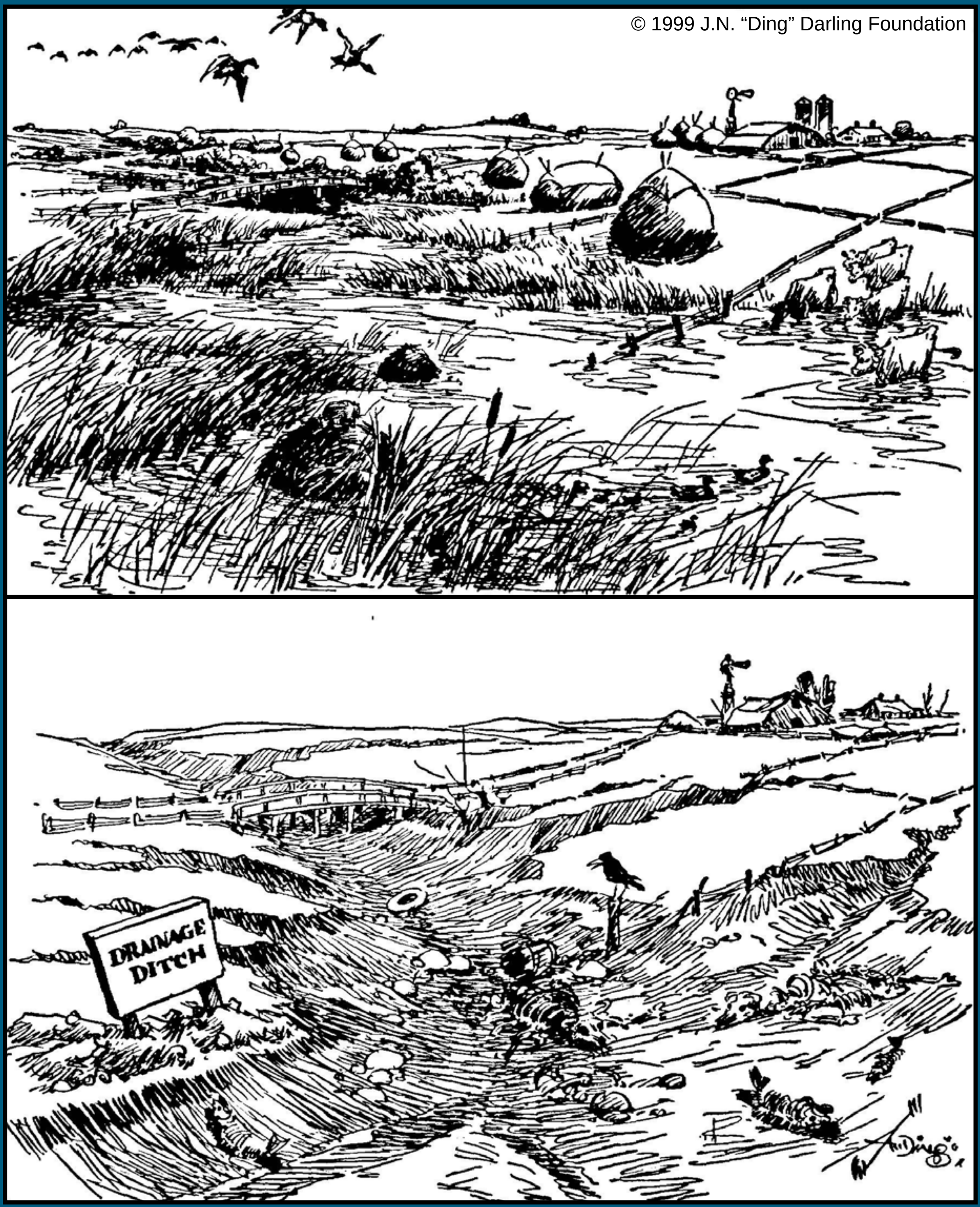
# wetland science & practice

published by the Society of Wetland Scientists
Vol. 35, No. 2 June 2018




**How Man Does Improve on Nature** (cartoon by Jay "Ding" Darling, 1938)

## FROM THE EDITOR'S DESK

**What a great time was had by all at our Denver meeting!** Great attendance, fabulous weather, exciting and informative field trips, and excellent presentations covering a wide-range of topics from floating islands and peatlands to wetland threats to restoration and conservation, for example. All that plus a time to reconnect with friends and meet new wetlanders. It's strange to be considered one of the "old timers." I was also pleased to become a SWS Fellow and thank the Society for the recognition.

Ralph Tiner
WSP Editor

I spent most of my time running from room to room to take in a broad array of topics with a keen interest in finding topics that would be of interest to our members through future contributions to *Wetland Science & Practice*. As expected there were far more interesting presentations than I could possibly attend due to the sheer number of concurrent sessions. I did find a significant number of presentations that would make for good subjects for future issues of WSP and have begun to invite presenters to convert their talks into summary papers for publication.

Now to the current issue. We have the second part of Mal Gilbert's series on applied wetland science-wetland restoration and creation, an article on two pioneers of wetland conservation (Jay "Ding" Darling and Joseph Knapp) by Arnold van der Valk, a technical paper on the use of *Salvinia* in bioremediation of heavy metals by Syed Shakeel Ahmad and others, and a short piece on Bill Mitsch's third "wetlaculture" mesocosm. This issue also contains the Final Resolution of the Europe Chapter meeting calling for designation of the Lake Ohrid system (including Studenchishte Marsh) as a Wetland of International Importance, plus other SWS News – photos from the Denver meeting, the Society's amicus brief filed in New York to emphasize science as the basis in administrating the Clean Water Act, and project summaries by six students awarded research grants last year. Future issues will include their results (project completion reports submitted to SWS). Nate Hough-Snee provided a review of a book about the secret life of beaver, while Doug Wilcox prepared another cartoon for our enjoyment. Thanks to all contributors!

With the Denver meeting behind us, presenters should seriously consider converting their presentations or posters into an article for WSP, so that their research can reach the widest audience possible (issues are open access via internet after 3 months of publication).

Happy Swamping! ■

## CONTENTS

Vol. 35, No. 2 June 2018



**COVER PHOTO:**

*Cover: Courtesy of the Jay N. 'Ding' Darling Wildlife Society*

SOCIETY OF WETLAND SCIENTISTS
22 N Carroll St., Ste 300, Madison, WI 53703
608-310-7855
www.sws.org

**Note to Readers:** All State-of-the-Science reports are peer reviewed, with anonymity to reviewers.

## PRESIDENT'S MESSAGE

### OUTGOING

**When I ran for president, my primary objective was to further the internationalization of SWS.** Internationalization of SWS was already one of the primary goals of our current Strategic Plan, but the Society had made little progress toward becoming a truly international organization.

Arnold van der Valk
SWS Outgoing President

Scientific societies provide two important benefits to their members:

1. access to the latest information about the field through journals, meetings, workshops, fieldtrips, etc.
2. opportunities to meet and interact with other people with similar interests (networking).

SWS already is an international leader in providing access to the latest developments in wetland science around the world through its journals, *Wetlands* and *Wetland Science and Practice*. SWS meetings, however, do not provide sufficient opportunities for networking for our members from around the world. There are two reasons for this. One, very few SWS annual meetings have been held outside the US. Two, the majority of speakers and topics in symposia and workshops at SWS annual meetings are American. I am going to focus in this report on what has been done during my presidency to change the latter.

In its development, SWS went from a regional organization in the southeastern US to an American organization with chapters all over the US to an international organization with chapters outside the US. Being organized around chapters has given SWS a geographically biased governance structure and outlook on what is most important in wetland science. Having international chapters does not make SWS an international organization. International chapters, just like American chapters, are focused on a limited geographic area. Internationalizing SWS means overcoming this geographic bias and focusing on global wetland issues and scientific advances.

Besides chapters, SWS has had for many years a second kind of special interest group, sections. Sections focus on the professional interests of our members (e.g., restoration ecology, biogeochemistry, wildlife, peatlands, education, etc.) or on their professional aspirations (e.g., women is wetlands, students). Unlike chapters, sections are inherently international in scope. They have no geographic boundaries, and they attract members from all over the world. Sections, however, were second class groups within SWS. They, unlike chapters, had no vote on the SWS Board of Directors and they, unlike chapters, are not funded from annual dues paid by our members. To internationalize, SWS needed to change the status of sections and to invest in sections to ensure that they attract and involve more international members in their activities.

*Continued next page*

wetland science & practice

## PRESIDENT ELECT'S MESSAGE

**The first morning home the day after I became president of SWS at the annual meeting in Denver, I note the wilting of my garden and the grumpiness of my cats as the dawn of my new reality.** The extra hours that I will spend as president of SWS will manifest itself as more cat and garden unhappiness as travel and responsibilities grow.

Beth Middleton
U.S. Geological Survey,
Wetland and Aquatic
Research Center
SWS President Elect

The cats gleefully blast out of the door into the backyard, because they have been cooped up indoors during the Denver meeting. My husband is more supportive than the cats and garden. So far, being the president of SWS recreates for me both the feelings of boundless possibilities I felt when president of my 4-H club when the changing future was in my hands, and of the heavy responsibility of my temporary summer chairmanship of my university department. "I am ready", I think as I sleepily sip coffee that morning.

My observations at the Denver annual meeting led to my realization that SWS is changing in sync with the breakneck speed of the world around us. Importantly, the new Student Section is contributing new insights into all aspects of SWS. Our students are the way forward for SWS, so it is incredibly exciting to witness increasing student involvement. Please, if you are a student and you want to participate in SWS activities, contact me.

Other new things emerging at the Denver meeting included the Traditional Ecological Knowledge initiative, which will be an important step in our internationalization efforts. Also related to internationalization, we are linking regional South American and African meetings to SWS section initiatives. Our PCP program is working toward offering certifications to members with training outside of North America, which will be of incredible value to these members.

Other great ideas are emerging from the Denver meeting. The chapter presidents and section chairs are creating consortia to foster intra-meeting exchange of ideas. The New Media committee is offering a venue for member-created videos and phone apps. And now, we prepare for the 40th anniversary of SWS in 2020 with the planning of various celebrations as well as special issues on emerging issues in wetland science, and the history of SWS.

Much of my year will be spent shepherding these and other SWS activities, which will come together at the next annual meeting in Baltimore (May 28-31, 2019). In this world of electronic communication, the networking time at the annual meetings is precious. Hope to see you in Baltimore. A long time ago, SWS membership information was stored in a shoebox. Despite the substantial changes in our organization since then, I view SWS as a shoebox-full of members that I want to know personally. If you have ideas or concerns in the next year, please contact me: middletonb@usgs.gov ■

### Outgoing President's Message, continued

This year, as a result of the vote of the membership, sections within SWS were raised to the same status as chapters. Sections now have a vote on the Board of Directors. They can now influence the future direction and development of the Society. Raising the status of sections to same level as chapters is the major accomplishment of my presidency. What we were unable to do this year because of budgetary constraints was make the funding of sections equivalent to that of chapters. We need to do this as soon as possible so that sections have the resources needed to enable them to involve SWS members from all around the world in the symposia and other activities that they organize each year for our annual meetings. Investing in sections will enable symposia at our annual meetings to become more international in scope by enabling members from around the world to present talks. This will make SWS more visible and relevant internationally. It will also enhance networking opportunities for people attending our annual meetings.

This year SWS made a significant change in its organization and governance by equalizing the status of sections and chapters. Although this is an important step in our internationalization effort, it is only a first step. We need to make many additional changes, including (1) developing a detailed internationalization strategy, (2) setting up an internationalization fund to promote SWS international activities and projects, and (3) having more annual meetings and more regional meetings outside the US.

Making SWS a truly international organization has only just begun. ■

Outgoing President Arnold van der Valk passes the Presidential Spoon to incoming President Beth Middleton at the SWS 2018 Annual Meeting in Denver. More Annual Meeting pictures are shared on pages 58-59, as well as on the SWS Facebook page.

## SWS Recognizes Five Wetland Scientists At Annual Meeting

At the 2018 SWS Annual Meeting, held May 29-June 1 in Denver, Colorado, USA, five scientists received awards for their significant contributions to wetland science, education, and management. Robert McInnes and Christopher Freeman were recognized as International Fellows and Ralph Tiner as a SWS Fellow, while Reyam Naiji Ajmi (in absentia) received the Merit Award and David Cooper the Doug Wilcox Award. For a list of past awardees go to http://sws.org/Awards-and-Grants/society-awards.html. To view more photos from the meeting, please see those featured later in this section, or visit the SWS Facebook page (https://www.facebook.com/societywetlandscientists/). ■


Loretta Battaglia, SWS Awards Committee Chair, with four of the five awardees.

### Save the date for 2019!

The 2019 Annual Meeting will be held in Baltimore, Maryland, USA, May 28-31, 2019. The theme is:

*The Role of Wetlands in Meeting Global Environmental Challenges: Linking Wetland Science, Policy, and Society*

**WE LOOK FORWARD TO SEEING YOU THEN!**

## SWS Files Amicus Brief in Clean Water Rule Suspension Case

The Society of Wetland Scientists filed an *amicus curiae* brief in the U.S. District Court for the Southern District of New York to emphasize the importance of science in agency rulemakings. Several states and organizations have filed suit against the Trump administration for the suspension of the Clean Water Rule. The SWS brief asserts that the U.S. Environmental Protection Agency and U.S. Army Corps of Engineers must consider the scientific basis of the 2015 Clean Water Rule before suspending it. To read the brief, visit http://www.stetson.edu/law/international/biodiversity/media/brief_of_sws_as_amicus_curiae_may_2018.pdf.

The Clean Water Rule was designed to protect the streams and wetlands on which Americans' health and economy depend. The U.S. Environmental Protection Agency and U.S. Army Corps of Engineers are now considering repealing that rule. While no repeal has been finalized, the agencies added an "applicability date" to the Clean Water Rule in February of 2018, suspending it for two years.

Professor Royal Gardner and attorney Erin Okuno from the Institute for Biodiversity Law and Policy at Stetson University College of Law, along with a team of attorneys including Dr. Steph Tai, Kathleen Gardner, and Christopher Greer, wrote the brief on SWS's behalf.

"Every aspect of the Clean Water Act's implementation requires the use of science," said Stetson Law Professor Royal Gardner. "When the agencies disregard science, their judgments deserve no deference."

"The ongoing attempt, if successful, by the EPA and USACE to undermine the scientific basis of the Clean Water Act, specifically to restrict the definition of what is a water of the United States, would have a significant impact on the future of wetlands in the US. SWS will do everything in its power to ensure that science not politics will continue to be the foundation for American wetland regulations and policies." Arnold van der Valk, President, SWS.

In accordance with the SWS Mission, Vision, and Strategic Plan, SWS works to "promote sound science in wetland policy and stewardship" and to promote "science-based management and sustainability of wetlands". SWS has taken many steps over a number of years to support the Clean Water Rule since its inception, as the Clean Water Rule is based on the best available science, including an analysis of over 1,200 peer-reviewed scientific publications. See prior SWS comment letters pertaining to the Clean Water Rule on the SWS Publications/Comment Letters page http://www.sws.org/Resources/letters-of-comment.html. ■

## Take Full Advantage of Your Membership Through SWS' Monthly Webinar Series

Participate in outstanding educational opportunities without leaving your desk! SWS is pleased to provide its webinar series that addresses a variety of wetland topics. The convenience and flexibility of SWS webinars enables you to educate one or a large number of employees at once, reduce travel expenses, and maintain consistent levels of productivity by eliminating time out of the office.

We are proud to announce that our webinars are now pre-approved by the SWS Professional Certification Program. Webinar registration is a complimentary member benefit. Certificates of completion are available upon request and can be used towards PWS certification. A limited number of spots are available for each webinar. If you're unable to participate in the live webinar, all webinars are recorded and archived for complimentary viewing by SWS members.

Webinars are now viewable with subtitles on YouTube! The Webinar Committee is excited to announce that our free webinar recordings are now available on the SWS YouTube channel. SWS supporters around the world can watch the webinars with subtitles in their native language. To view the webinars with subtitles, click the "CC" button in the bottom, right-hand corner of the video. You can change the language of the subtitles by clicking on the settings button in the bottom, right-hand corner and going to subtitles/CC > auto-translate > and choosing the language of your choice. Attend a webinar with subtitles: http://sws.ontrapages.com/youtuberegistration. ■

**MORE INFORMATION ABOUT UPCOMING WEBINARS:**
www.sws.org > Events > Upcoming Webinars

**MISSED A WEBINAR?**
View webinar archives at:
www.sws.org > Events > Past Webinars

## SWS Awards Grants to 12 Students

All SWS student members conducting undergraduate or graduate level research in wetland science at an accredited college or university who have not previously been awarded an SWS Research Grant are eligible to apply for a student research grant. In 2017, twelve students received a grant to support their studies. In the March issue of *Wetland Science and Practice*, a summary of 6 of these projects was presented to highlight their research. The June issue includes the summaries for remaining 6 student projects. Thanks to David Bailey, Chair of the SWS Student Research Grants Subcommittee, for his coordination and to the students for their summaries and photographs.

**WILLIAM SIPEK**
Southern Illinois University
william.sipek@siu.edu

### Drivers of Bird-Dispersed Exotic Plant Species in the Southeastern United States

Many biodiverse regions, such as the Coastal Plain in the Southeastern United States, have been severely damaged due to land development. These unnatural disturbances have allowed many exotic plant species to gain a foothold and proliferate. Continued disturbances may accelerate or inhibit this spread, depending on the nature of the disturbance and the tolerance level of the focal species. Several exotic species produce fleshy fruits and are dispersed by birds. If frugivores travel between separate plant species when foraging, then plants may indirectly influence the spread of fellow plants through contagious dispersal. We pose two questions: 1) How do natural disturbance regimes (e.g. tropical storms and wildfires) impact the growth and spread of an exotic tree species, *Triadica sebifera* (Chinese Tallow)? and 2) How do native and exotic winter-fruiting plant species affect the spread of fellow fruit-producers through contagious dispersal? To answer these questions, 150 samples of *T. sebifera* in coastal Mississippi and Alabama were cut down and cross-sections obtained in order to study the impacts of disturbances on the growth and recruitment of this exotic tree through tree-ring analysis. Annual growth rates and ages of collected specimens will be compared to years of known disturbance events to determine their impacts on this species. At nearby sites, a total of 110 seed traps were set up underneath fruiting individuals of *T. sebifera*, a fellow fruit-producing exotic species (*Cinnamomum camphora*) and three fruit-producing native species (*Ilex vomitoria, Morella cerifera* and *Persea borbonia*). Bird-dispersed seeds will be collected from these traps and analyses will determine the effects of each plant species, as well as the species' class (exotic or native), on the dispersal of fellow fruit-producers. This research will provide insight into the proliferation of exotic species in the Southeast United States and assist in the creation of management plans.

**NATHAN STOTT**
Bowling Green State University
stottnd@bgsu.edu

### Reconnected Coastal Wetlands in Lake Erie: Spawning and Nursery Habitat for Northern Pike

Northern Pike (*Esox lucius*) and Common Carp (*Cyprinus carpio*) are both species of interest in Lake Erie coastal wetlands for very different reasons. Northern Pike is a highly sought after native species with both ecological value as a native top predator and economic value as a sought-after game fish species. Common Carp is an invasive species with potentially detrimental impacts on wetland habitats due foraging and spawning activity that increases turbidity and decreasing macrophyte abundance. Current wetland management strategies utilize a grating system to limit access by Common Carp to restored wetland habitats. Managers often lift the grates to allow entrance by spawning Northern Pike, but then lower grates when it is surmised that Northern Pike have left and Common Carp are beginning to enter the wetlands. Additionally, if these grates are maintained in place they may inhibit large Northern Pike from accessing these systems and thus limiting the reproductive potential of the wetland. The objective of this study in progress is to create a field-based model that would predict when spawning migrations of each species occurs in Lake Erie coastal wetlands. A DIDSON high frequency sonar was deployed at a control structure that connects a coastal Lake Erie wetland to the lake itself from February 10 to April 21 when the wetland was closed off for a water draw down to promote vegetative growth. Nearly all fish moving into or exiting this system were imaged using this method as the field of view contained the whole constriction point that fish must pass through in order to gain access to the wetland habitats. Methods to identify fishes ensonified throughout the study are currently in progress; this involves controlled ensonification with known species and the development of discriminant analyses using morphometrics. This research could aid management practices and reduce the trade-off between Common Carp exclusion limiting Northern Pike access by allowing the possibility of only installing the exclusion grates when Common Carp are expected to be entering the system and allowing all fishes access when they are not.

**NICHOLAS BUSS**
Binghamton University
nbuss1@binghamton.edu

### Effects of NaCl and Host Diversity on Host Parasite Dynamics

Wetland communities face a diversity of natural and anthropogenic stressors. As human populations continue growing, considering how natural and anthropogenic stressors interact will become increasingly important. Theory suggests that maintaining wetland biodiversity is critical to buffering these communities from stressors. For example, as host species richness increases, studies show that overall infection within these host communities generally decrease (i.e. the dilution effect hypothesis). However, wetland organisms also face other stressors, such as contaminants, which can alter host-parasite outcomes. Therefore, contaminants may influence the positive effect of biodiversity (i.e. dilution effect) in buffering wetland host communities from parasitic infection. Using an amphibian-trematode model, my research asks: (1) Does increased amphibian host diversity lead to a dilution effect? (2) Does NaCl exposure alter the predicted outcome of the dilution effect hypothesis? To answer these questions, I completed an additive and substitutive experiment with 6 [community assemblages: (1) six wood frogs (2) six peepers (3) six toads (4) three wood frogs + three peepers, (5) three toads + three peepers, (6) two wood frogs + two toads + two peepers] x 2 [salinity treatments: 0 g/L and 1 g/L NaCl] x 10 replicates. I predict that in the most diverse community, amphibians that are less susceptible to parasites (i.e. wood frogs and toads) will dilute parasites away from more susceptible hosts (i.e. spring peepers), reducing overall infection in the community. In contrast, in the presence of NaCl, based on preliminary work, I predict that there will be a toxicant-induced shift in susceptibility in host susceptibility to parasites which will alter predicted dilution effect outcomes. By examining the role that contaminants play in shaping host-parasite interactions at the community-level, we will be better able to understand the mechanisms that shape infection outcomes within wetland communities.

