TIEE

Teaching Issues and Experiments in Ecology - Volume 12, March 2017

PRACTICE

The Anacostia River: A socio-environmental perspective

Caroline M. Solomon[1,3] and Khadijat Rashid[2]

[1]Department of Science, Technology and Mathematics, Gallaudet University 800 Florida Ave NE, Washington, DC 20002

[2]Department of Business, Gallaudet University, 800 Florida Ave NE, Washington, DC 20002

[3]Corresponding author: caroline.solomon@gallaudet.edu

ABSTRACT

In two 4-6 week modules (case studies) students explore the influences of urban practices on the ecosystem health of the Chesapeake Bay. A field trip to the Anacostia River helps introduce the case study. In a jigsaw design, students first act as expert groups or stakeholders and then are assigned into different mixed groups. During each step of the process, students utilize social and natural science datasets and discuss their sources, intent, and purpose to create synthetic products aimed at achieving actionable science.

KEYWORD DESCRIPTORS

- **Ecological Topic Keywords:** aquatic ecology, estuaries, ecological economics, environmental justice, eutrophication, nitrogen cycle, nutrient loading, watershed, sustainability, waste management
- **Science Methodological Skills Keywords:** collecting and presenting data, correlation versus causation, graphing data, quantitative and qualitative data analysis
- **Pedagogical Methods Keywords:** Assessment, concept mapping, formal groupwork, jigsaw, scoring rubrics, role playing, case study

CLASS TIME

The module utilizes four to six weeks (10 class sessions) of the course. Introduction to the topic leading up to the modules was six class sessions of which two were devoted to the concept of socio-environmental synthesis, two

TIEE, Volume 12 © 2017 – Caroline M. Solomon, Khadijat Rashid, and the Ecological Society of America. *Teaching Issues and Experiments in Ecology* (*TIEE*) is a project of the Committee on Diversity and Education of the Ecological Society of America (http://tiee.esa.org).

sessions served as an introduction to economic tools and concepts, and two sessions were an introduction to ecology.

OUTSIDE OF CLASS TIME

Students spent about 75 hours on classwork and related projects (including extra time spent on field trips).

STUDENT PRODUCTS

For each module students are expected to produce the following:

1. What do you need to know (WDYNTK) list
2. Pre-socio-ecological system map
3. Expert or stakeholder group presentations which is scaffolded with two mini-assignments:
    a. Large datasets
    b. Normative thinking
4. Synthesis group discussions
5. Synthesis product (actionable science)
6. Post-socio-ecological system map

SETTING

This module includes two field trips (one on the River and one to a sewage treatment plant), with the rest taking place in a standard classroom. Students will need access to on-line datasets during some of the class sessions, either via their own or provided computers.

COURSE CONTEXT

The modules are designed for a general studies or special topics course in socio-ecological synthesis for upper-classmen (juniors and seniors) including students with majors in both the social and natural sciences.

INSTITUTION

Private, small liberal arts university primarily offering undergraduate degrees.

TRANSFERABILITY

The modules were developed at Gallaudet University, the only bilingual liberal arts university for deaf and hard of hearing people in the United States. However, they are transferable to any setting in which class sizes are small and students

TIEE, Volume 12 © 2017 – Caroline M. Solomon, Khadijat Rashid, and the Ecological Society of America. *Teaching Issues and Experiments in Ecology* (*TIEE*) is a project of the Committee on Diversity and Education of the Ecological Society of America (http://tiee.esa.org).

have declared majors in either a science or a social science, business or humanities discipline and have already taken courses in their majors. Use of the modules in places that are distant from the Chesapeake Bay will need to substitute alternative sites for the field trips embedded in the modules, or provide virtual, on-line or text-based exposure to the sites and issues. These include sites with increasing population density in a six-state area that includes the political (Washington, DC) and economic (New York City) capitals of the United States as well as a sizeable fraction of its population.

