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FROM THE EDITOR'S DESK

It's been an interesting year, hasn't it? I'm sure that this is true from a number of standpoints. For me it's been my first full year of retirement and I've enjoyed it immensely, even though I really liked my work with the U.S. Fish and Wildlife Service (FWS). Besides traveling with my wife, I received a career service award from the FWS and the second edition of my book – *Wetland Indicators* – was published in full color (see Wetland Bookshelf). Plus I learned from my eldest son that I'll be a grandfather in 2017, my daughter is engaged with wedding plans for next August, and my youngest child (son) graduated from college and is now a gainfully employed adult. Also *Wetland Science & Practice* (WSP) is making progress, getting more unsolicited contributions.

Ralph Tiner
WSP Editor

> "WSP is your journal for communicating the results of various projects or even providing your perspective on certain topics – so be sure to take advantage of this opportunity."

For this issue, we've got two articles dealing with coastal wetlands – one about Nigerian mangroves and the other offering a perspective on restoration of Mid-Atlantic (USA) salt marshes. Besides my editorial and the President's message, it also includes an announcement about a new SWS Program – the Wetland Ambassadors Program (contributed by Dr. Bianca M. Wentzell), other news, and a cartoon from Doug Wilcox (From the Bog).

As this is the last issue for 2016, I want to thank all the contributors who submitted articles and information for this year's issues. WSP is your journal for communicating the results of various projects or even providing your perspective on certain topics – so be sure to take advantage of this opportunity. While I already have at least one article for the March 2017 issue, I would encourage others to submit articles for publication in future issues of WSP. Please feel free to contact me if you have questions. Also if you'd like to submit a photograph for consideration as a cover image for a future issue, please send it to me (rtiner@eco.umass.edu) along with a caption describing the image and location. At a minimum, we'll include it along with others received at the end of the next issue along with the caption and photo credit.

Meanwhile, enjoy the holidays and like you, I'm looking forward to seeing what 2017 brings.

Happy Swamping! ■

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

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Cover photo:
Maine salt marsh showing an abundance of ponds
by William French, U.S. Fish and Wildlife Service

www.sws.org

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

SOCIETY of WETLAND SCIENTISTS

wetland science & practice

Yesterday I attended the funeral of a good friend and environmentalist, Boy Scout leader, former U.S. Marine, patron of the arts, and Massachusetts Minuteman revolutionary war re-enactor. James Norton had the gift of being present in the lives of hundreds of people, and he was always prepared. Prepared not just for his own life, but prepared to jump in and help others with whatever they were struggling with, literally from helping with an untied shoelace, to finding energy alternatives and strategies that lessen our impact on the planet. During the service yesterday, the minister invited us to follow in our friend's footsteps, to, "Be prepared to be present".

Gillian Davies, PWS
SWS President

Our future is always uncertain, and now, it seems, more so than ever. How do we move forward in uncertain times? I find the minister's words to be particularly helpful – "Be prepared to be present". Now, more than ever, the Society of Wetland Scientists, and the work that we do on a daily basis matters. Like the actions of James Norton, our daily efforts tilt the world towards the good.

With thanks to those who preceded me in SWS leadership, I often look to our Strategic Plan as a guide. Now more than ever, the core values that we express as a Society provide a roadmap as we navigate into the future. As we follow our mission, "To promote understanding, conservation, protection, restoration, science-based management, and sustainability of wetlands", we do so by:

- Encouraging and promoting incorporation of sound wetland science into policy (Goal 4)
- Increasing human diversity of SWS and the wetland science community (Objective 6.2)
- Fostering the international scope of Wetland Science and SWS (Goal 5)
- Fostering high quality and effective basic and applied wetland research (Goal 1)
- Promoting science-based stewardship of wetlands (Goal 3)
- Supporting education and public awareness of wetlands (Goal 2)

These are exemplary goals and objectives, and I feel proud to be part of an organization that will continue to promote and support wetland science, science-based policy, science-based stewardship of wetlands, and sound wetland education in a manner that values not only biodiversity but also human diversity, both within nations, and by fostering international cooperation. Our collective work brings with it the power of our global community, so that we can "be prepared to be present" in our work to meet the challenges ahead of us.

James Norton's obituary ended with the famous words of Massachusetts native Henry David Thoreau: "In wilderness is the preservation of the world." A parting gift to us all, to be reminded of these insightful and inspiring words.

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Growing the Society Through Real Connections

Michelle Czosek, CAE, SWS Managing Director

Michelle Czosek, CAE
SWS Managing Director

Networking is not collecting contacts! Networking is about planting relations.
– MiSha.at

Reflecting on this past year, there's no quote that better sums up what I continuously see happening through SWS and what I hope to see even more of in the future. I first noticed the remarkable relationships people have built or strengthened through their involvement, when I started working closely with the SWS Board of Directors.

One of the aspects of my position with SWS that I enjoy the most is the ability to interact with members on a daily basis. While most of my interactions take place via email, it's the phone and in person interactions that I value most. In discussions, a lot of you have mentioned that's what you value as well. Throughout my career in association management, I've seen the power of making those connections first hand. I've seen personal relationships that started as an introduction at a meeting turn into lifelong friendships, business partnerships formed at opening receptions and new jobs found through association contacts.

Associations have the ability to help you develop both personally and professionally. And it's the growth of the organization that fuels it all. As our community grows, so will your opportunities to connect with other wetland scientists around the world. I encourage you to make the most of your association membership by getting involved in a committee, attending chapter activities and making plans to attend the annual meeting in Puerto Rico. The annual meeting is the perfect place to interact with and learn from your peers. It's our largest gathering of the year and your opportunity to expand your network.

I heard someone say in a presentation recently, "Don't let technology rule you. Be a champion of personal relationships." I hope that as our SWS relationships develop, we'll do exactly that – pick up the phone and meet face-to-face as often as we can to grow relationships and, in turn the organization, through personal contact and real connections. This real connection time with our peers is the foundation that our association is built on and it benefits us all.

I challenge you reach out to someone you know and invite them to join SWS this year. By inviting them to join, you'll allow them the unique opportunity to see the power of our association. Our strength is in the knowledge and resources that we all bring to the table and membership growth benefits each one of us, in addition to the organization as a whole.

I look forward to hearing from you, and hopefully seeing you, in 2017! ■

Learning and adventure makes really connecting with colleagues fun and easy on SWS Annual Meeting field trips and workshops, like this one from the 2016 Annual Meeting in Corpus Christi, Texas.

Shop AmazonSmile this Holiday Season

In preparation for this holiday season, consider using AmazonSmile to shop; the AmazonSmile Foundation will donate .5% of the price of your purchase to the Society of Wetland Scientists! If interested in donating to SWS via AmazonSmile, visit https://smile.amazon.com/ch/48-1146960. You will be prompted to log into your Amazon account and select a charitable organization before you begin shopping. For more information, visit www.smile.amazon.com/about. ■

Looking for a Last-Minute Gift?

The 2017 SWS calendar is a great stocking-stuffer and is now available online at lulu.com for $15.00, plus shipping! This 13-month calendar features photographs from this year's SWS photo contest, including winning photos by SWS members, Karri Smith and Jason Smith. Order your calendar here as a holiday gift! ■

'Tis the Season to Renew

Membership renewal season is in full swing! Your membership will expire at the end of the year, so take the time to be jolly, and renew today! You can do so online, over the phone or through the mail. If you have any questions, please contact us at membership@sws.org or call us at (608) 310-7855. ■

Wetland Ambassadors Graduate Research Fellowship

The SWS Wetland Ambassadors Fellowship provides the opportunity for graduate students to travel to another country and conduct groundbreaking wetland research with some of the world's top wetland scientists. In order to be considered for a fellowship, the applicant must be currently enrolled in a M.S. or Ph.D. program at one of our partner institutions. For more information on whether you qualify, or how to apply, please visit: http://tinyurl.com/zgea2yu. All applications are due by Friday, January 13, 2017, at 11:59 p.m. EST. ■

Now Accepting Award Nominations and Student Grant Applications

The SWS Awards Committee invites individuals to apply or nominate a fellow SWS colleague for a Society award or student research grant. Recipients will be recognized at the 2017 SWS Annual Meeting in San Juan, Puerto Rico. Visit our Society Awards page and Student Research Grant page to learn more. If you have any questions please contact Kara Miller at kmiller@sws.org. Applications are due Thursday, February 12, 2017.

FELLOW AWARD

The highest recognition of membership bestowed by the Society. Nominees must be active SWS members who have been nominated by other active members to receive the honor, recommended by the Fellows Committee and elected by the SWS Board of Directors.

LIFETIME ACHIEVEMENT AWARD

To honor wetland scientists who have achieved special distinction in their career through sustained contributions to research, education, or policy in any field of wetlands science or management. The award includes a Lifetime membership to SWS.

MERIT AWARD

Recognizes individuals demonstrating outstanding original research, achievement or contribution to wetland science and inspires future efforts. The award includes a three-year membership to SWS.

STUDENT RESEARCH GRANT

Awarded on a competitive basis to graduate or undergraduate students who conducts research on wetlands Please note: SWS Student Research Grants are intended to aid students' costs of travel, room and board during the course of field investigation and to help cover costs of expendable materials and supplies required in the execution of the proposed research.

INTERNATIONAL TRAVEL AWARD

Provides financial assistance for travel to the 2017 Annual Meeting to talented and well-motivated wetland scientists from developing countries who are disadvantaged due to regional economic conditions. The recipient will also receive a free SWS membership for three years. ■

1. See President's Message for other news on SWS activities. Also access chapter websites for updates of their activities.

Annual Meeting Registration Opens December 15, 2016: www.swsannualmeeting.org!

FIELD TRIPS AND WORKSHOPS PROMISE EXPLORATION, DEEP LEARNING

SWS is pleased to present exciting field trip and workshop options as part of the SWS 2017 Annual Meeting in Puerto Rico. Dig deeper into your research interests by participating in one of these hands-on activities from sites including the El Yunque National Forest, Las Cabezas de San Juan Nature Reserve, Northeast Ecological Corridor and the Jobos Bay National Estuarine Research Reserve. Get full descriptions of each opportunity at www.swsannualmeeting.org. Additional registration fees are required. ■

CALL FOR ABSTRACTS

We invite those passionate about the advancement of wetland science to submit an abstract relating to this year's theme: Celebrating Wetland Diversity Across the Landscape: Mountains to Mangroves. The program will highlight the interdisciplinary nature of wetland science and practice, how wetlands function, and how protection and restoration play a significant role in the health of our ecosystems and society. The importance of using sound science to inform management strategies and enhance environmental values to society will also be emphasized. Instructions and guidelines are available online through our abstract submission site. The abstract submission deadline is Monday, Jan. 16, 2017. ■

TAKE TIME FOR NETWORKING AND SOCIAL EVENTS

We've scheduled plenty of time during the Annual Meeting to connect with colleagues and learn from your peers. The Welcome Reception on Monday night is a great way to kick things off. On Tuesday, a special mixer is planned for college students. The Awards Lunch and Annual Membership Meeting on Wednesday is a must for recognizing fellow and future scientists and catching up on the latest SWS news. Back again is the poster session and silent auction on Wednesday evening — the fun is in the bidding! Stick around on Thursday for an evening kayak tour of one of Puerto Rico's bioluminescent bays (additional registration fee required.) ■

MAKE YOUR TRAVEL PLANS

SWS has secured a block of rooms at the Sheraton Puerto Rico Hotel. Located only a few steps from the Puerto Rico Convention Center, this hotel is sure to fill up fast! Visit the meeting website for booking instructions and more information. ■

Society of Wetland Scientists Annual Meeting
SWS2017 Puerto Rico
June 5-8
Celebrating Wetland Diversity Across the Landscape: Mountains to Mangroves

Sponsorship Opportunities

A variety of sponsorship levels are available on a first-come, first-selected basis and are sure to provide international exposure to supporting organizations. 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 2017 Annual Meeting a success by making a general contribution. Sponsor's logo will be featured on the meeting website with a link to their corporate page, on signage at registration and in the meeting mobile app.

BRONZE LEVEL — $1,000

- **DAILY PLENARY SPEAKER.** The SWS 2017 Annual Meeting will feature three highly renowned plenary speakers who will present the latest wetland research. 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

- **STUDENT MIXER.** This special reception will provide students the opportunity to exchange ideas and network with expert wetland professionals. All attendees welcome.
- **AWARDS LUNCH & ANNUAL MEMBERSHIP MEETING.** Meeting registrants will be invited to attend this special event to honor SWS award winners and catch up on the latest SWS initiatives.
- **POSTER SESSION & SILENT AUCTION RECEPTION.** The 2017 poster session will showcase the latest wetland research and will provide an opportunity for all meeting attendees to network. The South Atlantic Chapter will also be holding a special silent auction to help fund Chapter activities.
- **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.

GOLD LEVEL — $5,000

- **REGISTRATION BAG.** Meeting branded registration bags will be distributed to all participants containing relevant meeting materials. The sponsor's logo will be featured on each registration bag.
- **LANYARDS.** Meeting themed lanyards will be distributed to each attendee at registration. The sponsor's logo will be featured on each lanyard.
- **WATER BOTTLE.** Attendees will receive a meeting themed water bottle at registration which will feature the sponsor's logo.

PLATINUM LEVEL — $7,500

- **MOBILE APP.** Attendees will be able to access the meeting program, general meeting information and session details via their smart phones and the web. The sponsor's logo will be featured on the homepage of the app.
- **WELCOME RECEPTION.** The SWS 2017 Annual Meeting will kick off with a special Welcome Reception.

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 registration 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 are quoted in US dollars.*

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

SWS Establishes Wetland Ambassadors Program

New Exchange Program Benefits Graduate Students to Conduct International Research

The Society of Wetland Scientists is pleased to announce the launch of the brand new Wetland Ambassadors Program. The mission of this international student exchange program is to provide opportunities for graduate students to participate in a visiting research fellowship at a university outside of their home country that features rigorous wetland science research. This initiative is expected to not only provide top-notch educational opportunities for future wetland scientists around the globe, but also to enhance international networking, wetland science information exchange, and communication among members of the Society of Wetland Scientists.

Over the past year, our committee (Table 1) has worked tirelessly to assemble an inaugural group of partner institutions from around the world that are represented by established and successful wetland scientists who are eager to participate in our program (Table 2). In the coming years, we welcome wetland scientists from any country to contact us (Table 1) if they are interested in representing their institution. We especially encourage scientists at institutions in developing countries to join us.

The Wetland Ambassadors Program will be launching with our first set of five research fellowships this summer (2017). Each fellowship includes a $2000 contribution from the Society of Wetland Scientists as an acknowledgment that we are committed to advancing the research education of students around the world, and especially in developing countries. We welcome graduate students who are currently enrolled in M.S. or Ph.D. programs at any of our partner institutions (Table 2) and who are proficient in the English language to apply. The application is due by **Friday, January 13th at 11:59pm EST** and can be found at https://fs24.formsite.com/SWS2015/WetlandAmbassadors/form_login.html. Before applying, all applicants must contact a potential research mentor in order to work out the details of a research project, budget, and any additional funding sources. The list of research mentors who are available to host a Wetland Ambassador during the Summer of 2017 can be accessed at http://tinyurl.com/hl8zwha.