**TESSA DOWLING**
University of New England
tdowling@une.edu

### Factors Influencing Growth of High Salt Marsh Plants in Upland Soils

Salt marshes are important ecosystems that act as water purifiers, buffers against coastal storms, and vital habitat for fish nurseries and waterfowl. Currently, sea level rise is increasing inundation levels in this ecosystem and altering vegetation zone boundaries. Typical New England salt marsh vegetation is divided into two zones; the high marsh, dominated by salt hay (*Spartina patens*) and the low marsh, dominated by smooth cordgrass (*Spartina alterniflora*). Rising sea levels drives the low marsh inland, which squeezes the high marsh between the encroaching low marsh and the upland. To maintain a high marsh community, the salt marsh must migrate into the upland. My thesis research tests environmental factors that might limit the ability for salt hay (*S. patens*) to grow in upland soil. We collected 240 salt hay plugs from three salt marshes along the coast of Southern Maine, and transplanted them into 5 gallon pots with either marsh or upland soil. The salt hay plugs were also subjected to either a high or low salinity level (to take into account coastal variations), and the presence or absence of ground litter (which can act as a physical barrier and inhibit growth). Growth was measured be taking the dried weight of the stems (aboveground biomass) and rhizomes (belowground biomass) at the end of one growing season. We predict that salt hay growth will decrease when grown in upland soil under high salinity conditions and the presence of ground litter. The results of this experiment will give insight into the ability for salt hay to migrate inland, and help conservation efforts to prioritize areas adjacent to salt marshes where high marsh migration will have the greatest likelihood of success.

**ERIK YANDO**
University of Louisiana at Lafayette
erik.yando@gmail.com

### Assessing Hydrological Connectivity in Coastal Wetland Restoration Projects Utilizing Fine Scale Hydrological Monitoring

Wetland loss due to both anthropogenic and natural processes is a major issue worldwide, and is particularly severe in many deltaic systems, such as coastal Louisiana. To maintain the important ecosystem properties, processes, and services coastal wetlands provide, restoration and creation efforts are necessary to help abate net wetland loss. Appropriate hydrology is one key factor in allowing for the successful restoration of these threatened wetlands. Elevation is often used as a proxy for hydrology, but other factors such as hydrological connectivity and regime also need to be considered to return suitable hydrology to restored wetlands. This study will utilize fine scale hydrological assessments paired with elevation surveys to determine hydrological connectivity in both natural and restored locations in coastal wetlands in Louisiana. In comparing this data to local tidal gauges, I will be able to elucidate how microtopography, marsh position, and pre-existing barriers can influence hydrologic connectivity throughout an entire year. In using both fine-scale elevation measurements paired with site specific water loggers, I hope to show how these restored sites differ from nearby natural marshes and provide suggestions on how to improve hydrology for future projects.

**MARISA SZUBRYT**
Southern Illinois University Carbondale
marisaszubryt@gmail.com

### Influence of Wetland Plant Evolutionary History on Soil and Endophyte Microbial Communities and Implications

Wetlands are responsible for over a quarter of global emissions of methane, a greenhouse gas approximately twenty-five times more potent than carbon dioxide over a one-hundred year time scale. Methane is produced by methanogenic archaea within marsh soils and sediments, where it may be consumed by methanotrophic bacteria or escape through ebullition. However, methane and other gases can also diffuse through specialized plant tissue (known as *aerenchyma*) that can dramatically increase rates of diffusion into and out of soil. Aerenchyma also allows oxygen transfer from the atmosphere into root and adjacent soil (rhizosphere). This oxygen is available for plant root and submerged stem respiration, with excess oxygen leaking into the rhizosphere. The rates of gas flow and oxygen demand varies among plant taxa, however, determining how much excess oxygen is available for microbial consumption. Plant taxa also vary in their release of high and low molecular weight root exudates and senesced tissues into soils, providing a wide range of carbon substrates that support microbial growth. Little is known about the effects of dominant wetland plants on sediment and endophyte microbes, and previous studies have not taken host phylogenetic history into account. This study aims to determine how microbial communities are affected by the presence of five species (*Bolboschoenus fluviatilis, Phalaris arundinacea, Phragmies australis, Sparganium eurycarpum*, and *Typha x glauca*), each of which form large monotypic stands. *Phalaris* and *Phragmites* are both grasses which are related to the sedge *Bolboschoenus; Sparganium* and *Typha* are sister genera but more distantly related within the Poales. We will collect unvegetated, bulk, and rhizosphere soils, plus leaf and root tissues from a stand of each plant species, and perform 16S rRNA amplicon sequencing to examine overall microbial community structure. We will additionally perform quantitative PCR of both the mcrA and pmoA genes to examine the absolute abundance of methanogens and methanotrophs, respectively, as related to both plant species and sample type (bulk soil, rhizosphere, root, or leaf). Finally we will examine whether differences in methanogen and methanotroph population sizes and microbial community composition are related to plant phylogenetic distance. Closely related plants have been known to bear similar biochemical and structural features that may influence the survival of particular symbiotic microbes and geochemical cycling. ■

# SWS-Europe Chapter Meeting in Ohrid Calls for Protection of Studenchishte Marsh

**Final Resolution adopted at the 13th Society of Wetland Scientists**
**Europe Chapter Meeting**

The 45 SWS Europe wetland conference participants in Ohrid, Macedonia, from over 18 countries and representing a wide range of expertise in wetland science, green technology, policy and management, acknowledge the timely moment in which we have gathered here; and, have come to agreement on the following issues:

***Recognizing*** the unique magnificence of the region with the two connected lakes (Ohrid and Prespa), in terms of overall biodiversity, number of endemic species of many plant, animal and microbial groups, excellent water quality and relatively undisturbed mountainous landscapes in the transition between Central Europe, the Mediterranean and the Balkan peninsula;

***Recognizing*** the unrivalled length of time of undisturbed development of Lakes Ohrid and Prespa, spanning at least 1.6 million years, which (1) has led to layered sediments with unique thickness enabling studies of climate and evolution in these systems for their entire lifetime, which is unique in the world and (2) has led to a large number of endemic species of plants, animals and microbes in these systems;

***Recognizing*** the excellent current condition of Lake Ohrid with its low nutrient water quality and inflow of very healthy water from the surrounding mountains, which is, however, threatened by polluted inflows from increasing human populations of local residents and tourists and from agricultural use of former floodplains in the catchment of the Lake, which dates back only a few decades since these floodplains were drained and the course of the river Drim and other water courses were strongly modified, bringing polluted water into the Lake.

***Recognizing*** the deteriorating status of the very last intact marsh on the shores of Lake Ohrid, Studenchishte Marsh. The wetland area remaining is only a minor part of the much larger wetland system which used to be here 50 years ago but which has suffered from (1) building development, (2) encroaching drainage and agricultural use, (3) dumping of building materials and other wastes; (4) creation of a plant nursery, (5) recent road construction along the Lake shore, compromising the ecological integrity between the Marsh and the Lake, which are vital for the long-term sustainability of the system;

***Recognizing*** the critical importance and high value of the remaining part of Studenchishte Marsh in terms of inter alia (1) species diversity of plants and animals, with some communities (e.g. Caricetum elatae) being very rare in the region at large; (2) the presence of undisturbed peat layers with a thickness of several meters, which have developed over at least 4000 years and are particularly rare in Macedonia and (3) the very last fully functioning marsh ecosystem along the lake with a unique species composition and set of wetland ecosystem services such as water quality improvement, carbon storage, flood retention and some other functions (spawning of fish species from the Lake) that could be revitalized by reversing some of the recent modifications;

***Recognizing*** that Lake Ohrid does have a protection status following its inscription as a UNESCO World Heritage program, however, this has not been sufficient to halt the fluxes of polluted water into the Lake and does not provide any explicit protection of the valuable Studenchishte Marsh;

***Recognizing*** that the Lake Ohrid system, including Studenchishte Marsh, is of key importance as the core resource on which economic development through sustainable tourism can be achieved, so that the protection and revitalization of this ecosystem must be the number one priority for regional development.

***Therefore***, call upon the Macedonian authorities from the national to the local level to substantially enhance the status of protection of Lake Ohrid, including Studenchishte Marsh and its catchment through existing legislation and instruments. This should also be achieved by designating the Lake system as a Wetland of International Importance under the Ramsar Convention. Macedonia is a Contracting Party of the Ramsar Convention and SWS has information that the designation would be welcomed by the Ramsar Secretariat in Gland, Switzerland, and that this designation can be based on the information that is currently available;

***Therefore***, in addition, call upon the urgent development and implementation of an action plan to protect Studenchishte Marsh and to revitalize it as much as possible. This should include inter alia: the local replacement of the current hard boundary with the Lake with a wooden walkway allowing direct water flows and ecological exchange between the Marsh and Lake; the cessation of dumping; and the encroachment of agricultural activities. The enlargement of the surface area of the marsh towards its original extent should be the long-term goal. Removal of solid wastes and rewetting of agricultural areas should be carried out with great care. Current land users should be compensated in the best possible way;

***Therefore***, call upon a substantial revision of the water management practices in the cities and rural villages around the Lake to prevent discharges of polluted water into the Lake; this should be part of a long-term plan including the use of wetland restoration and constructed wetlands to improve water quality and funding opportunities should be investigated from appropriate organizations, e.g. the EU and the World Bank;

***Therefore***, call upon the city government of Ohrid to develop multiple nature tourism attractions in the area to increase revenues by offering more diverse options and extending the tourist season; this could be achieved by developing locations such as Studenchishte Marsh as a nature park with facilities such as a visitor and environmental education center, a nature trail with boardwalks and wildlife watching buildings. Culturally important sites such as Biljanini Springs and the archeological monuments around it could also become part of this attraction and would give visitors an interesting experience where they can learn about the unique nature, culture and history of the region.

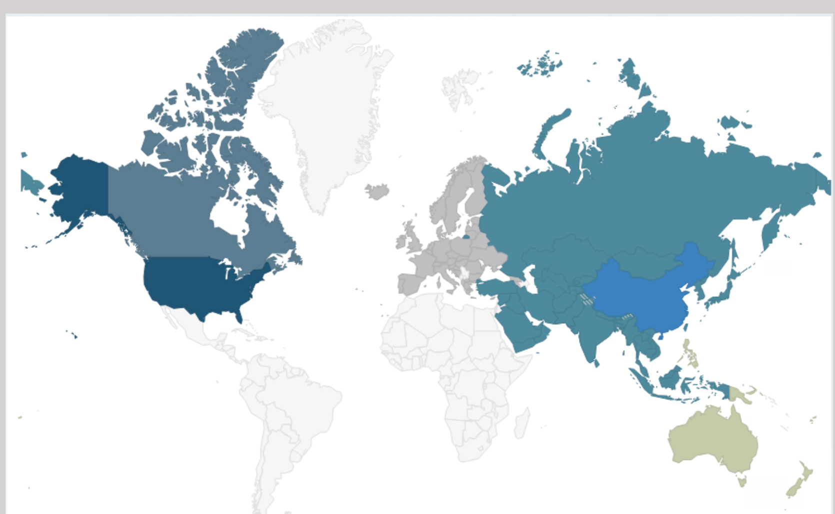
We thank the Governments of Macedonia and Ohrid, the St. Clement of Bitola University in Ohrid, the St. Cyril and Methodius University in Skopje and Ohrid SOS for hosting and contributing to the 13th SWS Europe meeting.

Signed on behalf of all participants in Ohrid, Macedonia on 3 May 2018 by Matthew Simpson, Keith Edwards, Matthew Cochran and Jos T. A. Verhoeven.

## Upcoming SWS chapter meetings

- **2018 ASIA AND CHINA CHAPTER JOINT MEETING**
  August 17 - 21, 2018
  Changchun, P.R. China

- **SWS PACIFIC NORTHWEST CHAPTER AND SER NORTHWEST JOINT MEETING**
  October 15 - 19, 2018
  Spokane, Washington USA



SWS 2018 Annual Meeting **Denver, Colorado ■ May 29 - June 1**

Wetland Science: Integrating Research, Practice, and Policy - An Exchange of Expertise

**MORE PHOTOS ARE POSTED TO THE SWS FACEBOOK PAGE.**

Bocce ball and more at the student mixer.

Reconnecting with old friends at the Opening Reception.


New President-Elect Max Finlayson with the Denver Declaration, signed by many meeting attendees.


SWAAMP participants take over meeting registration.

Discussing the latest research results during the poster presentations.

Break-out sessions aligned with attendees' areas of particular interest.

Starting out the day with a Plenary Speaker.


Break time!

Getting hands dirty on the optional field trips.

Bidding on Silent Auction items, to raise money for the host Rocky Mountain Chapter.

## Thank you to 2018 Annual Meeting sponsors:

WESTERVELT ECOLOGICAL SERVICES

ARCADIS Design & Consultancy for natural and built assets

BURNS McDONNELL CREATE AMAZING.

DERRICKSON PIKE

ETIC CONSULT ENGINEER CONSTRUCT

ERM

Sevenson Environmental Services, Inc. 100 YEARS OF FAMILY Est. 1917

HDR

SMITH

BSC GROUP

CROUCH ENVIRONMENTAL SERVICES, INC.

ERO ERO Resources Corporation Consultants in Natural Resources and the Environment

Wetlands INTERNATIONAL

# Assisting Nature: Ducks, "Ding" and DU

*Arnold G. van der Valk[1], Ecology, Evolution and Organismal Biology, Iowa State University, Ames, IA*

## ABSTRACT

Jay "Ding" Darling (1876-1962) was a newspaper editorial cartoonist and duck hunter. Because of his pro-conservation cartoons, he had become one America's most prominent conservationists by the early 1930s. Joseph P. Knapp (1864-1951) was a prominent businessman, philanthropist, conservationist, and duck hunter who, like Darling, had become concerned about the decline of waterfowl populations. Both worked to reverse this duck decline. Darling was appointed chief of the Bureau of Biological Survey in 1934 by President Franklin Roosevelt. During his short tenure as its chief (1934-1935), he focused the Bureau's mission more on wildlife conservation and he oversaw the expansion of the national wildlife refuge system. In 1930, Knapp founded the More Game Birds in America Foundation. This Foundation through its waterfowl surveys documented that western Canada was the major breeding ground of ducks in North America. This resulted in the Foundation establishing Ducks Unlimited, Inc. in the US and Ducks Unlimited (Canada) in 1937. DU, Inc. would raise money, and DU (Canada) would spend this money in western Canada on wetland conservation and restoration projects. Both men helped to slow down the loss of wetlands by stressing the need for the public and private sectors to conserve and restore them as waterfowl habitat. They also shaped future wetland science by creating opportunities for the employment of wetland scientists.

## INTRODUCTION

By the early 1930s, the United States faced numerous crises: climatic, economic, environmental, and social (Cart 1972, Worster 1979). Among the many longstanding environmental crises that were finally addressed in a significant way during the 1930s was the drastic decline of waterfowl populations. This decline was so severe that many hunters and associations of duck hunters were convinced that duck hunting would soon be impossible or illegal (Phillips and Lincoln 1930, Furtman 2011). This decline in waterfowl populations was in large part due to the drainage of wetlands in breeding areas between 1880 and 1920 that was facilitated by the development of drainage tiles and establishment of drainage districts (McCorvie and Lant 1993, Allen 2016). Up to the 1930s, wetlands had been largely perceived by most private citizens and many government agencies as wastelands that should be converted to productive use, i.e., to farmland (Prince 1997, Vileisis 1997, Allen 2016).

This decline in waterfowl populations had been occurring for some time, but was exacerbated by the droughts of the 1930s in the Great Plains. These droughts created the "Dust Bowl" that decimated agriculture throughout the region, especially in states like Oklahoma and Kansas (Worster 1979). These droughts affected the entire prairie pothole region, the most important breeding grounds for waterfowl in North America. However, it was not only drainage and droughts that were the underlying causes of the waterfowl population decline. Although downplayed by hunting interests, overhunting of waterfowl had also taken its toll.

Phillips and Lincoln (1930) in the Introduction to their book, *American Waterfowl: Their Present Situation and the Outlook for their Future*, threw down the gauntlet to American waterfowl hunters: "Unless the more intelligent sportsmen can be made to give serious and immediate attention to the many adverse factors which to-day confront our most valuable wild-fowl, we believe it soon will be too late to save these birds in numbers sufficient to be of any real importance for recreation in the future." American and Canadian sportsmen did rise to the occasion. Their efforts to save duck populations have had a profound effect on the development of wetland science. They resulted in a significant expansion of wetland conservation programs by a US government agency (Bureau of Biological Survey, a forerunner of the Fish and Wildlife Service) and the establishment of a new private organization (Ducks Unlimited) that focused on the conservation and restoration of wetlands.

For any science to develop, there have to be institutions (museums, universities, government agencies, private organizations, etc.) that are focused, at least in part, on that discipline. Not only are new ideas needed to develop a new scientific discipline, but also new job opportunities. Without institutions that hire wetland scientists, wetland science would not exist. Although ante-

1 Corresponding author: valk@iastate.edu, 515-294-4374

cedent wetland scientists could already be found before the 1930s working in universities and museums (van der Valk 2017, 2018), during the 1930s new institutions arose or expanded that are to this day important employers of wetland scientists.

By the 1930s, there were two very different solutions proposed to reverse the decline in waterfowl populations. One group of individuals and organizations believed the only solution was to increase waterfowl breeding habitat through acquisition and restoration of wetlands by the federal government. Jay "Ding" Darling exemplified this approach. The other approach was based on the European model of game management. This approach was to rear and release waterfowl so that they could be shot by hunters. Initially, Joseph P. Knapp was a proponent of rearing and releasing game birds. In fact, this latter approach had been adopted by a number of state game agencies and private hunting clubs for a few waterfowl species, most notably mallards. A seminal paper by Frederic C. Lincoln (1934) on the efficacy of rearing ducks for release made it clear that this approach would not work. Its title says it all: "Restocking of marshes with hand-reared mallards not proved practical." These two disparate approaches had a significant implication for the future of waterfowl hunting in North America. The European approach of stocking hard-raised game birds for hunters to shoot would result in "hunting" becoming "shooting". Raising game birds for release is expensive, and this would eventually make waterfowl hunting a rich man's sport that would be out of reach to most American hunters (Furtman 2011). This was what many American waterfowl hunters feared.

It is the response of two duck hunters, Jay Norwood "Ding" Darling (1876-1962, Figure 1) and Joseph Palmer Knapp (1864-1951), to the decline in duck populations that is the focus of this paper. Their efforts to save ducks emphasized for the first time the need to stop and even reverse wetland losses. Because they stressed the benefits of wetlands, their efforts eventually resulted in a change in the public's perceptions of wetlands from mostly negative to positive. They did it in very different, but complimentary, ways. Ding Darling reshaped the waterfowl agenda of an existing US government agency (Bureau of Biological Survey). Joseph Knapp created a new private conservation organization (Ducks Unlimited). To this day, their institutional legacies help to shape wetland policy, management, and science in North America.

## JAY "DING" DARLING

Jay Norwood "Ding" Darling (1876-1962) was born in Michigan, but grew up in Sioux City, Iowa. After a false start at Yankton College in South Dakota from which he was expelled for going on a joy ride with the president's horse and buggy, he enrolled in Beloit College, WI. His goal was to become a medical doctor. At Beloit his favorite courses were in biology, but he was not an exemplary student. While at Beloit, he began to draw satirical cartons of some of some of the faculty for the Beloit yearbook. These got him suspended for a year. He finally graduated in 1900. After graduation he got a job with the Sioux City Journal and eventually became its editorial cartoonist. He moved to the Des Moines Register in 1913. Because his editorial cartoons for the Register, many dealing with conservation issues, were published in newspapers around the US, Darling became a nationally recognized and influential advocate for a variety of conservation causes, including reducing soil erosion and wildlife conservation. By the 1930s, he was one of the most visible wildlife conservationist in the US. See Lendt (1979) for a detailed account of Darling's life and many achievements.

**FIGURE 1.** Jay Norwood "Ding" Darling hunting in South Dakota in 1931. Source Lendt (1979)

Darling was both a life-long conservationist and staunch Republican. Throughout his career, he used his cartoons to promote a variety conservative political and environmental issues. His first conservation cartoon was published in 1901. It was in support of Theodore Roosevelt's campaign to establish the Forest Service. Because he was an avid duck hunter, one of Darling's major conservation concerns was the decline in waterfowl populations. Like Phillips and Lincoln (1930), he believed that this decline was due to drainage of wetlands in the breeding grounds and to overhunting. Although Darling, was a persistent critic of the New Deal, Franklin Roosevelt would call on him to try to help solve the duck decline problem, which had become a political liability for Roosevelt among wealthy sportsmen. Joseph P. Knapp (see the following section for more on him), who was a politically well-connected businessman and conservationist, tried to get the US government more involved in saving waterfowl populations and waterfowl habitat. Knapp's More Game Birds in America Foundation (more on the Foundation in the next section) sent a memo to President Roosevelt that suggested that projects to reverse the waterfowl decline might provide


**FIGURE 2.** Help. A Ding Darling cartoon from the *Report of the President's Committee On Wild Life Restoration* (Beck et al. 1934).

unemployment relief. These were the kinds of projects that appealed to Roosevelt.

In 1934, in response to criticism for not doing anything to reverse the decline in wildlife populations from conservationists and hunters, President Roosevelt appointed a President's Committee to examine the causes of the duck decline and to make specific recommendations to reverse this decline. He appointed Darling as one of the three members to this Committee on Wild Life Restoration. It is more commonly called the Beck Committee after its chair, Thomas H. Beck. Beck was the editor of *Collier's Weekly*, a popular magazine of the time that had regularly run articles on wildlife conservation issues. *Collier's* was part of a publishing company owned by Joseph P. Knapp. The third member of the committee was Aldo Leopold, who had recently been appointed to a faculty position in game management at the University of Wisconsin and who also had just published a pioneering book on *Game Management* (Leopold 1933). In addition, Leopold had been chair of the Game Policy Institute of the American Game Conference and had helped formulate its influential American Game Policy of 1930. Today Leopold is best known for his book, *A Sand County Almanac*, in which he developed his "land ethic" (Leopold 1949).

