Illinois and the World: A Comparison of Biological Diversity

Overview

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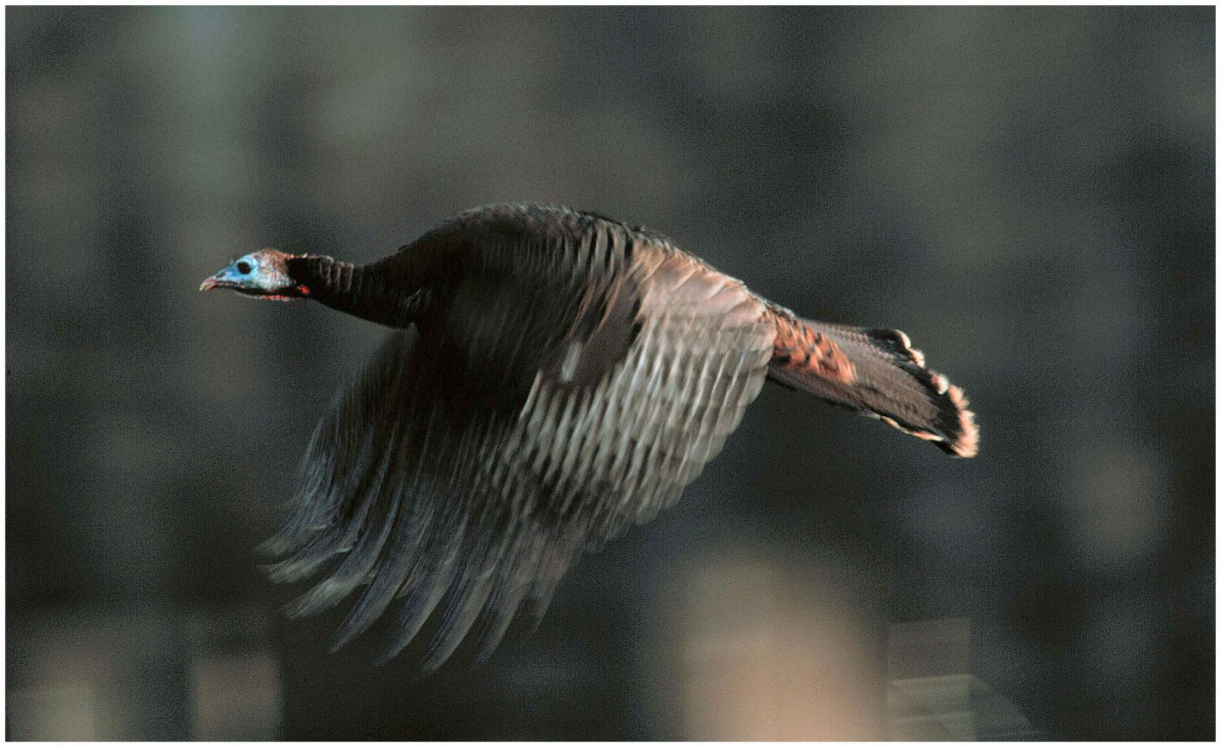

Title

Illinois and the World: A Comparison of Biological Diversity

Investigative Question

How does the biodiversity of Illinois compare to the biodiversity found in the rest of the world?

Overview

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Objective

Students mathematically compare the Earth's biodiversity with the variety of organisms that inhabit Illinois.

Materials

Per student: Student Pages 1 and 2

Per group of 5 or 6 students: paper, glue, scissors, colored pencil, compasses, protractors

Per class: a copy of video *Illinois: A Study in Diversity*

Optional: poster board, calculator, computer with graphing software and printer

Time

Two 50-minute class periods and a follow-up half period: a portion of one class period to view video that introduces biodiversity in Illinois; one class period to construct pie charts followed by a take-home assignment to complete the comparison of the biodiversity of Earth and with that of Illinois; a follow-up half period for discussion.

Advance Preparation

1. Copy student handouts and assemble materials.

2. Obtain a DVD player and monitor to show video.

3. Order the video http://www.inhs.uiuc.edu/chf/pub/index.html

Introducing the Activity

Students are likely to be familiar with the concept of biodiversity on a rather superficial level. They will certainly have heard of the "charismatic megafauna" (the lions and tigers and bears of the world) but may know little of the diversity of life that actually exists on the Earth or in their own state. Show the video *Illinois: A Study in Diversity* to the class.

Procedure

1. Present your own informal version of the background material for this activity, or ask students to read these pages as a homework assignment prior to introducing the activity. In either event, discuss that material now. Students should be generally familiar with this material, but their level of scientific understanding will be governed by grade level and experience.

