WOMEN IN WETLANDS: ANTECEDENT AMERICAN FEMALE WETLAND SCIENTISTS

Arnold G. van der Valk, Professor Emeritus

Department of Ecology, Evolution, and Organismal Biology
Iowa State University, Ames, IA 50011
Email: valk@iastate.edu

ABSTRACT

The careers of seven women who obtained Ph.D. or Master's degrees between 1900 and 1920 and who published at least one paper on some topic related to wetland science are examined: Freda Detmers, Louise Dosdall, Minna Jewell, Emmeline Moore, Ann Haven Morgan, Gertrude Norton, and Laetitia Snow. Dosdall, Detmers, Norton, and Snow collectively published few papers, and they had little impact on the development of wetland science. However, Jewell, Moore, and Morgan all published important papers or books that significantly contributed to the development of wetland science. Minna Jewell wrote papers on the effects of acidity on freshwater biotas, the ecology of prairie wetlands, the impacts of groundwater inputs into lakes, and the freshwater sponges of Wisconsin. Emmeline Moore was an important fisheries biologist who worked most of her career in the Department of Conservation of New York State. Her pioneering work inspired many women to become fisheries biologists. Ann Haven Morgan, an expert on mayflies, wrote an influential book, *Field Book of Ponds and Streams: An Introduction to the Life of Fresh Water*, which enabled several generations of amateur naturalists to explore the biota of wetlands.

INTRODUCTION

While researching the history of wetland science, I encountered only a few papers or books written by women, with the notable exceptions being those by the English antecedent wetland scientist Agnes Arber (van der Valk 2023a). I became familiar with her work in graduate school in the late 1960s. Bronstein and Bolnick (2018) report that only 76 out of 2,889 papers, or 2.6%, published in *The American Naturalist* from 1867 to 1916 were authored by women, which is no surprise given the state of society at the time. They noted that their results were typical of natural history journals of the period. Nevertheless, Langenheim (1996), in her history of female ecologists in the United States, demonstrated that there were female antecedent wetland scientists in the early decades of the twentieth century. Surprisingly, she pointed out that a high percentage (50% or higher, depending on the institution) of doctoral degrees at midwestern universities from 1900 to 1920 had been granted to women. Two American women highlighted by Langenheim who worked on aquatic systems were Emmeline Moore and Minna Jewell. Were they the only ones?

I used three ways to identify other female American scientists who published scientific papers on any aspect of wetland science between 1890 and 1920. First, I examined the areas of specialization of the founding members of the Ecological Society of America. Then, I examined all papers published in the era's two most important scientific journals, *Plant World* (the forerunner of *Ecology*) and the *Botanical Gazette*, in which antecedent male wetland scientists published. Finally, I consulted three histories of women biologists: Bonta (1991), Bierman et al. (1997), and Creese (2000). My searches focused on identifying women who received their doctoral or highest degree before 1920 and published at least one paper on some aspect of wetland science.

Of the 307 founding members (284 charter members and 23 more elected in December 1916) of the Ecological Society of America (ESA Bulletin 1(3) 1917), about 7% of its founding members were women. Of those, only a few indicated an interest in some aspect of wetland science. These included Freda Detmers, assistant professor of botany at Ohio State University, who studies lake vegetation and bogs, and Laetitia Morris Snow, Associate Professor at Wellesley College, who is interested in water plants and aquatic insects. Some other women indicated an interest in wetlands, aquatic plants, insects, or animals but never published a scientific paper on any wetland topic. My examination of papers published in *Plant World* and the *Botanical Gazette* turned up only a small number of papers on wetland topics by other female authors: Frederica Marie Detmers, Louise Therese Dosdall, Emmeline Moore,

and Gertrude Parmelee Norton. The only person who was also a founding member of the Ecological Society was Frederica Marie Detmers. Ann Haven Morgan was the only person added from examining the three histories of female scientists consulted.

