This is to certify that the

thesis entitled

New Curriculum And Strategies For The
Instruction Of Ecological Succession

presented by

Elizabeth Baker-Munro

has been accepted towards fulfillment
of the requirements for

M.S. degree in Interdepartmental Biological Science

Major professor

Date 20 July 99

NEW CURRICULUM AND STRATEGIES FOR THE INSTRUCTION OF ECOLOGICAL SUCCESSION

By

Elizabeth Baker-Munro

A THESIS

Submitted to
Michigan State University
In partial fulfillment of the requirements
For the degree of

MASTER OF SCIENCE

Division of Science and Mathematics Education
College of Natural Science

1999

ABSTRACT

DYNAMIC NEW CURRICULUM AND STRATEGIES FOR
THE INSTRUCTION OF ECOLOGICAL SUCCESSION

By

Elizabeth Baker-Munro

The new laboratories and activities described in this thesis were developed for a high school biology class. Specifically, these activities were created to improve the learning of ecological succession by my ninth and tenth grade biology students. In previous years there has been no hands-on investigations of ecological succession in my class. Consequently, students did not enjoy nor fully understand the concepts being taught. To measure the success of the revised unit and new laboratories, a pretest and post test were given and results compared. Assessment was also conducted during each new laboratory. All new curriculum is described and analyzed for effectiveness, and suggestions are given for further improvement.

DEDICATION

This thesis is dedicated to my students. Their patience and input were both invaluable and greatly appreciated.

ACKNOWLEDGEMENTS

I would first like to thank the Towsley Foundation for their generous funding. I have been blessed on multiple occasions to receive stipends and am forever grateful for the financial support.

Merle Heidemann has played a significant role in both my undergraduate and graduate studies. She sets high standards with the expectation that they will be met. Although humbled on occasion, I am deeply grateful for the challenges she established for me. I am always very proud if I earn Merle's seal of approval.

I would also like to thank Helen Waldo for her patience and kindness. I know no other who can get a parking permit like this woman.

Friends like Peggy Najarian and Mary Hoyt are truly priceless. I thank them for their late night pep talks, sense of humor and time spent proofreading this paper. The best thing about this program was the life-long friends it helped me to meet and make.

Last but not least, I would like to thank my parents and my husband. They have endured my stress attacks, crazy summer schedules, and my occasional moody behavior. They always support me, even when I'm doing schoolwork in the car, on the phone, during the weekend, during meals, during the summer. . . .

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

RATIONALE:

What is ecological succession? Why do some communities appear stable while others quickly change in the face of disturbance? What determines the amount of diversity in an ecosystem?

During the past four years my biology students have been confronted with questions like these with regard to ecosystem development and change. The rational for teaching succession includes standards set by the Michigan Essential Goals and Objectives for Science Education (MEGOSE, 1991). The following objectives are met either directly or indirectly by teaching the unit described here.

- "Describe ecosystem responses to events that cause it to change.
- Describe general factors regulating population size in ecosystems.
- Explain the effects of agriculture and other human activities on the environment."

Our text, <u>HOLT Biology Visualizing Life</u>, only dedicates a third of a chapter (5-7 pages) to competition, ecosystem development and ecosystem stability. After reviewing the MEGOSE objectives, I clearly needed more materials.

During my first two years teaching ecological succession, I did not use any supplemental material. I have subsequently discovered that students did not particularly enjoy learning about succession. They did not seem to value the information nor did they appear to have learned what ecological succession was, the causes, or implications. "In fact, few textbooks compel students to do anything other then know or recall the information presented" (Gusky, 1985). This, of course, I found discouraging since I believed that I had taught the material in a way that they would understand and enjoy.

A November 1997 survey administered by the National Environmental Education and Training Foundation to adult Americans revealed that 95% of those surveyed support children being taught environmental education in schools (NEETF/Roper survey, 1997). Yet, when questioned further, only 23% of those Americans were able to identify run-off as the leading cause of water pollution. Only 40% could correctly define the term "biodiversity". When asked in a pretest, about factors that limit the number and types of species in an ecosystem, my students offered a variety of answers. Some included human interference, hunters, weather, number of predators, amount of food available, and there were some who could offer no explanation. The NEETF survey, along with informal discussions with my students, showed that people have no understanding of the environmental issues we face and why.

> "The lack of basic or essential environmental knowledge can affect everyone. It is important to individuals as it affects their health and daily lives. However, it has the most serious implications for policy makers. If the public fails to understand complex or even simple environmental issues, it will be much more difficult to get their support for changes and remedial programs" (NEETF/Roper survey, 1997).

My goal was to teach ecological succession and related environmental issues in a way that would fill the void. To do this, I also consulted Benchmarks for Science Literacy (1993) which suggested that students, grades 9 - 12, should know the following with regard to ecosystems.

- "Ecosystems can be reasonably stable over hundreds or thousands of years. As any population of organisms grows, it is held in check by one or more environmental factors: depletion of food or nesting sites, increased loss to increased numbers of predators, or parasites. If a disaster such as a flood or fire occurs, the damaged ecosystem is likely to recover in stages that eventually result in a system similar to the original one.

- Like many complex systems, ecosystems tend to have cyclic fluctuations around a state of rough equilibrium. In the long run, however, ecosystems always change when climate changes or when one or more new species appear as a result of migration or local evolution.

- Human beings are part of the earth's ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems (Benchmarks for Science Literacy, 1993)."

I found these guidelines, although comparable, to be more specific than those provided by MEGOSE. As previously stated, they too have contributed to the development of this unit and serve as a guide for revising and teaching this material.

PEDAGOGOGY & SCIENTIFIC LITERATURE:

I gave a pretest (Appendix A) before I taught this unit. Dr. Charles (Andy) Anderson and his teaching colleagues at Michigan State University taught me that discovering what students know and what their misconceptions are, would greatly influence how the teacher teaches and students learn. This piece of wisdom was reinforced by Arthur Carin who explained how students learn science.

> "What they bring to their problem solving and learning experiences critically affects how they learn and build new knowledge. The acquisition of new knowledge always occurs in the context of and is heavily influenced by pre-existing knowledge" (Carin, 1993).

Arthur Carin also suggested that students would learn best through a hands-on approach in cooperative learning situations. These situations should involve teamwork where students observe, predict, investigate and explain a problem. To foster student involvement and cooperation in all classroom activities, the effective teacher should plan a variety of activities that are appropriate for learning (Wong and Wong, 1991). Both daily work in science classes, and in life is dependent on group work and collaboration within that group. Cooperative work and verbal exchanges among students in class form the learning experience that successfully prepares them for the future (Bybee and Trowbridge, 1990). Suggested benefits of cooperative learning include improvement of cognitive and high-order thinking skills, communication and conflict-resolution skills, self-esteem, longer retention of material and an increased positive attitude (Jasmine and Jasmine, 1996). I created cooperative learning groups for each of my new laboratories. My goal was for my students to achieve the above benefits and to allow myself more freedom to facilitate the activities.

