Curriculum Units by Fellows of the Yale-New Haven Teachers Institute
2005 Volume V: Ecology and Biodiversity Conservation

Species Diversity in Ecosystems with Different Techniques of Land Management

Curriculum Unit 05.05.07
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Goals and Objectives

By the end of this unit students will

1 Be able to name and classify organism commonly found in the New Haven geographic area.

2 Identify the major components of plant and animal anatomy.

3 Be able to organize organisms into tropic levels.

4 Recognize organisms as parts of complex natural systems such as food webs.

5 Write a detailed laboratory report on their experiments and field work.

6 Be able to read for scientific content from a variety of media.

7 Be able to analyze data using basic mathematical tools.

8 Write about several ways to interact positively with their young children.

9 Discover something interesting in the natural world.

Introduction

This curriculum unit will explore species diversity in a number of different ecosystems. The ecosystems will be differentiated according to the amount of land management being practiced on them by humans. So, for example, a city park with swings, paved paths, and a soccer field would be considered one ecosystem while a state park in the same area with unpaved walking trails and open meadows would be considered a different

ecosystem.

In this unit ecosystems are used as a way to study many related topics. Classification and taxonomy are essential for identification of organisms found in any ecosystem. Statistics and other mathematical tools also fit well into this curriculum unit as it is impossible to count every organism within the large areas we will study. Reading for content will be necessary to obtain information about the different ecosystems we will study in this unit. Strictly speaking, statistics and reading skills are not the purview of most science departments, but without the math and language backgrounds provided by these two activities, the observations made by the students are useless. So, there will be scientific topics covered in this unit as well as many topics typically covered in other classes.

At the end of this curriculum there is a collection of educational strategies for teaching various parts of this unit as well as a list of resources to help teach the unit. One of the more important resources is the list of books containing background for teachers. The book, Last child in the Wood by Richard Louv discusses the importance of allowing children to explore the world outside of the boxes, house, school bus, car, school room, sports field, in which we spend most of our lives. He advances some interesting theories about the connection between a lack of outdoor education and the prevalence of mental health diseases that seem to be becoming more common in children. While I'm not entirely sure that I agree with his analysis of the mental health improvements to be gained by outdoor education, he certainly makes some good arguments for getting children outside and allowing children the time that they need to absorb what they experience outside. Reading the Mountains of Home and Reading the Forested Landscape are similar to each other in topic, but they are written in very different styles. They both address the changes that appear in the landscape as different economic times demand different uses of the land. Both provide interesting insights into why we various organisms in their present locations. For example, they might answer the puzzle of why there are a large number of apple trees growing in what appears to be a common New England forest lot. Both books are useful when considering what organisms to expect in a given environment. And, both provide an interesting commentary on the ways that humans transform the world to suit our own need. The Earth Moved is a fascinating look at the earth worms. It goes into great detail about the different varieties currently found in the United States as well as a few interesting varieties in other parts of the world. It gives some of the best advice on vermicomposting (composting using worms) that I have found anywhere. It is a wonderful resource to have for addressing decomposition, a part of the food web that is so often left out of basic biology text books. Finally, Changes in the Land is useful in a few contexts. It is a good source of excerpts for students who are at home or unable to attend field trips because it contains many descriptions of the New England landscape as the land use practices have changed over time. In particular, this book contains many descriptions of the land before Europeans started using it heavily, which are difficult to find. Furthermore, William Cronon details some of the pitfalls inherent in using the sources he quotes. His caveats are useful reminders that the landscape descriptions usually were not written for the purpose of aiding later ecologists.

Students

I teach all of the science classes at the Polly T. McCabe Center. Our school is a transitional high school in the New Haven public school system, but our enrollment is limited to pregnant students and new mothers. The school was founded in an era before abortion was legal, when pregnant girls tended to disappear from school, frequently never to be seen again. The school's founders did not think that being pregnant ought to be a

reason to quit school. Today our mission remains the same as it was then. Our core mission is to help the girls have a healthy pregnancy and childbirth while continuing their education in standard high school subjects.