We look forward to welcoming five graduate students from around the world as the very first Wetland Ambassadors. We anticipate a summer of productive, collaborative, and immersive wetland science research for our ambassadors, their current graduate advisers, and their new international host advisers. In the meantime, we welcome any inquiries about the Wetland Ambassadors Program, as well as the involvement of new institutions so

TABLE 1: List of current Wetland Ambassadors committee members, their geographic locations, and their e-mail addresses.

Committee Member	Geographic Location	E-mail Address
Dr. Bianca Wentzell, Chair	New Jersey, USA	wentzellb@mail.montclair.edu
Dr. Andrew Baldwin	Maryland, USA	baldwin@umd.edu
Dr. Curtis Richardson	North Carolina, USA	curtr@duke.edu
Dr. Christopher Craft	Indiana, USA	ccraft@indiana.edu
Dr. Jan Vymazal	Prague, Czech Republic	vymazal@knc.czu.cz
Dr. Hsiao-Wen Wang	Tainan City, Taiwan	whw82@mail.ncku.edu
Mr. Sean Charles	Florida, USA	schar056@fiu.edu

that we can continue to grow and provide opportunities to advance the field of wetland science on an international scale. If you have questions about the program, please contact Dr. Bianca M. Wentzell, Chair of Wetland Ambassadors Committee at Bianca.m.pier@gmail.com. ■

TABLE 2: List of current partner institutions and their geographic locations for the Wetland Ambassadors Program.

Partner Institution	Geographic Location
Aarhus University	Aarhus, Denmark
Czech University of Life Sciences	Prague, Czech Republic
Duke University	North Carolina, USA
Hamburg University	Hamburg, Germany
Indiana University	Indiana, USA
Inha University	Incheon, South Korea
Ljubljana University	Ljubljana, Slovenia
National Cheng Kung University	Tainan City, Taiwan
Pennsylvania State University	Pennsylvania, USA
University of Florida	Florida, USA
University of Maryland	Maryland, USA
University of Massachusetts Amherst	Massachusetts, USA
University of Natural Resources and Life Sciences (BOKU)	Vienna, Austria
University of Padova	Padua, Italy
University of South Bohemia	České Budejovice, Czech Republic

Take Advantage of SWS Resources

SUBSCRIBE TO WETLAND BREAKING NEWS

The Association of State Wetland Managers produces a monthly newsletter that summarizes current events on wetlands – *Wetland Breaking News*. This is largely a collection of news clips addressing wetland issues. Access the latest issue at: http://aswm.org/news/wetland-breaking-news/892-current-issue#national. Past issues can also be accessed there. Sign up to be put on the mailing list. ■

VIDEO AVAILABLE TO AID IN USING WETLANDS MAPPER

The U.S. Fish and Wildlife Service has produced a video tutorial to help people use the National Wetlands Inventory's "Wetlands Mapper." To access, go to: https://www.youtube.com/watch?feature=player_detailpage&v=CB398gj3O04. ■

PAST ISSUES OF *WETLAND SCIENCE & PRACTICE*

Past issues of WSP can be viewed on the SWS website: http://www.sws.org/Publications/wetland-science-and-practice.html. On Feb. 6, 2015, the SWS board of directors voted to allow free public distribution of past issues of *WSP*. This means that all issues published, except the four most recent issues, are available via the internet to the general public. More recent issues, available for viewing by SWS members only, will be phased in for distribution as they reach the one-year threshold. This means that the audience for *WSP* articles is virtually limitless. Such availability will hopefully stimulate more interest in contributing to the journal. We are working out the details for distribution and welcome this opportunity that will promote the good work done by our members. ■

SWS FREE MONTHLY WEBINAR SERIES

Take advantage of your SWS membership by participating in outstanding educational opportunities without leaving your desk! SWS is pleased to provide a webinar series on wetland science topics of interest. 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. Webinar registration is a complimentary member benefit. A limited number of spots are available for each webinar. If you're unable to participate in the live webinar, all webinars are recorded and archived for complimentary viewing by SWS members. ■

ALSO, PLEASE SEE THE *WETLAND BOOKSHELF* SECTION OF THIS PUBLICATION FOR ADDITIONAL RESOURCES.

SWS Receives Thank You from Nanjing University for Assisting with 10th INTECOL Wetland Conference

We received the following letter expressing thanks for our support:

南京大学

NANJING UNIVERSITY

Letter of Thanks

November 1, 2016

Society of Wetland Scientists,

Here we're writing to express our sincere thanks for your attention and support in the 10th INTECOL International Wetlands Conference which was successfully closed on 24th, September. There were about 800 official representatives, including over 300 foreign participants, from 72 countries and regions and more than 10 international organizations participating in the conference. The conference set 11 plenary speeches and 71 brilliant sessions involving the fields of global change, biodiversity, ecosystem services, biogeochemical processes, ecosystem monitoring, biological invasion, sewage treatment, wetland evaluation, wetland sustainable management. Over 50 media like China Central Television (CCTV-1, CCTV-4), People's Daily, network of Ministry of Science and Technology of the People's Republic of China *etc.* reported the conference.

It is the first time that the conference be held in Asian countries in nearly 40 years. Famous institutions, experts and scholars at home and abroad all attended. During the conference, the 'Chinese Wetland Protection and Construction Exhibition' was held, which fully showed the great achievements since the second national general survey of wetlands in China and the implement of *China Wetland Conservation Action Plan* from 20 years ago. During the conference there were various forms of sessions, which provided a solid scientific & technical support for the promotion of wetland conservation and eco-civilization construction in China.

Under the support from China Compliance Office for International Wetland Convention, Ecological Society of China and Wetland International-China Office, on September 21, 2013, Nanjing University

地址:南京市仙林大道 163 号　　邮编: 210046

南京大学

NANJING UNIVERSITY

honorably achieved the right to host the 10th INTECOL International Wetlands Conference. In these three preparation years from 2013 to 2016, we've got strong support and selfless help from you. We'd like to express our deepest respect for your hard work. We sincerely thank you for your outstanding contribution to this conference, and hope that, as always, to strengthen the exchange and cooperation with you, in order to promote the global wetlands research, conservation and management in the future!

Sincerely,

Nanjing University

地址:南京市仙林大道 163 号

邮编: 210046

SWS Joins Other Natural Resource Organizations in Offering Assistance to President-elect Trump

As a member of the Consortium of Aquatic Scientific Societies, the SWS has joined our partner organizations in sending the following letter to President-elect Trump offering our assistance to provide input on matters affecting America's natural resources.

c/o American Fisheries Society
425 Barlow Place, Suite 110
Bethesda, MD 20814
301-897-8616

November 21, 2016

Dear President-Elect Trump,

The Consortium of Aquatic Scientific Societies (CASS) is writing to offer our best wishes and assistance as you begin your Presidency. We understand that your transition team and future administration will have many important decisions to make regarding our Nation's aquatic resources, and CASS is ready to provide the requisite expertise to help your administration address those pressing concerns.

CASS is comprised of six professional societies representing diverse knowledge of the aquatic science realm. CASS members include the: American Fisheries Society; Association for the Sciences of Limnology and Oceanography; Coastal and Estuarine Research Federation; Phycological Society of America; Society for Freshwater Science; and Society of Wetland Scientists. Our collective membership totals almost 20,000 individuals that span the private sector, academia and various tribal, state, and federal agencies. The CASS organizations represent professionals who combine deep subject-matter expertise, a commitment to independent objectivity, and the critical review of environmental information, along with a passion for the natural places and resources that form the foundation of American greatness. Many of our members are dedicated anglers, hunters, and outdoor enthusiasts.

When deliberating over issues pertaining to our natural environment we urge you to consult with CASS. Our member societies can provide unbiased information through meetings, briefings, or position papers on important issues including but not limited to:

- Ensuring the Nation's water is clean and in good supply
- Managing sustainable fish populations for food and recreation
- Building resilient systems for our natural resources and our human communities
- Repairing the fragmentation of our Nation's rivers and streams
- Improving and protecting the habitat of our Nation's aquatic resources
- Maintaining the biodiversity of aquatic systems by managing aquatic invasive species, protected species, and other species of concern
- Developing sustainable aquaculture to secure America's protein demands and support recreational opportunities
- Protecting America's conservation heritage and the enormous economic and cultural benefits derived from outdoor recreation

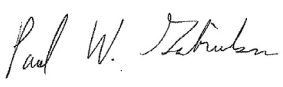
Input from CASS leaders and members will help to ensure that your choices secure the cultural heritage and economic prosperity of all Americans. We look forward to addressing your inquiries in the weeks to come.

Respectfully,

Joe Margraf
President, American Fisheries Society

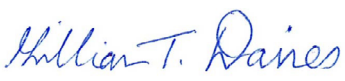
Linda Duguay
President, Association for the Sciences of Limnology and Oceanography

Robert R. Twilley
President, Coastal and Estuarine Research Federation



Paul Gabrielson
President, Phycological Society of America

Emily Bernhardt
President, Society for Freshwater Science



Gillian Davies
President, Society of Wetland Scientists

SUMMARY OF RECENT SWS ACTIVITIES

We have had a very busy few months since I last wrote a President's Message, and I am extremely grateful for all of the hard work and dedication that members of SWS contribute on a daily basis to support our organization and the protection of wetlands. The summaries below provide a snapshot in this regard.

INTERNATIONAL WETLAND CONVENTION, TAIPEI, TAIWAN

Kudos and thanks go out to the tireless and inspired leader of our Asia Chapter, Dr. Wei-Ta Fang, who led the organization of a highly successful SWS Asia Chapter meeting as part of the International Wetland Convention, held from September 13 – 14, 2016, in Taipei, with wetland tours following two days of meetings (Photo 1). The Convention was convened jointly by the Taiwan Construction and Planning Agency, Society of Wetland Scientists, and the Taiwan Wetland Society, and hosted over 500 people. The Deputy Minister of the Interior, Dr. Tsyr-Ling Lin gave opening remarks (Photos 2 & 3), and the Taiwanese press covered the event extensively.

Most significantly, during this meeting, six Taiwanese government agencies signed the Taiwanese Wetlands Conservation Intersectoral Cooperation Agreement of 2016-2021 (Photo 4). Through this agreement, the government agencies created a vehicle for inter-agency cooperation and coordination with regard to protection of wetlands in Taiwan. These agencies were represented by the Dr. Yue-Hsing Star Huang, Director General of Taiwan Forestry Research Institute, Council of Agriculture; Mr. Kuo-Yun Fang, Director General of Endemic Species Research Institute, Council of Agriculture; Dr. Hwa-Ching Lin, Director General, Forestry Bureau, Council of Agriculture; Mr. Wun-Long Hsu, Director General of Construction and Planning Agency, Ministry of the Interior; Mr. Ruei-Te Wang, Director General of Water Resources Agency, Ministry of Economic Affairs; Mr. Jui-Hsiang Liu, Deputy Director General of the Bureau of Water Quality Protection, Environmental Protection Administration. The Minister of the Interior, Dr. Jiunn-Rong Yeh, was not able to attend due to the need for him to manage the country's response to the typhoon that was impacting the country during the convention, but was able to join SWS leaders and others for breakfast on our last day in Taiwan (Photo 5). Having recently passed the Taiwanese Wetland Conservation Act, the Taiwanese government is providing impressive support for improving wetland protection and conservation.

During the conference, SWS and the Taiwan Construction and Planning Agency renewed our Memorandum of Understanding for a Regional Strategic Program

PHOTO 1. 2016 International Wetland Convention in Taipei, Taiwan

PHOTO 2. Deputy Minister of the Interior, Dr. Tsyr-Ling Lin, giving opening remarks.

PHOTO 3. SWS President Gillian Davies and Immediate Past President Kim Ponzio with Dr. Tsyr-Ling Lin

PHOTO 4. Taiwanese Agency leaders signing the Taiwanese Wetlands Conservation Intersectoral Cooperation Agreement of 2016-2021. From left to right: Dr. Yue-Hsing Star Huang, Director General of Taiwan Forestry Research Institute, Council of Agriculture; Mr. Kuo-Yun Fang, Director General of Endemic Species Research Institute, Council of Agriculture; Dr. Hwa-Ching Lin, Director General, Forestry Bureau, Council of Agriculture; Mr. Wun-Long Hsu, Director General of Construction and Planning Agency, Ministry of the Interior; Mr. Ruei-Te Wang, Director General of Water Resources Agency, Ministry of Economic Affairs; Mr. Jui-Hsiang Liu, Deputy Director General of the Bureau of Water Quality Protection, Environmental Protection Administration

PHOTO 5. Breakfast meeting with Dr. Jiunn-Rong Yeh, Minister, Ministry of the Interior, Republic of China (Taiwan). From left to right: Mr. Kelin Chen, Director, Wetland International-China; Dr. Yuji Arakaki, Professor, Department of Tourism, Faculty of International Studies, Meio University, Japan; Dr. Wei-Ta Fang, Regional President, SWS Asia Chapter; Dr. Ben LePage, President, Society of Wetland Scientists, 2011-2012; Ms. Gillian T. Davies, President, Society of Wetland Scientists, 2016-2017; Dr. Jiunn-Rong Yeh, Minister, Ministry of the Interior, Republic of China (Taiwan); Ms. Kimberli J. Ponzio, President, Society of Wetland Scientists, 2015-2016; Dr. James E. Perry, President, Society of Wetland Scientists, 2014-2015; Mr. Wun-Long Hsu, Director General, Construction and Planning Agency, Ministry of the Interior, Republic of China (Taiwan); Prof. Hsin-Juh Lin, President, Taiwan Wetland Society; Prof. Monica Kuo, Director, Department of Landscape Architecture, Chinese Culture University; Mr. Jimmy Chen, Director, Urban and Rural Development Branch, Construction and Planning Agency, Ministry of the Interior, Republic of China (Taiwan)

of Action (Photo 6), and the attendees of the conference signed the Taipei Declaration of International Wetlands.

SWS Past President Jim Perry, Wetlands Editor-in-Chief Marinus Otte, SWS Europe Chapter President Jos Verhoeven, SWS Past President Ben LePage, SWS Immediate Past President Kimberli Ponzio, and I gave keynote speeches (Photo 7). We were honored as Taiwan's Wetland Conservation Honorable Advisors by Dr. Jiunn-Rong Yeh, the Minister of the Interior, who was represented by Deputy Minister of the Interior, Dr. Tsyr-Ling Lin (Photos 8 and 9).

Many SWS members and collaborators were involved in planning the convention and in giving presentations, including Hsin-Juh Lin, Wei-Ta Fang, Hsiao-Wen Wang, Monica Kuo, and Pin-Han Kuo, Lei Yang, Hui-Chen Su, and Po-Hsiu Kuo. Special thanks go to Cheng-Hsiang Liu for staffing our SWS Asia Chapter membership table that collected approximately 25 names of people interested in SWS and potential members.

Following the convention, Jim Perry, Wei-Ta Fang, and Hsiao-Wen Wang led the effort to write a letter to the Taiwanese government regarding protection of the Jiading Wetland, a wetland that meets the criteria for a Ramsar wetland of International Importance. Please see our website http://www.sws.org/Resources/letters-of-comment.html for the full text of the letter.

What is so notable about the International Wetland Convention is that, in addition to the usual sharing of scientific information and opportunities to network with colleagues from around the world, several significant concrete actions to protect wetlands occurred as a direct result of the convention. Our hats are off to our dedicated Taiwanese colleagues and to the Taiwanese government for their impressive leadership in this regard.

