Restoring Everglades Wetland Plant Communities

(Editors’ Note: In January 2002, the Duke University Wetland Center began a new phase of Everglades research on plant community restoration. The project, funded by the Everglades Agricultural Area Environmental Protection District at $240,000 during 2002, focuses on two goals: (1) a field-based restoration plan utilizing existing information from the center’s research archives and (2) a management restoration plan primarily based on the interactions of fire, nutrients, and hydrology with the goal of restoring appropriate natural plant communities to areas that have been taken over by dense invasive monocultures of plants such as cattail. This article is based on a presentation of recent DUWC restoration research at the Nanjing International Wetlands Symposium in September 2002.)

INTRODUCTION

The Florida Everglades, a 618,000 ha Ramsar wetland site of international importance is highly impacted by drainage canals, nutrient additions, and altered hydrology. Only 51% of its original size, the Everglades remains the largest and most ecologically important subtropical fen in the United States.

The Everglades is currently undergoing a significant shift in its native flora and fauna due to excessive loadings of total phosphorus (P) from agricultural runoff and Lake Okeechobee outflow, and severe alterations in its hydrologic and fire cycle. Extensive changes in algal species and macroinvertebrate populations, significant changes in macrophyte composition, and altered community structure have occurred, especially in highly and moderately P-enriched areas. What is not known is how to restore the disturbed areas back into native plant and animal communities. This will require an understanding of how the interactions of fire, hydrology and nutrients control the successional pattern of communities in the Everglades.

BACKGROUND

The Everglades peatlands formed about 5000 years before present (YBP) over low-permeability limestone in the northern portion of the Everglades basin and around 2000 YBP in the southern areas, which are underlain by highly permeable limestone. Bedrock configurations established the Everglades north to southwest drainage patterns prior to peat deposition, and these patterns had changed little over the course of time until drainage canals were dug starting in the early 1900’s. Lake Okeechobee was a major source for surface water flow into the Everglades, but the main source of water came from rainfall (~ 120 cm/yr).

On The Inside

From the Director: China–A Civilization Built on Wetlands

Edward Maltby, Joy Zedler Featured in the DUWC 2002-2003 Speaker Series

continued on page 4
In September 2002, Dr. Mengchi Ho and I traveled to the People's Republic of China to represent the Duke University Wetland Center at the Nanjing International Wetlands Symposium. While there, we had the rare opportunity to travel over 2,000 km across the country to view some of the world's most spectacular wetlands.

Currently, the total wetland area in China is more than 26 million ha, 2.8% of China's total land area. Marshes and swamps comprise 16.8 million ha. There are 9.1 million ha of shallow lakes, and coastal salt marshes and mud flats make up the remaining 0.8 million ha of wetlands.

As this article's title suggests, China has been dependent on managed wetlands for thousands of years, utilizing wetlands for agriculture more than any other country. China now has more than 50 million ha of managed rice fields, ponds, and waterside wetlands in addition to its 26 million ha of natural wetlands. With a population in excess of 1.3 billion, it is essential that China maintain a highly productive rice culture in these highly managed wetlands.

Our trip was hosted by the Chinese Academy of Sciences in conjunction with the World Wildlife Federation and the USDA Forest Service. A special tour to northern China was sponsored by the Northeast Institute of Geography and Agricultural Ecology (Changchun) and hosted by Dr. Yongxing Yang, who was a visiting researcher at the Duke University Wetland Center during the year 2000.

The scientists and farmers we visited in each region clearly presented their plans for future development of wetland reserves and maintenance of the China's rice culture. Two issues are of great concern: (1) massive water quality problems in bodies of water downstream of agriculture and urban/industrial areas and (2) migration of large numbers of farmers away from the agricultural centers and into the inner cities during the great industrial and technological revolution taking place in China.

I will present a series of articles on China's wetlands in future issues of Wetland Wire.

—Curtis J. Richardson
Director, Duke University Wetland Center
In September 2002, DUWC Director Curtis Richardson, his wife Carol, and DUWC Research Associate Mengchi Ho traveled to China for the Nanjing International Wetland Symposium. Wetland researchers from around the world converged on Nanjing for the 10-day conference and related field trips. During their three-week tour, the Richardsons and Ho visited northern China, the site of many of the country’s most important natural and managed wetland areas.

