

Surveys and Needs Assessments

Engaging Florida's Youth to Increase Their Knowledge of Invasive Species and Plant Biosecurity

Morgan G. Pinkerton,¹ Sage M. Thompson, Nicole A. Casuso, Amanda C. Hodges, and Norman C. Leppla

Department of Entomology and Nematology, University of Florida, 1881 Natural Area Drive, Gainesville, FL 32611 and

¹Corresponding author, e-mail: morgan0402@ufl.edu

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Abstract

Invasive species are causing problems globally due to substantial economic losses, decreased biodiversity, human health hazards, and disruption of native ecosystems. Concerning agriculture, it is estimated that the United States loses nearly \$120 billion annually to the impacts of invasive pests. Florida is at high risk for the introduction and establishment of invasive species due to its multiple climate zones and geographic location. Yet, the general public, and especially youth in Florida, do not understand the need for the early detection and eradication of invasive species, since these concepts are not typically integrated into classroom curricula. An informed public audience begins by providing improved educational opportunities to youth. Over the 2-yr project, interactive outreach presentations were delivered to 30 classrooms in 10 schools throughout Florida to raise awareness of invasive species and the necessity of plant biosecurity. Prior knowledge of students and project effectiveness were evaluated using pre- and post-surveys based on classroom presentations. The outreach events significantly increased students' understanding of invasive species and the importance of plant biosecurity.

Key words: youth outreach, invasive plant pest, extension

Strategic plant biosecurity policies and procedures have been developed and implemented to prevent the introduction of non-native invasive species that can be harmful to plants grown for human food and animal feed, maintained in established landscapes, and existing in the natural environment (Hodges and Stocks 2011). A non-native species is considered invasive if its establishment or spread is injurious to plants, animals or humans, or it is shown to be potentially injurious by risk analysis (FAO, IPPC 2016). A species may be introduced into a new environment intentionally, such as the introduction of a commercial ornamental plant, or unintentionally as an insect hitchhiker arriving on an agricultural commodity (Winberry and Jones 1973, Sargent et al. 2011). Invasive species have become a global problem due to an increase in the potential pathways for introduction resulting from people and products, especially agricultural commodities, moving around the world at an accelerating rate (Meyerson and Mooney 2007). It is estimated that invasive species cause losses of over \$120 billion annually in the United States (Pimentel et al. 2005). Florida is a particularly high-risk state for the introduction of invasive species because of its temperate, subtropical

and tropical habitats, and diversity of high-value agricultural commodities, including citrus, other fruit, vegetables, ornamental plants, and field crops (FDACS 2016). Florida has eight main destination airports and 11 commercial seaports that receive passengers and commodities that often continue to move throughout of the United States (Szyniszewska 2013). It also has many tourist attractions that bring millions of people to the state each year.

In recent years, many problematic invasive species of arthropods and pathogens have impacted Florida. For example, the Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann) (Diptera: Tephritidae), was detected multiple times during the last century and required costly eradication in addition to continued monitoring throughout the state (Steck 2002). Another example of a successful detection and eradication occurred with *Oxycarenus hyalinipennis* (Costa) (Hemiptera: Oxycarenidae), which was detected in the Florida Keys in 2010 and promptly eliminated (Sharma 2014). Similarly, the giant African snail, *Lissachatina fulica* (Bowdich) (Stylommatophora: Achatinidae), was detected in 2011 and is currently being eradicated with public assistance in Miami-Dade County

