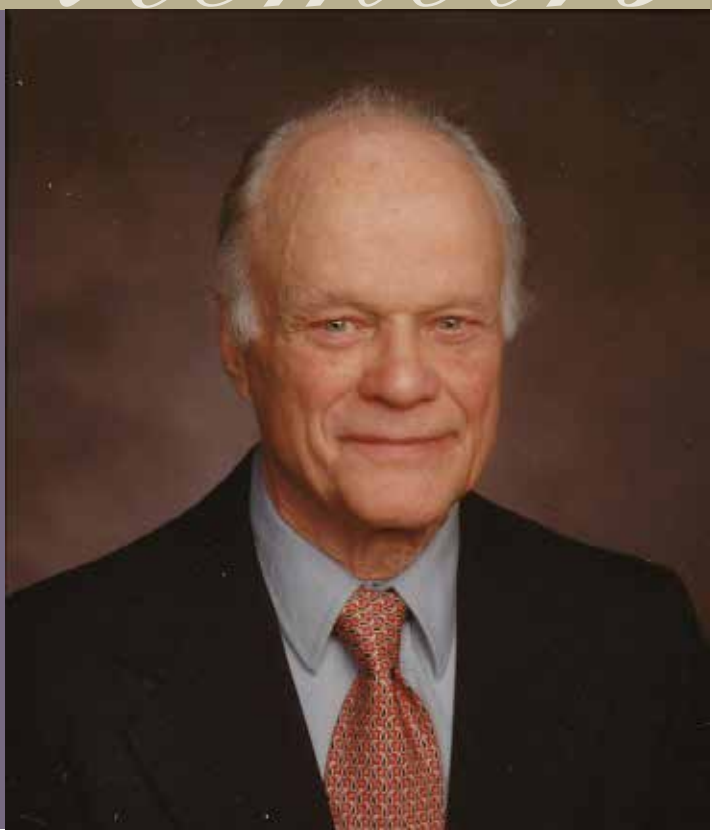
F. Herbert Bormann

1922–2012

BIOGRAPHICAL *Memoirs*



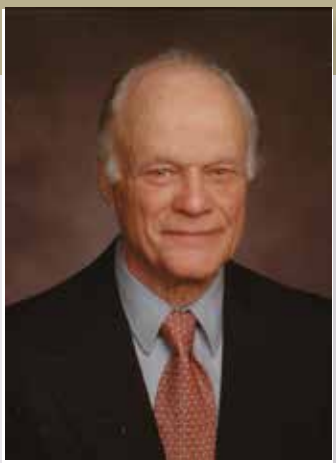
A Biographical Memoir by
Gene E. Likens
and Lars O. Heidin

NATIONAL ACADEMY OF SCIENCES

FREDERICK HERBERT **BORMANN**

March 24, 1922–June 7, 2012

Elected to the NAS, 1973



By Gene E. Likens[1] and Lars O. Heidin[2]

Frederick Herbert Bormann, or "Herb," as many called him, was one of the leading ecosystem ecologists in the twentieth century. He was a visionary with unusual talent for thinking big about ecological systems. Perhaps his most important scientific contribution was the development of an ecosystem-based approach to understanding forests and their role in biogeochemical cycles. He was co-founder of the Hubbard Brook Ecosystem Study in the White Mountains of New Hampshire. By explicitly including the influence of human activities in his studies of natural ecosystems, he made major contributions to the basic understanding of forested ecosystems across diverse subdisciplines of ecology, including natural history, plant systematics and physiology, ecosystem ecology, nutrient cycling, biogeochemistry, and environmental sustainability.

Herb was born on March 24, 1922, in New York City. His parents, Carl Bernhardt Bormann and Gertrude Anna Andle, were immigrants from Germany and Austro-Hungary, respectively, and he grew up in Westwood, New Jersey. Herb spent one semester at the University of Idaho before enlisting in the United States Navy after the attack on Pearl Harbor. He was a ship fitter petty officer and a welder on submarines in Hawaii. From there, he attended officer candidate school on the Princeton University campus until the end of World War II.

