TIEE

Teaching Issues and Experiments in Ecology - Volume 1, January 2004

EXPERIMENTS

Ecology of Habitat Contrasts: An Example from the Holyoke Range, MA

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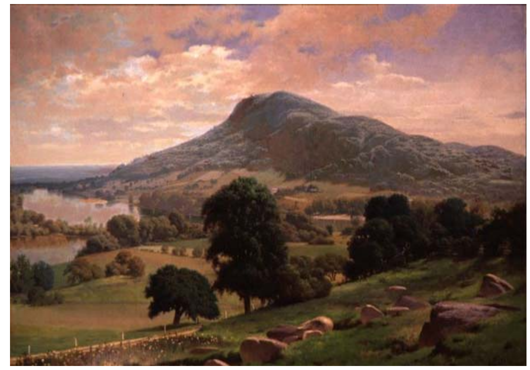

View of Mount Holyoke, by John Gue, circa 1900, courtesy of Mount Holyoke College Art Museum {www.mtholyoke.edu/proj/cel/ref/place/natplaces/holyoke_range.shtml}

ABSTRACT:

In this lab, students examine tree communities found on the north and south slopes of a local mountain (in the Holyoke Range, near Amherst, MA). Student-generated questions include: are the tree species different on the two slopes? are there density and size differences? are these differences due to climate and adaptation to cold and drought? are there other important factors that help us understand the types and sizes of trees that we find there?

Table of Contents:

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KEYWORD DESCRIPTORS:

Principal Ecological Question Addressed: Are tree communities different on the north and south slopes of a mountain, and if so, what important factors could account for any differences observed?

Ecological Topic Keywords: plant ecology, autecology, environmental adaptation, population ecology, community ecology, biogeography.

Science Methodological Skills Developed: field observations especially in ecological situations where habitat contrasts are obvious, experimental design and quantifying observations, correlation of physical factors (such as light and temperature) with community composition and biodiversity, hypothesis testing, use of spreadsheets and graphing programs; use of primary literature, oral communication, writing primary research paper.

Pedagogical Methods Used: student-directed inquiry, cooperative learning, problem-based learning.

CLASS TIME: MULTIWEEK - four three-hour lab periods (2 for field trips, 2 for data analysis).

OUTSIDE OF CLASS TIME: 4-12 hours needed for students to finish their research papers.

STUDENT PRODUCTS: Students are assessed based on their individual research paper based on student-collected data.

SETTING: Field data collection in two different habitat types (any season), with data analysis in lab.

COURSE CONTEXT: Undergraduate freshmen and sophomore-level course in Ecology, about 20 students.

INSTITUTION: private undergraduate college.

TRANSFERABILITY: This activity would be amenable to any field situation where contrasting environments and communities of organisms exist in close proximity (e.g. for vegetation in dry/wet fields, young/older forest, grazed/ungrazed or mowed/unmowed fields, polluted/less polluted wetlands; see Description section for links). It could be used in basic ecology, plant ecology, or community ecology courses.

SYNOPSIS OF THE LAB ACTIVITY (audience: students)

WHAT HAPPENS:

In this lab, students examine tree communities found on the north and south slopes of a local mountain (in the Holyoke Range, near Amherst, MA). Student-generated questions include: are the tree species different on the two slopes? are there density and size differences? are these differences due to climate and adaptation to cold and drought? are there other important factors that help us understand the types and sizes of trees that we find there?

Students spend four three-hour lab sessions on this project. During the first field trip they make observations about the study site, ask and focus questions, develop hypotheses from these, and design a sampling regime to address their hypotheses. On the second trip, they collect data on tree types and other variables of interest to them (e.g., tree size). We use an array of recording thermometers to obtain temperature data over a week. During the third and fourth lab periods, they work in task teams to enter the data on spreadsheets and generate figures and tables for everyone's use. Students then work alone and write a research-style paper with references that I make available (e.g., including similar studies elsewhere).

