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The Necessity of Interdisciplinary Research in Wetland Ecology: the Cowles Bog Example

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INTERDISCIPLINARY APPROACHES

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THE NECESSITY OF INTERDISCIPLINARY RESEARCH IN WETLAND ECOLOGY: THE COWLES BOG EXAMPLE

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ABSTRACT

The importance of incorporating results from a number of scientific disciplines into the interpretation of wetland functions and processes was assessed by reviewing the history of research conducted in the Cowles Bog Wetland Complex in northwest Indiana. Early twentieth century work consisted primarily of descriptive studies that provided a historical reference for later work. The major research effort in the wetland was in direct response to hydrologic disturbances associated with industrial development adjacent to the site in the 1960s and 1970s. Geohydrology, surface-water hydrology, water chemistry, soil chemistry, stratigraphy, plant ecology, and animal ecology studies were all initiated at that time. These studies were continued after the industrial threats had lessened in an effort to better understand the wetland and ensure wise management of its resources. The studies also provided a framework for research on the developmental history of the wetland and its vegetation. Paleoecology, sedimentology, and remote sensing studies were added to the overall research effort to help delineate that history. The many disciplines used in the study of Cowles Bog were interrelated, and each provided information necessary for accurate interpretation of results from other studies.

INTRODUCTION

Wetland ecology encompasses a variety of scientific disciplines. Research practitioners may focus on studies of plant or animal communities, selected taxa, endangered species, hydrology, soil or water chemistry, geologic setting, or specialties such as paleoecology, seed bank analyses, or remote sensing. These studies may result in significant gains in knowledge within their own specialized fields, but they will not result in a reasonable understanding of the many functions and processes of wetlands unless they are interpreted together. Unfortunately, time and monetary constraints usually do not allow the luxury of possessing all of the interdisciplinary data necessary to draw completely accurate conclusions. As a result, management recommendations and decisions must often be made with a far-from-complete data set, and research and management personnel may lose sight of the value of gathering data from multiple disciplines.

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The purpose of this paper is to illustrate the value of an interdisciplinary data set by presenting a history of the research conducted in the Cowles Bog Wetland Complex (CBWC). The site has historical significance, a recent, controversial political significance, and a strong record of scientific research in a number of disciplines that makes it one of the more well-studied peatlands in the Great Lakes region.

STUDY SITE

The Cowles Bog Wetland Complex is a mixture of wetland and peatland communities that occupies approximately 80 ha of the basin between the Calumet and Tolleston dunes on the south shore of Lake Michigan in Porter County, Indiana (Reshkin, 1981). This interdunal wetland was included within the boundaries of Indiana Dunes National Lakeshore by the 1966 park-authorizing legislation, and a 22 ha peatland within the wetland was designated a National Natural Landmark in that same year. Cowles Bog is more properly termed a "rich fen" (Sjörs, 1950) or "spring mire" (Moore and Bellamy, 1974) because its major source of water is a highly mineralized, artesian flow of ground water (Wilcox et al., 1986). The upwelling of ground water caused a peat mound to form in the wetland, and the local hydrologic conditions have been correlated to the development of the vegetation types within the wetland (Wilcox et al., 1986). The vegetation types are: Typha marsh, Phragmites/Typha marsh, Carex/Calamagrostis marsh, shrub swamp, Larix laricina swamp, Thuja occidentalis swamp, and Acer rubrum swamp (Figure 1).

HISTORY OF RESEARCH IN THE COWLES BOG WETLAND COMPLEX

Early Studies

Professor Henry Chandler Cowles of the University of Chicago, often called the father of plant ecology in North America, led his classes as well as the 1913 International Phytogeographic Excursion (Tansley, 1913) to the site that was then called Cowles Tamarack Swamp (Brennan, 1923; Lyon, 1927; Pepoon, 1927). Herman Kurz, one of Cowles' graduate students, conducted research on the relationships between vegetation and pH in the wetland (Kurz, 1923, 1928) and was the first to use the term "Cowles Bog" in his published studies. Early descriptions of the wetland were published by Tansley (1913), Bailey (1917), Brennan (1923), Lyon (1927), and Cressey (1928). During that time period, much of the non-forested wetland was dominated by a sedge-grass association, and cattails (Typha) were not widespread. Grass-shrub-herb associations and shrub associations graded to swamp forests containing tamarack (Larix laricina), red maple (Acer rubrum), white pine (Pinus strobus), yellow birch (Betula lutea), and northern white cedar (Thuja occidentalis). The early descriptions of Cowles Bog provided a reference from which to assess changes that would result from continued development of the region by man.

