Youth Scientists: Creating Environmental Stewards
Unit 2

Emerald Ash Borer

Table of Contents

Page

Additional resources and information guides can be found on the curriculum DVD.

Unit Overview

Enduring Understandings (EUs) What do you want students to understand from this unit for the rest of their lives?	Essential Questions (EQs) What questions will students need to answer when constructing their understanding?
At the end of the unit, students will understand that… • EAB is an invasive species that is devastating forest and trees in Ohio. • With sufficient background information, students can make scientific hypotheses to solve real-world problems. • Scientific experiments or investigations must be used to adequately test a hypothesis. Students will learn and apply the process of science and consider important safety measures. • Data must be carefully collected and recorded. Analysis of scientific data is important to fully understand your results. Data can be visualized and shared in a variety of ways. • Scientists have a responsibility to communicate and share their research with the public. To do this, scientists must present and write up their findings and conclusions.	Questions that will spark meaningful connections, provoke genuine inquiry, and encourage transfer of knowledge. • What effects has EAB directly had on your life? On the state of Ohio? • How do you properly form a scientific hypothesis? • How do you test your scientific hypothesis? • What is involved in setting up and carrying out a scientific investigation? Keep safety in mind! • What is the purpose of collecting data during a scientific investigation? • Why is careful analysis of your data important? • What are some ways you can display and communicate your data? • How can you share your research findings with others? Why is this important?
Prioritized Knowledge & Skills What will lead students to the EUs and EQs?	
Conceptual Knowledge (What)	Procedural Skills (How)
• History of the Emerald Ash Borer • Life cycle and biology of EAB • Spread and distribution of EAB • Tree physiology and response • EAB current research • Nature of the scientific process	• Finding external symptoms of EAB • Designing scientific hypotheses and methods of investigation • Data collection techniques • Use of appropriate safety measures • Developing appropriate methods of communication for scientific results

Student Activity Objectives			
Student Activity	Objectives	*Standards	^Learning Goal
Introducing the Emerald Ash Borer!	1. Recognize the introduction of EAB into US ecosystems. 2. Understand their general ecology and life cycle. 3. Learn how to identify EAB spread and distribution.	Grades 5-8: Science Inquiry & Application (O) • Identify questions that can be answered through scientific investigations • Design and conduct a scientific investigation • Use appropriate mathematics, tools and techniques to gather data and information • Analyze and interpret data • Develop descriptions, models, explanations and predictions • Think critically and logically to connect evidence and explanations • Recognize and analyze alternative explanations and predications • Communicate scientific procedures and explanations. Grade 7: Life Sciences – Cycles of Matter and Flow of Energy (O) • Matter is transferred continuously between one organism to another and between organisms and their physical environments. • In any particular biome, the number, growth and survival of organisms and populations depend on biotic and abiotic factors. Grade 8: Life Sciences – Species and Reproduction (O) • Reproduction is necessary for the continuation of every species. • The characteristics of an organism are a result of inherited traits received from parent(s).	1 & 2
Investigating EAB (POE Activity)	1. Learn about the process of scientific investigations. 2. Develop scientific hypotheses and predictions about EAB distribution. 3. Collect and analyze data on EAB distribution. 4. Make inferences and share findings.		2 & 3

*Standards

- Ohio (O): Career and College (Ohio Revised) Standards in Science (In use by 2014-2015). For information on alignment between the Ohio Academic Content Standards (2002) and the Ohio Revised standards, please visit the Ohio Department of Education website at www.education.ohio.gov

- National (N): The National Science Standards (1996) are under revision with new standards to be released by 2013. For more information on the new framework and standards, please review National Science Education Framework (2012), available at www.nap.edu (National Academies Press).

^Unit 3 Learning Goals:

1. What is the Emerald Ash Borer (EAB)?
2. How do we predict, observe, and explain the presence and impact of EAB in Ohio?
3. The Scientific Process
    - Observation & Data Collection
    - Analysis & Inference

Acknowledgements:

US Forest Service – Department of Agriculture

The Ohio State University Extension

Ohio Department of Natural Resources – Division of Forestry

State of Ohio – Department of Agriculture

Ohio Environmental Protection Agency – Ohio Environmental Education Fund

INTRODUCING THE EMERALD ASH BORER!

Overview

Among invasive insects, the metallic-green beetle, Emerald Ash Borer poses one of the greatest threats of becoming a major pest in the United States (Ohio Department of Agriculture, Press Release 03/31/2007). Through this investigation, students will learn how to recognize the emerald ash borer and make predictions about its effect on forest systems, as well as the spread and distribution of the beetle. While learning about the emerald ash borer and it ecological impact, students will also be introduced to and participating in many of the practices of science emphasized by the *Framework for K-12 Science Education* (NRC, 2012).

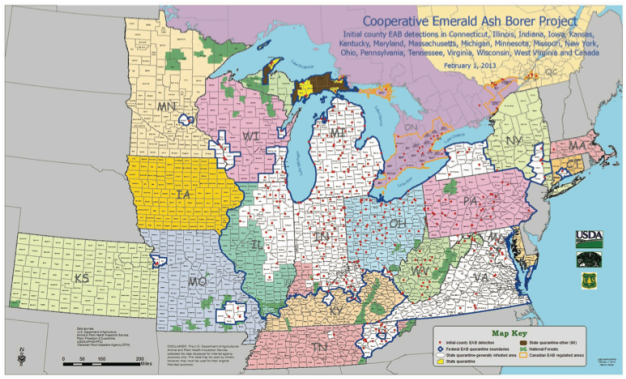
Background

The Emerald Ash Borer (EAB; *Agrilus planipennis*) is an exotic, invasive insect from Asia that has infested and killed millions of ash trees (more than 25 million as of 2011) since its accidental importation. EAB is now established in many states throughout the midwestern and northeastern United States. When emerald ash borer (EAB) was first discovered in Michigan in 2002, very little was known about this insect from Asia. Efforts to understand EAB's ecological impact indicate that outbreaks in Asia are relatively uncommon, isolated, and associated with ecological stress events – such as drought. This suggests that under normal conditions, Asian ash trees may be resistant to EAB, with the insect preferentially infesting stressed trees. These native trees may be more resistant to their native pests due to natural defenses that have evolved over eons. This has since spurred many avenues of research to better understand, manage, and control EAB. Some scientists studied the biology and ecology of the insect, both in the US and China, to understand its life cycle, mating habits, flight capabilities, and which species of trees it could eat. Some researchers created traps to detect EAB, determined where it was most likely to spread, and figured out how it was spreading. Other scientists studied ways to kill EAB and protect ash trees with insecticides, fungi, and parasitoid wasps. Another group of researchers began work to understand how ash trees could resist attack by emerald ash borer, with the ultimate goal of breeding EAB-resistant ash trees. Other scientists studied the forests to understand the

impact that EAB was having and to create management options to help keep the forests healthy. Research on EAB is continuing today and is essential to combatting this threat to trees and forests.

All major eastern North American ash species are susceptible to EAB, which infests trees ranging in size from one-half-inch diameter nursery stock to fully mature trees in forests. While most native borers colonize only weakened trees, EAB attacks healthy trees as well, making the problem especially devastating. The impact of EAB on ash in North America will likely be similar to that of the chestnut blight and Dutch elm disease. These exotic pests have devastated natural and urban forests in the 20th century.

While there is a federal quarantine on the movement of EAB infested wood to uninfested areas, the boundary is a constantly moving target in response to the rapid spread of EAB populations. And as of 2012, there were no federal restrictions on moving infested materials within the boundaries of the federal quarantine, but state regulations vary.



EAB Distribution as of February 2013

For more information and updated maps of the distribution of EAB, visit: http://emeraldashborer.info and click on "Where is EAB?"

Disclaimer:

As with many areas of scientific research, the content presented in this curriculum addresses a moving target. As scientists learn more about the biology and ecology of the Emerald Ash Borer, some of the information contained within this program may become inaccurate. Please visit the provided online resources for new findings and insights that can be incorporated into the existing materials!

Adapted from (Supplementary Materials): Herms, McCullough, & Smitley. Under Attack. American Nurseryman, 10/01/04.

Economic & Ecological Impact

According to the USDA Forest Service, there are more than 3.8 billion ash trees in Ohio, with standing timber valued at more than $1 billion. Initially detected in the state in 2003, the pest has spread to 63 counties by 2012. Once infested, EAB kill ash tress within 3 to 5 years. The pest has already caused tens of millions of dollars of damage to landscapes, urban forests and woodlots, and this cost is increasing at an exponential rate.

Taxonomy & Biology

The EAB is a beetle (Coleoptera) belonging to the family known as metallic wood-borers (Buprestidae). Larvae of these insects are known as flat-headed borers, as during the larval stage the beetle appears to have a broadly flattened head. EAB larvae are white with a long (about 1 inch when mature), narrow, segmented abdomen that is also flattened, giving them the appearance of small tapeworms. Adults are elongate, half inch-long beetles that are a striking metallic green.

Host Plants & Impact

When larvae hatch, they tunnel into the tree, where they feed on the phloem and outer sapwood, excavating S-shaped, serpentine galleries just under the bark, disrupting the flow of nutrients and water between the canopy and roots. This causes canopy thinning and branch dieback – and ultimately tree death. Larvae continue to feed through summer and into fall. They overwinter in the outer bark or within the outer inch of sapwood. Pupation occurs in mid- to late-spring. Adults emerge soon thereafter to complete the typical one-year cycle.

Signs & Symptoms

Symptoms usually associated with ash borer infestation include small, vertical splits in the bark that can sometimes be observed on large branches or on the trunk. To confirm the presence of EAB, one can widen the splits to reveal larvae and galleries under the bark. The presence of small, distinctly D-shaped exit holes in the trunk or a scaffold branch is a good sign of infestation. As the infestation progresses, the canopy starts to thin, and branch dieback may occur.