LAB OBJECTIVES:

At the conclusion of this multiweek lab, students will:

1. understand some of the basics of asking and attempting to answer ecological questions (beginning with observations in the field, focusing broad questions towards narrower answerable ones, developing hypotheses, designing a project to answer these questions, and actually conducting that project),

2. design and conduct a research inquiry including using skills in experimental design and data analysis (use of spreadsheets, simple statistics, data reduction, developing clear figures and tables that address specific questions),

3. advance their scientific critical thinking skills by revising their initial questions and hypotheses due to their findings as well as findings by others in published literature,

4. advance their skills in working in collaboration with their peers in conducting a scientific study,

LAB OBJECTIVES (con.):

5. advance their skills in communicating scientific findings to peers (written and oral presentation of research results and using primary literature relevant to each group's research project),

6. advance their skills at thinking about the abiotic factors that affect the distribution and abundance of plant species across a sharp climatic gradient, and thereby better understand the associated issues of individual organismal adaptation to environment,

7. advance their appreciation that other factors, particularly past disturbance (in this case hurricanes and tree cutting for firewood), can also greatly affect vegetation distribution and types; also that disturbance, light, temperature, moisture, and soils interact to influence the modern day plant community, and

8. learn how to identify trees in the study plots.

EQUIPMENT/ LOGISTICS REQUIRED:

* field clothing (which will include raingear if it is raining),
* this handout and data sheets,
* OnSet recording thermometers, Li-COR solar sensor, DBH tapes, meter tapes,
* transportation for two 3 hour blocks for field work,
* use of a computer facility for 2 three hour blocks for data analysis.

SUMMARY OF WHAT IS DUE:

From this multiweek lab, students submit From this multiweek lab, students submit an original research paper written individually based on the data their group collected and the literature that they consulted.

DESCRIPTION OF THE LAB ACTIVITY

INTRODUCTION (written for students):

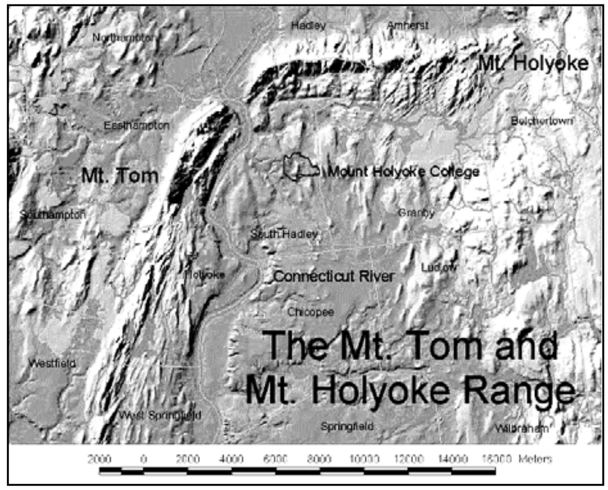
Some ecologists describe what they do in a way that sounds simple but in practice is pretty difficult: ecologists first see and describe patterns in organisms and then attempt to explain why those patterns exist. Examples of different patterns are high or low abundance of animals, or whether a site has many of the same type of plants. Mechanisms to explain these patterns might concern the amount of rainfall in a year or heavy grazing by some herbivore.

In this field investigation, you will have the opportunity to hone your "what" and "why" skills in a situation where the ecological patterns are fairly evident. You will study trees on the sharply contrasting environments of the north and south slopes of the Holyoke Range. This is a study of climate, topography, and the distribution, abundance and diversity of organisms in communities. We wouldn't expect to find a tree that is common in New England, like white birch, everywhere on the globe; organisms exist within fairly narrow ranges of rainfall, temperature, soil type, and other physical-chemical factors. On a global scale, climatic regions are characterized by distinct vegetation types such as the grasses and sedges of the tundra or trees that we find here in the northern deciduous forest. On a local scale, topographic features such as mountains result in localized climatic differences and also variations in soil. The unusual situations where mountains run east-west in northern temperate zones provide a terrific opportunity to determine how sharp gradients in temperature, soil moisture, and soil type influence vegetation characteristics such as dominance, presence/absence, or abundance of tree species. Such a study also allows us to examine what is known about adaptations of organisms to factors including cold, drought, and poor quality soil. Finally, knowledge that major events like hurricanes also alter the structure of tree communities on mountain slopes leads us to consider the additional role of disturbance in understanding patterns of organisms in communities

