wetland science & practice

published by the Society of Wetland Scientists

Vol. 36, No. 1 January 2019

FROM THE EDITOR'S DESK

Season's greetings to all! Now that the festivities of the holidays are behind us, we have to come back to our everyday schedule and do what we can to continue to support wetland conservation. On December 11, the U.S. Army Corps of Engineers and U.S. EPA proposed changes in the definition of "waters of the United States" which will, if implemented, undo some of the gains we've experienced in wetland conservation over the past few decades. Our Society has joined with other conservation organizations in opposing those changes (see notice in this issue). Lawsuits will be coming and will delay implementation of the proposed changes, so we'll see how this all shakes out. The State of Michigan is also proposing changes in its wetland regulations that will reduce protection (see http://www.michiganradio.org/post/bill-would-roll-back-wetlands-protections). An influential component of American society still doesn't fully appreciate the functions and values wetlands offer to society, or perhaps they are simply interested in making money today with little or no concern about lost values for future generations. This is a sad commentary on our society given constant gains in wetland conservation with each decade since the 1950s. Meanwhile we'll do what we can to press forward with our conservation efforts.

Ralph Tiner
WSP Editor

As we start the new year, we mourn the passing of one of our wetland pioneers, Dr. Rebecca Sharitz (see her obituary by Loretta Battaglia).

From 2019 onward, you'll find that our quarterly issues will be published in January, April, July, and October. The July issue will be dedicated to publishing abstracts from our annual conference which this year will be held in Baltimore, Maryland (registration is open!). For the January issue, I received contributions on a wide range of topics: role of science in U.S. wetland policy (Richard Smardon), South African wetlands (Fred Ellery), U.S. desert wetlands (Paul DuBowry), wetland conservation in Lake County, Illinois, USA (Juli Crane, Glenn Westman, and Michael Prusila), teaching redox (Doug Wilcox), a SWS fellowship research report on possible climate change impacts on bulrushes and common reed (Tatiana Lobato de Magalhães), and a commentary on wetland regulatory issues in Pennsylvania (Jim Schmid). I'm hoping that submissions on diverse topics will continue to flow to my desk. Thanks to all contributors including the chapter officers who provided updates on their activities and to Doug Wilcox for his cartoon – *From the Bog*.

I am looking forward to more positive news in 2019 across the board. Happy Swamping. ■

CONTENTS

Vol. 36, No. 1 January 2019

COVER PHOTO:

Streamside wetland and riparian forest, Capitol Reef National Park, Utah (Ralph Tiner photo)

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 ADDRESS

I am writing my president's update from the Panhandle of Florida as my field crew and I assess swamp forest damage from Hurricane Michael, which made landfall on October 10, 2018 near Mexico Beach, Florida. Local residents told us that they have never seen so much flooding around Newport, Florida. We notice the frost on the truck windshield as we travel to the cold swamps to venture out in our insulated waders to measure downed trees and branches.

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

This week in SWS news, the Board has approved the 2019 budget. Thank you to the Board, Executive Board, and especially our treasurer, Lori Sutter, and our staff, Michelle Czosek, Jennifer Brydges and Kim Striebel, in their diligence for getting the budget prepared.

SWS launched the first Twitter Symposium, entitled "Wetlands in a Changing World" (www.sws.org/images/pdfs/SWSTwitter-Symp2018_Schedule_171018.pdf). Many thanks to Nigel Taylor, Anna Puchhoff, Kristin McGuine and Rachel Hager for organizing and promoting the symposium, which was a great success. I look forward to more of these in the future.

The Webinar Committee has organized recent webinars including: Wetlands of the coast of Lima, Peru (November 2018), The Ramsar Convention and the Society of Wetland Scientists (October 2018), Practical advice for management and continuous improvement in wetland restoration (September 2018), and, Examining interactions among vegetation and water quality in conservation wetlands of the Mississippi Alluvial Valley (August 2018).

As a Ramsar Observer Organization, SWS sponsored a very successful Ramsar Side Event with about 30 national delegates and observers in attendance at the Ramsar COP13 in Dubai, UAE. Nick Davidson, Royal Gardner, Leanne Wilkinson and myself gave presentations at the event entitled: "Climate management, adaptation and key legal issue for Ramsar wetlands." Our individual presentations included an introduction (Davidson), role of wetlands in climate change (Middleton), importance of coastal wetlands in blue carbon (Wilkerson) and key legal issues in COP13 resolutions on climate change (Gardner). For more details, see Side Event #23: (www.ramsar.org/sites/default/files/documents/library/cop13_side_events_schedule_e.pdf).

In our efforts to internationalize, Lori Sutter attended the 2018 International Wetland Convention in Taiwan. Past-

President's Address, continued on page 13

wetland science & practice

SWS Joins Other Aquatic Science Societies in Opposing the WOTUS Rule to Replace the 2015 Clean Water Rule

On December 11, 2018, the EPA and US Army Corps of Engineers proposed a new definition of "waters of the United States" (WOTUS), which will greatly reduce the area of wetlands, headwaters, ephemeral and isolated wetlands and waters that are federally regulated (https://www.epa.gov/newsreleases/epa-and-army-propose-new-waters-united-states-definition). SWS members who wish to comment on this action have 60 days to submit comments. Agencies are providing information about the change at https://EPA.gov/wotus-rule. In a recent EPA briefing, officials outlined significant reductions in protection for many types of tributaries, lakes, ponds, and adjacent wetlands, and elimination of protection of ephemeral features. The new WOTUS Rule is based on Justice Scalia's definition of Waters of the United States, as well as past Supreme Court decisions such as Rapanos and SWANCC. Although stating that the three main goals included following the Clean Water Act and Supreme Court decisions, absent from the discussion was any explanation for how the new Rule would meet the objective of the Clean Water Act (33 USC 1251 Title I, Sec. 101(a)): "The objective of this Act is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters." However, officials stated that the two other primary goals are to make a clear distinction between what is regulated at the federal level and what is regulated at the state level, and to simplify the regulations so that property owners can determine for themselves whether their property is regulated or not.

Links to articles on the proposed Rule are https://www.eenews.net/stories/1060108967 , https://www.nytimes.com/2018/12/06/climate/trump-water-pollution-wotus-replacement.html, and https://www.sfchronicle.com/nation/article/Trump-administration-rolls-back-rules-on-stream-13456011.php.

Follow this link: https://www.sws.org/Blog/Magazine.html to read the press release that was issued by SWS and sister CASS societies. ■

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 monthly 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.

SWS webinars are free for members. Additionally, every quarter, one of our monthly webinars is open to the public. These free quarterly webinars are offered in March, June, September and December.

If you're unable to participate in the live webinar, all webinars are recorded and archived for complimentary viewing by SWS members.

The SWS Webinar Committee is excited to announce that our past webinars are available on YouTube. Non-members may access webinars that are three months or older on the SWS YouTube channel. As always, SWS members enjoy complimentary access to live webinars, and exclusive access to the all the previously recorded webinars.

Webinars are also viewable with subtitles on YouTube, allowing SWS supporters around the world to watch the webinars with subtitles in their native language.

SWS Members are able to access to our Webinar Participation Certificates at no cost, as well. The certificates are recognized for one hour of education toward a PWS (Professional Wetland Scientist) certification and other continuing education programs. All our webinars presented since January 2018 hold the distinction of being pre-approved by the SWS Professional Certification Program. Non-members are now able to purchase Participation Certificates at the SWS Store (https://netforum.avectra.com/eweb/shopping/shopping.aspx?site=sws&webcode=shopping&prd_key=6a34c680-24bc-406a-a8e1-54a2f53726a0) for $20. Visit the SWS Store online for information. ■

Carbon Drawdown Potential of Australian Wetlands - National Workshop

Contributed by Phil Papas, Vice President, SWS Oceania Chapter

Carbon sequestration through natural means offers hope for significantly reducing the carbon CO2e (carbon dioxide equivalent) burden on the planet. Potential drawdown of CO2e is a positive story to tell amidst the alarming scientific findings about climate change and still rising emissions. Wetlands are a missing gap in evaluating broad-scale opportunities for carbon drawdown in Australia. The role of wetlands in carbon sequestration and storage has generally been under-estimated while land-based solutions have been examined more thoroughly by Garnaut, Wentworth Group, CSIRO, Climate Works and Beyond Zero Emissions. Wetland pathways offer 14% of carbon mitigation opportunities needed to hold warming to <2 °C, and 19% of low-cost carbon mitigation. Compiling known and "best-guess" information about carbon stocks, sequestration and emissions by wetlands in Australia is urgently needed.

To address this need, the SWS Oceania together with Australian agency partners sponsored and coordinated a workshop to bring together a group of 35 participants that included leading Australian wetland greenhouse gas exchange scientists, wetland ecologists, policy experts, spatial data experts and a carbon drawdown network. The workshop had the following aims:

- synthesize current wetland greenhouse gas science (e.g. carbon, nitrous oxides) and knowledge needs;
- expand and enhance networks and create momentum for decisive action on carbon sequestration in wetlands;
- review carbon flux in Australian wetlands and carbon sequestration capacity.

Thirty-five participants presented their work over two days along with information on the policy and program context of wetland carbon at regional, state, national and international scales. Structured exercises either side of presentations elicited information on carbon stocks, flows and future scenarios, and workshop outputs. Publications are in development that will synthesize knowledge elicited in the workshop and more broadly to publish what is presently known on Australian carbon stocks, flux and to also highlight priority knowledge gaps. See this short video for further information on the event: https://www.youtube.com/watch?v=hGHWASEp9Zk&feature=youtu.be. ■

Share Your Work!

SWS members are doing some incredible work! We offer various opportunities for member wetland scientists to share their projects with the world. ■

New Media Initiative - Sharing Ideas Through Videos

Submit your wetland videos to be featured on the SWS YouTube channel (https://www.youtube.com/channel/UCLtuVCqUbRGJ91kwlv6WfAQ?view_as=subscriber)! The SWS New Media Initiative has posted its first submissions. If you wish to participate, go to the New Media Initiative web page (https://sws.org/About-SWS/new-media-initiative.html) to complete the necessary paperwork and submit your videos.

Recently approved videos:

- Interreg's Green Danube Project https://www.youtube.com/watch?v=1-BPUYMGUuU&list=PL8NOIq5cy6-f71s-mAnMB2EHi_v5wZLeCF&index=2
- Freeing a Trapped River: Pocomoke Restoration https://www.youtube.com/watch?v=PMBYlUzjlho

Instagram Takeovers

Please contact Kristin McGuine (mailto:kmcguine@sws.org) for information about how to participate through the SWS Instagram page (https://www.instagram.com/societywetlandscientists/).

Chapter Update Reports

EUROPE CHAPTER

by Dr. Matthew Simpson

This year the Europe Chapter held a very successful 13th meeting in the beautiful and historic city of Ohrid, Macedonia with representatives from 18 countries. The theme of the meeting was “Management of Wetland Ecosystem Services: Issues, Challenges and Solutions”, a topic closely tied to SWS support for local Macedonian groups trying to protect Studenchishte Marsh - the last remaining intact wetland on the Macedonian shoreline of Lake Ohrid (one of the oldest ([~2 mya] and ecologically special lakes in Europe). The meeting was held in there to show our continued support for the protection of Studenchishte Marsh, provide additional information about wetlands in general and the current state of Studenchishte Marsh in particular, and to meet and engage with local and national Macedonian politicians. The second day of talks began with an official session at which local (Jovan Stojanoski, Mayor of Ohrid; Trajce Talevski, Hydrobiological Institute in Ohrid and OhridSOS) and national (Aleksandar Nastov, Macedonian Ministry of the Environment) politicians, and scientists spoke about the need to protect the wetlands given the likely aspect of increased tourism in the area. Mr. Nastov mentioned that the national Macedonian government will now push for nominating Studenchishte Marsh as a Ramsar site within this year. The session was led by Jos Verhoeven, Past-President Europe Chapter, who also read a letter from the Ramsar Secretariat in support of designating Studenchishte Marsh as a wetland of international importance. A field trip day allowed participants to visit Studenchishte Marsh where Dr. Slavco Hristovski led a tour of this important wetland area.

The Europe chapter are continuing to promote the Professional Wetland Scientist certification programme to wetland professionals in Europe with now two members qualified as PWS and we are busy planning for our 14th conference to be jointly held with WETPOL in Aarhus, Denmark on June 17-21, 2019. We have continued our cooperation with the Constructed Wetland Association with presentations at each other’s conference and we are pleased that our cooperation with WETPOL has resulted in a joint conference. We also continue to support the Bangor University WetSoc student society and hope to encourage more student associations across Europe in the coming year. ■

ALASKA CHAPTER

by Emily Creely

The Alaska Chapter elected two new officers (Josh Grabel – Vice President; Zach Baer – Treasurer) and elevated one to President (Emily Creely, former chapter Treasurer). Chapter meetings were held throughout the year with presentations covering a variety of wetland related topics, especially focusing on the status of wetland assessment, conservation, and restoration in Alaska. In April, we hosted a presentation by the Greatland Trust’s David Mitchell, who provided information about and their current projects and mitigation program. In May, member Anjanette Steer provided an update on the progress of the Alaska Geospatial Wetlands Technical Working Group and member Jeff Mason provided an update on the wetland functional assessment method he is developing for Interior Alaska. In September, a large discussion on hosting the 2021 meeting was held and ideas were shared regarding a theme, recruiting partners, and identifying key committees that would need to form.   For 2019 the Alaska Chapter plans to continue presentations covering the many aspects of wetland science, new guidelines from the Corps, and networking with other related professional organizations. Finally, we are working to have the Anchorage chapter host the 2021 meeting, with assistance from the Pacific Northwest Chapter. ■

ROCKY MOUNTAIN CHAPTER

by Heather Houston

The Rocky Mountain Chapter was pleased to host the Society of Wetland Scientists Annual Meeting in Denver on May 29 – June 1, 2018. Most of our efforts during the past year were directed towards planning and organization of this meeting, with the dedicated help of the AMPED staff. We are hopeful that the meeting will be a way for us to increase membership and interest in our chapter. We had a booth for our chapter near the registration desk for the conference, and used this as a way to interact with potential new members, and to encourage existing members to become more involved. It was a great experience and we were very pleased with how the conference turned out.

Our next big event will be to host the Rocky Mountain Chapter’s Annual Meeting in Golden, Colorado on April 10, 2019. This year, we are partnering with the Colorado Riparian Association (CRA) to co-host this event. We are excited about the opportunity to partner with CRA, since there is a large overlap with our interests and some of our members are involved in both organizations. Our hope is that cross-promoting the event will draw in some new members to both organizations.

We are also working to organize a training workshop for our members to be held in late summer or early fall 2019. We are working with the Colorado Natural Heritage Program (CNHP) to organize a course on the Ecological Integrity Assessment (EIA) Method for evaluating wetland functions. The course will be taught by Joanna Lemly from CNHP, and will include both a classroom and field component. We are planning for a two-day course. We think this will be a great opportunity to create added value for our members. Other courses we are planning for the future include a field workshop on wetland soils, and a seminar on water rights in Colorado.

Two of our members, Liz Carner and Chris Prah, organized and hosted a wetland delineation workshop in partnership with the Boulder Chapter of the Colorado Native Plant Society in the fall of 2017. The course filled up quickly and the participants saw a lot of value in this hands-on activity. We would like to promote more of these events and use them as a way to draw in new members, increase knowledge and understanding of wetlands, and provide networking opportunities.

We are working to increase participation from all the states in our chapter. One idea we are exploring is designating a state representative from each of the five states that comprise the Rocky Mountain Chapter to increase participation. In addition, we are working to establish formal committees to make it easier to involve more of our members in helping to organize chapter events and communications. During our member meeting in May 2018, there was a lot of interest in establishing these committees. This will be an important part of our discussion at the Annual Meeting in April 2019.

Our chapter finances have allowed us to continue to sponsor travel grants to our annual meeting, as well as contributing to the SWAMMP program. We have been increasing our contributions to these programs over the past several years.

We are also working to promote our chapter at other events and conferences. We recently had a booth at the Sustaining Colorado Watersheds Conference in Avon, Colorado. SWS provided us with brochures and other promotional materials that were distributed at the conference. We are planning to develop additional materials to advertise our chapter activities and the benefits of membership. We do not currently have social media accounts, but have a goal of establishing Facebook and Instagram accounts in 2019. We will be holding elections for Chapter President, Vice President, and Treasurer this spring. ■

CENTRAL CHAPTER

by Katie Astroth

In early 2018, the SWS Central Chapter attended the Missouri Natural Resources Conference (MNRC) in Osage Beach, Missouri. The MNRC is an annual meeting organized and sponsored by the Missouri Chapter of the American Fisheries Society, The Missouri Chapter of the Society of American Foresters, Missouri Chapter of the Wildlife Society and the Show-Me Chapter of the Soil and Water Conservation Society. In May, Central Chapter's Vice President, Katie Astroth, attended the SWS Annual Meeting in Denver, Colorado. In November, the SWS Central Chapter hosted their annual meeting, along with a 1.5-day Stream Investigation, Stabilization, & Design Workshop at the Baker Wetlands Discovery Center in Lawrence, Kansas. During the workshop, led by potomologist, Dave Derrick, attendees learned about innovative bank protection methods and designing long-term sustainable stream stabilization and restoration projects. In addition to stream stabilization methodologies, innovative, environmentally sensitive, and cost-effective approaches to restoration were discussed. After the workshop, the SWS Central Chapter held its annual business meeting, during which, Chapter plans and objectives were discussed. In addition to hosting and attending meetings, the Central Chapter is working towards nominating one of Missouri's unique wetland complexes, the Lower Grand River Basin, as a Wetland of Distinction. With the start of the new year, the Central Chapter looks forward to planning their 2019 annual meeting. ■

SOUTH CENTRAL CHAPTER

by Dr. Jessica Brumley

The South Central Chapter (SCC) had a very active year of engaging its members and public in various opportunities. At the annual SWS meeting in Denver, the SCC hosted a symposium on "Working in Wetlands," bringing speakers from academia, industry, and government and talks in developing an online presence and how to navigate the job market.

The SCC annual chapter meeting was held in North Little Rock, Arkansas at the North Little Rock Chamber of Commerce October 10-12. The three-day meeting included a workshop "Developing a Wetland Management Plan for the White Oak Bayou Watershed" and a field trip to the White Oak Bayou. Five students and five professionals presented research and industry information/updates. Whitney Kroshel (1st place) and Hayden Hays (2nd place) both received student awards for presentations/research. The awards will provide scholarships for the students to attend the 2019 SWS Annual meeting in Baltimore, MD. Sponsors for our meeting included Cattails Environmental LLC, EcoNatural, GBMc & Associates, Lyrata Consulting LLC, Wetland Consultants Inc., and, and Whitenton Group.

Board member Amber Robinson arranged a swamp tour of the Henderson Swamp in Henderson, LA on May 12th. This included a boat tour, t-shirts, and jambalaya for members and nonmembers. Sponsors for this event included Delta Land Services, HDR, J.M. Burguières Co. LTD, and Whitenton Group Environmental Consulting.

Board member Jodie Murray Burns hosted a Northwest Arkansas birding tour at the Centerton Fish Hatchery on April 28th. The tour was guided by renowned ornithologist Joe Neal during peak spring migration. Our corporate sponsors for this event were Cattails Environmental LLC and Garver LLC.

The SCC continues to provide financial support to the SWS Multicultural Mentoring Program (SWaMMP) to support undergraduate students from underrepresented groups. Read more about SWaMMP at https://sws.org/Awards-and-Grants/sws-undergraduate-mentoring-program-swammp.html.

In the coming year, we anticipate another bird tour and swamp tour, adding a plant identification course and chairing another symposium on "Working in Wetlands" the SWS annual meeting in Baltimore. Meanwhile follow us on Twitter and Facebook at @swsscc. ■

SOUTH ATLANTIC CHAPTER

by Dr. Douglas Berry

The SAC started 2018 with a strong membership total of 647 – the largest chapter in the greater SWS organization (17% overall and 29% of U.S. membership). Heading into the Denver Annual Meeting, membership was still strong at 603 and, with anticipated renewals and new memberships, is expected to meet or exceed the year-opening numbers by the end of December. In 2018, the SAC continued to support our students with $4500 in contributed funds for student research (2 awards at $750 each), travel to the Annual Meeting (3 awards at $500 each), and the SWaMMP program ($1500 award). Student award recipients are listed below:

- SAC Student Research Grants - Hayden Hays (SHSU) and Elena Solohin (Indiana U)
- SAC Student Travel Awards - Jessica Dell (FAU), Steffanie Munguia (Middlebury), and Havalend Steinmuller (UCF)
- SWaMMP Award Recipient - Tasnim Mellouli (UCF)

The SAC breakout meeting at the 2018 Annual Meeting in Denver was well-attended, and members voted on changes to the SAC Bylaws and Standing Rules that clarified leadership roles and responsibilities, balloting procedures, expenses, standing committees, and use of social media outlets and email in chapter communications. Student representative David Riera (FIU) announced the establishment of a new Student Section for SWS, for which he is serving as Chair. In open discussion, there was continued dialogue on the potential for topical workshops for SAC members – comments and general level of interest from the SAC membership are welcome.

SAC members are encouraged to nominate exemplary wetland sites for the Wetlands of Distinction (WoD) program. Given the legacy of understanding that our region's wetlands have contributed to the compendium of wetland knowledge and human experience – scientific, cultural, aesthetic, or otherwise – the lack of WoD nominations in the South Atlantic Region is conspicuous. Please consider filling out an application for a wetland in our region – let's get some WoD pins on the map for the SAC! For more information, see the WoD website (https://www.wetlandsofdistinction.org/), or contact SAC Vice-Chair and WoD representative Brian Benscoter (bbenscot@fau.edu). ■

MID-ATLANTIC CHAPTER

by Emily Dolbin

The SWS Mid-Atlantic Chapter is busy preparing to host the SWS 2019 Annual Meeting in Baltimore, Maryland from May 28-31st. Abstract submissions are open through mid-January, so please submit and bring your ideas/research/projects to share in Baltimore.

Our theme this year is "The Role of Wetlands in Meeting Global Environmental Challenges: Linking Wetland Science, Policy, and Society." We aim to provide a space for scientists, policy makers, and practitioners to share their knowledge and gather ideas for the future of wetlands in an ever-evolving political climate. We'd like to highlight how science can inform design, how design can inform science, and how to relay this information to regulators and policy makers to continue to protect wetlands in the Chesapeake Bay, across the US, and around the world. Our unique conference is a wonderful forum for collaboration from all sides of the world of wetlands.

We have some outstanding field trips planned all around the Chesapeake Bay region. We also have some amazing plenary speakers, symposia, and workshops that will highlight coordination between different wetland sectors, and provide opportunities to collaborate. Networking events will be hosted throughout the week, and the conference itself is just blocks from Baltimore's inner harbor. Come visit the National Aquarium, our Maryland Science Center, or visit one of our local breweries or distilleries while you are visiting the Chesapeake Bay. We hope to see you in Baltimore!! ■

EUROPE

The SWS-Europe chapter will hold its 2019 annual meeting with WETPOL from June 17-21, 2019 in Aarhus, Denmark. SWS-Europe will be having a special symposium "Wetlands and ecosystem services: water quality improvement, climate regulation and flood control." For more information about the meeting and registration, please go to the meeting website at http://wetpol.com/. ■

2019 SWS Annual Meeting - Register Today!

Themed *The Role of Wetlands in Meeting Global Environmental Challenges: Linking Science, Policy, and Society*, the SWS 2019 Annual Meeting will be held May 28-31 in Baltimore, Maryland (USA). Be sure to visit the meeting website at swsannualmeeting.org, and join us on Facebook at https://www.facebook.com/events/2132311983690685/. ■

REGISTRATION

Are you excited to reserve your spot for the 2019 Annual Meeting? Registration is open. Please visit the registration web page (https://www.swsannualmeeting.org/register/) for more information.

ABSTRACT SUBMISSION

The abstract submission deadline is Monday, January 14, 2019. For more information about the submission process, please visit the abstract submission web page (https://www.swsannualmeeting.org/abstracts/).

SUPPORT THE SWS ANNUAL MEETING

See information about sponsorship, exhibiting, advertising and donating to the silent auction on the following pages. Thank you for investing in the future of wetland science!

RIDESHARE AND ROOMMATE MATCH

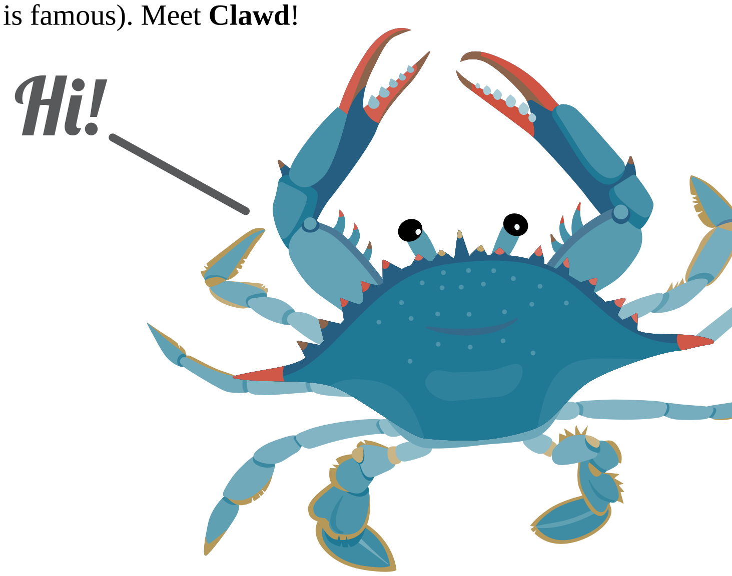
Are you looking to share transportation and/or lodging costs with fellow wetland scientists at the SWS 2019 Annual Meeting? Connect with your peers here (https://www.facebook.com/events/304844836939822/) to coordinate the details of your trip on Facebook!

FIELD TRIPS

The SWS 2019 Annual Meeting will offer unique opportunities for field trip enthusiasts! All field trips will be guided, include transportation, park fees and meals/snacks. Registration for field trips is limited. For more information: https://www.swsannualmeeting.org/field-trips/

MEET THE 2019 MASCOT!

Thank you to everyone who suggested names for our new little blue crab friend (for which the meeting host city, Baltimore, Maryland, as well as the entire Chesapeake Bay area, is famous). Meet **Clawd**!



Grad Students - Apply to the Wetland Ambassadors Fellowship

The Society of Wetland Scientists (SWS) is pleased to announce the availability of one Wetland Ambassadors Graduate Research Fellowship for the Summer of 2019. The fellowship will provide the opportunity for a graduate student to travel to another country and conduct groundbreaking wetland research with some of the world's top wetland research scientists. A grant of up to $5,000 will be awarded by SWS, while hosting institutions may provide for lab costs, meal plans, or room and board during the internship. Any funds or in-kind services that can be provided by the student's sending institution is appreciated. The application deadline is Friday, January 25, 2019. Learn more on the Wetland Ambassadors page (https://www.sws.org/Awards-and-Grants/wetland-ambassadors-graduate-research-fellowship.html) online. ■

Planning Underway for 2020

Planning is underway for the joint Québec RE3 Conference, *From Reclaiming to Restoring and Rewilding*. SWS is excited to join the Canadian Land Reclamation Association (CLRA) and the Society for Ecological Restoration (SER) in Quebec from June 7-11, 2020. Check out the website, and follow the event on Twitter and Facebook. **#QuebecRE3** ■

Sponsorship Opportunities

A variety of sponsorship levels are available on a first-come, first-selected basis and are sure to provide international exposure among leaders in wetland science. Not sure which sponsorship opportunity to choose? Construct your own sponsorship package to fit your unique needs and goals.

CONTRIBUTING LEVEL — $500

Help make the SWS 2019 Annual Meeting a success by making a general contribution.

BRONZE LEVEL — $1,000

- **DAILY PLENARY SPEAKER.** The 2019 Annual Meeting will feature three renowned plenary speakers who will share research findings and new perspectives. Three opportunities available.
- **DAILY MORNING & AFTERNOON REFRESHMENTS.** Attendees will enjoy light snacks and beverages during daily morning and afternoon refreshments. Six opportunities available.

SILVER LEVEL — $2,500

- **POSTER SESSION & SILENT AUCTION.** The 2019 Poster Session Reception will showcase the latest wetland research and provide an opportunity to meet with experts to learn about their scientific studies. The Mid-Atlantic Chapter will also be hosting a silent auction to help fund Chapter activities.
- **STUDENT MIXER.** A great opportunity for student attendees to mingle, exchange ideas and learn about opportunities for involvement in SWS.
- **ATTENDEE PEN.** **SOLD** Attendees will receive a meeting-themed pen in their attendee bag which will feature the sponsor's logo.

GOLD LEVEL — $5,000

- **HOTEL ROOM KEY.** All guests will receive a custom hotel key card as they check in under the SWS hotel block which will feature the sponsor's logo.
- **ATTENDEE BAG.** Meeting-branded attendee bags will be distributed to all participants containing important meeting materials. The sponsor's logo will be featured on each bag.
- **LANYARDS.** Meeting-themed lanyards will be distributed to each attendee at registration which will feature the sponsor's logo.
- **WATER BOTTLE.** Attendees will receive a meeting-themed water bottle in their attendee bag which will feature the sponsor's logo.

PLATINUM LEVEL — $7,500

- **WELCOME RECEPTION.** The 2019 Annual Meeting will kick off with a special Welcome Reception providing attendees the chance to network with friends, old and new, over hors d'oeuvres and cocktails.
- **MOBILE APP.** Attendees will be able to access the daily programming, general meeting information and connect with fellow attendees via their smart phones and the web. The sponsor's logo will be featured on the homepage of the app.
- **WIFI.** Internet access will be available at the meeting venue. The sponsor's logo will be featured on the landing page with the option to customize the WIFI network and password.

BENEFITS OF SPONSORSHIP	$500	$1,000	$2,500	$5,000	$7,500
Logo + hyperlink featured on meeting website	★	★	★	★	★
Logo featured on onsite sponsor signage	★	★	★	★	★
Special recognition during sponsored event		★	★		★
One marketing item dropped in attendee bag			★	★	★
One complimentary registration to the SWS Annual Meeting				★	
Two complimentary registrations to the SWS Annual Meeting					★
One complimentary exhibit booth at the SWS Annual Meeting					★

**Prices in U.S. dollars.*

To discuss sponsorship opportunities for your company, contact Amanda Safa, asafa@sws.org, 608-310-7855.

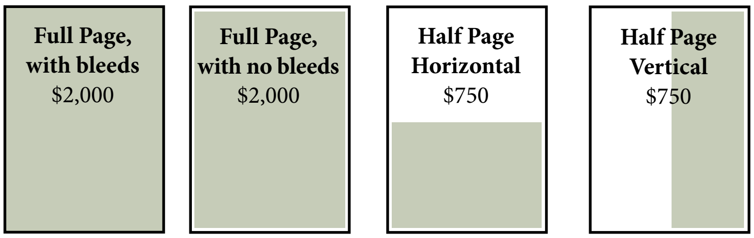
Conference Journal Advertising Opportunities

Increase your visibility at the SWS 2019 Annual Meeting by participating as an advertiser in the Conference Journal. Limited ad space available and insertion is on a first-come, first-served basis. Don't miss this special opportunity to showcase your brand to conference attendees.

SIZE OPTIONS (*prices in U.S. dollars)

Select	Size/Placement	Size	Rate
☐	Full Page (Inside Front or Back Cover), with bleeds	6.5"w x 11"h + .125" bleeds	$2,000
☐	Full Page (Inside Front or Back Cover), with no bleeds	6"w x 10.5"h	$2,000
☐	½-Page Horizontal *	6"w x 5.125"h	$750
☐	½-Page Vertical *	2.875"w x 10.5"h	$750

** Only eight ½-page ads will be sold.*



CONTACT AND BILLING INFO

Contact and billing information is the same:

Company name: ______________________________

Contact name: ______________________________

Street address: ______________________________

City/State/Postal code: ______________________________

Country ______________________________

Phone: (incl. country + city code) ______________________________

Email: ______________________________

Fill in this section for billing, if different from main contact:

Company name: ______________________________

Contact name: ______________________________

Street address: ______________________________

City/State/Postal code: ______________________________

Country ______________________________

Phone: (incl. country + city code) ______________________________

Email: ______________________________

☐ Advertisment attached/enclosed ☐ Advertisement arriving separately

IMPORTANT DATES

Advertising reservation deadline: March 29, 2019
Artwork submission deadline: April 5, 2019
Please send this reservation form, as well as print-ready art files, to asafa@sws.org.