10TH INTECOL INTERNATIONAL WETLANDS CONFERENCE, CHANGSHU, CHINA

The 10th INTECOL International Wetlands Conference (IWC), held in Changshu, China, from September 19th – 24th, 2016, with wetland excursions mid-week and following the conference, was a great success. SWS would like to thank conference hosts Nanjing University, China Compliance Office for International Wetland Convention, International Association for Ecology, Ecological Society of China, and Wetlands International, and conference

organizers People's Government of Changshu and Nanjing University Ecological Research Institute of Changshu, for all of the efforts to create a welcoming environment and a stellar international conference for all of the attendees. SWS was proud to join the Ramsar Convention on Wetlands, the United Nations Education, Scientific and Cultural Organization – Man and the Biosphere Programme (UNESCO-MAB), United Nations Environment Programme – International Ecosystem Management Partnership (UNEP_IEMP), Major Science and Technology Program for Water Pollution Control and Treatment (MSTP-WPCT), Wetland Conservation Association of China, World Wide Fund for Nature, SEE Foundation, Jiangsu Forestry, and Suzhou Agriculture Committee as Supporters of the conference.

Special thanks go to SWS members R. Eugene Turner (Co-Chair of the Organizing Committee), Europe Chapter President Jos Verhoeven (Vice-Chair of the Organizing Committee), Oceania Chapter Past President Jenny Davis (Secretary General of the Organizing Committee), and SWS members who served on the 10th INTECOL IWC International Scientific Committee: Immediate Past President Kimberli Ponzio, Past President Stephen Faulkner, Asia Chapter President Wei-Ta Fang, SWS Past President Bill Mitsch, Ramesh Reddy, Jorge Ramos, Jan Pokorny and Brij Gopal, for their work to bring such a world-class conference to fruition, and for their efforts to create stronger bonds between INTECOL and SWS. Through their efforts, I was able to represent SWS during Opening Ceremonies

PHOTO 6. SWS President Gillian Davies signing Memorandum of Understanding with Mr. Wun-Long Hsu, Director General of the Construction and Planning Agency, Ministry of the Interior, Republic of China (Taiwan), with Deputy Minister of the Interior, Dr. Tsyr-Ling Lin looking on.

PHOTO 7. SWS Past President Jim Perry giving Keynote Speech.

PHOTO 8. SWS Wetlands Editor-in-Chief Marinus Otte receiving award from Dr. Dr. Tsyr-Ling Lin.

PHOTO 9. SWS Past President Kimberli Ponzio receiving award from Dr. Tsyr-Ling Lin.

PHOTO 10. SWS President Gillian Davies speaking at 10th INTECOL International Wetland Conference Opening Ceremonies.

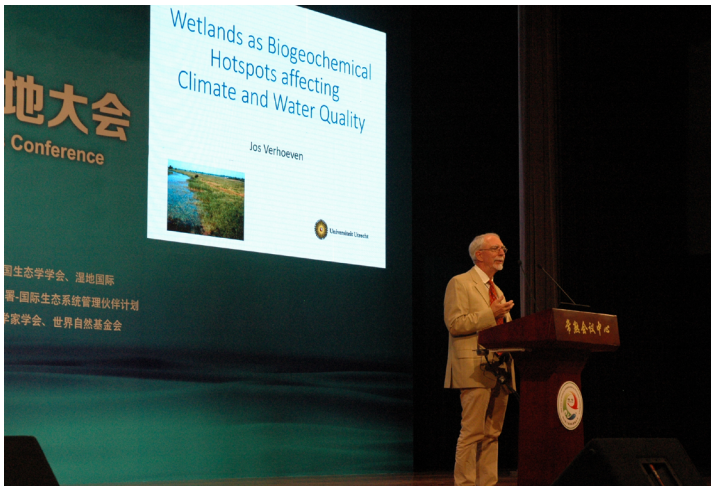


PHOTO 11. SWS Europe Chapter President and 10th INTECOL Organizing Committee Vice-Chair Jos Verhoeven giving Plenary talk.

PHOTO 12. P.V. Sundareshwar leading discussion on wetlands in the developing world.

PHOTO 13. SWS Past President Ben LePage signing the Changshu Declaration on Wetlands.

PHOTO 14. SWS member and 10th INTECOL Organizing Committee Co-Chair R. Eugene Turner, SWS Europe Chapter President and 10th INTECOL Organizing Committee Vice-Chair Jos Verhoeven, SWS Oceania Past President and 10th INTECOL Organizing Committee Secretary General Jenny Davis, and Ramsar Convention Deputy Secretary General Ania Grobicki signing the Changshu Declaration on Wetlands, with Chinese press looking on.

on the second morning of the conference, thereby increasing SWS visibility on the international stage (Photo 10). SWS members Max Finlayson, Bill Mitsch, and Jos Verhoeven presented compelling plenary talks (Photo 11).

Several SWS members were invited to be panelists on the "Wetlands and Eco-Civilization Practices" discussion panel, which was themed "Healthy Wetlands, Healthy Earth". The Mayor of Changshu (Qindi Zhou) awarded the panelists with a letter of appointment as Senior Scientific Advisors to the People's Government of Changshu. Panel keynote speakers were Bill Mitsch (Florida Gulf Coast University) and Ying Wang (Nanjing University) and the moderator was Shirong Liu (Chinese Academy of Forestry, President of Ecological Society of China). The panelists were: Kimberli Ponzio, Ania Grobicki (Deputy Secretary General of the Ramsar Convention on Wetlands of International Importance), R. Eugene Turner, Jenny Davis, Jos Verhoeven, Jun Chen (President of Nanjing University), and Guangren Ma (Director of China Compliance Office for International Wetland Convention).

P.V. Sundareshwar (Photo 12) deserves special commendation for his initiative in organizing an on-the-spot forum on wetlands in the developing world, where participants brainstormed means of identifying challenges, solutions, and actions for developing countries to move forward on protecting and restoring wetlands. Suggestions from this forum were submitted to the drafters of the Changshu Declaration on Wetlands. All conference attendees were invited to sign the Changshu Declaration on Wetlands (Photo 13). Conference organizers Shuqing An, R. Eugene Turner, Ania Grobicki, Jos Verhoeven, Shirong Liu and Jane Madgwick (CEO of Wetlands International) signed the final Changshu Declaration on Wetlands at the Closing Ceremonies (Photo 14), with the theme from Star Wars playing in the background. The signing can be viewed and heard on a video clip on the SWS website at https://www.youtube.com/watch?v=2wLe9bpV0no&feature=youtu.be

Over 50 Chinese news outlets covered the conference and the wetland excursions that followed. Many members of SWS leadership were interviewed by Chinese television stations on multiple occasions (Photos 15 & 16). In fact, news coverage of the conference preceded our arrival, with billboards announcing the conference placed around the city of Changshu, and along highways (Photo 17). I must admit that I was envious of the attention and importance that the Chinese and Taiwanese are placing on wetlands. Imagine a world where wetlands conferences make national, regional, and local news in every country, and displace product advertising on our billboards!

PHOTO 15. SWS President Gillian Davies being interviewed by Chinese T.V.

PHOTO 16. SWS Europe Chapter President Jos Verhoeven being interviewed by Chinese T.V.

PHOTO 17. 10th INTECOL International Wetland Conference billboard in downtown Changshu.

As important as the formal convention programming was, the opportunity to meet and network with our colleagues from around the world (Photos 18, 19, 20, 21, & 22) has accelerated our efforts to support our international chapters and to collaborate with other international organizations. Of note, our Oceania Chapter had the opportunity to meet together, and with SWS President Elect Arnold van der Valk and me, and to nominate officers for their chapter, who have been duly elected, following the conference. Congratulations to Neil Saintilan and Jayne Hanford for being elected to President and Secretary-Treasurer. SWS President Elect Arnold van der Valk, Past President Kimberli Ponzio, and I had the opportunity to meet with South African SWS member Fred Ellery and Columbian SWS member Luisa Ricaurte, who both accepted nominations for co-chairmanship of the International Chapter, and have been duly elected following the conference. I would especially like to thank those SWS members who staffed our SWS Asia Chapter membership table (Photo 23), where we passed out SWS information and collected 83 signatures of those interested in joining our society.

Our Ramsar Convention representative, Nick Davidson, and I met with Ramsar Convention Deputy Secretary-General Ania Grobicki, and discussed renewal of our Memorandum of Cooperation, as well as numerous opportunities for our organizations to increase our level of collaboration. Kimberli Ponzio and I enjoyed talking further with Ania Grobicki during the post-conference wetland excursions in this regard (Photo 24). Over the past few weeks, we have been developing ideas for collaborations through email and conference calls, with Bill Morgante, our Education & Outreach Chair participating as well, including a Ramsar Convention article about their wetlands Culture Network for Wetland Science & Practice, potential Ramsar Conven-

PHOTO 18. SWS members enjoy boat ride during mid-conference wetland excursion.

PHOTO 19. SWS members at wetland science center at Nanhu Lake Wetland Park.

PHOTO 20. SWS President Elect Arnold van der Valk, President Gillian Davies, and Asia Chapter President Wei-Ta Fang.

PHOTO 21. SWS Wetlands Editor-in-Chief Marinus Otte, President Gillian Davies, Immediate Past President Kimberli Ponzio, and Europe Chapter President Jos Verhoeven on wetland excursion.

tion webinars in the SWS webinar series, collaboration on wetlands curriculum development and work with students, collaboration and information sharing with regard to World Wetland Day, and other collaborations. And congratulations to SWS Asia Chapter President Dr. Wei-Ta Fang, who has been invited by Ania Grobicki to participate as an Observer for Asian wetlands in the Scientific and Technical Review Panel (STRP) 2016-2018 of the Ramsar Convention. The 20th Meeting of the Panel (STRP20) is scheduled for February 13 - 17, 2017 at the Ramsar headquarter offices in Gland, Switzerland.

We spoke with numerous colleagues from around the world about speaking in our webinar series, contributing symposia to our Annual Meeting, and submitting articles to Wetlands and Wetland Science and Practice. Stay tuned as these initiatives develop.

SOCIETY OF WETLAND SCIENTISTS AND SOCIETY FOR ECOLOGICAL RESTORATION SIGN MOC

On October 17th, Society for Ecological Restoration Executive Director Bethanie Walder and I signed a Memorandum of Cooperation between our Societies (Photo 25), and discussed opportunities for collaboration, including a potential joint meeting between three SER chapters, SWS and the Canadian Land Reclamation Association in Quebec, Canada in 2020. In keeping with the mission of the two Societies, the President of SWS, Gillian Davies, and the Executive Director of SER, Bethanie Walder signed the Memorandum while visiting the Tidmarsh Farm cranberry bog wetland restoration project in Plymouth, Massachusetts, where they had the opportunity to tour the largest (250 acres) freshwater wetland restoration site (in the background of the photo) in New England. Massachusetts

PHOTO 22. Wetland excursion at Lake Tianmu Wetland Park. Back Row: Ania Grobicki, Gillian Davies, Jenny Davis, Jos Verhoeven, Kimberli Ponzio, Nasreen Jeelani, Front Row: Shuqing An, Richard Hobbs, Jorge Ramos, Brij Gopal.

PHOTO 23. SWS Asia Chapter President Wei-Ta Fang at SWS membership table.

PHOTO 24. SWS President Gillian Davies and Ramsar Convention Deputy Secretary-General Ania Grobicki on Lake Tianmu Wetland Park excursion.

PHOTO 25. Society for Ecological Restoration Executive Director Bethanie Walder and SWS President Gillian Davies signed a Memorandum of Cooperation in October.

Division of Ecological Restoration Director Tim Purinton and restoration site owners Glorianna Davenport and Evan Schulman generously hosted SWS and SER.

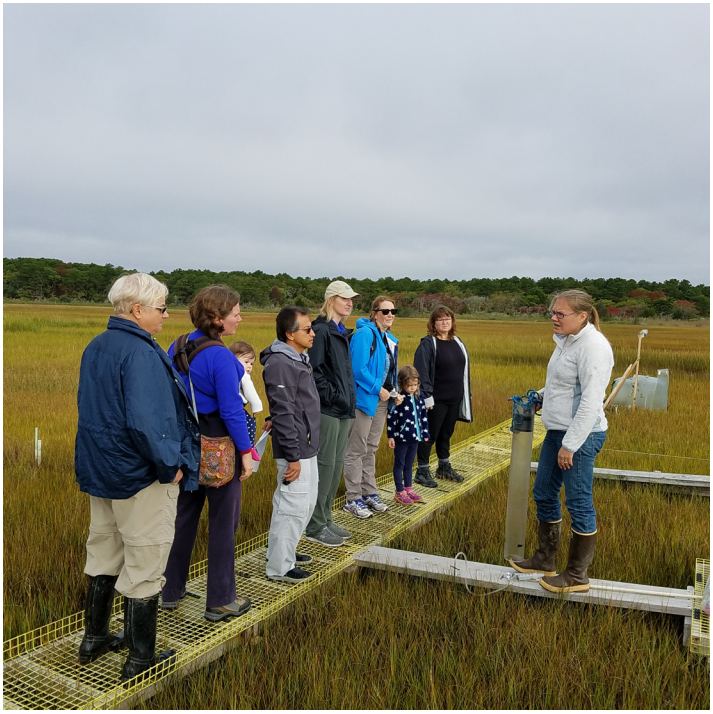
SOCIETY OF WETLAND SCIENTISTS MEMBERS PARTICIPATE IN NORTH AMERICAN BLUE CAROBN EXPERTS AND PARTNERS MEETING: SCIENCE FOR POLICY, FALMOUTH, MA

On October 4 - 6, 2016, SWS members (including Ariana Sutton-Grier, Gail Chmura, Tim Purinton, Kevin Kroeger, and myself) participated in and presented at the North American Blue Carbon Experts and Partners Meeting: Science for Policy, sponsored by the Commission for Environmental Cooperation (See Photos 26-27). This tri-national (Mexico, Canada, and U.S.A.) meeting of blue carbon scientists and policymakers discussed the state of the science for blue carbon, and policy opportunities and initiatives across North America, and worked to identify research needs and next steps in developing meaningful blue carbon policy at the international, national, provincial/state, and local levels. In addition to work sessions, the group was privileged to visit the Waquoit Bay National Estuarine Research Reserve, where they observed the "Bringing Wetlands to Market" project research site and the Herring River restoration project site at the Cape Cod National Seashore, Wellfleet, MA.

OTHER NEWS

Our committees and chapters are hard at work, developing programming and opportunities for members and students. Of particular note, Bianca Wentzell and the Wetland Ambassadors sub-committee continue to develop this new initiative and applications for our first five student ambassadors went live last month. We also welcome Roy Messaros as new co-chair of the Wetland Treasures sub-committee, where he will work with Abby Tyrna to move this initiative forward. We welcome David Riera as the new student representative to the SWS Board of Directors, Joe Christopher as President of the Alaska Chapter, and Christopher Thomas as President of the Central Chapter. ■

PHOTOS 26-27. SWS Members gather to discuss blue carbon policy.



Are Salt Marsh Pools Suitable Sites for Restoration?

Joseph Smith[1] and Larry Niles

Tidal marsh function and ecological integrity are influenced by an array of direct and indirect stressors. At the same time these marshes are responding to accelerated sea level rise. Alone or in interaction these stressors can contribute to marsh degradation and potentially reduce the resilience of marshes to sea level rise. Agencies and conservation organizations have acknowledged both the importance of marshes and the threat they face through the conservation and protection of marshes and, more recently, by investing in restoration.

