TIPS, TRICKS & TECHNIQUES

"Invented Invaders": An Engaging Activity to Teach Characteristics & Control of Invasive Species

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Abstract

Invasive species, defined as exotic species that reach pest status, are major threats to global biodiversity. Although invasive species can belong to any taxonomic group, general characteristics such as rapid growth and reproduction are shared by many invasive species. "Invented Invaders" is a collaborative activity in which students invent and draw the "perfect" invasive species, made up of a combination of characteristics of actual invasive species in their geographic region. Students then list sustainable ways to control or manage the invented invader. This activity engages students and educates them about a continuing global problem while encouraging creativity and advocacy for the environment.

Key Words: *Invasive species; classical biological control; characteristics; anthropogenic effects; conservation.*

Introduction

Invasive species, defined as exotic organisms that cause significant economic or ecological harm to humans or the environment (exotic pests; Invasive Species Advisory Committee, 2006), are considered among the most significant threats to global biodiversity. Invasive species cause massive economic costs at local, regional, and global scales, including annual costs exceeding $120 billion in the United States and $1.4 trillion globally (Wilcove et al., 1998; Pimental et al., 2005; Ricciardi et al., 2011; Simberloff, 2013). Human activities are major causes of introductions and invasions. Anthropogenic impacts on environments, such as urbanization and agricultural monocultures, create novel niches that can be occupied by introduced species. Populations of exotic species can increase to levels that cause harm when competitors, predators, and pathogens that would normally control populations are removed as a result of human activities. Purposeful transport (e.g., escaped ornamental plants) and inadvertent transport (e.g., insects "hitchhiking" on ornamental plants and lumber) by humans also increase the rate of introductions, giving introduced species numerous opportunities to become established.

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Most introduced species do not become pests (Zenni & Nuñez, 2013); only a small percentage pass each transition from introduction to establishment to pest status (Williamson & Fitter, 1996). Although the biology of invasive species can vary greatly, there are characteristics that enhance and reduce the likelihood of making each transition from introduction to pest status. For instance, characteristics that favor rapid population growth and dispersal at the cost of competitive ability – such as rapid growth, small size, high reproductive capacity, and generalist feeding habits – are shared among many invasive species (Sakai et al., 2001).

"Invented Invaders" is an in-class activity to design an invasive species that in Frankensteinian fashion combines the most injurious characteristics of real local invasive species. Invented Invaders was inspired by websites and magazine articles that "build a perfect (*fill in the blank*)" – for instance, the Bleacher Report's various "NFL Frankenstein" web pages.

Invented Invaders was originally developed for a college course in an introductory sequence for science majors, but it is also suitable for high school courses and can be modified for upper-level ecology and conservation biology courses. This activity has had success in the context of a course unit about local invasive species and their negative effects on biodiversity and ecosystem goods and services.

Learning Goals

After completing Invented Invaders, students should be proficient in doing the following:

1. Recognize and list local invasive species.
2. Describe characteristics shared by many invasive species, even if they are not closely related.

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3. Follow rules of biological nomenclature, such as
   a. Place an invasive species into the proper taxonomic group.
   b. Locate that group within the taxonomic hierarchy.
   c. Differentiate common and scientific names.
   d. Correctly write a scientific name.
4. Use appropriate resources to research a topic.
5. Describe appropriate control tactics for invasive species, and differentiate harmful and sustainable control tactics.

○ Procedure

Invented Invaders can be completed during two 50-minute class periods, as part of a "flipped" course or other environment that features active learning. The activity begins with a brief introduction of invasive species, which can include entertaining and engaging titles such as "ALIENS ARE COMING!!" The introduction should include some instructions and guidelines for finding online resources that list and describe local invasive species. Several examples of resources are provided in the Appendix, and most states have a variety of additional resources that can easily be found online.

Students can work individually, in pairs, or in small groups, depending on course context; in my experience, most parts work very well as collaborative exercises in which small groups discuss their responses. The four parts of Invented Invaders are described below.

Part 1: Select Local Invasive Species

Instructions: Students research the invasive species that are most problematic in their area. This will vary regionally, from kudzu and fire ants in the Southeast to leafy spurge and salt cedar in the Northern Great Plains. Students write down taxonomic information for each species they select to research. They finish Part 1 by listing the characteristics that make each species invasive, and how each characteristic facilitates that species becoming invasive. A list of online resources that students can use to select local invasive species is provided in the Appendix.