Our motto at Polly McCabe is "Educated Mothers; Healthy Babies", which is why I would like a significant component of this unit to be teaching the girls about nurturing their children. While nurturing your offspring may seem self-evident, almost instinctual, it can be less instinctive in our population of young mothers. Many of our students did not live in a nurturing environment growing up and, therefore, do not always know what a nurturing environment is. Additionally, all of our young mothers are teenagers which is a difficult time emotionally even without the added complication of a newborn infant. When the occasional post-partum depression is added in, it is easy to see why so many of our students sometimes need help learning to nurture their offspring. So, one of my objectives in this curriculum unit is to teach our students how to interact in a positive way with their children while regaining some of their own natural wonder about the world. A significant number of the activities in this unit will be similar to activities that they can do with their children prior to their child's entry into kindergarten. This will introduce an early childhood component to this unit.

As I stated earlier, our mission at Polly McCabe has two parts. The second is to help our students be good mothers; the first is to help our students be good students. So, about two thirds of this unit will be about the ecology that is part of the standard high school curriculum. Because of the nature of our student population, it is frequently the case that one or more students in a particular class may be legitimately out of school for several weeks; additionally, we continue receiving new students all year, on average one every week and a half. So, it is imperative that the curriculum be written in a way such that students can do large parts of it on their own either catching up or on bed rest. Because of the continual variability of the class population, I find it more efficient to present whole units as one project or lab to be completed in stages. In this way, all of the students know where they are going and can work at a pace which suits their ability and energy level on any given day. Furthermore, because we take all pregnant students, our classes, especially in science, are more fully integrated than many elsewhere. By giving a set of tasks to be completed, I can more easily adjust things like the reading level of texts to challenge each student, while teaching all students the same topic.

Finally, the nature of our student body requires that field trips be planned more carefully than in many other schools. Destinations must be within a short bus ride from school or bathroom breaks will be required. Locations must have bathroom facilities available to our students and must be readily accessible to medical care if necessary. At the same time, though, our student population is a single sex one which leads to a different, less competitive, dynamic than typically found in a coeducational classroom. And, although class sizes change on a frequent basis, the classes are rarely very large, so field trips to sensitive areas can be accommodated more easily.

Prior Knowledge

There are several skills that the students will need to be able to successfully complete this curriculum unit. In my experience, my students rarely have any of them. This section of the curriculum is designed to give the students the skills they need to complete the rest of the unit.

The primary skill the students will need to complete this curriculum is identification of organisms. This section of the unit applies to New Haven Science Standard 3.3e. In my experience, my students typically have trouble

identifying something as common as a dandelion or telling the difference between an oak leaf and a maple leaf. As a result, we will start with the basics. A good approach to this is to ask the students to think about how they might teach their child to identify different leaf shapes. For example, some leaves will look mostly triangular while others will look more circular. If a student is thinking about how her young child will learn the different shapes, she will also learn them herself.

Most of the organisms we will identify will be plants; they do not move around the way animals do, so they will not flee at approaching scientist. So, one of the first things we will look at is the way that plants are structured. In other words, we identify roots, shoots, leaves, twigs, buds, etc. Much of this is simply a vocabulary lesson. But, it is generally necessary because my English speaking students rarely have been taught the different parts of the plant and my non-English speaking students do not always know the English words for the plant anatomy. We will also look at the difference between alternate leave and opposite leaves, compound leaves and simple leaves, and other basic plant terms. Some of the plant identification books are organized according to leaf type, so this sort of introduction is especially useful. If the weather cooperates, we will take the plant identification books outside and practice on the trees out in the park across the street. We are gifted with a very wide variety of trees in the park that are frequently found in the woods around New Haven, so identifying them is very good practice. This section of the unit addresses New Haven Science Standard 1.2a.

After plants, the most common organisms likely to be encountered are birds. We will look into basic aviary anatomy. The students need be able to quickly identify a bird by its body size, tail shape, plumage color, beak shape, and other similar readily visible features.