SUBMISSION GUIDELINES

The advertising art file that you submit must follow these guidelines:

- .Pdf file type
- High-resolution, of at least 300 dpi
- CMYK color space
- Any bleeds need to be at least .125"

To discuss advertising opportunities for your company, contact Amanda Safa, asafa@sws.org, 608-310-7855.

In memoriam: Dr. Rebecca Reyburn Sharitz

by Loretta Battaglia

"Vat? A Voman?" (What? A Woman?)" This was the question and challenge posed by a certain senior professor of Germanic origin to a female field ecologist at the beginning of her career many years ago. When Becky met this man as a new graduate student, he suggested that she might be better off developing secretarial skills rather than adhering to her chosen curriculum of science courses. Fortunately, none of the young women to which he gave similar advice listened and instead formed a loose organization to support one another, named the "VAV" society. One of the inaugural members was Dr. Rebecca Sharitz.

Dr. Sharitz, known as "Becky" to her friends, students, and colleagues, began her career at Roanoke College (B.S. Botany, 1966) and followed up at the University of North Carolina (Ph.D. Ecology, 1970). Her first academic positions were at St. Andrews Presbyterian College and then Saginaw Valley College before arriving at the University of Georgia's Savannah River Ecology Laboratory in 1972, where she spent the remainder of her career.

Becky's career was an illustrious one. She became a world-renowned expert on southeastern US floodplains and isolated wetlands. She authored or co-authored more than 160 peer-reviewed papers or chapters, co-edited three books, and was the recipient of over 40 significant research grants. Most notably, her research was the first to demonstrate important linkages between hydrologic characteristics and wetland forest regeneration following thermal releases from nuclear reactors, alteration from dams, and tropical storm events.

She served as Vice President and Treasurer of the Ecological Society of America, Vice President and Secretary-General of the International Association for Ecology (INTECOL) and as a panel member on four National Academy of Science committees. She was awarded the Meritorious Teaching Award by the Association of Southeastern Biologists and the Friends of Congaree National Park, Order of the Cypress. She was elected as a Society of Wetland Scientists Fellow and received the prestigious National Wetlands Award in Science Research by the Environmental Law Institute. Of all her achievements, Becky was most proud of the graduate students, post-doctoral fellows and volunteers that she mentored and trained.

Photo of Becky Sharitz in the field.
Photo courtesy of Linda Lee.

Photo of Becky (center) playing a game during fieldtrip to Congaree Swamp National Park.
Photo courtesy of Priscilla Titus.

Becky Sharitz, Professor and Senior Research Ecologist at the University of Georgia's Savannah River Ecology Laboratory, passed away on October 20, 2018. She was a true pioneer in her field of wetland ecology; she helped to launch the careers of many and left behind an impressively long trail of accomplishments. ■

WHAT A WOMAN! INDEED!

"She made all the difference in my life. I will miss her forever."
—Loretta Battaglia

Excerpt from Adrienne Edwards' written account of a stormy night with Becky as they navigated their way out of the Congaree Swamp:
"Did you know that in some areas of shallow standing water, you can see the footprints of recent travellers floating up like ghosts? The bubbles of swamp gas carry up tiny bits of dust that create floating shadows on the water's surface."
—Adrienne Edwards, 1990

"I feel sure that Becky's footsteps are floating there still."
—Adrienne Edwards, 2018

Photo of Patricia Werner (left) and Becky Sharitz (right), two members of the "VAV" club, on a fieldtrip to the Northern Territory, Australia, 1981. The two often travelled together in the early days, including to the (then) Soviet Union, the UK, Ireland, Australia, and New Zealand. Scientific conferences were focus of these trips, but they also found time to climb Ayers Rock (Uluru) in Australia, land in an airplane on a NZ glacier and to fly faster than sound in a SST Concord. Photo courtesy of Pat Werner.

President's Address, continued from page 3

President Arnold van der Valk and Ian Bredin and others have been discussing an Africa initiative for a wetlands network and capacity development program.

Following this idea, Arnold van der Valk attended the National Wetlands Indaba (South African conference between or with native peoples) in Kimberley, South Africa, to discuss potential ways of linking or affiliating the South Africa Wetland Society with SWS. During the discussion of such a potential affiliation at the South African Wetland Society's annual business meeting, there was strong support for developing a formal link between the two societies. The SWS Executive Board will develop a protocol for a new category of membership, "affiliated society." Once this protocol has been developed and approved by the Board of Directors, it will be presented at the 2019 Indaba for approval by the South African Wetland Society. It is anticipated that many other national and regional wetland societies will also become affiliated with SWS in the future. Such affiliations with wetland societies around the world would do a great deal to internationalize SWS. More on this in a future president's address.

Preparations are underway for the SWS annual meeting in Baltimore, and symposia, field trips, talks and abstracts are taking shape. Please be sure to register for the meeting at www.swsannualmeeting.org. All the best for a great year in 2019. ■

HISTORIC PHOTOS REQUESTED FOR THE 40TH ANNIVERSARY OF SWS

As we near the 40th Anniversary year of SWS, we invite members to send us pictures of both historical and recent events. See some examples below, in this case from meetings of the Board of Directors and Executive Board.

A picture of the February 2003 meeting of the SWS Board of Directors that was held in Williamsburg, Virginia. President Frank Day arranged, led, and hosted the meeting. Those attending were (back row from left to right) Bulletin Editor Andy Cole, Charlie Newling, and Ann Neville, (front row left to right) Kell Weider, Barry Warner (President 2001-02), Paul DuBowy, A. McCullough, Webmaster Jay Lynch, Chad Roberts, Virginia Carter (President 2000-01), Frank Day (President 2002-03), Gordon Goldsborough, Mark Felton (President 2003-04), Rebecca Howard, Mike Miller, Beth Nixon, Heather Stout, Val Glooshenko, Ann Jennings, Glenn Guntgenspurgen (President 2010-11), Mary Kentula (President 2006-07).

Members of the SWS Executive Board visit Multnomah Falls in the snowy Columbia River Gorge east of Portland, Oregon, during a late afternoon break between the January 2007 Executive Board meeting and the beginning of the Board of Directors meeting the next day in Portland. Those in the picture are, from left to right: Leslie Felton (Treasurer), Mary Kentula (President), Barbara Bedford (Past President), Pat Megonigal (President Elect), Beth Middleton (Secretary General) and David Drupa (Burke and Associates, the SWS management company at the time).

The following pictures were taken during a special session at the 2004 SWS Annual Meeting in Seattle, Washington. The session was designed to review the history of the Society as part of the 25th Anniversary celebration at the meeting. Charlie Newling led the committee that put together the session. There was a special effort made to get as many of the past presidents as possible to attend. Those presidents in attendance are depicted in the following pictures.

SWS Presidents from left to right are: Walter Glooschenko (1983-84), Armando de la Cruz (1985-86), Curtis Richardson (1987-88), Jay Leitch (1989-90), Mark Brinson (1990-91).

SWS Presidents from left to right are: Ronnie Best (1991-92), Lee Ischinger (1993-94), Duncan Patten (1996-97), John Teal (1998-99)

SWS Presidents from left to right are: Janet Keough (1999-2000), Virginia Carter (2000-01), Barry Warner (2001-02), Frank Day (2002-03), Mark Felton (2003-04), Katherine Ewel (2004-05).

U.S. Clean Water Act Policy vs. Wetland Science - Nexus or Not?

Richard C. Smardon[1], SUNY Distinguished Service Professor Emeritus, SUNY College of Environment Science and Forestry, Syracuse, NY

INTRODUCTION

This is a historical overview of the role that wetland science has played in regard to wetland management policy in North America. The major focus will be U.S. based since this is where wetland science has a direct link to policy and vice versa. From an international perspective – please see the book- *Sustaining the World's Wetlands: Setting Policy and Resolving Conflicts* (Smardon 2009). The linkage of wetland science to policy has not always been symbiotic as one can see from this article, but even the problematic nexus issues are instructive. This author relied heavily upon Environmental Law Institute's *National Wetland Newsletter* from 1986 to 2016 as a major guide to policy versus wetlands science issues besides relevant journal articles, books, and other sources. For an in depth look at the history of U.S. wetlands and for coastal wetlands, readers are referred to *Discovering the Unknown Landscape: A History of America's Wetlands* (Vileisis 2012) and *Tidal Wetlands Primer: An Introduction to Their Ecology, Natural History, Status, and Conservation* (Tiner 2013), respectively.

U.S. EARLY HISTORY OF WETLAND SCIENCE AND POLICY – FUNCTIONS AND VALUES?

The value of wetlands as waterfowl habitat played a key role in influencing U.S. wetland policy. The U.S. Fish and Wildlife Service report in 1956 (Shaw and Fredine 1956) and a series of later reports in the 1960s (Tiner 2013) highlighted the decline of waterfowl habitat. Besides increased water pollution, the findings of this census and public concern about heavy losses of coastal marshes eventually led to the need for the Clean Water Act (CWA) of 1964 and amendments in 1977 that required federal U.S. Army Corps of Engineers permits for wetland alterations beyond those contiguous with traditional navigable waters. Further concern for continued wetland losses also eventually led to the 1986 Emergency Wetlands Resources Act (PL 99-645), which was enacted to promote wetlands conservation through acquisition (Scozzafava et al. 2007). This act plus the CWA Section 404 strengthened support for the U.S. Fish and Wildlife Service's National Wetlands Inventory (NWI) and for producing wetland status and trends reports at ten-year intervals. This has significance, as the NWI became the base inventory for the continental U.S. and for reporting the amount of wetland loss or gain over time – a type of monitoring program.

Moving beyond wetland value for wildlife habitat became a major focus for U.S. wetland research after passage of CWA Section 404 amendments in 1977. One of the best compendiums of wetland functions and values was compiled in the conference proceedings at Lake Buena Vista Florida in 1978, which addressed a very broad view of wetlands (Greeson et al. 1979). One of the first multi-attribute assessment methods was developed by a team of scientists from the University of Massachusetts - Joseph Larson, Frank Golet, Richard Healy, Tirith Gupta, John Foster, and me (Larson 1976; Smardon 1975, 1978). This assessment system considered water supply, aesthetic, recreational and educational values of inland wetlands in Massachusetts as well as wildlife habitat values. It even incorporated an economic model for projecting wetland values over time (Gupta and Foster 1975). It was a predecessor to wetland ecosystem service valuation and was utilized as a building base for other regional wetland assessment systems (World Wildlife Fund 1992).

WETLAND DELINEATION - WHEN IS WET LAND A WETLAND?

One of the key issues involved with the National Wetlands Inventory and the federal and state wetland permitting programs is 'when is wet land a wetland' and how do we determine the boundary of the wetland? Because of the continued loss of wetland area nationally and regionally and the lack of standardized practices for identifying and delineating wetlands for federal permits, both the Corps of Engineers and U.S. EPA developed wetland delineation manuals in the mid-1980s (USCOE 1987; Sipple 1985, 1988). These two agencies have joint responsibility for regulating wetlands under the CWA. Neither manual was required for use for regulatory purposes but was used for field-testing. After a year of field-testing both manuals, the two agencies met to discuss findings and with the expectation to reach agreement on a consistent delineation approach. The USDA Soil Conservation Service and U.S. Fish and Wildlife Service were invited to the meeting given their respective expertise in hydric soils and wetland identification and mapping.

1 Corresponding author: rsmardon@esf.edu

The consensus of the four agencies was that they should work cooperatively to prepare a single federal manual for wetland delineation that could be used by all agencies for regulatory purposes as well as for mapping wetlands for resource conservation and management. The new wetland delineation manual was developed by an interagency committee in 1988 (Federal Interagency Committee for Wetland Delineation 1989); it combined existing methods used by the four agencies into a consistent methodology. It was officially adopted by the Corps and EPA as the national standard for identifying wetlands regulated through the CWA on January 19, 1989 (https://www.epa.gov/cwa-404/memorandum-agreement-determiniation-geographic-jurisdiction-section-404-program-and). This was the first time that a consistent approach would be used to identify wetlands for federal regulatory purposes nationwide. Since a variety of approaches had been used before it was a given that this would have expanded the area of wetlands to be covered under waters of the U.S. under Section 404 of the CWA. Also as expected, it was met with uproar and lawsuits from land developers, farmers, and mining industries. Given this outcry, Congress threatened to deny the Corps its operating budget if it continued to use this manual so the Corps then adopted its 1987 manual as the mandatory national standard for delineating jurisdictional wetlands. To address forthcoming concerns about the scientific basis for the Corps 1987 manual given inconsistencies in its application, the National Research Council was tasked by Congress to address the issue of defining wetland characteristics and boundaries. Wetland scientists met for over a year, visited wetlands throughout the U.S. and heard testimony. Key issues revolved around wetland hydrology and soils as they defined growing conditions for wetland vegetation. Still there were disagreements amongst the wetland scientists and some felt that the report – *Wetlands: Characteristics and Boundaries* (National Research Council 1995) was not well received by Congress. The end result was support for the 1987 Delineation manual (USACOE 1987) with recommendation that it be regionalized. Consequently, the Corps worked to produce regional supplements to the delineation manual across the country: Alaska, Arid West, Atlantic and Gulf Coastal Plain, Caribbean Islands, Eastern Mountains and Piedmont, Great Plains, Hawaii and Pacific Islands, Midwest, North Central and Northeast, and Western Mountains, Valley and Coast (https://www.usace.army.mil/Missions/Civil-Works/Regulatory-Program-and-Permits/reg_supp/). These supplements contain the list of wetland indicators (hydrophytic vegetation, hydric soils and wetland hydrology) and the procedures for analyzing vegetation and for addressing problematic situations where such indicators are weak or lacking and disturbed areas (e.g., drained sites). For more on the topic of wetland delineation see *Wetland Indicators: A Guide to Wetland Formation, Identification, Delineation, Classification, and Mapping* (Tiner 2017).

WETLAND ASSESSMENT FOR FUNCTIONS AND VALUES

With the creation of the Section 404 wetland permit program by the U.S. Army Corps of Engineers plus state wetland permit programs in about one half of the U.S. states, the overriding policy issues became when to allow wetland alteration, what were the values and functions lost, and how should such loss be compensated or mitigated? As pointed out by Frank Golet (1986) one of the co-authors of the national wetlands classification system (Cowardin et al. 1989), major questions in the 1980s were:

- What is the justification for initial wetland alteration and when is it unavoidable;
- What are the criteria for selecting "best " mitigation options;
- The issue of uncertainty of projected results as well as certainty of adverse impacts;
- How to address replacement and substantiation of lost values and how to address specific values and functions lost;
- The importance of the wetlands setting;
- How to address net loss of wetland area, which is a common consequence;
- How to address cumulative impact of isolated mitigation projects;
- The issue of short term versus long term perspective;
- How to assess the comparability of original and replacement wetlands.

Dr. Golet went on to state that the role of value assessment in wetland mitigation "should not be used in simple before and after value comparison for mitigation projects" (Golet 1986, p. 4). Such questions led to the development of a myriad of wetland assessment systems most of which are reviewed in WWF's *Statewide Wetlands Strategies: A Guide to Protecting and Management the Resource* (WWF 1992) as well as Fennessy et al. (2004) and also reported in Dorney et al. (2018). The WWF source included: wetlands classification schemes such as Cowardin et al (1979 - the national wetland classification system for the U.S.; maps and national databases such as the U.S. Fish and Wildlife Service's National Wetlands Inventory (NWI); data sources on wetland status and trends such as the U.S. Fish and Wildlife Service status and trends reports (every ten years); rapid methods for evaluating, ranking or categorizing wetlands (which will be treated in more detail below) and data intensive methods for individual wetlands.

Rapid methods for evaluating wetlands can divide into methods intended for use in any area in the coterminous U.S. and methods developed for specific or particular regions. The methods intended to be used across the U.S. prior to 1992 include 1) the *Habitat Evaluation Procedures* (HEP) developed by the U.S. Fish and Wildlife Service (1980) - a very detailed process of assessing habitat impacts to selected fish, wildlife and invertebrates and is still in use and 2) the *Habitat Assessment Technique* (HAT) developed by Cable et al. (1989) that addresses only breeding bird habitat and requires extensive field work.

Paul Adamus and Lauren Stockwell (1983) developed a national system of wetland evaluation (WET) for the Federal Highway Administration in 1983. In 1987, it was adapted by the U.S. Corps of Engineers (Adamus et al. 1987). This system used the wetland literature to develop a series of indicators which then could be used to evaluate the following functions; groundwater recharge, groundwater discharge, flood flow alteration, sediment stabilization, sediment toxicant removal, nutrient removal /transformation, production export, aquatic diversity abundance, and wildlife diversity/abundance. Once these functions are assessed – they then are modified by their social significance and the wetland's effectiveness or capacity and opportunity to provide the various functions. The U.S. Corps of Engineers at the Waterways Experiment Station (Vicksburg, Mississippi) tried to regionalize this system but it is not extensively used these days.

Another national wetland assessment system developed in the early 1990s by the U.S. Environmental Protection Agency (Abbruzzese et al. 1997) was to be used at a watershed scale. Indicators are developed within any given watershed to assess the functions of wetlands within a watershed landscape. The system was tested in the states of Washington (Abbruzzese et al. 1990a) and Louisiana (Abbruzzese et al. 1990b) but was not heavily used because of the lack of watershed-based wetland science for any given application area. At the same time two Cornell University scientists were working on methods for assessing cumulative impact to wetlands within a watershed (Bedford and Preston 1998).

The next advance in wetland assessment came with the development of the hydrogeomorphic (HGM) approach created by East Carolina State University Professor Mark Brinson (1996 and Brinson et al. 1994). This system classifies wetlands based on abiotic properties that produce differences in functioning (e.g., where the wetland sits in the landscape, for example, upland depressional versus floodplain). The system also maintains a clear policy-science separation as societal issues are dealt with only after functional assessment. Third the HGH approach uses reference wetlands - sites that have the known variation in sub class function to rank wetlands. It is the major biophysical functions that are assessed and not social values or functions. The HGM system, used by the U.S. Corps of Engineers and some states, is highly data intensive and has been criticized by others. Kusler and Niering (1998) were critical of HGM and other assessment systems in regard for the need of "holistic" assessment; limitations in terms of types of information and scale of analysis; the need for value as well as function assessment; and the need to be proven in regard to breadth of information, cost-effectiveness, practicality, understandability, and scientific accuracy (Kusler and Niering 1998, p. 14).

The U.S. Army Corps of Engineers had continued to develop the HGM system with National HGM models regional guidebooks and research but development of HGM profiles faded by 2002. Regional and state HGM classifications and keys were produced for several states including Colorado, North Carolina, Oregon, Pennsylvania, and Washington in addition to reference wetlands and regional guidebooks for California, Kentucky, North Carolina, Oregon and Pennsylvania (Cole and Kooser 2002). Corps district offices are still struggling with rapid assessment techniques that have utility for assessing impact and or loss of wetland functions and values. The HGM concept has been coupled with the Cowardin et al. (1979) wetland classification to produce landscape-level wetland functional assessments for watersheds and other regions using GIS and remotely sensed data (see Dorney et al. 2017 for examples).

WHEN AND HOW TO MITIGATE

Even though we could delineate a wetland and conduct assessments of functions, values and impacts we were still losing wetland area and functions across the country so the next question became - is compensatory mitigation working under federal and state wetland permitting? From 1981 to 2008 the federal policy stated that when there are unavoidable wetland impacts and wetland area and functions are lost – required compensation should be on site and in-kind to replace lost area and functions. During the 1980s and 1990s many studies documented the lack of ecological effectiveness of replacement mitigation wetlands (e.g., Brown and Veneman 2001; Wilkinson et al. 2013). Again the National Research Council was tasked with reviewing compensatory wetland mitigation practice in the conterminous United States. The NRC committee examined the science behind wetland restoration and mitigation. The committee met five times in 2000 and visited actual mitigation sites in Florida, Illinois, and California (Zedler and Shabman 2001). The 2001 NRC report called upon regulatory agencies to "modify the boundaries of permit decision making in time and space" and advocated that mitigation" be conducted at watershed scale" (National Research Council 2001).

Two years later an interagency group released the *National Wetlands Mitigation Action Plan* (MAP 2002) with a goal of "no net loss" by undertaking a series of actions to improve the ecological performance and results of wetlands compensatory mitigation (Thomas and Lamb 2004). In May 2004 the Environmental Law Institute facilitated a meeting –*National Symposium on Compensatory Mitigation and the Watershed Approach* (https://www.eli.org/sites/default/files/eli-pubs/d14_10.pdf). The major objective of the meeting was to "identify and clarify what science says about making compensatory mitigation decision in a watershed context". Out of this symposium came a number of key points as part of this watershed approach, which included:

- Defining critical mitigation issues and objectives (Montgomery et al. 1995; Almendinger 1999; Lamy et al. 2002; Thomas and Lamb 2004);
- Having broad stakeholder participation (Gosselink et al. 1990; Llewellyn et al. 1996; National Research Council 2001; Lamy et al. 2002; Kershner 1977);
- Determining the appropriate scale and boundaries for analysis (Preston and Bedford 1988; Omerick and Bailey 1997; Griffith et al. 1999, Fennesy et al. 2004; Montgomery et al. 1995);
- The use of watersheds and basins as the unit of analysis (Montgomery et al. 1995; Kershner 1997; Lee and Gosselink 1988; Tiner et al. 2000);
- Assessing and understanding watershed and landscape functions (Montgomery et al. 1995);
- Understanding hydrologic equivalency (Bedford 1996); and
- Understanding relative ecologic significance.

MOVING TOWARD A WATERSHED APPROACH?

All of these points were to be incorporated in the U.S. EPA Synoptic Approach (Abbruzzese et al. 1997), which incorporates elements for site-specific assessments as well as prioritizing sites and designing mitigation and assessing performance. Although many scientists agree about the need for a watershed-based approach for wetland mitigation there were still issues regarding functional replacement versus biodiversity. Joy Zedler states that it is not clear that restored wetland services depend on biodiversity; three key wetland services - flood abatement, carbon sequestration and water quality enhancement - may not depend on diverse vegetation (Zedler 2005).

In order to improve the process of compensatory wetland mitigation and after almost two years of hearings and comments the Corps and EPA were charged with implementing the *Compensatory Mitigation Rule* (CFR 2008). This rule called for a "watershed approach" that would: 1) identify watershed needs, 2) identify potential project sites, 3) assess the potential of sites to meet watershed needs, 4) prioritize sites and 5) develop desired mitigation outcomes. As pointed out by Hershner (2013) the challenge to the wetland scientific community, given the assertion of goods and services from wetlands arise in part from the connection between wetlands and their landscapes: will wetland science provide practical and consistent advice for use of watershed scale assessment?

WETLAND ECOSYSTEM SERVICES

Costanza et al. (1997) in their legendary paper calculated the ecosystem services provided by nature including wetlands, while the *Millennium Ecosystem Project* (2005) developed an ecosystem services overview specifically for wetlands. This report outlined provisional (food and water), regulatory (maintaining water quality), cultural (aesthetics and recreation) and ecosystem support (habitat and food chain) in regard to wetlands from an international perspective. In the U.S. there were two research efforts that focused on sustainable wetland management (Euliss et al. 2009a, 2009b) and on means of quantifying ecosystem services provided to human beneficiaries (Boyd and Kruprick 2009).

According to Euliss et al. (2009a) a meeting was convened in 2006 at Bosque Del Apaches National Wildlife Refuge (New Mexico) to develop a sustainable approach for wetland management focusing on underlying wetland processes. The other focus was on long-term sustainability of critical habitats within altered landscapes by restoring or simulating natural processes (Euliss et al. 2009b; Smith et al. 2008).

The National Research Council (2005) and the U.S. Environmental Protection Agency (2009) have embraced the idea of ecosystem service valuation as part of environmental decision-making since the early 2000s. Economists and social scientists were developing ecosystem valuation theory and metrics (Boyd and Krupnick 2008; Daily and Matson 2008). From 2010-2011 the US EPA-Corvallis laboratory research group held a number of workshops in Denver to bring together both biophysical and social scientists to develop metrics for assessing and valuing ecosystem services derived from water resources such as coastal estuaries, lakes, rivers and freshwater wetlands (Nahlick et al. 2012; Ringold et al. 2013). From these workshops the US EPA developed a landscape classification covering both uplands and water areas with generic ecosystem services and respective beneficiaries (Landers and Nahlik 2013). The appendices include detailed descriptions of ecosystem benefits and beneficiaries derived from rivers and streams, freshwater wetlands, lakes and ponds, estuaries and near shore marine areas, and open ocean areas plus upland landscapes. The question remains as to whether ecosystem services will become useful for actual accounting of benefits as part of wetland permitting and mitigation decisions.

WETLANDS, CLIMATE CHANGE, AND BLUE CARBON?

One of the most controversial issues with regard to wetland science and policy is whether coastal and inland wetlands are actually sinks or exporters of greenhouse gases as we look forward to climate change and disruption. Kusler and Burkett (1999) called attention to this issue by pointing out that wetland destruction could release stored carbon and methane into the atmosphere as well as loss of carbon sequestration. They also pointed out that wetland flora and fauna often respond dramatically to climate change including:

- Inducing small permanent changes in water levels;
- Inducing further wetland fragmentation; and
- Inducing further wetland stress.

They go on to emphasize that wetlands having a greater climate change risk are coastal and estuarine wetlands, tundra, peatlands, alpine wetlands, prairie potholes, depressional slopes, flats, and river and lake fringe wetlands. One of the best compendiums or books in this regard is *Climate Change Impacts on Freshwater Ecosystems* by Kernan et al. (2010).

William Mitsch (2013, 2016) states that there is a significantly higher sequestration in wetlands worldwide - estimated at 1Pg yr-1 (=1000 Tg. (Teragram) yr-1+ 10 g yr-1) based on new data. He developed a dynamic carbon model to address both carbon sequestration and methane emissions. Sixteen natural wetlands were used as inputs for simulation. Most of the 16 wetlands became "sinks of radiative forcing within 100 years" (Mitsch et al. 2013). A recent article by Moomaw et al. (2018) documents the role of wetlands in addressing climate change. They state "peatlands and vegetated coastal wetlands are among the most carbon rich sinks on the planet and sequestering approximately as much carbon as do global forests" (p. 183). They stress that wetland scientists need to clearly communicate this significant wetland carbon sequestration function as well as align wetland science with specific climate mitigation/adaption/resiliency wetland ecosystem services in order to be more effective in influencing climate change policy.

In order to better integrate the amount of carbon storage in the world's ocean and coastal ecosystems, there has been development of protocols for determining "blue carbon" sequestration. Emmett-Mattox and Crooks (2014) report that the development of such protocols is key for conservation and restoration of such biogeochemical processes performed by coastal salt marshes, mangroves and seagrass beds. Examples of such protocols include:

- American Carbon Registry "Registration of Degraded Delta Wetlands of the Mississippi Delta Wetlands of the Mississippi Delta" Webinar December 12, 2012 https://tierraresourcesllc.com/wp-content/uploads/2014/01/ACR-Wetland-Rest-Meth-Webinar-12-12-12-COMBINED.pdf
- Verified Carbon Standard, "Baseline monitoring Methodology for the Rewetting of Drained Peatlands used for Peat Extraction, Forestry or Agriculture Based on GESTS) (greenhouse Gas Emissions Site Type) (see Tanneberger and Wichtmann 2011);
- Verified Carbon Standard " Methodology for Wetland Creation (see UNEP & CIFOR 2014)
- Verified Carbon Standard" Methodology for Tidal Wetland and Seagrass Restoration. http://verra.org/webinar-newly-approved-vcs-methodology-tidal-wetland-and-seagrass-restoration/

Further information on these carbon sequestration protocols can be seen in Mcleod et al (2011).

USING NEW TECHNOLOGIES TO IDENTIFY WETLAND CONNECTIONS AND TO MONITOR WETLAND CONDITIONS

Finally wetland science has progressed with the use of remote sensed technology and geographic information data systems – vital for keeping track of individual wetland conditions as well as larger scale watershed or regional landscape conditions. We have moved from the U.S. Geological Survey topographic maps and aerial photo interpretation initially used for the NWI in the 1970s and 80s (Cowardin et al. 1979; Cowardin and Golet 1995) to multi spectral imagery and geographic information systems of today (Tiner et al. 2015). A need for a surface waters and wetlands inventory (SWI) was created after the 2001 SWANNC Supreme court case where the hydrologic nexus of wetlands versus hydrologically isolated wetlands became an issue for nationwide wetland permitting. SWI system has a more complete geospatial data for surface waters and wetlands than the original NWI digital database, which did not include linear wetlands and watercourses mapped by NWI projects. Consequently SWI provides a more efficient means to determine flow and water movement in surface water basins, channels and wetlands (Dahl 2013). It was completed for 28 states and is publically available at http://www.fws.gov/wetlands/. A newer version of this product called NWI Version 2 adds buffered USGS hydrography data (e.g., linear streams) to the database (https://www.fws.gov/wetlands/data/Wetlands-Product-Summary.html). Adding these streams has greatly improved the utility of the data. Unfortunately the NWI data in this product are mostly from the 1980s (Figure 1). More support is needed to update this valuable program.

The U.S. EPA established the National Wetland Condition Assessment (NWCA) to keep track of the ecological condition of wetlands (Seronbetz 2016). The various components of the NWCA include the National Aquatic Resource Survey (NARS) for wadeable streams (2004), lakes (2007), rivers and streams (2008-2009) and coastal waters (2010) (available at [https://www.epa.gov/national-aquatic-resource-surveys).](https://www.epa.gov/national-aquatic-resource-surveys) As part of the reporting of the 2011 NWCA, there were two reporting documents (USEPA 2011a, USEPA 2011b). A second sampling was conducted in 2016 with the analysis of the change in wetland ecological conditions from 2011 to 2016 and a ranking of predominate stresses underway.

CONCLUSION

We have come a long way with wetland science but still have many unresolved questions. Sometimes there is congruence with wetland science and policy and sometimes not. Policy makers, especially at the national level, at times, are not attuned to wetland science results or find science not useful. Wetland scientists are often challenged by regulators to give them something with more immediate utility. The separation of wetland functions and values such as in the HGM assessment methodology maybe more useful for physical wetland mitigation but negates the social significance issue. The latter may have more political power in saving a wetland, as it is what affects people. Often times the best results are when wetland studies are co-produced with policy or regulators, thereby identifying a practical or operational use of the findings. ■

ACKNOWLEDGEMENT

The author would like to thank Ralph Tiner for his substantial editorial contributions.

REFERENCES

Abbruzzese, B. and S.G. Leibowitz. 1997. Environmental auditing: A synoptic approach for assessing cumulative impacts to wetlands. *Environmental Management* 21(3): 457-475. DOI: 10.1007/s002679900042.

Abbruzzese, B., S.G. Leibowitz, and R. Summer. 1990a. *Application of the Synoptic Approach to Wetland designation; A Case Study in Washington*. U.S. EPA Environmental Research Laboratory, Corvallis, OR. EPA/600/3-90/072.

Abbruzzese, B., S.G. Leibowitz, and R. Summer. 1990b. *Application of the Synoptic Approach to Wetland Designation; A Case Study in Louisiana*. U.S. EPA Environmental Research Laboratory, Corvallis, OR. EPA/600/3-90/066.