ACKNOWLEDGEMENTS

This project was part of a multi-institutional study supported by the NSF Socio-Environmental Synthesis Center to assess the effectiveness of teaching socio-environmental synthesis (SES) using different pedagogical approaches in a variety of undergraduate institutional settings. I thank all of our colleagues from the participating institutions (Washington State University (Vancouver), University of Maryland College Park, Gallaudet University, Widener University) and Alan Berkowitz of the Cary Institute of Ecosystem Studies. This work benefited from support from the National Socio-Environmental Synthesis Center (SESYNC) - NSF award DBI-1052875.

SYNOPSIS OF THE MODULE

Principal Ecological Question Addressed

What is the best socio-environmental approach for alleviating the problem of combined sewage and runoff contamination of the Anacostia River in urban Washington, DC?

What Happens

After two assignments (a what do you need to know “WDYNTK” (brainstorm) list and pre-socio-environmental system map), students are introduced to how the DC government is trying to solve the combined sewage and runoff flow problem. They are assigned to different stakeholder groups (DC residents, Developers, Non-DC residents (e.g. tourists, workers who live outside the city), NGOs, and Government). Each group has to present their perspective based on data they collect via various big data websites and interpret using visual or graphical representations. After the stakeholder group presentations, students are divided into synthesis groups that have a member from each stakeholder group and they discuss possibilities for actionable science. Students are asked to write a white paper to the DC municipal government suggesting steps for actionable science, and then complete a post-system map.

TIEE, Volume 12 © 2017 – Caroline M. Solomon, Khadijat Rashid, and the Ecological Society of America. *Teaching Issues and Experiments in Ecology* (*TIEE*) is a project of the Committee on Diversity and Education of the Ecological Society of America (http://tiee.esa.org).

Module Objectives

- Identify concepts and norms from the natural and social sciences to address the effect of DC's combined sewage system on the ecosystem health of the Anacostia River
- Interpret and analyze field or real-time data from scientific and social science databases and use correct visualization tools
- Integrate concepts, tools, methods from both the natural and social sciences to analyze the effects of combined sewage systems
- Synthesize urban issues in understanding the Chesapeake Bay watershed
- Evaluate the ethics, norms, and actionability of policies for building new storage tunnels or implementing more green infrastructure

Equipment/ Logistics Required

Students need access to large datasets (via the web), and transportation to the Anacostia River.

Summary of What is Due

1. What do you need to know (WDYNTK) list
2. Pre-socio-ecological system map
3. Expert group presentation scaffolded with two mini-assignments:
    a. Large datasets
    b. Normative thinking
4. Synthesis group discussions
5. Synthesis product (actionable science)
6. Post-socio-ecological system map

DETAILED DESCRIPTION OF THE MODULE

Introduction

The Anacostia River has been plagued by excessive nutrient loading and pollution from an antiquated sewage system that combines storm water and sewage into one pipe (combined sewage outfalls) that often overflows into the Anacostia River.

TIEE, Volume 12 © 2017 – Caroline M. Solomon, Khadijat Rashid, and the Ecological Society of America. *Teaching Issues and Experiments in Ecology* (*TIEE*) is a project of the Committee on Diversity and Education of the Ecological Society of America (http://tiee.esa.org).

The Anacostia Watershed Society sued the DC Water Sewer Authority (DC WASA) in 1999 for violation of the Clean Water Act for having combined sewage and runoff flow into the Anacostia River. In a settlement in 2004, DC WASA agreed to build three underground storage tunnels over the next twenty years, which is called "gray" infrastructure. However, this mechanism is costly so other "green" approaches and mechanisms such as green roofs, rain gardens, stormwater control have been suggested to alleviate the problem. You will be evaluating and critiquing them (or a suggesting a new one), and deciding which method is the best. Before beginning the module, you will learn the foundation of economics through a series of lectures and reading Stephen Smith's *Environmental Economics: A very short introduction*. You will also, through a series of lectures and reading of several chapters from Norman and Spoolman's *Environmental Issues and Solutions: A modular approach,* be exposed to different elements of environmental science.

