

A Hands-on Activity to Introduce the Effects of Transmission by an Invasive Species

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ABSTRACT

This activity engages students to better understand the impact of transmission by invasive species. Using dice, poker chips, and paper plates, an entire class mimics the spread of an invasive species within a geographic region. The activity can be modified and conducted at the K–16 levels.

Key Words: Invasive species; transmission; hands-on activity; infectious agent; microorganism; emerald ash borer.

An invasive species is defined as a “non-native species whose introduction does or is likely to cause economic or environmental harm or harm to human, animal, or plant health” (Invasive Species Advisory Committee, 2006). An invasive species can be a microorganism (i.e., virus or bacterium), animal, or plant. For example, the lionfish, naturally found in the Western Pacific Ocean, is now seen in increasing numbers in the Caribbean (National Ocean Service, 2012). Because it is a voracious eater, scientists worry about the lionfish’s presence disrupting an already fragile reef ecosystem.

The study of an invasive species in a classroom setting has many advantages. (1) It meets many core ideas presented in the new K–12 Frameworks provided by the National Academies (National Research Council, 2012). Table 1 provides ideas as to where this study fits the Life Science core ideas. (2) This is an opportunity to introduce various species from viruses (acellular) to plants and animals. (3) Discussion of invasive species provides a context for introducing core ideas, which helps students relate to the material, especially if the invasive species invades your home environment. (4) It engages and makes students aware of current scientific issues. (5) Many different disciplines, including history, ethics, economics, and geography, can be intertwined in the study of invasive species. (6) The addition of a hands-on activity provides alternative and engaging learning practices.

The following activity can be used at any K–16 level, depending on the depth of discussion and analysis. The emerald ash borer

(EAB), a beetle whose life cycle harms and kills ash trees, is our model invasive species.

○ Invasive Species Activity Preparation

- Pick an invasive species. Identify background information and resources for students. Materials presented here will need to be modified if not using EAB.
- Materials: one six-sided die for each student in the classroom, poker chips (or other plastic chips), and paper plates or trays.
- The activity takes approximately 15 minutes. Additional time for introduction and analysis may be desired.

○ Procedure for Student Engagement

Step 1: Introduce the Ecosystem That May Be Harmed

One short and useful hands-on activity to introduce the species and their relationships in an ecosystem is to construct a food web. I used an ecosystem that contained ash trees and could be invaded by EABs. I listed the following organisms and asked the group to draw how they are connected: snake, deer, tree, mouse, caterpillar, grass, sun, hawk, squirrel, cougar, and microorganisms. As a result, the following was identified: (1) living species depend on and interact with each other, (2) a food web is not really a chain, and (3) each group was creative and drew different representations (which is okay!).

This exercise set the stage to later discuss the impact of EAB on this ecosystem. Older students could organize the web into its trophic levels and discuss the energy flow within the web.

Step 2: What Is EAB?

The invasive species and its characteristics are introduced. To understand EAB transmission, it is helpful to understand its life cycle. As an example of an activity, each step of the EAB life cycle was placed

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Table 1. Core ideas in the life sciences addressed by this activity.

From Molecules to Organisms; Structures & Processes:
• Describe the life cycle of an invasive species.
Ecosystems, Interactions, Energy & Dynamics:
• Describe how an invasive species affects an ecosystem. • Explain the interdependent relationships in an ecosystem.
Biological Evolution: Unity & Diversity:
• Explain how humans can affect the diversity of living organisms. • Explain how an invasive species can influence natural selection by other species.

on a card (a picture of EAB at each stage and a description; adopted with permission from <http://www.emeraldashborer.info/lifecycle.cfm>). I asked students to place the cards in the order of the EAB life cycle.

Step 3: What Does the EAB Do to Ash Trees?

As eggs hatch in the ash tree's bark, EAB larvae develop and feed on the inner bark. This disruption interrupts water flow and nutrients

in the tree, ultimately killing it. Signs of infestation include foliage loss, shoots sprouting at the base, and S-shaped patterns (movements of larvae) in the bark. One predator for the EAB larvae is the woodpecker.

Step 4: How Does EAB Spread? Setting Up the Activity

This activity is developed to engage and help students measure the transmission of EAB. To prepare the activity, I used historical transmission data for EAB (Table 2; <http://www.emeraldashborer.info>). Using real data may help students find relevance to the activity. Briefly, EAB is native to Asia and can fly and move to nearby ash trees to meet their nutrient requirements. In addition, EABs move farther distances through human behavior. Ash logs are used for firewood, shipping crates, or even furniture. When these materials are moved to more distant locations, EAB embeds in the logs and transmits with them. This is believed to be the cause of EAB transmission from Asia to North America.

As seen in Table 3, to mimic transmission, paper plates (representing distinct geographic regions) are placed throughout a classroom. I identified three regions/spaces in the classroom based on the timing of EAB spread. Region 1 represents Asia, the starting point for the activity. Region 2 (placed closer to Region 1) represents locations

THE EARLY BIRD



Table 2. Transmission of the emerald ash borer (EAB; see <http://www.emeraldashborer.info/index.cfm>).