Another skill that the students will need is the ability to put an organism into the proper biological family. Not only is this in support of New Haven science performance standard 3.3e, but it is also important for the students who expect to continue with their biological education beyond high school. So, we will look at the hierarchy of organisms living here on Earth. We will look most specifically at the plant kingdom and at the plants we are most likely to encounter in the local ecosystems we will study. Studying the way that the plants are related will likely help the students remember the names of the plants more easily. Furthermore, the students in class are going to need to include the scientific names of many local plants in their work later in the unit.

Similar to organizing organisms into biological hierarchies, students need to be able to organize organisms into trophic levels. This addresses the New Haven Science Standard 1.2a. All ecosystems have various trophic levels and every organism has a place in one of the trophic levels. An exercise that I like to do with the students is to take them outside with a clip board and have them organize all of the organisms they see into different trophic levels. It is amazing how much can be seen even in a city park. Abandoned, overgrown lots work really well for this, too.

The last piece of essential prior knowledge we will cover is some basic statistics. Because we will be extrapolating results from data obtained from small sample plots, it is important to understand the tools needed to make sense of the data collected. So, we will look at terms like mean, median, bell curve, etc; all of which addresses New Haven Science Standard 1.2d. We will also look at the way that data analysis and skew the results in one direction or another. This topic ties into an ongoing theme for my classes which is making decisions. Much of the data reported on TV or in the news is created by persons who have been paid to make the data appear to support one idea or another. By looking at some of the extreme ways that data can be manipulated, I hope to encourage my students to more carefully consider the information they hear and read.

Generating Expectations

Later in this unit students will explore the relationship between human land management techniques and species diversity. To study this relationship, students will take trips to several different ecosystems and do biodiversity studies. However, before the students take the trips, they need to generate a list of species that they expect to see. This will help them to more quickly identify many of the organisms they will encounter on the trips.

As mentioned earlier, many of my students are legitimately absent for several weeks at a time. They will, therefore, need slightly different lessons than the students who can be expected to attend classes regularly. In this section, you will find two different sets of plans, one for students in school and one for students at home.

The goal of this section of the curriculum unit is the same for both groups of students, those at home and those at school. At this point in the curriculum unit the students will prepare a list of organisms that can be expected to live in the different ecosystems they will study. The students will be expected to list the organisms by local common name and possibly by scientific name. They will also list the type of habitat where they might expect to see the organisms.

In Class

Most of my students on any given day are in class. So the majority of my students will go through this section of the curriculum unit.

Peabody Museum

There are two things that I hope to get out of a full day trip to the Peabody museum. First, the museum has an extensive collection of preserved plants and animals. I would like to have the staff give the girls some ideas about what they might see in the local ecosystems. While I realize that preserved plants are hard to picture three dimensionally, my hope is that the staff at the museum will be able to give the students some tips on differentiating similar species and identifying some of the more common local species. Additionally, it is far easier to observe a stuffed bird than one that is flitting about the tree tops. Again, I hope that the staff at the museum will be able to show the students some simple ways to differentiate similar common species of birds and other local animals.

The second task for the students at the museum is related to their pregnancies. Their task is to choose two exhibits that they would like to bring their child to come see. They will write about why they chose their exhibits and explain how they think their child will benefit from the exhibits. Many of my students have never been to the Peabody museum outside of occasional school trips, which is a shame because it has so much to offer and is free on Thursday afternoons.

Beardsley Zoo

The Beardsley Zoo has an interesting program where they will bring small animals to classrooms. Outside of Bridgeport they will charge for the mileage they have to drive, but otherwise the service is free. Ordinarily, I would be inclined to bring the students to the zoo, but having the zoo come to us is an amazingly convenient option for my students for several reasons. First, it is very expensive to get a bus to anyplace outside the city limits, and, second, there are time limitations which make trips outside the city difficult. However, since the

zoo is willing to come to my classroom it opens up huge new possibilities. I would like the students to see some of the animals they may encounter in some to the ecosystems. The zoo staff will be able to explain the habits of the animals they bring and will be able to give some advice about where the students might expect to see the animals. The students, of course, will be able to see the animals up close and learn to identify them.

In addition to seeing the animals, the students will again write about what they would like to see at the zoo with their children. Bridgeport is not very far and the zoo admission is very reasonable.