This paper briefly examines the professional careers of seven women and their contributions to wetland science: Freda Detmers, Louise Dosdall, Minna Jewell, Ann Haven Morgan, Emmeline Moore, Gertrude Norton, and Laetitia Snow. For each of them, I attempt to answer five questions. What is known about their early lives? Where did they do their undergraduate and graduate work? Who were their major professors? Where did they find jobs after leaving graduate school? What did they contribute to the development of wetland science?

FREDERICA MARIE DETMERS (1869-1934)

Frederica Marie Detmers. (Courtesy of The Ohio State University Archives)

Freda Detmers was born in Dixon, Illinois in 1867. Her father, Henry Detmers, founded the Veterinary College at Ohio State University (OSU). She received all her degrees from OSU including a BS in 1887 and an MS in 1891. Her MS thesis was on the rust fungi of Ohio. Her PhD dissertation in 1912 was entitled *An Ecological Study of Buckeye Lake: A Contribution to the Phytogeography of Ohio* and was supervised by Alfred Dachnowski, a leading early American wetland ecologist (van der Valk 2023b).

Detmers worked as a researcher for the Ohio Agricultural Experiment Station from 1880 to 1892. From 1893 to 1906, she taught high school in Columbus, Ohio, but returned to OSU in 1906 as an instructor in the Botany Department. In 1914, she was appointed an assistant professor and in 1918, she rejoined the Experiment Station as its assistant botanist specializing in plant taxonomy and systematics. However, much of her research was on plant diseases and weed science. Detmers moved to the University of Southern California, Los Angeles, in 1927 to curate its herbarium. In March 1930, she was seriously injured in a fall during a plant collecting trip. Freda Detmers died in 1934 in Los Angeles at the age of 67.

Although Detmers had a productive career as a botanist, her contributions to wetland science are limited and mostly of regional interest. After completing her PhD research on Buckeye Lake, she never again worked on wetlands. She published several papers based on her doctoral research, the most important of which is her study of the vegetation of Buckeye Lake (Detmers 1912). What distinguishes her study from most other studies of lake vegetation and its development is that Buckeye Lake is not a natural lake. It started as a reservoir created about 80 years earlier as part of a canal system. When the state took over the reservoir, it was renamed Buckeye Lake. However, before the construction of the reservoir, the low areas that flooded seasonally were wetlands. Buckeye Lake gave Detmers a unique opportunity to study succession over a known time interval.

Her 1912 paper describes the species composition of the vegetation types found in and around the lake and those of various islands, including a relict cranberry bog. The geographic origin of the lake's flora is discussed in some detail, but its successional patterns are not. In short, Detmers's study emphasized floristics and the distribution of plant species. This makes it like most other comparable studies of wetland vegetation at that time. Her paper has been cited 23 times (Google Scholar). But many of these citations are in papers dealing with the flora of Ohio or surrounding states.

LOUISE THERESE DOSDALL (1893-1958)

Louise Therese Dosdall. (Courtesy of Department of Plant Pathology, University of Minnesota)

Louise Dosdall obtained her PhD in plant pathology at the University of Minnesota in 1922. After receiving her PhD, she joined the Minnesota Plant Pathology Department as its mycologist. Despite many decades of service to her department and the university, Dosdall was never advanced above the rank of instructor. Using money from her estate, Minnesota belatedly recognized her contributions to science and the university by establishing the Louise Dosdall Fellowship for "women with promise in scientific careers."

Before switching to plant pathology, Ms. Dosdall obtained a Master of Arts degree in botany at Minnesota. Her MA thesis (1917) was entitled "Water requirement and adaptation in *Equisetum*." Her major professor was the renowned plant ecologist Frederic E. Clements, while William S. Cooper, another important early plant ecologist, was also on her thesis committee. Why she did not pursue a career in plant ecology is unknown. It may be because Clements left Minnesota in 1917 to take a research position with the Carnegie Institution of Washington. Dosdall published her MA thesis in two parts in *Plant World* in 1919 in its last volume.

