Bog Men: Alfred P. Dachnowski and George B. Rigg

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ABSTRACT

Alfred P. Dachnowski and George B. Rigg were the foremost peatland scientists in the United States during the first half of the 20th century. Although trained as a botanist, Alfred Dachnowski (1875–1949) became an expert on peat soils, including their development, classification, and chemical characteristics. His early research focused on "bog toxins" and how they affected plant growth. After being forced to resign from Ohio State University, he worked for the U.S. Department of Agriculture for the remainder of his professional career. Dachnowski developed several peat soil classifications and published the first comprehensive account of peat deposits in the United States. George B. Rigg (1872-1961), who also was trained as a botanist, spent his entire professional career at the University of Washington. He became an authority on the ecology, development, and distribution of Sphagnum peat bogs and published two major monographs. Early in his career, he also wrote a review on the prevalent theory of "physiological drought" as the cause of the xeromorphic characteristics of some bog plants. However, most of his research focused on bog development (stratigraphy) and how the chemical and physical (air and soil temperature) environment affected the distribution of bog plants.

INTRODUCTION

In areas where they are abundant, like the British Isles and northern Europe, peatlands have been studied since the Middle Ages because they impacted settlement, travel, farming, etc., and because peat was used as fuel. Gorham (1953) examined the literature on peatlands in the British Isles and found detailed descriptions of peatlands as early as the 16th Century. Because of the economic importance of peatlands and peat, large-scale studies of peat deposits were done in Scotland in the early 19th century. One of the most important and impressive of these was Rennie's two-volume (1807, 1810) - *Essays on the Natural History of and Origin of Peat Moss*. This work contains an exhaustive account of peat and peat bogs in Scotland (Rennie 1807 is 233 pages, while Rennie 1810 is 665). His 1810 book's subtitle is a mouthful: "The peculiar qualities of that substance; the means of improving it as a soil; the methods of converting it into a manure; and other economical purposes to which it may be made subservient." A major motivation for Rennie's work was determining the feasibility of converting peatland to farmland. In other words, those scientists who studied peatlands centuries ago were the first antecedent wetland scientists (with Rennie foremost among them).

In North America, scientific studies of peatlands began appearing in the late 19th and early 20th century: Ganong (1891) in New Brunswick, Canada; Transeau (1903) in North America; Transeau (1905a, b, 1906) in Michigan; Davis (1907) in Michigan; Bastin and Davis (1909) in Maine; Dachnowski (1912a) in Ohio; Rigg (1914, 1919) in Alaska; and Rigg (1918) in Washington. In this paper, I examine the works of two of the most important early American peatland scientists, Alfred P. Dachnowski and George B. Rigg. Their publications on peatlands are among the most important scientific papers on wetlands in the first half of the 20th Century in the United States. Their research made their fellow scientists aware of the extent and value of American peatlands and peats. Although they were not the first American scientists to study peatlands, they were among the first to devote most of their careers to peatlands. They published papers on the composition and distribution of peatland vegetation, the origin of peats (stratigraphy, succession), and peatland's chemical and physical environments. Early in their careers, they were involved in the two most controversial topics in peatland science: 1) the ecological and agricultural significance of toxins in peat water and 2) the related debate about "physiological drought" and the xeromorphic characteristics of some bog vascular plants.

ALFRED PAUL DACHNOWSKI (1875–1949)

Alfred Paul Dachnowski (Figure 1) was born in Konigshutte, Germany, and attended universities in Berlin (1900-1901) and Vienna (1902) before coming to the United States. He received his Ph.D. in plant physiology from the University of Michigan in 1906. His dissertation was on the physiology of the liverwort *Marchantia polymorpha* L. While at Michigan, Dachnowski met Charles A. Davis (1861-1916). Davis, a botanist and geologist, studied the origin, uses, and distribution of peats in Michigan (Landa and Cohen 2011). Dachnowski presumably also interacted at Michigan with a fellow doctoral student, Edgar N. Transeau (1875-1960), who did his Ph.D. dissertation (1904) on the bogs of the Huron River Valley.

In 1908, Dachnowski was appointed a substitute assistant professor in the Botany Department at Ohio

Figure 1. Alfred P. Dachnowski-Stokes with two soil profiles. (Courtesy of the Smithsonian Institution Archives)

State University (OSU) and a regular assistant professor the following year. While at OSU (1908-1914), he was primarily associated with the Ohio Geological Survey (1909 to 1912) as a botanist and became its peat expert. In 1914, Dachnowski was one of the founding members of the Ecological Society of America (Burgess 1977).

