Using Ecosystem Case Studies to Teach Science Based on Next Generation of Science Standards through Project Based Learning

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Authorship

Both team members worked on the writing and editing of this paper equally.

Abstract:

In January 2016, the state of Massachusetts introduced a modified version of the Next Generation Science Standards (NGSS), a set of learning goals for science in K-12 education that combines practice with content, as the new standards for teaching science in the state. These standards emphasize a more skill based style of student evaluation. Therefore, a project based approach to learning was proposed as a good alternative to meet the new standards. A project based NGSS compliant lesson plan was designed to investigate the success of this teaching method. A six-day lesson plan on the topic of ecosystems was developed and tested in Jessica McDermott's eighth grade science class of Forest Grove Middle School in Worcester, MA. Despite the small amount of numerical data, the in-class observations by the teacher and us suggested that project based learning could be an effective method in teaching ecosystems in middle school based on the new standards.

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Introduction:

Science education is an important part of the middle school curriculum. Since the state of Massachusetts changed its science and engineering education standards to a modified version of the Next Generation Science Standards, it is important to consider finding the best way of how to present the material and concepts to the students.

In this project, we particularly look at whether project based learning can be a more effective method to teach middle school students about ecosystems compared to conventional methods. All while increasing student engagement and allowing for the development of other important skills such as asking questions, defining problems, planning and carrying out an investigation, conducting experiments, and developing and using models; all essential practices of science and engineering as outlined by the NGSS [4].

Our hypothesis was that the best way to teach science and engineering in middle school based on the new standards is through project based learning (PBL). In order to test our hypothesis, we developed a six day lesson plan on ecosystems adhering to the NGSS and taught in a project based learning format. We decided to use a case studies approach for the lesson plan, because case studies allow for scientific exploration of topics within the time constraints present in a middle school class.

Through our observations, conversations with students, test results, and an interview with the hosting teacher, we found that students seemed to learn at least as well as with conventional means. However, they were also able to engage in a series of actives teaching the eight essential practices of science and engineering as described in the NGSS. Overall, our experience indicates that a project based interpretation of the Next Generation Science Standards is beneficial to students.

Background

Science education is powerful in K-12 education because of its importance in guiding people to make informed decisions in their lives [4]. Science education directly informs people about some decisions they will be making like those regarding healthcare, using technology and understanding events, regardless of the career path they choose [4]. The skills people develop through different stages of their education, such as asking questions, logical reasoning, and problem solving influence all aspects of life [4]. In order to ensure that every student obtains these skills, education standards are set in place in every state. The education standards for the state of Massachusetts are currently derived from the Common Core Standards for English Language Arts and Mathematics, and The Massachusetts Science and Technology/Engineering Curriculum Framework for Science. However, since May of 2013, the state of Massachusetts was looking to introduce new standards, the Next Generation Science Standards (NGSS), to supplement the framework in place for Science, Technology, and Engineering. The intention of this change was to more closely match the layout used by the common core for English and Math. The transition was approved in January 2016. With the introduction of the new standards, new lesson plans will also need to be developed in order to accommodate for the fulfillment of these standards.

We hypothesize that the best way to teach science and engineering in middle school based on the new standards is through project based learning (PBL). PBL exposes students to "respond to the challenges and develop solutions to open-ended problems," [3] and therefore understand the material better. Worcester Polytechnic Institute, one of the leading schools in PBL as stated by the Princeton Review, can be taken as an example for how to teach "theory and practice" [5].

For this project, given the short timeframe, a lesson plan was developed for one eighth grade middle school topic: ecosystems. The Massachusetts Science and Technology/Engineering Curriculum Framework standards were compared to the NGSS ones in order to highlight the differences and to construct a plan that satisfies the new standards. Then PBL was analyzed to develop the best way to incorporate projects into the theoretical concepts.

Common Core Standards

State leaders and governors noticed that the academic progress of the nation's students was low compared to their international peers, especially in subjects like math and science. They came to the conclusion that this was mostly due to academic standards varying from state to state. The variation was in what students should know and be able to do at each grade level. Therefore, they took a step towards changing that in order for "all students to graduate from high school with the skills and knowledge necessary to succeed in college, career, and life, regardless of where they live" [2]. In 2009, the state school chiefs and governors that comprise Common Core State Standard Initiative (CCSSO) and the NGA Center, collaborated with teachers, school chiefs, administrators, and other experts. They coordinated a state-led effort to develop the Common Core State Standards (CCSS). CCSS is a set of English language arts and mathematics standards which explain what "a student should know and be able to do at the end of each grade" [2].

The standards set "a clear and consistent framework for educators" [2]. "Forty-two states, the District of Columbia, four territories, and the Department of Defense Education Activity (DoDEA) have voluntarily adopted and are moving forward with the Common Core"[2]. Massachusetts started the transition to Common Core in fall 2011. It " added more than 20 math standards, as well as pre-kindergarten and ELA standards" [1] The Department of Elementary and Secondary Education adopted the standards in order to make sure that “students are learning what they need to know and be able to do at each grade level.” [1]

State of Massachusetts Standards

The English Language Arts and Mathematics standards were updated, and are well developed and adopted from the Common Core. Meanwhile, the Massachusetts Science and Technology/Engineering Curriculum Framework was adopted in 2006 and was updated in January 2016, after the completion of this project. The Massachusetts Department of Elementary and Secondary Education states that its purpose “is to enable students to draw on these skills and habits, as well as on their subject matter knowledge, in order to participate productively in the intellectual and civic life of American society and to provide the foundation for their further education in these areas if they seek it.” [6] The 2006 Curriculum Framework aimed to “engage students in inquiry-based instruction” to develop “conceptual understanding, content knowledge, and scientific skills.”[6]

The framework idealizes that inquiry, experimentation, and design should all be integrated into each lesson rather than be treated as separate entities. It cites asking questions, investigations, and an understanding of an engineering design process as three key components of this. For middle schools specifically, it aims to have students to be able to “formulate a testable hypothesis, design and conduct an experiment specifying variables, select appropriate tools and technology, and make quantitative observations.” [6]. In addition, it aims for the students to be able to present and explain their findings as well as include tables, graphs, models, and demonstrations [6]. The framework also states that the students should be able to draw conclusions based on their data presented in tables or graphs, and make connections based on the trends in the data [6]. Finally, they should be able to “communicate procedures and results using appropriate science and technology terminology, and offer explanations of procedures, and critique and revise them."[6]

The Framework identifies ten Guiding Principles to drive the "inquiry-based educational environments that encourage student curiosity, engagement, persistence, respect for evidence, and sense of responsibility" [6]. These guiding principles are listed below [6]:

- To provide a comprehensive science and technology/engineering education program that enrolls all students from PreK through grade 12
- To provide a program that builds students' understanding of the fundamental concepts of each domain of science, and their understanding of the connections across these domains and to basic concepts in technology/engineering
- To ensure the integration of mathematics into science and technology/engineering
- To address student's prior knowledge and misconceptions
- To put an emphasis on investigation, experimentation, and problem solving.
- To help develop 'students' literacy skills and knowledge
- To convey high academic expectations for all students
- To ensure assessment serves to inform student learning, guide instruction, and evaluate student progress
- To provide students with the opportunities to collaborate in scientific and technological endeavors and communicate their ideas
- To have district-wide planning and on-going support for implementation

The Framework divides science into 4 disciplines "Earth and Space Science, Life Science (Biology), Physical Sciences (Chemistry and Physics), and Technology/Engineering" [6]. For each discipline there are a list of topics and specific points that students should know at the end of the course. For example in Life Science (Biology), the framework states that the topics include Classification of Organisms, Structure and Function of Cells, Systems in Living Things, Reproduction and Heredity, Evolution and Biodiversity, Living Things and Their Environment, Energy and Living Things, and Changes in Ecosystems Over Time . Then the framework narrows down to address each topic more in depth. For Energy and Living Things, for example, the framework states that the students should be able to "explain the roles and relationships among producers, consumers, and decomposers in the process of energy transfer in a food web, explain how dead plants and animals are broken down by other living organisms and how this process contributes to the system as a whole." [6] The framework also states that the students should be able to recognize the process of photosynthesis [6].

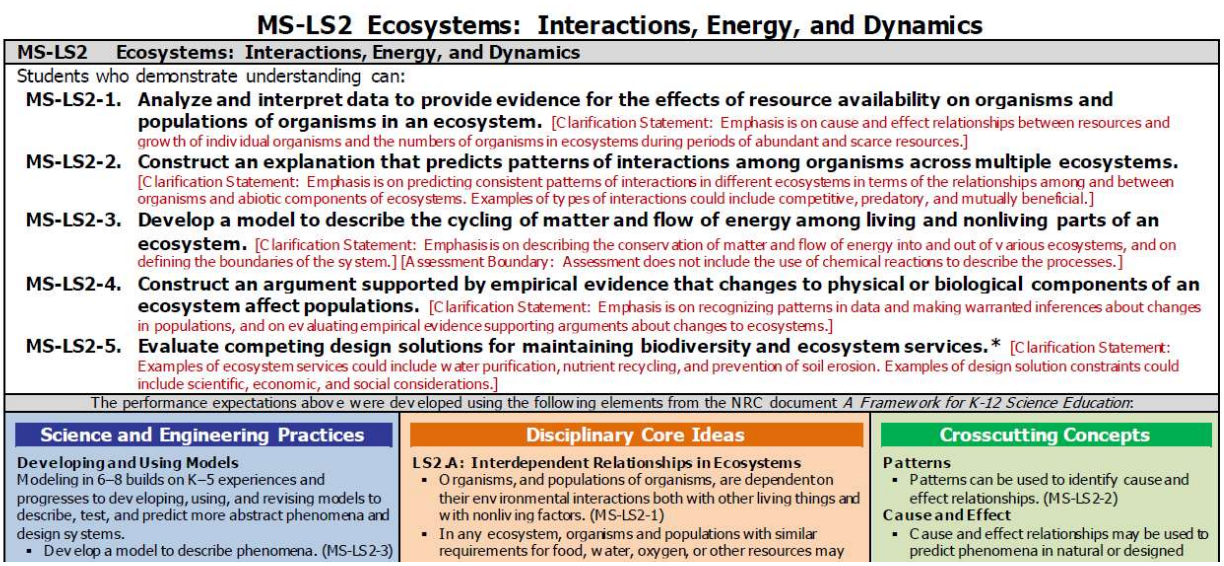
Next Generation of Science Standards

While the State of Massachusetts Curriculum frameworks for science have helped in improving the science education, better standards are needed that focus more on the development of the students' practical skills. Therefore, the state of Massachusetts is considering whether or not to adopt the Next Generation Science Standards (NGSS).

In an effort to improve science education and to introduce engineering as part of it, the National Research Council developed and published in 2013 new K-12 science standards called NGSS. The standards were based on the *Framework for K–12 Science Education*, a framework developed by 18 internationally well-known scientists. It was released on July 2011, and explains what K-12 students should know based on the latest science and science learning research. [4] A new addition to the guidelines was engineering being introduced along with Science.

The NGSS was designed to inform teachers about the performance expectations. It couples Practices and Core Ideas to combine content and practice, which has shown to be productive in the world of science and engineering [4]. NGSS is suggested to be seen as learning goals, not teaching strategies. “Coupling practice with content gives the learning context, whereas practices alone are activities and content alone is memorization. It is through integration that science begins to make sense and allows student to apply the material.” [4]

Unlike the previous standards, NGSS do not state what students should know regarding a given topic, but they list *performance expectations* that explain what students are expected to do. Every topic has performance expectations which are incorporated in three dimensions: science and engineering practices, disciplinary core ideas, and a crosscutting concepts. [4] The middle school topic “Ecosystems: Interactions, Energy, and Dynamics,” for example, presents the performance expectations as follows:



MS-LS2 Ecosystems: Interactions, Energy, and Dynamics

MS-LS2 Ecosystems: Interactions, Energy, and Dynamics
Students who demonstrate understanding can: **MS-LS2-1. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.** [Clarification Statement: Emphasis is on cause and effect relationships between resources and growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources.] **MS-LS2-2. Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.** [Clarification Statement: Emphasis is on predicting consistent patterns of interactions in different ecosystems in terms of the relationships among and between organisms and abiotic components of ecosystems. Examples of types of interactions could include competitive, predatory, and mutually beneficial.] **MS-LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.** [Clarification Statement: Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system.] [Assessment Boundary: Assessment does not include the use of chemical reactions to describe the processes.] **MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.** [Clarification Statement: Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes to ecosystems.] **MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services.*** [Clarification Statement: Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.]
The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. ▪ Develop a model to describe phenomena. (MS-LS2-3)	**LS2.A: Interdependent Relationships in Ecosystems** ▪ Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. (MS-LS2-1) ▪ In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may	**Patterns** ▪ Patterns can be used to identify cause and effect relationships. (MS-LS2-2) **Cause and Effect** ▪ Cause and effect relationships may be used to predict phenomena in natural or designed

Figure 1: Middle School- Life Sciences NGSS Standards for the topic of Ecosystems [4]
(continued on page 8)

Analyzing and Interpreting Data
Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.
- Analyze and interpret data to provide evidence for phenomena. (MS-LS2-1)

Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.
- Construct an explanation that includes qualitative or quantitative relationships between variables that predict phenomena. (MS-LS2-2)

Engaging in Argument from Evidence
Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).
- Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. (MS-LS2-4)
- Evaluate competing design solutions based on jointly developed and agreed-upon design criteria. (MS-LS2-5)

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence
- Science disciplines share common rules of obtaining and evaluating empirical evidence. (MS-LS2-4)

compete with each other for limited resources, access to which consequently constrains their growth and reproduction. (MS-LS2-1)
- Growth of organisms and population increases are limited by access to resources. (MS-LS2-1)
- Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared. (MS-LS2-2)

LS2.B: Cycle of Matter and Energy Transfer in Ecosystems
- Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. (MS-LS2-3)

LS2.C: Ecosystem Dynamics, Functioning, and Resilience
- Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. (MS-LS2-4)
- Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health. (MS-LS2-5)

LS4.D: Biodiversity and Humans
- Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling. *(secondary to MS-LS2-5)*

ETS1.B: Developing Possible Solutions
- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. *(secondary to MS-LS2-5)*

systems. (MS-LS2-1)

Energy and Matter
- The transfer of energy can be tracked as energy flows through a natural system. (MS-LS2-3)

Stability and Change
- Small changes in one part of a system might cause large changes in another part. (MS-LS2-4),(MS-LS2-5)

Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering, and Technology on Society and the Natural World
- The use of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time. (MS-LS2-5)

Connections to Nature of Science

Scientific Knowledge Assumes an Order and Consistency in Natural Systems
- Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation. (MS-LS2-3)

Science Addresses Questions About the Natural and Material World
- Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes. (MS-LS2-5)

Connections to other DCIs in this grade-band: **MS.PS1.B** (MS-LS2-3); **MS.LS1.B** (MS-LS2-2); **MS.LS4.C** (MS-LS2-4); **MS.LS4.D** (MS-LS2-4); **MS.ESS2.A** (MS-LS2-3),(MS-LS2-4); **MS.ESS3.A** (MS-LS2-1),(MS-LS2-4); **MS.ESS3.C** (MS-LS2-1),(MS-LS2-4),(MS-LS2-5)