Year of EAB Detection	Region of Detection	Number of Ash Trees on Timberland ^a
Previous to 2002	Asia (eastern parts and China)	
2002	Michigan and Ontario	MI: 692,900,000
2003	Ohio	279,400,000
2004	Indiana	146,900,000
2006	Illinois and Maryland	IL: 131,300,000
2007	West Virginia and Pennsylvania	WV: 150,400,000; PA: 299,700,000
2008	Wisconsin, Missouri, and Virginia	WI: 628,100,000; MO: 213,400,000; VA: 169,100,000
2009	Minnesota, New York, and Kentucky	MN: 692,900,000; NY: 767,300,000; KY: 291,600,000
2010	Tennessee and Iowa	TN: 261,600,000; IA: 33,000,000
2012	Connecticut	CT: 22,400,000

^aPotential for infestation (Nowak et al., 2003).

where spread first originated (i.e., Michigan, Ontario, Indiana, and Illinois). Region 3 (placed farther away from Region 1) represents farther and later spread (Wisconsin, Minnesota, Iowa, Virginia, and Missouri). Poker chips are placed on each paper plate to represent the ash trees in each region (Figure 1). Each student represents an EAB and obtains a die. Every roll of the die represents an EAB life cycle; based on the number rolled, students use the key to determine the outcome for EAB (Table 4). In some cases EAB spreads only locally, but in other cases EAB spreads via human behavior.

○ Conduct the Activity

Each student starts their life cycle in Asia. Their goal as an EAB is to survive and find additional nutrients (ash trees) for their life cycle. Five students roll their dice. Depending on the number they roll, they follow the key (Table 4). If they are killed by a woodpecker, they stop the game. If they survive and reproduce, they add another

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Table 3. Transmission activity set-up.

Model	Representation	Class of 20 Students
Dice	Emerald ash borer (EAB); each student takes one die; each roll represents one life cycle (1 year)	20 dice
Poker chips	Ash tree; chips are placed in each geographic region (paper plate); when the ash tree dies, it is removed from the plate	40 chips in native region; 20 chips in other regions
Paper plates	Geographic region; each region represents locations of EAB spread	10 plates (regions)



Figure 1. Poker chips representing ash trees. Colors indicate different regions.

Table 4. Dice key: results of one emerald ash borer (EAB) life cycle.

Number rolled:	What will EAB (you) do?
1	You are happy in this community and stay in the region. You killed one ash tree and move to a neighboring ash tree (remove a poker chip).
2	You are happy in this community and stay in the region. You killed one ash tree and move to a neighboring ash tree (remove a poker chip).
3	Oh no! A woodpecker has found you in the bark. You are eaten and will not survive. You did not kill the ash tree (do NOT remove a poker chip). Stop playing.
4	The ash tree you are living on is chopped down and used as campfire and crate material. Your tree is dead; remove a poker chip in your original home and move to a new location of your choice.
5	The ash tree you are living on is chopped down and used as campfire and crate material. Your tree is dead; remove a poker chip in your original home and move to a new location of your choice.
6	You killed an ash tree (remove a poker chip) but move to a different community in close proximity (this could be in a neighboring state).

EAB (i.e., another student) who will now roll their dice. This mimics the replication process and keeps students who “die” to continue participation in the activity as a new EAB larvae. If they killed a tree, they remove a poker chip from the paper plate. They may hang on to these chips. Please remember, EABs cannot fly long distances – only within the state and into neighboring states. This means that they cannot fly across oceans (all the way from Asia to the United States) or to nonbordering states without human help (rolling a 4 or 5). To better mimic the transmission, after leaving Asia, students must first move to Region 1. Then, when in Region 1, they can spread to Region 2, depending on their roll.

Once all of the EABs have died, the activity ends. There are several means for analysis:

- Count the number of ash trees left in each region. Averages for regions and graphs can be constructed to measure the change in ash populations.
- Students can count their collected poker chips (the number of ash trees they killed). You will likely notice some variability in numbers, which exemplifies the variation in a living species’ life cycle.
- Students can compare the number of ash trees lost in Asia, Region 1, and Region 2. What do these numbers suggest regarding the spread of EAB? Students could use percentages tabulated in the activity to predict the spread of EAB and the death of ash trees using the real data provided in Table 2.

After analysis, I ask students to return to the food web and add EAB. This helps stress the impact that EAB has not only on trees but on entire ecosystems. Some questions that might be addressed by students, particularly at the older grade level, include (1) At what trophic level does the invasive species exist? (2) Which species occupy the same niche as the invasive species? (3) How are energy levels and the food web disrupted by the invasive species? (4) This activity represents a model of invasive species’ spread. How is this model accurate, and what is problematic about it? For example, a large tree infested by EAB is often killed in 2–3 years, not exemplified in this model.

○ Discussion & Modifications

This activity gives the teacher flexibility to meet core ideas in the life sciences and address any grade level, and it can be modified as follows:

- You can use different invasive species and modify the key. For example, if using

a microorganism that causes disease in humans, means of transmission might be through human interaction. Microorganisms might be “killed” via antimicrobial agents.

- You can control the rate of transmission of your invasive species by how many numbers on the dice represent that means of transmission. For example, before preventive mechanisms for EAB transmission were established, the movement of EAB from state to state via human behavior was higher. This is represented by two numbers on the dice (as shown in Table 4). However, as preventive measures are established (i.e., pesticides), one number on the dice might be switched from a “transmission” outcome to death of EAB. A wonderful learning opportunity is to play the game before preventive measures were in place, then again after measures are taken (modify the key). The results will be substantially different.
- You can control the replication level. An EAB can lay 1 to 23 larvae per replication cycle. Commonly one egg is laid, and this is mimicked in the activity. However, one could increase the replication numbers by adding more than one student for each student who rolls the die and successfully replicates.
- Interdisciplinary topics can be expanded during the activity. Discussions on epidemiology, public health, ethical issues, geography, public policy, and economics may be included.

○ Additional Resources

- National Invasive Species Information Center (<http://www.invasivespeciesinfo.gov/index.shtml#.UEexijFR2So>)

- Emerald ash borer information (<http://www.emeraldashborer.info/index.cfm>; this website is a “collaborative effort of the USDA Forest Service, Michigan State University, Purdue University, and Ohio State University to provide comprehensive, accurate and timely information on the emerald ash borer to the site’s visitors.”)

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