At Home

All of my students at some point in time will have legitimate reasons for not being in school. Sometimes these absences are for very long periods of time. In other cases the absences are as little as two weeks after the delivery of the baby. However, because every student may be absent at some time, this section of the unit can be used in part or its entirety as the particular case dictates.

Students who are homebound will unfortunately miss out on the trip to the Peabody museum and the visit from the Beardsley zoo. They will, however, be able to carry out similar tasks to those of their class mates. They will read excerpts from several different text books about several different habitats. From these readings students will be expected to identify organisms that exist in different trophic levels of each ecosystem. The students will also be expected to discuss how much human land management they would expect to find in a typical example of each of the ecosystems they read about.

The reading level of each of the text excerpts can be carefully tailored to the reading ability of each student. Some of the texts can even be offered in Spanish for those students who are new arrivals and have yet to learn English well enough to express themselves.

Tying the expectations and prior knowledge together

The students will each select an organism from the New England forest to study. For my homebound students may be an extra credit assignment because of the difficulty of getting research materials. However, the students who will be in class will be required to find an image of the animal a write a one page piece about the organism's habits and how they fit into the forest ecosystem. The students will choose their organisms before we go to the museum and have the zoo visit so that they can collect information from the activities. The animal pictures and papers will go onto a wall organized according to tropic level with string connecting the different organisms into a food web. This section of the unit addresses several New Haven Science Standards, 3.6b, 3.4b, and 1.2a.

Into the Woods

By the time the students get to this phase of the unit, they should have a fairly good idea of what they can expect to find in many local ecosystems. The will have their lists of organisms and students in class will be fairly familiar with the use of the field guides for plants. In this section the students will use the skills they have acquired so far to collect data on species diversity in the field. Naturally, the students at home on bed rest will not be going out into the field, so they will have a slightly modified task, which is described below in

the appropriate section. This section of the unit addresses New Haven Science Standards, 6.3a, b, and c.

In Class

The students in class will use a bioblitz method to collect information about which species can be found in any given area. Each group of students will be given a square of the same size, probably about 18 inches on a side. These can be made from anything sturdy enough to take the wear and tear of use in the woods. I have seen them made of cardboard strips glued into a square, but I don't think those would last very long if the ground was damp. A better option that I have seen is a square made of narrow PVC pipe fitted together with elbow joints at the corners. The squares are lightweight and inexpensive to put together. In a pinch, pieces of string tied to stakes, similar to what is used at archeological sites, could be used. Each group of students, three or four students at most in a group, is given a square. The students count and record every organism in their square. This can include everything on the ground or can extend up into the sky. This is a good place to modify the task for students who are younger or are not quite up to recording every species by name. Different species can be simply the number of different looking plants students see. They could be plants and bugs students see, or they could be the full range of macroorganisms to the microbes in the soil. In a class like mine, I have many students of different abilities, so I am inclined to put students together in groups where more advanced students can help the less advanced students learn the names of the organisms in the square.

When the students have finished recording the organisms they find in their square, they will combine their data to get a picture of the whole ecosystem they are studying. Because my class size is extremely variable, my classes may need to do several squares to collect enough data to get reasonable results.

My students will do their first bioblitz in the park across the street because it is easy to get to and they are familiar with it. Beyond this park, though, there are several interesting options for different habitats in the New Haven area. One possibility is the land just off I-91, which is within walking distance from the school. We will not be able to actually set down square to do a bioblitz, but the students can still get a fairly good idea of what is growing in the area from the safe side of the fence. It is an area of what is essentially early successional habitat. There are, of course, other options in New Haven. The students will visit the farm at Common Ground High School in New Haven. They will also visit one of the parks that are wooded. East Rock and West Rock parks are good examples. The students may also visit the lighthouse or West Haven beach if there is time. These sites will give the students a fairly broad spectrum for collecting data.

At Home

Students at home will not, of course, be able to go on field trips to local parks. Instead they will collect data from literature written about the various ecosystems found in New England. There are a wide variety of book written about the various ecosystems in New England under different land management techniques. The books range from early European accounts of the forests they encountered which were managed by the first human inhabitants of New England to accounts of some of the same forests as they are today, recovering from the industrial revolution.