Articulation across grade-bands: **1.LS1.B** (MS-LS2-2); **3.LS2.C** (MS-LS2-1),(MS-LS2-4); **3.LS4.D** (MS-LS2-1),(MS-LS2-4); **5.LS2.A** (MS-LS2-1),(MS-LS2-3); **5.LS2.B** (MS-LS2-3); **HS.PS3.B** (MS-LS2-3); **HS.LS1.C** (MS-LS2-3); **HS.LS2.A** (MS-LS2-1),(MS-LS2-2),(MS-LS2-5); **HS.LS2.B** (MS-LS2-2),(MS-LS2-3); **HS.LS2.C** (MS-LS2-4),(MS-LS2-5); **HS.LS2.D** (MS-LS2-2); **HS.LS4.C** (MS-LS2-1),(MS-LS2-4); **HS.LS4.D** (MS-LS2-1),(MS-LS2-4),(MS-LS2-5); **HS.ESS2.A** (MS-LS2-3); **HS.ESS2.E** (MS-LS2-4); **HS.ESS3.A** (MS-LS2-1),(MS-LS2-5);

HS.ESS3.B (MS-LS2-4); **HS.ESS3.C** (MS-LS2-4),(MS-LS2-5); **HS.ESS3.D** (MS-LS2-5)

Common Core State Standards Connections:

ELA/Literacy –	
RST.6-8.1	Cite specific textual evidence to support analysis of science and technical texts. (MS-LS2-1),(MS-LS2-2),(MS-LS2-4)
RST.6-8.7	Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-LS2-1)
RST.6-8.8	Distinguish among facts, reasoned judgment based on research findings, and speculation in a text. (MS-LS2-5)
RI.8.8	Trace and evaluate the argument and specific claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient to support the claims. (MS-LS-4),(MS-LS2-5)
WHST.6-8.1	Write arguments to support claims with clear reasons and relevant evidence. (MS-LS2-4)
WHST.6-8.2	Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. (MS-LS2-2)
WHST.6-8.9	Draw evidence from literary or informational texts to support analysis, reflection, and research. (MS-LS2-2),(MS-LS2-4)
SL.8.1	Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly. *(MS-LS2-2)*
SL.8.4	Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation. *(MS-LS2-2)*
SL.8.5	Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. *(MS-LS2-3)*
Mathematics –	
MP.4	Model with mathematics. *(MS-LS2-5)*
6.RP.A.3	Use ratio and rate reasoning to solve real-world and mathematical problems. *(MS-LS2-5)*
6.EE.C.9	Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation. *(MS-LS2-3)*
6.SP.B.5	Summarize numerical data sets in relation to their context. *(MS-LS2-2)*

Figure 1: Middle School- Life Sciences NGSS Standards for the topic of Ecosystems [4]

Some states consider only the performance expectations as “the standards,” while other states also include the three foundation boxes and connections in “the standard.” [4] The state of Massachusetts was considering to adopt the performance expectations as well as the science and engineering practices, and disciplinary core ideas since May of 2013, and was able to approve the adaptation in January 2016.

Given that the performance expectations do not give a set of instructions on what the students should do, but what they should be able to do after given the instructions, it is up to the teachers, district, and state to decide on how their students will accomplish these goals. One way that the performance expectations can be met is through project based learning (PBL). Worcester Polytechnic Institute (WPI) is a university well-known for its use of PBL in instruction. Therefore, WPI’s approach to learning is taken as an example for developing a lesson plan that puts together “theory and practice.”[5]

Project Based Learning

WPI has implemented project-based learning as part of its undergraduate curriculum since 1970. It is used in project like the Interactive Qualifying Project (IQP) and Major Qualifying Project (MQP), as well as most courses. “Participating in team and individual research settings, students tackle authentic, open-ended projects under faculty guidance.” [7] Through the projects, they hone their research and critical thinking skills. In addition, project based learning is implemented in most courses, and this has resulted to be successful given the fact that WPI students are able to easily join the workforce and lead important projects as soon as they graduate.

In fact, the project description you are currently reading is an example of a project WPI students did. We hope to leverage our personal experiences with project based learning as a method of teaching science and engineering to create a lesson plan in the middle school classroom setting.

Research

This project was ideated by WPI professors Arne Gericke and Martha Cyr with the intent to create a project based learning environment in a middle school that also meets the Next Generation of Science Standards. Given the experience that a similar project had the previous year, it was decided that a lesson plan would be designed and implemented in various classes taught by the same teacher. First, Professor Cyr contacted local middle schools to find a teacher that would be willing to work with us to determine an appropriate topic and be willing to teach the designed lesson plan. Jessica McDermott, an eighth grade science teacher at Forest Grove middle school in Worcester, MA showed interest in helping us with this project. We contacted Mrs. McDermott, and after a quick interview with her, we found out that she was teaching four classes, two honors and two inclusion. The honors classes are faster paced than the typical classes, while the inclusion classes are slower paced and need additional teachers to meet the students' needs. The lesson would be taught to all four classes. During the time that we could apply our lesson, the topic of ecosystems would be covered in Mrs. McDermott's classes.

First, we analyzed the key points that had to be covered through the lesson plan that we would design on the topic of ecosystems. Mrs. McDermott showed us that the students did really well with little hands-on activities. Therefore, we tried to build a lesson plan that had many hands on activities and group work. Traditionally, the ecosystem topic would be taught by showing dependencies between populations through 'food webs.' The food web presentation is usually transmitted to the students, rather than constructed by the students themselves which doesn't allow the students to understand the complexity of ecosystems and the interdependencies between the populations in these ecosystems [8]. Therefore, we decided to build a lesson plan that was different from the traditional one and that would give the students a better understanding of how ecosystems work.

Initially, we planned on showing the students real ecosystems to work with, for example an ecosystem with algae and fish. However, such ecosystems take a few months to develop and we did not have the time to allow for the growing of the organisms. Additionally the time it would take students to complete such a complex task was not feasible over the six days the lesson plan was designed to take place in. Therefore, instead of using real ecosystems, we came up with the idea of using models made out of economical materials as can be seen in Figure 2. In addition, labeled stickers were used to label the organisms as producers, consumers or decomposers, and string was used to connect them to each other in order to form food chains and a food web. All the materials used for this project can be seen in Appendix D.

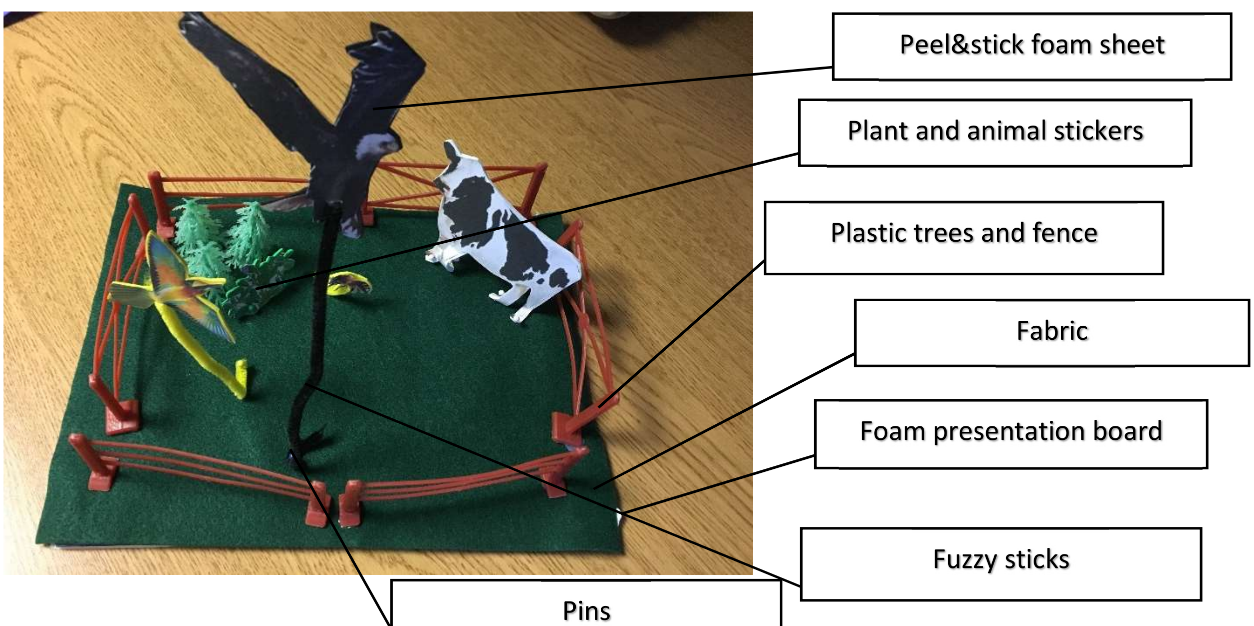


Figure 2: Materials used to construct the ecosystem models

The ecosystem topic covers many concepts including producers, consumers, decomposers, photosynthesis, energy flow in the system, and the impact that different factors have on the flourishment or destruction of an ecosystem. We knew the theoretical parts that had to be covered, and we had ideas for the build-up of the ecosystems. We also came up with daily activities that the students could do as group work in class. After seeing all the activities, Prof. Cyr advised us to use case studies to link all the activities together.

We decided to build the case studies using real ecosystem problems that were either present in the students' state of residence or that would interest the students. Given that the average classroom size is twenty five students, five case studies were built, one for each group of five. The specific topics for each case study are as listed below. The full case studies can be seen in Appendix A.

1. Let's save the bees, small insects with a huge impact in our lives!
2. The whales need your help!
3. Only three gray wolves left in the Isle Royale National Park!
4. No whales means no fish either?!
5. Sea otters, friends or enemies with the sea grass meadow?

First, we gave the students a prompt of what was going on with the ecosystem, as seen in Appendix A. Then, the students were given the role of scientific investigators to explore what went wrong with the ecosystem, and what could be done to help save the ecosystem. In addition to the prompt, pictures of each organism presented in the case study were given. This was suggested by Mrs. McDermott, because not all students were expected to be familiar with all the organisms. The overall project was divided into six class days, where each class period was approximately 50 minutes. Every day the students would learn something new about their main organism in the ecosystem or the ecosystem itself through reading articles, doing web research, building models, and working together to identify the problem and the solution. At the same time they would review the key terms from the ecosystem unit as well as the main concepts. On the last day of the project, the students made posters and presented their findings to the class. The rubric for assessing the presentations, and guiding the students on what to include in the posters was attached in the provided packet which can be found in Appendix A. The materials used for the models and the posters can be found in Appendix D, while the articles used for the five case studies can be found in Appendix B.

In addition to using the packet in Appendix A for the daily activities, Mrs. McDermott, added “Bell Work” at the beginning of each class. Bell Work included a question that complied with the daily activity. Its purpose was for the students to review the key theoretical concepts before doing the hands on activities.

Methodology

The goal of this project was to actualize a science lesson plan for a middle school class. This lesson plan was required to adhere to the NGSS standards and present the information in a project based format while fulfilling the current Massachusetts state guidelines for 8th grade science education.

We implemented our lesson plan in 8^{th} grade classes at Forest Grove Middle School in Worcester MA. The classrooms that we worked with had a size range of 26 to 33 students. Mrs. McDermott mentioned to us that this was average class size for the school. We worked with a total of 117 students broken up into four classes. Of those students 55 were female and the remaining 62 were male. A description of the daily activities is presented in Table 1.

Table 1: List of the activities that the students did each day of the project

Day 1	Students identified producers, consumers and decomposers, and then created food webs for their ecosystems
Day 2	Models of ecosystems were constructed and arranged into food webs and energy pyramids.
Day 3	Students visited the computer lab to further investigate their ecosystem and were asked to write a paragraph about their findings
Day 4	Teacher was not present. Students continued writing paragraphs
Day 5	Students answered additional questions about their ecosystem and were asked to think about what they felt was wrong with it.
Day 6	Students read an article explaining what was wrong with their ecosystem and were then asked to compare what they thought was wrong with what the article has said.
Day 7	Students built a poster to present to their classmates.

While working on this project, each class was broken down into groups of two boys and two girls where class composition would permit. In order to allow for fluid group work at each table, packets were made for the students. These packets had a number of questions as well as other prompts for the students to answer for their group’s ecosystem case study. Initially the plan was to have each student receive their own packet. However, this was later revised by Mrs. McDermott to be one package per table. These packets can be seen in Appendix A. The packets were supplemented by articles explaining the case studies, which can be found in Appendix B. In addition, the students utilized a computer lab to do further research on the main organism in their ecosystem using the website eol.org. The students were also provided with model components of their ecosystem for them to put together and build a food web. These models each comprised of different organisms within the given ecosystem cut out and glued to the back of foam sheet. We constructed a base out of foam board with green or blue fabric to represent either grass or water. The goal was for students to use pins, fuzzy sticks, and cut out arrows and string to assemble a food web for their ecosystem. Then, the students had to label their organisms as producers, consumers, and decomposers, and place them in the right energy level using the energy level bar that we gave them. They were not provided with any decomposers so the groups were asked to be creative. They had to draw or write their own decomposers and other organisms relevant to their ecosystems, and place them on their model.

The students built very nice models with the materials that we provided. Some of the resulting models can be seen in Figures 3 and 4, while more models and the students working on their project can be seen in Appendix D.

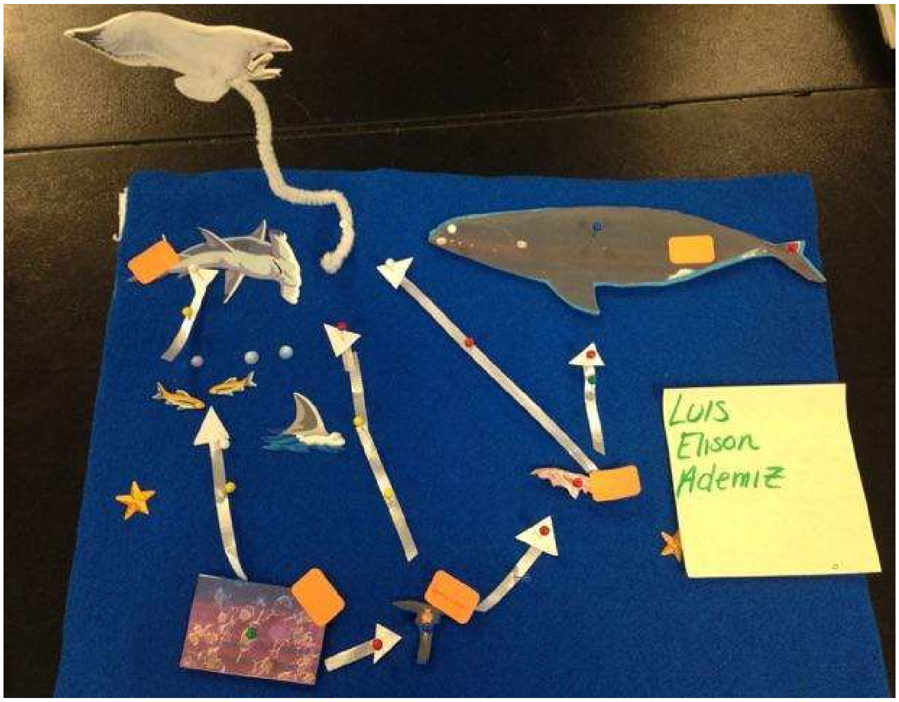


Figure 4: Model built by the students, aquatic ecosystem

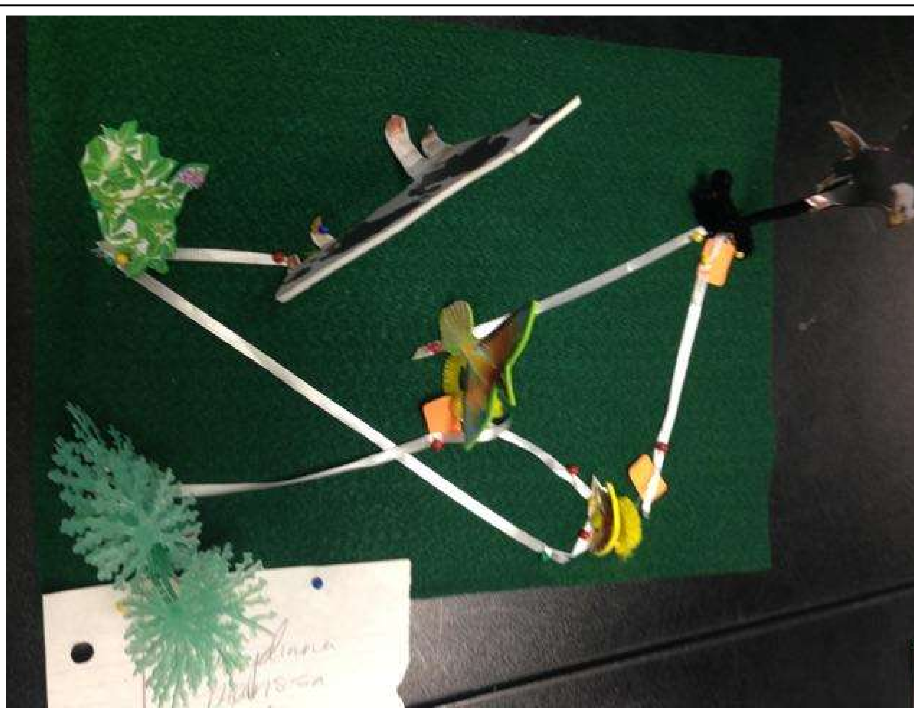


Figure 3: Model built by the students, terrestrial ecosystem

In order to evaluate the success of the lesson plan we wanted to observe how well the students were engaged in addition to how well they learned the material. In order to easily make these observations while in class, we created a chart to rank student engagement on a scale of one to three and then made a note of whether the student was male or female. A "one" represented little to no engagement, "two" indicated average engagement, and "three" was given for a high engagement level. We judged engagement on a few factors:

- how much effort was a student putting into each task
- how active each student was being with his group
- how enthusiastic a student was in doing each task
- how well did each student understand the task and materials

Additional questions were also placed at the end of the chart including how comfortable the teacher was with the teaching style, and how constantly she was checking on the groups and helping them as well as how comfortable the students were with this teaching style and how the work load was distributed within the group. This chart as well as all the in-class observations are given in Appendix C. In addition to filling out the chart, we went around talking to students to ask how the project was going and to assess how well they were understanding the tasks. We would then take notes on the student's work. Finally, we collected anonymous test scores of the students at the end of the unit in order to examine how well the students mastered the material.

This lesson plan was executed over the course of seven days. While it was initially planned to be done in six days, Mrs. McDermott could not be there for one of the days so an extra day was taken in order to avoid a substitute teacher having to present the lesson planed. Each day we attended as many classes as our schedule allowed, 2-3 out of 4 classes per day on average, and took notes on the how the students did. Our observations were principally focused on how well each student group was working on the project in addition to how well each student was understanding the material being presented. In order to better determine how well the students understood the material, we had short conversations with the students about the work they were doing throughout every activity. This was also used to gage whether or not a student was either not engaged in the project or just naturally introverted.

For a summary of the activities: over the six days, the students answered a variety of questions, some fact based and some open-ended, in order to spur the groups into having an engaged discussion on the topics related to their ecosystems. In addition, students constructed food webs and food pyramids both on paper and in model form as seen above. Students then needed to research their primary organism using eol.org and were then asked to think about the impact that this organism had on its ecosystem, and write a paragraph about it. Then, students were asked to think about how the problem of their ecosystem could be solved. Once students speculated on solutions to the problem, they were provided with an article explaining what experts in the field thought. Students were then asked to reflect the differences between the idea they formulated and that of the articles. The project culminated in a poster being made by each group that they could then present their findings to the class. Mrs. McDermott provided them with a sample poster, which can be seen on the left of Figure 5 and students built posters as the one on the right of Figure 5. More student posters can be seen in Appendix D.

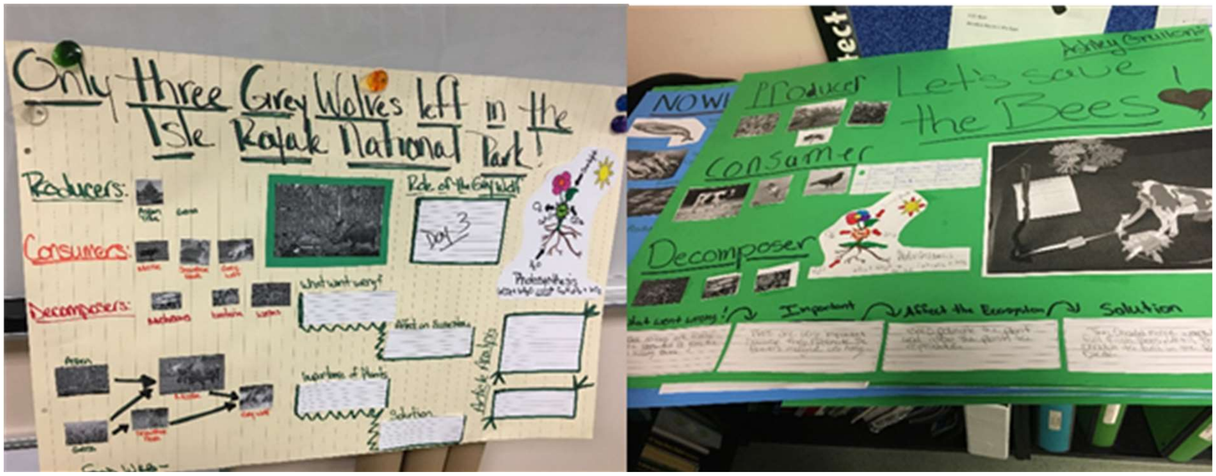


Figure 5: Poster Sample by the Teacher and Poster Built by Students on their Ecosystem

After the completion of the project, the students had to take two exams: a multiple choice one on both a cells unit as well as the ecosystems unit that were taught in our lesson, and an open response question that covered just the ecosystem unit. This means the amount of information that can be drawn from grades on the multiple choice exam has been decreased, because the test results included both units. We could not get the scores just for the ecosystem questions because the tests were returned to the students. Therefore, instead of focusing on the numerical data from the test as validation, we will be using it only to show that the students were able to learn the material from our method and focus on our observations of the students and interview with Mrs. McDermott as the justification for using this style of teaching.

Our goal for this lesson plan was to engage students in a project based lesson format as well as one that adheres to the NGSS. Table 2 presents what the NGSS expects students to gain from their ecosystem unit and how our lesson plan addresses these requirements:

Table 2: NGSS for ecosystems and how our lesson plan addresses each standard

NGSS Students should be able to:	How our lesson plan address these:
Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.	Some of the case studies deal with how different species are struggling with an increased scarcity of resources. Relevant case studies include the wolf, bee, and blue whale ecosystems.
Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.	In all case studies students investigated the interactions between different organisms such as how some depended on each other and others are harmful to each other.
Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.	Students worked with models to create a food web and energy pyramid.
Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.	All case studies were about ecosystems effected from changes to their physical or biological components.
Evaluate competing design solutions for maintaining biodiversity and ecosystem services.	Students read articles about solutions to the problems in their ecosystem and were asked to evaluate how the given solution would work as well as compare it to their own.

NGSS Science and Engineering Practices:	How our lesson plan address them:
Developing and Using Models	Students were asked to create a food web both on paper and using models.
Analyzing and Interpreting Data	Students were given descriptions of the problems their ecosystem was facing and were asked to come up with an explanation of what could be causing the issues.
Constructing Explanations and Designing Solutions	Upon investigating the problems with each ecosystem, students were asked to explain the cause and develop a solution.
Engaging in Argument from Evidence	Students were encouraged to discuss ideas with their group members. In addition they were asked to develop a solution to the problem their ecosystems faced and support it.

NGSS Disciplinary Core Ideas:	How our lesson plan address them:
Interdependent Relationships in Ecosystems	Many of the case studies showed how different organism within an ecosystem were dependent on each other. Relevant case studies include the bee, wolf, blue whale, and sea otter ecosystems.
Cycle of Matter and Energy Transfer in Ecosystems	Students were asked to create and model a food web and energy pyramid.
Ecosystem Dynamics, Functioning, and Resilience	Many case studies used describe how ecosystems change over time with the introduction and removal (or relative scarcity) of certain elements. Additionally, the case study about wolves involved lack of genetic diversity causing for a lessened resilience and threatening the extinction of the animal. Relevant case studies include the bee, wolf, blue whale, and sea otter ecosystems.
Biodiversity and Humans	Some case studies dealt with how biodiversity was effecting animal population and thus resources humans rely on. Relevant case studies include the bee and wolf ecosystems.
Developing Possible Solutions	Students were asked to develop a solution for the problems to the ecosystem they were investigating.

We developed our lesson plan so that the case studies addressed each of the NGSS guidelines. Though class presentation, every student learned about each case study.

Results

The success of this project can be evaluated by in-class observations, teacher endorsement, as well as the analysis of test grades. Detailed observations were made by us as well as by Mrs. McDermott in order to compare how this method of teaching helped the students understand the material when compared to the traditional methods that have been used in the past to teach this unit. In order to analyze this, we looked at indicators such as engagement levels students displayed and how receptive they were to our lessons. We investigated certain factors that affected these indicators. These factors included gender, learning level, and level of participation.

As a result of different tests being administered in previous years as well as the fact that a different teacher taught the class, a comparison between test scores of this year (with project based learning being applied), and the previous year (with the traditional way of teaching) could not be made. With no data to use as a benchmark, we used Mrs. McDermott's discretion as a basis for how well the students did. Students took the exam in two parts over the course of two days. A multiple choice section was taken on the first day. That section contained material on both a cell unit taught previously as well as the ecosystem unit that our lessons taught. On the second day, an open response exam was administered, and it covered just the ecosystem unit. Unfortunately, little quantitative information can be drawn from the multiple choice portion as the data included information learned in a different unit using a different teaching approach. However, the open response exam is a good indicator of how well the students understood and learned the material. The collective class average on the exam as a whole was 95%, with a median class score of 86%, a high of 100% and a low of 48% for the multiple choice (excluding students that did not take the whole test), and 80% for the open response with a high of 4/4 and a low of 1/4. According to Mrs. McDermott, these scores were good for her classes. We also observed that there was no discernible difference between male and female students who averaged within a percent of each other. The complete results from the two tests can be seen Table 3 where the maximal possible score for the multiple choice (MC) exam is 25 and for the open response (OR) is 4. Looking at different student levels, we found that the honors classes did only slightly better than the inclusion classes who averaged only 3.7 or 14% lower, as would be expected. However, Mrs. McDermott explained that both classes did seem to demonstrate a better understanding of the material on the tests when compared to other units.

Table 3: Test Results Data for the Multiple Choice (MC) test and Open Response (OR) test with a highest possible score of 25 and 4 respectively

Class	MC	OR	MC- M	MC-F	OR-M	OR-F
1	20.12	2.96	20.53	19.25	3.12	2.63
2	19.48	2.80	19.73	19.17	2.69	2.92
3	23.68	3.47	23.69	23.67	3.38	3.56
4	22.34	3.23	22.29	22.4	3.00	3.44
Honors classes (3+4)	23.01	3.35	22.99	23.03	3.19	3.50
Inclusion classes (1+2)	19.80	2.88	20.13	19.21	2.90	2.77
Overall	21.58	3.15	21.56	21.12	3.05	3.13

F-female, M-male, MC- multiple choice (averages out of 25), OR- open response (averages out of four)

While in class, we observed an overall positive experience for the students. They worked well together in groups and exhibited good communication skills. In addition, work division seemed amicable, and there was no indication of gender bias in groups. Most groups had two male and two female students by design which seemed to work well at keeping the students on task. The dynamics of some groups would change when students were absent leading to less work being accomplished. We found that the inclusion classes needed more instructions to get started as well as additional guidance while working. One addition to the overall project that seemed to help both levels of classes was the use of "bell work" by Mrs. McDermott. Bell work included a question or questions assigned before the start of class for students to do upon arrival. These questions had a thematic link to the lesson planned for the day and were a good way of getting the class focused and thinking about the topic they were about to learn. An example of bell work would be "What are producers, consumers and decomposers? Name an example of each." This bell work was used for the day 1 activity. It may be beneficial if questions like these were incorporated in future uses.

Overall, the students' participation was favorable. While participation among students was not equal, this was to be expected. . We found that in some cases, students who participated less on days where there was an emphasis on writing, took the lead on days that required a more artistic touch such as when the models were being used or when posters were made. The variety of activities in this method of teaching enabled different students to take a leading role in the group on different days. This shows that having students perform a variety of different tasks, each requiring their own skill set, enables the engagement of more students. Another observable factor in student participation was how introverted particular students were. Even though these students did not contribute as much to the group conversations, our observations indicated that they gained the same knowledge as those that did participate. When asked questions about what the group was doing and the topics that were being covered, they had a good understanding of what was taking place.

Upon concluding our classroom segment, we interviewed Mrs. McDermott on her thoughts of how our lesson plan was constructed and executed. Overall, her thoughts were positive. She had no difficulties in teaching this project and said "I thought it was a great project! The kids loved it! It incorporated a lot of different skills with: hands-on, the research portion, the writing. It was a well encompassed project that the kids did very well with." When asked if she would make any changes, she said she would not take anything away but "providing more paper articles to give them more resources to use" might be helpful going forward and that we "could add more case studies so that each group would have a different one in the class for presentation purposes". Initially, this was our plan. However, she had larger classes than we had anticipated. The incorporation of more case studies would allow for the students to be exposed to more ecosystems and gain more information on different organisms, their interactions with each other and how different factors influence different organisms. Mrs. McDermott felt as though the timeline for each lesson could be altered going forward especially for the inclusion classes but was quick to add "that's something you learn as you go". In addition she felt that "expectations [for the students] were made clear whether written down or spoken". She thought that the lessons were "very well designed lesson plans" and "everything was at grade level". As a closing remark she said she will "definitely teach this again" and "two other teacher are also using it". More notes on the interview with Mrs. McDermott can be found in Appendix F.

Overall, we found that students and the teacher, Mrs. McDermott, enjoyed the lesson plan. Additionally, we determined that the ecosystem lesson plan was at least as good as previous methods for teaching ecosystems, and had the added benefits of engaging students through hands on group work as well as adhering to the newly adopted NGSS. With the success of this project, applying a PBL approach to the NGSS, we think that more projects should be done to determine if other topics can be taught in a similar manner.

Conclusion

Due to the absence of the controls and the numerical data, conclusions on our hypothesis can only be examined based on general observations made by us and Mrs. McDermott. Based on our observations, it was noticed that the students were active in learning the material through the project based learning, and they had a good understating of the topics being covered. In addition, Mrs. McDermott stated in the interview that this style of teaching did help the students understand the material better and the test scores reflect that as well. However, in order to fully test the hypothesis, a class with more set controls would need to be chosen.

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Appendix A: Lesson Plan

This Appendix holds the entirety of the lesson plan designed in this project. The goal of this lesson plan was to teach groups of students in 8^{th} grade science classes at Forest Grove Middle School about ecosystems though the use of case studies. The following is either instructional material for the teacher or is designed to be handed out as a packet to the students.