Like so many other prominent, inquisitive, and insightful biologists, Herb's early love of nature was nurtured by his parents, particularly his mother. As an undergraduate at Rutgers University in New Brunswick, New Jersey, he had the privilege of being

1. Gary Institute of Ecosystem Studies, Millbrook, NY 12545.
2. Program in Environmental Studies, Princeton University Princeton, NJ 08544.

mentored and befriended by two of the most inspirational ecologists of the time, Murray and Helen Buell. He received his PhD at Duke University with Henry Oosting, whom he greatly admired. These early formative years helped him to see the value of integrating knowledge along a continuum of biological organization, from species to ecosystem.

A major turning point in Herb's career occurred when he was a young professor at Dartmouth College and when he first came in contact with his group of future collaborators: Gene E. Likens, Robert S. Pierce, and Noye M. Johnson. He had been working successfully at Dartmouth on experimental studies of root grafting in White Pine (*Pinus strobus L.*), where individual trees are directly connected through their root masses. But having been exposed to watershed studies at the Coweeta Hydrologic Laboratory in North Carolina when he was a graduate student, he saw a great potential for expanding such a watershed-based approach to the forested ecosystems at the newly established US Forest Service's Hubbard Brook Experimental Forest (HBEF) hydrologic facility in the White Mountains of New Hampshire. He believed that new ecological insights could be obtained by combining studies of hydrologic and nutrient cycles at the watershed scale.

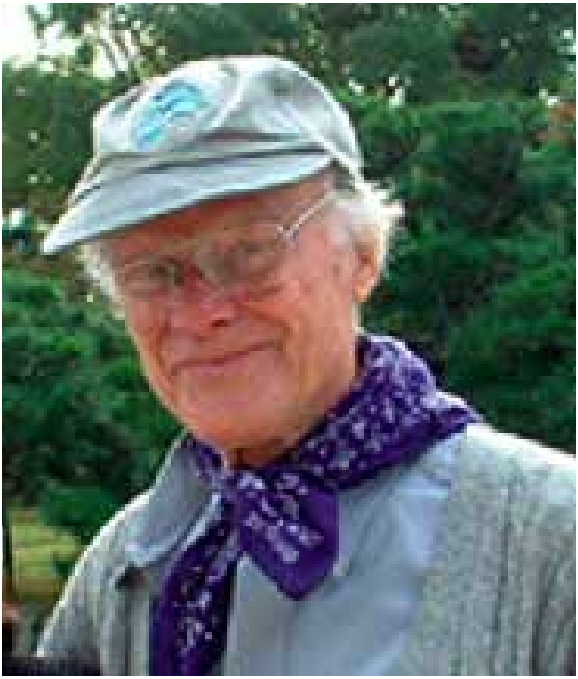
One of Herb's best-known research findings with colleagues of the Hubbard Brook Ecosystem Study included the realization that disturbing the forest ecosystem, for example by clear-cutting, would dramatically alter the nitrogen cycle and nutrient economy of the ecosystem.

When Likens joined the faculty of Dartmouth College in 1961 as an aquatic ecologist with strong interests in ecosystem ecology, he and Herb spent many hours talking about the exciting possibility of conducting ecosystem studies in the gauged watersheds of the Hubbard Brook Experimental Forest. Robert S. Pierce, US Forest Project Leader at HBEF, and Noye M. Johnson, a young geologist at Dartmouth College, enthusiastically joined the team.

The expertise of this group of scientists blended strongly, and on June 1, 1963, they initiated what was to become the highly successful, long-term Hubbard Brook Ecosystem Study. The conceptual design for this study, based on the small watershed ecosystem approach, was laid out in detail in a 1967 paper in *Science.* This conceptual model provided a rigorous foundation for long-term studies of complicated interactions

between air, land, and water in these forested northern hardwood ecosystems. Herb and Likens had an unusually productive and collegial partnership in science for more than fifty years. Johnson died in 1987 and Pierce died in 1993.