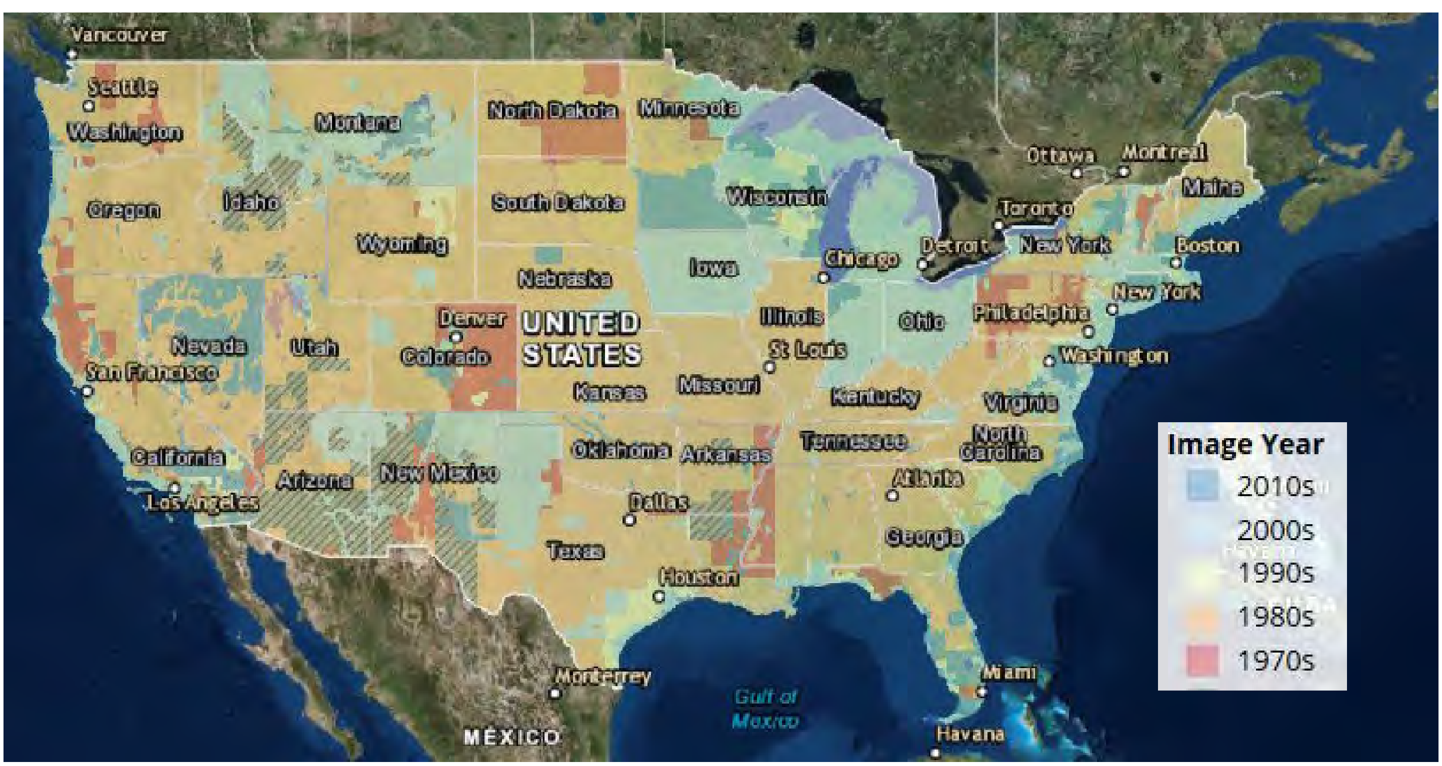
Adamus, P. and L.T. Stockwell 1983 *A Method for Wetland Functional Assessment. Volume 1: Critical Review and Evaluation Concepts*. Federal Highway Association, Office of research and Development Washington, DC. FHWA-IP-82-23, 181 pp.

Adamus, P.R., E.J. Clairain, Jr., R.D. Smith, and R.E. Young. 1987. *Wetland Evaluation Technique (WET*). *Volume II: Methodology*. U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS. Technical Report Y-87.

Almendinger, J.E. 1999. A method to prioritize and monitor wetland restoration for water quality improvement. *Wetlands Ecology and Management* 6: 241-251 https://link.springer.com/content/pdf/10.1023/A:1008439031165.pdf

Bedford, B. 1996. The need to define hydrologic equivalence at the landscape scale for freshwater wetland mitigation. *Ecological Applications* 6: 57-68. https://doi.org/10.2307/2269552

FIGURE 1. Date of imagery used in mapping wetlands for the National Wetlands Inventory. The data for most of the country are from the 1980s (tan areas). (Source: U.S. Fish and Wildlife Service, https://www.fws.gov/wetlands/data/Mapper.html, accessed November 2, 2018.)



Bedford, B. and E. Preston. 1998. Developing the scientific basis for assessing cumulative effects of wetland loss and degradation on landscape functions: Status, perspectives and prospects. *Environmental Management* 12: 751-771. https://doi.org/10.1007/BF01867550

Boyd, J.W. and A. Krupnick 2009. *The Definition and Choice of Environmental Commodities for Nonmarket Valuation*. Resources for the Future, Washington, DC.

Brinson, M. 1996. Assessing wetland functions using HGM. *National Wetlands Newsletter* 18(1): 10-16.

Brinson, M, W. Kruczynski, L.C. Lee, W. Nutter, R.D. Smith, and D. Whigham. 1994. Developing an approach for assessing functions of wetlands. In W.J. Mitsch (editor) *Global Wetlands; Old World and New*. Elsevier Science B.V. Amsterdam, The Netherlands. pp. 615-621.

Brown, S.C. and P.L.M. Veneman. 2001. Effectiveness of compensatory wetland mitigation in Massachusetts, USA. *Wetlands* 21: 508-518.

Cable, T.T., V. Brack, Jr., V.R. Holmes 1989. Simplified methods for wetland habitat assessment. *Environmental Management* 13: 207-213. DOI 10.1007/BF0186367.

Cole, A.C. and J.G. Kooser. 2002. HGM: Hidden gone missing. *National Wetlands Newsletter* 245(2): 1, 16.

Congressional Federal Registrar (CFR) 2008. *Compensatory Mitigation Rule* 33CFR pt. 332.

Costanza, R., R. d'Arge, R. deGroot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R.V. Oneill, J. Paruelo, R.G. Raskin, P. Sutton, and M. vandenBelt. 1997. The value of the world's ecosystem services and natural capital. *Nature* 387: 253–260. DOI: 10.1038/387253a0.

Cowardin, L.M., V. Carter, F.C. Golet and E.T. LaRoe. 1979. *Classification of Wetlands and Deepwater Habitats of the United States*. U.S. Fish and Wildlife Service, Washington, DC FWS/OBS-79/31.

Cowardin, L.M. and F.C. Golet. 1995. U.S. Fish and Wildlife Service 1979 wetland classification: A review. *Vegetation* 118: 139-152.

Dahl, T.E. 2013. Surface waters and wetlands inventory: a more comprehensive data set for the nation's water resources. *National Wetlands Newsletter* 35(2): 9-11, 24.

Daily, G.C. and P.A. Matson. 2008. Ecosystem services: from theory to implementation. *Proceedings of the National Academy of Sciences* 105 (28): 9455-56. https://doi.org/10.1073/pnas.0804960105

Dorney, J., R. Savage, R.W. Tiner, and P. Adamus (editors). 2018. *Wetland and Stream Rapid Assessments*. 1st Edition. Academic Press, Elsevier, London, UK. 582 pp.

Emmett-Mattox, S. and S. Crooks. 2014. Implementing blue carbon projects: lessons learned and next steps. *National Wetlands Newsletter* 36(1): 5-8.

Environmental Law Institute (ELI). 2004. *National Symposium on Compensatory Mitigation and the Watershed Approach Symposium Materials*. Environmental Law Institute, Washington, DC.

Euliss, N.H., Jr., L.M. Smith, D.A. Wilcox and B.A. Brown. 2009a. Linking ecosystem processes to sustainable wetland management. *National Wetlands Newsletter* 31(1): 1, 3-5, 22.

Euliss, N.H., Jr., L.M. Smith, D.A. Wilcox and B.A. Brown. 2009b. Linking ecosystem processes to sustainable wetland management goals: charting a course for a sustainable future. *Wetlands* 28:553-556. https://doi.org/10.1972/07-154.1.

Federal Interagency Committee for Wetland Delineation. 1989. Federal Manual for Identifying and Delineating Jurisdictional Wetlands. U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, and U.S.D.A. Soil Conservation Service, Washington, DC. https://digitalmedia.fws.gov/digital/collection/document/id/1341/.

Fennessy, M, A.J. Siobhan, and M. Kentula. 2004. *Review of Rapid Methods for Assessing Wetland Conditions*. U.S. Environmental Protection Agency, Washington, DC. EPA/620/R-04/009.

Golet, F.C. 1986. Critical issues in wetland mitigation: a scientific perspective. *National Wetlands Newsletter* 8(5): 3-6.

Gosselink, J., G. Shaffer, L. Lee, D. Burdick, D. Childers, N. Leibowitz, S. Hamilton, R. Boumans, D. Cushman, S. Fields, M. Koch, and J. Visser. 1990. Landscape conservation in a forested watershed: can we manage cumulative impacts. *Bioscience* 40: 588-600.

Greeson, P.E., J.R. Clark, and J.E. Clark (editors). 1979. *Wetland Functions and Values: The State of Our Understanding.* American Water Resources Association, Minneapolis, MN. 674 pp.

Gupta, T.R., and J.H. Foster. 1975. Economic criteria for freshwater wetland policy in Massachusetts. *American Journal of Agricultural Economics* 57(1): 40-45. DOI: 10.2307/1238838.

Hershner, C. 2013. Reality check: evaluating the progress toward watershed–level assessment. *National Wetlands Newsletter* 35 (1): 10-12.

Kernan, M., R.W. Battarbee and B. Moss (editors). 2010. *Climate Change Impacts on Freshwater Ecosystems*. Wiley-Blackwell, West Sussex, UK. 314 pp.

Kershner, J. 1997. Setting riparian/aquatic restoration objectives within a watershed context. *Restoration Ecology* 5.4s: 15-24. https://doi.org/10.1111/j.1526-100X.1997.00015.x

Kusler, J. and W. Niering 1998 Wetland assessment: have we lost our way? *National Wetland Newsletter* 20(2): 1, 9-11.

Kusler J. and V.R. Burkett. 1999. Wetlands and climate change-scientific approaches and management options. *National Wetlands Newsletter* 21(2): 1, 16-17.

Lamy, F., R. Brooks, S. Gwin, C. Holland, A. Sherman, and C. Smith. 2002. Development and evaluation of multiple objective decision-making methods for watershed planning. *Water Resources Bulletin* 38: 517-529.

Landers, D.H. and A.M. Nahilk. 2013. *Final Goods and Services Classification System (FEGS-CS)*. USEPA Office of Research and Development, National Health and Environmental Effects Research Laboratory, Corvallis, OR. EPA/600/R-13/ORD-004914. [online] https://gispub4.epa.gov/FEGS/FEGS-CS%20FINAL%20V.2.8a.pdf

Larson, J.S. (editor). 1976. *Models for Assessment of Freshwater Wetlands.* Water Resources Research Center, University of Massachusetts, Amherst, MA. Publication Number 32.

Lee, L and J. Gosselink. 1988. Cumulative impacts on wetlands: linking scientific assessments and regulatory alternatives. *Environmental Management* 12: 591-602. https://link.springer.com/article/10.1007/BF03160621.

Llewellyn, D., G. Shaffer, N. J. Craig, L. Chessman, D. Pashley, M. Swan, and C. Brown. 1996. Decision support system for prioritizing restoration sites on the Mississippi River alluvial plain. *Conservation Biology* 10: 1446-1555. https://doi.org/10.1046/j.1523-1739.1996.10051446.x.

Mcleod, E., G.L. Chumura, S. Boullon, R. Salm, M. Bjork, C. M. Duarte, C. E. Lovelok, W.H. Schlesinger, and B. R. Silliman. 2011. A blueprint for blue carbon: toward an improved understanding of the role of vegetated coastal habitats in sequestering CO2. *Frontiers in Ecology and Environment* 9(10): 552-560. [online] https://doi.org/10.1890/110004.

Millennium Ecosystem Assessment. 2005. *Ecosystems and Human Well-being; Wetlands and Water Synthesis; A Report of the Millennium Ecosystem Assessment*. World Resources Institute, Washington, DC. ISBN 1569735972.

Mitigation Action Plan (MAP) Workgroup. 2002. *National Mitigation Action Plan.* [online] http://www.fws.gov/habitatconservation/map-withsignatures.pdf

Mitsch, W.J. 2016. Wetlands and climate change. *National Wetlands Newsletter* 38(1): 5-11.

Mitsch, W.J., B. Bernal, A.M. Nahlik, U. Mander, L. Zhang, C.J. Anderson, S.E. Jorgensen, and H. Brix. 2013. Wetlands, carbon & climate change. *Landscape Ecology* 28: 583-597. DOI 10.1007/s10980-012-9758-8.

Montgomery, D., G. Grant, and K. Sullivan. 1995. Watershed analysis as a framework for implementing ecosystem management. *Water Resources Bulletin* 31: 369-386.

Moomaw, W.R., G.L. Chumura, G.T. Davies, C.M. Finlayson, B.A. Middleton, S. M. Natali, J. E. Perry, N. Roulet, and A.E. Sutton-Grier. 2018. Wetlands in a changing climate: Science, policy and management. *Wetlands* 38: 183-205. [online] https://doi.org/10.1007/s13157-018-1023-8.

Nahlik, A.M., D.H. Landers, P.L. Ringold, and M.A. Weber. 2012. Protecting our environmental wealth: connecting ecosystem goods and services to human well being. *National Wetlands Newsletter* 34(1): 14-18.

National Research Council. 1995. *Wetlands; Characteristics and Boundaries*. National Academy of Science, Washington, DC. {online] https://www.nap.edu/catalog/4766/wetlands-characteristics-and-boundaries

National Research Council Committee on Mitigating Wetland Losses. 2001. *Compensating for Wetland Losses Under the Clean Water Act*. National Academy of Science, Washington, DC. [online] https://www.nap.edu/read/10134/chapter/1

National Research Council. 2005. *Valuing Ecosystem Services: Toward Better Environmental Decision-Making*. National Academic Press, Washington, DC. [online] https://www.nap.edu/read/11139/chapter/1#viii

Preston, E. and B. Bedford. 1988. Evaluating cumulative effects on wetland functions: a conceptual overview and generic framework. *Environmental Management* 12: 565-583. DOI: 10.1007/BF01867536.

Ringold, P.L., J. Boyd, D. Landers, and M. Weber. 2013. What data should we collect? A framework for identifying indicators of ecosystem contributions to human well-being. *Frontiers in Ecology and the Environment* 11(2): 98-105. DOI: 10.1890/10156.

Seronbetz, G. 2016. National Wetland Condition Assessment 2011-2016: lessons learned and moving forward. *National Wetlands Newsletter* 38(3): 17-20.

Scozzafauna, M.E., T. Dahl, C. Faulkner, and M. Price. 2007. Assessing status trends and condition of wetlands. *National Wetlands Newsletter* 29(3): 1, 25-28.

Shaw, S.P. and C.G. Fredine. 1956. *Wetlands of the United States: Their Extent and Value to Waterfowl and Other Wildlife*. Circular 39. U.S. Fish and Wildlife Service, Washington, DC. 67 pp.

Sipple, W.S. 1985. *Wetland Identification and Delineation Manual.* U.S. Environmental Protection Agency, Office of Federal Activities, Washington, DC. Draft Report.

Sipple, W.S. 1988. *Wetland Identification and Delineation Manual Volume I. Rationale, Wetland Parameters, and Overview of Jurisdictional Approach. Volume II. Field Methodology*. U.S. Environmental Protection Agency, Office of Wetlands Protection, Washington, DC.

Smardon, R.C. 2009. *Sustaining the World's Wetlands: Setting Policy and Resolving Conflicts*. Springer, New York, NY. 326 pp.

Smardon, R.C. 1975. Assessing visual-cultural values of wetlands in Massachusetts. In E.H. Zube, R.O. Brush, and J.G. Fabos (editors). *Landscape Assessment; Values, Perceptions, and Resources*. Dowden, Hutchinson & Ross, Stroudsburg, PA. pp. 289-318.

Smardon, R.C. 1978 Visual–cultural values of wetlands. In P.E. Greeson, J.R. Clark, and J. E. Clark (editors). *Wetland Functions and Values: The State of Our Understanding*. American Water Resources Association, Minneapolis, MN. pp. 535-544.

Smith, L.M., N.H. Euliss, Jr., D.A. Wilcox, and M.M. Brinson. 2008. Application of a geomorphic and temporal perspective to wetland management in North America. *Wetlands* 28: 563-577. DOI: 10.1672/07-155.1.

Tanneberger, F. and W. Wichtmann. 2011. *Carbon Credits from Peatland Rewetting Climate-Biodiversity-Land Use*. Schweizerbart Science Publishers, Stuttgart, Germany. 223 pp. http://schweizerbart.com/9783510652716

Thomas, R. and Z. Lamb. 2004. Scientific perspectives on a watershed approach to compensatory mitigation. *National Wetlands Newsletter* 26(5): 17-20.

Tiner, R.W. 2013. *Tidal Wetlands Primer: An Introduction to Their Ecology, Natural History, Status, and Conservation*. University of Massachusetts Press, Amherst, MA. 536 pp.

Tiner, R.W. 2017. *Wetland Indicators: A Guide to Wetland Formation, Identification, Delineation, Classification, and Mapping*. 2nd Edition. CRC Press, Boca Raton, FL. 606 pp.

Tiner, R.W., M.W. Lang, and V.V. Klemas (editors). 2015. *Remote Sensing of Wetlands: Applications and Advances*. CRC Press, Boca Raton, FL. 574 pp.

Tiner, R., M. Starr, H. Bergquist, and J. Swords. 2000. *Watershed-based Wetland Characterization for Maryland's Nanticoke River and Coastal Bays Watersheds: A Preliminary Assessment Report*. U.S. Fish & Wildlife Service, National Wetlands Inventory (NWI) Program, Northeast Region, Hadley, MA. Prepared for the Maryland Department of Natural Resources, Coastal Zone Management Program (pursuant to National Oceanic and Atmospheric Administration award). NWI technical report. https://www.aswm.org/wetlandsonestop/preliminary_assessment_report.pdf

UNEP and CIFOR 2014. Guiding principles for delivering coastal wetland carbon projects. United Nations Environment Programme, Nairobi, Kenya and Center for International Forestry Research, Bogor, Indonesia. 57 pp.

U.S. Army Corps of Engineers. 1987. *Corps of Engineers Wetlands Delineation Manual*. Waterways Experiment Station, Vicksburg, MS. Wetlands Research Program Technical Report Y-87-1. [online] http://www.cpe.rutgers.edu/Wetlands/1987-Army-Corps-Wetlands-Delineation-Manual.pdf

U.S. Environmental Protection Agency. 2009. *Valuing the Protection of Ecological Systems and Services: A Report to the EPA Science Advisory Board*. U.S.EPA, Washington, DC. EPA-SAB-09-012.

U.S. Environmental Protection Agency. 2011a. *National Wetland Condition Assessment 2011 Results.* U.S. Environmental Protection Agency, Washington, DC. [online] https://www,epa.gov/national-aquatic-resource-surveys/national-wetland-condition-assessment-2011results&methods

U.S. Environmental Protection Agency. 2011b. *National Wetland Condition Assessment 2011 Draft Technical Report*. U.S. Environmental Protection Agency, Washington, DC. [online] https://www.epa.gov/national-aquatic-resource-surveys/national-wetland-condition-assessment-2011-draft-technical-report

U.S. Fish and Wildlife Service. 1980. *Habitat Evaluation Procedures (HEP) Manual* 102 ESM. U.S. Fish and Wildlife Service, Washington, DC. {online] https://www.fws.gov/policy/ESM102.pdf

Vileisis, A. 2012. *Discovering the Unknown Landscape: A History of America's Wetlands*. Island Press, Washington, DC. 445 pp.

Wilkinson, J., N.P. Smith, and N. Miller. 2013. The watershed approach: lessons learned through a collaborative effort. *National Wetlands Newsletter* 35(1): 9-13.

World Wildlife Fund. 1992. *Statewide Wetlands Strategies: A Guide to Protecting and Managing the Resource.* Island Press, Washington, DC. 267 pp.

Zedler, J. 2005. How compatible are biodiversity and ecosystems service restoration goals? *National Wetlands Newsletter* 27(6): 1, 11-13,19.

Zedler, J. and L. Shabman. 2001. Compensatory mitigation needs improvement, panel says. *National Wetlands Newsletter* 23 (4): 1, 12-14.

Less Water in the Face of Climate Change Reduces Erosion Vulnerability of South Africa's Wetlands

Fred Ellery[1], Geography Department, Rhodes University, Grahamstown, South Africa

ABSTRACT

Given the fact that southern Africa is semi-arid and situated at an exceptionally high altitude for a region of the world that has not undergone plate collision for a half a billion years, wetlands are prone to degradation by gully erosion. This is because wetlands typically form an integrated component of fluvial systems and evolve a longitudinal slope that is appropriate for their discharge. Factors that increase discharge in fluvial systems, such as hardening of surfaces through urbanisation or overgrazing in wetland watersheds, lead to increased erosion as the longitudinal slope of wetlands is too steep for the available discharge. Given that decreased rainfall is predicted in southern Africa due to climate change scenarios, wetlands are less likely to be subjected to levels of erosion currently witnessed. Despite a reduction in water inputs due to lower rainfall, this is good news for many southern African wetlands.

INTRODUCTION

Wetland scientists generally think about the ecosystems in which they work as driven primarily by water. Flooding of the soil leads to anaerobic conditions and thus the radical alteration of soil biogeochemical characteristics, making life in this environment hostile to organisms not highly adapted to these conditions (Mitsch and Gosselink 2015). A key feature of wetland environments is the prolonged saturation near the surface, typically flooding of the wetland landform to a shallow depth, be it a floodplain, valley-bottom, depression, or mire. Such flooding requires the evolution of landforms with a very gentle slope and near-horizontal cross-section (Ellery et al. 2008). I have long been intrigued about how such landforms develop, particularly in the southern African context where two features make the formation of wetlands somewhat enigmatic:

1. The region is semi-arid with a mean annual rainfall across the subcontinent of about 500 mm per annum and potential evaporation of between 1000 and 4000 mm per annum. Nowhere is rainfall greater than potential evaporation.
2. The region is situated at an unusually high altitude for a region of the world that has not undergone mountain-building by tectonic plate collision for 500,000 years, and where erosion is thus the dominant geomorphic process.

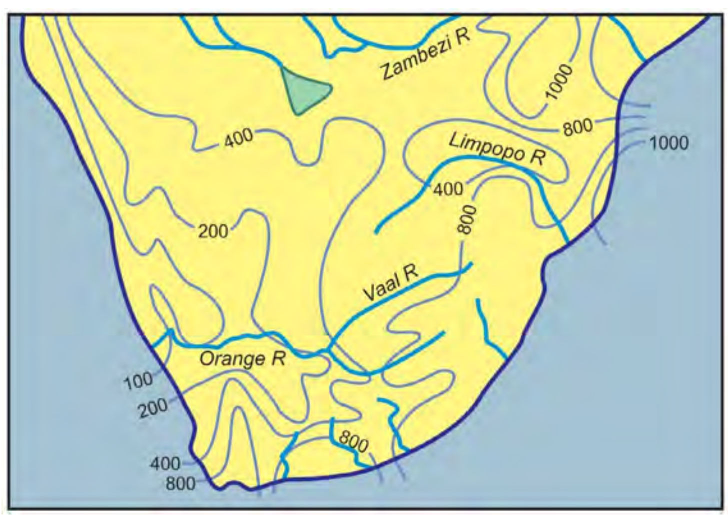
Erosion is viewed as the most serious threat to wetlands in the region, leading to degradation of these ecosystems across the subcontinent (Russell 2009). Erosion of wetlands is widely viewed as being caused by mismanagement of the land by humans, including overgrazing, wetland drainage, burning, removal of vegetation for crop production as well as urbanisation in wetland catchments (Russell 2009). There has been very limited research into the subject of wetland erosion, or of the geomorphic processes that contribute to wetland formation and dynamics. This brief analysis presents some new findings related to wetland erosion, and attempts to examine the implications of these for the vulnerability of wetlands to erosion in the face of predicted climate change in the region.

SOUTHERN AFRICA IS SEMI-ARID

The climate of southern Africa is generally dry (Schulze 1997). There is a gradient of decreasing rainfall from east to west and from south to north, such that the highest rainfall is experienced along the eastern and southern coastlines, and the lowest rainfall occurs along the west coast and the north-western interior of the subcontinent (Figure 1).

Given the low rainfall that characterises the region, wetlands typically occur as features integrated within the drainage network. They typically receive groundwater inputs

FIGURE 1. Rainfall patterns in southern Africa showing the declining rainfall from the eastern and southern coastlines towards the west and north. (Note: Rainfall in mm per year). (Adapted from copyrighted figure from Ellery et al. 2008, permission received from Water Research Commission.)



1 Corresponding author contact: f.ellery@ru.ac.za; Geography Department, Rhodes University, Grahamstown, South Africa, 6140.

where they occur in the upper regions of watersheds, or fluvial inputs where they occur in mid- and lower-positions of watersheds. Wherever they occur, they are characterised by a near-horizontal cross-section and very gentle longitudinal slope that is typically less than 1% (Ellery et al. 2008).

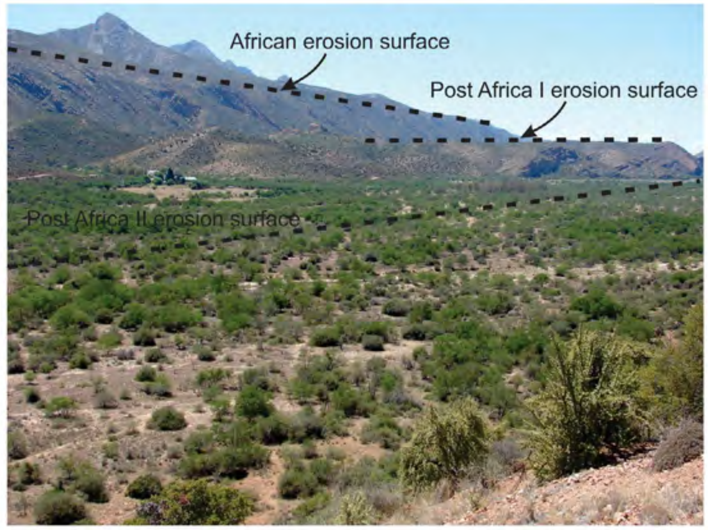
SOUTHERN AFRICA IS EROSIONAL DUE TO ITS GEOLOGICAL HISTORY

The high altitude of the subcontinent of southern and eastern Africa is anomalous on a global scale and results from two uplift events over the last 20 to 30 million years (Figure 2; Nyblade and Robinson 1994). The uplift events are thought to be the result of isostatic adjustment following the injection of heat into the crust by a hot mantle plume. Given that continental elevation results from a combination of the thickness of the crust and its density, the lowering of the density of the crust due to heating is proposed to explain the high elevation of a feature known as the "African Superswell." The first uplift event that happened 20 to 30 million years ago caused southern Africa to rise by about 150 m along the west coast and 250 to 300 m on the east coast. The second event caused the region to rise by approximately 150 m and 900 m on the west and east coasts, respectively. These events have led to the high elevation and gentle incline of the subcontinent from west to east (Figure 2).

It is worth stepping further back in time to appreciate what the surface of the subcontinent might have been like before these uplift events. The supercontinent of Gondwana, made up of India, Madagascar, Australia, Antarctica and South America (from east to west), broke apart around 150 million years ago. Following breakup, the African continent slowly eroded such that by about 30 million years ago the average elevation was approximately 300 to 400 m above sea level (Maud 2012). This land surface, known as the African Erosion Surface (Figure 2), was at an appropriate elevation for the available runoff such that erosion was negligible.

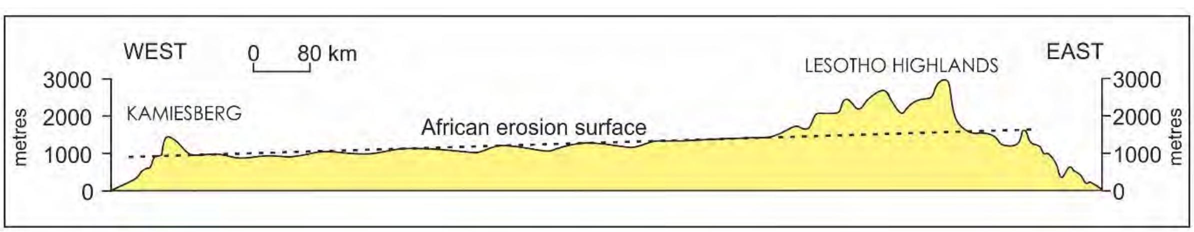
Following uplift and the associated lowering of sea level in relation to the southern African land mass, the subcontinent began eroding. Erosion was initially associated with streams incising into the pre-existing land surface, a process known as downcutting, which undoubtedly led to the loss of many wetlands that existed before the uplift events. Downcutting is followed by valley widening.

FIGURE 3. Evidence of uplift events recorded in many modern landscapes such as the Baviaanskloof valley in the Cape Fold Mountains of the Eastern Cape, South Africa. (Photo: Fred Ellery.)



These uplift events are written into the landscape that we see today. The Baviaanskloof valley in the Cape Fold Mountains of the Eastern Cape clearly shows the geomorphic history of the subcontinent as a result of the way that streams respond to uplift events (Figure 3). Before the first uplift event, the floor of the valley would have been at an elevation appropriate for sea level at the time. This surface, which is preserved in the landscape, is the African Erosion Surface. There is strong evidence on this erosion surface in the form of siliceous root casts preserved in sediments that a wetland existed here prior to the first uplift event. At an elevation about 150 m lower than the African Erosion Surface is a second erosion surface that formed between the first and second uplift events, known as the Post-Africa I Erosion Surface. The current valley floor (Post-Africa II Erosion Surface), which is about 100 m lower, is at an elevation that allows it to slope very gently (0.7 %) towards the Indian Ocean.

FIGURE 2. Cross-section of South Africa showing the gently-sloping interior plateau of the subcontinent that occurs at an average elevation greater than 1 000 m above sea level. (Adapted from copyrighted figure from Partridge and Maud 1987, permission received from Geological Society of South Africa.)



Given that erosion is the dominant geomorphic process in southern Africa and that downcutting generally leads to wetland degradation in the short- to medium-term, it is surprising that southern Africa supports a wide diversity of wetlands in regions at altitudes of 1000 m or more. Examples include the Nyl River floodplain, the Klip River floodplain, and floodplains in the foothills of the Drakensberg Mountains (Rogers 1997).

LEARINING ABOUT WETLAND GEOMORPHIC PROCESSES FROM THE WETLAND LONGITUDINAL SLOPE

Given that streams work through erosion and deposition to achieve a longitudinal slope that is appropriate for their discharge (Ellery et al. 2008), it is useful to plot the longitudinal slope of valley-bottom wetlands in relation to their size (Figure 4). There is a clear negative relationship between longitudinal slope and wetland size such that small wetlands typically have a high slope and larger ones have less slope. It is not difficult to argue that wetland size is a surrogate for mean annual discharge, such that large wetlands are likely to require a large amount of water to flood, but small ones are inundated by a small discharge. Valley-bottom wetlands varied from about 10 ha and reached a size up to about 1 000 ha.

Figures 5 and 6 show examples of valley-bottom wetlands that had either been incised by gully erosion (Figure 5) or that had not been incised (Figure 6). In many cases, gullying had been very recent, while in others, gullies had been present from the time of the earliest aerial photography in about the 1930s. While the formation of gullies is generally attributed to human impacts, in most cases in this study, it was not possible to attribute gully formation to human activities in the catchment or the wetland, with any degree of certainty.

It is clear from Figure 4 that those wetlands with a high slope for their size were gullied, while those wetlands with a low slope for their size were not gullied. The line on the figure separating gullied and non-gullied wetlands represents a threshold slope, such that steepening of a valley through processes such as deposition, can lead to the initiation of erosion. Given that wetland size is a surrogate for runoff, it also suggests that hardening of surfaces in a catchment such as through urban development, may lead to the initiation of gullies.

A recent study in the Krom River wetland in the Cape Fold Mountains near Joubertina in the Eastern Cape Province, attempted to explain the reason for the presence of a broad wetland with a near-horizontal cross section and very gentle longitudinal slope (<1 %), nestled within the Cape Fold Mountains (Figure 7). The wetland is dominated by *Prionium seratum* (Figure 8), which is a robust perennial palm-like plant named “palmiet” by early Dutch settlers in the Western Cape as they were not sure whether it was a palm or a reed (Dutch = “riet”).

FIGURE 4. The relationship between the longitudinal slope of valley-bottom wetlands in South Africa. The red circles represent wetlands that have erosion gullies present, while the wetlands that do not have erosion gullies are indicated by green circles. (Adapted from copyrighted figure from Ellery et al. 2008, permission received from Water Research Commission.)