Over the next 4-6 weeks, you will be doing a "jigsaw" case study about the impact of anthropogenic activities in the Anacostia watershed, that includes not only Washington D.C., but both Montgomery and Prince George counties, on the ecosystem health of the Anacostia River. After reading about the issue (*Anacostia: The Death & Life of an American River* and two anthropological journal articles), you will do two assignments (a what do you need to know "WDYNTK" list and pre-system map), to learn how the DC government is trying to solve the combined sewage and runoff flow problem. You will join a stakeholder group to collect and synthesize data about the issue from that perspective. After presenting to the whole class, you will be assigned to a synthesis group that has a member from each stakeholder group and your group will discuss possibilities for actionable science. You will write a white paper to the government suggesting steps for actionable science, and then complete a post-socio-ecological system map.

Materials and Methods

The overview of instructions for each stage of the case study is as follows:

(1) Introducing the Case Study

You will first do the WDYNTK and pre- socio-ecological system map assignments to acquaint yourself with the system that you will be studying in this module. Please read the handouts and readings we provide, attend lectures, and prepare

for the field trip (by filling out forms for site visit and read information on when/where to meet).

(2) Stakeholder Group Work / mini-assignments / presentation
The instructors will assign each of you to a stakeholder group (DC residents, Developers, Non-DC residents, NGOs, and Government) and provide you with mini-assignments #1 and #2 to guide you through how to find data and analyze them for your stakeholder group presentations.

(3) Synthesis Group Work / final product
The instructors will select students from each stakeholder group into various synthesis groups to share your knowledge from your stakeholder group. You will be provided with instructions on the tasks for the group activity and guidelines for your final synthesis product and post- socio-ecological system maps.

Study Site: The Anacostia River (and its watershed) in Washington, D.C.

Overview of Activities and Assignments:

Day	Part of jigsaw	Assignment
1	Introduction ● Pre-assessment ● Creating socio-ecological system maps	● WDYNTK list; ● Pre-socio-ecological system map
2	Introduction ● Field trip	● Select chapters from *Anacostia: The Death & Life of an American River* ● *A river runs through us* ● Washington's "People without History ● *Washington Post* articles
3-4	Part 1 – Stakeholder Group Work	● Working with Large Datasets ● Normative Thinking
5-6	Part 1 – Stakeholder Group Work ● Group presentations	● Stakeholder Group presentations

TIEE, Volume 12 © 2017 – Caroline M. Solomon, Khadijat Rashid, and the Ecological Society of America. *Teaching Issues and Experiments in Ecology* (*TIEE*) is a project of the Committee on Diversity and Education of the Ecological Society of America (http://tiee.esa.org).

7-8	Part 2 – Synthesis Group Work ● Choose medium for final product ● Synthesize across expert group perspectives	
9	Part 2 – Synthesis Group Work ● Whole class sharing	● Synthesis Products ● Synthesis Product Presentations
10	Conclusion ● Revise socio-ecological system map	● Post- socio-ecological system map

Questions for Further Thought and Discussion:

1. Were you limited by the type of data and evidence you found? Did you question where the data originated or what point of view was presented to you? Did you find that some sources of data were more trustworthy or reliable than others?
2. Why is it important to synthesize data and evidence from different disciplines and sources to better understand and create actionable science for cleaning up the Anacostia River? What was the biggest challenge (or step) in synthesizing the data and evidence?
3. Based on the skills and knowledge you have learned in this case study, what do you think is the best method for addressing the core problem (actionable science) of the urban impact on the Anacostia River?

References

(1) Textbooks, books and journal articles to provide you with background information:

a) *Environmental Economics: A very short introduction*. Stephen Smith
b) *Environmental Issues and Solutions: A modular approach.* Norman Myers and Scott E. Spoolman
c) *Anacostia: The Death & Life of An American River*. John R. Wennersten
d) Williams, B. (2001). A river runs through us. *American Anthropologist*. 103:409-431.