Assessment: Students are assessed on correctly writing taxonomic information for each species they select and on correctly describing how each characteristic facilitates its ability to become invasive.

Experiences: The characteristics most commonly included by students have been high reproductive rate (in almost all examples), flight, hunting ability, cryptic behavior, camouflage, small size, large size, poison, venom, armor, and ability to vector pathogens (both mechanical and biological). Prior to this activity, students tend to be animal-centric in terms of biodiversity knowledge. During research, they should recognize the large numbers of invasive plant species (many of which began as escaped ornamentals; Reichard & White, 2001) and the associated ecological and economic costs. Correctly writing scientific names has also been a consistent challenge – for example, students don't italicize genus and species, or they italicize other taxonomic groups like family and order – even though Invented Invaders has always followed our taxonomy units.

Best Practices: I instruct each student team to select five local invasive species. This number works well with time constraints in active classrooms, and the drawings (Part 3) can be difficult for students if more species are included; however, the number of species can be at the instructor's discretion. Part 1 is the chance for students to discover what characteristics facilitate a species becoming invasive. If time permits, students can research each species and make a list of characteristics related to dispersal ability, reproduction, growth rate, diet range, and so on. They should then be able to recognize patterns in shared characteristics that facilitate invasions, and a follow-up discussion can reinforce this knowledge. Alternatively, a brief lecture can be used to explain the shared characteristics of invasive species.

Part 2: Create the Invader

Instructions: Students conceptualize the invented "invader" and its characteristics and appearance. It must have at least one characteristic from the species selected in Part 1. The invader is assigned to an existing phylum or division. Real taxonomic groups that are more exclusive than this (class, order, family) are less feasible because students will probably combine unrealistic mixtures of characteristics. The invader is given a made-up common name and scientific name, which can be based on its characteristics.

Assessment: Students are assessed on their ability to select the most suitable existing phylum and scientific names. They can also be assessed on creating scientific names that use correct biological word roots that match the selected characteristics.

Experiences: Students enjoy naming the invader after themselves (e.g., *Lampertophthora*). Most invent an invader that is a chordate (vertebrate), with quite a few that are arthropods or angiosperms. In rare cases, invented invaders have been microbes or other animal phyla such as nematodes and molluscs. Most invaders have been terrestrial. Sometimes the invaders mix outlandish characteristics, such as flowers growing out of a mammal.

Best Practices: While students can be assessed on conceptualizing a possible living thing, it is more fun to allow students to invent impossible invaders.

Part 3: Draw the Invader

Instructions: Make a descriptive sketch or drawing of the invader based on the characteristics and real species selected in the previous parts. The drawing must include some labels of the characteristics.

Assessment: Drawings are assessed on correct, accurate labels of the characteristics that facilitate invasions. Drawings are not assessed on artistic quality, although they can be – for instance, if Invented Invaders is a collaborative activity between art and biology students.

Experiences: Most classes will have a mixture of drawings, some of which are crude and others that are impressively creative and intricate. Students who lack confidence in their artistic abilities will protest having to draw. Conversely, many students love to draw and are extremely skilled, and relish the chance to display their art. Examples of invaders drawn by students in Spring 2014 can be seen in Figures 1 and 2.

Best Practices: Drawing is an effective way to "model" science concepts, in this case the relationships between morphological, behavioral, and physical characteristics and interactions with the environment. Building models is a key component included in the dimensions of the *Next Generation Science Standards* (http://www.nextgenscience.org/three-dimensions) and has been shown to improve higher-level understanding and synthesis of difficult science concepts (Anderson & Farnsworth, 2000). Encourage students who are not confident in their artistic abilities.