The Beck Committee, which was appointed in January 1934, only existed for a short time and issued its report in February 1934. Among the people who helped with this report were John Huntington and Arthur Bartley of Knapp's More Game Birds in America Foundation. The Committee's main charge was to develop a wildlife restoration plan that would "dovetail" with the Roosevelt Administration's marginal land elimination program. Among the Committee's major recommendations were the "acquisition of 4 million acres potentially or actually suitable for migratory waterfowl" and the "purchase of 5,000,000 acres of submarginal land suitable for development and management of upland game areas" (Beck et al. 1934). It also requested \$25,000,000 to start land acquisition and an additional \$25,000,000 from existing government New Deal programs for the "restoration and improvement of the lands acquired." In addition, the Beck Committee recommended "A new administrative set-up to insure continued, coordinated, and businesslike execution of the plan for Nationwide restoration and conservation of our wildlife resources." (Beck et al. 1934). This recommendation reflected the lack of confidence in the Bureau of Biological Survey, the main federal agency that was expected to implement the Beck Committee's recommendations, by the Committee, especially its chair Thomas Beck. Beck wanted to recommend that the Bureau be abolished, but this was opposed by Darling and Leopold (Lendt 1979). In fact, the Bureau of

Biological Survey failed to implement the Beck Committee's recommendations. This put the Bureau at odds with conservationists, sportsmen, and politicians. The Bureau's chair ended up resigning because of his failure to act on the Beck Committee's recommendations.

To allay criticism for the failure of the government to take action on the recommendations of the Beck Committee, Roosevelt asked Darling to become the new chief of the Bureau of Biological Survey. The life-long Republican and New Deal critic reluctantly accepted the position. It was a case of put up or shut up. To entice him to take the position, Darling was promised money to expand the refuge system and was given full authority to shake up the Bureau. He started his temporary appointment as chief of the Bureau on March 10, 1934, but with considerable opposition from within the Bureau. Some of his staff considered him incompetent and unqualified (Lendt 1979). The Bureau, although nominally the US Government's main wildlife conservation agency was part of the Department of Agriculture. Consequently, it was not solely focused on wildlife conservation, but was also heavily involved in predator control, i.e., killing wild animals that damaged crops or that killed domestic animals. These predator control programs were anathema to hunters and conservationists. For the short time that he was its chief, Darling tried to broaden the mission of the Bureau and to make it more conservation oriented.

Just few days before Darling was appointed head of the Bureau of Biological Survey, President Roosevelt had signed the Migratory Bird Hunting Stamp Act, or as it is more commonly called, the Duck Stamp Bill. Darling had strongly supported the Duck Stamp Bill and drew the first Duck Stamp (Figure 3). Duck Stamps were, in effect, a federal waterfowl hunting license. Annual revenues from Duck Stamps would provide the funds needed by the federal government to purchase land for waterfowl refuges. This was a turning point in the history of American wetland conservation. Waterfowl hunters had imposed a voluntary tax on themselves to support the preservation, conservation and restoration of wetlands. See Dolin and Dumaine (2000) for a history of the Duck Stamp.

To try to reverse the decline in waterfowl populations, Darling did two things. One, he managed to get a $6,000,000 appropriation through Congress to fund land acquisition for national wildlife refuges, especially for new waterfowl refuges. Money from Duck Stamps would allow the Bureau to continue to acquire more land for refuges in the future. Two, in 1935 he turned his attention to the overhunting of waterfowl and he introduced the most restrictive hunting regulations ever seen. They reduced the length of the hunting season and bag limits. There was a significant backlash from waterfowl hunters and members of Congress, but Darling held his ground (Lendt 1979). These more restrictive regulations are the basis for current regulations. In addition, Darling established Cooperative Wildlife Units at Land Grant Universities around the US. He had helped to establish such a unit at Iowa State University (then College) prior to coming to Washington.


**FIGURE 3.** The first US Duck Stamp. It was drawn by Ding Darling. Source: USFWS Duck Stamp Collection

As chief of the Bureau of Biological Survey, Darling quickly began to shake up its leadership by getting rid of some of its ineffective staff. Among his appointees was J. Clark Salyer II who was only 32 years old when Darling appointed him the first head of the National Wildlife Refuge System. Salyer was to oversee the expansion of the national wildlife refuges from a handful of mostly neglected and unsupervised areas to 279 national wildlife refuges by the time he retired in 1961 (Lendt 1979). Darling also brought to Washington Ira N. Gabrielson who had been working for the Bureau in the northwestern US. Gabrielson became Darling's successor at the Bureau and he would eventually become the first director of the US Fish and Wildlife Service.

In 1935, Darling published an essay, *Conserving our wild life*. Its opening lines provide a clear statement of his vision for the Bureau: "THE BUREAU OF BIOLOGICAL SURVEY is the custodian of all of the wild life species that exist." He goes on to compare the Bureau's mission with that of Noah: "Noah started it. I think he must have been the first member of the Biological Survey! He built the ark to save a pair of all wild life. The only difference between Noah and my personal experience is that he started out in a flood and I started out in a drought." Later in his essay Darling describes the current status of duck populations: "We have taken it as a matter of course that nature provided us with a free gift of all of the ducks we wanted. We have never had to worry about the myriads that have gone North in the spring, and South in the fall. Now we know that if we don't watch out we won't have any. Some of the very choicest species are on the verge of extinction. … We have robbed them [ducks] of seventeen million acres of natural nesting areas in the North Central States of the United States, once the most prolific hatching ground in all of our migratory water fowl in this country." He ends his essay on an optimistic note: "I have $8,500,000 for the Bureau's work -- not a vast amount, but it represents the first money that has ever been put into nesting areas to restore our game. I hope that some day [sic] the $8,500,000 will produce about one million and a quarter acres of old nesting ground. That ought to produce about 8,000,000 extra ducks and geese and migratory water fowl to pass backward and forward." But it is the final paragraph that is the most revealing: "We are not doing all this for the hunters. I should not be here if all that I was doing was making it possible for people to go out and kill game. My chief interest lies in restoring America to itself." By this he meant restoring the habitat needed by America's wildlife and game birds. It was a complete reimagining of the mission of the Bureau. Needless to say, not all of the Bureau's employees at the time were onboard with their chief's radical new vision. Darling's concept of what was meant by conservation was ahead of its time, but it would eventually become widespread both inside and outside the US government.

During his brief time in Washington, Darling was frustrated by some New Deal programs and policies that negatively impacted wetlands. For example the US Government continued to underwrite the refurbishment and repair of wetland drainage networks by the Civilian Conservation Corps (CCC) while at the same time using the CCC to build infrastructure on new wildlife refuges (Vileisis 2009). Creating jobs and stimulating the economy were much higher priorities for the Roosevelt administration than promoting wildlife conservation. Likewise, Darling was not successful fighting a number of water projects proposed by the federal government (Lendt 1979). He resigned his position as chef of the Bureau of Biological Survey in November 1935 after only 22 months. In his letter of resignation, he wrote that he was leaving "with my tail between my legs!" (as quoted in Lendt (1979)). He had enough of the New Deal.

Darling contributed to the development of wetland science in three major ways: (1) his tireless campaigning on behalf of wetland preservation and restoration raised their visibility as an important national resource, not just for waterfowl hunters, but among the general public; (2) his reform of the Bureau of Biological Survey laid the foundation for increased efforts by the US government to conserve and protect wetlands through the establishment of waterfowl refuges; and (3) his efforts within the US government to develop programs to conserve, protect, and study wetlands would create important job opportunities for wetland scientists as managers and researchers within federal and state agencies. In short, Darling efforts on behalf of waterfowl advanced the development of wetland science by establishing or expanding institutions that would protect wetlands and employ wetland scientists.

## JOSEPH PALMER KNAPP

The founding of Ducks Unlimited has been chronicled in a number of books, including Farrington (1945), Tennyson (1977), Leitch (1978), Furtman (2011), and Batt (2012). Of these Leitch's (1978) and especially Tennyson (1977) are based on interviews of Arthur M. Bartley (1892-1981), who was the first executive director of Ducks Unlimited Inc. Bartley was involved in the establishment of More Game Birds In America and its successor, Duck Unlimited, from their beginning. Furtman (2011) based his account more on archival materials from the More Game Birds in America Foundation in the Ducks Unlimited, Inc. archives. My account is based primarily on Leitch (1978), Tennyson (1977), and Furtman (2011).

Joseph Palmer Knapp (1864-1951) was a wealthy American businessman and philanthropists. Like Ding Darling, he was also a keen duck hunter and like Ding Darling he wanted to reverse the calamitous decline in duck populations that had occurred in North America. To this end, in 1930 he founded and largely funded the More Game Birds in America Foundation. John Huntington was the new foundation's vice-president and Arthur Bartley, Huntington's navy buddy, was its director of field activities. John Huntington was the son of Dwight Huntington who had founded the Game Conservation Institute in 1912. Arthur Bartley was at one point the director of this Institute. Dwight Huntington considered game birds to be a crop and viewed game bird management as a form of crop management, i.e., farming. In other words, game birds could be raised like corn or rice. For this to work, however, game bird farming had to be based on sound business practices. Dwight Huntington's emphasis on sound business practices as the basis of conservation efforts would have a profound impact on Joseph Knapp and his conservation efforts.

As the More Game Birds in America Foundation's name makes clear, it was established to reverse the decline in game birds, especially waterfowl, that threatened the future of game bird hunting. As with other conservation groups, the Foundation believed that the declines in game bird populations was due primarily to loss of habitat and overhunting. The new Foundation published its manifesto, *More Waterfowl by Assisting Nature*, in 1931 (Figure 5). The anonymous author in the Forward of this manifesto made it clear that the Foundation was proposing "a comprehensive, sound, adequate, workable, and properly financed plan for preserving and increasing waterfowl." It would also "take no account of international boundaries." It outlined in detail the Foundation's business plan for saving ducks, including a budget. Duck hunters were asked to step up and do their share. What was proposed was not another government program, however, but a privately funded effort. The major features of the proposed plan of More Waterfowl by Assisting Nature are found in Figure 6.

As we saw in the previous section on Ding Darling, a memo from More Game Birds in America to President Roosevelt and similar efforts by other conservationist and hunting interests triggered the establishment in January 1934 of the Beck Committee. It took the Beck Committee only about a month to write its report, which was issued on February 8, 1934. As was previously noted, the chair of the Committee, Thomas Beck, was employed by the publishing company owned by Joseph Knapp. As noted, the Beck Commission's recommendations were ignored by the Bureau of Biological Survey, but this did not deter Joseph Knapp.

The More Game Birds in America Foundation initially focused on raising and releasing upland game birds, but it espoused a different strategy for restoring waterfowl populations. To produce more waterfowl would require more waterfowl breeding habitat. Thus the focus of the Foundation's waterfowl-related efforts would be on conserving and restoring waterfowl habitat. The main question facing the Foundation was where it should be doing this. Arthur Bartley, who was an employee of the Foundation from its beginning, made annual trips to western Canada to assess the status of the region's breeding duck populations. This resulted in him becoming acquainted not only with the waterfowl breeding grounds of western Canada but also with many of the region's businessmen, government officials, sportsmen, and politicians interested in waterfowl. Increasingly the Foundation focused its attention on western Canada.

In 1933, the More Game Birds in America Foundation published *The Duck decline in the Northwest*. This report included data on the status of ducks in western Canada. The report confirmed the importance of western Canadian breeding grounds for North American waterfowl production, and it also highlighted the threats to this production due to expanding drainage. In addition, this report pointed to the need for better data on waterfowl populations in North America. The More Game Birds in America Foundation decided to collect this data, and it organized a waterfowl survey of the duck breeding regions of the US and western Canada. The Foundation recruited state and provincial fish and game departments to do most of the field work with John Huntington overseeing the survey in Manitoba and Arthur Bartley in Alberta.

A major practical problem facing the proposed waterfowl survey was how to collect data on waterfowl numbers in parts of western Canada that had few, if any, roads. After some experimental flights in Manitoba and Saskatchewan

**FIGURE 4.** Joseph P. Knapp (1864-1961). From his obituary in the New York Herald Tribune, January 4, 1951.

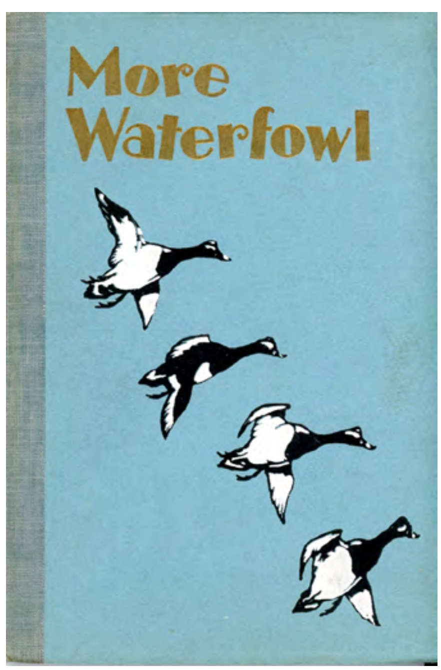
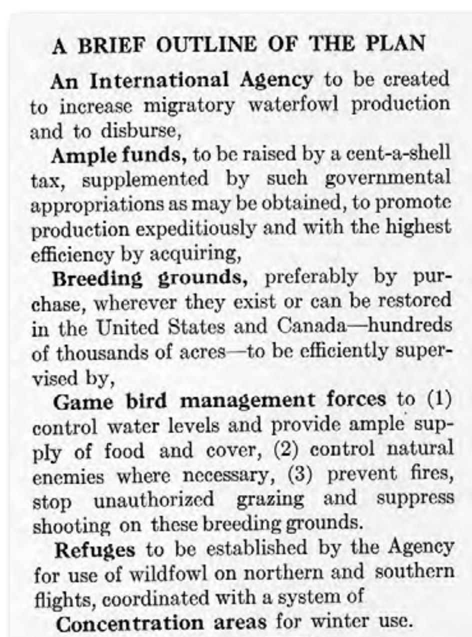



**FIGURE 5.** Cover of *More Waterfowl by Assisting Nature*. More game Birds in America Foundation (1931). Public domain.



A BRIEF OUTLINE OF THE PLAN

**An International Agency** to be created to increase migratory waterfowl production and to disburse,

**Ample funds,** to be raised by a cent-a-shell tax, supplemented by such governmental appropriations as may be obtained, to promote production expeditiously and with the highest efficiency by acquiring,

**Breeding grounds,** preferably by purchase, wherever they exist or can be restored in the United States and Canada—hundreds of thousands of acres—to be efficiently supervised by,

**Game bird management forces** to (1) control water levels and provide ample supply of food and cover, (2) control natural enemies where necessary, (3) prevent fires, stop unauthorized grazing and suppress shooting on these breeding grounds.

**Refuges** to be established by the Agency for use of wildfowl on northern and southern flights, coordinated with a system of

**Concentration areas** for winter use.

**FIGURE 6.** The plan of the More Game Birds in America Foundation's (1931) *More Waterfowl by Assisting Nature*. Public domain.


**FIGURE 7.** John C. Huntington (left) and Arthur Bartley during the 1935 International Wild Duck Census. Source Tennyson (1977).

to see if it was feasible to count ducks from an airplane, Arthur Bartley became convinced that this would be an efficient way to monitor the status of waterfowl in areas that could not be reached by road. Consequently, aerial surveys of duck abundance were done to supplement the other data being collected. Most of the survey, however, was done on the ground by about 1,500 volunteers or employees of wildlife agencies.

The More Game Birds in America Foundation quickly and successfully conducted the first international inventory of waterfowl and published its findings in *The 1935 International Waterfowl Census*. Their survey estimated that there were 40,000,000 ducks in Canada and only 2,200,000 in the US. Although there was some uncertainty about the accuracy of the estimated size of the duck population, the survey did establish that such an international survey of waterfowl was practical and subsequently such surveys became annual events. More importantly, the report demonstrated conclusively that the future of duck populations was tied to the fate of wetlands in western Canada.

Efforts to improve waterfowl conservation in the US, which had started when Ding Darling became chief of the Bureau of Biological Survey, could not be extended to Canada because of legal restrictions on spending US government funds outside the country. Because the More Game Birds in America Foundation's duck inventory had shown that 95% of midcontinent ducks come from western Canada, the Foundation quickly developed a plan to help conserve and restore wetlands in this region. In 1936, the Foundation published *Ducks Unlimited, a practical plan to perpetuate and improve duck shooting in the United State by the production of millions of more wild ducks annually through the restoration and businesslike management of Canadian duck breeding grounds*. The title literally is a succinct summary of their proposed plan. The new Ducks Unlimited would direct its efforts on western Canadian waterfowl breeding grounds using a two pronged approach.

The Foundation's plan was to establish a new non-profit organization in the US called Ducks Unlimited, Inc., which would raise money to be sent to another new organization in Canada, Ducks Unlimited (Canada), which would work on waterfowl conservation projects in western Canada. Both the American and Canadian non-profit corporations were established in 1937. With the creation of Ducks Unlimited, Inc., the More Game Birds in America Foundation effectively ceased to exist, and its staff became the initial staff of Ducks Unlimited, Inc. The establishment of Ducks Unlimited reinforced the idea that duck hunters would need to fund efforts to preserve and eventually increase waterfowl populations.

The establishment of Ducks Unlimited (DU) is an important milestone in the history of wetland science. DU emphasized the need to preserve and enhance breeding waterfowl habitat, i.e., wetlands. Because of its extensive fund-raising network in both the US and Canada to support its conservation programs, DU has done a great deal to improve the visibility of wetlands among the general public in both countries. Although it does not a have a large number of scientific staff, it has been and continues to be a significant employer of wetland scientists and in recent years a funder of wetland science research.

## CONCLUSIONS

Adversity often produces opportunity. The waterfowl population crisis in North America by the 1930s resulting from habitat loss, overhunting, and drought created such adverse conditions for waterfowl hunters that they began to believe that the future of waterfowl hunting was in peril. Two duck hunters, Jay "Ding" Darling and Joseph P. Knapp, used this crisis to propose ways to try to reverse this decline of waterfowl. Darling used his editorial cartoons to raise public awareness of the problem and then reluctantly agreed to become the chief of a government agency, Bureau of Biological Survey, during the Roosevelt administration. He turned this agency into a more conservation-minded institution and successfully raised money for the purchase of more land for the national wildlife refuge system. Darling also reformed hunting regulations to bring them more into line with contemporary waterfowl population sizes. Joseph Knapp through his More Game Birds in America Foundation demonstrated the overwhelming importance of wetlands in western Canada as breeding habitat for North American waterfowl. This resulted in a plan by the Foundation to establish two new, interlinked organizations in the US and Canada. The America organization, Ducks Unlimited, Inc., would raise money. This money would fund the wetland conservation and restoration programs of the second organization, Duck Unlimited (Canada), in western Canada. Darling and Knapp not only helped halt the decline in wetland losses and waterfowl populations, but they also raised awareness of the importance of wetlands among the general public. Both also expanded existing or created new institutions that would play an important role in developing wetland policy and in improving wetland management in the US and Canada as well as providing jobs for wetland scientists. ■

## REFERENCES


Allen, D. 2016. Conservation competition: perspectives on agricultural drainage during the New Deal. MA Thesis, Case Western Reserve University, Cleveland, OH.

Batt, B. 2012. The marsh keepers journey: the story of Ducks Unlimited Canada. Ducks Unlimited Canada, Winnipeg, Manitoba.

Cart, T.W. 1972. "New Deal" for wildlife: a perspective on federal conservation policy, 1933-1940. The Pacific Northwest Quarterly 63:113-120.

Beck, T.H., Darling JN, Leopold A. 1934. Report of the President's Committee 0n Wild Life Restoration. United States Government Printing Office, Washington, DC.

Darling, J.N. 1935. Conserving our wild life. Recreation. Available online from the University of Iowa's The Papers of Jay Norwood "Ding" Darling. (http://www.lib.uiowa.edu/scua/msc/tomsc200/msc170/wildlife.html)

Dolin, E.J. and B. Dumaine. 2000. The Duck Stamp story: art, conservation, history. Krause Publications, Iola, WI.

Farrington, S.K. 1945. The ducks came back: the story of Ducks Unlimited. Coward-McCann, New York, NY.

Furtman, M. 2011. The Ducks Unlimited story: Conservation for generations. Ducks Unlimited, Inc. Memphis, TN.

Lendt, D.L. 1979. Ding: the life of Jay Norwood Darling. Iowa State University Press, Ames, IA.

Leitch, W.G. 1978. Ducks and man: Forty years of co-operation in conservation. Ducks Unlimited (Canada), Winnipeg, Manitoba.

Leopold, A. 1933. Game management. Charles Scribner, New York, NY.

Leopold, A. 1949. A Sand County almanac. Oxford University Press, New York, NY.

Lincoln, F.C. 1934. Restocking of marshes with hand-reared mallards not proved practicable. pp. 310-313. Yearbook of Agriculture, 1934. US Department of Agriculture, Washington, DC.

McCorvie, M.R. and C.L. Lant. 1993. Drainage district formation and the loss of Midwestern wetlands, 1850-1930. Agricultural History 67:13-39.

More Game Birds in America. 1931. More waterfowl by assisting nature. More Game Birds in America Foundation, New York, NY.

More Game Birds in America. 1933. The duck decline in the Northwest: a report on the prairie duck-breeding region. More Game Birds in America Foundation, New York, NY.

More Game Birds in America. 1935. The 1935 international wild duck census; a report on the duck population in Alberta, Saskatchewan, Manitoba, North Dakota, South Dakota and Minnesota during August, 1935. More Game Birds in America Foundation. New York, NY.

More Game Birds in America. 1936. Ducks Unlimited, a practical plan to perpetuate and improve duck shooting in the United States by the production of millions of more wild ducks annually through the restoration and businesslike management of Canadian duck breeding grounds. More Game Birds in America Foundation, New York, NY.

Phillips, J.C. and F.C. Lincoln. 1930. American waterfowl: their present situation and the outlook for their future. Houghton Mifflin, Boston, MA.

Prince, H. 1997. Wetlands of the American Midwest: a historical geography of changing attitudes. University of Chicago Press, Chicago, IL.

Tennyson, J.R. 1977. A singleness of purpose: the story of Ducks Unlimited. Ducks Unlimited, Chicago, IL.

van der Valk, A.G. 2017. Antecedent wetland ecologists - German and Austrian in the Ninetieth Century. Wetland Science and Practice 34:112-117.

van der Valk, A.G. 2018. Stephen A. Forbes, antecedent wetland ecologist? Wetland Science and Practice 35:18-24

Vileisis, A. 1997. Discovering the unknown landscape: a history of American wetlands. Island Press, Washington, DC.