TIEE, Volume 12 © 2017 – Caroline M. Solomon, Khadijat Rashid, and the Ecological Society of America. *Teaching Issues and Experiments in Ecology* (*TIEE*) is a project of the Committee on Diversity and Education of the Ecological Society of America (http://tiee.esa.org).

e) McFadden-Resper, S. & Williams, B (2005). Washington's "People without History". *Transforming Anthropology*. 13:3-14.
f) Halsey, A. (February 15, 2014) Meet Lady Bird, a massive machine digging out a solution to D.C. wastewater woes. *Washington Post*.
g) Fears, D. (December 2, 2012). D.C. debates best path to clearer waterways. *Washington Post*.
h) Wilgoren, D. (December 3, 2004). Deal set to stem sewage overflows. *Washington Post.*

(2) You are also encouraged to read a newspaper or websites such as the Wall Street Journal, New York Times, Washington Post or CNN daily.

(3) The following links with big data are provided for your reference. All of these websites provide you with raw data so it will be up to you to crunch the numbers to understand what it means:

Social Science data

a) **Bureau of Labor Statistics** (http://data.bls.gov/): The Bureau of Labor Statistics of the U.S. Department of Labor is the principal Federal agency responsible for measuring labor market activity, working conditions, and price changes in the economy. Its mission is to collect, analyze, and disseminate essential economic information to support public and private decision-making. It provides a snapshot of the income and prospects of the average American including at the state and local level.
b) **Bureau of Economic Analysis** (http://www.bea.gov/itable/index.cfm): The mission of the Bureau of Economic Analysis (BEA) is to promote a better understanding of the U.S. economy by providing the most timely, relevant, and accurate economic accounts data in an objective and cost-effective manner. It is a source for statistics on national income accounts including gross domestic product, personal income, consumer spending, and other measures of the state of the American economy. It also provides state and regional data.
c) **Census Bureau** (http://www.census.gov/data.html): This is a source of information about the number of Americans living, working and dying in a particular region. The Census Bureau provides comprehensive and up to date data on the demographic and economic profiles of Americans in each census tract at the local, regional and national level.

d) **Maryland Department of Business and Economic Development** (http://commerce.maryland.gov/about/maryland-economy): promotes business in Maryland with access to property data, business incubators, research parks, sources of Maryland economic productivity, government agencies, and tax data.

e) **Chesapeake Bay Commission** (http://www.chesbay.us/publicationsmain.htm): The Chesapeake Bay Commission is a policy leader in the restoration of the Chesapeake Bay. As a tri-state legislative assembly representing Maryland, Virginia and Pennsylvania, the Commission's leadership covers a full spectrum of Bay issues: from managing living resources and conserving land, to protecting water quality. It combines its unique access to both the legislative and executive branches of each Bay state with well-honed skills in research, policy-development and consensus building to help develop policy toward the goal of restoring the Chesapeake Bay.

Scientific Data

f) **Chesapeake Bay Program** (http://www.chesapeakebay.net/data): The Chesapeake Bay Program is a regional partnership that leads and directs Chesapeake Bay restoration and protection. Bay Program partners include federal and state agencies, local governments, non-profit organizations and academic institutions. Among other things, the CBP provides data on water quality, toxic content level, land management, runoff and nutrients level, and other scientific raw data on the Bay. Data specific to the Anacostia River can be found by choosing monitoring stations starting with ANA (e.g. ANA0082, ANA01, ANA05 and so forth).

g) **U.S. Geological Survey** (http://chesapeake.usgs.gov/data.html): In 2009, the USGS was given the lead responsibility along with the National Oceanographic and Atmospheric Administration (NOAA) to strengthen the science and respond to climate change in the Chesapeake Bay. In fulfillment of this responsibility, USGS collects and uses scientific data to help restore clean water, recover habitat, sustain fish and wildlife, and conserve land and public habitat in the Chesapeake Bay. Data specific to the Anacostia (http://waterdata.usgs.gov) can be found at three sites on the Anacostia River in DC: Anacostia at Aquatic Gardens (USGS 01651750) and Watts Branch (USGS 01651800) and Hickey Run (USGS 01651770).

