

# Urban Ecology: Redesign on the Fly

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The Biology department at Boston University designs and implements inquiry-based laboratory experiments for outreach programs in order to bring science to High School students at a level that they can enjoy and learn from the experience. The Urban Ecology module exposed visiting students to ecological theory in a classroom and experiments at a nearby field site. Here we present the strategies and ideas utilized to successfully and efficiently update a field ecology module while integrating flexibility regarding the unpredictability of a field site. In addition, we present ideas and guidelines for others undergoing redesigns of current labs.

**Keywords:** human impacts, field study, ecosystem

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## Introduction

Biology Inquiry and Outreach with Boston University Graduate Students (BIOBUGS) is an outreach program to encourage local high school (HS) students to become excited about science. This is accomplished by implementing the following three objectives: 1) exposing them to sophisticated scientific equipment, 2) providing interaction with graduate students who utilize that equipment in their research, and 3) introducing them to a university campus and laboratory environments. Participation in this program also benefits Boston University's (BU) graduate students by providing opportunities to develop pedagogical techniques critical to their success as graduate students and as future science, technology, engineering, and mathematics (STEM) faculty members.

In addition to the aforementioned objectives shared by all BIOBUGS modules, the Urban Ecology module is designed to foster interest in field ecology by exploring the urban environment and human impacts on the ecosystem, which aligns with Massachusetts Department of Education STEM Curriculum Frameworks for Biology, specifically 6.1 (explain how biotic and abiotic factors cycle in an ecosystem (water, carbon, oxygen, and nitrogen)) and 6.4 (analyze changes in an ecosystem resulting from natural causes, changes in climate, human activity, or introduction of non-native species) in the ecology broad concept. In addition, HS teachers can benefit from bringing their students by elaborating on the concepts from the BIOBUGS module in their own classrooms, form contacts with BU students, faculty, and staff to discuss their students' future post-secondary education, and

potentially inspire them to modify their own pedagogical techniques.

Another significant benefit of the BIOBUGS program is that it helps train BU biology graduate students to be more effective teaching assistants (TAs). Boston University has recently joined the Center for the Integration of Research, Teaching and Learning (CIRTL) network, whose mission is to enhance STEM undergraduate education by implementing advanced effective teaching practices. The BIOBUGS program is part of the "teaching-as-research" pillar of the CIRTL network. Currently, biology graduate students at BU receive TA training in the following sequence: 1) attendance at the College of Arts and Sciences Graduate Student Orientation and 2) enrollment in a 2-credit course, A Bridge to Knowledge, taken during the first semester of teaching (Spilios et al, 2012).

Graduate students at BU have the potential to be assigned to any biology laboratory or discussion course. Graduate TAs face many challenges (e.g. unknown subject matter, unclear expectations from faculty, difficult students, etc.) and are not necessarily given the tools to overcome these challenges. Teaching and volunteering with a BIOBUGS module provides additional teaching skills to the graduate students via experiential learning in three ways. First, graduate students are in a classroom with a demographically unfamiliar and diverse audience, which forces them to explore new teaching techniques and introspectively assess previously used methods. Sec-

ond, graduate students are asked to present material that is novel or unfamiliar as the topics are outside of their research or coursework backgrounds. Third, since many of our graduate students teach or volunteer in successive BIOBUGS semesters, participation affords them the opportunity to refine their methods in a lower risk, lower pressure environment relative to their roles as TAs. By gaining experience teaching novel material to diverse populations, graduate students are forced to reassess pedagogical methods that need improvement and actively pursue development in those areas.

For each day of the module, there are one or two BU teachers whose responsibilities include background lecture, time management, and supervising the BU volunteers. There are four or five BU volunteers who are directly in charge of up to six HS students each. The BU volunteers are responsible for ensuring the HS students complete the activities properly and answer any questions that come up. For additional information, please visit the BIOBUGS' website at <http://www.bu.edu/lnet/biobugs/>.

An ecology module previously existed within the BIOBUGS repertoire; however, there were several logistical issues that made it difficult to implement. A task force of eight biology graduate students and staff with various research backgrounds, teaching and BIOBUGS experience was assembled to identify the major needs of a redesigned ecology module. The "four needs" were: 1) a clearly defined purpose; 2) an indoor contingency; 3) less reliance on the BU teacher and more responsibilities for the BU volunteers; and 4) the use of BU graduate student expertise and equipment that the HS teachers and students do not have access to in their own classrooms. The task force was given a three-month period in which to create curricula and put in place the necessary infrastructure to complete the module. Here we briefly describe the resulting module, explain effective design strategies utilized by the design team, and relate these findings to development or redesign of other ecology modules.