(FDACS 2018a). Once widely distributed, however, it is not possible to eradicate all invasive species that have established in Florida, such as spotted-wing drosophila, *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae) (Iglesias et al. 2009); *Aulacaspis yasumatsui* Takagi (Hemiptera: Diaspididae) (Mannion et al. 2006); redbay ambrosia beetle, *Xyleborus glabratus* Eichhoff (Coleoptera: Curculionidae) (FDACS 2018b); *Candidatus* Phytoplasma palmarum (Acholeplasmatales: Incertae sedis) (Elliott 2009); Huanglongbing (Greening), *Candidatus* Liberibacter asiaticus Jagoueix et al. (Rhizobiales: Phyllobacteriaceae) (Hodges and Spreen 2015); and *Myllocerus undecimpustulatus undatus* Marshall (Coleoptera: Curculionidae) (Thomas 2005). In an attempt at early detection, surveillance is being conducted for some other pests of concern but not yet established in Florida, such as the Old World bollworm, *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae); *Bagrada hilaris* (Burmeister) (Hemiptera: Pentatomidae); Asian longhorned beetle, *Anoplophora glabripennis* (Motschulsky) (Coleoptera: Cerambycidae); light brown apple moth, *Ephiphys postvittana* (Walker) (Lepidoptera: Tortricidae); *Phytophthora ramorum* Werres, de Cock & Man in't Veld (Peronosporales: Peronosporaceae); and Oriental fruit fly, *Bactrocera dorsalis* Hendel (Diptera: Tephritidae).

The general public, particularly youth, remain largely uninformed about plant biosecurity and invasive species. This lack of knowledge must be addressed because invasive species will continue to cause substantial economic losses, decrease biodiversity, introduce human and animal health hazards, and disrupt natural ecosystems (Hodges and Stocks 2010). To inform the public about these risks, a youth outreach project was developed to deliver information on plant biosecurity and invasive species to middle and high school students throughout Florida. The students received instruction on how to define and identify plant pests; distinguish between native, non-native and invasive pests; and the importance of early detection and rapid eradication of invasive species. This knowledge is crucial for volunteer-based networks to succeed in preventing the establishment of additional invasive species in Florida, as they have in the past (Pimentel et al. 2005, Bois et al. 2011, Burrack et al. 2012, Andow et al. 2016, Stubbs et al. 2017).

Expected Outcomes

Purpose

The purpose of the outreach events was to raise awareness in Florida's youth of risks posed by invasive species, deliver the concepts of plant biosecurity, and promote early detection of non-native species.

Objectives

1. Evaluate current knowledge of Florida's youth about invasive species and plant biosecurity.
2. Measure the effectiveness of the outreach events targeting a youth audience.

Methods

Audience

The target audience was 11- to 18-yr-old middle and high school students throughout Florida. Schools were selected based on the presence of biology, agriculture, or natural science classes, and if interested, teachers were contacted via e-mail to schedule outreach events. Thirteen classes were selected in the 2016–2017 school year at five different high schools in Alachua, Marion, and Palm Beach

counties. In the 2017–2018 school year, 25 classes were selected at an additional five high schools in Alachua, Brevard, Orange, and Palm Beach counties. Thus, over 2 yr, 730 students were surveyed on their knowledge of two topics with 359 participants in the 'Plant Biosecurity-Local and Global Perspectives' topic and 371 participants in the 'Invasive Species that Affect Plants' topic. Surveys with missing answers were discarded from the analysis. Classes usually had 15–25 students, but several larger auditorium-style events combined multiple classes to include 50–60 students.

Outreach Events

Each outreach event consisted of a 40-min presentation on one of the two topics selected by the teacher, 10 min of hands-on activity, and an additional 5–10 min for answering student questions. Teachers selected one of two topics to be presented to their students: 'Plant Biosecurity-Local and Global Perspectives' (Hodges and Stocks 2011) or 'Invasive Species that Affect Plants' (Hodges and Stocks 2010). The incorporated educational PowerPoint presentations were modified for the target audience from existing Protect U.S. scripted lectures (www.protectingusnow.org). Presentations were based on survey results of a preliminary study completed in 2016 at two high schools with a total of 161 students. The presentations were modified to adequately explain the core concepts tested in the survey. Each presentation was co-delivered by two Doctor of Plant Medicine (www.dpm.ifas.ufl.edu) students, one being a coordinator that was different for each academic year. To ensure consistency between outreach events, presenters were trained prior to delivering a presentation by first attending one of the presentations, and then delivering both presentations for evaluation by a faculty member. Presentations were designed to be as interactive and engaging as possible, with periodic critical thinking questions. For example, questions such as 'How do you think invasive species could affect what you eat?' or 'What are some of the reasons you can think of that caused the price of rice to increase in 2008?' were used to engage students throughout the presentations.