The following quote was made in support of using historical vignettes as a unique way to teach content and capture student's interest.

> "Teachers need a method by which to teach the nature of science while meeting the content goals established by state and local authorities. One way to do this is with stories" (Roach and Wandersee, 1993).

I incorporated this advice into my revised unit. Instead of a vignette, we read a book entitled <u>Water A Natural History</u>, Outwater, (1996). Alice Outwater, an environmental engineer and consultant in sludge management, records the history of water pollution in our country. In summary, she tells us how an altered ecosystem, no longer able to succeed naturally, can reap disastrous effects. She compared Native Americans to settlers with respect to their living standards. Native Americans were nomadic and set fires, regularly creating patches of varying habitat and increased diversity. Colonists created permanent villages, cleared fields and turned pigs and cattle loose to forage in forests and marshes. "The net result was a simplification of plant and animal communities" (Outwater, 1996).

She further states that as commercial logging gained popularity trees like the giant sequoias became endangered within sixty years after felling began. By 1850 approximately 40% of climax forests were cleared, by 1870, 60% were forever gone. Thanks to transcendentalists Ralph Waldo Emerson and Henry David Thoreau, the quickly diminishing wilderness was in fact saved to some extent. Inspired by their view of nature as a source of freedom and spiritual rejuvenation, John Muir helped to advocate government ownership of Yosemite, General Grant and Sequoia National Parks in 1890. President Theodore Roosevelt was able to reserve 250,000 square miles of forest due to a provision added in 1891 allowing a president to reserve land. Unfortunately most forests in the early 1900's remained privately owned. By 1930 only 13% of our country's original forests remained intact. This paralleled a reduction of a large percent of beaver, bison and prairie dog populations. The prairie dog is a keystone species, which greatly alters the landscape and subsequently creates habitat for other species. According to the Bureau of Land Management, 163 species of animals use prairie dog towns as feeding grounds or shelter, and the population and diversity of insects is also greater there. This serves as a reminder that without fires, old buffalo wallows and prairie dog towns that biological diversity has and will continue to decline in such ecosystems.

Yet, cattle ranchers do not seem to be moved by this information. They frequently shoot prairie dogs because they consider them to be a nuisance. Ranchers do not realize that both agricultural development and the departure of indigenous organisms leads to simplified communities no longer able to succeed naturally. "Agriculture constitutes a continuous and drastic interference to natural processes. When man stops interfering, nature takes over and complex ecosystems develop in place of the simplified man-made agrosystems" (Giourga, et al., 1998). My students belong to

a agricultural community. This information can be applied to their own experiences. They can examine succession in their own community observing, like others, that agriculture by its very nature keeps an area in the earliest stages of succession (Bodkin and Keller, 1998).

There are principles that focus on the relationships between biodiversity and the landscapes created by different ecosystems. It is thought that high species diversity reduces the risk of large changes in ecosystem processes in response to invasions of pathogens and other species (Chapin, et al., 1998). The authors remind us that we must protect climax communities and biodiversity because of the impact biodiversity has on ecosystem processes. These processes determine air and water quality, from which we as a society benefit and need to conserve.

Humans, however, have made an indelible mark on the direction and rate of succession. Some ecosystems are changed remarkably, many becoming sterile in comparison to what they once were. Scientists like Irving Knobloch (1994), warn us about the possible effects of desertification. When trees are harvested without reforestation top soil is eroded. Without the vegetation, infertile soil is exposed as sand or clay. "During this century, African deserts have increased by more than 380,000 square miles, an area equal to the size of Egypt" (Knobloch, 1994). Students do not typically have experience with desertification and demonstrating this process could create both interest and a smooth segue into principles of erosion and carbon, water and nutrient cycles.

Part of this unit involved the study of dune succession. Here we were able to study the sand dune environment from beach to climax community. Scientists at PJ Hoffmaster State Park described dune succession as having the following stages: wet beach and storm beach, pioneer dune grass, Cottonwood and Sand Cherry, Conifer zone, White Pines and Black Oak, Barrier dune/climax forest. "The basic principles of plant succession now used in the United States were developed in the late 1800's and are the basis for the exhibit" (DNR, 1997). Unfortunately for the dune community, many plants that have been introduced into Western Michigan have multiplied without control in the wild. Invaders, such as Norway Spruce, European Mountain Ash and Purple Loosestrife, crowd out native species and alter habitat. This, of course, can affect succession as non-native species quickly out-compete and devastate local plant populations. It was important that students understood the difference between exotic species introduction versus natural factors such as shade or crowding, as a mechanism for species replacement. "In addition to introducing organisms into a new territory, man has upset the balance in nature by doing the following things: (1) starting forest fires through carelessness, (2) recklessly cutting down trees, (3) allowing sheep and cattle to overgraze the land, (4) overcultivating the land, (5) contaminating waterways, (6) destroying certain animals, and (7) breeding new plants and animals" (Morholt, et al., 1958).

DEMOGRAPHICS:

My school is located in a rural district. There are approximately 24,000 people living in the community, 4,214 of which attend public school. Of the 4,214 school children, 1,181 are currently enrolled in high school. There is only one high school and one junior high school. There are five kindergarten-sixth grade elementary schools and one pre-kindergarten through kindergarten elementary school that ultimately feed into our high school. Furthermore, there are two Catholic elementary schools which also send us junior high and high school students.

Approximately 100% of the students are Caucasian. Some have had rich past experiences in science, others have had little memorable exposure. The elementary schools vary greatly by both building and teacher as to what and how science is taught. Also, teaching inconsistencies exist between our junior high school teachers.

Besides myself, two other faculty members at the high school also teach biology. Although we teach the same material at approximately the same pace, we were not yet fully aligned. Our objectives were the same but our teaching style and forms of assessment, including final exams, were not. This situation has been an asset to me this past year as I've been able to incorporate new plans, activities and evaluation tools into the typical schedule without objection.

Most of the students enrolled in my classes were freshmen, although it is not unusual for sophomores to enroll. The data collected for this research was from two classes, each a mix of ninth and tenth grade students. We constantly battled "quality versus quantity" issues, as a typical biology class attempts to cover basic chemistry, cell structure and function, photosynthesis and respiration, genetics, classification and ecology. Most of our students would take chemistry the following year. From that point some may choose to take Senior Biology, AP Biology, AP Chemistry or Physics.

There is quite a mix of students based on how much they already know and believe to be true. The following unit attempts to evaluate and meet the needs of all students in my classroom with regard to the study of ecosystems and ecological succession.

IMPLEMETATION OF UNIT

NEW TEACHING STRATEGIES:

The implementation of hands-on activities naturally created an environment fostering problem solving in groups and cooperative learning situations. When I put students in groups of 2 - 4, I did so randomly. My new succession unit was embedded in a larger unit of basic ecology. The development of teaching strategies, materials and laboratories for this unit was both tedious and exhilarating. Table 1 is a summary of the entire ecology unit, the new activities are highlighted. Complete daily plans are found in Appendix B.

