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# K-12 Partnership Lesson Plan

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# *Farming for Ecosystem Services*

## Overview

 In this lesson students will explore the relationship between biodiversity and ecosystem services, from basic ecological theory to their economic value. Provided with a short introduction to the types of ecosystem services and their importance, students will play a game where they must make decisions regarding how to invest a limited amount of money on their own for-profit farm—can they manage economic and ecological tradeoffs to design a productive farm that also enhances ecosystem services?

**Objectives**

At the conclusion of the lesson, students will be able to:

* Define “ecosystem services” and explain the differences between supporting, provisioning, regulating, and cultural services.
* Compare and contrast “ecosystem services” and “ecosystem function” and explain the importance of each
* Using evidence obtained from a classroom activity, explain the biodiversity-ecosystem function hypothesis
* Justify decision-making in a farming simulation as decisions relate to economic and ecological factors

**Length of Lesson**

One 50-minute class period

**Grade Levels**

Middle and high school

**Standards covered (NGSS)**

Disciplinary Core Ideas:

 *Middle School*

* **MS-ESS3-3**: apply scientific principles to design a method for monitoring and minimizing a human impact on the environment
* **MS**-**ETS1-2**: evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem
* **MS-LS2-5**: evaluate competing design solutions for maintaining biodiversity and ecosystem services

*High School*

* **HS-ESS3-1:** construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity
* **HS-ESS3-2**: evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios
* **HS-ETS1-3**: evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts
* **HS**-**LS2-2**: use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales
* **HS**-**LS2-7**: design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity
* **HS**-**LS4-6**: create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity

Cross Cutting Concepts:

* Patterns
* Systems and system models
* Stability and change of systems

Science and Engineering Practices

* Developing and using models
* Constructing explanations and designing solutions

***Previous Michigan Standards Met:***

* **E.ES.07.41**: explain how human activities (surface mining, deforestation, overpopulation, construction and urban development, farming, dams, landfills, and restoring natural areas) change the surface of the Earth and affect the survival of organisms
* **L**.**EC.06.41**: describe how human beings are part of the ecosystem of the Earth and that human activity can purposefully, or accidentally, alter the balance in ecosystems
* **B3**.**4A**: describe ecosystem stability. Understand that if a disaster such as flood or fire occurs, the damaged ecosystem is likely to recover in stages of succession that eventually result in a system similar to the original one
* **B3**.**4B**: recognize and describe that a great diversity of species increases the chance that at least some living organisms will survive in the face of cataclysmic changes in the environment
* **B3**.**4C**: examine the negative impact of human activities
* **E4**.**3B**: describe the damage resulting from, and social impact of thunderstorms, tornadoes, hurricanes, and floods

**Materials**

* Introductory powerpoint slides (available on “Farming for Ecosystem Services” lesson page on the KBS GK-12 website)
* “Croptions” game materials (all are available online for printing, except calculators)
	+ Calculators
	+ Blank game boards (farm template, 2 per student- begin with 1)\*
	+ Score cards (1 per student, score cards are for two years)
	+ Croptions Menus
	+ Game pieces (crop squares, buffer strips, bee hives)\*\*

\* Begin by assigning each student one game board (farm template) to work with. If students have money to use after the first round of the game (Year 1), a second game board can be provided to “expand” their farm.

\*\* Game pieces are provided in a PDF online for printing and cutting for use in the classroom. However, an alternative to using game pieces is to have students write/draw on their blank game boards. Keep in mind that this game is designed to be played for two rounds (years), so if students write on their game board, they will need a new copy for the second year of the game.

**Background**

Ecosystem services are defined as the benefits that humans obtain from ecosystems. These benefits can span a wide range of services, from nutrient cycling to aesthetic value. The 2005 Millennium Ecosystem Assessment (link provided in “Resources”) breaks up ecosystem services into four general categories:

1. **Supporting services** are necessary for the production of all other ecosystem services. These include nutrient cycling, primary production, and soil formation.
2. **Provisioning services** are products obtained from ecosystems. These include food, raw materials (such as timber), water, energy, and medicinal resources.
3. **Regulation services** are benefits obtained from the regulation of ecosystem processes. These include carbon sequestration and climate regulation, waste decomposition, purification of water and air, and pest and disease control.
4. **Cultural services** are nonmaterial benefits that people obtain from ecosystems. These include spiritual enrichment, benefits to cognitive development, recreation, and aesthetic experiences

Although the value of ecosystem services can be hard to quantify, humans benefit greatly from them and could not survive without them.

Ecosystem services and ecosystem functions are related measures, however they are not the same. While ecosystem services are benefits to humans, ecosystem functions are the biological, geochemical and physical processes and components that take place or occur within an ecosystem. These functions are more easily quantified by scientists compared to ecosystem services. Much ecological theory is devoted to investigating the relationship between biodiversity and ecosystem function, with the hypothesis that increasing biodiversity increases ecosystem function. This has shown to be true in some systems, particularly terrestrial plants, where increases in biodiversity are associated with increased plant productivity, nutrient use and retention, community and ecosystem stability, and invasion resistance. As this positive relationship between biodiversity and ecosystem function is often found, it has led scientists to question whether a positive relationship between biodiversity and ecosystem services also exists. In some ecosystems, such as agricultural systems, biodiversity has been shown to have a positive relationship with ecosystem services.

### Elucidating the factors that influence ecosystem services can help us better manage these services. With an understanding that the relationship between biodiversity and ecosystem services has the potential to be positive, we can make decisions when managing landscapes to promote ecosystem services.

### Activities of the session

1. Introductory material slides presentation (refer to lesson plan “Background” and notes provided in PowerPoint file for further information)
2. Instruction for “Croptions” decision-making game (detailed instructions and example illustrations are provided in the introductory slides file. There are additional slides at the end of the PowerPoint for use DURING the game, depending on which game cards are drawn)
3. “Croptions” decision-making game (Years 1 and 2)
4. Gallery walk upon conclusion of game. At this time, have students display their farm designs and score cards. Then, have students walk around the classroom to view the farms that their classmates created as well as their profits.
5. Follow-up Discussion (guiding questions are provided in the PowerPoint slides)

**Resources**

* GK-12 lesson plan, game with instructions, printable game pieces and materials (all available on GK-12 lesson plan webpage)
* UN Millennium Ecosystem Assessment: (<http://www.millenniumassessment.org/documents/document.356.aspx.pdf>)
* (http://islandpress.org/new-economy-nature)
* “The value of the world’s ecosystem services and natural capital” article (link to PDF available on GK-12 lesson plan page

Citation: Costanza, R., D’Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O’Neill, R. V., Paruelo, J., Raskin, R.G., Sutton, P. & van den Belt, M. (1997) The value of the world’s ecosystem services and natural capital. *Nature*, **387**, 253–260.

**Extensions and Modifications**

The “Croptions” game allows for multiple extensions and modifications. Blank game cards are included in the printable PDF of game pieces and can be used to create new climate conditions (e.g., wildfire could be a new climate card) or pest/disease options. Keep in mind that addition of new game cards will require assigning a “cost” to them – refer to the score card for examples. Another extension of the game is to allow students to use additional game boards (farm templates) after Year 1 of the game if they have made enough money to purchase crops for additional spaces.

If there isn’t enough time for the class discussion following completion of the game, the discussion questions can be modified to be a take-home writing activity by asking students to answer the discussion questions on their own.

**Assessment**

This lesson includes time for a class discussion following completion of the game activity. Assessment of student understanding can be completed informally using these questions. Alternatively, the discussion questions can be used as a follow-up writing activity for individual students to complete prior to sharing their answers with classmates.