What's Green and Grows All Over? Studying Ecosystem Biodiversity

Activity Overview
Students compare the biodiversity of a natural or restored ecosystem with a lawn or other cultivated "ecosystem."

Objectives: Students will
- Understand issues related to species biodiversity and distribution
- Collect and interpret data to answer a question
- Graph data and extract, interpret and use information presented in the graph
- Explore and determine best data collection procedures

Subjects Covered: Science, Math

Grades: 6 through 12

Activity Time: 45 minutes - 1 Hr

Season: Late spring, Summer, Early fall

Materials:
for each group:1 hula hoop or four equal-length sticks (30cm each) for quadrats, and two accessible "ecosystems" for comparison—one natural or restored and one cultivated, such as lawn.

State Standards:

Science:

Develop themes/questions (A.8.1) Use scientific vocabulary & themes (C.4.1), Use scientific vocabulary & themes (C.4.1)

Ask questions, plan investigations, make observations, predictions (C.4.2)

Select multiple information sources (C.4.3)

Use scientific equipment (C.4.4)

Use data to answer questions (C.4.5)

Evaluate data (C.12.3)

Choose & evaluate data collection methods (C.12.4)

Use explanations & models to describe results (C.12.5)

Understand physical properties of objects (D.4.1)

Find connections among living and non-living things (F.4.4)

Background

Biodiversity is the variety of all living organisms in an area – all species of plants, animals, and microorganisms. The definition of diversity can also be summarized as the "totality of genes, species, and ecosystems of a region," or simply "life on earth." Biodiversity is generally described in these ways:
- Species diversity – the different types of living organisms
- Genetic diversity – the variability of genetic information within individuals of a species
- Ecosystem diversity – the variety of habitats as well as the variety of ecological processes and interrelationships within the ecosystem

Species diversity and their interrelationships are important for enhancing the stability and resilience of an ecosystem. Genetic diversity is important for the survival and adaptability of species when the environment changes. With less gene variation within a species, healthy reproduction becomes difficult.

Biodiversity provides the life support system for us all. It provides us with ecosystem services such as fresh air, clean water, soil fertility, flood and drought control, and climate regulation. It provides us with food, medicine, and natural resources. It provides economic benefits and natural beauty, both of which improve our quality of life. Finally, it provides us with a personal connection to nature.

Currently, the rate of biodiversity loss and species extinction rate is one of the highest that the Earth has experienced, and is caused by human activity. E.O. Wilson uses the acronym HIPPO to describe the causes of biodiversity loss: **H**abitat destruction, **I**nvasive species, **P**ollution, Over**P**opulation, and **O**verharvesting.

Prairie Example
The prairie is so rich in wildflowers that, on the average, a new plant comes into flower almost every day during the summer. There are nearly 300 prairie plants that have evolved living closely together in this part of the world. More plant species are found per acre of prairie than almost any other ecosystem acre. In contrast, our lawns have northern European plants such as clover and plantain and some have only one plant in them: bluegrass. Any small area of prairie or lawn may have only a few different kinds of plants. However, several acres of prairie will have dozens and even hundreds of different kinds of plants. Several acres of lawn usually have only the same five or six plants. When rainfall is less than normal, the more diverse the plant community, the less its productivity declines during dry years and the faster it recovers from severe conditions. Previous research indicates that after a dry spell, land with many species regains productivity within a year, while

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Math:

Use reasoning abilities (A.4.1, A.8.1, A.12.1) Communicate mathematical ideas (A.4.2) and logical arguments (A.8.2, A.12.2)

Connect mathematical learning with other subjects (A.4.3)

Use vocabulary, symbols, notation (A.4.4) Develop effective oral & written presentations (A.8.4)

Organize work & present mathematical procedures & results (A.12.5)

Read & understand mathematical texts & writing (A.12.6)

Represent & explain whole numbers, decimals, & fractions (B.4.1,B.4.3)

Select & use appropriate computational procedures (B.4.5),

Read, represent, & interpret rational numbers (B.8.1)

Compare real numbers (B.12.2)

Create & evaluate numerical arguments (B.12.5)

Recognize & describe measurable attributes & units (D.4.1), understand measurement (D.4.2, D.4.3) using standard tools (D.4.4)

Demonstrate understanding of measurement facts, principles, techniques (D.8.2)

Determine measurement directly by using standard units and tools (D.8.3, D.12.2)

Determine measurement indirectly (D.8.4)

Work with data in real-world situations (E.4.1, E.8.1)

Use graphs, tables, or charts (E.4.3)

Determine if future events are likely or unlikely to occur (E.4.4)

Organize & display data from statistical investigations (E.8.2)

Analyze information from organized & displayed data (E.8.3)

those areas with 5 or less species can take over 4 years to recover.