The First Section of this appendix, pages A2 through A5, includes the teacher's instructions. This gives a basic walkthrough of the setup, each day's activity and an estimate on the time it will take for each activity to be completed. Next sections are the ecosystems case study descriptions. These should be assembled into individual packets and handed out to each of the students in the relevant group. These case studies and page numbers are:

- Bees, pages A6-A8, and A21-A28
- Right Whales, pages A9-A11, and A21-A28
- Wolves, pages A12-A14, and A21-A28
- Blue Whales, pages A15-A17, and A21-A28
- Sea Otters, pages A18-A20, and A21-A28

These sections contain everything specific to each case study needed for the assignments. Next, pages A21 through A28, contain the main packet. These are generic and should be handed out to all students regardless of the case study being implemented. The articles used for each case study are contained in Appendix B.

Teacher Instructions:

Divide the class in groups of 4-5 students.

The groups answer each question and fill out the charts in their worksheets.

Then, on the final day, they cut out the pieces from their worksheets and use them to create their poster presentation.

Day I (estimated time: 15-20 min)

Advise the students to answer the following questions and put their responses into the table:

1. A) Identify the producers and consumers mentioned in the story and write them in the table below.

   B) Think of other producers and consumers that could be present in this ecosystem and write them down.

2. Identify the decomposers mentioned in the story. If there are no decomposers, think of any that could be present in this ecosystem and write them in the table below.

Day II (estimated time: 30-40 min)

Instruct the students to build their food chains and food web as described below.

1. A) Sketch a possible food chain that includes your main organism using the box below.

   B) Then construct a model of the food web that includes the food chain you have just sketched using the provided pictures, objects and string.

   C) Add other food chains your team can think of for this ecosystem by using the extra stickers.

2. Use the model and energy bars to show how the energy flows in your team's ecosystem.

Day III (estimated time: 20-25 min)

Advise the students to follow the instructions in order to find information about their main organism in the given website. Then, ask them to answer the question in a paragraph or bullet point form.

1. Find out the key role of your main organism in the ecosystem by exploring them in eol.org. Follow the instructions associated with your investigation case. Write a paragraph to answer the question.

Day IV (estimated time: 40 min)

Ask the students to answer the following questions in a paragraph or bullet point form.

1. Think of what went wrong with this ecosystem. Why and how is the lack of your main organism affecting the rest of the ecosystem?

2. Why are the plants important in this ecosystem? Draw a diagram to show where they get their energy from?

3. Propose a solution to this problem. How can the ecosystem return to normal? What evidence supports your decision?

Day V (estimated time: 25-30 min)

Instruct the students to read the article or the highlighted parts of an article and answer the following question in a paragraph form.

1. After your thorough analysis, you find an article related to this problem.

a) Read the highlighted parts of the article.

b) Write a paragraph comparing what you read to what you thought the problem was with the ecosystem.

c) Do you think the solution you proposed the previous day would still work? If not, what is the revised suggestion for the solution?

Day VI (estimated time: 20-25 min)

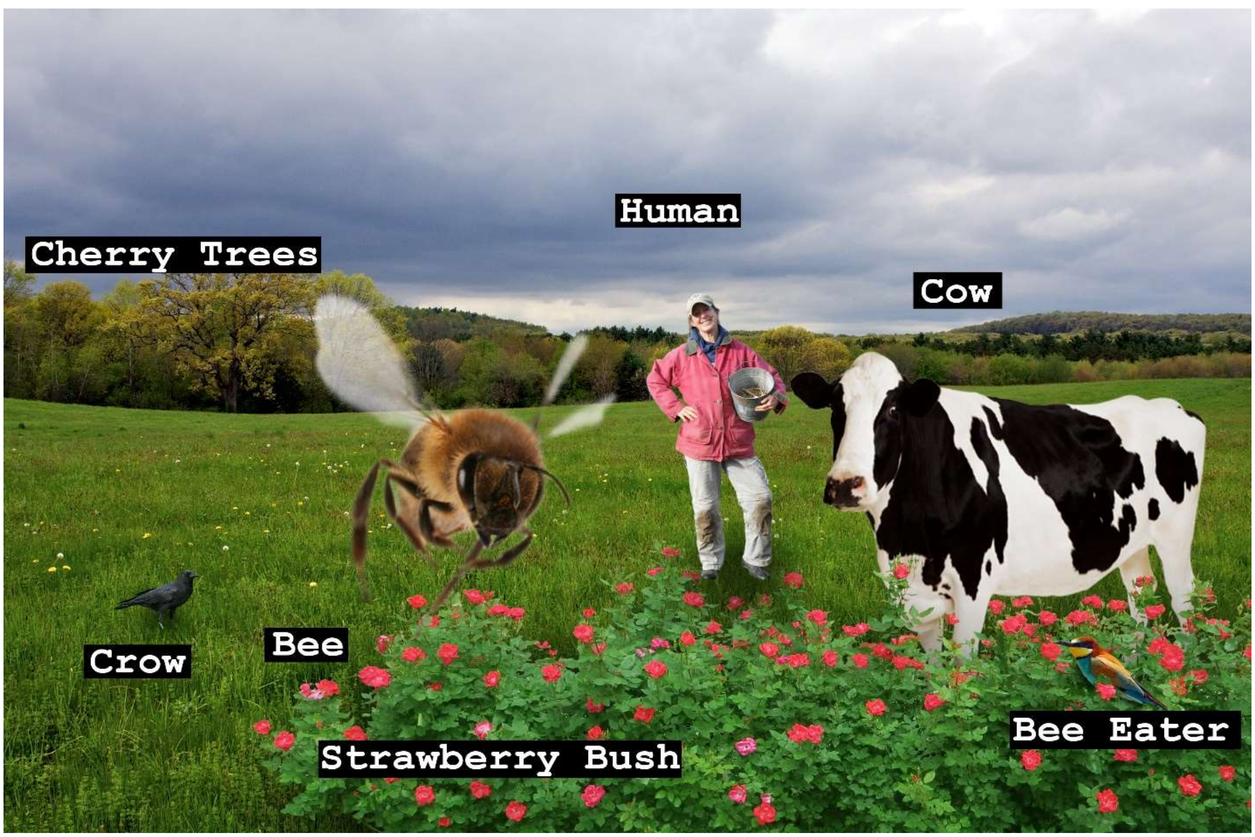
The students should present on the role of their main organism in the ecosystem and how they think the problem with their ecosystem can be solved. The students should follow the rubric for their presentation.

Ecosystem Presentation Rubric

	4- Exceeds Standards	3- Meets Standards	2- Approaching Standards	1 – Below Standards
Animals and Plants Identify producers, consumers and decomposers in the story. Identify other animals that could be present in the given setting	All producers, consumers and decomposers in the story were identified and listed. Other relevant animals were identified and listed.	All producers, consumers and decomposers in the story were identified and listed. Other animals were listed.	Some producers, consumers and decomposers in the story were identified and listed. Other animals were identified and listed.	Some producers, consumers and decomposers in the story were identified and listed. No other animals were identified and listed.
Food Web Create at least one food web in the ecosystem, including a minimum of two food chains. Place animals in the right part of the energy line.	A drawing and a model was used to show the flow of energy in a food web for the ecosystem, with pictures of species whenever possible. More than two different food chains were included.	A drawing was used to show the flow of energy in a food web for the ecosystem. A minimum of two different food chains were included.	A list of the food web for the ecosystem was included with no drawing. Less than two different food chains were included.	A food chain was included.
Role of plants Fill out the photosynthesis diagram and identify the role of the plants in your ecosystem.	The photosynthesis diagram is filled out correctly, and all parts of the reaction are identified. The role of the plants in the given ecosystem is identified and explained.	The photosynthesis diagram is filled out correctly. The role of the plants in the given ecosystem is identified and somehow explained.	Part of the photosynthesis diagram is filled out correctly. The role of the plants in the given ecosystem is identified.	Part of the photosynthesis diagram is filled out correctly.
Environmental Concerns Identify the role of the main organism in the ecosystem. Note any issues with the ecosystem and propose a solution.	Detailed information was included regarding the main organism, and issues with the ecosystem. A solution was proposed and supported with arguments.	Detailed information was included regarding the main organism, and issues with the ecosystem. A solution was proposed.	Minimal information was included regarding the main organism, issues with the ecosystem, and the solution.	Minimal information was included regarding the main organism, and issues with the ecosystem. No solution is proposed.
Presentation Prepare a poster and use your model to explain the role of the main organism and how the problem with your ecosystem can be solved (3-5 minutes)	A poster was prepared and the model was used for the presentation. Work was completed on time and research was evident. The role of the main organism and the solutions to the problem were explained clearly for the class to understand.	A poster was prepared and the model was used for the presentation. Work was completed on time and research was evident. The role of the main organism and the solutions to the problem were somehow explained.	A poster was prepared and the model was used for the presentation. Work was completed on time. The role of the main organism and the solutions to the problem were mentioned.	A poster was prepared with lack of care, and the model was used for the presentation. Work was completed on time. The role of the main organism and the solutions to the problem were not mentioned.

<u>Let's save the bees, small insects with a huge impact in our lives!</u>

You and your family walk into a field near a farm during early summer and you see less cherries and strawberries than in previous years. You also observe less alfalfas, a type of plant in which cows feed on. You notice something else missing as well. There are no bees around. They are not moving from flower to flower like they usually would at this time of the year. No bees means no honey for you! Oh no! Why are there less alfalfas?! What are the cows going to feed on now?! Does this mean these cows will produce less milk?! Honey and milk are used to make cheese, yogurt, ice-cream and many other products that you love to eat. What caused all of this? Could it be the lack of bees? Let's investigate.



Key terms that will help you in your investigation:

Alfalfas- type of flowering plant cows feed on.

Insecticides- type of chemical used for killing insects that feed on plants.

Bee-eater- a type of bird that feeds on bees.

Eagle- a large bird that feeds on other birds.

Day 3 instructions:

a. Write “bee” in the search bar and select “Go”.

b. Select the “Detail” tab on the top of the page.

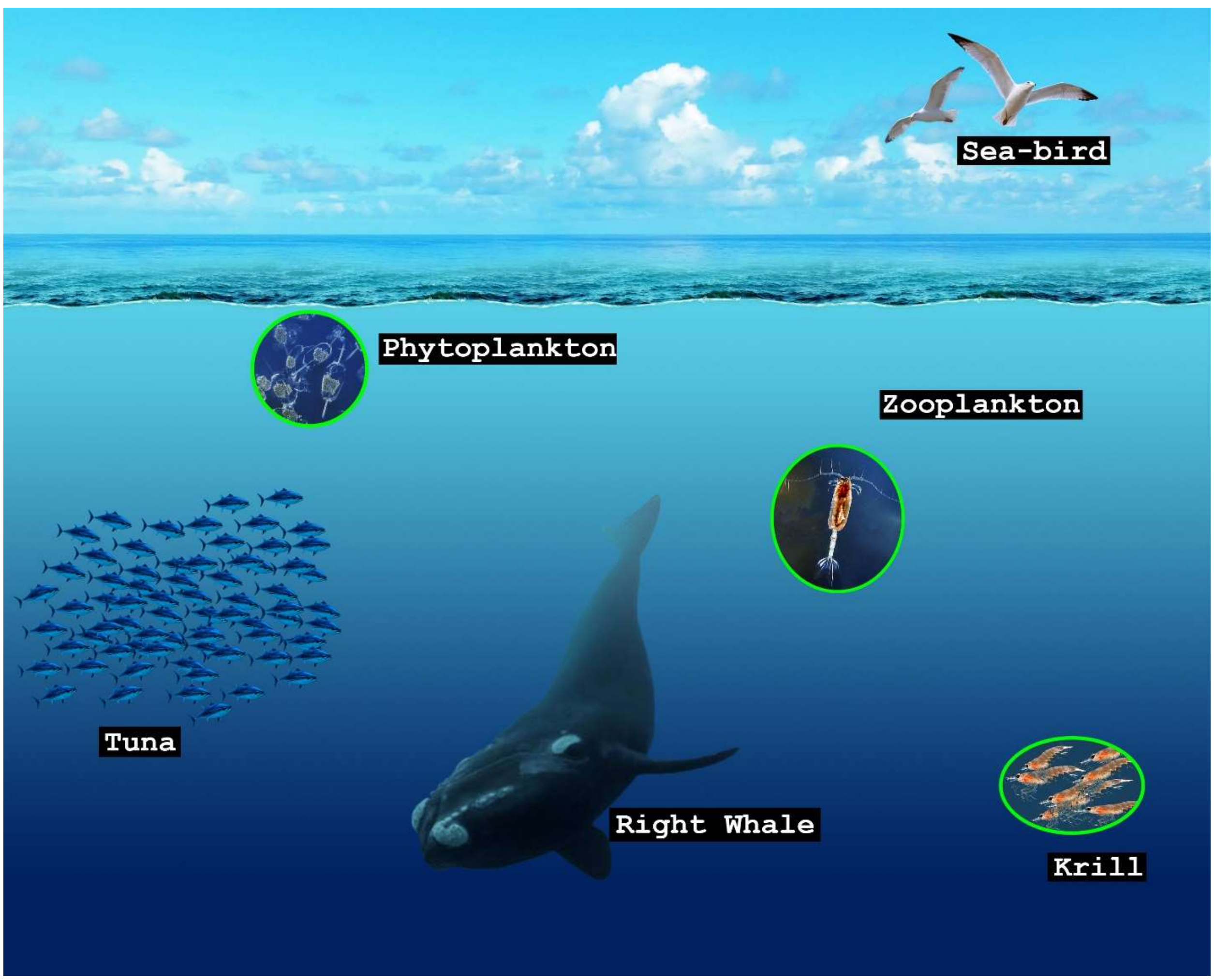
c. In the “Detail” page, select “Associations” from the Table of Contents on the left

d. Read about the role of bees in the ecosystem.

e. Answer the question: What role do bees play in the ecosystem?

The whales need your help!

You and your classmates are going on a fieldtrip to Cape Cod. Everyone gets on a boat to watch the whales. While on the boat, you see not only the endangered *right whales*, but also many different species including tuna, sharks, and seabirds. Your teacher explains that the whales feed on zooplankton and krill. She also says there are less whales coming back each year. Therefore, there might be no whales coming back the following year. Oh, no! Why?! You really like whales and you wonder if you can do something to make them return. You and your fellow explorers decide to investigate.

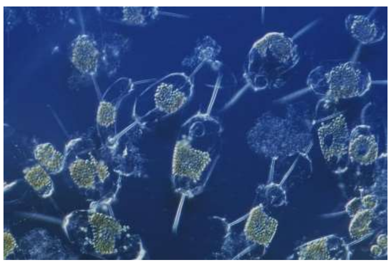


Key terms that will help you in your investigation:

Endangered- animals in danger of not existing anymore.

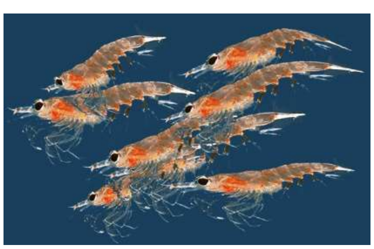
Right whale- a species of whale.

Phytoplankton- plant like plankton that live in the uppermost sunlit layer of the ocean called the photic zone.



Zooplankton- animal like plankton that drift in oceans and seas around the world. They vary in size from single cell organisms to much larger multicellular organisms. Zooplankton's diet consists of phytoplankton and smaller zooplankton.

Krill- small crustaceans who live in all of the world's oceans. They feed mainly on Phytoplankton.



