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Forest Stearns
University of Wisconsin - Milwaukee

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FOREST STEARNS

Department of Biological Sciences, University of Wisconsin–Milwaukee
Milwaukee, Wisconsin 53201

ABSTRACT

Ecological research on plants and plant communities has been an active program at UWM, involving several faculty, many undergraduate and graduate students and the UWM Field Station. Aquatic and urban environments, forests and wetlands have received most attention although prairie and landscape ecology and endangered species have not been neglected. Descriptive, theoretical and applied studies are included spanning the spectrum from the autecology of a single species to examination of entire landscapes. Over the period of 20 years, 54 M.S. theses, nine Ph.D. dissertations and numerous published papers and reports have resulted.

University-sponsored research serves several purposes: discovery of new and specific knowledge, the application of this knowledge and of research skills to problems of society, and, not least, the training of new generations of scientists. Programs may be oriented narrowly toward the specific interests of the senior researchers or they may be directed toward a more varied interest of successive groups of students and toward the evident needs for basic information. The availability of travel funds, supplies and equipment may also influence the choice of research problems.

Worldwide, ecological research began of necessity with descriptive studies of communities and autecology of species. Research moved from description of "what" was present to "why" and "how" -- delving into function in relation to environmental factors, into species interactions and eventually various aspects of community development and plant and animal relationships. More recently, ecologists have begun to examine the interrelationships between ecosystems and the influence of human activities upon these relationships. Our work at UWM spans the entire range from community description and function and species-environment interactions to landscape ecology.

Descriptive studies are particularly well-adapted for master's research; they provide the student with an opportunity to explore and see for himself the complexity of plant communities and ecosystem function and to accomplish this within a reasonable time. More complex, descriptive studies and those concerned with function and complex interrelationships, generally building on earlier descriptive work and on theoretical work from elsewhere, require experience and time, hence are better suited for Ph.D. dissertations.

Since 1965 there have been 54 master's theses and nine Ph.D. dissertations completed in plant ecology. Twelve authors of M.S. theses have continued on to the doctorate, either at UWM or elsewhere. Research in plant ecology at UWM has been largely under the direction of faculty members Philip B. Whitford and

Peter Salamun (now retired), John Blum and Forest Stearns. In addition to graduate student and faculty research, many undergraduate research projects have provided valuable information on the local flora and plant communities.

Over the years our ecological research has developed in many directions, including studies of aquatic communities, wetlands, forests and urban systems, and, more recently, endangered species. Earlier emphasis on prairies resulted from P. B. Whitford's interest and early training. Most ecological research has been centered in southeastern Wisconsin, although several studies have been conducted elsewhere in and outside of Wisconsin.

The International Biological Program (1967 to 1974) placed strong emphasis on productivity of ecosystems, and productivity studies of Wisconsin ecosystems were carried out at UWM in cooperation with UW-Madison (Stearns et al. 1971, 1973). The former manager of the UWM Field Station, Paul Matthiae, cooperated in several of these studies.

Financial support has come from organizations as diverse as the Wisconsin Department of Natural Resources, The Wisconsin Coastal Zone Program, the UW College Sea Grant Program, the U.S. Forest Service, U.S. Park Service, the National Science Foundation, the Department of Defense, and the Department of Energy. A benchmark site still active today was established at the Field Station in 1970 in cooperation with the U.S. IBP Phenology Program. Many research projects have been done by students utilizing their own resources or with very moderate amounts of University support. Alphabetical lists of theses and dissertations are appended and thesis advisors are indicated. Theses are cited by name only. Summaries of many of these theses have appeared in the Field Station Bulletin. Other pertinent references listed by author and cited with the date will be found in the Literature Cited list.

The first UWM doctoral degree in Botany was awarded in 1968 to Thomas Grittinger for a study on vegetational patterns and edaphic relationships in the Cedarburg Bog; much of our understanding of the plant communities of the bog is derived from that study.

The late Professor A. L. Throne deserves much credit for initial work in plant ecology. His efforts to establish a UWM Field Station led to its final acquisition in 1964 with the financial support of the Wisconsin Chapter of the Nature Conservancy. During the early 1970's three major research thrusts began to develop broadly - forest, wetland and urban ecology. Our emphasis on urban ecology began with a national workshop in Austin, Texas, which was organized at UWM, sponsored by the Institute of Ecology and funded by the National Science Foundation (Stearns and Montag 1974).

In 1970 a team of plant ecology graduate students and faculty surveyed 17 potential national landmark sites in Wisconsin and Michigan. One result of that survey was the designation of the UWM Maple-Beech Woods and the Department of Natural Resources' Cedarburg Bog as National Natural Landmarks. Recently, in

cooperation with Norman Lasca (UWM-Geology) and his students, a theme study was completed for the Superior Upland Physiographic Region (Stearns et al. 1982a), and this year three prairie sites were evaluated for the Park Service.

