tild wa** tür): Water that has been through a process where almost all impurities in the water have been removed.

Acidity (uh **sid** uh te): The degree or amount of acid in a solution. An acid has a pH less than 7.

Alkalinity (**al** kuh lin uh te): The degree or amount of base in a solution. A substance with a pH more than 7.

Phosphorus (**fôs** fôr us): Phosphorus is an essential nutrient for plant growth. It helps plants with photosynthesis, plant structure, and energy.

Potassium (po **täs** e um): Potassium is an essential mineral that helps with photosynthesis, the quality of fruit, and disease reduction.

Nitrogen (**nit** ro jen): Nitrogen is a part of chlorophyll and helps plants with rapid growth and fruit and leaf production.

Economy (e **kän** o me): The production, consumption, and distribution of goods and services.

Parasitic (pair uh **sid** ik): An organism living in, with, or on another organism.

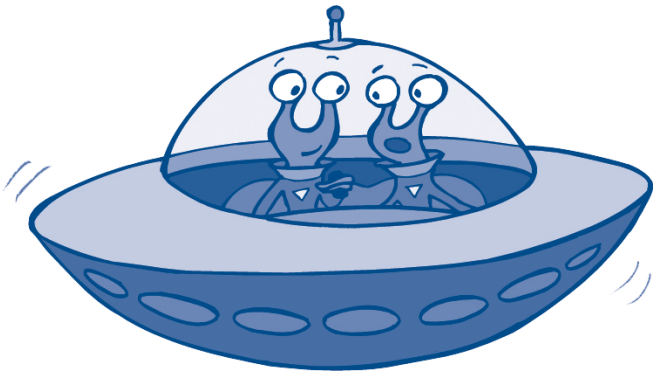
Larvae (**lär** ve): The immature, wingless, and often wormlike feeding form that hatches from the egg of many insects.

Entomologist (**en** to **mal** o jist): A scientist who studies insects.

Pronunciation Guide

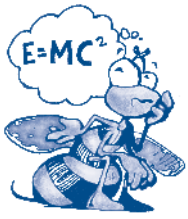
a	as in ape
ä	as in car
e	as in me
i	as in ice
o	as in go
ô	as in for
u	as in use
ü	as in fur
oo	as in tool
ng	as in sing

Accented syllables are in **bold**.



Although invasive species do not come from another planet, they can come across oceans from distant countries. Invasive species have the potential to cause a lot of damage. They cost the United States $100 billion each year! The Oxbow area in Greenfield Village, part of The Henry Ford, has been invaded by emerald ash borer (EAB). In this research, you will learn about student research and the EAB.

Thinking About the Environment



What is an invasive species? If you are thinking of invaders from a distant planet, you are almost right, except that these species invade from right here on Earth. Invasive species are any plant, animal, or organism that is not native to the ecosystem it is in. An invasive species is likely to cause harm to the environment, the economy, or human health.

Thinking About Science

Scientists need the proper equipment to do their work. This is true for student scientists as well. In this research, the student scientists were able to use a soil testing kit. Without the soil testing kit, the students would have been unable to do this research. If the proper equipment is not available, scientists must make their own equipment or change their methods. As you can see, science often depends on technology to make new kinds of investigations. Name one kind of investigation made possible today by technology that was not possible 50 years ago.

Introduction

Agrilus planipennis, (**ag** ruh lus **plan** uh **pen** us) or emerald ash borer is a colorful beetle, native to eastern Russia, northern China, Japan, and Korea **(figure 1)**. The average beetle's length is 20 millimeters long and 4 millimeters wide **(figure 2)**. An EAB is an invasive beetle known for killing ash trees. The damage to trees is caused after EAB bores or tunnels itself into the tree. The EAB adult lays eggs in the bark which hatch into larvae. The EAB larvae feed off of the trees by eating the inner bark and taking much of the tree's nutrients.

Figure 2. The EAB is an emerald colored beetle, 20 millimeters long and 4 millimeters wide.

Photo courtesy of http://www.bugwood.org. David Cappaert from Michigan State University.

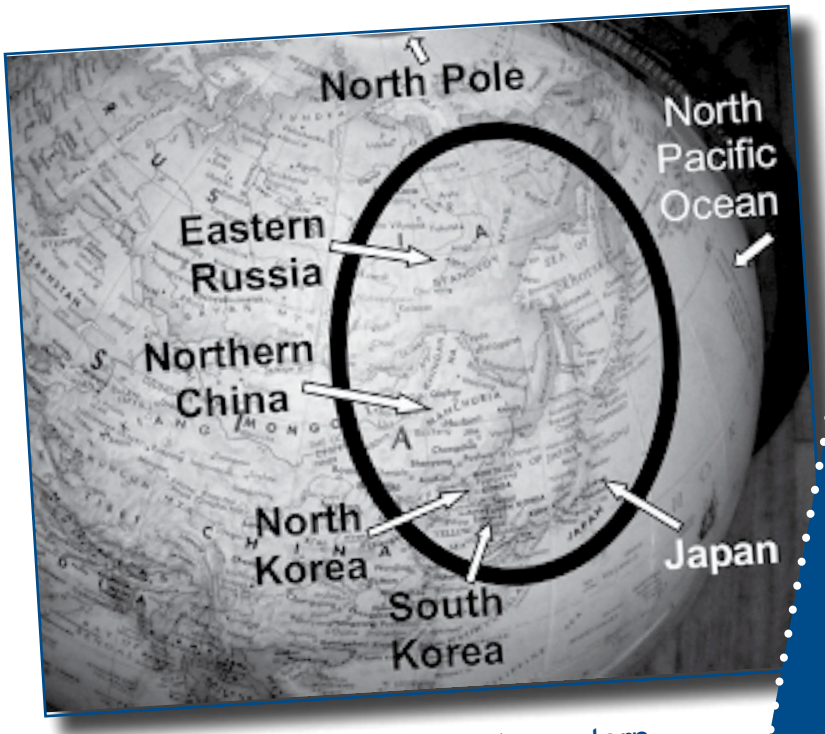


Figure 1. The EAB is native to eastern Russia, northern China, Japan, and Korea.

Number Crunches

How many inches long and wide is the average EAB beetle? Multiply 20 millimeters X 0.039, and 4 millimeters X 0.039 to find out.

Before 2002, EAB had never been found in North America. It is not known how it got into North America, but it most likely came in ash wood in ships or from packaging or crating. One of the major ways that EAB was transported and spread so fast within North America was by people moving firewood from one place to another. Since ash trees make very good firewood people sell it or bring it on vacation.

All species of North American ash trees are at risk now. In 2002, the EAB was found in southeastern Michigan and Ontario **(figure 3)**. Evidence suggests that EAB had been in the United States for at least 10 years before it was first detected.

Since the EAB was first detected, it has killed over 20 million ash trees in Michigan alone. EAB has also been found in Indiana, Ohio, Illinois, Maryland, Kentucky, New York, Pennsylvania, Missouri, Minnesota, West Virginia, Wisconsin and Virginia. Most of these **infestations** are not new. Scientists have just become better at finding them.

We studied an area near our school called the **Oxbow**. The Oxbow is an area of land surrounded by an Oxbow lake of the Rouge River in Dearborn, Michigan. The Oxbow was infested with EAB, which has infested all of the ash trees. We were interested in studying the soil in the Oxbow and how soil properties are related to ash trees infested by the EAB.

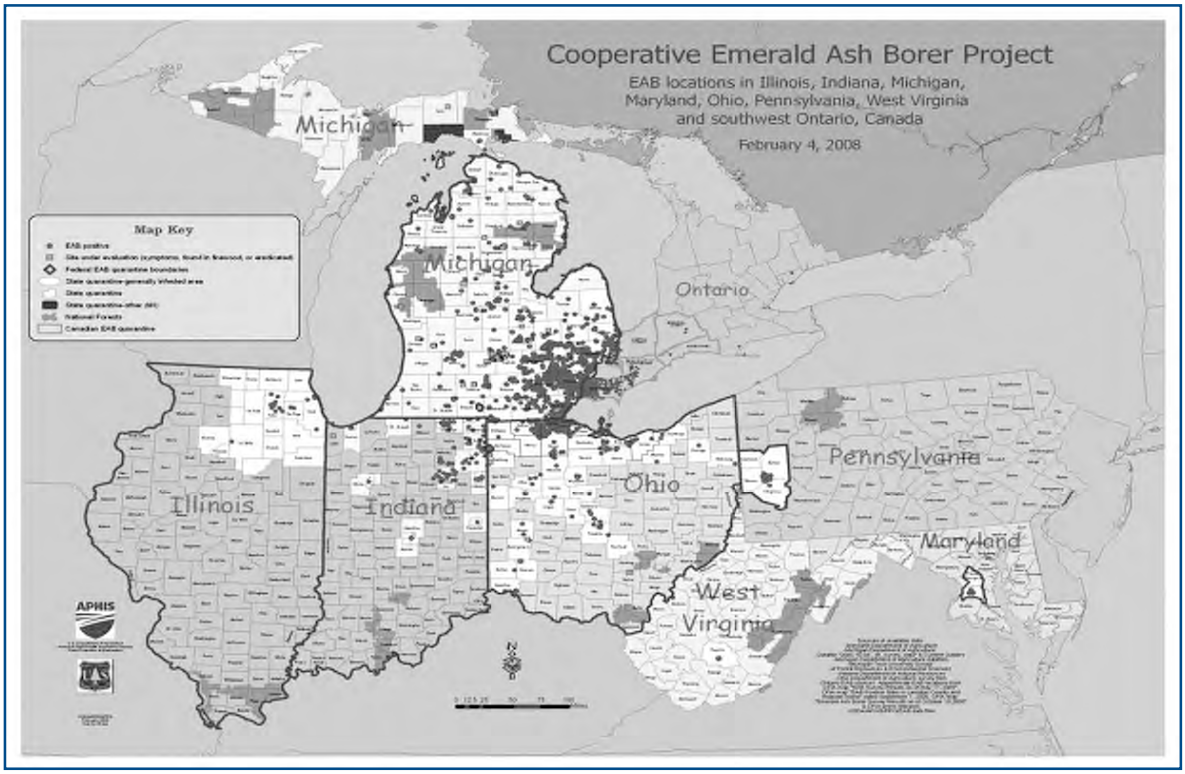


Figure 3. A map of EAB infestations. The areas in gray show where the EAB has been found.

Reflection Section

From what you read so far, do you think the EAB problem will improve worsen, or stay the same? Why?

What was the question the student scientists wanted to answer?

Method

We collected our data from the Oxbow area in Greenfield Village, which is part of The Henry Ford, located in Dearborn, Michigan **(figures 4, 5, and 6)**, during the week of November 28, 2007. Our data consisted of soil samples taken underneath various trees, including ash trees.

We tested the pH levels of the soil samples by using a pH kit and pH paper. The equipment we used included a shovel to dig up the dirt, bags to hold the dirt, a pH kit to test the pH levels, pH paper to also test the pH levels, test tubes, and **distilled water.** The variables we studied were the pH levels in the different soil samples.

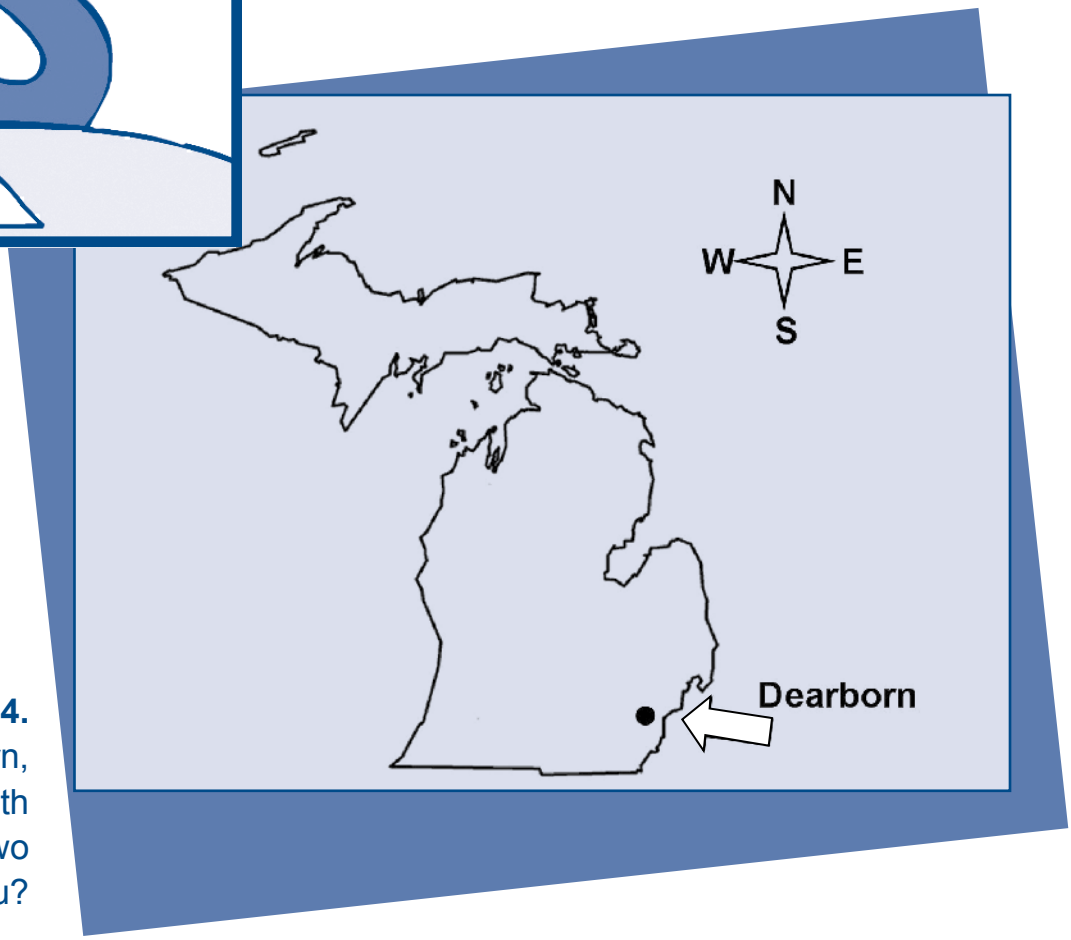


Figure 4.
Location of Dearborn, Michigan. Compare this with figure 3. What do these two maps together tell you?