Worster, D. 1979. Dust bowl: The southern plains in the 1930s. Oxford University Press, New York, NY.

# Principles of Wetland Creation and Restoration: Reflections

## Part 2: Technology Transfer, Cross-over of Disciplinary Approaches, and the 1988 Burlington County (NJ) Case Study

*Mallory N. Gilbert[1], M.N. Gilbert Environmental, Troy, NY*

This is the second in a series for articles prepared for WSP to address what, from my perspective, have become principles of wetland creation and restoration that have evolved after working in this field for more than 40 years. Before moving into the case study presented in this offering, I would like to address another fundamental principle that relates to planning and improving outcomes. This principle centers on the obvious, that wetlands are complex ecosystems, and these ecosystems are often driven by physical and chemical processes that in some circumstances supersede or override purely biological aspects of a particular site. Further, due to specialized training, education and experiences, in the past, practitioners and researchers may have been inclined to concentrate their efforts in much narrower problem-solving parameters (their *comfort zone*) rather than actively embracing multiple aspects of a much larger and interwoven web of functional drivers.

A colleague referred to "other" disciplines outside of his "parochial scientific training niche" as being separate "STEM disciplines" that form quasi-insular reservoirs of scientific knowledge and "arts" that he and others refer to as "technological silos." His premise in assuming this perspective is that persons working within these "silos" tend to resist interaction with the other insular disciplines, even though engaging them might greatly benefit their projects. This perspective is not new in complex fields and is also acknowledged in formal business training[2], but it is exceptionally noteworthy as a potential fatal flaw for practicing wetland science professionals engaged in restoration and creation projects.

To reinforce this perspective, consider some of the many biologically-based scientific skills that a wetland restoration/creation specialist might need in order to be successful. In general, designers and/or design teams will often employ or need to acquire detailed working-knowledge of basic biology, zoology, microbiology, marine biology, botany, plant physiology, plant taxonomy, plant ecology, plant propagation/horticulture, fundamentals of ecology, field ecology practices, aquatic ecology, restoration ecology, wildlife management, mammalogy, ornithology, ichthyology, limnology, entomology, mycology, various forestry disciplines, and soil sciences (soil microbiology, soil chemistry, soil fertility, agronomy), just to name a few. Other physical and chemical sciences likely to be needed include basic chemistry, biochemistry, biogeochemistry, organic chemistry, toxicology, quantitative analysis, hydraulics, basic physics, soil physics, hydrology, fluvial geomorphology, geology, geography, minerology, photogrammetry and remote sensing, and meteorology. Ancillary but often critical "other skills" extend to include land surveying, GIS/GPS technologies, hazardous materials management, regulatory compliance/permitting, erosion and sedimentation control, pesticide management, integrated pest management, general civil engineering and structural design disciplines, earthmoving and construction principles, construction inspection, risk management, statistical analysis, overall project management, and many other project-specific technical skills including field-installation/maintenance/replacement of scientific monitoring and data recording equipment, and many more. Consequently, this professional niche actually spans administrative and management expertise as well as purely scientific approaches.

Considering the above, it is important for us to evaluate critically and honestly our own competence in the listed technical disciplines. Sincere reflection will probably lead us to accept that most of us cannot be experts in everything, and we will therefore need to occasionally tap into one or more of those other insular "silos" to produce successful projects. An example applicable to a number of the case studies provided in this series of articles, including the first already presented for Wyandot County, Ohio[3], relates to the ability of a person trained primarily in biological/ecological sciences to be able to predict flooding frequency for a floodplain riparian corridor project site; and further, to identify the minimum 24-hour storm event (depth of precipitation) necessary to trigger overbank flooding. So, yes, there have been and continue to be times when planners will need to sharpen their own skills or approach one or more of those other disciplinary silos, and perhaps bring

1 Corresponding author: mngilenv@nycap.rr.com

2 The term functional silo syndrome was coined in 1988 by Phil S. Ensor who worked in organizational development and employee relations for Goodyear Tire and Rubber Company, Eaton Corporation, and as a consultant. "Silo" and "stovepipe" (as in "stovepipe organization" and "stovepipe system") are now used interchangeably and applied broadly.

3 Wetland Science & Practice Vol. 35, No. 1, March 2018

in an engineer, a meteorologist, or someone with specialized hydraulics and/or fluvial-geomorphology training and expertise, or others.

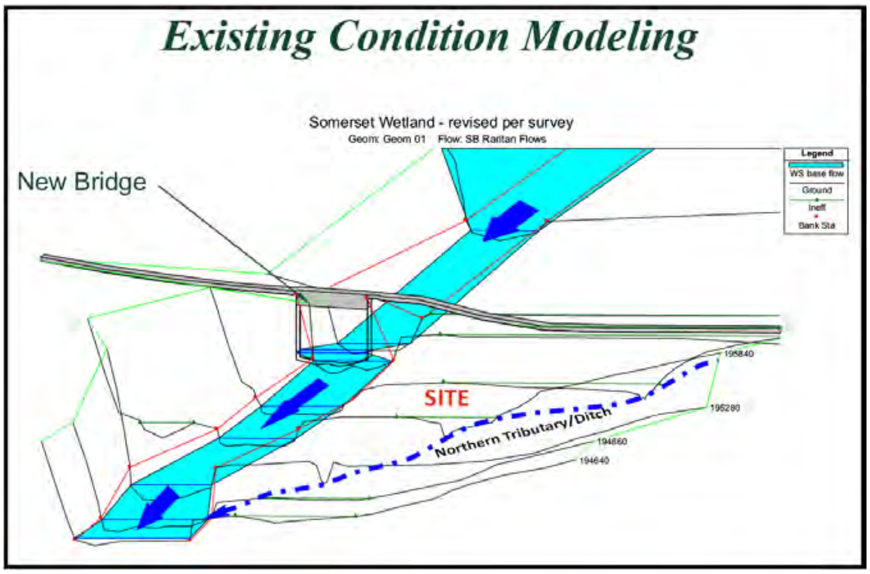
Over the last 40 years, the sophistication of the information we can glean from predictive models has evolved and accelerated exponentially with development of various equations and IT applications. For example, a collaboration of researchers from Virginia Tech, Old Dominion University, and University of Kentucky have tweaked and added to early predictive hydrograph models introduced by Gary Pierce circa 1993 (Pierce 1993, 2015). These early efforts were in turn modified shortly thereafter by Michael Rolband, founder of Wetland Studies and Solutions, Inc. (WSSI) of Gainesville, Virginia. Acknowledging Rolband's and Pierce's efforts, these present-day researchers have approached the challenge of preparing existing and predictive hydrograph models via a computer program they have developed and dubbed "Wetbud" (version 1.7.0.29, updated 7 Feb. 2018), which is short for "**Wet**land water **bud**get modeling software" (Stone 2017). This research effort is funded by two non-profit groups managed by WSSI. The Wetbud program (http://www.landrehab.org/WETBUD) integrates the USGS MODFLOW 3D numerical groundwater flow model (McDonald 2003) with streamlined computer algorithms and codes for basic hydrograph preparation. Wetbud allows for direct internet links to regional meteorological data, enhances prediction of groundwater inputs and losses, and has advanced and improved upon precursor approaches to predicting existing and candidate site hydrograph models.

In working with Wetbud, Lee Daniels (Virginia Tech) has noted another computational approach for groundwater modeling that may also prove useful in future wetland construction scenarios. Dr. Daniels suggests that the expanded HYDRUS software package for simulating water, heat, and solute movement in two- and three-dimensional variably saturated media (Šimůnek 2011) may have some promise as well. This Windows-based software package consists of a computational computer program and an interactive graphics-based user interface that could have value in modeling groundwater behavior in a number of constructed wetland project scenarios (http://www.groundwatersoftware.com/hydrus.htm).

An established example of applied-hydraulics modeling for streams, rivers and floodways is the collective and ever-evolving effort and program iterations of the U.S. Army

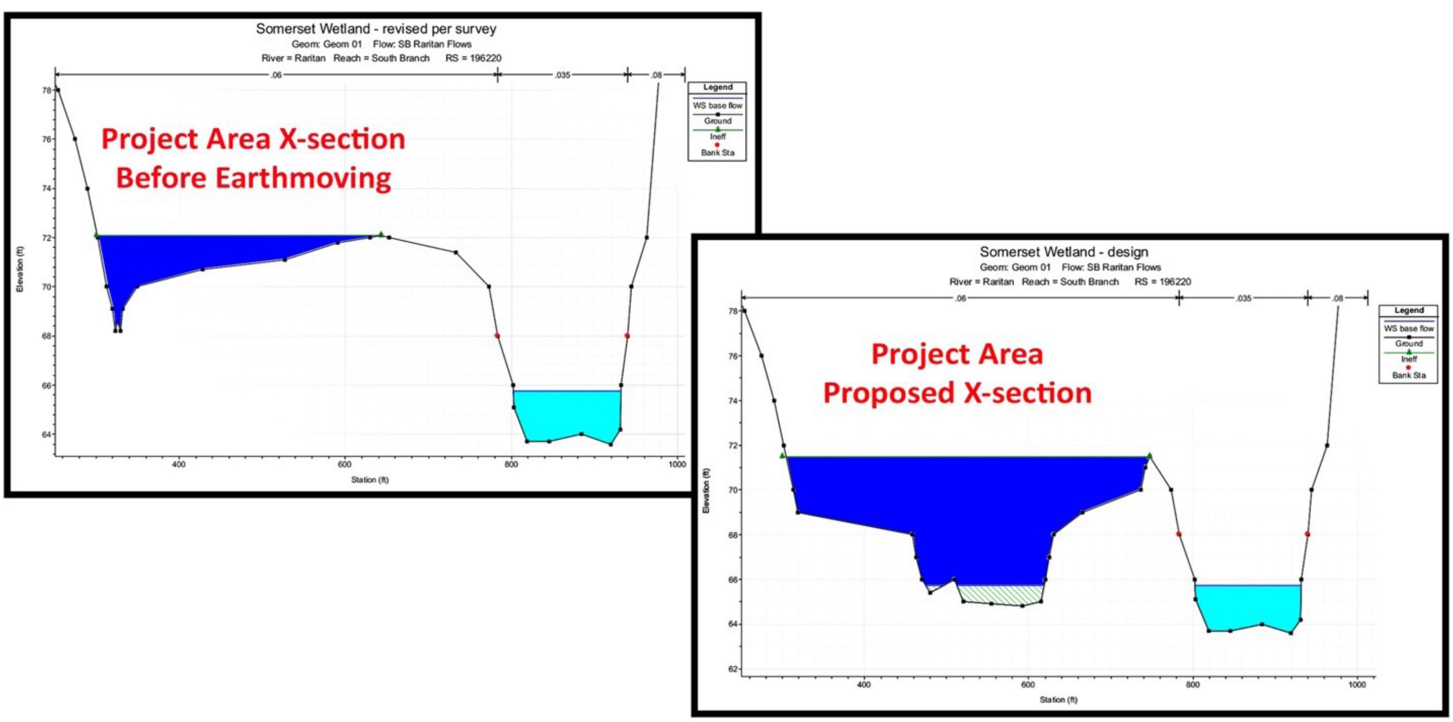

**FIGURE 1.** Aerial images of a floodplain mitigation site on the South Branch of the Raritan River in Neshanic, New Jersey. The vertical axis of each photo is North. No scale is provided, but the project area is ± 20-acres in size. The left image shows the Princeton Hydro site mentioned below as seen on May 5, 2003, prior to earthmoving, grading and replanting. Right image shows the site on August 27, 2016. A challenge for success of this project was prediction of periodic flooding from the adjacent small tributary along the northern limit of the project area as well as prediction of larger-scale flooding and backwater events driven by the whole of the riparian corridor watershed charging the main channel of the river.

**FIGURE 2.** Hydrologic modeling integrating the cross-sectional areas of the upstream watershed, physical structures, and site contours allowed planners to create visual illustrations of how water would be likely to behave on the project site before and following various storm events. This oblique illustration shows the approximate distribution of typical stream baseflow (the turquoise color) within the confines of the stream "bed and banks" before the effects of runoff and the flooding generated by various frequency storm events. The dark blue arrows indicate the direction of stream flow. The dashed blue line indicates the approximate location of the small tributary that flows along the northern boundary of the project site. Using present day HEC-RAS hydrologic modeling software similar images can be produced showing the incremental deepening of water within the channel and spreading of flood waters across the site for storm events of increasing intensity.




Corps Hydraulic Engineering Center (HEC) mentioned in the Wyandot case study presented in the Part 1 of these WSP articles. Since the mid-1960s, U.S. Army Corps engineers and technical staff working in the Hydraulics Engineering Center have incrementally improved upon and expanded their computational approaches to modeling flooding in and along the reaches of multiple stream-order riparian landscapes. At the time of the Wyandot project, the late 1980s and early 1990s, the Corps Hydraulic Engineering Center analyses employed to project overbank flooding were also being expanded and improved upon. The calculations used at that time were embedded in the "HEC-2 water surface profile computer program" (CEIWR-HEC 1990). These early modeling efforts were focused primarily on predictive analysis of "backwater flooding" in floodplains and floodways taking into account the size of the watershed and evaluation of multiple cross-sectional areas of the riparian corridor. However, fifty years later, the nuances and advances of "HEC-RAS" modeling projected from Version 1.0 released in 1995, to Version 5.0.3 released in

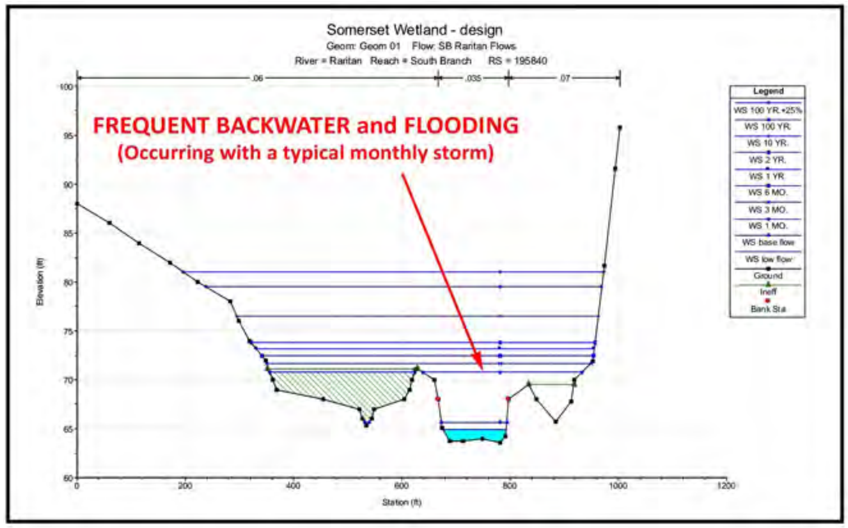
**FIGURE 3.** Before and proposed-after cross-sections of the central part of the site, illustrating the increased storm water storage capacity to be gained based on the depth of projected inundation before and after spoils removal and grading. The dark-blue color represents before and after flood storage potential before the site is completely inundated during an overbank flooding event.



September 2016 (Brunner 2016) collectively dwarf the first incremental efforts more than five decades ago.

Figures 2-5 that follow are printed with permission of Princeton Hydro, LLC of Ringoes, New Jersey. These figures illustrate how modern floodway modeling on one of Princeton Hydro's wetland mitigation project sites allowed the designers to visualize stream reaches in two and three dimensions and predict how and when a riparian corridor wetland creation and enhanced flood water storage project site would be incrementally inundated. These few figures are offered as just one example of the value-added when we engage persons with expertise in other disciplinary silos and also to illustrate how innovations and advances have improved predictable outcomes for contemporary projects.

**FIGURE 4.** This cross-sectional graphic shows how hydrologic modeling program allowed designers to predict inundation effects for various storm frequencies ranging from monthly to greater than 100-year events.




### CASE STUDY 2. RIPARIAN CORRIDOR WETLAND CONSTRUCTION, ASSISCUNK CREEK, BURLINGTON COUNTY, NJ – 1986-1988

#### Relevance of the Burlington County, New Jersey Case Study

Considering the wealth of information accumulated over the years, technical innovations, and improved present-day internet access to various technologies, the case study that follows serves primarily to highlight progress made in planning wetland construction and restoration since the mid to late-1980s. The Burlington County project was planned by biologists and ecologists with a sound understanding and appreciation of local wetland resources, and they managed to cobble together a plan to construct "mitigation wetlands" based on the skills they had available at the time. The intent was not simply to "dig a hole and let it fill with water." However, even in the late 1980s, a successful outreach to other "technological silos" might have benefitted the planning process. This observation is not a criticism, but rather it reflects the somewhat rudimentary "state-of-the-art" at the time.
In any event, despite a somewhat narrow-disciplinary approach, this project has proven over time to have been a success. It was sited appropriately to prosper as a replacement wetland resource. The site selection process included anecdotal accounts of flooding and

**FIGURE 5.** This plan-view perspective shows the extent of surface water inundation projected for a storm event likely to occur on a monthly basis. In this case, the project area floods first from water entering it from the small tributary on the northern edge of the site (initially from the northwest – red and yellow arrow). With more intense storms, additional water depth is again first added to the site footprint from the northern tributary and is augmented as water levels also rise in the main channel of the river. Subsequently, the river water and the waters within the project area footprint co-mingle as river water backs into the site from the confluence of the small tributary with the main river channel (double black and green arrow). With even more significant storms, the backwater inundation occurs first and is followed by complete overbank inundation as water depths rise in the river channel. As noted, this project example shows how active interaction with other technological "silos" with specialized tools can have significant value to wetland construction and restoration planners and designers. Ultimately, these integrated approaches enhance our ability to generate predictable outcomes for our projects.

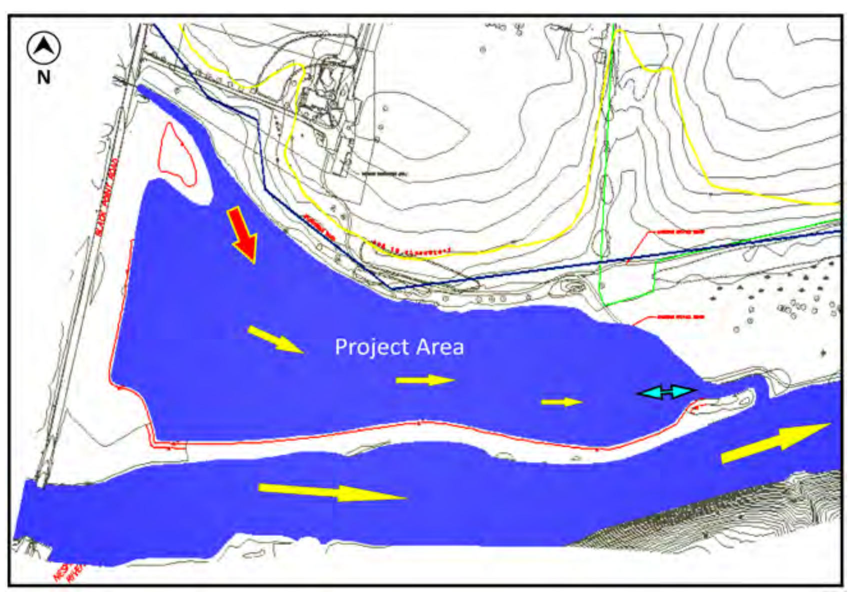
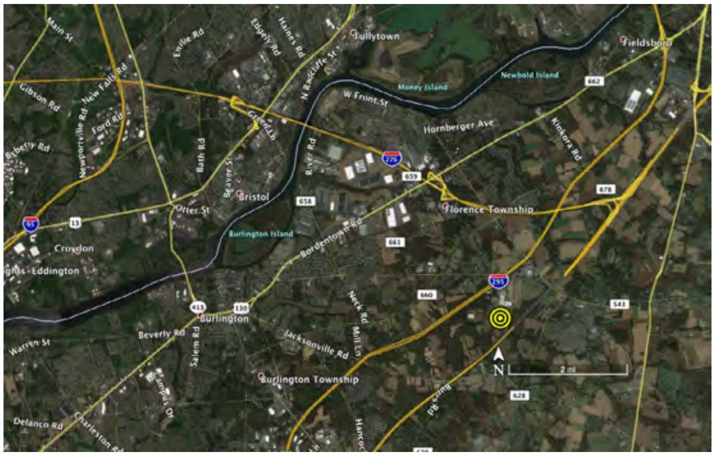


**FIGURE 6.** The circle symbol marks the site of the wetland construction project in Burlington Township (Burlington County, NJ).



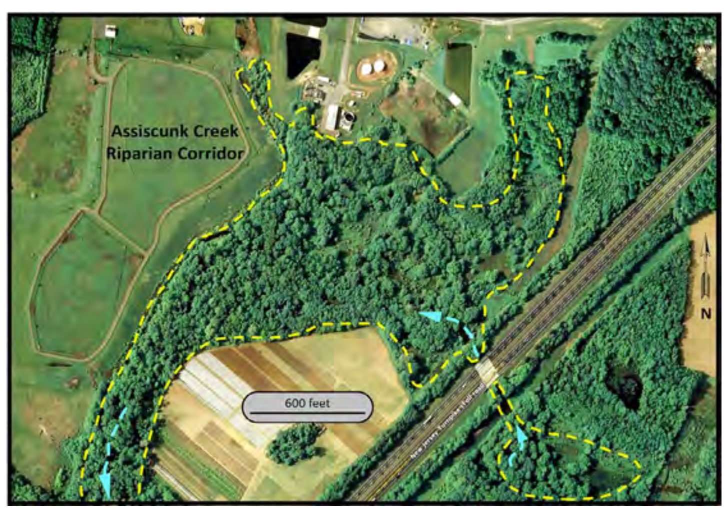

flooding frequency in the riparian corridor, soil investigations, on-site observations of scour and elevations of wrack deposits in the floodway (to confirm anecdotal reports of flooding and flooding depths used in the design), comparative inventories of local reference wetland types also occurring within the floodway corridor and consultation with regulatory agencies. Given the infancy of wetland mitigation, it should be noted that the quantity and variety of plant materials from commercial sources were limited at the time. Consequently, while the species planted in the constructed wetland cells were local natives, these plants were introduced primarily as "place-holders" that might allow *natural recruitment* of other riparian species that were not available as planting stock. In addition, upon completion of construction and planting, a few minor adjustments were made during the first several months of observation and monitoring (i.e., "proactive monitoring").

