

Ecosystem Exercises for Summer School and Distance Students

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Students use non-destructive sampling to examine simulated “ponds” that can be maintained easily on desktops for a week. Students are exposed to a variety of algae and invertebrate species, in which, they observe locomotion and feeding. In distance education sections, students go on a virtual tour by opening an interactive forest panorama from the Internet. As they turn 360° within the panorama, hot spots are found which contain video clips of organisms living there. Students construct a productivity pyramid that places each organism at the appropriate trophic level. This exercise can also be used as homework in the campus-based course.

Keywords: ecosystem exercises, desktop mini ponds, interactive panorama, virtual tour of forest

Introduction

The workshop introduced the way we treat invertebrate diversity, basic ecological relationships and ecosystems in the laboratory component of our seated and on-line sections of Introductory Biology. Our invertebrate diversity laboratory introduces nine phyla (major animal clades) and includes living representatives, as well as, appropriate preserved and slide material for each phylum. Students are assigned a task for each phylum or major clade that focuses on observable structure or behavior so that they have to apply lecture material as they examine specimens. For example, for arthropods, they look at three living crustaceans and determine how they differ with respect to how segments are consolidated as functional units (tagmenization) and how different appendages are used in locomotion. They then compare tagmenization in other arthropods available as preserved specimens.

Following this laboratory is an exercise on “ecosystems” (Exercise A in Student Outline) where one of their activities involves nondestructive sampling from an artificial pond in which they place species found in “trophic” levels. Students are somewhat amazed that they can place most specimens found, even those they have not seen before, into major invertebrate clades or phyla. This exercise also introduces

them to the common “protists” found in ponds and so allows them to apply what they have learned previously about using keys. Our on-line introduction to invertebrates is comparable, although students work with photographs and videos of invertebrates.

In our on-line course (Exercise B in Student Outline), students work with a forest panorama as part of their ecosystems laboratory to identify typical inhabitants, learn more about them, and place them in appropriate trophic levels. This could serve as a valuable review or homework resource for any course. As in our seated laboratories, students are asked to apply previous knowledge obtained via the on-line website and other previous laboratory activities. To support these exercises, students in some sections (both seated and on-line) are asked to work with *Extinction 2*, a game-like program that introduces them to the species relationships of competition and predation as species. Students assume the identity of fictitious species with computer generated genetic profiles that include important characteristics such as type of reproduction, motility, and predator defenses; then they analyze the struggle for the species to exist on an island divided into a series of habitats in which all are not favorable for a particular species.

Student Outline

Exercise A. The In-class Summer Lab

Background

1. Most summer school classes at North Carolina State University are five weeks long. The current schedule only allows nine instead of the twelve laboratory periods offered during the Fall term. To add insult to injury, the time periods available for laboratories are shorter in summer. To compensate for this, we redesigned the scientific method and the systems ecology exercises so that they could be completed during one period. During the regular academic year, these exercises take several periods to complete. In the ecology laboratory, for example, students collect samples one week to be analyzed the second week.
2. Samples collected from available lakes in the summer yield data that are conflicting and confusing to students. Lake levels are low and turnover among layers is high. Students are just as likely to find photosynthetic organisms in the lowest lake level sampled as in the highest lake level sampled.
3. Because of the nature of collection, the focus is on protists. Students make slides of small volume samples of a larger aerated sample kept in a small aquarium. Although students experience collecting these samples, in truth the samples which are analyzed have to be re-collected by staff, because they cannot be maintained for more than a day or two on our bench top. Part of the maintenance problem stems from the differences in temperature, light, and nutrients in the lake compared to our aquaria.

The Summer Solution

We have redesigned the exercises using simulated ponds, flasks with aerators, (Fig. 1) that students examine quickly using gridded petri dishes and non-destructive sampling. One of the major topics covered by the course is biodiversity and our simulated ponds brim with algae and invertebrates that the students have been introduced to in previous laboratories. They have rated this laboratory as their favorite, mainly because they can use the knowledge to identify organisms and, even better, recognize organisms related to others observed in other laboratories. The ecology laboratory has always been a favorite but many students rate it high because they get to go out in the field. We are very pleased that students now are rating it as high because of what they learn from it.