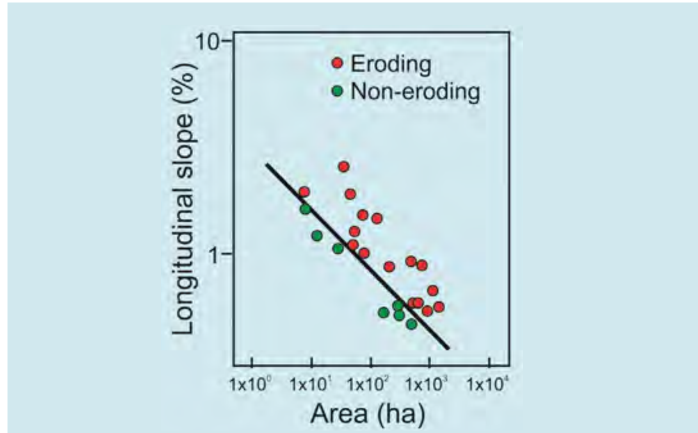
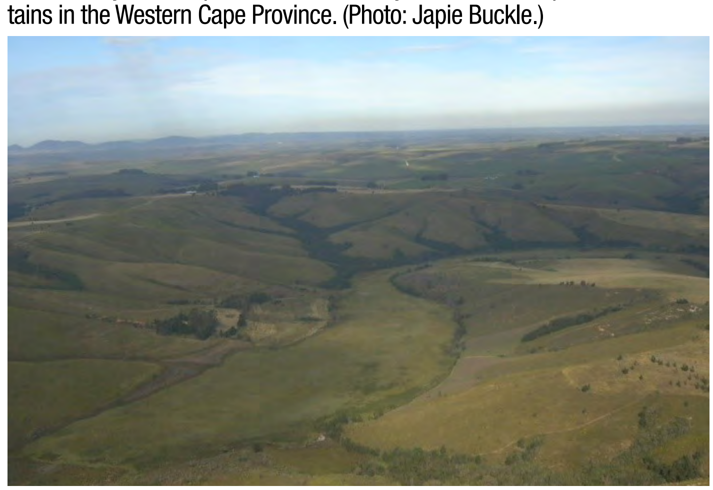


FIGURE 5. A recently formed erosion gully in a tributary of the Goukou wetland near Riversdal in the Western Cape Province, South Africa. A person standing in the image (center) provides a sense of the scale of the erosion of this remarkable peatland. (Photo: Fred Ellery.)

FIGURE 6. An aerial image of the head of the Goukou wetland, an unchannelled valley-bottom peatland immediately south of the Cape Fold Mountains in the Western Cape Province. (Photo: Japie Buckle.)



Cores were taken through valley-fill sediments (Figure 9a) in order to examine stratigraphy and the cross-sectional form of bedrock across the valley floor. Many cores could not reach bedrock due to the presence of a sand layer that collapsed and limited coring depth (Figure 9a, yellow dots). These cores contained clastic and organic sediments to the depth of the sand layer (Figure 9b). A limited number of cores located gullies that were overgrown by floating entangled stems of palmiet (Figure 9a, red dots). These overgrown gullies were not visible from the ground or in high resolution aerial photography. Beneath the mat of palmiet, which could easily be penetrated by coring, water was found to occur to a depth just above bedrock (Figure 9c). Based on dating of organic sediment at the base of these cores, it is clear that they started filling with sediment as far back as about 7060 years BP, with several subsequent cycles of cutting and filling having been identified at 4770, 1290, and 470 BP (Pulley et al. 2018). These dates long precede settlement of the valley by European settlers, and demonstrate natural cycles of erosion that have led to valley widening and the creation of a valley with a gentle longitudinal slope of about 1%.

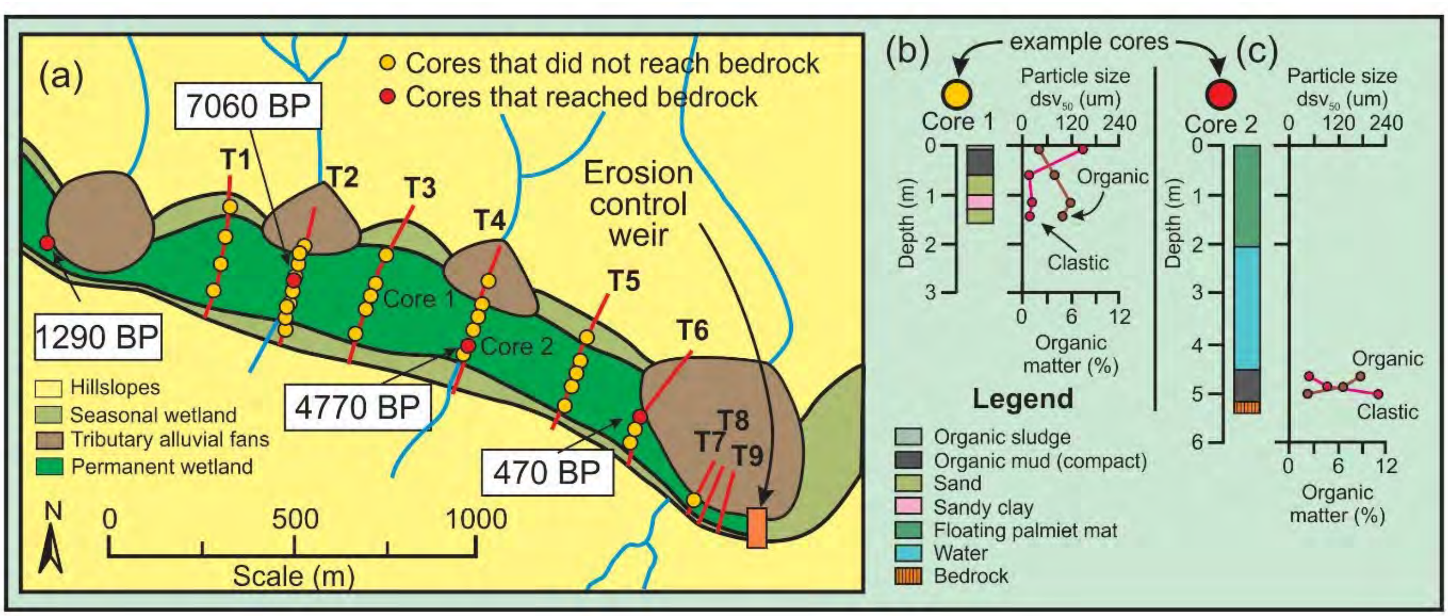
WETLAND VULNERABILITY TO EROSION IN RELATION TO PAST CLIMATE VARIABILITY

The Dome C Ice Core, taken by an international group of scientists working in Antarctica, reveals climate variability

FIGURE 7. The Krom River wetland with a near-horizontal cross-section and gentle longitudinal slope, situated in the Cape Fold Mountains of the Eastern Cape Province. (Photo: Fred Ellery.)

FIGURE 8. The Krom River wetland is dominated by the robust plant palmiet, (Prionium seratum) which has stems with a diameter of about 100 mm and grows to a height of 3.5 m. (Photo: Nancy Job.)

FIGURE 9. A series of cores taken to bedrock (red dots) and to a sand layer above bedrock (yellow dots) in a basin of the Krom River unchannelled valley-bottom wetland, Eastern Cape, South Africa. Core locations (a) and typical sedimentary fill are shown for cores that did not reach bedrock (b) and for those that did reach bedrock (c). The age of sediment (years before present) at the base of cores that reached bedrock is shown (a). (Adapted from copyrighted figure from Pulley et al. (2018), permission received from John Wiley and Sons.)



as indicated by variation in the concentration of deuterium (δD), a stable isotope of the hydrogen atom in water (EPICA community members 2004). A higher concentration of deuterium in the ice is related to higher ambient temperatures in the southern hemisphere. The core shows that the last 10,000 years have been very warm, but that over the last 800,000 years, temperatures were generally cooler than today (Figure 10a). The dust concentration in the ice is related to rainfall in the southern continents such that a high dust concentration suggests arid conditions (Figure 10b; Lambert et al. 2008). Temperature and dust concentration are inversely related suggesting that during warm periods the climate of southern continents appears wet, but during cool periods the climate appears dry. Consequently, we are currently experiencing a warm and wet phase of the Earth's climatic history.

Given that the prevailing climate from about 100,000 to about 10,000 years ago was cooler and drier than presently, we might expect wetlands to develop geomorphologically to a higher slope than the threshold slope that currently prevails in southern Africa. Increased rainfall and runoff associated with the warmer modern climate may be the reason that wetlands in the region are eroding to the extent that we currently witness (Ellery et al. 2008). Of the restoration work undertaken by the South African statutory agency Working for Wetlands, about 80-90% of the expenditure is on gully stabilisation and restoration. The geomorphic understanding that we have of wetland formation in South Africa suggests that this erosion may have been natural given long-term climate cycles.

HOW MIGHT WETLAND VULNERABILITY TO EROSION RESPOND TO PREDICTED CLIMATE CHANGE?

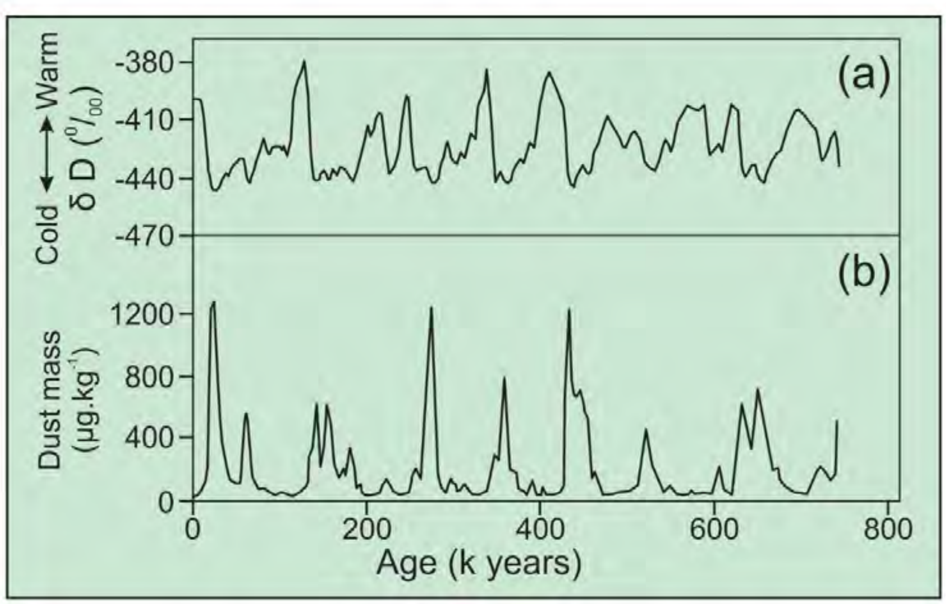
In contrast to what the past climate record shows, predictions for future climate in South Africa suggest a warmer and drier climate (Engelbrecht et al. 2015; Maúre et al. 2018). If this is the case, we might expect runoff to decline and therefore wetlands to be less vulnerable to erosion than is presently the case. The key factor is that the relationships described above are nonlinear because a drier climate will reduce the extent of wetlands, which might be viewed as a threat to wetland security. However, erosion is a much greater threat as it often leads to complete wetland destruction. Based on a better understanding of the geomorphology of South African wetlands, it is clear that predictions for future climate change in the region suggest a reduced risk of wetland erosion and therefore lower the impact of what is viewed as the single greatest threat to these ecosystems. While the extent of wetlands will be reduced as a result of declining water inputs, they are less likely to be completely destroyed through erosion. Therefore, although the extent of wetlands will decline in the face of reduced water inputs due to likely scenarios of climate change, wetlands are less likely to be destroyed through gully erosion than they are at present.

THE SIGNIFICANCE OF THIS UNDERSTANDING FOR CATCHMENT MANAGEMENT

An understanding of the role of geomorphology in wetland structure and functioning highlights the importance of improved catchment management in order to enhance wetland protection. Given that in Figure 4, area is a surrogate for runoff, land use changes in catchments that increase runoff may shift a wetland with a slope below the threshold of erosion to above the threshold, thereby resulting in gully erosion in the wetland that radically alters wetland hydrology due to lowering of the water table and widespread desiccation of the wetland.

In contrast to this scenario, if climate change decreases runoff from the catchment into the wetland, wetlands that are at risk of erosion or that have eroded under present climate conditions, may be restored naturally through reduced ability of the stream to transport sediment. Climate change may therefore reduce the risk of erosion in wetlands and promote increased sediment trapping, thus

FIGURE 10. The climate record of the last 750,000 years as shown by variation in the concentration of the stable hydrogen isotope, deuterium, in the Dome C ice core from Antarctica (a). Dust concentration (b) is inversely related to rainfall given that vegetation cover is related to rainfall and reduces aeolian dust transport. (Adapted from copyrighted figure from Lambert et al. 2008, permission received from Springer Nature.)



leading to wetland restoration through processes that are consistent with what wetland restoration efforts in South Africa attempt to achieve artificially. Understanding geomorphic processes in wetlands under different flow conditions thus supports wetland restoration efforts in South Africa. Given climate change predictions for the region, it is likely that wetland restoration efforts nationally will be more sustainable than at present.

CONCLUSION

It is also evident from our work that we need to better understand the geomorphology of wetlands if we are to answer questions about what might happen next under certain scenarios of change. A key issue is that wetlands have evolved geomorphologically to develop slopes that are very close to the geomorphic threshold slope for the current or past climate. We therefore need to think of the water that enters and flows through a wetland as shaping the morphology of the basin that hosts the wetland, as well as modifying soil biogeochemistry and therefore the biota that we find in a wetland. This seems a relatively unexplored frontier in our science, and it seems there are many opportunities for novel insights that allow us to better manage wetlands in the future. ■

REFERENCES

Ellery, W.N., M.C. Grenfell, S.E. Grenfell, D.C. Kotze, T.S. McCarthy, S. Tooth, P.L. Grundling, H. Beckedahl, D. le Maitre, and L. Ramsay. 2008. WET-Origins: Controls on the Distribution and Dynamics of Wetlands in South Africa. Water Research Commission, Pretoria. Report TT 334/09.

Engelbrecht, F., J. Adegoke, M-J. Bopape, M. Naidoo, R. Garland, M. Thatcher, J. McGregor, J. Katzfey, M. Werner, C. Ichoku and C. Gatebe. 2015. Projections of rapidly rising surface temperatures over Africa under low mitigation. *Environmental Research Letters* 10:085004. http://iopscience.iop.org/article/10.1088/1748-9326/10/8/085004/meta

EPICA community members. 2004. Eight glacial cycles from an Antarctic ice core. *Nature* 429:623-628. http://doi.org/10.1038/nature02599

Lambert, F., B. Delmonte, J.R. Petit, M. Bigler, P.R. Kaufmann, M.A. Hutterli, T.F. Stocker, U. Ruth, J.P. Steffensen and V. Maggi. 2008. Dust – climate couplings over the past 800 000 years from the EPICA Dome C ice core. *Nature* 429:623-628. https://www.nature.com/articles/nature06763

Maud, R.R. 2012. Macroscale geomorphic evolution. In: P.J. Holmes and M.E. Meadows (eds.), Southern African Geomorphology: Recent Trends and New Directions. Sun Press, Bloemfontein. pp. 7-21.

Maúre, G., I. Pinto, M. Ndebele-Murisa, M. Muthige, C. Lennard, G. Nikulin, A. Dosio and A. Meque. 2018. The southern African climate under 1.5 °C and 2 °C of global warming as simulated by CORDEX regional climate models. *Environmental Research Letters* 13: 1-6. http://iopscience.iop.org/article/10.1088/1748-9326/aab190

McCarthy, T.S. and B. Rubidge. 2005. The Story of Earth & Life: A Southern African Perspective on a 4.6 Billion-year Journey. Struik Publishers, Cape Town, SA.

Mitsch, W.L. and J.G. Gosselink. 2015. Wetlands, Fifth edition. John Wiley & Sons Inc., New Jersey, USA.

Nyblade, A.A. and S.W. Robinson. 1994. The African Superswell. *Geophysical Research Letters* 21:765–768.

Partridge T.C. and R.R. Maud. 1987. Geomorphic evolution of southern Africa since the Mesozoic. *South African Journal of Geology* 90:179-208.

Pulley, S., W.N. Ellery, J.V. Lagesse, P.K. Schlegel and S.J. McNamara. 2018. Gully erosion as a mechanism for wetland formation: An examination of two contrasting landscapes. *Land Degradation and Development* 29:1756-1767. DOI: 10.1002/ldr.2972

Rogers, K.H. 1997. Freshwater wetlands. In: R.M. Cowling, D.M. Richardson and S.M. Pierce (eds.). Vegetation of Southern Africa. Cambridge University Press, Cambridge, UK. pp. 322-347.

Russell, W. 2009. WET-RehabMethods: National Guidelines and Methods for Wetland Rehabilitation. Water Research Commission, Pretoria, SA. Report TT 341/09.

Schulze, R.E. 1997. South African Atlas of Agrohydrology and Climatology. Water Research Commission, Pretoria, SA. Report TT 82/96.

Tooth, S. and T.S. McCarthy. 2007. Wetlands in drylands: geomorphological and sedimentological characteristics, with emphasis on examples from southern Africa. *Progress in Physical Geography: Earth and Environment* 31:3-41. DOI: 10.1177/0309133307073879

Desert Wetland Ecosystems: Springs, Seeps and Irrigation

Paul J. DuBowy[1], Ecohydrology Associates LLC, Lovell, Wyoming

While walking through endless xeric shrublands in the Great Basin or far-western Great Plains many people may think they are stark, barren and devoid of water. John Wesley Powell, an early director of the U.S. Geological Survey, pointed out in an important 1878 government study that the defining characteristic of the Great Plains and the West was its lack of water and stated that much of the area would be uninhabitable without extensive systems of irrigation. The region is in the rain shadow of the North American Cordillera. To the north the area is typical cold desert –only 200-300 mm of annual precipitation with long, cold winters and short, hot summers; to the south long, protracted drought periods may be punctuated by rain events from the Pacific Ocean. Yet there are many natural and man-made water features throughout these regions that translate into important wetland ecosystems.

Before the early 1900s the only water sites in the region besides the large river systems (including the Colorado, Snake, Yellowstone and Rio Grande drainages) were meltwater streams originating high in the mountains and dotted with beaver ponds, and at lower elevations springs and ephemeral seeps where geologic faults brought water-bearing strata to the surface. The springs and seeps were pools or wet meadows, and the rivers and larger creeks were riparian corridors bracketed by cottonwood gallery forests with willows on the sandbars (Figure 1). Today it is hard to imagine a world with no Russian olive (*Elaeagnus angustifolia*) or salt cedar (*Tamarix* spp.). Water availability and mesic habitat were limited for native people and fauna. Away from those corridors was an endless tapestry of sagebrush (*Artemisia* spp.), creosote bush (*Larrea* spp.), rabbitbrush (*Chrysothamnus* spp.), and junipers (*Juniperus* spp.). The region has been reworked many times creating a patchwork mosaic of old and new wetland areas embedded in this dry environmental matrix.

FIGURE 1. Riparian corridor along the Green River in Dinosaur National Monument, Utah.

SPRINGS AND SEEPS

While climate across much of the west produces xeric environments, underlying aquifers and water bearing strata hold copious amounts of water potentially available to

1. Corresponding author contact: ecohydrology.associates@gmail.com. Note: All photos were taken by the author.

augment surface wetland ecosystems. Extensive geologic faulting brings these water bearing layers to the surface resulting in fracture springs and seeps (ciénegas). Many of these wetland sites are ephemeral, as groundwater is often the consequence of short-term snowmelt and long-term wet-dry cycles. In many locations in the West, seeps may be absent most years and only reappear after a lengthy period of time[2]. Some of these areas may be dry for so long that shrub-steppe habitat develops with the counter-intuitive result of sagebrush or cacti (Cactaceae) seemingly growing in water when the seep reappears (Figure 2).

For native people and early settlers, as well as wildlife, these springs and seeps were critical sites providing water for daily life as well as irrigation. For thousands of years, western tribes developed their own methods of living with the natural world and its limited water supply. Water, bodies of water and places of water, occur as characters and settings in many Native American mythologies and such sacred narratives remain for Native Americans fundamental to an understanding of the world. Water is, of course, portrayed as vital for physical survival and the source of much life-giving sustenance. Many of the animal and plants associated with these aquatic systems have gained prominence for Native American nations. Nearly all ancient sites of habitation are located adjacent to a spring or stream, and many sites are thought to have been abandoned due to shifts in climate or weather that resulted in these water sources being reduced or going dry (Figure 3).

Due to the rock strata through which the water passes, and occasionally geothermal activity, many western springs show high levels of carbonate or sodium but also of such elements as sulfur or metals leading to local names such as Thermopolis or Mineral Wells. William (Buffalo Bill) Cody, an early proponent of tourism in Yellowstone National Park went so far as to change the name of the Wyoming canyon which serves as the eastern entrance to the park from the "Stinking Water" to Shoshone River. A visit to Coulter's Hell, a sulfurous geothermal spring along the river on the west side of Cody, Wyoming helps recall the reason for the original name. Because of their water chemistries and isolated locations these springs often exhibit endemism – species unique to those springs or regions. Perhaps the most studied spring in the southwest, Montezuma Well in Arizona produces a nearly constant daily 5.7 million liters of water with high levels of carbonate and arsenic. It is home to five endemic species – a diatom, snail, water scorpion, amphipod and predaceous leech – the most endemic species of any spring in the desert southwest (Figure 4). In some locations hot springs can be important desert refugia for rare aquatic species, such as pupfish (Cyprinodontidae).

FIGURE 2. Ephemeral seep in Bighorn Canyon National Recreation Area (Wyoming) has only flowed a few times in the past 50 years. Sagebrush standing in water attests to the fact the site is usually dry.

IRRIGATION

Since European settlement, additional water areas have been developed across the Great Basin. While human-constructed for water supply and irrigation, they also have the additional benefit of attracting wildlife and becoming birding hotspots. The large rivers now have dams and lakes/reservoirs, such as Lakes Mead and Powell, and Buffalo Bill and Elephant Butte Reservoirs, for water supply, flood control, and recreation. Together with smaller reservoirs and check dams along the rivers these large reservoirs provide the water for the extensive irrigation projects first started by Mormon pioneers and later expanded by the U.S. Bureau of Reclamation. In a satellite view of the Great Basin it is easy to detect the green swaths of agricultural land along each river (Figure 5).

The irrigation projects have additional reservoirs constructed to regulate the flows of water or to capture return drain water. Leaching of alkali from the soil often produces a ring of white crust around these areas. Many sites are characterized by hard-stem bulrush (*Schoenoplectus* spp.), branchiopods such as tadpole shrimp (Notostraca) and shore and brine flies (Ephydridae) and attract alkaline-loving birds including white pelicans (*Pelecanus erythrorhynchos*), western and eared grebes (*Aechmophorus occidentalis*, *Podiceps nigricollis*), California gulls (*Larus californicus*), ruddy ducks (*Oxyura jamaicensis*), and yellow-headed blackbirds (*Xanthocephalus xanthocephalus*). Some people may find the alkali deposits unattractive, but their biogeochemistry is an important factor for many waterbird species. Likewise, the green patches of irrigated pasture and hayland that mimic herbaceous vegetation in

2. These wetlands may not meet the proposed definition of "waters of the United States" (https://www.epa.gov/newsreleases/epa-and-army-propose-new-waters-united-states-definition) and may lose any protection they now enjoy under current federal wetland regulations.

FIGURE 3A. Spring at El Morro National Monument (New Mexico) shows evidence of Native American, Spanish and pioneer use for centuries.

FIGURE 3B. Adjacent to the spring are hundreds of petroglyphs and inscriptions. “On the 25th of the month of June, of this year of 1709, passed through here on the way to Zuni. Ramón García Jurado”

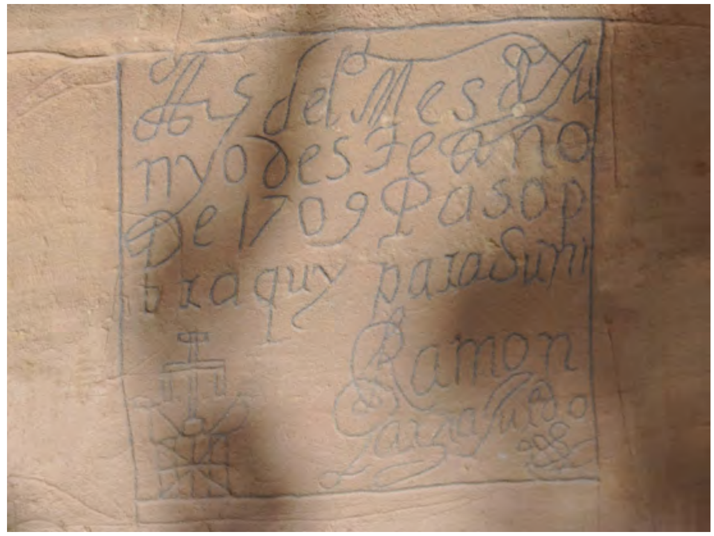


FIGURE 4. Montezuma Well (Montezuma Castle National Monument, Arizona), a natural limestone sinkhole. The site is still considered sacred by local tribes.

FIGURE 5. Irrigated land contrasts sharply with xeric native habitat along the Snake River in Idaho.

seeps are attractive to many wildlife species. Two animals that have responded favorably to this new agrohabitat are Pronghorn (*Antilocapra americana*) and Sandhill cranes (*Grus canadensis*) that use alfalfa and fallow fields to forage on vegetation or invertebrates.

Some irrigation water is purposed specifically for wetland habitat creation. An area that I visit on a regular basis is the Yellowtail Wildlife Habitat Management Area near Lovell, Wyoming. Much of the area is managed for upland habitat and species, but there are also several important created water areas which use irrigation water from the Shoshone Project (Figure 6). Thousands of waterbirds and shorebirds utilize the area, especially during migration, and muskrats (*Ondatra zibethicus*) and mink (*Neovison vison*) are abundant. Four species of concern are frequently seen or heard in these wetland areas: Virginia rail (*Rallus limicola*), sora (*Porzana carolina*), black-crowned night-heron (*Nycticorax nycticorax*) and American bittern (*Botaurus lentiginosus*). Broods of rail chicks have been observed during summer. I have also watched thousands of blackbirds and starlings (*Sturnus vulgaris*) come in to roost in the wetlands at dusk in early winter.

Important municipal sites also utilize irrigation water. Parks and golf courses often have ponds –“water hazards” in golf parlance – incorporated into the layout of the area. In many locations geese have prospered so well as to cause a nuisance in these sites. Most cities and towns in the basin have sewage treatment ponds somewhere removed from

FIGURE 6. Created wetland at Yellowtail Wildlife Habitat Management Area (Wyoming) utilizes water from the federal Shoshone Irrigation Project, the first large-scale irrigation effort in the western United States.

the town proper, Sewage is a nutrient soup that promotes phytoplankton growth which in turn supports high populations of zooplankton, e.g., water fleas (*Daphnia)* and other macroinvertebrates. Since the effluent is relatively warm and often aerated, the ponds can remain ice-free longer in winter than many nearby waters. Like alkaline lakes similar species respond to these habitats. At some treatment ponds northern shovelers (*Anas clypeata*) can be found in large numbers, and American avocets (*Recurvirostra americana*), black-necked stilts (*Himantopus mexicanus*) and Wilson's phalaropes (*Phalaropus tricolor*) may often be seen. Many other waterbird species can also be observed. It may not be "pristine" wildlife habitat, but do not discount the importance of these wetland areas.

I do not mean to imply that created wetlands could ever provide all the functions and values of natural ecosystems. Many people decry the global changes brought about by human manipulation and alteration, but we need to take the good with the bad. While the Great Basin has been modified by people for the past 100+ years, these changes have also benefitted many wildlife species to the enjoyment of birders and outdoor enthusiasts. ■

Using Landscape-Level Wetland Assessment to Aid in Local Management of Wetlands for Lake County, Illinois

Juli E. Crane[1], Glenn H. Westman, and Michael E. Prusila, Lake County Stormwater Management Commission, Libertyville, IL

INTRODUCTION

The Lake County Stormwater Management Commission (SMC) is a planning and regulatory agency that coordinates stormwater management activities on a county-wide basis. The SMC staff provide technical assistance, local knowledge and problem-solving skills to coordinate the stormwater activities of over 50 local jurisdictions to enhance water quality, reduce flood damages, mitigate flood hazards, and restore/enhance the natural drainage system. Wetlands are an important, natural component of the county's stormwater management system. On August 14, 2001, Lake County amended its Watershed Development Ordinance (WDO) to regulate development of isolated waters and wetlands. The amendment was in response to the Supreme Court's January 9, 2001, decision in *Solid Waste Agency of Northern Cook County v. U.S. Army Corps of Engineers* that most isolated waters and wetlands could no longer be regulated under the federal Clean Water Act. "Isolated Waters of Lake County" (IWLC) are defined as "All waters such as lakes, ponds, streams (including intermittent streams), farmed wetlands, and wetlands that are not under U. S. Army Corps of Engineers jurisdiction" (WDO, as amended 2015, Appendix A).

Suloway and Hubbell (1994) estimate that Lake County has lost 40 to 50 percent of the wetlands that existed prior to European settlement; losses primarily were due to drainage for agriculture and conversion to urban land uses. Isolated wetlands and waters account for approximately 44 percent of waters and wetlands within the county by number and comprise about 15 percent of its total land area (SMC unpublished GIS data). In comparison, the Illinois Department of Natural Resources (Levin et al. 2002) estimates that isolated wetlands comprise about 12 percent of the state's wetland resources. The loss of wetlands and the important functions they provide have resulted in a higher risk of flooding, surface water quality degradation, and wildlife habitat deterioration. Recognizing these losses, Lake County has adopted a "no net loss" wetland policy and set a goal for a "net gain" of wetland function (WDO, as amended 2015). How does an agency, community or even individual landowner decide the best place(s) to restore or preserve wetlands as a means toward achieving the "no-net-loss" policy and objective of a "net gain" of wetland function? With funding support from a U.S. Environmental Protection Agency Wetland Program Development Grant (WPDG), the Lake County Wetland Restoration and Preservation Plan (the "WRAPP") is a county-wide planning effort to help address that question. The goal of the WRAPP is to provide a wide audience of end-users with decision-making support to help prioritize wetland restoration and preservation efforts. A major component of doing this is to predict wetland and water body functionality.

The WRAPP identifies the type and functions (services) of mapped wetland and water resources in Lake County for both existing and pre-settlement conditions. It also identifies locations of potentially restorable wetlands (PRWs) and will include an on-line decision support tool (DST) to help users prioritize restoration and preservation opportunities based on acreage, wetland function or functional loss. This will allow the user to make informed decisions on wetland restoration and preservation options targeted to user-specific goals and objectives. The SMC is using a landscape-level assessment approach in a county-wide WRAPP to help local governments manage the county's wetlands.

In this article, we use several terms that may have been defined differently by others. For our WRAPP, "restoration" refers to the re-establishment of wetlands in areas where they previously existed but were altered by drainage activities or landscape modifications. "Preservation" refers to actions taken to maintain the size and functions of an existing wetland or water body. "Wetland function" is a general term referring to the various services that wetlands provide, for example, wetlands can store flood water, protect and enhance water quality, provide fish and wildlife habitat, and provide recreational opportunities and aesthetic benefits for communities. "Functional assessment" determines the functions (services) a wetland (or water body) provides and predicts or measures how well it performs each function.

SUBJECT AREA

Located in the northeast corner of Illinois, Lake County is bordered by Cook County on the south; McHenry County on the west; Kenosha County, Wisconsin, on the north; and

1. Corresponding author contact: JCrane@lakecountyil.gov.

Lake Michigan on the east. The county covers approximately 301,435 acres or about 471 square miles (not including Lake Michigan water surface area) (Calsyn 2005). Geographically, Lake County drains via four major watersheds (Figure 1). Historically rich in wetlands left behind when the last glaciers retreated about 10,000 years ago, the SMC WRAPP Geographic Information System (WRAPP-GIS) data estimates, based on the large extent of mapped hydric soils, that 96,700 acres (32% of the county) were wetlands and waters prior to European settlement in the early 1800s. The WRAAPP-GIS data indicates that approximately 59,730 acres are presently wetlands and waters, representing about 20 percent of the county's landscape.

DEVELOPING A COUNTY-WIDE WETLAND RESTORATION AND PRESERVATION PLAN

Because a major objective of the WRAPP is to predict wetland and water body functionality, various supporting characteristics needed to be added to the County's existing wetland and water body database. SMC assessed functions of wetlands and water bodies using a five-step process.

Step 1: Enhance the existing Lake County Geographic Information System (GIS) database to refine wetland and water body shapes (polygons) and develop a pre-settlement (i.e., historic) database.