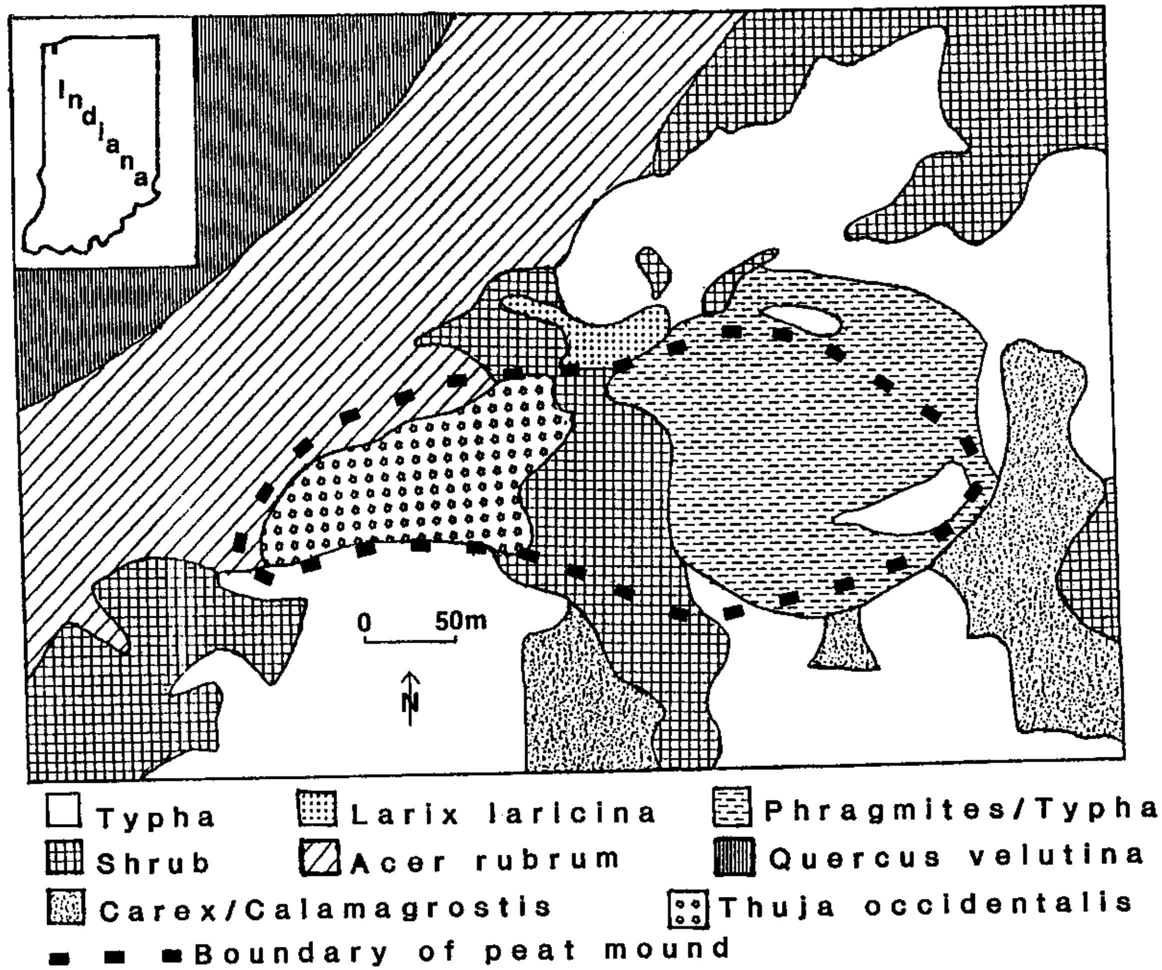

Figure 1. Map of Cowles Bog National Natural Landmark (adapted from Wilcox et al., 1986).

Environmental Impact Studies

Following the early activity, very little work was done in the CBWC until the mid-1970s when the wetland was threatened by actions associated with nearby industrial development. Specifically, a coal-fired generating station was constructed about 2 km west of the wetland in the mid 1960s, and fly-ash settling ponds were constructed within 0.7 km of the wetland. Still other ponds were constructed adjacent to the CBWC as future storage sites for fly ash dredged from the settling ponds. Seepage of water through the sand dikes of the ponds raised the water levels in adjacent wetlands of the park and also posed the threat of contamination from chemical constituents that leached from the fly ash.