Dachnowski's career at OSU ended abruptly in 1914 because he had a fistfight with another faculty member who ran the Botany greenhouse. Dachnowski believed that some of his experiments had not been properly looked after in the greenhouse and, as a result, his experiments had failed. In those days, university administrations did not tolerate faculty fistfights, and Dachnowski was asked to resign (Landa and Cohen 2011). After leaving OSU, he took a position in 1915 with the United States Department of Agriculture (USDA) in Washington, DC, and remained with the USDA until his retirement in 1942, mostly in its Bureau of Chemistry and Soils.

Alfred P. Dachnowski also called himself Alfred P. Dachnowski-Stokes. In 1913, Dachnowski married Margaret Stokes Finney, who was an art instructor at OSU. Why he added Stokes rather than Finney to his surname is unknown (Landa and Cohen 2011). In any case, he only did this more than a decade after his marriage. To keep things simple and consistent, I will refer to him in the text as Dachnoswki, except for citations of papers he published as Dachnowski-Stokes. When I began researching this paper, I was uncertain if Dachnoswki and Dachnowki-Stokes were the same person.

PEAT AND PEATLAND STUDIES

From 1909 to 1912, Dachnowski worked on a study of Ohio's peat resources, published as *Peat Deposits of Ohio: Their Origin, Formation and Use*s (Dachnowski 1912a). In this report, he integrated geology, soils, and botany. Dachnowski had what today would be called an earth science perspective on peatlands rather than a geological or ecological one. "Among the fundamental problems in Geology is … the origin as well as the nature of soil. But the origin of soil, though a geologic question, can often be approached only by the methods which the botanist employs, while the consideration of its nature, its productivity, and rational treatment, … are very largely within the domain of botany and that of its more practical aspect, agriculture" (Dachnowski 1912a). Peat soils would become the focus of Dachnowki's career.

The 1912 Ohio report is wide in scope and ranges from the stratigraphy of peat deposits (Figure 2) to the culturing of microorganisms found in bog soils. The report was modeled on the 1907 report of peat deposits in Michigan by Charles A. Davis, and Davis even contributed a chapter to the Ohio report on the uses of peat. About 25% of the report describes peat deposits in Ohio counties. Other chapters deal with the development of peat deposits, historical peat (coal) deposits, succession, factors controlling peat formation, and the effects of peat soils on plant growth. The Ohio report made Dachnowski one of the few peat specialists in the United States. When Davis died in 1916,

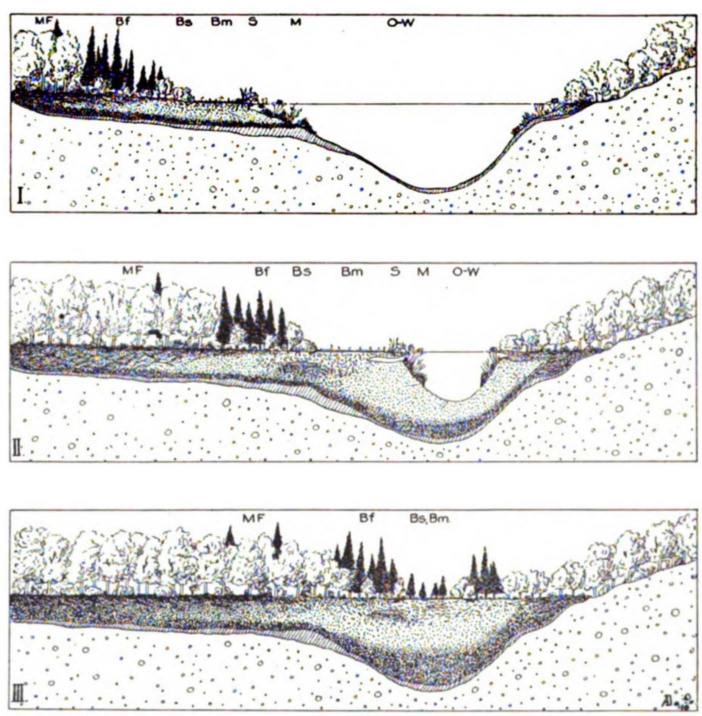

Figure 2. Stages in the formation of a peat deposit. Dachnowski recognized that multiple successional pathways occurred in different places in a basin: O-W – Open water succession, M – Marginal succession, S – Shore succession, B – Bog successions (Bm – Bog meadow, Bs – Bog shrub, and Bf – Bog forest), and MF – Mesophytic forest succession. (Source: Dachnowski 1912a)

Dachnowski, who was then working for the USDA, became *the* peat specialist in American federal agencies.

