Ecosystems:
Interactions and Dynamics

Science Grades 9-12

Biology/Environmental Science

Using high school Biology standards for ecology (HS-LS2), students will encounter the ecosystems of Cape Cod and evaluate the interactions and dynamics between the biotic and abiotic factors within and between different habitats. This lesson plan is designed to be presented at the end of an ecology unit in order to summate the entire unit, or to allow the teacher to give a final laboratory or alternative assessment. Students should approach these activities with a basic knowledge of the vocabulary and major themes of ecology. These activities can be used to teach much of ecosystems, abiotic and biotic factors, adaptation, and interaction—but a base knowledge is assumed.

Students will research the ecosystems of Cape Cod, and apply the research to what they see in the field at the Cape Cod Museum of Natural History. They will record their observations in a field guide, and be directed towards observing relationships and interactions within and between the many ecosystems they will encounter. At the end of the unit, students will use what they have learned in the classroom and in the field to ask questions, and find and evaluate solutions based on their personal interactions with the ecosystems of Cape Cod. Students will also evaluate the impact humans have had on the natural history of these ecosystems, and the impact we continue to see today.

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Please provide us some background information on the unit development. In order to help others who are interested in this topic understand a bit more about what you created, we will write a short introduction to each unit and provide some images, in addition to posting the completed units on the Cape Cod Regional STEM Network website (www.capecodstemnetwork.org). Please help us by answering the questions below after you have completed your unit.

1. Who helped to create this unit?

Names	School (Grade/course taught)
Anne Poirier	St. John Paul II High School (8-12/biology, chemistry, anatomy)

2. What were some sources of inspiration for this unit?

The Cape Cod Museum of Natural History holds a wealth of information about the many ecosystems of Cape Cod, and provides a unique opportunity for students to experience ecology through hands-on and up-close investigation and observation. Ecosystems are one of four core ideas in Biology, and the exhibits at the museum would allow for a teacher to access many of those state teaching standards. As high school focuses on modeling, analysis, and evidence, the museum and its resources also provide a space and materials for older students to practice scientific inquiry: to observe data and evidence, to ask questions, to observe and create solutions.

3. In your own words, what are you hoping students learn—big picture—through this unit?

I am hoping students will learn to better appreciate the many ecosystems around them through observation and asking questions. Students will learn how and why different organisms interact within and between ecosystems to keep our environment stable. They will also observe human impact and discuss what we can do to preserve these delicate and crucial ecosystems.

4. What might students find exciting in this unit?

It is exciting that students will be able to make observations and answer questions in the field—students will be outside in the ecosystems they are studying, surrounded by enthusiastic, knowledgeable volunteers. CCMNH is full of exhibits that suit a variety of interests, from the Arts, to Technology and Engineering, to History, to Environmental Science. It is exciting to take the time to study our own Cape Cod ecosystems, rather than reading in books. The field trip is structured so that students can direct their attention and focus towards the topics and areas in which they are most interested and excited.

5. What science standards or real-world content did you strive to emphasize?

I have emphasised the overarching best practices in the sciences: inquiry, analyses, supporting evidence, etc. through direct observation of the local ecosystems. Because of the material at the museum, ecology and ecosystems are the focus of the unit, however, I have attempted to make room for inquiry, student-led

questions and design, and flexibility to suit curricula in many classrooms/for many teachers.

6. How would you say that this unit "matters" to the STEM community? Or to our community on Cape Cod? Or to the larger community?

So many students living in this coastal community do not know about the many ecosystems that are a short walk from their backyard. It is important for students to experience local science, so that it becomes relevant—we can make connections between biology and everyday life for these students, and hopefully inspire action in either the pursuit of STEM careers, or care and interested in the conservation and appreciation for these ecosystems.

7. What's the most important lesson you learned as you created this?

In creating this lesson, I found it both overwhelming and exciting how much information is available within and on the trails of the CCMNH. The CCMNH lends itself well to a more self-directed study with high school students, where they can focus on what is most relevant and interesting to them. I have also learned that much of high school standards are focused on modeling, analysis, and evidence based arguments—which lend themselves beautifully to an inquiry-based field trip, reflection, and unique discussions.