In the mid-1970s, construction began on a nuclear power plant at the same industrial site. The excavation for the building foundation was dug deeper than the ground-water table at the site, so dewatering or pumping of water from the excavation was required to keep it dry. This action would create a local decline in the water table and posed the threat of lowering ground-water levels in the park. Neither action, flooding nor dewatering, was acceptable to the National Park Service (NPS), an agency charged with preserving the natural character of the land. Studies were therefore initiated to determine the magnitude of the actions on water levels in the park and to learn more about the wetlands so that the impacts of water-level changes could be assessed.

The initial efforts to study water level changes were contracted out by the power company and involved monitoring of surface-water levels in the fly-ash ponds, intradunal ponds, and the CBWC, ground-water levels in a small number of observation wells, and daily precipitation records (Texas Instruments Ecological Services, 1974-1981). The U.S. Geological Survey (USGS) was contracted by the NPS to develop a computer simulation model that would predict the amount of water-level change due to the dewatering activities. The boundaries of the two-dimensional model of the surface aquifer that was developed (Marie, 1976) included the western portion of the CBWC, but the study did not provide very much information related directly to the wetland.

The initial studies to gather baseline ecological data included biological surveys by Texas Instruments Ecological Services (1974-1981) for vegetation, mammals, birds, reptiles, amphibians, and invertebrates. A USGS study of water chemistry in the park (Arihood, 1975) reported values from the CBWC that would classify the peatland as a rich fen (specific conductance, 387 μS/cm; pH, 7.4; alkalinity, 176 mg/L as $CaCO_3$; calcium, 43 mg/L; magnesium, 19 mg/L). Classification as a fen was formally given by Carter and Stottlemyer (1978) in their ecological assessment of the wetland. They established 3 transects across the CBWC and described vegetation, soil materials, and general hydrologic conditions in an attempt to predict the effects of water-level changes on the wetland vegetation.

Boelter (1978) conducted somewhat more-detailed stratigraphic studies along one of the transects established by Carter and Stottlemyer. He assessed the types of peat materials encountered and made note of the presence of shell layers and marl deposits. He reported the presence of a peat mound in the wetland and speculated on the developmental history of the entire wetland basin, a process that involved major changes in water levels through time. Boelter also classified Cowles Bog as a fen and pointed out the importance of ground-water flow to the system. Soil chemistry analyses of samples collected along 2 of the Carter and Stottlemyer transects showed elevated levels of boron, iron, strontium, zinc, aluminum, and sulfur that were speculated to be of industrial origin (Patterson and Fenn, 1978).

A more-sophisticated, three-dimensional model for predicting water-level changes associated with construction dewatering was developed by the USGS (Meyer and Tucci, 1979) in response to changes in the dewatering plans. The new model also simulated the effects of halting seepage from the fly-ash settling ponds (in response to an agreement between the Department of the Interior and the power company to seal the ponds). The entire CBWC was included within the boundaries of the new model, which considered flow in 2 main aquifer units--the surficial water-table aquifer and a lower confined aquifer. The modeling study utilized water-level measurements from a series of observation wells around the CBWC area and generated considerable hydrologic data. The model predicted that water levels in the surface aquifer at Cowles Bog could decline by as much as 1 foot (30 cm) when the fly-ash settling ponds were sealed, and that construction dewatering for the nuclear power plant would have little effect on the Cowles Bog Wetland Complex.

A stratigraphic cross-section of the CBWC showing greater detail than Boelter's (1978) work was prepared by Hendrickson and Wilcox (1979). They first reported the clay layer that confines the deeper aquifer in Cowles Bog and also reported that wells screened in sands beneath the peat mound flowed at the peat surface. The flowing wells indicated that there was a discontinuity in the clay confining-layer beneath the mound. More extensive collections of water chemistry data utilized boron concentrations to trace waters from the fly-ash settling ponds into the southern part of the CBWC. Water chemistry data also confirmed the classification of the peatland as a rich fen (mean specific conductance, 844 µS/cm; mean pH, 7.14; mean alkalinity, 404 mg/L as $CaCO_3$; mean calcium, 88.6 mg/L; mean magnesium, 52.6 mg/L). The vegetation was found to be characteristic of a fen, also.