The lasting success of the Hubbard Brook Ecosystem Study can be assigned to the scientific and conceptual ideals that led to its development, as well as the personal ideals of its originators. Herb believed that strong social bonds made for strong collegial interdisciplinary science, and he believed that close conversation among collaborators with diverse but complementary perspectives was essential for understanding complicated ecosystems. Herb and Likens jointly applied this approach in the initiation and development of the Hubbard Brook Ecosystem Study.



Herbert Bormann.

This culture of scientific and social collaboration extended to a very large number of graduate students and postdoctoral associates who have been trained at Hubbard Brook. Herb asked questions that were cleverly designed to challenge students to place their findings in an "ecosystem context." But for Herb, science could never truly be separated from a game of softball, a match of doubles in tennis, or a potluck dinner at his house. And at any hour of the day he looked for a sympathetic ear with whom he could talk about baseball, with special attention to the persistently poor fortunes of his beloved New York Mets.

One of Herb's best-known research findings with colleagues of the Hubbard Brook Ecosystem Study included the realization that disturbing the forest ecosystem, for example by clear-cutting, would dramatically alter the nitrogen cycle and nutrient economy of the ecosystem. While it was expected that forest disturbance would change the hydrology of the system, it came as a major surprise that experimental disturbance

Gene Likens, Robert S. Pierce, and Herbert Bormann.

of entire watershed-ecosystems also triggered fundamental changes in nutrient cycles. Herb was also widely known for co-discovering acid rain in North America during the team's early studies at Hubbard Brook. The research team was measuring precipitation chemistry as one of the major inputs to chemical ecosystem budgets when this discovery was made.

Herb's most cited publication is *Pattern and Process in a Forested Ecosystem*, a book that was very influential in shaping thinking about how northern hardwood forest ecosystems recover from major disturbances such as clear-cutting, and about how the nutrient dynamics (e.g., carbon and nitrogen) of these ecosystems can change.

Herb's strong interests in how ecology is related to social issues bloomed later in his career and inspired the production of two books: *Redesigning the American Lawn*, published with students in 1993, and a book co-edited with Steve Kellert, *Ecology, Economics and Ethics: The Broken Circle*, published in 1991.

Herb's attention to social interactions for enhancing scientific communication and productivity also made him an inspiring teacher. His students remember perhaps most vividly how he always challenged them to think bigger and deeper. He was most effective (and happiest) when he could do this kind of big ecology teaching in the field or on a long walk with colleagues or students.

Herb died on June 7, 2012, in North Branford, Connecticut. He is survived by his wife of sixty years, Christine Williamson Bormann, and his four children, Dr. Bernard T. Bormann, Dr. Rebecca E. Oehlert, Amelia E. Bormann-Smitka, and Dr. Lincoln H. Bormann, as well as six grandchildren.

AWARDS

Elected to the American Academy of Arts and Sciences in 1972

Elected to the National Academy of Sciences in 1973.

President of the Ecological Society of America from 1970 until 1971.

The Aldo Leopold Award from Yale University in 2012.

The Blue Planet Prize (with Likens), given by The Asahi Glass Foundation in 2003 for pioneering an approach that has become a model for the scientific world, and for comprehensive understanding of ecosystems through long-term measurement of the flows of water and chemical substances in watersheds.

The Eminent Ecologist Award, given by the Ecological Society of America (with Likens) in 1995, for outstanding contributions to the science of ecology.

The National Conservation Achievement Award in Science, given by the National Wildlife Foundation in 1995, for outstanding contributions to the wise use and management of the nation's natural resources.

The Tyler Prize for Environmental Achievement (with Likens), given in 1993 for creating the premier model for ecosystems study in the world utilizing the small watershed technique for the study of the biogeochemistry of whole forest ecosystems, which changed American law and forestry practice and resulted in recognition of acid rain as a major environmental problem in North America.