Non-destructive sampling allows each pair of students to examine many different samples. Students are exposed to a greater variety and quantity of organisms (from small unicells to small crustaceans) than observed in the lake samples. These lake samples were “simulated” by staff that re-collected samples the day before second laboratories met. Students simply pour a sample from our flasks or “ponds” into a petri dish and examine the petri dish under the highest power available for their stereoscopes. We replace the top of a typical petri dish with a gridded bottom of a square dish (Fig. 2). The grids allow students to quickly and systematically move through the sample. Our small flasks maintain good cultures for a week as long as prey is replenished for the more active predators and students get to observe several incidences of feeding by various organisms.

This exercise is very open-ended and although all sections build trophic level pyramids, some sections spend more time on comparing the type of inhabitants found in the “pond” to a leaf litter sample also available. Leaf litter samples are kept in



Figure 1. Simulated pond setup. Aeration is crucial to success, but keep bubbling to a minimum so that only a small portion of the surface (see arrows) is disturbed.

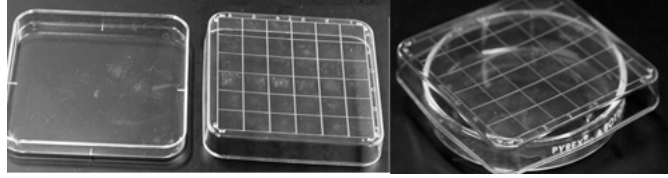


Figure 2. Petri dishes with grid. Grid is on bottom but we use it to top our round petri dishes. Carolina Biological catalog number 74-1470. I have not found these offered for sale anywhere else.

plastic bags that also have grids drawn on them. Other groups spend more time comparing their results for the pond to results from other groups. These comparisons often lead to a discussion of the influence of sample size, random founder effects, etc. Some groups have focused on the behavior they can observe. Their discussions focus on adaptations of prey and predators found in the ponds.

Materials - Live specimens

I usually order two cultures of most organisms. I use one culture to start six ponds, and the other as a reserve, so teaching assistants can replenish organisms as needed. The live specimens for this exercise are listed in Table 1. Catalog numbers listed are from Carolina Biological Supply which is close to our university, but I have ordered the same material for my invertebrate zoology class from Wards, and had the same success with their cultures.

I pour one sixth of a culture jar into each “pond” at prep time. Teaching instructors examine the “ponds” before each class and add a few mLs of protist cultures if they need liquid, and larger organisms if they cannot see many organisms moving about in the “pond”. Petri dishes can be rinsed with spring water between sections. If you feel that you need more unicellulars, you can add a pinch, a very small pinch, of *Spirulina* to cultures or “pond”. Do not add *Spirulina* more than once and again, add an almost microscopic pinch. *Spirulina* should be available in most fish stores. I have one small bottle that I have had for five years that I use to start *Daphnia* colonies. I use one pinch and place the starting culture in a sunny window. I have maintained *Daphnia* colonies for years, without adding more *Spirulina*.

Additional supplies for this exercise are illustrated in Figs. 3 and 4.

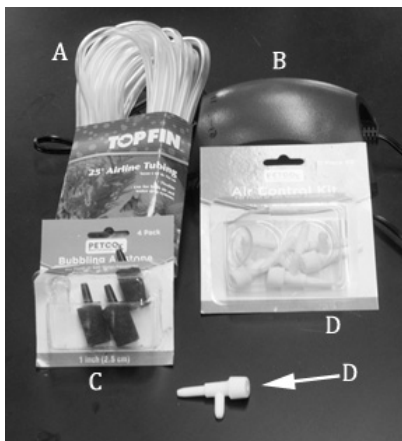


Figure 3. Supplies needed. A. Tubing. B. Small pump. C. Air stones. D. Valves to control aeration are crucial