MATERIALS AND METHODS.

Study Site(s).

We are fortunate here in Amherst to have a small mountain range called the Holyoke Range within a 5 minute drive. This range in unusual in that it runs east-west and therefore has north and south slopes that often differ dramatically in daily irradiance and temperature At your location you might compare mowed/unmowed or grazed/ungrazed fields, polluted/unpolluted areas, burned/unburned or old/young forests etc. (see examples in links below).



relief map image from www.mtholyoke.edu/ proj/cel/ref/place/natplaces/ holyoke_range.shtml}

Data Collection Methods.

During the first 3 hour lab session, we walk up to a fairly easily accessible spot of the ridge of the range. Along the way I teach students how to identify the 10 or so dominant trees. When we reach our destination, I ask the students to form groups of 2-4, walk around on the upper parts of both slopes, make a list of 10 or so observations, and return in 30 minutes. After we re-group, the students begin to talk about their observations and some of the more obvious ecological questions that come from these observations. They inevitably note differences in wind, temperature, and light on the two sides and also that some of the trees appear to be different. With my guidance in sharpening their questions, they typically ask ones such as: Are the tree types, densities, and sizes different on the two slopes? Is air temperature different? If the tree types are different on the north and south aspects, is this due to climatic differences or are there other variables that are likely important as well?

Back at school (same day or next class), we work on the experimental design. Their time in the field is restricted to one afternoon. In regard to the tree sampling, some students often have had some experience with ecology in high school, and the concept of sampling by quadrats usually comes up early on. I suggest how to do this simply in this setting (e.g. a circle drawn in the snow; one student holds one end of a rope and another walks around the circumference). I also recommend a quadrat size (in this case 10 m diameter). The students usually decide to distribute the samples randomly, but fairly closely together, and they decide how to do that simply in the field (e.g. walking a set distance from a center point). See below for links describing various plant sampling techniques and analyses.

Since 1996, I have used recording thermometers sold by On-Set (On-Set Computer Corp. (www.onsetcomp.com), 536 MacArthur Blvd, Pocasset MA, 02559, 508-759-9500). These are very easy to use and allow us to collect a rich temperature data set that is especially helpful for this investigation. A small team of students takes on this aspect of the work; they decide how to arrange the thermometers (I have 10) through the air column (e.g. on a line strung between trees or on the trees themselves), in replicate locations, in the tree sampling sites on both sides of the range. These students also choose the frequency and duration of sampling, and they are responsible for temperature data reduction and presentation as figures. These data are shared with the other students.

During the second lab period the students work in teams of 2-3 and collect the tree data (type, number, diameter) in as many quadrats as possible. First we review the sampling methods. Then I give each team a plastic bag containing a clip board and data sheets that I make up, copies of pages from a good plant ID book with drawings, pencils, DBH tape, meter tape - and maybe some chocolate candies if it is cold! (Organization of all of this is quite important; you also need to make sure that everyone knows how to use the DPH tapes, data sheets, etc.). At the same time the temperature group sets up their recording thermometers.

I also use walkie-talkies to keep track of teams and so that students can discuss problems (e.g. are we counting dead trees?) together. This also makes the lab more fun.