Subjects
6-8 Grade: Biology, Environmental Science, Math, Agriculture

Skills
1. Classification and categorization
2. Identifying individual attributes, relationships, and patterns
3. Designing and conducting scientific investigations
4. Making observations and predictions
5. Communicating procedures and explanations

Objectives
1. Learn about the process of scientific investigations.
2. Develop scientific hypotheses and predictions about EAB distribution.
3. Recognize the introduction of EAB into US ecosystems.
4. Understand the general biology and life cycle of EAB.
5. Learn how to identify EAB spread and distribution.
6. Collect and analyze data on EAB distribution.
7. Make inferences and share findings.

Time Considerations
Teacher Preparation: 3.1 Discovering EAB: 30 min; 3.2 Process of Science: 30 min; 3.3 Investigating EAB: 50 min

Student Activities: 3.1A/B: 50 min; 3.2A/B: 50 min; 3.3: (3 days) 50 min each

2.1 Discovering EAB

Option A

Getting Ready

Make copies of the "Invasive Species – Emerald Ash Borer," "EAB life cycle (visual)," and the "Signs and Symptoms (visual)." Gather field guides for trees and insects for your students' references (see Appendix for suggestions). You may want to have an idea of nearby forested areas that might be suitable for observing the signs and symptoms of EAB infestations. The area does not have to be large, it could be a plot of a few trees at the school, a nearby park, etc. Alternatively, you could have samples of EAB infested wood for students to observe and maps of nearby wooded areas with known infestations marked for them to use in their observations and predictions about the spread and distribution of EAB.

Activity

1. Interest your students in studying invasive species by asking them to think about the variety of natural species that they know of and what roles they play in forests and other ecosystems. You could also have students focus their thinking on *insects* in particular, rather than any species. Divide the class into pairs or small groups, giving students about 10 minutes to write down their ideas. Then combine all of their responses for review and ask them how an invasive species might compare. Have the students share a few of their ideas. (Total Time: 15 minutes)

2. Explain to students that they are going to study a species that is currently invading Ohio – the Emerald Ash Borer. Provide them with the "Invasive Species – Emerald Ash Borer" handout and have the students work on Questions 1 – 3 in

their pairs or small groups, giving them about 10 minutes to write down their responses. Then read and/or visually display the "Press Release" by the Ohio Dept. of Agriculture (TreEAB Curriculum Kit) and as a class respond to Questions 4 – 6. (Total Time: 15 minutes)

3. Next, provide students with the blank "EAB Life Cycle" handout and the "Signs and Symptoms" visual guide (electronic and laminated copies available in the TreEAB curriculum kit). Students can fill these in as you go through the EAB PowerPoint and use this information to answer Questions 7 – 10 on the "Invasive Species" sheet as an exit ticket. (Total Time: 20 min)

4. Ask students to observe trees around their home to see if they notice any signs or symptoms of EAB in their neighborhood. Tell them they will be using their observation skills when they are on their site visit (or during in class observation of EAB wood samples).

Option B

Getting Ready

This activity serves as a supplement for OR an extension of the activities presented in Part 1A. Both activities provide students with the opportunity to learn about EAB biology, spread, and distribution. For this activity, make copies of the "EAB Research Log" and the "Emerald Ash Borer FAQs."

Note: If using as an extension of Part 1A, ask your students if they observed any signs or symptoms of EAB infestations in trees around their home. If using this activity in place of Part 1A start with #1 below.

Activity

1. Divide your students into small groups or pairs and provide each of group with a single card of the "Emerald Ash Borer FAQs" sheet (there are 8 different cards). Tell the students they are about to become experts on the EAB and as scientists, they need to be able to communicate their understanding of the EAB to the public. They are responsible for reviewing the information on one of the cards and summarizing it by using the "EAB Research Log." Give students about 15 minutes to review their FAQ section and respond to Part 1 of the research log. (Total Time: 20 minutes)

2. Once the individual FAQ summaries have been completed, divide the class into new groups, with each group containing an expert for each FAQ. Tell your students that their new task is to collaborate with their fellow experts to provide an overall "expert response" to the questions in Part 2 of the research log. Optional: Have the student groups come back and report on their expert responses. If there are differences in the group summaries the class could discuss and come up with an overall consensus. **It would also provide an opportunity to discuss why science is a community endeavor.* (Total Time: 30 minutes)

Extension Activities and Assignments

Exit Ticket: "3-2-1" of the Emerald Ash Borer

Homework: Life Cycle of the Emerald Ash Borer

EAB Assessment: Want to know what your students learned about EAB? Use this as a diagnostic or summative assessment to gauge how well the students understand the impact of EAB and invasive species in general.

Public Awareness: Have students develop a flyer using their expert responses from the "EAB Research Log" or "Invasive Species" activity sheets. Students can post these around the school and at home to help increase public awareness of EAB spread and distribution.

Reading Materials

Emerald Ash Borer Invasion of North American Forests – Impacts on native plants, animals, and general ecology.

Supplemental Web Resources

US Forest Service: Forest Health Protection – The Emerald Ash Borer
http://na.fs.fed.us/fhp/eab/

The Ohio State University: EAB Outreach Team
http://ashalert.osu.edu/

National Emerald Ash Borer Website: Emerald Ash Borer
http://emeraldashborer.info

2.2 Process of Science

Option A

Getting Ready

Make copies of the "Guided Notes: The Process of Science," and "Science Flow Chart." You may also want to prepare an overhead of the completed "Flow Chart" or use the Process of Science PowerPoint.

Activity

1. Interest your students in the process of scientific research by asking them to think about what being "scientific" means. Have students create a class list of what they think are "characteristics of science" that they can refer to and revise at the end of the activity. (Total Time: 10 minutes)

2. Next, provide students with the blank "Guided Notes: The Process of Science" handout and the "Science Flow Chart" activity sheet. Students can fill in the handout as you have a guided class discussion about the nature of science. (Total Time: 30 minutes)

3. Have students complete the *exit ticket* portion of the worksheet and brainstorm research questions they are interested in about EAB biology, distribution, or reproduction that could be investigated using what they learned about scientific methods. (Total Time: 10 minutes)

Option B

Getting Ready

Make copies of the "Process of Science Info Guide" and the "EAB Research Guide" handouts. You may also want to prepare an overhead or handouts of supplemental information guides (TreEAB curriculum kit).

Activity

1. Open this activity with Step 1 of Option A. (Total Time: 10 minutes)

2. Provide students with blank copies of the two handouts: "Process of Science Info Guide" and "EAB Research Guide." Review the key "steps" in the flow chart provided in the handout, and then have the students (as a class or in small groups) come up with definitions for the vocabulary terms: hypothesis, treatment, control, independent variable, and dependent variable. (Total Time: 20 minutes)

3. Next, have students break out into groups of 2-4 to complete the "EAB Research Guide" activity. This handout contains a real-life example of EAB research (multiple examples are provided). Students should work together to come up with a scientific hypothesis for their research scenario and identify the treatment, control, and the independent and dependent variables in their project description. (Total Time: 20 minutes).

4. If time allows, return to their list from part 1 about "characteristics of science" to have them try and identify these components in their research scenarios OR revise/add to the list.

2.3 Investigating EAB

Necessary Materials

Unlike the previous activities, ***parts of this activity requires wood segments from infested ash trees*** and the materials included in the TreEAB curriculum kit (see List of Materials, p. 11).

Safety Guidelines

Whenever we are working with sharp objects and lab equipment, we must keep lab safety in mind! In addition to the lab safety rules you have in place in your classroom, please remind your students to:

1. Keep all fingers, arms, faces, legs, etc., away from the drawknife when it is in use!
2. Pull on the drawknife slowly and steadily.
3. Walk – don't run – around the classroom, as the bark and sawdust can make the floor slippery. Rubber mats or removable rugs may be useful to keep the floor from getting slick.

Day 1: Developing a Hypothesis

Getting Ready

Make copies of the "The Scientific Process" (graphic organizer) and "Hypothesis Formulator" handouts. You may also want

to have overhead displays or copies of supplemental information guides (TreEAB curriculum kit).

Organize informational and physical materials for student observations; see List of Materials (p. 11) for details.

Activity

1. Interest your students in scientific research on EAB by asking them to brainstorm research questions they think are interesting and important for understanding EAB biology. *Note: If you completed the Process of Science – Option A, you could have students refer back to their lists to select specific questions.* (Total Time: 15 minutes)

2. Divide students into work groups of 2-4 and assign a research question to each group from the "The Scientific Process" graphic organizer. Provide students with blank copies of the graphic organizer and have them record their research question at the top. They will come back to this handout on Day 2. (Total Time: 5 minutes)

3. Students should use classroom materials and/or physical samples (i.e., wood samples from an infested ash tree) to make observations relevant to their research questions that will help them formulate a hypothesis. Provide each student group with the "Hypothesis Formulator" handout to help them develop a scientific hypothesis. (Total Time: 20 minutes)

4. Ask for students to share their hypotheses. Have a few groups share their hypotheses to emphasize the importance of communication between scientists. *Note: This activity can be done with any number of research questions. If multiple research questions are provided, it may provide opportunities for student groups to investigate and learn about different aspects of EAB biology. If a single research question is used, it may generate a diversity of hypotheses that could be tested for a specific aspect of EAB biology.* (Total Time: 10 minutes)

Day 2 and 3: Hypothesis Testing

Getting Ready

If you completed the *Developing a Hypothesis* activity, have students take out their "The Scientific Process" graphic organizer. Alternatively, provide copies of the graphic organizer with Steps 1-3 completed. Similar to the previous activity, this can be manipulated to address a single or multiple research questions/hypotheses. While this activity is estimated to take 2 class periods (55 minutes each), addressing multiple research questions may require an additional class period to complete the activity.

You may also want to have overhead displays or copies of supplemental information guides (TreEAB curriculum kit).