Above. Water levels in the managed wetland areas are controlled by a series of locks which allow free access for fishing boats and other conveyances.

Left. The area around Taihu Lake in eastern China abounds in fish ponds that are part of the country’s 50 million ha of managed wetland areas that provide important food resources.

Bottom left. The Honghe National Nature Reserve in northeastern China is a Ramsar Site of International Importance. This marsh is part of China’s 26 million ha of natural wetlands.

Below. Yongxing Yang leads a group including Curtis and Carol Richardson and scientists from the Sanjiang Plains Research Station into marsh research areas made accessible by bamboo boardwalks.
Paleoecological pollen studies suggest that until modern times ecosystem changes in the vegetation of the Everglades occurred gradually. Its resistant and resilient flora and fauna have evolved to survive in an ecosystem pulsed by hurricanes, flooding, seasonal droughts, and fire. Growth is restricted by severe phosphorus (P) limitations. The overall trend in vegetation history of the Everglades from peat initiation up to the present is shown in Figure 1. The main community types include: (1) sawgrass monocultures (*Cladium jamaicense*), the dominant vegetation community found throughout the alkaline mire; (2) wet prairie, transitional areas between sawgrass and sloughs with standing water present 6 to 10 months per year; (3) sloughs, open water marsh areas dominated by floating aquatic plants and a rich diversity of aquatic insects, fish and alligators; and (4) tree islands, hundreds of clustered trees and shrubs that stand several feet above a matrix of surrounding shorter sedge vegetation. The diversity and pattern of these communities are highly dependent on the hydrologic conditions (hydroperiods and hydropatterns), periodicity of fires, and the availability of phosphorus and calcium.

One of the key benefits of examining the historical Everglades and the rates of successional change is that it is possible to utilize information about the natural communities and the variations in the system prior to the industrial era to develop a scientifically based restoration plan. This information, when coupled with an assessment of the original area of each community type, gives us a reasonable restoration target. The Duke University Wetland Center’s Everglades research—carried out during the past 12 years in both undisturbed areas and in highly P-enriched cattail (*Typha domingensis*) communities—provides us with insights into the processes controlling plant community dynamics as well as factors controlling nutrient biogeochemistry. For example, the recent problem of P-induced eutrophication has occurred mainly in the northern remaining Everglades due to increased runoff from agricultural lands and eutrophic Lake Okeechobee. A series of outflow structures have created a P-enrichment gradient that often extends 5-7 km into the interior of the wetlands. Surface water P concentrations along these gradients during the past 20 years have ranged from ppb (170 \( \mu g.L^{-1} \)) near agricultural outflow gates to near 10 ppb (\( \mu g.L^{-1} \)) in interior background areas. Increased P nutrient loadings have resulted in major alterations in the water chemistry and elevated P concentrations.
which in turn have caused major shifts in plant communities to cattails when soil P concentrations exceed 650 ppm (mg/kg). Knowledge of the rates and magnitude of such changes, as well as recovery rates from disturbances, is critical to any future restoration plans. Moreover, restoration plans that incorporate the natural variation and known responses to disturbance such as fire are likely to be more ecologically and economically feasible. Early findings suggest that areas of cattail monocultures can be converted into sawgrass monocultures if the cattail community can be burned and destroyed during the right season of the year, provided that the peat soil is not burned as well. However, burning or removal of cattail is not easily accomplished, and the conditions under which this can be successfully accomplished on a consistent basis are yet to be determined.

Efforts to successfully manage and restore the Everglades will first require a reduction in the amount of P being released into the system. Efforts are underway by the State of Florida to complete construction on 41,000 acres (16,000 ha) of Storm Water Treatment areas to reduce the P inputs concentrations from 150 ppb to values less than 20 ppb. The farming community has reduced P inputs by 50% by utilizing best management practices over the past few years. Thus, the P discharge problem may be close to being solved, although the FDEP 10µg/L TP threshold based on interior reference sites has not been justified scientifically for the entire Everglades. However, the Corps of Engineers had plans approved by Congress in 2000 to increase water flow by nearly 1 million acre feet per year. What this amount of additional water will do to the existing plant communities is unknown in terms of hydroperiod effects, fire periodicity patterns or increased delivery of nutrients into the interior of the Everglades. In addition, few plans exist for the restoration of the highly impacted and nutrient enriched areas of the Everglades. For example, it is not clear how cattail will be eradicated from the existing P enriched areas. Also, we do not yet know how to restore tree islands that have been lost from many areas due to excessive flooding.