BOG TOXINS

Toxins were an important topic in American soil science in the early 20th Century (Landa and Cohen 2011). In 1908, Franklin H. King, who had previously worked for the USDA but by then was at the University of Wisconsin, published a paper in *Science* critical of the claim by scientists at the USDA that soil toxins were primarily responsible for low crop production. While still at OSU, Dachnowski published papers on the effects of bog water and soils on plant growth (Dachnowski 1908, 1909, 1912b). "This question has an added interest just now because … the sterility of unproductive and "exhausted" agricultural soils may partly be caused by some toxic substance of a similar physiological and chemical origin …. The data obtained from various lines of experiments all go to prove that "exhaustion" cannot always be attributed to the removal of plant nutrients from the soil by previous crops or by previous plant societies. … the results thus far obtained point strongly to the view that decreased physiological activity of plants lies rather in the toxic condition of the soil (Dachnowski 1909)." Dachnowski's experimental work on bog toxins and their effect on plant growth was a major reason the USDA hired him (Landa and Cohen 2011).

Dachnowski's (1909) experimental studies of wheat growth in bog water solutions from which toxins were removed to various degrees (Figure 3) showed that bog water adversely affected wheat growth. Some comparable studies around this time showed similar results (e.g., Rigg 1913). Although the term had yet to be coined, Dachnowski and Rigg were studying what is now called allelopathy — chemical interactions among plants (Willis 2007). This term entered the ecological literature only in the early 1970s (Whittaker and Feeny 1971). The significance of allelopathy in peatlands is still an area of active research, and experiments comparable to those done by Dachnowski and Rigg continue to be done (Chiapusio et al. 2013). The major advance in later peatland allelopathic studies is improved knowledge of the chemistry of bog waters. Today, phenolics released by *Sphagnum* are believed to be responsible for the adverse effects of bog water on both plant growth and seed germination (Verhoeven and Liefveld 1997; Chiapusio et al. 2013).

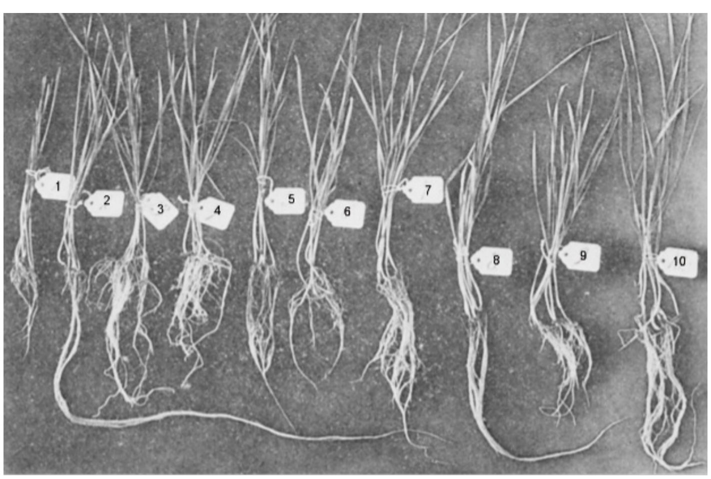

Figure 3. Growth of wheat seedlings in bog water, filtered bog water, and soils contaminated with bog water. From left to right, the treatments are 1. Bog water untreated, 2. Bog water quartz-filtered, 3. Bog water clay-filtered, 4. Bog water humus-filtered, 5. Contaminated quartz soil, 6. Contaminated clay soil, 7. Contaminated humus soil, 8. Control quartz soil. 9. Control clay soil, and 10. Control humus soil. (Source: Dachnowski 1909)

SOIL CLASSIFICATION

Because there was no classification system for peat soils, they were a problem for early American soil scientists, especially those working on soil surveys. Dachnowski's most important contributions to peatland science were his various peat classifications. Initially, Dachnowski classified peat based on its botanical composition and physical and chemical characteristics (Dachnowski 1919). This early peat classification had four main groups: aquatic, marsh, bog, and swamp. The aquatic group was subdivided by the degree of decomposition of organic matter into macerated, colloidal, and dopplerite (amorphous or jelly-like) types. The other groups were subdivided by dominant vegetation type. In his 1933 monograph on American peatlands in Volume 7 of the *Handbuch der Moorkunde*, he outlined a new classification system whose main groupings are based on dominant environmental conditions (climate, vegetation, and topography). Its subdivisions are based on the developmental and morphological features of peat profiles, the degree of peat decomposition, and other characteristics of peats. His 1933 monograph was also important because it summarized field studies of peatlands from Alaska to Florida. Its maps and tables provided one of the first estimates of the magnitude of wetland resources in the United States. After his 1933 monograph on the peatlands of the United States, Dachnowski continued to publish papers on the peatland resources, on those of the Pacific Coast States (1930a, 1936) and of Alaska (1941).