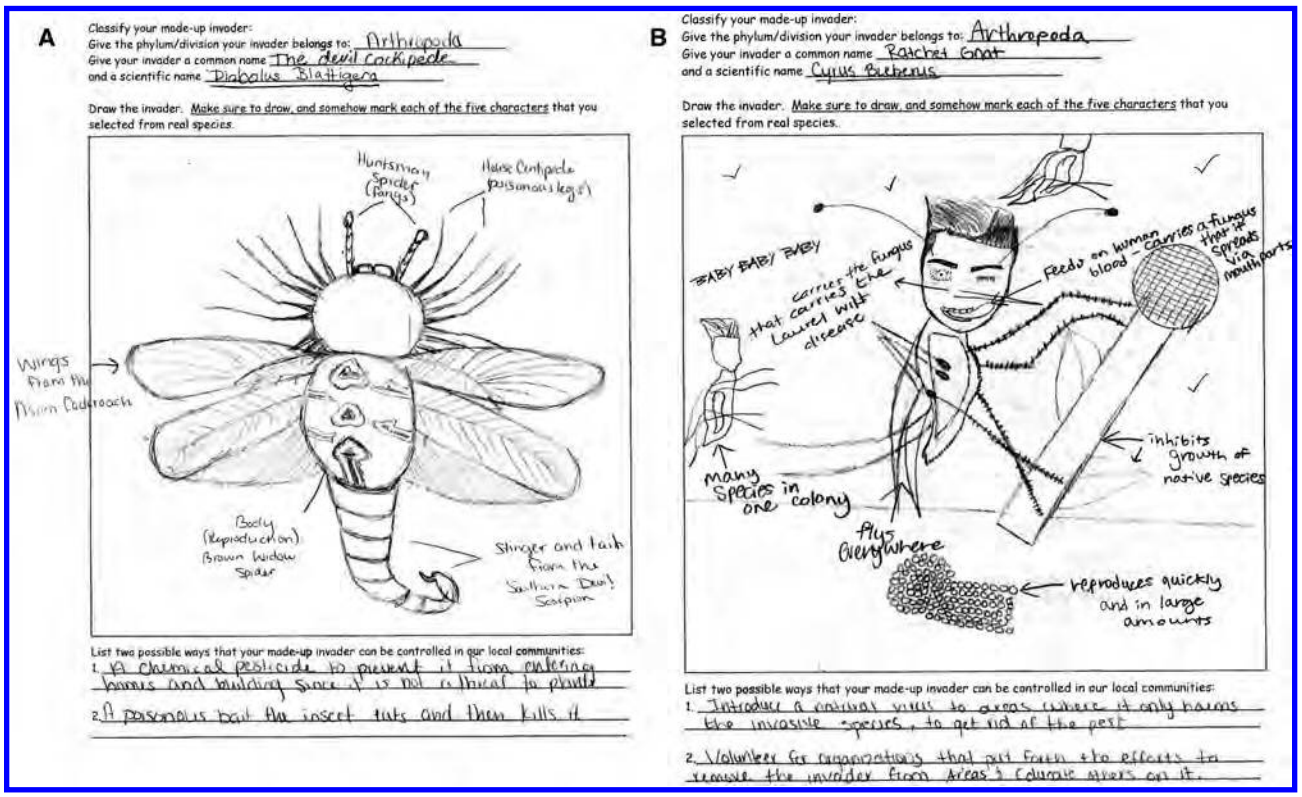

Figure 1. Two examples of animal "invented invaders" created in spring 2014. Art by Megan Ward and Kendarius Freeman, University of North Georgia students.