Prairie Ecology

In his earlier work, Whitford studied prairies along the prairie-forest border, and in 1972 noted the presence of native prairie on outwash sands in central Wisconsin. In 1973 he reported that an experiment begun in 1966 to establish a prairie at the UWM Field Station was successful and that at least 16 of the species seeded had become established (Whitford 1973). Results of that effort are visible today as a well-established prairie community. The work was based on one of the earliest projects in prairie establishment in Wisconsin reported in an M.S. thesis in 1968 (Ode).

In the mid-sixties, two M.S. studies examined mineral balance in prairie border plants (Franz) and compared dispersal methods of prairie and forest species (Hasse). The vegetation of the Benedict Prairie in Kenosha County was described in 1974 (Curtis). Monitoring of the prairie at the Field Station is continuing.

Forest Ecology and Productivity Research

In 1954 a survey of the upland forests of the Milwaukee area (Whitford and Salamun 1954) marked the beginning of a long series of studies on forest ecology.

A baseline description of the Field Station beech-maple woods (Dunnum) was followed shortly afterward by a benchmark report on the history and vegetation of the Downer Woods (Salamun 1972), while an undergraduate report on phenology was completed in the Fairy Chasm Scientific Area (Klopatek 1972).

Early ecological research at UWM was not restricted to southeastern Wisconsin. An M.S. thesis (Lindsley) described the influence of forest opening size on microclimate in Forest County and investigation of the productivity of Wisconsin landscapes included the entire state.

In March, 1976 a severe ice storm hit the Field Station resulting in the loss of over 50% of the tree canopy. Several studies were begun to determine the changes produced by this natural experiment (Bruederle). A manuscript reporting on the initial results is now in press. Prior to the ice storm, a major study on productivity and mineral cycling had been done in the beech-maple forest. This study examined nutrient and water flow in relation to tree growth (Kobriger). In 1976 plans were developed for a project that would explore the implications of island biogeography for terrestrial forest islands.

The concept of island biogeography had attracted much attention because it related colonization, species diversity and extinction to island size, and because it had potential application to the preservation of species' gene pools. It was evident that national parks, etc., could be treated as islands. Our study, supported by the National Science Foundation, was concerned with the significant effects of woodlot size and of forest and nonforest land pattern upon local forest ecosystems, (i.e., forest islands or woodlots). In this work, graduate students

and faculty from UWM cooperated with scientists from the Oak Ridge National Laboratory, Rutgers University, and the University of Wisconsin-Madison in exploring the nature of forest island communities in urban and urban/rural matricies.

Studies on maple-beech communities (Levenson), (Hoehne) and oak forest communities (Mudrak) supplemented by a detailed examination of forest edge (Bruner) and a study of forest mammals (Matthiae) indicated that the relationship between island size, species, diversity and abundance was not as close for terrestrial islands as had been found for oceanic islands. Human disturbance often overrode the influence of island size and distance.

Forest islands of sugar maple-beech and associated species were found to require an area of at least 3-4 Ha to maintain the forest interior species (Levenson). In contrast, a study of oak woodlot dynamics (Mudrak) indicated that oak woodlots need to be at least 7-8 hectares in area to avoid domination by edge species. Oak woodlots were often forest islands in a prairie matrix and have changed little since settlement, save for the absence of fire; they are now islands in an agricultural matrix. Related work in forest pattern included investigation of seedling distribution in old fields (O'Donnell). A continuing project in cooperation with David Sharpe of Southern Illinois University has produced evidence on the effects of urbanization on forest pattern during post-settlement time in southeastern Wisconsin (Sharpe et al. 1985). Currently, study of forest pattern in an agricultural matrix, Green County, is focusing upon relationships between forest composition, the size and isolation of the forest patch, and historical changes in land use. Related to this study, individual dissertations are in progress on wetland forests in southeastern Wisconsin (Dunn*) and on the invasion of forest islands by an exotic shrub, buckthorn Rhamnus cathartica (Leitner*). These studies relate to the ability of the native regional forest to sustain itself under pressure of modern agriculture and urbanization.

On July 4, 1977 a catastrophic series of downbursts hit northern Wisconsin. This wind storm provided a unique opportunity to study the result of massive disturbance in the old-growth hemlock-hardwood stand located in the Flambeau State Forest. An initial study, made with the help of a Sigma Xi grant, has been published and further work is in progress (Dunn et al. 1983).