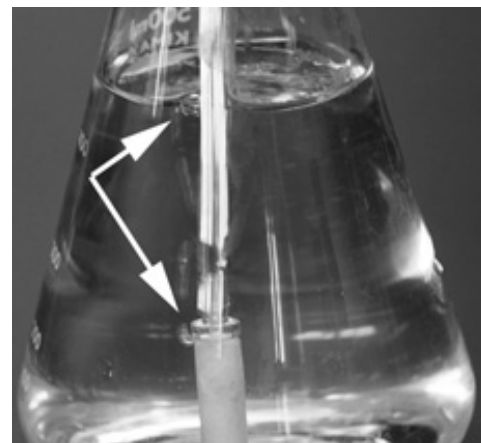


Figure 4. Aeration is needed but must be kept to a minimum.

Table 1. Live specimens added to mini ponds.

Specimen	Catalog #
Hydra	13-2810
Mixed crustaceans	14-2350
Flagellate set	13-1050
Sarcodina set	13-1030
Ciliate set	13-1040
<i>Aelosoma</i> , freshwater annelid	14-1748
<i>Dero</i> , freshwater annelid	14-1748
Left over from other labs if viable.	
<i>Lumbriculus</i> (Only a few or they will foul pond.)	14-1720
Amphipods	14-2355
Copepods	14-2365
<i>Daphnia magna</i>	14-2360
Amphipods	14-2355
<i>Volvox</i>	13-1860
<i>Stentor</i>	13-1598
<i>Eloдея</i>	16-2102
<i>Blepharisma</i>	13-1430
<i>Bursaria</i>	13-1434
<i>Stentor</i>	13-1598
<i>Eloдея</i> (Only a small amount or it will foul sample.)	16-2102
Planaria (Only a few or they will eat everything.)	13-2950
Snails (Only if have very small specimens and then only one or so per pond.)	From our fish tanks
<i>Micrasterias</i>	15-2345
Rotifers (If I feel ambitious, I collect soil sample containing eggs. Add spring water to a beaker. Aerate, low bubbling only. Add a pinch or two of dirt. Can add a pinch of Spirulina when rotifers start to hatch. Should have rotifers within 24-48 hours.)	

References

Our students use keys from other laboratory exercises but listed are some websites they use to confirm their identifications.

<http://www.microscopy-uk.org.uk/index.html?http://www.microscopy-uk.org.uk/pond/index.html>

<http://www.microscopy-uk.org.uk/index.html?http://www.microscopy-uk.org.uk/ponddip/index.html>

<http://www.microscopyu.com/moviegallery/pondscum/>

Life in the leaf litter <http://cbc.amnh.org/center/pubs/pubscbcinverts.php?npid=8>

A handout and other information regarding this laboratory is available from the author (mnfeaver@unity.ncsu.edu)

and at <http://www.ncsu.edu/project/interactivebiology/>

Part B. The Virtual Field Trip

Background

It is especially difficult to provide a field-oriented experience by distance education. Our approach allows students to “discover” a variety of plants and animals, including microscopic forms, residing in the appropriate microhabitat or strata of the forest. The panorama was photographed in a forest near Raleigh, and most organisms were videographed there. Microscopic or very small organisms were collected from the forest and brought to our laboratory for video microscopy. A comparable opportunity to view a variety of living organisms in their natural habitat is not available to the campus-based students due to lack of laboratory time, cost of transport, and potential destruction of forest habitats by the huge number of students enrolled in Introductory Biology (1,400 per year).