Students will not be reading the entire books, but rather, they will read selected excerpts which give an idea of the degree of land management being used and the diversity of species found in the area being described. Some book from which excerpts might be taken can be found in the appendix at the end of this unit. The students will be expected to classify each ecosystem in the literature according the degree of human interference in the landscape. In each group of similarly managed ecosystems, the students will then list the species described. For example, a farm and a large garden might both be classified as the same type of

ecosystem. So, a student might count both the corn from the farm field and the beans in a garden as organisms found in this particular ecosystem. In this way the students at home will be able to collect data on average species diversity in differently managed landscapes.

This technique of collecting data is especially useful for my students who are unable to come to school, but it can also be useful in classes where large numbers of students make reliable observations in ecosystems either unfeasible or inaccurate. I can readily understand the reluctance of a teacher to bring 30 children into the woods to attempt to conduct bioblitz observations without scaring off everything that could move. Furthermore, in a case where you have multiple classes following the same curriculum, going out to all of the field sites is really unfeasible, although one site close by might work. In cases like these, the literary option is a good alternative.

Generating Results

The results from this curriculum unit will be in the form of a lab report. Any decent lab report addresses New Haven Science Standard 1.1f. The specifications for the report are a standard in every class I teach. The report requirements are found in an appendix at the end of this unit. All students, even the ones at home will be required to write a report detailing their findings. The format of the lab report helps student to organize their thoughts into a logical flow of information. The practice is especially useful in high school because the format is so similar to a five paragraph essay and is a good basis for writing research papers, which all of our students do. I generally give extra credit for typing the reports; it makes them easier to read and encourages the students to practice using the computers.

The results to be generated for this lab report consist primarily of two types of data analysis. The first is mathematical. The second is more analytical. The mathematical part of the data analysis is mechanical. It is simply applying formulae to a collection of data and generating more numbers. The more thought provoking pursuit is explaining what those numbers tell a reader about the data that was collected.

In this case, there are several mathematical models to follow, some or all of which could be used depending on the level of the class or of individual students. In the end, all methods should yield generally similar results; the differences being in the degree of detail yielded by the data. The simplest approach is to have the students compose a bar graph showing the different numbers of species found in the different habitats. This will show a general trend in the data, but make it difficult to derive any mathematical relationships between the species diversity and the land management technique. Furthermore, it does not give much information about the richness or density of various species. A slightly more sophisticated approach would be to create a line graph showing the relationship again between the number of species and an approximate degree of human interference in a given habitat. This approach will yield something more nearly resembling a mathematical relationship between the two quantities. However, it again lacks the information about species richness. A more sophisticated approach might use weighted averages to show the abundance of some species and the scarcity of others. These data could be plotted against the land management techniques to show how different organisms fare under different land management styles. For example, one might expect to find corn very prevalent in a corn field, but corn borers also ought to be present in large numbers. The variability of data analysis techniques are really only limited by the mathematical abilities of the students in a particular class.

For my classes, I expect students to answer the fundamental question of "what do all these numbers mean"? So, if the student finds ten species in the first landscape, five species in the next and only two in the third, I expect not only a description of the trend, but also a possible explanation for the results. Furthermore, I expect my students to describe the accuracy of their data. If, for example, all the students entered the study area in a noisy wave, I expect an explanation for why there were no animals found in a particularly favorable location and whether they expect to get similar results in a different trial.

For many students the mathematics is challenging, but it is the interpretation of the results that is most difficult. Instinctively, they know what the numbers mean, but they have trouble converting numbers to what they saw when collecting their data.

Conclusion

This curriculum unit covers many facets of ecology. However, it does not cover everything. One thing which I have not included in this unit, but might be an interesting addition especially in an elementary classroom is vermicomposting. Vermicomposting is the process of composting organic waste by using worms. There are composing systems available for sale in garden stores and lots online, but the systems are also extremely easy to set up in the classroom for a pittance. There are also some very good links on the Connecticut Department of Environmental Protection web page for Recycling and Organics Composting. Vermicomposting allows students to study in detail what earthworms and decomposers do to decompose the organic materials we throw away. Furthermore, because earthworms are not native to New England, it provides an opportunity to discuss invasive species, which is another topic not thoroughly covered in this unit.