The stated goal of her research was to "throw light upon the nature of bog xerophytes and successional relations of *Equisetum*." More specifically, it was to determine if *Equisetums* are xerophytes or not. "In the group of plants known as bog xerophytes many members, while superficially exhibiting xerophytic structures, also show characteristics of hydrophytes, namely, large air spaces and diaphragms. Moreover, these plants grow in the same habitat with true hydrophytes such as *Sagittaria*, *Ranunculus*, and *Caltha*… While the nature of the habitat has been subjected to much investigation, very little inquiry has been made as to the nature of the plants themselves. The purpose of this experimental study of *Equisetum*'s water requirements and adaptations was to determine whether this plant is a xerophyte as has been supposed, or whether it is truly a hydrophyte as its habitat suggests" (Dosdall 1919a). For more information about bog xerophytes and physiological drought, important topics in wetland ecology at the time, see van der Valk (2023b).

Her experimental approach compared *Equisetum* species' water use to that of other plants ranging from xerophytes to hydrophytes. These comparative experiments measured plant characteristics like time to wilting, transpiration rates, and growth under different soil moisture regimes. The results indicated that *Equisetum fluviatile* is a true hydrophyte, while *Equisetum arvense* and *Equisetum hyemale* are mesophytes. These results were consistent with the occurrence of these *Equisetum* species in seral stages.

According to Google Scholar, Dosdall (1919a) has been cited 11 times, starting in 1921 and most recently in 2014. However, Dosdall (1919b) has only been cited twice, in 2013 and 2014. This is hard to explain because Dosdall (1919b) contains most of her results and conclusions.

Although far from an ecological classic, Dosdall's papers did make a minor contribution to the debates about bog xerophytism/physiological drought that preoccupied many wetland ecologists in the early decades of the twentieth century. However, the impacts of her papers were minor because *Equisetums* were at the time not widely regarded as bog xerophytes, most of which were members of the Ericaceae.

MINNA ERNESTINE JEWELL (1892-1985)

Minna Ernestine Jewell. (Source: The Pike's Peak Nugget Vol. 14. 1913. Colorado College, Colorado Springs, CO)

Minna Jewell was born in 1892 on a farm near Irving, Kansas. She graduated from Irving High School in 1910 and then attended Colorado College, where she studied biology. After Jewell graduated from Colorado College in 1914 with an AB, she did graduate work at the University of Illinois. Jewell earned an AM in 1915 and her PhD in 1918. Victor E. Shelford, a pioneer animal ecologist, directed her doctoral research. Her dissertation was on the "Effects of the hydrogen ion concentration and oxygen content of water upon regeneration and metabolism in tadpoles."

Jewell's first job after completing her doctorate was with the Illinois Water Survey (1918-1920), but she quickly moved on to Milwaukee-Downer College, a women's college in Wisconsin, where she taught zoology. In 1923 and 1924, she was an assistant professor of zoology at Milwaukee-Downer and a zoology instructor at Kansas State Agricultural College (now Kansas State University). During the summers in the early 1920s, she was an instructor and researcher at the University of Michigan Biological Station. In late 1924, Jewell was promoted to assistant professor of zoology at Kansas State. She resigned from Kansas State in 1930 and moved to Thornton Junior College (now South Suburban College) in Harvey, Illinois. There she taught zoology and botany courses until her retirement in 1961. Over her four-decade-long career, Jewell studied aquatic systems in

Illinois, Kansas, Michigan, and Wisconsin, as well as tapeworms, amphibians, fishes, and sponges. She was a leading expert on freshwater sponges at the end of her career. Jewell conducted some of the first studies of groundwater inputs to lakes (Jewel 1927a), prairie aquatic systems (Jewell 1927b), and the biota of acidic aquatic systems (Jewell 1922; Jewell and Brown 1924).