8. Anything else you would like fellow teachers or others to know about this unit?

This lesson plan is designed to be presented at the end of an ecology unit in order to summarize the entire unit, or to allow the teacher to give a final laboratory or alternative assessment.

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Stage 1 Desired Results

MA STE Standards

LS2. Ecosystems: Interactions, Energy, and Dynamics

HS-LS2-1. Analyze data sets to support explanations that biotic and abiotic factors affect ecosystem carrying capacity.

HS-LS2-2. Use mathematical representations to support explanations that biotic and abiotic factors affect biodiversity within a population and species diversity within an ecosystem.

HS-LS2-6. Construct an argument supported by evidence that ecosystems with greater biodiversity tend to have greater resistance to change and resilience.

HS-LS2-7. Analyze direct and indirect effects of human activities on biodiversity and ecosystem health, specifically habitat fragmentation, introduction of non-native or invasive species, overharvesting, pollution, and climate change. Evaluate and refine a solution for reduce the impacts of human activities on biodiversity and ecosystem health.

Other Possible Applications:

HS-LS4-5. Evaluate models that demonstrate how changes in an environment may result in the evolution of a population of a given species, the emergence of new species over generations, or the extinction of other species due to the processes of genetic drift, gene flow, mutation, and natural selection.

ESSENTIAL QUESTIONS

- How and why do organisms interact with their environment, and what are the effects of these interactions?
- How and why do biotic and abiotic factors interact within and between the ecosystems of Cape Cod?
- How and why have humans impacted the ecosystems of Cape Cod?

UNDERSTANDINGS

Students will understand that…

- Cape Cod is comprised of numerous ecosystems. Organisms occupy specific niches within and between ecosystems.
- Adaptations of evolutionarily successful organisms can serve as a model for useful technology.
- Human history is closely linked to the natural history of Cape Cod.

Students will be skilled at…..

Observing, interpreting evidence, collecting data, modeling ecosystems, identifying niche and beneficial adaptations, evaluating opportunities for technology based on ecology, identifying human impact on Cape Cod.

HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's hydrosphere can create feedbacks that cause changes to other systems. *HS-ETS1-1.* Analyze a major global challenge to specify a design problem that can be improved.	**TRANSFER** ***Students will be able to independently use their learning to…*** ● Model the ecology of Cape Cod ecosystems by describing both abiotic and biotic factors and their interactions. ● Evaluate the potential for technological solutions to human problems using nature/ecology as a model. **Cross-Curricular Connections** ● Engineering/Technology: identifying problems and designing solutions ● Math: modeling and graphing ● ELA: Evaluating evidence, constructing arguments, communicating information in multiple formats cause and effect; systems models; energy and matter; structure and function; stability and change; Influence of STEM on society and the natural world

Stage 2 Evidence

Formative Assessment Ideas:

- Ecosystems Brainstorming worksheet: do they get it?
- Ecosystems Presentation: can students identify the most important factors in an ecosystem?
- Field Guide: have students paid attention to the patterns and interactions they see in the field?

Summative Assessment Ideas:

These lesson plans are intended to be used as a summation of a unit on Ecology. Students should combine classroom learning and preparation with their firsthand observation and analysis to show that they have mastered the concepts of the unit. This lesson could be incorporated into summative assessments at the end of an ecology unit as:

- Research Paper/Report based on students' experience with museum exhibits and field observations; incorporate full unit vocabulary and concepts as they relate to the study of ecosystems on Cape Cod and Human Impact.
- Discussion/Debate: How humans affect ecosystems and their dynamics (from geology to energy pyramids).

Stage 3 Learning Plan

Summary of Key Learning Events and Instruction

- Review of ecosystems: biotic and abiotic factors (Ecosystems WS)
- Presentations of Cape Cod ecosystems
- Field Trip to CCMNH (STEAM Scavenger Hunt; Field Guide for Students)
- Discussion/Debate: Human Impact

Prerequisites

This lesson is a cumulative application of ecological concepts. It will allow students to apply their knowledge to ask and answer questions. Before completing these lessons, students should be familiar with (or have been exposed to) the fundamentals of ecology:

1. Ecology: the study of the interactions of organisms with one another and with the nonliving components of their environment
2. Levels of Organization in the Environment
    a. Biosphere: broadest, most inclusive level—Earth and its atmosphere which supports life
    b. Ecosystems: all the organisms and non-living environment found in a particular area
        i. Terrestrial Biomes: tundra, taiga, temperate deciduous forest, temperate grassland, desert, savanna, tropical rain forest
        ii. Aquatic Ecosystems: ocean, estuary, fresh water (lakes, ponds, rivers, and streams)
    c. Community: all interacting organisms living in one ecosystem
    d. Population: all the members of a species living in one ecosystem at one time
        i. Species: organisms that can reproduce and have fertile offspring
    e. Organism: an individual living thing
3. Structure of Ecosystems
    a. Habitat: where an organism lives
        i. Biotic factors: living things that affect the organism
        ii. Abiotic factors: nonliving things; chemical and physical characteristics of the environment
    b. Niche: specific conditions and resources in an area that contribute to the survival of a particular species; organism's role in the ecosystem
4. Trophic Levels
    a. Producers (autotrophs): photosynthesis and chemosynthesis
    b. Consumers (heterotrophs):
        i. Herbivores (primary consumers)
        ii. Omnivores
        iii. Carnivores
        iv. Scavengers and detritivores
    c. Decomposers (cause decay)
5. Feeding Relationships and Energy Flow

   a. Food chain: a single path of feeding relationships among organisms
   b. Food web: interlinking food chains in an ecosystem
   c. Energy pyramid: shows trophic levels and energy flow between organisms
6. Species Interactions
   a. Predation: predator kills prey
   b. Mimicry: imitation to avoid predation
   c. Competition: niche overlap and competition over limited resources
   d. Symbiosis: special feeding relationships
      i. Parasitism: parasite benefits; host is harmed
      ii. Commensalism: one species benefits, the other is not affected
      iii. Mutualism: both species benefit; cooperative relationship
7. Ecosystem Structure
   a. Terrestrial: temperature, moisture/precipitation, light, wind, and soil
      i. light, temperature, and precipitation affect productivity of ecosystem
      ii. most productive = tropical rainforest
   b. Aquatic: temperature, light, size of area, depth, salinity, tides and currents, wind, and substrate
      i. Light and available nutrients affect productivity of ecosystem
      ii. Most productive = estuary
8. Ecosystem Recycling
   a. The water cycle
   b. The carbon cycle
   c. The Nitrogen cycle
   d. The Phosphorus cycle

Lesson 1: The Ecosystems of Cape Cod

Overview of the Lesson: Students will evaluate their prior knowledge of the ecosystems (abiotic and biotic factors) that can be found on Cape Cod. They will also prepare a field guide to use on their field trip to the CCMNH (or individual field observations throughout Cape Cod)

Time (minutes): 2 x 45 minutes

Standard(s): What standard(s) will be the focus of the lesson?

- HS-LS2-1
- HS-LS2-2

Essential Question(s): What essential questions will be addressed in this lesson?

- What features define an ecosystem?
- How do biotic and abiotic factors interact in these ecosystems?

Science Objectives

- Describe the ecosystems of Cape Cod and discuss defining features and key organisms
- Analyze and model the key factors of ecosystems
- Explain the interactions between abiotic and biotic factors in different ecosystems
- Ask questions and explore evidence in research, literature, and the field to support observations and classroom learning

Language Objectives and/or Targeted Academic Language

- Ecology: ecosystems, habitats, abiotic and biotic factors, niche, symbiosis, interactions

Anticipated Student Pre-conceptions/Misconceptions (optional)

- The “beach” is just the beach—we have open ocean, salt marshes, dunes, tidal flats, etc—there is more than meets the eye!
- Ecosystems that are close in proximity will have the same/very similar organisms and biodiversity.
- Cape Cod has primarily marine aquatic ecosystems: we have many kettle ponds and fresh water resources as well!

Instructional Materials/Resources/Tools

- Ecosystems Worksheet and Answer Key
- Ecosystem Presentation Rubric

- Student Field Guide Packet Template
- CCMNH Teacher Guide
- A Walk through CCMNH (ppt)

Assessment: Students should be working on their field guide for the field trip.
Understanding of ecology should be assessed before this activity, and after the field trip.