This unit looks at basic classification, which is essential for keeping track of the billions of species on our planet. It looks at methods for differentiating between organisms that are outwardly similar, which helps train students to observe details carefully. Careful observation is a useful skill to a new mother who needs to observe her baby's moods and needs to assess the child's health and growth. This unit continues with data collection. Whether the student is able to come into the woods or simply reads about them, she is introduced to the wonder of the natural world. There is so much of the natural world that is easily accessible, even in New Haven, that it is a pity that more children are not exposed to it. My hope is that students who start the class afraid of squirrels will come to understand that they prefer nuts to ankles and really are just trying to make a living in a harsh world. Furthermore, I hope that if my students can be made comfortable in the more natural settings of places like West Rock park, that they will, in turn, bring their children to explore the little streams that run in the park and the marvelous creature that can be seen if you sit still and wait for them. Finally, even if a particular student hated the field trips to the "wilds" of New Haven, she will still learn to organize her thoughts in a logical way in her lab report, which is a useful skill in life regardless of what she does.

Educational Strategies

Teaching identification

As was mentioned above, one the ways I intend to teach identification is to have the students look for common, easily recognizable shapes in the different organisms they are studying. The students will then create a key based on the basic shapes. This is a technique that is used in teaching drawing that I think will work well to also identify many different organisms.

The first step in this process is to identify the basic shape of the organism. I will use tree leaves in this example. A sweetgum tree leaf, *Liquidambar styraciflua L.* , looks just like a five pointed star. For this tree, you wouldn't really have to go much beyond this step, but for most other trees you do. So, if a student finds a leaf that is shaped just like a five pointed star, her key will tell her it is probably a sweetgum tree leaf.

The second step is to look in a bit more detail at the leaf shape. So, for example, all elm leaves have a basically oval shape, but so do Dogwood leaves. Ash leaflets have an oval or elliptical shape, too, but the leaf itself is actually compound. The distinction between simple and compound leaves is a good thing to consider at this step in addition to looking for modifications of the basic shape. So, for example, elm leaves are toothed, but dogwood leave are not. Both leaves have a central vein with smaller veins coming off the central vein, but the patterns created by the secondary veins are different. In the elm leaves the secondary veins run straight off the central vein forming a "v" shape. In a dogwood leaf, the secondary veins curve, following the oval shape of the leaf. I recommend the National Audubon Society field guide to Eastern Trees to help illustrate this step.

The next step is to consider texture, overall shape, fruits, flowers and habitat. Once you know that your leaf is probably an elm, the next step is to figure out which elm it is. There are a number of factors to consider in this step. First, is the leaf smooth or rough? Is the leaf the same color on top and below? What sort of bark is on the tree? If you can find fruit or seeds below the tree, are they specific to one species or another. Is the overall shape of the tree unmodified, or can you tell what the natural shape of the tree should be? And, finally, does this tree actually grow in this area and this habitat? These sorts of questions will help a student differentiate one tree from another.

In the case of an animal instead of a plant or tree, the steps are the same, but the questions might be slightly modified. So instead of leaf shape, a student might look at wing and tail shape for a bird or body type and colored markings for a quadruped.

Museum and Zoo strategies

Visiting museums and having speakers come always requires preparation. In fact, the success of the visit really depends on the quality of the preparation. In this case, the students will have particular organisms they are studying for the foodweb project, so the students should have a list of questions about their organisms. However, the preparation goes far beyond that. The teacher should exhaustively explain behavioral expectations and the schedule of the trip with the students as well as why they are going and what they are expected to gain from the trip.

In addition to preparing the students for the trip, the teacher should prepare the museum and zoo staff as well. The teacher should discuss particular topics of interest with the museum and zoo staff prior to the visit to

ensure that students get some answers to their questions. The teacher should also arrange an appropriate schedule with the museum and the zoo.