Minna Jewell's most cited work (116 times according to Google Scholar) is "An ecological study of the fresh-water sponges of northeastern Wisconsin (Jewell 1935)." Beginning in 1931, she sampled 127 lakes and 17 streams and collected 1,389 sponge samples, including ten species not previously recorded in Wisconsin. This monograph is among the most influential papers on freshwater sponges ever published.

Her "Aquatic biology of the prairie" (Jewell 1927b) describes how extreme environmental fluctuations from floods to droughts influence the hydrology and chemical characteristics and, consequently, the biota of prairie streams, rivers, and lakes. This paper is a classic—it demonstrated how different prairie aquatic systems differed from the better-studied systems of the eastern United States and Europe. Jewell (1927b) ends her paper with a summary of the characteristics of the aquatic systems in the prairies of central and western Kansas. "The streams of the prairie differ from those of savannah and woodland in their swifter currents, greater fluctuations in water level, greater turbidity, and absence of humus or organic detritus from the bottom, which is usually of sand, gravel or clay. These factors give a sparse fauna because of the necessity of migration of many forms during the dry season, the uprooting of aquatic vegetation, the washing out of depositing organic matter, and the constant shifting of sand bottoms. Small permanent streams are few because springs are few, and only the larger streams have cut down to ground water level. Where they do occur, the ponds of spring fed streams are the most productive waters of the prairie. Of the bodies of standing water, the larger so called 'lakes' are subject to much greater wind action than the lakes of hilly or wooded areas. Since they are usually shallow the resulting wave action stirs up the bottom, resulting in increased turbidity, and may be a factor in preventing the growth of bottom vegetation. Of the smaller bodies of water, the prairie ponds or 'buffalo wallows' are usually temporary. In spring and fall these may teem with crustaceans especially phyllopods and ostracods, and with amphibious insects, although, in some localities, they are almost barren, due, apparently, to high salt content and alkalinity." For more information about Minna Jewell and her publications, see www.zotero.org/groups/4942703/minna_ernestine_jewell_bibliography.

EMMELINE MOORE (1872-1963)

Emmeline Moore. (Courtesy of the American Fisheries Society)

Emmeline Moore was born in 1872 and grew up on a farm in Batavia, NY. She graduated from Geneseo Normal School (now SUNY Geneseo) in 1895 and then taught there. Moore earned a BA from Cornell University in 1905 and an MA from Wellesley College in 1906. After her MA, she taught biology in normal schools in the United States for four years and botany for one year (1911) at Huguenot College in South Africa. After returning to the USA, Moore did her PhD at Cornell (1916). Her major professor was James G. Needham, an influential limnologist in the early years of the twentieth century. From 1914 to 1919, she taught biology at Vassar College during the academic year and worked at the Bureau of Fisheries during the summer.

In 1920, Moore was the first woman hired as a research biologist by the New York State Conservation Department. She became its chief aquatic biologist and then director of the New York State Biological Survey in 1932. While working for the Conservation Department, she studied rivers, lake pollution, and fish diseases and assessed watersheds with her staff. Moore conducted surveys of aquatic biota in relation to water chemistry, hydrology, and the presence of pollutants in New York waters. Moore was the first woman to be elected President of the American Fisheries Society (1927-1928). After her retirement, she continued research at the Laboratory of Oceanography at Yale University. The American Fisheries Society established the Emmeline Moore Prize to recognize members committed to promoting diversity and greater involvement of underrepresented groups in fisheries education, research, and management. For a more complete account of Ms. Moore's life and scientific career, see Zatkos et al. (2020).

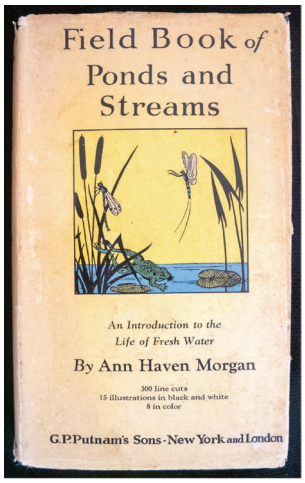
Moore's most important early work (1915) was "The *Potamogetons* in relation to pond culture." Based on her PhD dissertation, it describes "the natural and

artificial propagation of the *Potamogetons* as will render cultural methods economical and practical." Besides describing their reproduction and spread by tubers, winter buds, rhizomes, plant fragments, and seeds, it also has sections on the propagation of seeds, vegetative propagules, and animals associated with *Potamogetons*. Moore (1915) has been cited 49 times (Google Scholar); it is her most cited publication.