The presence of enough different plants ensures that some can withstand whatever stress nature provides, be it fire, flood, drought, disease, or insects. Diverse fields are more likely to include plants that can tolerate the stress. Those plants use nutrients freed up by the loss of less fit species and help maintain the overall productivity of the ecosystem. Maintaining the diversity of the prairie is one indication of the importance of restorations and of saving species.

This activity provides students with an opportunity to sample and compare the plant biodiversity of different sites. For this exercise, the plant biodiversity is defined as the number of different plant species on a site. Sites that would provide interesting comparisons include a lawn, an old field, a one-year restoration, an older restoration or a remnant.

The most direct way to inventory the number of different plant species on a site is to count them. However, usually one cannot count all species in an ecosystem and therefore must be content to sample a small portion of the system and use this sample to estimate the total. These sampling areas, or "quadrats," can be of any known size or shape but need to be randomly distributed and sufficiently numerous so that the number of species found within the quadrats is representative of the entire population.

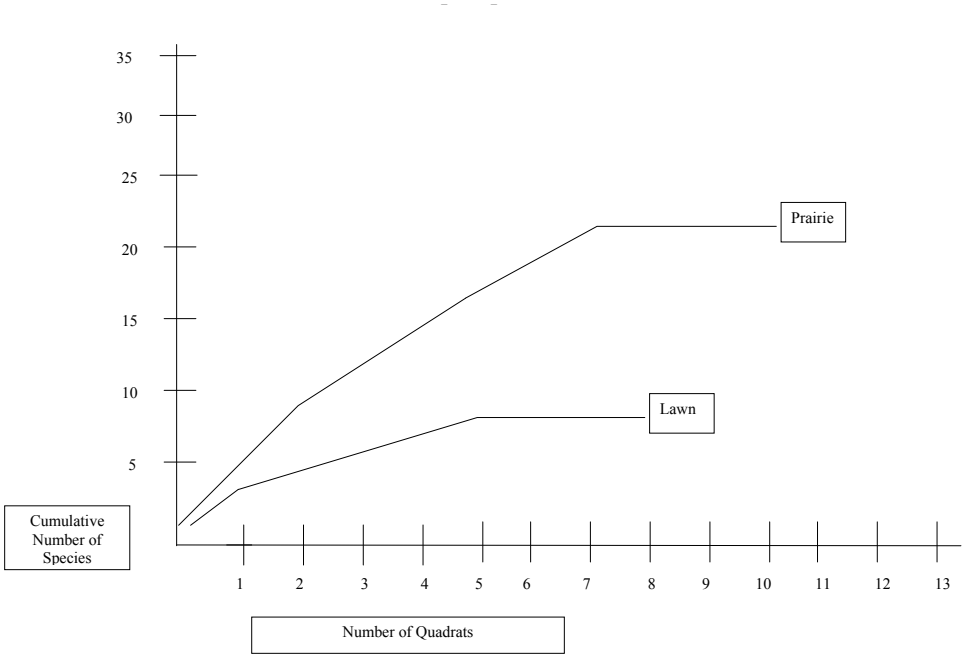
In many cases, a single prairie quadrat will have fewer different species than will a quadrat taken from a lawn. However, this is not due to a lower biodiversity in a prairie but rather to the fact that prairie species tend to clump together, whereas in a lawn species are distributed in a more homogeneous pattern. Therefore, a single quadrat may "capture" most of the lawn species but only a few of the species in the prairie. Subsequent quadrats in the lawn will reveal few new species while subsequent prairie quadrats will contain numerous new species.

The Species Area Curve helps examine this situation. A sample species-area curve is shown below. The graph plots the cumulative number of species encountered versus the number of quadrats. The graph levels off when additional quadrats encounter no new species. Note that after several quadrat samples the total number of species found in the prairie exceeds that of the lawn.

In addition to being used to compare ecosystems, the Species Area Curve is a useful tool in determining whether students have sampled enough quadrats to determine the diversity of the ecosystem. The number of sampling quadrats needed depends in part on the nature of the vegetation being sampled (in particular, its diversity and spatial distribution). As long as the graph continues to rise, students are still finding new species, and more quadrats

are needed to inventory the ecosystem completely. At the point when the Species Area Curve levels off, a sufficient number of quadrats will have been taken to accurately assess the species diversity.