In 1935, he published another peatland classification that had three major soil fertility/zonal groups (Dachnowski-Stokes 1935a): Oligotrophic/Northern group (moss peat and muck), Mesotrophic/Central group (woody and fibrous peat and muck), and Eutrophic/Southern and Western groups (fibrous peat and muck) (Figure 4). Each zonal group had two or more major geographic divisions, each with multiple subdivisions.

VALUES OF PEATLANDS

In *Scientific American* in 1922, Dachnowski published a one-page paper, *A Question in National Resources*. In it, he argued that peatlands are an important natural resource

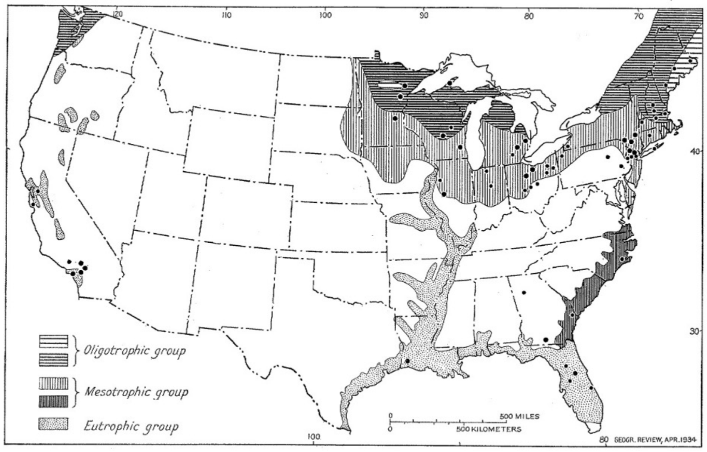

Figure 4. Areas in the United States with Oligotrophic, Mesotrophic, and Eutropic peatlands. (Source: Dachnowski-Stokes 1934)

for the United States that can be used in agriculture (crop production, dairying) and as a source of energy for industry. However, he points out that effective peatland exploitation must be based on a sound scientific foundation. There are different kinds of peatlands, and farmers and industrialists must understand the most appropriate use of each type (Dachnowski 1919; 1920; Dachnowski-Stokes 1926). If this is not considered, much time and money will be wasted trying to exploit unsuitable peatlands. To facilitate the rational and cost-effective exploitation of peatlands, Dachnowski proposed the establishment of a Central Station for Peat and Muck Investigations. "A national institution for peat investigations is the right place to undertake this work, to sift the information, and to use it properly for the benefit of all. It would remove a vast amount of duplication by many states and private agencies now gathering uncoordinated data, and it would result in a saving of public funds and of needless expense (Dachnowski 1922)."

Dachnowski worked for the U. S. Department of Agriculture, and part of his job was to promote the utilization of peat and peatlands. Thus, it is unsurprising that he was a proponent of converting peatlands to agricultural and industrial uses. "These areas represent not only the last unused natural resources of the country in both land and raw material, but the prosperity and well-being, the maintenance of many rural communities in states having a large acreage of peat deposits depends upon the possibility, of increasing the usefulness of these "waste" land areas" (Dachnowski 1922). Not once in this paper does he propose the conservation or preservation of peatlands or mention their biological or ecological significance and importance as natural areas. Perhaps fortunately, Dachnowski's "Central Station" was never established, but his proposal was an effort to establish formal institutional support for developing peatland science. Other efforts to establish institutional support for the fledgling aquatic sciences in the 1920s were successful, for example, the establishment in 1929 of the Freshwater Biological Association in England (van der Valk 2023).