ANN HAVEN MORGAN (1882-1966)

Ann Haven Morgan. (Courtesy of Wikipedia: wikipedia.org/wiki/Ann_Haven_Morgan)

Ann Haven Morgan was born in Waterford, Connecticut. She started undergraduate work in 1902 at Wellesley College but transferred to Cornell University where she received a BA in 1906. After graduation, she worked until 1909 as an instructor at Mount Holyoke College in its Zoology Department. Morgan then returned to Cornell University and obtained her PhD in 1912. Her dissertation is titled "A Contribution to the Biology of the May-flies." Her major professor was James G. Needham, who was also Emmeline Moore's major professor. Morgan returned to the Zoology Department at Mount Holyoke College and was promoted to associate professor in 1914 and full professor in 1918. From 1916 until her retirement in 1947, she served as the chair of the department. During summers, she also taught marine zoology at the Woods Hole Marine Biological Laboratory. For additional information about Ann Haven Morgan, see Alexander (1967) and Wurtzburg (1997).



Field Book of Ponds and Stream by Ann Haven Morgan (1930).

Morgan was an expert on mayflies but also wrote papers and books on various other topics including animals in winter and kinship. Her most influential publication was her *Field Book of Ponds and Streams: An Introduction to the Life of Fresh Water* (Morgan 1930). According to Morgan, "I hope that it may help toward wider enjoyment and further acquaintance in the field of water biology that offers abundant opportunity to all explorers, both beginners and seasoned investigators." The book contains 19 chapters. The first two introduce aquatic organisms and the environments in which they are found. The third deals with collecting and preserving aquatic animals. The remaining 16 chapters describe all major groups of plants and animals found in streams, lakes, and wetlands. There are numerous illustrations, mostly line drawings and some photographs. Her book did much to acquaint Americans with aquatic systems for a couple of generations and to turn many of them into avid naturalists and conservationists. In short, Morgan's goal for the book was realized.

NOTE: Kathleen Carpenter's (1928) *Life in Inland Waters* was published two years before Morgan's book. Carpenter (1891–1970) was a British aquatic ecologist best known for her studies of heavy metal contamination of British streams. Her book is widely regarded as the first limnology textbook. Consequently, Carpenter has been called the "mother" of limnology. Carpenter worked in the United States during the 1930s.

GERTRUDE PARMELEE NORTON (1875-1920)

Very little is known about the life and professional career of Gertrude Norton. She was born in or around Syracuse, New York in 1875 and attended Syracuse University. Around 1900 she moved with her sister to East Helena, Montana, where she taught school. During the summers starting in 1903, she worked as a guide in Glacier National Park. In 1905, she became associated with Flathead Lake Biological Station of the University of Montana, at least during the summers. In the 1905 Bulletin of the Station (Anonymous 1905), Norton is listed as an instructor in charge of nature studies and artist. In the 1917 Bulletin (Anonymous 1917), she is listed as the instructor for Elementary and Field Botany and Systematic Botany. Norton was also a plant collector and botanical illustrator. In her honor, a species of plant was named after her by Marcus Jones (1910) in his Montana Botanical Notes, *Hypericum Nortonae* (Miss Norton's St. John's Wort), and she did the illustrations for his publication. Norton eventually moved to Utah, but nothing is known about her life there. She died in Salt Lake City in 1920. According to a brief notice in *Science* in 1921, Norton's plant collection of about 1,000 specimens was acquired by her alma mater, Syracuse University.