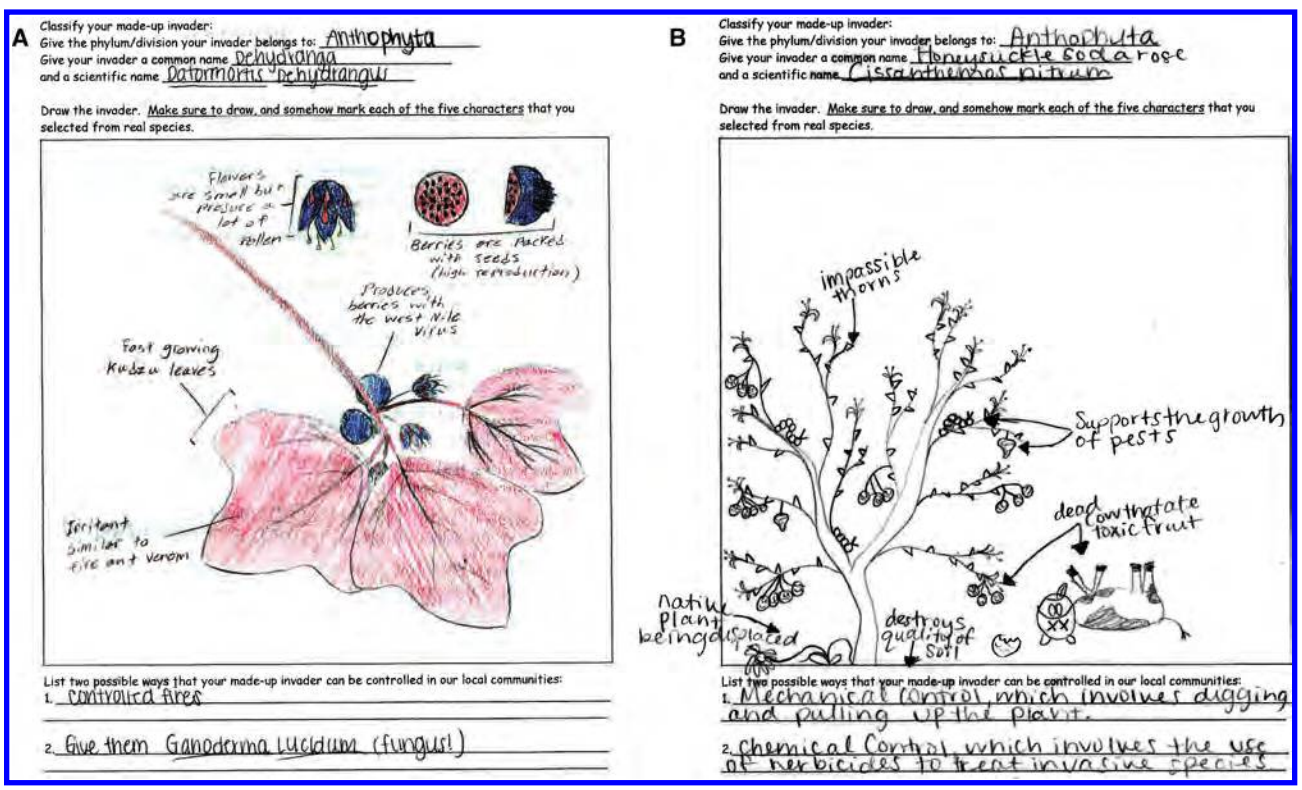

Figure 2. Two examples of plant "invented invaders" created in spring 2014. Art by Della Tapley and Eden Hulsey, University of North Georgia students.

Part 4: Control the Invader

Instructions: Students research and present sustainable methods that can manage or control the invader. At least two different methods should be presented, and more can be added at the instructor's discretion.

Assessment: Students are assessed on providing control methods that are effective and suitable to the characteristics of the invader and the local environment. Students are penalized for providing control tactics that are more harmful to the environment than the invader itself.

Experiences: Most commonly, students have suggested a haphazard version of classical or neoclassical biological control, defined as the introduction of a pathogen, herbivore, or predator from the pest's native (classical) or introduced (neoclassical) range in order to reduce the invader population. When this occurs, the instructor has the opportunity to discuss risk assessment and examples of biological control "gone wrong" (Simberloff & Stiling, 1996). Activities in which humans directly control the pest – such as inspections, hunting, and trapping – have been common suggestions. Environmentally damaging control methods, such as burning, clear-cutting, and poisoning, have also been frequent suggestions, presenting an opportunity to teach students that poorly planned control methods can be more harmful to native species than the invader.

Best Practices: Like Part 1, this part can include a class discussion or a brief lecture.

○ Extensions

The following are five extensions of Invented Invaders that can be used to increase the impact of the activity in high school or introductory college courses, and to increase the rigor of the activity for use in upper-level college courses. These expansions can be used to make Invented Invaders part of a community-based or service-learning course module.

First, a field experience in which students observe real invasive species and their characteristics in their new habitats makes Invented Invaders more of an inquiry-based activity. Plants and insects, which make up the majority of invasive species in terrestrial environments (Lowe et al., 2000), are easily located, observed, and collected by students. Students who observe invasive species in the field can also contribute data to the Early Detection & Distribution Mapping System (see Appendix). If planned carefully, it might even be possible to have students participate in control of the invasive species in their area.