Since the time of construction, the wetland construction areas have settled nicely into the landscape. Thirty years later, largely due to natural selection and seed rain from intermittent flooding, the constructed wetland cells are difficult to distinguish from present-day *natural wetlands* found in the same riparian corridor. Consequently, this case study is an acknowledgement that although early in the development of wetland construction principles and protocols, when science-based approaches were applied, minor adjustments were made during post-construction monitoring, and appropriate siting and hydrology expression were considered, time and natural selection ultimately combined to facilitate project success – the establishment of a constructed wetland similar in form and function to nearby natural wetlands.

**Location:** Burlington Township, Burlington County, NJ (Figure 6).

**Introduction:** This site was proposed and constructed as mitigation for wetland impacts occurring in the footprint of an adjacent county operated landfill. Note that the wetlands were identified and delineated in the approximate timeframe of release of the 1987 U.S. Army Corps Delineation Manual. Wetland impacts were proposed to be mitigated by construction of replacement acreage at an approximate 2:1 ratio. Detailed functional analysis of the impact wetlands was not completed per se, but "general" primary wetland functions were documented and acknowledged, and nearby local replacement was considered to be most appropriate. The impact wetlands were located primarily in former agricultural areas in "upper-terrace" landscape positions, but they clearly drained to the adjoining Assiscunk Creek floodplain and riparian corridor. Consequently, the permittee and the oversight regulatory agencies agreed that the replacement wetlands would have benefit if constructed within and along the Assiscunk stream corridor that abuts landfill operations. Readily accessible records of the project planning process were difficult to find, but it is surmised that the total wetland impact acreage was limited, and the encroachments were therefore permitted under a USACE Nationwide permit.

**FIGURE 7.** June 2004 aerial view of the riparian corridor of Assiscunk Creek where a number of small wetlands were constructed in the late 1980s and early 1990s. Stream flow is from east to west, flowing under the New Jersey Turnpike and meandering within a gently undulating, primarily wooded, floodway floor. Anthropogenic modifications of the natural stream corridor floodway are inescapable in this setting. Nutrient loading from industrial, urban, and agricultural activities are also factors that affect functions being performed and composition of vegetation cover types. Candidate areas for wetland construction were investigated within the potential project area defined by the yellow-dashed lines. The wetlands constructed more than a decade earlier are visible in this image but are not necessarily obvious in this context (see Figure 8).



**Project Sponsors:** The Burlington County Landfill, a county-owned and operated facility at the time of the project.

**Project Objectives:** The primary objective of this project was to convert 1 to 2 acres of "upland" within and adjacent to the riparian corridor of Assiscunk Creek (tributary to the Delaware River) to areas of emergent, scrub/shrub, and forested bottomland wetlands. The suites of vegetation planted in each component area were chosen to reflect local flora and the landscape context to the maximum extent practical considering the availability of plant materials from commercial sources.

**Planning and Design:** This site was planned and designed by Mr. Mark Gallagher (at the time, employed by Princeton Aqua Science) and was constructed and planted between 1986 and 1988. The planting and some initial monitoring were accomplished by Dr. Gary Pierce through his company Southern Tier Consulting. Dr. Pierce also made planting suggestions and early modifications to the outlet weir elevation for Wetland Area B. Details of the original site design grading plans are not available. However, the project area has been used as a teaching site for continuing education courses since 1990 (Rutgers Office of Continuing Professional Education and others). Aspects of the successional development of the constructed wetland components have been observed and discussed annually in the field with students for nearly three decades.

From an anecdotal account provided by Mr. Gallagher, initial remote sensing and field surveys completed for the candidate replacement wetland cells also included use of the published USDA NRCS National Cooperative Soil Survey mapping from 1970. Careful reading of the profile descriptions of the Keyport soil series (where Wetland A was constructed by excavating and re-grading a terrace slope) suggested that a restrictive clay layer might be found at depth. If present, interception of this layer when excavating could result in exposure of a lateral ground water seepage area. In this case, the seepage area was actually exposed during construction and has subsequently provided additional water input to Wetland A nearly continuously since the wetland was constructed. The exposed seepage area also resulted in creation of a "ground water slope wetland" (Novitzki 1982, 1989) that in turn drains down-gradient into the depressional floor of the constructed wetland basin. Although somewhat serendipitous, this outcome could have been projected with careful reading of the soil survey descriptions. Nevertheless, the bonus of additional wetland acreage and supplemental hydrology could not be definitively factored in as part of the initial predicted "wetland footprint."

Considering these variables, project cells were designed primarily as shallow depressional basins mimicking other "meander scars" and depressions with higher linear mounded "natural levee" inclusions found within the Assiscunk riparian corridor. Obvious inlet and outlet "structures" placed to allow expected floodwaters to enter and exit each site were not specifically incorporated in designs. Vegetation zonation was projected to develop based on graded contour elevations and anticipated persistence of inundation and saturation. Fringes of the wetland cells were expected to be scrub-shrub cover types that would eventually support planted larger bottomland hardwood trees,

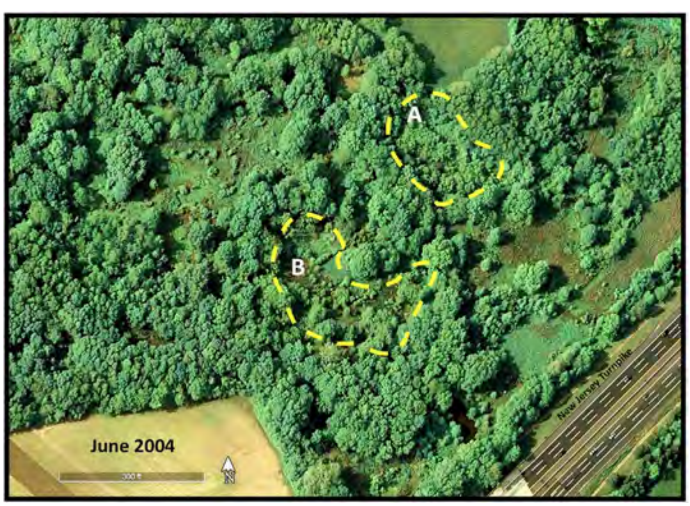



**FIGURE 8.** Closer view showing Wetlands A and B that were created in the areas indicated by the dashed yellow lines. Note: A few years after Wetlands A and B were constructed additional wetlands were created (circa 1990-1991, not shown in this photo) on the south side of the NJ Turnpike (southeast of the two areas shown here).


**FIGURE 9.** The constructed wetlands are seen more easily in this early spring 2003 aerial image.

as were other minimally and seasonally inundated areas within each wetland footprint. Initially, assuming minimal sediment accumulation following flooding events, semi-permanent emergent areas and refugium depressions within the wetland floor were expected to resist colonization by tree species due to persistence of shallow inundation. In any case, the successional development of plant community zonation was expected to progress from the initial plantings driven in concert with dynamic changes in the riparian corridor. Natural "seed rain" imported with flooding events was also expected to play a significant role in re-vegetation of the wetland cells. Pin oak, river birch, bur-reeds, pickerelweed, arrow-arum, tussock sedge, warm-season grasses, and cow lily were included in the suite of initial plantings.

**Site Hydrology:** Potential hydrographs for each constructed wetland cell were not part of the 1980s planning process, but factors related to water inputs were definitely acknowledged. Inputs considered were frequency of overbank flooding from Assiscunk Creek, direct precipitation, potential for limited surface water runoff from adjacent slopes, and groundwater (interpreted from soils of the proposed wetland cells). Potential lateral seepage from the Keyport soil excavation area along the riparian corridor terrace slope was also acknowledged but was not part of the input estimates. Soil infiltration and evapotranspiration losses were not addressed specifically but were implicitly considered when evaluating on-site soils and local reference sites.

**Construction:** A simplified excavation and grading plan was prepared for the candidate cells and on-site construction inspection was provided by the design team. Excess earthen spoil material excavated from the cells was relocated to uplands outside of the riparian corridor, and stripped topsoils were reapplied to create the wetland substrate. As noted, groundwater seepage was confirmed in the excavated cut-slope of Wetland A. Following primary earth-moving and grading, the site was seeded with annual and warm-season (switch grass, *Panicum virgatum*) grasses and to protect it from erosion. Wetland hydrophyte plantings were delayed over winter while a qualified "wetland planting contractor" was being sought to complete springtime planting of selected species. The planting crew placed their introduced plant materials at elevations based on observa-

**FIGURE 10.** Soil mapping of the project area circa 1970. Wetland Basin A was created by excavating a slope above the floodway dominated by Keyport soils (KIC) and then re-grading the area to elevations consistent with the active floodplain of Assiscunk Creek. Wetland Basin B was created by excavating and re-grading a mounded area of nonhydric alluvial soils (Ao) to create a concave depressional wetland within the stream meander.

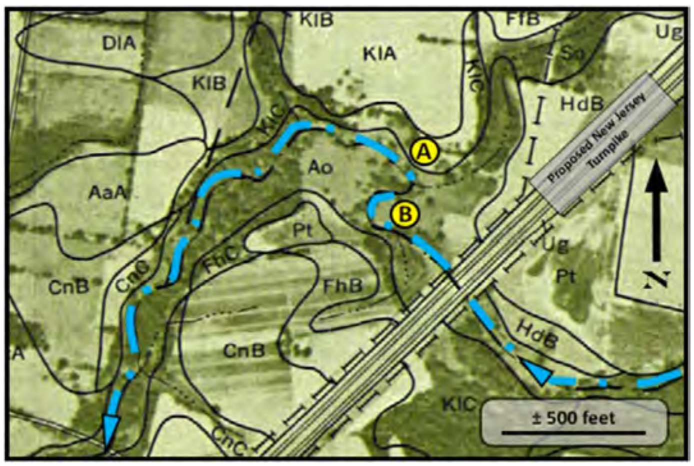



**FIGURE 11.** Fieldtrip students from Rutgers' freshwater wetlands construction course entering Area "A" approximately four years after planting. A seepage area was encountered when the hillside on which the students are walking was cut away to create the wetland floor. By keeping much of the substrate saturated throughout the growing season, this persistent groundwater discharge had a profound effect on the development of the wetland.


**FIGURE 12.** After observing the Wetland A slope seepage area and the emergent portion of the site (Figure 11), students are seen moving into and through the scrub-shrub fringe of Wetland A enroute to Wetland B.

tion of springtime hydrology, but shortly after planting, Dr. Pierce also installed an earthen outlet channel for Basin B to provide a more reliable fixed elevation to control maximum water depth (when not flooded) that would also allow more predictable vegetation zonation in the basin footprint.

**Project Initiated:** Circa 1987; wetland construction completed – June 1988.

**Monitoring***:* Site monitoring was conducted intermittently during the first 2-3 years following site construction. This monitoring was required by permit conditions, but formal monitoring reports were very rudimentary at the time. The progress and successional development of the project site is detailed in the photo documentation that follows.

**Lessons Learned:** The following points are offered as lessons learned from this project.

- Although early in the regulatory context of wetland restoration/creation, this project once again emphasized the importance of coordination with regulatory stakeholders in developing an acceptable mitigation alternative.
- Persons with solid scientific training in biological disciplines were engaged in assessing the ecological context and biological nuances of impact wetlands and of candidate replacement sites. These persons also developed and prepared a list of primary functions the replacement sites were intended to perform over time. These "big picture" target functions centered on floodwater attenuation/storage and slower release, sediment retention, nutrient uptake, and provision of suites of general wildlife habitat niches. Although not emphasized on this project per-se, sequestration of organic materials generated on site as well as materials transported and deposited during significant flooding also relate to more contemporary concerns associated with carbon sequestration. As an aside, it is noteworthy that conscious efforts to target any one of these primary functions will tend to also benefit, facilitate, or enhance the others as ancillary products of an individual effort.
- This project highlights again the importance of having a reference context for the types of wetlands that were being targeted for construction and in using remote sensing and available soil data for initial identification of nearby candidate sites in appropriate landscape positions. Having this perspective improved the probability that the constructed wetlands would continue to be self-sustaining long after regulatory oversight (monitoring) had ended.
- Hydrology inputs and soils were addressed in the planning process, but, in particular, the depth, duration and timing of water inputs (and losses) might have been more clearly defined with more in-depth analysis. Additionally, the energy associated with flooding events might have been investigated more thoroughly from an engineering and erosion-control perspective, in particular assessing erosive overbank flooding and hydraulic shear stress. Yet, in retrospect and with deference to the designers, the cross-over and interaction of potentially "symbiotic" technical disciplines was not as well developed at the time of this project. In the present day, there is ample opportunity to improve our projects by actively seeking out other technical disciplines that have techniques

**FIGURE 13.** Another group of fieldtrip students entering Wetland A approximately sixteen years after planting. The transition from an emergent/scrub-shrub plant community to a young forested wetland was well underway for the entire project area as early as 2001.


**FIGURE 14.** Dense emergent growth dominated Wetland B for a decade after its initial planting. However, by 2004, planted river birch (*Betula nigra*), silky dogwood(*Cornus ammomum*), buttonbush (*Cephalanthus occidentalis*), and black willow (*Salix nigra*) had encroached and encircled the emergent center of the basin. Bur-reed (*Sparganium eurycarpum*), arrow arum (*Peltandra viginica*), duck potato (*Sagittaria latifolia*), smartweeds (*Persicaria* spp./*Polygonum* spp.), rice cutgrass (*Leersia oryzoides*), tussock sedge (*Carex stricta*), and an occasional cow-lily (*Nuphar luteum*) persist as emergent species in this 2004 photo.

and skills to generate data we can exploit to improve project outcomes. For this project, engaging a person or persons with training in fluvial geomorphology and/or open-channel flow (a branch of hydraulics and fluid mechanics) and erosive shear stresses, would have been helpful in first acknowledging the dynamics of the floodway and then in reinforcing the stability of the areas being constructed. In particular, assigning a fixed (and perhaps stone-lined weir) elevation within a channel strategically positioned for flood waters to back into the wetland cells and flow back out would have reinforced the durability and longevity of the wetlands, especially if these structures could have been installed at the time of earthmoving and construction. However, how much additional technical input we solicit for any given project will of course be dependent on the variables at play and the complexity of the design challenges. Sites with complex hydrology inputs/losses, difficult soils, challenging geomorphic landscapes, and/or complex ecosystem dynamics are more likely to benefit from seeking input from other specialty disciplines.

- During the 25-year span that this site had been followed by Rutgers trainees, a field discussion of the dynamic nature of floodplain and riparian corridor landscapes has surfaced repeatedly nearly every year since classes first visited the site in 1990. Students have noted the vulnerability of the Assiscunk Creek landscape and that gradual or sometimes catastrophic changes in the morphology of these higher energy flood-prone areas is inescapable. They have pointed out man-made infrastructure modifications, old meanders, natural streambank levees, oxbows, undercut streambanks and vulnerable larger trees, and have noted floodwater wrack and sediment deposits. They have also commented on the energy exerted on both the natural and constructed wetlands in the corridor, and the inexorable incremental changes being driven

**FIGURE 15.** Hydric soil morphology was documented in both constructed wetland basins within 3 years following establishment. The sample shown here was removed on fringes of Wetland B at a depth of approximately 10-15 cm from the soil surface and is from a horizon located immediately below a 1-2 cm thick surface fibric organic layer (an Oi horizon). It has a coarse sandy loam texture and easily meets Hydric Soil Indicator F3 (Depleted Matrix). The high percentage of the redoximorphic concentrations and oxidized rhizospheres is evidence of the alternating oxgenated and anoxic aquic conditions common in these frequently flooded soils.

**FIGURE 16.** Fieldtrip students entering the forested portion of constructed Wetland A nineteen-years after planting. Spicebush (*Lindera benzoin*), river birch, buttonbush, and black willow are the dominant woody plants. At this developmental stage, the site had clearly met the criteria for classification as a Palustrine Forested (PFO) wetland.


**FIGURE 17.** Under a closed canopy of river birch and black willow, Gary Pierce (red shirt) shares observations regarding transition of vegetation cover in Wetland A during the first twenty-years of development. Understory species include duck potato, halbred-leaved tearthumb (*Polygonum arifolium*), arrowleaf tearthumb (*P. sagittatum*), wood reedgrass (Cinna arundinacaea), rice cutgrass (*Leersia oryzoides*), remnant cattail (*Typha latifolia*), arrow arum, swamp rose-mallow (*Hibiscus moscheutos*), buttonbush, and sapling willows.

by recurring flood events. These observations along with ample evidence in contemporary and archival aerial photography suggest that phrases that include "permanent" or "in perpetuity" are either inappropriate or perhaps exuberantly optimistic when used in this landscape context. In general, regarding riparian corridor and floodplain projects, it appears that increased longevity and perhaps more stable expression of constructed wetlands over time can be anticipated where floodwater energies are spread widely, are more evenly dispersed, and the corridors have ample cross-sectional area over which the volumes of water can be distributed. The more energy associated with the floodway corridor, the more vulnerable a constructed wetland project is likely to be.

- Once again, the importance of looking beyond the project site to acknowledge surrounding land uses, potential future land use changes, and physiographic subtleties was an important factor in preparing the plan and design. To some extent, this awareness has allowed this site to be remain viable over time in its current but dynamic landscape position. Although somewhat simplistic, there was a deliberate effort to emulate floodplain meander/oxbow depression settings.
- It is important to have a plan for reestablishing and pushing vegetation in a preferred direction. In this case study example, there were limited plant material resources available to provide a strong suite of species to occupy each anticipated vegetation layer. Nevertheless, use of native species with affinity for site conditions being developed, in concert with natural "seed rain" and recruitment from repeated flooding, species competition, and successional development were factors that combined to generate tiered hydrophyte-dominated cover types that have been relatively free of non-native invasive species. In this case, the positive outcome may have been somewhat fortuitous, but the lesson once again is that we must be exceptionally thoughtful in developing planting plans, understanding the "needs" of targeted species, and in proper handling and installation of the plant materials.
- "Monitoring" is critical to success. Therefore, those responsible for this project component are encouraged to be "proactive" in their monitoring efforts and to monitor with the intent to detect potential problems and to facilitate, coordinate, or, if authorized by team and client consensus, to personally take corrective actions. This can also be viewed as "adaptive management," but in a regulatory context where a project is expected to meet specific milestones in a set period of time, being proactive and conscientious is essential. Individual monitors looking for small, incidental, or large adjustments that can be made early-on post construction can potentially salvage a project that is heading in the wrong direction.
- A recurring theme for all wetland construction is exemplified in this project. This is an awareness that *time* and *natural processes* are factors over which we ultimately have little control (Mitsch et. al. 2010). Yet, if an appropriate landscape position is chosen, a serviceable rooting medium is provided with potential to facilitate physical support of plant species,

**FIGURE 18.** Field trip students on the fringes of Wetland B in September 2015. At this stage, the constructed wetland had blended into the natural physiognomy of the riparian corridor to a point where it is difficult to distinguish it from natural wetland depressions. Photographer's vantage point was from atop a 3-foot wide, 2-foot tall tussock sedge.

**FIGURE 19.** Students leaving Wetland B in September 2015. Students at left are walking along the earthen outlet fashioned twenty-six years earlier circa 1989. This outlet "channel" also allows waters from the adjacent stream to back into and then flow out of the wetland depression more gently as flood waters rise and fall in the riparian corridor.

necessary nutrients are available, adequate hydrology inputs (versus losses) are included, and suites of plant species with affinity for the ecological niches expressed at the site are introduced, there is a very high probability that an upland project site can be converted to wetland. As scientists and wetland restoration/creation practitioners, it is our responsibility to do those things within our purview that will nudge our project site in a direction to express the physical appearance and functions we hope to achieve over time. We must, however, acknowledge and respect the fact that natural processes are always in play, and despite human intervention and our very best intentions, Nature is ultimately in charge. ■

**FIGURE 20.** The wetlands constructed in the Assiscunk riparian corridor do not have complex or complicated water control structures and fit well into the surrounding landscape. Having been in place for nearly 30 years and now supporting a predominance of native species common in the riparian corridor, the constructed wetlands are nearly impossible to distinguish from other "natural" wetland depressions found within and along the stream corridor floodplain. Yellow dots pin-point four areas of constructed wetlands built between 1988 and 1993; the two upper ones are the subject of this article.


## ACKNOWLEDGEMENTS

Input, recollections, and feedback provided by Mark Gallagher and Michael Rolband were most helpful in preparing this article and are very much appreciated. I would also like to thank Stephen Stone for his timely response in providing the most recent citation pertaining to the Wetbud water budget model.

## REFERENCES

Brunner, G. W. 2016. HEC-RAS: River Analysis System, 2D Modeling User's Manual, Version 5.0, February 2016. US Army Corps of Engineers Institute for Water Resources Hydrologic Engineering Center (HEC), Davis, CA.

McDonald, M. G., and A. W. Harbaugh, 2003. The History of MODFLOW. Ground Water. 41(2): 280–283.

Mitsch, W. J., L. Zhang, K. C. Stefanik, A. M. Nahlik, C.J. Anderson, B. Bernal, M. Hernandez, and K. Song. 2010. Creating wetlands: primary succession, water quality changes, and self-design over 15 years. *Bioscience* 62(3): 237-250.

Novitzki, R. P. 1982. Hydrology of Wisconsin Wetlands Wisconsin Geological and Natural History Survey. Circular 40. University of Wisconsin, Madison. 22 pp.

Novitzki, R. P. 1989. Wetland Hydrology. Chapter in: Majumdar, S. K., R. P. Brooks, F. J. Brenner, and R.W. Tiner, Jr. (eds) 1989. Wetland Ecology and Conservation: Emphasis in Pennsylvania. Pennsylvania Academy of Science, Easton, PA. pp. 47-64.

Pierce, G. J. 1993. Planning Hydrology for Constructed Wetlands. Wetland Training Institute, Inc. Poolesville, MD

Pierce, G. J., R. J. Pierce, and M. N. Gilbert, 2015. Wetland Mitigation: Planning Hydrology, Vegetation and Soils for Constructed Wetlands. Wetland Training Institute, Inc. Glenwood, NM.

Šimůnek, J., M. Th. van Genuchten, and M. Šejna. 2011. The HYDRUS Software Package for Simulating Two- and Three-Dimensional Movement of Water, Heat, and Multiple Solutes in Variably-Saturated Media. Technical Manual, Version 2.0, PC Progress, Prague, Czech Republic, pp. 258.