Activity – Day 2

1. Open this activity by reviewing the hypothesis and research questions listed on the graphic organizer. Next, divide the students into their working groups of 2-4 and assign them 1 (or more) wood segment to use for their data collection. Provide students with the "EAB Data Collection Table" and tell them they will be collecting data that will be used to test their hypotheses. (Total Time: 10 minutes)

2. Have students begin their external investigation of the ash log segment. Students should (1) use the DBH tape to measure the diameter of the wood piece and (2) count, paint and mark EAB exit holes relative to other holes. (Total Time: 15-20 minutes)

   Blue = Woodpecker
   Red = EAB Exit Hole
   Yellow = Other Insect Holes

3. Next, have students peel their log using the drawknife and begin the internal investigation of the log for EAB larva and adults. Students should tally all organisms that they find and use a sharpie to mark on the log where the insects were found (using the assigned colors). Organisms can be removed using forceps and probes and placed in petri dishes or vials for safekeeping. Remind students to use their visual guides for identification! (e.g., Data Collection Info Guide) (Total Time: 20-25 minutes)

Activity – Day 3

4. Have students examine the galleries on their log and tally the number of EAB galleries that end near an exit hole relative to those that end near a woodpecker hole or with a prepupal plug. Next, have students calculate the percent coverage of EAB galleries on the north facing and south facing sides of their wood segment. (Total Time: 10-15 minutes)

5. Have students enter their data into a class spreadsheet (on a computer or on the board). Ask students what they notice about the class data – are there similarities or differences between groups? How could these be explained? What can their data tell them about EAB infestations? (15-20 minutes)

6. After students have discussed the class data, have them identify variables that they can use to test their hypothesis. Have them graph the data of the two variables on the "EAB Analysis & Conclusions" sheet and complete the final questions. (Total Time: 10-15 minutes)

7. Wrap up the EAB investigation by having a few working groups share their conclusions based on their hypothesis testing! (Total Time: 5 -10 minutes)

Extension Activities & Assignments

Exit Ticket:
Understanding the Process of Science

Homework: Observing Scientifically; EAB Research Study: Analysis

Research Project: Have students conduct their own scientific research based on their observations, research questions, and hypothesis. A blank "research guide" handout has been included for them to record their observations, questions, hypotheses, and experimental design.

Public Awareness: Have students put together a scientific presentation or news broadcast of their results. This would be a great way to have students participate in informing their community about the presence and spread of EAB.

Supplemental Materials

Information Guide #1 – A reference for learning more about EAB.

Information Guide #2 – A reference for recognizing insect galleries in EAB detection trees in Minnesota

Natural Enquirer (Youth Scientists Kit)

Don't Move Firewood! (Poster; Youth Scientists Kit)

Field Guides (TreEAB Kit)

Peterson First Guide to Insects of North America

USDA Forest Service – Important Forest Trees of the Eastern United States

University of Minnesota – Ash Tree Insect guide

TreEAB Kit List of Materials

Item	Quantity & Source		Item Used to…
Drawknife	1	TreEAB Kit	Peel bark from wood segments
Chaps	1		Protect legs and lab while peeling bark
DBH Tapes	1		Measure the diameter of wood segments
Grids (transparencies)	4		Calculate the percent gallery coverage of the wood segment
Washable paint in squeeze bottles (red, yellow, blue)	3		Mark the wood segments
Paint brushes	3		
Sharpies (blue, red, green brown, black)	5		
Forceps & Probes (each)	5		Collect and preserve specimens found in the wood sample
Magnifying sheet	1		
Weigh boats	5		
Petri dishes (and filter paper)	20		
Collecting vials	30		
Wax pencils	2		
Labels (sheet)	1		
Marking tape	1		Mark trees from which wood segments was collected (if applicable)
Rubbing Alcohol	As needed	School/Organization	Preserve collected specimens (if desired)
Dissecting microscope			Examine collected specimens, etc. (if desired
Magnifying glasses			
Goggles			Protective eyewear
Woodcutting tools			Collect wood samples and cut into 1 m or ½ m segments
1 m ruler or tape			Measure wood segments
Tarp & Floor mats			Protect desks/floor while peeling bark (sawdust buildup, etc.)
Trash can, wet rags, etc.			Clean up
Misc. classroom supplies			As needed

Information Guides and Materials…

- Emerald Ash Borer ID Kit
- Peterson First Guide to Insects
- Peterson First Guide for Trees
- Leaf ID Key – 88 Ohio Trees
- Important Forest Trees of the Eastern United States
- Ash Tree Insect Guide
- Natural Enquirer magazine
- Don't Move Firewood Poster
- **DVD of Youth Scientist Curriculum & Supplemental Materials**

Fun extras!

- EAB temporary tattoos
- EAB bumper magnets
- EAB info cards

Student & Teacher Pages

SP: Student Page *TP: Teacher Page*

3.1 Discovering the Emerald Ash Borer

3.2 The Process of Science

3.3 Investigating the Emerald Ash Borer

Electronic Resources

- EAB Powerpoint

Extension Activities & Supplemental Resources

Discovering the Emerald Ash Borer

Investigating the Emerald Ash Borer

Electronic Resources

- Dempsey Middle School Data
- Electronic Curriculum Materials
- *Teacher Answer Keys*
- Parasitoid ID Form

SP – 1A: INVASIVE SPECIES!

Invasive Species! – Emerald Ash Borer Activity

Name:_____ Date:_____

Answer the questions below using complete sentences. If you get stuck, you can use the EAB info guides for help!

1. What is an invasive species? If you do not know, then try and list some characteristics that might make you label a species as "invasive."

2. List some possible effects that invasive species could have on the environment.

3. What does the acronym "EAB" stand for? _____

STOP: Breaking News – Ohio Department of Agriculture Press Release

4. Where did EAB originate? _____

5. How were EAB first introduced into the US and how did they spread?

6. What is one way that we can stop EAB from spreading further?

STOP: Let's Learn a Little More About the Problems Caused by EAB

7. Give 2 examples of why EAB are a problem:

    a.

    b.

8. Explain the life cycle of EAB (draw a picture if it helps)

9. What is some damage that EAB has already caused and what conclusions can you make about what damage might be caused by EAB in the future?

10. Propose a new idea of how the public can help stop the spread of EAB.

SP – 1B: RESEARCH LOG

Name_____ Date_____

Part 1

Directions: *Read your assigned section. Working with your group, identify the main idea and three important details.*

Main Idea: _____

_____

_____

Important Detail # 1:_____

Important Detail # 2:_____

Important Detail # 3:_____

Part 2

Directions: *In your new group, share the main idea and the three most important details you recorded above. Then discuss and answer the following questions:*

1. What do we know about this exotic species?

2. What do we know about how it spreads?

3. How does it impact become a bigger problem?

4. How can we reduce the threat?

5. How can we teach others to help reduce the threat?

SP – 1B: FAQS

Emerald Ash Borer FAQs

What is EAB?

A new exotic beetle from Asia, known as the emerald ash borer (EAB), was discovered killing ash trees in southeastern Michigan in June 2002. Larvae feed in the phloem and outer sapwood, just under the bark, producing galleries that eventually girdle and kill branches and entire tress. Surveys using detection trees and destructive sampling to determine the extent of the spread of the infestation are underway.

Adult beetles are 7.5 to 13.5 mm (about ½ inch) long, and females are larger than males. The adult body is brassy or golden green overall, with darker metallic, emerald, green wing covers. The top of the abdomen is purplish to coppery red in color. EAB larvae are white with a long, narrow, segmented abdomen that is also flattened, which gives them the look of small tapeworms. Larvae reach a length of 25.4 mm (1 inch).

P1 – EAB Background Information Card

What is the life cycle of EAB?

The EAB typically has one generation per year, although it has been observed that some may take two years to complete the life cycle. This usually occurs when populations are new to an area, and the trees are healthy and vigorous. Adult emergence begins in mid-to late May, and continues through early August. The peak emergence is usually in the early part of July. The adults are active during the day, particularly when conditions are warm and sunny. Most beetles remain in protected locations in bark crevices or on foliage during rain, heavy cloud cover, high winds, or temperatures above 32C (90F).

Male adults live an average of 13 days and females live about 21 to 22 days. Females can mate multiple times and oviposition begins 7-9 days after initial mating. Females lay 80-90 eggs during their lifetime. Eggs are deposited individually on the bark surface or in bark crevices on the trunk or branches.

Eggs hatch in 7-10 days. After hatching, larvae chew through the bark and into the cambial region. Larvae feed on phloem and the outer sapwood for several weeks, which cuts off the flow of nutrients and water up and down the tree. The s-shaped feeding gallery winds back and forth, becoming progressively wider as the larva grows. Galleries are packed with fine frass. In some areas, woodpeckers feed heavily on larvae and are often used as a diagnostic tool when looking for EAB infestations.

The insect overwinters as a full-grown larva in a shallow chamber excavated in the sapwood. Pupation begins in late April or early May. Adults may remain in the pupal chamber for 1-2 weeks before emerging headfirst through a D-shaped exit hole that is 3-4mm (1/16 – 1/8 in) in diameter.

P2 – EAB Background Information Card

How did EAB get to the United States?

EAB is not native to the United States. Scientists believe that the beetle "hitchhiked" to this country in wooden crates and other wooden packing materials used to import cargo and products from Asian countries. Survival was possible because the wood that was made into the pallets or crates was not fully debarked and there were enough nutrients left in the remaining cambium layer to sustain life in the wood. The products were then shipped to the United States, and the beetles emerged from the wood of the crates and infested nearby ash trees.

Once established, EAB spread by flying to new ash trees in the local vicinity. They move much farther through the unintentional movement of infested firewood, ash logs, ash nursery stock, pallets, wooden crates, or other ash tree materials.

First discovered in Michigan in June 2002, EAB was found in Ohio in 2003, northern Indiana in 2004, and northern Illinois in 2006. Since its discovery, EAB has killed millions of ash trees, cost municipalities, property owners, nursery operators, and forest product industries tens of millions of dollars, and caused regulatory agencies and the USDA to enforce quarantines and fines to prevent people from moving potentially infested ash trees, logs, or firewood from areas where EAB occurs.

