wetland science & practice
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FROM THE EDITOR'S DESK

Greetings to all. Boy, after dealing with all the snow here in late January and February, I am really looking forward to seeing the ground again! As I write this we are due for 8-16 inches of snow followed by bitter cold – the Alberta Clipper. For those of you in the Northern Hemisphere, I hope you got through the winter without any major issues at home and are beginning to see signs of spring – the rebirth of life, if you will. And for those in the Southern Hemisphere I would hope that you have enjoyed the benefits of summer and are readying for winter. During the winter I've been wrapping up a few writing projects both at work and at home. The ones at work are especially pressing as I'm preparing for retirement in the next couple of months.

Ralph Tiner
WSP Editor

In this issue, you'll find news from the Pacific Northwest Chapter and about access to past issues of WSP along with articles on an evaluation of a 12-year old wetland created with the use of dredged material, a study of salt tolerance of *Phragmites* in Massachusetts, two methods for vegetation analysis (Prevalence Index vs. Hydrophytic Cover Index), and a new approach to wetland assessment – "*Wetland Ecogenomics*." The latter will be the subject for a special session at the annual meeting in Providence. You'll also find a tribute to Dr. James Gosselink who passed away in January. Dr. Gosselink gave us our first insight into determining the economic value of wetlands – "The Value of the Tidal Marsh" (co-authored with E. P. Odum and R. M. Pope in 1974) as well as many other contributions including reports on coastal wetlands and bottomland hardwoods and "Wetlands" (co-authored with W.J. Mitsch). You will not see "*Notes from the Field*" in this issue since no one has reported any observations and all I see besides snow are twigs, buds, dried leaves and stems, and evergreens. I'm sure we'll have some reports as vegetation begins to green-up this spring, so feel free to send me observations from your locale.

It's been a year since I've been the editor of WSP. With the new design and e-presentation, we've been able to generate more interest in contributions, but I feel that we still have a long way to go. For example, I'd like to have each Chapter submit an update of Chapter activities at least once a year to alert others on what's going on in your region and if you have any new published information available on your websites that may have broad appeal. I thank all who have submitted articles and other information to help move this publication forward during the past year and look forward to receiving more. With our annual meeting on the horizon and folks preparing posters and presentations, with a little more effort you can prepare an article for WSP and gain more widespread awareness of your project. Feel free to see me at the annual meeting if you'd like to discuss your work and publishing through WSP.

Meanwhile, looking forward to seeing you in Providence! ■

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Cover photo:
Wood storks on mangrove island rookery
Peace River, Florida
Photo by Ralph Tiner

www.sws.org

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

PRESIDENT'S MESSAGE

Greetings and I hope your winter has been productive. So, half a year has already gone by. As you can imagine, it has been a busy 6 months-for us so far. Below are a few things that we are working on, or have accomplished to date.

James E. Perry, PhD, PWS
SWS President

2015 SWS Annual Meeting: Our 2015 meeting in Providence is in great shape. With a theme of Global Climate Change we have 27 symposia set up and look forward to the many individual presentations. The 2016 meeting is set for June in Corpus Christi, Texas. Unfortunately, no SWS Chapter came forward with a proposal for the 2017 meeting. Therefore, following the Standing Rules, the EB asked the Future Meeting Committee and AMPED staff to find an appropriate venue. This has brought us to Puerto Rico, where we are looking at holding out 2017 annual meeting. Please let us know if you have any thoughts on holding a meeting in a US Protectorate.

SWS Asian Chapter Meeting: In October 2015, Kim Ponzio (President-Elect), SWS member John Bourgeois, and I, at the invitation of the Asian Chapter, attended the SWS Asian Chapter meeting in Taipei, Taiwan. We reviewed numerous restoration projects throughout Taiwan as well as met with Asian wetland scientists and students (we signed up six new student SWS members). At the end of the trip we prepared a set of recommendations to help Taiwan with their restoration efforts. These recommendations are to be published in the June issue of WSP. We also discussed the possibility of holding a Regional SWS meeting in Taiwan in 2016 in which SWS may consider providing funds to help bring in SWS Asian member from as far away as Mongolia.

Furthermore, I stayed on in Taiwan for another month and presented our recommendations to four public meetings with government officials, local stakeholders (NGO's, aquaculturist, fishers) and one international wetlands ecotourism workshop. I also spent my time working with faculty members and students at the National University of Chen Kung University to set up several wetland hydrologic and ecological research projects on restored inland and coastal ecosystems.

Education and Outreach Committee: E&O has been asked to undertake several new tasks. First we have asked them to establish (with help of EB) an ad-hoc committee to design the format for the set-up of on-line production/presentation of speakers who would be of interests to our members. Second, they will be tasked with setting up a sub-committee to determine the appropriate talks/presentations to provide access to (e.g. Keynote and Plenary Speakers).

Finally, we have proposed a new initiative: we have asked them to look at a mechanism to fund an SWS booth at local and regional wetland meetings. This would provide funding to ship our exhibit to local

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wetland science & practice

Pre-Meeting Field Trips Promise Exploration, Deep Learning

SWS is pleased to present an amazing array of field trip options as part of the SWS 2015 Annual Meeting in Providence. Make plans to arrive early as all field trips take place the Sunday before Annual Meeting festivities get underway.

Get full descriptions of each trip at www.swsannualmeeting.org. All field trips will conclude plenty of time for you to join us for the Welcome Reception on Sunday evening. Additional registration fees are required.

Dig deeper into your research interests by participating in one of these fascinating trips.

- Barn Island Wildlife Management Area
- Block Island
- Rhode Island National Wildlife Refuges
- South-Coastal Rhode Island
- Charleston, RI Barrier Island and Salt Marsh Kayak Trip
- Pawcatuck River
- Pawtuxet River Dam Removal and Oxbows Floodplain Restoration Project
- Plymouth: Town Brook, Eel River Headwaters Preserve and Tidmarsh Farms
- Waquoit Bay National Estuarine Research Reserve ■

Take Time for Networking and Social Events

We've scheduled plenty of fun time during the Annual Meeting, so you can connect with colleagues and learn from your peers in casual and entertaining settings. The Welcome Reception on Sunday night is a great way to kick things off. The Awards Lunch on Monday is a must for recognizing fellow and future scientists. A special mixer is also planned for college students on Tuesday. Back again this year is the poster session and silent auction on Wednesday evening — the fun is in the bidding! Finally, we'll end on a spectacular note with the closing reception Thursday night. ■

Past Issues of *Wetland Science & Practice* to Go Public

On February 6, the Society's Board of Directors voted to allow free public distribution of past issues of WSP. This means that all issues published prior to the June 2014 issue will soon be available via the internet. More recent issues will also 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. ■

Sponsorship Opportunities

Annual Meeting 2015
SOCIETY OF WETLAND SCIENTISTS

Changing climate. Changing wetlands. Providence, Rhode Island, May 31 - June 4

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 2015 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 meeting registration and in the program book.

BRONZE LEVEL — $1,000

- **DAILY PLENARY SPEAKER.** The SWS 2015 Annual Meeting will feature four highly renowned plenary speakers who will present the latest wetland research. Four opportunities available.
- **DAILY MORNING & AFTERNOON REFRESHMENTS.** Attendees will enjoy light snacks and beverages during daily morning and afternoon refreshments.

SILVER LEVEL — $2,500

- **PROGRAM BOOK AD.** Meeting attendees will receive a program book at registration which will include all sessions, special events and meeting highlights. The sponsor may include an advertisement on the back cover of the program.
- **STUDENT MIXER.** This special reception will provide students the opportunity to exchange ideas and network with expert wetland professionals. All attendees welcome. Students will be given the opportunity to network and exchange ideas during this mixer.
- **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 2015 poster session will showcase the latest wetland research and will provide an opportunity for all meeting attendees to network. The New England Chapter will also be holding a special silent auction to help fund Chapter activities.

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 — $10,000

- **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 2015 Annual Meeting will kick off with a special Welcome Reception.

BENEFITS OF SPONSORSHIP	$500	$1,000	$2,500	$5,000	$10,000
Logo + hyperlink featured on meeting website	★	★	★	★	★
Logo featured on onsite sponsor signage	★	★	★	★	★
Logo featured in program book	★	★	★	★	★
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 Brittany Marsala Olson, bolson@sws.org, 608-310-7855.

SWS Pacific Northwest Chapter Announces Washington State Wetland Program Plan, New Executive Board, and 2015 Chapter Meeting

Nate Hough-Snee, SWS-PNW President

Early winter, commonly thought of as a dormant season, has been extremely productive for wetland scientists of all varieties in the Pacific Northwest. The biggest news within the SWS Pacific Northwest Chapter's focal region of Washington, Oregon, and Idaho, was a public comment period for Washington State's Wetland Program Plan. The new plan spans a six-year period, and sets priorities for the future of wetland management across the state. While the public comment period passed between issues of *WSP*, the Washington State Department of Ecology will be finalizing the plan by late March 2015. More information on the Washington State Wetland Program Plan can be found at: http://www.ecy.wa.gov/programs/sea/wetlands/ProgramPlan.html

Additionally, this serves to remind SWS-PNW members that Oregon's wetland program plan, approved by EPA in 2012, can be found at: http://www.oregon.gov/DSL/WETLAND/Pages/wetland_plan_approved_2012.aspx

The full list of approved state and tribal wetland program plans are available through the EPA: http://water.epa.gov/type/wetlands/wpp.cfm

In addition to ongoing wetland business in the Chapter's focal region, the Chapter itself has been extremely busy. Following elections, a new executive board was sworn in last fall. Maki Denzell (HDR Engineering) and Katrina Poppe (Northwest Ecological Services LLC) were elected co-secretaries general and will be promoting chapter events and news to our membership. Longtime SWS-PNW treasurer and SWS-PNW lifetime achievement award winner, Yvonne Vallette (EPA Region 10), is working with treasurer-elect, Karla Van Leaven (Aqua-Terr Systems Inc.) to keep our books in order and charitable giving (scholarships, grants, etc.) up and running. Dr. Lizbeth Seebacher (Washington State Department of Ecology) will be serving as the Chapter's program vice president and is chairing the 2015 Chapter meeting committee (see below for more meeting news!). Tom Kohl (Washington State Department of Transportation) has been elected Chapter executive vice president, and will be taking an active role in numerous SWS-PNW programs. Lastly, I have been dealt a pair of large shoes to fill, as Colin Maclaren (Interfluve) moves

from Chapter president into the immediate past president role as I assume the duties of president. I wish a hearty welcome to the new board, a new year, and big things for SWS-PNW!