The teacher should also arrange enough adult supervision so that the students can break up into smaller groups to go see particular parts of the museum or zoo which interest them. Part of the museum and zoo experience is an assignment in which the students have to plan a trip to the museum and the zoo with their child. So, it is important that the students be able to explore thoroughly.

Food web project in more detail

The students will have access to the internet at school as well as several field guides, text books, and magazines like National Geographic. From these resources the students will find or draw a picture of their organism. The written paper will contain information about the feeding habits of the organism, their habitat requirements, their reproductive strategies, the threats to their existence, and other similar information. The students will receive a rubric for their project giving the exact requirements and the point values assigned to each piece of the project. The pictures and papers can then be arranged on a wall in the form of a foodweb. The individual piece will be connected by stings or paper arrows or something similar. To ensure a balanced and complete foodweb, the teacher should probably supply a list of organisms for the students to research.

Bioblitz

The concept of a bioblitz is not new, but I have included it here because it is a very useful way to survey populations. A bioblitz is a method of surveying a population without actually counting every single organism in a given area. The surveyors, students in this case are given a small piece of a larger area. The size of the small pieces and their locations will influence the results of the survey as they may reflect local prevalent organisms rather than a true picture of the whole ecosystem. This risk of sampling error can be reduced with a very large number of samples; however, this may not be practical using students. My suggestion is to choose sample sites carefully and have the students come up with some solutions to the problem. Another possibility is to sample the same site over several years to build up a database of many samples, but this approach also has problems. Change over time is inevitable, so that could be a subject of discussion with students if the long term study approach is taken. However, given the greater impractibility of counting every organism in a large forest, this solution is a good way to get a general picture of the ecosystem composition.

The basic system of doing a bioblitz is very simple. Each surveyor or team of surveyors records every relevant organism within the survey area. The varieties of survey areas are pretty much infinite. They can range from a set of squares that border each other and cover the entire site, such as what you might see at an archeological dig, to a scattering of equal area polygons across the site. The most important consideration, though, is to make sure that all the survey areas have contain the same area. Without this basic constant, the results of the individual surveys can not be easily compared.

Elements of a Complete Laboratory Report

Introduction

The introduction explains to the reader why the study being described in the report was done. It introduces the topic of discussion and states the problem or phenomenon being studied. It may also contain background on the subject being studied, references to prior works on the subject, and justifications for the any assumptions made or theories being used in the performance of the study being described in the report.

Hypothesis

The hypothesis contains a proposed answer to the problem or explanation of a phenomenon. It is an initial guess based on the prior knowledge and experiences of the experimenter.

Procedure

This is possibly the most important part of the report. In this section, the actions preformed in the study are described in such a way that the study can be repeated as long as similar conditions can be found to exist. Illustrations sometime accompany this section to more adequately explain complicated experimental setups.

Data

In this section the data that was collected during the study is displayed in labeled tables, photographs, sketches, and other descriptive formats. Calculated results are not found in this section.

Data Analysis and Results

This section contains examples of the calculations done to analyze the data collected during the study. It also contains a basic description of the results of any calculations. For example, "six" is not a result, but "six different species were found in quadrant three" may be considered a proper result. This section frequently contains graphs and charts showing the results of the study.

Discussion of the Results

Results alone do not answer questions. Students must complete the fundamental task of interpreting the results. They must explain the significance of the results. This is frequently the most difficult part of the report for students, but it is essential for their growth as students and as future citizens.

This section of the report is also the place where experimental disasters are reported. Anything that may have affected the accuracy or the precision of the data collected should be explained here. Additionally, the report should describe how the aberrant event may have changed the results; for example, are the data too large, too small, scattered, or something else? All of these considerations go into an estimated experimental error.

Conclusions

The conclusion gives a concise description of the opinion of the student about the question or phenomenon they set out to study. The conclusion is based on the collected data and the data analysis preformed. The reader should also be given an estimate of the accuracy of the conclusions reached based on her estimated experimental error.