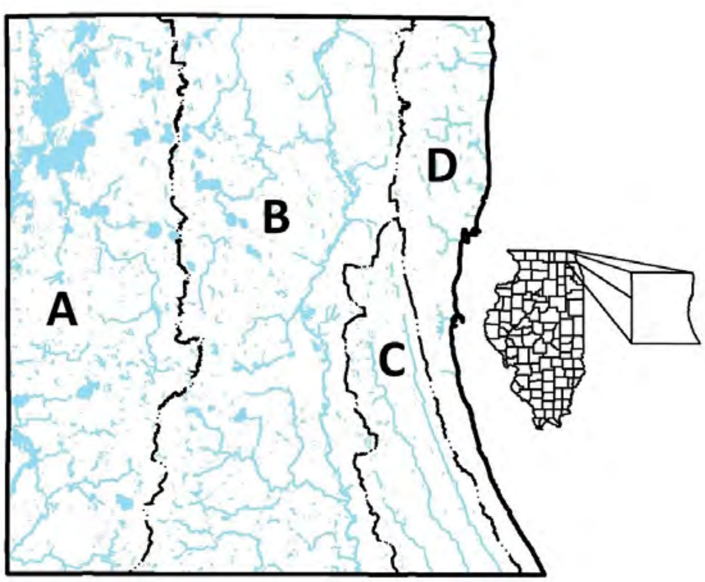
Step 2: Encode each existing and historic wetland and water body using nationally-accepted methods and standards for basic classification attributes (i.e., system, class, subclass, water regime, and special modifiers per the Federal Geographic Data Committee 2013) and hydrogeomorphic attributes related to landscape position, landform, water body type, and water movement. Combined, these classification attributes greatly expand the functionality of the wetlands database, creating an "enhanced" county-wide wetland and water body inventory.

Step 3: Develop preliminary criteria for determining the functionality of wetlands and water bodies using GIS-based data and qualitatively rate the level to which each class provides the given function (i.e., high, moderate, low, or not applicable).

Step 4: Conduct field studies of representative wetlands/water bodies to verify assumptions on the preliminary functional assessments and refine the functional ratings developed in Step 3.

Step 5: Perform a GIS-based assessment of the refined functions (flood water storage, water quality enhancement, wildlife habitat, etc.) for each wetland and water body in the existing and historic databases.

FIGURE 1. Major watersheds in Lake County, Illinois: (A) Fox River, (B) Des Plaines River, (C) North Branch Chicago River, and (D) Lake Michigan.



Technical Advisory Group

To increase the accuracy and relevance of the WRAPP, SMC assembled a 13-member Technical Advisory Group (TAG) comprised of local and regional wetland professionals, engineers, planners, and cartographers (e.g., Illinois-based specialists in the fields of wetland science, hydrology, water quality, soil science, biology/ecology, and information technology/GIS) who voluntarily provided local and regional expert advice and technical guidance during all phases of the WRAPP planning effort.

The TAG involvement included the following tasks achieved through a series of office meetings and field studies:

- Identification of potential end users of the WRAPP and guidance on plan development to meet user needs;
- Input on wetland/water body classification using Hydrogeomorphic (HGM) descriptors and National Wetlands Inventory (NWI) attributes;
- Selection of wetland/water body functions to be assessed;
- Review and tailoring correlations for functional assessment criteria and associated significance ratings to local conditions in Lake County;
- Selection of representative wetland and water body types (e.g., emergent, forested, lake, stream, etc.) for field study;
- Input on the field methodology developed specifically for assessment of various functions in the selected representative wetlands; and
- Input on design and implementation of the on-line decision support tool.

Update and Enhance GIS Datasets
Early in the process, SMC decided to use the best GIS data available for the WRAPP, as that would be important when evaluating functional capabilities. WRAPP development involved aggregating existing geographic data and incorporating additional data sources into the GIS, as practicable.

Existing Wetland Mapping. For the WRAPP, SMC generated a county-wide inventory of existing wetlands and water bodies, termed the Existing Wetland Inventory for Lake County (EWI-LC), using the pre-existing Lake County Wetland Inventory (LCWI) as a base. The LCWI, originally developed in 1992 and updated in 2002, mapped wetlands and water bodies within the county in greater detail than the NWI mapping (i.e., LCWI at map scale 1:12,000 vs. NWI at 1:24,000). The impetus for the original LCWI was the under-representation of Lake County wetlands in the NWI. By way of comparison, the LCWI contains roughly twice the number of wetland and water body polygons as the NWI mapping.

Using the LCWI as a base, SMC captured additional changes in wetland and water body coverage from 2002 through 2015. This primarily involved removing developed wetland areas and adding areas that may support wetlands. Figure 2 reflects a representative sequence of the process of wetland polygon mapping and enhancement. The 2002 LCWI polygon "base" layer (A) was overlaid with the Lake County "building and edge of pavement planimetric" layer (B). Areas of intersection (C) were used to flag potential areas for wetland polygon enhancement (D) for the EWI-LC. For a limited number of sites where existing data were unclear or uncertain, SMC staff conducted field inspections to confirm wetland presence. While the EWI-LC provides an outstanding county-wide base layer for the WRAPP, it is not a comprehen-

FIGURE 2. Polygon mapping and enhancement process: (A) base wetland layer (2002 LCWI mapping), (B) planimetric layer, (C) overlay of planimetric layer (red) on base wetland layer, and (D) EWI-LC wetland mapping reflecting wetlands remaining post-development as of 2014.

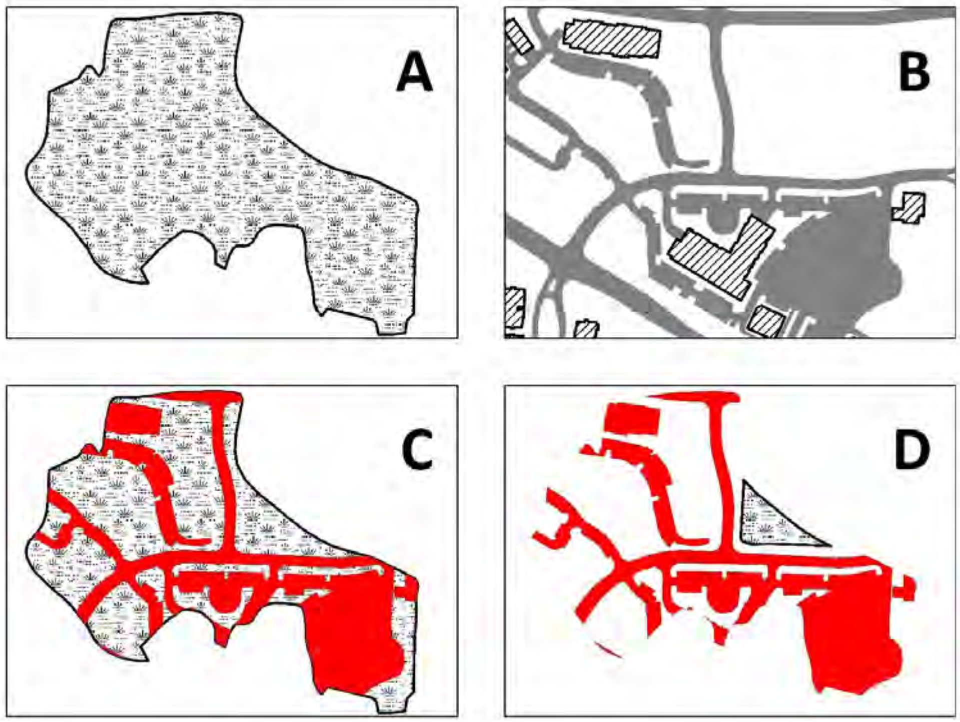
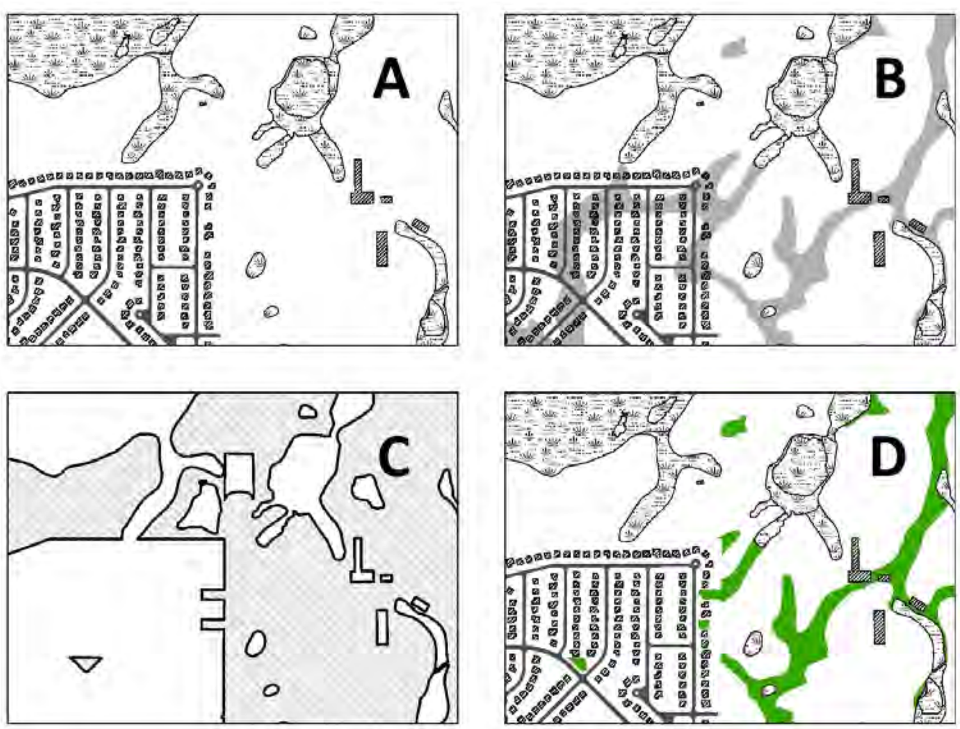


FIGURE 3. Potentially restorable wetlands (PRW) mapping process (representative sequence): (A) mapped EWI-LC and developed footprint, (B) HWI-LC areas not already mapped as wetland (gray), (C) locations not suited to potential wetland restoration (white), and (D) PRW sites (green).



sive wetland mapping effort and should not be construed as a substitute for site-specific wetland delineations required for regulatory permitting purposes.

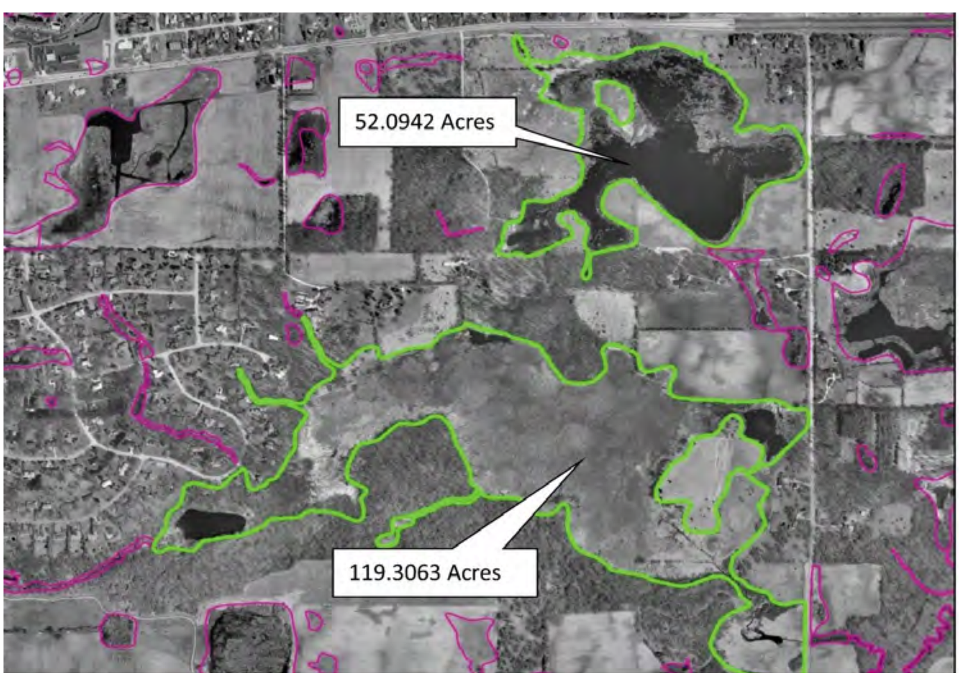
Historic Wetland Mapping. SMC also mapped historic wetlands—those present prior to European settlement of the county. The database for historic wetlands of Lake County (HWI-LC) is based on 1) soil survey data from the USDA Natural Resource Conservation Service (NRCS), 2) historic vegetation information derived from Government Land Office Survey (GLO) plat maps created between 1832 and 1840 (Bowles and McBride 2005; LCGIS 2003; Moran 1978) and local Lake County Forest Preserve mapping (Westerman not dated), and 3) USGS topographic maps from the early 1900s. The soils data were relied upon more heavily, with the historic vegetation and topographic maps used to address gaps in the classification of wetland type. Recognizing that interpretation of source data involved various assumptions, the HWI-LC dataset reflects a best-approximation of wetland presence and extent in pre-settlement times.

Potentially Restorable Wetlands. Potentially restorable wetlands (PRWs) refer to those areas with predominantly wet soils (i.e., USDA hydric soil units) that were not mapped as wetlands on the LCWI as updated in 2002 and have not been converted to urban land use. Figure 3 shows a representative sequence of the process of mapping PRWs. Starting with the EWI-LC polygons and land use layers, SMC added HWI-LC polygons, then clipped out areas not suited to potential wetland restoration to filter the HWI-LC layer and identify PRW sites. Most of the county's PRWs occur on land drained by subsurface tiles or surface ditches for agricultural purposes.

Classification. The updated 2002 LCWI only reflects coarse distinctions between wetland types: artificial wetlands, farmed wetlands, and wetland (Figure 4). The LCWI dataset provides no information on the classification, hydrogeomorphology, or function of each wetland polygon. What is the structural composition of wetlands? What is their hydrologic regime? What functions do the wetlands perform and at what level of performance? To answer those and other questions required enhancement of the datasets.

SMC classified all LCWI polygons using both the Cowardin classification system and hydrogeomorphic descriptors. The process began by "starting with what you know"—correlating the classifications from the NWI maps and data from the *Advanced Identification Study (ADID) for Lake County, Illinois* (Dreher et al. 1992) with the county's wetland/water body polygons and filling in any remaining 'gaps.' The ADID study identified 203 high-quality wetland sites and commented that "[t]he diverse ecosystems within wetlands offer necessary habitat for wildlife and plant communities, including many threatened and endangered species. Wetlands in the county are critical in controlling flooding, and in protecting hydrologic cycle functions such as groundwater recharge, flow attenuation, and maintenance of baseflows."

FIGURE 4. Example of wetlands from the 2002 Lake County Wetland Inventory. The two polygons outlined in green are clearly different, with each being mapped in hydric soils based on soil survey data (Paschke and Alexander 1970; Calsyn 2005). However, the LCWI dataset only reflects a size difference. Looking at the aerial image, one sees distinct physical differences between the two polygons. Most notably, the lower polygon has more vegetation coverage than the upper polygon, which has a greater component of open water.



The SMC classified each historic and existing wetland (or water body) polygon according to the U.S. Fish and Wildlife Service's official classification system for wetlands and deepwater habitats (FGDC 2013, adapted from Cowardin et al. 1979). For each polygon, SMC expanded on the Cowardin descriptors by adding hydrogeomorphic descriptors for landscape position, landform, water flow path, and waterbody type ("LLWW descriptors" from Tiner 2011a) that focus on abiotic properties that are key to predicting wetland functions. To do this, SMC interpreted available map information, consulted aerial photographs, and, in some cases, conducted field checks.

TABLE 1. Summary of Functions Assessed for the WRAPP.

Carbon Sequestration The ability of a wetland to store carbon and help reduce greenhouse gases, slowing climate change. Wetlands with deep organic soils (not ditched, drained, or farmed) support this function at a high level, as do areas of aquatic bed. Woody wetlands (e.g., forested, scrub-shrub, and mixes of those types) that are flooded or saturated seasonally or longer also have high functionality as woody plants can store a large mass of carbon above-ground.
Flood Water Storage The ability of a wetland or water body to store water and delay downstream flooding and/or lower flood heights, which helps minimize flood-related injury and property damage. Except for slope wetlands located outside of mapped flood hazard areas (e.g., seeps/springs on ravines), most wetlands perform this function to some degree.
Native Fish Habitat* Wetlands and water bodies in this category are predicted to provide spawning, nursery, foraging, refuge and/or cover habitat for at least some portion of the native Lake County fishes' life cycle during most or all years.
Nutrient Transformation (P-focus*) This function relates to the transformation of phosphorus (P), as this is the limiting nutrient for many water quality concerns within Lake County. All wetlands perform this function to some degree, and size is not a factor in the ability to perform the function, although it is a factor in the degree, as larger wetlands typically have greater capacity. Vegetated wetlands on the wetter end of the spectrum (e.g., flooded seasonally or longer) perform this function at a high level.
Sediment and Other Particulate Retention The ability of a wetland or water body to retain sediment that would otherwise move downstream and build up in rivers, streams, lakes, or ponds. This function supports improved water quality by capturing sediment particles and any nutrients or heavy metals bonded to them. All wetlands perform this function to some degree; however, vegetation is a key factor to higher functionality because plants slow the water down, which allows sediment to settle out. Water depth also is a key factor.
Shoreline/Streambank Stabilization The ability of wetlands to protect shorelines from erosion by wave action and cutting by stream currents. Vegetation and width of the flanking wetland are primary characteristics for a high rating, with wider bands of vegetation providing more protection than narrower bands.
Stream Baseflow Maintenance The ability of a wetland or water body to source water that sustains base flow levels in streams. This function is especially critical during dry periods and is an important aspect in supporting aquatic life.
Stream Shading High vegetation along streams and rivers can provide shading, which helps regulate the water temperature. Cooler water temperatures decrease the solubility of many chemicals, which reduces the toxic stress on aquatic organisms and increases the significance of the fish and amphibian habitat wetland functions. Forested or scrub-shrub headwater wetlands and forested wetlands within 50 feet of streams or rivers provide this function at the highest level.
Unique Wetland Resources Wetlands and water bodies identified in this category are considered unique on a global (e.g., RAMSAR), state or local level. They perform biological and/or stormwater management functions at an exceptional level. Many of these wetlands/water bodies contain a wide variety of fauna and flora, including threatened or endangered species in some locations.
Waterfowl Habitat The ability of a wetland or water body to provide habitat for waterfowl (e.g., ducks, geese, swans). Wetlands designated as important for waterfowl are generally those used for nesting, feeding or reproduction.
Wetland-Dependent Bird Habitat, Other This function attempts to capture the wetland types and water bodies that provide desired habitat for a variety of wading birds, shorebirds and songbirds (e.g., herons, bitterns, sandpipers, yellow-headed blackbirds). Aquatic beds, island wetlands, and emergent and scrub-shrub wetlands that are seasonally to semi-permanently flooded or are intermittently exposed provide this function at a high level for a wide diversity of bird species that nest, feed and reproduce in these wetland types.
Wildlife Movement Corridors* This function emphasizes connectivity that enables movement of mammals, birds, and insects between wetland environments, so accessibility and proximity are key. Vegetated corridors increase a wetland's ability to provide habitat because a larger pool of species can access and use the wetland.
Woodland Amphibian Habitat* This function assesses a wetland's suitability to provide breeding habitat specifically for woodland amphibians (e.g., spotted salamanders, wood frog). In general, rankings are based on wetland size (2-acre threshold), wetland type, presence/absence of predators, and proximity to other wetlands on the local landscape.
***** Denotes functional assessments unique to the Lake County WRAPP.

Develop Criteria for Identifying Wetland Significance for Functions

The WRAPP evaluated 13 functions as summarized in Table 1. By reviewing the literature (Fizzell 2007; MDEQ 2011; Miller et al. 2012; PGE 2014; Tetra Tech 2015; Tiner 2003, 2011b; Tiner et al. 2014) and working with the TAG, the SMC developed correlations to link attributes in the enhanced GIS database to various functions and identify relative significance of performance: high, moderate, low, or not applicable.

S*ignificance* refers to the relative degree to which a mapped wetland/water body polygon performs the indicated function compared to other mapped polygons. As stated by Tetra Tech (2015), "[t]hese rankings are not related to the perceived human value of a wetland function or its benefit to the watershed…. Functional *significance* is only meant as a method to classify and rank wetlands for their ability to perform natural processes. The human *value* of the wetland function and the ecological services that it provides is determined by the goals of regulators and watershed planners."

Produce Desktop Assessment for Field Review

After developing the criteria for identify wetlands of significance for different functions, SMC conducted a preliminary assessment of wetland and water body functions for the county. This primarily was a desktop exercise using GIS to qualitatively determine the level to which each wetland or water body polygon performed the various functions based on the correlations.

Field Refinement

SMC conducted field studies on various wetland and waterbody types and used those observations to inform and refine the preliminary functional correlations. SMC worked with the TAG to develop a Wetland Field Check Protocol specifically for the WRAPP and select representative wetland and water body study sites. Assessed sites included a cross-section of wetland/water body types, with emphasis placed on the types with the highest percentage of occurrence in each watershed based on the GIS analysis. The sites selected were located on publicly owned land to allow for easier site access and because of the higher potential for representative sites on public lands to be in a more natural, undisturbed condition than sites on privately owned lands. Each field review had a minimum of two assessors, with at least one person on the team able to identify dominant plant species, understand common wetland plant communities, and basic hydrologic processes affecting wetlands and waters in the Midwest Region, and be acquainted with biological aspects of the aquatic environment (i.e., wildlife habitat).

A total of 48 field sites were reviewed (Figure 5) during the growing season (typically May through October). The number of sites per watershed was roughly proportional to the number of polygons in the watershed and were selected using a randomization process: Lake Michigan (7), North Branch Chicago River (6), Fox River (14), and Des Plaines River (21).

For each field site, data were recorded on a Wetland Field Check Data Form (see Figure 6). The field check form addressed two main objectives for the WRAPP: 1) to ground-truth the mapped wetland polygon boundaries and NWI and LLWW classification codes and 2) to review and refine the preliminary wetland functional assessment criteria developed by TAG for each of the 13 selected functions. At least one photograph was taken of the site depicting typical features. The field check process ranged from 30 minutes to 2 hours per site.

SMC refined and adjusted the functional assessment rating criteria based on comments in Section 4 of the field form, as warranted. Most changes proposed to the selection criteria document based on field refinement fell into two types of non-substantive changes: 1) changes to the narrative criteria for clarification and consistency and 2) changes to the "Classification Codes" column to ensure selection of polygons in the GIS mirrors the narrative criteria. For example, the following NWI water regimes were added, where appropriate, throughout the selection criteria based on field comments related to the presence of these regimes: seasonally saturated ("B"), continuously saturated ("D"), and seasonally flooded/saturated ("E"). These regimes apply primarily to slope (seep), bog, and fen types. While such wetland types represent a small portion of the polygons in the LCWI, these hydrologic regimes are important for predicting functional significance. Using the refined criteria, SMC performed a final GIS desktop exercise to assign functional assessment ratings to each existing and pre-settlement wetland and water body.

FIGURE 5. Lake County WRAPP field site locations (indicated by black dots).

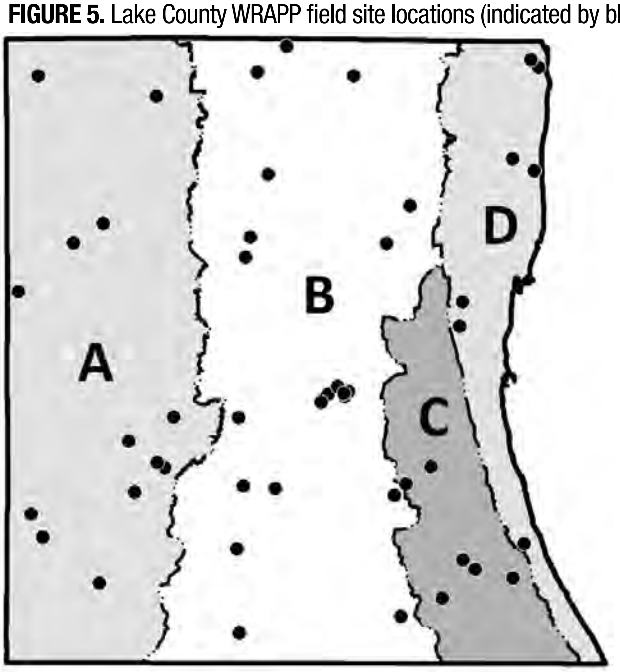


FIGURE 6. The WRAPP field data sheet.

Fig. 6A

Wetland Restoration & Preservation Plan (WRAPP) (6/15/16)

Wetland Field Check Data Form

1: General Information

Watershed: **Sub-watershed:** **Wetland ID:**

Date: **Assessed By:** **GIS/Photo ID #:**

Lat: ° Long: ° Location:

	Cowardin Classification:	**LLWW Classification:**
Slope: Weather Conditions: Recent (24 hr) Precipitation: ☐ Designated as HQAR or ADID?		Landscape Position: Landform: Water Flow Path: Water Body:

Reference Maps: ☐ LCWIe ☐ FEMA ☐ Soils ☐ ADID ☐ Topo ☐ Aerials ☐ Other:

2. Mapping Review/Verification of GIS

- ☐ Wetland/water body is present and boundary generally matches LCWIe
- ☐ Wetland/water body is present, but mapped location differs from LCWIe (see field mark-up for revised boundary)
- ☐ Wetland does NOT appear to be present in mapped location – remove from LCWIe
- ☐ Mineral soil verified ☐ Organic soil verified

For wetlands/ water bodies confirmed as present:

Cowardin classification from NWI/LCWIe confirmed? ☐ Yes ☐ No

If NO, recommended changes based on observations:

LLWW classification from LCWIe confirmed? ☐ Yes ☐ No

If NO, recommended changes based on observations:

3. Field Observations (check all that apply)

Hydrology:

Source	Surface Connectivity	Indicators
☐ Overbank flooding	☐ Within the FEMA 100-yr floodplain	☐ Surface water depth (in):
☐ Depressional flooding/ponding	☐ Within the FEMA 500-yr floodplain	☐ Water table depth (in):
☐ Groundwater (seeps, high water table)	☐ Connected by drainage/stream (incl. ephemeral)	☐ Soil saturation depth (in):
☐ Lake Michigan coastal wetland	☐ Contiguous/adjacent	☐ Water marks height (in):
☐ Surface Runoff	☐ Area discharges to surface water	☐ Drift deposits
☐ Stormwater outfall	☐ Headwaters position	☐ Sediment deposits
☐ Other:	☐ Channelized flow	☐ Water-stained leaves
	☐ Non-channelized flow	☐ Crayfish burrows
		☐ Other:

Wildlife Habitat Features:

	Canopy:	**Connectivity:**	Connectivity Interruptions:
☐ Standing snags >12" dbh	☐ Most trees <6" dbh or no trees	☐ No connection to other natural area/open space	0-2 ☐ 3-4 ☐ 5+ ☐
☐ Coarse woody debris (10'+ long, 6"+ diam) on ground	☐ Most trees between 6-12" dbh, a few >12"	☐ Connection with natural area/open space of <10 ac	☐ 50+ ft-wide corridor connection
☐ Hummocks/tussocks	☐ Canopy >6"dbh and many large trees >12" dbh	☐ Connection with natural area/open space 11-25 ac	☐ 200+ ft-wide corridor connection
☐ Woodland amphibian breeding pools/ nursery		☐ Connection with natural area/open space 25-50 ac	Adjacent Land Use:
☐ Other wetlands within 500 ft		☐ Connection to open space of 51-100 ac	**Notes:**
☐ Beach		☐ Connection with open space of >100 ac	
☐ Shoreline			
☐ Mudflat			

Additional Observations/Remarks:

Wildlife species (insect, mammal, bird, amphibian), type of observation (scat, direct, track, feather, etc.), other wetlands nearby, hydrologic notes (e.g., flow rate, depth to overtopping channel, average channel width), etc.

Fig. 6B

Wetland Restoration & Preservation Plan (WRAPP)

Wetland ID:__________

Wetland Field Check Data Form

3. Field Observations, Continued (check all that apply)

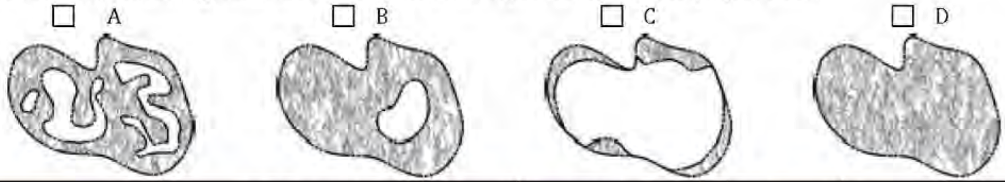
Vegetation: General	Diversity	Plant Strata
Main Plant Community: _____ Secondary Plant Community: _____ ☐ Dense, persistent vegetation ☐ Dense, non-persistent vegetation ☐ Marsh only: <25% cover by vegetation ☐ 25%+ cover by vegetation ☐ ☐ Potential for erosion due to wind fetch, pond or open water area (1+ ac) Littoral Zone Wetland Width: ☐ <10 ft ☐ 10-20 ft ☐ 20+ ft	☐ High (<10% cover by non-natives) ☐ Low (10-50% cover by non-natives) ☐ Dominated by non-natives **Dominant plant species:** **Notable Plant Species:** ☐ Rare plant species known (within past 10 yrs) ☐ Rare plant species observed	☐ Trees (woody, 3"+ dbh) Closed ☐ Sparse ☐ ☐ Sapling/shrub (woody, <3"dbh & >3.3' tall) Dense ☐ Sparse ☐ ☐ Herb (non-woody + woody <3.3' tall) Dense ☐ Sparse ☐ ☐ Graminoids (non-woody, not broadleaf) ☐ Vines

Percent Ground Cover:

☐ Very Sparse (0-10%) ☐ Sparse (11-30%) ☐ Mod. Sparse (31-50%) ☐ Moderate (51-70%) ☐ Mod. Dense (71-90%) ☐ Dense (91-100%)

Interspersion: Select the figure that best represents the degree of interspersion between vegetation and open water during the growing season. Patterned areas represent vegetated areas and white areas represent open water/aquatic bed.

☐ A ☐ B ☐ C ☐ D



Alterations: Evidence of Water Quality Issues	Evidence of Altered Hydrology/Hydrologic Connectivity	Relative Level and Permanence of Disturbance, and Sources	Ground Surface/Vegetation Condition of the Wetland
☐ Dead fish, amphibians ☐ Dredging ☐ Odor ☐ Point-source discharge (NPDES) ☐ Receives agricultural runoff ☐ Stormwater inputs ☐ Sediment deposits on plants ☐ Excess nutrients (algae blooms, macrophytes) ☐ Water discoloration (cloudy, oily sheen) ☐ Road runoff **Notes:**	☐ Drainage (ditches, tiles) ☐ High proportion of open water, dead/dying trees ☐ Water control: weirs, dikes, dams, berms ☐ Beaver dams ☐ Stream channelization ☐ Constricted outlet ☐ Artificial flooding ☐ Overbank flow is NOT severely altered ☐ Overbank flow is severely altered ☐ Overland flow is severely altered	☐ Buffer* disturbance ☐ Wetland disturbance ☐ Recent disturbance (not at equilibrium) ☐ Historic disturbance (at equilibrium) *buffer=50' except HQAR=100' **Relative Percent Disturbance:** Buffer / Wetland ☐ <5% ☐ <5% ☐ 6-25% ☐ 6-25% ☐ 26-50% ☐ 26-50% ☐ 51-75% ☐ 51-75% ☐ 76-95% ☐ 76-95% ☐ >95% ☐ >95%	☐ Filling ☐ Grading ☐ Plowing, disking, tilling ☐ Vehicle tracks, ORVs ☐ Herbicide ☐ Mowing ☐ Soil compaction ☐ Intensive grazing, hooved animals ☐ Human-induced sedimentation or burial ☐ Human-induced erosion or exposure ☐ Clear cutting ☐ Selective cutting

Fig. 6C

Wetland Restoration &
Preservation Plan (WRAPP)

Wetland ID:__________

Wetland Field Check Data Form

4: Checklist for Probable Wetland Functions				
Use this table to identify functions associated with the wetland or watershed services relevant to your inventory or mapping effort and record appropriate information.				
	Function	**Ability to Perform Function (H, M, L, or n/a)**	**Field Observations to Support Function**	**Recommended Changes to Preliminary Wetland Functional Assessment Criteria Based on Field Observations**
Hydrologic	Flood water storage/surface detention			
	Stream baseflow maintenance			
Biodiversity	Native fish habitat			
	Waterfowl habitat			
	Other wetland-dependent bird habitat			
	Woodland amphibian habitat			
	Unique wetland resources			
	Stream Shading			
	Wildlife Movement Corridor (Riparian Habitat)			
Water Quality	Nutrient Transformation (Phosphorus)			
	Sediment and other particulate retention			
	Shoreline/streambank stabilization			
	Carbon Sequestration			

Predicting Wetland and Water Body Functions for Lake County

The enhanced datasets generated by the above process enabled prediction of 13 functions for wetlands and water bodies in Lake County and the relative level to which each function is provided. Using the enhanced datasets, SMC also determined the locations of potentially restorable wetlands (PRWs) and developed an online decision-support tool that interested parties can use. Users can compare functions between wetland classes and assess opportunities for wetland restoration or preservation, depending on site-specific goals.