Hands-on activities in the classrooms involved live agricultural insect pests, preserved insect displays, and pest-infested plants. Live insects were provided by the Biosecurity Research and Extension Laboratory colonies reared for both outreach and research. Preserved insect displays contained curated insects from throughout Florida, including agricultural and ecological pests, non-native and invasive species, and beneficial or common insects. The students were provided with greenhouse-raised plants naturally infested with aphids (Hemiptera: Aphididae), whiteflies (Hemiptera: Aleyrodidae), and thrips (Thysanoptera). Dissecting microscopes were brought to every classroom so that students could study the organisms in detail. Insects rather than plant pathogens were provided because they are larger and easier to view. Each student was also given a magnifying hand lens, a pen, and a notepad to record observations throughout the outreach event.

At the end of the 'Invasive Species that Affect Plants' presentation, students received instruction on the term invasive species, and the issues and risks associated with establishment of non-native species. The presentation described a variety of invasive species including plant pests and pathogens, and plants. Several examples of invasive species that have established in the United States were covered, such as the invasive plant, Kudzu, *Pueraria lobata* (Lour.) (Fabales: Fabaceae); Huanglongbing (Greening), *Ca. L. asiaticus*, a bacterial plant pathogen and its vector the Asian citrus psyllid, *Diaphania citri* Kuwayama (Hemiptera: Psyllidae); and soybean rust, *Phakopsora pachyrhizi* Syd (Uredinales: Phakopsoraceae)

(Hodges and Stocks 2010). This topic also included prominent case studies on current pests of concern to Florida including *B. hiliaris*; the brown marmorated stink bug, *Halymorpha halys* (Stål) (Hemiptera: Pentatomidae); Laurel wilt, *Raffaella lauricola* (Harrington, Fraedrich & Aghayeva) (Ophiostomatales: Ophiostomataceae) and its vector the redbay ambrosia beetle, *X. glabratus*; and the emerald ash borer, *Agilus planipennis* Fairmaire (Coleoptera: Buprestidae). Lastly, using messages from programs underway at agencies like the United States Department of Agriculture (USDA) and the United States Department of Homeland Security-Customs and Border Protection (USDHS-CBP), it was reinforced that everyone, including the public, is responsible for protecting plants from invasive species.

In the 'Plant Biosecurity-Local and Global Perspectives' presentation, the terms biosecurity, bioterrorism, and agroterrorism were covered. By the end of the presentation, students should have been able to broadly define these terms. Plant biosecurity was described as protecting plant health, the food supply, and the overall environment using an integrated and strategic approach (Hodges and Stocks 2011). Students gained an understanding of how plant biosecurity affects their lives, the consequences of globalization, and how this raises concerns about food security globally. This presentation also included information on bioterrorism, the use of a living organism as a weapon. Agroterrorism was more specifically defined as the release of a pest or pathogen with the intention of disrupting or destroying the food supply. For example, anthrax, *Bacillus anthracis* Cohn (Bacillales: Bacillaceae), was used by Germany as a weapon of agroterrorism during World War II to kill livestock of the Allied forces (Croddey 2005). Another historic example of agroterrorism was release of the Colorado potato beetle, *Leptinotarsa decemlineata* (Say) (Coleoptera: Chrysomelidae) in World War II by Germany in an attempt to target the food supply of their enemies (Garrett 1996). The USDA Select Agents and Toxins List includes biological agents and toxins that could pose a severe threat to human and animal health, plant health, or to animal and plant products (FSAP 2018). Brief case studies of several current select agents were provided, including bacterial wilt, *Ralstonia solanacearum* (Smith) (Burkholderiales: Burkholderiaceae) race 3, biovar 2, and *Rathayibacter toxicus* (Riley and Ophel 1992) (Actinomycetales: Microbacteriaceae). Also included was the previous select agent and toxin, Huanglongbing (Greening), *Ca. L. asiaticus*, which was removed from the list after establishing in Florida and causing severe economic losses to citrus. Huanglongbing serves as an example to reinforce how invasive species can greatly impact agriculture (Hummel and Ferrin 2011).