P3 – EAB Background Information Card

Why is EAB a problem?

EAB is an exotic, invasive species that does not occur naturally in the United States. The predators, diseases, and environmental conditions that keep the EAB population under control in its native land do not occur here. An invasive species is one that spreads rapidly. This situation means that beetle populations can increase quickly and destroy thousands of trees in a short time.

The emerald ash borer is indigenous to Asia and is known to occur in China, Korea, Japan, Mongolia, the Russian Far East, and Taiwan. In the United States, this borer has been observed only on ash trees. It has killed green ash, white ash, blue ash, pumpkin ash, and black ash, as well as several horticultural varieties of ash. At this time there is no known cure, although researchers are working very hard to learn more about this insect and treatment options. Trees that are attacked are usually dead within 3-5 years.

Loss of ash tree populations could hurt industries that depend on wood, such as the lumber and furniture industries and baseball bat companies. It is estimated that if EAB is not stopped, these industries could lose millions of dollars. Trees in urban and rural areas provide beauty and shade, improve air quality, prevent soil erosion, and shelter animals like birds, squirrels, and native insects. If trees become infested with EAB, those trees will eventually die, which decreases the quality of life for the people living nearby.

P4 – EAB Background Information Card

How can an infestation be identified?

EAB kills ash trees of various sizes and conditions. Larvae develop on trees as small as 2.5 cm (1 in) in diameter. Bigger diameter trees used for poles and lumber are also affected by EAB. Stress likely contributes to vulnerability of ash trees. However, Emerald Ash Borer also attacks and kills vigorous trees in woodlots and urban trees under regular irrigation and fertilization regimens.

Infestations of EAB can be difficult to detect until canopy dieback begins. Infested branches in the canopy die when the serpentine tunnels excavated by feeding larvae girdle them. Many trees appear to lose about 30-50% of the canopy in one year, and the tree is often killed after 3-5 years of infestation.

Callus tissue produced by the tree in response to larval feeding may cause vertical splits 5-10 cm (2-3.9 in) in length to occur in the bark. Distinct, larval tunnels etch the outer sapwood and phloem of the trunk and branches. An elliptical area of discolored sapwood, likely a result of secondary infection by fungal pathogens, sometimes surrounds larval feeding galleries in live trees.

Often several shoots grow at the margin of life and dead tissue on the trunk. When trees are dying, dense root sprouting occurs as the tree's last effort to survive.

Evidence of infestation includes D-shaped exit holes on branches and the trunk. These holes are left behind when the beetle exits the tree. Woodpeckers like to eat the larvae under the bark. Woodpecker damage is also often evident.

P5 – EAB Background Information Card

How is EAB being controlled?

EAB is an extremely destructive plant pest, and it is responsible for the death and decline of millions of ash trees. Ash in both forested and urban setting constitute a significant portion of the canopy cover in the United States.

In areas were the pest is widespread, such as Ohio, there are no longer quarantine regulations within the state (or other widely infested states). This is an attempt to contain the hard to detect beetle before it spreads beyond known areas. However, it is still recommended that you exercise caution when moving firewood, to prevent unintentional spread of EAB.

Both the state and federal government regulate moving firewood and other ash wood materials within areas infested with EAB. The United States Department of Agriculture (USDA) regulates the movement of materials from a quarantined area, making it illegal to take all ash tree material and all hardwood (non-coniferous) firewood out of quarantined states.

To learn more about quarantine restrictions and to see a current map of the quarantined area, go to: http://www.aphis.usda.gov/plant_health/plant_pest_info/emerald_ash_b/index.shtml

P6 – EAB Background Information Card

What can be done to slow the spread of new EAB infestations?

Monitor

It is important to monitor ash trees for infestations, as early detection of EAB can be difficult. Trees tend to exhibit few visible external symptoms of infestation. However, it is important for communities to know when EAB is in or near an area so that they can prepare and implement management actions that can reduce the environmental and economic impact brought by the loss of ash trees. Some techniques include:

1. Purple Prism Traps – The USDA uses this tool to monitor EAB populations. It is a 3-sided, 60cm long hollow prism trap that is coated with non-toxic glue on all sides and baited with a lure that mimics the oils of ash trees. This lure may attract adult EAB that are in the area.
2. Bio-surveillance – The use of a native predatory wasp *Cerceris fuminpennis* is another effective tool. Female wasps capture and paralyze many wood-boring beetles, included EAB. Once a wasp nest has been identified, it can be observed to determine if females are bringing in EAB prey.
3. Surveying for woodpecker damage – This is a reliable way to identify trees that may be infested with EAB, and is easy to do on personal property. Woodpecker damage is easy to spot in winter and early spring.

Regulate

Quarantines are in place to prevent infested ash firewood, ash logs, or ash nursery trees from being transported out of infested areas. It is illegal to move ash trees, ash tree logs, ash branches, ash wood chips, ash bark, and all hardwood firewood out of quarantined areas. A federal quarantine prohibits the movement of ash tree materials and hardwood firewood out of the quarantine area without federal certification.

P7 – EAB Background Information Card

What can the public do to help?

Watch ash tress for signs and symptoms and report findings. Properly and safely dispose of dead and dying ash trees. Follow all regulations and…

Don't Move Firewood!

Outreach and education programs have been implemented to inform the public and enlist their help. Messages highlighting the importance of buying and burning local firewood are shared through public meetings, public service announcements on radio and television, billboards, road signs, advertising at sporting events, and direct mailings. Comprehensive EAB websites for citizens and stakeholders help raise awareness of EAB and the importance of the quarantine. Information on invasive pests has been supplied to the school age audiences to increase knowledge of the impacts of invasive species on the local natural resources.

Restoration activities can also help. Restore the canopy of trees by replanting. And remember to diversify tree varieties when landscaping.

P8 – EAB Background Information Card

SP - 2A: GUIDED NOTES

Name: _____ Date:_____

The Process of Science

What is the process of science?

It is the steps someone takes to _____a question, develop a _____ carry out steps or _____ to test the hypothesis, and document _____ _____and findings to _____with someone else. In other words, _____.

Scientists have to take the time to think _____when they are _____a question or problem. They _____into many steps that make sense.

As scientists, we will follow this procedure for scientific investigations!

Make an _____then ask a _____ about it!

What types of things can science observe?

Gather more _____ if necessary.

Form a _____ and an _____ to test it.

What is a hypothesis?

Record_____the _____ of the experiment.

Communicate the _____ and share with the scientific community.

TP – 2A: GUIDED NOTES

Name: _____ Date:_____

The Process of Science

What is the process of science*?*

It is the steps someone takes to **ASK** a question, develop a **HYPOTHESIS**, and carry out steps or **EXPERIMENTAL PROCEDURES** to test the hypothesis, and document **DATA FROM OBSERVATIONS** and findings to **SHARE** with someone else. In other words, **THE SCIENTIFIC METHOD.** Scientists have to take the time to think **CRITICALLY** when they are **TESTING** a question or problem. They **BREAK IT DOWN** into many steps that make sense.

As scientists, we will follow this procedure for scientific investigations!

Make an **OBSERVATION** then ask a **QUESTION** about it.

What types of things can science observe?

Gather more **INFORMATION** if necessary.

Form a **HYPOTHESIS** and an **EXPERIMENTAL PROCEDURE** to test it

What is a hypothesis?

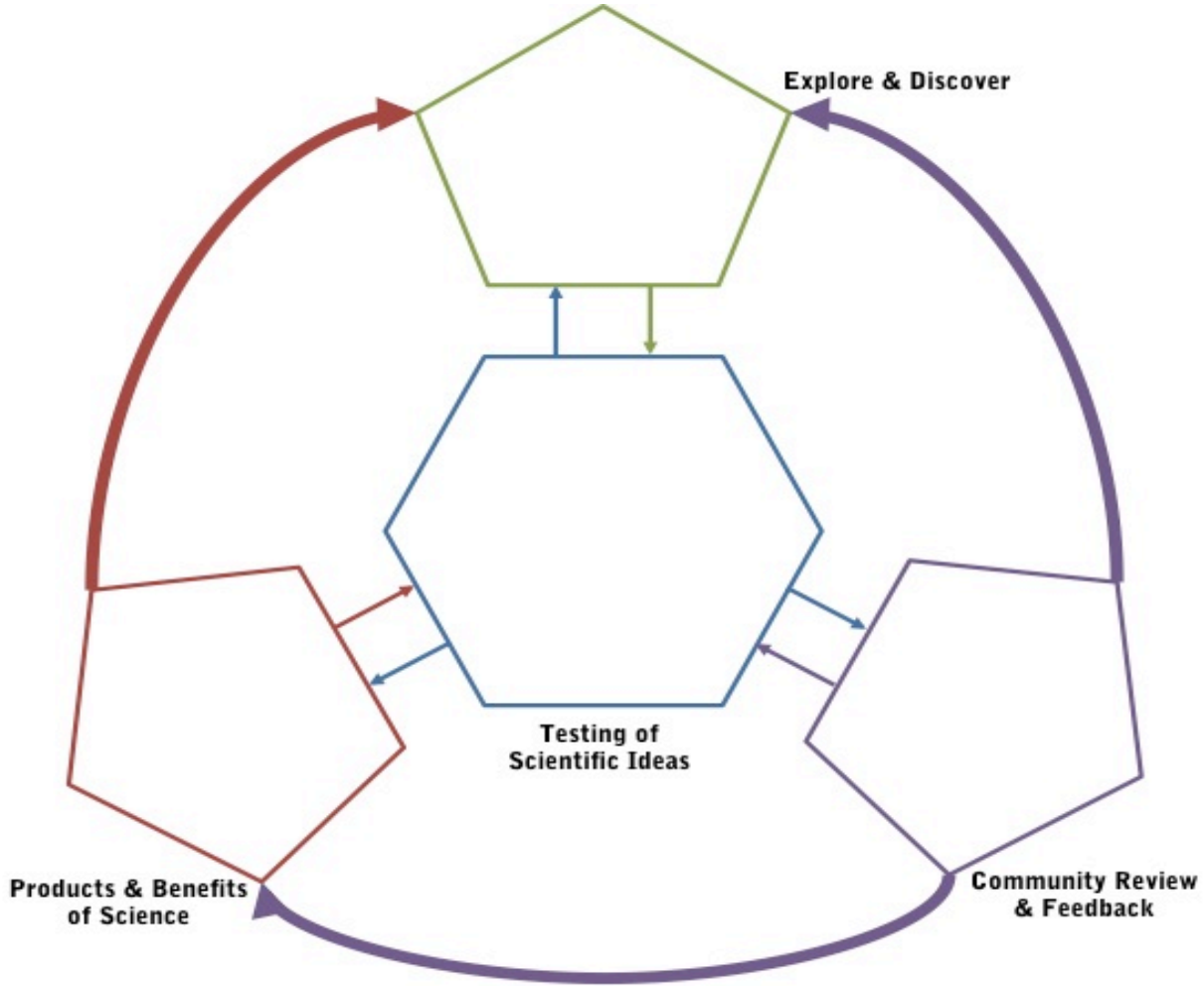
RECORD the **DATA** of the experiment.

