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NORTHEASTERN RESEARCH STATION
USDA FOREST SERVICE

ENVIRONMENTAL RESEARCH, TECHNOLOGY & LEADERSHIP

Hubbard Brook Experimental Forest

Celebrating 50 Years as a Forest Service National Scientific Treasure

"The Forest Service's system of experimental forests is a national treasure. These environmental laboratories have provided decades-long research data that help us understand what has happened to our forests, the environment, and, in the case of the Hubbard Brook Experimental Forest, how forest ecosystems respond to disturbance."

MICHAEL T. RAINS
Director, USDA Forest Service,
Northeastern Research Station, 2005

What characteristics would make a tract of land a national treasure? Yosemite and the Grand Canyon bring to mind beauty and grandeur; Kitty Hawk and Valley Forge, historical significance. The Everglades and the Cache River Big Woods in Arkansas (home to the newly rediscovered ivory-billed woodpecker) have ecological significance and Kitt Peak National Observatory and the Hubbard Brook Experimental Forest have scientific significance. The importance of these examples is probably apparent to most readers, but the Hubbard Brook Experimental Forest's significance may not.

This special part of the Forest Service's Northeastern Research Station and National Forest System has a unique role in forest ecology and environmental studies. In the debate about global change, the comparison to past conditions is crucial, and to know what has changed, you must know what has gone before. But how do we know what world conditions were like in times gone by? Researchers have found some clues in historical documents and archeological sites, but scientifically useful environmental databases of any age or duration are extremely rare. The data and samples from 50 years of research at Hubbard Brook Experimental Forest (HBEF)—7,800 acres in the White Mountain National Forest in central New Hampshire—are a unique library of information for environmental

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NE Forest Science Review is dedicated to presenting clear and concise information on current problems and issues relating to forests and forestry in the Northeast and the role of the nearly 100 scientists in the USDA Forest Service's Northeastern (NE) Research Station in exploring these topics and finding solutions for problems.

We hope that land managers, policymakers, science communicators, extension specialists, environmental advocates, and educators, as well as conservationists and all others interested in the health and productivity of forests in the Northeast, will find our quarterly newsletter useful and informative.

The NE Research Station is part of the USDA Forest Service's Research & Development national network of six regional research stations, the Forest Products Laboratory, and the International Institute of Tropical Forestry. NE scientists work at research sites in 13 states—Hamden/Ansonia, CT; Newark, DE; Amherst, MA; Baltimore, MD; Bradley, ME; Durham, NH; Burlington Co., NJ; Syracuse, NY; Delaware, OH; Warren and Newtown Square, PA; Burlington, VT; and Morgantown, Parsons, and Princeton, WV.

NE scientists work in laboratories and a wide variety of field sites, including eight experimental forests (several of these maintain long-term data sets that are unique to science) and six research natural areas, sited on National Forest System lands. Two important research locations are the Forest Service's only primary quarantine laboratory on the continental United States (Hamden/Ansonia, CT), a facility certified for biological control research on non-native forest pests and their natural enemies as well as the Baltimore (MD) Long Term Ecological Research Site, where NE scientists and other cooperators study the ecology of an urban forest.

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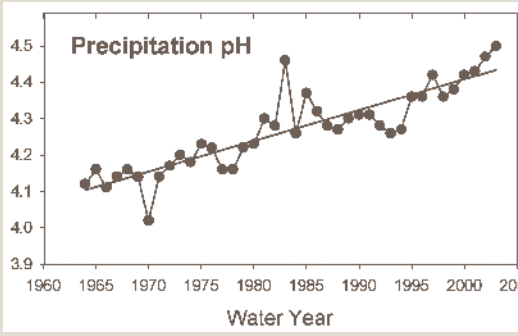
scientists to consult, examine, or even re-analyze with more modern technologies. In addition, because of its hydrological studies, the Hubbard Brook EF is the place where, in 1967, a significant piece of environmental information—the presence of acid rain (now more inclusively called "acid deposition") in North America—was first noted in rain samples.