New this year was the incorporation of a book entitled Water a Natural History written by Alice Outwater (1996). This provides an extensive explanation of the water cycle and how water is able to shape biotic communities. Specific habitats and how humans have disrupted natural cycles are described with discussion about the consequences of our behaviors. Those consequences include simplified communities, extinct organisms and habitats dramatically altered from their original state, the state they would be in if allowed to succeed naturally.

Table 1 - Unit Activities

Topic	Activity	Approximate Time Needed	Objectives
Ecosystems - participants and relationships	• Concept map • Selected questions • Biome reports	• 2 days • 1 week	Energy flow through ecosystems
Water and nutrient cycles	• Diagrams • Selected questions • **Water Book and questionnaire**	• 3 -4 days	How Water, CO_2, and N_2, cycles through selected ecosystems
Affects of natural events and human activities on ecosystems	• Water book and questionnaire • Video - commensalism, mutualism, parasitism, predation • **Competition Drives Change Lab and Journal** • Various text questions • Worksheet - **Examining Stages of Ecological Succession**	• 2 weeks • 2 weeks	Responses of ecosystems to events causing change
Affects of natural events and human activities on ecosystems	• **Dune Succession Lab** • **Studying Forest Succession** • **Pond Water Succession Lab**	• 2 days • 2 days • 2 weeks	Responses of ecosystems to events causing change
Ecosystem diversity and human disruption	• Selected readings and text questions	• 1 week	Responses of ecosystems to events causing change

For me, the book served a dual purpose. It was used as a tool to improve reading comprehension and to teach scientific concepts. Our MEAP scores are quite low, in the fiftieth percentile, for both reading and writing. Our MEAP science scores fall in the low sixtieth percentile.

Each person was required to buy the book. I wanted everyone to have their own copy so that they could individually read it outside of class. For some of my students this was the longest book they had ever read (186 pages)!

For discussion purposes I split the reading into thirds. For each third (3-4 chapters) I developed a series of questions (Appendix C). Sometimes the students worked in groups of 2-4 to discuss the material and answer questions. Sometimes we did this as a class. One time I gave the questionnaire as a pop quiz. This proved to be disastrous. Some students did not do the reading, and for those who did, many had questions or could not identify pertinent information or recognize significant cause and effect relationships.

Also new this year was a 15 minute video and slides that I created specifically to help teach succession using our Michigan sand dune community. This was part of a concerted effort to incorporate dune succession into my ecology unit. I have not used a video for this part of my ecology unit in the past. It helped me to better explain the process of, and reasons for, species replacement in a community to which students can relate.

NEW LABORATORIES AND EVALUATIONS OF EACH:

1. Competition Drives Change

Because competition plays such a pivotal role in how ecosystems develop, I chose to develop a lab that examined how competition affects the growth of plants before engaging students in activities directly representative of ecological succession. To do this, students planted different kinds of seeds and monitored their growth. My plan worked out nicely because our textbook introduces competition before introducing succession.

This activity was used to help identify factors regulating population size, number and types of species found in ecosystems, particularly young communities apt to change. Refer to Appendix D for details of set-up.

Since the results would not be immediately available for analyses, the students recorded progress in a journal every 3-4 days for two weeks. They needed to document the amount of emergent seedlings, when and what type, heights, change in appearance, decline in number or health etc. The goal was to see whether, at the end of two weeks, one species would be significantly diminished or eliminated due to competition. I chose the seed combinations with the knowledge that one would germinate quicker, grow quicker, have larger cotyledons or have larger leaves. In such a small space, it does not take long for a seedling with such advantages to out-compete the neighboring species.

For this lab, the domination of one plant species by another was used as an analogy for pioneering plant species succumbing to new invaders. The students also received their first independent assignment. The worksheet entitled "Examining Stages of Ecological Succession" (Miller, et al., 1987) asked general questions about both a pond and forest community. It also asked the students to make predictions about future changes in each environment. This was the first time I had used this assignment as a "performance" assessment.

To evaluate student achievement, I employed two mechanisms. The first was a student journal. I required each group to document specific data about their seedlings every 3-4 days for two weeks. The very first journal page needed to include the lab procedure, types of seeds planted, numbers planted, date planted and depth of each type. Sample journal pages are included in Appendix D.

Because this lab does not exhibit immediate results, there is a possibility that students will lose interest and/or lose sight of the purpose. The journal was intended to keep them motivated and mindful of our primary goal: the demonstration of competition between two plant species.

The worksheet "Examining Stages in Ecological Succession" (Miller, et al., 1987) begins with a story about pond succession to a forest. Descriptions of the pond are given as it evolves, including the autotrophic and heterotrophic communities found in each stage due to specific needs of the organisms. As the pond becomes a marsh, and eventually dries up students are asked to describe organisms found in each stage as designated by the assignment. Competition and ever-changing environment creates a noticeable replacement of species, or succession.

The assignment then presents diagrams of a field changing into a beech-maple forest over a 300 year period of time. The students are then asked to explain what is happening in the illustration. This question is similar to the pretest question. In essence, I chose this activity as a method of evaluation because it was appropriate for beginners, it helped to bring meaning to my lab and it consistently reflected my goals for student achievement.

2. Dune Succession

This activity encompasses more than one MEGOSE objective. Primarily it documents responses of an ecosystem to events causing changes over time. It examines cycling of soil nutrients through this particular ecosystem, and in so doing, demonstrates the effects of human activities on the dune community. I developed this activity to replace one that dealt with an Alaskan ecosystem which did not interest my students.

The preceding summer, while doing research, two colleagues and I drove to PJ Hoffmaster State Park near Muskegon. We collected soil samples ranging from the beach up to and over the dunes at measured increments. We also videotaped our trek from the water to the climax community. I first showed the video to my class in an attempt to describe succession in a way that connected with their experiences. Most of my students have been to sand dunes in our state and could better relate to this example than to the one of the Alaskan glacier.

The video also includes the effects of erosion and multitudes of litter left behind by sunbathers. It was not uncommon to see large trees with exposed root systems no longer attached to the dunes. I then shared some of my collected data with the students. Table 2 documents the type of plants found at intervals approximately 50 paces apart. The air and soil temperatures are measured in degrees Celsius. The data collected was in July, during the early afternoon.

As students analyzed the species found in each successive location moving up the dune from the water, the concept of species replacement over distance became clearer. At this point students now seemed ready to tackle the question of why this gradual change occurs over time.

The search for answers began with analyses of the soil samples I brought back from the sand dunes. Using simple soil test kits purchased from a local grocery store, groups tested four soil samples for nitrogen, potassium and phosphorus. Expected soil profiles were compared qualitatively as a class. The goal was to show that the beach sample was significantly nutrient poor compared to successive samples, and that ultimately, the sample collected from the forest floor was one of the richest. The forest floor of course won't be extraordinarily rich because what is available will be immediately used by the autotrophic community.

I wanted the students to realize that plant species differ in their need for water, sunlight and amount and type of nutrients.

