Biodiversity: Bird Populations

Global change can be monitored by examining numerous environmental parameters. Long-term data covering a large area are helpful to determine if change is occurring on a wide scale over time. Large databases such as the information gathered by the United Nations Environment Program (UNEP) and the International Union for Conservation of Nature and Natural Resources (IUCN) provide a global tracking of environmental changes and trends.

While these international sources provide important and valuable information, they are often removed from students' own environment and personal experience. One large database directly available to students that provides information about areas with which they are likely to be familiar is the annual Christmas Bird Count (CBC). The Christmas Count began in 1900 with 26 locations. Since that time, the count has expanded to 1563 locations in the U.S., Canada, Mexico, and Central and South America. The original counts involved 27 individuals. In 1992, 43,189 individuals participated in the count by observing over 54 million birds. Each count location involves about 30 volunteers spending a 24-hour period doing a winter census of the bird population in a 15-mile-(24.1-km-) diameter area. Each group selects a day from a two-week period, generally in December/January. The count procedures have remained relatively constant over the years, so the data can be used for comparative purposes.

Birds that overwinter in the northern latitudes have to contend with numerous climatic and environmental conditions. Dr. Terry Root, at the University of Michigan in Ann Arbor, has been conducting studies on birds that overwinter in North America, particularly in northern areas. She found strong associations between the distribution of 148 land birds and six environmental factors. These included average minimum January temperature, mean length of frost-free period, potential vegetation, mean annual precipitation, average humidity, and elevation. Temperature is the factor of concern in this activity.

As autumn approaches in the middle and high latitudes, the temperature begins to drop, and many birds start to migrate to warmer areas. Some species migrate to tropical regions south of the U.S. border, while others migrate to warmer areas in the southern U.S. Some, however, do remain in the northern, colder areas. These include the cardinal, crow, chickadee, and others. Some of these bird species will remain in the lower regions of the northern latitudes, while other species are located in the higher latitudes.
Activity: Do Christmas Bird Count data reflect trends associated with global change?

In her work, Dr. Terry Root found for the Eastern Phoebe “a striking association” between the average minimum temperature in January and the limit of bird’s northern range (Root and Schneider, 1993, p. 263). In this activity the class will investigate the temperature/range limit relationship.

Materials

- Paper and pencils
- Figures and graphs included in the activity

Earth Systems Understandings

This activity applies to ESUs #1 (aesthetics and value), #2 (stewardship), and #7 (careers and hobbies). Refer to the introduction of this book for a detailed explanation.

Scenario Reference

#2. Will Biological Diversity in the Great Lakes Region Suffer?

Answers

1. Local and yearly climatic variations allow the bird species' range to deviate around the isotherm. Therefore, a distributional range may deviate each year. The bird's range is a composite of a number of these yearly deviations.

2. Fragmentation of habitat is not highly variable from year to year, yet fluctuations of bird species over winter are extremely variable. Does this definitely indicate temperature as the main factor influencing bird distribution? Maybe.

3. As one proceeds from south to north, (1) the ambient air temperature gets colder, and (2) nights get longer. These factors have a great influence on species' and individuals' capacity to overwinter.

Objectives

When students complete this activity, they should be able to:

- understand how wildlife adapt to variations in the environment.
- relate environmental factors, such as temperature, to bird ranges.
- predict changes in the range of bird populations as a result of global climate change.

Procedure

1. Figure 1 illustrates the influence of temperature on a species' range. Note that the range tends to fluctuate along the isotherm. Why does this fluctuation occur?

2. Is temperature the only factor driving the location of the northern boundary of the phoebe's range? Could variations in vegetation distribution be an influence?

3. Dr. Root decided to examine other temperature-dependent species belonging to the order of passerines, including juncos, sparrows, robins, cardinals, and many others. Passerines are generally small- or medium-sized perching songbirds. For the 51 species she selected, their northern range limits were associated with temperature. In fact, two dominant environmental factors were found to influence the winter lifestyle of birds the farther north they traveled. With your team of students, hypothesize what these factors were.