Communicate the **RESULTS IN A CONCLUSION** and share with the scientific community

SP – 2A: FLOWCHART

Name: _____ Date: _____

The Process of Science



Exit Ticket: EAB Research Questions – What do YOU want to know?

1.

2.

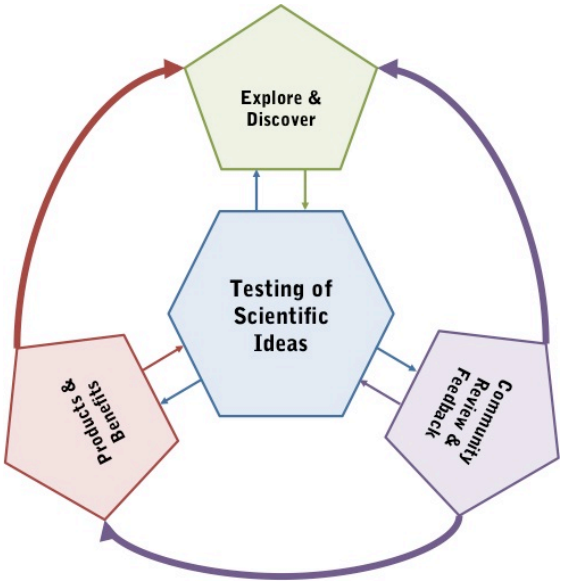
TP – 2A: FLOWCHART

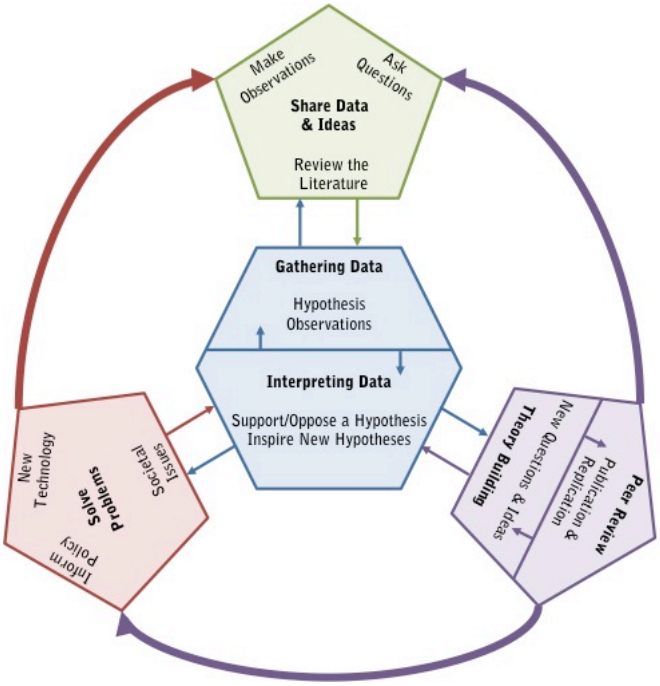
The Process of Scientific Flowchart

The process of science is **iterative**; it circles back on itself to investigate deeper and more complex levels.

There are **many routes** in the process of science; the progression from step to step is not predetermined.

Scientific testing is at the heart of the process; all scientific knowledge is based on observations of the natural world.





Scientific accuracy is a **community** endeavor; collaboration among scientists is important for generating, testing, and evaluating ideas.

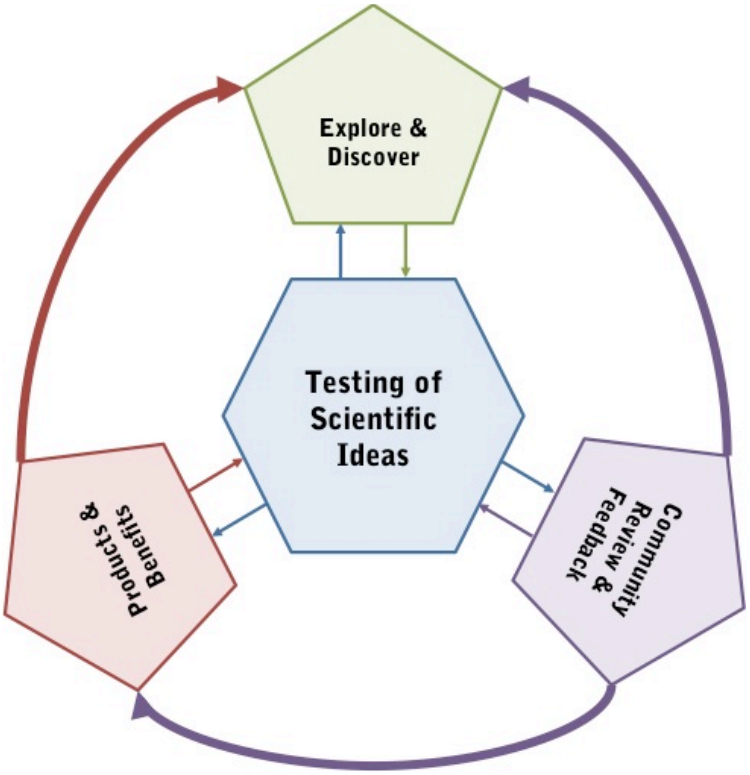
Science is intertwined with **society**; the advancement of science both influences and is influenced by society.

Images adapted from: Understanding Science. 2012. University of California Museum of Paleontology. 15 August 2012 <http://www.understandingscience.org>.

SP – 2B: INFO GUIDE

Name: _____ Date: _____

The Process of Science Info Guide



Write definitions for the following terms:

Hypothesis: _____

_____

Treatment: _____

_____

Control: _____

_____

Independent Variable: _____

_____

Dependent Variable: _____

_____

SP – 2B: RESEARCH GUIDE

Name: _____ Date: _____

Example #1: Dr. Daniel Herms, an entomologist at the Ohio State University, was interested in how to protect ash trees from emerald ash borer.

Observation: Insecticides can kill many insect species. Homeowners with ash trees would like to be able to treat their ash trees with an insecticide to protect the tree from emerald ash borer.

Question: Can imidacloprid insecticide soil treatments protect ash trees from emerald ash borer?

Gather more information: The systemic insecticide imidacloprid had been shown to effectively protect trees from native wood-borers that are closely related to emerald ash borer.

Hypothesis: _____

_____

_____

_____

Experiment: Four randomly selected ash trees were treated with soil a drench of imidacloprid at a rate of 1.4 grams per inch of trunk diameter (measured four feet from the ground) in May of each year for five years (2006-2010), and five trees were treated at the same rate in October of each year. The appropriate amount of insecticide was mixed in 1 gallon of water and poured on the soil at the base of each tree. Four randomly selected trees were treated with water only. Trees ranged in size from 5 to 8 centimeters in trunk diameter. At the end of five years, Dr. Herms measured the percentage of the canopy that was dead (canopy dieback) for each tree.

Treatment: _____

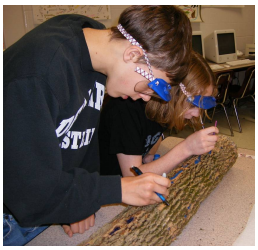
Control: _____

Independent Variable: _____

Dependent Variable: _____

SP – 2B: RESEARCH GUIDE

Name: _____ Date: _____



Example #2: Dempsey Middle School advanced science 7th and 8th grade students in Delaware, OH, working with USDA Forest Service scientists Kathleen Knight and Joanne Rebbeck, were interested in understanding parasitism of EAB larvae by native parasitoids at their school forest.

Observation: At the end of some EAB galleries, parasitoid cocoons and parasitoid larvae beside EAB larvae were discovered.

Question: What percentage of EAB larvae is parasitized? What species of parasitoids are parasitizing EAB larvae at Dempsey Middle School?

Gather more information: Parasitoid expert David Cappaert came to the school and explained the life cycle of parasitoids and how to recognize them, collect them, and rear them. He explained that parasitoids can only be identified once they are reared and emerge as adult wasps. There are three species of parasitoid wasps that parasitize EAB in China, and scientists are studying whether they can be used as a biocontrol to control EAB in the US. There are also several species of parasitoids that are native to the US that have been found parasitizing EAB. In order to control EAB populations, the parasitoids would have to kill a very large percentage of the EAB larvae.

Hypothesis: _____

_____

_____

Sampling study: As the trees were peeled, the students recorded the number of EAB and the number of parasitoids. Parasitoid larvae and cocoons that were found were reared, and the adult wasps along with their cocoons and the EAB cadaver were sent to Dr. Robert Kula, a taxonomist at the Smithsonian Museum.