Data Analysis

During weeks 3 and 4 in lab, the students work in task teams (tree types, tree size, temperature) to enter the data on spreadsheets (I use Microsoft's Excel) and begin producing figures and tables. At the end of the 4th week, the teams present their findings, now in final figure or table form, to the entire group. All the data, crunched or raw, is available to everyone through the college's computer network.

If you need to teach your students how to use excel, there are some good tutorials online (for examples see below). In my experience some students know or quickly learn to use spreadsheets; you can pair them with less experienced students, but make sure that everyone gets a chance to work with the data. Be sure to give students enough time to learn how to use the spreadsheet and make simple, mock figures similar to ones they will be making later. This is also a useful way for them to think about the figures/tables they can make to address the questions they are asking.

For comparison of density and number of species on the two slopes my students use a simple chi-square test (for tutorials see below). I go over the basic idea of the chi-square fairly quickly and leave more detailed descriptions for a statistics class. A hand-out is useful (e.g. www.hum.utah.edu/communication/classes/sp03/3710-1/handouts.pdf). For size comparisons we use t-tests (see tutorials below and http://demeter.hampshire.edu/%7Embruno/general/statistics.html for a hand-out). Despite complaints that t-tests cannot be done correctly on Excel, my statistician friends assure me that it is ok for a simple paired t-test for this lab.

The figures my students make are usually simple histograms. For instance, one figure is density (mean ± std. deviation) of common tree species on the N and S slopes. For diversity I only use species counts because there is so much data analysis as is.

I focus on temperature because this is an early winter project in New England. The ground is frozen and often covered with snow. In other situations soils could be compared (e.g. water content simply by weight before and after drying or loss on ignition for organic content; see physio-chemical analyses in http://groups.ucanr.org/danranlab/Methods_of_Analyses545/#soil3). Light is also easy to measure accurately; I have used LI-COR meters with success.

Report Format

Each student writes a research-style paper (abstract, introduction, methods, results, discussion, references). In class, I go over what should and should not be included in each section and give them handouts about how to write scientific research papers. In this course, by the time their first lab paper is due, students have already read 4-5 primary ecology papers and so they are familiar with the structure. The students are encouraged to work on the papers together to discuss the references I put on reserve or what the data might indicate. The references I give them include other similar studies done elsewhere, geologic and soil maps of the range, and other types of ecological studies of the Holyoke Range.

Students' research papers are structured according to the following criteria (see also links below)

Abstract: includes ecological context, why this study would be of interest to ecologists, specific questions addressed, overview of methods, specific results and conclusions from these data.

Introduction: explains ecological context, geologic and ecological setting, other relevant studies and findings, specific questions addressed (2-3 pages).

Methods: enough detail so that study could be repeated but not so much as to be tedious to read (1 page).

Results: clear explanations of tables and figures with no interpretation; tables and figures are clean and professional (1-2 pages).

Discussion: nutshell summary of overall results, interpretation of results, comparison with other studies, professional discussion of limitations of the study, suggestions for follow-up studies (3-5 pages).

References: in Ecology format, 5-10 references expected.

QUESTIONS FOR FURTHER THOUGHT AND DISCUSSION.

1) Consider local vs. regional distribution of tree communities. Would we expect that the community on the north slope of the Holyoke Range to look just like communities far north of here (say in northern Vermont) and the community on the south slope to be typical of tree communities in Maryland or Virginia? Why or why not?

2) We are doing our study in midwinter. Design a year round study to address the questions we are asking. What times of year would be especially important to study and what would you do?

3) Students in beginning ecology courses when asked why a plant or animal is found in a certain place often say something like "it likes it there?" Critique that statement.

4) Ecology texts are often divided into sections called autecology, population ecology, community ecology, and ecosystems ecology. If you were studying the Holyoke Range from each of these points of view, what kinds of questions might you ask and what types of studies would you do?

5) Suppose you noticed a typically northern tree like hemlock growing on the south slope. What kinds of studies would you do to determine why this was the case?