Since being elected, the board and numerous volunteers have been busy preparing for the Chapter's biannual meeting. "*From a Watershed Perspective: Integrating Science into Policy*" will take place October 6-8, 2015 at the Red Lion Hotel and Conference Center in sunny, Olympia, Washington. A call for organized symposia and panel discussions and a call for contributed abstracts will circulate in late January 2015. In addition, the Chapter will sponsor numerous student scholarships for undergraduate and graduate students attending school or working in the Pacific Northwest. Information on the 2015 SWS-PNW meeting will be updated regularly on the Pacific Northwest Chapter's website, the Chapter's newsletter, Ooze News, and through updates in upcoming issues of *WSP*. We also encourage SWS members to use the hashtag #SWSPNW on Twitter as we promote conference events via social media.

Lastly, our chapter thanks SWS-PNW chapter member Tracie Nadeau of the USEPA Region 10 for working with Andy Herb (SWS - Rocky Mountain), Matt Schweisberg (SWS – New England), Jane Rowan (SWS – Mid-Atlantic), to coordinate the SWS Restoration Section's annual symposium for the 2015 annual meeting in Providence Rhode Island. This year's symposium will be broken into three thematic sessions focused on the restoration of inland wetlands, coastal wetlands and riparian ecosystems. The last two SWS-Restoration Section symposia were absolutely packed and received great feedback from speakers and attendees. Thanks to Tracie, Andy, Matt, and Jane for continuing this tradition of excellence in 2015!

Although it's early so far, 2015 is shaping up to be a fantastic year for the Society and the Pacific Northwest Chapter. If you have any questions or comments, or a desire to get more involved in PNW-Chapter happenings, please have a look at our website and don't hesitate to drop me a line via email or on Twitter @NHoughSnee. ■

2015 SWS Election of Officers

President-Elect and Treasurer Candidate Profiles

Dear SWS Member,

Our organization continues to grow and remains vibrant thanks to you, our members, and the dedicated leadership of our Board of Directors, committee members, volunteers and staff. It is important to continue this leadership through the election of two individuals to serve as President-Elect and Treasurer of SWS. The President-Elect serves a one-year term, followed by a one-year term as President, and then a final year as Past-President. The Treasurer will serve a three year term. The elected officials will be introduced and take office during the 2015 SWS Annual Meeting in Providence, Rhode Island, USA.

Please take a moment to read the profiles and vote for one of the following two candidates for President-Elect:

• Gillian Davies, PWS, BSC Group, Inc., Worcester, Massachusetts, USA

• Leandra Cleveland, PWS, HDR Engineering, Inc., Portland, Oregon, USA

Please also review the profile and vote for the candidate for Treasurer (note that the candidate is running for re-election and is unopposed):

• Julia Cherry, PhD, University of Alabama, Tuscaloosa, Alabama, USA

All individual members are entitled to one vote, which may be submitted with a paper ballot or using the electronic ballot circulated via email. All ballots must be received by 8pm EDT on Friday, April 17, 2015.

Thank you for your participation in choosing the leaders of your professional society – SWS.

Sincerely,

Stephen Faulkner, PhD
SWS Past-President & Nominations Committee Chair

*The statements on the following pages were provided by the candidates for this office and are listed solely in alphabetical order by last name.

Candidate for Treasurer

Julia A. Cherry, PhD
Associate Professor, University of Alabama

WETLANDS BACKGROUND AND EXPERIENCE:

I received my B.S. in Biology from Rhodes College in Memphis, TN in 1999 and my Ph.D. in Biological Sciences at the University of Alabama in 2005. After completing a post-doctoral appointment at the USGS National Wetlands Research Center (NWRC) in Lafayette, LA, I returned to the University of Alabama in 2006 as an Assistant Professor in the Departments of Biological Sciences and New College. I have since been promoted to the rank of Associate Professor. Currently, my research is aimed at understanding the effects of climate change and other environmental impacts on wetlands of the Southeastern United States.

WHY DO YOU WISH TO SERVE ON THE SWS BOARD OF DIRECTORS?

Over the past 10 years, I have served the Society in various capacities, including leadership roles at the Chapter and Section levels, and most recently, as Treasurer. Based on these prior experiences and the knowledge I've gained as Treasurer over the past 3 years, I am prepared to, and very much interested in, continuing as Treasurer on the Executive Board.

WHAT WILL YOU CONTRIBUTE TO THE BOARD?

As Treasurer, I have gained a great deal of insight into the Society's operations and finances and have cultivated good working relationships with staff and various SWS members, which should help me continue to serve the Society well.

WHAT DO YOU ENVISION FOR SWS' FUTURE?

I will continue to work with the Board and AMPED to set the annual budget and provide general financial oversight, and to serve as co-Chair of the Ways and Means Committee, which is pursuing various initiatives related to the Society's investment strategy. In addition, I will continue to develop relationships with Chapter, Section, and Committee representatives to promote the mission of the Society. In particular, I would like to improve the mechanisms by which Chapters and Sections generate and access their funds, and help smaller Chapters increase their membership and generate funds for new education and outreach initiatives. I believe that working toward these goals will strengthen the Society's finances and further its mission.

Candidate for President-Elect

Leandra Cleveland, PWS
Professional Associate, Environmental Scientist, HDR Engineering, Inc.

WETLANDS BACKGROUND AND EXPERIENCE:

I have a BS in Environmental Science and Regional Planning from Washington State University. I currently work at HDR Engineering, Inc. My involvement in SWS began with the Pacific Northwest Chapter where I have been a key member in planning the chapter conference since 2007. I have also served as Executive Vice President (2007-2009), President (2010-2013), and am finishing my term as Immediate Past President (2014-2015) for the Pacific Northwest chapter. In 2011 I joined the SWS Diversity Program Committee and have continued to be an active member of this committee. Since 2010, I have had the unique opportunity to be a minority, undergraduate student mentor as part of this program. In 2011 I became involved in the SWS Professional Certification Program (PCP) as a member of the Outreach Committee. Currently I serve as a member of the Certification Review Panel (2014-2015) and Ethics Committee (2014-2015). I have also served as the President Elect, President, and Immediate Past President of SWS PCP (2012-2015).

WHY DO YOU WISH TO SERVE ON THE SWS BOARD OF DIRECTORS?

Serving on the SWS Board of Directors is an opportunity to further strengthen the relationship between the membership and the Board. My experience on the SWS PCP board as well as serving on the SWS Board of Directors is an opportunity to further strengthen the relationship between the membership and the Board. My experience on the SWS PCP board as well as the Pacific Northwest Chapter board and numerous committees, gives me an understanding of the challenges and opportunities of leading an organization. An important aspect of leading an organization is bringing a variety of people together. It takes listening to the ideas of many and taking the positive aspects of those ideas to make a strong and implementable idea and turn it into action. SWS has many committees all working to advance SWS's mission and goals. To have a truly robust organization, each committee needs to have a clear mission with achievable goals that are put into action. I also want to capitalize on the connections with other similar organizations to expand our membership and look for opportunities to partner to further our mission and bring differing experiences and opportunities to our membership. Overall, serving on the Board of Directors would be an opportunity to continue the positive work and momentum of those who have served and continue to make SWS a great organization.

WHAT WILL YOU CONTRIBUTE TO THE BOARD?

Serving in a leadership position for the Pacific Northwest Chapter and also with SWS PCP has given me experience and insight into what it takes to lead an organization. The success of my chapter as well as SWS PCP comes from the dedication of the membership and their willingness to actively participate in the various committees to support and coordinate with the executive board. In my role as the President of SWS PCP and my chapter I have lead these organizations and will use that experience with the SWS executive board. I understand the importance of being organized and communicating effectively as well as managing my time. Having served on several committees, I understand that they are critical to the success of an organization including SWS. In my time with my own chapter as well as SWS PCP I have been able to interact with other organizations and look for partnerships which I will continue to do as a member of the Board of Directors. I also understand the value of turning complaints into opportunities and building on a series of ideas to create a new action to continue to grow and provide value for our membership.

WHAT DO YOU ENVISION FOR SWS' FUTURE?

I would work with the Board of Directors to continue to build the organization. I understand the important of committees and that they are critical to the success of an organization. They are the place where ideas are generated and create a well rounded organization that attracts a strong membership. I would continue to improve the committees to provide the greatest value for the Board of Directors and the membership. SWS has strong connections with other organizations, and I would work to enhance those partnerships to build diversity within SWS. SWS is also critical in educating people on the technical aspects of wetland science. I want to work with the Board of Directors to continue to improve and creatively identify other ways to provide education. There is also a need to bridge the gap between academia, policy development, and implementation. With policy lagging far behind science, it is imperative that SWS lead that charge. The diversity of our membership allows SWS a unique advantage in bridging that gap through dialogue and creative action.

Candidate for President-Elect

Gillian Townsend Davies, PWS
Senior Wetland Scientist, BSC Group, Inc.

WETLANDS BACKGROUND AND EXPERIENCE:

I hold a Master of Environmental Studies (concentration in ecosystem ecology) from Yale School of Forestry & Environmental Studies, and a Bachelor's degree (cum laude) from Williams College. I received certification as a Soil Scientist through the New England Regional Soil Science Certificate Program at UMass Amherst. Through the SWS-PCP program, I am a PWS. Additionally, I am a Certified Erosion, Sedimentation & Storm Water Inspector. Currently, I am serving as SWS New England Chapter President and Chair of 2015 Providence Annual Meeting Program Committee, and previously served as Vice President of New England Chapter. In the past, I served as President, Vice President, and Past President of the Assoc. of MA Wetland Scientists. While on the AMWS Board, I was a leader in the planning of two AMWS Annual Meetings. I have been employed as a Senior Wetland Scientist at BSC Group, Inc. since 2003. Prior to working at BSC, I was a Circuit Rider (education & outreach) at the MA DEP Division of Wetlands & Waterways, Northeast Region (1999-2003). I had my own wetlands consulting company from 1996-1999, and began my career as a Wetland Ecologist for Jason Cortell & Assoc. from 1991-1996.

WHY DO YOU WISH TO SERVE ON THE SWS BOARD OF DIRECTORS?

I enjoy opportunities to make contributions to the wetlands community, to society at large, and to be involved in education (broadly defined). I believe that SWS is uniquely positioned to facilitate communication across the research-to-practice spectrum (wetland academics, policy makers, practitioners & students). If we are to meet the challenges of the 21st century, collaboration between these wetland professional sectors is needed more than ever before, as is collaboration with other scientific organizations/disciplines. SWS is a bridge for these sorts of connections, and I have greatly enjoyed being a bridge builder while chairing the 2015 Providence Annual Meeting Program Committee. I would look forward to continuing to work with all of the interesting wetland scientists whom I have gotten to know while serving on the SWS Board. I have particularly enjoyed the chance to collaborate and get to know academics, since I work in the practitioner/policymaker world.

WHAT WILL YOU CONTRIBUTE TO THE BOARD?

