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Ecological Anniversaries to Celebrate in 2020: 50 and 100 Years Ago

The year 2020 is rich with anniversaries in ecological sciences and in the Ecological Society of America. This year we celebrate the centennial of the journal *Ecology*, the first American journal devoted to ecological science, and ESA's first scientific journal.

Ecology began in 1920 as a continuation of a magazine called *The Plant World*, which was established in 1897 as a monthly journal of popular botany aimed at teachers. In 1902 it became the official organ of one of the country's first conservation organizations, the Wild Flower Preservation Society of America. Several botanists from the New York Botanical Garden, itself just recently opened, were involved in the Society and its magazine. The Botanical Garden's scientists also helped to advise the Carnegie Institution of Washington when it was created in December 1901 and had to decide what kinds of scientific work it should support. On the advice of the New York botanists, along with other botanical experts, it chose to support botanical research by creating a Desert Botanical Laboratory in 1903, located about two miles from the town of Tucson, Arizona.

After construction of the laboratory building and hiring of a permanent scientific director and staff, the Desert Botanical Lab turned into a vibrant research community for desert ecology and related subjects. Research in desert ecology continued until 1940, although the Carnegie had by then shifted its experimental studies to Stanford, where it had built a new laboratory, leaving the Arizona group somewhat isolated. The Desert Lab in its early years was staffed largely by botanists from the New York Botanical Garden, and supported the research of many botanists who were developing the new field of ecology. In 1907 the Lab took over publication of *The Plant World*. Many of its early articles were on ecological themes, such as fire as a biological factor, the plant associations of the Desert Laboratory site, and the rate of establishment of the giant cactus. As the Desert Laboratory grew into an important research center for ecology, plant physiology, and general evolutionary studies, its expanding research helped to define the new discipline of ecology, giving it credibility as a serious scientific field. Several of the Desert Laboratory's botanists in turn became charter members of the new Ecological Society of America, and in 1919 they handed *The Plant World* over to the new Society, which renamed it *Ecology*.

The name change was a sign that it would no longer be a botanical journal. *Ecology*'s first issue invited contributions from any field of biology, not just botany, and expressed the hope that by adopting a common ecological point of view, articles would attract interest from people in different specialties. For those interested in the prehistory of *Ecology*, issues from *The Plant World* are archived in JSTOR along with *Ecology*.

Earth Day Plus Fifty

This year also marks the 50th anniversary of the first Earth Day on April 22, 1970. F. Herbert Bormann was ESA's president about that time, and later in 1996 he wrote a fascinating memoir reflecting on his scientific career and his involvement with environmental activism (F. H. Bormann, "Ecology: A Personal History," *Annual Review of Energy and the Environment* 21:1-29). Shortly after finishing his Ph.D. at Duke University in the mid-1950s, his travels made him aware of many types of regional environmental problems, such as the detrimental impacts of open-pit mining, metal smelting, clear-cutting of forests, and wildfires.

Growing public concern about the impact of nuclear and chemical technologies expanded his view of ecology in the late-1950s and 1960s. Rachel Carson's best-selling exposé of pesticide over-use, *Silent Spring*, appeared in 1962, the traumatizing effects of DDT on birds could be readily observed on the Dartmouth campus where Bormann worked, and he began to follow the scientific studies of these effects. During a sabbatical year in 1963-1964 with George Woodwell at Brookhaven National Laboratory, their conversations focused on the ecological implications of nuclear fallout and pesticides. "Somewhat puffed up," he wrote, "we made a missionary trip around the country spreading the message to ecologists that 'ecology is more powerful than ecologists' and that ecologists needed to emerge from their cocoon. We gained few converts, but many enemies."

Bormann did not elaborate on the reasons for the negative reactions that he and Woodwell encountered on their tour, but they realized that these environmental problems demanded leadership from ecologists. Bormann himself continued to explore the wider dimensions of the crisis and to bring these ideas into his teaching and public lectures. Woodwell was one of the co-founders of the Environmental Defense Fund in 1967 and went on to a long and illustrious career that combined ecological science and environmental stewardship.

