Hubbard Brook Experimental Forest
Student Activities

HBEF Activity 1
Introduction to the Hubbard Brook Experimental Forest

Introduction

During a raging snowstorm in late March, a frozen water droplet falls on a New Hampshire forest in the form of a snowflake. It stays in the meter-deep snowpack until the arrival of warm weather and snowmelt a month later. When the droplet warms and melts, its water molecules slowly seep into the forest soil, where the roots of a yellow birch tree quickly take them up. The tree transports the water molecules up to its leaves, where they evaporate back into the atmosphere in a process known as transpiration.

What else could happen to the water droplet as it warms and leaves the snowpack? Perhaps a trout lily – a small, short-lived plant common in New Hampshire forests – could take up its water molecules. When the trout lily dies, it would return the molecules to the forest floor, where microorganisms that decompose plant material would absorb them. Or maybe the molecules could move through the soil, bypassing plants and seeping directly into a small stream. The stream would flow into larger and larger streams and rivers, and the molecules would eventually make it to the ocean. In fact, there are dozens of possibilities.

Nutrient cycle: Pathway of a nutrient through an ecosystem from assimilation (transformation into living tissue) by organisms to release by decomposition.

Now, consider what might be *in* the water droplet when it falls on the forest as precipitation. This droplet contains pure water molecules, as well as different types of elements (like carbon and nitrogen) and compounds (for example, nitrate or sulfate) What happens to these compounds when they enter a forest ecosystem: do they quickly leave by flowing out in streams, or are they used by plants or animals that live in the forest? How do they *cycle*, or move through, the ecosystem? Could some compounds even have negative effects on the forest?

Scientists at the Hubbard Brook Experimental Forest (HBEF) in New Hampshire have been asking these and other questions for more than forty years. Their research is part of the Hubbard Brook Ecosystem Study (HBES), and is the focus of the activities in this manual.

Most of these scientists are *ecologists*. In your science classes you have probably learned about many different types of scientists. You may have learned about chemists who study how elements and other chemicals react with one another, and you may have had a chance to read about geologists who study different types of rocks and minerals. These types of scientists study physical, non-living things. And you have probably learned about scientists who study the behavior of different animals, or about scientists who study photosynthesis and other aspects of plant growth. Scientists like these study biological, living things.

Ecology: The study of the interactions of living organisms with one another and with their nonliving environment.

While the scientists who conduct research in the HBEF are interested in many different topics, most of them are studying how the biological components of an ecosystem interact with the physical features. An ecosystem is a community of different species interacting with one another and with their nonliving environment. An ecosystem can be small (for example, a pond), or very large (for example, a river valley). The branch of science that looks at the interactions in ecosystems is known as *ecology*.

> **Ecosystem**: A community of different species interacting with one another and with the chemical and physical factors making up the nonliving environment.

Answering questions about ecosystems is neither quick nor easy for several reasons. First, the interactions between physical and biological factors can be very complicated. In the HBEF, the physical factors include a large number of environmental variables (for example, wind, temperature, and precipitation) and the biological factors include many different types of organisms (for example, trees, smaller plants, birds, invertebrates, and microorganisms). The potential interactions between these factors are numerous and complex.

Second, many ecosystem processes happen slowly or occur only once in a great while. For example, it can take tens or even hundreds of years for a fallen tree to decay and for the nutrients in that tree to cycle back to the soil. It may take hundreds or thousands of years for small amounts of bedrock to erode. A forest may experience only small changes for several decades, but in the span of a few hours or days can be drastically altered by a large storm. For example, in 1998 a tremendous two-day ice storm ripped through the HBEF, coating everything with ice and causing massive damage to limbs, branches, and entire trees. Scientists might miss these types of large, infrequent events if they only conduct two- or three-year studies.