Figure 5. Greenfield Village is a living history village.

Figure 6. The Oxbow is a natural area and a part of Greenfield Village.

Altogether, we took seven different soil samples from under each of seven different trees. The soil was taken from around the following trees: two different dying ash trees, a sugar maple, a hackberry, a cottonwood, a sycamore, and a box elder tree **(figures 7-12)**. The pH was the unit of measure. We analyzed our data by using the pH kit and the pH paper to determine the pH levels in the different soil samples.

The pH scale is a measure of the degree of **acidity** or **alkalinity** of the soil. The pH scale has 14 divisions ranging from 1 to 14. At the midpoint of this scale, 7, soil is neutral (neither acid nor alkaline). Those between 1 and 6.9 are acidic soils; soils that measure 7.1 to 14 are increasingly alkaline (also called basic). Increments between each number represent a tenfold increase. For example, at pH 5 it is 10 times more acidic than at pH 6. Soil pH of 5.5 to 6.5 is suitable for most plant growth. Gardeners should know the pH of their soil because it affects the availability of plant nutrients. Nutrients become less available at pH extremes.

Figure 7. Ash tree.

Figure 8. Sugar maple tree.

(Note: All photos courtesy of bugwood.org and forestpests.org)

Figure 9. Hackberry tree.

Figure 10. Cottonwood tree.

Figure 11. Sycamore tree.

Figure 12. Box elder tree.

We also determined the amount of **phosphorus**, **potassium**, and **nitrogen** in the soil. The soil testing kit enabled us to identify these amounts as low, medium, or high. We tested these amounts for all seven soil samples.

Reflection Section

What might be an advantage of taking 7 soil samples from under each tree, instead of taking just 1 or 2 samples?

Look at the photos in figures 7-12. What is one common feature of all of these trees?

Findings

As the chart shows below the only real difference in the data is the pH levels collected with the pH kit. From the data that was collected it is clear that soil samples 1 and 7 seem optimal for plant growth. The interesting aspect of this finding is that 1 and 7 were the samples collected near infected ash trees while all the other samples were from areas free of infected trees. However, the conclusion that the EAB is making the soil better for other plants to grow in cannot be drawn from these results as of yet. It is important to conduct more research to better understand the relationship between soil pH and ash trees affected by EAB.

Reflection Section

Are you surprised at the student scientists' findings? Why or why not?

What might you conclude about the EAB and soil properties from these findings?

If you had an opportunity to repeat this research, what might you do differently?

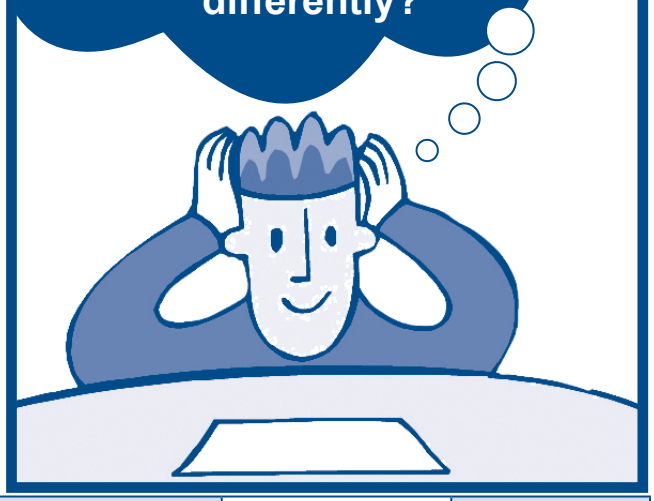


Figure 13. This table shows the results of our research. The level of phosphorus, potassium, nitrogen, and pH for the seven soil samples.
L=Low M=Medium H=High

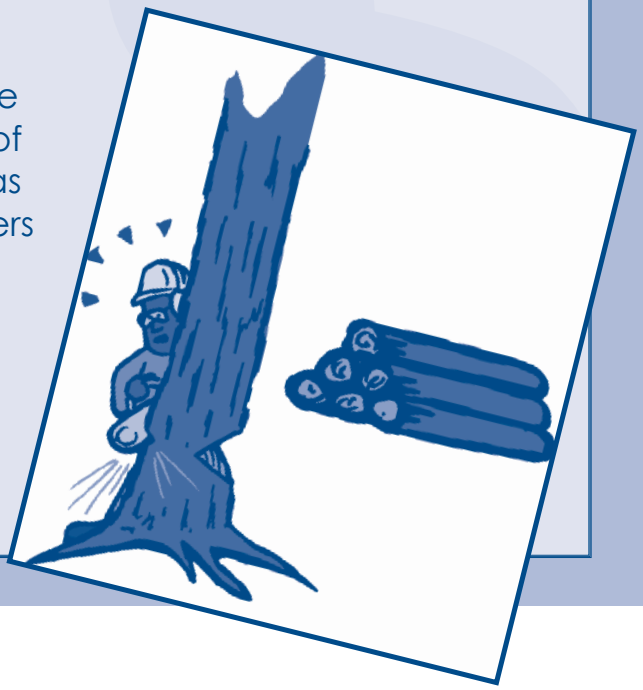
	Phosphorus	Potassium	Nitrogen	pH Kit	pH Paper
Soil Sample 1	L	H	L	6.5	6.0
Soil Sample 2	M	M	L	7.5	6.0
Soil Sample 3	M	H	L	7.0	6.0
Soil Sample 4	L	H	L	7.0	6.0
Soil Sample 5	M	H	L	7.5	7.0
Soil Sample 6	L	H	L	7.5	6.0
Soil Sample 7	L	H	L	6.5	6.0

EAB
Effects on the Economy

Almost 114 million board feet, worth $25.1 billion, are produced from ash trees grown in northeastern U.S. Therefore, it's easy to see the potential danger and problems the EAB can cause. Ash trees are used in making of all sorts of things from cabinets to baseball bats for Major League Baseball. The EAB can have quite a large impact on the economy. The local economy has already been impacted as over 300 million ash trees that have been planted for landscaping purposes must be removed because of EAB.

However, the EAB is actually supposed to have a larger negative impact on the economy in Ohio than in Michigan. This is because Ohio has more ash trees and a greater variety of them. Ash trees contribute more than $20 million of Ohio's annual revenue, and without most of these trees it's easy to see the hefty cost of losing them. Over the next ten years the EAB is projected to cost over $20 million in damages in Ohio alone.

Detroit newspapers have previously said that because of the EAB infesting so many of the urban trees, the cost of removing the trees has forced property owners to take out second mortgages.



Discussion

Among other places, the EAB has been detected in 52 different counties in Ohio. There are some possible solutions for the ash tree-eating beetles. Foresters have destroyed the infested trees and quarantined counties where the infested trees are found to slow down the spread. This is not the only way that the government has tried to stop the spread.

There are three parasitic wasps that could possibly help control the EAB population. One type of wasp is the stingless parasitic wasps that are native to China. A possible solution to the problem may be the release of stingless **parasitic** wasps that are native to China **(figure 14)**. The tiny female wasps insert their eggs through the bark into or on the EAB larvae. The larvae that hatch out of the eggs then eat the damaging EAB **larvae**. **Entomologists** in Michigan have been experimenting with the Chinese wasp and have bred thousands of them, ready and waiting to be released. They are planning to release the wasps in Michigan where EAB has hit the hardest in order to investigate the success of using these wasps.

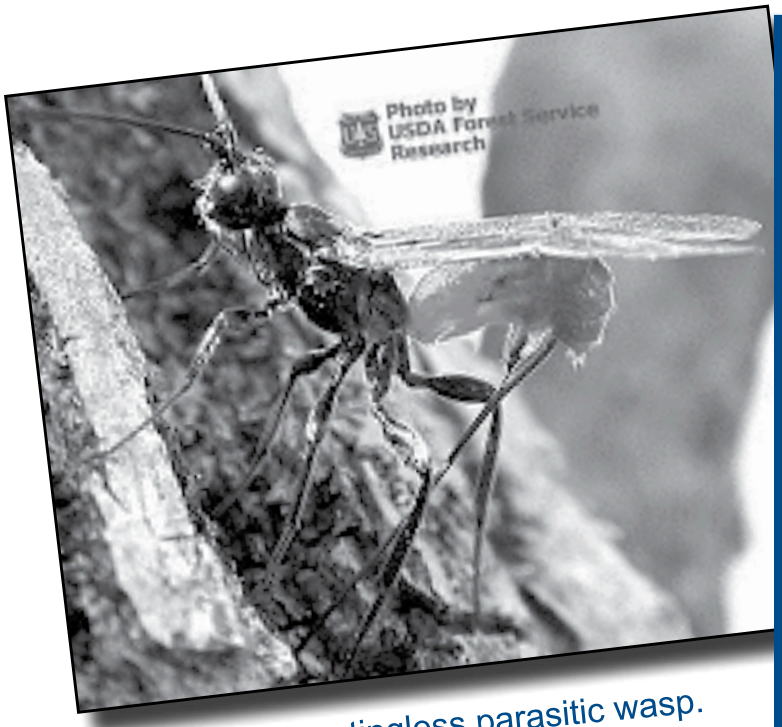
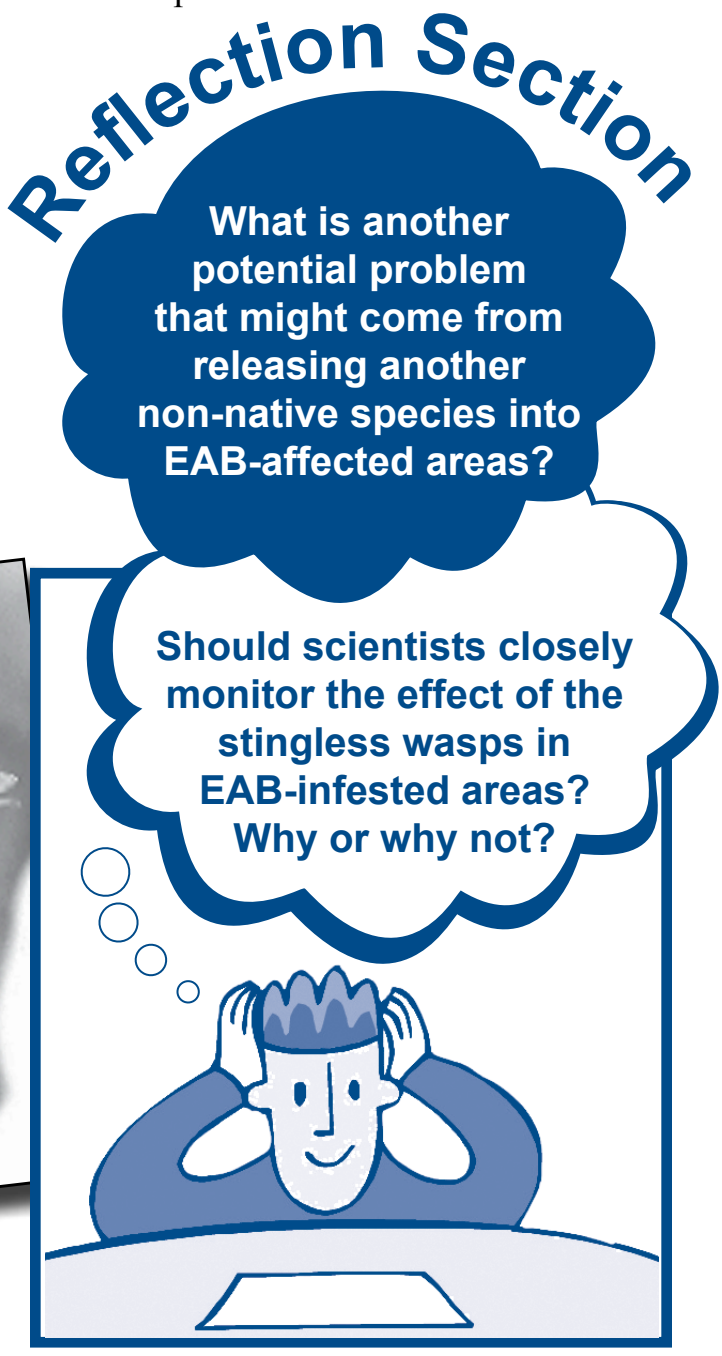


Figure 14. The stingless parasitic wasp.



FACTivity

In this FACTivity, you will explore soil just like the student scientists. The question you will answer is what is the soil profile like near my school or home?

Background: If you look in a soil pit or on a roadside cut, you will see various layers in the soil. These layers are called soil horizons. The arrangement of these horizons in a soil is known as a soil profile. Soil scientists, who are also called pedologists, observe and describe soil profiles and soil horizons to classify and interpret the soil for various uses.

Soil horizons differ in a number of easily seen soil properties such as color, texture, structure, and thickness. Other properties are less visible. Properties such as chemical and mineral content, consistence, and reaction require special laboratory tests. All these properties are used to define types of soil horizons.

Soil scientists use the capital letters O, A, B, C, and E to identify the master horizons, and lowercase letters for distinctions of these horizons. Most soils have three major horizons -- the surface horizon (A), the subsoil (B), and the substratum (C). Some soils have an organic horizon (O) on the surface, but this horizon can also be buried. The master horizon, E, is used for subsurface horizons that have a significant loss of minerals. Hard bedrock, which is not soil, uses the letter R.

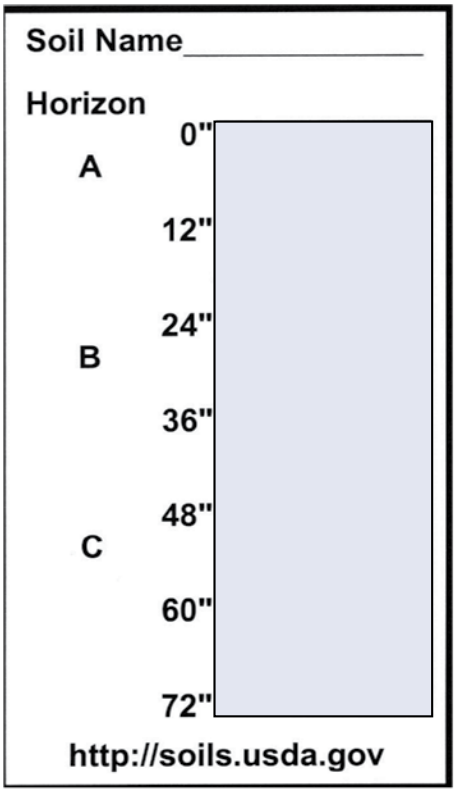
The method you will use is:

1. Get a copy of the soil profile card.
2. Attach some double-sided tape to the card. One inch, carpet tape is preferable.
3. Go out into the school yard and find a place where you can see the layers of the soil. If an area like this is not available, you may dig a small hole down into the ground to reveal the layers of soil.
4. Take a small sample of each layer of soil and pull back the sticky tape for the surface layer of soil. Place some soil on the tape to represent the depth of this first layer of soil.
5. Pull back the tape for each additional layer of soil and repeat the same procedure.
6. Properly dispose of any remaining tape.
7. The soil card can now be placed in an envelope or small plastic bag for protection.