Surveys

Students under the age of 18 were required to return a signed document from a parent or legal guardian giving consent for the student to be surveyed. After the consent forms were collected at the beginning of a class, each student received a packet containing a pre- and post-survey. The pre-survey was completed and collected before the presentation, and the post-survey was taken at the end of the class. Surveys were designed similarly with seven questions for both presentation topics (Figs. 1 and 2). Question 1 asked each student to rate their level of understanding of the topic as none, minimal, general, or extensive. Based on preliminary studies in 2016, questions 2–7 were modified to ensure that the students could understand the questions and answers. The questions were based directly on presentation content and had correct answers. Answers given by the students were used to evaluate their knowledge of the topic before and after the outreach event. The surveys were numbered and given

a specific class code, and each student had a survey identification number so that pre- and post-surveys could be paired for analysis. Survey results were analyzed using R 3.5.0 (R Core Team 2013) with question 1 being evaluated separately from questions 2–7. All surveying was approved by the University of Florida, Institutional Review Board (Protocol ID: IRB201602341).

Results and Discussion

Student's Comfort Level

For the 'Invasive Species that Affect Plants' topic (question 1), students ($n = 371$) were asked to rate their level of comfort in their ability to define the term 'invasive species' as none, minimum, moderate or complete understanding of the definition. Before the presentation, only 7.0% of students had a complete understanding of invasive species, 43.1% had a moderate understanding, 32.9% had a minimal understanding, and 17.0% had no understanding. Based on this pre-evaluation, over half of students in the surveyed classes had minimal or no understanding of invasive species despite the importance of this topic to the public. Following the presentation, complete understanding increased to 32.6% and the percentage of students with a moderate understanding increased to 55.8%. Furthermore, the students with a minimal understanding decreased to 9.2% and no understanding of the concept of invasive species dropped to 2.4%. Based on a paired t -test comparing the overall pre- and post-survey results for question 1, the results indicated that the outreach event significantly increased understanding of the topic of invasive species so that most students felt moderate to completely comfortable with the subject (P value $2.2e-16$).

For the 'Plant Biosecurity-Local and Global Perspectives' presentation (question 1), students ($n = 359$) described their comfort in understanding the terms 'biosecurity' and 'agroterrorism'. The comfort level was described as knowing neither terms, only one term, having a basic understanding of the two terms, or a strong understanding of both terms. In the pre-survey, only 0.8% stated that they had a strong understanding of both terms, 20.3% of students had a vague understanding, 24.5% claimed to only understand one of the two terms without specifying which term they understood, and another 54.3% of students indicated that they did not understand both terms. Thus, more than three-quarters of students did not understand the terms 'biosecurity' nor 'agroterrorism' or only understood one of the terms before the outreach event. After the presentation, 2.8% still did not understand both terms, 7.8% understood one term, 49.3% understood both terms at a basic level and 40.1% understood both terms completely. Analysis of question 1 results with a paired t -test indicated that students significantly increased their believed understanding of the two terms following the presentation (P value $2.2e-16$). Increased comfort in these topics is a first step toward involving students in volunteer-based networks for invasive species and plant biosecurity, and encouraging their interest in related fields in the future.

Student's Knowledge Level

Based on the information delivered, the student's knowledge level was tested with multiple-choice questions (questions 2–7) on the pretests and posttests. Results were paired to measure improvement of individual students before and after the presentations. Students were grouped by class and results represented the percentage of students that improved their scores (Figs. 3 and 4).