Table 2 - Dune Vegetation

Location	Vegetation	Soil Temp. C°	Air Temp. C°
Beach	None	28	26
50 paces	Grasses	26	28
	Quaking Aspen		
50 paces	Grasses	29	31
	Blueberry		
	Milkweed		
50 paces	Grasses	29	29
	Oak		
	Dogwood		
	White Pine		
	Ash		
	Various weeds		
50 paces	Grasses	28	26.5
	Oak		
	Thistle		
	Cherry		
50 paces	Beech	23	26.5
	Red Maple		
	Hemlock		
	Sassafras		
	Lichens		
	Moss		
	Bracket Fungus		
	(no grass)		

Because of these factors, those who were pioneer plants would be replaced by others as they enriched the soil and provided shade. We then discussed the impact of competition, citing results from our previous lab.

One way I was able to assess student understanding of succession thus far was to assign an activity called "Studying Forest Succession" (Beller and Tomera, 1989). The students, in groups of two, were asked to measure the number and types of tree species over a 45 year period using data provided by the activity. Students were to answer a series of questions based on this data. The questions target the appearance and disappearance of specific species and asks them to predict which will be part of the climax community for that region.

Informally, I was able to monitor student achievement as we tested soil samples for various nutrients. As I moved from group to group I asked what they expected their measurements to be, what their measurements meant etc. At the end of the lab we compiled everyone's results and discussed them as a class. Unfortunately the soil test kits were not as accurate as the one I had used during the previous summer. There was a need for sensitive equipment to make such measurements. We found negligible differences between soil samples. This was a let down for both myself and my students. I did share my results from the previous summer. This data allowed me to salvage the activity.

After analyzing the soil samples I wanted to see if my students could apply what we had done to another familiar community, a forest. The activity called "Studying Forest Succession" (Beller and Tomera, 1989) asked students to draw conclusions about field succession to an eventual forest. It was difficult for my students to let go of the misconception that adult trees represent a climax community. It had not occurred to them that some full grown trees would not be able to successfully reproduce.

One activity question asked students to account for differences between air and soil surface temperatures between a five year quadrant and a fifty year quadrant. This parallels the data I shared about air and soil temperature at the sand dunes. I liked this question because it gave us an opportunity to reflect back on the lab experience and to identify why this type of data was significant.

3. Pond Water Succession

Before conducting the laboratory called "Pond Water Succession", the students examined a photograph of an emergent pond. This activity, called "Projecting Pond Succession" (Beller and Tomera, 1989), asked the students to identify the pond as young, middle-aged or old. The students were to predict its appearance both ten years and one hundred years from now. Next, they identified what organisms may appear and disappear during specific time periods. The students completed this activity individually, and then we discussed the possible answers as a class. This served as a warm-up to the lab I developed which gave students an opportunity to observe and analyze pond water samples. Once again, I wanted to teach succession using materials to which students could relate.

Each team of two received two samples of pond water (200-300 ml). My original intent was to let them manipulate one of the samples (i.e. add acid, salt, detergent, oil etc.) but because of time constraints I did not try that this year. Instead, we studied them as they were in their natural state. The teams also received a data packet that I designed. Each packet contained sheets asking about the date, color of sample, distribution of material, at the top or bottom, and if life was present just by looking at the sample with the naked eye. These initial observations were meant to be qualitative. Another data sheet required the students to examine the samples under a microscope and to record the temperature and pH of both. Each time they examine the pond water under the microscope they must make at least four slides from each sample and record the estimated number of organisms and types of organisms found (both autotrophic and heterotrophic). We did this every 3-4 days for twelve days or until the water evaporated.

My intent was to use a micro-ecosystem that would demonstrate succession over a relatively short period of time. I wanted the students to document conditions of species replacement so that they would better understand factors regulating population size and responses of an ecosystem to events causing it to change. In this situation, the events may have included evaporation, predation, extinction, increased temperature or amount of sunlight.

To help me measure the depth of their understanding regarding succession of a micro-ecosystem, I wrote a series of questions and included those in my data packet. Not only did I ask about what happened to their individual samples, I also asked about factors that may influence a typical pond. This forced the students to imagine an entire pond community versus the isolated cup of water.

I did this to illustrate how human activities and specifically agriculture can effect an ecosystem. We had discussed possible cause and effect scenarios prior to this lab. I wanted to evaluate how well students listened, understood, remembered and could apply that knowledge. What if there were run-off from a near-by farmer's field? How do you think copper sulfate affects the rate of succession? Based on what we had done in class, all teams should have been able to answer the distributed questions.

For this lab I created a series of data sheets and a set of conclusion questions as a means of evaluation (Appendix D). Questions 1-5 were worth two points apiece and question 6 was worth ten points, for a total of twenty points. Table 3 represents the class averages for my third hour class (Group 1) and my fifth hour class (Group 2).

Table 3 - Analysis of Pond Water Conclusion Questions

Mean Scores Group 1	Mean Scores Group 2
14	12
15	15
17	16
18	17
18	17
18	18
18	19
18	19
19	20
19	20
19	20
20	
Mean = 17.8	Mean = 17.5
Median = 18	Median = 18

EVALUATION

PRETEST AND POST TEST DISCUSSION:

Before beginning my ecology unit, I gave a pretest which is included in Appendix A. Its purpose was to determine how much the students already knew, and what some of their misconceptions about the topic were. One of the five pretest questions targeted succession. The question was: "Imagine that a forest fire has occurred, as it did in Yellowstone National Park. What kind, if any, organisms do you think would be found in a. 1 day, b. 1 year, c. 10 years and d. 100 years?" Before I discuss how their answers influenced my curriculum and teaching strategies, I would first like to compare some poor answers with some acceptable answers. Responses to letters a-d are each worth two points apiece. A zero was given for a blank or wrong answer, a one was given for a partial answer and a two was given for an acceptable answer. The student responses will demonstrate what I consider to be a zero, one or two point answer. The first examples are representative of students who scored very low (19% of the students skipped this question altogether).

Response 1 - poor
a. small insects
b. birds
c. fish
d. bears or a new kind of species

Response 2 - poor
a. none to little bugs
b. bugs, small animals (rabbits, squirrels, birds)
c. bears, bigger animals etc.
d. (blank)

There was no mention of producers in either answer. Neither of these responses earned any points.

Response 3 - partial
a. none
b. some small growth
c. small trees
d. big trees

Response 4 - partial
a. nothing
b. small plants
c. small trees
d. large forest

Although not very descriptive, I did give half credit (one point per answer) for responses such as these because they demonstrate a logical progression, in size at least, of the autotrophic community. The next set of answers were the best that I received. Before each response there is a number representing the score I gave for that particular response.

Response 5 - acceptable
a. 2 - microscopic organisms
b. 1 - mosses and other small animals
c. 1 - grasses and tree sprouts
d. 2 - full grown trees and a variety of animals

Response 6 - acceptable
a. 2 - decomposers
b. 2 - new trees, small animals moving back in
c. 2 - trees are growing taller, larger animals start to come
d. 1 - well established forest ecosystem

Response 7 - acceptable
a. 1 - none
b. 2 - smaller plants and tree saplings, small animals
c. 2 - thicker, bigger trees, more animals
d. 2 - thick forest, many animals back

These answers however, fail to identify any species replacement. All demonstrate that the producers progress in size and number yet nothing is mentioned about diversity or loss of species. Only the addition of new and increased numbers of species is cited.