I would contribute a similar level of time, energy and enthusiasm as I currently devote to planning the 2015 Annual Meeting and leading the NE Chapter! My cumulative volunteer experience, work experience, education, collaborative and goal-focused approach, and strong communication skills will allow me to work well with a range of people to further the SWS mission. I will bring creativity and personal commitment to expanding understanding of wetlands in the context of a changing climate and other stressors. The 2015 Providence meeting could be a springboard for follow-on climate change and wetlands activities such as: state of the science paper(s), forming a working group, continued networking with other science organizations, and development of webinars. My lifelong interest in education and facilitating communication across disciplines/groups coincides with the SWS mission, as does 24 years of wetlands work experience. My experience leading the planning of the 2015 Providence Annual Meeting and experience planning AMWS annual meetings will be valuable, as Pres-Elect duties include assisting with future annual meeting planning. In striving to fulfill the SWS mandate to promote human diversity, I would draw upon my life experience of living and working in a broad diversity of communities, including spending a year and a half living, working (as a teacher in a refugee camp in Thailand) and traveling in Asia.

WHAT DO YOU ENVISION FOR SWS' FUTURE?

I envision SWS building on existing strengths as the leading international wetlands organization, in terms of mission, structure, and a growing membership. In addition to maintaining and strengthening existing SWS programs, SWS is well positioned to develop new initiatives and continue to inform the larger community not only through Wetlands and WSP, but also by continuing to develop state of the science papers, publish books on issues of the day and develop webinars. As we face multiple challenges of the 21st century, collaboration with other scientific societies/entities/disciplines becomes more important, as does strengthening relationships and communication between different SWS membership sectors (academic, policymaker, practitioner, student) and further developing student & practitioner participation. Strengthening relationships between chapters could be a means of increasing the visibility and vibrancy of the various chapters, and could help distinguish them from state wetlands organizations. Strengthening international chapters and increased participation by students from diverse backgrounds will facilitate growth of human diversity within SWS, and thus will improve the ability of our Society to respond to the global challenges of the 21st century.

ELECTION BALLOT

All individual members are entitled to one vote, which may be submitted with this paper ballot or using the electronic ballot circulated via email. If you prefer to submit a paper ballot, please complete and return the following form to the address below. You may print mail, fax or email the ballot as an attachment by Friday, April 17, 2015. Post mail must also be postmarked by Friday, April 17, 2015.

Society of Wetland Scientists
22 North Carroll Street, Suite 300
Madison, Wisconsin 53703
USA

608.521.5941 Fax
mczosek@sws.org

DUTIES OF THE PRESIDENT-ELECT:

The President-Elect shall assume duties and responsibilities of the President at the conclusion of the President's term or if the office is vacated. In the absence of the President or in the event of inability or refusal to act, the President-Elect shall perform the duties of the President, and when so acting shall have all the powers of and be subject to all the restrictions of the Presidency. The term of office of the President-Elect shall be one year or until the next annual meeting and then the President-Elect shall automatically become President for the year following his or her term as President-Elect. If the President-Elect assumes the duties of President prior to the normal end of term, he or she shall complete the President's remaining term and then complete his or her term as President or which he or she had been previously elected. If the President-Elect is unable to fulfill the term of office of the President, the immediate Past-President shall assume the interim Presidency until an election can be held. The primary duties of the President-Elect shall be to assist the President in the execution of duties, and any other duties delegated by the Bylaws of the Society or designated by Board of Directors from time to time.

Please vote for one of the following President-Elect candidates:

_____ Leandra Cleveland, PWS

_____Gillian Davies, PWS

DUTIES OF THE TREASURER:

The term of office of the Treasurer shall be three years. The terms of office for the Secretary-General and Treasurer shall be staggered so that their election does not normally coincide during the same year. The Treasurer is to administer the financial resources of the Society and serve as signatory on all Society financial accounts, including those established by a Chapter or Section. Treasurer shall work with staff to draft an annual budget for Board approval. Treasurer shall receive monthly financial reports from staff and provide reports to the Board of Directors. The Treasurer shall serve as a member of the Ways and Means Committee. In the event the Treasurer is not able to perform his or her duties, as defined by the President or Board of Directors, the position will be filled by appointment of the President with ratification at the next meeting of the Board of Directors.

Please vote for the following Treasurer candidate. Please note that the candidate is running for re-election unopposed.

_____ Julia Cherry, PhD

PLEASE PROVIDE THE FOLLOWING INFORMATION:

Name: _____

SWS Member ID: _____

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and regional meetings which are attended by one or more of our SWS members (SWS Ambassadors).

Leadership Manual: Steve Faulkner, our past president, and Michelle Czosek, our AMPED staff representative, have worked diligently to complete the revamping of our Standing Rules and Leadership Manual including the Policies and Procedures. This has been an ongoing process that has taken them several years: I'd like to thank them for their continuous diligence and hard work.

EPA comments: An ad-hoc committee comprised of Drs. Joy Zedler, Daniel Larkin, and Carter Johnson completed a review of the proposed rule change to "define the scope of waters protected under the clean water act…." (33CFR Part 328). The proposed changes are deemed necessary in order to provide for consistency and predictability in enforcement of the Clean Water Act (CWA) and increase the "…clarity to scope of "waters of the United States" (33CFR Part 328 pg 22188). In June 2014, I asked the ad-hoc committee to prepare a position paper for SWS. Their report was published in the Summer edition of WSP, was approved by the SWS Board of Directors at our Nov. 5th conference call, and submitted electronically to the EPA in Nov. 2014.

2015 nominations: Steve Faulkner has put together a slate of candidates for our President-Elect position for this year. Julia Cherry has agreed to run again for Treasurer. Please review the election information in this issue and cast your vote.

Strategic Plan: I appointed an ad-hoc committee chaired by Dr. Jan Keough. She reports that the committee, comprised of her, Dr. Frank Day, Christina VanZomeren, Jason Smith, and Michelle Czosek (AMPED staff) has held several conference calls so far. They have devised a survey to be sent to the SWS Leadership (Exec Board, Chapter and Section Chairs, Committee Chairs, Editors, and special representatives). Michelle is helping to identify the various categories of leadership for the survey. Following that effort, the committee will review the survey responses, conduct their own review, and provide us with a review of the old plan and a recommendation for the 2015-20 plan well in advance of the June SWS Conference. They expect also to provide the SWS leadership team with a summary of the survey results. Work will be required from the SWS staff to help them make this process go forward.

Following the board meeting and BOD feedback, the committee will finalize the survey form and distribute it. Their plan is to give the SWS leaders 2 weeks to address the on-line (surveymonkey) questionnaire. Note that it is important that all leaders try to fill out the survey questionnaire. They plan on completing their task by early spring.

Contracts:
AMPED – The new contract has been completed and signed. The contract covers the period of January 1, 2015 through December 31, 2017. AMPED staff met with Kim Ponzio and me to go over 2015 action items. Progress toward these goals will be tracked throughout the year.
Springer – We now have a new five year contract with our publisher, Springer. A big thanks needs to go to Steve Faulkner and Michelle Czosek for their insistence on a favorable contract – many emails flew back and forth across the Atlantic until we had a final version.

State of the Art Papers (SOTA): We have two ad-hoc committees preparing SOTA papers for SWS-WSP Bulletin. The first is on the use of the Floristic Quality Index (FQI) in restoration monitoring: I have received a first draft and will be providing comments. With review by the BOD and approval of the EB, we hope to have it ready for a future edition of WSP. The second is on the Impacts of Fracking on Wetlands. We plan on having this one ready for the summer edition of WSP. It is important to note that neither of these are OPINION papers, rather they meant to present the SOTA and present both positive and negative impact. I've found these SOTA papers are a great way to get new PhD's not only involved with SWS, but it allows them to reach out and communicate with professionals in their communities.

There are many possibilities for future subjects, such as Everglades Restoration, comparison of new Wetland Hydrology Models, different types of methods for wetland monitoring or design, etc. The potential for these SOTA's to provide valuable information to SWS members is high. Therefore I strongly suggest that we identify new SOTA's in the future and continue to publish them in WSP.

Believe me, none of these ideas or processes would have been possible without the major efforts of our Board of Directors, various Committees, our extremely efficient AMPED staff, and, of course, without the input by many of our society members. I send my thanks to all of them. See you in Providence in June! ■

In Memorium - Dr. James Gordon Gosselink

Dr. James G. Gosselink, emeritus professor of Louisiana State University's Coastal Ecology Institute, passed away on January 18, 2015. He was an inspiration to many students and colleagues for more than 40 years and is a name recognized by most, if not all, wetland scientists. He authored and co-authored more than 100 scientific contributions on wetland ecology, and he has collaborated with virtually every federal agency responsible for managing wetlands in North America. Most recently, he has worked to improve the scientific basis for understanding and managing bottomland hardwood wetlands and to protect them from losses due to the cumulative impacts of many small individual decisions. He co-authored one of the most widely read textbooks on wetland ecology and management- *Wetlands* (Mitsch and Gosselink), with the fifth edition now in press. In 1998, he received the Lifetime Achievement Award from the Society of Wetland Scientists in recognition of his distinguished career (only 10 scientists have been so honored). In 2001, Jim received the National Wetlands Award for Science Research from the Environmental Law Institute. The following is a tribute from Dr. Bill Mitsch, Eminent Scholar and Director, Everglades Wetland Research Park, Florida Gulf Coast University:

How do you celebrate a genius, a gentleman, and a friend? Jim Gosselink was one of the nicest men I have had the opportunity to work with in the academy. It may have been some sort of divine intervention that occurred when I saw him across the room at the 1982 AIBS/ESA meeting at Penn State University and immediately invited him to be coauthor for a book contract I had from Van Nostrand Reinhold for what would become Wetlands. He immediately accepted the invitation and it was the beginning of a great collaboration and friendship over more than 25 years. Jim brought in plant physiology, salt marsh ecology, and a wealth of experience in cumulative impact (e.g., Gosselink et al., 1990), wetland valuation, and other wetland management issues to the book. He was too ill to help with Wetlands 5th edition, which ironically is coming out in less than a month, but I wrote in the preface that his "spirit and incredible knowledge of wetlands are embedded in this book from his contributions to the previous editions, so there was no question that his name should remain on the front of this book."

Not many people know that Jim spent a year in the early 1970s (before I knew him) at the University of Georgia, where he collaborated with Gene Odum and eventually published, at the Center for Wetland Resources at LSU in 1974 a little report called "The Value of the Tidal Marsh" (Gosselink et al., 1974). They dared to put economic values on wetlands! This is stuff that a lot of ecologists did not discovered until 20 years later with Bob Costanza's much cited ecosystem value paper in Nature or even 30 years later in the Millenium Ecosystem Assessment "ecosystem services" blitz.

Not many people know that Jim Gosselink was a member of the National Wetlands Policy Forum that wrote "Protecting America's Wetlands: An Action Agenda" (NWPF, 1988), the document that introduced "no net loss" to our wetland management vocabulary. There were only two academics on that NWPF that included three governors, a state legislator, state and local agency heads, CEOs of businesses and environmental groups, farmers, and ranchers and Jim was one of them. Knowing his ability to bring consensus, I suspect to this day that if Jim had not been there, we would not have that policy in our Federal government today.