For all 16 classes that received the 'Invasive Species that Affect Plants' presentation, the performance of most students improved

Presentation Topic: Overview – Invasive Species that Affect Plants

1. Rate your level of comfort with providing a response to the following statement: “Define an invasive species.”
 - a. Wait, what is an invasive species?
 - b. I am only slightly comfortable, but want to know more.
 - c. I can jot down a few good bullet points.
 - d. Very confident. I could write an essay on invasive species!
2. Kudzu vine was first introduced to the United States at the Philadelphia Centennial Exposition of 1876 as
 - a. An ornamental plant
 - b. Soil erosion control
 - c. Forage for cattle
 - d. Clothing fiber
3. Which 4 states are responsible for the majority of commercial citrus production citrus in the United States?
 - a. Florida, California, Georgia, and South Carolina
 - b. Florida, Georgia, Louisiana, and Texas
 - c. Florida, California, Texas, and Arizona
 - d. Florida, California, Virginia, and New Mexico
4. Huanglongbing (HLB) also known as Citrus Greening is a devastating bacterial disease vectored by the Asian Citrus Psyllid affecting citrus in the United States. What are some symptoms of this disease in the fruit?
 - a. Soft sunken spots, extra sweet pulp
 - b. Lopsided fruit, green rind, bitter taste
 - c. Yellow and black cankers on the rind
 - d. None of the above
5. Invasive species only threaten agricultural commodities. They are not problematic in landscapes or natural areas.
 - a. True
 - b. False
6. The U.S. Department of Agriculture (USDA) has a special agency and branch dedicated to protecting our agriculture and natural resources called “APHIS-PPQ”. What does this acronym stand for?
 - a. Animal and Plant Health Investigation Service, Plant Production and Quality
 - b. Animal and Plant Health Interrogation Services, Plant Protection and Quarantine
 - c. Animal and Plant Health Inspection Service, Plant Protection and Quarantine
 - d. Animal and Plant Health Inspector Station, Plant Protection and Quality
7. Who is responsible for protecting our agriculture and natural areas from invasive species?
 - a. Regulatory Agencies and Private Industry Companies
 - b. University researchers, extension agents, and conservationists
 - c. Homeowners and the general public
 - d. All of the above

Fig. 1. Survey questions for the ‘Invasive Species that Affect Plants’ topic.

(over 50%) with only three classes showing improvement in less than 75% of students. The greatest improvement was in classes 1 and 2 where 100% of students improved their scores. A paired *t*-test indicated a significant change (P value $2.2e-16$) in student scores following the presentation with an average increase of 1.95 questions answered correctly. Based on these findings, the program is highly effective in teaching students about invasive species.

Responses of students in classes that received the ‘Plant Biosecurity-Local and Global Perspectives’ presentation were more variable than for the first topic. At least 50% of students in 18 out of 22 classes showed improvement although this percentage was higher in several classes (Fig. 4). For this topic, the greatest improvement

was in class 22 where 90.6% of students improved their scores. Students increased their scores in the posttest by an average of 1.05 questions answered correctly. A paired *t*-test indicated that students improved their scores significantly after receiving this presentation (P value $2.2e-16$).

Overall, the students were more comfortable in their understanding of invasive species than plant biosecurity. The level of comfort in the topics was translated to learning and understanding of the material as indicated by the improvement of scores in the post-survey for both topics. However, the instructors were more interested in plant biosecurity, because this topic generated more discussion by the students due to its novelty in the classroom.

Presentation Topic: Plant Biosecurity – Local and Global Perspectives

1. Rate your level of comfort with understanding the terms “biosecurity” and “agroterrorism”.
 - a. I have not heard of either term before.
 - b. I know one of these terms but not the other.
 - c. I have a vague understanding of both terms.
 - d. I can easily provide descriptions and examples related to these terms.
2. How are invasive species introduced to the United States?
 - a. International commercial trade
 - b. Traveler baggage
 - c. Private citizens
 - d. a and c
 - e. All of the above
3. The United States Department of Agriculture (USDA) works very closely with the U.S. FDA to help keep our food safe for consumption. What does the acronym “FDA” stand for?
 - a. Food and Drug Association
 - b. Food Delivery Administration
 - c. Food and Drug Administration
 - d. Food and Drink Association
4. Anthrax is a fatal disease in livestock (and humans) because symptoms are seen too late for treatment. What type of organism causes this disease?
 - a. Bacteria
 - b. Fungus
 - c. Virus
 - d. Insect
5. In 2002, what act required the USDA “to establish and regulate a list of biological agents that have the potential to pose a severe threat to animal health and safety, plant health and safety, or to the safety of animal or plant products (Select Agents and Toxins List)”?
 - a. The Food Quality Protection Act
 - b. The Agricultural Bioterrorism Protection Act
 - c. The Protection Against Biological Threats Act
 - d. The Federal Insecticide, Fungicide, and Rodenticide Act
6. Citrus Greening, *Candidatus Liberibacter asiaticus*, is no longer listed as a Select Agent in the U.S.
 - a. True
 - b. False
7. Ricin is a poison that can be derived from the waste material left over from processing which plant?
 - a. Coffee beans
 - b. Canola
 - c. Quinoa
 - d. Castor beans