Figure 1. The distribution and abundance of the winter range of the Eastern Phoebe. The northern boundary lies very close to the -4°C isotherm for January. Minimum temperature (heavy solid line).

(Source: Root and Schneider, 1993.)

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From this information, Dr. Root constructed the following graph (Figure 2) to illustrate the relationship between the various parameters.

**Figure 2. Relationship between metabolic rate and ambient temperature for birds that overwinter in North America**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>NBMR</td>
<td>Northern Boundary Metabolic Rate. The highest metabolic rate at which a bird can survive. Above this rate, a bird would not have enough energy reserves to maintain its body heat through the night.</td>
</tr>
<tr>
<td>BMR</td>
<td>Basal Metabolic Rate (Resting Rate). Birds can increase this in order to stay warm (the slope of the line reflects this increase as the temperature gets colder).</td>
</tr>
<tr>
<td>TDIST</td>
<td>Temperature at the edge of distribution range. The coldest temperature a species can tolerate.</td>
</tr>
<tr>
<td>TCRIT</td>
<td>Temperature at which a species must increase its metabolic rate in order to keep warm.</td>
</tr>
</tbody>
</table>


4. The Basal Metabolic Rate of the bird is the rate at which it is not performing any function except staying alive (e.g., it is asleep, not cold, not hot, not digesting food). The Northern Boundary Metabolic Rate is the bird’s metabolic rate at the northern edge of its range. Figure 2 indicates that the bird’s metabolic rate increases as the temperature drops below TCRIT. How would the metabolic rate of an individual in Florida compare to an individual in Michigan in the winter-time?

5. By examining this information from several species, Dr. Root found that the NBMR tended to be an average of 2.5 times the BMR. This has become known as the 2.5 Rule.* But what controls this rule? Various environmental factors could have an influence. What happens to the winter environmental conditions as a bird travels from South to North?

6. On a normal day, passerines accumulate body fat to about 11 percent of their total mass during each day. The following morning, little fat remains. Why?

4. As a species moves farther away from the average temperature of its range toward the northern edge, its metabolic rate increases (slope of line). This is a result of shivering, which generates heat. The survival mechanism of shivering requires energy that the bird gets by burning body fat. The metabolic rate of an individual bird in Michigan would be higher than that of an individual in Florida where it is warmer.

5. Two main things happen as a bird travels north during the winter: the ambient temperature gets colder, and the nights get longer.

* The 2.5 Rule was proposed by Jared Diamond in 1988 in an article in Nature.

6. To survive the low night temperatures, the bird must shiver. This action requires energy that is obtained from the bird’s fat reserves.
Dr. Root concluded that the amount of fat lost over one night must fuel the mechanism for survival.

7. Accumulation of fat depends on various factors. What do you think are the most important of these? (Consider how people accumulate fat!)

To examine the issue of fat and its influence on bird distribution in winter, Dr. Root decided to sample cardinals on a north-south axis and determine if indeed birds in the northern latitudes did have less body fat in the morning. Figure 3 shows the results of this sampling on a south/north transect from Alabama, through Tennessee, Indiana, and Michigan. Estimates are for the amount of fat still present just after dawn.

![Graph showing hours of metabolism vs. latitude](image)

Figure 3. Hours of metabolism that can be fueled by body fat of Northern Cardinals sampled at different latitudes. Birds were sampled in the morning at each location. The average length of time the birds could survive indicated with a line (Source: Root, 1991). Reproduced from the book Acta XIX Congressus Internationalis Ornithological, under the supervision of Henri Ouellet, 1991.

8. How many hours (mean) of metabolism after waking do the birds possess in body fat for each of the states? Have students locate the various states on a map. What type of weather conditions dominate these states in winter?

9. Consider climatic conditions and the hours of metabolism remaining for cardinals in the morning at each latitude.
Imagine what the cardinal’s day is like. How can the climate conditions in winter affect the cardinals living in each state?