## Notes for the Instructor

### Initial Redesign Phase

Boston University is located close to a portion of the "Emerald Necklace", a park system designed by Frederick Law Olmstead that encircles the city of Boston. The portion of the park that exists near BU is known as the Fens. The Fens is a relatively narrow park surrounding the Muddy River, a river created by the damming of the Charles River. The park is maintained by the City of Boston and presents an ideal image of an urban ecosystem. Because of the convenience and field site potential of the park to host a visiting group of students, the design team chose to design activities around features found within the park.

The design team decided to create three activities that highlighted human impacts on the urban ecosystem: 1) a scavenger hunt in which teams of HS students would com-

pete to complete a number of tasks in an allotted time, 2) a water station where students would test water quality and collect samples of water and sediment to look at under microscopes in the classroom, and 3) a trash activity where students would collect trash throughout the day in the field and examine the garbage they collected and calculate how long it would take to break down. In order to address the four needs before the deadline, the task force was divided into three teams, one team each for the "Scavenger Hunt", "Urban Water", and "Tough Stuff Here to Stay" activities.

All teams were told the module needed to focus on human impacts in an urban ecosystem with each activity and discussion relating back to that topic. In addition, all BIOBUGS modules have a tight schedule due to limited time with the HS students and the desire to present as many topics as possible. Two specific objectives were discussed and methods to accomplish those objectives were designed. First, the teams should create a competition among the HS students so that they will feel motivated to complete each task correctly and efficiently. In all activities, a point system for successful completion of tasks was created. Second, BU volunteers are relatively inexperienced TAs and/or lack experience with HS students and needed help to guide the HS students to accomplish these tasks.

To help guide the BU volunteers, personalized cards were created for each activity that included a purpose for the activity, procedures, guiding questions and answers to ask HS students, and an answer key for any quantitative data to that needed to be collected. This maintains a structured 1:6 BU volunteer to HS student ratio throughout the three hours of the module and increases the inquiry-based design of all activities. Finally, each component needed to have the ability to move indoors without losing the message or expertise, nor confuse the BU volunteers by forcing them to potentially prepare for two separate modules.

### Activity Design Phase

In order to prepare for the module, several group and individual trips to the Fens were made and species seen were documented such that customized ID cards could be created and bound together to be a field guide specifically for the Fens. This circumvented the issue of bulky and hard to navigate field guides. In addition, the BU biology department has an extensive collection of stuffed and preserved specimens representing entire ecosystems that is mostly underutilized by the department in BU's undergraduate courses. Many of the specimens representing local fauna were utilized in the matching game that was used to train students to identify common organisms prior to entering the field (see below). The HS students were broken up into groups of 3-6 students during the activities. Each group was assigned to a volunteer in the classroom section of the module. In order to ensure students were invested, each activity was created as a competition where individuals within the same team were plotted against one another or where teams were competing against each other.

*Mass Invaders Activity*

Mass Invaders is a game that introduces HS students to how invasive species impact native species. The activity consists of at least two rounds of a simple high-low card game that illustrates competition. The first round models competition with native species (i.e. no competitive advantage) and the second round models competition with one invasive species introduced (i.e. uneven competition).

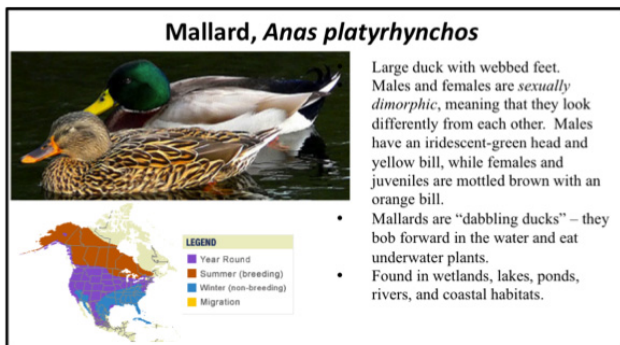
*Matching Game Activity*

The purpose of this activity is to have HS students practice using the customized field guides on bird (Figure 1) and mammal specimens from the biology museum’s collection that would be found at the Fens. During the Matching Game activity, which is utilized in both the indoor and outdoor versions, HS students practiced using their field guides to identify as many birds and mammals from the biology museum as possible that they would potentially see at the Fens.

*Scavenger Hunt Activity*

The purpose of this activity is to allow HS students to discover how humans impact the urban environment by assessing ecosystem health and identifying native and invasive plants and animals at the Fens. Tasks were created for the students to complete while in the field. These tasks were created such that no student could possibly finish them all before the time was up. This guaranteed that students remained active and motivated throughout the module.

The HS students entered the field with a field pack that included a field worksheet packet, a field guide that included a map of the field site (Figure 2) and species cards gloves, a garbage bag, a plastic ruler, and watertight plastic containers with screw top lids. The HS students had approximately 30 minutes (flexible depending on quality of weather and enthusiasm of the students) to complete as many of the 9 tasks as possible. In order to assist the students, BU volunteers were placed at 6 stations where they would ask the HS students questions pertaining to that particular task. At certain stations,



**Figure 1.** Example of a single page within the student field guide. Cards were created to exhibit species common to the specific field site.