Sample Species Area Curve



Activity Description

Divide into research teams. Each team should take an index card with a large loop of tape on it and a hula-hoop (or four sticks of equal length for a square quadrat). Randomly choose a spot in the prairie for the quadrat by throwing the hoop or a stick over your shoulder. If you are doing an annual survey of your restoration, you may have permanent sampling plots set up.

Count the number of different species of plants in your quadrat. If the plants are very small, place a small leaf of each species on the tape (generally appropriate for spring studies). If the plants are large, sketch the leaf and note any other identifying traits. Identification of the plant is not necessary. Repeat the process in a lawn.

Rejoin the class and examine the cards and sketches. As a class, plot the number of species found in one group's quadrat on a Species Area Curve. A second group should then examine their data to see if they found additional species that the previous group did not mention. Plot the second data point by taking the number of species found by the previous group and add to that the number of additional species found by the second group.

Below is an example of how the class findings can be collectively organized before the graphing portion of this activity. Here, Group One found 15 species on the prairie. Group Two found three species that Group One did not find, making the total number of species to 18. Similarly, Group One's lawn card indicates they found five plant species. The card for Group Two indicates they found one additional plant in their lawn quadrat, bringing the lawn total species to six. Continue to complete the cumulative totals until all group cards are compiled. Based on the totals for each group (i.e., the shaded columns below), students can graph these data points and create a Species Area Curve. Plot the number of additional species each group found. Continue plotting the number of new species found by each group in the class. Create separate curves for each ecosystem sampled. Determine the average number of species per plot and the total number of species by the class.

Prairie Card	Lawn Card	Prairie # of New Species Identified	Prairie Cumulative Total # Species	Lawn # of New Species Identified	Lawn Cumulative Total # Species
Card #1	Card #1	15	15	5	5
Card #2	Card #2	3	18	1	6
Card #3	Card #3	5	23	2	8
Card #4	Card #4	7	30	1	9
Card #5	Card #5	5	35	0	9

What is the difference in species distribution between the two ecosystems sampled? How could misleading results arise from improper sampling methods?

Extensions

- Record the number of insects, spiders and larger animals in each quadrat. Become a sleuth and find as many traces of animals as possible. Traces of animals can include decayed leaf matter, a litter layer in the soil, a gnawed leaf, a spotted or slightly diseased leaf, a spider's web, and so on.
- Repeat this study each year in your restoration to monitor the change in the restoration as it matures.
- Instead of randomly selecting the quadrat spot, sample a spot that you consider to be representative of the prairie. How does this change the results?
- For Older Students: Identify the plants in your plot. Identification of plants prior to blooming is very difficult but a good key should allow identification of all blooming plants.

Additional Resources

- Brewer, R. (1979). *Principles of ecology*. Philadelphia: W.B. Saunders Co.

Assessments

- Write a short essay explaining sampling methods, results, and related Species Area Curves for the restoration and lawn sampling areas.
- Create visual displays (e.g., graphs, tables) of results and Species Area Curves. Make oral presentations of findings and conduct peer reviews of these reports.
- Explain the various species distributions in the quadrats. Propose and implement additional research to determine possible impacts of the species distribution between lawn and restoration site.

Biodiversity Activity Assessment*

After completing the activity, choose one of the following:

1) Create a visual comparison of the biodiversity of the two ecosystems.

2) Write about the following questions:

- How do you account for the biodiversity of each system?
- What does the biodiversity of the ecosystem offer the biota of the system?

Grading Categories	Highest Grade Goal
Participation	• Species were collected from the designated site. • Cooperative and effective part of the team.
Data Collection	• The # of species collected accurately depicts the actual diversity for a sample area. • No duplicate species were collected.
Data Organization	• A table is used. • Units are indicated for each column. • Data is visibly organized and legible. • There are no erasures.
Analysis	• Calculations are accurate. • Graph is labeled and titled.
Conclusion	• Several differences between the ecosystems are depicted. • Similarities between the ecosystems are depicted. • Reasons for the level of biodiversity are included. • Effects of the level of biodiversity on the ecosystem are contemplated.

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CARD	CARD	# of New Species Identified	Cumulative Total # Species	# of New Species Identified	Cumulative Total # Species
CARD # 1	CARD # 1				
CARD # 2	CARD # 2				
CARD # 3	CARD # 3				
CARD # 4	CARD # 4				
CARD # 5	CARD # 5				