That was his style, making significant contributions to wetland science and management and university research and teaching, including a long tenure as a department chair of Oceanography at LSU, but doing it quietly and effectively.

We met several times to work on the book, several times in Baton Rouge at the department and at his and Jean's lovely home, and at least once in Columbus in 1999, when he had just retired from LSU and moved to Tennessee. I finally was able to show him the experimental wetlands we had created at Ohio State University and that were mentioned for the first time in our Wetlands, 3rd edition (Mitsch and Gosselink, 2000). As I recall we had a great time maneuvering on those 16-inch-wide boardwalks, which may explain the big smile you see on Jim Gosselink in the attached photo. Those were always happy times when meeting with Jim.

There is a message here to all the readers of this celebration of Jim's life to stay in close contact with your friends because you never know what the future will bring. Jim and Jean Gosselink sent us a Christmas card in December 2009. I recall there was a nice photo of them at the Tennessee mountain retreat. I send him a quick email in January 2010, asking him if he received the email so we could reestablish connections. His response was "Hi Bill, Your email came through fine. I'll try to get back to you about a couple of things, but can't do it right now. Hope all is well with the family. Best, Jim." A few months later he had a stroke and we were never able to communicate directly long distance again.

His family has established a scholarship fund at Louisiana State University to honor Jim's commitment to wetland science, especially his concern over losses of bottomland hardwoods and other wetlands. In lieu of flowers, donations in his memory can be made to the Gosselink Scholarship fund at www.lsufoundation.org/gosselink . ■

References

Gosselink, J. G., E. P. Odum, and R. M. Pope. 1974. The Value of the Tidal Marsh. Publication LSU-SG-74–03, Center for Wetland Resources, Louisiana State University, Baton Rouge. 30 pp.

Gosselink, J. G., L. C. Lee, and T. A. Muir, eds. 1990. Ecological Processes and Cumulative Impacts: Illustrated by Bottomland Hardwood Wetland Ecosystems. Lewis Publishers, Chelsea, MI. 708 pp.

Mitsch, W.J. and J.G. Gosselink. 2000. Wetlands, 3rd ed. John Wiley & Sons, New York. 920 pp.

National Wetlands Policy Forum. 1988. Protecting America's Wetlands: An Action Agenda, Conservation Foundation, Washington, DC. 69 pp.

Ecological Survey of a Dredged Material-supported Wetland in the Atchafalaya River, Louisiana: An Engineering with Nature Case Study

Jacob F. Berkowitz[1], Nathan R. Beane[1], Darrell E. Evans[1], Burton Suedel[1], and Jeffrey M. Corbino[2]*

The geographical extent of wetlands continues to decrease at national and regional scales, including major wetland losses across southern Louisiana (Barras et al. 2003; USACE 2004). Wetland distribution and functional losses in coastal Louisiana have been linked to a lack of sediment inputs among other causes (Day et al. 2007). These losses have been accompanied by a decrease in wetland functions.

The U.S. Army Corps of Engineers (USACE) conducts dredging activities to maintain navigation channels in the lower Atchafalaya River (Figure 1). These dredging activities remove sediment from navigation channels, which is then available for the creation and/or expansion of wetlands (Boustany 2010). During the 1990s, placement of shoal material dredged from the Horseshoe Bend section of the river occurred at eight wetland development sites located along the river's banklines (Berkowitz et al. 2014). Capacity of these placement sites was nearly exhausted by 1999. Thus, to meet the anticipated disposal requirements for future channel maintenance, in 2002 USACE began mounding dredged material in an open water placement site upriver of a small naturally forming shoal. Open channel displacement reduces transport costs associated with moving sediment to traditional disposal areas or open ocean disposal. The strategic placement of sediments upstream of the natural shoal area created a 35-ha wetland island (Figure 2). As a result, this project adheres to USACE Engineering With Nature (EWN) principles by utilizing natural processes in support of navigation and environmental goals (Bridges et al., 2014; Gerhardt-Smith and Banks 2014; http://el.erdc.usace.army.mil/ewn/). In 2014, USACE constructed a new navigation channel route on the east side of the island. The new route is anticipated to increase flow velocities in the navigation channel, encouraging the channel to "self maintain" and reducing dredging maintenance requirements. Any required future activities will adhere to EWN principles by mounding dredged material upriver of the island or in the former navigation channel.

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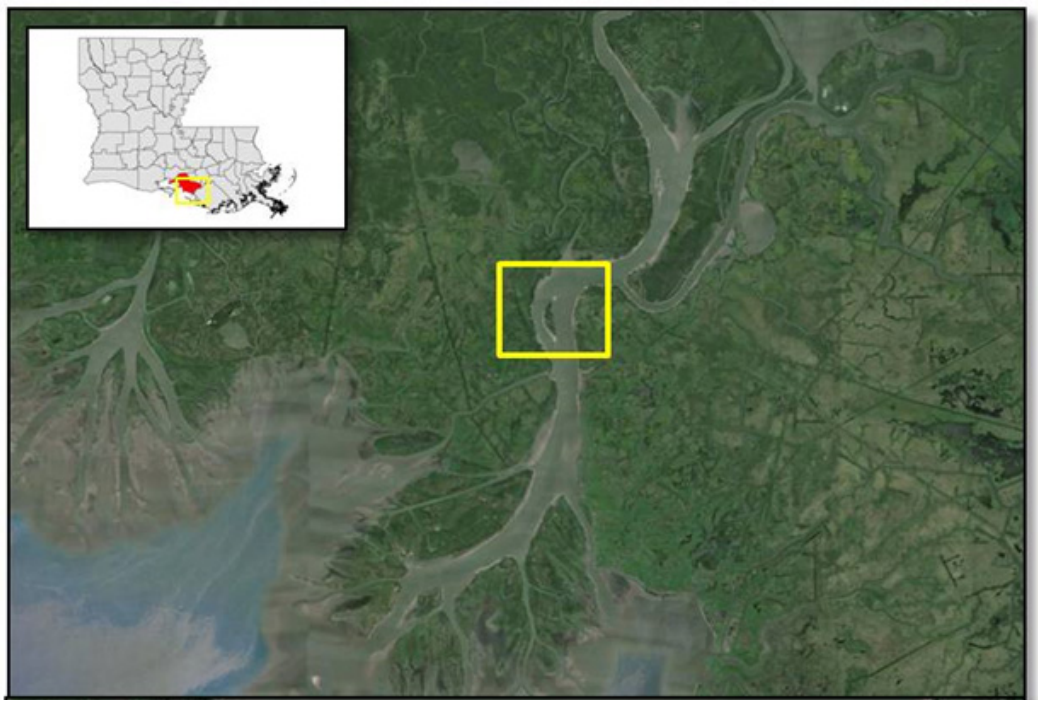

Figure 1: Study location (rectangle) within the lower Atchafalaya River, St. Mary Parish, LA.

This article presents results from an initial ecological survey of the 12-year old created wetland island to quantify the ecological functions and benefits of strategic open water placement of dredged material. Ongoing and future research initiatives are also discussed.

Methods

Aerial image interpretation, ground truthing, and recorded GPS reference points were evaluated to determine ecological community boundaries and island area (Figure 3). Wetlands were classified according to Cowardin et al. (1979). Data collection occurred during August 2013 .Vegetation sampling included quantification of dominant species

within each distinct vegetative community. Seven sample plots were located within forested,shrub-scrub, and emergent habitats on the island and seven sample plots were evaluated in aquatic bed environments with submerged and emergent vegetation. Within each wooded area, dominant overstory species, tree stem density within 0.04 ha plots, and shrub-sapling stem densities within two nested 0.004 ha sub-plots were recorded. Herbaceous ground cover were also estimated within four representative 1 m2 sub-plots. In the aquatic beds, ocular estimation of percent vegetation cover (USACE 2010) included all rooted, free-floating, and visibly submerged aquatic species within four representative 1 m2 sub-plots . Incidental observations of all faunal species encountered on the island were recorded. Species were identified visually, by their calls, or by the presence of indirect signs (e.g., scat and tracks). Soils were examined at each sample location within each wetland community (USACE 2010; USDA-NRCS 2011). Soil descriptions included soil horizon depth, matrix color, redoximorphic features, and textural analysis within 50 cm (20 in) of the surface.

Results

Wetland Vegetation

Wetland classification identified four distinct types on the island: palustrine forested wetland, palustrine scrub-shrub wetland, persistent emergent wetland, and aquatic bed features. Forested, shrub-scrub, and emergent wetlands occupied approximately 12 ha (34%) of the island (Figure 3). These habitats were dominated by black willow (*Salix nigra*), eastern baccharis (*Baccharis halimifolia*) and common elderberry (*Sambucus nigra* ssp. *canadensis*) . Other prominent species included annual marsh elder (*Iva annua*) and red mulberry (*Morus rubra*). The average diameter of woody stems was 12.5 cm dbh, ranging from 5-20 cm dbh. Total tree density per hectare ranged from 1,500 to 17,325 woody stems. Ground cover ranged from 4-48% (average 20%). Average tree height was 6 m, with a maximum height of 10 m. Higher elevations exhibited dogfennel (*Eupatorium capillifolium*) and stiff dogwood (*Cornus foemina*). Less commonly observed were buttonbush (*Cephalanthus occidentalis*), climbing hempvine (*Mikania scandens*), whorled marsh pennywort (*Hydrocotyle verticillata*), smallspike false nettle (*Boehmeria cylindrica*), flatsedge (*Cyperus* sp.), goldenrod (*Solidago* sp.), hairypod cowpea (*Vigna luteola*), broadleaf cattail (*Typha latifo-*