To address these problems and develop a scientifically based restoration plan for the Everglades, the Duke University Wetland Center and the Florida Game and Fish Commission have combined efforts to conduct a series of experiments in different plant community types. The studies involve a series of controlled burns under different soil nutrient concentrations and hydrologic regimes (Figure 2). It is hypothesized that appropriate fire periodicity and hydrologic regimes for each native community will maintain Everglades diversity. Moreover, our early work suggests that communities of fire species like sawgrass and other native species can be restored through the use of controlled burns (Figure 2). However, much still remains to be learned about the optimum timing for the burns, the amount of fuel that provides the best fire, the effects of different hydrologic regimes, the role of soil P status, and the importance of seed banks in restoring the native communities after fire. It is hoped that the findings from these studies will help define how managers could use the dynamics of fire and hydrology to restore native plant communities in the Everglades as well as maintain the historic natural communities.

—Curtis J. Richardson
Director, Duke University Wetland Center

![Figure 2. Flow chart of successional paths in phosphorus-enriched wetland areas subject to surface fire under different hydrologic restoration scenarios](image-url)
Curtis J. Richardson, Director of the Duke University Wetland Center, was an invited plenary speaker at the Society of Wetland Scientists 23rd Annual Meeting in Lake Placid, NY, June 2002. His address, “Pocosins: Isolated or Integrated Wetlands on the Landscape?” was part of the SWS Special Symposium on Isolated Wetlands in the USA. In September, Richardson gave two presentations at the Nanjing International Wetlands Symposium in China, the plenary lecture “Restoration of the Everglades: Can it be successful without the application of ecological principles?” and “Restoring Everglades Wetland Plant Communities.” During November 2002, Richardson was the invited speaker at Princeton University’s Geosciences Department on the topic “An Ecological Basis for Everglades Restoration.”

DUWC Research Associate P.V. Sundareshwar is the lead author of “Phosphorus limitation of coastal ecosystem processes,” an article that appeared in the January 24, 2003 issue of Science. Research by Sundareshwar and his co-authors J.T. Morris, E.K. Koepfle, and B. Fornwalt shows that phosphorus limitation of the growth of nitrogen-transforming bacteria will affect carbon fixation, storage, and release mediated by plants, a result that has important implications for ecosystem management. The article may be viewed online through a link to be found at http://www.env.duke.edu/wetland/sundareshwarpublications.htm.

Gregory Bruland, a Duke University Wetland Center doctoral candidate, has won a Student Presentation Honorable Mention at the Society of Wetland Scientists Annual Meeting, Lake Placid, NY in June 2002. Bruland’s talk was entitled “Soil properties and processes in natural and mitigation nontidal forested wetlands in North Carolina.” The study’s objectives were to (1) quantify differences in soil properties (bulk density, texture, moisture, organic matter, pH, and microbial biomass) of both mitigation and natural wetlands and (2) examine how differences in soil properties lead to differences in soil process (P sorption, denitrification). Bruland also presented "A comparison of soil properties and processes in natural and mitigation wetlands of the Southeastern coastal plain" at the Fifth Annual North Carolina Stream Restoration Institute Conference held during October 2002 in Wilmington, NC.

Ryan Elting (MEM 2003) gave the presentation "A nutrient budget to assess the pre-restoration state of Sandy Creek, Durham, NC" at the 14th Annual Wildlife Habitat Council Symposium: "Investing in Biodiversity." November 2002 in Baltimore, MD. During summer 2002, Elting worked on the Duke University Wetland Center's Duke Forest/Sandy Creek restoration project site near Duke's West Campus. He collected data that included hourly stream flow measurements, pH, DO, conductivity, turbidity, and total nitrogen and phosphorus concentrations. The data were synchronized in time, with special attention paid to storm pulse concentrations and flows. Elting's symposium presentation detailed pre-restoration conditions of Sandy Creek, addressing specific inputs to the stream and historical land use in the watershed while also explaining the development of the current restoration project and site-specific conditions considered in the final design.