10. What impact could birdfeeders have on cardinals in each of these states?

It would seem from this information that foraging time (length of day) and ambient air temperature will both play a significant role in the survival and distributional patterns of birds.

11. From what we know of the possible changes that will accompany global warming, which of the two factors is likely to have the greater effect on the bird populations of North America? Examine the CBC of an area of the continent where climate may be similar to the type of climate predicted as a result of global warming for the area where your school is located. What kinds of birds can you expect to move into your area? What factors would determine whether they would survive there?

12. Consider the possible impacts of the last two winters on individual cardinals and other species and their populations.

**REVIEW QUESTIONS**

1. What factors influence the overwintering distribution of birds? How was the 2.5 Rule determined? How do birds stay warm and remain alive during the night when the temperature drops? What consequence does this force on the birds?

2. Would the birds in the 30°N latitude area have fewer or more hours of metabolism remaining in the morning in comparison to birds at 40°N?

3. Develop a concept map illustrating the Earth Systems interactions in this activity. Include all the Earth Subsystems and use connection lines and verbs to explain the interactions.

4. Scientists involved with global change use proxy data, such as the CBC, to try to predict future changes in population numbers and dynamics resulting from possible climatic alterations. From the evidence in this activity, do you think it is possible to use CBC data to predict the influence of possible climatic changes on bird populations and populations of other organisms? Write a paper describing your position on the use of such datasets to predict change.

10. These could have the greatest impact on survival of birds in Michigan. If a cardinal can get to a feeder in time, it should be able to replenish its fat reserves fairly quickly.

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.The following can be purchased.
The National Audubon Society Field Notes. CBC Issue. This contains results of all previous Christmas Bird Counts.

For disks of CBC data or analysis of population changes, contact:
National Biological Service
301/497-5819
HomePage:
http://www.im.nbs.gov/im.html
EXTENSIONS

1. What happens to the birds that migrate South for the winter? Investigate a species that uses this mechanism to overcome falling temperature. What impact would habitat fragmentation have on such a species? (Read the World Book Science Year 1994 article, “The Case of the Missing Songbirds,” and the Audubon article, “Mystery of the Missing Migrants,” for good discussions of this topic.)

2. We intuitively understand that weather and climate vary with latitude, but there are datasets that document such differences and perhaps hold a few surprises. Use the NCDC climate data (via Internet, e-mail, or CD-ROM) for winter in Michigan, Alabama, Tennessee, and Indiana. Graph relevant temperature and precipitation data to help understand what conditions birds must survive. Regional temperature data can also be downloaded from Trends '93, CDIC's ftp, for example the Great Lakes, South Coastal Plain, and Eastern Prairies regions, pp. 717, 721, and 723. The National Climatic Data Center's homepage on the World Wide Web provides precipitation data by reporting site.

3. From your library or the local chapter of the Audubon Society, have students obtain the fourth issue of each year's American Birds for the last twenty years for the count location nearest your school. The students can create spreadsheets either manually or on computer for the location. Then they can graph trends either for an individual species or a group of species over that time period.

REFERENCES


Biodiversity: Forest Ecosystems

Scientists today are concerned that the world’s climate is changing at an unprecedented rate because of human activities. If global climate change occurs as predicted, the northern latitudes could experience warmer climates than presently exist, resulting in a northward displacement of ecological zones. This will have a dramatic effect on some trees, such as the sugar maple population found in the Great Lakes region.

Forest composition is known to change over time. One way that these changes are studied is by looking back through time (to as early as the last Ice Age) and analyzing preserved pollen samples. More recent forest changes, occurring within the past several hundred years, can be identified by studying old recordings that were made following major events such as fires and clear-cutting. Indirect methods, such as historical records of travelers’ journals and surveyors’ notes, are also used to compare the forests of the past to those of today. These forest changes provide clues as to how forests evolve over time and how global climate change might affect the forests of the Great Lakes region.