Stone S., Z. Agioutantis, G. R. Whittecar, W. L. Daniels, T. Thompson, and K. Dobbs. 2017. WetBud – A Free Water Budget Modeling Tool for Created Wetland Design. Proceedings of the 8th International Conference on Sustainable Development in the Minerals Industry, Volume 2: 182-188.

U.S. Army Corps of Engineers Institute for Water Resources (CEIWR) Hydrologic Engineering Center (HEC). 1990. HEC-2 Water Surface Profiles User's Manual. US Army Corps of Engineers Institute for Water Resources Hydrologic Engineering Center (HEC) 609 Second Street Davis, CA

# Experimental Wetlaculture (Wetlands + Agriculture) Mesocosm Compound Established in Naples, Florida, to Restore Wetlands, Solve Harmful Algal Blooms, and Develop Sustainable Agriculture

*William J. Mitsch, Ph.D.[1], Everglades Wetland Research Park, Florida Gulf Coast University, Naples, FL*

We have been using ecological engineering principles to design and construct experimental mesocosm systems in Ohio, Florida and elsewhere for the past 2 years to investigate a new landscape-scale approach to integrate created or restored wetland retention of nutrients from agricultural and urban stormwater with a more sustainable agriculture. We refer to our proposed system as "wetlaculture" because it integrates wetlands and agriculture (see our Barley Prize video for a description of the wetlaculture concept at: http://www.barleyprize.com/#/venture/0a430af4-1d11-79e4-659e-e68f05aef4ac).

On May 3, 2018 we planted a newly constructed 28-mesocosm compound at Freedom Park (Figure 1) in Naples Florida with sawgrass (Cladium jamaicense). This represents the third mesocosm compound designed and created by our Everglades Wetlands Research Park scientists and the first one constructed in Florida (https://www.naplesnews.com/story/news/environment/2018/05/04/fgcu-wetlands-researcher-starts-experiment-colliers-freedom-park/577229002/ and http://www.winknews.com/2018/05/07/fgcu-scientists-studying-ways-to-combat-algae-growth-in-swfl-waterways/). The research is aimed at providing insight into using wetland creation and restoration to help reduce nutrient loading in the Everglades and Florida waterways while eventually recycling the nutrients back to agriculture.

The other two mesocosm compounds are in Ohio. Buckeye Lake mesocosms (central Ohio; Figure 2) were constructed in 2016-17 adjacent to hyper-eutrophic Buckeye Lake. Defiance mesocosms (Figure 3) were constructed in 2017-18 upstream of the Maumee River in the former Black Swamp that now directs drainage-ditch phosphorus pollution into western Lake Erie (http://www.dispatch.com/news/20170731/project-tests-whether-wetlands-can-reduce-buckeye-lake-algae, http://www.dispatch.com/news/20171002/could-restoring-swampland-fix-lake-erie-algae-crisis, and http://www.toledoblade.com/local/2017/09/22/Restoration-of-historic-Great-Black-Swamp-could-help-save-Lake-Erie.html). This research may help

**FIGURE 1.** Wetlaculture mesocosm compound, Freedom Park, Naples, Florida planted with sawgrass (Cladium jamaicense) in May 2018; experiment starts in June 2018. photo by L. Zhang.

**FIGURE 2.** Wetlaculture mesocosm compound, Buckeye Lake, Ohio planted with bulrush (Schoenoplectus tabernaemontani) in October 2016; experiment started April 2017. photo by L. Zhang.


1 Corresponding author: wmitsch@fgcu.edu

plan restoration activities in the former Great Black Swamp that once covered a million acres in northwestern Ohio (https://en.wikipedia.org/wiki/Great_Black_Swamp) while reducing phosphorus pollution flowing into Lake Erie.

Our long-term research plan involves the development of interlinking physical, mathematical, and business models to optimize design parameters for wetlaculture in different climates, soils, landscapes and waterscapes. First, wetlaculture utilizes wetlands to reduce nutrient fluxes from agriculture and cities that otherwise would go directly into lakes, rivers, and estuaries. The second aspect of wetlaculture is what distinguishes it from a typical linear combination of agriculture and treatment wetlands. In wetlaculture, the wetland, in x number of years, would be "flipped" back to an agricultural field, with the idea that the food-production crop would grow well without applying any additional fertilizers over those that accumulated over those "x" years by the wetlands. Then after "y" years, the agricultural field would be "flipped" back to being a wetland. Our physical (mesocosms) and mathematical models will enable to understand what those "x" and "y" years are for different climates, soils, and nutrient loading rates.

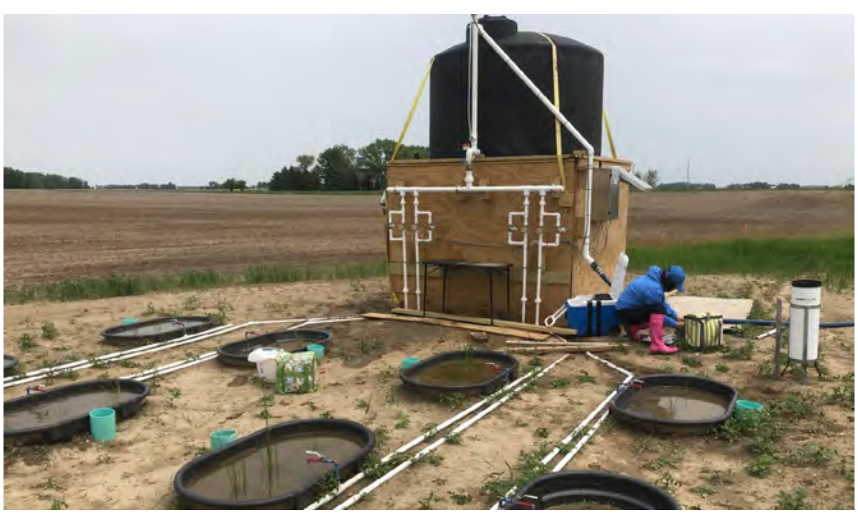
Our mesocosm research program continues to be supported by a variety of individuals, NGOs, public agencies, and corporations in Florida and Ohio including Collier County (Naples, FL), the Judy Sproul Endowment for Habitat Restoration at the Naples Botanical Garden (Naples, FL), the College of Arts & Sciences, FGCU (Ft. Myers, FL), Buckeye Lake for Tomorrow (Buckeye Lake, OH), Dr. Doug Poorman (Buckeye Lake, Ohio), Steiner and Associates (Columbus, OH), the South Central Power Company (Lancaster, OH), the Lenhart Family (Defiance, Ohio), and Stream and Wetlands Foundation (Lancaster, OH). ■

## REFERENCES


Mitsch, W.J. 2017. Solving Lake Erie's harmful algal blooms by restoring the Great Black Swamp in Ohio. Ecological Engineering 108: 406-413.

Mitsch, W.J. 2017. Solving harmful algal blooms: Progress in 2016-2017 at a wetlaculture experiment at Buckeye Lake, Ohio. Ohio Wetland Association Wetland Trumpeter Newsletter, September 2017. pp. 8-9, 11.


**FIGURE 3.** Wetlaculture mesocosm compound, Defiance, Ohio (near Lake Erie) planted with bulrush (Schoenoplectus tabernaemontani) in October 2017; experiment started March 2018. photo by W.J. Mitsch



## Support Wetland Ambassadors

The Wetland Ambassadorse are kicking off a crowdfunding campaign through CrowdRise to provide supplemental funds for their Wetland Ambassadors. SWS provides $5000 to each ambassador to complete visiting research fellowships under the guidance of some fantastic wetland scientists. However, they would like to raise supplemental funds to ensure the students are not spending any money out of pocket. Please consider donating any amount on our campaign page (https://www.crowdrise.com/o/en/campaign/support-for-the-2018-wetland-ambassadors).

To learn more about our Ambassadors, please either visit the campaign page, or the Wetland Ambassadors program page (http://www.sws.org/Awards-and-Grants/wetland-ambassadors-graduate-research-fellowship.html). ■

# Phytoremediation of Heavy Metals by *Salvinia natans* in a Kashmir Himalayan RAMSAR Site

*Syed Shakeel Ahmad[1], Zafar A. Reshi, Manzoor A. Shah, and Irfan Rashid, Department of Botany, University of Kashmir, India.*

## INTRODUCTION

Heavy metals are metals having a density greater or equal to 5 g/cc (Nies 1999). In water (both surface water and ground water) they pose a serious environmental problem threatening not only the aquatic ecosystem but also human health through contamination of drinking water. Being persistent, heavy metals accumulate in water, soil, sediment and living organisms (Gomes 2013; Miretzky et al. 2004). Exposure to heavy metals has been linked with developmental retardation, various cancers, kidney damage, autoimmunity, and even death in some instances when exposed to very high concentrations (Glover-Kerkvil et al. 1995). Essential metals such as copper (Cu), manganese (Mn), iron (Fe) and zinc (Zn) have normal physiological regulatory functions (Hodgstrand and Haux 2001) but many also bioaccumulate and reach toxic levels (Rietzler et al. 2001). Non-essential heavy metals are usually potent toxins and their bio-accumulation in tissues leads to intoxication, decreased fertility, cellular and tissue damage, cell death and disjunction of a variety of organs (Damek-Poprawa and Savicka Kapusta 2003; Oliveira et al. 2000, 2002). High levels of Cd (cadmium), Cu, Pb (lead), and Fe can act as ecological toxins in aquatic and terrestrial ecosystems (Alkorta et al. 2004; Guilizzoni 1991; Lenntech 2015).

Recent concerns regarding environmental contamination have initiated the development of appropriate technologies to assess the presence and mobility of metals in soil, water and wastewater (Shtangeeva and Ayrault 2004). The chemical methods commonly used for the treatment of surface waters may be successfully replaced by phytoremediation (Holtra 2010). Presently, phytoremediation has become an effective and affordable technological solution used to extract or remove inactive metals and metal pollutants from contaminated soil. Phytoremediation using vegetation to remove, detoxify or stabilize persistent pollutants is an accepted tool for cleaning polluted soil, water, and waste water. Phytoremediation has the advantage of the unique and selective uptake capabilities of plant root systems, together with the translocation, bioaccumulation, and contaminant degradation abilities of the entire plant body (Hinchman et al. 1995). This technology is environment friendly and potentially cost-effective. The potential of aquatic macrophytes for heavy metal removal has been investigated and reviewed thoroughly (Ahmad et al. 2014, 2015; Devlin 1967; Ellis et al. 1994; Kara et al. 2003; Marques et al. 2009; Rahman et al. 2008; Rai 2005; Sharma and Gaur 1995; Sitarska et al. 2015; Vymazal 1995).

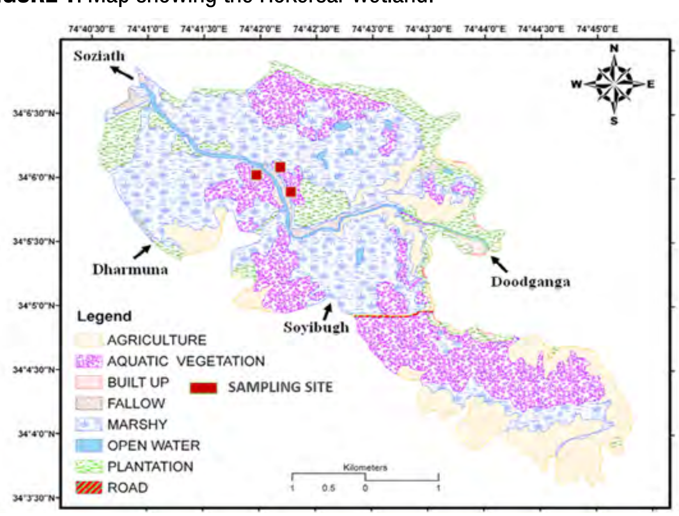
Ahmad et al. (2014, 2015) recently reported the heavy metal removal capability of *Ceratophyllum demersum, Phragmites australis* and *Potamogeton natans* in Hokersar wetland - an important Ramsar site in the Kashmir Himalaya, India. These species significantly reduced the supply of metals available for avifauna and prevented their bio-accumulation. The present study assesses the metal-removing capability of a most common macrophyte *Salvinia natans* in the Hokersar wetland.

## METHODS

### Study area

Hokersar wetland (34° 06′ N, 74° 05′ E) is a protected and world-famous game reserve situated at an altitude of 1,584 m (amsl). The wetland is about 12 kms Northwest of Srinagar city in Kashmir Himalaya, India (Figure 1). This wetland with a fluvial origin is a permanent but relatively shallow water body subject to a sub-Mediterranean climate (Figure 2). The area of the wetland comprises mostly Karewa table lands with lacustrine deposits (clay, silt, sand particles, conglomerates, boulders, and pebbles) of Pleistocene age. Once spread over an area of 19.5 km$^2$, the wetland has presently shrunk to just 13.26 km$^2$. The wetland is fed by a perennial channel at Dharmuna and Soyibugh. The water leaves the wetland through needle weir gate at Soziath village on the western side. Hokersar wetland is an ideal habitat for many migratory and residential birds and during winter harbors about two million waterfowl that migrate from Central Asia, China, northern Europe, and

**FIGURE 1**. Map showing the Hokersar wetland.




1 Corresponding author: ssahmad900@gmail.com

Siberia. The wetland attains a maximum depth of 2.5 m in spring due to increased runoff from the snow meltwater in the upper reaches of Doodhganga catchment, whereas in autumn the water is just 1 m deep.

Geological weathering and anthropogenic activities such as municipal wastes and use of pesticides in the adjoining rice fields and heavy vehicular traffic running on highway adjacent to the wetland have introduced heavy metals into the wetland. Being an important game reserve, the past practice of hunting/poaching of birds with lead shot has been another source of heavy metals for the wetland.

**Study species**

*Salvinia natans* L. (floating fern, floating water moss or water butterfly wings) is a pantropical aquatic fern belonging to the family Salviniaceae (Figure 3). It is an annual free-floating species that appears similar to moss and reproduces by sexual and asexual (vegetative) means. The macrospore develops into the female gametophyte and the microspore has pouches of air sacs that help in floating. Fertilization takes place on the water surface, producing a zygote which becomes the sporophyte (Szmeja and Gałka 2013). Available fossil data indicate that *Salvinia* was distributed in tropical latitudes as well as in temperate latitudes of the Northern Hemisphere throughout most of the Cenozoic. Its modern pantropical distribution could be the result of Pleistocene extinction of *Salvinia* in temperate regions due to global cooling climate trend (Consuegra et al. 2017).

**Sampling**

Leaf, water, and sediment samples were collected from the Hokersar wetland for analysis of heavy metals. Leaf samples were randomly collected from different sites in the wetland and were sealed in airtight polythene bags. The samples were then transported to the laboratory and stored at 4°C. One liter of water was collected in high density polyethylene (HDPE) bottles from each site during the spring season to determine the metals in solution. The samples were preserved with 2 ml of concentrated $HNO_3$ (Ultrex) per liter and were kept at 4°C until analyzed. The sampling quality control in water was ensured by introducing bottle blanks (distilled water) and field samples in duplicate which were analyzed to measure the integrity of the samples and reproducibility, respectively. Sediment samples were collected with the help of a dredger and taken to the laboratory in plastic bags. The samples were stored at 4°C for about 1 week. Prior to sampling all the sampling equipment was pre-treated as specified by American Public Health Association (APHA 1998).

**Analysis**

The plant samples were thoroughly washed with distilled water in the laboratory. Plant samples were oven-dried at 60°C for 24 hours. The dried samples were weighed and ground using a Wiley mill to pass through a 40 mesh screen. The analysis of plants was carried out by acid digestion of dry samples with an acid mixture (9 parts nitric acid: 4 parts perchloric acid) at about 80°C. All the reagents were of analytical grade. The reaction vessels were washed well to avoid external contributions of the metals. Sample blanks consisting of only chemical reagents used for sample analysis were analyzed to correct for possible external contributions of the metals while replicate samples were also evaluated and all the analyses were done in triplicate to ensure reproducibility of the results. The digested samples were analyzed for nine metals (Al

**FIGURE 2**. View of the Hokersar wetland showing different macrophytic species.

**FIGURE 3**. Closeup of *Salvinia natans*. (Photo courtesy of Le.Coupe.Gris).

[aluminum], Mn [manganese], Zn [zinc], Cu [copper], Pb [lead], Co [cobalt], Cr [chromium], Ni [nickel] and Cd [cadmium]) using an atomic absorption spectrometer (AAS; Perkin Elmer, model Analyst 800 with a detection limit of ppb).

Water samples (50 mL) were digested with 2M $HNO_3$ at 95°C for 2h and were increased to 100 mL in volumetric flask with demineralized water. The digestion was done in glassware previously soaked in nitric acid and washed with demineralized water. Sample blanks were also analyzed to correct for any contamination in the course of analysis. The digested samples were analyzed for metals on an AAS.

The bioconcentration factor (BCF) is defined as the ratio between heavy metal concentration in the plant tissues by dry weight and heavy metal concentration in water (Zayed et al. 1998). Zayed et al. (1998) reported that the appropriateness of a plant for phytoremediation potential is often judged by its BCF. BCF values over 1000 are generally considered evidence of a useful plant for phytoremediation (Ahmad et al. 2015; Matache 2013).

For statistical analysis metal concentrations were expressed in µg/L in water and mg/kg in plant tissues. Standard error was determined from three replicates for every set of data.

## RESULTS

The results of the concentration of heavy metals in *S. natans* and water collected from the Hokersar wetland are given in Table 1. Al and Mn are bioaccumulated in much higher concentrations than the rest of the heavy metals.

**TABLE 1**. Concentration of heavy metals in *S. natans*, water and bioconcentration factor (BCF) of *S. natans* depicting transfer of heavy metals from water to plant tissues. (Note: Plant species having BCF greater than 1000 are generally considered positive plants for phytoremediation.)

| Heavy metal | Concentration (mg/kg) | Water (mg/L) | BCF |
|---|---|---|---|
| Pb | 39.61±2.31 | 0.062±0.00 | 638 |
| Mn | 3858±179.66 | 0.67±0.06 | 5758 |
| Al | 3667±217.4 | 7.85±0.78 | 467 |
| Cr | 9.32±0.63 | 0.025±0.00 | 372 |
| Co | 9.65±0.25 | 0.01±0.00 | 965 |
| Zn | 30.62±2.05 | 0.06±0.00 | 510 |
| Cu | 16.75±0.44 | 0.30±0.01 | 55 |
| Cd | 3.63±0.24 | 0.004±0.00 | 907 |
| Ni | 9.59±0.21 | 0.03±0.08 | 319 |
| Mo | 18.87±0.41 | 0.36±0.02 | 52 |
| Ba | 158.82±2.22 | 0.26±0.00 | 610 |

The accumulation of the different elements in *S. natans* was in order of Mn > Al > Ba > Pb > Zn > Mo > Cu > Co > Ni > Cr > Cd.

The phytoremediation potential of *S. natans* was determined by calculating the BCF, which is defined as the ratio of metal concentration in the roots to that in water (Table 1). In *S. natans* the highest BCF corresponded to Mn metal (5758) followed by Co (965) and Cd (907) in decreasing order. Consequently, *S. natans* has high capacity to hyperaccumulate these heavy metals.

## DISCUSSION

Kamel (2013) reported that plants show critical toxicity (affecting plant and inhibiting its growth) between the range of Cd 10-30, Co 1-8, Cu 25-90, Ni 10-50 Pb 30-100, and Zn 100-400. Dhir and Srivastava (2013) suggested that *S. natans* has fairly high levels of tolerance to Zn, Cd, Co, Cr, Fe, Cu, Pb and Ni with the levels of tolerance varying from metal to metal. Thilakar et al. (2012) reported that *S. natans* is a hyperaccumulator of heavy metals and has great potential to accumulate heavy metals and can be effectively used to clean up aquatic ecosystems. Dhir et al 2011 reported that accumulation of osmolytes under heavy metal stress might help in imparting tolerance to the heavy metals. *S. natans* possesses effective metabolic machinery that is capable of overcoming the osmotic stress induced by heavy metals including mercury (Hg) (Dhir and Sitarska 2011; Sitarska 2014). Sen and Bhattachariya (1994) reported that in the absence of other pollutants *Salvinia* plants may be used for the removal of Ni (II) in effluents and as an indicator of Ni pollution.

## CONCLUSION

*S. natans* is among the more dominant species in Himalayan wetlands. Demonstration of its heavy metal accumulation potential and growing incidence of heavy metal contamination around the world make this species among the choicest for heavy metal remediation in regions where *S. natans* naturally occurs. This plant can be easily transferred to heavy metal-contaminated sites and encouraged to grow for bioaccumulation particularly of Mn, Co and Cd. The species can also be easily planted in constructed wetlands designed to treat wastewater containing different heavy metals. The present study and other studies conducted across the world confirm that *S. natans* serves as a potent phyoremediation plant for the removal of heavy metals particularly Mn, Co and Cd. It is important to note, however, that this species is viewed as an invasive species (e.g., a noxious weed in the United States; https://plants.usda.gov/core/profile?symbol=SANA5), so caution must be exercised in using this plant beyond its natural range. ■

## ACKNOWLEDGMENTS

We are thankful to Head, Department of Botany and Director, University Science and Instrumentation Centre (USIC), University of Kashmir, J and K, India, for providing necessary facilities during the course of this study. We are also grateful for financial support from University Grants Commission (UGC) India in the form of grants to Zafar Ahmad Reshi.

## REFERENCES

Ahmad S.S., Reshi Z.A., Shah M.A., Rashid I., Ahmad S.S., Reshi Z.A., Shah M.A. and Rashid I. 2016. Constructed wetlands: role in phytoremediation of heavy metals. In Ansari, A.A., Gill, S.S., Gill, R., Lanza, G., and Newman, L. (eds.). *Phytoremediation* (3rd ed.). Springer International Publishing, Switzerland. pp 291-304.