Ecological parameters estimated: _____

_____

_____

_____

SP – 2B: RESEARCH GUIDE

Name: _____ Date: _____

Example #3: Dr. Kamal Gandhi, a forest entomologist at the University of Georgia, was interested in whether the changes in forest due to dead ash trees created by emerald ash borer could affect carabid beetle populations.

Observation: As emerald ash borer kills ash trees, there are physical and chemical changes in the soil layer as gaps are created in the forest canopy. These changes in the soil layer including lower moisture and higher temperatures levels will create different microclimatic conditions that may affect carabid beetle populations that live in this habitat.

Question: Do carabid beetle populations differ in areas with low and high-levels of ash tree mortality? Also, how do carabid beetle populations change over time as ash tree mortality increases in a stand?

Hypothesis: _____

Experiment: _____

Independent Variables: _____

Dependent Variable: _____

SP – 2B: RESEARCH GUIDE

Name: _____ Date: _____

Example #4: Dr. Kathleen Knight an ecologist working at the USDA Forest Service, was interested in how fast emerald ash borer kills ash trees in forests.

Observation: After EAB invades an area, some ash trees ide soon, and others survive for a few years. Other research has shown that for tree species that are killed by other insects, the initial health of the trees can affect how quickly the trees die. Research has also shown that EAB's are attracted to stressed ash trees.

Question: How fast do the ash trees in a forest die after EAB is detected? Is the initial health of ash trees related to how fast the ash trees die?

Hypothesis: _____

Experiment: _____

Independent Variables: _____

Dependent Variable: _____

SP – 2B: RESEARCH GUIDE

Name: _____ Date: _____

Observations: _____

Question: _____

Hypothesis: _____

Experiment: _____

Independent Variables: _____

Dependent Variable: _____

SP – 3: GRAPHIC ORGANIZER

Name_____ Date_____

Use this graphic organizer as we research EAB this week to fill out what you have done/will be doing for each step of the scientific process with your EAB experiment.

The Scientific Process

Steps	EAB Research
1. Make an **observation** and then ask a **question** about it.	**Observations:** **Research Question:**

Possible EAB Research Questions:

1. *What proportion of EAB is in each life stage (larvae instars, pre-pupae, pupae or adult as evidenced by exit holes)?*
2. *What is the fate of EAB that lived in this tree (death, eaten by woodpeckers, parasitized or emerged)?*
3. *How infested are the trees near our school?*

2. Gather more **information** if necessary, so that you can come up with a hypothesis! *Gather information to make sure you can recognize each life stage of EAB, symptoms of EAB, distinguish EAB from other insects that may also be in ash trees, and recognize the signs that show the fate of EAB that lived in a tree.*	**Information:** 1. 2. 3. 4. 5.
3. Form a **scientific hypothesis**.	**Hypothesis:**

Use the Hypothesis Formulator worksheet to help you develop a scientific hypothesis!

4. Conduct an **experiment** to test your hypothesis.

5. **Record data** from your experiment.

6. **Communicate** your results and conclusions.

SP – 3: HYPOTHESIS FORMULATOR

Name_____ Date_____

In your own words, explain what a scientific hypothesis is: _____

_____

_____

You have made observations and formed questions on Emerald Ash Borers. Record EAB observations for each question provided (even if it is not your question). Then, think of hypotheses you can make for each question and write them in the column labeled 'Hypothesis'. If you come up with your own testable question, use the bottom row to fill in your observations, question and then form a hypothesis for that question.

Observation and Testable question	**Hypothesis**
Observations: **Question** 1:	
Observations: **Question 2:**	
Observations: **Question 3:**	

After scientists form a hypothesis they must design fair tests to study the question to discover if their hypothesis is correct. Therefore, **a hypothesis must be testable** just like your testable research question.

Is YOUR hypothesis testable? YES NO

SP – 3: DATA COLLECTION

Name_____ Date_____

Group: _____ Wood #: _____

Note: If wood segments are not available, the Dempsey MS data can be used to complete this activity and the following analysis activity.

External Investigations:

1. *Measure the segment diameter in the center of log using the tape measure.*
   _____cm

2. *Quantitative Observations: Paint and count external holes that go through the bark.* You should only paint and record holes that go <u>all the way through</u> the bark to the phloem – use a probe to check! Use only enough paint to mark the bottom of the hole.

Paint Color	Description	Tally
Red	External EAB Exit	
Blue	External Woodpecker	
Yellow	External Other Insect	

3. *Qualitative Observations*: *Record your observations below.*

Get your work checked before you start peeling your log!

Internal Investigation:

4. *Quantitative Observations: Make tally marks in the correct boxes, then write the totals at the right.*

Description	Tally	Total
EAB Prepupae		
Live EAB larvae in a gallery		
Dead EAB		
Non-EAB insect in EAB gallery		
Non-EAB insect NOT in EAB gallery		
Parasitoid larva or cocoon in EAB gallery beside dead EAB		

5. *Qualitative Observations: Include any notes and/or drawings that are helpful in the space below.*

Get your work checked before Moving ON!

Use the Information Guides or other resources for this section.

6. After you have finished peeling, examine the galleries on your log and determine which ones are EAB galleries and which ones other insects probably made.

7. Re-examine your wood segment for prepupal plugs (look like rice grains and usually found in pairs about 1-2cm apart.) **Circle in brown marker.**

8. Decide what happened to each EAB gallery (unless there are too many overlapping galleries to tell). **Each EAB gallery should end with one of the following: larvae, dead EAB, prepupal plug, exit hole, or woodpecker hole**.

EAB Gallery Counts:

Marker Color	EAB Galleries Ending…	Tally	Total
Red	**Near EXIT hole**		
Blue	**Near WOODPECKER hole**		
Brown	**With PREPUPAL plug**		
Black	**Dead EAB (larvae or adult)**		

9. Determine the **total number** of EAB prepupae:
Prepupae found while peeling _____ + prepupal galleries with plugs _____ = _____

10. Put a 5cm x 5cm grid on your log at the bottom, middle, and top of each side of the log and count the number of 1 cm squares that contain an EAB gallery. If there is a knot in the way, move the grid up or down the log.

	Bottom	Middle	Top
Side 1			
Side 2			

11. Count the number of EAB galleries on the log. Trace with a marker to help you count if they overlap.

Total EAB Galleries: _____

Enter your data on the computer!

SP – 3: ANALYSIS & CONCLUSIONS

Name_____ Date_____

Research Question: _____

_____

Hypothesis: _____

_____

Look at the data table for the entire class. Which variables will you use to test your hypothesis?

Calculate the means or percentages you will need to answer your question:

a. Calculate the percentage of EAB found in each life stage: larva, pre-pupa, pupa, and emerged (as evidenced by exit holes)

% EAB larva	
% EAB pre-pupa	
% EAB pupa	
% emerged (exit holes)	

b. Calculate the percentage of EAB that met each of the following fates: died, parasitized, eaten by woodpeckers, emerged.

% died	
% parasitized	
% woodpeckers	
% emerged (exit holes)	

c. There are a few ways to measure the level of infestation of a tree: (1) Calculate the mean percent cover of galleries on the trunk; (2) Calculate the total number of EAB that lived in each tree.

Mean % cover of galleries: _____

Total # of EAB/tree: _____

In the spaces below, draw a graph of your data (pie chart for Q1 and Q2, bar graph for Q3).

1. What observations did you make during your research?

2. What inferences can you make about these observations?

3. What is your conclusion, based on your analysis of the data?

4. Was your hypothesis suported?

5. What other hypotheses could you test with the class data?

2.1 EXIT TICKET

Name:_____ Date:_____

The "3-2-1" of the Emerald Ash Borer

3 - New Things That You Learned:

1.

2.

3.

2 - Questions That You Still Have:

1.

2.

1 - Thing That You Enjoyed Learning:

1.

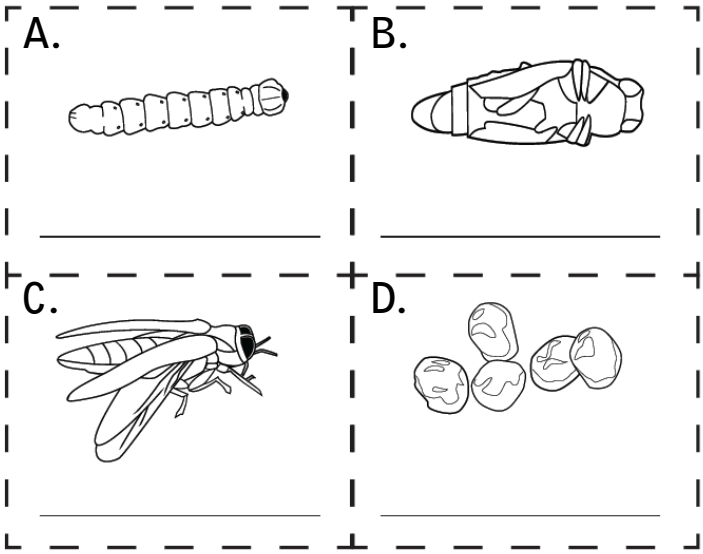
2.1 HOMEWORK

Name:_____ Date:_____

The Life Cycle of the Emerald Ash Borer

Using your understanding of the Emerald Ash Borer from our class activities, answer the following questions.

1. Label each stage of the EAB life cycle.



2. For each of the above stages, write one sentence that explains what happens during that stage.

    1. _____
    2. _____
    3. _____
    4. _____

3. How did EAB first arrive in the United States?

4. Based on the activities and readings, how do you think EAB has rapidly spread to so many states?

2.1 EAB ASSESSMENT

Name:_____ Date:_____

How well do you know the EAB? Let's find out!