EXAMPLES OF WRAPP USE

Examples of anticipated stakeholder interest and use of the WRAPP include the following:

- SMC can incorporate WRAPP information into its watershed-based plans to identify potentially restorable wetlands and existing wetlands that provide key stormwater storage, water quality and other high functional services that could be considered for preservation. This would also put SMC in a better position to develop design plans and cost estimates for grant requests to direct limited funds to identified high priority wetland restoration projects.
- Public road agencies can seek off-site mitigation areas or potential wetland mitigation bank sites to meet regulatory requirements for mitigation to offset impacts from road projects in the watershed; municipal and Lake County (unincorporated areas) land use planning jurisdictions may use the WRAPP to identify high priority locations to protect/restore wetlands as green infrastructure to provide ecosystem services such as water quality improvement, aquatic and terrestrial habitat, and stormwater storage to reduce flooding risk by incorporating high priority restoration and preservation sites into updated land use/zoning plans.
- Natural resource/conservation agencies and organizations can seek high priority wetland areas for acquisition and preservation.
- Private landowners can potentially lower their tax burden by legally dedicating high priority wetland restoration-preservation sites on their property in perpetuity under a conservation easement.
- Land development interests can readily identify and avoid existing wetlands wherever possible and adequately replace functional value with mitigation once the functional value is determined.

The WRAPP does not create any additional regulations or natural resource protections, replace the need for site-specific wetland delineations or jurisdictional determinations, or recommend land acquisition or zoning changes. Whether a potentially restorable wetland identified by the WRAPP is viable or not will depend on site-specific characteristics, landowner interest, agency funding/priorities, and other factors.

LIMITATIONS OF THE WRAPP

The WRAPP is a county-wide plan that provides a basic characterization, a preliminary assessment of functions, and a remotely-sensed assessment of wetlands and water bodies in Lake County. As such, it is useful as an initial screening tool for prioritizing wetland restoration and preservation efforts and as an educational resource to help the user better understand the relationships between wetland characteristics and performance of individual functions. However, the WRAPP does not eliminate the need for site-specific assessment prior to developing actual restoration or preservation plans.

Any mapping effort done primarily through remote sensing will inherently have limitations. For example, the LCWI used as the base reference for this plan may have inadvertently omitted certain wetlands due to scale, image interpretation, and map complexity issues. A second limitation is that a large wetland or water body polygon may contain small “inclusions” that are different from the mapped type. For example, a three-acre polygon of emergent wetland may contain a quarter-acre section of scrub-shrub wetland.

Finally, despite efforts at quality control, some errors of interpretation and classification are likely due to the sheer number (about 22,000) of wetland and water body polygons in the Lake County GIS database.

CONCLUSION

The WRAPP will provide a wide audience of end-users with a planning tool that can identify opportunities for restoring and preserving wetlands to maintain and increase wetland functions throughout Lake County. The WRAPP will 1) help direct efforts of voluntary wetland restoration programs, 2) support wetland mitigation efforts by identifying potential mitigation and restoration sites, 3) help target limited resource dollars meant for restoring and preserving wetlands and their functions, 4) strengthen grant and funding requests, and 5) identify critical areas in watershed planning. The WRAPP does not recommend additional regulations, land acquisition, zoning changes, or natural resource protections. The WRAPP tool and datasets do not replace the need for site-specific wetland delineations or jurisdictional determinations. The WRAPP is intended as a tool for various user groups (e.g., government, development sector, and the public) to aid in decision-making and project management. It enhances the LCWI with a depth of information related to functions of individual wetland areas following nationally-accepted methods and standards. The WRAPP consists of data analysis, a summary report (in preparation at the time of this submittal), and a web-based interactive tool (also in development at the time of this submittal) that can be used by a wide audience for planning purposes. It will aid in identifying wetland restoration and preservation opportunities through objective criteria based on nationally-accepted methods and standards. Whether a potentially restorable wetland identified by the WRAPP is a viable location will depend on site-specific characteristics, landowner interest, agency funding/priorities, and other factors. ■

REFERENCES

Bowles M. and J. McBride. 2005. Pre-European Settlement Vegetation of Lake County, Illinois. The Morton Arboretum, Lisle, IL.

Calsyn, D.E. 2005. Soil Survey of Lake County, Illinois. United States Department of Agriculture, Natural Resources Conservation Service, in cooperation with the Illinois Agricultural Experiment Station.

Cowardin, L., V. Carter, F. Golet, and E. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. FWS/OBS-79/31. U.S. Fish and Wildlife Service, Washington, DC.

Dreher, D., S. Elston, and C. Schaal. 1992. Advanced Identification (ADID) Study, Lake County, Illinois. Final Report, November 1992.

Federal Geographic Data Committee (FGDC). 2013. Classification of Wetlands and Deepwater Habitats of the United States, Second Ed. Adapted from Cowardin, Carter, Golet and LaRoe (1979). FGDC Wetland Subcommittee. August 2013. FGDC–STD-004-2013.

Fizzell, C.J. 2007. Assessing Cumulative loss of Wetland Functions in the Paw Paw Watershed Using Enhanced National Wetlands Inventory Data. Michigan Department of Environmental Quality, Land and Water Management Division, Wetlands, Lakes and Streams Unit, Ann Arbor, MI.

Lake County Department of Information Technology, GIS Division (LCGIS). 2003. Georeferenced and Mosaicked Federal Township Plats for Lake County, IL. Waukegan, IL.

Lake County Stormwater Management Commission (SMC). 2018. Lake County Wetland Restoration & Preservation Plan GIS Database. Libertyville, IL.

Lake County Stormwater Management Commission (SMC). 2015. Lake County Watershed Development Ordinance of Lake County, Illinois. Last amended Oct. 13, 2015.142 pp., plus appendices.

Levin, G.A., L. Suloway, A.E. Plocher, F.R. Hutto, J.J. Miner, C.A. Phillips, J. Agarwal, and Y. Lin. 2002. Status and Functions of Isolated Wetlands in Illinois. Illinois Natural History Survey Special Publication 23.

Michigan Department of Environmental Quality (MDEQ). 2011. Landscape Level Wetland Functional Assessment, Version 1.0, Methodology Report. Michigan Department of Environmental Quality.

Miller, N., T. Bernthal, J. Wagner, M. Grimm, G. Casper, and J. Kline. 2012. The Duck-Pensaukee Watershed Approach: Mapping Wetland Services, Meeting Watershed Needs. The Nature Conservancy and Environmental Law Institute, Madison, WI.

Moran, R.C. 1978. Presettlement Vegetation of Lake County, Illinois. In D.C. Glenn-Lewin and R.O. Landers (eds). Proceedings of the Fifth Midwest Prairie Conference, Iowa State University, Ames, IA. pp. 12-17.

Paschke, J.E. and J.D. Alexander. 1970. Soil Survey of Lake County, Illinois. University of Illinois Agricultural Experimental Station Soil Report 88.

PG Environmental, LLC (PGE). 2014. Methods and Results for a Geographic Information System Landscape Model of Wetland Functions in the Sandusky Subbasin. March 31, 2014. Unpublished report prepared for USEPA Region 5.

Suloway, L. and M. Hubbell. 1994. Wetland Resources of Illinois: An Analysis and Atlas. Illinois Natural History Survey Special Publication 15.

Tetra Tech. 2015. Final Report – Region 5 Wetland Management Opportunities and Marketing Plan: Select Watersheds in the Lower Fox and Des Plaines River Watersheds. March 2015. Unpublished report prepared for US EPA Region 5.

Tiner, R.W. 2003. Correlating Enhanced Wetlands Inventory Data with Wetland Functions for Watershed Assessments: A Rationale for Northeastern U.S. Wetlands. U.S. Fish and Wildlife Service, National Wetlands Inventory Program, Region 5, Hadley, MA.

Tiner, R.W. 2011a. Dichotomous Keys and Mapping Codes for Wetland Landscape Position, Landform, Water Flow Path, and Waterbody Type Descriptors: Version 2.0. U.S. Fish and Wildlife Service, National Wetlands Inventory Program, Northeast Region, Hadley, MA.

Tiner, R.W. 2011b. Predicting Wetland Function at the Landscape Level for Coastal Georgia Using NWIPlus Data. U.S. Fish and Wildlife Service, National Wetlands Inventory Program, Region 5, Hadley, MA. In cooperation with the Georgia Department of Natural Resources, Coastal Resources Division, Brunswick, GA, and Atkins North America, Raleigh, NC.

Tiner, R.W., B. Diggs, I. Mans, and J. Herman. 2014. Wetlands of Pennsylvania's Lake Erie Watershed: Status, Characterization, Landscape Level Functional Assessment, and Potential Restoration Sites. Prepared for the Pennsylvania Department of Environmental Protection, Coastal Zone Management Program, Harrisburg, PA. U.S. Fish and Wildlife Service, Northeast Region, Hadley, MA.

Westerman, A. Not dated. Presettlement Vegetation Map of Lake County, Illinois. Unpublished data from Lake County Forest Preserve District, Libertyville, IL.

Teaching Redox as a Chinese Buffet

Douglas A. Wilcox[1], Department of Environmental Science and Ecology, SUNY College at Brockport, Brockport, NY

I have taught Wetland Ecology 25 times - 15 as an Adjunct Associate Professor at the University of Michigan and UM-Dearborn while I worked at the USGS-Great Lakes Science Center in Ann Arbor and 10 in my new life in academia as the Empire Innovation Professor of Wetland Science at SUNY--The College at Brockport in my native western New York State. Surprisingly, my favorite lecture of all time is on oxidation-reduction, or redox. Here is the story behind that strange outcome and an overview of the lecture.

In my first year at Michigan, I presented a somewhat straightforward lecture on redox from the Mitsch and Gosselink textbook (first edition) that followed the reading assignment. I thought it was going well until I saw the need to pose this question, "When I say 'ion,' does everyone know what I mean?" Four students in the class of 40+ informed me that they did not, which was reasonable because they were landscape architecture grad students taking the course because they had interests in design work for wetland restorations and had no chemistry background.

I am not sure how I managed to finish the lecture, but I knew that a new approach was needed for the following year that could reach students with limited understanding of chemistry. I like to use analogies during lectures, and it dawned on me that I could make an analogy with a Chinese buffet. I truly enjoy Chinese buffets, so imagine me giving the following lecture with exaggerated hand gestures and voice intonations as I move through Powerpoint slides (•) and get into the buffet analogy (*with accompanying spoken explanations and asides*).

- REDOX (OXidation-REDuction) *sounds better than OXRED*.
- As organic matter decomposes, it is oxidized (a process that emits electrons). Something has to be reduced (accept the electrons) *or maybe lightning would discharge from the sediment*.
- During oxidation, a chemical loses electrons (e.g., $Fe^{+2} \rightarrow Fe^{+3} + e^{-}$). *That Fe^{+3} ferric ion is the reddish brown color that you see on your old car when the paint is gone and the iron is exposed to the air and oxidation.*

FIGURE 1. Diagram showing decrease of organic substrate by oxidation and release of electrons through time, accompanied by sequential reduction of oxygen, nitrate, manganese (manganous), iron (ferrous), sulfate, and carbon dioxide. (Source: copyrighted image from Mitsch and Gosselink 2015, derived from Reddy and DeLaune 2008; permission received from John Wiley & Sons;)

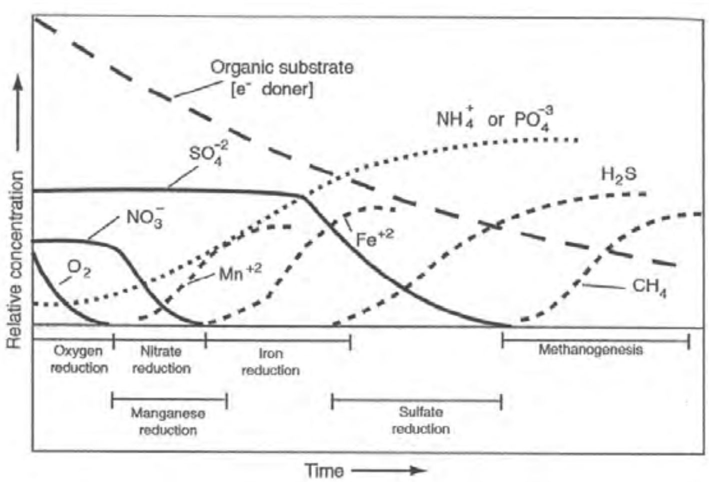


FIGURE 2. Chinese buffet (D.A.Wilcox: From the Bog).

1. Corresponding author contact: dwilcox@brockport.edu; Department of Environmental Science and Ecology, SUNY College at Brockport, 350 New Campus Drive, Brockport, NY 14420

- During reduction, a chemical gains electrons (e.g., $Fe^{+3} + e^{-} \rightarrow Fe^{+2}$).
- Eh = redox potential, or the proportion of oxidized to reduced components. It is a measure of electron availability or pressure of electrons. Eh is given in units of mV (electron availability measured on a hydrogen scale).
- When in an oxidized environment, a lot of electrons are available, so Eh is high. As reduction occurs, electrons are taken up and Eh goes down.
- See Figure 1. *This can be a confusing diagram. Did any of you figure out what it means from your reading assignment? Within five to ten minutes, you will understand it completely.*
- See Figure 2. *I am going to teach redox as if we were at a Chinese buffet, and I love Chinese buffets!*
- It is the end of the evening; all entrees are available but in limited quantities, and they will not make any more because they do not want to throw food away.
- Look again at Figure 1. *It has concentrations of various components on the Y-axis and time on the X-axis. As you can see, as the organic substrate is oxidized over time, it decreases in concentration and serves as an electron donor (spelled with an o).* The analogy to redox is that the depletion of organic substrate is actually loss of stomach space, and stomach space is valuable at a Chinese buffet.
- My Objective:
  - Stomach space is limited, so use it wisely.
  - EAT NO RICE or anything with little taste that can use up stomach space.
  - There is competition with others for limited quantities of the tastiest food.
  - Eat favorite food until it is all gone (Hunan beef) and do not let anyone else eat it. I then pick a student and use a basketball move to box them out.
  - When gone, move to second favorite (there really is none) and eat the sesame chicken until it is nearly all gone.
  - Then move to the third favorite (Szechwan chicken), fourth favorite (Mongolian beef), etc.
  - See Table 1, noting chemical reactions, and refer to Figure 1.
  - *Hunan beef is oxygen (O_2).*
  - *Sesame chicken is nitrate (NO_3^-).*
  - *Szechwan chicken is manganese (Note that Figure 1 shows the increase in reduced manganous (Mn^{+2}) ion, rather than the original oxidized manganic (Mn^{+4}) ion to avoid a messy graph – same for the remaining chemicals).*
  - *Mongolian beef is oxidized ferric (Fe^{+3}) ion.*
  - *Kung Pao chicken is sulfate (SO_4^{-2}).*
  - *Hunan bean curd is carbon dioxide (CO_2).*
- See Figure 3. *When carbon dioxide is the electron acceptor, the end product is methane, a process known as methanogenesis.*

TABLE 1. Order of food eaten at Chinese buffet and corresponding reduction reactions.

Hunan beef	$O_2 \rightarrow H_2O$
Sesame chicken	$NO_3^- \rightarrow N_2$
Szechwan chicken	$Mn^{+4} \rightarrow Mn^{+2}$
Mongolian beef	$Fe^{+3} \rightarrow Fe^{+2}$
Kung Pao chicken	$SO_4^{-2} \rightarrow HS^-$
Hunan beef curd	$CO_2 \rightarrow CH_4$

FIGURE 3. Methanogensis (D.A. Wilcox: From the Bog).

• See Figure 4. *Derived from the text (Mitsch and Gosselink), here are the full chemical reactions for oxidation and reduction.*

Figure 4. Chemical equations showing oxidation of organic substrate and sequential reduction of oxygen, nitrate, manganese (manganous), iron (ferrous), sulfate, and carbon dioxide. (Source: Mitsch and Gosselink 2015; permission received from John Wiley & Sons)

Oxidation of organic substrate:

$$[CH_2O]n + nH_2O \rightarrow nCO_2 + 4ne^- + 4nH^+$$

Reduction transformations:

$$O_2 + 4e^- \rightarrow 2H_2O$$

$$2NO_3 + 10e^- + 12H^+ \rightarrow N_2 + 6H_2O$$

$$MnO_2 + 2e^- + 4H^+ \rightarrow Mn^{++} + 2H_2O$$

$$Fe(OH)_3 + e^- + 3H^+ \rightarrow Fe^{++} + 3H_2O$$

$$SO_4^{=} + 8e^- + 9H^+ \rightarrow HS^- + 4H_2O$$

$$CO_2 + 8e^- + 8H^+ \rightarrow CH_4 + 5H_2O$$

• See Table 2. *More simply, from the text, here are the electron acceptors in order, showing oxidized and reduced forms, along with the Eh ranges in mV.*

Table 2. Oxidized and reduced forms of several elements and approximate redox potentials for transformation. (Source: Copyrighted image from Mitsch and Gosselink 2015; permission received from John Wiley & Sons)

Element	Oxidized Form	Reduced Form	Approximate Redox Potential for Transformation (mV)
Nitrogen	NO_3^- (nitrate)	N_2O, N_2, NH_4^+	250
Manganese	Mn^{4+} (manganic)	Mn^{2+} (manganous)	225
Iron	Fe^{3+} (ferric)	Fe^{2+} (ferrous)	+100 to −100
Sulfur	$SO_4^{=}$ (sulfate)	$S^{=}$ (sulfide)	−100 to −200
Carbon	CO_2 (carbon dioxide)	CH_4 (methane)	Below −200

• Look again at Figure 1. *This diagram now makes sense. It shows organic substrate being oxidized (emitting electrons) and the succession of electron acceptors/end products. That is redox.* ■

REFERENCES

Mitsch, W.J. and J.G. Gosselink. 2015. Wetlands. Fifth edition. John Wiley & Sons, Hoboken, New Jersey, USA.

Potential Climate Change Impacts on Native Bulrush Seeds (*Schoenoplectus spp.*) Relative to Invasive Common Reed (*Phragmites*) – Methods and Preliminary Results and Experience from the Wetland Ambassadors Program

SWS Fellowship Research - Final Report

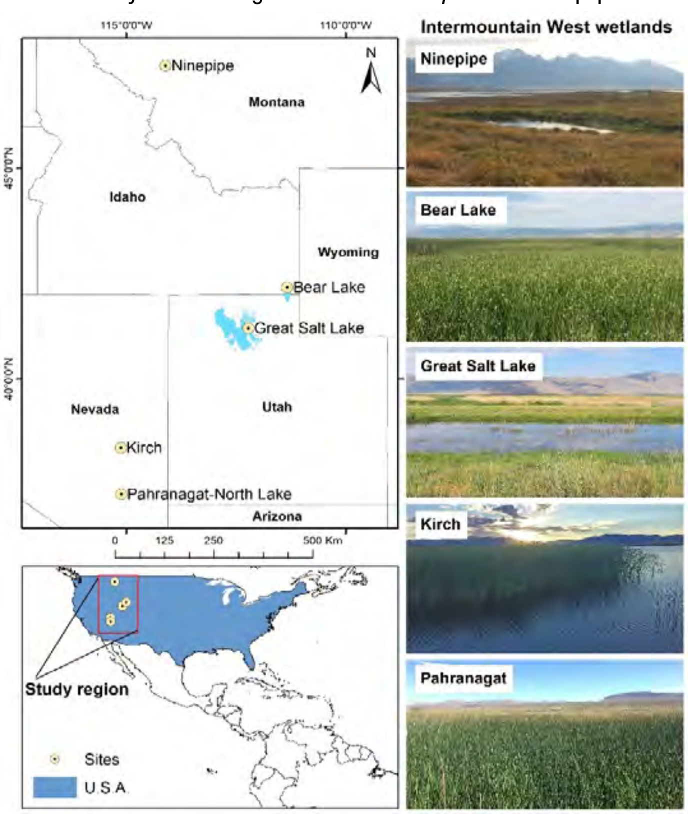
Tatiana Lobato de Magalhães[1], *Wetland Ecology Lab, Utah State University, Logan, UT*

INTRODUCTION

Through funding from the Society of Wetland Scientists' Wetland Ambassadors Graduate Research Fellowship[2], two experiments were conducted in the Wetland Ecology Lab at Utah State University and one field experiment (seeding trial) in Great Salt Lake wetlands during the summer of 2018. The experiments were focused on answering five questions: (1) How do changes in temperature and water potential impact native bulrush seed germination (Growth Chamber Experiments 1 and 2)? (2) How do bulrush germination rates correspond with *Phragmites* germination (Growth Chamber Experiments 1 and 2)? (3) How do changes in temperature and water potential impact the germination of native bulrush seeds sourced from different regions (Growth Chamber Experiment 2)? (4) How does bulrush seed germination vary with temperature and water potential in the field (Field Study)? (5) How do field germination rates correspond with germination under simulated climate change conditions in growth chambers (Growth Chamber Experiments 1 and 2 and Field Study)?

These experiments focused on two native bulrush species - *Schoenoplectus acutus* (Muhl. ex Bigelow) Á. Löve & D. Löve (hardstem bulrush) and *Schoenoplectus americanus* (Pers.) Volkart ex Schinz & R. Keller (three-square bulrush) and one non-native species - *Phragmites australis* (Cav.) Trin. ex Steud. (common reed). The native bulrushes serve as critical food and nesting sources for migratory birds and are target species for Great Salt Lake wetland restoration (Evans and Martinson 2008; Marty and Kettenring 2017). Great Salt Lake wetlands are threatened by increasing demands on water upstream for development and agriculture and by the proliferation of invasive species (Long et al. 2017; Wurtsbaugh et al. 2017). One such invasive species that is particularly harmful to these wetlands is *Phragmites australis*. Restoring this ecosystem following *Phragmites* control is a high priority and often relies on seeding with bulrushes in an effort to return native vegetation to the area. *Phragmites* seeds have high rates of germination (Mauchamp et al. 2001; Kettenring and Whigham 2009). Recent research indicates that *Phragmites* germination rate more than doubles under increased temperature conditions (Martin 2017). As such, climate change may also intensify the expansion of the invasive *Phragmites* (Tougas-Tellier et al. 2015). Understanding how seed germination of *Phragmites* and *Schoenoplectus* spp. changes in response to changing temperature and water regimes could provide insights on current and future plant community dynamics in natural and restored wetlands. Another topic of interest was how seeds may vary within hardstem bulrush populations in response to temperature and water potential changes. A range of geographically different seed sources from five populations of *S. acutus* were collected and used in the experiments (Figure 1): Great Salt Lake (41.2061 N, -112.2131 W), Kirch Water Management

FIGURE 1. Study area showing location of *Schoenoplectus acutus* populations.



---

1. Corresponding author contact: tatilobato@gmail.com. Note that the original report entitled *Wetland Ambassadors Graduate Research Fellowship Final Report – 2018* was reformatted along with minor edits for publication in this journal.

2. The SWS Wetland Ambassadors Graduate Research Fellowship allows graduate students to travel to another country and conduct groundbreaking wetland research with some of the world's top wetland research scientists.

Area (38.3642 N, -115.1223 W), Ninepipe Water Management Area (47.4399 N, -114.1007 W), Bear Lake (42.1724 N, -111.3227 W), and Pahranagat-North Lake (37.2596 N, -115.1098 W).

METHODS

In two experiments, bulrush and Phragmites seeds were placed in separate growth chambers (Conviron® Model A1000, Conviron, North Branch, Manitoba, Canada) set to one of four temperature regimes. Three replicates of > 100 seeds for each species and populations were placed in parafilm sealed germination boxes (11 x 11 x 4 cm) with 100 mL of distilled water and solutions of polyethylene glycol (PEG). Germination was recorded daily for four weeks (Figure 2). To simulate current and future predicted temperatures for the Great Salt Lake, maximum and minimum monthly average temperatures came from the global climate model (GCM) data of CMIP5 manually pulled from Worldclim (Hijmans et al. 2005). For Experiment 1, germination boxes of each species (S. acutus, S. americanus, and P. australis) were distributed among four temperature regimes (monthly average of daytime and nighttime temperatures): 23/10° C (present May in Great Salt Lake wetlands), 28/14° C (present June), 33/18° C (present July and also June 2070), and 36/20° C (July 2070), and each water potential (0, -0.15, -0.3, -0.6, and -1.2 MPa). In total, Experiment 1 had 216 sample units (60 treatments + 12 extra treatments of Ψ_0 MPa X 3 replicates X 100 seeds = 21,600 seeds) and 60 treatments (3 species X 4 temperature X 5 water potential). The experiment was run in two phases: phase 1 (installed on June 9, 2018, with the water potential 0, -0.15, and -0.3 MPa) and phase 2 (installed on July 3, 2018, with the water potential 0, -0.6, and -1.2 MPa). For Experiment 2, a range of geographically different seed sources (five populations of *S. acutus*; Figure 1) were used. Germination boxes of each population were distributed among the same four temperature regimes of Experiment 1, and each water potential (0, -0.6, and -1.2 MPa). In total, Experiment 2 had 180 sample units (60 treatment X 3 replicate X 100 seeds = 18,000 seeds) and 60 treatments (5 populations X 4 temperature X 3 water potential). The experiment was installed on July 5, 2018 and ran through August 2, 2018.

The field experiment (seeding trial) occurred in June and July 2018. Fifty seeds of the two bulrush species (*S. acutus* and *S. americanus*) were distributed among eight germination plots (~20 L, bag strainer) at two sites (Farmington Bay and Bear River Migratory Bird Refuge). Temperature sensors (iButtons model DS1922L) and soil water potential sensors (Watermark Sensors) were installed in each seed bag (Figure 3). Each of the temperature sensors was enclosed in an iButton case (model DS9107) to prevent water from damaging the sensor. The temperature was recorded every 2 hours and water potential every 4 hours. The experiment was initiated on June 18, 2018, and total germination was recorded after four weeks.

PRELIMINARY RESULTS

While final analysis of the study data is underway and will be reported later, there are some preliminary observations of note.

1. Seed germination in all species was affected by temperature and water potential changes.
2. Total germination in all species was reduced as the water potential decreased.
3. Total germination of S. americanus was lower than S. acutus and P. australis in all treatments.
4. In the 0 MPa treatments, the total germination of P. australis was the same for all temperature regimes.
5. There were no significant differences between seeds sourced from the different regions.
6. Field germination rates for both bulrush species was lower than germination under simulated climate change conditions in growth chambers. ■

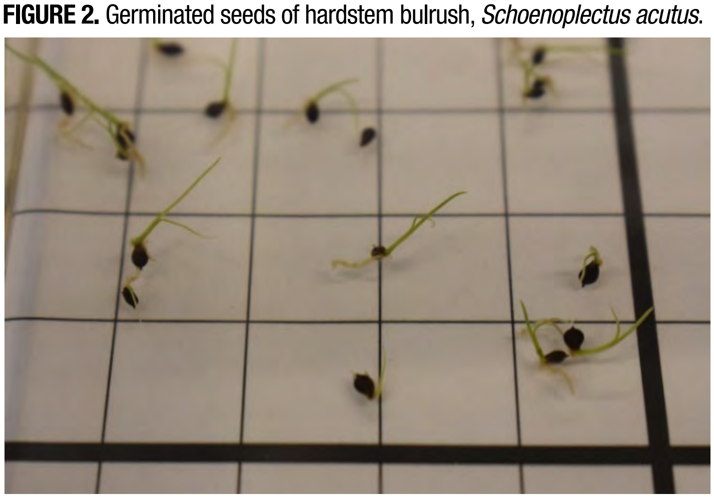


FIGURE 2. Germinated seeds of hardstem bulrush, *Schoenoplectus acutus*.

FIGURE 3. Soil water potential sensors and seed bags in the field.

REFERENCES

Evans, K.E. and W. Martinson. 2008. Utah's Featured Birds and Viewing Sites: A Conservation Platform for Ibas and Bhcas. Sun Litho.

Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones, and A. Jarvis. 2005. Very high resolution interpolated climate surfaces for global land areas. *International Journal of Climatology* 25(15): 1965–1978.

Kettenring, K.M. and D.F. Whigham. 2009. Seed viability and seed dormancy of non-native *Phragmites australis* in suburbanized and forested watersheds of the Chesapeake Bay, USA. *Aquatic Botany* 91(3): 199-204.

Long, A.L., K.M. Kettenring, C.P. Hawkins, and C.M. Neale. 2017. Distribution and drivers of a widespread, invasive wetland grass, *Phragmites australis*, in wetlands of the Great Salt Lake, Utah, USA. *Wetlands* 37(1): 45-57.

Martin, R.M. 2017. Effects of warming on invasive *Phragmites australis* and native *Spartina patens* seed germination rates and implications for response to climate change. *Northeastern Naturalist* 24(3): 235-238.

Marty, J.E. and K.M. Kettenring. 2017. Seed dormancy break and germination for restoration of three globally important wetland bulrushes. *Ecological Restoration* 35(2): 138-147.

Mauchamp, A., S. Blanch, and P. Grillas. 2001. Effects of submergence on the growth of *Phragmites australis* seedlings. *Aquatic Botany* 69(2-4): 147-164.

Tougas-Tellier, M.A., J. Morin, D. Hatin, and C. Lavoie. 2015. Freshwater wetlands: fertile grounds for the invasive *Phragmites australis* in a climate change context. *Ecology and Evolution* 5(16): 3421-3435.

Wurtsbaugh, W.A., C. Miller, S.E. Null, R.J. DeRose, P. Wilcock, M. Hahnenberger, and J. Moore. 2017. Decline of the world's saline lakes. *Nature Geoscience* 10(11): 816.

My Experiences as a Wetland Ambassador

I am currently a Ph.D. candidate in Biological Sciences at the Autonomous University of Queretaro, Mexico. I completed my Master's degree in the field of Plant Sciences at Santa Catarina State University, Brazil in 2013. My research interests are broad, but they focus on biodiversity, ecology, genetics, and conservation of freshwater ecosystems. I have been working on large-scale spatial patterns of aquatic plants, combining community and population approaches. I have conducted graduate research mainly on central Mexico highland sites, where temporary wetlands are part of the landscape and are geographically isolated. The title of my Wetland Ambassadors fellowship project was "Potential climate change impacts on native seeds relative to invasive *Phragmites*: implications for Great Salt Lake wetland restoration".

I carried out my SWS Wetland Ambassadors fellowship at the Wetland Ecology Lab at Utah State University, Logan, U.S.A, under the mentorship of Dr. Karin Kettenring. Being a Wetland Ambassador this summer helped me to reach my goal to become an innovator in the field of wetland science. I achieved my previous aims for joining this program specifically to: (1) improve my scientific skills for high-level research, (2) meet future research collaborators, and (3) publish scientific papers. I was also involved in other projects of the Wetland Ecology Lab, including with some restoration projects, insect surveys, and rhizome collections (Figure 4). With these activities I had the opportunity to learn new techniques, to meet interesting people working in Dr. Kettenring's Lab, and to visit wetlands along Utah Lake and Clear Lake, and at Salt Creek Waterfowl Management Area (WMA), Bear River Bird Refuge, and Farmington Bay WMA.

The following are some outputs from this experience:

- Webinar: Dr. Karin Kettenring and I presented the experiment results in an SWS webinar (December 13th 2018), entitled "Potential climate change impacts on native seeds relative to invasive *Phragmites*: implications for Great Salt Lake wetland restoration."
- Scientific paper: Dr. Karin Kettenring, Emily Martin (a graduate student at Utah State University), and I are working on a publication using the data from my experiments in the Wetland Ecology Lab.

- Conference: The Biological Sciences graduate program at Autonomous University of Querétaro (the Ph.D. program in which I am enrolled) invited me to present a talk to graduate students about my experience in Utah.