Ahmad S.S., Reshi Z.A., Shah M.A., Rashid I., Ara, R., and Andrabi, S.M.A. 2016. Heavy metal accumulation in the leaves of Potamogeton natans and *Ceratophyllum demersum* in a Himalayan RAMSAR site: management implications. *Wetlands Ecology and Management* 24(4): 469–475. https://doi.org/10.1007/s11273-015-9472-9

Ahmad S.S., Reshi Z.A., Shah M.A., Rashid I., Ara R. and Andrabi S.M.A., 2014. Phytoremediation potential of *Phragmites australis* in Hokersar Wetland - a Ramsar site of Kashmir Himalaya. *International Journal of Phytoremediation* 16: 1183–1191. https://doi.org/10.1080/15226514.2013.821449

Alkorta I., Hernandez-Allica J., Becerril J.M., Amezaga I., and Albizu I. and Garbisu C. 2004. Recent findings on the phytoremediation of soils contaminated with environmentally toxic heavy metals and metalloids such as zinc, cadmium, lead, and arsenic *Reviews in Environmental Science and Biotechnology* 3: 71–90.

APHA (American Public Health Association). 1998. *Standard Methods for Examination of Water and Wastewater* (20th Edition). Washington, DC, USA.

Bacha M.S. 2002. Central Assistance for Hokersar Critical Wetland Final Report Department of Wildlife Protection, Srinagar, Jammu and Kashmir.

Choppala G., Saifullah Bolan N., Bibi S., Iqbal M., Rengel Z., Kunhikrishnan A., Ashwath N., and Ok Y. S. 2014. Cellular mechanisms in higher plants governing tolerance to Cadmium toxicity. *Critical Reviews in Plant Science* 33: 374–391.

Consuegra N.P. 2017. Paleogene *Salvinia* (Salviniaceae) from Colombia and their paleobiogeographic implications. Review of Paleobotany and Palynology 246: 85-108.

DamekProprawa M. and Sawicka-Kapusta K. 2003. Damage to the liver, kidney and testis with reference to burden of heavy metals in yellow necked mice from areas around steel works and zinc smelters in Poland. *Toxicology* 186: 1–10.

Devlin, R.M. 1967. *Plant Physiology*. Van Nostrand Reinhold Company, New York.

Nies D.H. 1999. Microbial heavy-metal resistance. *Appl Microbiol Biotechnology* 51: 730–750.

Dhir, S.S. 2003. Heavy metal tolerance in metal hyperaccumulator plant Salvinia natans. *Bulletin of Environmental Contamination and Toxicology* 90(6): 720–724.

Dhir B., Nasim S.A., Samantary S. and Srivastava S. 2012. Assessment of osmolyte accumulation in heavy metal exposed *Salvinia natans*. *International Journal of Botany* 8(3): 153–158.

Dhir B., Sharmila P., Pardha Saradhi P., Sharma S., Kumar R., and Mehta D. 2011. Heavy metal induced physiological alterations in Salvinia natans. *Ecotoxicology and Environmental Safety* 74(6): 1678–1684.

Ellis J.B., Revitt. D.M., Shutes R.B.E. and Lang Ley J. M. 1994. The performance of vegetated biofilters for highway runoff control. *Science of the Total Environment* 146/147: 543–550.

Glover-Kerkvliet J. 1995. Environmental assault on immunity. *Environ Health Perspectives* 103: 226–239.

Gomes P.I.A., and Asaeda T. 2013. Phytoremediation of heavy metals by calcifying macro-algae (*Nitella pseudoflabellata*): Implications of redox insensitive end products. *Chemosphere* 92(10): 1328–1334.

Gullizzoni P. 1991. The role of heavy metals and toxic materials in the physiological ecology of submerged macrophytes. *Aquatic Botany* 41: 87–109.

Hinchman R.R., Negri M.C. and Gatliff E.G. 1995. Phytoremediation: using green plants to clean up contaminated soil, groundwater and wastewater. Argonne National Laboratory and Applied Natural Sciences, Inc. https://pdfs.semanticscholar.org/2a1a/a6fdd3da623761a4febbab509bf9189c14a1.pdf

Hodgstrand C. and Haux C. 2001. Binding and detoxification of heavy metals in lower vertebrates with reference to metallo-thione. *Journal of Compd Biocnhemistry and Physiology* 100: 137–141.

Joshi P.K., Bose M. and Harish D. 2002. Haematological changes in the blood of Clarias batrachus exposed to mercuric chloride. *Journal of Ecotoxicology and Environmental Monitoring* 12: 119–122.

Kamel. 2013. Phytoremediation potentiality of aquatic macrophytes in heavy metal contaminated water of El-Temsah Lake Ismaili Egypt. *Middle East Journal of Scientific Research* 14(12): 1555–1568.

Kara Y., Aran D.B., Kara Y, Ali Z. and Genc I. 2003. Bioaccumulation of Nickel by aquatic macrophyta, *Lemna minor* (Duckweed). *International Journal of Agriculture and Biology* 3: 281–283.

Lenntech. 2015. Health Effects. Retrieved from http://www.lenntech.com/periodic/elements/ 17/12/2017

Matache M.L., Tudorache A., Rozylowicz L., and Neagu E. 2013. Trace elements concentrations in aquatic biota from the Iron Gates wetlands in Romania. In *Proceedings of the 16th International Conference on Heavy Metals in the Environment.* E3S Web of Conferences (Vol. 1, 2013). Article number 32005.

Miretzky, P. Saralegui A., & Cirelli A. F. 2004. Aquatic macrophytes potential for the simultaneous removal of heavy metals (Buenos Aires, Argentina). *Chemosphere* 57(8): 997–1005.

Oliveira Ribeiro C.A., Schatzmann M., Silva de Assiss H.C., Silva P.H., Pelletier E. and Akaishi F. M. 2002. Evaluation of tributyl tin subchronic effects in tropical freshwater fish (*Astyanax bimaculatus* L. 1758). *Ecotoxicology and Environmental Safety* 51: 161–67.

Oliveira Ribeiro, C.A., Pelletier, E., Pfeiffer W.C., and Rouleau C. 2000. Comparative uptake, bioaccumulation, and gill damages of inorganic mercury in tropical and nordic freshwater fish. *Environmental Research* 83(3): 286–92. https://doi.org/10.1006/enrs.2000.4056

Rahman M.A., Hasegawa H., Ueda K. and Maki T.R.M. 2006. Influence of phosphate and iron ions in selective uptake of arsenic species by water fern (*Salvinia natans* L.). *Chemical Engineering Journal* 145: 179–184.

Rai U.N., Sinha S., Tripathi R. D. and Chandra P. 1995. Wastewater treatability potential of some aquatic macrophytes: Removal of heavy metals. *Ecological Engineering* 5(1): 5–12. https://doi.org/10.1016/0925-8574(95)00011-7

Rakhshaee R., Giahi M. and Pourahmad A. 2009. Studying effect of cell wall's carboxyl-carboxylate ratio change of *Lemna minor* to remove heavy metals from aqueous solution. *Journal of Hazardous Materials* 163: 165–173.

Rietzler A.C., Fonseca A.L. and Lopes G.P. 2001. Heavy metals in tributaries of Ampulha reservoir, Minas Gerais. *Brazzilian Journal of Biology* 61: 363–370. https://doi.org/10.1590/S1519-69842001000300004

Sen A.K. and Bhattacharyya M. 1994. Studies of uptake and toxic effects of NI (II) on Salvinia natans. *Water Air and Soil Pollution* 78: 141–152.

Sharma S.S. and Gaur J.P. 1995. Potential of Lemna polyrhiza for removal of heavy metals. *Ecolgical Engineering* 4: 37–45.

Shtangeeva, I. and Ayrault S. 2004. Phytoextraction of thorium from soil and water media. *Water Air and Soil Pollution* 154: 19–35.

Sitarska M., Traczewska T. and Filyarovskaya V. 2015. Removal of mercury (II) from the aquatic environment by phytoremediation. *Desalination and Water Treatment* 57:3, 1515-1524. doi: 10.1080/19443994.2015.1043492

Sitarska M., Traczewska T.M., Stanicka-Łotocka A., Filyarovskaya V. and Zamorska-Wojdyła D. 2014. Accumulation of mercury in the biomass of selected pleustophytes. *Environmental Protection Engineering* 40: 165–174.

Teixeira S., Vieira M.N., Esphinha Marques J., and Pereira R. 2013. Bioremediation of iron rich mine effluent by *Lemna minor*. *International Journal of Phytoremediation* 16 (12): 1228-1240. https://doi.org/10.1080/15226514.821454

Thilakar R.J., Jeya R.J. and Pillai P.M.. 2012. Phytoaccumlation of chromium and copper by *Pistia stratoides* L. And *Salvinia natans*. All. *Journal Natural Products and Resources* 2(6): 725–730.

Vymazal J. 2010. Constructed Wetlands for Wastewater Treatment. *Water* 2(3): 530–549. https://doi.org/10.3390/w2030530

Vymazal J. 1995. *Algae and Element Cycling in Wetlands*. Lewis Publishers Inc., Boca Raton, FL.

Zayed A. and Gowthaman S.and Terry. N. 1998. Phytoaccumulation of trace elements by wtland plants: I. Duckweed. *Journal of Environmental Quality* 27: 715–721.



## Submit a Video to Be Featured on the SWS YouTube Channel

The SWS mission is to promote understanding, conservation, protection, restoration, science-based management and sustainability of wetlands. The SWS New Media Team launched the SWS YouTube channel to share our mission with a wider audience. To help us with this initiative, we ask for members and non-members alike to share their work and experiences by submitting a video to be featured on our YouTube channel! Featured videos will showcase various wetland topics that help to further our mission. Visit theNew Media Initiative page (http://sws.org/About-SWS/new-media-initiative.html) to learn more and to submit a video! ■

## Wetlands of Distinction

SWS Wetlands of Distinction is an initiative to raise public awareness of wetlands and their many benefits to human health and the environment. To meet this goal, the SWS Wetlands of Distinction will create a one-stop-shop for information on the biology, ecology, conservation status and access opportunities of high-functioning wetlands, across the nation. SWS is also collaborating with the U.S. National Ramsar Committee so that this initiative can become a vehicle for identifying and processing future applications for U.S. Ramsar designation.

First, we need to create an inventory of wetlands that have already been deemed important by agencies and organizations. These prequalified wetlands will be used as a reference to judge future wetland applications. All applications will be reviewed by a team of regional experts to ensure that the criteria for SWS Wetlands of Distinction status are met. There is a team of wetland professionals waiting to assist you with your application questions. Please visit www.wetlandsofdistinction.org or email the committee at swswetlandsofdistinction@gmail.com for more information.

SWS Wetlands of Distinction team is calling all government and non-government organizations with critical, special or rare wetland lists to submit an application. Visit www.wetlandsofdistinction.org to learn more about the initiative, create a new account, and fill out an application for a wetland! ■

# WETLANDS IN THE NEWS

Listed below are some links to some random news articles that may be of interest. Members are encouraged to send links to articles about wetlands in their local area. Please send the links to WSP Editor at ralphtiner83@gmail.com and reference "Wetlands in the News" in the subject box. Thanks for your cooperation. ■

Moving a floating wetland from a beach in Minnesota
https://www.atlasobscura.com/articles/what-happened-to-the-minnesota-bog

Stop using "Swamp" as a negative term (e.g., "drain the swamp")
https://www.nytimes.com/2018/05/05/opinion/sunday/stop-calling-washington-a-swamp-its-offensive-to-swamps.html

Upcoming ASWM webinar on compensatory mitigation registration
https://attendee.gotowebinar.com/register/7485952740901587715

Restoring wetlands for desert pupfish
https://www.ecowatch.com/desert-fish-endangered-2569323966.html

North Carolina wetland regulations
https://portcitydaily.com/local-news/2018/05/11/3-days-vs-3-months-regulatory-structure-makes-it-tougher-protect-wetlands/

Massachusetts wetland enforcement
https://www.ecori.org/government/2018/5/3/appeals-court-upholds-decision-to-restore-damaged-wetlands

Wetlands for downtown Durham, NC
http://www.heraldsun.com/news/local/counties/durham-county/article209713499.html

Wetland conservation in Texas
http://kfdm.com/news/local/additional-wetlands-protection-provides-defense-against-flooding

Wetland banking in Minnesota
http://www.startribune.com/bank-gives-landowners-committed-to-restoring-minnesota-wetlands-a-financial-incentive/480463381/

Columbian wetlands
http://www.columbian.com/news/2018/apr/18/shoring-up-a-key-wetland-in-camas/

Wetland restoration in Milwaukee
https://www.jsonline.com/story/news/local/milwaukee/2018/04/17/restoration-one-last-wetlands-milwaukees-harbor-estuary-provide-more-public-recreation-ato-restored/522547002/

Kansas wetland park
http://www.kansas.com/news/politics-government/article208500834.html

Walden Pond revisited
https://www.smithsonianmag.com/smart-news/new-study-details-man-made-damage-done-walden-pond-180968700/

Wisconsin Frac mining permit
https://www.wpr.org/dnr-staff-felt-pressure-approve-wetland-fill-frac-sand-mining-project

Minnesota wetland conservation
http://www.startribune.com/federal-project-leader-scott-glup-sees-work-as-the-front-lines-of-protection-for-wetlands-and-waterfowl/479060743/

Hong Kong wetlands
https://www.hongkongfp.com/2018/04/08/trouble-paradise-suspicious-fires-land-battles-afflict-hong-kongs-nam-sang-wai-wetlands/

Spokane County wetland restoration
http://www.spokesman.com/stories/2018/apr/03/spokane-county-central-valley-district-make-saltes/#/0

Florida wetland regulation
https://www.tcpalm.com/story/news/local/indian-river-lagoon/health/2018/03/19/wetland-protection-poised-shift-corps-engineers-florida-dep/417298002/

Sea-level rise threatens local tribe in Louisiana
https://e360.yale.edu/features/on-louisiana-coast-a-native-community-sinks-slowly-into-the-sea-isle-de-jean-charles

Turtles in crisis
http://therevelator.org/turtle-extinction-crisis/

Pantanal wetlands
https://www.worldwildlife.org/stories/5-interesting-facts-about-the-pantanal-the-world-s-largest-tropical-wetland

http://www.worldwaterforum8.org/en/news/brazil-bolivia-and-paraguay-signed-declaration-conservation-pantanal

Penguins seen from space
https://gizmodo.com/poo-stains-seen-from-space-lead-to-discovery-of-massive-1823457294

Wisconsin wetland regulations
http://www.gazettextra.com/news/government/county-officials-say-isolated-wetlands-bill-could-have-adverse-effects/article_7f98b9ef-48eb-55cc-b4b6-f851f1213d3d.html

http://host.madison.com/wsj/news/local/govt-and-politics/politicized-wisconsin-dnr-erasing-rare-wetlands-retirees-say/article_881666fc-f9c0-5cf7-ac2a-272e9c1d4094.html

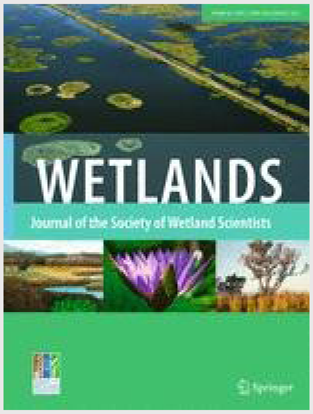
Ballona wetlands historic images
http://www.businessinsider.com/history-of-los-angeles-ballona-creek-wetlands-watershed-2018-2

Mining impacts proposed for Minnesota
https://search.app.goo.gl/EUQb6

## What's New in our Journal - *Wetlands*?

The following articles will appear in Volume 38, Issue 2 of *Wetlands*:

- Wetlands In a Changing Climate: Science, Policy and Management
- Monitoring the Wildlife, Hydrology and Water Quality of Drained Wetlands of the Des Moines Lobe, Northern Iowa: Introduction to Special Feature
- Waterbird Use of Sheetwater Wetlands in Iowa's Prairie Pothole Region
- Pesticides, Including Neonicotinoids, in Drained Wetlands of Iowa's Prairie Pothole Region
- Investigating Hydrologic Connectivity of a Drained Prairie Pothole Region Wetland Complex using a Fully Integrated, Physically-Based Model
- Groundwater Hydrology and Quality in Drained Wetlands of the Des Moines Lobe in Iowa
- Spring Nutrient Levels in Drained Wetlands of IOWA's Prairie Pothole Region
- A Review of Techniques for Effective Tropical Peatland Restoration
- Modelling the Diurnal Variations of Methane Emissions from the *Cyperus malaccensis* Tidal Marsh in the Minjiang River Estuary
- Sediment Geochemistry, Accumulation Rates and Forest Structure in a Large Tropical Mangrove Ecosystem
- Consumption of an exotic plant (*Spartina alterniflora*) by the macrobenthic fauna in a mangrove wetland at Zhanjiang, China
- Controlling Cattail Invasion in Sedge / Grass Meadows
- Wetland restoration and hydrologic reconnection result in enhanced watershed nitrogen retention and removal
- Restoration of Cordgrass Salt Marshes: Limited Effects of Organic Matter Additions on Nitrogen Fixation
- Impact of Salinity, Hydrology and Vegetation on Long-Term Carbon Accumulation in a Saline Boreal Peatland and its Implication for Peatland Reclamation in the Athabasca Oil Sands Region
- Impacts of Agricultural and Reclamation Practices on Wetlands in the Amur River Basin, Northeastern China
- Macroinvertebrate Community in Subsurface-Flow Constructed Wetlands for Wastewater Treatment under High and Low Pollutant Stress in China
- Relationships of Marsh Soil Strength to Belowground Vegetation Biomass in Louisiana Coastal Marshes




**DO YOU WANT TO PUBLISH YOUR ARTICLE IN THIS JOURNAL?**
Please visit the homepage of *Wetlands* for full details on aims and scope, editorial policy and article submission.

**SIGN UP FOR SPRINGERALERTS!**
Register for Springer's email services providing you with info on the latest books in your field. https://www.springer.com/gp?SGWID=0-150903-0-0-0&wt_mc=alerts.TOCjournals&utm_source=toc&utm_medium=email&utm_content=13157&utm_campaign=&countryChange=true ■

For the latest news on wetlands and related topics, readers are referred to the Association of State Wetland Managers website. Their "Wetland Breaking News" section include links to newspaper articles that should be of interest: https://www.aswm.org/news/wetland-breaking-news. Their blog – the Complete Wetlander – may also be of interest: https://www.aswm.org/wordpress/. Additional resources are listed below. Please help us add new books and reports to this listing. If your agency, organization, or institution has published new publications on wetlands, please send the information to Editor of Wetland Science & Practice at ralphtiner83@gmail.com. Your cooperation is appreciated. ■

## BOOKS

- Eager: The Surprising Secret Life of Beavers and Why They Matter https://www.chelseagreen.com/product/eager/
- Wetland Indicators – A Guide to Wetland Formation, Identification, Delineation, Classification, and Mapping https://www.crcpress.com/Wetland-Indicators-A-Guide-to-Wetland-Identification-Delineation-Classification/Tiner/p/book/9781439853696
- Wetland Soils: Genesis, Hydrology, Landscapes, and Classification https://www.crcpress.com/Wetland-Soils-Genesis-Hydrology-Landscapes-and-Classification/Vepraskas-Richardson-Vepraskas-Craft/9781566704847
- Creating and Restoring Wetlands: From Theory to Practice http://store.elsevier.com/Creating-and-Restoring-Wetlands/Christopher-Craft/isbn-9780124072329/
- Salt Marsh Secrets. Who uncovered them and how? http://trnerr.org/SaltMarshSecrets/
- Remote Sensing of Wetlands: Applications and Advances. https://www.crcpress.com/product/isbn/9781482237351
- Wetlands (5th Edition). http://www.wiley.com/WileyCDA/WileyTitle/productCd-1118676823.html
- Black Swan Lake – Life of a Wetland http://press.uchicago.edu/ucp/books/book/distributed/B/bo15564698.html
- Coastal Wetlands of the World: Geology, Ecology, Distribution and Applications http://www.cambridge.org/us/academic/subjects/earth-and-environmental-science/environmental-science/coastal-wetlands-world-geology-ecology-distribution-and-applications
- Florida's Wetlands https://www.amazon.com/Floridas-Wetlands-Natural-Ecosystems-Species/dp/1561646873/ref=sr_1_4?ie=UTF8&qid=1518650552&sr=8-4&keywords=wetland+books
- Mid-Atlantic Freshwater Wetlands: Science, Management, Policy, and Practice http://www.springer.com/environment/aquatic+sciences/book/978-1-4614-5595-0
- The Atchafalaya River Basin: History and Ecology of an American Wetland http://www.tamupress.com/product/Atchafalaya-River-Basin,7733.aspx
- Tidal Wetlands Primer: An Introduction to their Ecology, Natural History, Status and Conservation https://www.umass.edu/umpress/title/tidal-wetlands-primer
- Wetland Landscape Characterization: Practical Tools, Methods, and Approaches for Landscape Ecology http://www.crcpress.com/product/isbn/9781466503762
- Wetland Techniques (3 volumes) http://www.springer.com/life+sciences/ecology/book/978-94-007-6859-8
- Wildflowers and Other Plants of Iowa Wetlands
- https://www.uipress.uiowa.edu/books/2015-spring/wildflowers-and-other-plants-iowa-wetlands.htm
- Wetland Restoration: A Handbook for New Zealand Freshwater Systems https://www.landcareresearch.co.nz/publications/books/wetlands-handbook
- Wetland Ecosystems https://www.wiley.com/en-us/Wetland+Ecosystems-p-9780470286302
- Constructed Wetlands and Sustainable Development https://www.routledge.com/Constructed-Wetlands-and-Sustainable-Development/Austin-Yu/p/book/9781138908994

## ONLINE PUBLICATIONS

### U.S. ARMY CORPS OF ENGINEERS

- Regional Guidebook for the Functional Assessment of Organic Flats, Slopes, and Depressional Wetlands in the Northcentral and Northeast Region http://acwc.sdp.sirsi.net/client/en_US/search/asset/1047786
- Wetland-related publications:
  -http://acwc.sdp.sirsi.net/client/en_US/default/search/results?te=&lm=WRP
  -http://acwc.sdp.sirsi.net/client/en_US/default/search/results?te=&lm=WRP
- National Wetland Plant List publications: http://rsgisias.crrel.usace.army.mil/NWPL/
- National Technical Committee for Wetland Vegetation: http://rsgisias.crrel.usace.army.mil/nwpl_static/ntcwv.html
- U.S. Environmental Protection Agency wetland reports and searches: http://water.epa.gov/type/wetlands/wetpubs.cfm
- A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Forested Wetlands in Alluvial Valleys of the Coastal Plain of the Southeastern United States ERDC/EL TR-13-1
- Hydrogeomorphic (HGM) Approach to Assessing Wetland Functions: Guidelines for Developing Guidebooks (Version 2) ERDC/EL TR-13-11
- Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing the Functions of Flat and Seasonally Inundated Depression Wetlands on the Highland Rim ERDC/EL TR-13-12
- Wetland Plants and Plant Communities of Minnesota and Wisconsin (online publication) http://www.mvp.usace.army.mil/Missions/Regulatory/?Page=12