The forest panorama

To create the forest panorama, we used a parabolic mirror mounted on a digital camera. This allowed a 360° image to be captured with a single camera shot. The resulting image was “unwrapped” and imported into software designed to create a panoramic Flash™ object (Pano2VR 3.0™, Garden Gnome Software). While in the forest, we also videographed close-up regions of ten areas within view of the panoramic image. Samples from some areas, such as water from a tree hole and leaf litter, were collected and videographed in the laboratory using a stereomicroscope equipped with a digital camcorder. When on campus, we downloaded the video into a Macintosh computer and exported it as Quicktime™ movies that were later changed to Flash™ video. Several undergraduate biology majors assisted in videomicroscopy, downloading, and editing of the video. We added audio narration to the video clips of areas within the panorama and embedded all video clips on HTML pages. In the final step of creating an interactive learning object, we linked these pages to hotspots in the panoramic image and linked additional video clips of animals to the pages. The final product can be viewed from a CD, computer hard drive, or via the internet.

The panoramic vista is opened from a web page (using the Flash™ player). The user can then rotate around the horizon by using the mouse to move the cursor to the left or right, depending on the direction of movement desired, or by using arrow keys on the keyboard. The entire horizon can be scanned over 360°, and multiple circuits can be achieved in a seamless fashion. Hotspots appear when passed over by the cursor; the cursor changes shape and the hotspot name appears (Fig.5).

Any hotspot can be selected by clicking on it. A video emerges that shows a close-up of that region of the environment. The video is accompanied by audio narration that identifies the animals portrayed and informs about their habits, ecology and various bits of interesting information. In most of these videos, additional organisms can be accessed by clicking their names which are listed beneath the video. This brings up additional video clips, but without audio narration (Fig. 6). There are 10 hotspots and a total of 29 organisms in the panorama, as listed in Table 2.

The introduction to on-line laboratory work includes a description of forest stratification in which students learn about forest levels and representative organisms that live at each level. Students then enter the forest panorama and explore the various levels to discover a variety of plants and animals. As an organism is discovered, students are asked to place it in the appropriate forest stratum using a table downloaded from the course website in which the strata are: subterranean level (soil), ground layer, herb layer, shrub layer, sapling layer (includes tree hole), and canopy. Students then use the same organisms to construct a productivity pyramid. They have learned about such pyramids in the lecture portion of the course and are now asked to show their understanding of trophic levels by filling out the image of a pyramid downloaded from the course website (Fig. 7).



Figure 5. A view from the forest panorama showing one hotspot

Table 2. Hotspot regions in the forest panorma and organisms found in the hotspot videos.

Hotspot regions	Organisms in hotspot video	Additional organisms	
Soil around tree roots	Isopods	Beetles	
Large log	Blue-tailed skink		
	Millipede		
Under a rock	Millipede		
Leaf litter	Copperhead	Toads	
		Beetle	
		Centipede	
		Spider	
		Mite	
Ferns	Fern fronds	Fern sporangia	
Rotten wood	Salamander	Ants carrying larvae	
		termites	Spider
			Centipede
Moss	Moss plants	Springtail	
		Daddy longlegs	
		Rotifer	
		Tardigrade	
Pine log	Flies mating		
Wet tree hole	Instructor collecting water	Mosquito larva	
		Caddis fly larva	
		Nematode	
Canopy	Gray squirrel	Nuthatch	
		Woodpecker	



Figure 6. Video of the panorama showing an instructor collecting water from a tree hole. Clicking on mosquito larvae opens a new video showing a larva found in the water.