The pretest mean for this question, for group one was 31%, for group two it was 30%. It was typical for the two groups to score similarly. It was obvious to me after reading the pretest that no one really understood the principle of ecological succession. In fact, when I first used the term in class, no one remembered discussing it in previous science classes. Their lack of exposure validated my choice for my research and this thesis. I knew right away that I would need to instruct, model and give guided practice multiple times, in various ways, before assigning independent work.

Our environmental studies lasted approximately seven weeks. Four to five of those seven weeks I was able to incorporate my new activities regarding succession. At the end of the unit I gave a post test (Appendix E). My post test mean for ecological succession questions only, for group one was 64%, representing a 33% increase in comprehension. My post test mean for group two was 62%, representing a 32% increase in comprehension. Once again the averages for each group were very much alike. Although pleased with the consistency, I was disappointed by what I considered to be a mediocre amount of improvement. Once again I would like to compare student responses ranging from poor to acceptable, this time for two of the post test questions.

Question: Please identify two differences between a pioneering community and a climax community.

Response - poor
Pioneering: not very much life
Climax: full of growth and life

Response - acceptable
Pioneering: small changes can disrupt the community, soil is warmer, not very stable
Climax: more diversity, species types tend to be permanent, soil is cooler due to shade, more stable due to greater diversity

Question: Why would succession stop (i.e. reach a climax community)?

Response - poor
Because competition slows down and the animals and plants have become comfortable with the habitats and the organisms around it.

Response - acceptable
Because the ecosystem has enough diversity to create a stable environment to handle small changes, whatever they are, without changing the entire ecosystem.

Table 4 and Table 5 compare the pretest and post test scores for my third hour (group 1) and fifth hour (group 2) classes. A t-test was conducted using this data and the result follows Table 5.

Table 4 - Group 1 Scores

Student	Pretest Score (Out of 8)	Post Test Score (Out of 30)
1	4	17
2	7	24
3	7	26
4	0	12
5	0	13
6	5	14
7	0	13
8	0	21
9	5	22
10	2	13
11	1	24
12	0	8
13	0	17
14	0	27
15	6	17
16	2	20
17	6	19
18	2	12
19	2	24
20	0	27
21	3	25
22	2	27

Table 5 - Group 2 Scores

Student	Pretest Score (Out of 8)	Post Test Score (Out of 30)
1	0	15
2	0	18
3	4	21
4	2	24
5	0	14
6	0	24
7	2	18
8	4	20
9	2	14
10	6	11
11	0	20
12	0	19
13	0	24
14	4	23
15	6	10
16	6	21
17	0	10
18	4	20
19	2	15
20	0	16
21	0	22
22	2	20
23	7	26
24	6	21

I compared the pretest and post-test means for each group statistically using the t-test to see if they are significantly different. The formula for the t-test is:

$$t = \frac{x_{big} - x_{small}}{s_{Dx}}$$

<u>Group 1</u>
$t = 12.21$

<u>Group 2</u>
$t = 15.28$

My conclusion was to reject the Null Hypothesis and assume that learning has taken place.

NEW TEACHING STRATEGIES:

My primary new teaching strategy, as previously stated, involved the use of a book documenting how human interference has changed the water cycle influencing succession in our country. To help me measure student comprehension, I developed a series of questions that also helped students identify key concepts and relationships they may have overlooked while reading independently (Appendix C). We used the packets as a communication device, study sheets and as post test practice material.

After reading the book I asked the students to evaluate the book and methods used to teach it. Based on their written responses and my own professional opinion, I will definitely create questions aligned with the reading again next year. I won't however, assign so much reading as homework. Students explicitly advised that I spend more time reading and discussing the material in class to foster better understanding and to heighten enthusiasm. Other recommendations are as follows.

"This book helped me understand the relationship between certain animals and the water cycle. I found it to be pretty interesting, especially about the beaver and the forest. I think you should use this book in future classes."

"This book was hard to get into, but it was definitely an asset to the unit. You may want to go slower next time."

"The book was good at describing the water cycle. The first few chapters were hard to read though, sometimes I didn't know what I was reading. The discussions in class were really interesting and I got into those."

"I think that this was a good book, however I am not much of a reader. It would have been better for me if we did all the chapters in class. You could also just assign sections that are really important instead of the whole book."

"It makes me want to do something to help."

New too was the grouping of students. In previous years students worked independently instead of collaboratively. The groups were typically chosen at random and were never larger than 4. Overall, I feel that cooperation between students provided them a more meaningful experience, because it allowed for more discussion and comprehension.

STUDENT FEEDBACK:

After completing our unit, I asked my students to rate my four new activities in order from what they considered to be the most enjoyable and meaningful (1) to least enjoyable and meaningful (4). I compiled their responses and the results are listed under each activity in Table 6.

Table 6 - Student Feedback

Water A Natural History

Rating	Percent
1	0%
2	4.5%
3	4.5%
4	91%

Competition Drives Change

Rating	Percent
1	0%
2	73%
3	20%
4	7%

Dune Succession

Rating	Percent
1	7%
2	7%
3	64%
4	22%

Pond Water Succession

Rating	Percent
1	97%
2	3%
3	0%
4	0%

In general, "Pond Water Succession" was the overwhelming favorite followed by "Competition Drives Change", "Dune Succession" and Water A Natural History. Some students also provided comments as to why they did or did not enjoy or understand the various activities. Sample comments are listed under each activity.

Water A Natural History

- "If we could incorporate the book with an outdoor activity it would be so much more interesting. Maybe we could have gone to a pond or small river to look at something the book was trying to point out."

* "I believe that I liked this section because I had time to read ahead."

Competition Drives Change

* "Growing our own plants was cool and watching them mature was very interesting."
* "The competition lab was difficult because the seeds got flooded and moved from compartment to compartment."

Dune Succession

* "This project was quite interesting. Using the chemicals to test pH and nutrient composition of the dirt was cool."
* "It wasn't very exciting working with sand."
* "Going to the dunes on a Saturday for extra credit to study succession would be awesome."

Pond Water Succession

* "I liked this the most because it was the most hands-on lab and I liked seeing life I would not usually see."
* "My favorite lab was Pond Succession. I liked checking to see if there were different types of species. I LOVED the part where we looked in the microscopes and had to decide which species it was."
* "My favorite lab was Pond Water Succession. This lab took awhile to do and that's why I like it. A lab that takes a while allows you to get involved more and see the changes."
* "I really liked the pond succession. I think it was because it was hands-on and it was about real life. I mean, you can look at a picture in a book, but it doesn't really mean anything. When you see it in real life, in its environment or habitat, you can see how cool it is."

DISCUSSION AND CONCLUSIONS

To summarize the success of my three new laboratories, I examined them in two ways; what was effective and what needed improvement. Because the effectiveness of each lab has been discussed prior to this section, more is said about changes that I would like to make next year.