6) Consider a totally different ecological situation where zonation is clearly evident. Pick any example either from your observations or from the literature, and describe the situation in detail. Design experiments to test possible causes of the pattern zonation in your example.

REFERENCES AND LINKS.

Writing Research Papers

* http://carbon.hampshire.edu/%7Embruno/general/paperhints.html
* http://www.mhhe.com/biosci/genbio/maderinquiry/writing.html
* http://www.columbia.edu/cu/biology/ug/research/paper.html

Plant Sampling Techniques

* digital.library.okstate.edu/oas/oas_pdf/v71/p43_45.pdf (Oklahoma Biological Survey; good general discussion of methods for grassland plants including guadrat, transect, distance, point, and gradient methods; references)
* http://www.serg.sdsu.edu/SERG/techniques/mfps.html (for Colorado Desert restoration analysis; nice discussion of quadrat sampling, plot-less, distance methods, some references)
* www.geobotany.uaf.edu/teaching/biol474/lesson14slides.pdf (geobotany course; includes random and other sampling, cover, frequency, basal area methods)
* http://fire.r9.fws.gov/ifcc/monitor/RefGuide/frequency_methods.htm (for smaller vegetation includes frequency and cover methods for quadrats along transects, chi square tests)
* www.ci.eugene.or.us/wewetlands/Mitgn_Rpt/2002/App_A-Methods.pdf (methods for monitoring replacement wetland includes point intercept for herbaceolus plants and line intercept for shrubs, rare plant analysis, frequency)
* www.plantbio.ohiou.edu/epb/instruct/ecology/lab3.pdf (Plant Biology class Ohio University (used to compare upper and lower slope forests; PCQ point-centered quarter method for trees - a distance method for density)

Chi-squared Tutorials

* http://www.georgetown.edu/faculty/ballc/webtools/web_chi_tut.html#overview
* http://www.physics.csbsju.edu/stats/chi-square.html
* http://www.stat.uiuc.edu/courses/stat100/java/chisquare/ChiSquareApplet.html
* http://bmj.bmjjournals.com/collections/statsbk/8.shtml

t-test Tutorials for Excel

* http://www.ntu.edu.au/faculties/science/sbes/resources/SBI209/Excel.PDF
* http://www.wfu.edu/users/massd2/T_test.htm

Excel Tutorials

* www.usd.edu/trio/tut/excel/
* homepage.cs.uri.edu/tutorials/csc101/pc/excel97/excel.html
* www.fgcu.edu/support/office2000/excel/
* www.baycongroup.com/el0.htm

References

Abrams, M. C. 1990. Adaptations and responses to drought in *Quercus* species of North America. Tree Physiology 7: 227-238.

Abrams, M. D. 1992. Fire and the development of oak forests. BioScience 42:346-353.

Abrams, M. D., M. E. Kubiske, and S. A. Mostoller. 1994. Relating wet and dry year ecophysiology to leaf structure in contrasting temperate tree species. Ecology 75:123-133.

Abrams, M. D., D. A. Orwig, and T. E. DeMeo. 1995. Dendro-ecological analysis of successional dynamics for a presettlement origin white pine-mixed oak forest in the southern Appalachians, USA. J. of Ecology. 83:123-133.

Abrams, M. D. 1998. The red maple paradox. BioScience 48:355-364.

Bellemare, J. M. G. and D. Foster. 2002. Legacies of the agricultural past in the forested present: an assessment of historical land-use effects on rich mesic forests. Journal of Biogeography 29: 1401-1420.

Boose, E. R., K. E. Chamberlin, and D. R. Foster. 2001. Landscape and regional impacts of hurricanes in New England. Ecological Monographs 7: 27-48.

Bürgi, M., E. W. B. Russell, and G. Motzkin. 2000. Effects of postsettlement human activities on forest composition in the north-eastern United States: a comparative approach. Journal of Biogeography 27: 1123-1128.