In order to assess salt marsh condition and select appropriate restoration sites and strategies, it is first necessary to identify signs of marsh degradation and their causes. To do this, the impacts of direct alteration of marshes and associated hydrology must be assessed apart from climate change-driven sea level rise to understand the relative roles that direct human impacts and climate change play in marsh degradation. Only then can effective restoration projects be developed and implemented.

Ditching, impoundment, and tidal flow and range alterations can impact marsh condition and resilience, even in the absence of sea level rise. For example in Delaware Bay, more than half of the marshes were impounded and farmed (Smith et al. in review). Although most of the impounded areas are now subject to relatively unrestricted tidal flow, this former activity has resulted in present-day marshes that are lower in elevation than surrounding marshes that were never impounded. The elevation change has resulted in the loss of 10,000 acres of marsh. The remainder are struggling to keep pace with sea level rise while attempting to recover from farming-related elevation deficits. In this case, marsh deterioration is largely attributable to a direct human management impact rather than sea level rise.

While marsh farming was somewhat limited in extent in the Northeast, one author estimates that approximately 90% of all salt marshes in this region have been ditched (Bourn 1950). Ditching for mosquito control became widespread in the early 20th century and permanently changed the ecological character of marshes (e.g., Tiner 2013). Researchers are still grappling to understand its effect on marshes' capacity to keep pace with sea level rise. Nonetheless there is evidence that changes in hydrological function from ditching can potentially decrease marsh resilience to sea level rise (LeMay 2007).

Changes in tidal range resulting from channel deepening and shoreline hardening can also impact marsh condition. The deterioration of marshes in Jamaica Bay, New York is the result of dramatic increases in tidal range attributed to a variety of human actions (Swanson and Wilson 2008). The surface of the bay has decreased by more than 50% while the volume of the bay has increased by 350%. The tidal range has increased by 1.3 feet causing rapid loss of marshes that formed under a lower tidal range.

Each of these alterations can elicit symptoms of degradation. Like medical treatment, tidal restoration can treat the causes and/or the symptoms of degradation. Ideally the goal is to treat the root cause of degradation to achieve a lasting restoration outcome.

One feature of tidal marshes that may be misinterpreted as a symptom of degradation is the presence of marsh pools. This misinterpretation is be partly due to the fact that the genesis and geomorphic function of marsh pools have, until recently, been poorly understood (Harshberger 1916; Miller and Egler 1950; Redfield 1972; Wilson et al. 2009). In some settings pools are characteristic features of marshes with high ecological integrity, whereas in other settings they may represent marsh degradation from human impacts. These nuanced interpretations must be understood for practitioners to be effective in the efforts to manage and conserve tidal marshes. In this article we review research on the role of pools in both hydrological altered and unaltered tidal marshes to aid marsh assessment determinations and restoration decision-making.

DYNAMIC MARSH POOLS

Tidal marsh pools are characteristic features of many tidal marshes that have never been ditched or impounded (Adamowicz and Roman 2005; Lathrop et al. 2000). An emerging body of literature has clarified our understanding of these features and demonstrates that tidal marsh pools

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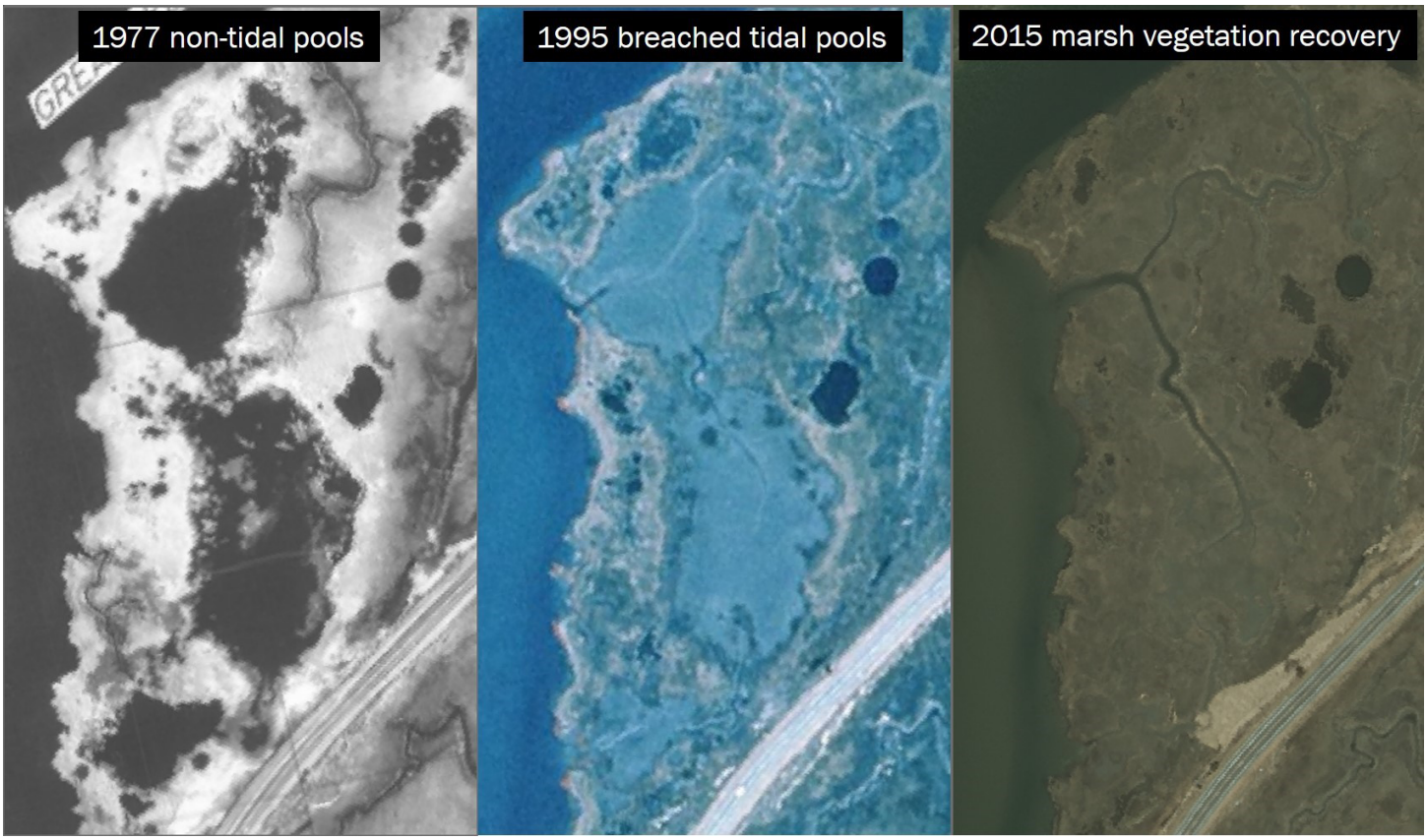
in some settings are part of a dynamic cyclical geomorphic process: pools form, expand, breach and revegetate over time (Mariotti 2016; Wilson et al. 2009, 2010, and 2014). Pools form in areas of poor drainage where a combination of waterlogging stress and low productivity produce nonvegetated patches that coalesce into pools (Wilson et al. 2014). Pools change in dimensions over time, typically expanding until their sides intersect with an adjacent tidal creek. At this point the pool becomes tidal with increased tidal action and sedimentation eventually promoting the return of vegetation to the former pool (Figure 1). The tall form of *Spartina alterniflora* is the first species to colonize the former pool because elevations are lower than the surrounding marsh surface. Over time, elevation increases because areas that are lower in the tidal prism experience more rapid accretion - sediment accretion rates in breached pools can be two to four times that of the surrounding marsh platform (Wilson et al. 2014).

Pools revegetate as long as their bed elevation is above the lower limit for marsh growth and/or if sediment deposition is greater than the rate of relative sea level rise (Mariotti 2016). Pool recovery can take between 10 and 100 years depending on the setting (Wilson et al. 2014).

Several lines of evidence demonstrate that pool formation and recovery can be a cyclical process in dynamic equilibrium that does not result in net marsh loss over time. Coring studies show that a given area of marsh has alternated between pool and vegetated marsh throughout the last thousand years (Wilson et al. 2009, 2010). Direct evidence from aerial photos also demonstrates this process over the course of decades (Mariotti 2016; Wilson et al. 2009, 2014). Modelling shows that pools in marshes with relatively high tidal range, high amounts of suspended sediment and surfaces above mean high water become revegetated marsh after breaching (Mariotti 2016). This model was validated in several regions in the eastern United States including Atlantic Coast tidal marshes near Cape May, New Jersey and Plum Island, Massachusetts, where the moderate tidal range and relative sea level rise allow for tidally breached pools to become vegetated marsh over time (Mariotti 2016). Pool formation and expansion typically occurs at elevations above mean high water in marshes with vegetated surfaces that are keeping pace vertically with relative sea level rise (Mariotti 2016). Thus the presence of pools on unaltered marshes is not necessarily a symptom, as some have interpreted it (Cavatorta et al. 2003;Hartig et

Figure 1. Depiction of pool dynamics at Nummy Island, Cape May County, NJ. Pools breached between 1977 and 1987. By 2015, extensive vegetation recovery has occurred. (Source Imagery New Jersey Geographic Information Network.)



al. 2002; Kelley et al. 1995; Smith 2009), of marsh degradation attributed to accelerated sea level rise.

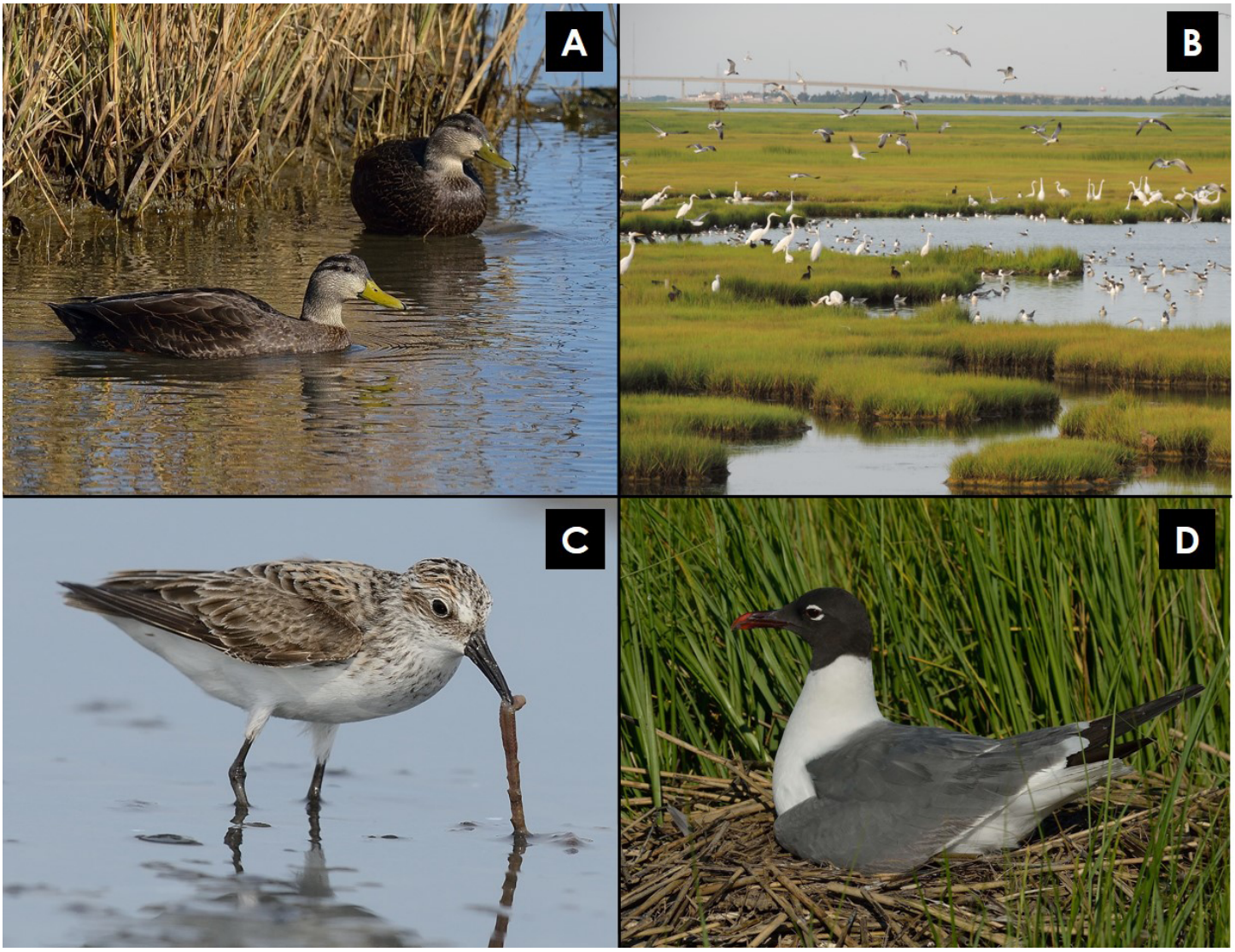
DYNAMICS DRIVE HABITAT DIVERSITY

Marsh pools are important habitat for a wide range of tidal marsh vertebrates. Significantly greater numbers of wading birds, shorebirds and terns use marshes with pools than marshes without them (Clarke et al. 1984). Spectacular congregations of herons and egrets along with terns and gulls occur in tidal marsh pools where the birds feed on small fish throughout the summer and fall (Master 1992).

Bird species diversity and abundance on marshes is directly related to pool area (Erwin et al. 1991). Pools offer feeding opportunities on submerged aquatic vegetation, fish, worms, mollusks and insect larvae (Erwin 1996). Pool habitats are unique in that they exist at a high elevation on the marsh platform and thus provide aquatic habitat at all tide stages.

Waterfowl are attracted to the unique feeding opportunities in pools (Stewart 1962), the most notable being the presence of widgeongrass (*Ruppia maritima*) (Bourn 1950; Miller and Egler 1950). Widgeongrass, a cosmopolitan species used by waterfowl throughout the world, is one of the most common plant foods for overwintering black ducks (Eichholz et al. 2010). This plant is very sensitive to wave action and currents and therefore finds suitable growing conditions in the still waters of small tidal marsh pools. These pools also have high numbers of snails, another important food for wintering black duck (Heck et al. 1995). Not surprisingly, black ducks show preferential habitat selection for tidal marsh pools (Morton et al. 1989). Erwin

FIGURE 2. A. Waterfowl feed in both breached and unbreached pools (American black duck); B. marsh pools are used extensively by wading birds (mixed species feeding aggregation of great egret, snowy egret, glossy ibis and laughing gull); C. breached pools provide shorebird feeding habitat (semipalmated sandpiper); D. revegetating pools after breaching provide high-quality nesting habitat for colonial gulls and terns (laughing gull). (Photos A, C and D courtesy of ©M.J. Kilpatrick. Photo B courtesy of ©J. Smith.)



(2006) suggests that the prospect of fewer pools could be detrimental to wintering black ducks.

Breached pools provide mudflat habitat that is exposed for a longer period of time compared with adjacent tidal creeks and mudflats. At least ten species of shorebirds use breached pools as alternate feeding habitats, particularly when tides cover other intertidal areas (Erwin et al. 2006).

Beyond birds, marsh pools are important for fish production and overwintering (MacKenzie and Dionne 2008; Smith and Able 1994). One study suggested that the majority of mummichog (*Fundulus heteroclitus*) in marshes move into tidal marsh pools during winter because marsh pools maintain warmer water temperatures (Smith and Able 1994).