In a short notice in *Science* in 1927, Dachnowski announced that "an international organization for the study of peatlands (*Moorforschung*) has been formed as a sub-commission of Commission VI of the International Society of Soil Science [now the International Union of Soil Scientists]." Besides promoting international cooperation among peat scientists, its other main mission was to "coordinate and develop, in cooperation with governmental, state and private agencies such research and uniformity of methods in laboratory and field practices as are deemed in the interest of the fullest investigation, utilization and protection of peatland resources." This second objective echoes many of the objectives of Dachnowski's previously proposed U. S. Central Station for Peat and Muck Investigations. Dachnowski was the first chairman of this new international organization. He promoted the next meeting of the Peat Soil Sub-commission, as he now called it, at the Second International Congress of Soil Sciences held in Russia in June 1930 with notices in *The New Phytologist* (Dachnowki-Stokes 1929) and *Journal of Ecology* (Dachnowski-Stokes 1930b). The latter was published in August 1930, months after the Congress. Dachnowski's new international peatland organization was greatly reduced in scope by its first meeting to a Peat Soil Sub-commission. I have not found any evidence that this Sub-commission significantly impacted the development of American peatland science. Nevertheless, Dachnowski was among the first to recognize the need for an international society devoted to peatland research, management, and conservation. It was not until 1968, nearly 20 years after his death, that such a society was founded, the International Peatland Society.

Throughout his career, Dachnowski wrote papers demonstrating the economic and societal importance of peatlands: for understanding climate change — "Peat deposits and their evidence of climatic changes" Dachnowski (1921); for water conservation and flood control — "Peat land as a conserver of rainfall and water supplies" Dachnowski-Stokes (1935b) and "Peat Land in the service of flood control and water conservation" (Dachnowski-Stokes 1937)); and for wildlife — "Improvement of unproductive and abandoned peatland for wildlife and related uses" Dachnowski-Stokes (1939). His studies in the Everglades were among the first to demonstrate the dramatic impacts of drainage and fires on the rate of peat oxidation — "The stratigraphic features of the 'Upper' Everglades and correlation with environmental changes" DachnowskiStokes (1930c). He also wrote about the commercial uses of peat and drained peatlands for agriculture — "Peat-land utilization" Dachnowski-Stokes (1934). In the latter half of his career, Dachnowski began to recognize and publicize the ecological and societal value of peatlands.

SUMMARY

Dachnowski combined his botanical training with concepts from ecology, geology, and soil science in his studies of peats and peatlands. In the early 20th Century, he was one of the most prominent and prolific American scientists studying these wetlands. Early in his career, Dachnowski pioneered the study of allelopathy in wetlands. However, his most lasting contributions were his peat classification systems and his inventory of American peat resources. His peat classifications emphasized that different kinds of peats had very different chemical and physical properties. Dachnowski also documented peatlands' economic values (hydrologic, wildlife, agricultural, and industrial). He also was among the first to recognize the need to develop institutional support for peatland science, but his two attempts to establish peatland organizations had only limited success. Today, he is remembered more for contributing to soil science than wetland science, yet among wetlanders he may be most recognized for his presentation of bog or hydrarch succession (Figure 2). His research greatly raised the visibility of peatlands within the scientific community and, to a more limited extent, outside of it.

GEORGE BURTON RIGG (1872-1961)

George Burton Rigg (Figure 5) was born in 1872 near Woodbine, IA. He grew up on a farm and developed an interest in plants in high school. Rigg received a B.S. from the University of Iowa in 1896 and then worked ten years in Iowa high schools. Through his contacts at Iowa, he became acquainted with the new discipline of ecology as presented in Warming's (1896) plant ecology textbook. Rigg received an M.A. with a major in botany and a minor in chemistry from the University of Washington in 1909 and a Ph.D. from the University of Chicago in 1914. At Chicago, he was influenced by the pioneering plant ecologist Henry C. Cowles' succession studies and the plant physiologist William Crocker. Rigg's entire academic career (1909–1947) was spent as a faculty member at the University of Washington. He had two research specialties, the ecology of *Sphagnum* bogs and Pacific kelp. Only his work on bogs will be considered here. Rigg began his field research in 1908 on the peat bogs of the Puget Sound region. He eventually studied bogs in Alaska, British Columbia, Minnesota, Ohio, New England, and West Virginia. His bog studies focused on the development of *Sphagnum* bogs, that is, their stratigraphy and the physiology of bog plants (Anonymous 1956, Hansen 1962). He was named the Ecological Society of America's eminent ecologist in 1956.