### U.S. FISH AND WILDLIFE SERVICE, NATIONAL WETLANDS INVENTORY

- Wetland Characterization and Landscape-level Functional Assessment for Long Island, New York http://www.fws.gov/northeast/ecologicalservices/pdf/wetlands/Characterization_Report_February_2015.pdf or http://www.aswm.org/wetlandsonestop/wetland_characterization_long_island_ny_021715.pdf
- Also wetland characterization/landscape-level functional assessment reports for over 12 small watersheds in New York at: http://www.aswm.org/wetland-science/134-wetlands-one-stop/5044-nwi-reports
- Preliminary Inventory of Potential Wetland Restoration Sites for Long Island, New York http://www.aswm.org/wetlandsonestop/restoration_inventory_long_island_ny_021715.pdf
- Dichotomous Keys and Mapping Codes for Wetland Landscape Position, Landform, Water Flow Path, and Waterbody Type Descriptors. Version 3.0. U.S. Fish and Wildlife Service, Northeast Region, Hadley, MA.
- Connecticut Wetlands Reports
- Changes in Connecticut Wetlands: 1990 to 2010
- Potential Wetland Restoration Sites for Connecticut: Results of a Preliminary Statewide Survey

- Wetlands and Waters of Connecticut: Status 2010
- Connecticut Wetlands: Characterization and Landscape-level Functional Assessment
- Rhode Island Wetlands: Status, Characterization, and Landscape-level Functional Assessment http://www.aswm.org/wetlandsonestop/rhode_island_wetlands_llww.pdf
- Status and Trends of Prairie Wetlands in the United States: 1997 to 2009 http://www.fws.gov/wetlands/Documents/Status-and-Trends-of-Prairie-Wetlands-in-the-United-States-1997-to-2009.pdf
- Status and Trends of Wetlands in the Coastal Watersheds of the Conterminous United States 2004 to 2009. http://www.fws.gov/wetlands/Documents/Status-and-Trends-of-Wetlands-In-the-Coastal-Watersheds-of-the-Conterminous-US-2004-to-2009.pdf
- The NWI+ Web Mapper – Expanded Data for Wetland Conservation http://www.aswm.org/wetlandsonestop/nwiplus_web_mapper_nwn_2013.pdf
- Wetlands One-Stop Mapping: Providing Easy Online Access to Geospatial Data on Wetlands and Soils and Related Information http://www.aswm.org/wetlandsonestop/wetlands_one_stop_mapping_in_wetland_science_and_practice.pdf
- Wetlands of Pennsylvania's Lake Erie Watershed: Status, Characterization, Landscape-level Functional Assessment, and Potential Wetland Restoration Sites http://www.aswm.org/wetlandsonestop/lake_erie_watershed_report_0514.pdf

### U.S. FOREST SERVICE

- Historical Range of Variation Assessment for Wetland and Riparian Ecosystems, U.S. Forest Service Rocky Mountain Region. http://www.fs.fed.us/rm/pubs/rmrs_gtr286.pdf
- Inventory of Fens in a Large Landscape of West-Central Colorado http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5363703.pdf

### U.S. GEOLOGICAL SURVEY, NATIONAL WETLANDS RESEARCH CENTER

- Link to publications: http://www.nwrc.usgs.gov/pblctns.htm (recent publications are noted)
- A Regional Classification of the Effectiveness of Depressional Wetlands at Mitigating Nitrogen Transport to Surface Waters in the Northern Atlantic Coastal Plain http://pubs.usgs.gov/sir/2012/5266/pdf/sir2012-5266.pdf
- Tidal Wetlands of the Yaquina and Alsea River Estuaries, Oregon: Geographic Information Systems Layer Development and Recommendations for National Wetlands Inventory Revisions http://pubs.usgs.gov/of/2012/1038/pdf/ofr2012-1038.pdf

### U.S.D.A. NATURAL RESOURCES CONSERVATION SERVICE

- Link to information on hydric soils:http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/use/hydric/
- Field Indicators of Hydric Soils of the United States, Version 8.1 (online publication) https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_053171.pdf

### PUBLICATIONS BY OTHER ORGANIZATIONS

- The Nature Conservancy has posted several reports on wetland and riparian restoration for the Gunnison Basin, Colorado at: http://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/Colorado/science/climate/gunnison/Pages/Reports.aspx (Note: Other TNC reports are also available via this website by looking under different regions.)
- Book: Ecology and Conservation of Waterfowl in the Northern Hemisphere, Proceedings of the 6th North American Duck Symposium and Workshop (Memphis, TN; January 27-31, 2013). Wildfowl Special Issue No. 4. Wildfowl & Wetlands Trust, Slimbridge, Gloucestershire, UK.
- Report on State Definitions, Jurisdiction and Mitigation Requirements in State Programs for Ephemeral, Intermittent and Perennial Streams in the United States (Association of State Wetland Managers) http://aswm.org/stream_mitigation/streams_in_the_us.pdf
- Wetlands and People (International Water Management Institute) http://www.iwmi.cgiar.org/Publications/Books/PDF/wetlands-and-people.pdf
- Waubesa Wetlands: New Look at an Old Gem (online publication) http://www.town.dunn.wi.us/land-use/historic-documents/

### ARTICLES OF INTEREST FROM VARIED SOURCES

- Comparative phylogeography of the wild-rice genus Zizania (Poaceae) in eastern Asia and North America; American Journal of Botany 102:239-247. http://www.amjbot.org/content/102/2/239.abstract

## LINKS TO WETLAND-RELATED JOURNALS AND NEWSLETTERS

### JOURNALS

- Aquatic Botany http://www.journals.elsevier.com/aquatic-botany/
- Aquatic Conservation: Marine and Freshwater Ecosystems http://onlinelibrary.wiley.com/journal/10.1002/%28ISSN%291099-0755
- Aquatic Sciences http://www.springer.com/life+sciences/ecology/journal/27
- Ecological Engineering http://www.journals.elsevier.com/ecological-engineering/
- Estuaries and Coasts http://www.springer.com/environment/journal/12237
- Estuarine, Coastal and Shelf Science http://www.journals.elsevier.com/estuarine-coastal-and-shelf-science/
- Hydrobiologia http://link.springer.com/journal/10750
- Hydrological Sciences Journal http://www.tandfonline.com/toc/thsj20/current
- Journal of Hydrology http://www.journals.elsevier.com/journal-of-hydrology/
- Wetlands http://link.springer.com/journal/13157
- Wetlands Ecology and Management https://link.springer.com/journal/11273

### NEWSLETTERS

Two of the following newsletters have been terminated yet maintain archives of past issues. The only active newsletter is "Wetland Breaking News" from the Association of State Wetland Managers.

- Biological Conservation Newsletter contained some articles that addressed wetland issues; the final newsletter was the January 2017 issue; all issues now accessed through the "Archives") http://botany.si.edu/pubs/bcn/issue/latest.htm#biblio
- For news about conservation research from the Smithsonian Institution, please visit these websites:
  - -Smithsonian Newsdesk http://newsdesk.si.edu/
  - -Smithsonian Insider http://insider.si.edu/
  - -The Plant Press http://nmnh.typepad.com/the_plant_press/
  - -SCBI Conservation News http://nationalzoo.si.edu/conservation
  - -STRI News http://www.stri.si.edu/english/about_stri/headline_news/news
- Wetland Breaking News (Association of State Wetland Managers) http://aswm.org/news/wetland-breaking-news
- National Wetlands Newsletter (Environmental Law Institute) – access to archived issues as the newsletter was suspended in mid-2016 due to the changing climate for printed publications. https://www.wetlandsnewsletter.org/

## The Beaver-based Sensation That's Sweeping the Nation

*Eager: The Surprising Secret Life of Beavers and Why They Matter* (2018) Chelsea Green Publishing, $24.95, 304 Pages

*Reviewed by Nate Hough-Snee, Meadow Run Environmental, Leavenworth, WA, USA*

An acquaintance of mine once said something akin to, "there are two types of book readers, people who know and care about every detail of a topic, and people starting on the periphery of interested." This individual's point was that most readers of a given non-fiction book will fall into one of two camps, the *acquainted* and the *unacquainted*. And, based on their camp of origin, each group's take-aways from a given book may vary dramatically. Luckily readers of Ben Goldfarb's *Eager: The Surprising Secret Life of Beaver and Why They Matter,* regardless of their starting camp, will enjoy the book if they are at all interested in the natural history of the North American continent, human-wildlife conflict and resolution, changes in watershed health and the integrity of streams, wetlands, and floodplains.

In the case of Goldfarb's audience, the acquainted will likely be from one of several overlapping sets of professionals, practitioners, volunteers, and students from across the country who study, conserve, restore, or otherwise manage wetlands, streams, or watersheds and the creatures and ecosystems they sustain. The unacquainted may be of the camp of those generally interested in natural and environmental history, perhaps because they enjoy hiking and fishing, or maybe because they're just a casual fan of post-colonial rodent extermination narratives.

Individuals from both camps were likely born in the twentieth century and came of age when popular environmental history usually highlighted people's actions on the landscape, often glossing over the sum of the many moving pre-existing parts of the landscape on which those actions were taken. *Eager* welcomes the unacquainted and acquainted alike with Goldfarb's sum-of-the-parts history of watersheds, humans, and rodents (namely American beaver, *Castor canadensis* with some attention to European beaver, *Castor fiber*), emphasizing the outsized role that beaver have played in building aquatic ecosystems over time. In ten chapters, Goldfarb draws a compelling picture of the North American continent in roughly four anthropogenic epochs (my words, not his).

The epochs are loosely: Before Europeans (BE), After Europeans (AE), Before Restoration (BR - when Europeans had not yet realized the magnitude of their destructive behavior toward watersheds and streams), and After Restoration (AR – also known as the "Oh crap, can we fix this mess" era). These epochs are told through the places beaver work their magic, and most intriguingly, through the people who help them to do it. Goldfarb, a seasoned environmental journalist, hit the road and made himself one with these "beaver believers," disentangling the epochs across New England's forests, Oregon's arid highlands, the Basin and Range of Utah, the Lamar Valley of Yellowstone, coastal and central California, and Washington's Methow Valley, just to name a few case studies.

Each case cleverly narrates humans' relationships with watersheds as mediated by beaver, paying homage to watersheds and landscapes as maintained by beaver's dams, side channels, herbivory (and predation), and overland travel. From mitigating conflicts between beaver and human infrastructure with deception to relocating beaver and emulating beaver dams, *Eager's* case studies show that while beaver pelts may be a fashion item of the past, beavers are *the fashionable* character at the forefront of the new ecological, physical, and hydrological process-based watershed restoration paradigm.

With such accessible characters, iconic places, and clear narratives, the unacquainted and acquainted alike will enjoy Goldfarb's stories of real life characters working to sustain watersheds with and alongside beaver.

But, what if as a Wetland Scientist you're not as I suggest, a binary acquainted or unacquainted reader of Goldfarb's *Eager*? What if you're an overly-acquainted expert who manages watersheds, including using beaver and their dams on a weekly or daily basis? Well, then you may find *Eager* to be more of a VH-1 *Behind the Music* style exposé on the who, what, where, and when of the current U.S. watershed restoration paradigm. The experts and professionals who appear in Goldfarb's book will certainly enjoy the stories of their colleagues.

As Ed Sullivan might introduce *Eager,* and the sustainability paradigm it shines light on before the first chord (beaver dam analog?) rings out, "It's the new craze in rodent restoration that's improving watersheds across our nation, ladies and gentlemen…I want to welcome beaver relocation, conflict mitigation, and dam emulation!" Ideally the beaver-based vision for sustainable watersheds, wetlands, and streams that Goldfarb prosaically narrates will continue to be as well received by land and water managers now and in the future as the Beatles were back in 1964. ■

## About *Wetland Science & Practice*

*Wetland Science and Practice* (WSP) is the SWS quarterly publication aimed at providing information on select SWS activities (technical committee summaries, chapter workshop overview/abstracts, and SWS-funded student activities), brief summary articles on ongoing or recently completed wetland research, restoration, or management projects or on the general ecology and natural history of wetlands, and highlights of current events. *WSP* also includes sections listing new publications and research at various institutions, and links to major wetland research facilities, federal agencies, wetland restoration/monitoring sites and wetland mapping sites. The publication also serves as an outlet for commentaries, perspectives and opinions on important developments in wetland science, theory, management and policy.

Both invited and unsolicited manuscripts are reviewed by the *WSP* editor for suitability for publication. Student papers are welcomed. Please see publication guidelines at the end of this issue.

Electronic access to Wetland Science and Practice is included in your SWS membership. All issues published, except the the current issue, are available via the internet to the general public. At the San Juan meeting, the SWS Board of Directors voted to approve release of past issues of WSP when a new issue is available to SWS members only. This means that a WSP issue will be available to the public four months after it has been read by SWS members (e.g., the June 2017 issue will be an open access issue in September 2017). Such availability will hopefully stimulate more interest in contributing to the journal. And, we are excited about this opportunity to promote the good work done by our members.

### HOW YOU CAN HELP

If you read something you like in WSP, or that you think someone else would find interesting, be sure to share. Share links to your Facebook, Twitter, Instagram and LinkedIn accounts.

Make sure that all your SWS colleagues are checking out our recent issues, and help spread the word about SWS to non-members!

Questions? Contact editor Ralph Tiner, PWS Emeritus (ralphtiner83@gmail.com). ■

## WSP Manuscript – General Guidelines

### LENGTH:

Approximately 5,000 words; can be longer if necessary.

### STYLE:

See existing articles from 2014 to more recent years available online at:
http://www.sws.org/category/wetland-science-practice.html

### TEXT:

Word document, 12 font, Times New Roman, single-spaced; keep tables and figures separate, although captions can be included in text. For reference citations in text use this format: (Smith 2016; Jones and Whithead 2014; Peterson et al. 2010).

### FIGURES:

Please include color images and photos of subject wetland(s) as WSP is a full-color e-publication.
*Image size should be less than 1MB* – 500KB may work best for this e-publication.

### REFERENCE CITATION EXAMPLES:

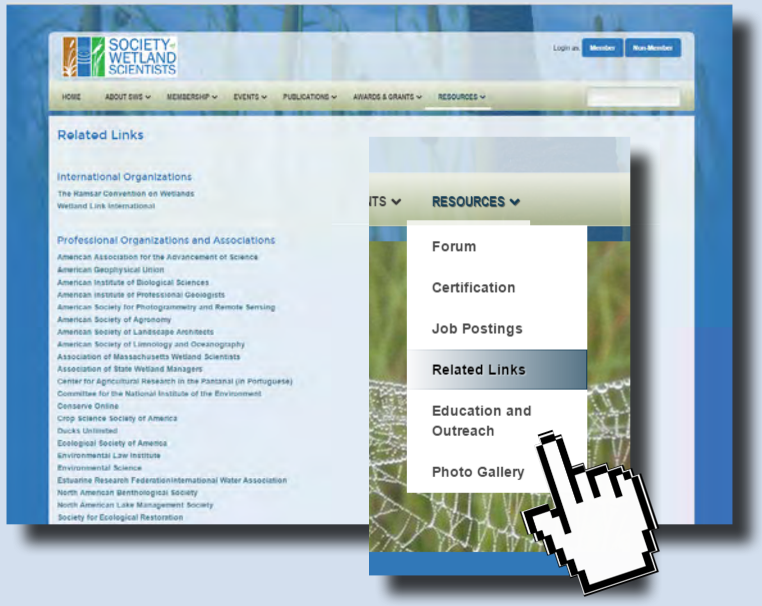
- Claus, S., S. Imgraben, K. Brennan, A. Carthey, B. Daly, R. Blakey, E. Turak, and N. Saintilan. 2011. Assessing the extent and condition of wetlands in NSW: Supporting report A – Conceptual framework, Monitoring, evaluation and reporting program, Technical report series, Office of Environment and Heritage, Sydney, Australia. OEH 2011/0727.
- Clements, F.E. 1916. *Plant Succession: An Analysis of the Development of Vegetation*. Carnegie Institution of Washington. Washington D.C. Publication 242.
- Clewell, A.F., C. Raymond, C.L. Coultas, W.M. Dennis, and J.P. Kelly. 2009. Spatially narrow wet prairies. *Castanea* 74: 146-159.
- Colburn, E.A. 2004. *Vernal Pools: Natural History and Conservation*. McDonald & Woodward Publishing Company, Blacksburg, VA.
- Cole, C.A. and R.P. Brooks. 2000. Patterns of wetland hydrology in the Ridge and Valley Province, Pennsylvania, USA. *Wetlands* 20: 438-447.
- Cook, E.R., R. Seager, M.A. Cane, and D.W. Stahle. 2007. North American drought: reconstructions, causes, and consequences. *Earth-Science Reviews* 81: 93-134.
- Cooper, D.J. and D.M. Merritt. 2012. Assessing the water needs of riparian and wetland vegetation in the western United States. U.S.D.A., Forest Service, Rocky Mountain Research Station, Ft. Collins, CO. Gen. Tech. Rep. RMRS-GTR-282.

WEB TIP

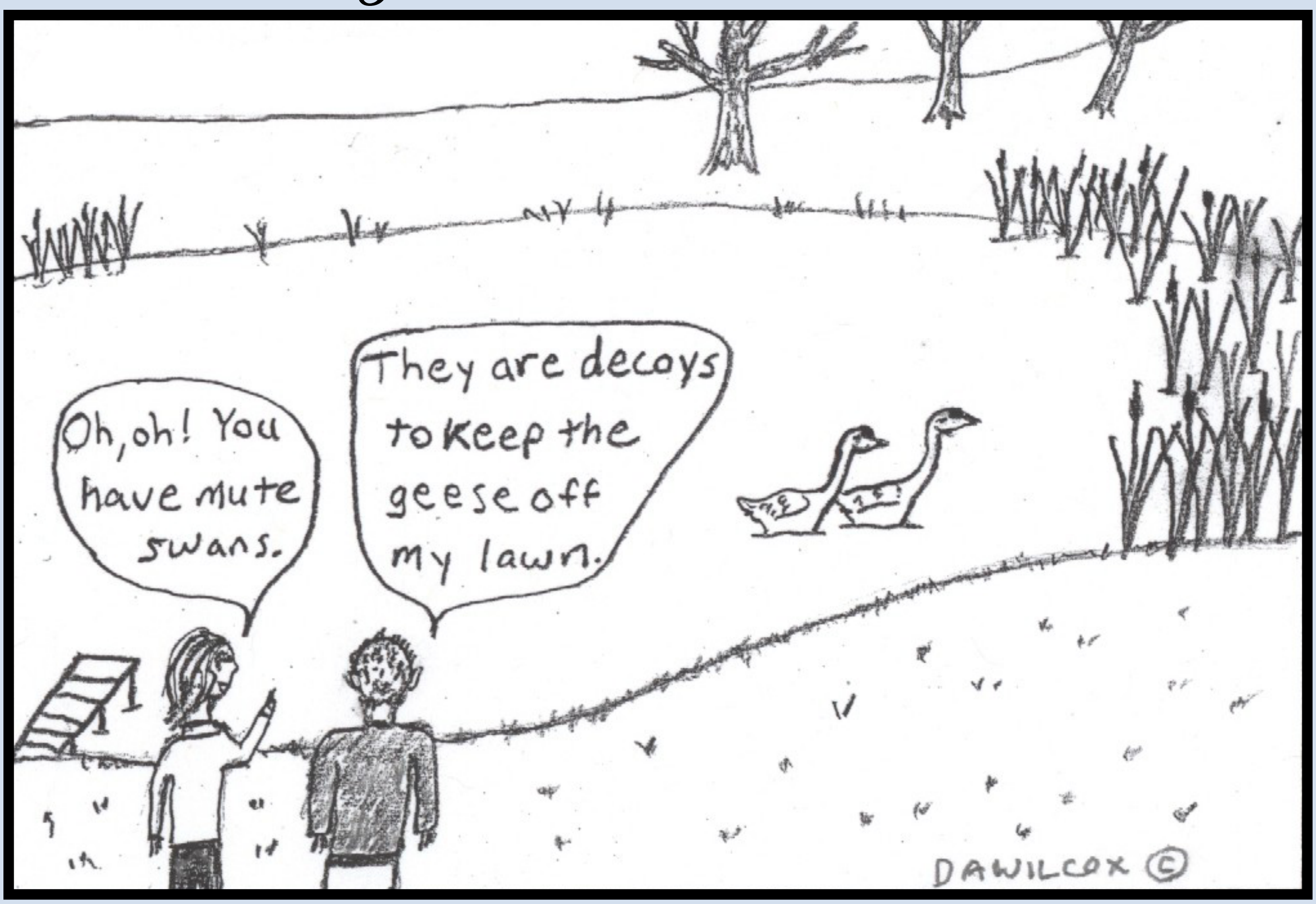
# Resources at your fingertips!

For your convenience, SWS has compiled a hefty list of wetland science websites, books, newsletters, government agencies, research centers and more, and saved them to sws.org.

Find them on the Related Links page sws.org.




## *From the Bog*




**by Doug Wilcox**

wetland science & practice

WSP is the formal voice of the Society of Wetland Scientists. It is a quarterly publication focusing on the news of the SWS and providing important announcements for members and opportunities for wetland scientists, managers, and graduate students to publish brief summaries of their works and conservation initiatives. Topics for articles may include descriptions of threatened wetlands around the globe or the establishment of wetland conservation areas, and summary findings from research or restoration projects. All manuscripts should follow guidelines for authors listed above. All papers published in WSP will be reviewed by the editor for suitability and may be subject to peer review as necessary. Most articles will be published within 3 months of receipt. Letters to the editor are also encouraged, but must be relevant to broad wetland-related topics. All material should be sent electronically to the current editor of WSP. Complaints about SWS policy or personnel should be sent directly to the elected officers of SWS and will not be considered for publication in WSP. ■