**Figure 2.** Map of the Fens given to HS students within the field guide. Sites, tasks, and landmarks are included.

the HS students were asked to write down answers on their field worksheet packet. At stations with volunteers, the BU volunteer would ask the students a series of thought-provoking questions relating to that particular task. If the HS students answered sufficiently, the BU volunteer would sign off on their worksheet at that station and send them on to the next available station to continue the hunt.

In the field, the objectives of the tasks were as follows:

1. Write a general site description of three different sites, noting the types of plants and animals present, which includes identifying invasive species. The BU volunteer discusses the impacts of local invasives as a direct connection to the Mass Invaders activity.
2. Observe the remains of a cut tree in order to calculate the age, infer health of the tree, and predict historical environmental conditions in a discussion with a BU volunteer. The BU volunteer also monitors the HS students as they collect water for the “Urban Water” activity.
3. Identify multiple trees and assess the health of a tree using a customized dichotomous tree from the field guides after being trained at an example tree by a BU volunteer. On their own, HS students are tasked with drawing leaves and determining the leaf shape and venation pattern based on a customized plant fact guide included in the field guide.
4. Assess the impact of a rusted bridge and discuss with another BU volunteer about how construction impacts the ecosystem.
5. Listen for animal and man-made sounds and, with the help of the final BU volunteer, identify the source of those sounds. The BU volunteer also discusses the potential impacts of urban living on animal sounds.

Each task is worth a certain number of points allotted based on difficulty and time required (i.e. tree identification



is arduous and therefore worth the most points while the site description is worth far less per site). Also, in preparation for the last activity, during the time at the field site, HS students pick up loose garbage and identify the trash/recycling receptacles.

To replicate the field site for the indoor contingency, a second classroom was set up to recreate the Fens as closely as possible with prepared slideshows and samples that represented each task. Also, the “Urban Water” activity required storage of a water and sediment sample from the field site for HS student collection during the indoor contingency.

#### *“Urban Water” Activity*

The purpose of this activity is to allow HS students to discover how humans impact “Urban Water” systems. In the previous activity, HS students collected water samples as one of their tasks to identify microorganisms living in the Muddy River.

The “Urban Water” activity was a guaranteed opportunity to view and identify microorganisms, as well as satisfy HS teachers who wanted a microscope activity. In addition, the task force set up the Moticam as a microscope demonstration for the HS students to practice viewing and identifying a sample of live rotifers that was gathered from the marine group at Boston University. In the event of rain, the task force provided a stock of Muddy River water and sediment at the same task for the indoor version of the Scavenger Hunt activity. It was very important that students collected both water and sediment because many of the organisms seen hide in the sediment during the day. After this activity, HS students shared the data collected and made conclusions about the Fens, which has been impacted by humans.

#### *“Tough Stuff Here to Stay” Activity*

The purpose of this activity is to allow HS students to discover how much and what type of trash is left at the Fens. During the Scavenger Hunt activity, HS students collected trash, sorted, counted, and estimated relative degradation times. Then, through a discussion with the BU volunteers, HS students reflected on how they could personally minimize their impacts on the environment.

The “Tough Stuff Here to Stay” activity of the second version was an entirely new activity, which is important because it increases the module’s flexibility. Due to variability between BU teachers and volunteers, and HS classes, the time it takes to complete the preceding activities can differ significantly among the days in one semester. In order to ensure that the module ends at the same time each day, this activity was created with the intention of being able to extend or reduce the time spent. The background and protocol have numerous portions that can be expanded upon such as group discussions, sorting activities, and analysis. As written, this activity was meant to be flexible to fit within as short or long a window as needed without deviating from the activity’s purpose of educating students about the additive impacts of small-

scale litter. The shortened version eliminates background and emphasizes group discussions while the longer version adds background and both the sorting and time-to-degrade activities.

### **Effective Design Strategies**

Completing the module redesign in less than three months was extremely challenging but was successful because of a number of the practices that we utilized. These practices included:

#### *Clearly defined goals/targets for each activity*

A key for students to complete any task is for them to have understanding of the goal or point of each one. For that reason, we decided to identify the goal of each task prior to creating it. In addition, we ensured that these goals matched to our overall theme, lending to a common thread throughout the entire module.

#### *Finding proper field sites that illustrate the overall theme of the module and provide sufficient locations for unique tasks*

Without a field site that demonstrates the topic of the module, it would be impossible for students to understand the necessary concepts. The site we utilized had many examples of human impacts while still exhibiting a relatively large diversity of organisms to observe. If timing permits, it is good to have a second site available which shows many differences when compared to the original site. For example, when modifying this module for an 18-hour summer session, two additional sites were added that exemplified a “pristine” ecosystem and a heavily impacted ecosystem. A key concept of the urban ecosystem is that any campus is, in and of itself, an ecosystem. Any campus could potentially design an ecology module to fit its own unique environment, whether it is rural or urban.