2. Distribute copies of Student Page 1

3. Because of the large total number of species and the variation in size (i.e., number of species) of the groups, we have combined relatively small groups (viruses, bacteria, and blue-green algae) to form manageable units for graphing. The groups that we have combined are not necessarily closely related to each other, and students should be apprised of this arbitrary grouping. For example, because blue-green algae do not have an organized nucleus (the nucleus is not enclosed in a membrane), they are not grouped with other algae.

4. Divide the class into groups of 5 or 6 students. Although students are working in small groups in order to share materials, each student should complete the Student Pages and produce his or her own graph. Ask students to find the total number of described species on Student Page 1 by adding the number of species for each group. Then have them determine the fraction (decimal fraction) of the total that each group represents and enter those numbers in the column labeled "fraction of total." Next, students compute the number of degrees of a circle represented by each decimal fraction and enter those numbers in the final column. Numbers should be rounded to the nearest tenth. The fraction data can then be presented as a circle graph (pie chart). You might elect to have one group of students present the data on circle graphs and another on bar graphs.

5. When all computations have been made, students plot the data on a circle large enough to accommodate the silhouettes on Student Page 3. Each segment of the pie chart should be labeled, either within the boundaries of the circle or outside. Segments may be colored by hand or wedges may be cut from colored paper and glued in place on the circle. The silhouettes on Student Handout 3 are then glued in the appropriate segments. Explain to students that they should "read" each row of silhouettes from left to right in order to follow the list of organisms on Student Page 3.

6. Discuss the completed pie charts or graphs. What is the largest group of organisms? The smallest? Which groups do you think have the most unknown species? Why? In what other graphic forms could this information be presented? Is one method of presentation preferable to the others? If so, why?

7. Distribute copies of Student Page 2. Relying on information from the previous handouts, students complete the third column (Earth) and compute the percentage (decimal fraction x 100 = percentage) of each group of organisms that is found in Illinois. Computations may be completed in the classroom or as homework. The questions on the handout may be used as a written assignment or as the basis for class discussion. Possible answers to questions 1 and 2 on Student Page 2 are given here.

Example:

$$\frac{\text{\# bird species}}{\text{total \# species}} = \text{fraction of all species that are birds}$$

fraction of birds x 360 degrees = fraction of pie chart that represents birds

Question 1. Many groups of organisms live primarily in habitats or ecosystems that are not present in Illinois. Sponges, for example, live primarily in salt water. Nonetheless, Illinois is a relatively large state and has a tremendous diversity of terrestrial and freshwater habitats that support a large number of groups (plants, fungi, insects)

Question 2. Many of the organisms found in Illinois occur in a relatively small area of the state. Even though the overall number of species appears to be great, the population of individuals for a given species can be quite low because of lack of suitable habitat. When the population of a species gets very low, that species is categorized as threatened or endangered; it may become either extinct or extirpated (eliminated) from the state. Given the small portion of Illinois that contains habitats suitable for many species, each of these biological "islands" becomes very important. These island habitats must be preserved to ensure the survival of the organisms that inhabit them.

Assessing the Activity

The completed pie charts and bar graphs assess the technical aspects of this activity. To assess attitudes, ask students to write two short paragraphs that answer the following question: What does biodiversity mean to you and why is it important?

Extending the Activity

1. Extend this activity as a class project by using a large piece of poster board to create a pie chart as a bulletin board display. Instead of using the small silhouettes of organisms for the pie chart, ask students to locate pictures in magazines (*National Wildlife*, *National Geographic*, etc.) to illustrate the diversity of organisms.

2. This activity can also be completed using a computer with appropriate spreadsheet and graphing software. Students may also try different ways of portraying the biodiversity data (scatter diagrams, line graphs, etc.).

References

Jeffords, M. R., S. L. Post, and K. R. Robertson. 1995. Illinois Wilds. Phoenix Publishing, Tolono, IL. 156 p.

State Goals

11,12 (Objectives 11.4.02-04, 12.4.08, 12.4.13)

Concept

Due to its apparent success, the human species has come to view itself as all-important and self-sufficient. We have failed to realize that with the ability of conscious thought and action comes an enormous responsibility for what happens to the Earth, a responsibility that is not shared by other organisms. Humans are responsible for the quality of the Earth's environment on which all life depends, and it is highly unlikely that current or future technology will change our dependence on other life forms, that is, on the Earth's biodiversity. The first step in developing an appreciation for Earth's ecosystems and those that exist within our state is an awareness of the vast numbers and infinite diversity of species that inhabit these ecosystems.