Third, ecological processes also occur across areas of different sizes. For example, some HBEF scientists are interested in how microorganisms interact with nutrients and very small tree roots. Others want to know how these interactions affect the growth rate of trees in the entire Hubbard Brook valley. Similarly, some avian ecologists (ecologists who study birds) look at interactions between male black-throated blue warblers in a small patch of forest. Others study how these migratory birds transfer nutrients from the food they eat in the tropics (winter grounds) to their summer habitat (HBEF).

> **Monitor**: To *systematically keep track* in order to collect information.
> **Experiment**: *To alter or change something* in order to gain experience or learn new information.

When studying complex interactions over long time periods and large areas, it is difficult to find all the answers in laboratory studies. Thus, ecologists often conduct long-term research outside in the ecosystems they are studying. Scientists use a variety of methods, including *monitoring* changes in plant and animal populations or in atmospheric conditions. For example, bird watchers may monitor the date of first arrival of spring migrant birds and meteorologists record the high and low temperatures over many years. Field *experiments* are another kind of long-term research. As opposed to monitoring, where scientists observe changes occurring naturally, in field experiments scientists actually change something in nature and then compare the area they have altered to an area that is left intact.

In the HBEF, many long-term field experiments have been conducted on small *watersheds*. A watershed is the drainage area for a stream, river, or other body of water. A small stream generally has a small watershed, while a large river (like the Merrimack River) drains very large areas. The Merrimack River's watershed includes much of Massachusetts and New

Hampshire. Scientists have identified and marked out nine small watersheds in the HBEF, each of which contains a stream that drains a small, forested area. Each of these watersheds has similar characteristics like slope (steepness) and vegetation, and they vary in size from 10 to 70 hectares (about 25-175 acres).

Watershed: The drainage area of a stream, river, or other body of water; an area used for experiments and monitoring at the HBEF.

Scientists first monitor the amount of water, nutrients and other chemicals (compounds) that *enter* watersheds in precipitation or dry deposition. Dry deposition consists of small particles that fall on the forest, similar to the dust in your house. Next, they measure the water and compounds *leaving* each watershed in streamwater, through evapotranspiration (transpiration from plants and evaporation from soil), or as different gases. Finally, they study what happens *in* each watershed (for example, how quickly trees grow). Studying all components of an entire watershed is known as the, "Small Watershed Concept." Why do you think studying entire watersheds might be interesting or important?

Some of the most fascinating research at Hubbard Brook has examined how watersheds change after an experimental treatment. For example, in a study conducted in Watershed 2, scientists wanted to know how a major disturbance like deforestation (cutting down all the trees) would affect the forest and its water yield (how much water leaves the forest). One of their hypotheses was that because trees take up large amounts of water from the soil, if they were cut down more water would drain from soils and eventually leave the forest. This was particularly important at the time, because there was widespread concern about drought and low reservoir levels. By cutting down the trees in the forest, scientists reasoned, more water would leave the forest and eventually accumulate in reservoirs. As you will learn later in this manual, streamflow increased substantially in the first few years following the cut.

HBEF Research: From 1963 to 2001 HBEF scientists have published 6 books and more than *1000 scientific papers*. In addition, 535 abstracts were published, and over 160 theses were completed.

HBEF scientists are also interested in other types of research. For example, the United States Geological Survey is learning more about how water moves underground, and limnologists (scientists who study lakes and streams) are examining nearby Mirror Lake. Other scientists are monitoring acid precipitation and its effects on organisms and ecosystems, while forest ecologists are carefully measuring the growth of trees and forests.

In the activities in this manual you will read about some of these projects, will examine data generated from them, and will get a chance to measure different components of your schoolyard or community using the same basic protocols that HBEF scientists use. Finally, we hope you may take what you have learned and explore some basic research questions either individually or with your class.

A Quick Site Description

The HBEF is located near Thornton, New Hampshire, and is within the boundaries of the White Mountain National Forest. It is about 15 minutes north of Plymouth, and an hour north of

Concord, the state capital. The HBEF has hilly terrain, ranging from 222 to 1,015 meters in altitude, and it generally covered by an unbroken forest of northern hardwood trees. The northern hardwood forest biome consists primarily of American beech, yellow birch, and sugar maple. Red spruce and balsam fir are frequently found at higher elevations.