Data courtesy of G. Likens

Early Days at the Hubbard Brook EF

The Northeastern Forest Experiment Station, as the NERS was then known, established the Hubbard Brook EF in 1955 so that its scientists could study the effects of forests and forest management on components of the hydrologic cycle, erosion, and water quality. The site is part of the White Mountain National Forest, and the Hubbard Brook watershed was chosen for its special site characteristics. There is the main brook and a network of small feeder streams on north- and south-facing slopes. The New Hampshire granite bedrock is watertight and covered with shallow soils and the vegetation is a fairly uniform beech-birch-maple forest, known as the northern hardwood forest type. On nine of these small streams (three on the north-facing slopes and six on the south-facing slopes), water gauges were established (the first ones in 1955) for long-term hydrological research on the effects of various forest management and forest disturbance treatments on water yield and quality.

"Over the past 50 years, Hubbard Brook Experimental Forest has provided an ideal setting for major research on water yield, water quality, and the effects of acid rain; these studies have gained us a fundamental understanding of forest and aquatic ecosystems."

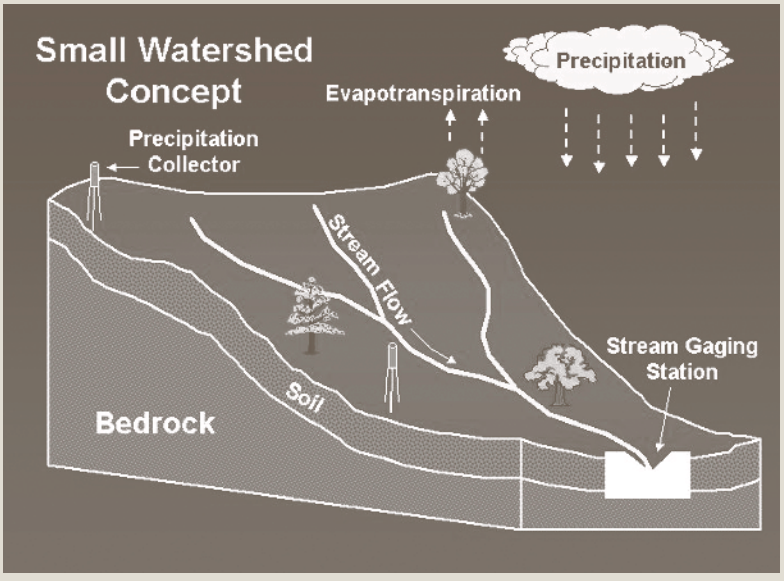
Christopher Eagar
Forest Service research ecologist and project leader, 2005

In 1963, the potential value of the site and the small-watershed technique being used for monitoring and research was recognized by Robert Pierce, the lead FS scientist, and his colleagues Herbert Bormann and Gene Likens (then at Dartmouth College). They began early

cooperative work to understand the complex ecosystem processes, such as nutrient cycling through the evaluation of input and output budgets for important chemical elements. The research at the HBEF expanded to include many facets of applied ecosystem-level research. Thus, Hubbard Brook scientists were perfectly placed to provide data on environmental problems.

Now the Center of a Community of Scientists

Now the Hubbard Brook EF is the focus of a large network or community of scientific partners—scientists and graduate students from private research organizations and universities—studying the hydrology and ecology of forested watersheds. This community is organized as the Hubbard Brook Ecosystem Study (HBES). Although the original studies were carried out solely by NE scientists, most of the research done now at the HBEF is cooperative. The HBEF is a member of several world-wide networks: it is 1 of only 26 Long Term Ecological Research Sites organized by the National Science Foundation. In addition, the HBEF participates in a number of national data collection networks, such as the Environmental Protection Agency's Clean Air Status and Trends Network (CASTNET), the Natural Resources Conservation Service's Soil Climate and Analysis Network (SCAN), and the National Atmospheric Deposition Program (NADP). It also participates in the Organization of Biological Field Stations (OBFS) and operates Hubbard Brook as a Terrestrial Ecosystem Monitoring Site in the international Global Terrestrial Observing System (GTOS) initiated by the World Meteorological Organization and as a Biosphere Reserve in the United Nation's Scientific, Educational, and Cultural Organization's Program.