FIGURE 3. Combination of ditching and open marsh water management, West Creek, Ocean County NJ. Tidal range, 0.61 m. (Source Imagery © Google Earth.)

FIGURE 4. Marsh ponding between ditches, Great River, Suffolk County, NY. Hydrological restoration is planned at this site. Tidal range, 0.34 m. (Source Imagery © Google Earth.)

Pool revegetation dynamics also may have an underappreciated role for tidal marsh nesting birds. Laughing gulls and terns select nest sites in taller grass above mean high water (Bongiorno 1970); nests in taller grass have a reduced probability of flooding (Montevecchi 1978). Nest sites that are less exposed to wind and tidal action are less likely to wash away (Montevecchi 1978). Gulls (Montevecchi 1978) and terns (Burger and Lesser 1978) build nests upon wrack that collects among tall grass in the higher parts of the marsh. These nest habitat descriptions suggest the conditions created by a revegetating pool, where tall *Spartina alterniflora* grows adjacent to higher elevations in the marsh interior. The only other tall *Spartina alterniflora* in these marshes exists along creek channels which is more limited in extent and is exposed to greater wave and tidal action.

Considering the importance of pools as wildlife habitat and the geomorphic process that perpetuates cyclical pool dynamics, we conclude that this process is a key driver of habitat diversity in tidal marshes. The dynamic successional process of pool formation, breaching and recovery maintains a diversity of habitats used by different species at different times. In summary, these include:

1. Intact pools are important feeding habitat for ducks (particularly for dabbling species that seek out *Ruppia*), wading birds, terns and gulls and serve as roosting habitat for shorebirds.
2. Breached pools are also foraging habitat for the above species and most importantly provide mudflat habitat for feeding shorebirds that is the only available habitat at higher tide stages when mudflats in creeks and sounds are inundated.
3. Revegetating pools are used by colonial nesting gulls and terns that preferentially choose nest sites in these tall grass areas.

MARSH POOLS IN HYDROLOGICALLY ALTERED MARSHES – A SIGN OF DEGRADATION?

The research evidence presented above makes it clear that pools are not necessarily a sign of degradation in tidal marshes that have never been the subject of direct human alteration. However, it is important to make the distinction between pools in marshes that have never been directly

altered and those that have been hydrologically altered by ditching and open marsh water management.

Pools on altered marshes take two forms: those created intentionally during open marsh water management activities (Figure 3) and those that have formed and expanded over time between ditches (Figure 4). The impact of hydrological alterations on marsh function and resilience to sea level rise is poorly understood (Elsey-Quirk and Adamowicz 2016). Preliminary evidence suggests that the rates of vertical accretion in these marshes may be lower than surrounding unaltered marsh (LeMay 2007) and that natural pond dynamics cease when these hydrological alterations are made (Wilson et al. 2014). In marshes subject to microtidal regimes, interior ponding between ditches is not displaying the same cyclical dynamics of pools in unaltered marshes. The combination of low accretion rates associated with low tidal amplitude (Kirwan and Guntenspergen 2010), altered hydrological function and sediment availability may be contributing to continuous expansion of pools in these areas while limiting the potential for tidal breaching that could lead to revegetation.

Ditching drains natural marsh pools, changes soil pore water levels, modifies accretion, and alters plant communities. One study that compared ditched marshes to those with natural hydrology found that natural marshes had consistently higher elevation compared with ditched marsh (LeMay 2007). Increasing ditch density was correlated with decreasing elevation. These elevation differences corresponded with dramatic differences in hydrology between ditched and natural marsh. In ditched areas, interior marsh flooded first and stayed flooded longer while in marshes with natural hydrology, the marsh interior only flooded after water topped creek banks. Despite longer periods of inundation, ditched sites did not receive more sediment deposition than sites with natural hydrology. Overall the lowered elevations may be due to reduced organic matter accumulation, plus increased sediment trapping in ditches and/or increased sediment export from the marsh surface.

Ditches are sinks for sediment accumulation that might otherwise be deposited on the marsh surface (Corman et al. 2012). Ditched areas also have longer pore-water retention in the rooting zone, lower soil bulk density and lower mineral content (Vincent et al. 2013*a*). Compared with marsh areas adjacent to natural creeks, ditched marshes have significantly less plant cover and significantly more plant species associated with poor drainage conditions (Vincent et al. 2013*b*). Siltation and narrowing of ditches that prevents proper drainage can further drive marsh interior degradation (Vincent et al. 2013*a*). This pattern has been observed in Rhode Island marshes where interior marsh ponding was associated with blocked ditches (Watson et al. 2016).

All of these patterns may be exacerbated or attenuated with varying tidal range. It is well-established that microtidal regions have the greatest lags in vertical accretion with respect to sea level rise (Kirwan and Guntenspergen 2010). Any impact that ditching has on a marsh's resilience to sea level rise may therefore be more exaggerated in microtidal areas.

With the hypothesis that ditching is the ultimate cause of runaway pool expansion in ditched marshes, restoring natural hydrology to marshes affected by ditching (in conjunction with sediment application where necessary) may allow for the return of natural pool dynamics, increase habitat diversity, and ultimately improve resilience to sea level rise. On the other hand, restoration projects that counter runaway pool expansion by filling these pools with dredged sediment without restoring hydrology may be treating a symptom rather than the cause of degradation.

A FRAMEWORK FOR INTERPRETING MARSH POOLS.

Some observers have interpreted pool formation, expansion and pool breaching as signs of sea level rise-induced marsh degradation and permanent marsh loss (Cavatorta et al. 2003; Hartig et al. 2002; Kelley et al. 1995; Smith 2009). But, as reviewed here, more recent research cautions against broadly applying this interpretation to all marsh pools. Mariotti (2016) and Wilson et al. (2014) provide new insights to better understand the relationship between pools and the condition of the marshes they occupy. Determining whether pools represent permanent marsh loss depends on past human impacts, marsh elevation, suspended sediment concentration and tidal range.

Using the framework proposed by Mariotti (2016), pools occur in unditched marshes under three general regimes: marsh drowning, pond collapse, and pond recovery. Each regime is determined by varying levels of relative sea level rise (RSLR), tidal range and sediment supply. Marsh drowning, when the vegetated marsh platform does not keep pace with relative sea level rise (Morris et al. 2002), has occurred in only a few regions (Mariotti 2016) and is associated with either altered tidal ranges (Swanson and Wilson 2008), unusually high rates of subsidence (DeLaune et al. 1994) and/or settings with very narrow tidal amplitude (Kirwan et al. 2016).

Pond collapse, when the vegetated marsh platform keeps pace with relative sea level rise, but pool platforms do not, occurs in settings with narrow tidal range and low suspended sediment supply. In these situations pools continue to expand after breaching and do not experience vegetation recovery. An example of this regime are the marshes surrounding the Blackwater River, Maryland (Schepers et al. 2016)

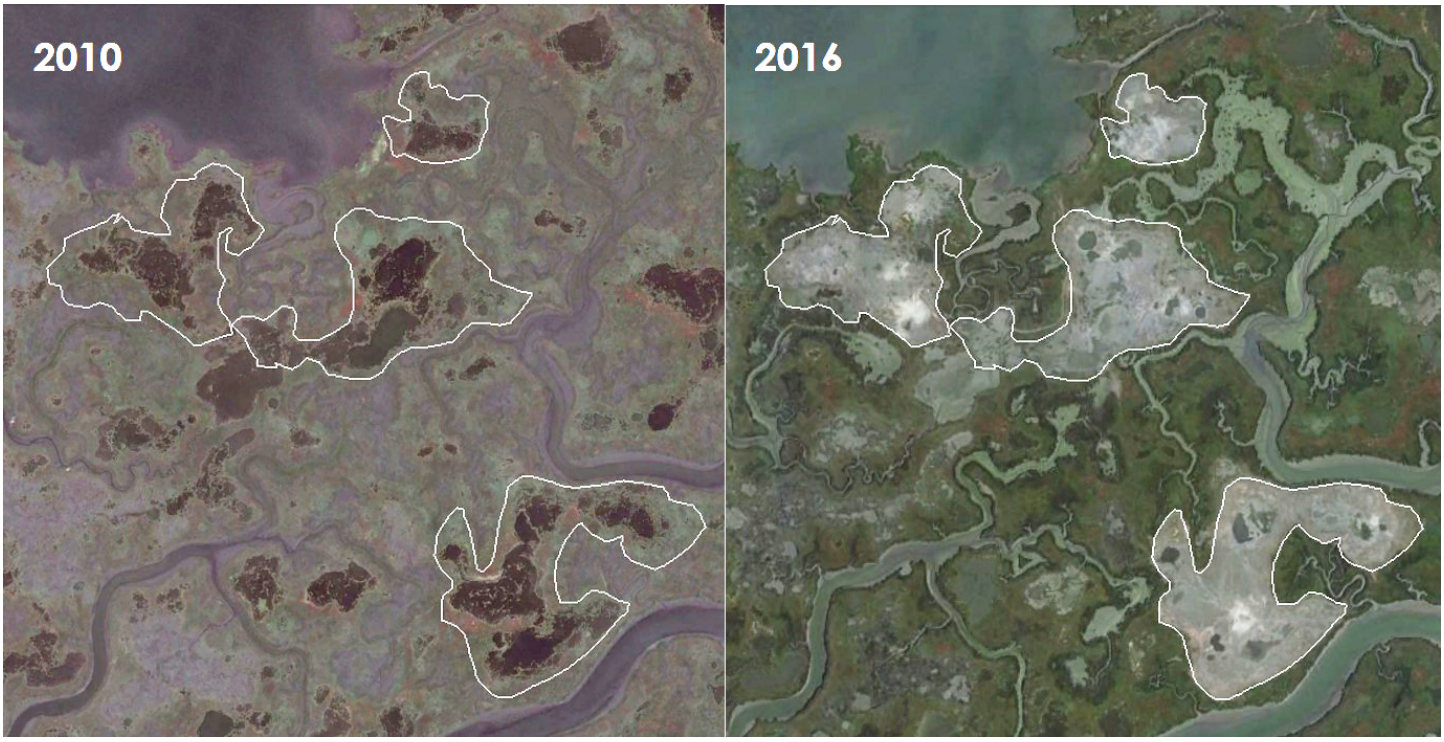
Finally, pond recovery, when the vegetated marsh platform keeps pace with RSLR and the pool platform accretes faster than RSLR, occurs in marshes with high tidal range and moderate RSLR. These marshes experience cyclical pool dynamics where vegetation recovery proceeds after pool breaching. Examples of this regime are Atlantic Coast marshes near Cape May, New Jersey and Plum Island, Massachusetts (Mariotti 2016). This framework can be used to guide conservation practitioners in evaluating whether pools represent permanent marsh loss and the results of this evaluation then can inform conservation and management decisions.

Without an evaluation of this kind, conservation practitioners risk taking action where it may not be warranted. One recent project near Cape May, New Jersey interpreted marsh pools as permanent marsh loss (U.S. Army Corps of Engineers 2014; Greenvest LLC 2015) where pools form, breach, and experience eventual vegetation recovery (Mariotti 2016).

The New Jersey Department of Environmental Protection-led project, in collaboration with several partner agencies, consulting groups and NGOs, used sediment from Army Corps intra-coastal waterway maintenance dredging to fill a series of pools along with adjacent areas of vegetated marsh with dredged sediment at a site in southern New Jersey comprising approximately 50 acres (Figure 5). The project is considered a demonstration project in anticipation of more widespread implementation of the technique throughout New Jersey if deemed successful.

Given what we know about pool dynamics and its role in providing diverse wildlife habitat, there is no clear ecological justification for placing dredged material on marshes and marsh pools experiencing a pond recovery regime, particularly those with a marsh platform that is predominately above mean high water. On the other hand, if a marsh is in a drowning or pond collapse regime, the use of dredged sediment to reverse permanent marsh loss may be warranted. Given their rarity, marshes that have not been directly altered by humans are crucial resources that need guarded against direct human alteration, at least until there is well-documented evidence for sea level rise-driven degradation. These marshes need to be conserved both for their high wildlife habitat value as well as for their scientific importance. Unaltered marshes are essential to our understanding of fundamental tidal marsh processes and for learning how such processes are affected by sea level rise and global climate change. The natural cyclical dynamics of pools has only become widely recognized in the last decade (e.g., Mariotti 2016; Wilson et al. 2014). These recent insights into the role of pools in tidal marsh geomorphology would not have been possible if it were not for the existence of naturally functioning tidal marshes with unaltered hydrology. For restoration, knowledge of unaltered marsh character and function is essential for guid-

FIGURE 5. Cape May Coastal Wetlands Wildlife Management Area near Avalon, New Jersey before and after sediment deposition on marshes and in pools. Tidal range 1.23 m. (Source Imagery © Google Earth.)



ing restoration designs and as a reference for evaluating restoration outcomes.

With the critical conservation importance of unaltered marshes in mind, dredged material application on previously unaltered marsh raises concern. Waterways and marinas that require frequent maintenance dredging are often directly adjacent to many of these unaltered marshes, as in the example of pool-filling in southern New Jersey. In this region of New Jersey, there are thousands of acres of relatively unaltered marshes within the wetland complexes stretching from Cape May to Great Bay. The unaltered component is comprised primarily of lagoonal marshes between mainland and back barrier marshes that are ditched (Figure 6). They are likely among the largest tracts of unaltered tidal wetlands in the northeastern United States. To the north, Little Egg Harbor, Barnegat Bay and other northern New Jersey marshes are profoundly and perhaps irreversibly altered by ditching and open marsh water management.

SETTING RESTORATION PRIORITIES

Worldwide, there are vast areas of tidal marshes that have suffered direct human impacts from impoundment, tidal restriction, dredging, ditching and mosquito control alterations. Such marshes would benefit greatly from management, including the use of dredged material, to restore function, habitat quality and increase sea level rise resilience.

Restoration is a response to ecological degradation that is the result of human impacts. In the case of tidal marshes these impacts are direct alterations as well as impacts from climate change. Restoration cannot typically respond to degradation that has not yet occurred (e.g. future sea level rise). Existing degradation as a result of sea level rise can be addressed with restoration, but such actions at the site level can only treat the symptoms of degradation (not its cause). With this in mind, reversing past direct alterations that have caused marsh degradation is a particularly fruitful restoration approach because management can potentially treat the root cause of degradation and ultimately improve resilience to current and future sea level rise. For example, in Delaware Bay where the loss of elevation from marsh impoundment and farming has greatly reduced the long-term resilience of marshes to sea level rise, the addition of dredged sediment (to raise marsh elevations) could increase the capacity of these marshes to persist in the future. Likewise, restoring natural hydrology to marshes affected by ditching (Figure 6) in conjunction with sediment addition would, by correcting hydrological impairments and reducing elevation deficits, restore natural dynamic processes and improve wildlife habitat value.

Even among unaltered marshes, there may be ways to productively use dredged material for marsh conservation. Although the greater vegetated portion of these unaltered marshes may be keeping vertical pace with sea level, marsh loss is occurring in some locations due to horizontal erosion. For example, erosion of the marsh edge, caused by wind-driven waves along the shores of broad bodies of

FIGURE 6. Sloughs Gut Project (Delaware) restored natural tidal marsh hydrology without sediment addition including breached and unbreached pools to a grid-ditched marsh. Tidal range 0.75m. (Source Imagery © Google Earth.)

water and exacerbated by boat wakes, is driving horizontal loss of marshes (Mariotti and Fagherazzi 2013). Since mudflats adjacent to marsh edges play an important role in dampening wave action, the use of dredged material to augment intertidal flats is one potential way to help stem marsh edge erosion (Foster et al. 2013).