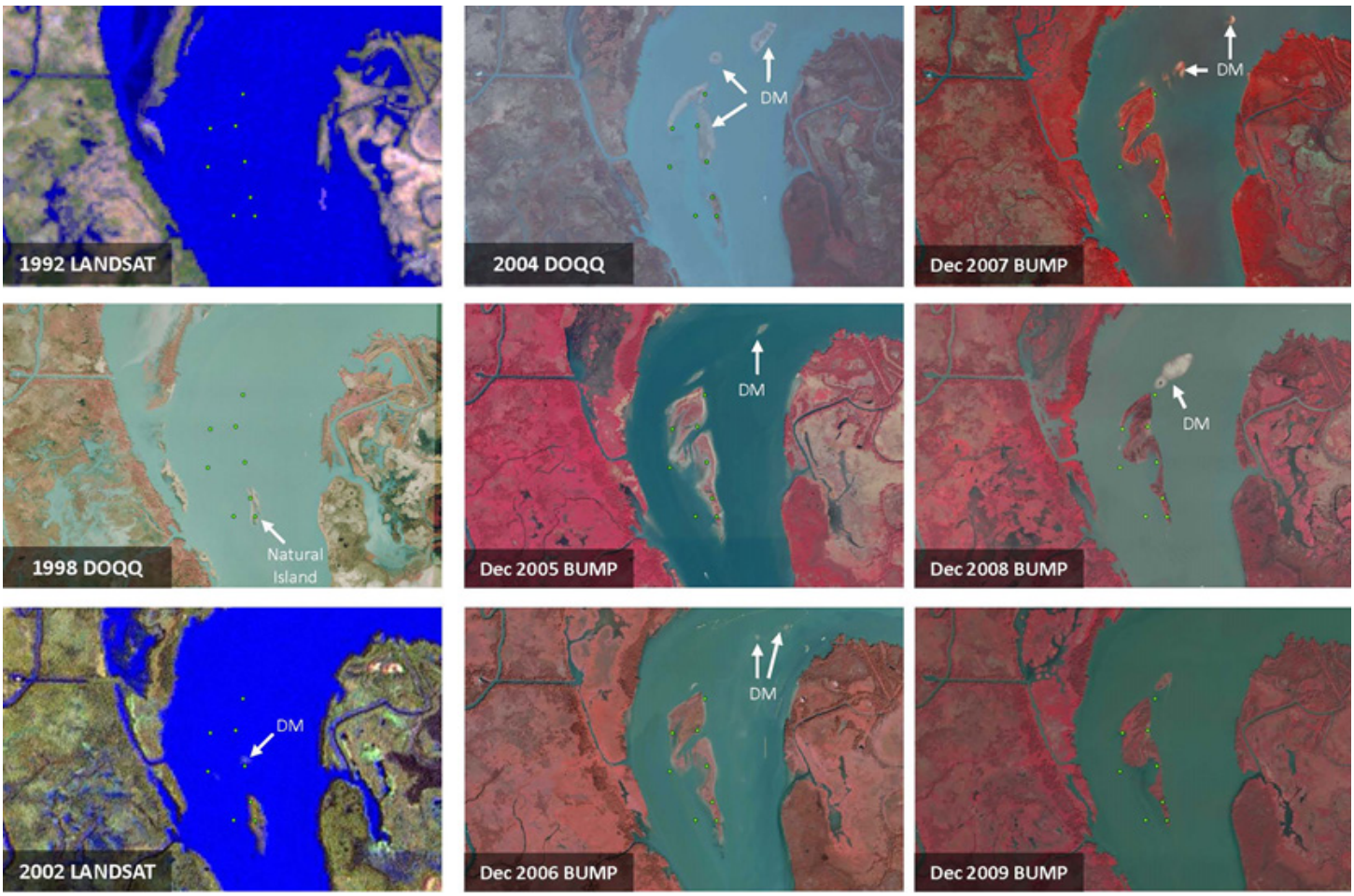

Figure 2: Imagery displaying island location prior to dredged material (DM) placement and subsequent formation (1992 and 1998 images), establishment, and growth since placement began in 2002 (USACE New Orleans District). The island is located at latitude 29°31'37.50"N, longitude 91°16'25.80"W.

lia), invasive Chinese tallowtree (*Triadica sebifera*), rose mallow (*Hibiscus lasiocarpos*), and broadleaf arrowhead (*Sagittaria latifolia*). Dominant herbaceous layer species in emergent wetlands varied from densely aggregated clumps of vegetation >1 m in height (e.g., coco yam (*Colocasia esculenta*)) to extensive ground cover by invasive torpedo grass *(Panicum repens*), smartweed (*Polygonum* spp.), or invasive alligatorweed (*Alternanthera philoxeroides*). Aquatic beds occupied approximately 23.1 ha (66%) of the island. Three species predominated common water hyacinth (*Eichhornia crassipes*), alligatorweed, and water sprangles (*Salvinia minima*; Table 1). A comprehensive list of all plants observed on the island was developed (USDA 2013; Berkowitz et al 2014).

Table 1. Vegetation species and abundance in aquatic bed wetlands.

Species	Common name	Average cover (%)
Eichhornia crassipes	Common water hyacinth	37.5
Alternanthera philoxeroides	Alligatorweed	34.8
Salvinia minima	Water spangles	31.7
Lemna minor	Common duckweed	12.5
Ludwigia sp.	Primrose-willow	10.0
Hydrilla verticillata	Waterthyme	6.5
Open water	Open water	5.2
Nelumbo lutea	American lotus	4.6
Leersia oryzoides	Rice cutgrass	1.0
Colocasia esculenta	Coco yam	0.2

Figure 3. Recording data on species composition of the marsh.

Wildlife

Twenty-three faunal species representing 12 families were observed on the island during the site visit (Table 2). Wading birds were the primary vertebrates observed. An active rookery containing juvenile white ibis, great egret, and other species was found on the northwest corner of the island (Figure 4). Several species of seabirds were seen in the immediate vicinity of the island. Four reptile species and the exoskeleton of one White River crawfish were found. No mammals were observed on the island but several burrows and "runs" (likely made by small mammals) were noted. One bald eagle was seen taking flight from the island, but no other species of concern were encountered.

Soils

Soils textures ranged from loamy sands to very fine sands. Surface soil layers contained thin dark, organic rich horizons (10YR 3/1 or 10YR 3/2) underlain by depleted materials (e.g., 10YR 5/2) in subsurface horizons. Soils exhibited redoximorphic concentrations and met one or more field indicators of hydric soils (USDA-NRCS 2011). Observed hydric soil indicators included: F3 – depleted matrix, S6 – sandy redox, and A5 – stratified layers. Additionally, soils displayed the presence of buried surface horizons, signatures of recent sediment inputs, and indicators of active soil forming processes associated with overbank flooding and material deposition. Detailed soil descriptions are provided in Berkowitz et al. (2014).

Discussion and Conclusion

Horseshoe Bend Island exhibited four distinct wetland types including forested, scrub-shrub, emergent, and aquatic bed assemblages within a relatively small area (35 ha). The created island contained a diverse array of species characteristic of the larger Atchafalaya River wetland ecosystem, with 81 plant and 23 animal species observed. Faulkner and Poach (1996) conducted a vegetation survey within created and natural wetlands in the Atchafalaya Basin, identifying a total of 53 plant

species. The higher number of species found at Horseshoe Bend Island suggests that its species richness and diversity is comparable to other wetlands in the region. Additionally, Faulkner and Poach (1996) and Craft et al. (1999) report that created wetlands require 5 to 10 years prior to approaching the vegetation characteristics observed within natural wetland ecosystems. Thus, the 12-year successional development of Horseshoe Bend Island appears comparable with similar-aged natural wetland ecosystems in the region. The occurrence of an active bird rookery on the island is particularly noteworthy since no other active rookeries were observed within the portion of the Atchafalaya River examined.

The soils of the created island displayed common properties characteristic of riverine wetlands exposed to periodic inundation, overbank flooding, and sediment deposition (Vepraskas 2001; Noe and Hupp 2009). The abundance of depleted materials interspersed with higher chroma sandy minerals from recent flooding events with buried soil horizons and wavy/turbulent boundary transitions demonstrated the frequency of deposition events as observed through the presence of stratified layers (USDA-NRCS 2011). Further, the development of dark, organic-rich surface horizons indicated a decrease in microbial decomposition rates resulting fromanaerobic conditions (Vepraskas and Sprecher 1997). The profusion of redoximorphic features indicates that chemical reduction regularly occurs within island soils, promoting wetland biogeochemical functions including carbon sequestration, nutrient cycling, removal and sequestration of elements and compounds, and denitrification (Reddy and DeLaune 2008; Smith and Klimas 2002).

Initial surveys of vegetation, fauna, and soils suggest that the 12-year old Horseshoe Bend Island provides ecological functions and services at levels comparable to similar-aged ecosystems within the region. Ongoing studies will 1) quantify the density and community composition of avian nesting sites, 2) examine infaunal communities in aquatic bed wetland sediments, 3) measure nutrient cycling functions of island soils, and 4) compare vegetative characteristics to other wetland islands in the region. An additional benefit being realized is that as the island enlarges it reduces the overall cross-sectional area of the river, potentially increasing flow through the navigation channel to velocities sufficient for reduced shoaling and dredging requirements. As a result, a model is being developed to examine channel morphology and hydrodynamics. ■

Acknowledgements

Thanks to Brandon Gaspard and John Newton for help with field data collection and plant identification as well as the USACE New Orleans District for logistical support throughout the project. Funding was provided by the USACE Dredging Operations and Environmental Research Program.

Figure 4. Juvenile snowy egret observed in rookery on Horseshoe Bend Island.

Table 2. Faunal species observed during the ecological survey of a dredge material supported island.

Scientific Name	Common Name	Scientific Name	Common Name
Alligator mississippiensis	American alligator	*Fulica americana*	American coot
Anas discors	Blue-winged teal	*Gelochelidon nilotica*	Gull-billed tern
Anolis carolinensis	Carolina anole	*Haliaeetus leucocephalus*	Bald eagle
Archilochus colubris	Ruby-throated hummingbird	*Hydroprogne caspia*	Caspian tern
Ardea alba	Great egret	*Leucophaeus pipixcan*	Franklin's gull
Ardea herodias	Great blue heron	*Libellula needhami*	Needham's skimmer
Corvus brachyrhynchos	American crow	*Nerodia rhombifer*	Diamond-backed watersnake
Egretta caerulea	Little blue heron	*Ajaja ajaja*	Roseate spoonbill
Egretta rufescens	Reddish egret	*Procambarus acutus*	White River crawfish
Egretta thula	Snowy egret	*Quiscalus quiscula*	Common grackle
Egretta tricolor	Tricolored heron	*Sterna forsteri*	Forster's tern
Erythemis simplicicollis	Eastern pondhawk	*Sterna hirundo*	Common tern
Eudocimus albus	White ibis	*Thamnophis proximus orarius*	Gulf Coast ribbon snake

References

Barras, J., S. Beville, D. Britsch, S. Hartley, S. Hawes, J. Johnston, P. Kemp, Q. Kinler, A. Martucci, J. Porthouse, D. Reed, K. Roy, S. Sapkota, and J. Suhayda. 2003. *Historical and Projected Coastal Louisiana Land Changes: 1978–2050*. U.S. Geological Survey, USGS Open File Report 03–334, Washington, D.C.

Berkowitz, J. F., N. R. Beane, D. E. Evans, B. C. Suedel, and J. M. Corbino. 2014. Preliminary use of strategic placement of dredged sediment to support Horseshoe Island in the Atchafalaya River, Louisiana: A preliminary ecological survey. DOER Technical Notes Collection ERDC TN-EWN-14-4. Vicksburg, MS: US Army, Engineer Research and Development Center.

Bridges, T.S., Lillycrop, J., Wilson, J.R., Fredette, T.J., Suedel, B.C., Banks, C.J. and Russo, E.J. 2014. Engineering With Nature Promotes Triple-Win Outcomes. *Terra et Aqua*. 135:17-23.

Boustany, R. G. 2010. Estimating the benefits of freshwater introduction into coastal wetland ecosystems in Louisiana: Nutrient and sediment analyses. *Ecological Restoration 28*(2), 160-174.