International St. Francis of Assisi Prize for the Environment, given in 1992.

The Yale School of Forestry & Environmental Studies Excellence in Teaching Award, given in 1989.

Rutgers University's Distinguished Alumni Award, given in 1988.

The US Forest Service 75th Anniversary Award (with Likens), given in 1980.

The American Motors Conservation Award (with Likens), given in 1969.

The Ecological Society of America George Mercer Award, given in 1954.

POSITIONS HELD

Adjunct Professor, School of Natural Resources, University of Vermont 1994–2012

Professor Emeritus and Senior Research Associate, Yale University, 1992–2012

Oastler Professor of Forest Ecology, Yale University, 1966–1992

Professor of Botany, Dartmouth College, 1962–1966

Associate Professor of Botany, Dartmouth College, 1959–1962

Assistant Professor of Botany, Dartmouth College, 1956–1959

Assistant Professor of Biology, Emory University, 1952–1956

EDUCATION

University of Idaho, 1941

Princeton University, V-12 Navy College Training Program, Class of 1947

Rutgers University, BS, Agricultural Science, 1948

Duke University, PhD, Plant Ecology, 1952

MILITARY SERVICE

United States Navy, 1942–1945

AUTHORS' NOTE

This memoir is based in part on two other articles we have written: Resolution of Respect: F. Herbert Bormann 1922–2012 (Likens, G. E. 2013. *Bull. Ecol. Soc. Amer.* 94:304–308) and Retrospective: F. Herbert Bormann (1922–2012) (Hedin, L. O. 2012. *Science* 337:534).

SELECTED BIBLIOGRAPHY

1953 Factors determining the role of loblolly pine and sweetgum in early old-field succession in the Piedmont of North Carolina. *Ecol. Monogr.* 23:339–358.

1957 Moisture transfer between plants through intertwined root systems. *Plant Physiol.* 32:48–55.

1958 The statistical efficiency of sample plot size and shape in forest ecology. *Ecology* 43:474–487.

1959 With B. F. Graham, Jr. The occurrence of natural root grafting in eastern white pine, Pinus strobus L., and its ecological implications. *Ecology* 40:677–69.

1961 With B. F. Graham. A study of intraspecific root grafts in white pine, *Pinus strobus L.*, by means of radioisotopes and dyes. *Rec. Adv. Bot. Sec.* 12:1375–1377.

1964 With M. F. Buell. Old-age stand of hemlock-northern hardwood forest in central Vermont. *Bull. Torrey Bot. Club* 91:451–465.

1966 The structure, function, and ecological significance of root grafts in *Pinus strobus L. Ecol. Monogr.* 36:1–26.

With B. F. Graham. Natural root grafts. *Bot. Rev.* 32:255–292.

1967 With G. E. Likens. Nutrient cycling. *Science* 155:424–429.

With G. E. Likens, N. M. Johnson, and R. S. Pierce. The calcium magnesium, potassium and sodium budgets for a small forested ecosystem. *Ecology* 48:772–785.

1968 With N. M. Johnson, G. E. Likens, and R. S. Pierce. Rate of chemical weathering of silicate minerals in New Hampshire. Geochem. *Cosmoch. Acta* 32:531–545.

1969 With G. E. Likens and J. S. Eaton. Biotic regulation of particulate and solution losses from a forest ecosystem. *BioScience* 19:600–610.

With N. M. Johnson, G. E. Likens, D. W. Fisher, and R. S. Pierce. A working model for the variation in stream water chemistry at the Hubbard Brook Experimental Forest, New Hampshire. *Water Resour. Res.* 5:1353–1363.

With G. E. Likens and N. M. Johnson. Nitrification: importance to nutrient losses from a cut over forested ecosystem. *Science* 163:1205–1206.