Cantlon, J. E. 1953. Vegetation and microclimates of north and south slopes of Cushetunk Mountain, New Jersey. pp. 241-270.

Carlton, C. G. and F. A. Bazzaz. 1998. Regeneration of three sympatric birch species on experimental hurricane blowdown microsites. Ecological Monographs 68: 99-120.

Foster, D. and J. Aber. (Eds) 2003. Forests in Time: the Environmental Consequences of 1000 Years of Change in New England. Yale University Press, New Haven, CT.

Foster, D., S. Clayden, D. A. Orwig, B. Hall, and S. Barry. 2002. Oak, chestnut and fire: climatic and cultural controls of long-term forest dynamics in New England. Journal of Biogeography 29: 1359-1379.

Foster, D., D. Knight, and J. Franklin. 1998. Landscape patterns and legacies of large infrequent disturbances. Ecosystems 1: 497-510.

Foster, D., G. Motzkin, and B. Slater. 1998. Land-use history as long-term broad-scale disturbance: regional forest dynamics in central New England. Ecosystems 1: 96-119.

Kubiske, M. E. and M. D. Abrams. 1994. Ecophysiology analysis of woody species in contrasting temperate communities during wet and dry years. Oecologia (Berlin) 98(3-4):303-312.

Lallardy, S. G., and J. L. Rhodes. 1993. Morphological adaptation to drought in seedlings of deciduous angiosperms. Canadian Journal Forest Research 23:1766-1774.

Ledig, F. T., and D. R. Korboro. 1983. Adaptation of sugar maple populations along altitudinal gradients: photosynthesis, respiration, and specific leaf weight. American Journal of Botany 70: 256-265.

Lei, T. T., and M. J. Lechowicz. 1990. Shade adaptation and shade tolerance in saplings of three *Acer* species from eastern North America. Oecologia 84: 224-228.

Comments by Contributing Author – Charlene D'Avanzo

CHALLENGES TO ANTICIPATE AND SOLVE.

I have identified 5 challenges that commonly arise:

1. making field observations: Students who are not used to making observations in the field will need some help and special training. One way to do this is to show slides of field sites in class and work with students on making observations first (we call this "page one") and developing explanations for these second ("page two"; see essay on this in the Teaching section. Many students have a difficult time distinguishing between observations and interpretations. Another idea is to go outside near your building and have students write down observations of what they see, and back in class to discuss their observations. The next step is to help students develop specific questions based on their observations.

2. using their observations and questions: Another skill is to use their observations and questions in the field site to develop a project that you have already have sketched out. You need to be open to their ideas, but the project needs focus and must meet your course objectives. This is a very tricky balance. For the first project of the semester especially, I tend the guide the questions a fair amount.

3. dealing with large data sets: An issue for students will be dealing with a fairly large data set. You will have to decide how much creative chaos you find useful for your students and how much you need to own and orchestrate to effectively accomplish data reduction. Students who don't how to use the spreadsheet and graphics package should be taught this ahead of time. You can do this in class or perhaps a student assistant can do a session outside of class.

4. focusing their data set: Many students have trouble finding a focus for their paper from this large data set. I ask them to ask specific questions that require use of only part of the data so that they can develop a few ideas in more detail. For instance, some students may analyze the temperature data in more depth than others or focus on one tree species. During lab time you can ask students who have a more focused idea to describe it to other students as an example.

5. writing a research style paper: How much time you spend teaching students how to write scientific style research papers depends on their prior experience with this. If they have not written such papers before take class or lab time to explain the structure of research papers and how to write them. If the class is small enough and if you have time, ask your students to rewrite this paper. They will benefit enormously by doing this.

COMMENTS ON THE LAB DESCRIPTION.