In 1919, Gertrude Norton published her only scientific paper, "Shore vegetation of Flathead Lake, Montana." She died the following year. Her paper appeared in the last issue of *Plant World*, which became *Ecology* the following year. The focus of Norton's paper is plant succession. Why did Norton, who had worked as a plant collector, botanical illustrator, and plant taxonomy teacher, become interested in plant ecology? Most of her shoreline succession paper's fieldwork was done in 1916 when Frederic E. Clements published *Plant Succession*. *Plant Succession* was one of the most important ecological publications of the first half of the twentieth century. Norton does not cite Clements or any other author in her paper. By 1916, however, succession had become the principle organizing concept in vegetation studies. The concept of succession appeared to explain the relationships between plant assemblages and environmental conditions and how these assemblages changed in composition with time. Many papers dealing with the vegetation of an area used the concept of succession to make sense of patterns observed in the local vegetation, for example, W. S. Cooper's (1916) paper on succession in the Mount Robson region of British Columbia, which was also published in *Plant World*.

In her 1919 paper, Norton describes four successional sequences around Flathead Lake: two xerophytic (rock shore and stony beach) and two hydrophytic (swamp meadow and delta swamp). The only data presented are lists of plant species observed at sites around the lake. She claims that "the same kind of climax forest results from either [xerophytic or hydrohytic successions]." She provides no convincing evidence to support this conclusion. This concept of convergent succession is pure Clementsian dogma. Norton's assumption that all successional sequences around Flathead Lake would end in the same climax formation suggests she was familiar with his Plant Succession.

Norton notes at the beginning of her paper that Flathead Lake undergoes significant seasonal water level fluctuations: "For the entire season the difference between high and low water mark was 160 in." That is over 13 feet! Norton goes on to say, "From the record of this season [1916], it can be seen that the shore plants had no chance to begin growing until midsummer. Some were killed from remaining too long under water. Every high-water year, many acres of low-lying meadow and swamp-thicket are submerged." Surprisingly, the effects of these extraordinary water level fluctuations on shoreline succession were ignored by Norton. The importance of large annual and interannual water level fluctuations on lake shore vegetation was later studied in detail by another early female plant ecologist, Jennifer Walker (1959, 1966), in the Delta Marsh in Manitoba, Canada.

Norton's 1919 paper has been completely ignored. In the more than 100 years since its publication, according to Google Scholar, it has been cited only once in a book on Flathead Lake. Why was it ignored? Norton never published another wetland paper because of her early death at 45. Consequently, she never established herself as a wetland expert, as her male contemporaries like George Rigg and Alfred Dachnowski did (van der Valk 2023b). Norton worked in Montana, far from major American centers of ecological activity in the Midwest and East and West coasts. She had the misfortune to publish in the last issue of a journal. If she had published a year later in the first volume of *Ecology*, would her paper have become better known? Perhaps most importantly, her paper broke no new ground scientifically and was one of many similarly forgotten papers in the early twentieth century describing local successional sequences in a Clementsian framework.

LAETITIA MORRIS SNOW (1874-1972)

Laetitia Morris Snow. From the 1905 edition of The Virginian, Longwood University. (Courtesy of Wikidata: www.wikidata.org/wiki/Q98822422)

Laetitia Snow received an AB from Goucher College in 1895 and a PhD from the University of Chicago in 1904. Her dissertation examined how various physical, chemical, and other factors affected root hair development. Her major professor was one of the leading plant ecologists of the day, Henry C. Cowles. After receiving her doctorate, Ms. Snow taught at the State Normal School (now Longwood University), Farmville, VA, from 1904 to 1908. She moved to Wellesley College in 1911, beginning as an instructor. She also spent time at the University of Chicago and Woods Hole Marine Biological Laboratory.