Corwardin, L. M., Carter, V., Golet, F. C., and E. T. Laroe. 1979, Reprinted 1992. *Classification of Wetlands and Deepwater Habitats of the United States*. U.S. Fish and Wildlife Service, FWS/OBS-79/31, 103 pp. Washington, D.C.

Craft, C., Reader, J., Sacco, J. N., and Broome, S. W. 1999. Twenty-five years of ecosystem development of constructed Spartina alterniflora (Loisel) marshes. *Ecological Applications 9*(4), 1405-1419.

Day, J. W., Jr., D. F. Boesch, E. J. Clairain, G. P. Kemp, S. B. Laska, W. J. Mitsch, K. Orth, H. Mashriqui, D. J. Reed, L. Shabman, C. Simenstad, B. J. Streever, R. R. Twilley, C. C. Watson, J. T. Wells, and D. F. Whigham. 2007. Restoration of the Mississippi Delta: lessons from hurricanes Katrina and Rita. *Science* 315:1679–1684.

Faulkner, S. P., and Poach, M. E. 1996. *Functional Comparison of Created and Natural Wetlands in the Atchafalaya Delta, Louisiana*. Technical Report WRP-RE-16. U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Gerhardt-Smith, J.M., and C.J. Banks. 2014. *USACE Regional Sediment Management and Engineering With Nature 2013 Workshop Summary*. EWN Technical Notes Series. ERDC TN-EWN-14-3, Vicksburg, MS: US Army Engineer Research and Development Center. *www.engineeringwithnature.org or http://el.erdc.usace.army.mil/ewn*

Noe, G. B., and Hupp, C. R. (2009). Retention of riverine sediment and nutrient loads by coastal plain floodplains. *Ecosystems 12*(5), 728-746.

Reddy, K.R., and DeLaune, R.D. 2008. *Biogeochemistry of Wetlands: Science and Applications*. CRC Press. Boca Raton, FL.

Smith, R. D., and Klimas, C. V. 2002. *A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Selected Regional Wetland Subclasses, Yazoo Basin, Lower Mississippi River Alluvial Valley*. ERDC/EL TR-02-4 US Army Engineer Research and Development Center, Vicksburg, MS.

U.S. Department of Agriculture (USDA) - Natural Resources Conservation Service (NRCS). 2011. *Field Indicators of Hydric Soils in the United States, Version 7.0*. ed. L. M. Vasilas, G. W. Hurt, and C. V. Noble. Washington, DC: USDA NRCS in cooperation with the National Technical Committee for Hydric Soils.

U.S. Department of Agriculture (USDA). 2013. The PLANTS Database (http://plants.usda.gov, 25 October 2013). National Plant Data Team, Greensboro, NC 27401-4901 USA.

U.S. Army Corps of Engineers (USACE). 2010. *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Atlantic and Gulf Coastal Plain Region (Version 2.0)*, ed. J. S. Wakeley, R. W. Lichvar, and C. V. Noble. ERDC/EL TR-10-20. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

U.S. Army Corps of Engineers. 2004. Louisiana coastal area (LCA), Louisiana: ecosystem restoration study. U.S. Army Corps of Engineers, New Orleans, Louisiana.

Vepraskas, M. J. 2001. Morphological features of seasonally reduced soils. In: *Wetland Soils: Genesis, Hydrology, Landscapes, and Classification*. Lewis Publishers. Boca Raton, FL., 163-182.

Vepraskas, M. J. and S. W. Sprecher. 1997. Overview of aquic conditions and hydric soils. In: M.J. Vepraskas and S.W. Sprecher (Eds.). *Aquic Conditions and Hydric Soils*. Soil Science Society of America. Madison, WI.

Salinity Tolerance of Common Reed *(Phragmites australis)* at the Medouie Creek Restoration Site, Nantucket MA

Jennifer M. Karberg[1], Karen C. Beattie, Danielle I. O'Dell and Kelly A. Omand, Science and Stewardship Department, Nantucket Conservation Foundation, Nantucket MA

In 2008, the Nantucket Conservation Foundation (NCF) initiated a salt marsh restoration project at the Medouie Creek Wetland Complex, Nantucket, Massachusetts. This involved installing a box culvert under a restrictive dike road to reconnect tidal, saltwater hydrology throughout the marsh, in which the restricted portion had converted to freshwater conditions sometime in the 1930s (Karberg 2014; Figure 1). The impounded marsh hosted a large population of *Phragmites australis* (common reed) (1.58 hectares) and the re-introduction of salt water was intended to dramatically impact the population, potentially reducing the future need for herbicide treatment. Since the culvert opened in 2008, monthly soil pore water salinity monitoring has documented steadily rising salinity levels, as well as dramatic reductions in *Phragmites* patch size, stem density and stem height (Karberg 2014). The *Phragmites* population has been reduced since the restoration but not eliminated. This article examines a greenhouse study designed to determine the salinity tolerance of *Phragmites* stems collected from the restoration area.

Impacts and Ecology of Non-Native *Phragmites*

Phragmites populations can be found on all continents except Australia. In North America there exists both a native and a non-native genotype. The non-native genotype is now seen most commonly in dense, monoculture stands primarily in freshwater wetlands but occasionally in brackish and salt water wetlands (Roman et al. 1984; Saltonstall 2002). Numerous studies have documented the expansion of the non-native *Phragmites* into marsh habitats (e.g., Rice et al. 2000; Amsberry et al. 2000; Chambers et al. 1999) and the resulting decline in diversity of vegetative species, leading to habitat loss for waterfowl, shorebirds, and other wildlife (Meyerson et al. 2000). Aggressive eradication of *Phragmites* in freshwater wetlands has been shown to increase native plant diversity (Meyerson et al. 2000). Understanding how to effectively control expanding non-native *Phragmites* populations is important to maintaining the ecological integrity of many North American wetlands.

Many control mechanisms have been examined for *Phragmites* including mowing, burning, digging and herbicide application (Michigan Natural Features Inventory, no date). Each of these methods can negatively impact native species and the surrounding wetland and soil ecology. On Nantucket, NCF primarily employs direct application

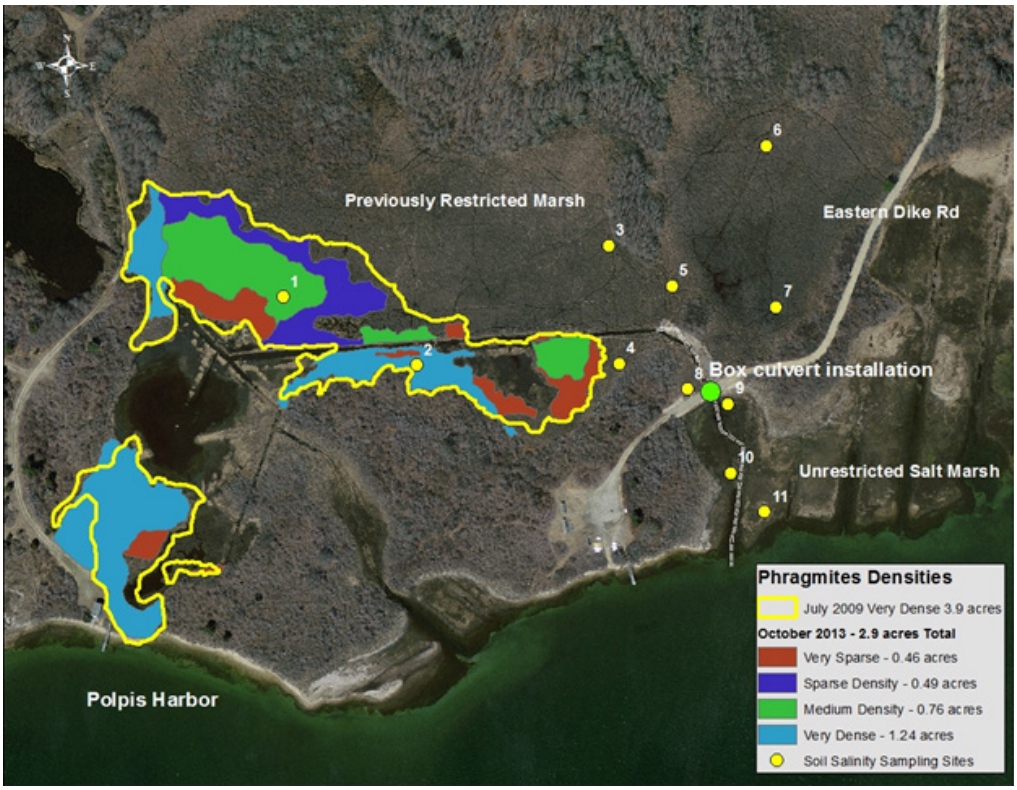

Figure 1. Medouie Creek Wetland Complex restoration area. In December 2008, a culvert was placed under the Eastern Dike Road, opening up the previously restricted marsh and reintroducing tidal flow and salinity.

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of herbicide to individual *Phragmites* stems (the cut and drip method) which can be both time and labor intensive (Omand 2014; Simmons 2013), particularly when addressing a large stand like that at Medouie Creek. A less direct method of *Phragmites* control is the introduction of salt water to marsh soils, particularly for areas that previously received saltwater inputs. Many recent studies have examined the influence of different salinity levels on the growth and production of *Phragmites* plants with varied results (Chambers et al. 2003) but they generally observed a decline in *Phragmites* with increased salinity. Lissner and Schierup (1997) saw *Phragmites* stands dieback in response to salinities higher than 15 ppt within the soil rooting zone, while their greenhouse study showed plant growth rates negatively correlated to increases in salinity. *Phragmites* morphology (e.g., height) and biomass production have been negatively correlated with increasing soil salinity levels (Hellings and Gallagher 1992) although plants collected from different locations show negative responses at different levels of salinity which may indicate a local adaptation to soil salinity levels.

Phragmites at Medouie Creek

Based on the results of previous research a restoration project was designed, attempting to reduce the population of *Phragmites* at Medouie Creek by reintroducing salt water through the installation of a culvert under the eastern dike road in 2008 (Figure 1). Overall, the population has responded negatively to increased salinity since the restoration, however, not all areas of the marsh have seen dramatic reductions in *Phragmites* populations. This may be due to differences in salinity levels throughout the marsh. Other research has shown that *Phragmites* appears to respond to increased salinity to varying degrees, possibly related to different *Phragmites* genotypes (Chambers et al. 2003; Hellings and Gallagher 1992; Lissner and Schierup 1997). On average, soil salinity has increased from approximately 0-5 ppt to 15-30 ppt across the restoration area although salinity increases have been variable across the marsh leaving some areas of *Phragmites* not as heavily impacted as others (Karberg 2014). Biennial vegetation monitoring has documented a decrease in overall *Phragmites* area from 1.58 hectares (3.9 acres) in 2008 to 1.17 hectares (2.9 acres) in 2013, as well as a decrease in *Phragmites* stem density (from ~40% to 20% within 1 m^2 plots) and height (from ~ 3.3 m to 1.26 m) (Karberg 2014) (Figure 2).