Researching in Dr. Karin Kettenring's Lab broadened my experience and knowledge of wetland science and restoration. This experience gave me the opportunity to learn new techniques for wetland restoration, data analysis, and new tools for field data collection. I will take advantage of the new knowledge acquired, and apply it in the developing world, thereby advancing the science by practicing it in places where wetland conservation is less established. Also, conducting a project in another country in a new (to me) wetland type increased my understanding of the ecology and diversity patterns in these environments. In this Fellowship program, I had the opportunity to strengthen my multi-disciplinary research approaches, which will allow me to do projects better in the future.

I seek opportunities for promoting the SWS specifically by increasing international awareness of it. Also, I am looking for ways to contribute to the Society's goals on these points: (1) promote discussions about wetlands in forums and blogs, (2) encourage integration of different branches of wetland science and practice, and (3) enhance exchange of ideas and data through an SWS webinar.

Finally, I thank the Society of Wetland Scientists for this unique opportunity. ■

FIGURE 4. Working on an aquatic insect survey (the author, Jack Trice, Emily Leonard, and Emily Martin), bulrush rhizome collections (Karin Kettenring and the author), and wetland restoration projects (Emily Martin, Amanda Mast, Dave England).

Inaccurate Cover Classification Leads to Unnecessary Loss of Pennsylvania Palustrine Wetland Forest Structure and Functions

James A. Schmid[1], Schmid & Company, Inc., Media, PA

ABSTRACT

Regulators and consultants have an obligation to insure accurate identification and reporting when inventorying vegetation, delineating wetlands, and assessing impacts on land proposed for development projects. This includes the proper characterization of internal and external cover of vegetation in wetlands proposed for destruction, as well as the species of plants present. Otherwise, environmental impacts will not be minimized, functions will be lost, and post-disturbance wetland ecosystem recovery will be unlikely, even where compensatory mitigation is attempted. Palustrine forested wetlands in Pennsylvania are being identified as emergent herbaceous wetlands in projects affecting thousands of hectares of land and many hundreds of individual wetlands. Not only are the forest functions being lost for indefinitely long periods of time, but "required" compensatory mitigation for the loss of forest is being ignored.

During project impact assessments, Cowardin Classes ("external cover" – percent cover by the tallest life-form of plants) have been erroneously recorded recently in Pennsylvania, resulting in palustrine forested wetlands mischaracterized, impacts not avoided or minimized, and compensatory mitigation not provided. Such basic scientific error can be avoided by careful attention to technical terms on the part of consultants and regulators, accurate reporting of what exists on the ground, and thorough inspection of jurisdictional boundaries and cover types on project sites prior to disturbance. Lacking accurate inventory and site restoration design, compensatory mitigation in compliance with regulatory directives can offer no prospect of wetland forest restoration to benefit future generations.

INTRODUCTION

For at least a decade the U.S. Army Corps of Engineers (Corps) has directed that the Cowardin classification (Cowardin et al. 1979), especially "Class," be reported for the wetland polygons identified in applications for permits and jurisdictional determinations (Riley 2008). That classification system, based on the common sense visual inspection of the uppermost layer of vegetation, was designed to communicate scientific and resource management information and for use in National Wetlands Inventory (NWI) mapping based on airphotos. The "Class" level of the hierarchical classification addresses overall vegetation structure, not species composition.

Forest structure typically is more complex than herbaceous vegetation, and forested wetland functions are not replaced by wetlands where succession is arrested at an herbaceous stage (Schmid & Co., Inc. 2014a). The Corps and the US Environmental Protection Agency observed in 2008 rulemaking regarding compensatory mitigation for losses of aquatic resources:

> *We understand that different functions often develop at different rates after aquatic resource restoration, establishment, or enhancement activities are implemented, because of the ecosystem development processes that occur. … It is important to understand that temporary impacts may result in permanent changes to, or losses of, specific functions. As an incentive for timely mitigation, district engineers may determine that additional compensation for temporal losses is not necessary if the mitigation project is initiated prior to or concurrent with the permitted impacts, except in the case of resources with long development times, (e.g., forested wetlands). [33 CFR 325 and 332, 40 CFR 230; 73 FR70:19638]*

Little is known about the restoration of forest soils after human changes in wetland and non-wetland ecosystems (Lovett et al. 2018). Even beneath restored herbaceous wetlands, soil development requires decades to centuries to approximately recover functions such as the denitrification performed under undisturbed reference conditions nearby (Ballantine and Schneider 2009; Hossler et al. 2011; Moreno-Mateos et al. 2012, 2015) or the capture of human-produced carbon dioxide (Griscom et al. 2017).

No supplemental guidance has been provided suggesting any modification of the Cowardin classification when using it for Corps regulatory purposes that typically demand greater precision than regional NWI mapping. Corps three-parameter wetland identification and delineation

1. Corresponding author contact: schmidjamesa@gmail.com

methodology itself is specifically described as not having been designed for wetland classification. Users of the 1987 Corps of Engineers Wetlands Delineation Manual are advised to become familiar with the older Cowardin system as a means for classifying wetlands (EL 1987, p.7).[2]

The Pennsylvania Department of Environmental Protection (PADEP) by regulation has adopted Corps methodology for wetland identification and assessment.[3] PADEP would specifically adopt the Cowardin Class designations for use when designing compensation for wetlands damaged in Pennsylvania (PADEP 2014a). Impacts requiring mitigation include "conversion of a forested wetland system to a non-forested state through chemical, mechanical or hydrologic manipulation that results in a maintained state of vegetation" (PADEP 2017b). Such changes are most common along electric power lines and pipelines, where a permanent right-of-way is kept open to facilitate inspection and maintenance.

The hierarchical Cowardin descriptive classification of wetland habitats requires that vegetation be assigned to categories based on the Class (i.e., the aggregate external cover) of their tallest plants.[4]

> *"If living vegetation (except pioneer species) covers 30 percent or more of the substrate, we distinguish Classes on the basis of the life form of the plants that constitute the uppermost layer of vegetation and that possess an areal coverage 30 percent or greater. For example, an area with 50 percent areal coverage of trees over a shrub layer with a 60 percent areal coverage would be classified as Forested Wetland; an area with 20 percent areal coverage of trees over the same (60 percent) shrub layer would be classified as Scrub-Shrub Wetland. When trees or shrubs alone cover less than 30 percent of an area but in combination cover 30 percent or more, the wetland is assigned to the Class Scrub-Shrub. When trees and shrubs cover less than 30 percent of the area but the total cover of vegetation (except pioneer species) is 30 percent or greater, the wetland is assigned to the appropriate Class for the predominant life form below the shrub layer." [FGDC 2013, p. 19-20, emphasis added]*

Total aggregate external cover of the ground or water surface by plants must be at least 30% for a wetland to be placed in any Cowardin vegetation cover Class (or "vegetated" Subclass), by definition. Subclasses and modifiers can be identified, depending on the level of detail needed. More than 7,500 distinct Cowardin classification codes have been used for NWI mapping (Dahl et al. 2015). Bare ground, open water, shrubs, herbaceous plants, lichens, and/or mosses may be found beneath the tree canopy in a forested wetland.

The term "cover" also is used for other regulatory purposes, notably when quantifying the "internal cover" of each named species formed by the individuals growing within each layer of a wetland plant community. This "internal" cover metric (i.e., cover within a plot) routinely is used to determine dominant species for the three-parameter methodology identifying federally regulated wetlands in accordance with the 1987 Corps Manual and its regional supplements (e.g., USACE 2012). Internal and external measures of cover and the recorded data (from which they are derived) may differ for an individual wetland sample plot. Both are meaningful, but if these distinct measures of cover are muddled, the result can be misclassification, lack of required regulation, and inappropriate mitigation of impacts—especially for small wetlands. That leads to loss of wetland functions and values (Schmid & Co., Inc. 2014).

WETLAND MAPPING IN PENNSYLVANIA

Pennsylvania lies within the deciduous forest biome of eastern North America (Braun 1950). The great majority of its mapped wetlands are forested (Tiner 1990). National Wetlands Inventory and Geological Survey topographic mapping typically omit the small headwater wetlands and streams not recognizable on high-altitude aerial photographs because of overhanging forest cover. Such features are usually discovered during on-ground inspection. Furthermore, plant succession, beavers, forest fires, hurricanes, and human activities often lead to changes in actual vegetation subsequent to the taking of aerial photographs, and thus warrant on-ground confirmation. During a recent field investigation of more than 350 selected wetlands in Kentucky, Guidugli-Cook et al. (2017) found that more than 50% of their wetlands mapped as emergent herbaceous by NWI in fact exhibited forest cover, while more than 20% of NWI-mapped forested wetlands were dominated by herbaceous cover at the time of field inspection. For Pennsylvania, PADEP (2017b) directs that analysis of aerial photographs be followed by field inspection when assessing wetlands, so on-the-ground classification is the ultimate step.

The misapplication of the Cowardin classification for wetland cover is significant in Pennsylvania permit applications seeking approval to destroy wetlands, where compensatory mitigation requirements on paper are more

2. The current version of the Cowardin system is that of the Federal Geographic Data Committee (FGCD 2013).

3. 25 Pa. Code 105.451(c).

4. Plant names are not relevant for basic Cowardin classification.

stringent for forested wetlands than for emergent herbaceous wetlands (PADEP 2017b). This creates an incentive for applicants to mischaracterize small wetlands as herbaceous rather than forested and thus underreport the actual qualitative extent of proposed damage. Making a mistake in classification can occur if a field investigator forgets to look around and supplement a Corps data form, which does not allocate space for data identifying Cowardin cover.[5] In Pennsylvania, wetlands shown on permit drawings subsequently are not carefully reviewed for consistency with collateral information or field conditions. Such mistakes could be corrected when brought to the attention of applicants and regulators.[6] Too often, however, they are not corrected.

For pipelines, power lines, and high-extraction underground coal mining projects, for example, where hundreds of wetlands and streams are proposed for damage on a single project site that encompasses hundreds or thousands of hectares of land, cumulative impacts become important (Schmid & Co., Inc. 2000, 2015; Helbing and Szybist 2014). Failure to identify and properly classify wetlands in the field precludes avoidance and minimization of those impacts. This problem is typical for streams and wetlands in Pennsylvania that are: 1) not mapped by the National Wetlands Inventory, 2) not depicted on U.S. Geological Survey topographic quadrangles, or 3) not shown in the National Map hydrography database[7]. Unless properly disclosed during the permit process, such resources remain unknown and unprotected. Misclassification in the field also makes it: 1) impossible to consider avoiding forested wetlands, 2) understates the need for forest replanting in temporarily disturbed wetlands or riparian areas, and 3) precludes compensation for the permanent conversion of forested wetlands to herbaceous cover in rights-of-way to be maintained permanently as treeless. Federal regulations declaring each stream or wetland crossing typically to be an individual project approvable in isolation via general permits[8] appear to have deflected attention from accurate analysis of individual wetland impacts as well as from the cumulative effects of major linear projects.

5. The current forms do have a small blank for reporting NWI classification, which typically is recorded as "none" for headwater wetlands not identified on NWI maps (as in Figure 3 below). No supporting data are prompted for recording wetland classification in the field. Field recording of Cowardin cover might help reduce the frequency of gross documentation errors such as those discussed in this article.

6. Pennsylvania regulations state that a permit application will not be approved unless the applicant demonstrates that the application is complete and accurate [25 Pa. Code 105.21(a)(1)]. Actual permit files suggest otherwise, and questions from agency reviewers often remain unaddressed.

7. All of these products are derived from remote sensing and therefore have recognized limitations and are not intended to identify all wetlands and streams, hence the focus on on-the-ground determinations for permit applications.

8. Definition of "Single and Complete Linear Project" (USACE 2016:12).

I recently have examined drawings, text assertions, and data forms in applications for new linear projects that currently are being built across hundreds, if not thousands, of wetlands and streams in Pennsylvania to see how vegetation cover is being characterized and impacts addressed. I frequently encountered inconsistencies which were not discussed in agency permit reviews. Consequently, I went into the field and checked about two dozen sites where the wetlands proposed for impact were on public lands or adjacent to public roads (most affected wetlands are on private lands where there is no public access) and am disturbed by what I found.

EXAMPLES FROM ONE PROJECT

My examples here were drawn from one major pipeline project that has disturbed about 1,200 hectares (3,000 acres) of land and for which extensive information is available online (https://www.dep.pa.gov/Business/ProgramIntegration/Pennsylvania-Pipeline-Portal/Pages/Mariner-East-II.aspx).[9] This applicant acknowledged its intent to disturb 15 ha (37 acres) within the 562 wetlands crossed by the new pipeline corridor and 5 ha (13 acres) within the 883 streambeds crossed. For the project discussed here, construction on the roughly 500-km long right-of-way was claimed to require the permanent conversion of only 0.2 ha (0.405 ac) of palustrine forest (PFO) to herbaceous (PEM) within a total of 19 wetlands. Natural reforestation of the land in the active right-of-way above the new pipelines is to be prevented long-term to facilitate inspection and maintenance. The applicant also acknowledged a project total of only 0.12 ha (0.288 ac) in PFO wetlands to be damaged temporarily during construction, which it proposed to replant with young trees. This minimal acknowledged total of wetland forest conversion and of temporary wetland forest construction disturbance with replanting suggests that an extraordinary effort was apparently made to minimize wetland forest impacts along 500 km of right-of-way. The applicant claimed to have minimized impacts by collocating the proposed pipelines near existing pipeline rights-of-way as much as possible. In most cases the existing cleared pipeline corridor is too narrow to accommodate the new pipelines, so new construction encroached into adjacent forest even where it did not strike out across new alignments. The proposed pipelines entailed the clearing of a new permanent right-of-way generally 23 m (75 ft) wide, reduced to 15 m (50 ft) in wetlands where "possible" and widened for additional temporary work space wherever "necessary." Rather than avoiding forested wetlands, how-

9. Similar errors are not confined to the specific project I discuss here or to linear projects in Pennsylvania (Schmid & Co., Inc. 2000, 2014a, 2014b, 2015, 2016a, 2016b, 2017a, 2017b; Helbing and Szybist 2014).

ever, this applicant appears often to have minimized instead the wetlands it characterized as forested.

The actual extent of forested wetland damage appears to be significantly greater than acknowledged, because: 1) the wetlands inventoried were not field flagged by the applicant, and 2) few wetland boundaries and cover types were field checked by agency staff. I found numerous errors during my spot inspections of accessible sites where application documents presented contradictory information. Careful examination of the project drawings, confirmed by field inspection, suggests that the consultant's claimed "streamlining" of aquatic resource inventory led to recurrent errors which regulators then failed to address. The figures here excerpted from this immense permit application warrant close scrutiny. In most cases, the contradictory information led to a significant cumulative underestimate of the actual damage proposed to forested wetlands and riparian forests when the sites were examined directly in the field. At two small locations where wetlands were mischaracterized as discussed below, the actual permanent conversion increases the acknowledged total conversion of PFO to PEM for this entire project by 38%.

FIGURE 1. Obvious misclassification of forested wetland (pale blue stripes) along a partially identified perennial headwater stream (dark blue) in this excerpt from a July 2015 applicant aerial site plan drawing. Pale blue striped wetland polygon was recorded as palustrine emergent (PEM). Yellow lines show project study area limits; red lines are proposed new pipelines through the mature forest. Yellow box is applicant's wetland data log location for W-L24, where data in Figures 3 and 4 were recorded. The applicant's photobase, other aerial photos, and onsite observations (Figure 2) confirm the applicant's failure to record trees present at the sampling location. This airphoto apparently was taken circa autumn 2013.

Since no field flagging of wetland limits was provided by this applicant, boundary locations had to be reconstructed in the field from application graphics using global positioning system (GPS) and geographic information system (GIS) technology. When questioned regarding the apparent wetland misclassification identified in Figure 1, the consultant's response was that no rooted trees had been found in these "herbaceous" wetlands because no trees were listed on the Corps wetland data form completed at the sampling location (applicant's yellow box), and there was no need to check further[10].

Actual conditions at this sampling location are shown in Figure 2. The basic error was misrecording the plants present, and that became the "justification" for erroneous cover classification. The mapped location of this sampling station differed from its reported latitude and longitude coordinates by 21 m (68 feet), although agency reviewers did not notice the misrepresentation or that any alternative sampling location in this wetland was similarly forested. The applicant's accompanying stream data sheet S-L41 representing the proposed pipeline crossing of the stream within wetland W-L24 records the stream channel itself as having 50% tree cover (presumably external cover determined following the conventions of Barbour et al. 1999). Corrections were not made by the applicant or required by regulators, despite landowner protest. Because of misclassification, the intended permanent conversion of 0.027 ha (0.066 acre) of forested wetlands to herbaceous wetlands here was not acknowledged. That omission alone is 42% greater than the acknowledged conversion in the surrounding county and 16% of the entire acknowledged project total. No applicant plans show any proposed replanting of the riparian forest to be "temporarily" destroyed here during construction.

Figures 5 through 8 likewise warrant close examination that was never done by regulators. They show Pennsylvania "Exceptional Value" riparian wetlands along two designated High Quality ("Special Protection") headwater streams tributary to a reproducing wild trout stream.[11] PADEP regulations specify among other things that no permit can be issued that has an "adverse impact" on Exceptional Value wetlands [25

10. Overhanging trees should be included in plot data wherever the trees are rooted in the plot and thereby part of the plant community. Furthermore, it is common knowledge that roots extend well beyond the canopy of individual trees.

11. Pennsylvania-designated Exceptional Value wetlands are Tier 3 Outstanding National Resource Waters in the terminology of the federal Clean Water Act (CWA) of 1948, with major amendments in 1972, 1977, and 1981 (33 USC §1251 et seq.)

Pa. Code 105.18a (1)]. As in the prior example, the actual forested nature of much of these Exceptional Value wetlands was not recognized, and it is clear that no effort was made to minimize wetland impacts here, despite repeated claims of impact minimization throughout the permit application documents for this project.

In Figure 6, forest tree canopy edge lines (black scalloped lines that I highlight in green) are shown along the existing pipeline right-of-way (compare base photo in Figure 5), contradicting PEM designation north of the existing mowed pipeline. The applicant again did not provide accurate information in its application text and drawings. This is not simply misclassification of Cowardin cover, but actual gross misrepresentation of the geographical extent of purported documentation represented by the Corps data form. The construction corridor was not inspected by regulators, and corrected drawings were not required prior to permit approvals or construction. Pennsylvania regulators clearly are not prepared to review large projects to this level of detail, but approve permits for them nonetheless.[12]

The western segment of this alignment, beginning just east of the public road was shifted to the south of the existing pipeline in late 2016 (Figure 5). Within the mowed, existing pipeline corridor new construction disturbance in PEM wetland is minimized by the southern alignment, but the workspace to the north caused unnecessary, easily avoided clearing of the Exceptional Value forested wetland mislabeled as herbaceous (Figure 6). The actual permanent conversion of 0.036 ha (0.09 ac) of forested wetland to herbaceous cover here above the pipelines was never acknowledged on drawings and was not included in proposed offsite mitigation. This single omission is more than 2.5 times the total area of permanent PFO to PEM conversion in this entire county that was identified in the state's record of decision (0.014 ha, 0.034 ac; PADEP 2017e) and 22% of the acknowledged total for the entire project. The recently added jog in the new pipelines could have been started 122 m (400 feet) further east to avoid the forest in Wetland Q63 entirely (Figures 5 and 7), or the temporary construction workspace could have been run through the mowed right-of-way along the south side of the new pipeline trenches, thus reducing wetland and non-wetland riparian forest impact significantly. The temporary timber mats for heavy equipment traversing these in-fact forested wetlands could have been shifted southward to cross the already disturbed cover of herbaceous wetland above the existing pipeline (as done elsewhere).

Because of inaccurate and uncorrected inventory information, neither the design engineer nor regulators were informed that forested wetland was being converted permanently at Wetland Q63. No riparian forest restoration (either wetland or non-wetland) is shown on drawings wherever temporary forest disturbance occurs within 150 feet of these Special Protection streams (as required to achieve 60% uniform canopy cover at maturation by special verbal condition of the applicable PADEP permit).

Drawings that show some of the applicant's proposed post-construction restoration measures along the new pipelines nowhere illustrate where the state's verbal permit conditions to replant forested wetlands and non-wetland riparian forest trees will be implemented. Many regulated preconstruction riparian forests were never accurately displayed on the permit inventory drawings along these proposed pipelines.

Given the absence of drawings showing the post-construction replanting of trees for riparian forest restoration called for by verbal permit condition in temporary construction areas previously forested (within 46 m [150 ft] of Special Protection streams, 30 m [100 ft] of Cold Water Fisheries streams, and 15 m [50 ft] of Trout Stocking and Warm Water Fishery streams), construction personnel may find compliance difficult. No forest restoration is required in any non-wetland forests clearcut outside riparian zones.

FIGURE 2. Man stands in the center of the applicant's recorded wetland sampling location, the yellow box for W-L24 shown in Figure 1. View northeast, April 2018. Recent clearing in background at right surrounds the area of red lines (proposed new pipelines) in Figure 1. Facultative hydrophytic trees (chiefly red maples, Acer rubrum) in fact are obviously rooted in this wetland. No trees were listed on the vegetation data form allegedly recorded here (Figure 4). Hence this wetland was erroneously reported as PEM and defended merely by reference to the erroneous data form.

12. "The Department has not received and continues not to receive complete permit applications that provide environmental assessments that adequately comply with the regulatory requirements when a project involves stream and wetland crossings in multiple counties" (PADEP 2017c). Despite this admission, the permits are approved.

Inventory errors were not limited to wetlands, but also extended to streams in this permit application. Stream S-Q64, for example, is represented on Figure 6 as about 7.6 m (25 ft) wide, although it was recorded on the applicant's stream data form as 1.2 m (4 ft) wide, which notation describes actual preconstruction field conditions more accurately than the Figure 6 drawing. In a 2017 addendum to the permit application, the designation of Stream S-Q64 was changed by the applicant to ephemeral rather than intermittent, but the drawing from which Figure 6 was taken was not revised. Potential impact to this stream thus is overstated by Figure 6. Such inconsistencies characterize many among the many hundreds of drawings and other documents in the applications for this project.

As the Pennsylvania Independent Oil and Gas Association has stated, "applicants should be encouraged to construct projects in areas that have been previously impacted" (PADEP 2017c), and this applicant claimed maximum collocation of its proposed new pipelines with existing development. Mere approximate collocation adjacent to an existing pipeline, of course, is not the same as conscientiously minimizing wetland or forest impacts, as illustrated in Figures 5 through 8. Regulators hardly began to review these applications and request corrections before approving the permits, and their review questions and comments largely went unaddressed.[13]

FIGURE 3. First page of applicant's Corps data form for wetland W-L24 (Figures 1 and 2). NWI classification is properly noted as "None". Reported latitude and longitude of sampling point contradict Figure 1. No data support the erroneous summary conclusion of Cowardin PEM herbaceous cover, which is contradicted also by the applicant's ground-level photos, stream cover classification, and tree lines on drawings.

Project/Site: PPP City/County: Huntingdon County Sampling Date: 06/24/2014
Applicant/Owner: Sunoco State: PA Sampling Point: W-L24
Investigator(s): A. Grech, A. Stott Section, Township, Range:
Landform (hillslope, terrace, etc.): Valley bottom Local relief (concave, convex, none): concave Slope (%): 0-4%
Subregion (LRR or MLRA): LRRS Lat: 40.358046 Long: -78.006565 Datum: NAD 83
Soil Map Unit Name: Andover extremely stony loam, 0-8 percent slopes NWI classification: None
Are climatic / hydrologic conditions on the site typical for this time of year? Yes ✔ No ___ (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes ✔ No ___
Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present? Yes ✔ No ___
Hydric Soil Present? Yes ✔ No ___
Wetland Hydrology Present? Yes ✔ No ___
Is the Sampled Area within a Wetland? Yes ✔ No ___

Remarks:
Cowardin Code: PEM
HGM: Riverine
WT: RPWWD

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)
___ Surface Water (A1)
✔ High Water Table (A2)
✔ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Inundation Visible on Aerial Imagery (B7)
___ Water Stained Leaves (B9)
___ Aquatic Fauna (B13)
___ True Aquatic Plants (B14)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres on Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tilled Soils (C6)
___ Thin Muck Surface (C7)
___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)
___ Surface Soil Cracks (B6)
___ Sparsely Vegetated Concave Surface (B8)
___ Drainage Patterns (B10)
___ Moss Trim Lines (B16)
___ Dry-Season Water Table (C2)
___ Crayfish Burrows (C8)
___ Saturation Visible on Aerial Imagery (C9)
___ Stunted or Stressed Plants (D1)
✔ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ Microtopographic Relief (D4)
✔ FAC-Neutral Test (D5)

Field Observations:
Surface Water Present? Yes ___ No ✔ Depth (inches): ___
Water Table Present? Yes ✔ No ___ Depth (inches): 4"
Saturation Present? (includes capillary fringe) Yes ✔ No ___ Depth (inches): 0"
Wetland Hydrology Present? Yes ✔ No ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

US Army Corps of Engineers Eastern Mountains and Piedmont – Version 2.0

WHAT REGULATORS SHOULD DO

Clearly large linear projects like pipelines are a challenge for regulators to evaluate given the length of the projects and funding/time constraints for regulatory review. In order to implement applicable statutes and regulations protecting aquatic resources in Pennsylvania,

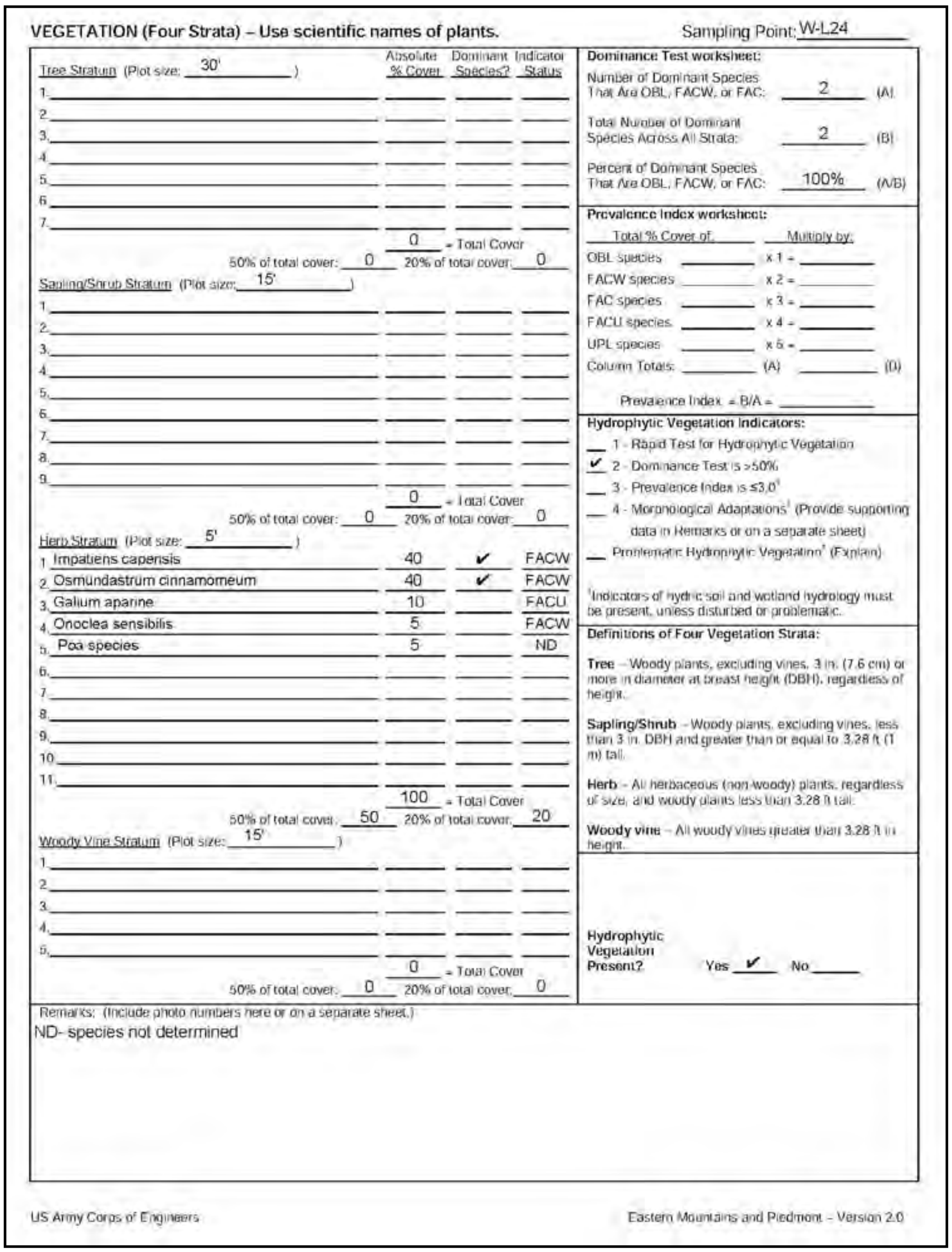
13. The kinds of misrepresentation discussed above are not confined to major or linear projects in Pennsylvania. While completing this paper I became aware of a nearby 47-acre tract of mature, mostly non-wetland forest on steep slopes proposed as part of a suburban residential development adjacent to a water supply reservoir. The land was described accurately by this applicant's environmental consultant as consisting "entirely of woods," consistent with aerial photographs and field documentation. The applicant's engineer claimed in the permit application, however, that all onsite wetlands here to be destroyed permanently by roads and utilities were PEM, contradicting the attached consultant delineation report. State reviewers never noticed the contradictory information when authorizing permanent damage to wetlands and streams. Moreover, they issued federal CWA approval, despite the fact that the applicant did not commit to placing a permanent conservation easement on the 0.207 ha (0.512 ac) of acknowledged wetlands that could remain undisturbed onsite. Lacking such commitment, a stream and wetland fill application is "required" to undergo federal agency review and coordination pursuant to Pennsylvania Statewide Programmatic General Permit-5 prior to Corps approval (PADEP Instructions 3150-PM-BWEW0051, March 2018, p. 2), but this one did not. Sedimentation of the reservoir resulted from severe thunderstorms during clearcutting.

certain changes are necessary on the part of permit applicants and by federal and state regulators. I offer a few suggestions for improvement. Immediate practical changes are needed for permits affecting water resources: 1) require and provide accurate delineation and classification of potentially affected resources; 2) require and provide visible, in-field flagging of wetland boundaries to correspond with surveyed drawings that meet Corps accuracy requirements; 3) require and provide accurate identification and acknowledgment of actually minimized temporary and permanent damage to streams, wetlands, and buffers; 4) require and provide drawings that show planned post-construction site restoration in compliance with permit conditions and enabling compliance inspection; and 5) withhold permit approvals until complete, accurate, and consistent applications and drawings are submitted and reviewed by regulators on behalf of the public. Approved Corps Jurisdictional Determinations, supported by thorough agency field inspections, should be secured for all projects. PADEP should post all applications for 25 Pa. Code Chapter 102 and 105 permits online, so that the public can review such documents; considerable transparency can be easily achieved by such posting. Regulators should seriously consider comments received from the public, and there should be consequences for systematic misrepresentation of resources inventoried in permit applications.

Regulatory guidance needs clarification and updating by PADEP and by the Corps. There is no mention of the Cowardin classification in the ten regional supplements that update the 1987 Corps Manual.[14]

The minimum regulatory parcel size for reporting discrete cover classes on project sites should be specified, because it appears to be quite different from that used for National Wetlands Inventory purposes.[15] The definition of single and complete linear projects should be reconsidered, because it has the effect of deflecting attention from impact minimization and avoidance.

FIGURE 4. Second page of applicant's Corps data form for wetland W-L24. No trees are recorded. Page 3 correctly records a hydric soil meeting "depleted matrix" (F3) criteria.



14. The undated online Army Corps Baltimore District "Regulatory Sourcebook" defines wetland types (a) with woody vegetation covering at least 20% of the ground as forest (trees >5 m or 16.4 ft tall) or scrub-shrub (shrubs <5 m tall) rather than the Cowardin 30% Class threshold and Cowardin 6 m (20 ft) break between trees and shrubs, and (b) as persistent emergent vegetation only when exhibiting 80% minimum total cover atop the soil or water (http://www.nab.usace.army.mil/Portals/63/docs/Regulatory/Pubs/sourcebook.pdf). Those definitions would yield more forest than the Cowardin definitions used in this paper, but apparently are not used by the District or PADEP.