1970 With G. E. Likens. The nutrient cycles of an ecosystem. *Sci. Amer.* 223:92–101.

With T. G. Siccama, G. E. Likens, and R. H. Whittaker. The Hubbard Brook Ecosystem Study: composition and dynamics of the tree stratum. *Ecol. Monogr.* 40:373–388.

With G. E. Likens, N. M. Johnson, D. W. Fisher, and R. S. Pierce. Effects of forest cutting and herbicide treatment on nutrient budgets in the Hubbard Brook watershed-ecosystem. *Ecol. Monogr.* 40:23–47.

With T. G. Siccama and G. E. Likens. The Hubbard Brook Ecosystem Study: productivity, nutrients and phytosociology of the herbaceous layer. *Ecol. Monogr. 40*:389–402.

1972 With G. E. Likens and N. M. Johnson. Acid rain. *Environment* 14:33–40.

With R. S. Pierce, C. W. Martin, C. C. Reeves, and G. E. Likens. *Nutrient loss from clearcuttings in New Hampshire.* Symposium on Watersheds in Transition, Ft. Collins, Colorado, pp. 285–295.

1974 With G. E. Likens, T. G. Siccama, R. S. Pierce, and J. S. Eaton. The export of nutrients and recovery of stable conditions following deforestation at Hubbard Brook. *Ecol. Monogr.* 44:255–277.

With G. E. Likens. Acid rain: a serious regional environmental problem. *Science* 184:1176–1179.

With G. E. Likens. Linkages between terrestrial and aquatic ecosystems. *BioScience* 24:447–456.

With R. H. Whittaker, G. E. Likens, and T. G. Siccama. The Hubbard Brook Ecosystem Study: forest biomass and production. *Ecol. Monogr.* 44:233–254.

1976 Edited with W. R. Burch. *Beyond Growth, Essays on Alternative Futures*, Bulletin 88 (New Haven: Yale University School of Forestry and Environmental Studies).

1977 With G. E. Likens, R. S. Pierce, J. S. Eaton, and N. M. Johnson. *The Biogeochemistry of a Forested Ecosystem* (New York: Springer-Verlag).

1979 With G. E. Likens. *Pattern and Process in a Forested System* (New York: Springer-Verlag)

1981 With D. G. Sprugel. Natural disturbance and the steady state in high-altitude balsam fir forests. *Science* 211:390–393.

1985 Air pollution and forests: an ecosystem perspective. *BioScience* 35:434–441.

1986 With K. C. Weathers, et al. A regional acidic cloud/fog water event in the eastern United States. *Nature* 319:657–658.

1987 With G. E. Likens. Changing perspectives on air-pollution stress. *BioScience* 37:370.

With W. B. Bowden, R. S. Pierce, S. P. Hamburg, R. C. Ingersoll, G. E. Likens, and G. K. Voigt. The Hubbard Brook sandbox experiment. In *Restoration Ecology: A Synthetic Approach to Ecological Research*, edited by W. R. Jordan III, M. E. Gilpin, and J. D. Aber, New York: Cambridge University Press.

1991 With S. R. Kellert. *Ecology, Economics and Ethics: The Broken Circle.* New Haven: Yale University Press.

1993 With D. Balmori and G. Geballe. *Redesigning the American Lawn, A Search for Environmental Harmony.* New Haven: Yale University Press.

1995 With G. E. Likens. Biogeochemistry of a Forested Ecosystem, second edition (New York: Springer-Verlag).

2007 With G. E. Likens. Environmental challenges in the Twenty-First Century and our respect for nature. 2003 Blue Planet Prize Commemorative Lecture. A Better Future for the Planet Earth Vol. III—*Commemorative Book for Blue Planet Prize Winners.* Tokyo: Asahi Glass Foundation, 78–95.

Published since 1877, *Biographical Memoirs* are brief biographies of deceased National Academy of Sciences members, written by those who knew them or their work. These biographies provide personal and scholarly views of America's most distinguished researchers and a biographical history of U.S. science. *Biographical Memoirs* are freely available online at www.nasonline.org/memoirs.