1. How were EAB introduced to the United States?
    a. They gradually spread throughout the world
    b. They were brought to the US as exotic insect pets
    c. They were accidently imported from Asia on wood materials
    d. They were brought to the US for pest control

2. True / False – The EAB reproduces quickly with multiple generations per year.

3. The life cycle of the EAB has many stages. Which of the following is in the correct order?
    a. Pupa, Adult, Larva, Eggs
    b. Adult, Eggs, Larva, Pupa
    c. Larva, Pupa, Eggs, Adult
    d. Eggs, Pupa, Larva, Adult

4. True / False – The EAB has impacted both the environment AND the economy.

5. Which of the following is NOT a typical sign of an EAB infestation?
    a. Canopy die off
    b. D-shaped holes in branches and the trunk
    c. Lichens appearing on the tree trunk
    d. Vertical slits in the outer bark

6. The larval stage of the EAB life cycle has the most negative impact on ash trees. Explain why EAB larvae are particularly harmful for ash trees.

7. What is (1) specific environmental impact of EAB infestations?

8. What is one way in which YOU can help prevent the spread of EAB?

2.1 EAB PUBLIC AWARENESS

Name:_____ Date:_____

Now that you are EAB experts, it's time to share your knowledge with the public! Your task is to create an informational flyer that can be used to educate people in your community about the presence and impact of EAB. You need to decide what information is important to share and how to communicate it clearly. The questions below may help you get started!

1. What is the Emerald Ash Borer and how did it get here?

2. What are the most important signs or indicators of an EAB infestation?

3. Are there EAB infestations in your community? County? State? Where are they?

4. How does the EAB impact the natural environment? What are some specific environmental or economic impacts that are relevant in your community?

5. What is its distribution and rate of spread of EAB in the United States?

6. What does current research say about the spread and impact of EAB? What predications are there for the future of EAB infestations?

2.2 EXIT TICKET

Name:_____ Date:_____

The Process of Science

1. When forming a hypothesis, it is important to…
   a. Be specific and answer the question
   b. Make it a testable statement
   c. Make an educated guess
   d. All of the above

2. The difference between a hypothesis and a prediction is that a <u>prediction</u> is…
   a. A description about what has happened
   b. An educated guess
   c. A statement that suggests what might happen
   d. A statement that answers your question

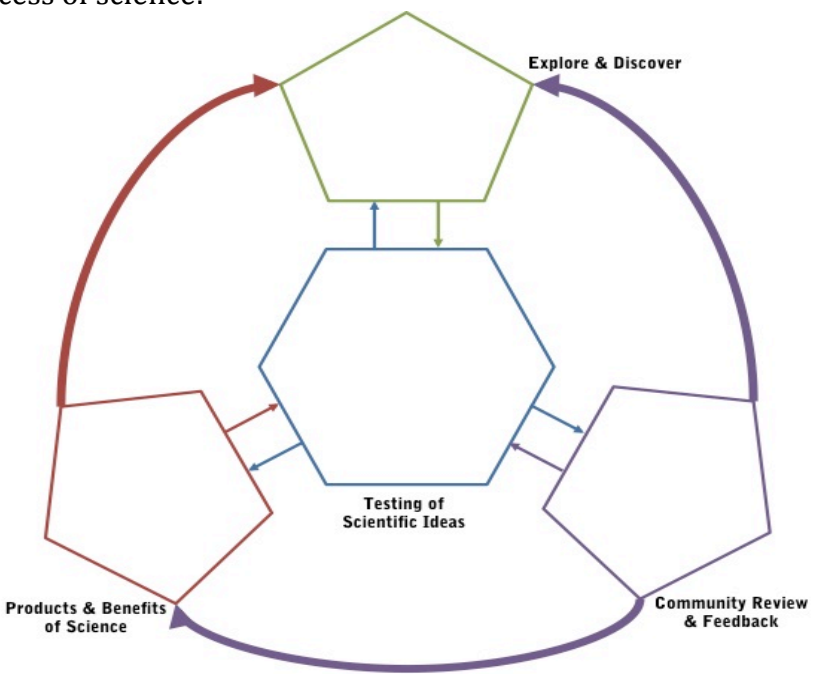
3. What is a *variable*? _____

4. The variable that is **changed** by scientists is called the _____. (*circle one)*

   INDEPENDENT DEPENDENT

5. What does it mean to *interpret* data?
   a. Trying to understand data
   b. Breaking complex data into smaller pieces
   c. Explaining or communicating the meaning of data

6. Complete the flow chart below with brief descriptions of the components that make up the process of science:



2.2 HOMEWORK 1

Name:_____ Date:_____

EAB – Scientific Observations

Think about how the scientific method relates to our EAB investigation. We have already completed the first steps in class and are now preparing for our EAB experiments. For the steps below, briefly explain what you have done OR what you will be doing to complete those steps.

1) Make an observation and then ask a question about it:

2) Gather more information if necessary:

3) Form a hypothesis:

4) Experiment to test the hypothesis:

5) Record the results of the experiment:

6) Communicate the conclusion:

2.2 HOMEWORK 2

Name:_____ Date:_____

Making Scientific Observations

Look at the italicized part of the sentences below and write whether it is an ***observation (O)*** *or* ***inference*** **(I).**

_____: I *measured the volume of the uncovered liquid and saw that it was 50 mL, but it was 80 mL last week*. The liquid has evaporated.

_____: I saw two children standing by the bus stop, and they were holding backpacks*. They were probably on their way to school.*

_____: *It is cold in this room and I can hear the vent blowing air into the room.* The air-conditioning must be on.

_____: The clouds are dark gray and it is windy outside. *It is going to rain today.*

Directions: Read the following observations and make 2 appropriate inferences. (O = observation; I = Inference)

For example:

O: There is a boy putting on clothes. It is raining outside. It is cold outside.

I: The boy will put on a raincoat before he goes outside.

O: There is a boy crying on the ground. He has on a football uniform. His leg is twisted…

I:_____

_____

O: You put a pizza in the oven, but forgot to set the timer. You smell burning and see smoke coming from the oven…

I:_____

_____

2.2 HOMEWORK 3

Name:_____ Date:_____

EAB Research Study - Analysis

Read the following information about an Ohio State University research project to complete the following questions.

Dr. Daniel Herms Knight, an entomologist at The Ohio State University was interested in how to protect trees from emerald ash borer.

Observation: Many insect species can be killed by insecticides. Homeowners with ash trees would like to be able to treat their ash trees with an insecticide to protect the tree form emerald ash borer. Some insecticides can be applied to the soil as a liquid. The tree roots absorb the insecticide and it gets distributed throughout the tree. It is known as a systemic insecticide. This does not harm the tree, but may harm insects feeding on different parts of the tree.

Question: Can soil treatments with the insecticide imidacloprid, protect ash trees from emerald ash borer?

Hypothesis: The systemic insecticide imidacloprid has been shown to effectively protect trees from native wood-borers that are closely related to emerald ash borer, so it will also protect ash trees from emerald ash borer. The effectiveness will depend on when the dose is applied.

Experiment: Four randomly selected trees were treated with soil drench of imidacloprid at a rate of 1.4gram/inch of trunk diameter (measure four feet from the ground) in May of each year for five years (2006-2010), and five trees were treated at the same rate in October of each year. The appropriate amount of insecticide was mixed in 1 gallon of water and poured on the soil at the base of each tree. Four randomly selected trees were treated with water only. Trees ranged in size from 12 to 20 inches in trunk diameter. At the end of five years, the percent canopy dieback (percentage of the canopy that was dead) was measured for each tree.

1. Based on what you have read so far, identify the following factors:

Treatment: _____

Control: _____

Independent variable: _____

Dependent variable: _____

Data analysis: Here is the data for the four trees in each treatment.

2. Calculate the mean crown dieback for trees protected with insecticide in the spring, insecticide treated in the fall, and control. Create a bar graph to show your results

% Die back of ash trees in June 2011	Tree #1	Tree #2	Tree #3	Tree# 4
Treated in Spring	0	20	20	10
Treated in Fall	100	20	70	100
Untreated trees	100	100	100	100

3. **Conclusion**: What are the answers to the research questions? Were they hypotheses supported?

2.2 HOMEWORK 3

Name:_____ Date:_____

EAB Research Study - Analysis

Read the following information about a USDA Forest Service research project to complete the following questions.

Dempsey Middle School advanced science 7th and 8th grade students in Delaware, OH, working with USDA Forest Service scientists Kathleen Knight and Joanne Rebbeck, were interested in understanding parasitism of EAB larvae by native parasitoids at their school forest.

Observation: At the end of some EAB galleries, parasitoid cocoons and parasitoid larvae beside EAB larvae were discovered.

Question: What percentage of EAB larvae is parasitized? What species of parasitoids are parasitizing EAB larvae at Dempsey Middle School?

Hypothesis: One of the native parasitoid wasps that has been observed parasitizing EAB larvae elsewhere is parasitizing a small percentage of EAB larvae at Dempsey Middle School.

Sampling study: As the trees were peeled, the students recorded the number of EAB and the number of parasitoids. Parasitoid larvae and cocoons that were found were reared, and the adult wasps along with their cocoons and the EAB cadaver were sent to Robert Kula, a taxonomist at the Smithsonian Museum.

1. Based on what you have read so far, identify the following factors:

Ecological parameters estimated: _____

Data analysis: The students found 2,567 EAB larvae or prepupae (dead or alive), 45 parasitoid cocoons, and 10 parasitoid larvae. Each parasitoid was beside one EAB cadaver. 20 parasitoid adult wasps emerged from their cocoons after incubation, and they didn't look like any of the other wasps that people had previously seen parasitizing EAB. Robert Kula identified most of the wasps as *Leluthia astigma*. He was very excited that no one else had ever seen this species of wasp parasitizing EAB!

Organism	Number Found
EAB larvae and prepupae	2,567
Parasitoid cocoons	45
Parasitoid larvae	10

2. Calculate the percent of EAB larvae parasitized and create a pie chart.

3. **Conclusion**: What are the answers to the research questions? Were they hypotheses supported?