Science and Engineering Practices included (put the included ones in bold):

1. **Asking questions (for science) and defining problems (for engineering)**
2. **Developing and using models**
3. **Planning and carrying out investigations**
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. **Obtaining, evaluating, and communicating information**

Notes about Science and Engineering Practices included: Focus is on analysis of the major characteristics of terrestrial and aquatic ecosystems of Cape Cod.

Lesson Overview:

- Students prepare for a field trip to the Cape Cod Museum of Natural History by learning about the many ecosystems of Cape Cod and constructing a field guide to assist them in making observations and asking questions on the available material during the field trip. Students will work primarily in partners or small groups to complete a brainstorming activity, and then to create brief presentations to share research on one of the ecosystems they will be studying in depth.

Opening/Engagement:

1. *5-10 minutes* In partners, students brainstorm what ecosystems they could find on Cape Cod and the features of those ecosystems (Ecosystems Worksheet)
2. *5 minutes* Students compare answers and ideas with other pairs in order to refine their descriptions
3. *10 minutes* As a class, identify the major ecosystems on Cape Cod. (see CCMH Teacher Guide and Ecosystems Worksheet Answer Key) Assign each pair or small group one or two ecosystems to research independently.

During the Lesson:

4. *20 minutes* Pairs or small groups work to research specific Cape ecosystems and define major abiotic and biotic factors
5. *Homework (class time if available)* Small groups prepare an illustrated poster *(in class)* or brief slideshow *(homework)* (mostly pictures, few words) to introduce the class to their assigned ecosystem. (see Ecosystem Presentation Rubric)
6. *30 minutes* Students present their research to classmates. Presentations should be short and limited to defining biotic and abiotic features of the ecosystem.
7. During presentations, students should begin to fill out their Field Guide (label ecosystems, describe expectations; see Student Field Guide Packet Template)

Lesson Closing

8. Students should have prepared their field guide for their trip to the CCMNH.
9. *As time permits* Discuss human impact on the ecosystems and brainstorm positive and negative impacts that people have had on the ecosystems. [find evidence on the field trip]
10. Review field trip expectations: rules; identifying ecosystems and interactions; identifying human impact; asking and solving questions/problems

Instructional Tips/Strategies/Suggestions for Teacher: What other ideas would you like to highlight? What grouping strategies are important? What are adjustments for struggling learners, enrichment, or for students who are English Learners?

Higher level students should be more self-directed and allowed to ask their own guided questions for their field observations on the field trip. Most students will be able to complete these assignments without much teacher direction. Consider giving guiding questions to struggling learners or lower level students.

- For College Preparatory/remedial biology students: Consider reducing the number of ecosystems you discuss. (forest, salt marsh, mudflats/tidal pools, ocean) Students will need more direction in identifying ecosystems. Lesson could start with assigned ecosystems and presentations, and use the presentations to fill out the ecosystems chart.
- For ELLs: Provide assistance in naming each ecosystem. Students may be able to draw and describe, but will need help in naming organisms and environmental features.
- Enrichment: Consider a pre- or post-discussion of how humans fit into and impact these ecosystems. Humans have a rich history of how we have shaped Cape Cod (in negative and positive ways). This will be the focus of lesson 4.

Lesson 2: Cape Cod Museum of Natural History

Overview of the Lesson: Students will use their background in ecology and their prepared Field Guides to explore the Museum of Natural History and the surrounding trails. Focus will be on observing the interactions and dynamics in and between the many ecosystems of Cape Cod. Follow up discussions will focus on the unique features of these ecosystems, and how humans interact with them.

Time (minutes): Field Trip (approx. 4-5 hours)

Standard(s): What standards (s) will be the focus of the lesson?

- HS-LS2-1
- HS-LS2-2
- HS-LS2-6

Essential Question(s): What essential questions will be addressed in this lesson?

- How are the ecosystems of Cape Cod unique?
- How do the interactions and dynamics within these ecosystems compare?
- How do the ecosystems interact with one another?
- How have humans shaped the biotic and abiotic factors of the Cape?