Development of several excellent nature centers in the Milwaukee area stimulated ecological studies pertinent to those areas. This is especially true of the Riveredge Nature Center in Ozaukee County, where studies have included work on forest succession (Swartz) and vegetation distribution in relation to soils (Purtell).

To understand existing vegetation, it is essential to know the nature of the original vegetation at the time of settlement. In several cases, this has been investigated as part of a larger study (Levenson) in the Milwaukee area and for

* Dissertation in progress.

Cadiz Township in Green County; other studies have dealt with presettlement vegetation specifically, such as Ozaukee County (Brumm), southeastern Wisconsin (Dorney), the southern Kettle Moraine State Forest (Bartz), an area in Oneida County damaged by a tornado (Schultz), and the Moquah Barrens of Ashland County (Dunn and Stearns 1980). Vegetation studies at the Field Station have also included cooperative efforts with David Miller (UWM-Geology) on cold air drainage and radiation effects relative to the plant community development (Levenson and Matthiae 1976), (Miller 1977).

Research in Wetland Ecology

Wetland work that had begun in the Cedarburg Bog (Grittinger) developed into a major research thrust. Studies of the productivity of submergent macrophytes in Theresa Marsh (Washa), (McNelly and Klopatek 1973), and of productivity and mineral relationships of emergent plants (Klopatek) provided basic data on root and shoot productivity for freshwater marshes.

A parallel study of productivity in a Wisconsin River marsh near Rhinelander indicated that emergent macrophytes were capable of vigorous growth despite nutrient limitations. This work clarified seasonal growth patterns and utilized P^{32} as a tracer for nutrient translocation (Lindsley). Decomposition processes involving emergent plants had been neglected and, using material from Theresa Marsh, Puriveth demonstrated initial losses by leaching and showed that microbial decomposition preceded detritivore activity with seasonal changes in rates of loss for different nutrients (Puriveth).

Human disturbance is an important factor in wetlands, and the results of disturbance were described for the Menomonee Falls Swamp (Luebke). Study of American larch in the Cedarburg Bog documented the considerable age and slow-growth rates of larch within much of the bog and particularly in the string bog area (Meyer 1973). Farley and Salamun (1973) reported on the land uses of the area in and around the Cedarburg Bog, providing a record of historical events essential in understanding plant community development. Description of the wet hardwood forest in the bog provided other essential data on the impact of disturbance (Farley).

In the past six years, wetland studies have become an increasingly important component of our program. Study of an effluent disposal bog near Drummond, Wisconsin (in cooperation with UW-Stevens Point, UW-Stout and the U.S. Forest Service) has demonstrated (Guntenspergen and Stearns 1983a) that there is little additional nutrient uptake by bog plants but that disposal of effluent on an ombrotrophic sphagnum bog produces a drastic vegetational change that progresses with time. Eventually the black spruce-tamarack forest may be converted into a cattail swamp.

The nutrient uptake strategies of emergent aquatic plants have been studied and the relationship of these strategies to the evolution and speciation of emergent macrophytes is being examined (Guntenspergen).

The Mink River estuary on the Door County peninsula was investigated and a management plan prepared for the Wisconsin Coastal Zone Program. The plan included

descriptions of the marsh communities and preliminary models of nutrient and energy flows in the system (Stearns and Keough 1982b).

Other wetland oriented research in progress includes work on distribution and productivity analyses of submerged plants in Door County bays (Summerfield*), (Salamun 1978a), experiments on the effect of current flow and water depth on phenotypic and genotypic behavior in the genus Scirpus (Keough*) and on the potential impact of Extremely Low Frequency (ELF) radiation on northwestern Wisconsin bog forests. Nearing completion is a study of the relationship of sediment type to distribution of submergent macrophytes in Henrietta Lake, Waukesha County (Reifel**).

A project in cooperation with Rexnord (Enviroenergy Technology Center) provided an opportunity to review the effects of highway use on wetland characteristics and functions (Stearns et al. 1983b) and to provide biological input to highway planning.

Aquatic Research

Professor Blum has directed a variety of ecological studies, largely in algal ecology, including work on the ecology of bluegreen thermophyllic algae (Sperling), phytoplankton dynamics and productivity of a shallow eutrophic lake (Sloey), the submerged macrophytes (Washa) and the algal flora of Theresa Marsh (Granert), the ecology of Cladophora glomerata in the Milwaukee Harbor (Herbst), and phytoplankton species dominance and succession in Big Muskego Lake (Kohler). Other projects were concerned with primary productivity at Mud Lake (Liptak), and water quality relative to the macrophyte communities (Summerfield). Seasonal changes in algal populations of bog lakes (Mueller), the algal ecology of the Milwaukee River (Woelkerling) and changes in the macrophyte populations of Green Lake over 50 years' time (Bumby) have also been studied.