2.2 HOMEWORK 3

Name:_____ Date:_____

EAB Research Study - Analysis

Read the following information about a USDA Forest Service research project to complete the following questions.

Dr. Kamal Gandhi, a forest entomologist at the University of Georgia, was interested in whether the changes in forest due to dead ash trees created by emerald ash borer could affect carabid beetle populations.

Observation: As emerald ash borer kills ash trees, there are physical and chemical changes in the soil layer as gaps are created in the forest canopy. These changes in the soil layer including lower moisture and higher temperatures levels will create different microclimatic conditions that may affect carabid beetle populations that live in this habitat.

Question: Do carabid beetle populations differ in areas with low and high-levels of ash tree mortality? Also, how do carabid beetle populations change over time as ash tree mortality increases in a stand?

Hypothesis: Carabid beetle populations are going to be lower in stands with high ash tree mortality. Carabid beetle populations will decline from one year to the next as ash tree mortality increases within stands.

Experiment: Pitfall traps were operated in 8 ash stands that had varying levels of tree decline and mortality to catch carabid beetles. These stands were sampled in 2006 and 2007 as more trees died over time.

1. Based on what you have read so far, identify the following factors:

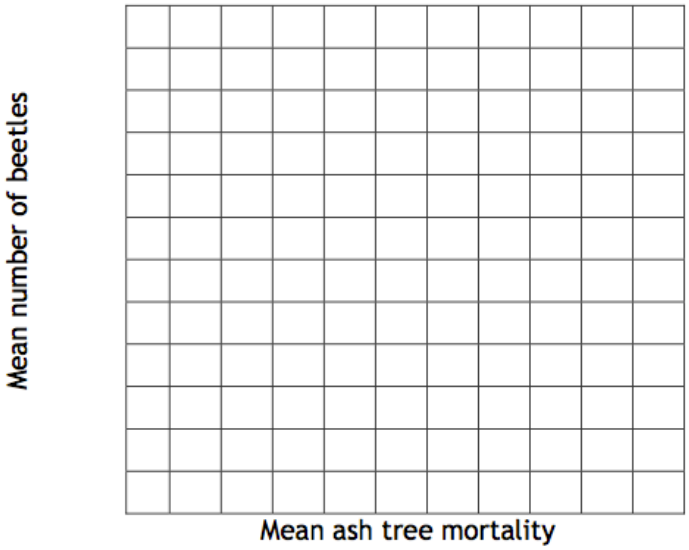
Independent variable: _____

Dependent variable: _____

Data analysis:

2. Using the data provided below, create a scatter graph.

Ash stand	A	B	C	D	E	F	G	H
Mean ash tree mortality (x-axis)	25	35	45	55	65	75	85	95
Mean number of beetles (y-axis)	145	135	123	110	75	56	34	21



3. Using the data table below, calculate the mean number of beetles caught in each year. Make a bar graph for mean carabid beetle numbers in 2006 and 2006.

Year	**2006**									**2007**								
Stand	1	1	1	2	2	2	3	3	3	1	1	1	2	2	2	3	3	3
Beetles	156	139	430	239	178	159	310	211	256	19	23	45	12	52	9	10	23	13

4. **Conclusion**: What are the answers to the research questions? Were they hypotheses supported?

2.2 HOMEWORK 3

Name:_____ Date:_____

EAB Research Study - Analysis

Read the following information about a USDA Forest Service research project to complete the following questions.

Dr. Kathleen Knight, an ecologist working at the USDA Forest Service, was interested in how fast emerald ash borer kills ash trees in forests.

Observation: After EAB invades an area, some ash trees die soon, and others survive for a few years. Other research has shown that for other tree species that are killed by insects, the initial health of the trees can affect how quickly the trees die. Other research has also shown that EAB's are attracted to stressed ash trees.

Question: How fast do the ash trees in a forest die after EAB is detected? Is the initial health of ash trees related to how fast the ash trees die?

Hypothesis: After EAB is detected in an area, most of the ash trees will be dead within 4 years. Ash trees that are initially stressed, which have canopies with thinning leaves and dead branches, will die more quickly than ash trees that are initially healthy.

Sampling study: Kathleen collected data in forests in Ohio that have ash trees. In each forest, Kathleen set up three sampling plots where she recorded the health and death of the ash trees every year from 2005 to 2010. The initial year of infestation was defined as two years before she saw the first exit holes at that site. It is possible the sites were infested earlier at low levels.

4. Based on what you have read so far, identify the following factors:

Ecological parameters estimated: _____

Independent variable: _____

Dependent variable: _____

Data analysis: Here is the data for four forests that were initially infested in 2005. There were 56 healthy trees and 31 stressed trees in the sampling plots in 2005. For the initially healthy trees, 16 were dead in 2008 and 50 were dead in 2009. For the initially stressed trees, 20 were dead in 2008 and 29 were dead in 2009.

5. Calculate the percent of trees that were dead in 2008 and 2009 and use the space below to make a bar graph to compare the percentage of initially healthy and initially stressed trees that died over time.

Initial Health in 2005	**Healthy**	**Stressed**
Total number of trees	56	31
Number of trees dead in 2008	16	20
Number of trees dead in 2009	50	29
Percent of trees dead in 2008		
Percent of trees dead in 2009		

6. **Conclusion**: What are the answers to the research questions? Were they hypotheses supported?

2.3 EAB PUBLIC AWARENESS

Name:_____ Date:_____

Now that you are EAB experts, it's time to share your knowledge with the public! Your task is to create a scientific presentation or news broadcast that communicates your results to the people in your community! You need to decide what information is important to share and how it should be presented. The questions below may help you get started!

1. What is the Emerald Ash Borer and how did it get here?

2. What are the most important signs or indicators of an EAB infestation?

3. Are there EAB infestations in your community? County? State? Where are they?

4. What does your research say about the spread and/or distribution of EAB infestations in your community?

5. How does the EAB impact the natural environment? What are some specific environmental or economic impacts that are relevant in your community?

6. What solutions can you suggest to help to treat and prevent further spread of EAB in your community?

How can I tell if an EAB larva is dead or parasitized?

A live EAB larva has a white body. Record EAB larvae as alive if YOU just killed it with your drawknife. Record EAB larvae as dead if they look like they have been dead for a while. Dead EAB larvae start to turn brownish white and get gooey as they rot. Here is a picture of a dead EAB larva with a parasitoid larva beside it. Later, if the dead EAB larvae rots or gets moldy, or it dries up and turns black.

Here is a picture of a dead, dried up black EAB larva with a parasitoid cocoon beside it. There are several different species of parasitoids that parasitize EAB, so the parasitoid larvae and cocoons may look different depending on what species they are. If you find a dead EAB larva and see no evidence of a parasitoid larva or cocoon beside it, it probably died of other causes such as disease, too hot or too cold temperatures, drying out, or starvation.

What should I do if I find a parasitized EAB larva with a parasitoid larva or cocoon?

It is interesting to find out what species of parasitoids are parasitizing EAB - this is an ongoing area of research and could lead to a discovery that would help control EAB. If you find a parasitoid larva or cocoon beside a parasitized EAB:

1. Take a picture of it, then without disturbing the parasitoid, carefully chip off the piece of bark with the parasitoid larva or cocoon and the dead EAB.
2. If it's a parasitoid cocoon, put it in a petri dish.
3. If it's a parasitoid larva, get another chip of bark and carefully put it on top (to sandwich the larva without squishing it and make it feel like it's inside the tree again), then put it in a petri dish so it can form a cocoon after it's done feeding on the EAB.
4. If you want to try to rear the parasitoid yourself, keep the petri dish in an enclosed, dark area at room temperature. An empty cooler is a good place. Wait for the adult parasitoid to emerge. This can take a couple months, but it's neat to see what the parasitoid adult looks like.
5. If you don't want to rear it yourself, or after you have successfully or unsuccessfully tried to rear it, send the parasitoid, along with the bark chip with the dead EAB, to Robert Kula at the systematic entomology laboratory at the Smithsonian Museum for identification. Fill out the Parasitoid ID form (on DVD) and send it to the address at the bottom of the form.

ADDITIONAL RESOURCES

Journal Articles:

Capparet, D., McCullough, D.G., Poland, T.M., & Siegert, N.W. (2005) Emerald Ash Borer in North America: A research and regulatory challenge. *American Entomologist*, 51(3), 152-165.

Hausman, C.E., Jaeger, J.F., Rocha, O.J. (2010). Impacts of the emerald ash borer (EAB) eradication and tree mortality: Potential for a secondary spread of invasive plant species. *Biological Invasions*, 12(7), 2013-2023.

Herms, D.A., McCullough, D.G., & Smitley, D.R. (October 1, 2004) Under Attack. *American Nuseryman*, 20 – 26.

Kovacs, K.F., Haight, R.G., McCullough, D.G., Mercader, R.J., Siegert, N.W., Liebhold, A.M. (2010). Cost of potential emerald ash borer damage in U.S. communities, 2009 – 2019. *Ecological Economics*, 69, 569 – 578.

Lovett, G.M., Canham, C.D., Arthur, M.A., Weathers, K.C., Fitzhugh, R.D. (2006). Forest ecosystem responses to exotic pests and pathogens in Eastern North America. *BioScience*, 56(5), 395-405.

Poland, T.M., & McCullough, D.G. (2006). Emerald ash borer: Invasion of the Urban Forest and the threat to North America's ash resource. *Journal of Forestry,* 118-124.

Vannatta, A.R., Hauer, R.H., & Schuettpelz, N.M. (2012). Economic analysis of emerald ash borer (Coleoptera: Buprestidae) management options. *Journal of Econ. Entomol.* 105(1): 196-206).

Websites:

USDA Forest Service – Northern Research Station
http://www.nrs.fs.fed.us/disturbance/invasive_species/eab/

USDA – Animal and Plant Health Inspection Service
http://www.aphis.usda.gov/

USDA National Agricultural Library – National Invasive Species Information Center
http://www.invasivespeciesinfo.gov

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