Day 3 instructions:

a. Write “right whale” in the search bar and select Go.

b. Select the “Detail” tab on the top of the page.

c. In the “Detail” page, select “Associations” from the Table of Contents on the left.

d. Read about the whales.

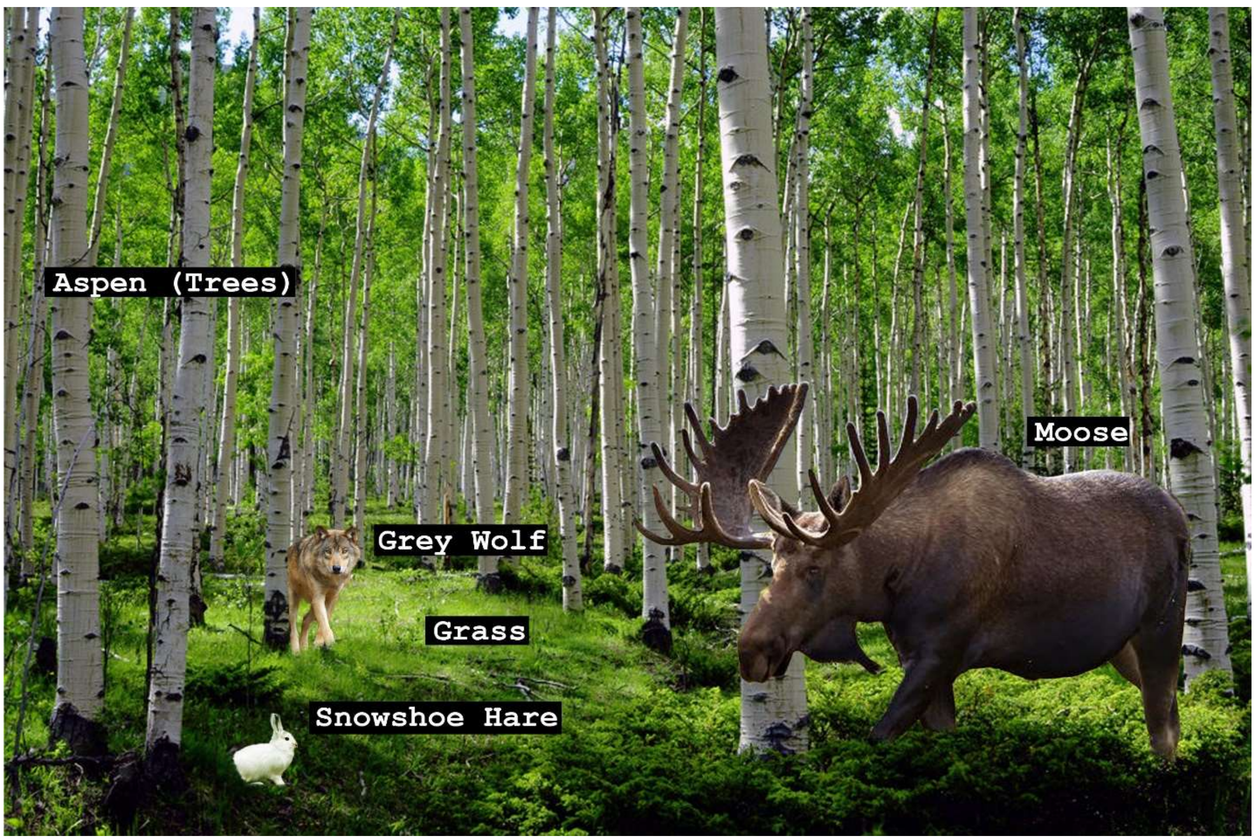
e. Answer the question: What do right whales feed on?

f. Then, select “Habitat”

g. Look through the graphs and see how much oxygen these whales need. Where could the oxygen come from?

Only three grey wolves left in the Isle Royale National Park!

Have you ever seen a wolf? You might have seen one in documentaries or movies on the TV. Wolves are fascinating animals, which unfortunately are seen less and less in some of their habitats in the United States. One of the last places to find them in is the Isle Royale National Park, which only has three wolves left. Wolves are a keystone of this park's ecosystem, and their loss could cause the whole ecosystem to destabilize. You want to find a way to keep them around. You and your fellow explorers decide to investigate.



Key terms that will help you in your investigation:

Endangered- animals in danger of not existing anymore.

Grey wolf- a type of wolf that feeds on animals such as moose and rabbit. The grey wolf is an endangered animal.

Moose- the largest species of the deer family. Moose diet mainly consists of plants like Aspen and grass.

Snowshoe Hare- type of rabbit that gets its name from its large hind feet. Snowshoe hare feed on small plants and flowers such as grass.

Aspen- the common name of the tree species *section populous*. It grows in Northern and Western North America.

Day 3 instructions:

a. Write “Grey Wolf” in the search bar and select Go.

b. Select the “Detail” tab on the top of the page.

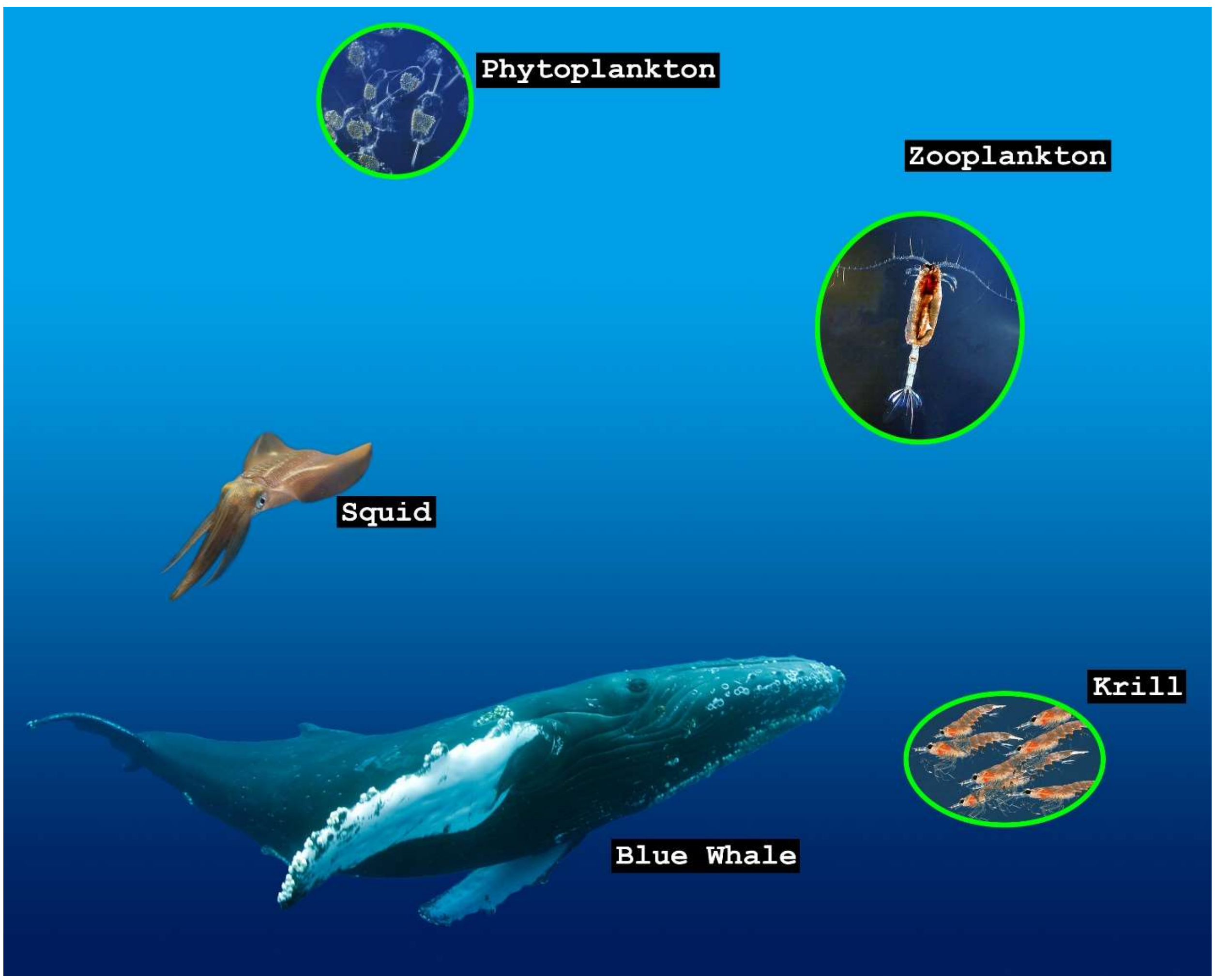
c. In the “Detail” page, select “Associations” from the Table of Contents on the left.

d. Then look at “Ecology” and “Conservation.”

e. Answer the question: What role do Grey Wolves have in the ecosystem?

No whales means no fish either?!

Have you ever seen a whale? You might have seen one on a whale watching trip or on TV. Unfortunately whale sightings have become rarer as they are being severely hunted. In the past, scientists believed that if the whale population decreased, the krill population, their food source, would increase. They further expected that the oceans would have more fish since there would be more food available to them. Strangely enough however, as the whale population has declined so has the population of krill and other fish. It has become clear that whale and krill populations are linked. You and your fellow explorers want to find out why the presence of whales benefits the whole ocean. If you find this information, you can advocate against whale hunting.

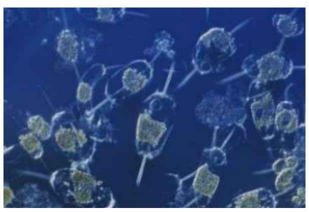


Key terms that will help you in your investigation:

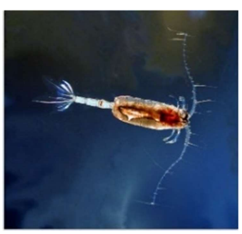
Endangered- animals in danger of not existing anymore

Blue whale- the largest living animal and the heaviest known to have ever existed. Blue whales eat mainly krill. Blue whales are endangered species.

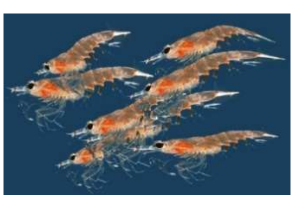
Phytoplankton- plantlike plankton that live in the uppermost sunlit layer of the ocean called the photic zone.



Zooplankton- animal like plankton that drift in oceans and seas around the world. Zooplankton's diet consists of Phytoplankton and smaller zooplankton.



Krill-small crustaceans who live in all of the world's oceans. They feed mainly on Phytoplankton.



Squid- found in all oceans. They feed mainly on Zooplankton.

Day 3 instructions:

a. Write “Blue Whale” in the search bar and select Go.

b. Select “Detail” tab on the top of the page

c. In the “Detail” page, select “Associations” from the Table of Contents on the left

d. Then look at “Ecology” and “Conservation”

e. Answer the question: What role do blue whales have in the ecosystem?

Sea otters, friends or enemies with the seagrass meadow?

Have you ever wondered what keeps the ocean clean? Seagrass meadows are one of the main plants along the ocean coasts that can filter the water. They are the foundation of an ecosystem that encompasses a host of sea life such as sea slugs, crabs, and sea otters. Unfortunately seagrass is dying, destroying the ecosystem they support. Knowing the importance of the sea grass, you want them to flourish and you wonder what ocean animal could help you with that. You and your fellow explorers decide to investigate.

Key terms that will help you in your investigation:

Seagrass- aquatic plant that grows along most coasts although it favors warmer climates. Seagrass often grows in large meadows.

Sea Otters- animals whose diet is composed of a variety of organisms including crabs and starfish. Sea otters are endangered.

Rock crabs- sea crabs that eat small fish and sea slugs.

Sea Slug- type of snail that live in water temperatures ranging from frigid to tropical. Sea slugs eat mainly algae.

Algae- a word for a large group of aquatic plants including seaweed. Algae grows in oceans all over the world.

Day 3 instructions:

a. Write “Sea Otter” in the search bar and hit Go

b. Select “Enhydra lutris”

c. Then select the “Detail” tab on the top of the page

d. In the “Detail” page, select “Associations” from the Table of Contents on the left

e. Then look at “Ecology” and “Conservation”

f. Answer the question: What role do Sea Otters have in the ecosystem?

Main

Organism:_____________________

Name:_________________________

Group Members: ______________

____

Day 1:

1. A) Identify the producers and consumers mentioned in the story and write them in the table below.

   B) Think of other producers and consumers that could be present in this ecosystem and write them down.

2. Identify the decomposers mentioned in the story. If there are no decomposers, think of any that could be present in this ecosystem and write them in the table below.

Producers	Consumers	Decomposers

Day 2

My team and I are working on a case study that involves _______________.

1. a) Sketch a possible food chain that includes your main organism using the box below.

b) Then construct a model of the food web that includes the food chain you have just sketched using the provided pictures, objects and string.

c) Add other food chains your team can think of for this ecosystem by using the extra stickers.

2. Use the model and energy bars to show how the energy flows in your team's ecosystem.

Day 3:

Today we will find the role of our main organism_________________.

1. Find out the key role of your main organism in the ecosystem by exploring them in eol.org. Follow the instructions associated with your investigation case. Write a paragraph to answer the question.

Day 4:

My team and I are trying to find a solution to the problem with our ecosystem involving ____________.

Write a paragraph to answer each of following questions:

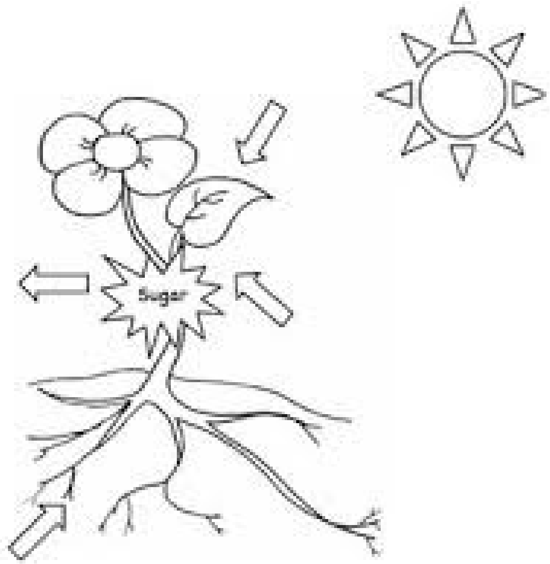
1. a) What went wrong with this ecosystem?

b) Why and how is the lack of your main organism affecting the rest of the ecosystem?

2. a) Why are the plants important in this ecosystem?

b) Fill out the diagram to show where they get their energy from and what they produce.

Photosynthesis diagram



3. Propose a solution to this problem.

   a) How can the ecosystem return to normal?

   b) What evidence supports your decision?

Day 5:

My team and I will read an article about ________________ to find out what actually went wrong with our ecosystem.

After your thorough analysis, you find an article related to this problem.

a) Read the highlighted parts of the article.
b) Write a paragraph comparing what you read to what you thought the problem was with the ecosystem.

c) Do you think the solution you proposed the previous day would still work? If not, what is the revised suggestion for the solution?

Day 6:

The day has come! Your team finally found a solution to the problem with ______________!

a. Cut out the parts from your worksheets, and place them on a poster board. Add the title of your project as well as subtitles for the different sections of your poster.
b. Present your findings to the class using your poster and your model. Follow the rubric for your presentation.

YALE environment360
Reporting, Analysis, Opinion & Debate

30 APR 2013: **REPORT**

Declining Bee Populations Pose A Threat to Global Agriculture

The danger that the decline of bees and other pollinators represents to the world's food supply was highlighted this week when the European Commission decided to ban a class of pesticides suspected of playing a role in so-called "colony collapse disorder."