CONCLUSION

The signs and causes of marsh degradation must be correctly identified in order to plan restoration actions that (1) do no harm to functioning ecosystems, (2) produce lasting results, and (3) use scarce restoration dollars effectively. There are many ways to productively use dredged material to conserve, manage and restore tidal wetlands. The broad acceptance of dredged sediment use for tidal marsh conservation is an important step forward in the management of marshes. However, sediment must be used in a way that does not adversely impact systems that are currently functioning well, such as unaltered marshes with dynamic pool systems. ■

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FIGURE 7. Marshes between barrier islands and the mainland in southern New Jersey. Notice the ditched sections along the mainland and the barrier island, while large sections of relatively unaltered marshes are surrounded by open water. (Source Imagery © Google Earth.)

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Mangroves of the Niger Delta: Their Importance, Threats, and Possible Restoration

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INTRODUCTION

Mangroves are among the most important ecosystems in the world. Mangroves has social, economic and ecological functions, hence are true agents of sustainable development. Mangroves are made up a unique group of trees and shrubs that grow in the intertidal zones of tropical and subtropical estuaries, creeks and sheltered bay across the world (Osborne and Berjak 1997; Ukpong 2000). Mangroves ecosystems are found approximately between 30°N and 30°S (Gilbert and Janssen 1998). They are variously described as coastal woodland, tidal forest and are still regarded as wastelands in some uninformed communities. Mangrove trees can grow up to 40 meters high or as shrubs below the high-water level of spring tides (Corcoran et al. 2007). Blasco et al. (1996) refers to mangrove as ecological term referring to the taxonomically diverse assemblages of trees and shrubs that form the dominant plant communities in tidal, saline wetlands along sheltered tropical and subtropical coasts. Tomlinson (1986) include the taxonomically diverse group of species that are restricted to and do play a major role in the intertidal environment as 'true' mangroves. Mangrove species exhibit a range of adaptations for coping with flooding, anaerobic conditions and high salinities, which fluctuates daily and seasonally depending on tidal movement. The term mangrove has been used in a broad sense to include species that are restricted to and those that occur in, but not necessarily restricted to the intertidal environment. Due to the dynamic nature of the swamp landscape, several physiographic habitats have evolved within mangrove ecosystems. Habitat differences relate to several factors including swamp gradient, hydrology and topography, salinity, substrate texture and carbonate content of the soil (Ukpong 1997). Mangrove is an ecosystem complex consisting not just mangrove vegetation, but also mangrove soils, brackish water, fisheries, wildlife and even microbes. Human populations live in and around mangrove ecosystems forming part of the complex because of their activities such as resources extraction that affect the survival of mangroves, both existing stands and newly revegetated mangroves (Walter 1997). Anthropogenic activities in the current century are fast impacting on mangrove ecosystems globally.

Despite the importance of mangroves, the ecosystem is under threat due to human exploitation. The unsustainable exploitation of mangrove trees for fuel wood has led to the destruction of mangrove ecosystems globally. Mangroves are also destroyed by expanding coastal cities with mangrove ecosystems filled with sand for construction purposes. Sewage, solid wastes and other kinds of wastes including non-biodegradable plastics are freely dumped into mangrove forests. The exploitation of petroleum resources located in mangrove ecosystems has impacted the ecosystems. Oil exploration activities that impact on mangroves include dredging, seismic exploration, pipeline construction, and well drilling. In addition, oil spills arising from oil production and transportation have detrimental effects on mangroves. Due to the activities of illegal bunkering, oil spills are becoming a regular occurrence in the Niger Delta. The impacts on mangrove from multiple sources are now overwhelming the ecosystem and starting to threaten the ecological functions and integrity of the wetlands. For instance, the role of mangroves in the control of coastal erosion, which is now more relevant owing to the observed climate change, is threatened. Hence, the aim of this paper is therefore to present the importance of mangroves, threats facing mangroves and possibility of mangrove restoration.

MANGROVE ECOSYSTEM OF NIGERIA

The size of mangrove ecosystem in the World was estimated as 150,000 – 182, 000 km^2 (Spalding et al. 1997; Lewis 2001; Blasco et al. 1996; Dodd et al. 1998). Nigeria has the largest mangrove stand in Africa and the third largest in the world after India and Indonesia (Corcoran et al. 2007). The authors estimated the current size of Nigerian mangrove to be 7,386km^2 having lost 26% since 1980. While many authors estimated the size of mangrove ecosystem in Nigeria as 10,000 km^2 (Jackson and Lewis 2000; Lewis and Jackson 2000), but Spalding et al. (1997) in the Mangrove Atlas of the World estimated 11,134 km^2 of mangrove in Nigeria. Estimates by Wilkie and Fortuna (2003) also show

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that Nigeria has over 10,000 km^2 of mangrove ecosystem. Nigeria mangroves occupy the area from Calabar estuary in the east to Badagery in the West. Mangroves are present in the entire Nigeria coastline, with the largest width of 30-40 km in the Niger Delta and 7-9 km in the other coastlines. Hence, the majority of Nigerian mangrove is located in the Niger Delta region. Moffat and Linden (1995) and World Bank (1995) estimated the size of mangroves found in the Niger Delta to be 6000 km^2.

The development and composition of mangrove communities depend largely on temperature, soil type, salinity, duration and frequency of inundation, accretion of silt, tidal and wave energy (Hutchings and Saeger 1987; Blasco et al. 1996; Ukpong 1997). Plants of the mangrove community belong to many different genera and families, most of which are not closely related phylogenetically. What they do have in common is a variety of morphological, physiological and reproductive adaptations that enable them to grow in a particular kind of rather unstable, harsh and salty environment (Saeger 1982; Tomilinson 1986; Blasco et al. 1996). Mangrove vegetation is typically classified as true mangroves and mangrove associ-

FIGURE 1. Healthy *Concocarpus erectus* with *Rhizophora racemosa* mangrove (in the background, with prop roots evident) in the Niger Delta

TABLE 1. Mangroves of Nigeria. (Modified from Ukpong 1997; Lewis and Jackson 2000)

	Scientific name	Common name in Nigeria	Remarks
True mangrove	*Rhizophora racemosa*	Tall red mangrove	Occurs on mostly recently deposited inceptisols
	Rhizophora mangle	Short (dwarf) red mangrove	Often located behind the tall red mangroves
	Rhizophora harrisonii	Short (dwarf) red mangrove	Regarded as a putative hybrid of *R. Racemosa and R. mngle*
	Avicennia germinans (A. africana)	White mangrove	Regarded as blank mangrove in the USA
	Laguncularia racemosa	Black mangrove	Regarded as white mangrove in the USA
	*Conocarpus erectus**	Buttonwood tree	Localized near Kidney Island , Rivers State
Mangrove associates	*Acrostichum aureum*	Leather fern (mangrove fern)	
	Hibiscus tiliaceus	Hibiscus	
	Thespesia populnea	-	
	Drepanocarpus lanatus	-	
	Chrsobalanus spp.	-	
	Pandanus candelabum	Screw pine	Occurs at transition zones between freshwater and mangrove ecosystems
	Nypa fruticans	Nipa palm (mangrove palm)	Was imported into Nigeria in 1901 and is fast replacing true mangroves in the country and along the Atlantic coast of West Africa

* C*onocarpus erectus* is referred to as true mangrove in some literature and as mangrove associate in others.

ates (Tomlinson 1985; Dodd et al. 1998; Lewis and Jackson 2000). There are approximately 80 species of mangrove plants (with about 60 in the Indo-Pacific region and 20 in the Western Hemisphere) belonging to about 30 genera in 20 families (Blasco et al. 1996), of which 17 species exist in 26 countries of Sub-Saharan Africa. African mangroves are widespread along the west coast from Senegal to the Congo, and occur locally in East Africa, interlinked with highly productive coastal lagoons, tidal estuaries and deltas (Corcoran et al. 2007). Of the 17 mangrove species in Africa, only 6 species of true mangroves and about 7 species of mangrove associates are found in Nigeria (Ukpong 1997; Lewis and Jackson 2000) listed in Table 1. *Rhizophora harrisonii* is often referred to as a putative hybrid of *R. racemosa* (Figure 1) and *R. mangle* (Dodd et al. 1998; Sanger and Bellan 1995).

IMPORTANCE OF MANGROVE ECOSYSTEMS

Mangroves are true agents of sustainable development because they posses environmental, social and economic relevance. There are over 70 documented uses of mangrove ecosystem (IUCN 1993). Generally, wetlands provide human with a wide range of goods and services including staple food plants, fertile grazing land, support for coastal and inland fisheries, flood control, breeding and foraging grounds for birds and source of fuel wood (Tri et al. 1998). Food items include finfish (many species), crustaceans (prawns, shrimps, and crabs) and mollusks (oysters, mussels, and cockles). Honey bees reside and produce honey in the mangrove ecosystem. However, in Nigeria and many other African countries, wild animals including various mammals, birds and reptiles are unsustainably hunted in the mangroves for food, skin and traditional practices. Forestry products particularly wood are obtained from mangrove ecosystems. Mangrove woods are used for civil construction activities (boat construction, buildings and bridges) and due to their high energy content are also used as fuel woods. The organic matter and nutrient flow from the mangrove ecosystem to a great extent support the benthic population of the sea (Das et al. 1997). Sylla et al. (1995) reported the use of mangrove ecosystems for rice farming in West Africa. Apart from the disused rice farm in Diebu Creek (Peremabiri, Bayelsa State), mangrove rice farming is not a common practice in Nigeria. However, mangrove ecosystems are commonly used for fish farming in the Niger Delta (Dublin- Green 1987; Dublin-Green et al. 2003). Bandaranayake (1998) reviewed the various traditional and medicinal uses of Nigeria's mangrove species (Table 2). The environmental/ecological use of mangroves includes hydrological cycle, carbon fixation, sediment control, and buffering of storms (Gilbert and Janssen 1998). One of the notable functions of mangroves is the treatment of wastewater containing heavy metals. Mangrove soil has the capacity to retain heavy metals in non-available forms (Tam and Wong 1996). Blasco et al. (1996) reported the economic values of mangroves to include

TABLE 2. Medicinal uses of mangrove plants. (Sources: Gordon 2005; Bandaranayake 1998.)

Botanical name	Mangrove type	Uses (tissues)
Acrostichum aureum	Mangrove associate	Boils and wounds, (rhizome), rheumatism (L)
Avicennia germinans	True Mangrove	Incontinence, rheumatism, (B). throat pains, ulcers of the mouth, (L, B); ashes used as salt substitutes (L); powdered bark mixed with palm oil for treatment of lice, ring worm and mangles (B); germinating seeds used as a poison (S). Cure of thrush, cancer, gangrenous wounds, skin parasites, tumors (B), and ulcers (B).
Concocarpus erectus	True Mangrove	Catarrh (R), febrifuge (L), gonorrhoea, malaria, and stops bleeding (B).
Hibiscus tiliaceus	Mangroves associate	Ear infections (flowers)
Nypa fruiticans	Mangroves associate	Asthma, diabetes, leprosy, rheumatism, and snake bite (L, F).
Rhizophora mangle	True Mangrove	Angia, boils and fungal infections (B), antiseptic, diarrhoea, dysentery, elephantiasis, fever, malaria, leprosy (B, L), minor bruises (B), plaster for fractured bones (B), and tuberculosis (B, L).
Rhizophora racemosa	True Mangrove	Stops bleeding (L); used with palm oil as an ointment for boil (R); extract used for fungal infections of the skin (B); treatment of diarrhoea and dysentery in children (B), leprosy (B), Sore throat (B).

(B-bark; L-leaves; F-fruits; R-roots, S-seed)

source of timber, poles, tanning material, food, and medicine. Readers are directed to IUCN (1993) report for a detailed review on the uses of mangroves.

THREATS TO MANGROVES

Table 3 presents legal framework pertaining to mangrove and wetlands conservation in Nigeria. Some of the regulations are international and regional to which Nigeria is a signatory, while the rest are national. The policies though many are inadequate to effectively prevent mangrove destruction. For instance, there is no no-net-loss of wetland policy in Nigeria. Therefore, wetland best management practices like wetland banking are not practiced in Nigeria. Moreover, due to institutional weakness, policy enforcement in the country is generally poor. Hence, mangroves continue to decline in Nigeria and globally due to anthropogenic impacts. In many countries, including Nigeria, many people still regard wetlands as wastelands, hence they are freely destroyed (Figure 2) or converted to other uses (Adekola et al. 2012). In most cases, losses of mangrove are due to over-exploitation, clearing and pollution (Saenger et al. 1983), whereas in other areas losses are due to natural causes such as coastal erosion, permanent inundation and increased salinization, all linked to sea-level rise (Saenger et al. 1983; Blasco et al. 1996). In Senegal, the change in hydrological regime causing rainfall deficit, triggered ecological processes resulting in increased evaporation, low humidity, higher frequency of dry winds, increased salinity and acidification; all cause a decline in mangroves (Diop et al. 1997). Reports from other countries also indicate that mangrove ecosystems are fast disappearing. For instance, the size of the mangrove ecosystem in Puerto Rico has declined from 24,310 ha to 6,410 ha. Similar losses have been reported in other countries such as Philippines (60%), Thailand (55%), Vietnam (37%) and Malaysia (12%) (Lewis 2001). In Nigeria, mangroves loss of 26% has been reported (Corcoran et al. 2007).

The causes of mangrove decline in Nigeria are many but could be classified broadly into two namely anthropogenic and natural. The anthropogenic factors include increasing population pressure, rapid urbanization, mining oil, industrial waste pollution, uncontrolled tilling for crop production, overgrazing, logging, land reclamation, road and dam construction, and other infrastructural developments (Uluocha and Okeke 2004). Increases in waterfront residences together with an increasing population and land shortages has induced unprecedented wetland reclamation projects in the southern areas of Lagos and the Niger Delta (Adekola et al. 2012). Other anthropogenic impacts on mangrove are waste disposal, reclamation and sand filling. Ecological factors (which could also be induced by human activities) include climate change, marine and coastal erosion, subsidence, ocean water intrusion, invasion by non-native biota, desertification, and droughts.

Oil and gas exploration activities affecting mangrove ecosystems include seismic operations, drilling, pipeline installation, dredging, and oil spills. Seismic operations cause one of the most devastating impacts on mangrove. Seismic lines criss-cross the entire Niger Delta (Figure 3); seismic lines cut in the mangrove ecosystem over five decades ago are still quite visible. Crude oil is toxic in nature and when plant and animals are covered by these products results to suffocation, starvation and other inference with physiological functions (Hoff 2002). Studies have shown that mangroves are affected by lethal and sub-lethal effects associated with oil spills. During oil spills, oil soaks into sediment and coat exposed trunks, prop roots and pneumatophore causing high mortality of mangroves and fauna. Long-term

FIGURE 2. Impacted *Rhizophora racemosa* mangrove forest in the Niger Delta

TABLE 3. Legal framework pertaining to mangrove management in Nigeria.