SPHAGNUM BOGS

Not all peatlands are *Sphagnum* bogs. According to Rigg (1916a), *Sphagnum* bogs have a surface layer (acrotelm) of living *Sphagnum* species, under which is a brown peat layer or layers composed mainly or entirely of partially decomposed Sphagnum plants. A second feature is their water has an acidic pH. A third is the prevalence of Ericaceous shrubs. *Sphagnum* species have characteristics that are fundamental for understanding the ecology of peat bogs: 1) they create a wet, acidic, nutrient-poor, and anoxic organic substrate, 2) they tolerate and may even require low nutrient and dissolved mineral concentrations, 3) their litter decays slowly, and 4) different *Sphagnum* species occupy distinct zones in bogs, depending on water levels, pH, and light levels (Verhoeven and Liefveld 1997). Several classes of organic chemicals found in Sphagnums affect the ecology of peat bogs. Uronic acids, a major constituent of *Sphagnum* cell walls, have a high cation exchange capacity and release hydrogen ions to and take up cations from bog water. Because they inhibit microbial growth, phenols, which are also associated with *Sphagnum* cell walls, are one reason for the slow decomposition rates of bog organisms. As noted previously, when released into bog water, phenols have been shown to have allelopathic properties and can inhibit the growth of vascular plants and reduce their seed germination (Verhoeven and Liefveld 1997; Chiapusio et al. 2013). For a recent overview of the role of *Sphagnum* in bogs, see Rydin et al. (2006).

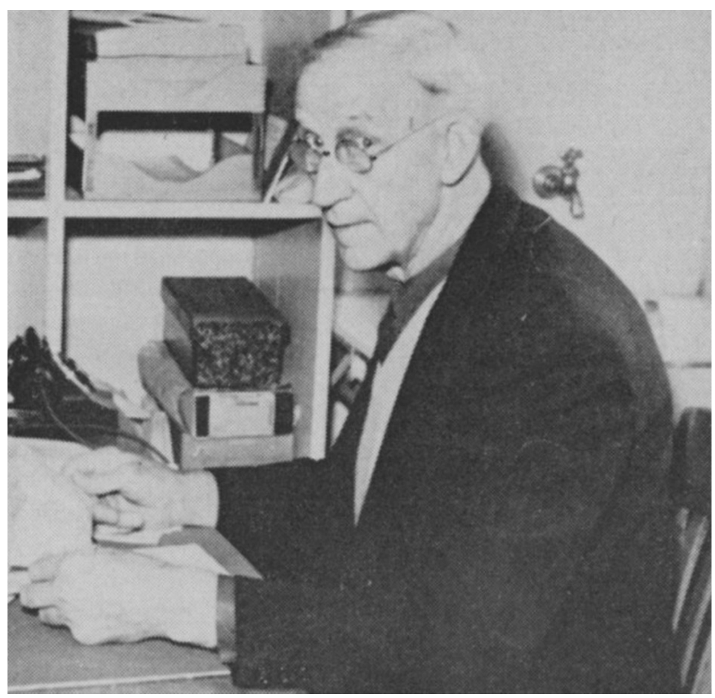

Figure 5. George Burton Rigg. (Source: Hansen 1962; courtesy of the Ecological Society of America)

PHYSIOLOGICAL DROUGHT

Transeau (1906) studied the anatomy and morphology of *Sphagnum* bog plants and found that "… [their] epidermal and hypodermal tissues are thick-walled, … a heavy cuticle is present, frequently supplemented by wax and hairs. Resinous bodies are to be found in the roots and leaves of many of the plants. The leaves are usually small and revolute-margined. Palisade tissue makes up a large part of the mesophyll. …. Bog plants resemble the plants of dry sand plains in reduction of foliage area, in development of protective coverings for above-ground parts, and in palisade tissues, but differ from the latter in the matter of root development and root structures." The most common xerophytic plants of bogs are Ericaceous shrubs, such as *Ledum*, *Kalmia*, and *Andromeda* species.

Plant ecology arose from a fusion of plant geography and physiology in 19th Century Germany (van der Valk 2011). One of the major goals of early plant ecologists was to identify the anatomical, morphological, and physiological adaptations of species that enabled them to live under the environmental conditions where they were found. What fascinated Transeau, Dachnowski, Rigg, and other early ecologists studying peat bogs was that some plant species, mostly Ericaceous species, had xerophytic features that suggested they were adapted to dry habitats. To account for this anomaly, early bog ecologists proposed that, despite appearances to the contrary (after all, these plants were growing in standing water or saturated soils), environmental conditions in bogs must be physiologically comparable to those in dry habitats. Schimper (1898), in his *Plant Geography upon a Physiological Basis*, called this "physiological dryness."