BY ELIZABETH GROSSMAN

One of every three bites of food eaten worldwide depends on pollinators, especially bees, for a successful harvest. And in the past several months, a scramble in California's almond groves has given the world a taste of what may lie in store for food production if the widespread — and still puzzling — decimation of bee colonies continues.

For much of the past 10 years, beekeepers, primarily in the United States and Europe, have been reporting annual hive losses of 30 percent or higher, substantially more than is considered normal or sustainable. But this winter, many U.S. beekeepers experienced losses of 40 to 50 percent or more, just as commercial bee operations prepared to transport their hives for the country's largest pollinator event: the fertilizing of California's almond trees.

Spread across 800,000 acres, California's almond orchards typically require 1.6 million domesticated bee colonies to pollinate the flowering trees and produce what has become the state's largest overseas agricultural export. But given the widespread bee losses to so-called "colony collapse disorder" this winter, California's almond growers were able to pollinate their crop only through an intense, nationwide push to cobble together the necessary number of healthy bee colonies.

'In the long run, if we don't find some answers, we could lose a lot of bees,' says one expert.

"Other crops don't need as many bees as the California almond orchards do, so shortages are not yet apparent, but if trends continue, there will be," said Tim Tucker, vice-president of the American Beekeeping Federation and owner of Tuckerbees Honey in Kansas, which lost 50 percent of its hives this past winter. "Current [bee] losses are not sustainable. The trend is down, as is the quality of bees. In the long run, if we don't find some answers, and the vigor continues to decline, we could lose a lot of bees."

The gravity of the situation was underscored on Monday, when the European Commission (EC) said it intended to impose a two-year ban on a class of pesticides known as neonicotinoids, now the world's most widely used type of insecticide. Neonicotinoids are one of the leading suspected causes of colony collapse disorder, and the European Commission announced its controversial decision three months after the European Food Safety Agency concluded that the pesticides represented a "high acute risk" to honeybees and other pollinators.

The EC action will restrict the use of three major neonicitinoids on seeds and plants attractive to bees, as well as grains, beginning December 1. "I pledge to my utmost to ensure that our bees, which are so vital to our ecosystem and contribute over 22 billion Euros [$29 billion] annually to European agriculture, are protected," said European Union Health Commissioner Tonio Borg.

The EC action comes as scientists and regulators have grown increasingly

BRANDON KEIM 08.09.12 6:30 AM.

THE HIDDEN POWER OF WHALE POOP

THE LARGEST ANIMALS ever to have lived on Earth, blue whales are colossal in every respect — including, it must be said, the scatological. When a blue whale goes, it goes big.

This remarkable phenomenon was recently captured on camera by Eddie Kisfaludy, a marine biologist and oceanographic consultant. While conducting an aerial survey off the coast of southern California, he flew over a pod of 40 blue whales.

The waters were rich in krill, the tiny crustaceans on which blue whales feed, and their orange hue was brightly visible in a fecal plume he photographed. It's hard to judge absolute distances from the photo, but in scale the deposit is nearly as long as a full-grown blue whale.

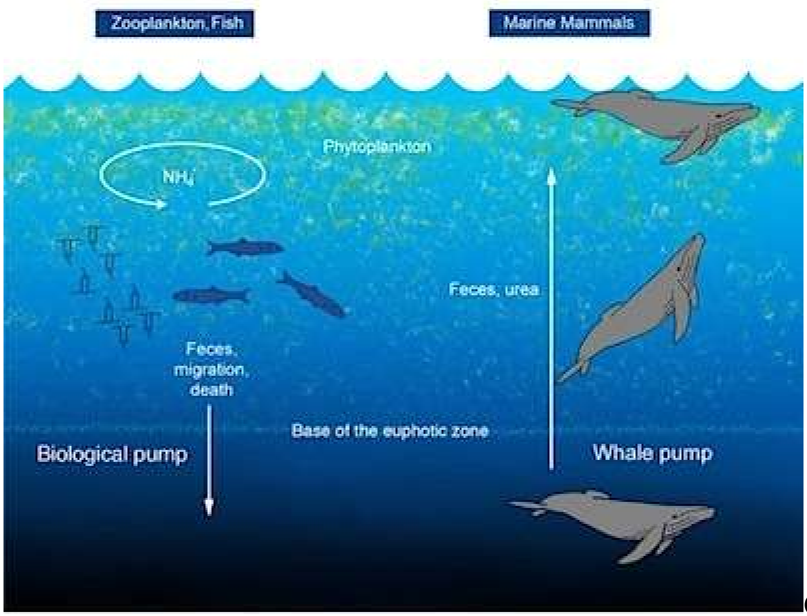
It may well be the world's largest documented poop. It's also an exclamation point to a line of research pursued in recent years by marine biologists who say whales are the ocean's unappreciated gardeners, playing enormous roles in nutrient and carbon cycles. In short — or perhaps in long — their poop helps make the aquatic world go round.

"Whales and marine mammals can fertilize their surface waters," said Joe Roman, a conservation biologist at the University of Vermont, when shown Kisfaludy's picture. "This can result in more plankton, more fish, and more whales." How could that be true? It now turns out that whales maintain the populations of their prey.

They often feed at depth, but they seldom defecate there, because when they dive the stress this exerts on the body requires the shutdown of some of its functions. So they perform their ablutions when they come up to breathe. What they are doing, in other words, is transporting nutrients from the depths, including waters too dark for photosynthesis to occur, into the photic zone, where plants can live.

In 2010, after sampling the scat of humpback whales in the Gulf of Maine, Roman and Harvard zoologist James McCarthy proposed what they called the "whale pump": A mechanism describing how whales feeding at depth carry nitrogen to warm, energy-rich surface waters, discharging it in "flocculent fecal plumes."

Flocculent is a lovely word for a loose aggregation of particles, fluffy or woolly in nature. It's also why whale poop floats. Most previous research on oceanic carbon and nitrogen flows fixated on their downward drift, but the whale pump represented a flow in the opposite direction, a way for surface waters to continually be recharged, stimulating the growth of plankton and everything that eats them.



Click to Open Overlay GalleryA schematic of the “whale pump.” *Image: Roman & McCarthy/PLoS One*

Before commercial whaling, calculated Roman and McCarthy, the whale pump distributed three times more nitrogen across the Gulf of Maine than entered it from atmospheric sources. Even today, with whale populations at a fraction of historical levels, they added more nitrogen than all rivers and streams running into the Gulf combined.

Perhaps that’s why sea life in the Gulf of Maine was once so abundant, and the benefits wouldn’t have ended there.

As aquatic plants and animals grow, and in particular as plankton grows, they absorb carbon, then bury it on the seafloor when they die. That’s the rationale behind iron fertilization, a geoengineering technique that some researchers think could counteract global warming.

From this perspective, whales aren’t just gardeners, but geoengineers as well. Marine biologist Trish Lavery of Australia’s Flinders University estimated that defecation by the Southern Ocean’s sperm whales ultimately sequesters some 400,000 tons of carbon dioxide every year. Prior to their commercial whaling decline, that population alone would have accounted for about roughly the amount emitted by one decent-sized coal-fired power plant.

(Factor in the amount of carbon sequestered in whale bodies as they grow, calculated University of Maine marine biologist Andrew Pershing, and you can think about whale conservation in terms of carbon credits.)

An open and important question is how whale abundance alters ecosystems, Pershing said. Their effects could be enormous, especially when conceived in historical terms: Once there were more than 200,000 blue whales in the Antarctic Ocean alone, whereas today there are perhaps 8,000 in the whole world. Whatever they once provided has largely been lost, and restoring their populations might bring it back.

“Although other air-breathing vertebrates, such as seabirds and seals, can also pump nutrients to the surface, none are as large, or as abundant, as baleen whales were before the age of commercial whaling,” said Roman. Blue whales’ feces “must have a large impact on their ecosystems.”

Asked what he thought when seeing Kisfaludy’s photograph, Roman said, “I wish we had a net on hand to gather the poop.”

Said Pershing, “I’m glad I don’t have to pick that up.”

Correction: The article originally stated that 400,000 tons of carbon dioxide was equivalent to the emissions of 400 coal-fired power plants. That is inaccurate. We apologize for the mistake.

Right Whale Article

THE PEW CHARITABLE TRUSTS

FACT SHEET

Protecting New England's Marine Ecosystem: Habitat at Risk

March 12, 2014

New England Ocean Conservation, Atlantic Herring Campaign

All animals need safe places to grow, reproduce, and find food. Marine animals are no different. In the ocean, their habitats can be the sandy bottom, a seamount rising from the ocean floor, or a deep canyon carved into the continental shelf. These places are affected by pollution and other human activities such as oil and gas drilling and commercial fishing, which research shows can have negative consequences. The National Oceanic and Atmospheric Administration is tasked with regulating ocean fishing and protecting our nation's ocean resources.

Stellwagen Bank National Marine Sanctuary

Some areas of New England's waters have been closed to various types of fishing gear for decades in order to encourage the return of healthy populations of important groundfish (such as cod, haddock, and flounder), but the region does not have a plan for habitat management, as required by federal law. A plan for protecting essential fish habitat has been under development for 10 years.

A variety of alternatives will be presented to the public later this year, many of which propose a reduction in the size of the area currently protected. Some of these proposals ignore established science and place the short-term interests of the commercial fishing industry above the need to protect habitat for the long-term benefit of the ecosystem, its fish populations, and the coastal communities they support.

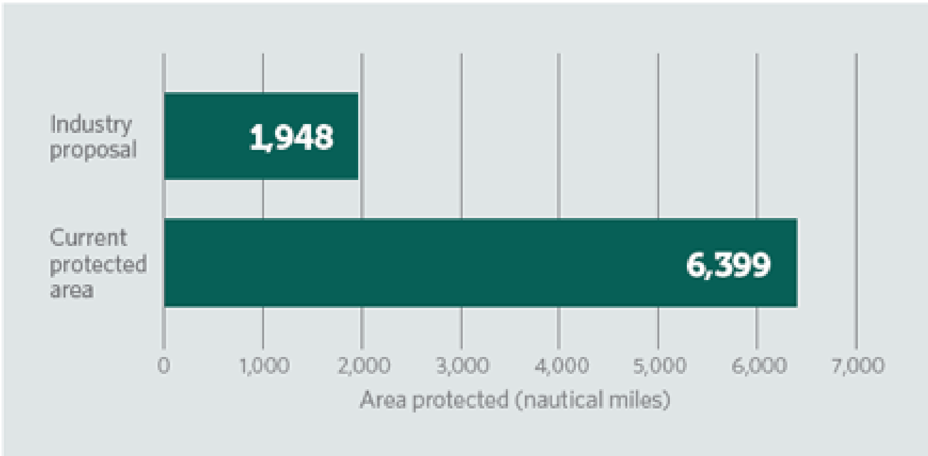
Healthy fish

Biologically productive habitat of ample size is essential to maintain healthy fish populations. For example, recent work by the Gulf of Maine Research Institute found that older cod—critical to the reproductive success of the species—are far more abundant inside protected areas, making these places crucial to the recovery of depleted cod populations.[1] Closed areas also contributed to the recovery of New England's scallop fishery.[2]

Healthy ecosystems

Habitat protection may be more important now than ever before, because these areas can provide resilience for marine species and ecosystems against the effects of climate change. New England waters are warming, disrupting fish populations and undermining the marine food web.[3] A climate change adaptation strategy produced in 2012 by NOAA and other federal agencies made habitat protection a top priority for helping fish adapt to warming oceans.[4]

Protected Habitat Faces Dramatic Cuts



Note: This graph shows the extent of the area currently protected in New England waters and the amount that would be protected under the fishing industry's plan. This proposal would reduce the total protected habitat by 70 percent.

Source: New England Fishery Management Council data

A new way to manage fish

Protecting habitat is part of a new way of managing fish, and it can lead to better ecosystem health in the future. Instead of looking at each fish species in isolation, this ecosystem-based fisheries management approach takes into account the ways that marine species interact with one another and with their environment. Leading scientists have advocated for such a management model for many years. It's time to take action. Fisheries managers should:

- Protect habitat.
- Leave enough small fish in the water to feed the entire food web.
- Minimize the incidental take (bycatch) of nontarget fish, birds, and mammals.

Sea Otter Article

UC Santa Cruz
Newscenter

Sea otters promote recovery of seagrass beds

Recolonization of Elkhorn Slough by sea otters led to recovery and expansion of seagrass beds due to cascading effects on the food web, study finds

August 26, 2013
By Tim Stephens

Scientists studying the decline and recovery of seagrass beds in one of California's largest estuaries have found that recolonization of the estuary by sea otters was a crucial factor in the seagrass comeback. Led by researchers at the University of California, Santa Cruz, the study will be published in the *Proceedings of the National Academy of Sciences* the week of August 26.

Eelgrass beds in Elkhorn Slough benefit from the presence of sea otters. (Photo by Ron Eby)

Seagrass meadows, which provide coastal protection and important habitat for fish, are declining worldwide, partly because of excessive nutrients entering coastal waters in runoff from farms and urban areas. The nutrients spur the growth of algae on seagrass leaves, which then don't get enough sunlight. In Elkhorn Slough, a major estuary on California's central coast, algal blooms caused by high nutrient levels are a recurring problem. Yet the seagrass beds there have been expanding in recent years.

"When we see seagrass beds recovering, especially in a degraded environment like Elkhorn Slough, people want to know why," said Brent Hughes, a Ph.D. candidate in ecology and evolutionary biology at UC Santa Cruz and first author of the *PNAS* study. His coauthors include Tim Tinker, a wildlife biologist with the U.S. Geological Survey, and Kerstin Wasson, research coordinator for the Elkhorn Slough National Estuarine Research Reserve, who are both adjunct professors of ecology and evolutionary biology at UCSC.

Hughes and his colleagues documented a remarkable chain reaction that began when sea otters started moving back into Elkhorn Slough in 1984. The sea otters don't directly affect the seagrass, but they do eat enormous amounts of crabs, dramatically reducing the number and size of crabs in the slough. With fewer crabs to prey on them, grazing invertebrates like sea slugs become more abundant and larger. Sea slugs feed on the algae growing on the seagrass leaves, keeping the leaves clean and healthy.

"The seagrass is really green and thriving where there are lots of sea otters, even compared to seagrass in more pristine systems without excess nutrients," Hughes said.

In addition to the sea slugs, small crustaceans known as *Idotea* are also important grazers on the algae, and they too increase in number when sea otters control the crab population.

This kind of chain reaction in a food web is known to ecologists as a "trophic cascade." Scientists have long known that sea otters have a big impact on coastal ecosystems. Their importance in maintaining kelp forests by preying on animals that graze on kelp is especially well documented. The new study shows sea otters play a slightly different but equally important role in estuarine ecosystems like Elkhorn Slough, according to Tinker.

"This provides us with another example of how the strong interactions exerted by sea otters on their invertebrate prey can have cascading effects, leading to unexpected but profound changes at the base of the food web," he said. "It's also a great reminder that the apex predators that have largely disappeared from so many ecosystems may play vitally important functions."

Crabs are a favorite prey item for sea otters in Elkhorn Slough. (Photo by Ron Eby)

The sea otter population in Elkhorn Slough has had its ups and downs, reflecting trends in the ongoing recovery of California's sea otters. The slough's initial recolonizing population of about 15 declined in the late 1980s, then grew to nearly 100 in the 1990s before declining again, followed by a recovery over the past decade. These fluctuations in the otter population were matched by corresponding fluctuations in the seagrass beds, Hughes said. Even within the slough, he said, sea otter density varies among the different seagrass beds, and those with more otters have fewer and smaller crabs and healthier seagrass.