Legislation	Coverage/ spread	Implications
The Ramsar Convention, 1971	International	Provides a framework for national action and international cooperation for the conservation and wise use of wetlands and their resources.
Convention on Biological Diversity (CBD), 1992	International	The three main goals of CBD are the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits arising from utilization of genetic resources.
International Union for Conservation of Nature and Natural Resources (IUCN) Guidelines	International	Guidelines for oil and gas exploration and production in mangrove areas, conservation of mangroves and enhancing the protection of marine ecosystems.
The Convention on International Trade In Endangered Species Of Wild Flora and Fauna, 1975 (CITES)	International	CITES represents a cooperative effort between countries to prevent loss of species resulting from international wildlife trade.
Convention on the conservation of Migratory Species of wildlife animals, 1979 (Bonn Convention)	International	Aims to "conserve terrestrial, marine and avian migratory species throughout their range."
Convention for cooperation in the protection and Development of the Marine and Coastal Environment of the West and Central African Region, 1981	Regional	The convention provides an important framework through which national policy-makers and resource managers implement national control measures in the protection and development of the marine and coastal environment of the Region.
Nigerian Legislation Guiding Biodiversity Protection National Environmental (Wetlands, River Banks and Lake Shores Protection) Regulations, 2009 (S. 1. 26 of 2009)	National	Contained regulations pertaining to the protection of Wetlands, River Banks and Lake Shores
National Environmental (Control of Bush/Forest Fire and Open Burning) Regulations, 2011 (S.I. No 15)	National	Regulation for the control of forest fire
National Environmental (Protection of Endangered Species in International Trade) Regulations, 2011 (S. I. No 16)	National	Protection of Endangered Species in International Trade
The Natural Resources Conservation Act 1989	National	The Act establishes the Natural Resources Conservation Council, which is empowered to address soil, water, forestry, fisheries and wildlife conservation by formulating and implementing policies, programmes and projects on conservation of the country's natural resources
Federal Environmental Protection Agency Act (Chapter 131, Laws of the Federation, 1990)	National	The Federal Environmental Protection Act was promulgated to protect the country's environment from degradation. The functions of FEPA have been subsumed by the Federal Ministry of Environment
Environmental Impact Assessment Act (No 86 of 1992)	National	This Act requires that environmental impact assessment must first be carried out before any project likely to impact the natural environment could be undertaken.
National Parks Decree (Decree No 36 of 1991)/ National Parks Act of 1999	National	The Act was promulgated to provide a protective sanctuary for wildlife species as well as to promote and preserve the beauty and conservation of the country's natural vegetation.

TABLE 3, Continued.

Legislation	Coverage/ spread	Implications
Forestry Law CAP 52, 1994	National	The law prohibits any act that may lead to the destruction of or cause injuries to any forest produce, forest growth or forest property.
The Navigable Waterways Declaration Act, 1985	National	This act prohibits the taking of such natural resources as sand, gravel or stone from rivers, creeks, lakes, lagoons and intra-coastal water ways. It also bans the erection of permanent structures within the right of way or the diversion of water from wetlands.
River Basin Development Authority, 1986	National	Established River Basin Authorities which will ensure that surface and underground water resources are used for agriculture, irrigation, forestry and fisheries with utmost environmental care.
Niger Delta Development Commission Act, 2000	National	This established the NDDC with the aim, amongst other things, of tackling ecological and environmental problems that arise from the exploration of oil mineral in the Niger Delta region.
National Environmental Standard and Regulation Enforcement Agency Act, 2004	National	Established NESREA to regulate and enforce environmental standards through protecting and developing strategies for quality environment, biodiversity conservation and sustainable development of Nigeria's natural resources.
National Oil Spill Detection and Response Agency Act, 2006	National	Established NOSDRA which is expected to restore and preserve Nigeria's environment by ensuring the best oil field, storage and transmission practices in exploration, production and use of oil in the quest to achieve sustainable development in Nigeria.

chronic oiling or oil spills that produce elevated concentrations of polynuclear aromatic hydrocarbons in the sediment are capable of producing chlorophyll-deficient mutations in *Rhizophora mangle* (Proffitt et al. 1995). When spills occur, oil gets washed into the mangrove back swamp at high tide and gets stranded there when the water retreats at low tide, where the spilled oil becomes persistent due to the anaerobic nature of mangrove sediments. However, mangroves have physiological mechanisms that enable them to adapt and survive in a low-oxygen (compounded by oil spill) and high salinity habitat. For instance pneumatophores with their hypertrophied lenticels aid gaseous exchange (Boer 1993), while the leaves and submerged roots help in the excretion of salts. Studies have shown that 96% of *Avicennia marina* that are exposed to an oil spill usually die-off (Grant et al. 1993). During oil spill, symptoms like leaf staining, chlorosis, leaf death, defoliation and tree death occurs (Duke et al. 2000). Study of an oil spill in Panama in 1986 suggests that after clean-up, the remaining oil in the mangrove sediments continues to affect root survival, canopy conditions and growth rate of mangrove seedlings as 6 years later, the surviving forests fringing deforested areas continued to deteriorate (Burn et al. 1993). Wardrop et al. (1996) showed that the 1992 Era spills in Australia failed to recover even 4 years after the spill.

According to the official estimates of the Nigerian National Petroleum Corporation, a total of approximately 2300m^3 of oil was spilled in 300 separate incidences annually. Since the oil companies frequently underestimate the quantity of oil spilt and a large number of other spills go unreported, the total volume of oil spilt may be 10 times higher than the official figure (http://www.stakeholderdemocracy.org/massive-nigerian-oil-spill-goes-unreported/, https://therawreport.org/2012/10/25/the-oil-spills-that-went-largely-unreported/). Nigerian oil is a very light crude oil which might indicate an evaporation loss close to 50% within 48 hours (Moffat and Linden 1995).

Other activities of the oil industry that kill mangrove are dredging, spoil disposal, and sand filling (Fagbami et al. 1988; Ohimain, 2004; Ohimain et al. 2004). Since the mangrove ecosystem, because of its several shallow and meandering creeks, is largely inaccessible for most oil and gas related activities (IUCN 1993), dredging is performed to provide access to drilling sites, pipeline installation, production facilities, and logistic base (camp) accommodation (Ohimain 2008a, 2008b). Dredging could involve the

following activities including clearing of mangrove vegetation, straightening, widening and deepening of existing creeks, and creating new canals. In the process of dredging, the dredged spoils (soil, sediment and vegetation) are typically discharged at creek banks and abandoned (Ohimain 2002, 2003a, 2003b, 2003c). Besides the mangroves killed via direct removal (dredging) and smothering (spoil disposal), changes in the topography, hydrology and salinity result in mangrove mortality beyond the immediate impact area (Ohimain 2004, 2008a, 2004b; Ohimain et al. 2004, 2010). Both permanent flooding and lack of tidal inundation kill mangroves on a large scale (Ohimain 2003a), whereas the abandoned dredged spoil soon becomes acidic and drains into the mangrove back swamps killing more mangroves (Ohimain et al. 2004; Ohimain 2001, 2004). The environmental impacts of acidification can be overwhelming, affecting virtually all components of the ecosystem including phytoplankton (Ohimain and Imoobe 2003), zooplankton (Ohimain et al. 2002), benthic invertebrates (Ohimain et al. 2005), and vertebrates especially fishes (Fagbami et al. 1998; Ohimain 2003a). Dredging and spoil abandonment has also been implicated in widespread hydrological changes (Ohimain 2003a), topography changes (Ohimain et al. 2010), water quality changes (Ohimain et al. 2008b), heavy metal pollution (Ohimain et al. 2008a, 2008c), shift in vegetation types (Ohimain, 2005; Ohimain et al. 2004, 2005), increased erosion and siltation (Ohimain et al. 2004), excessive flooding of the back swamp (Ohimain et al. 2004) and coastal retreat (Eedy et al. 1994).

Nipa palm, which is often referred to as mangrove palm is of immense benefit in Southern East Africa, and was introduced to Nigeria in 1901. It is now replacing mangroves in the Niger Delta (Bioresources Development and Conservation Programme 2010; Moffat and Linden 1995) and poses a serious threat to the entire mangrove ecosystem of the Niger Delta. The government of Nigeria is at a loss on how to control nipa palm that is rapidly expanding along the entire West African coastline at the expense of indigenous mangroves.

MANGROVE RESTORATION

There have been various attempts at mangrove restoration in Nigeria (Figures 4 and 5) and all over the tropical world. The success of most of these efforts especially in Nigeria is not verifiable. Many of the failures are often unreported. Possible causes of mangrove restoration failures are presented in Table 4. In most of the reported successes, it is uncertain if they became fully established because of the short time of post re-vegetation monitoring, which is less than one year in most cases. Mangrove can present

FIGURE 3. Seismic lines across mangrove swamp in the Niger Delta. (Note freshwater swamps beside the mangrove swamp)

FIGURE 4. Re-established mangroves in the Niger Delta

FIGURE 5. Restored site with *Rhizophora* (with *Avicennia* in the background)

TABLE 4. Reasons for failures of mangrove restoration projects in Nigeria

Causes of failures	Explanation	References
Community disturbance	Due to limited farming lands in the mangrove swamp, indigenous people use abandoned spoils for farming. Hence, they resist mangrove restoration on abandoned spoils.	Ohimain et al. 2004; Ohimain 2004
Acidification	Acidification typically results following the exposure of mangrove spoils containing pyrites	Ohimain 2003a, 2003b, 2004, 2008a, 2008b
Physicochemical changes and heavy metal pollution	Physicochemical changes follows dredging and exposure of pyritic dredged materials resulting in physicochemical changes such as extreme acidity and heavy metal pollution	Ohimain et al. 2003a, 2008a, b, c
Maintenance dredging	Maintenance dredging result in the deposition of dredged spoils upon fringing mangroves, thus killing them	Ohimain 2002, 2004
Topographic and hydrological deficiencies	Changes in topography often results in altered hydrology, which do not favour mangrove recruitment, establishment and growth	Ohimain et al. 2010
Competition by alien species	Due to altered hydrology, abandoned spoils are becoming less saline after years of weathering, which favours invasive species over mangroves	Ohimain et al. 2010
Gardening effect	Plant of mangroves without due regards to hydrology, resulting in mangrove failures	Lewis 2001; Lewis and Streever 2000
Poor site preparation	Planting mangrove without effective site preparation or poorly designed site preparation often results in failures	Lewis 1999; Lewis 2001
Oil spills	Oil spills upon new recruits is devastating and often results in failures	Hoff 2002
Stressor unaddressed	Mangrove restoration in areas where the original cause of mangrove death have not been effectively addressed such as oil spill, alteration in salinity, topography and hydrological changes	Lewis 2001; Lewis and Streever 2000; Hoff 2002; Ohimain et al. 2010, 2014

initial success and later die due to unfavorable conditions that even existing at the time of planting. Mangroves are not known to be good competitors except under special hydrological conditions, which prevent other competitors from establishing. The four major aims for rehabilitating mangroves are for conservation, landscaping, sustainable production and coastal protection (Field 1999).

SITES SELECTION AND PREPARATION

Elster (2000) reported that mangrove success depends largely on site selection and preparation. Particular attention must be paid to topography, hydrology (flooding regimes and fresh water runoff), water chemistry, tidal and wave energy, natural propagule availability and regeneration, re-vegetation techniques (natural, transplanting, and nursery stock), adequate monitoring and maintenance (spacing, thinning and weeding), and budget. Planting without due consideration to these factors could lead to failures. Unfortunately, most of the mangrove re-vegetation projects reported in Nigeria fall short of most of these considerations. Some were even planted on dredged spoils without due consideration to the topography and hydrology. This poor practice is often regarded as the gardening effect (Lewis 2001; Lewis and Streever 2000). Many mangrove-restoration projects move immediately into planting of mangroves without determining why natural recovery has not occurred. Identification of the underlining causes of mangrove death is very important to their restoration. Sanyal (1998) reported that between 1989 and 1995 about 9,050 ha of mangroves were planted in West Bengal, India with only a 1.52% success rate. A study in Philippines attempted to restore 22,723 ha of mangrove primarily by direct planting on mudflats but recorded 0 to 66% success with average of 17% (Lewis 1999, 2001). Site preparation is critical to the success of any mangrove restoration project.

MANGROVE RESTORATION TECHNIQUES

There are both macro- and micro-propagation (tissue culture) methods for mangroves (Table 5; Saenger 2002). Mangrove can also be propagated through air layering techniques (Kathiresan and Ravikumar 1995; Saenger 2002). This article focuses only on macro-propagation methods because these methods have been successfully demonstrated in many countries including Nigeria. Approaches for macro-propagation of mangrove include direct planting of propagules, seedlings and saplings collected from the wild and planting nursery-raised seedlings and saplings. Another method of mangrove re-vegetation and restoration is enhanced natural restoration. Each of these techniques is further discussed below with application to Nigeria mangroves species.

TABLE 5. Mangrove propagation methods.

Macro-propagation methods	Micro-propagation method
Direct planting of propagules, seedlings and saplings	Tissue culture
Planting nursery-raised seedlings and saplings	
Enhanced natural restoration	
Air layering techniques	

FIGURE 6. Mangrove seedling established in the intertidal zone in the Niger Delta

Enhanced natural restoration. Degraded mangrove forest may self repair within 15-30 years provided there exist adequate seeds/seedlings under normal wetland hydrology (Lewis 2000, 2001; Lewis and Streever 2000). Enhanced natural restoration involves removal of the underlining causes of mangrove death by, for example, oil spill clean-up and restoring topography and normal hydrology, which could promote natural recruitment of volunteer propagules and their establishment at the site. This method is relatively cheap and applicable for mass propagation of all the three genera of Nigerian mangroves (*Rhizophora, Avicennia* and *Laguncularia*). Of the three genera *Rhizophora* is the slowest to recover naturally within 10-110 years (Jackson and Lewis 2000), yet this time could be shortened if the correct site topography and hydrology is restored. Hydrologic restoration is also critical because, without it other restoration measures could fail.

Direct planting of propagules, seedlings and saplings. Collecting and planting of propagules from local mangrove swamps is the next restoration method to consider if natural recruitment is shown to be inadequate. In

this method, planting materials such as propagules (fruits/seeds), seedlings (young plants 30-60 cm tall) and saplings (shrubs 1-2 m tall) are collected from the wild and planted in a site. For most mangrove species, matured propagules are only available 2-4 months of the year, so direct planting of propagules needs to be scheduled accordingly (Saenger 2002). Propagules, generally from *Rhizophora,* are young plants with no roots or open leaves that develop while still attached to the parent tree. When mature, the propagules drop from the parent plant and becomes establish in the mud. Propagules can be harvested directly from the tree when mature, or collected from litter under the tree if they have not already rooted into the ground. Direct planting of propagules is recommended for *Rhizophora*. *Avicennia*, and *Laguncularia* seeds can be collected from the wild and broadcasted to restore mangroves, but their survival rate and establishment are typically less than 30% (Jackson and Lewis 2000).

Nursery techniques. In nursery techniques, mangrove propagules and seedlings are obtained from the wild and raised in nurseries before transplanting to the site of interest. Propagules are typically collected during the fruiting season, raised in nurseries and grown to 0.50-1 m before transplanting. Mangrove nurseries are typically established in intertidal areas (Figure 6). Establishing mangrove plants in a nursery can be practical as plants are ready for restoration planting when needed, but it can be costly (Jackson and Lewis 2000). Notwithstanding, nursery-grown plants can demonstrate high-survival rates. Seedlings can be transplanted within 6-12 months of growth in the nursery. *Rhizophora*, *Avicennia* and *Laguncularia* trees 0.5 to 1.5 tall have been successfully used as transplant stock (Jackson and Lewis 2000).