TIEE, Volume 12 © 2017 – Caroline M. Solomon, Khadijat Rashid, and the Ecological Society of America. *Teaching Issues and Experiments in Ecology* (*TIEE*) is a project of the Committee on Diversity and Education of the Ecological Society of America (http://tiee.esa.org).

h) **Anacostia Watershed Restoration Partnership (AWRP)** (http://www.anacostia.net/restoration/stream_station_network.html): In June 2006, the Anacostia Watershed Restoration Partnership was established to improve (1) inter- and intra-jurisdictional coordination and implementation (2) long-term funding support and (3) credibility among citizens who live in the watershed. The AWRP website provides interactive maps and real-time data (through USGS).

i) **DC Department of Energy and Environment (DC DOEE)** (http://doee.dc.gov/node/9752): DC DOEE has an Anacostia and Potomac Monitoring Program that provides real-time data. DC DOEE has two monitoring sites for water quality variables at South Capitol Bridge and Benning Road.

Tools for Assessment of Student Learning Outcomes

Your learning and attainment will be assessed at several points during the module. Rubrics for evaluating each assignment you complete are available via the links in the following table.

Assignment	Learning Outcome Assessed	Link to Rubric
What do you need to know (WDYNTK) list	#1	
Pre-socio-ecological system map	#1, 3	Link to Rubric
Working with Large Datasets	#2, 3	
Normative Thinking	#5	
Expert group presentations	#2, 3, 4	Link to Rubric
Synthesis group discussions	#1-5	
Synthesis product	#1-5	Link to Rubric
Synthesis presentations	#1-5	Link to Rubric

TIEE, Volume 12 © 2017 – Caroline M. Solomon, Khadijat Rashid, and the Ecological Society of America. *Teaching Issues and Experiments in Ecology* (*TIEE*) is a project of the Committee on Diversity and Education of the Ecological Society of America (http://tiee.esa.org).

Final socio-ecological system map	#1, 3, 4	Link to Rubric

NOTES TO FACULTY

Challenges to Anticipate and Solve

Challenge #1: Understanding context outside of the student's major or discipline. Students often struggle to understand information that is outside of their major or based on an unfamiliar framework. For instance, social science datasets include both qualitative and quantitative data, and science majors wrestle with accepting interview data. It is important to have a continuous discussion of the rigor with which social science data is collected to reinforce this understanding. It is helpful if there are two instructors teaching the course from the natural and social sciences who model respect and collaboration for the contributions from either area and show that neither approach is inherently "superior."

Challenge #2: Utilizing large datasets. Students have difficulty differentiating raw from analyzed data, and in finding the large datasets with raw data they need to analyze the problem at hand. We recommend building on the assignment (mini-assignment Expert Groups, Work Day 1: Expert Group Exercise #1) to carefully scaffold on how to utilize large datasets. Students may benefit first from an exercise where a large dataset is given and they have to analyze it themselves before having them search for datasets relevant to the module.

Challenge #3: Normative thinking. Students are hesitant to question data sources and their limitations. Instructors can provide examples from their own disciplines (e.g. in economics, unemployment statistics do not apply to the whole population as most assume, but only include people between the ages of 16 and 64 who are actively seeking work).

Challenge #4: Students often do not understand who the 'stakeholders' are thus we assigned certain stakeholder groups to expose them to the different possible ones, but we explained to students that these are not the only stakeholders who are in this socio-environmental system. We asked students to investigate further the different type of stakeholders within the stakeholder designation we assigned to them.

TIEE, Volume 12 © 2017 – Caroline M. Solomon, Khadijat Rashid, and the Ecological Society of America. *Teaching Issues and Experiments in Ecology* (*TIEE*) is a project of the Committee on Diversity and Education of the Ecological Society of America (http://tiee.esa.org).