After observing declines in *Phragmites* in the field, a greenhouse study was undertaken to document the specific response of *Phragmites* stems collected from the Medouie Creek Wetland Complex to different levels of soil water salinity over a two-year growth span. Understanding the response of these local *Phragmites* plants to different salinity levels in a controlled environment will provide a better understanding of target salinity levels that need to be achieved at Medouie Creek to effectively control and/or drastically impact *Phragmites*. This information will assist in planning and prioritizing additional restoration activities at Medouie Creek in the future.

Methods

Collection of *Phragmites* Stems from Medouie Creek

In late May 2012 (Year 1), *Phragmites* rhizomes were randomly selected for hand digging at the Medouie Creek Wetland Complex and immediately placed in buckets of water and transported to the NCF research greenhouse. Stems were gently washed to remove soil and pulled apart so only one stem was present on each rhizome. Stems were planted into three gallon pots using a 2:1 potting mixture of sterile potting mix (Metro Mix® 200) and washed local sand. Up to three stems were planted in each pot to help simulate the degree of competition seen in the field (Chambers et al. 2003; Ravit et al. 2007). Pots were placed in large black

Figure 2. Photos taken in October 2008 (left) and October 2013 (right) from the exact same position within Medouie Creek showing the dramatic reduction in both height and density of Phragmites stems after the restoration. Stem heights in October 2008 averaged 3.3 m whereas heights in October 2013 averaged 1.26 m (Karberg 2014).

plastic trays, with six pots per tray. Trays were initially filled with unaltered tap water. Pots were first watered top down and then routinely watered from the bottom up by watering directly into the trays, to maintain moist soil. Pots were placed on greenhouse benches located outside on the north side of a building to provide shade and shelter from the wind.

Salinity Treatment and *Phragmites* Monitoring

Phragmites stems were allowed two weeks to equilibrate to transplanting before the application of salinity treatments. In mid-June, Instant Ocean Sea Salt® (by Instant Ocean, purchased from www.amazon.com) was mixed with tap water and applied to each tray to adjust salinity levels. A total of five trays with six pots per tray were included in this study, with each tray containing a different salinity treatment (0 ppt, 10 ppt, 20 ppt, 30 ppt, or 40 ppt) (Figure 3). Salinity was checked using a refractometer every four days. Water levels and salinity were adjusted to avoid drying out and to maintain the correct treatment levels. Trays were also visited after major rainfall events to check and adjust salinity levels.

Initial morphological measurements were taken prior to salinity application and repeated every two weeks over the course of the growing season. Morphological characters measured on each plant included stem height (mm) to the apex of the plant, basal diameter (cm), total leaf number per stem and number of dead leaves per stem. Additionally leaf length and leaf width measurements of all leaves on each stem were taken at the beginning and end of each growing season. At the end of the first growing season (October 2012) trays were placed in a fenced community garden. Trays were dug into holes in the garden soil and filled with water to allow the rhizomes to over winter without freezing. In May 2013 (Year 2), trays were removed from the community garden and again placed on greenhouse benches in the same location as in Year 1. Experimental salinity levels were reestablished for each tray and all *Phragmites* stems that emerged during the Year 2 growing season were monitored. Salinity levels and morphological measures were repeated as in Year 1.

Data Analysis

A repeated measures general linear model examined changes in each morphological characteristic between the five treatment levels in each treatment year (SPSS version 21.0) (IBM Corp 2012). Mauchly's test assessed sphericity and, depending on the value of ϵ, corrected when necessary with the Greenhouse-Geisser ($\epsilon < 0.75$) or the Huynh-Feldt ($\epsilon > 0.75$) corrections. Analysis was conducted separately for each treatment year: Year 1 (2012) and Year 2 (2013). A Bonferroni post-hoc test examined differences between salinity levels (IBM Corp 2012).

Results

During the first season of salinity treatments (Year 1), *Phragmites* stems showed significantly lower stem heights in the 30 ppt ($p \leq 0.001$) and 40 ppt ($p=0.037$) salinity treatments only as compared to the 10 ppt and significantly lower leaf numbers per stem in the 30 ppt ($p \leq 0.001$) and 40 ppt ($p=0.002$) salinity treatments as compared to the 10 ppt. No significant difference was observed in stem diameter or number of dead leaves related to salinity treatment during the Year 1 growing season.

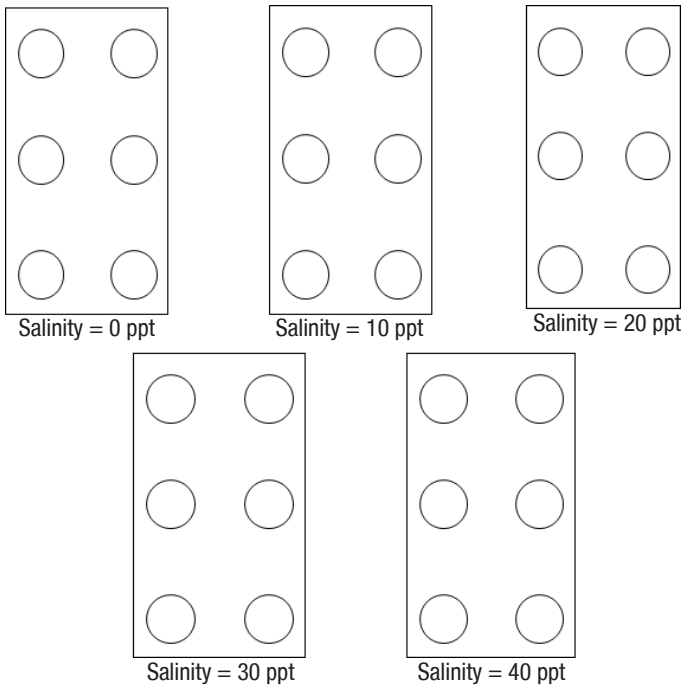

Figure 3. Experimental setup consisting of five trays, each containing six pots of Phragmites stems. Each tray was filled with water and salinity was maintained at 0, 10, 20, 30, or 40 ppt. In Year 2, each tray contained the same pots and received the same salinity treatment as in Year 1.

Figure 4. Experimental set up showing physical differences in Phragmites stems at the end of Year 2 (2013), with stems subjected to higher salinity treatments, particularly 30 ppt and 40 ppt, showing decreased stem height and robustness.

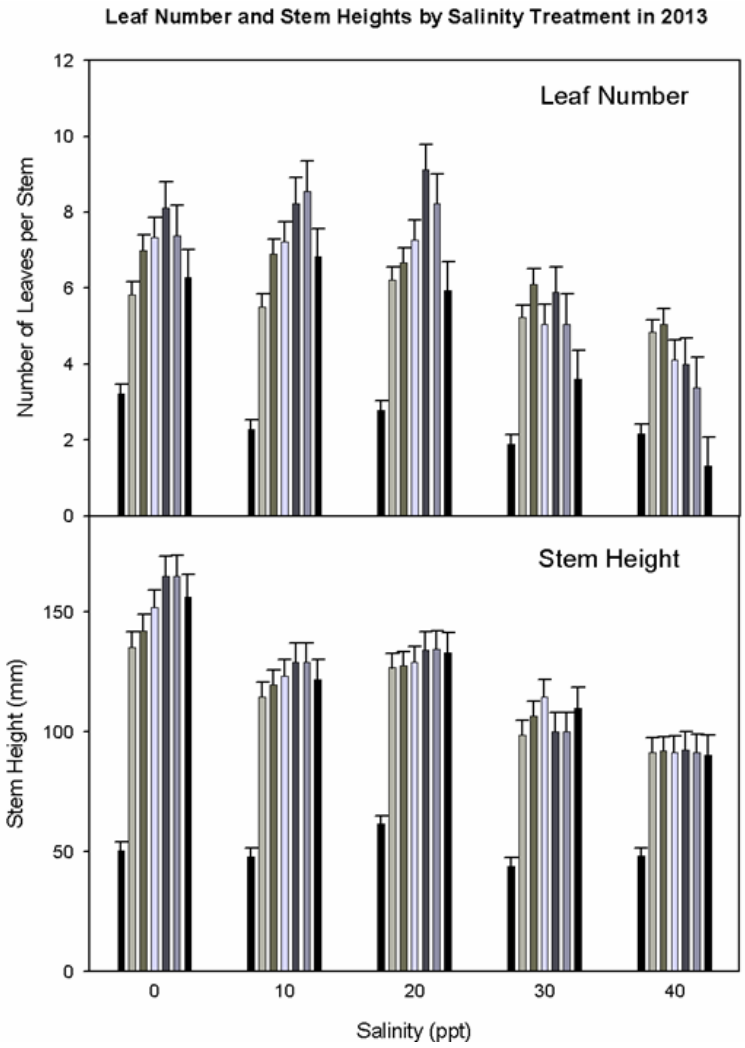

Figure 5. Leaf number and stem height in Year 2 (2013) by salinity treatment level over the course of the growing season. Plants in the 30 ppt and 40 ppt treatment had significantly less leaf production compared to the lower salinity treatments ($p<0.001$). Initial stem heights were equivalent, but heights at the lower salinity treatments quickly increased past the 30 and 40 ppt treatments ($p<0.001$).

Phragmites growth was more severely impacted by salinity treatments during Year 2 of this study. Stem heights, after an initial month of growth, decreased significantly with increased salinity, with dramatic, significant decreases seen at the 30 ppt ($p\leq0.001$) and 40 ppt ($p\leq0.001$) treatment levels (Figure 5). Leaf numbers significantly decreased in the 40 ppt treatment compared to the 0 ppt ($p\leq0.001$), 10 ppt ($p\leq0.001$) and 20 ppt ($p\leq0.001$) treatments (Figure 5). Initial stem diameters decreased significantly at 40 ppt as compared to the 0 ppt ($p\leq0.001$), 10 ppt ($p=0.049$), and 20 ppt ($p=0.010$) treatments at the start of Year 2 and did not recover over the growing season (Figure 6). The number of dead leaves significantly increased with increasing salinity levels. Overall, *Phragmites* growth and robustness significantly decreased at 30 ppt and 40 ppt after two years of exposure to elevated salinity levels (Figure 4). Morphological characters were not significantly impacted between 0-20 ppt.

Discussion

Increased Salinity Directly Impacts *Phragmites* Growth

Salinity impacts appeared cumulative over time, with stem diameters significantly smaller when exposed to high salinity levels after two years of treatment (Figure 6). The cumulative impacts of two years of exposure to higher salinity levels appeared to cause increased response in Year 2.

Phragmites has shown varying responses to increased salinity levels, potentially indicating localized adaptations to salinity tolerance (Chambers et al. 2003; Lissner and Schierup 1997). Examining the response of *Phragmites* stems collected from the Medouie Creek restoration area to increased salinity levels suggests that 30 ppt appears to be the salinity level at which, all things being equal, *Phragmites* plant health and vigor begins to dramatically decline.