CONCLUSION

In recent years, mangrove restoration and conservation practices have increased all over the world with support from several international organizations. Mangrove restoration techniques that have been demonstrated in Nigeria include enhanced natural restoration, transplanting of propagules/seeds/saplings obtained from the wild or raised in nurseries. In spite of the increased attention to the mangrove ecosystem, various anthropogenic activities such as logging, dredging and dredged spoil disposal, oil and gas activities, and rising population along the coastal communities, failures in public policy have hampered efforts to both conserve and restore mangrove ecosystems. Despite the array of legislations and policies, wetlands continue to be overexploited due to the preference for short-term economic gain rather than long-term sustainable use of the ecosystem (Saenger et al. 1983). An integrated approach to coastal area management through coherent policy development, enforcement of environmental policies, and concerted action through restoration and environmental education is increasingly being regarded as the best way to achieve conservation and sustainable use of mangrove and other coastal resources (Chua and Scura 1992). ■

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Women's Role in Managing International Wetlands

Mariam Kenza Ali and Ania Grobicki have written an article about the role that women play in conserving wetlands around the globe. Using examples from Burkina Faso, Greece, and Iraq the authors demonstrate how women serve as guardians of wetland and water resources, while recognizing that the nature of women's role is heavily dependent on local culture and environmental conditions. Consequently, what works to empower women in one country will not necessarily work in other countries. The article proposes five principles for enhancing women's participation in wetland and water management:

1. Recognize women's central role in providing, managing, and safeguarding wetland and water resources;
2. Actively support women's full participation in the governance of these resources at all levels;
3. Mainstream gender issues across wetland, water, and cross-sectoral policies and plans;
4. Value the economic, cultural, and social benefits of women's wetland-based livelihoods; and,
5. Ensure that solutions to enhance gender equality are adapted to local cultural contexts."

For more information on the three case studies, read the online article at https://www.thesolutionsjournal.com/article/womens-roles-managing-wetlands/. ■

Reduction of Global Sea Ice Continues

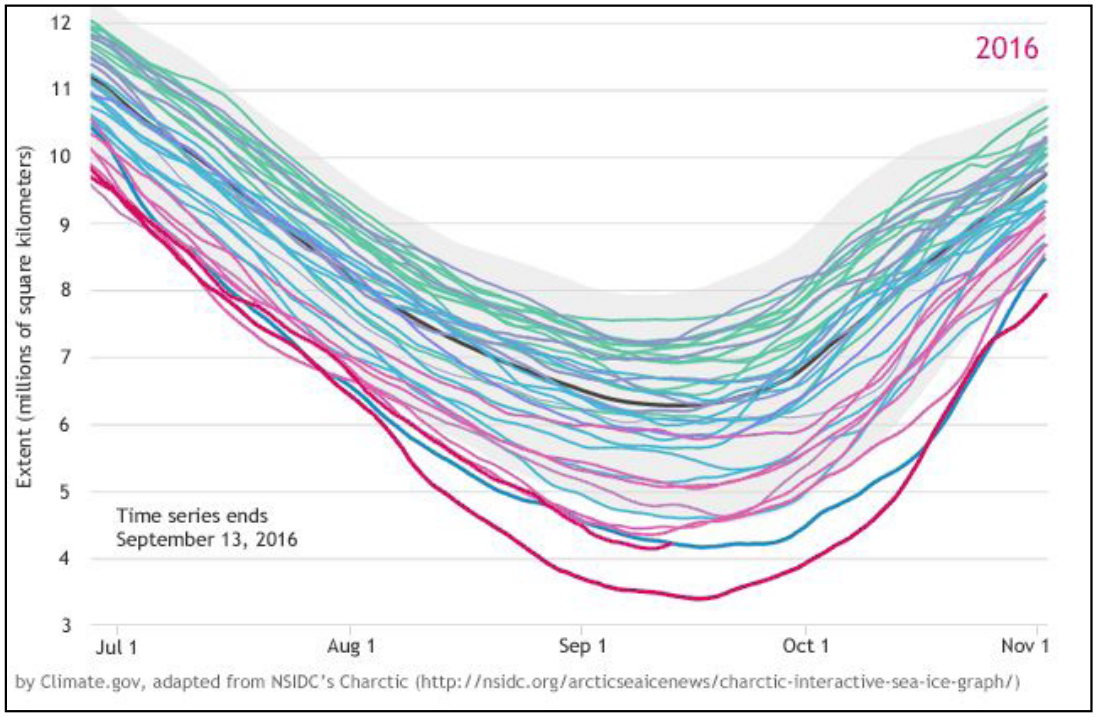
Contributed by Jeffrey T. Malloy, Senior Resiliency Planner at BSC Group, Inc.

The National Snow and Ice Data Center (NSIDC) has tracked the extent of Global Sea Ice since 1979. Over the previous 35 years, a gradual reduction in maximum global sea ice coverage persists. The sharp decrease in 2016 maximum global sea ice represents a significant deviation from an already alarming trend. While the southern hemisphere (Antarctic Sea Ice) has shown only a 2.02-percent reduction in sea ice below the 1981-2010 average, the northern hemisphere (Arctic Sea Ice) accounts for the majority of global sea ice loss with a 27.83-percent reduction according to NSDIC.

What remains to be seen are the adverse positive feedback loops that may result from these changes. Sea ice, for example, reflects a notable 50% of solar radiation back to space, while the open ocean reflects a mere six percent. As sea ice maximums continue to decrease, the amount of energy absorbed into the oceans and atmosphere will likely compound the warming effects on global ocean, surface, and low-atmospheric systems. These temperature changes materialize slowly across the globe, with anticipated effects that remain only partially understood.

The effects on the jet stream however present an opportunity to observe the more immediate effects of changing global sea ice conditions. As the Arctic continues to warm at a faster rate than the rest of the globe, the ratio between high and low pressure systems (think warm tropical air versus cold polar air) diminishes. When these high and low pressure systems meet under unusually warm Arctic air conditions, the jet stream slows as it circles the earth. A slower jet stream tends to meander (think ridges versus troughs) leading to weather patterns that tend to remain in place for long periods of time. For a recent example of this condition, think back to the 2014 Winter Season which brought the Northeast U.S. a stagnant weather pattern, three straight months of bitterly cold weather, and record snowfall totals. ■

FIGURE 1. Changes in Arctic sea ice from July 1 to November 1 since 1979, with the bottom line (red) representing seasonal changes in 2016. The black line which is largely obscured represents the average from 1981-2010; the online interactive figure (at: https://www.climate.gov/news-features/event-tracker/arctic-sea-ice-ties-second-lowest-2016) shows the annual variation over this time period.



WETLAND BOOKSHELF

As the year comes to a close, one new wetland book hits the market – the second edition of *Wetland Indicators – A Guide to Wetland Formation, Identification, Delineation, Classification, and Mapping* (CRC Press). This full-color edition includes a new 100-page chapter on wetland formation and hydrology that should be of interest to all wetlanders; note that the word "formation" has been added to the original subtitle. Check out some initial reviews at the web link listed below.

If you know of other books and reports on wetlands, please send information to Ralph Tiner, Editor of *Wetland Science & Practice* at: rtiner@eco.umass.edu. Your cooperation is appreciated.

BOOKS

- 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 http://www.pineapplepress.com/ad.asp?isbn=978-1-56164-687-6
- 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

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

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-onestop/5044-nwi-reports
- Preliminary Inventory of Potential Wetland Restoration Sites for Long Island, New York http://www.aswm.org/wetlandsonestop/restoration_inventory_long_island_ny_021715.pdf
- Dichotomous Keys and Mapping Codes for Wetland Landscape Position, Landform, Water Flow Path, and Waterbody Type Descriptors. Version 3.0. U.S. Fish and Wildlife Service, Northeast Region, Hadley, MA.
- Connecticut Wetlands Reports

- Changes in Connecticut Wetlands: 1990 to 2010
- Potential Wetland Restoration Sites for Connecticut: Results of a Preliminary Statewide Survey
- Wetlands and Waters of Connecticut: Status 2010
- Connecticut Wetlands: Characterization and Landscape-level Functional Assessment
- Rhode Island Wetlands: Status, Characterization, and Landscape-level Functional Assessment http://www.aswm.org/wetlandsonestop/rhode_island_wetlands_llww.pdf
- Status and Trends of Prairie Wetlands in the United States: 1997 to 2009 http://www.fws.gov/wetlands/Documents/Status-and-Trends-of-Prairie-Wetlands-in-the-United-States-1997-to-2009.pdf
- Status and Trends of Wetlands in the Coastal Watersheds of the Conterminous United States 2004 to 2009. http://www.fws.gov/wetlands/Documents/Status-and-Trends-of-Wetlands-In-the-Coastal-Watersheds-of-the-Conterminous-US-2004-to-2009.pdf
- The NWI+ Web Mapper – Expanded Data for Wetland Conservation http://www.aswm.org/wetlandsonestop/nwiplus_web_mapper_nwn_2013.pdf
- Wetlands One-Stop Mapping: Providing Easy Online Access to Geospatial Data on Wetlands and Soils and Related Information http://www.aswm.org/wetlandsonestop/wetlands_one_stop_mapping_in_wetland_science_and_practice.pdf
- Wetlands of Pennsylvania's Lake Erie Watershed: Status, Characterization, Landscape-level Functional Assessment, and Potential Wetland Restoration Sites http://www.aswm.org/wetlandsonestop/lake_erie_watershed_report_0514.pdf

U.S. FOREST SERVICE

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

U.S. GEOLOGICAL SURVEY, NATIONAL WETLANDS RESEARCH CENTER

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

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

- Link to information on hydric soils:http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/use/hydric/

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

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 http://link.springer.com/journal/11273

NEWSLETTERS

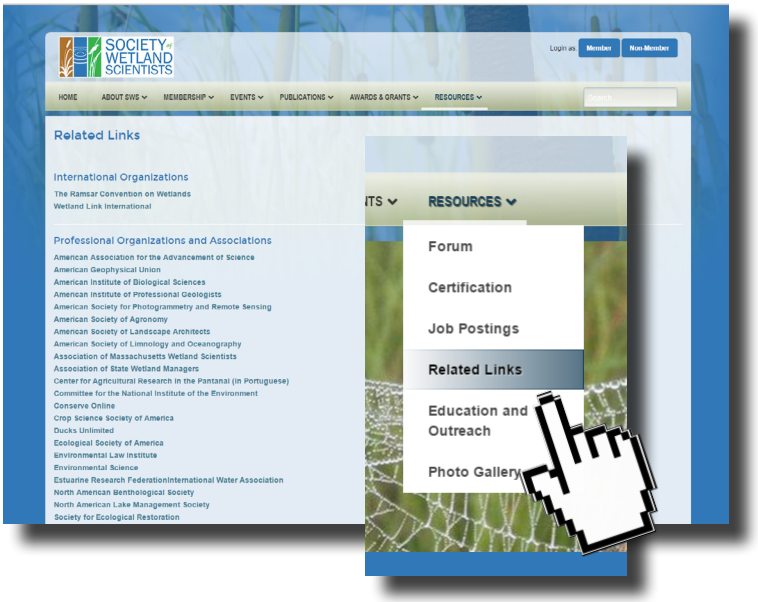
- Biological Conservation Newsletter (this monthly newsletter contains a listing of articles that include many that address wetland issues – current and others back to 1991 in the "Archives") http://botany.si.edu/pubs/bcn/issue/latest.htm#biblio
- Wetland Breaking News (Association of State Wetland Managers) http://aswm.org/news/wetland-breaking-news
- National Wetlands Newsletter (Environmental Law Institute) http://www.wetlandsnewsletter.org/welcome/index.cfm

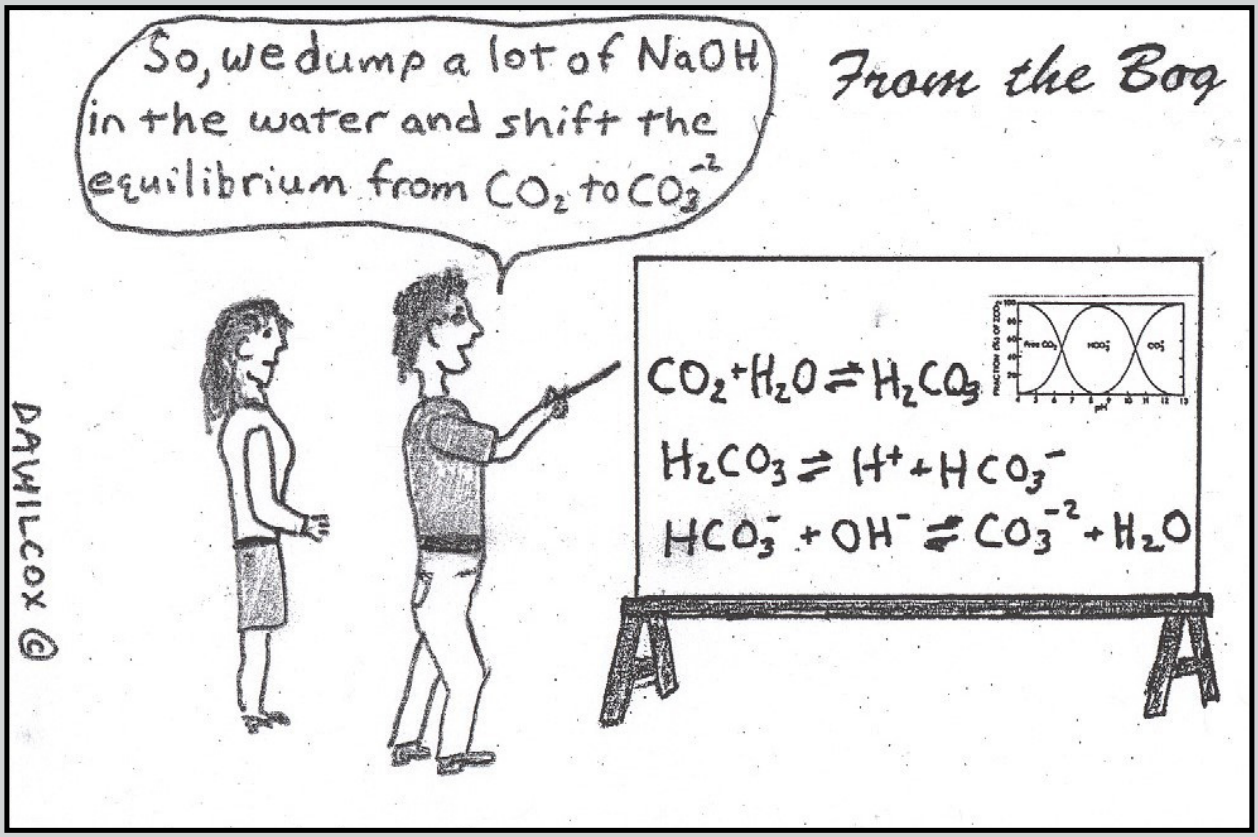
WEB TIP

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.





A "basic" approach for handling climate change

wetland science & practice

The WSP is the formal voice of the Society of Wetland Scientists. It is a quarterly publication focusing on the news of the SWS, at international, national and chapter levels, as well as important and relevant announcements for members. In addition, manuscripts are published on topics that are descriptive in nature, that focus on particular case studies, or analyze policies. All manuscripts should follow guidelines for authors as listed for Wetlands as closely as possible. All papers published in WSP will be reviewed by the editor for suitability. 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.