When global change occurs slowly, plants adapt and/or migrate to other more favorable geographic locations. When global climate change occurs rapidly, plants cannot adapt or migrate quickly enough and consequently die out. Several projections have been made about the sugar maple (Acer saccharum) and where it will migrate during global climate change. Figure 1 shows the present-day maple forest and two projection models of where their range might be under warmer climate conditions. Figure 2 shows how quickly various tree species have migrated over the course of several years. While studies have been done to predict patterns of migration, little has been done to ascertain what species will become dominant in the Great Lakes region when the maples are gone.

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**Figure 1. Changes that may occur in the range of sugar maple trees if atmospheric CO$_2$ were to double**

Source: Zabinski and Davis (1989)

<table>
<thead>
<tr>
<th>Present</th>
<th>General Circulation Models</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goddard Institute for Space Studies (GISS) 2 x CO$_2$</td>
<td>Geophysical Fluid Dynamics Laboratory (GFDL) 2 x CO$_2$</td>
</tr>
</tbody>
</table>
Sugar maples have been important to people for a long time. The wood of maple trees is stiff and heavy. It is often used to make furniture and musical instruments because of its beautiful grain. Early settlers and Native Americans in the Eastern United States depended on maple trees to help sustain them through the winters. They could turn the sap into maple sugar to be used as an important source of energy throughout the cold season.

The maple season is dependent on temperature. When the nights are below freezing and the days are above freezing, the sap flows. This happens in the fall and the spring as the seasons change. The sap of sugar maple trees is approximately 2 percent sugar, and it takes between 30-55 gallons of sap to make one gallon of syrup depending on the density of the sap. Imagine how big a 50-gallon drum is. That’s a lot of sap! One tree can usually produce more than 50 gallons of sap in a season (usually between 10-15 gallons per tap hole, though some holes have been known to give 40 gallons in an unusually long season).

Humans are not the only “animals” to enjoy maple sap. Many birds, such as sapsuckers, leave their telltale marks on the side of maple trees.

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Tree Species Migration Rates from Palaeoecological Studies

<table>
<thead>
<tr>
<th>Tree Species</th>
<th>Speed of migration required to keep up with current rate of warming</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scots Pine</td>
<td>0</td>
</tr>
<tr>
<td>Chestnut</td>
<td>250</td>
</tr>
<tr>
<td>Engelmann Spruce</td>
<td>500</td>
</tr>
<tr>
<td>Hemlock</td>
<td>750</td>
</tr>
<tr>
<td>Beech</td>
<td>1250</td>
</tr>
<tr>
<td>Jack Pine</td>
<td>1750</td>
</tr>
<tr>
<td>White Spruce</td>
<td>2000</td>
</tr>
<tr>
<td>Black Spruce</td>
<td>2000</td>
</tr>
</tbody>
</table>

Meters per year

Figure 2: Tree Species Migration Rates from Palaeoecological Studies
Activity A: After the maples, then what?

This activity is patterned after the 1953 study done by Catherine Keever, an ecologist with exceptional foresight, when she studied the dominant species remaining after the chestnut blight removed the chestnut trees from the oak-chestnut forests of the Blue Ridge Mountains. Students will go out into a maple forest and, using Catherine Keever’s methods, will predict the possible dominant species if the maple trees are removed.

Objectives

At the completion of this activity, the student should be able to:

- Identify a sugar maple (Acer saccharum) tree and associated species of a maple forest.
- Locate on a map the general area where sugar maples grow today and where they may migrate with global warming.
- Explain one way in which ecological studies are done to predict future dominant species in an ecosystem.
- Make a prediction as to the possible dominant species if maples are removed from the forest.

Procedure

In this activity, students will identify and count trees in three different size plots, each nested within each other. Since maple trees are the main concern of this activity, it is important that students can identify them. One way to help with tree recognition is to bring in twigs from several types of trees and have the students examine the differences and pick out the maples. Some distinguishing characteristics of maple twigs are their buds, bud scars, and opposite branching.