For instance, students do not even know what NGOs are so they were not even familiar with the various ones, such as United for a Healthy Anacostia River, Anacostia Watershed Citizens Advisory Committee, Anacostia Riverkeeper, Anacostia Watershed Society, DC Environmental Network, Federal City Council, Groundwork Anacostia River DC, NRDC, Clean Water Action, Friends of Sligo Creek, and Neighbors of the Northwest Branch among others.

Students also struggle to understand the role of local, state, and federal government (including numerous agencies) in managing and improving the Anacostia River watershed.

Module Description

Introducing the Module to Your Students:

Students were introduced to the issue during one lecture session through a PowerPoint that encouraged discussion. Students were also assigned readings related to the issue. Students then proceeded to create pre- socio-ecological system maps (this is similar to a pre-test to see how students view the socio-environmental system), and instructors commented on them through guided inquiry (e.g. why did you include that? why did you not include X?) The instructors emphasized the importance of looking at the issue through different lenses (both social and natural sciences) and being open-minded to new ways of approaching an issue.

The introduction of students to the module on the Anacostia River differed between the two years the course was taught. The first year students were introduced to the module via readings related to the construction of the storage tanks at three locations in DC (e.g. Washington Post article, “Meet Lady Bird, a massive machine digging out a solution to D.C. wastewater woes”) while during the second year students were introduced to the module by going out on the Anacostia River.

Comments on the Data Collection and Analysis Methods Used in the Module:

Students are given some links to some real data sets, but one of the aims of the module is for them to learn how to search for data. They may require considerable assistance in finding suitable datasets that are relevant to the issue, and then in analyzing and synthesizing the information gathered. We

recommend including an in-class activity where they find a dataset and utilize it to make a graph.

Comments on Questions for Further Thought

1. *Were you limited by the type of data and evidence you found? Did you question where the data originated or what point of view was presented to you? Did you find that some sources of data were more trustworthy or reliable than others?*

    a. Discuss the different data and evidence that students found. Ask them about the type of organization or group that put the information up on the web. Some instructors like to use the librarian developed CRAP (currency, reliability, authority and purpose) test to help students evaluate various websites and sources.
    b. Students seemed to have difficulty differentiating between reliable and unreliable sources of data on the web. They thought that if data was on the web, then it was acceptable whether it was from a private individual's blog full of opinions or from a government agency. The point of this question is to help students question the veracity of every data source in order to develop an understanding of what is acceptable.

2. *Why is it important to synthesize data and evidence from different disciplines and sources to better understand and create actionable science for cleaning up the Anacostia River? What was the biggest challenge (or step) in synthesizing the data and evidence?*

    a. Students often had difficulty viewing and understanding data from different disciplines and how they could relate to or complement each other and often were interdisciplinary but not synthetic in their thinking. It may be helpful to show students the pyramid that is often used to show Bloom's taxonomy of skills to show them that synthesis is the most complex skill in the learning process.

TIEE, Volume 12 © 2017 – Caroline M. Solomon, Khadijat Rashid, and the Ecological Society of America. *Teaching Issues and Experiments in Ecology* (*TIEE*) is a project of the Committee on Diversity and Education of the Ecological Society of America (http://tiee.esa.org).

b. You can provide examples of how one can view a problem from two disciplines, but then take it further and show how the problem changes when one or more disciplines provide more information.

3. *Based on the skills and knowledge you have learned in this case study, what do you think is the best method for addressing the core problem (actionable science) of the urban impact on the Anacostia River?*

a. The goal of this is to encourage students to "think outside the box" and to come up with innovative and actionable solutions to the issue under study. Encourage students to consider all the data and use these to come up with new solutions.

Comments on the Assessment of Student Learning Outcomes:

We emphasized learning instead of grades and there were times when we gave feedback to students via rubrics but did not use it to provide grades. For example, we did not grade the WDYNTK submissions or the pre- socio-ecological system maps because we wanted to encourage students to be bold and creative and submit whatever questions or ideas they had. From the pre-socio-ecological system map, we helped students develop and finesse their ideas into the post- socio-ecological system map that was graded.

Occasionally, it was clear that the entire class was having difficulty with a concept and when that happened, we went back and reviewed the material and then had students re-do the work to demonstrate understanding.