This lab is a multi-week field project that I use in my undergraduate second semester basic ecology class during February in Massachusetts. I have found that this a good first investigation because it is based on students' own observations of tree types and also common-sense environmental characteristics such as air temperature. In addition, this project gets them working in the field in groups right away. Another reason why I use this as the first investigation is because the question the students address at the onset is fairly straightforward. The question concerns contrasts in tree species on two very different, adjacent sites - the north and south aspects of a small mountain. This topic also fits well with the opening of my course on autecological approaches to ecology such as discussed in Ricklefs' chapters on "Organisms in Physical Environments." During the course of this lab, the students start to work on the most obvious questions related to climate difference, and their thinking becomes more sophisticated as they consider more subtle issues such as disturbance history.

Questions Addressed and Ecological Context

The structure of this ecology class is bottom-up, and I use this investigation to stimulate student thinking about physical-chemical factors contributing to local tree distribution in a site where there is a sharp climatic gradient. In this domain, I would expect a student to consider, for example, adaptations that might allow hemlock to grow in colder climates. In addition, I hope that students will begin to think about other factors affecting trees in this location. Many students quickly recognize the limitation of the "tree-is-there-because-it-likes-it" thinking because they see evidence of prior land use such as grazing (e.g., juniper bushes in the woods), and they read about the 1938 hurricane that flattened trees on south facing slopes in our area. My hope is that each student will consider the importance of additional factors such as disturbance in addition to climate and soil in influencing tree type and size in our study site.

Time Commitment and Expected Product.

This is a largely student-developed investigation which requires a significant amount of time. We spend two lab sessions in the field (3 hours each) and two more labs working with computers to process the data. The students work outside of class to write individual research papers. I provide background primary particles.

COMMENTS ON THE QUESTIONS FOR FURTHER THOUGHT.

Comments on Q1. Consider local vs. regional distribution of tree communities...
Comment for instructors: what you are looking for here is not necessarily the correct answer but rather evidence of good ecological and scientific thinking. Help students further develop statements and questions like: how do I know what tree communities look like north and south of here? Is there such a thing as a typical community for a region? If some trees are the same but others are missing, does that mean the communities are different? What about animals; would we think they would have distributions like the plants, and if they don't would that make a difference? Is the weather on the south slope really like weather south of here? To prevent the discussion from being too diffuse, follow some lines of thought with further questions about how students would test their assumptions or get more information to address their questions.

Comments on Q2. Design a year round study to address the questions we are asking...
Comment for instructors: the kind of thinking you are looking for here is targeting data collection to address specific questions and hypotheses (as opposed to a shot gun approach) and more focus on critical data sets (such as more frequent sampling of temperature in spring when changes are rapid or in mid summer when extremes might occur).

Comments on Q3. Students in beginning ecology courses when asked why....
Comment for instructors: this questions leads to the realization that the actual distribution of organisms is much narrower than the potential distribution (or niche if you choose to use that term). Have students consider what factors might limit the distribution of a plant or animal and how they would test that.

Comments on Q4. Ecology texts are often divided into sections called....
Comment for instructors: this might be a good review question towards the end of the semester. It is important for students to recognize that the types of question an ecologist asks depends on the type of topics that interest them.

Comments on Q5. Suppose you noticed a typically northern tree....
Comment for instructors: again you are looking for sound scientific thinking and so strong answers would include: I would see where else hemlocks are found on the south slope and measure their abundance. I would look to see if anything was different about the places where hemlocks were growing, come up with a hypothesis based on those observations, and then test the hypothesis with field studies.

Comments on Q6. Consider a totally different ecological situation where zonation....
Comment for instructors: This could be a class-wide activity in which you discuss other locations where zonation is clearly evident. For example, seaweeds and invertebrates are sometimes found in distinct zones on rocks in the intertidal or wetland plants are often sharply zoned. Show slides of these places and have students first describe the patterns they see and then develop ideas as to why these patterns exist. Have them design experiments to test their assumptions and ideas.