15. Agencies in Pennsylvania direct that wetland boundaries be drawn to +/- 15 cm (0.5 foot) horizontal accuracy (http://www.nab.usace.army.mil/Portals/63/docs/Regulatory/Pubs/checklist.pdf) and that tallies of wetland area be reported to the accuracy of 40 square meters (a 21-foot square or 0.01 acre) for permit applications (PADEP 2017d). Applicants have little incentive to comply.

FIGURE 5. Pipelines proposed as of November 2016 (red lines) adjacent to an existing mowed, treeless pipeline right-of-way in the forest matrix. Black arrows indicate the camera location of ground-level views in Figures 7 and 8. Applicant's proffered classifications for Wetland Q63 (toothed lines) in the study corridor are white for PEM, green for PSS. South of the proposed pipelines PEM designation is accurate, but not for the PFO north of them. Earlier site plans showed the new pipelines continuing westward across the public road along the north side of the existing pipeline corridor. Leaf-off airphoto is from online ESRI World Imagery, date not specified.

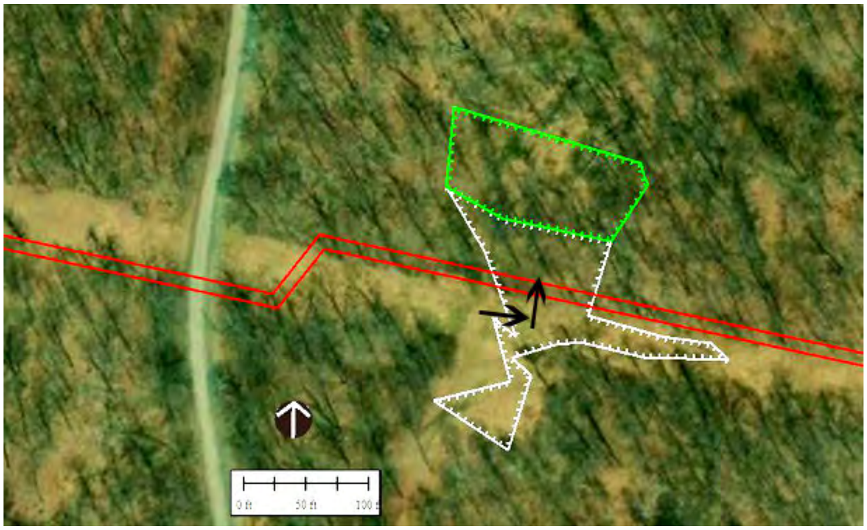
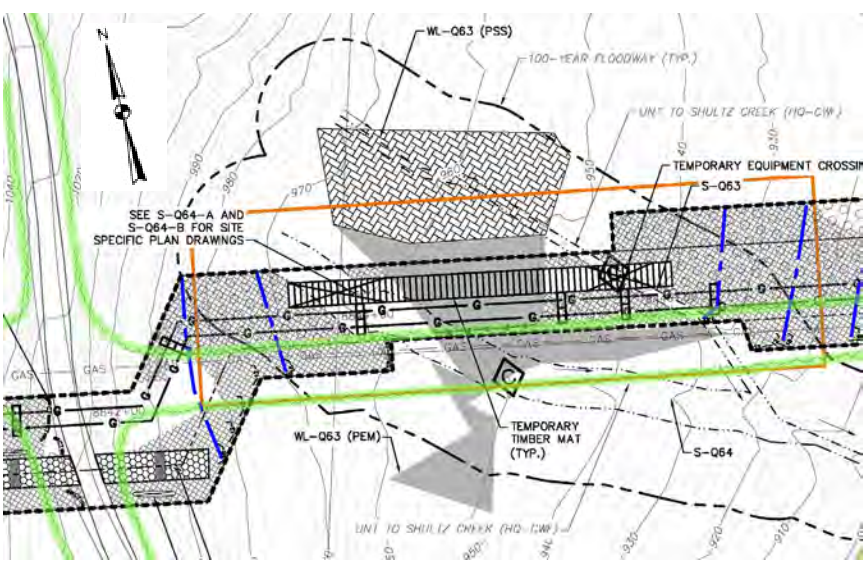


FIGURE 6. Excerpt from applicant's November 2016 erosion and sediment control plan for the area shown in Figure 5. Construction disturbance corridor width has been reduced to 15 m (50 ft) in the center of this crossing. The existing pipeline is labeled "-GAS-"; proposed new pipelines, "-G-". Stream channels are shown by thin dashed black lines with two dots inside regulated floodway limits marked by thick black lines with three dashes. The forest edge tree line along rights-of-way is shown by scalloped black lines highlighted here in green; black freestanding hexagons within the limits of disturbance denote existing riparian forest (hidden from view here beneath the erroneous PEM shading north of the existing pipeline).[16] Conterminous hexagons denote proposed rock construction entrances; square cross-hatch pattern, proposed erosion control blankets on steep slopes. Dashed blue lines are applicant's proposed permanent water bars. The "site specific plan drawings" referenced by the orange-boxed area show no replanting of riparian forest within temporary construction right-of-way, although such replanting is "required" by verbal permit condition to extend 150 feet from disturbed, previously forested streambanks of all Special Protection streams such as these.



16. Freestanding hexagons identifying preconstruction riparian forests are often hidden by this applicant's wetland patterns on erosion and sediment control plans.

CONCLUSION

The structural and functional losses in wetlands damaged by human activities worldwide are incurring "recovery debt" (Moreno-Mateos et al. 2015, 2017) that rarely is recovered completely despite human efforts at mitigation (Jones et al. 2018). This problem appears to be occurring in Pennsylvania, where forested wetlands go unrecognized and unmitigated, and their biological structure and especially their biogeochemical functions require many decades or centuries to recover, even where post-construction restoration is attempted (Ballantine and Schneider 2009; Moreno-Mateos et al. 2012; Jones et al. 2018).

From my field review of several projects, it appears that state and federal regulators of proposed impacts on aquatic resources in Pennsylvania too often remain oblivious to errors of cover classification (i.e., wetland type identification), wetland boundary delineation, and other aspects of environmental inventory, and fail to: a) require wetland boundary point flagging that is visible in the field, b) inspect and verify applicant-delineated wetland boundaries on construction sites, and c) demand complete, accurate, and consistent data in permit applications to damage streams and wetlands prior to granting permit approvals. Permit conditions for restoration and compensatory mitigation that on paper might appear protective of resources in fact are not.[17] Mistakes in reporting what might be thought simple, basic Cowardin Classes of wetlands in Pennsylvania, as well as appropriate acknowledgment of proposed damages, onsite restorations, and proposed offsite compensatory mitigation entered on project drawings and application summary tables, are now commonplace.

17. Pennsylvania also chooses not to require compensatory mitigation for impacts it broadly defines as "temporary" (viz., "those that are avoided or minimized, rectified by repairing, rehabilitating or restoring the impacted environment, or reducing or eliminating the impact over time by preservation or maintenance operations, and [thus] do not require compensatory mitigation…" [PADEP 2017c]). It further adds that "only permanent impacts must be assessed for meeting the applicable regulatory requirements pertaining to cumulative impacts for wetlands … and antidegradation impacts for streams …" (Ibid.). But in fact these are not assessed during actual permit reviews.

Moreover, consultants cannot assist the public, affected landowners, or regulators by verifying site inventories where site access is unavailable and where regulators do not follow up to resolve issues raised in comments provided during permit review. When consistent, accurate wetland inventory information is not required of applicants by regulators on behalf of the public prior to permit approval, compliance with regulatory "requirements" is precluded (Schmid & Co., Inc. 2000, 2014b, 2015, 2016a, 2016b; Helbing and Szybist 2014). Based on my observations, existing regulatory procedures need to be revised to promote the objectives of the wetland regulations. ■

ACKNOWLEDGMENTS

The author expresses his thanks to longtime colleague Stephen P. Kunz for much assistance in preparing this article, to Ralph W. Tiner for editorial suggestions, and to Joy B. Zedler for references on restoration success. Any errors remain the sole responsibility of the author.

FIGURE 7. View east toward Schultz Ridge about 1.8 km (1.1 mile) distant, February 2017. PEM wetland (foreground at right) is in cleared right-of-way of existing pipeline with PFO wetland to north (left) mislabeled as PEM. The distribution of trees shown in the aerial photo (Figure 5) and by the applicant's treeline in Figure 6 is confirmed as accurate by field inspection. Several applicant drawings claim that PEM extends for 15 m (50 feet) to the north (left of the man in photo), in contradiction to the applicant's accurate tree canopy line on the north side of the existing pipeline corridor in Figure 6. Photo location is shown by horizontal arrow in Figure 5. Man stands in the same place along the tree line in Figures 7 and 8.

REFERENCES

Ballantine, K. and R. Schneider. 2009. Fifty-five years of soil development in restored freshwater depressional wetlands. *Ecological Applications* 19(6):1467-1480.

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid bioassessment protocols for use in streams and wadeable rivers: periphyton, benthic macroinvertebrates and fish. Second edition. U.S. Environmental Protection Agency, Office of Water, Washington, DC. EPA 841-B-99-002.

Braun, E.L. 1950, 1972. *Deciduous forests of the eastern United States.* Hafner Publishing Co., New York, NY. 596 pp.

Cowardin, L.M., V. Carter, F.C Golet, and E.T. LaRoe. 1979. Classification of wetlands and aquatic habitats of the United States. U.S. Fish and Wildlife Service, Office of Biological Services, Washington, DC. 103 pp. [An interim version was issued in 1976.]

Dahl, T.E., J. Dick, J. Swords, and B.O. Wilen. 2015. Data collection requirements and procedures for mapping wetland, deepwater and related habitats of the United States Version 2. U.S. Fish and Wildlife Service, Division of Habitat and Resource Conservation, National Standards and Support Team, Madison, WI. 92 pp.

EL [Environmental Laboratory]. 1987. Corps of Engineers wetlands delineation manual. U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS. Technical Report Y-87-1. 165 pp.

FIGURE 8. View north directly into mislabeled, red maple-dominated PFO wetland across foreground PEM wetland in the cleared right-of way of the existing pipeline, February 2017. PFO extends northward through the alleged PEM and PSS wetlands here. All these trees subsequently were cut unnecessarily, and no proposed replanting of trees in "temporarily" disturbed sections of riparian forest is shown on applicant drawings. Photo location is depicted by the vertical black arrow in Figure 5. Man stands at same location as in Figure 7.

FGDC. 2013. Classification of wetlands and deepwater habitats of the United States. Second Edition. Wetlands Subcommittee, Federal Geographic Data Committee, and U.S. Fish and Wildlife Service, Washington, DC. FGDC-STD-004-2013. 86 pp.

Griscom, B.W., J. Adams, P.W. Ellis, R.A. Houghton, G. Lomax, D.A. Miteva, W.H. Schlesinger, D. Shoch, J.V. Siikamäk, P. Smith, P. Woodbury, C. Zganjar, A. Blackman, J. Campari, R.T. Conant, C. Delgado, P. Elias, T. Gopalakrishna, M.R. Hamsik, M. Herrero, J. Kiesecker, E. Landis, L. Laestadius, S.M. Leavitt, S. Minnemeyer, S. Polasky, P. Potapov, F.E. Putz, J. Sanderman, M. Silvius, E. Wollenberg, and J. Fargione. 2017. Natural climate solutions. *Proceedings of the National Academy of Sciences* 114(44):11645-11650.

Guidugli-Cook, M S.C. Richter, B.J. Scott, and D.R.Brown. 2017. Field-based assessment of wetland condition, wetland extent, and the National Wetlands Inventory in Kentucky. *Wetlands Ecology and Management* 25(5):517-532.

Helbing, M.D., and M.C. Szybist. 2014. PPL Corporation-PPL Electric Utilities water obstruction and encroachment permit applications No. E40-759 and E45-590, Jenkins-West Pocono 230 kV line and 138 kV connector lines out of West Pocono Substation. Letter to Northeast Regional Office, Pennsylvania Department of Environmental Protection. Citizens for Pennsylvania's Future, Wilkes-Barre, PA. 20 pp. www.schmidco.com/PennFuture_Comment_Letter_7_Nov_2014.pdf Accessed 15 November 2018.

Hossler, K, V. Bouchard, M.S. Fennessy, S.D. Frey, E. Anemat, and E. Herbert. 2011. No-net-loss not met for nutrient function in freshwater marshes: recommendations for wetland mitigation policies. *Ecosphere* 2(7):1-36.

Jones, H.P., P.C. Jones, E.B. Barbier, R.C. Blackburn, J.M.R. Beneyas, K.D. Holl, P. Meli, D. Montoya, and D. Moreno-Mateos. 2018. Restoration and repair of Earth's damaged ecosystems. *Proceedings of the Royal Society B* 285(1873). https://doi.org/10.1098/rspb.2017.2577

Lovett, G.M., C.I. Goodale, S.V. Ollinger, C.B. Fuss, A.P. Ouimette, and G.E. Likens. 2018. Nutrient retention during ecosystem succession: a revised conceptual model. *Frontiers in Ecology and the Environment* 16(9):532-538.

Moreno-Mateos, D., E.B. Barbier, P.C. Jones, H.P. Jones, J. Aronson, J.A. Lopez-Lopez, M.L. McCrackin, P. Meli, D. Montoya, and J.M.R. Benayas. 2017. Anthropogenic ecosystem disturbance and the recovery debt. *Nature Communications* 8(14163):1-14.

Moreno-Mateos, D., P. Meli, M.I. Vara-Rodriguez, and J.Aronson. 2015. Ecosystem response to interventions: lessons from restored and created wetland ecosystems. *Journal of Applied Ecology* 52:1528-1537.

Moreno-Mateos, D., M.E. Power, F.A. Comin, and R. Yockteng. 2012. Structural and functional loss in restored wetland ecosystems. *PLOS Biology* 10(1):1-8.

PADEP [Pennsylvania Department of Environmental Protection]. 2014. Pennsylvania function based aquatic resource compensation protocol. Bureau of Waterways Engineering and Wetlands, Division of Wetlands, Encroachment, and Training, Harrisburg, PA. Draft Technical Guidance Document 310-2137-001. 36 pp.

PADEP. 2017a. Chapter 105 dam safety and waterway management final technical guidance: Pennsylvania wetland condition level 2 rapid assessment comment and response document. Bureau of Waterways Engineering and Wetlands, Harrisburg, PA. Technical Guidance Document 310-2136-002(CR). 19 pp.

PADEP. 2017b. Pennsylvania wetland condition level 2 rapid assessment protocol. Bureau of Waterways Engineering and Wetlands, Division of Wetlands, Encroachment, and Training, Harrisburg, PA. Technical Guidance Document 310-2137-002. 32 pp.

PADEP. 2017c. Chapter 105 dam safety and waterway management final technical guidance: comprehensive environmental assessment of proposed project impacts for Chapter 105 water obstruction and encroachment permit applications comment and response document. Bureau of Waterways Engineering and Wetlands, Harrisburg, PA. Technical Guidance Document 310-2137-006(CR). 19 pp.

PADEP. 2017d. Environmental assessment form (EA form) instructions. Bureau of Waterways Engineering and Wetlands, Harrisburg, PA. Document 3150-PM-BWEW0017 Rev. 6/2017. 42 pp.

PADEP. 2017e. Environmental review for Chapter 105 Application No. E50-258. Clean Water Section, Bureau of Clean Water, Harrisburg, PA. 28 pp.

Riley, D.T. 2008. Regulatory guidance letter 08-02: jurisdictional determinations. U.S. Army Corps of Engineers, Washington, DC. 11 pp.

Schmid & Company, Inc. 2000. Wetlands and longwall mining: regulatory failure in southwestern Pennsylvania Prepared for the Raymond Proffitt Foundation, Langhorne, PA. Media, PA. 123 pp. http://www.schmidco.com/Wetlands%20and%20Longwall%20Mining%202000.pdf Accessed 15 November 2018.

Schmid & Co., Inc. 2014a. The effects of converting forest or scrub wetlands to herbaceous wetlands in Pennsylvania Prepared for the Delaware Riverkeeper Network, Bristol, PA. Media, PA. 48 pp. http://www.schmidco.com/Conversion_Final_Report.pdf Accessed 15 November 2018.

Schmid & Co., Inc. 2014b. Analysis of impacts on wetlands and buffers, proposed Williams Transco Leidy Southeast Franklin Loop D Pipeline, Monroe and Luzerne Counties, Pennsylvania Prepared for the Delaware Riverkeeper Network, Bristol, PA. Media, PA. 53 pp. http://www.schmidco.com/Leidy_Final_22_July_2014.pdf Accessed 15 November 2018.

Schmid & Co., Inc. 2015. Undermining the public trust: a review and analysis of PADEP's Fourth Act 54 Five-year Assessment report. Prepared for the Citizens Coal Council, Bridgeville, PA. Media, PA. 67 pp. http://www.schmidco.com/Undermining_the_Public_Trust_March_2015.pdf Accessed 15 November 2018.

Schmid & Co., Inc. 2016a. The effects of the proposed PennEast Pipeline on exceptional value wetlands in Pennsylvania. Prepared for the Delaware Riverkeeper Network, Bristol, PA. Media, PA. 54 pp. http://www.schmidco.com/PennEast_Wetland_Report_Final_July_2016.pdf Accessed 15 November 2018.

Schmid & Co., Inc. 2016b. Wetland and stream impacts of Sunoco's Mariner East II Pipeline Prepared for the Mountain Watershed Association and Clean Air Council. Media, PA. 22 pp. http://www.schmidco.com/Letter_Report_Mariner_East_II_22_August_2016.pdf Accessed 15 November 2018.

Schmid & Co., Inc. 2017a. Potential impacts of the Atlantic Sunrise Pipeline on exceptional value wetlands and special protection waters in Schuylkill County, Pennsylvania. Prepared for Delaware Riverkeeper Network and Schuylkill Pipeline Awareness. Media, PA. 21 pp. http://schmidco.com/Sunrise_Schmid_Report_26_June_2017.pdf Accessed 15 November 2018.

Schmid & Co., Inc. 2017b. Potential impacts of Mariner East II Pipeline on wetlands, streams, and water supplies in Middletown Township, Delaware County, Pennsylvania. Prepared for Middletown Coalition for Community Safety. Media, PA. 18 pp. http://www.schmidco.com/Comments_on_MEII_Delaware_County.pdf Accessed 15 November 2018.

Tiner, R.W. 1990. Pennsylvania's wetlands: current status and recent trends. Prepared for Pennsylvania Bureau of Water Resources Management. U.S. Department of the Interior, Fish and Wildlife Service, Newton Corner, MA. 104 pp.

USACE [U.S. Army Corps of Engineers]. 2016. Pennsylvania Statewide Programmatic General Permit-5. Baltimore District, Baltimore, MD. 56 pp.

USACE. 2012. Regional supplement to the Corps of Engineers wetland delineation manual: Eastern Mountains and Piedmont region, Version 2.0. Berkowitz, J.F., J.S. Wakeley, R.W. Lichvar, and C.V. Noble (eds.). US Army Engineer Research and Development Center, Vicksburg, MS. ERDC/EL TR-12-9. 182 pp.

New Books for Identifying Wetland Graminoids Published

For wetlanders with an interest in identifying graminoids, two books should be on your bookshelf: Sedges of Maine (Matt Arsenault and others) published by the University of Maine Press (reprint of 2013 book) and Sedges and Rushes of Minnesota (Welby Smith, 2018) printed by the Minnesota Department of Natural Resources. Both books are copiously illustrated with color photographs that definitely aid in plant identification. Another graminoid book – Grasses and Rushes of Maine – is in production and should be available in late January.

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

- Sedges of Maine https://umaine.edu/umpress/books-in-print/
- Sedges and Rushes of Minnesota https://www.upress.umn.edu/book-division/books/sedges-and-rushes-of-minnesota
- Wetland & Stream Rapid Assessments: Development, Validation, and Application https://www.elsevier.com/books/wetland-and-stream-rapid-assessments/dorney/978-0-12-805091-0
- 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. https://www.fws.gov/northeast/EcologicalServices/pdf/wetlands/Dichotomous_Keys_and_Mapping_Codes_for_Wetland_Landscape_Position_Landform_Water_Flow_Path_and_Waterbody_Type_Version_3.pdf
- 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/

What's New in the SWS Journal - *Wetlands*?

The following articles appear in Volume 38, Issue 5 of *Wetlands*:

- Mangrove Species Discrimination from Very High Resolution Imagery Using Gaussian Markov Random Field Model
- Effects of Seed Treatments, Delayed Planting and Groundwater Levels on the Restoration of Sedge Meadows
- Responses of Tidal Freshwater and Brackish Marsh Macrophytes to Pulses of Saline Water Simulating Sea Level Rise and Reduced Discharge
- Contrasting Photosynthetic Responses of Two Dominant Macrophyte Species to Seasonal Inundation in an Everglades Freshwater Prairie
- Greenhouse Gas Dynamics of a Northern Boreal Peatland Used for Treating Metal Mine Wastewater
- Patterns of Spatial Diversity and Structure of Mangrove Vegetation in Pacific West-Central Mexico
- Diurnal Patterns of Methane Flux from a Seasonal Wetland: Mechanisms and Methodology
- Seasonal and Spatial Variation of Nitrogen Oxide Fluxes from Human-Disturbance Coastal Wetland in the Yellow River Estuary
- Functional Assemblages of Macroinvertebrates in Pools and Ditches in Drained Forest Landscape
- Litter Decomposition Rates in Six Mine Water Wetlands and Ponds in Oklahoma
- Effects of Flood Pulse Dynamics on Functional Diversity of Macrophyte Communities in the Pantanal Wetland
- Tidal Hydrology and Salinity Drives Salt Marsh Vegetation Restoration and Phragmites australis Control in New England
- Farmer Preferences for a Working Wetlands Program
- Beaver Dams Induce Hyporheic and Biogeochemical Changes in Riparian Areas in a Mountain Peatland
- Diversity of Rotifera (Monogononta) and Egg Ratio of Selected Taxa in the Canals of Xochimilco (Mexico City)
- Classification of Small Seasonal Ponds Based on Soil–Water Environments in the Cuvelai Seasonal Wetland System, North-Central Namibia
- Using Turbidity Measurements to Estimate Total Phosphorus and Sediment Flux in a Great Lakes Coastal Wetland

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

The following articles appear in Volume 38, Issue 6 of *Wetlands*:

- Eco-Biology and Management of Alligator Weed [Alternanthera philoxeroides) (Mart.) Griseb.]: a Review
- Imbalance of Ecosystem Services of Wetlands and the Perception of the Local Community towards their Restoration and Management in Jimma Highlands, Southwestern Ethiopia
- Technical Viability of Constructed Wetland for Treatment of Dye Wastewater in Gadoon Industrial Estate, Khyber Pakhtunkhwa, Pakistan
- Spatio-Temporal Impacts of Lake Victoria Water Level Recession on the Fringing Nyando Wetland, Kenya
- Emergy Evaluation of three Rice Wetland Farming Systems in the Taihu Lake Catchment of China
- The Effects of Area and Habitat Heterogeneity on Bird Richness and Composition in High Elevation Wetlands ("Bofedales") of the Central Andes of Peru
- Spatial and Seasonal Dynamics of Water Quality, Sediment Properties and Submerged Vegetation in a Eutrophic Lake after Ten Years of Ecological Restoration
- Annual Growth Rings in Two Mangrove Species from the Sundarbans, Bangladesh Demonstrate Linkages to Sea-Level Rise and Broad-Scale Ocean-Atmosphere Variability
- Exploring Social-Ecological Complexities of Wetlands of International Importance (Ramsar Sites): the Carlos Anwandter Sanctuary (Valdivia, Chile) as a Case Study
- Uses and Preferences of Visitors to Coastal Wetlands in Tourism Destinations (Costa Brava, Spain)
- Estimating the Potential Fishery Benefits from Targeted Habitat Repair: a Case Study of School Prawn (*Metapenaeus macleayi*) in the Lower Clarence River Estuary
- The Role of in Lieu Fee Programs in Wetland/Stream Mitigation Credit Trading: Illustrations from Virginia and Georgia
- Science as a Bridge in Communicating Needs and Implementing Changes towards Wetland Conservation in Taiwan
- *Spartina patens* Productivity and Soil Organic Matter Response to Sedimentation and Nutrient Enrichment
- Multi-Element Composition of Prairie Pothole Wetland Soils along Depth Profiles Reflects Past Disturbance to a Depth of at Least one Meter
- The Role of Propagule Type, Resource Availability, and Seed Source in *Phragmites* Invasion in Chesapeake Bay Wetlands
- From Mountains to Plains: Ecological Structure of the South Ural (Russia) Fen Vegetation
- Dynamics of *Ludwigia hexapetala* Invasion at three Spatial Scales in a Regulated River
- Are Boreal Riparian Bird Communities Unique? Contrasting Riparian and Upland Bird Assemblages in the Boreal Plain of Western Canada
- Densities and Zonation Patterns of Native and Non-Indigenous Oysters in Southern California Bays
- Salt Marsh Aboveground Production in New England Estuaries in Relation to Nitrogen Loading and Environmental Factors

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. ■

Novato wetlands project cleared for $5.7M infusion
https://www.marinij.com/2018/12/25/state-approves-funding-for-next-phase-of-hamilton-wetlands-project/

City adds to wetlands preservation along Salt Creek
https://journalstar.com/news/state-and-regional/govt-and-politics/city-adds-to-wetlands-preservation-along-salt-creek/article_4c18b7a5-9c5e-59ad-96e6-4f0aa3e61731.html

Global sea level could rise 15 meters by 2300, study says
https://phys.org/news/2018-10-global-sea-meters.html

New Climate Report Was Too Cautious, Some Scientists Say
https://www.scientificamerican.com/article/new-climate-report-was-too-cautious-some-scientists-say/

What's Another Way to Say 'We're F-cked'?
https://www.rollingstone.com/politics/politics-news/climate-change-sea-level-rise-737012/

Cows help battle invasive grass at Great Salt Lake wetlands
https://www.sltrib.com/news/2018/10/13/cows-help-battle-invasive/

Developer cited for violating clean water act after developing part of subdivision in wetlands
http://www.wbrz.com/news/developer-cited-for-violating-clean-water-act-after-developing-part-of-subdivision-in-wetlands/

Rising Seas Threaten Iconic Mediterranean Sites
https://www.scientificamerican.com/article/rising-seas-threaten-iconic-mediterranean-sites/

The future of wetlands: We've been warned
https://forestsnews.cifor.org/57861/the-future-of-wetlands-weve-been-warned?fnl=en

Prevent red tide? Start with more wetlands, experts say
http://floridapolitics.com/archives/277986-wetlands-water-red-tide

Climate change doubters are finalists for Environmental Protection Agency Science Advisory Board
https://www.sciencemag.org/news/2018/10/climate-change-doubters-are-finalists-environmental-protection-agency-science-advisory

Sea level rise doesn't necessarily spell doom for coastal wetlands
https://www.sciencenews.org/article/sea-level-rise-doesnt-necessarily-spell-doom-coastal-wetlands

West Marin wetlands project hits 10-year mark
https://www.marinij.com/2018/10/22/nature-reclaims-giacomini-wetlands-a-decade-after-major-restoration-project/

As Sea Levels Rise, How Best to Protect Coasts?
https://www.yaleclimateconnections.org/2016/07/as-sea-levels-rise-how-best-to-protect-our-coasts/

World's Largest Tropical Wetland Has A Problem With Roadkill
https://www.iflscience.com/plants-and-animals/worlds-largest-tropical-wetland-has-a-problem-with-roadkill/

Rising Seas Forcing Changes on Maryland's Historic Eastern Shore Farms
https://www.voanews.com/a/climate-change-maryland-farms/4633200.html

Climate change: 'Wetlands vital to protect cities'
https://www.bbc.com/news/science-environment-46020176

As Insect Populations Decline, Scientists Are Trying to Understand Why
https://www.scientificamerican.com/article/as-insect-populations-decline-scientists-are-trying-to-understand-why/

Rising sea levels may build, rather than destroy, coral reef islands
https://phys.org/news/2018-11-sea-coral-reef-islands.html

$400,000 grant to plan wetlands restoration between Bucktown and Bonnabel in Jefferson Parish
https://www.nola.com//environment/2018/11/400000-grant-to-plan-wetlands-restoration-between-bucktown-and-bonnabel-in-jefferson-parish.html

Saltese Flats wetlands project underway for wildlife, water
http://www.spokesman.com/stories/2018/nov/15/saltese-flats-wetlands-project-underway-for-wildli/

Industries face closure for polluting wetlands, water bodies
https://www.newtimes.co.rw/news/industries-face-closure-polluting-wetlands-water-bodies

Oasis Lost - With urbanization sprawling west, one of the most important landscapes in the western hemisphere—the wetlands of the Great Salt Lake—is at risk of disappearing.
https://www.cityweekly.net/utah/oasis-lost/Content?oid=10443272

End of an era as Ireland closes its peat bogs 'to fight climate change'
https://www.theguardian.com/world/2018/nov/27/ireland-closes-peat-bogs-climate-change

Bill would roll back wetlands protections
http://www.michiganradio.org/post/bill-would-roll-back-wetlands-protections

Marin gets $520,000 for Novato wetlands restoration project
https://www.marinij.com/2018/11/27/marin-county-gets-520000-grant-to-design-novato-wetlands-restoration-project/

West Coast Wetlands Could Nearly Disappear in 100 Years
https://www.scientificamerican.com/article/west-coast-wetlands-could-nearly-disappear-in-100-years

Wetlands are a natural climate solution. Guess who's turning them into big polluters?
https://grist.org/article/wetlands-are-a-natural-climate-solution-guess-whos-turning-them-into-big-polluters/

Requiem for our wetlands? What's at risk in NE Minnesota
https://www.minnpost.com/community-voices/2018/11/requiem-for-our-wetlands-whats-at-risk-in-ne-minnesota/

Michigan Senate votes to drain wetlands regulations
https://www.detroitnews.com/story/news/local/michigan/2018/12/04/michigan-senate-votes-drain-wetlands-regulations/2206092002/

As he exits, Michigan lawmaker wants to gut wetland protection, boost waste
https://www.bridgemi.com/michigan-environment-watch/he-exits-michigan-lawmaker-wants-gut-wetland-protection-boost-waste

Trump EPA Proposes Major Rollback Of Federal Water Protections
https://www.npr.org/2018/12/11/675477583/trump-epa-proposes-big-changes-to-federal-water-protections

Southeast Long Beach land swap could net more wetlands—and more greenhouse gases
https://lbpost.com/news/coastal-commission-southeast-long-beach-oil-wetlands/

Saving the Graniteville Woods and Wetlands: How a poor community is fighting to save their only open, green space
http://www.sicwf.org/

CLEAN WATER ACT: EPA falsely claims 'no data' on waters in WOTUS rule
https://www.eenews.net/stories/1060109323

LSU wetlands mitigation bank plan moves forward
https://www.businessreport.com/realestate/lsu-wetlands-mitigation-bank-plan-moves-forward

Trump wetlands rule rollback makes about 6 million acres in Florida unprotected
https://www.tampabay.com/environment/trump-wetlands-rule-rollback-makes-about-6-million-acres-in-florida-unprotected-20181213/

In India, Nature's Power Overwhelms Engineered Wetlands
https://e360.yale.edu/features/in-india-natures-power-overwhelms-engineered-wetlands

Controversial wetlands legislation gets scaled back by state Legislature
https://www.detroitnews.com/story/news/local/michigan/2018/12/21/scaled-back-wetlands-legislation-gets-house-ok/2379537002/

Wetland damage from roseau cane plague visible in satellite images
https://articles.nola.com/environment/index.ssf/2018/09/wetland_plague_damage_in_missi.amp

Wetlands disappearing 3 times faster than forests threatening fresh water supplies: Report
https://timesofindia.indiatimes.com/india/wetlands-disappearing-3-times-faster-than-forests-threatening-fresh-water-supplies-report/articleshow/65974012.cms

Why we must save the Endangered Species Act
https://e360.yale.edu/features/why-we-must-save-the-endangered-species-act-from-the-trump-administration-babbitt

Beavers are redefining the landscape at Smith and Bybee Lake Wetlands Natural Area
https://katu.com/news/local/beavers-are-redefining-the-landscape-at-smith-and-bybee-lake-wetlands-natural-area

What the world needs now to fight climate change: More swamps
http://theconversation.com/what-the-world-needs-now-to-fight-climate-change-more-swamps-99198

Proposal for wetland buffers doesn't hold water in Lewes
https://www.capegazette.com/article/proposal-wetland-buffers-doesn%E2%80%99t-hold-water-lewes/165372

Future of tidal wetlands depends on coastal management
https://www.nature.com/articles/d41586-018-06190-x

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

About *Wetland Science & Practice (WSP)*

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. ■