LABORATORY ASSESSMENT:

1. Competition Drives Change

Effective:

Writing in a journal, I believe, significantly and positively influenced how much the students participated physically and mentally during this lab. Many students expressed enthusiasm about working in groups and planting their seeds. Many groups immediately exhibited ownership and pride in regard to their seedlings. It was not uncommon for groups to compete, checking to see whose plants were germinating the quickest or which plants were dominating neighboring plants.

Needs Improvement:

When I do this lab again, I will not use egg cartons. Small cups or peat pots will probably work much better. Often a student would water their seedlings excessively, creating overflow down the length of the carton. All depressions would then flood. Sometimes seeds would get carried into other depressions causing various degrees of experimental error. I also think that using a different container will allow us to keep the plants thriving longer, providing a better opportunity to analyze the effects of competition.

I will have students work in groups of two instead of four. Inevitably, only one student took responsibility for writing the journal entries, leaving three others with nothing to do at times. If two people were in a group, I would have them take turns writing or have them each make an entry on the designated day.

2. Dune Succession

Effective:

I believe that that success of this activity is due to the variety of techniques used. The video, analyses of Table 1 and the soil sample analyses, logically and clearly demonstrate species replacement. With this lab, we were able to acquaint ourselves with members of the dune pioneering community and climax community. Furthermore, comparing air temperature, soil surface temperature and soil nutrient composition allowed us to begin deciphering why some communities change. I believe that knowing the reasons for instability is tremendously valuable.

Needs Improvement:

I may show the video more than once next year. I think it may be worthwhile to show dune succession again, after completion of this lab and follow-up activities. At the first showing, at the beginning of this lab, there were probably many students who still did not understand the process of ecological succession. Although entertaining, the point of the video would not have been significant to those students. Showing again may be just the thing for them to experience an "Aha" moment.

While we are testing soil samples from the dune, I think it would be beneficial to test soil samples from a young field, middle-aged field and an established woodlot. We may get more conclusive results from these samples since the sand was devoid of any significant amounts of nutrients (i.e. nutrients sampled). This would also create a smooth segue into my follow-up investigation of forest succession. I also plan on purchasing different test kits.

I am toying with the idea of taking a group of students to the sand dunes at PJ Hoffmaster State Park. As to how I am going to organize this, I do not yet know. It would however, be a great experience for everyone.

3. Pond Water Succession

Effective:

I am pleased to say that this was everyone's favorite laboratory, including me. One student summed up the reason for this in one sentence, "We <u>love</u> looking at living things under the microscope". My students are my most reliable barometers when it comes to measuring the effectiveness of my endeavors. "The pond succession lab was my favorite. I think it was fascinating because we discovered so many different creatures. Monitoring the water from day to day was exciting - especially when totally new organisms appeared." This was exactly the reaction I was aiming for as I designed and taught this activity. My goal is for all of my students to be this enthusiastic.

I consider "Pond Water Succession" to be my most successful new endeavor. All of my students were able to witness change in their micro-ecosystem and they had a wonderful time doing so. I am satisfied with the class averages with regard to the conclusion questions and was pleased with the quality of their data tables. Many students made more slides than required and included beautiful diagrams of what they observed in their packets.

Needs Improvement:

I should have used larger sample containers to keep samples in. The students loved to check on their developing ecosystems and were disappointed when they dried up. (Some became emotionally attached to their critters and were upset to know that they had died.) If I had added water back into their containers it would have been likely that some species would reappear demonstrating that succession can take place rapidly. It would also be neat to keep some of the same pond water in an aquarium for the class to informally monitor for an entire semester or school year.

Originally I had planned on allowing the students to manipulate one of their pond water samples. Possible variable situations could include the addition of salt, detergent, oil, acid or base. I think that doing this would engage them even more. This manipulation would also help to fulfill one of my objectives, which was to explain the effects of agriculture and human activities on the environment.

I would like to add more questions to my conclusion section or assign one or two questions every time they examine their samples. If I were to ask questions as we go it may help to reinforce the objective of the laboratory and keep them more focused both on that intent and the experiment at hand. I have also discovered, through past experience, that if there are not formal questions to tackle, many students end up wasting class time. From my perspective our time is so short and precious, I want to do whatever it takes to keep everyone mentally and physically engaged at all times.

APPLICATION TO OTHER UNITS & CONCLUSION:

Upon examination of my data, I believe that the single most influential contribution to the overall design and success of this unit was summer research. Realistically, no one has time to devote five consecutive weeks to curriculum development, especially on the Michigan State University campus, each summer. However, I do feel that it would be valuable to allot time specifically for personal research so that each year an old unit or lab can be revised according to the advice of professional scientists, colleagues and students. My personal goal is to establish a habit of improving other pieces of my curriculum much in the same way I did this unit.

Reflection on the past year is also necessary. To gauge student success and validity of an activity, it would be helpful for me to write in a journal regularly about what was effective and what needs improvement. If a journal sounds intimidating to some, it may be simpler to keep comments directly on lesson plans.

Another lesson learned was how important pretests are. My best advice to any teacher would be, write pretests to evaluate prior student knowledge and identify misconceptions before beginning new units. How can we as teachers presume to enhance what students know or erase and replace their misconceptions if we are not even aware of what those misconceptions are? Initially it may seem like hard work or too time consuming, but the reward for both teacher and student is considerable.

I discovered how I want to teach this unit (as well as others) by surveying my students. Their feedback was honest, sometimes brutal, and extremely important for me to know so that I could evaluate myself from an entirely new paradigm. On many occasions students were able to identify areas needing improvement better than I could because they were the ones ultimately experimenting with my new activities. For me, often the learner's perspective is more important than my perspective. I am grateful for their compliments, criticisms and suggestions. I plan on garnering much more student feedback for all of my units in the upcoming year.

In conclusion, I am excited about my new activities and look forward to improving and trying them again next school year. I will be tracking pretest and post test scores, to facilitate increased student achievement even more than this past year. In essence, I am proud of what I and my students were able to accomplish as a result of pursuing a Master's Degree. Having high expectations of myself and my students has helped us meet the goals of this program as well as set new goals for the future.

APPENDICES

APPENDIX A

Pretest

PRETEST
CHAPTER 13
HOW ECOSYSTEMS CHANGE

1. Two or more species may form close relationships. For each of the following examples, describe why you think the relationship exists. (Hint - which organisms benefit and why?)
   a. flea and dog
   b. water buffalo and egret
   c. owl and rabbit
   d. whale and barnacles

2. How would you describe the niche of a honeybee?

3. Do you think that all organisms are able to utilize all of the potential resources available in their environment? If not, why?

4. Imagine that a forest fire has occurred, as it did in Yellowstone National Park. What kind, if any, organisms do you think would be found in:
   a. 1 day

   b. 1 year

   c. 10 years

   d. 100 years

5. What factors may limit the diversity of species in an ecosystem?

APPENDIX B

Daily Plans & Activities for Succession

The following represents the material I taught, in regard to succession, in sequence over a four to five week period. My actual ecology unit lasted approximately seven weeks. The information provided in the outline represents only parts of my unit which include the teaching of ecological succession.