Initial speculation about xerophily's cause(s) focused on bog water chemistry, especially its acidic pH. However, Livingston (1905) proposed that "… the generally observed xerophilous character of bog vegetation may be due to small amounts of dissolved substances of such nature that they affect the plants chemically through toxic stimulation." The theory that bog toxins are the cause of xeromorphic characters was endorsed by Dachnowski (1910): "The necessity for such protection [xeromorphic leaves] in bog plants is the greater, not on account of the fact that the vegetation is directly exposed to the drying effect of wind, to lower humidity, and to stronger light, but because roots absorb water with difficulty when it contains any considerable percentage of toxic ingredients. Unless bog plants differ from other plants in some phase of root function, the amount of transpiration must be kept low by structural modifications, that is, in order to compensate a reduced absorbing activity of the roots, the escape of water from the shoots must be correspondingly checked."

Rigg (1913) credits Livingston with first proposing "… the toxin theory of the cause of the exclusion from bogs of plants other than certain xerophytes." Livingston (1905), based on a correlational study, drew two conclusions from his fieldwork: 1) "The stimulating substances [of xerophily] are most markedly present in water from those swamps whose vegetation is most definitely of the bog type." and 2) "The stimulating substances here demonstrated may play an important role in the inhibition from bogs of plants other than those of xerophilous habit." The concept of physiological drought and its ecological consequences was born.

Rigg (1916a), his most important early publication, was the first to critically examine the theory of physiological drought to explain why xerophytic shrubs are found in peat bogs. He notes, "The flora of sphagnum bogs is widely recognized as being prevailingly xerophytic. ... That is, these plants characteristic of bogs show such structural characteristics as we would expect in plants growing in dry places, even though the substratum in which they grow is wet. This is a "physiological drought" as distinguished from physical drought" (Rigg 1916a). However, physiological drought as the reason for xerophilous species in peat bogs soon began to be challenged.

Rigg (1916a) outlines three theories that attempt to explain why xerophytic species are found in bogs. One, they are glacial relics. In other words, they are Arctic species pushed south by Pleistocene glaciation. This theory never had many supporters, and Charles A. Davis, among others, found it "untenable." Rigg also points out that *Sphagnum* bogs are found in non-glaciated areas. This theory also fails to explain why xerophilous species were found in bogs in the first place. Two, these species are relicts from when boreal plants were found under different climatic, presumably drier, conditions: "…bog xerophytes … are dry-land plants, which have retained the distinguishing marks of the original habitat (Dachnowski 1910)." This theory had few supporters, but one was the influential early American plant ecologist Frederic E. Clements. Three, The most widely held theory was that environmental conditions in bogs, especially soil conditions, "account" for xerophily. Schimper's (1898) plant ecology text gives the most prevalent explanation of why xerophily was advantageous for bog plants: "… on the very acid humus of moors the vegetation assumes a decidedly xerophilous character because the humous acids impede the absorption of water by the roots." As previously noted, this theory was supported by Dachnowski (1909, 1910). However, Transeau (1906) had already found little support for this theory — "Experiments indicate that the local bog water itself has no tendency toward the production of xerophilous modifications."

Many other factors were suggested to explain xerophily with or without the implication that it was an adaptation to physiological drought, including low soil temperatures, poor soil aeration, low nutrient levels, and soil toxins. According to Transeau (1906), "Low soil temperatures and lack of soil aeration … cause a reduction in the development of the several plant organs. When these two factors are combined, the effect is very marked.” Other authors stressed the importance of low nutrient levels in bog soils, especially inorganic nitrogen, as a possible cause of xerophily. Dachnowski (1910) believed toxins derived from decomposing plants were responsible, including toxins produced by bacteria involved in peat decomposition. However, he admitted, “In so far as the adjustments arise through resistance to toxicity and consequent drought, one is painfully aware that neither the nature of the drought resistance, its origin, its specific governing factors, nor the specific type of resistance involved in the adaptation of plants to toxic bog conditions is known” (Dachnowski (1910).Three major shortcomings hampered early studies of the xerophily of bog plants and its putative cause, physiological drought: 1) an inadequate knowledge of the chemistry of humic substances in bog water and soils, 2) little data about bog environments (e.g., soil temperatures), and 3) a Lamarckian evolutionary perspective in the search for possible mechanisms - “It seems possible to raise forms in which the special resistant power [to water loss by transpiration] becomes a permanent hereditary character” (Dachnowski 1910). While Rigg’s (1916a) review of physiological drought contains a lot of speculation about why xerophily might be ecologically advantageous for bog plants, it presents little data on what those advantages might be. By the early 1970s, however, sophisticated studies of the water relations of Ericaceous plants in peat bogs demonstrated that their xeromorphy was not an adaptation for coping with drought stress (Small 1972). In other words, the xerophytic growth form was not an adaptation to reduce transpiration because of physiological drought. Instead, the poor growth of vascular plants in bogs appears to be due to a combination of factors: 1) low nutrient availability, 2) anoxia, 3) low soil temperatures, and 4) high acidity (Van Bremen 1995). Xerophily is now believed to be an adaptation primarily to low nutrient levels (Marchant 1975).