Additional discussion questions to use in your class:

1. Locate a data set comparing ecological communities among different habitat types from previous student projects or published data from one of the references for this lab or from some other source. Show and discuss data. For instance, show the air column temperature data the students collected and ask them to predict what the soil temperature profile might look like. Xerox temperature data from a relevant research paper and ask students to discuss how they might use this information in their own papers. Propose that the abundance of tree species X is related to soil moisture, and ask students to draw figures that describe this relationship.

2. Community vs "other" ecologies: This study concerns some classic aspects of community ecology including measures of relative abundance and diversity and their physical-chemical correlates, the role of disturbance in community structure, and gradients. However, depending on your personal interests and when during the course you do this lab, you can also emphasize other aspects of ecology that typically are found in chapters called "organisms in their physical-chemical environment" (adaptations, abundance as a function of soil moisture). Population ecology also could be emphasized such as age distribution of trees. This points out of course the artificial separation of these "ecologies" in our textbooks. It is important that you clearly think through the focus of your particular study and explain this very clearly to the students. I use this as an opportunity for then to practice "thinking like" ecologists with differing interests.

3. Trained ecologists would quickly recognize the important of disturbance (in our location primarily hurricanes) in this field site, but most students are slow to see disturbance as critical. Instead of telling them about hurricanes, I hope for the "ah-ha" by giving them reference material for their research papers that includes data about New England hurricanes. I also lead a discussion in class about the role of disturbance in other communities such as fire out west or wrack in salt marshes. After the students hand in their papers, I ask them to talk about what disturbances might be important in out study and the evidence they would look for. This also leads us to discussion of the role of humans in New England forests, including native Americans and also settlers who lived here in the 1700 and 1800's and cut down the forests for pasture and firewood. To enrich this topic, I often bring students to a local museum at the Harvard Forest in Petersham, MA, where there is a wonderful diorama depicting a New England forest from pilgrim times on and dramatic photos of hurricanes.

4. The students in my class are freshmen and sophomores and so they are just taking or haven't yet had a statistics course. For this study I set up the excel spreadsheet so that they can very easily do chi-square analyses of their tree data and we talk in lab about what these numbers mean. In my experience, most students fairly quickly understand the definition of "significance" sufficiently to use these data in their papers.

ASSESSMENT OF STUDENT LEARNING OUTCOMES.

Student assessment is based mainly on the quality of the research paper as outlined in the "report format" section - Description: Tools for Assessment of Student Learning Outcomes. Effectiveness of students as group members and leaders is also important in this class and is noted in a written summary by me at the end of the semester of each student's performance in my course.

FORMATIVE EVALUATION OF THIS EXPERIMENT.

Please examine the specific suggestions for evaluation tools that are in the "Description: Tools for Formative Evaluation" page.

In addition, extensive notes on how to conduct a formative evaluation are in the Teaching Resources sector of TIEE under the keyword "Formative Evaluation."

TRANSLATING THE ACTIVITY TO OTHER SCALES.

This lab should provide a useful model for any ecology lab faculty to adapt and use to study the effects of locally accessible major environmental gradients on organisms and communities. This activity would be amenable to any field situation where contrasting environments and communities of organisms exist in close proximity (e.g. for vegetation in dry/wet fields, young/older forest, grazed/ungrazed or mowed/unmowed fields, polluted/less polluted wetland). In the Synopsis I list several www sites concerning sampling plants in other habitats. However, avoid the temptation to compare x area to y area "just because it is there". The project must be based on interesting and important ecological concepts.

Reading research papers is difficult in large classes. Here, students could do posters instead of writing papers (for an example rubric see www.rickhershberger.com/bioactivesite/library/writingcenter/).

CREDITS AND DISCLAIMERS

CREDITS FOR THIS EXPERIMENT:

This submission was greatly improved by comments from anonymous reviewers.

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.

Lastly, we request that you return your students' and your comments on this activity to Susan Musante (smusante@aol.com), Managing Editor for TIEE, for posting at this site.