1. Using stakes and twine, students mark off three plots in a woods containing maple trees. See Figure 4 for measurements. The two smaller plots do not have to be in the exact center of the larger one, but they should be nested within one another inside the 10 m x 10 m plot.

Earth Systems Understandings

This activity focuses on ESU 3 (science methods and technology), 4 (interactions), and 5 (change through time). In addition, Extensions address ESU 1 (aesthetics and value), 2 (stewardship), and 7 (careers and hobbies). Refer to the introduction of this book for a full description of each understanding.

Scenario Reference

#10. How will forests in the Great Lakes region be affected?

Materials

- a forest (or woods of any size) with maple trees and associated species
- 12 stakes at least 60 cm long and pointed at one end
- rope or twine, about 70 m
- several meter sticks or rope cut to specific lengths for measuring the height of trees
- paper, pencil, and clipboard
- graph paper or prepared grid sheets
- tree and plant field guides for identification

Figure 5. Sugar maple twig and leaf.
2. In each plot, the students will inventory different size trees. Each tree of the specified height must be identified and plotted on a grid sheet. In the 10 m x 10 m plot, the canopy and understory trees 3 m or taller are identified and recorded. In the 4 m x 4 m plot, the trees between 1 m and 2 m tall are identified and recorded, and in the smallest plot (2 m x 2 m), any trees 30 cm and shorter are identified and recorded. Figure 5 illustrates one method of recording.

3. After all the trees have been identified and recorded in their successive plots, have the students compare their data from each plot for similar species. Overhead transparencies work well for this step.

4. If any one species is found in all plots and all sizes, it is possible that it may become a dominant species of the maple forest. After comparing all of your data, what prediction can your class make for the dominant species of your maple forest if maple trees would die out or migrate northward?

**Answers to Review Questions**

1. Have students brainstorm and discuss. Responses should include wildlife habitat needs, human foods, lumber, and ecological factors of the forests.

2. If climate change occurs, the plants will survive only in more favorable geographic locations. That is, as their seeds are disseminated, only those that fall in the new favorable habitats will survive. This change happens slowly. For an excellent activity about how trees migrate, see *Activities for the Changing Earth System* (1993) from the Earth Systems Education Program, The Ohio State University.

3. Other tree species that rely on the maple for shading and protection may be lost. Some tree species that can tolerate the new environmental conditions better than the maples will become the dominant species. Any animals or humans that rely on maples must adjust.

4. The "new dominant trees" will have to be more tolerant to warmer climate conditions, and possibly a different seasonal pattern of moisture. Note: there is no guarantee that some of these trees are already growing in the sample plot, as they may move in from other areas.

5. The health of a forest is vital to the life of the whole ecosystem. Global warming is likely to change the nature of the present maple forests significantly. It may take a century or more before a stable new forest ecosystem emerges.

**Review Questions**

1. Why are people concerned that sugar maples and other tree species will be lost with global warming?
2. How and why do forests get displaced (migrate)?
3. Predict the impact of maple "migration" on other trees and on animal and human communities.
4. What characteristics will "new dominant trees" have compared to those which were displaced?
5. Will global warming damage the overall health of maple forests?
Figure 6. Grids for recording tree species in the three plot sizes
EXTENSIONS

1. In groups of four to six students, discuss how human activities are impacting maple forests. Brainstorm how these impacts can be minimized.

2. Do research on hardwood forests, particularly maple forests, to learn how natural factors (soil, precipitation, humidity, etc.) affect their location and growth. How do you think global climate change might affect these factors, which will in turn affect the forests?

3. Discuss how humans use maple trees and the products we get from them. How might your life change if there were no more maples? Describe substitutes that you might use in place of maple products.

4. Imagine that you are the oldest person in a community, having lived nearly 100 years. The school children contact you and ask you about the maple forest that they have never seen. Write a letter to their class, or draw a picture, describing a maple forest, telling them of your recollections and experiences in a maple forest of your youth.

5. Sketch or paint your impression of the maple forest where you did this plot study, or draw a single maple tree to capture its character.

REFERENCES


