One Is the Loneliest Number: Exploring Monocultures

Essential Question: How does the human introduction of monocultures affect succession in natural communities?

Introduction/Background

Natural communities are characterized by their diversity. “Biodiversity,” the ratio of species to organisms, is a recognized quantitative measure of ecosystem quality and stability. Areas that have been cultivated or changed for human use often have less biodiversity; these “monocultures,” or the growing of single crops over a wide area, have specific effects on all of the organisms in the area.

It’s often possible to observe the effects of monoculture in areas that are not currently being controlled by human agriculture. For example, a cultivated field at the Brandwein Nature Learning Preserve (BNLP) contains a high proportion of timothy grass. While there are certainly other plants growing in the field, the high population of Timothy is clear evidence that this field was not formed by natural succession.

Timothy grass is thought to have originated in Europe. Early colonists accidentally brought the seeds to America. Timothy Hansen is credited with the idea of cultivating the grass for hay. However, he didn’t name the hay. Records suggest that Ben Franklin did that.

Timothy grass is used in animal feed (for cattle and horses) along with other ingredients. It is also used by domesticated animals like guinea pigs and rabbits. The grass is noted for its low protein, low moisture levels, and high fiber content.

In human diets we often talk about fiber. It’s really cellulose, a form of carbohydrate that we have no enzymes to digest. Some animals like termites and ruminants (grazing animals) have symbiotic organisms in their stomachs that help them get nutrients out of the cellulose. In addition, grass-eating mammals must have strong and ever-growing teeth to handle the tough, scouring quality of the grass.

In this activity students investigate and compare the biodiversity of a (currently or formerly) cultivated field and use survey tools to determine answers to questions like:

- Do agricultural fields only contain one kind of plant community?
- What effect does agriculture have on biodiversity?
- How does biodiversity change near the edge of a cultivated field?
- What is the effect of monoculture on herbivory and predators?

National Science Education Standards

Content Standard C: As a result of their activities in grades 5-8, all students should develop an understanding of:

- Populations and Ecosystems
- Diversity and adaptations of organisms

Student Learning Objective

As a result of these activities, students will

- Define biodiversity and monocultures.
- Count and measure populations.
- Compare biodiversity in cultivated and uncultivated areas.

Materials List

- "L" viewing tool which consists of two cut out L-shaped cardboard shapes that can be intersected to create a viewing area that is larger or smaller, depending upon the type of area to be observed.
- Transect (100 m tape or string marked in 1 m lengths.)
- Quadrat tool (1 m square created by pvc pipe or small "hula hoop" with ~1 m area
- Science journalingtools such as notebooks, drawing pencils, and cameras
- Field guides

Procedures

Part I: Honing Observation Skills
Use a collection of natural objects, such as fall leaves, apples, stones, for student observation. Ask students to write a description of one type of item that is so precise that when all the items are put back together and they read their description, other students can identify the object.

Part II: Calculating biodiversity
Biodiversity is an important and generally recognized measure of environmental stability (often equated to quality.) Scientists use a formula called the biodiversity index to describe the amount of specie diversity in a given area. A simple biodiversity index is calculated as follows:

the number of species in the area (numerator)
---------- = biodiversity index
the total number of individuals in the area (denominator)

For example, a 1 X 1 meter square area in a formerly farmed field might have 80 Timothy plants, all the same species, and 20 samples of four other plant species. The plant biodiversity of that area would be 5/100 or 0.20. Students can practice calculating biodiversity on any site, or simply simulate a count with tiny plastic organisms. Note that students do not need to know the names of the plants in order to do this index. They can draw the various species and label them by number.

Part III: Exploring an old field

To appreciate the effect of monoculture vs. biodiversity, students should identify two areas of approximately equal light penetration, the field and an adjacent meadow.

- Either by themselves or with a partner, students should spread along the perimeter of the field.
- Begin with qualitative measurements: Using a "viewer" made of cardboard L's select various areas of (formerly) cultivated and uncultivated open areas. Describe the observed biodiversity in words and diagrams.
- Slowly students should move from within the cultivated area to an area that does not appear to have been cultivated. Let students have access to field guides as needed. However, actual identification or research for identification can be done later, as long as the students write very detailed notes that can be used later to identify a species.
- Stretch a 100 m tape or string transect across an area that spans both the cultivated (or formerly cultivated) field and an adjacent open area.Toss a quadrat tool at random at various locations on the tape. Record the location. Count the species and calculate the biodiversity index.

Data:

Area	Observations	Biodiversity Index
Cultivated field		
Edge of cultivated area		
Uncultivated area		

Questions to Consider:

- Plants often develop specific defenses (often chemical) to insect predation. Why would a monoculture be more susceptible to insect or other herbivory (predatory herbivores) than an area with higher biodiversity? [First order consumers can reproduce more efficiently and are present in higher numbers.]
- In areas that have not been cultivated for years. the biodiversity may still be lower than areas that have never been cultivated. Why would this be so? [Plants change the abiotic factors around them.]

Conclusions

Human cultivation can change soil and other abiotic factors for many years, changing food webs, and biodiversity.

Evaluation

Rubric for evaluation:

	Acceptable	Good	Excellent
Safety precautions	Generally followed	Strictly followed	Helped others follow
Journaling	Notes are collected	Notes include measurements and drawings.	Notes include extensive measurements, drawings, and information integrated from field guides or other sources
Biodiversity measurements	Qualitative measures only	Some quantitative measurements included	Quantitative biodiversity index calculated for all areas.

Extensions

- Compare the soils and/or number of insects in monoculture vs. open meadow.
- As a class, graph and compare numbers of species in each area.
- Have students make posters of their findings.
- Have students research a species that they found.

Sources

Digestive System of the Cow http://pubs.ext.vt.edu/400/400-010/400-010.html#L2
Exploring Local Biodiversity
www.fna.org/files/imported/Outreach/FNA_lesson_**biodiversity**.pdf
How to Do a Transect Study
http://alaska.fws.gov/fire/role/unit1/complete_transect_study.pdf