Further changes in the construction dewatering plans were made in 1979 that included an artificial ground-water recharge system in the surface aquifer and pumping of water from the confined aquifer beneath the construction site. These changes, coupled with the knowledge that the confined aquifer was breached beneath the peat mound of Cowles Bog, prompted further USGS computer-model simulations to determine the effects of dewatering on the CBWC (Gillies and Lapham, 1980). The new simulations predicted that water levels in the surface aquifer could decline by as much as 0.7 feet (21 cm) at the Cowles Bog peat mound under the new plans.

The final chapters on the direct impacts of power plant operations on the CBWC were studies by Hardy (1981) on the effects of fly-ash seepage on water quality and by Cohen and Shedlock (1986) on the changes in water levels and water quality following termination of the seepage in 1980. Construction activities at the nuclear plant site were terminated in 1981 by cancellation of the project.

Recent Ecological Studies

The modern floristic composition of the CBWC was reported by Wilhelm (1980) and surveys for threatened and endangered plant species were conducted by Bowles et al. (1984, 1986). Further surveys of vegetation, small mammals, and birds were conducted by Apfelbaum et al. (1983), and Titlow (1986) mapped the vegetation types in the CBWC through photointerpretation, according to the classification scheme developed and used for the entire park.

Remote sensing was also utilized by Wilcox et al. (1984) to analyze vegetation changes in the CBWC through time. Four major vegetation types were mapped from black/white and color aerial photographs in each of 9 years between 1938 and 1982. The results, replacement of large areas of sedge/grass meadow by cattail marsh, were compared to the hydrologic disturbance history of the wetland. Elevated and stabilized water levels in the CBWC, associated with the construction of one of the diked ponds by the power company, were concluded to be the main factors contributing to the invasion of cattails.

Additional stratigraphic, hydrologic, water chemistry, and vegetation studies in Cowles Bog were conducted in the early 1980s through the cooperative efforts of the NPS and the USGS. Detailed topographic and stratigraphic maps of the wetland further defined the nature of the peat mound, the artesian water supply was explained by the stratigraphy, water chemistry differences were explained by hydrologic data, plant species composition was related to water chemistry, and vegetation patterns were related to water levels/hydrology/topography. The information obtained in these studies was also correlated to changes in Lake Michigan water levels over the past 6000 years, and a reasonably-informed hypothesis of the sequence of events that led to formation of the wetland was developed (Wilcox et al., 1986). Still further studies of regional geology and hydrology formed the basis for understanding the regional ground-water flow system that causes the artesian flow of water to Cowles Bog (Shedlock, Wilcox, and Thompson, in review).

Other studies have provided great insight into the developmental history of the CBWC. Sedimentology studies by Thompson

(1986) gave many details of the geological processes involved, as well as very detailed stratigraphic information. Fossil pollen and charcoal analysis of a peat core from Cowles Bog by Futyma (1985) explained the changes in vegetation that accompanied each developmental stage of the wetland and corroborated changes in water levels that were hypothesized from stratigraphic data. Fossil mollusc analyses (Miller and Thompson, 1987) from the sediment cores of Thompson provided new faunal data and further corroborated the water-level changes hypothesized.

Current research efforts in Cowles Bog include a continuation of fossil mollusc studies (Miller, unpublished) and an assessment of airborne heavy metal deposition related to regional industrial development, as recorded in peat soil profiles (Cole, unpublished).

CONCLUSIONS

Research has been conducted in the Cowles Bog Wetland Complex utilizing a number of scientific disciplines, including geohydrology, surface water hydrology, stratigraphy/sedimentology, water chemistry, soil chemistry, paleoecology, remote sensing, plant ecology, and animal ecology. Each study could have been used solely to add new information to the data banks of its own discipline or to make limited recommendations for management of the wetland. Instead, the interdisciplinary data set has been used to foster a broad understanding of the forces at work in Cowles Bog and of the developmental history of the basin. With this knowledge, management decisions can be made with much less chance for error.

The disciplines involved also have many common denominators, and results from one study may not be readily interpretable without results from another (Wilcox, 1987). In the Cowles Bog research, studies of stratigraphy and sedimentology related directly to an understanding of ground-water hydrology, which in turn affected surface-water hydrology. Water chemistry and soil chemistry were influenced by hydrology, and all of these factors exerted strong influences on biotic development and structure within the wetland. Remote sensing, field studies of plant and animal communities, and analyses of sediment cores for pollen and macrofossil records provided modern and historic information about wetland biota. The paleoecology studies, coupled with radiocarbon dating, related directly back to the stratigraphic studies. Clearly, there was great value in working from a data set that included results from many scientific disciplines. Within the contraints of time and money, such an approach should be the goal of most wetland research efforts.

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