Fig. 2. Survey questions for the ‘Plant Biosecurity-Local and Global Perspectives’ topic.

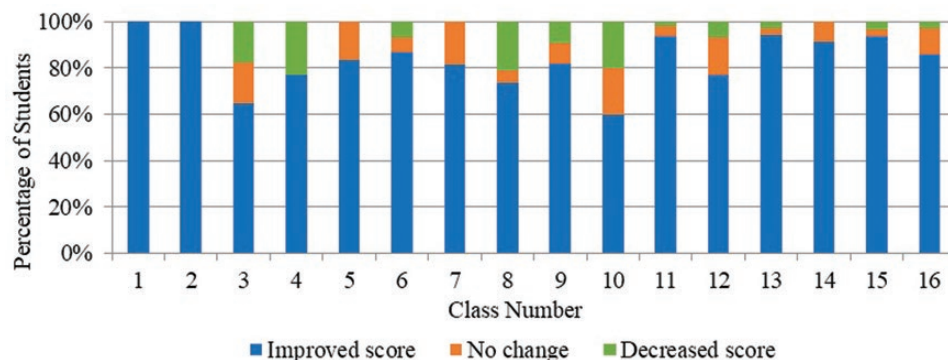


Fig. 3. Mean percentage of students in each class that received instruction on ‘Invasive Species That Affect Plants’ that improved, did not change, or decreased their score from the pretest to the posttest for the concept questions 2–7.

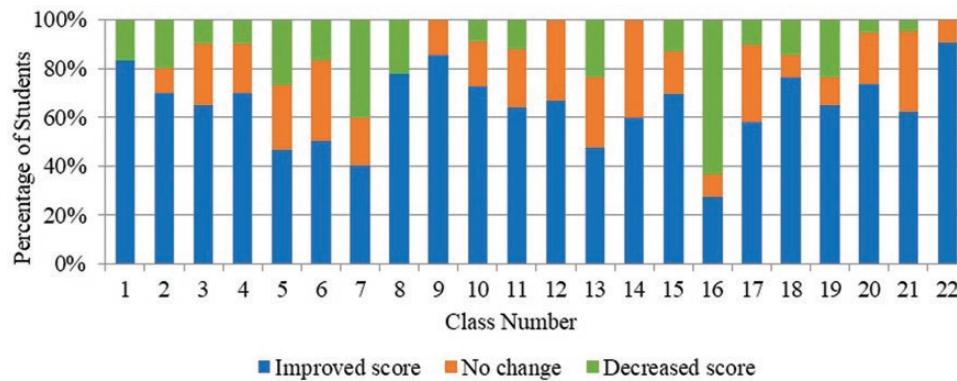


Fig. 4. Mean percentage of students in each class that received instruction on 'Plant Biosecurity-Local and Global Perspectives' that improved, did not change, or decreased their score from the pretest to the posttest for the concept questions 2–7.

Conclusion

Based on survey results, the base level of knowledge about invasive species and plant biosecurity is low for most students. The outreach presentations and associated hands-on activities significantly increased the level of knowledge about invasive species and plant biosecurity for the majority of the students. Students understood most of the basic concepts in the presentations on 'Plant Biosecurity-Local and Global Perspectives' and 'Invasive Species that Affect Plants' by the end of outreach events. Although these concepts are universal, the outreach events could be adapted to a variety of classroom settings and incorporate plant pests and pathogens of local concern. The students and general public must be informed about these topics to decrease the impacts of invasive species on agriculture, communities and the environment.

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