Science Objectives

- Analyze and compare the interactions and dynamics of different ecosystems

Language Objectives and/or Targeted Academic Language

- See ***Prerequisites***

Instructional Materials/Resources/Tools

- CCMNH Teacher Guide
- A Walk Through CCMNH
- Student Field Guide Packet Template
- Consider providing clipboard or other writing support for field observations in Student Field Guides

Science and Engineering Practices included (put the included ones in bold):

1. **Asking questions (for science) and defining problems (for engineering)**
2. **Developing and using models**

3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. **Constructing explanations (for science) and designing solutions (for engineering)**
7. Engaging in argument from evidence
8. **Obtaining, evaluating, and communicating information**

Opening/Engagement:

1. Discuss rules and expectations for museum behavior and deliverables (Field Guide)
2. Encourage exploration, questions, and following individual interests in the museum space

During the Lesson:

3. Introduction with Museum Staff
4. *1.5-2 hours* Guided Field Walk: students walk through the John Wing Trail and observe, sketch, and write about the ecosystems through which they walk
5. Museum Exhibits: Aquaria and Bird Alley (downstairs): observe aquatic and terrestrial ecosystems on display
6. Museum Exhibits: Marshview room, biomimicry, and History Hall: observe terrestrial ecosystems, and technology innovations based on adaptations

Lesson Closing

7. Field guide and questions should be finished at the museum or soon after for discussion in Lesson 3.

Instructional Tips/Strategies/Suggestions for Teacher: Students might do well if assigned partners or small groups. Large groups should be discouraged in order to foster an environment of exploration and to open doors for students to ask more questions.
For ELLs or lower level learners, it would be helpful for teachers or chaperones to stay close by to ask guiding questions or direct learning and exploration. Provide students with a clipboards. Make sure students understand the appropriate dress for the day--sturdy shoes, long pants, hat,...

Lesson 3: Interactions, Dynamics, and Relationships in the Ecosystems of Cape Cod

Overview of the Lesson: Students will reflect and share after their time spent at CCMNH. This lesson is discussion-based. Teacher or students should take notes on the board to help students summarize. The lesson ends with a complete model of Cape Cod that encompasses the many ecosystems and how they interact.

Time (minutes): 45 minutes

Standard(s): What standards (s) will be the focus of the lesson?

- HS-LS2-2
- HS-LS2-4
- HS-LS2-6

Essential Question(s): What essential questions will be addressed in this lesson?

- How do biotic and abiotic factors interact within an ecosystem? Between ecosystems?

Science Objectives

- Compare and contrast the ecosystems seen at CCMNH
- Use data and observations to draw conclusions about how the ecosystems are self-sustaining, and how they work together

Language Objectives and/or Targeted Academic Language

- See ***Prerequisites***

Instructional Materials/Resources/Tools

- Student Field Guide

Science and Engineering Practices included (put the included ones in bold):

1. **Asking questions (for science) and defining problems (for engineering)**
2. **Developing and using models**
3. Planning and carrying out investigations
4. **Analyzing and interpreting data**
5. Using mathematics and computational thinking
6. **Constructing explanations (for science) and designing solutions (for engineering)**
7. **Engaging in argument from evidence**
8. **Obtaining, evaluating, and communicating information**

Opening/Engagement: **1.** Visit and share answers from the “Review” section of the field guide packet. Highlights? Surprises? **2.** Review the major ecosystems and what makes them unique.
During the Lesson: **3.** Adaptations: talk about the species in each ecosystem and how they are well-suited to that environment. **4.** Dynamics: are any species well-suited to multiple ecosystems/live in and between different areas of Cape Cod? **5.** Interactions: what types of interactions did you observe: symbiosis, predation, competition, etc.
Lesson Closing **6.** Make a model (food web, illustration, or story/paragraph) that describes Cape Cod as a whole and how all of the ecosystems interact to make this part of MA uniquely beautiful and functional.

Lesson 4: Investigating Human Impact on Cape Cod

Overview of the Lesson: What will students be doing?

Time (minutes): 60 Minutes (time for preparation and time for discussion/debate)

Standard(s): What standards (s) will be the focus of the lesson?

- HS-LS2-7

Essential Question(s): What essential questions will be addressed in this lesson?

- How did human activity shape the history and geography of Cape Cod?
- What positive impacts have humans had on the environment/ecosystems of Cape Cod?
- What negative impacts do humans have on the environment?
- What changes can we make to reduce our impact and improve the environment?