#### *Hierarchical system of graduate student and staff designers, each with specific assignments*

Role designation is crucial for volunteers in this setting. Volunteers come from a range of backgrounds and may not be experts in the specific field that the laboratory covers. To create new activities quickly, we divided our task force into teams that were asked to work independently and design the necessary tasks. Each team reported directly to the task force leader. The design allowed the task force leader to focus on quality control and deadline management, while the teams were able to focus solely on one component of the module.

#### *Increased use of discussion groups led by BU volunteers*

Examining post-module HS student and HS teacher evaluations from previous modules, it became clear that the HS students wanted high levels of participation and hands-on activities. In order to facilitate this, we broke the class into small groups throughout the day and provided the volunteer

group leaders with questions and answers relating to relevant discussion topics. Small groups allowed the students to feel more comfortable with the graduate student volunteers and encouraged interaction and conversation by all students as opposed to the vocal few.

*Use of “Personal Cards” that provide volunteers with:*

- Individual duties for each task
- Stock questions and answers for BU volunteers to ask HS students
- Answers for each question on Student Worksheet to be answered at that volunteer’s assigned task

8x10” cards were created and laminated for use by volunteers with each activity and task. There were a total of four sheets handed to each volunteer. Generic cards were created for Mass Invaders, the matching game, and the urban water activity, and one for the scavenger hunt which reflected that volunteer’s role during the activity. The cards gave the volunteers the ability to hold thought provoking conversations with the students while ensuring that they stayed on topic and on task. Volunteers also told us after the fact that the cards gave them additional confidence when asking or answering questions.

*Design more tasks than could be completed by HS students in the time allotted for guided-inquiry activities*

An important reality of both ecology and education is that there is quite a bit of variation in the ability to obtain results. In order to ensure that all students remained active during the module, enough tasks had to be created such that, even in perfect conditions and with very capable students, the students could not complete every one. In addition, this helped prevent logjams of multiple groups at the same station at the same time.

*Creation of a viable indoor contingency that enabled students to experience the field site in the event of inclement weather*

Boston University runs this ecology module during the spring semester and weather is a major uncertainty. In order to ensure that every group of students received the same learning experiences, the module was carefully designed so that any task performed outside could be replicated very closely inside. For example, instead of watching and listening for bird sounds, a PowerPoint presentation was created where bird sounds were played and the students had to match those sounds to the correct bird. The indoor version was unavoidably different in some areas, which required us to create indoor versions of the volunteer cards. The content of the indoor cards were largely the same as the outdoor versions,

however, their procedural sections differed.

*Thorough run-throughs, with and without HS students, to discover and troubleshoot any inherent problems*

During the design process, each portion of the module was staged and run by the task force in order to ensure that the component flowed smoothly and in order to create accurate and detailed personal cards for volunteers. Each section was timed during the trial runs so that an accurate estimate of the module’s timing could be identified. Overall, each component of the module was tested no less than 2 times prior to being introduced to the teachers and volunteers.

*Proper training of BU teachers and volunteers*

In the week prior to the program, all teachers and volunteers were asked to attend a prep session in which the module was run through from start to finish allowing the graduate students to experience their roles and identify areas of concern. The task force ran the prep session and fielded any questions relating to procedures or content. The prep session focused on the outdoor version of the module, however, the indoor version was also covered. The prep session ensured that the volunteers and teachers were all on the same page and that everybody understood their role in the classroom on the day or days they were assigned. In addition, it was important to inform the teachers and volunteers that they needed to be flexible with each component as frequently, something would not go exactly to plan and the teacher or volunteers would have to adapt.

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## About the Authors

Nathan Rycroft is pursuing his Ph.D. in Marine Biology at Boston University. He has been involved in multiple avenues of outreach including the NSF GK-12 program, BIOBUGS, and hosting high school students in the laboratory of which he is a member. He has taught Introductory Biology, Animal Behavior, and Systems Physiology laboratories.

Angela Seliga earned her Ph.D. in biology from Boston University and is currently the Physiology Laboratory Coordinator at BU, where she teaches, trains staff to teach, and develops curriculum for multiple physiology laboratory courses. As a graduate student at BU, she participated in the NSF funded GK-12 program where she taught biology and chemistry to sophomores through seniors with special needs at Brighton High School. She designed or oversaw the design of several BIOBUGS modules and continues to participate in outreach programs such as Center for Talented Youth (CTY), the semi-annual NorthEast Undergraduate Research On Neuroscience (NEURON), and the Upward Bound Math Science (UBMS) program.

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