Research in Urban Ecology

Initial work in urban ecology was focused on wildlife habitat, but soon shifted to investigation of urban plant communities and the effect of urban environments on plant growth. The voluntary urban vegetation of Racine was characterized (Boehmer) as were weed communities in Milwaukee (Casey). The urban climate was shown to affect date of tree development (March) and the impact of air pollutants on vegetation was investigated (Zieve). Plants were shown to be useful monitors for ozone detection (Esser) while city road salt proved to have little impact on Milwaukee street trees (VanWyck). Other work has shown the ability of certain tree species to reproduce in the city (Boyd) while a seedbank study indicated a major reservoir of seed in soil of vacant urban land (Janik). Leaching of phosphorus from urban tree leaves was found to make an appreciable contribution to urban runoff (Dorney 1979). Human disturbance, documented earlier by Levenson, was shown to affect

* Dissertation in progress.

** M.S. Thesis in progress.

urban parklands, such as the Wehr Nature Center (Nowak). Most recently, a pioneering study on productivity of urban vegetation documented biomass and production rates of woody vegetation in the Village of Shorewood (Dorney et al. 1984).

In related work, precipitation at the Field Station was monitored and acidity levels were compared with precipitation at the UWM campus. Vegetation at the Field Station is subjected to appreciable levels of acid precipitation, especially during the spring. At present, the soils appear to have adequate buffering capacity (Kobriger 1979). An extensive study, supported by the Argonne National Laboratory, explored the response of soybeans to acid precipitation and to sulphur dioxide under field conditions (Irving).

Rare and Endangered Species

Endangered species have not been neglected. A detailed population study was conducted on a species of sundew, Drosera linearis, in the Cedarburg Bog (Stromberg) and another study on Plantago cordata indicated that the major cause for decline of this species has been loss of habitat. The first-year seedling is the critical stage in the life cycle (Kunowski), (Stromberg and Kunowski 1981). Northern Monkshood, Aconitum noveboracense, an endangered species, is now under study to determine factors responsible for its limited and specific distribution under rock ledges and on algific (ice) slopes. This work involves a field demographic study and laboratory experiments (Kuchenreuther et al. 1984), (Cervelli**). Earlier, autecological research was completed on two species of Aureolaria (Musselman). A study just completed examined the distribution of pitcher plants, Sarracenia purpurea, in calcareous fens and found no relationship with the nutrient levels of fen water (Golembiewski) while an investigation of calcareous fens in southeastern Wisconsin suggests an obligate relationship between Ca and Mg in groundwater and the presence of typical fen species (Reed**). Another study examined the relationship between the pitcher plant and an obligate moth parasite (Guntenspergen and Rupprecht 1983b).

Not all of the plant ecological studies by students and staff at UWM are listed above. Other students have studied primary production in wild and cultivated cranberries (Walstrom), comparative energetics of agronomic and emergent species (Kobriger), cadmium uptake by cattail (Wenger), the role of fire in the maintenance of oak-hickory woodlands (Bintz), the ecology and distribution of certain aquatic fungi (Bronaugh), the frequency and distribution of ferns in the upland hardwoods in the UWM Field Station (Carlson), and the effects of highway deicing spray on coniferous trees (Foss).

Other studies have ranged far afield, including work on the ecology and economics of strip mine reclamation in Iowa (Ballou), a diatom succession on Isle Royale (Sanders) and on pond vegetation on Amchitka Island, Alaska (Reich).

** M.S. Thesis in progress.

Examination of mineral relations of plants has been of considerable importance and includes work on radioactive cesium dynamics in the Cedarburg Bog (Pattison) as well as being a major part of most studies of wetland and forest ecology. Studies on the population ecology of common mullein, Verbascum thapsus, are in progress at the Field Station (Reinartz 1980), and a common and important cornfield weed, velvet leaf, Abutilon theophrasti, is being studied to examine the effects of the environment on plant development and allocation of mineral nutrients (Kuchenreuther**).

We anticipate that when Diane De Steven joins the UWM faculty, she will stimulate additional studies in plant/animal relationships and old field succession.

Students and faculty have also been involved locally in activities requiring ecological expertise, such as directing the Shorewood Dutch Elm Disease Eradication Program, helping to plan the Shorewood Nature Preserve, evaluating Lake Michigan shoreline vegetation (Salamun and Stearns 1978b), and planning for development at Cliffside Park, Racine County and the Pigeon River, Sheboygan County.

Plant ecology has been an active and productive area of research at the University of Wisconsin-Milwaukee. Student problems and faculty research have been both practical and theoretical in nature and the results have contributed to basic scientific understanding and to solution of problems at the local and national level.

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PLANT ECOLOGY

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