8. You may want to repeat this activity at several different locations and compare the soil depths.

9. You may also want to create a drawing of a hill slope or the landscape to go along with this soil card.

10. After you have finished your soil cards, you can compare your cards with your classmates. Are they similar? Different? Why?



This FACTivity is from The United States Department of Agriculture Natural Resources Conservation Service.

A larger reproducible soil card is on the next page.

PLT

If you are a PLT-trained educator, you may use #70 "Soil Stories" as an additional resource.

For more information about this activity, visit http://soils.usda.gov/education/resources/k_12/lessons/profile/

Student Article Citations

www.semired.org/ash

www.inspection.gc.ca/eng

www.saveqourash.info

www.emeraldashborer.info

www.michigan.gov/eab

www.ohioagriculture.gov/eab

www.elmhurst.edu/~chm/vchembook/184ph

www.invasivespeciesinfo.gov/plants/garlicmustard

http://www.invasive.org/eastern/biocontrol/29GarlicMustard.html

www.invasive.org/eastern/biocontrol

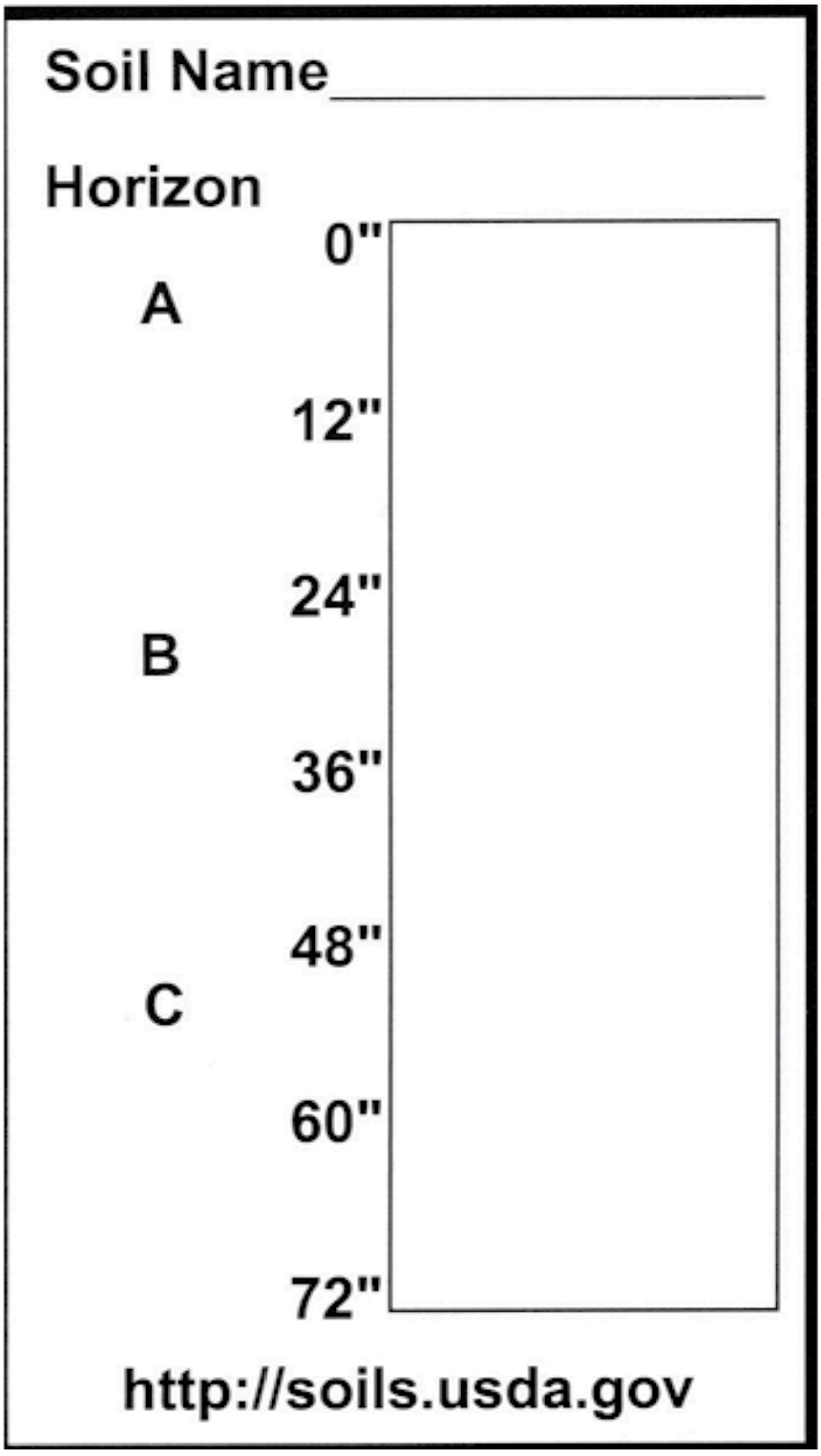
www.wildmanstevebrill.com

http://www.dnr.state.oh.us/tabid/1998/default.aspx

http://na.fs.fed.us/spfo/pubs/pest_al/garlic/garlic.htm

http://www.nps.gov/plants/alien/fact/alpe1.htm

http://www.nps.gov/plants/alien/pubs/midatlantic/alpe.htm


Soil Name_____
Horizon
0"
A
12"
24"
B
36"
48"
C
60"
72"
http://soils.usda.gov

The Garlic Mustard Plant

All Around and Down the Oxbow

Student Scientists

Tommy Beard, Branden Omoregie, and Jeremy Barnes-Smith

Glossary

Invasive species (in **va** siv **spe** ses)- Any plant, animal, or organism that is not native to the ecosystem it is in, and is likely to cause harm to the environment, economy, or human health.

Understory (**un** dür **stôr e**)- Vegetation in a forest that is near the ground.

Native (**na** tiv)- Naturally occurring in an area.

pH (pe ach)- A measure of the amount of acidity or basicity of a solution. The scale ranges from 0 to 14. A pH of 7 is considered neutral. Acidic solutions will have a pH less than 7 and a basic solution will have a pH greater than 7.

Acidity (uh **sid** uh te)- The degree or amount of acid in a solution. An acid has a pH less than 7.

Germination (**jür** muh **na** shun)- The act of sprouting or beginning to grow.

Resistance (re **zis** tens)- The ability of an organism to resist harmful influences.

Distilled water (dis **tild wa** tür)- Water that has almost all impurities removed by distillation. Distillation involves boiling the water and then condensing the steam into a clean container.

Pipette (pi **pet**)- A narrow tube into which liquid is drawn by suction and then dispensed.

Average (**av** rij)- The number gotten by dividing the sum of two or more quantities by the number of quantities added.

Median (**me** de un)- A value in a series arranged from smallest to largest below and above which there are an equal number of values or which is the average of the two middle values if there is no one middle value. For example, in the number series 5, 6, 7, 8, 9 the median is 7.

Mode (mod)- The most frequent value in a set of values. For example, in the number set 3, 4, 4, 5, 7 the mode is 4.

Domesticated (do **mes** tuh ka ted)- Living near or with humans.

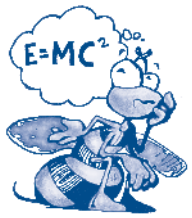
Herbivores (**ür** buh vôrz)- An animal that feeds on plants.

Pronunciation Guide

a	as in ape
ä	as in car
e	as in me
i	as in ice
o	as in go
ô	as in for
u	as in use
ü	as in fur
oo	as in tool
ng	as in sing

Accented syllables are in **bold**.

Thinking About Science



When scientists begin an experiment, they usually have an idea of how the experiment will work out. However, sometimes they have no idea what their results will show. In this experiment, the student scientists were uncertain about the possible results. Think of a time when you tried something new and had no idea how it would work out.

Thinking About the Environment

All plants need minerals to grow and survive. In this research, the student scientists were interested in discovering whether the amount of certain minerals in the soil affected the growth of an **invasive species**. Because these minerals promote plant growth, the students wondered if they would find a relationship between the presence of an invasive plant species and the amount of minerals in the soil.

Introduction

Looking at Oxbow Island, one would be surprised that the island has any invasive species **(figure 1)**. Invasive plant species that are growing uncontrollably are changing the scenery of the North American **understory**, including Oxbow Island. What was once a stunning forest full of wild plants is now changing into areas of overpopulated organisms that harm the **native** species by competing for resources such as water, space, and sunlight.

Invasive plant species are often brought to the United States as a product to sell. For example, invasive plants can be sold as garden plants. Seeds can also be brought over intentionally or accidentally as hitchhikers on other products. One reason invasive species do not spread as quickly in their native lands as the ones they invade is because animals living in the native lands consume some of the plants before they have time to seed. When introducing a plant or animal into a new environment, it generally does not have as many predators in its new area. Another potential reason for increased spread of invasive species is the

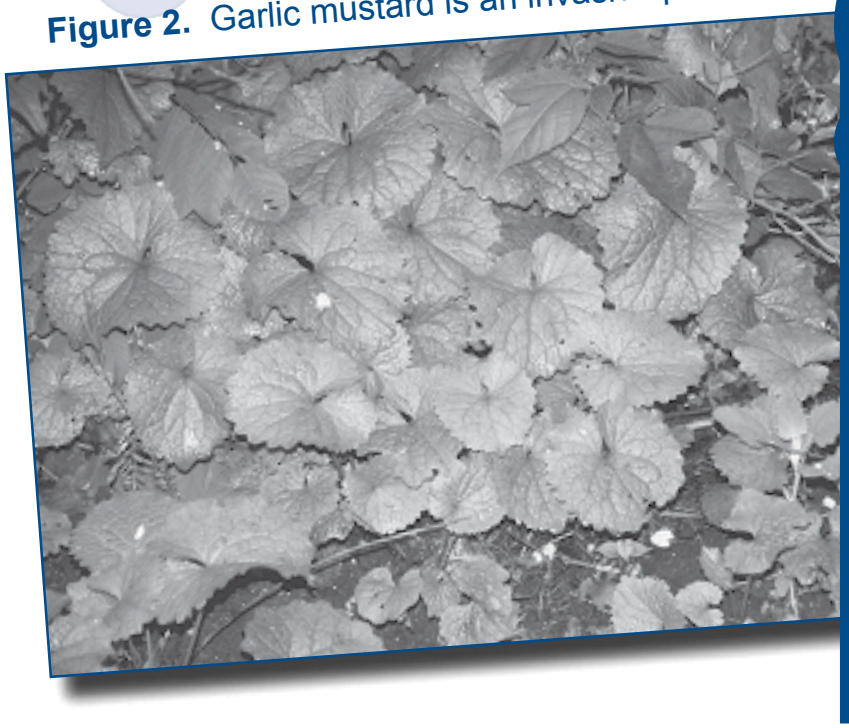
Figure 1. The Oxbow area of Greenfield Village, Dearborn, Michigan.

soil's fertility, which is determined by things like the soil's **pH**, potassium, nitrogen, and phosphorous levels. These nutrients are necessary for a plant's growth. We studied the effects of **acidity**, potassium, nitrogen, and phosphorous on the invasive species garlic mustard **(figure 2)**. We wanted to find out how nitrogen, phosphorous, potassium, and acidity levels in the soils affect the growth of garlic mustard.

Soil pH levels affect mineral levels which affect plant growth. More basic soils are usually more fertile than acidic soils. Acid rain physically touching plants also may affect plant growth, health, and **germination** rates. If time had permitted, the effects of acid rain would have been part of this research. We do believe that pH, potassium, nitrogen, and phosphorous levels might influence the spread and health of the garlic mustard plant.

Nitrogen is used in plant growth, while potassium enhances resistance to disease in plants by strengthening stalks and stems. Phosphorous helps with the transfer of energy. So, minerals help a plant **resist** any predators. We wanted to see just how much the minerals and pH were related to a concentration of garlic mustard in a particular area of the Oxbow Island that we were studying.

Figure 2. Garlic mustard is an invasive plant.



Reflection Section

State in your own words the question the student scientists wanted to answer.

Plants need nutrients like nitrogen, potassium, and phosphorus to grow. What things do you need to grow?

Method

The first step was collecting soil samples in the Oxbow. We gathered the materials we would need such as: a shovel, detailed map of the Oxbow, plastic bags, and paper for recording any additional notes. After entering the Oxbow, we used the map as our guide to locate some areas that included garlic mustard. There were three different locations—one with a large amount of garlic mustard (high concentration), one with lower amounts of garlic mustard (medium concentration), and one with very little garlic mustard (low concentration). While collecting each soil sample, we recorded facts about the area surrounding the garlic mustard plants. In addition, we labeled the areas we collected soil from on the Oxbow Island map. From each of the three sites we collected two samples.

After conducting the soil test to examine levels of nitrogen, phosphorous, and potassium, we tested each concentration of the soil using a pH level kit. We used a fluid called "wide range indicator." We used the **pipette** to remove the soil solution, and also to put it into another test tube **(figure 3)**. We put 10 drops of the wide range indicator into each concentration of soil solution. Then we shook the test tube for five minutes and let it sit for an additional two minutes. The solution changed into a certain color. The color helped us determine the pH level.