Safety and Waste Disposal

No dangerous or hazardous materials are used.

Student Page 1: Computations for a Circle Graph Name _____

Total the number of species for all groups listed. Determine the percentage of the total that each group represents and the number of degrees of a circle that each percentage represents.

Number of Described Species on Earth

Group	No. of Species	Fraction of Total	Fraction x 360
viruses, bacteria, blue-green algae	5,800	_____	_____
fungi	47,000	_____	_____
algae	26,900	_____	_____
protozoans	30,800	_____	_____
ferns	10,000	_____	_____
dicots	170,000	_____	_____
monocots	50,000	_____	_____
other plants	18,500	_____	_____
sponges	5,000	_____	_____
jellyfish & relatives	9,000	_____	_____
worms	36,200	_____	_____
mollusks	50,000	_____	_____
starfish & relatives	6,100	_____	_____
insects & relatives	875,000	_____	_____
other invertebrates	9,300	_____	_____
primitive chordates & fishes	21,000	_____	_____
reptiles & amphibians	10,500	_____	_____
birds	9,040	_____	_____
mammals	4,000	_____	_____
TOTAL	_____		

Student Page 2: Biodiversity in Illinois Name _____

Complete the second column by inserting the number of species found on Earth. These numbers are given on Student Page 1. For each group of organisms, calculate the percentage that is found in Illinois. Write your answers in the last column.

	Illinois	Earth	Percentage Found in Illinois
fungi	20,000		
ferns	75		
monocots & dicots	1,955		
sponges	14		
insects & relatives	27,800		
mollusks	271		
reptiles & amphibians	98		
birds	297		
mammals	67		

1. Can you think of reasons why some groups of organisms have relatively few species in Illinois whereas others have enormous numbers?

2. Today a large percentage of Illinois (over 60%) is farmland in monoculture (only one plant species, such as corn or soybeans, grows there), and at least 6% is urban. What do these percentages tell you about where the more than 54,000 species of plants and animals live in Illinois? Are small habitat fragments important for maintaining biodiversity? Explain.

3. Do you know of places in Illinois where you can find "wild" native (not introduced by humans from other places) species? If you do, can you explain why these species have remained in these places?

Biodiversity

Introduction

What sets Earth apart from the other planets in our solar system – perhaps from all other planets in our galaxy? The answer is simple: life. To refer to the variety of this life on Earth and of the habitats in which life is found, scientists use the term biodiversity. Earth is home to an amazing variety of species living in a wide assortment of habitats and ecosystems. This biodiversity is our most important yet least understood natural resource.

In recent decades the science of systematics (the study of organisms with regard to their natural relationships) has expanded rapidly, and a considerable body of information about the diversity of organisms has been accumulated. Of the 1.4 million species that have been described, approximately 750,000 are insects, 41,000 are vertebrates and 250,000 are plants. The remaining species include various kinds of invertebrates, fungi, algae and microorganisms.

A word about what makes a species is in order. A species is generally defined to be a population (or group of populations) in which each organism is capable of breeding and producing offspring with any individual of the opposite sex in that population. (This definition, the best that scientists have been able to devise, cannot be applied to organisms that reproduce by means other than sexual reproduction, such as self-fertilization or parthenogenesis.)

Biodiversity is important for many reasons. For example, because medicines are often derived from chemicals found naturally in plants, a greater number of living plant species means more potential for finding new, effective medicines. On another level, the diversity of genes, species and ecosystems provides the basis for adapting to inevitable environmental changes. The loss of even a single species reduces the options for nature – and for us – to respond to change. A decline in biodiversity is not usually the direct result of human exploitation of species. Rather, the decline is directly linked to the habitat destruction associated with expansion of human populations and human activities.

Aside from its potential usefulness, biodiversity is inherently valuable because it is part of our heritage, as important as our heritage in technological achievement, art, or politics. We must, therefore, learn to

appreciate biodiversity for its own sake, quite apart from any direct benefits we might currently perceive. Indeed, the almost instinctive interest that most children and adults show in nature suggests that we already consider biological resources in terms other than cash value. Just consider the hundreds of wildlife clubs and organizations to which we donate time and money and the increasing popularity of zoos, aquaria, wildlife parks, botanical gardens, and nature films.