Previous Topics:

- Parts of an ecosystem
- Autotrophs vs. heterotrophs vs. decomposers
- Flow of energy through an ecosystem
- Diversity (defined)
- Began the water cycle, carbon cycle and nitrogen cycle
- Biome comparisons

We are ending Chapter 12 Ecosystems this week. Next week we will begin Chapter 13 How Ecosystems Change. It is this chapter that compliments my unit best and where I have chosen to give the pretest.

Week One
Monday - Wednesday:

- Assign chapters 1-3 of Water A Natural History (there will be some class time available to read, however there is the expectation that students will also be reading as homework).
- As we begin the book, we are also putting closure to a project regarding biomes.
- The first part of the novel focuses on the way beavers are able to create wetlands as a result of their lifestyle. To compliment the reading, freshwater ecosystems were also discussed.

Thursday:

- Pass out the first questionnaire.

- Students were to work as individuals for this particular packet of questions - as a quiz. I did it this way, so that I could determine who had actually read and to convey how important it was to have done so.
- Collect the questionnaires (quizzes) and begin discussing as a class if time allows.

Friday:
- Finish discussion of chapters 1-3 (water book).
- Assign chapters 4-7, this should be read by Monday.

Week Two
Monday:
- Put students in groups of 3 or 4.
- Pass out the second questionnaire. Each person will get a packet and the group itself will be responsible for a packet. The group's packet will be turned in for credit. Everyone in the group must be active participants! (Walk around all hour to monitor the progress of each team, answer questions etc.)

Tuesday:
- Allow 10 - 15 minutes of class time for groups to finish their questions if necessary.
- Administer the pretest.
- Show video clips depicting predation, mutualism, commensalism and parasitism. Do not yet define the relationships using these specific terms. Ask the students what they think the relationships are. (As in pretest question 1.)
- Assign the rest of the water book, chapters 8-11, we will discuss these Friday.

Wednesday:
- Begin Chapter 13, section 1 (material corresponding to pretest question 1).
- Discuss the video and define the relationships we watched yesterday.
- If time allows, students may read their water books.

Thursday:
- Work on Chapter 13, section material (questions, concept map).
- Read water books in class, answer related questions etc.

Friday:

- Group discussion of water book, chapters 8-11, people are encouraged to take notes.

Week Three
Monday:

- Refer to pages 272-273 in the text.
- Begin "Competition Drives Change" - state the problem. How is growth affected by competition?
- As the groups are working they must be documenting their procedures and beginning their journals.

Wednesday:

- Discuss the journal requirements and dates expected for entries.
- Read pages 274-275 in preparation for tomorrow's activities. (These are the pages in the text that define ecological succession.)
- Homework - "Examining Stages of Ecological Succession" (Miller, et al., 1987).

Thursday:

- Homework due. Answer any questions regarding the assignment.
- Show the video and slide presentation of dune succession.
- Share and analyze the data from Table 1.

Friday:

- Conduct soil nutrient testing from the dunes to determine the connection between nutrients and the types of autotrophs present at testing sites.
- Analyze the data and discuss its significance.

Week Four
Monday:

- Begin the activity "Studying Forest Succession" (Beller and Tomera, 1989) in teams of 2.

Tuesday:

- Finish the forest succession investigation - turn in.
- Begin the procedures for "Pond Water Succession".

Wednesday - Thursday:

- Set-up "Pond Water Succession" and begin collecting data.

Friday:

- Examine everyone's seedlings ("Competition Drives Change")and discuss the significance of the results in respect to succession. Journals are also due.

Week Five:
As we move into other topics such as factors affecting diversity and how humans disrupt ecosystems, we keep collecting data from our pond water samples. There is however, no more formal labs or activities directly representative of ecological succession from this point. At the end of the Pond Water Succession lab, the data sheets and conclusion questions are turned in for examination and credit.

APPENDIX C

WATER BOOK QUESTIONS

WATER BOOK QUESTIONS
(IN RESPECT TO SUCCESSION ONLY)

1. Describe the life cycle of a typical beaver and describe how that influences the surrounding habitat.

2. How has the near extinction of beavers influenced the surrounding habitat?

3. After beavers were slaughtered, what was the next natural resource exploited in our country? How has this influenced the water cycle and soil composition in affected regions?

4. Why are reforested areas in existence today so unlike primeval forests that the settlers first encountered?

5. How do man-made dams affect water temperature, flow, dispersion of nutrients, sediments and dissolved oxygen?

6. How do the above factors affect fish in regard to diversity of species, types of species and means of reproduction?

APPENDIX D

NEW LABORATORIES

COMPETITION DRIVES CHANGE!

Purpose: To observe the success of one plant species as compared to another due to the effects of competition.

Materials:
6-7 Styrofoam egg cartons
potting soil
various seeds
light source

The following list is only a suggestion. Group A seeds are faster growing than Group B seeds. The kids however, are not aware of this.

Group A	Group B
Lettuce	Bean
Radish	Green Pepper
Sunflower	Marigold
Clover	
Pea	

Teacher Instructions:
1. Assemble students into groups of 2-4.
2. Give each group an empty egg carton and enough soil to fill all depressions.
3. Give each group two types of seeds.
4. One side of the egg carton will be used as the control side for this experiment.
5. On the control side groups should plant one seed of seed type one in the first depression, three seeds in the next and five seeds in the next.
6. On the control side, beginning with the fourth depression, students should plant one seed of seed type two, three seeds in the next and five seeds in the last spot.
7. In the bottom row students should plant one of each seed type in the first depression, three of each in the next, five of each in the next and ten of each in the fourth depression. If you want them to continue to increase the ratios, they should use the last two depressions to do so.
8. Students should write their procedure and outcomes at intervals designated by the instructor in a journal.

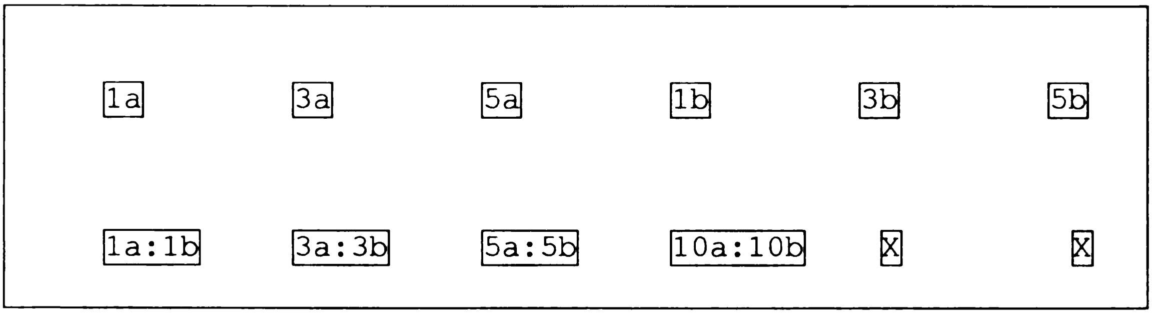

Figure 1 - Competition Lab Set-up

POSSIBLE STUDENT JOURNAL PAGES

First Page:
1. Procedure
2. Types of seeds used
3. Number of seeds plants and their locations - include a diagram
4. Depth of each seed type