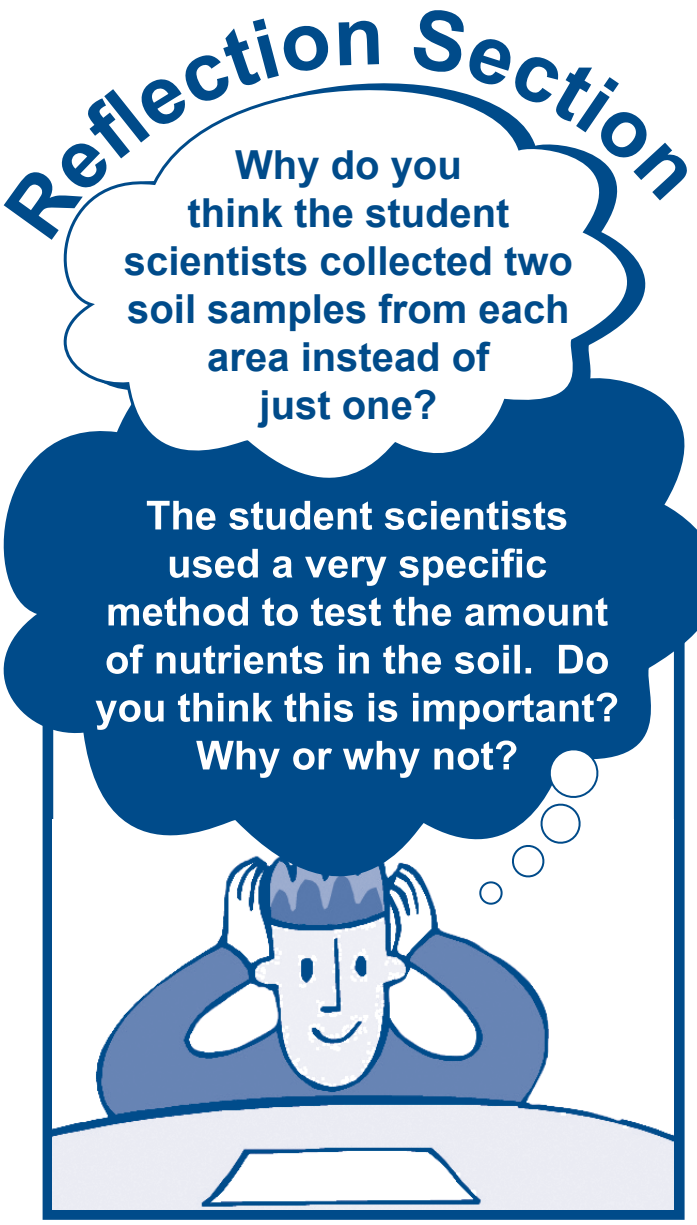


Figure 3. Pipettes are used in all different types of science experiments. Have you ever used a pipette?

Findings

While waiting for the results of the test for the nutrients in the soil, the soil solution with the nitrate began to change to a bluish color, the phosphorous to a pinkish color, and the potassium began to get cloudier. The degree of blue, pink, and clarity is what determined the level of the particular nutrient in the soil. The names of the trees indicate that the particular soil was close to that tree **(figure 4)**.

Garlic Mustard Present

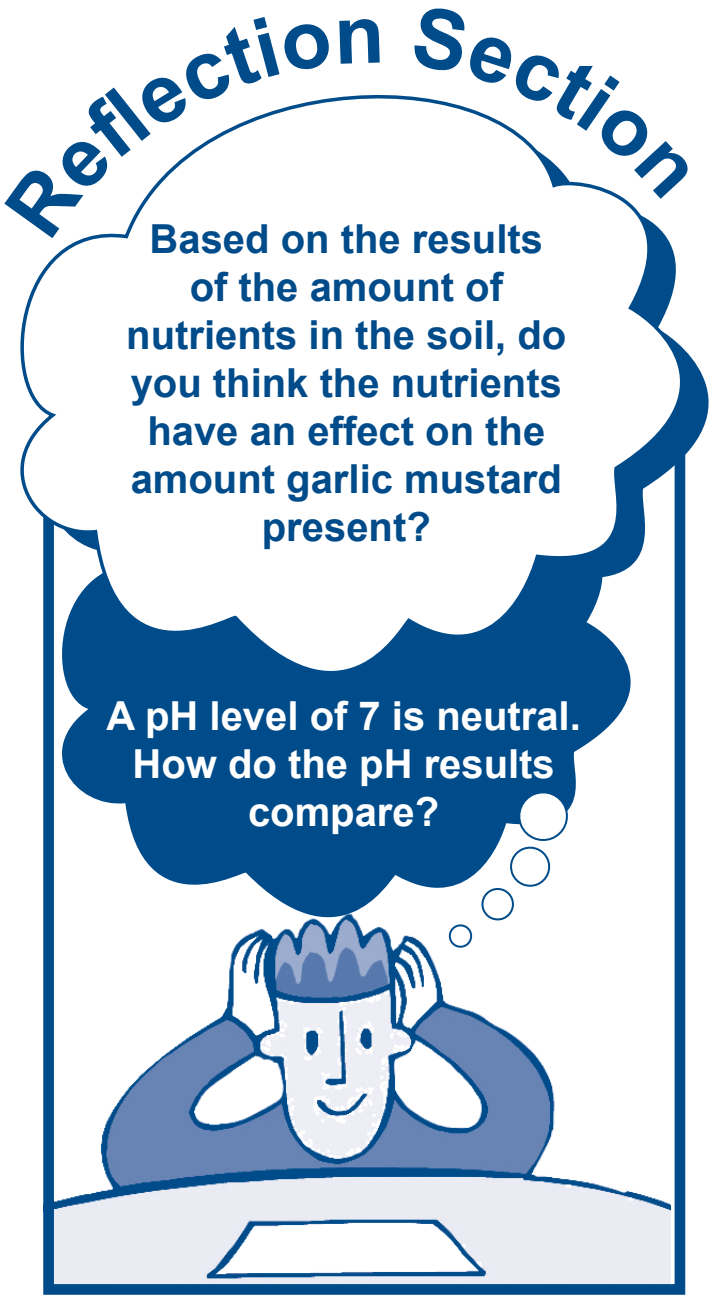
Concentration of garlic mustard	Level of nutrients
Phosphorous	
Low	Medium
Medium	Medium
High	Low
Nitrate	
Low	Low
Medium	Low
High	Low
Potassium	
Low	High
Medium	Medium
High	Low

No Garlic Mustard Present

	Potassium	Phosphorous	Nitrate
Hackberry 1	Low	Low	Low
Hackberry 2	High	Medium	Low
Ash 1	Medium	Low	Low
Ash 2	Medium	Medium	Low
Cottonwood 1	Medium	Low	Low
Cottonwood 2	Medium	Medium	Low

Figure 4. Results for the level of nutrients.

After studying the nutrients in the soil, we tested the pH levels. Using the pH level chart from the kit we compared our results to another soil testing example **(figure 5)**. The second table comes from an area where no garlic mustard was present **(figure 6)**. The names of the trees indicate that the particular soil was close to that tree.



Level of Garlic Mustard	pH Level
High	6.7
Medium	7.1
Low	6.9

Figure 5. pH level where garlic mustard was present.

Hackberry 1	7.3
Hackberry 2	7.3
Ash 1	7.3
Ash 2	7.3
Cottonwood 1	6.7
Cottonwood 2	6.1

Figure 6. pH level where garlic mustard is not present.

Discussion

The experiment was planned differently than what actually occurred. Initially the plan was to collect garlic mustard seeds and allow them to grow in various levels of pH and minerals. The time of year did not allow the research group to do that experiment. After searching for seeds, we found that a sufficient amount of seeds could not be found to complete the experiment. The objective was to find out how different pH levels and minerals affected the growth of garlic mustard, so we figured out a different way to test this question.

The experiment we did answered the same question, but used a different method. The experiment we did may have been undermined by outside variables: chemicals used in or around the area in which the plants were found; less or more resources in one place over another (for example, water, too much or too little sunlight, weeds or other organisms in the area competing for resources); type of soil (for example, sandy or clay-like, full of stones or fine grained); and room for growth.

In the second experiment, samples were taken from parts of the Oxbow that did not have garlic mustard in the area. Those samples were compared to areas that did have garlic mustard. The average pH for non garlic mustard areas happened to come out exactly to 7. The **median** and mode was 7.3. The **average** pH for areas with garlic mustard was 6.9. The median was 6.9.

The data set is very small, so the calculations are just a beginning. The numbers indicate that there is not much variation in the data. The numbers are all pretty close to average, and the range is low in each set. Because the numbers are all pretty close and do not vary, we can take the average of each set and see that they are nearly the same. Therefore, this

leads us to believe that the effect of pH on garlic mustard is inconclusive and needs more research.

As for the effect of minerals on garlic mustard, where there was a low amount of phosphorous, potassium, and nitrogen, there was a high concentration of garlic mustard. These findings lead us to believe that areas with a low amount of minerals allow garlic mustard to grow well. However, this finding needs additional research before we can say this with any certainty.

One thing we do know for sure is that garlic mustard is rapidly spreading through Oxbow Island, the state of Michigan, and North America. Currently, ways to effectively control or reverse the spread of garlic mustard without possible adverse effects to the environment are limited. For example, small areas of garlic mustard can be pulled out by hand with success. Additionally, according to a progress report done at Michigan State titled, Evaluating the Potential Biological Control of Garlic Mustard in Michigan, many animals, wild and domesticated, that are herbivores eat garlic mustard. However, the study showed that the herbivores did not eat enough to control its spread. We hope that scientists will make progress in findings ways to control garlic mustard.

Student Article Citations

PCA Alien Plant Working Group: http://www.nps.gov/plants/ALIEN/fact

USDA plants: http://www.plants.usda.gov/java/profile

Evans, J.A., Landis, D.A., Schemske, D. W., and Davis, A.S. (2005). Evaluating the potential for biological control of garlic mustard in Michigan: 2005 progress report. Michigan State University. Retrieved from http://www.ipm.msu.edu/pdf/2005garlic-mustard-reprot.pdf

FACTivity

In this FACTivity, you will learn about invasive species in your area. The questions you will answer are: What invasive species are in my area? And, what can be done to help stop the spread of them?

You will complete this FACTivity with a partner or in a small group. With your partner you will choose an invasive species to research. Your teacher may want to assign each group/pair with a certain invasive species. Once you have your invasive species, you will research this species using books and the Internet (if available). The following list is information you will want to find out about your species:

- What is the name of the species you are learning about?
- Where does this species live naturally?
- Where has this species invaded?
- How do scientists think the invasive species arrived in its new location?
- Why is this species harmful? Helpful?
- What can be done to help stop the spread of this species?
- What research is being done on this species?

Once you have gathered this information, you are going to create an information pamphlet about your species that you will share with your class and the school.

PLT

If you are a PLT-trained educator, you may use #70 "Soil Stories" as an additional resource.

The Emerald Ash Borer

Invading Ash Trees in the Oxbow

Student Scientists

Travis Bullock, Chyna Penson, Natalie Leo, Ta'janae Ford, Joseph Hunter

Glossary

Non-native (nän **na** tiv): Not naturally occurring in an area.

Invasive species (in **va** siv **spe** ses): Any plant, animal, or organism that is not native to the ecosystem it is in, and is likely to cause harm to the environment, the economy, or human health.

Adversely (ad **vürs** le): Results in negative effects.

Economic (**e** ko **nom** ik): Of or relating to the production, consumption, or distribution of goods and services.

Ecological (**e** ko **lawj** uh kül): Dealing with the relationships of organisms and their environment.

Monoculture (**maw** no kül chür): A population of one kind of organism.

Native (**na** tiv): Naturally occurring in an area.

Abundant (uh **bun** dent): Plentiful.

Global Positioning System (GPS) (**glo** bul po **sish** un i*ng* **sis** tem): A radio navigation system that allows land, sea, and airborne users to determine their exact location, speed, and time 24 hours a day, in most weather conditions, anywhere in the world.

Pronunciation Guide

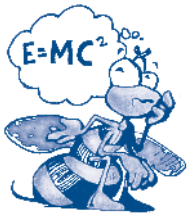
a	as in ape	**ô**	as in for
ä	as in car	**u**	as in use
e	as in me	**ü**	as in fur
i	as in ice	**oo**	as in tool
o	as in go	***ng***	as in sing

Accented syllables are in **bold**.

Thinking About Science

Scientists often work as a team. Within a team, each scientist contributes his or her special skills to the research. In this research, the student scientists used the assistance of a scientist to help them collect their data. The scientist taught them how to identify and classify the health of ash trees. When you work as a team, it is best to match a person's knowledge and skills with the task they can do best.

Thinking About the Environment



Sometimes, animals and plants that are not native to an area invade a new area. When the **non-native** species causes harm to the environment or economy, it is called an **invasive species**. After an invasive species has invaded a new area, it can spread further. This research is about an invasive insect called the emerald ash borer (EAB).

EAB adults can fly at least a ½ mile from the ash tree from which they emerge as adults. EAB can spread even farther when people move infested ash nursery trees, logs, or firewood into new areas. Shipments of ash nursery trees and ash logs with bark are now regulated by government agencies. Transporting firewood outside of quarantined areas is illegal, but many people are not aware of this restriction. Transport of infested firewood remains an ongoing concern, because it causes the further spread of many invasive species.

Introduction

The natural environment offers many things to learn about. It is interesting to learn the way different organisms grow and develop, how they survive, and how they continue to change over time. As a class we studied invasive species. An invasive species is an organism that is living where it did not originate and that **adversely** affects the habitats it invades.

An invasive species may cause **economic**, environmental, or **ecological** harm. The organism is so reproductively successful and aggressive that it can dominate the area it invades, often to the point of becoming a **monoculture**. An invasive species can seriously interfere with the natural functioning and diversity of the system where it becomes established. Examples of invasive species are garlic mustard, pampass grass, and EAB.

EAB is unique and it is as invasive as any other invasive species you could find **(figure 1)**. This alien invader is from northern China and Korea. It may also be found in eastern Russia, Japan, and Mongolia. It isn't a major pest of ash trees in its **native** range, but it causes trouble in the United States. In 2002, it was identified in Southeast Michigan in the city of Canton **(figure 2)**. Canton is a suburban community of metro Detroit.

Researchers believe the EAB arrived in Southeast Michigan 10-12 years earlier, probably as a stow-away in wooden packaging materials aboard a ship. Since no one noticed the death of ash trees until the EAB became **abundant**, it is difficult for researchers to find a solution to stop these insects. It would have been easier to control them when their numbers were low. The exact number of EAB in Michigan is unknown but it's probably more than several million.