Although her best-known work is on the development of root hairs in crop plants (Snow 1905), she also

published a significant paper on the anatomy of *Scirpus validus* (Snow 1914). Her paper deals with the functional significance of diaphragms in aquatic plants. She reviews previously proposed theories about the role of diaphragms and reports on her morphological studies, primarily of *Scirpus validus*. She concludes that diaphragms are a characteristic feature of aquatic and wetland plants and that "Diaphragms have the following functions: (a) to resist strains and keep the spaces open; (b) to support cross-bundles; (c) to prevent entrance of water by the small size of the perforation; (d) perforations permit air to circulate; (e) while young and green, to manufacture carbohydrates; (f) to store food …; (g) to conduct food materials from the crossbundle to the partition walls of the space." This paper has been cited 27 times (Google Scholar). In 1920, Snow published a follow-up paper that describes some experiments (water versus air, temperatures, atmospheric pressures) to determine what controls the growth and distance between diaphragms of *Scirpus validus*. As she admits, her results were sometimes contradictory, and that the experiments needed to be repeated to resolve these uncertainties. Unfortunately, she did not do additional studies on the *Scirpus validus* or any other aquatic plant. This study has been cited only three times.

Earlier, Snow had published a 1902 study on the ecology of lake drift lines. During the spring of 1902, she collected drift-line samples from the shore of Lake Michigan in the Chicago area. She realized they were "[a] little community of food providers and food obtainers." Her paper focuses on the food obtainers, specifically the invertebrates in these drift lines. Although she could not identify many of them, she recorded 114 species, which included herbivores, predators, and scavengers. The exact composition of the drift-line fauna depended on many factors, including beach conditions, water temperatures, and the amount of live and dead material in the drift line. Snow's post-1920 work is mainly on soil bacteria.

Snow had a successful career as an academic at Wellesley College. Over four decades, like many early biologists, she published on various topics including shorelines, plant morphology, microbiology, and invertebrate zoology. Her impact on the development of wetland science is limited but of interest to plant ecologists studying emergent wetland plants.

DISCUSSION

I was pleasantly surprised to discover that women had begun researching wetlands in the early part of the twentieth century. Why had I been unaware of them? There were two main reasons: (1) disciplinary bias and (2) in most cases, the limited impact of their publications. I was trained as a plant ecologist. My research has focused on wetland plants and plant communities. Consequently, I have paid little attention to wetland papers that did not deal with plants. This bias largely explains why I was unaware of the work of zoologists like Minna Jewell, Emmeline Moore, and Ann Morgan. It is incredibly embarrassing that I was unaware of Minna Jewell's overview paper on the aquatic systems of the prairies of Kansas. After all, much of my research was in the prairie region. The lack of impact of the publications of the others (Detmers, Dosdall, Norton, and Snow) is due primarily to the limited number and scope of their wetland papers.

When I began graduate school, I was told that to be considered an expert in a field, you had to publish five or more papers. Although this criterion has the apparent problem of favoring quantity over quality, it does have the advantage of simplicity. Three women meet this criterion: Minna Jewell, Emmeline Moore, and Ann Morgan. Detmers and Norton published only one, Dosdall two, and Snow four. These women never established themselves as leaders in the newly developing field of wetland science.

Which of the more prolific women had the most significant effect on the development of wetland science? The two standouts are Ann Morgan and Minna Jewell. Morgan introduced many people to wetlands and other aquatic systems through her 1930 book, *Field Book of Ponds and Streams: An Introduction to the Life of Fresh Water.* In her 1927 overview paper, "Aquatic Biology of the Prairie," Minna Jewell demonstrated that aquatic systems existed that differed from those of the more humid Eastern United States and Northern Europe. In other words, she expanded the scope of wetland science. However, neither influenced the development of wetland science as much as some of their male contemporaries like Stephen A. Forbes (van der Valk 2018). According to Google Scholar, his paper "The lake as a Microcosm" (Forbes 1925) has been cited nearly 900 times.