BOG STUDIES

Much of Rigg’s subsequent work was descriptive studies of peat bogs in Alaska and along the Pacific Coast. His research dealt mostly with peat bog development (stratigraphy) and emphasized physiographic succession. Three important papers during this period were: 1) Rigg (1937) — “Some raised bogs of Southeastern Alaska with notes on Flat Bogs and Muskegs”, 2) Rigg and Richardson (1938) — “Profiles of some *Sphagnum* bogs of the Pacific Coast of North America;” and Rigg (1940b) — “Comparisons of the development of some *Sphagnum* Bogs of the Atlantic Coast, the Interior, and the Pacific Coast.” He summarized his work and those of his contemporaries in two influential review papers: “The development of *Sphagnum* bogs in North America” (Rigg 1940a) and “The development of *Sphagnum* bogs in North America. II.” (Rigg 1951).

Because it lasted an entire year (Rigg 1947), his study of soil and air temperatures of a *Sphagnum* bog on San Juan Island (Figure 6) was a major contribution to the study of bog microclimate. This study significantly expanded his earlier study (Rigg 1916b) of physical conditions in peat bogs. Rigg (1947) concluded, “The most important temperature conditions during the growing season in this bog, which are evidently large factors in determining what species can grow there, are (1) low minimum air temperatures, (2) large sudden changes in air temperatures, and (3) high air temperatures at times when soil temperatures at the same time are comparatively low.” Exactly why these temperature conditions favored some species but excluded others from this bog is never explained. Nevertheless, his study illustrated the quantitative approach needed before the distribution patterns of bog plant species could be explained and predicted.

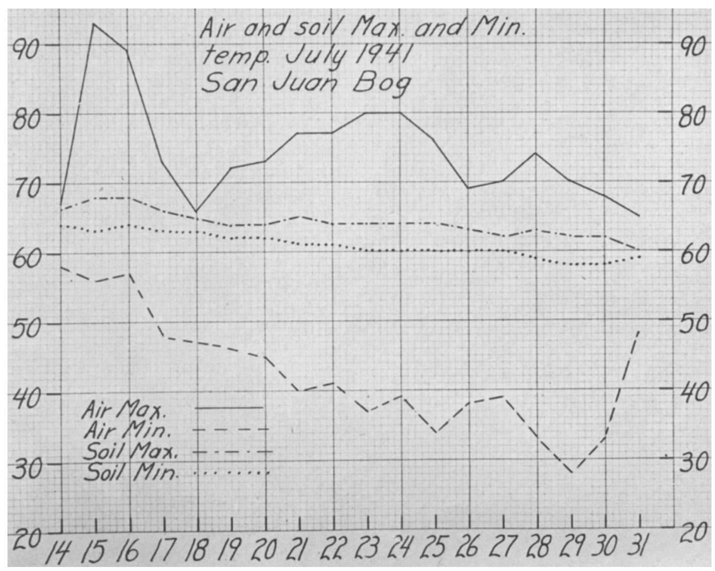

Figure 6. Daily maximum and minimum soil and air temperatures (°F) in a San Juan Island Bog for July 1941. (Source: Rigg 1947)

Rigg’s most extensive research project was done and published after he retired: “Peat Resources of Washington” was published by the Washington State Division of Mines and Geology in 1958. This report is a comprehensive and detailed account of the peat areas in the State, showing the location and extent of its peat deposits and their stratigraphic profiles, developmental history, and peat types. Rigg was over 80 years old when this project was completed.

SUMMARY

Rigg’s studies greatly expanded our knowledge of the species composition, structure, development, and physical environment of peat bogs in the United States. His three major review papers: "A summary of bog theories" (1916a), "The development of Sphagnum bogs in North America" (1940), and "The development of Sphagnum bogs in North America. II." (1951), made information about peat bogs and theories about the factors that made them unique easily accessible to other wetland and non-wetland scientists. The Ecological Society of America (ESA) celebrated his contributions to peatland science and ecology by naming him their eminent ecologist in 1956.

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