Both sea slugs and *Idotea* (the crustacean between the two sea slugs above) feed on algae and increase in numbers when the crab population is controlled by sea otters. (Photo by Brent Hughes)

The researchers used a combination of field experiments and data from long-term monitoring of Elkhorn Slough to study these interactions. "We used multiple approaches, and they all came up with the same answer," Hughes said.

Eelgrass *(Zostera marina)* is the dominant seagrass in Elkhorn Slough and elsewhere in the northern hemisphere. Seagrasses in general provide important nursery habitat for juvenile fish, and eelgrass beds along the west coast are especially important for species such as Pacific herring, halibut, and salmon. In addition, seagrass beds protect shorelines from storms and waves, and they soak up carbon dioxide from seawater and from the atmosphere.

"These are important coastal ecosystems that we're losing, and mostly that's been associated with bottom-up effects like nutrient loading. This study shows that these ecosystems are also being hit by top-down forces due to the loss of top predators," Hughes said.

The findings in Elkhorn Slough suggest that expansion of the sea otter population in California and recolonization of other estuaries will likely be good for seagrass habitat throughout the state, he added.

According to Wasson, the study has important management implications, suggesting that to restore valued coastal habitats, it may be necessary to restore entire food webs. "That is a new perspective for us," she said. "Most estuarine managers focus on the bottom-up approach, bringing back marshes and eelgrass and hoping the rest comes along with it. But in this case, it's clear you need to focus on the top and bottom of the food web at the same time."


The sea slug *Phyllaplysia taylori,* also known as the "eelgrass sea hare," feeds on algae growing on the leaves of eelgrass. (Photo by Brent Hughes)

In addition to Hughes, Tinker, and Wasson, the coauthors of the study include Ron Eby and Eric Van Dyke at the Elkhorn Slough National Estuarine Research Reserve; Corina Marks at California State University Monterey Bay; and Kenneth Johnson at the Monterey Bay Aquarium Research Institute. This work was supported by the National Estuarine Research Reserve System, the California Department of Fish and Wildlife, and the U.S. Geological Survey's Western Ecological Research Center.

See Also

- Excess nutrients threaten Elkhorn Slough ecosystem
- Research at Elkhorn Slough guides conservation and restoration efforts
- UCSC study shows how urchin-loving otters can help fight global warming

Wolves Article

Only 3 Wolves Are Left at Isle Royale National Park

by Megan Gannon, Live Science Contributor | April 22, 2015 05:23pm ET

Last year, ecologists counted nine wolves at Isle Royale. This year, they counted three.

Sixty years ago, Michigan's Isle Royale was one of the only places you could find gray wolves in the contiguous United States.

Today, the wolf population at the remote national park is in trouble. Now there are just three individuals — a mated pair and their pup — left on the island in Lake Superior, according to a new report. Inbreeding is to blame, ecologists say, but climate change may be an indirect culprit in the decline.

It might be too late for the population to recover on its own, and wildlife managers are considering bringing more wolves to the island to keep the growing moose population in check and restore the health of the ecosystem. [Gallery: Photos of Brand-New Baby Wolves]

"Isle Royale is the last place on the planet where you have a forested ecosystem, a wolf population and moose population where none of them are exploited by humans," said John Vucetich, a wildlife ecologist at Michigan Technological University, who worked on the new report.

Because it is somewhat isolated from human influence, Isle Royale is an ideal place to study predator-prey dynamics. And since the late 1950s, scientists have been conducting yearly surveys to figure out how and why the populations of wolves (predators) and moose (prey) on this island shift over time.

Moose arrived on Isle Royale by 1900. Without any predators, the moose population was kept in check only by starvation, and the animals were stripping the island of its native plants and trees, such as balsam firs. Conservationists in the early 20th century, including Aldo Leopold, entertained the idea of introducing gray wolves on Isle Royale to take care of the moose problem, Vucetich said. But then wolves came to the island on their own via an ice bridge in the late 1940s. The wolf population increased to as many as 50 individuals over time, but has averaged at about 25.

The last time the wolf population dropped significantly was around the year 1980, when there was an outbreak of canine parvovirus, which was introduced to the island by pet dogs, Vucetich said. The population stayed low for another 10 or 15 years and then started to increase again in the 1990s. But in the last six years, biologists have witnessed another crash in wolf abundance.

In January 2014, nine wolves were counted in the survey. The three wolves counted in January 2015 mark a new low. Over the same one-year period, the moose population grew 19 percent, from 1,050 to 1,250, according to the report.

With such a small population, the wolves are susceptible to inbreeding, which can lead to serious health and reproductive problems. Bone deformities that occur at a rate of 1 in 100 in the general wolf population have been occurring recently at a rate of 1 in 3 in the wolves on Isle Royale, Vucetich said. And the small family of wolves left on the island doesn't seem to be faring so well. The two adults, which have been a mated pair for four years, had three pups two years ago, none of which survived beyond their second birthdays, Vucetich said. The pup that's currently with them appears to have a hunched posture and a deformed tail. [In Photos: The Fight Over Gray Wolves' Endangered Status]

A comeback is unlikely without new genetic material. But climate change might make it more difficult for roving wolves from the mainland to get to Isle Royale on their own, as warming temperatures in Lake Superior already make it less likely for an ice bridge to form in the winter, Vucetich said.

"If you think the purpose of a national park is to protect ecosystem health, you need to do something," Vucetich said. "The National Park Service has known about this problem for some time now, and they are delaying making a decision. That's disappointing."

But a wolf reintroduction program would likely take a few years to get off the ground. The National Park Service is currently weighing if and how they should intervene. Phyllis Green, superintendent of Isle Royale National Park, said an environmental impact analysis about how to manage wolves and moose on the island should be up for public comment in the next couple of months. But it's complicated because her agency has to manage for an entire ecosystem, not just wolves, in the face of a warming world.

"What are we going to do about climate change with species other than wolves?" Green said. "That's the larger question. That's why we have to decide where we put the park service's energy."

People focus on wolves because they're charismatic animals, Green said. But in her eyes, the true face of climate change on the island might be a type of cisco fish that was only found in the park's lakes and streams, but is now extinct.

"They're gone forever because their genetic strain is gone," Green said. "With wolves, we are fortunate because we have options to explore through this planning process. We have healthy wolf populations with healthy genes all around this island."

Follow Megan Gannon on Twitter. Follow us @livescience, Facebook & Google+. Original article on Live Science.

Appendix C: Detailed Notes From Observations

Observer 1:

Notes from Observations:

Class 1: Nguyen College
Class 2: McD College
Class 3: Apostoly Honors
Class 4: Lavalle Honors

-every day started with a question and general explanations

- Day 2: teacher made students draw a food pyramid in addition to the food chain
  - teacher gave detailed instructions on what to do for the inclusion classes
  - teacher advised working as a group
  - Class 3: 16 boys and 16 girls into 8 groups of 2 boys and 2 girls each
    - group 1 needed extra help and instructions on how to build their models
    - group 3 had equal distribution of group and helped each other when confused
  - Class 2: 11 boys and 10 girls: 2 groups of 3 boys where one group was very active and distributed work equally while the other group had moderate partic.
- Day 3: website did not work for the first two classes so google was used
  - the teacher printed out the information from the website in case some of the students missed part of the information
  - the paragraph was assigned as HW
- Day 4: teacher put questions into 1, encouraged group work
  - Class 2: 13 boys and 7 girls (most groups reading the article individually and then worked together to answer the questions)
    - used pg. 48 for photosynthesis diagram
- Day 5: the class was very interested on the question of comparing their solution to the actual solution
  - Class 4: 15 boys and 17 girls (generally groups of 2 and 2)
  - Class 1: 13 boys and 8 girls: group 3 and 4 have help from 2 more teachers
- Day 6: teacher printed out pictures, had a sample poster, "all days put together." "what did we say the solution to the problem was?"
  - Class 4: groups divided work equally

-no gender differences were seen in all classes
-more group work seen during building the model and building the posters
-the inclusion classes needed step by step guidance or more detailed explanations on the questions

Observer 2:

General Notes:

1. Implementation
   a. Inclusion class was given additional instructions
   b. Inclusion class moved slower causing some spill over into other days however most other
1. classed seemed to be moving along at a good pace
2. Engagement:

a. Students engagement did not seem to be based on gender

i. However groups of 2 males and 2 females seemed to be

3. more focused than groups that had different combinations

c. Student engagement did seem to have to do with how shy or not a student was as well as

4. attitude towards school.

i. Based on conversations with students

d. Many students that were less engaged during the more science based part of the lesson

5. became engaged during the more artistic side.

i. Through observation I found that the artistic parts

6. still required enough knowledge that these students learned the material as well

e. “Bell Work” seemed to do a good job getting the class focused may be a good idea to

7. implement in lesson

f. When poster was being build all students seemed to contribute well

Class 1: Nguyen College
Class 2: McD College
Class 3: Apostoly Honors
Class 4: Lavalle Honors

Day 1:
Class 3: 16 males, 16 females
Class 2: 11 males, 10 females

1. Day one and two materials were partially combined
2. Some groups seemed to finish early while others did not
3. Most students seemed receptive to the work
4. Students seemed engaged and focused on the task especially those that finished early

Day 2:
Class 1: 13 male 7 female
Class 4: 15 males, 16 females

1. Models where reused which was not intended
2. Reuse led to additional time requirement in set up and put away
3. Many groups had difficulty with arrow direction

Day 3:
Class 2: 13 males, 7 females
Class 3: 16 males, 15 females
Class 4: 15 males, 16 females

1. Website was down initially however it went back up later in the day
    a. When the website was down students looked on google for answers
2. 8 computers did not work in comp lab however I was able to fix 6 of them for the last class

1. of the day
    a. This led to some people having partners while looking for the information on the
2. computers
    b. This may have led to more distraction
3. Essays where put off to another day

Day 4:

Class 1: 12 males 7 females

Class 2: 13 boys and 7 girls

Class 4: 16 males 16 females

1. Classes seemed somewhat confused about how to answer some questions but overall it went well
2. Ms. McDermott decided it would be best to combine multiple questions into one this led to some confusion at first but overall let to a better discussion between students
3. Students used textbook formula to answer photosynthesis diagram
4. Discussion was good students seemed engaged
5. Some students came up with very strange ideas
6. Some students were quieter however they when asked they showed understanding of material

Day 5:

Class 2: 12 male 6 female

Class 3: 16 male 16 female

1. Some students needed to complete the work due yesterday still which they got out of the way first
2. There was some argument about who had to read the article (everybody reads it by them self or one person does it out loud)
3. Once article was read students had nice discussions
4. While some students were quite they seemed to be doing a good job answering the questions and when talked to they seemed to understand the material

Day 6:

Class 1: 10 male 6 female

Class 3: 15 male 16 female

1. Students did a good job making poster
2. They were very creave
3. Ms. McDermott made a sample for them
4. Some students needed extra time on posters
5. Inclusion class spent time into next period
6. Overall poster looked good
7. Nice division of work
8. Some students did art some did layout and some did the handwriting

Appendix C: Observations Sheet

B -> Boy
G -> Girl

Engagement
1 -> low
2 -> medium
3 -> high

- Do students encounter difficulties with the case study approach? Do they understand what is expected of them?

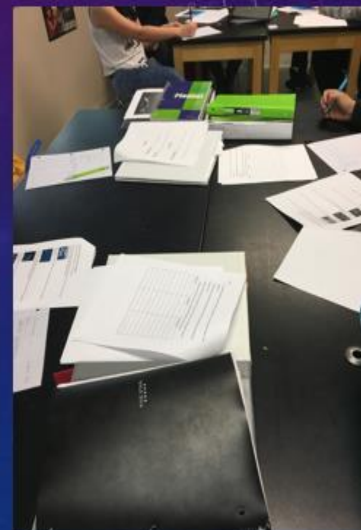
- Are all students adjusting well in their groups? Is every member of the group participating? Have they split roles within a group? Are there any issues of gender?

- Is the teacher encountering any difficulties with the case study approach? Does she seem comfortable with this teaching style?

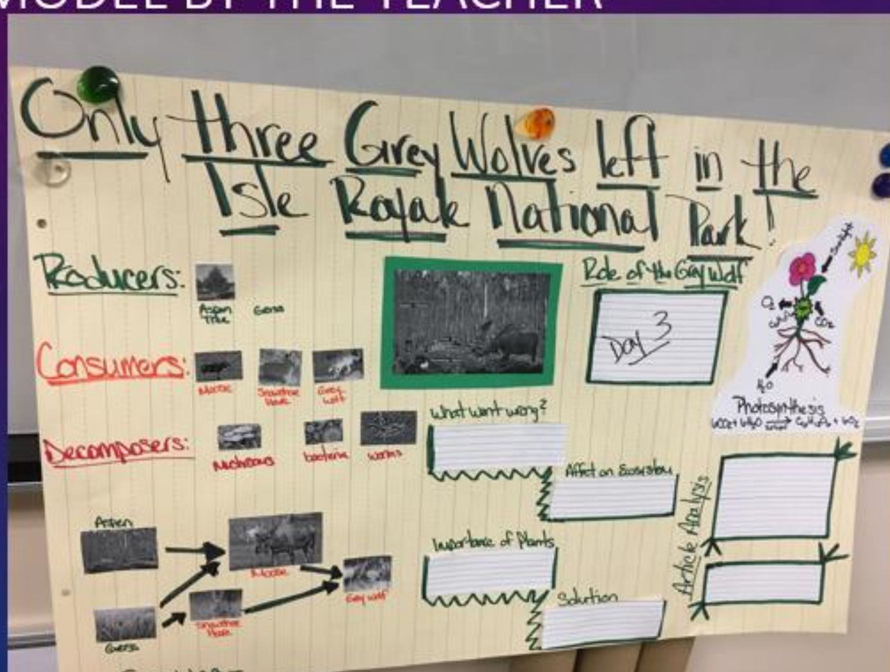
- Is she constantly checking on the groups? Is she dropping hints and/or stepping back?