Except for Gertrude Norton about whose graduate education, if any, nothing is known, the other women

all studied in prestigious graduate programs at major universities (Chicago, Cornell, Illinois, Minnesota, and Ohio State). As Langenheim (1996) pointed out, women had access to graduate programs in the ecological sciences, especially at Midwestern universities. These women's major professors were internationally renowned scientists in their fields: Freda Detmers at Ohio State with Paul Dachnowski, Louise Dosdall at Minnesota with Frederic E. Clements, Minna Jewell at Illinois with Victor E. Shelford, Emmeline Moore and Ann Morgan at Cornell with James G. Needham, and Laetitia Snow at Chicago with Henry C. Cowles. Detmers, Dosdall, Jewell, Moore, Morgan, and Snow held academic positions at prestigious colleges or universities for part or all their careers. However, Dosdall changed fields after her master's degree and became a plant pathologist, and Detmers, Jewell, and Snow stopped publishing on wetland topics shortly after receiving their doctoral degrees. Emmeline Moore, the only one who continued to publish on aquatic systems over her entire career, spent most of it working for the New York State Conservation Department. Her visible and successful career as a fisheries biologist inspired many women to become aquatic biologists. It is unclear how Gertrude Norton made a living, except that she did work during the summers at the Flathead Lake Biological Station. None of these women appear to have graduate students working in wetlands. This also limited their influence on the subsequent development of wetland science. However, two of them have become important role models for beginning female graduate students as borne out by awards in their names: Dosdall at the University of Minnesota and Moore through the American Fisheries Society.

Two types of institutions played an essential role in the education and careers of many of these scientists: women's colleges (Goucher, Mount Holyoke, Wellesley, and Vassar) and biological field stations (University of Michigan Biological Station, University of Montana Flathead Lake Biological Station, Trout Lake Biological Station, and Woods Hole Marine Biological Station). The importance of the former is self-evident. Women's colleges provided these women a path to higher education and scientific careers. Biological field stations provided them with summer jobs, a safe place to live, a base from which to do fieldwork, and opportunities to interact with like-minded colleagues from other institutions. For example, Minna Jewell, who was teaching at a junior college, did the fieldwork for her monograph on freshwater sponges (Jewell 1935) at Trout Lake Biological Station. "It is doubtful whether any place in the world could be found better adapted to a study of the ecology of the *Spontgillidae* than the Wisconsin State Biological Survey headquarters on Trout Lake. In Vilas County alone there are approximately eight hundred lakes and ponds, most of which have been mapped and are readily accessible. As a result of the extensive investigations of Drs. Birge and Juday with their corps of able assistants, one or more complete physical and chemical analyses has now been made of the waters of each of the larger and many of the smaller lakes. All of these data, unpublished as well as published, were most generously placed at the author's disposal" (Jewell 1935). She also describes the help the students and staff at Trout Lake provided with boat handling, sampling gear, bringing in specimens, and microphotography.

Like Agnes Arber in England (van der Valk 2023a), these pioneering women undoubtedly had a difficult time in male-dominated science and, for some of them, at male-dominated institutions. We know little about their struggles for acceptance, recognition, and respect except for those of Louise Dosdall whose promotion at Minnesota was repeatedly blocked by her male colleagues. Given the biases and limited opportunities in science for women in the early twentieth century (Bonta 1991; Langenheim 1996; Grinstein et al. 1997), it is not surprising that there were so few female antecedent wetland scientists. I found it surprising that there were so many.

In this paper, I have ignored women and women's organizations involved in conserving wetlands. However, I have previously described the crucial role of a few women in the struggle to preserve The Everglades and to establish Everglades National Park (van der Valk 2022). Nevertheless, many more such examples need to be better documented. Many women who received postgraduate degrees during the early twentieth century spent their careers teaching in high schools, normal schools, community colleges, or women's colleges (Langenheim 1996). Undoubtedly, they introduced many students to wetlands and other ecosystems in their classrooms and laboratories and increased wetland visibility among the general public. Unfortunately, their contributions to the development of wetland science are impossible to document.

AUTHOR DECLARATION

This is an original work that has not been previously published. Citations are given for quotations from published sources. Sources for all images are also given in figure legends.

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