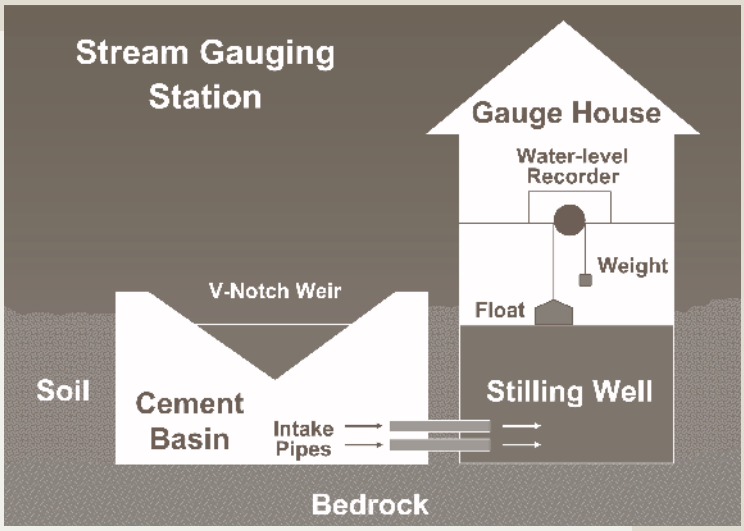


Chiefly, Hubbard Brook Ecosystem Study scientists examine the long-term effects of acid precipitation on soil chemistry and terrestrial and aquatic ecosystems, both of the streams and Mirror Lake. This beautiful little lake lies at the bottom of the valley and is considered by ecosystem scientists to be "one of the most studied lakes in the world!"

The Next Fifty Years

But what does all this research mean? And what comes next? Additional scientific research has expanded on the early nutrient cycling studies and long-term monitoring. Now calcium (Ca) is being tracked through the entire ecosystem to evaluate its role in regulating the structure and function of base-poor (that is, acidic, low-pH) forest and aquatic ecosystems. In 1999, with NSF funding, NE scientists dumped 56 tons of Ca back onto one of the watersheds. This is the amount estimated to have been lost due to leaching by acid rain. Rocks of calcium silicate were quarried in New York, broken up into small fragments, and applied by helicopter to watershed #1 on the south-facing slope. In addition, within the last 5 years, there has been a major effort to characterize vegetation and streamwater chemistry across the entire Hubbard Brook Valley. Data from this work will be used to improve understanding of spatial variation throughout the Hubbard Brook Valley and to develop models that can be used on larger, regional landscapes.

Small-Watershed Model: Key to Discoveries



The small-watershed model provides a tool for researchers at the Hubbard Brook EF to quantify nutrient cycling. A naturally occurring and bounded watershed underlain by water-impermeable bedrock is the basic unit of study. All water entering the watershed is measured by rain gauges within and around the watershed. All water leaving the watershed is measured, or gauged, by a special small dam called a weir located at the base of the watershed. Then the estimated amount of precipitation per area entering the watershed is multiplied by the area of the watershed to give the volume of water entering. The volume entering as precipitation minus the volume leaving in stream water gives the amount of water that is lost from the watershed as evaporation and transpiration from trees and other surfaces. Collectively, water input minus water output constitutes the hydrologic budget for the watershed.

To make these precipitation measurements more meaningful, many other characteristics are measured, including concentrations of chemicals such as nitrogen, calcium, magnesium, sulfur, and potassium, and characteristics such a pH, which is the measure of the acid-base nature of a liquid. The scale of measurement is from 1 to 14. Pure water and milk are considered to have a pH values of 7 and unpolluted rainwater has a pH of around 5.6. Low pH values are acidic and dissolve many minerals, including calcium (Ca), aluminum (Al), and iron (Fe) compounds. Battery acid has a pH of 1 and lemon juice, 2. All fish die in water at pH 2.1. High pH values are termed basic; ammonia has a pH of 12 and lye, 13. Susceptible soils and rocks can be altered by acidic deposition—rain water, snow, and mist—and affect the long-term health of forests.

Long-term watershed input-output budgets have shown a significant depletion of calcium, an essential plant nutrient, from the soil. As acid precipitation moves through soil, it mobilizes calcium and leaches it into streams. Replacement of calcium through the natural process of weathering of rocks in the soil is slow and cannot keep up with leaching losses. Current research is seeking to determine what affects, if any, calcium depletion may have on the long-term health of forests.