Eugene Odum, ESA's President in 1965, realized that such momentous challenges suggested a change in the nature of ESA as a scientific society. With membership of 2,500 at that time, ESA was well-positioned to take a more active role in synthesizing knowledge and action, to help ensure that policy decisions were based on sound science. In his Presidential report on the state of the Society, published in ESA's *Bulletin* in March 1966, Odum evoked the idea of the Society as part of a broader social-scientific ecosystem, and called for the Society to fill an "open niche" in the professional structure of U.S. science by serving as an "error detector" in a "feedback system between basic and applied knowledge." Odum was unsure whether the Society's meager resources would enable it to occupy this empty "niche", or whether it would be a better strategy to push for the establishment of a National Center for Ecology. The Society would later help to establish what became The Institute of Ecology (TIE), a type of ecological think tank for the promotion of ecology along all fronts, including the application of ecological science to environmental policy.

The emerging environmental movement shook ecology and transformed it under the leadership of Odum, Bormann, Woodwell and other ecologists. After Bormann moved to Yale University in the mid-1960s, he helped organize a lecture series in 1969 that included environmentalists of many stripes: Stewart Udall (Secretary of the Interior from 1961-1969), Clarence Glacken (one of the first environmental historians), LaMont Cole (ESA's President in 1967-1968), Paul Ehrlich (who had just published the best-selling book, *The Population Bomb*, in 1968), and Kenneth Boulding (influential economist and environmentalist). The lecture series was hugely successful at Yale and became a best-selling book, *The Environmental Crisis: Man's Struggle to Live with Himself* (edited by H. W. Helfrich, Jr., and published in 1970 by Yale University Press).

Bormann's past-presidential address to ESA in 1972 dealt with problems of growth and over-population, and he continued his environmental teaching at Yale for many years, along with his colleagues there. In his later reminiscences, Bormann also had advice for the training of students in ecology, for Duke had been unusual because ecologists and foresters had a close relationship. As he wrote, "I feel strongly that ecologists need exposure to both applied and theoretical aspects of ecology in order to be prepared to link ecological science to the solution of human problems."

These reports and recollections of ecologists on the frontlines of the emerging environmental movement add many insights to our understanding of the evolving relationship between ecology and environmental activism. We encourage members of ESA to write down their own stories, and to preserve the valuable records of their careers and activities.

The Physiological Ecology Section also Turns Fifty in 2020

As we have reported in previous newsletters, this is also the 50th anniversary of the Physiological Ecology Section, which was approved in 1969 and started its work in 1970. It's now one of the largest sections in the Society. In this newsletter we highlight some of the advances in plant physiological ecology in the two decades prior to the founding of this section. As Hal Mooney, R. W. Pearcy, and J. Ehleringer explained in an overview of the field published in 1987, the expansion of plant physiological ecology was the result of a combination of theoretical, conceptual, and technological advances that by the mid-1980s had made the field increasingly predictive and capable of providing management tools in areas like forestry and pollution control (H. A. Mooney, R. W. Pearcy, and J. Ehleringer, "Plant Physiological Ecology Today," *BioScience* 37 (1987):18-20).

Among the many developments in this field, a good example of the link between technological and conceptual advance is the improved understanding of the biochemical pathway of photosynthesis that emerged in the 1950s and 1960s. During the 1950s, Melvin Calvin and collaborators at the University of California, Berkeley, worked out the biochemical pathway of photosynthesis using radioactive carbon-14 to trace the path of carbon from atmospheric CO_2 through the plant during photosynthesis. For this research elucidating what became known as the "Calvin cycle", Calvin received the Nobel Prize in Chemistry in 1961. Most studies of this process focused on the alga *Chlorella,* and only a few higher plants were investigated. But there was evidence in the literature that a different process for assimilating carbon dioxide might operate in tropical grasses, which had unusual leaf anatomy and showed physiological differences related to photosynthesis.