Figure 1. Emerald ash borer.
(Photo courtesy of bugwood.org)

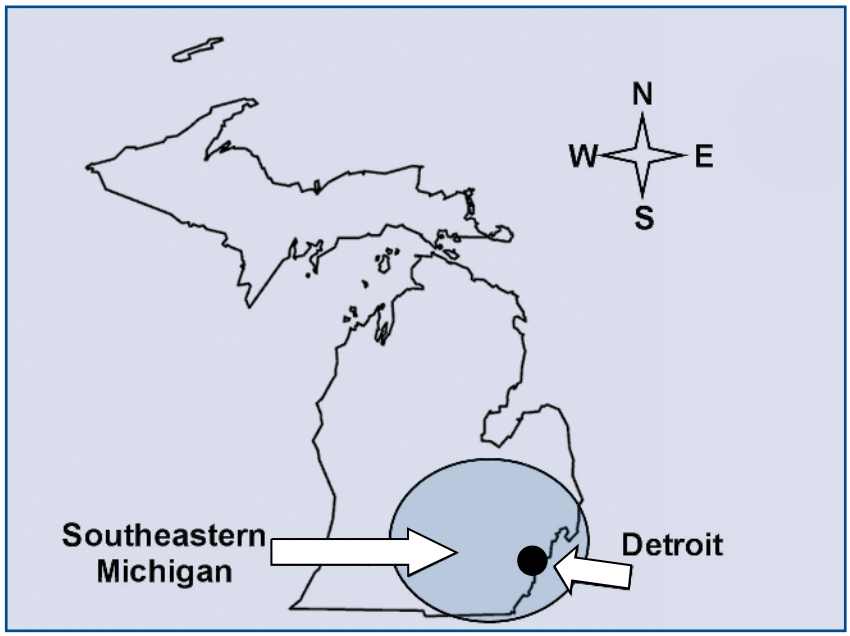


Figure 2. Southeast Michigan.

EAB has killed tens of millions of ash trees in Michigan and the economic impact far exceeds the $1 million. **(figure 3)**. (Contact the Michigan Department of Agriculture at 517.241.2485 for correct dollar value.) Because of this more than $1 million has been lost because of infested wood. Not only is there an unfavorable impact on economics, but also on the animals that make a home in or around the ash trees.

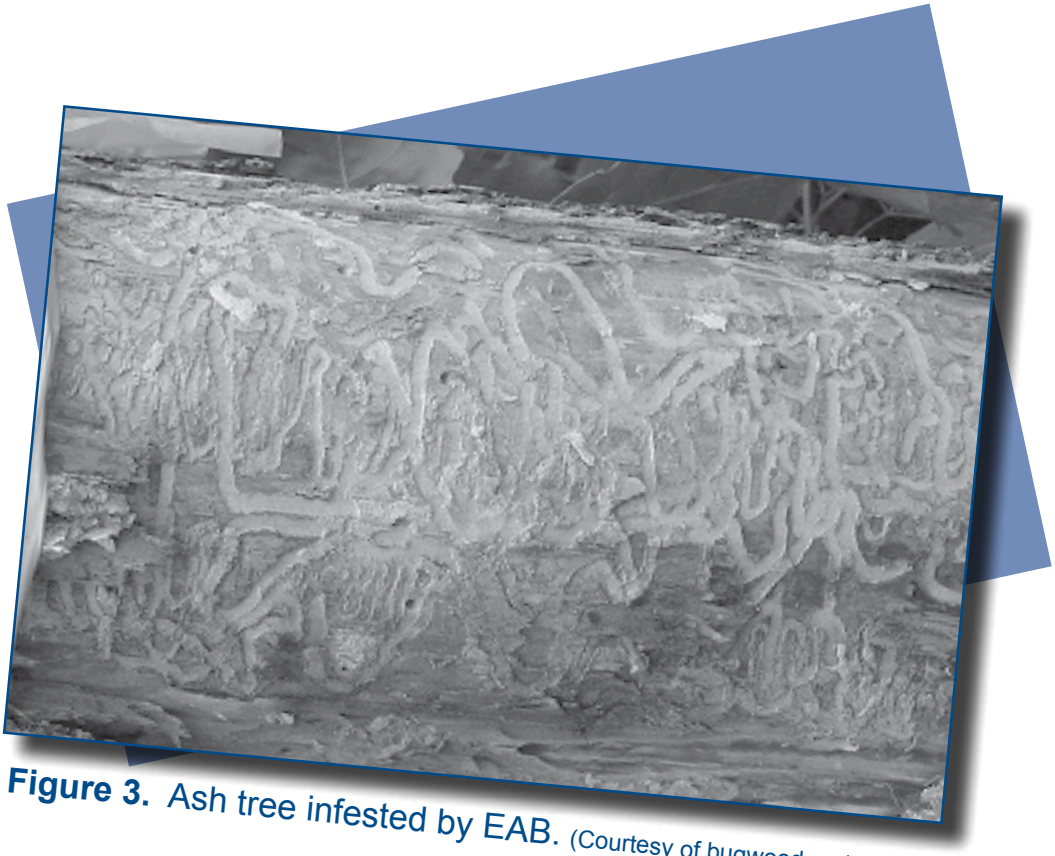
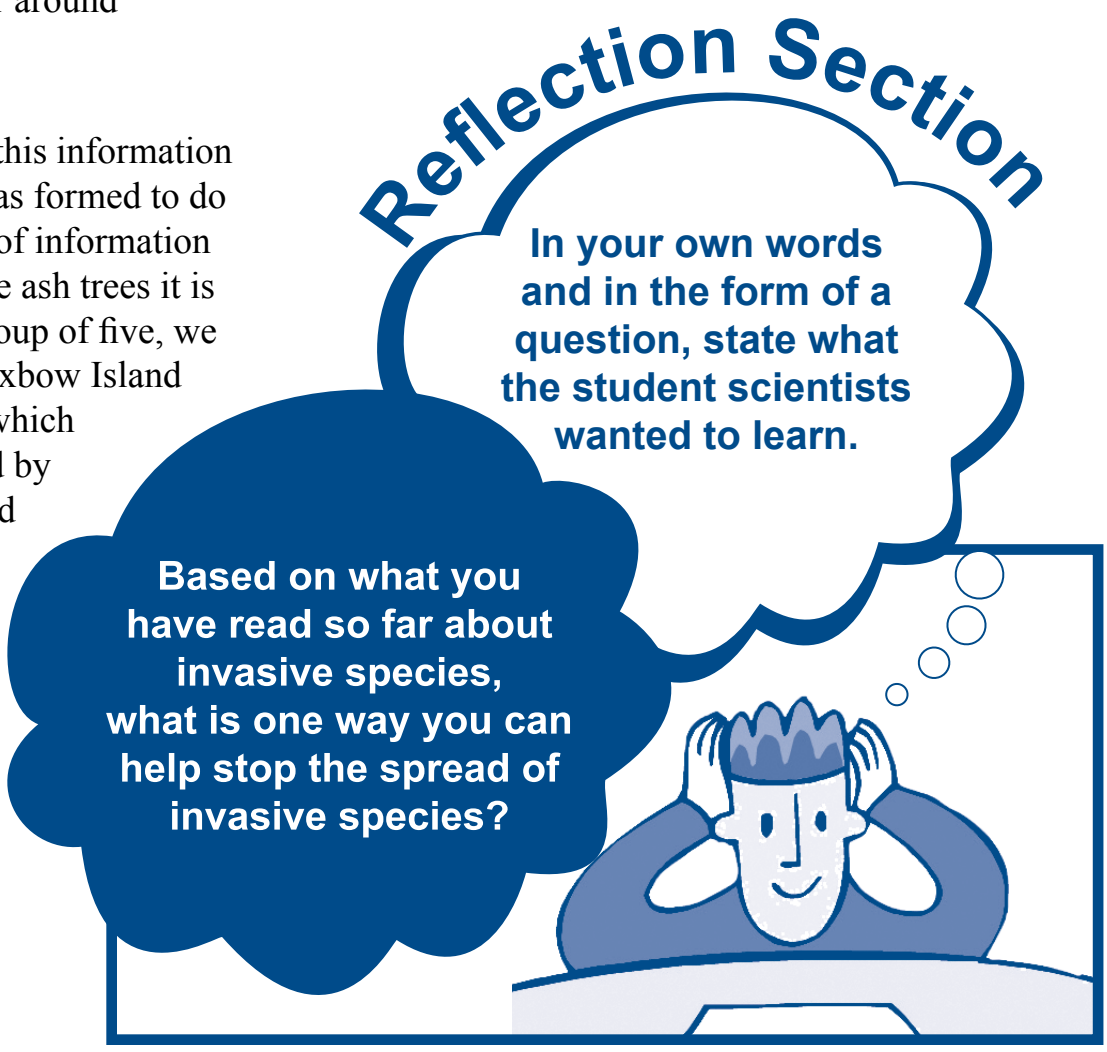


Figure 3. Ash tree infested by EAB. (Courtesy of bugwood.org)

After learning this information a student group was formed to do further collecting of information about EAB and the ash trees it is infesting. As a group of five, we investigated the Oxbow Island and the ash trees which have been infested by EAB. We decided to study the effects of EAB in the Oxbow.



Method

We randomly investigated a number of ash trees and collected data such as the **global positioning system (GPS)** number, the tree's diameter, whether the tree was dead or alive, and if it had epicormic shoots. Epicormic shoots are small branches that grow from the base of the trees. They may also be called water shoots. They often grow after a tree has been severely pruned, or an unhealthy tree has lost many of its leaves.

The first step in collecting the data in the EAB experiment was figuring out what trees the EAB were infesting, and where EAB was found. The information was collected through Internet articles and other resources on EAB infesting of ash trees. There were an abundance of ash trees close to us for us to do research. These trees were located in Dearborn, Michigan on land near our school. We were able to research the ash trees located on an island behind the Henry Ford Academy known as Oxbow Island **(figure 4).**

Oxbow Island is home to a variety of animals, plants, and other living organisms. We noticed that the Oxbow Island contains a lot of ash trees. An area was picked randomly in which the research and experiment would be done.

Figure 4. The Oxbow Island.

As a group we decided that it would be best if the data were collected in a span of two days in the middle of November. The reasoning was that we wanted to collect as much data as possible before the weather became extremely cold and had a chance of affecting our data collection. The idea was that if we could collect as much data as possible on the ash trees in the Oxbow, then the rest of the time could be dedicated to finding information on the background of EAB, the possible future of EAB in Michigan, the money being spent to stop EAB, and ways EAB could be stopped.

Our inexperienced group was assigned a person named Toby who was knowledgeable in the field of classifying trees. Toby showed us how to determine if a tree was alive or dead and infested or not infested by EAB. These two things were tested by looking at the bark of the tree. We looked to see if the bark was loose, if there were exit holes in the bark, if the pattern of branches had been disrupted, and what color the tree was inside the bark. When examining the bark a blade was used to cut off a small portion of the tree without harming it. Once we were aware of those things we were able to place the trees in different categories.

We collected a lot of information about the ash trees **(figure 5)**. With a tape ruler we were able to find out the diameter of the tree's trunk. Joseph, a member of the group, wrote down the information we collected. Ta'Janae tied

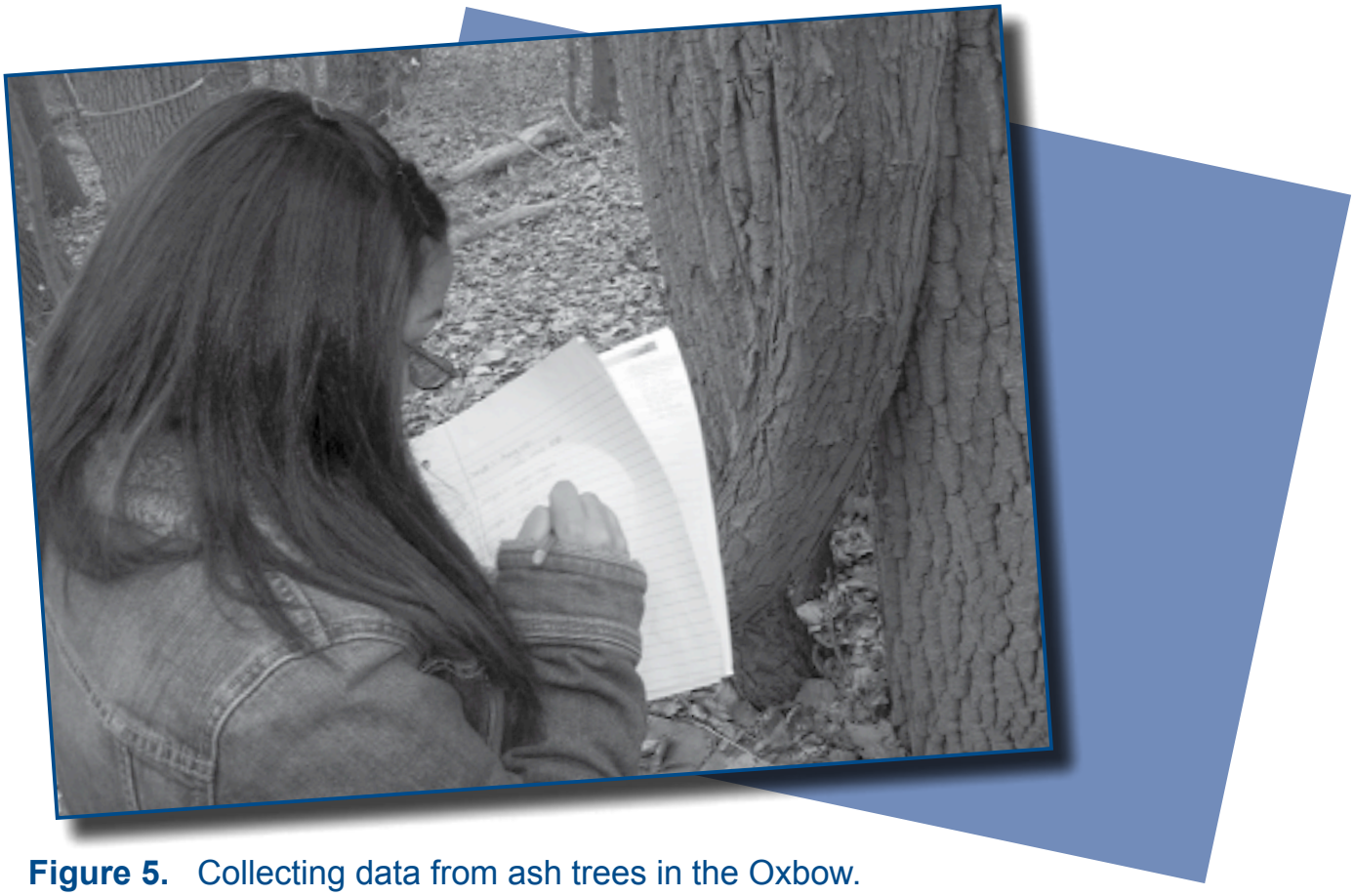
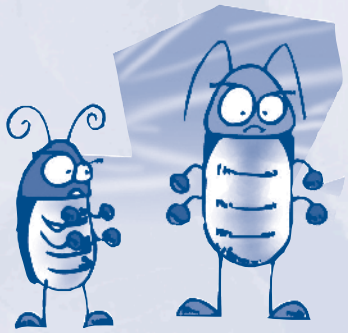


Figure 5. Collecting data from ash trees in the Oxbow.

a rope around each tree we measured so we would not lose track of the number of trees we examined. Every person in the group was obligated to complete a chart with accurate information. This information included the tree's diameter, whether the tree was alive or dead, and if it had epicormic shoots, woodpecker holes, beetle exit holes, or loose bark. The exit holes are "D" shaped holes that show where recently developed adult beetles have left a tree.