Science Objectives

- Evaluate human impact on the environment and suggest solutions for reducing impact or improving local environmental conditions

Language Objectives and/or Targeted Academic Language

- ecological stewardship; see ***Prerequisites***

Anticipated Student Pre-conceptions/Misconceptions (optional)

- Humans have only negatively impacted the ecosystems in which we live.
- There is no way to repair damage humans have done, so why should I care?

Instructional Materials/Resources/Tools

- Completed Student Field Guide Packets

Assessment: Engage the class in a structured debate or conversation. Each student should be required to participate.

Science and Engineering Practices included (put the included ones in bold):

1. **Asking questions (for science) and defining problems (for engineering)**
2. Developing and using models
3. Planning and carrying out investigations

4. Analyzing and interpreting data 5. Using mathematics and computational thinking **6. Constructing explanations (for science) and designing solutions (for engineering)** **7. Engaging in argument from evidence** **8. Obtaining, evaluating, and communicating information** **Notes about Science and Engineering Practices included:** Students will practice engaging in discussion or argument based on observations and data collected in the classroom and in the field at CCMNH.
Opening/Engagement: **1.** Divide students into three groups (or into groups of three). One of each trio should be tasked with describing observations or evidence of human impact in the following ways: 1) Positive Human impacts on the ecosystems of Cape Cod; 2) Negative human impacts on the ecosystems of Cape Cod; 3) possible solutions to reduce impact or repair ecosystems
During the Lesson: **2.** Each group (or individual) should first use evidence collected, observed, or learned at the museum to discuss their topic. **3.** Students should seek reputable resources to delve further into research. **4.** Each group or individual should come up with 3-5 strong talking points to share their evidence
Lesson Closing **5.** In small groups (groups of 3) or as a class (3 groups), discuss the evidence for human impact and the solutions to reduce human impact. **6.** Further discussion by determining what would be feasible as individuals or as a class.
Instructional Tips/Strategies/Suggestions for Teacher: Remove 'positive human impacts' from discussion for ELLs, lower level learners, or for time. It may make more sense to focus on Ecological stewardship in terms of solutions and repair, rather than on ecological history.

Information to Support Teaching Learning

What additional resources can support teachers in developing background understanding of content or ideas in this unit?

- See the "CCMNH Teacher's Guide" (.doc and .ppt) for a detailed explanation of the exhibits and resources available for you and your class when you visit the museum!
- CrashCourse is an excellent resource for the review of biology concepts and can be found on YouTube or Khan Academy. [https://www.youtube.com/playlist?list=PL3EED4C1D684D3ADF]
- Current Science News articles [standard and student versions available]
    - https://www.sciencenews.org/topic/earth-environment OR https://www.sciencenewsforstudents.org/topic/earth-environment
    - https://www.sciencenews.org/topic/life-evolution OR https://www.sciencenewsforstudents.org/topic/life-evolution

- The National Park Service has wonderful resources about the local ecosystems, research, and conservation efforts: https://www.nps.gov/caco/learn/nature/index.htm ; https://www.nps.gov/caco/learn/nature/fact-sheets-and-field-guides.htm

List of Unit Resources (in lesson sequence)

What additional resources can support the teaching and learning of this unit? What resources can support the teacher in implementing the unit?

Pre-lesson for teacher OR students

- A Guide to the CCMNH (PowerPoint presentation and photographic walk-through of museum exhibits and trails)

Lesson 1: Ecosystems of Cape Cod

- PBS "Earth on the Edge" online exploration of ecosystems: http://www.pbs.org/earthonedge/index.html
- Ecosystems of Cape Cod Worksheet (.doc)
- Student Field Guide template (.doc) [up to 8 ecosystems for honors, less ecosystems for lower level learners]

Lesson 2: A Field Trip to Cape Cod Museum of Natural History

- Student Field Guides (prepared in **Lesson 1**)

Lesson 3: Interactions, Dynamics, and Relationships in the Ecosystems of Cape Cod

- Student Field Guides (completed in **Lesson 2)**

Lesson 4: Investigating Human Impact on Cape Cod

- Student Field Guides (completed in **Lesson 2)**