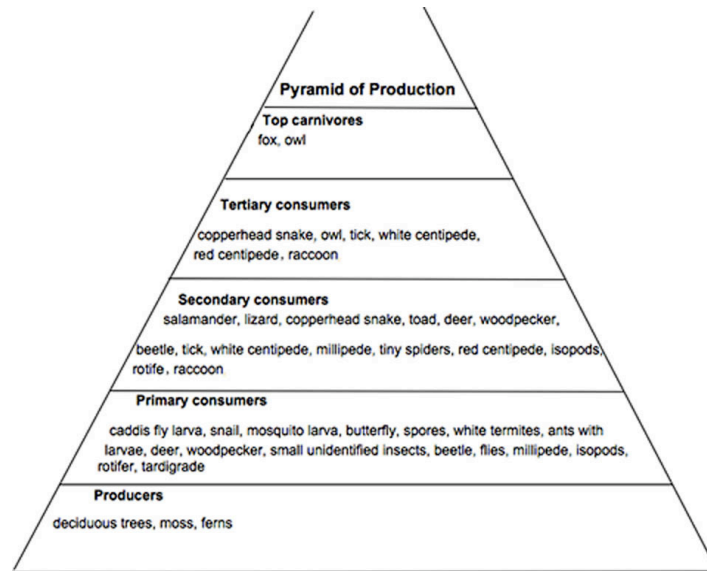


Figure 7. Productivity pyramid filled out by a student and submitted for grading. Students must determine which of the organisms discovered in the forest panorama are producers or several different levels of consumers.

We encourage faculty to utilize the panorama and modify as desired. To facilitate a variety of uses, the images and videos of organisms are embedded on separate web pages that are linked to hot spots within the panorama. This allows the contents of each hot spot to be edited or customized by deleting organisms and/or adding new ones from an instructor's own inventory of images and video clips. The panorama may be viewed at:

http://www.ncsu.edu/project/bio181de/forest_panorama/forest_360.html

and the entire on-line exercise (including the Extinction game) at

<http://www.ncsu.edu/project/bio181de/Lab/ecosystems/ecosystems1.html>.

Instructors who wish to modify the panorama will need the linked files. A CD containing the entire Forest Panorama package and directions for modifying the content may be obtained free of charge by contacting the author (blblack@ncsu.edu).

Notes for the Instructor

Non-Majors Course:

Introductory level general biology course – Biodiversity lab:

In the biodiversity lab, students learn what a dichotomous key is, how it is constructed, and how to use a key to identify a specimen. Once those exercises are completed, the students are asked to use the Vernier LabQuest with the temperature probe and GPS activated when finding an insect (and/or plant sample) to bring back to class for identification during a short field trip on campus. Students are made aware of this outdoor field trip beforehand, so that they dress in appropriate clothing (shoes, hats, etc.) and take whatever other appropriate precautions they personally need to take to be outside (sunscreen, allergy medication, etc.) for 30 – 45 minutes on that day. The students are given instruction on how to use the LabQuest using the LabQuest Emulator Software (www.vernier.com/products/software/labquest-emulator) and given brief written instructions as a reminder.

Students are supplied with:

- Insect net
- Collection vials
- Vernier LabQuest with probe and GPs along with instruction for using it
- Instructions on collecting specimens
- Forceps

Students supply:

- Notebook
- Writing utensil
- Optional camera
- Items necessary for them to be outdoors for 30 to 45 minutes in the specific climate on that day

The students will work in pairs to collect specimens, one specimen per person. The students are to note the environment in which they find their specimen (shady, full sun, wet, dry, pond, etc.) and what activity the specimen may be engaged in at the time of collection.

Estimate travel time for going to and coming back from your collection site(s) into the time needed for this part of the lab. Avoid lawns and other cultivated areas. If a stream is nearby, that will provide a more varied environment in which to collect specimens. Go to the site(s) you are considering beforehand to be sure it is suitable for your purposes and to test the equipment used in the field. If there is not a good area near to the classroom to take students to by walking, here are a couple of suggestions:

1. If the group is small enough and you are able to obtain transportation and proper permissions, take the students to an area that is in a more natural state.
2. If you have enough equipment, check out equipment to the students and provide them with instructions for its use and how to collect specimens. Have them come to the next class with the equipment and specimens.

Tips on collecting and preserving insects:

Have container with a lid, e.g. a jar. Use the jar to trap the insect, slide a piece of paper under the jar, and then carefully put on a lid. An alternate version is to use an insect net and then transfer what you catch into a jar.

Place the closed jar in the freezer until the insect is dead, and then with a pair of tweezers carefully place the insect inside of the ethanol vial or in a larger container if needed.

Where to find insects:

A way to attract nocturnal insects (especially moths) is to set up a light trap. A simple light trap is made by hanging a white sheet, or find a white wall, and project either a regular light (or a blacklight) onto it. The best areas are sites near natural vegetation and away from city lights. Either hang out to watch or come back in an hour or two.