We used rubrics for most major assessments, but then we realized that we had some unstated and in some cases unclear expectations that were not in the rubrics and so we wrote them down and codified them in the rubrics to help assure consistency of evaluation.

Comments on Formative Evaluation of this Module:

We conducted a pre- and post-survey of the class via SurveyMonkey. The pre-survey provided instructors with student demographics and level of comfort with interdisciplinary and/or synthetic thinking as well as how much basic content

TIEE, Volume 12 © 2017 – Caroline M. Solomon, Khadijat Rashid, and the Ecological Society of America. *Teaching Issues and Experiments in Ecology* (*TIEE*) is a project of the Committee on Diversity and Education of the Ecological Society of America (http://tiee.esa.org).

knowledge students had. A course evaluation was also given at the end of the semester.

We asked students probing questions about their understanding of the material at the beginning of almost every class. These questions underlined areas of student weakness and loose grasp of concepts, and we followed up with explanations in class.

We frequently assigned students group work, and mixed up the groups regularly so that each student got to work with every other student in the class and no groups had all “strong” members. We observed the group discussions and these provided us with information about areas where students were struggling, which we addressed after the group discussion or in the following class. Occasionally, instructors would get involved in the group discussion to provide a course correction or information to aid student understanding.

Formative “transfer and apply” evaluation was built into both modules with the pre- and post-system maps where students initially did not understand the subject matter but by the end could redraw their system maps to show new and incorporated knowledge based on class discussion, research, professor input, and other sources of data.

Both professors met with all students, individually and in groups, to review progress and give feedback throughout the semester.

The evaluation of the pre- socio-ecological system maps via rubric (but was not scored) by the instructors also provided feedback on how students viewed the socio-ecological system and which areas needed to be emphasized during the module.

Comments on Translating the Activity to Other Institutional Scales or Locations:

The module works the best if it is embedded into a full course along with the other module on poultry farming since then it can include the two integrated modules under an overarching theme, with super-synthesis occurring at the end of the semester. However, this module could easily stand-alone. For best results to model synthesis between the social and natural sciences, two professors from each discipline should be present full time so that each can contribute disciplinary knowledge and help students as they struggle with new material as well as synthesizing the information.

TIEE, Volume 12 © 2017 – Caroline M. Solomon, Khadijat Rashid, and the Ecological Society of America. *Teaching Issues and Experiments in Ecology* (*TIEE*) is a project of the Committee on Diversity and Education of the Ecological Society of America (http://tiee.esa.org).

We offered the course on two separate occasions. The first time the course was taught, it was as an elective for both biology and business/economics majors, and the students in the class were all upperclassmen who had already taken several courses in one or both fields of study. Students had a strong background and interest in socio-environmental synthesis and were more invested in the course. Class size was relatively small with ten students, allowing for ample one-on-one time for each student with one or both professors. The class was also well balanced with five business and five biology majors, and group work was assigned in such a way that each group had equal numbers of biology and business majors.

The second time, we offered it as a general studies course with different student dynamics. The class was larger and included 18 students who were first year students or sophomores with undeclared majors exploring their interests. Because of this, students had limited knowledge of both biology and economics. As a result, both professors had to spend much more time on teaching basic content than expected, which meant that synthesis work was reduced. Due to the larger class size, the one-on-one time with professors was more limited. The quality of student work and understanding of the material compared to the first cohort was measurably lower. Based on this experience, we believe that the modules will work best with juniors and seniors. The modules may be adapted for first and second year students with the understanding that instructors will need to provide more background and support in content knowledge both inside and outside of the classroom.