Reflection Section

The student scientists collected their data over a two-day time period. Do you think this was enough time? Why or why not?

Often scientists work in teams or have an expert provide information on a certain subject area. The student scientists had Toby help them with tree identification. Think of a time when someone helped you with your project. What are the advantages and disadvantages of having someone help you with a project?

Findings

Data collected from seven ash trees in the Oxbow is presented in **figures 6 and 7**.

Tree	GPS #	Diameter (in feet)	Dead	Epicormic shoots	Woodpecker holes	Exit holes	Loose bark
1	001	4.7	No	Yes	Yes	Yes	No
2	002	5.9	No	Yes	Yes	Yes	No
3	003	4.7	No	Yes	Yes	Yes	No
4	004	3.7	Yes	Yes	Yes	Yes	Yes
5	005		No	No	Yes	No	No
6	006	1.8	No	Yes	No	No	No
7	007	4.6	Yes	Yes	Yes	Yes	Yes

Figure 6. Data collected from seven ash trees in the Oxbow.

Tree Condition	Number of Trees
Ash trees with exit holes	36
Ash trees without exit holes	22
Dying ash trees	36

Figure 7. More ash tree statistics.

Reflection Section

Look at Figure 6 again. What do you notice about the two trees that are dead compared to the other trees?

Based on the student scientists' findings, do you think the five trees that are still alive will survive? Why or why not?

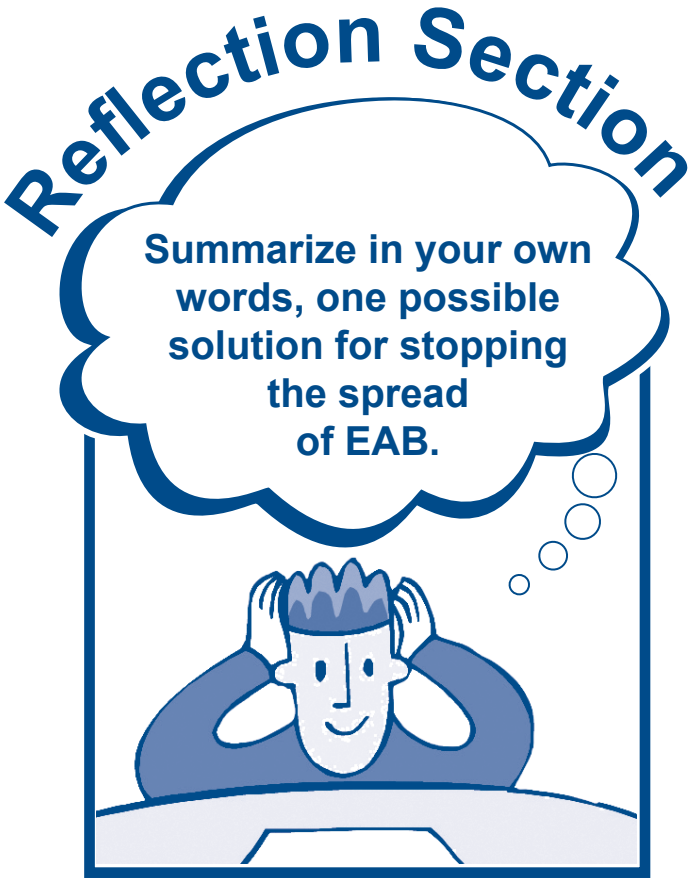
Discussion

As you can see from our research, EAB is infesting the ash trees in the Oxbow. Two out of the seven trees we studied had already died. The other five trees had signs of distress like exit holes and woodpecker holes. Therefore, it is important that we understand and put a stop to the spread of EAB.

EAB is not only affecting the environment but also has a financial impact in Michigan. We should help stop or at least get this invasive species under control. As a group we decided to do research on the EAB to find out why it is not harmful in China but it is harmful in the United States. The information we found could be a key to stopping the EAB. U.S. Forest Service research entomologists from Michigan have now completed a study of the EAB in its natural habitat in China. They have discovered three tiny parasitic wasps that keep it under control there.

The three wasps are drawn only to ash trees. Some walk all over the bark looking for EAB eggs to lay their own eggs in; others listen for ash borer larvae below the surface and then drill through the bark. Then they lay their eggs on the EAB. What happens next is a tiny version of the "Alien" movies. After wasps lay their eggs, the eggs hatch by bursting out of the embryonic borers, killing them. This is only one way the wasp kills the EAB. The wasps also go into the tree when the EAB is at its larva stage and eat the larva before the EAB are able to develop.

This investigation allowed us not only to come up with an experiment, analyze data, and create a conclusion, but to also grow knowledgeable in a variety of areas. For instance we became knowledgeable about tree classification, invasive species, and habitat concerns for humans, animals, and plants. Because of regulations, we were not able to release the stingless wasps on the Oxbow Island. But hopefully in the future, the possible solution may be used by Forest Service scientists in the Oxbow to see if the EAB can be controlled with stingless wasps. If the stingless wasps work, then the rest of the ash trees may have a chance of survival.



FACTivity

In this FACTivity, the question you will answer is: What is the health of the trees around my school?

The method you will use to do this is the following:

Divide up into pairs or small groups.

Examine Figure 1 and discuss the different parts of a tree.

Get a pencil and the tree health survey and head outside. Each pair should survey 1 tree in the school yard. Assign trees so that trees are not surveyed twice.

Look at the examples pictures of decay, cracks, holes/pest damage, and wounds and injury (see Figures 1–10) so you have an idea of what to look for when you are examining the tree. It would be helpful to have some books on trees available in the classroom as well.

Once you have collected your information, share it with your class and create a class chart for all the trees in the school yard. Discuss what you found. Are the trees healthy? Why or why not? Look at the Growing Conditions worksheet to give you some help. If they are not very healthy, what can be done to help the trees?

An extension for this activity is to begin by identifying the trees using tree guides and other resources. After you have identified the tree you can create a presentation about your tree.

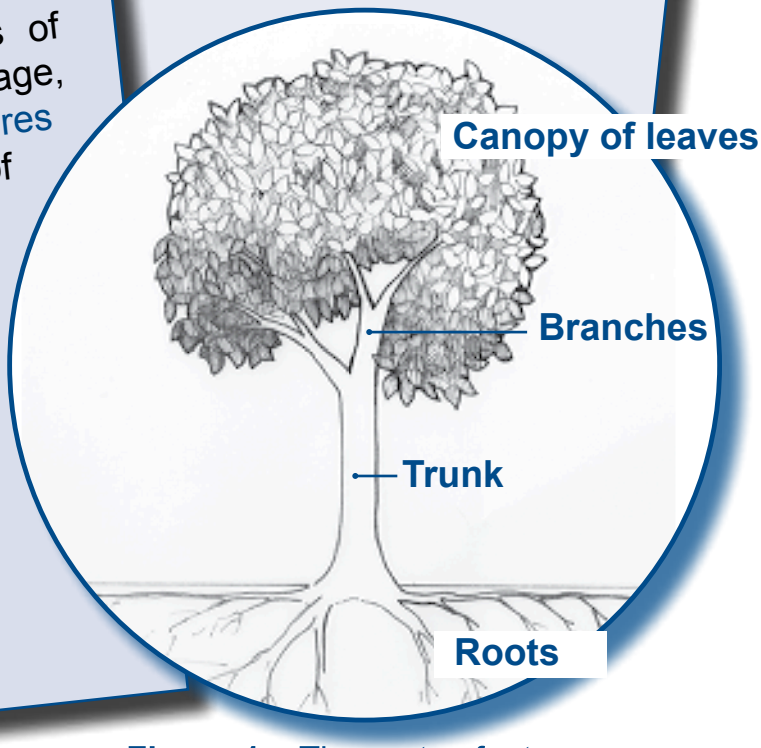


Figure 1. The parts of a tree.

Tree Health Survey

To survey the health of the tree, make sure you look at the tree carefully. Walk all the way around the tree and observe the tree from a distance and up close. Put a check mark in any column where you see a problem. When you have finished surveying the trees, calculate your total points and circle the tree health rating at the bottom of the sheet.

Problem	Not evident	Very little	Some	A lot
Trunk				
Missing Bark				
Decay				
Leaning				
Cracks				
Holes/ Pest damage				
Wounds/injury				
Roots				
Decay				
Wounds/injury				
Crown				
Dieback (branch tips in the crown that are dead)				
Not much of a crown				
Broken branches				
Lack of balance				
Total # of Checks				
	Total x 0=	Total x 1=	Total x 2=	Total x 3=

Overall Point Total= _____

Dead/Dying	Poor	Fair	Good	Excellent
Greater than 20	15-19	10-14	5-9	0-4

Growing Conditions Survey

Place a check mark in each column where there is a problem. When you have finished surveying the area your tree lives in, calculate the point total and circle the growing condition rating.

Condition	Not evident	Very Little	Some	A Lot
Not much space for the tree to grow				
Tree is close to roadway				
There are a lot of other plants competing for the same space				
There are problems with the ground cover				
Total # of Checks				
Sub-totals	Total x 0=	Total x 1=	Total x 2=	Total x 3=

Overall point total= _____

Poor	Fair	Good
Less than 7	4-7	0-3

(Note:This tree health survey is from American Forests. Please visit http://www.americanforests.org/productsandpubs/citygreen/school.php for more information.)

Examples of Different Problems with Trees.

(Note: All photos courtesy of bugwood.org and forestpests.org)

Figure 1. A tree with a canker.

Figure 2. A tree with damaged bark.

Figure 3. An emerald ash borer's exit hole in the bark.

Figure 4. A tree with peeling bark.

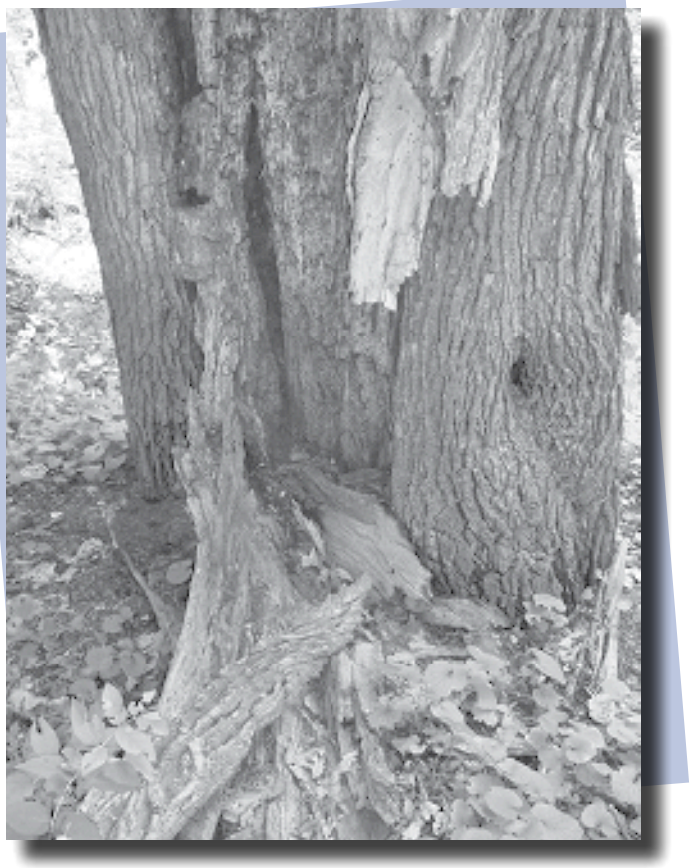


Figure 5. A decaying tree.

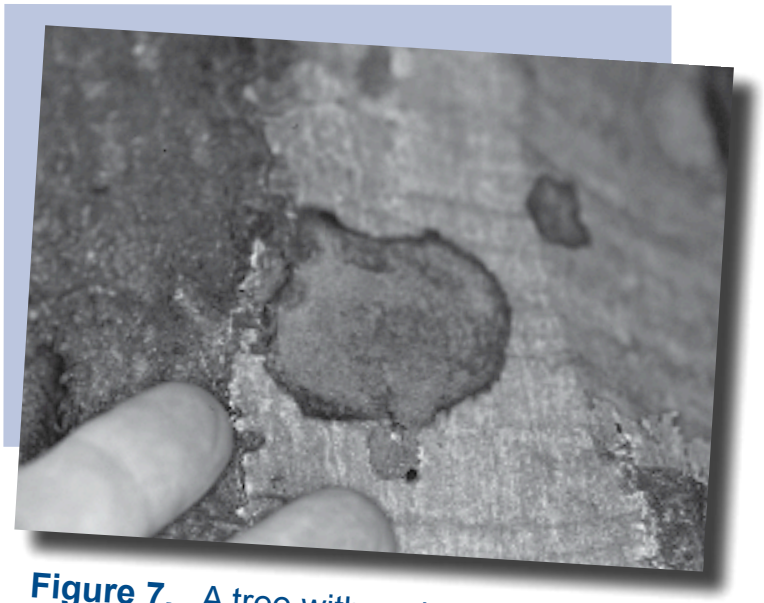


Figure 7. A tree with sudden oak death.