The HBEF officially became an experimental forest in 1955, when the US Forest Service established it as a major center for hydrologic (water) research in New England. Then, in the early 1960s, Yale professor F. Herbert Bormann and others decided to study entire watersheds to learn more about how nitrogen, carbon, and other elements cycle through ecosystems. In 1963, Bormann, Gene Likens, Noye Johnson, and Robert Pierce proposed using this Small Watershed Concept to study how water and nutrient cycles interact. They were also interested in how natural and human disturbances – such as air pollution, insect population fluctuations, climate changes, and more – affected these cycles. Why do you think the Small Watershed Concept would be a useful study design for this type of research?

Small Watershed Concept: At the HBEF, scientists use the Small Watershed Concept to study how *all* the plants, animals, soil, and water interact in a single unit – a watershed.

Between 1955 and 1963, the Forest Service set the stage for long-term research: They built a number of precipitation, weather and stream measurement stations, and they started studying soil and vegetation throughout the forest. At first, they were interested in learning how to manage forests to control water quality and floods. But as the Ecosystem Study was initiated and more scientists started working in the HBEF, the research program expanded tremendously. Today over 100 scientists, graduate students, and technicians conduct research in the HBEF, and contribute to the longest dataset of this type in the entire country. In fact, if you decide to do environmental or ecological research in college, you may be able to get a summer job at the HBEF.

Virtual Tour

To help you learn more, you will now take an online tour of the HBEF. The tour begins with a brief description of the Hubbard Brook Experimental Forest, and then shows the forest, the history of the valley, the current facilities, short- and long-term research, and the people who make it all happen. When you are taking the tour, think about questions you would ask if you were an ecologist. Would you study trees and how they interact with soil, or would you be more likely to examine insects that live in streams? Are you curious about how nutrients move around in a lake, or would you rather study how winter snow levels affect forest growth? Or are you more interested in songbird reproduction or other types of animal behavior? Are there other questions you have asked when walking through forests near your home or school?

Protocol 1
Taking the HBEF online virtual tour

1) Go to the Hubbard Brook Ecosystem Study's website: http://www.hubbardbrook.org/.
2) Click on the "Educational Resources " link and then go to the "Student's Homepage."
3) Click on the button labeled, "Virtual Tour." Take some time to view the tour, following the links that are interesting to you. Then, answer the questions on the handout your teacher has given you. Most of the answers can be found in the tour.

Suggestions for further study

If you are interested in learning more about the HBEF after you have completed the tour, there are several online resources available to you.

- View other sections of the HBEF website. This site contains real data, in-depth explanations of research projects not covered in the Virtual Tour, contact information on HBEF scientists, and more.
- Visit the Long Term Ecological Research (LTER) network's website (www.lternet.edu). This website contains information about and links to the 24 LTER sites.
- For more information on the HBEF, you may be interested in reading all or sections of the following books:
    - Bormann, F. H. and G. E. Likens. 1979. *Pattern and Process in a Forested Ecosystem*. Springer-Verlag New York, Inc. 253 pp.
    - Likens, G. E. and F. H. Bormann. 1995. *Biogeochemistry of a Forested Ecosystem.* Springer-Verlag New York, Inc. 159 pp.

Acknowledgements

Some of the material in the introduction was adapted from *Long Term Ecological Research: teacher's manual of classroom activities**. The activities in this manual introduce high school students to the National Science Foundation's Long Term Ecological Research (LTER) program and the variety of research being conducted at LTER sites. The activities also are designed to teach basic ecological principles and inquiry skills, and to make students aware of the value of long-term research as a basis for conservation management and regional planning decisions.

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* Krasny M, Berger C, and Welman TA. 2001. Long Term Ecological Research: teacher's manual of classroom activities. http://www.dnr.cornell.edu/ext/LTER/lter.asp