Second, restricting the taxonomic groups used can improve exposure to biodiversity and the ecosystem services affected in various habitats. For instance, this is a good way to force students out of their biodiversity "comfort zones" of vertebrates and arthropods. Students can be assigned aquatic species, only plants, or only microbes.

Third, context and global perspective can be broadened by adding the ability to select invasive species from other regions. Ideally, students will come to realize that control methods and efficacy may differ, depending on the infrastructure and environment in different regions.

Fourth, students in an upper-level course can use information from resources such as the Gund Institute for Ecological Economics (found at http://www.uvm.edu/giee/) to estimate the cost of the invader and the value of its control.

Table 1. Summary of responses by students surveyed after completing "Invented Invaders" in summer 2014. This student population comprised 35 students in the second course of a two-semester introductory biology sequence for science majors at a teaching-focused university.

Prompt 1: What is the most important piece of content you learned from this activity?
• That invasive species are a large problem in any ecosystem
• Ways invasive species can colonize an ecosystem
• The names and characteristics of invasive species in our local ecosystems [Many were surprised how many species there actually are in our state, or that specific species like pigs were invasive]
• Ways to control those species
Prompt 2: What is one important skill you learned while completing this activity?
• Critical thinking
• Research using appropriate sources
• Identify characteristics of an invasive species
• Problem-solving, such as developing effective but safe control methods
• Name species based on characteristics, and write the scientific name the right way
• Place species into correct taxonomic groups (classify) based on characteristics

Finally, students can "reverse" the entire project to invent the perfect biological control agent or the perfect native species that provides the most ecosystem services.

○ Conclusions

Experience using this activity for six semesters (as of summer 2014) has shown this to be an engaging and effective way to learn about invasive species and ways to control them (Table 1). Students have exhibited remarkable creativity and talent while gaining knowledge in important ecological concepts. Invasive species are a major global concern, and using Invented Invaders to discover what characteristics are shared by invasive species can help students understand methods to lessen their negative impacts on the local and global environments.

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Appendix. A partial list of online resources that provide lists of invasive species. Most of these resources have web pages for specific states or geographic regions. Note that several resources are specific to plants.

- Defenders of Wildlife (http://www.defenders.org) publications list the worst invasive species in most states.
- USDA National Invasive Species Information Center (http://www.invasivespeciesinfo.gov/index.shtml) – browse by geography or by subject.
- USDA PLANTS database (http://plants.usda.gov/java/noxiousDriver) – state and federal lists of introduced, invasive, and noxious weeds.
- Early Detection & Distribution Mapping System (http://www.eddmaps.org/distribution/) – provides distribution maps of several invasive plants. Includes Canadian provinces and several U.S. regional networks:
  - EDDMapS West (http://www.eddmaps.org/west/) – CO, ID, KS, MO, MT, NE, NV, ND, OR, SD, UT, WA, WY; includes a smartphone app
  - Mid Atlantic Early Detection Network (http://www.eddmaps.org/midatlantic/report/plants.cfm?id=US_DE) – DE, DC, MD, NY, PA, VA, WV
  - Invasive Plant Atlas of the MidSouth (http://www.gri.msstate.edu/research/ipams/about.php) – AR, LA, AL, MS, TN
  - Invasive Plant Atlas of New England (http://www.eddmaps.org/ipane/ipanespecies/fednox.htm) – CT, ME, MA, NH, RI, VT
  - Southeast Early Detection Network (http://www.eddmaps.org/southeast/index.html) – AL, FL, GA, KY, LA, MS, NC, SC, TN; includes a smartphone app
- Most states' DNR websites have lists of invasive species.
- Several states (e.g., AS, DE, GA, HI, NJ, NY, ND, WA) have their own invasive species taskforce website that can be found with a web search.
- Several universities, especially land grant universities, have state invasive species websites.
- Wikipedia's page for Invasive Species in the United States (http://en.wikipedia.org/wiki/Invasive_species_in_the_United_States#Invasive_species_by_area) has a limited list of invasive species.