A breakthrough came in the mid-1960s when two Australian scientists, Marshall D. Hatch and C. Roger Slack, working on sugarcane for the Colonial Sugar Refining Company in Brisbane, Australia, found that the photosynthetic pathway in sugarcane was indeed different. They proposed a new model in 1966, and noted that it was unlikely that it was peculiar to sugarcane. Their model became known as the C_4 pathway or C_4 photosynthesis. It was found in a wide variety of plants, which became known as C_4 plants, while the plants with just the Calvin cycle became known as C_3 plants. Improved laboratory facilities played an important role in Hatch and Slack's work, as well as in subsequent research on C_4 plants. The Colonial Sugar Refining Company had just opened a modern phytotron, the David North Plant Research Centre, a controlled-environment laboratory, in Brisbane in 1961. It offered Hatch and Slack superb state-of-the-art laboratory facilities.

The world's first phytotron had opened in 1949 at Caltech, under the direction of Frits Went, a plant physiologist and ecologist. One of Went's goals was to render ecology more exact, in the hope of reducing the controversies that so often beset the field. Went was an enthusiastic promoter of "phytotronics" and invited scientists from all over the world to work in his laboratory.

The Caltech model stimulated similar laboratory developments elsewhere, including in Brisbane. The plans for that phytotron were initiated in 1958 by Harry Highkin and Pret Keyes of Caltech, and by Israeli scientist Dov Koller, who was then visiting Caltech. When the Australians opened another phytotron in Canberra in 1962, designed to be an improved version of the Caltech prototype, it too became a hub of research on photosynthesis. An international conference held in Canberra in 1970 brought together scientists in the rapidly developing fields of photosynthesis and photorespiration (see M. D. Hatch, C. D. Osmond, and R. O. Slatyer, eds. *Photosynthesis and Photorespiration*, Wiley-Interscience, New York, 1971). By this time there was overall agreement about the C_4 pathway, although some details still needed to be worked out.

This work in turn influenced Olle Björkman, a Swedish biologist who came to the Carnegie Institution of Washington's Stanford laboratory in 1964, where he joined a group of botanists working on what was then called "experimental taxonomy." This field originally focused on working out which features of a plant were genetic (and therefore inheritable), and which were products of the environment (and not inheritable), as a way to help taxonomists decide which characters of a plant were most useful for classification. This field gradually expanded from the 1930s to embrace studies of micro-evolution, focusing on how species became separated geographically and morphologically into sub-species. The Carnegie botanists developed a strong, decades-long research program in this subject, and one member of that group, William Hiesey, also used the Caltech phytotron for experimental studies.

When Björkman joined the group in the 1960s, he was making comparative studies of photosynthesis in species and races of higher plants from diverse ecological habitats. The recent discovery of the C_4 pathway became highly relevant to his ecological inquiries, for the two pathways represented adaptations to different environments. C_4 plants were adapted to more extreme environments with higher light intensities, high temperatures, and often severe drought. The Carnegie group continued with their experimental studies on the nature of species, showing the importance of physiological divergence in the pathways of photosynthesis. Björkman took over leadership of the group after William Hiesey retired in 1969, and in 1970 he replaced the term "experimental taxonomy" with "physiological ecology."

Mooney, Pearcy, and Ehleringer commented that this group's work not only illustrated the importance of new tools and theories, but also exemplified a "unique working philosophy" that emerged in the 1960s and 1970s, and that came to characterize the field of physiological plant ecology. They explained that "this philosophy brought vertical integration to the study of plant adaptive traits by leading investigators to seek the biochemical and physiological mechanisms underlying adaptive features and to demonstrate the relevance of these mechanisms to performance under natural conditions." They also pointed out that the strong evolutionary approach of this group was important in opening up comparative studies of the physiological behavior of closely related species from contrasting environments.

In addition to the article cited in this essay, those curious about physiological plant ecology will find much of interest in the chapter by W. D. Billings, "The Historical Development of Physiological Plant Ecology," in B. F. Chabot and H. A. Mooney, eds. *Physiological Ecology of North American Plant Communities*, Chapman & Hall, New York, pp. 1-15; and H. A. Mooney, "On the Road to Global Ecology," *Annual Review of Energy and the Environment* 24 (1999): 1-31.