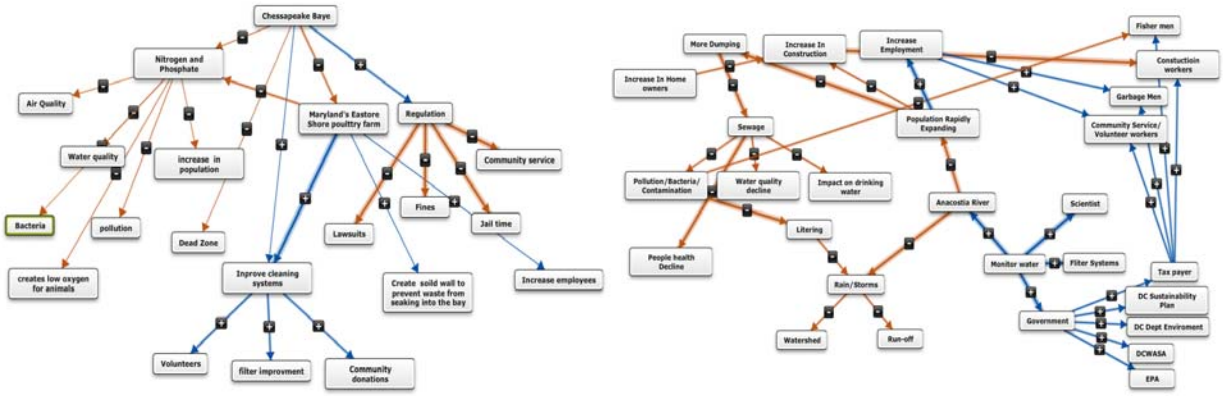
Gallaudet University has a unique interdisciplinary general studies program that typically features two professors from different disciplines in the classroom. As more professors have become familiar with the interdisciplinary model, the University has switched to having several sophomore-level general studies courses now taught by one faculty member. We recommend that the first few iterations of the module(s)/course have two professors. Later iterations of the module(s)/course could be taught by one faculty member if the other faculty member can attend a few classes to emphasize information from his or her discipline or provide feedback on certain assignments such as expert groups or system maps which require specialized content knowledge.

TIEE, Volume 12 © 2017 – Caroline M. Solomon, Khadijat Rashid, and the Ecological Society of America. *Teaching Issues and Experiments in Ecology* (*TIEE*) is a project of the Committee on Diversity and Education of the Ecological Society of America (http://tiee.esa.org).

STUDENTS COLLECTED DATA FROM THIS MODULE

Students did not collect data during the modules, but rather used large datasets that were available to them.

Below are examples of pre- (left) and post-systems (right) maps.



COPYRIGHT STATEMENT

The Ecological Society of America (ESA) holds the copyright for TIEE Volume 12, and the authors retain the copyright for the content of individual contributions (although some text, figures, and data sets may bear further copyright notice). No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of the copyright owner. Use solely at one's own institution with ***no intent for profit*** is excluded from the preceding copyright restriction, unless otherwise noted. Proper credit to this publication must be included in your lecture or laboratory course materials (print, electronic, or other means of reproduction) for each use.

To reiterate, you are welcome to download some or all of the material posted at this site for your use in your course(s), which does not include commercial uses for profit. Also, please be aware of the legal restrictions on copyright use for published materials posted at this site. We have obtained permission to use all copyrighted materials, data,

figures, tables, images, etc. posted at this site solely for the uses described in the TIEE site.

Lastly, we request that you return your students' and your comments on this activity to the TIEE Managing Editor (tieesubmissions@esa.org) for posting at this site.

GENERIC DISCLAIMER

Adult supervision is recommended when performing this lab activity. We also recommend that common sense and proper safety precautions be followed by all participants. No responsibility is implied or taken by the contributing author, the editors of this Volume, nor anyone associated with maintaining the TIEE web site, nor by their academic employers, nor by the Ecological Society of America for anyone who sustains injuries as a result of using the materials or ideas, or performing the procedures put forth at the TIEE web site, or in any printed materials that derive therefrom.

TIEE, Volume 12 © 2017 – Caroline M. Solomon, Khadijat Rashid, and the Ecological Society of America. *Teaching Issues and Experiments in Ecology* (*TIEE*) is a project of the Committee on Diversity and Education of the Ecological Society of America (http://tiee.esa.org).