Figure 6. A tree with a gall in the crown.

Figure 8. A tree with crown dieback.

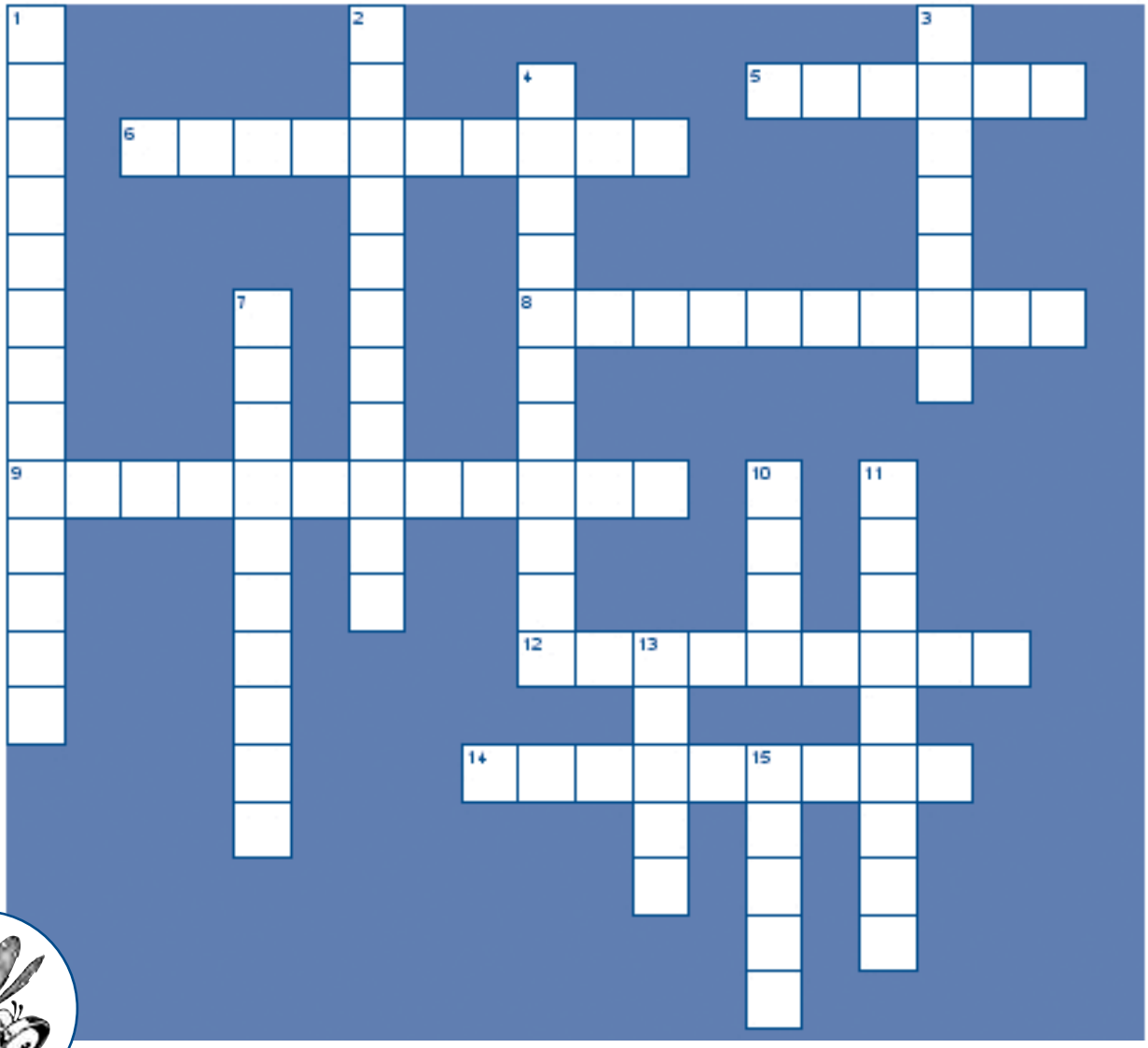
PLT

If you are a PLT-trained educator, you may use #77 "Trees in Trouble" as an additional resource.

Figure 9. A tree with root rot.

Figure 10. A tree with root disease.

Student Scientist Crossword



Across

5. Naturally occurring in an area
6. Vegetation in a forest that is near the ground
8. Prepared for planting
9. Living near or with humans
12. Community of plant and animal species interacting with one another and the nonliving environment
14. An animal that feeds on plants

Down

1. Too many
2. The act of sprouting or beginning to grow
3. A narrow tube into which liquid is drawn by suction and then dispensed
4. A population of one kind of organism
7. An essential nutrient for plant growth. It helps the plant with structure and energy.
10. Animal hunted or seized for food
11. Relating to or occurring at night
13. A U-shaped bend in a river
15. Any of the various small rodents that typically have a heavy body, blunt nose, and short ears. They live in meadows.

Student Scientist Word Search

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                G
              K Q Y
            H E I Q C
          T I E R F T U
        E S B Y F Q W N W
      Y T I N I L A K L A O
    G X P G Z I E V T Z T D U
  E C O L O G I C A L L X D N J
K W F M U L T Y N M X T H E T U J
C O D K B N O I T A T S E F N I M B I
C R I Z X R K M Q I T J R M V S U A S A O
  I O T Z S O O L B S B Q S H I Y Q Q I
    A C I D I T Y V I Q P L S T Z C Z
      Q E S F N Q V S S Q S F Y B C
        U X A E O Y E J A I N T K
          Q I R X I R T W X I U
            E V A E O Z B B W
              Y L P T M Y T
                C G A B E
                  N X K
                    T
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1. Plentiful
2. The degree or amount of acid in a solution
3. The degree or amount of base in a solution
4. The amount of matter in a given space
5. Dealing with the relationships of organisms and their environments
6. A scientist who studies insects
7. An animal that feeds on plants
8. To swarm or spread in and over in a troublesome manner
9. The most frequent value in a set of values
10. An organism living with, in, or on another organism
11. An essential mineral that helps with photosynthesis, the quality of fruit, and disease reduction
12. The ability of an organism to resist harmful influences

Note to Educators

The mission of the Forest Service is to sustain the health, diversity, and productivity of the Nation's forests and grasslands to meet the needs of present and future generations.

For more than 100 years, our motto has been caring for the land and serving people. The Forest Service, U.S. Department of Agriculture (USDA), recognizes its responsibility to be engaged in efforts to connect youth to nature and to promote the development of science-based conservation education programs and materials nationwide.

The *Natural Inquirer* Student Scientist Edition was developed as a part of the Forest Service's **More Kids In the Woods** initiative. Using the *Natural Inquirer* in two high school classrooms, the journals were first used to teach students at the Henry Ford Academy in Dearborn, Michigan to read and write actual scientific papers. The students then developed, conducted, and wrote up their own research. Their research was conducted on a natural area near the school's campus. This area is known as the Oxbow (or the Oxbow Island) because it contains an oxbow lake which is connected on one end to the Rouge River.

The *Natural Inquirer* is a science education resource journal to be used with learners grade 5 and up. The *Natural Inquirer* contains articles describing environmental and natural resource research. The articles are easy to understand and aesthetically pleasing to the eye, contain glossaries, and include hands-on activities. The goal of the *Natural Inquirer* is to stimulate critical reading and thinking about scientific inquiry and investigation while learning about ecology, the natural environment, and natural resources. In this edition of the *Natural Inquirer*, you will find five articles researched and written by high school students.

The Format of a *Natural Inquirer* Article:
Each *Natural Inquirer* article follows the same format. The articles written by the students have been reviewed by US Forest Service scientists for accuracy. Each article contains the following sections, which you may introduce to your students as they read:

Glossary: Introduces possibly new scientific or other terms to students. The first occurrence of a glossary word is bold in the text.

Thinking About Science: Introduces something new about the scientific process, such as a scientific habit of mind or procedures used in scientific studies.

Thinking About the Environment: Introduces the environmental topic being addressed in the research.

Introduction: Introduces the problem or question being addressed by the research.

Method: Describes the method used by the scientists to collect and analyze their data.

Findings: Describes the results of the analysis.

Discussion: Discusses the findings and places them into the context of the original problem or question.

Citation: Gives information about where students located their information.

Science Education Standards and Evaluations
In the back of the journal, you will find a matrix that enables you to identify articles by the national science education standards that they address. Evaluation forms for both educators and students are available on our Web site. We welcome any feedback so please visit http://www.naturalinquirer.org and complete the online evaluation forms. Additionally, you may contact Dr. Barbara McDonald at the address below with any comments you have.

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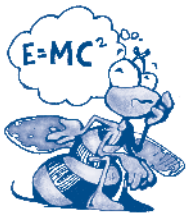
(Please put "Educator Feedback" in the subject line)

Educator Resources
Visit the updated *Natural Inquirer* Web site at http://www.naturalinquirer.org. From this site, you can read and download lesson plans, word games, and other resources to help you use the *Natural Inquirer* in your classroom. You can also view and download a yearlong lesson plan aimed at helping your students learn about the scientific process.

Visit the *Natural Inquirer* Web site at
http://www.naturalinquirer.org.



Lesson Plan

Teacher's note: This is a generic lesson plan that can be used with any one of the articles in this journal, or with a combination of articles. It may also be used with any *Natural Inquirer* article.

This lesson introduces scientific abstracts to the students.

Time required: 1 class period

Materials required: One or more articles from the *Natural Inquirer,* Student Scientist Edition FACTivity sheet, pencils

National Science Education Standards:

5 minutes: Introduce scientific abstracts

A scientific abstract is a very short version of an entire scientific paper. Although the abstract is placed at the beginning of the paper, it is written last. The abstract contains enough information for the reader to identify: **1)** the problem and the research question; **2)** how the study was conducted; **3)** the major findings; and **4)** the significance of the results. An abstract is usually written in one paragraph, just long enough to provide the essential information. The reader of a scientific article begins by reading the abstract. If the article is of sufficient interest, the whole article can be read.

Next, provide students with a copy of the following abstracts, printed on page 70. Explain to students that the abstracts were written from student scientist papers from the Henry Ford Academy, a public high school in Dearborn, Michigan. Students should individually read the abstracts, noting the following pieces of information:

1. The problem and research question;
2. How the study was conducted;
3. What was discovered; and
4. The significance of the findings

For each of the abstracts, have students complete the abstract summary sheet on page 68.

After students have completed this exercise, hold a class discussion about whether this was easy or difficult to do. Use this as a beginning point to discuss the four main sections of a research paper (Introduction, Method, Findings, Discussion).

In this *Natural Inquirer,* you will find five complete articles about research in the Oxbow. Each of these articles was written by a high school team of student scientists. As a class or individually, select an article to read. You may divide your class into groups, with each group reading one of the articles. Either individually or in groups, have students write an abstract for the article they read. To begin to write the abstract, students may use the template on page 69.

After students have identified the four essential points, have them write the abstract in paragraph form, using the abstracts they read earlier as models.

Hold a class discussion about the value of scientific abstracts. Here are some questions to get you started: Did their written abstracts adequately summarize the study they read? How might abstracts be used by scientists? Should an abstract be used without reading the entire article? Why or why not? The abstract summary sheet and writing sheet can be used as assessments.

Abstract Summary Sheet

Student name:_____

Name of abstract	Problem or research question	Method used	Findings	Significance of findings
Outdoor Recreation				
Bats				
Water Quality				

Abstract Writing Sheet

Student name(s):_____

Name of the paper:

What is the problem and what is the question being answered by the research? (3-4 sentences)	
What method or methods were used? (3-4 sentences)	
What was discovered? (3-4 sentences)	
What is the significance of the findings? (3-4 sentences)	

Sample Student Abstracts

The Oxbow and Outdoor Recreation

Our group addressed the recreational issues at the Henry Ford Oxbow. One major problem in urban areas is getting more people involved in outdoor recreation. Greenfield Village, where the Oxbow is located, would like to see more people involved in outdoor recreation activities and also at the same time have fun. Our group went outside and explored the Oxbow to determine what types of activities would be good to have. We observed the Oxbow and determined where different activities might be placed. We also took a survey to see what visitors would really like. Through our research we determined that there are barriers and restrictions everywhere. Regardless of the environment there are things you should be aware of. The first barrier would have to be safety. Safety means protecting the visitors from poison ivy, animal attacks, and anything else. Another thing that could be a barrier is mosquitoes. Activities should be restricted to daytime, since anyone who is in the Oxbow would need to see what they are doing. Some ideas for activities are making walking sticks, fishing, hiking, and learning the history of the island. Through our survey we learned that visitors would like all the activities we had planned, which worked out well for our group. So now we hope that everyone who did not take our survey feels the same as we do.

Bringing Bats to the Oxbow

The mosquito population in the Oxbow is staggering. Unfortunately they are a menace to tourists because of their huge numbers. The large number of mosquitoes makes the Oxbow one of the least popular attractions in Greenfield Village. Bats are a necessary part of a forest ecosystem. Bats feed on insects that reproduce quickly. Although they provide the best mosquito-eating service, they have gained a bad reputation. We decided that it would be good to attract one species, the Big Brown Bat, to the Oxbow using bat houses. We went to the Oxbow and identified the best places to put wooden bat houses. As part of our project, we visited the Oxbow and marked potential trees for houses. We recommend placing wooden bat houses on living trees or hollowing out some dead ash trees. These wooden houses should attract bats. If bats are attracted to the Oxbow, the population of mosquitoes will be reduced, making the area more attractive to tourists.

Water Quality and the Oxbow

The Rouge River Oxbow Restoration Project is located at the Henry Ford Museum and Greenfield Village. Until recently, the water quality of the Rouge River had degraded significantly as a result of pollutant loadings from various sources. In general, what we studied was the water quality of the Oxbow. We collected our data on the west bank of the Oxbow in early December 2007. To collect our data, we used a water scooper that carried about one liter of water. We performed the following tests: pH test, turbidity test, and dissolved oxygen test. Through our research we found that there is a high oxygen level in the water of the Oxbow and that sediment levels are higher than more clear-flowing streams. We concluded that the level of oxygen in the water is good.