***Hubbard Brook Experimental Forest** will mark its 50 years on July 12 with a celebration event that will focus on the "Past, Present and Future of Watershed Research." The morning session begins at 9 a.m. and will include short talks by individuals who helped make HBEF the renowned research site that it is. The afternoon session will include a more detailed presentation on the future of watershed research.*

Past, Present and Future of Watershed Research

Morning Session:

- Opening Remarks by Chris Eagar, Michael Rains and others
- History: The Weeks Act, and establishment of HBEF – Charlie Gogbil
- Beginnings at Hubbard Brook - 1955-1965: A student's perspective - Tony Federer (retired FS scientist)
- The heart and soul of HBEF: Reflections on Robert Pierce – Carol Pierce
- The HBES – Gene Likens (co-founder HBES)
- More than watershed studies – Richard Holmes
- Day in and Day out: Two careers at HBEF:
  The Sheriff of HB – Wayne Martin (retired FS scientist and site manager for HBEF)
  Gazillions of water samples – Don Buso (long-term cooperator)
- Floods, Droughts, and Erosion: Hubbard Brook Answers the Call – Jim Hornbeck (retired FS scientist)
- Contributions to natural resource management – Steve Fay (retired soil scientists for WMNF)
- Views from the present – Amey Bailey and John Campbell
- Concluding Remarks – Herb Bormann (co-founder HBES)

11:30 – 1:00 Lunch

Afternoon Session:

Mini Symposium on the Future of Watershed Research, with presentations by Richard Hooper, Gene Likens, Scott Bailey or Lindsey Rustad, and Charles Driscoll.

Web Resources

USDA Forest Service Northeastern Research Station's field unit at Hubbard Brook EF:
www.fs.fed.us/ne/durham/4352/hb.shtml

Hubbard Brook Ecosystem Study:
www.hubbardbrook.org

Commemorative Lecture by Drs. Likens and Bormann at receipt of the 2003 Blue Planet Prize, summarizing the work at HBES:
www.af-info.or.jp/eng/honor/2003lect-e.pdf

Experimental Forests and Ranges of the USDA Forest Service. 2004. By Adams M.B., Loughry L., Plaugher L. Newtown Square, PA: USDA Forest Service Northeastern Research Station. Gen. Tech. Rep. NE-321. Available for order or viewing at the following URL:
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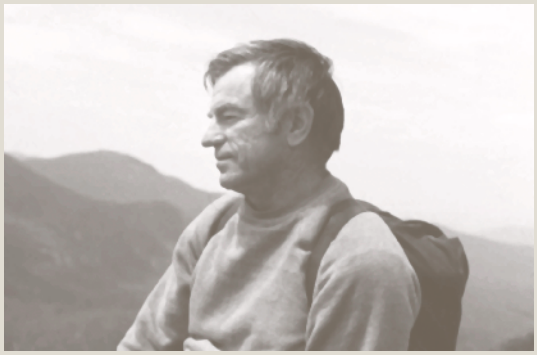
Christopher Eagar received a BS in business administration in 1969, an MS in forestry in 1978, and a PhD in ecology in 1985, all from the University of Tennessee. From 1981 to 1988, he worked as an ecologist for the National Park Service at Great Smoky Mountains National Park, studying acid rain effects on high-elevation forest ecosystems. Eagar then joined the Forest Service in 1988 and later became leader of the Durham, NH–based work unit entitled "Ecological Processes: A Basis for Managing Forests and Protecting Water Quality in New England." In addition to conducting research throughout New England, this group is responsible for the Hubbard Brook Experimental Forest. Eagar's address is USDA Forest Service, Northeastern Research Station, 271 Mast Road, Durham, NH 903825; tel: 603-868-7636; e-mail: ceagar@fs.fed.us

Amey Schenck Bailey is the forestry technician who maintains, processes, and transmits data from the long-term hydrometeorological monitoring networks at the Hubbard Brook Experimental Forest. She also leads tours there and participates in education and outreach efforts. Bailey received her BA in botany and music from Connecticut College, New London, in 1986 and an MF from Duke University School of Forestry, in 1991. She began working for the USDA Forest Service at the HBEF in 1992. Her mailing address at the HBEF is 234 Mirror Lake Road, Campton, NH 03223; tel: 603-726-8902; e-mail: ameybailey@fs.fed.us



The late **Robert Pierce** began working for the Forest Service's Northeastern Forest Experimentation Station at the newly founded Hubbard Brook Experimental Forest in 1955 and made the HBEF his life's work until his death in 1993. The FS laboratory center at HBEF is named in his honor. Pierce received a BS in forestry from the University of Michigan and MS and PhD degrees in forest soils from the University of Wisconsin.