Nevertheless, our everyday activities continue to erode the capacity of the Earth to support biodiversity. As the human population has grown from about a billion in 1820 to nearly 5.2 billion today, we have increasingly polluted our environment and jeopardized the health of other species, which are now becoming extinct at the fastest rate ever. To stop this dangerous trend, we must acknowledge that all species matter, many in unknown but potentially important ways. We must recognize that biodiversity is an indicator of our planet's health and that a decrease in biodiversity bodes poorly for the future of the human species.

Biodiversity in Illinois

Scientists at the Illinois Natural History Survey recently compiled data on the biodiversity of Illinois. They conservatively estimated that more than 53,000 species are native to our state. This is an especially large number for a region the size of Illinois in a temperate climate.

The diversity of organisms in an area is linked to the number of different habitats present and to the ability of those habitats to support various species. Illinois contains nearly 100 types of habitat, each of which is favorable only to particular plants and animals. Among the habitat types found in Illinois are forests, prairies, savannas, wetlands, lakes and ponds, streams, and caves. Although each of these habitats continues to exist, many are no longer easy to find because of extensive urban and agricultural development over the past 150 years. Fortunately, remnants of nearly all the native habitats can be found in nature preserves, state parks, conservation areas, and other protected sites.

Because of its location, Illinois has within its borders an unusually large number and variety of plants and animals. Scientists have determined that Illinois has at least 17,000 native species

of insects, over 2.500 species of plants, about 100 species of reptiles and amphibians, more than 250 species of birds, 79 species of mussels, nearly 200 species of fish, 67 species of mammals, and even 23 kinds of crayfish! Situated on the edge of the eastern deciduous forest, the western great plains, the southern coastal plain, the Ozark uplift, and the boreal (northern) forests, Illinois provides a meeting ground for organisms from very different regions.

Scientists have apportioned Illinois into 14 natural divisions based on characteristics such as topography, glacial history, bedrock, soils, weather, and the distribution of plants and animals. Within each division are various unique habitats and communities. Many species of plants and animals are restricted to a single natural division or to a given habitat within a divisions. Some are limited to a highly specific habitat, such as wet prairie or limestone glade. Many of these organisms are unfamiliar to us because of their restricted distribution or because their habitats have been severely reduced by human activities, such as urban and agricultural development. (portions excerpted from Norton, B. 1988. Commodity, amenity, and morality: the limits of quantification in valuing biodiversity. Pages 200-205 in E.O. Wilson, ed. Biodiversity. National Academy Press, Washington, DC. 521 pp).

The Value of Biodiversity

Biological resources are priceless. To compete for the attention of government and commercial interests, however, the value of biodiversity must often be demonstrated in economic terms.

The dollar value of biological resources to the social and economic development of a state or nation might be determined by combining four estimates: the value of resources obtained directly from nature and consumed without passing through a market (for example, firewood, forage, and game); the value of resources that are commercially harvested (for example, timber, fish, animal products, and medicinal plants); the indirect values related to the functions of an ecosystem (for example, watershed protection, photosynthesis, climate regulation, and soil development); and the most difficult value to estimate – retaining options for the future.

Another approach might be to determine the value of a single species

and multiply it by the number of species on Earth, but values would undoubtedly vary greatly depending on who is doing the evaluating. To get some idea of the enormous total generated by this method, we should keep in mind that estimates of the number of species range from 5 to 30 million!

A third method might be to assign commodity, amenity, and moral values to species. A species would have commodity value if it could be made into a product that could be sold in the marketplace or if it could serve as a model for other products (for example, many synthetic drugs are based on chemicals found in plants and animals). A species would have amenity value if its existence improved the lives of humans in an intellectual or psychological way: hunting, fishing, birdwatching, hiking, and nature study, for example. The moral value of a species would exist apart from any use to which we might put it. Merely knowing that bears, lady's slippers, bobcats and darters exist would be enough. In essence, moral value depends on how we view biodiversity. Even from the egocentric perspective of the human intellect, any and all species should have moral value, and that value should not have to be justified in economic terms.

When the interactions among organisms are considered, the value of biodiversity exceeds the sum of its parts. Indeed, biodiversity can be said to encompass the value of the entire natural world. Whether we like it or not, we are not only part of the exceedingly complex web of life on Earth but are totally dependent on it for survival.

At present, we are woefully ignorant of the organisms with which we share the Earth. Only a small percentage of species (less than 15%) have been named, and we have knowledge of the life histories and ecological interactions of only a small portion of those.

Our actions over the next decade will shape the future. Will our treatment of the Earth's resources be characterized by overexploitation and abuse to meet short-term goals, or will we work to maintain the greatest possible degree of biological diversity and use these resources in a sustainable manner? Only time will tell.