New Haven Science Standards Addressed in this Curriculum Unit

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New Haven Science Standard 3.3e "Students will be aware that biological classifications are based on our best understanding of how organisms are related. Organisms are classified into a hierarchy of groups and subgroups based on similarities which reflect their evolutionary relationships. The species is the most

fundamental unit of classification."

A key concept in science education is rational, orderly thought. The Linnaean system of classification was the first such system used to try to organize an otherwise chaotic world of organisms into an easily studied collection of organisms. Our modern classification system is largely based on the prior Linnaean system. The classification of organisms done by students throughout this unit encourages the students to see subtle similarities and differences between organisms. Classification forces my students to look closely at the organisms they are studying. Classification also requires that students learn to ask questions of themselves. For example, my students are expected to check that a particular organism they have just identified in a field guide actually lives in the area in which we are studying. These questions make my students better scientists and better citizens.

New Haven Science Standard 6.3a, b, and c "Students will recognize that human populations use resources in the environment in order to maintain and improve their existence. Natural resources have been and will continue to be used to maintain human populations." "Students will understand that the earth does not have infinite resources. Increasing human consumption places severe stress on the natural processes that renew some resources, and it depletes those resources that cannot be renewed." "Students will be aware that humans use many natural systems as resources. Natural systems have the capacity to reuse waste, but that capacity is limited. Natural systems can change to an extent that exceeds the limits of organisms to adapt naturally or humans to adapt technologically."

A major topic of this curriculum unit is the many ways in which humans cause changed in the landscape around them. Even the decision not to interfere in a landscape has an impact on the land and its denizens. By studying the organisms found in the ecosystems in and around New Haven, the students will begin to see how organisms react to one another as well as how human interference can change those interactions. Because we will be doing so much of our work outdoors, we will inevitably and unfortunately see a good bit of human refuse in our lessons. This will provide an opportunity to discuss what happens when a student throws a piece of trash on the ground or even into the garbage can. Finally, many of the organisms we will encounter in the forests around New Haven are resources that my students use without understanding how the resource come into existence. Sugar maples are a good example.

New Haven Science Standard 1.2a "Students will demonstrate the ability to inquire about how physical, living, or designed systems function. Scientists use conceptual principles and knowledge to guide scientific inquiries. Historical and current scientific knowledge influence the design and interpretation of investigations and the evaluation of proposed explanations made by other scientists."

Again, the majority of this unit addresses this scientific standard. The two major projects in this curriculum unit, the food web wall and the inquiry into the relationship between human interference and species diversity, both require that student master the fundamentals of scientific research. The students must design and conduct investigations using multiple sources to reach a conclusion about the issues we will study in this unit.

Reading List

Background for the students and teacher

Cronon, William Changes in the Land Hill and Wang (1983)

Elder, John Reading the Mountains of Home Harvard University Press (1998)

Louv, Richard Last Child in the Woods Algonquin Books of Chapel Hill (2005)

Stewart, A The Earth Moved Algonquin Books of Chapel Hill (2004)

Wessels, Tom Reading the Forested Landscape: A Natural History of New England The Countryman Press (1997)

Any Decent Biology Textbook

Excerpts from these for girls who aren't able to go on trips and more background for the teacher

Bates, M The Forest and the Sea Random House, NY (1960)

Black, G The Trout Pool Paradox Houghton Mifflin Company (2004)

Carson, R. Under the Sea Wind and Silent Spring

Hoover, H The Years of the Forest Alfred A. Knopf (1973)

Jorrin, S Sylvia's Farm Bloomsbury (2004)

Pollan, M Second Nature Grove Press (1991)

Thoreau, H. D. Walden, The Maine Woods, and A Week on the Concord and Merrimack Rivers

Warner, C. D. My Summer in a Garden Random House (2002)

Field Guides

National Audubon Society Field Guide to Reptiles and Amphibians

National Audubon Society Field Guide to North American Birds: Eastern Region

National Audubon Society Field Guide to Trees: Eastern Region

Peterson Guide to Mammals

Peterson Guide to Trees and Shrubs

Peterson Guide to Wildflowers: Northeast/North-central North America

Newcomb's Wildflower Guide