Build a simple funnel trap with a piece of paper rolled into a cone, and placed into a jar containing something that has a strong smell. Insects (especially flies) will fly in, but not be able to escape.

Take a piece of cardboard, put it under a bush or tree limb and shake the foliage, collect herbivorous insects (or their predators) that fall off (grasshoppers, lady bugs, stinkbugs).

Look under rocks, decaying leaves, or break apart rotten wood (beetles).

Visit a flowering plant and collect a pollinator (bees, flies, butterflies) or a pond or stream with a small net (such as those used for aquaria) and see if you can collect a mature aquatic insect (e.g. a water strider)

Place out bait, such as something sweet, or something rich in protein/fat such as raw meat, on the ground (ants, wasps). Check back later see what has come along.

Introductory Majors Course:

Much of this activity can be tailored to any course. It has been utilized to bring students into a natural environment to see the organisms studied in lab, but in their natural setting. Students apply the knowledge learned in class to answer question concerning why the organisms are found where they are. We ask students to think about the adaptations of various lineages of organisms, and also to key out the organisms they find.

The first decision to make is on a location. A natural prairie, wetland, or other undisturbed area is best, though any space with diverse flora and fauna may be used. The types of organisms that you wish the students to find can be tailored to your course.

After you have a location, you will want to test the data collection devices you are using in that location. It has been helpful to do some preliminary collection, prior to sending students out. You will then know the approximate locations of the various organisms and may assist students during the activity. The devices used in this mini are the Vernier LabQuest (I and II). For training students or TAs on the use of the devices there is a free emulator program described in the links following.

For the major students, we bring along a number of relevant dichotomous keys to assist the students in identifying the specimens they find. Applicable keys will depend upon your region. Some general keys we utilize are from the “How to Know” Series. Many are out of print but can be bought cheaply on Amazon.com

Students need to be provided with a GPS enabled data collection device (Vernier LabQuest). Some other items we use to promote student activity are nets, capture containers, binoculars, bug spray. Remind students to dress appropriately, and warn them of any dangerous organisms, poison ivy, etc. Water bottles might also be a necessity if traveling off campus.

Upon returning from the field all of the student data can be pulled from the LabQuest devices and analyzed within the Vernier software. The software can be attained free of charge (Logger Lite), or a paid version (Logger Pro) can be purchased for \$189.00. Once a copy of the software is purchased, anyone in your institution who would like may copy and use it. Multiple copies do not need to be purchased. Within this software you can export all your data points into a Google Earth view to see exactly where each of the organisms was found. This will assist students with answering why they found the organisms where they found them. If this activity is being done in an upper level course it would be recommended that students be brought back to the field after designing experimental procedures utilizing the various Vernier sensors to test their hypotheses about why they found specific organisms where they found them.

Important Links:

Vernier: www.vernier.com

Logger Software: www.vernier.com/products/software/

LabQuest2: www.vernier.com/products/interfaces/labq2/?lq2-home

Emulator Software: www.vernier.com/products/software/labquest-emulator/

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About the Authors

Marianne Niedzlek-Feaver received her Ph.D. from the University of Michigan. As an evolutionary ecologist, she is interested in identifying factors that shape the mating systems of grasshoppers and katydid. She currently teaches Evolution, Darwinian Medicine, Invertebrate Zoology, Parasitology (distance course) and Introductory Biology courses. She has received various grants to improve the laboratory and active learning classroom experience, or develop interactive on line teaching resources, has published in these areas, and is a member of the NCSU Academy of Outstanding Teachers.

Betty L Black received her Ph.D. from Washington University (St. Louis) and has pursued research on development of embryonic and post-natal intestine. She currently teaches a course in Developmental Anatomy of the Vertebrates, plus distance education courses in Introductory Biology, Histology, and Animal Diversity. She has received two University awards for “Innovative Excellence in Teaching and Learning with Technology” and has 18 publications on teaching technology topics.

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