Student Abstract Word Search

ecosystem
Greenfield Village
mosquito
oxbow
oxygen
population
recreation
safety
sediment
survey
turbidity
water quality

Reflection Section Answer Guide

Note to Educator: The purpose of the Reflection Section Questions is to encourage students to think critically about what they have read. The following "answers" are only suggestions to assist you in using these questions in the classroom.

The Great Horned Owl in the Oxbow

Introduction

What is the research question the student scientists wanted to answer? *Is the Oxbow a good habitat for the great horned owl?*

How would you determine if an area would provide a good habitat for the great horned owl? *You would need to see if the habitat had food for the owl and a place for the owl to live. You would also want to know if there was anything in the habitat that would hurt the owl population.*

Method

Invasive species are plants or animals that overtake an area and cause harm to the native plants or animals that naturally live there. Do you think that all native plant or animal species are harmed by an invasive species? Why or why not?
No, some native plant or animal species may benefit from an invasive species. For example, the great horned owl has more places to live because there are more dead trees due to the emerald ash borer. The emerald ash borer is an invasive species.

How do you think the student scientists researched the food sources of the great horned owl? *The student scientists read books, encyclopedias, and searched the Internet.*

Findings

When you improve the habitat for the great horned owl, do you think other animals benefit from the improvement also? Why or why not? *This is an individual question. Students' answers should be supported with reasoning and logic.*

What are some benefits of attracting more great horned owls to the Oxbow? *There are several answers to this question. For example, great horned owls could be beneficial because they eat mice and other rodents. Encourage your students to come up with as many benefits as they can.*

Discussion

Do you think it is a good idea to enhance the great horned owl's habitat in the Oxbow? Why or why not? *This is an individual question. Students' answers should be supported with reasoning and logic.*

Let's say the student scientists were able to plant a wheat field where the horse pasture is now. How might the student scientists find out if planting the wheat field had any impact on the number of great horned owls living in the Oxbow? *The students could take an estimate of the number of owls before the field is planted and take an estimate again after the field has been planted.*

Oxbow Soil Vitality: Is It Healthy?

Introduction

What were the questions the student scientists wanted to answer? *How the soil has been affected by irrigation water? What is the overall status of the soil's health in the Oxbow?*

How do you think irrigation water could pollute a river? *Irrigation water can send chemicals from fertilizers and pesticides into the water. Waste products from animals can also be washed into the river. Irrigation also causes soil erosion which can cause pollution.*

Method

Why did the student scientists have to modify the SQI? *The students had to modify the SQI because as students they did not have access to all the same equipment as the Forest Service scientists.*

Why did the student scientists focus on ash, hackberry, and cottonwood trees? *Because they are dominant in the Oxbow.*

Findings

In your own words, summarize what the student scientists found through their study. *The student scientists found that the soil quality is not excellent but it is also not horrible. The soil fell in the middle of the scale. The soil pH is suitable for plants and plants that like a high potassium area to grow in would like the Oxbow as well.*

The SSQI value ranges from 33.33-66.67. The average is 50.00. Based on these findings do you agree with the students' assessment of their findings? Why or why not? *This is an individual question. Student answers' should be supported with reasoning and logic.*

Discussion

The student scientists wished they could have measured more chemicals. If they had been able to do so, do you think they might have come to a different conclusion? Why or why not? *It is possible that they may have come to a different conclusion because the pollution from the irrigation may be from chemicals that the student scientists did not originally measure in the SSQI.*

The SSQI used 5 different measures to come up with an overall value. Think of a similar situation in your life where many different measures are combined in some way to produce one overall value. Explore this process of evaluation in a class discussion. What are its advantages and disadvantages? *This is an individual question. Student answers' should be supported with reasoning and logic. One example is grading in school.*

The Emerald Ash Borer: An Ash Tree's Worst Enemy

Introduction

From what you read so far, do you think the EAB problem will improve worsen, or stay the same? Why? *It sounds like the problem will worsen because the EAB has spread quickly and it doesn't sound like there is a way of stopping it from what I have read so far.*

What was the question the student scientists wanted to answer? *The scientists wanted to find out how soil properties are related to ash trees infested with EAB.*

Method

What might be an advantage of taking 7 soil samples from under each tree, instead of taking just 1 or 2 samples? *If you only take one or two samples you could be getting incorrect information. By taking seven samples you are increasing the chance that you are getting reliable information.*

Look at the photos in figures 7-12. What is one common feature of all of these trees? *There could be several answers to this question. For example, they are all deciduous trees. Encourage your students to discuss this question and their answers.*

Findings

Are you surprised at the student scientists' findings? Why or why not? *This is an individual question. Students should support their answers with reasoning and logic.*

What might you conclude about the EAB and soil properties from these findings? *The study is not conclusive, but it does seem like there should be more research done to determine whether EAB makes soil better for plants.*

If you had an opportunity to repeat this research, what might you do differently? *This is an individual question. Students should support their answers with reasoning and logic.*

Discussion

What is another potential problem that might come from releasing another non-native species into EAB-affected areas? *Releasing another non-native species may cause problems because it may become a problem too since it will have no natural predators.*

Should scientists closely monitor the effect of the stingless wasps in EAB-infested areas? Why or why not? *Scientists should definitely monitor the effect of the wasp closely to make sure that the wasp populations do not get out of control and cause yet another problem.*

Garlic Mustard: All Around and Down the Oxbow

Introduction

State in your own words the question the student scientists wanted to answer. *How do minerals and pH level in the soil affect how much garlic mustard is in an area?*

Plants need nutrients like nitrogen, potassium, and phosphorus to grow. What things do you need to grow? *Humans need food, air (specifically oxygen), water, and shelter. Humans also need things like clothing and companionship to survive.*

Method

Why do you think the student scientists collected two soil samples from each area instead of just one? *The more soil samples the better chance you have of obtaining accurate information about the soil.*

The student scientists used a very specific method to test the amount of nutrients in the soil. Do you think this is important? Why or why not? *The more specific and detailed your method is the better. It is easier for others to replicate your experiment this way and verify your findings. Additionally, a detailed method allows the scientists to more easily remember what they did when they explain their findings.*

Findings

Based on the results of the amount of nutrients in the soil, do you think the nutrients have an effect on the amount garlic mustard present? *In areas with a high concentration of garlic mustard there were low levels of phosphorous, potassium, and nitrogen.*

A pH level of 7 is neutral. How do the pH results compare? *All the results are around 7. Where garlic mustard was present the pH levels were a little lower than areas without garlic mustard. The exception was the soil around cottonwood trees which had the lowest pH levels.*

Discussion

The student scientists said that the original experiment they planned had to be changed. Do you think this happens to other scientists? Why or why not? *Scientists sometimes have to modify an experiment based on new things they learn or due to problems being able to conduct the experiment.*

Do you agree with the student scientists that more research needs to be done? Why or why not? *Yes, it is a good idea to do more research and conduct additional experiments. In science, it is important for others to be able to replicate your experiment and come to the same conclusions in order to verify what your research has found. Another advantage of additional experiments is that scientists may find out other information that is helpful in combating garlic mustard.*

The Emerald Ash Borer: Invading Ash Trees in the Oxbow

Introduction

In your own words and in the form of a question, state what the student scientists wanted to learn. *What are the effects of the emerald ash borer in the Oxbow?*

Based on what you have read so far about invasive species, what is one way you can help stop the spread of invasive species? *When traveling, be aware of what you bring back with you. Make sure firewood is not infected. Students may come up with other ways.*

Method

The student scientists collected their data over a two-day time period. Do you think this was enough time? Why or why not? *This is an individual question. Students should use reasoning and logic to support their answer.*

Often scientists work in teams or have an expert provide information on a certain subject area. The student scientists had Toby help them with tree identification. Think of a time when someone helped you with your project. What are the advantages and disadvantages of having someone help you with a project? *This is an individual question. Students should use reasoning and logic to support their answer.*

Findings

Look at Figure 6 again. What do you notice about the two trees that are dead compared to the other trees? *The two trees that were dead were also the only two trees with loose bark.*

Based on the student scientists' findings, do you think the five trees that are still alive will survive? Why or why not? *This is an individual question. Students should use reasoning, logic, and evidence from the figures to support their answer.*

Discussion

Summarize in your own words, one possible solution for stopping the spread of EAB.
One possible solution for stopping the spread of EAB is having parasitic wasps distributed in the area where the EAB are.

National Science Education Standards for the Student Scientists' Edition of the *Natural Inquirer*

	The Great Horned Owl in the Oxbow	Oxbow Soil Vitality	The Emerald Ash Borer- A Tree's Worst enemy	Garlic Mustard-	The Emerald Ash Borer- Invading Ash Trees
Science as Inquiry					
Abilities necessary to do scientific inquiry					
Understandings about scientific inquiry					
Physical Science					
Properties and Changes of Properties in Matter					
Life Science					
Regulation and Behavior					
Populations and Ecosystems					
Earth Science					
Structure of the Earth System					
Science and Technology					
Understandings about Science and Technology					
Science in Personal and Social Perspectives					
Natural Hazards					
Risks and Benefits					
Science and Technology in Society					
History and Nature of Science					
Science as a Human Endeavor					
Nature of Science					

Michigan Curriculum Framework Science Standards (Middle School) for the Student Scientists' Edition of the *Natural Inquirer*

	The Great Horned Owl in the Oxbow	Oxbow Soil Vitality: Is it Healthy?	The Emerald Ash Borer- An Ash Tree's Worst Enemy!	The Garlic Mustard Plant – All Around and Down the Oxbow	The Emerald Ash Borer- Invading Ash Trees in the Oxbow
Strand I. Constructing New Scientific Knowledge					
Standard I.1 Constructing New Scientific Knowledge					
Strand II. Reflecting on Scientific Knowledge					
Standard II.1 Reflecting on Scientific Knowledge					
Strand III. Using Scientific Knowledge in Life Science					
Standard III.2 The Organization of Living Things					
Standard III.5 Ecosystems					
Strand IV. Using Scientific Knowledge in Physical Science					
Standard IV.1 Matter and Energy					
Standard IV.2 Changes in Matter					

What Is the Forest Service?

The Forest Service is an agency of the United States Department of Agriculture. It is made up of thousands of people who care for the Nation's forests and grasslands. The Forest Service manages over 150 national forests and almost 20 national grasslands. National forests, like national parks, provide places for people to recreate, they provide homes for wildlife, and they provide clean water and air for everyone. National forests also provide resources for people to use, such as trees for lumber, minerals, and plants used for medicines. Some people in the Forest Service are scientists, whose work is presented in this monograph (**mon** o graf). These scientists work to solve problems and provide new information about natural resources so we can make sure our natural environment is healthy, now and into the future.

Learn more about the Forest Service by visiting **http://www.fs.fed.us**

What is The Henry Ford?

The Henry Ford, in Dearborn, Michigan, is the world's premiere history destination and a National Historic Landmark that celebrates American history and innovation. Its mission is to provide unique educational experiences based on authentic objects, stories and lives from America's traditions of ingenuity, resourcefulness and innovation. Its purpose is to inspire people to learn from these traditions to help shape a better future. Five distinct attractions at The Henry Ford captivate more than 1.5 million visitors annually: Henry Ford Museum, Greenfield Village, The Ford Rouge Factory Tour, The Benson Ford Research Center and The Henry Ford IMAX Theatre. The Henry Ford is also home to Henry Ford Academy, a public charter high school which educates 485 students a year on the institution's campus and was founded in partnership with the Henry Ford, Ford Motor Company and Wayne County Public Schools.

For more information please visit our website **thehenryford.org**

What is Urban Connections?

Urban Connections is a Forest service program in the eastern region of the United States (see figure 1). This program connects people living in cities, suburbs, and towns with natural areas, including forests, lakes, and parks.

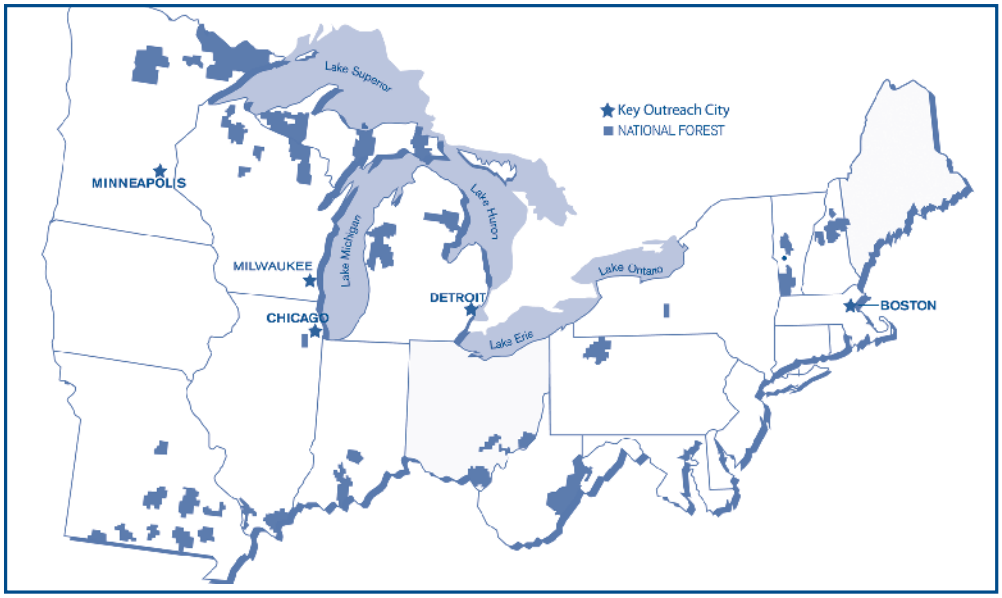


Figure 1. This map shows the cities in which the Urban Connections program works. Is one of those cities located near where you live?

Janet Johns' 7th grade classes, Cass Middle School, Cartersville, Georgia

For additional information, please visit these Web sites:

Henry Ford Academy
http://www.hfacademy.org/

Forest Service's Initiative- More Kids in the Woods
http://www.fs.fed.us/emphasis/kids.shtml

National Invasive Species Center
http://www.invasivespeciesinfo.gov/

Emerald Ash Borer Information
http://www.emeraldashborer.info/