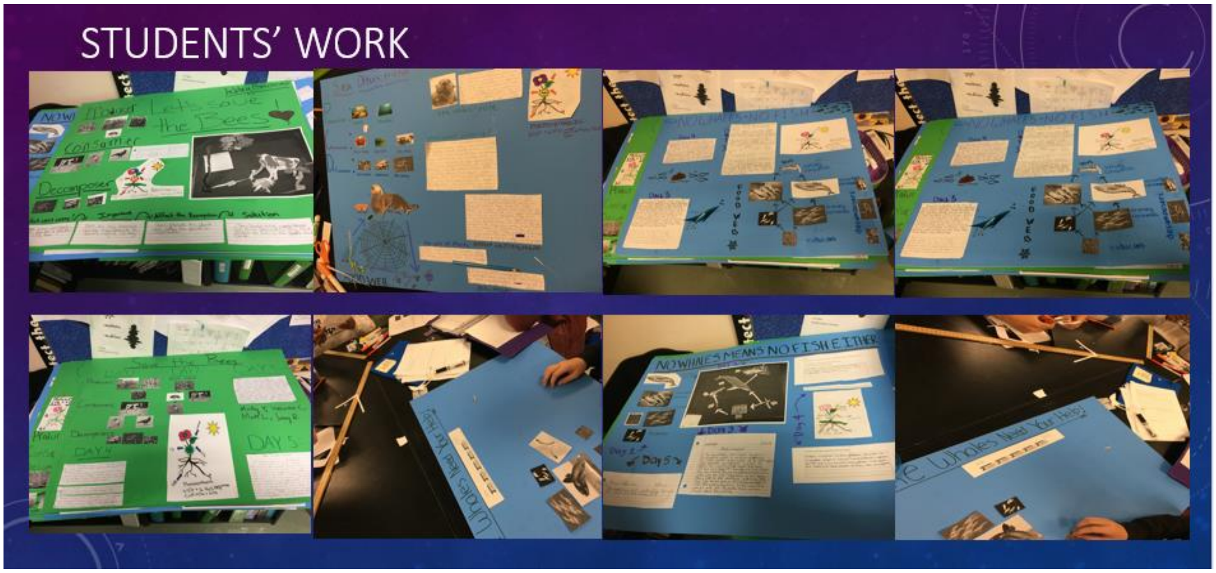
Appendix D: Pictures from Observations

STUDENTS WORKING ON THE ESSAY PARTS



POSTER MODEL BY THE TEACHER




STUDENTS' WORK
Let's save the Bees
Consumer
Decomposer
NO WHALES MEANS NO FISH EITHER
Save the Bees
DAY 5

Appendix E: Exams

Cells & Energy

Multiple Choice
Identify the choice that best completes the statement or answers the question.

1 What are the products of photosynthesis?
- A carbon dioxide and water
- B oxygen and water
- C carbon dioxide and sugars
- D oxygen and sugars

2 What happens during photosynthesis?
- A The cell uses oxygen to make food.
- B The cell uses the energy in sunlight to make food.
- C The cell uses glucose to make oxygen.
- D The cell uses the energy in sunlight to make carbon dioxide.

3 What is the total magnification of a microscope with two lenses when one lens has a magnification of 15, and the other lens has a magnification of 30?
- A 15
- B 30
- C 45
- D 450

4 Which of the following statements is NOT part of the cell theory?
- A Cells are the basic unit of structure and function in living things.
- B All cells are produced from other cells.
- C Only animals are composed of cells.
- D All living things are composed of cells.

5 What is the function of a cell membrane?
- A to support the cell
- B to perform different functions in each cell
- C to control what enters and leaves the cell
- D to form a hard outer covering for the cell

6 Which organelle is the control center of a cell?
- A mitochondrion
- B ribosome
- C nucleus
- D chloroplast

7 Which of the following *best* describes the function of mitochondria?
- A They convert energy from food molecules into energy the cell can use.
- B They store energy from food molecules.
- C They store energy from sunlight.
- D They produce nucleic acids that release energy.

8 All organic compounds contain the element
- A water.
- B oxygen.
- C carbon.
- D nitrogen.

9 Why is water important for a cell?
- A Water is the main ingredient in DNA.
- B All proteins are made of water.
- C Most chemical reactions in cells require water.
- D Water is an essential organic compound for the body.

10 Which term refers to the movement of molecules from an area of higher concentration to an area of lower concentration?
- A collision
- B diffusion
- C active transport
- D concentration

11 Which term refers to the diffusion of water molecules through a selectively permeable membrane?
- A osmosis
- B engulfing
- C active transport
- D passive transport

12 Enzymes are important because they
- A contain water.
- B speed up chemical reactions.
- C contain genetic material.
- D help the cell maintain its shape.

13 What is the function of a cell wall?
- A to protect and support the cell
- B to perform different functions in each cell
- C to prevent water from passing through it
- D to prevent oxygen from entering the cell

14 Which organelles store food and other materials needed by the cell?
- A mitochondria

B chloroplasts
C ribosomes
D vacuoles

15 When two or more elements combine chemically, they form a(n)
A lipid.
B atom.
C element.
D compound.

16 Consumers that eat both plants and animals are called
A omnivores.
B herbivores.
C carnivores.
D scavengers.

17 Which of these consumers is a herbivore?
A lion
B deer
C spider
D snake

18 If a kestrel eats a mouse that eats grass, the kestrel is a
A producer.
B second-level consumer.
C first-level consumer.
D decomposer.

19 The many overlapping food chains in an ecosystem make up a(n)
A food web.
B niche.
C energy pyramid.
D feeding level.

20 A diagram that shows the amount of energy that moves from one feeding level to another in a food web is called a(n)
A food chain.
B energy pyramid.
C ecosystem.
D niche.

21 In an energy pyramid, which level has the most available energy?
A producer level
B first-level consumer level
C second-level consumer level
D third-level consumer level

22 An organism that can make its own food is called a
A consumer.
B decomposer.
C producer.
D scavenger.

23 Vultures, which feed on the bodies of dead organisms, are
A first-level consumers.
B scavengers.
C producers.
D herbivores.

24 The first organism in a food chain is always a
A consumer.
B herbivore.
C carnivore.
D producer.

25 What do producers release as a result of photosynthesis?
A hydrogen
B nitrogen
C oxygen
D carbon dioxide

Cells & Energy
Answer Section

MULTIPLE CHOICE

1 ANS: D PTS: 1 DIF: L2 REF: p. C-46
OBJ: C.2.1.2 Describe what happens during the process of photosynthesis.
STA: 2.4 | 2.16 BLM: comprehension

2 ANS: B PTS: 1 DIF: L1 REF: p. C-45
OBJ: C.2.1.1 Explain how the sun supplies living things with the energy they need.
STA: 2.4 | 2.16 BLM: knowledge

3 ANS: D PTS: 1 DIF: L2 REF: p. C-12
OBJ: C.1.1.4 Describe how microscopes produce magnified images.
STA: 4.7.1 BLM: application

4 ANS: C PTS: 1 DIF: L2 REF: p. C-10
OBJ: C.1.1.3 State the cell theory. STA: 2.2 | 2.5 BLM: comprehension

5 ANS: C PTS: 1 DIF: L1 REF: p. C-17
OBJ: C.1.2.2 Describe the functions of cell organelles. STA: 2.2 | 2.4
BLM: knowledge

6 ANS: C PTS: 1 DIF: L2 REF: p. C-18
OBJ: C.1.2.2 Describe the functions of cell organelles. STA: 2.2 | 2.4
BLM: comprehension

7 ANS: A PTS: 1 DIF: L2 REF: p. C-19
OBJ: C.1.2.2 Describe the functions of cell organelles. STA: 2.2 | 2.4
BLM: comprehension

8 ANS: C PTS: 1 DIF: L2 REF: p. C-26
OBJ: C.1.3.2 Identify the four main kinds of organic compounds in living things.
STA: 3.7 BLM: comprehension

9 ANS: C PTS: 1 DIF: L1 REF: p. C-30
OBJ: C.1.3.3 Explain how water is important to the function of cells.
STA: 3.7 BLM: knowledge

10 ANS: B PTS: 1 DIF: L1 REF: p. C-33
OBJ: C.1.4.1 Describe how most small molecules cross the cell membrane.
STA: 2.2 | 2.4 BLM: knowledge

11 ANS: A PTS: 1 DIF: L1 REF: p. C-34
OBJ: C.1.4.2 Explain why osmosis is important to cells. STA: 2.2 | 2.4
BLM: knowledge

12 ANS: B PTS: 1 DIF: L2 REF: p. C-28
OBJ: C.1.3.2 Identify the four main kinds of organic compounds in living things.
STA: 3.7 BLM: comprehension

13 ANS: A PTS: 1 DIF: L1 REF: p. C-17
OBJ: C.1.2.1 Identify the role of the cell wall and the cell membrane in the cell.
STA: 2.2 | 2.4 BLM: knowledge

14 ANS: D PTS: 1 DIF: L1 REF: p. C-22
OBJ: C.1.2.2 Describe the functions of cell organelles. STA: 2.2 | 2.4
BLM: knowledge

15 ANS: D PTS: 1 DIF: L1 REF: p. C-26
OBJ: C.1.3.1 Define elements and compounds. STA: 3.7

BLM: knowledge

16 ANS: A PTS: 1 DIF: L1 REF: p. E-43
OBJ: E.2.1.1 Name and describe the energy roles that organisms play in an ecosystem.
STA: 2.13 | 2.14 BLM: knowledge

17 ANS: B PTS: 1 DIF: L2 REF: p. E-43
OBJ: E.2.1.1 Name and describe the energy roles that organisms play in an ecosystem.
STA: 2.13 | 2.14 BLM: comprehension

18 ANS: B PTS: 1 DIF: L2 REF: p. E-44
OBJ: E.2.1.2 Explain how energy moves through an ecosystem.
STA: 2.13 | 2.14 | 2.15 BLM: application

19 ANS: A PTS: 1 DIF: L1 REF: p. E-44
OBJ: E.2.1.2 Explain how energy moves through an ecosystem.
STA: 2.13 | 2.14 | 2.15 BLM: knowledge

20 ANS: B PTS: 1 DIF: L1 REF: p. E-46
OBJ: E.2.1.3 Describe how much energy is available at each level of an energy pyramid.
STA: 2.13 | 2.14 | 2.15 BLM: knowledge

21 ANS: A PTS: 1 DIF: L1 REF: p. E-46
OBJ: E.2.1.3 Describe how much energy is available at each level of an energy pyramid.
STA: 2.13 | 2.14 | 2.15 BLM: knowledge

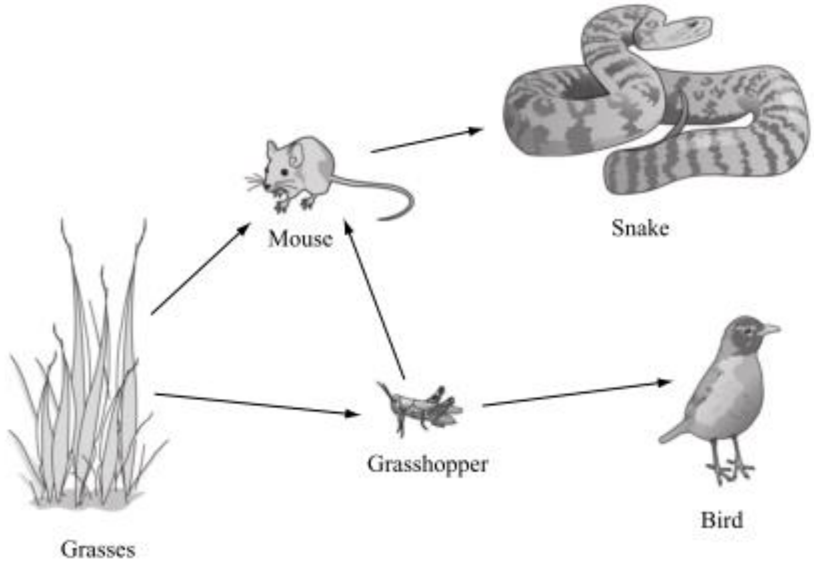
22 ANS: C PTS: 1 DIF: L1 REF: p. E-43
OBJ: E.2.1.1 Name and describe the energy roles that organisms play in an ecosystem.
STA: 2.13 | 2.14 BLM: knowledge

23 ANS: B PTS: 1 DIF: L2 REF: p. E-43
OBJ: E.2.1.1 Name and describe the energy roles that organisms play in an ecosystem.
STA: 2.13 | 2.14 BLM: application

24 ANS: D PTS: 1 DIF: L1 REF: p. E-44
OBJ: E.2.1.2 Explain how energy moves through an ecosystem.
STA: 2.13 | 2.14 | 2.15 BLM: knowledge

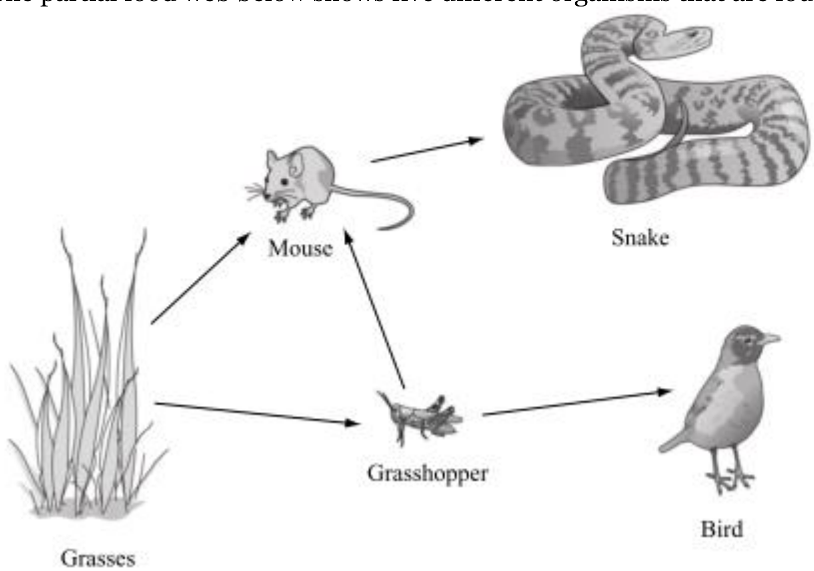
25 ANS: C PTS: 1 DIF: L1 REF: p. E-50
OBJ: E.2.2.2 Explain how carbon and oxygen are recycled in ecosystems.
STA: 1.4 BLM: knowledge

The partial food web below shows five different organisms that are found in a prairie ecosystem.



a. Identify **each** organism in this food web as a producer, a primary consumer, or a secondary consumer.
b. Using only the organisms from this food web, describe **one** change in this prairie ecosystem that would result in a decrease in the grasshopper population. Explain the reasoning for your answer.

The partial food web below shows five different organisms that are found in a prairie ecosystem.



a. Identify **each** organism in this food web as a producer, a primary consumer, or a secondary consumer.
b. Using only the organisms from this food web, describe **one** change in this prairie ecosystem that would result in a decrease in the grasshopper population. Explain the reasoning for your answer.

Appendix F: Detailed Notes from Interview with Mrs. McDermott

Notes from the interview:
•The teacher found no difficulties teaching this project. “I thought it was a great project! The kids loved it! It incorporated a lot of different skills with: hands-on, the research portion, the writing. It was a well encompassed project that the kids did very well with.”

•She wouldn’t take anything way, but would add more help with the research portion: “providing more paper articles to give them more resources to use.”

•More time needed for some of the activities than anticipated “but that’s something you learn as you go.” (especially inclusion vs honors)

•She says “students loved the project, did a great job,” and found “no difficulties”

•“The expectations (for the students) were made clear whether written down or spoken” (note: the teacher gave more instructions when needed, and repeated the instructions when necessary)

•The teacher notes that generally, the students participated very well in this project. “You will never get equal participation from every student, but that comes from students who are stronger with certain skills are going to lead, and the kids who are not as strong are going to sit back and watch. So, the one thing that was great about this project was that there was something for every skill level so if they didn’t do well on one day, they were able to make up for it and add their part another day. They really were able to show show their strength and do well on at least one day even if they couldn’t on others”

•On whether this style of teaching helped the students understand the material better and/or helped them improve their test scores: “The test scores were great.” “Most of them got the food web/pyramid questions right, and it was the cell and organelles part that they got wrong” “It definitely was a project that allowed them to be successful on the exam.”

•Groups are tried to be split up so that they are equal on number of boys and girls so that there is not “as much talking and drama.” “One class has eight girls and twenty boys and there is one girl at each table with 2 or 3 boys”

•The teacher says that she will “definitely teach this again.” “2 other teacher are also using it”

•“very well designed lesson plan”; “everything was at grade level”; “could add more case studies so that each group would have a different one in class for presentation purposes” (larger classes than what the norm should be)