Following Pages:

SEED TYPE 1
1. Date of germination for each seed
2. Sizes of seedlings in either mm or cm
3. Average size of seedlings per depression
4. Surface area of cotyledons or leaves
   a. measure a piece of paper (i.e. 5 cm x 5 cm)
   b. weigh the paper in grams
   c. trace a leaf on a piece of paper and cut out
   d. weigh this piece of paper in grams
   e. determine the surface area
5. General description

SEED TYPE 2
- Same as above

CARE OF PLANTS
1. When the plants were watered
2. The amount of water added
3. Other

POND WATER SUCCESSION

Purpose:
To observe and document a gradual replacement of species (i.e. succession) in a sample of pond water.

Materials:
Pond water
Beakers/flasks/cups
Thermometer
Litmus paper or pH meter
Microscope
Microscope slides
Coverslips
Eye dropper
Light source
Scale
Protist and Algae identification guides
- Possible Variables:
  - Oil
  - Detergent
  - Acid
  - Base
  - Salt
  - Fertilizer

Procedure:
1. Fill two 500ml flasks with 400ml of pond water.
2. Label both with your name and one as the control and the other as the variable (you choose the variable situation).
3. Make necessary additions to the variable sample.
4. Please record the following information on your data sheet for each sample:
   a. color
   b. amount of material on top (qualitative)
   c. amount of material on bottom (qualitative)
   d. amount of material dispersed (qualitative)
   e. Does there seem to be life present? (Answer Yes or No.)
5. Take the temperature of each sample in degrees Celsius and record this on your data sheet.
6. Using litmus paper (or a pH meter if available), determine the pH of each sample and record this on your data sheet.

7. Make at least 4 wet mount slides from each sample and document the following on the data sheet:
   a. An approximate number of organisms
   b. The types of organisms (both autotrophic and heterotrophic) - refer to supplied diagrams to help you do this. You may not be able to identify everything you find.
8. Diagram what you find.
9. Steps 4 - 8 will be done every 3 - 4 days for two weeks.
10. When you are done making observations, please return samples to designated places.

DATA SHEET 1
POND WATER SUCCESSION

Date:

Sample	Color	Material Top	Material Bottom	Material Dispersed	Life
1 - Control					
2 - Variable					

Date:

Sample	Color	Material Top	Material Bottom	Material Dispersed	Life
1 - Control					
2 - Variable					

Date:

Sample	Color	Material Top	Material Bottom	Material Dispersed	Life
1 - Control					
2 - Variable					

DATA SHEET 2
POND WATER SUCCESSION

Date:

Sample	Temperature	pH
1 - Control		
2 - Variable		

SLIDES:

Sample	Number of Organisms	Type of Organisms
1 - Control		
2 - Variable		

DIAGRAMS:

CONCLUSIONS
POND WATER SUCCESSION

1. How do you think increased exposure to light would affect your community?

- Next year I will ask them to design an experiment to test this.

2. How do you think copper sulfate affects succession in a typical pond community?

3. What are some factors that may increase or decrease the rate of succession and why? How would these factors be introduced? (You may discuss human influences).

4. Do you think that increasing the rate of succession is beneficial for the pond community? Why or why not?

5. What would you predict a pond community (like the one our samples were taken from) to look like in 150 years?

6. Please describe what happened in your samples during the course of this experiment. Did your individual experiment fulfill the purpose of this lab? (Please make your explanation as detailed as possible.)

APPENDIX E

POST TEST QUESTIONS

POST TEST QUESTIONS
(IN RESPECT TO SUCCESSION ONLY)

1. What is the difference between primary and secondary succession? Which do you think occurs slower and why?

2. Please identify two differences between a pioneering stage of succession and a climax community.

3. What is the climax community in our state?

4. How does copper sulfate affect succession in a typical pond community?

5. When you deciphered the data given for forest succession, why didn't the presence of adult trees signal that a climax community had been reached?

6. Why would succession stop (i.e. reach a climax community)?

LITERATURE CITED

LITERATURE CITED

Beller, J., and A.N. Tomera. 1989. Ecological Concepts. Portland, Maine: J. Weston Walch.

Benchmarks For Science Literacy. 1993. New York: Oxford University Press, Inc.

Bodkin, D.B., and E.A. Keller. 1998. Environmental Science: Earth As A Living Planet. 2nd ed. New York: John Wiley & Sons, Inc.

Bybee, R.W., and L.W. Trowbridge. 1990. Becoming A Secondary School Science Teacher. 5th ed. Columbus, Ohio: Merrill Publishing Company.

Carin, A.A. 1993. Teaching Science Through Discovery. New York: Macmillan Publishing Company.

Chapin III, S.F., et al. 1998. "Ecosystem Consequences of Changing Biodiversity." BioScience 48:45-51.

E. Genevieve Gillette Sand Dune Visitor Center Pamphlet. 1997. n.p., n.p.

Giourga, H., N.S. Margaris, and D. Vokou. 1998. "Effects of Grazing Pressure on Succession Process and Productivity of Old Fields on Mediterranean Islands." Environmental Management 22:589-596.

Gusky, T.R. 1985. Implementing Mastery Learning. Belmont, California: Wadsworth Publishing Company.

Jasmine, G., and J. Jasmine. 1996. Activities For Science Cooperative Learning Lessons. Huntington Beach, California: Teacher Created Materials Inc.

Johnson, G.B. 1994. Biology Visualizing Life, Austin, Texas: Holt, Rinehart and Winston.

Knobloch, I.W. 1994. Liveable Planets Are Hard To Find, An Overview Of Our Terrestrial Home For The Layperson. n.p., Irving W. Knobloch.

Michigan State Board of Education. Michigan Essential Goals And Objectives For Science Education (K-12). 1991. Lansing, Michigan: Michigan State Board of Education, Michigan Department of Education.

Miller, K., and J. Levine. 1987. Biology, Englewood Cliffs, New Jersey: Prentice-Hall.

Morholt, E., P.F. Brandwein, and A. Joseph. 1958. A Sourcebook for the Biological Sciences. 2nd ed. New York, Chicago, Burlingame: Harcourt, Brace & World, Inc.

National Environmental Education and Training Foundation. National Report Card on Environmental Knowledge, Attitudes and Behaviors: The 6th Annual Survey of Adult Americans. 1997. Washington D.C.

Outwater, A. 1996. Water A Natural History. New York: BasicBooks.

Roach, L.E., and J.H. Wandersee. 1993. "Short Story Science." The Science Teacher 60:18-21.

Wong, H.K., and R. Tripi Wong. 1991. How To Be An Effective Teacher. Sunnyvale, California: Harry K. Wong Publications.