Paul Benzing (Ph.D. 2001) completed his doctoral work with the dissertation "The Role of Iron and Redox in the Distribution and Dynamics of Soil Phosphorus in Histosols of the Florida Everglades." On graduation, he accepted a one-year appointment in the Environmental Studies and Science in Context Programs at the University of Puget Sound in Tacoma, WA. In Winter 2002/2003 Benzing joined the faculty at Farleigh Dickinson University in Madison, NJ as Assistant Professor in the Department of Biological and Allied Health Sciences.

Tara Childs (MEM 2002) is employed by HGS, LLC, a private environmental consulting company in northern Virginia. She is involved in the firm's pond, stream and wetland restoration work, which includes regulation, assessment and feasibility, and conceptual mitigation plans.

Micah Wait (MEM 2002) is an ecologist working for Washington Trout, a non-profit wild salmonid conservation organization. He is currently doing videography work to document and record salmonid presence and abundance in Washington rivers. He is also the project leader on the restoration of Crockett Lake, a tidally influenced wetland on Whidbey Island. Additional research includes interactions between native salmonids and introduced warmwater species, and the distribution and abundance of freshwater sponges and freshwater mussels in Washington state.
Nicholas Visiting Distinguished Scholar Edward Maltby Opens DUWC 2002-2003 Speaker Series

Dr. Edward Maltby, Director of the Royal Holloway Institute of Environmental Research at the University of London, visited Duke University in October 2002 as one of this year’s Nicholas Visiting Distinguished Scholars. Maltby’s visit was part of a growing collaboration between the Nicholas School of the Environment and Earth Sciences and the Royal Holloway Institute of Environmental Research.

Maltby is Professor of Environmental and Physical Geography in the University of London’s Department of Geography in addition to being Director of the Royal Holloway Institute. He is also Director of the Wetland Ecosystems Research Group (WERG), an organization with an emphasis on wetland functioning and the development of functional assessment procedures for European wetlands, sustainability of wetland resource use, and human impacts. Maltby has also held leadership positions in the Centre for Ecosystem Dynamics and Environmental Management (CEDEM) and the IUCN Commission on Ecosystem Management.

He is an advocate on key issues relating to translation of science for decision-makers, wise use of wetlands, catchment management, and the role of human communities in conservation and environmental protection issues. Maltby is the author and co-author of 8 books and over 150 publications and reports focusing on the importance of wetland ecosystems at all scales—from global to local—and on the results of fundamental and applied wetland ecosystem research.

During his visit to the Nicholas School, Maltby presented class lectures and took part in individual discussions with faculty and students. He also presented the first lecture of the 2002-2003 Duke Wetland Center Distinguished Speaker Series.

In his Distinguished Speaker lecture, Maltby used examples from Southern Iraq, Vietnam, and pre-historic England to illustrate the direct relationships between human activities, ecosystem status, and human welfare. Dr. Maltby emphasized the need to break down perceived dichotomies separating people and nature, ecology and economy, and environmental science and policy to effectively manage wetland ecosystems for human and ecological benefit in the developing world.

Joy B. Zedler, Professor of Botany and Aldo Leopold Chair in Restoration Ecology at the University of Wisconsin-Madison, will be the spring lecturer in this year’s Duke Wetland Center Distinguished Speaker Series. Details of Dr. Zedler’s presentation, scheduled for April 8, 2003, are available at http://www.env.duke.edu/wetland/speaker.htm.

Wyatt Hartmann
Ph.D. Student, Duke University Wetland Center

EIGHTH SYMPOSIUM ON BIOGEOCHEMISTRY OF WETLANDS
September 14-17, 2003

The Eighth Symposium on Biogeochemistry of Wetlands will be held September 14-17, 2003 in Ghent, Belgium. The symposium will emphasize various biogeochemical processes and functions of freshwater, estuarine and coastal wetlands and provide numerous opportunities to discuss up-to-date research from around the world. Each day, three concurrent sessions will focus on different topics of wetland biogeochemistry and functions.

Final Registration: May 1, 2003
Abstract Submission Deadline: June 1, 2003

on the web at
http://allserv.rug.ac.be/~janverme/Wetlands/
Available online

EVERGLADES RESTORATION: A PRIMER
by C.J. Richardson & J. K. Huvane
http://www.env.duke.edu/wetland/Everglades%20Restoration.pdf

PHOSPHORUS LIMITATIONS OF COASTAL ECOSYSTEM PROCESSES
by P.V. Sundareshwar et al.
http://www.env.duke.edu/wetland/sundareshwarpublications.htm