Phragmites Response in the Field to Salinity

Field observations of *Phragmites* and salinity at Medouie Creek showed a response of the stems to a lower soil salinity level than that observed in this common garden experiment. Since 2008 (one year prior to restoration), our monthly sampling has shown steadily increasing salinity over time post-restoration, with salinities now averaging between 10-32 ppt for once essentially freshwater areas. Stations directly within *Phragmites* populations currently average 10-20 ppt. Despite the fact that these sites have not been exposed to the consistently high salinities that the common garden experiment suggested were needed to negatively impact *Phragmites,* significant decreases in *Phragmites* stem density, height and vigor were observed in the field (Karberg 2014). These changes could be a result of periodic pulses of high salinity due to extreme high tides, storm surge, and/or other environmental stressors that increase rhizome exposure and sensitivity to salinity. Additionally, many of the large pulses of salinity occurred during winter storms which can concentrate salinity within the soil, impacting plant growth at the start of the growing season. Although these results are encouraging, colonization by juvenile *Phragmites* stems has been observed in areas of the marsh with lower average salinities, indicating that additional management actions will likely be required in this marsh particularly as *Phragmites* shifts its distribution.

Management Considerations

This common garden experiment showed significant negative impacts to *Phragmites* stems with soil salinities of 30 ppt and higher. Current salinities observed at Medouie Creek average between 20-30 ppt but further increases in salinity appear to have leveled off. Without additional dramatic increases in soil salinity, further impacts to the current *Phragmites* population are unlikely. Lissner and Schierup (1997) observed that *Phragmites* plants with established rhizomes can exist at 22 ppt, while juvenile plants experienced high mortality which may help limit future spread of *Phragmites* throughout the marsh. Additionally, Chambers et al. (2003) reported that once *Phragmites* has effectively colonized a wetland, it can persist in soil salinities of 45 ppt and 100% inundation, although juvenile plant colonization is unlikely to occur where soil salinity is higher than 10 ppt.

The results of this study, coupled with observations of *Phragmites* at Medouie Creek suggest that soil salinity modification alone is not likely to be an effective management strategy unless the entire *Phragmites* population can be consistently exposed to adequate, increased salinity levels. At sites like Medouie Creek where the *Phragmites* population extends across a natural gradient of soil salinity levels, there will likely always remain a portion of the marsh favorable to *Phragmites*. Therefore, further management at Medouie Creek to control the *Phragmites* population could include opening up additional tidal access creeks to increase salinity throughout the marsh as well as targeted herbicide treatments to decrease and eliminate *Phragmites* located at sites exposed to lower, more tolerable salinity levels. ■

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References

Amsberry, L., Baker, M.A., Ewanchuk, P.J., and Bertness, M.D. 2000. Clonal integration and the expansion of *Phragmites australis*. *Ecological Applications* 10: 1110-1118.

Chambers, R.M., Meyerson, L.A., and Saltonstall, K. 1999. Expansion of *Phragmites australis* into tidal wetlands of North America. *Aquatic Botany* 64: 261-273.

Chambers, R.M. Osgood, D.T. Bart, D.J., and Montalto F. 2003. *Phragmites australis* invasion and expansion in tidal wetlands: interactions among salinity, sulfide, and hydrology. *Estuaries* 26:398-406.

Hellings, S.E. and Gallagher, J.L. 1992. The effects of salinity and flooding on *Phragmites australis*. *Journal of Applied Ecology* 29:41-49.

IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBMCorp.

Karberg, J. 2014. Medouie Creek salt marsh restoration 2013 annual progress report. Nantucket Conservation Foundation Internal Report.

Lissner, J. and Schierup, H. 1997. Effects of salinity on the growth of *Phragmites australis*. *Aquatic Botany* 55:247-260.

Michigan Natural Features Inventory. "*Phragmites australis* Treatment." *Michigan State University Extension*. Web. 02 July 2014. <http://mnfi.anr.msu.edu/*Phragmites*/treatment.cfm>.

Meyerson, L.A., Saltonstall, K. Windham, L. Kiviat, E., and Findlay, S. 2000. A comparison of *Phragmites australis* in freshwater and brackish marsh environments in North America. *Wetlands Ecology and Management* 8:89-103.

Omand, K. 2014. Invasive species monitoring and management report 2012-2013. Nantucket Conservation Foundation Internal Report.

Ravit, B., Ehrenfeld, J.G. Haggblom, M.M., and Bartels, M. 2007. The effects of drainage and nitrogen enrichment on *Phragmites australis*, *Spartina alterniflora*, and their root-associated microbial communities. *Wetlands* 27:915-927.

Rice, D., Rooth, J., and Stevenson, J.C. 2000. Colonization and expansion of *Phragmites australis* in Upper Chesapeake Bay tidal marshes. *Wetlands* 20:280-299.

Roman, C.T., Niering, W.A., and Warren, R.S. (1984) Salt marsh vegetation change in response to tidal restriction. *Environmental Management*, **8**, 141-150.

Saltonstall, K. 2002. Cryptic invasion by a non-native genotype of the common reed, *Phragmites australis*, into North America. Proceedings of the National Academy of Sciences of the United States of America 99: 2445-2449.

Saltonstall, K. 2003. Microsatellite variation within and among North American lineages of *Phragmites australis*. *Molecular Ecology* 12:1689-1702.

Simmons, T. 2013. Successfully Managing Phragmites. Ecological Landscape Alliance. http://www.ecolandscaping.org/07/invasive-plants/successfully-managing-phragmites/ Published July 15, 2013.

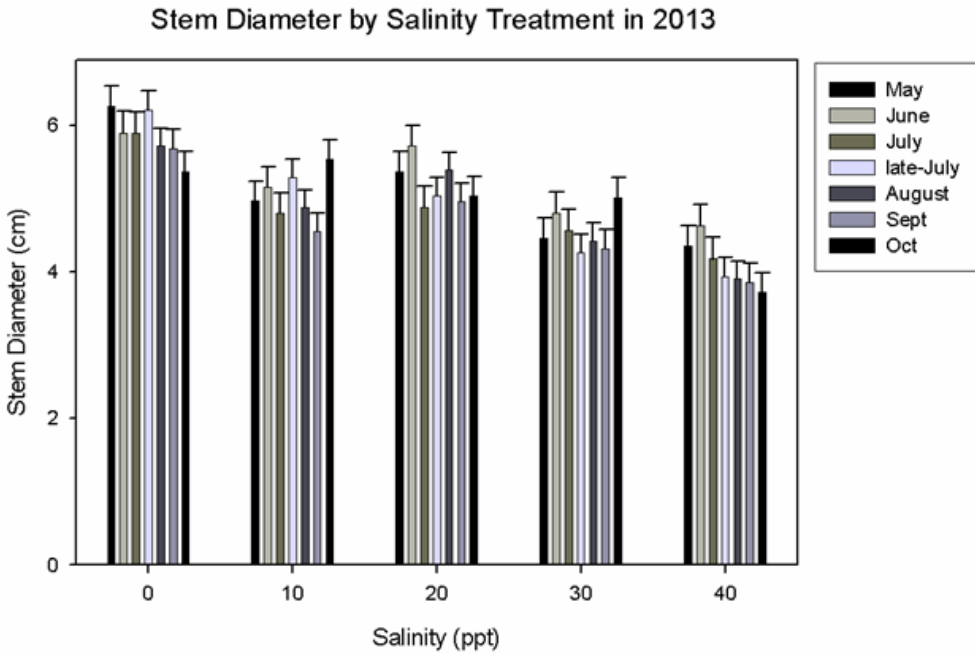

Figure 6. Stem diameters in Year 2 (2013) by salinity treatment level over the course of the growing season. Stems showed decreased diameters with increased salinity levels even at the beginning of the growing season with stems at 40 ppt much smaller compared to the 0 ppt ($p<0.001$), 10 ppt ($p=0.049$), and 20 ppt ($p=0.010$) treatments.

Metrics for Determining Hydrophytic Vegetation in Wetland Delineation: a Clarification on the Prevalence Index

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A recent publication and an article in *Wetland Science & Practice* (Lichvar and Gillrich 2014b, 2014a) discuss two metrics for determining if vegetation is hydrophytic for purposes of U.S. wetland delineations, the Prevalence Index (PI) and a proposed Hydrophytic Cover Index (HCI). Based on Wentworth et al. (1988), the PI is a weighted average of ordinal scores (1–5) for species in five wetland-indicator categories (defined in Table 1). Scores of 1–3 represent hydrophyte species, and the associated rule is that PI values ≤ 3.0 represent a positive determination for hydrophytic vegetation (U.S. Army Corps of Engineers 2010). The HCI uses a simple ratio of summed hydrophyte cover as a percentage of total cover; the proposed HCI rule is that HCI values > 50% represent a positive determination. The two papers note that the PI appears to give conflicting results in some cases, whereas the HCI has clear advantages in terms of simplicity and reliability. This is because the proposed HCI rule reflects the original conceptual definition of "hydrophytic vegetation" as having more than 50% representation of hydrophytic species (Environmental Laboratory 1987). However, the papers suggested that the PI scores over-weight non-hydrophyte[2] species, thus biasing the resulting index. That is not strictly the case. The purpose of this comment is to clarify the nature of the PI and to illustrate that the two indices are mathematical analogues with different emphasis.

Table 1 presents cover data for a field site (LW2) with 18 species (names omitted), including a FACU species ('P') with high percent cover. The math is presented in a form that makes the analogies more evident. The calculations show that the PI and HCI are both an average descriptive score that is weighted by cover. For the PI, the ordinal scores of all species are weighted by their respective covers, yielding an average score of 3.15. In the HCI, each species is, in effect, assigned an ordinal "score" of either 1 (hydrophyte) or 0 (non-hydrophyte), yielding an average score between 0 and 1 that represents a weighting of the 1s and 0s by the relative covers. In other words, the 5-rank scale is collapsed to a 2-rank scale with simpler mathematical properties. By excluding non-hydrophytic species, the HCI reduces to the simple metric of relative hydrophytic cover. If only species with PI scores of 1–3 are considered, their summed covers as a proportion of total cover would equal the value of the HCI (0.65, or 65%) — the equivalent of assigning a score of 1 or 0 to each species.

The conceptual intent of the Prevalence Index was to allow quantitative description of qualitative wetland-fidelity classes (OBL, FACW, etc.) for all species in a vegetation sample. Non-hydrophyte scores do not bias the PI, because the species scores are arbitrary ranks (not quantities) weighted by abundance[3]. As a weighted score, the PI is a descriptor of what indicator-class of species is predominant, on average (whether mainly FAC, mainly FACW, etc.). In contrast, the HCI is a descriptor of relative coverage for two rating classes (hydrophyte, non-hydrophyte), where one class "counts" and the other does not.

The site in Table 1 passes the HCI test but fails the PI test as it is currently applied for wetland delineation. This is not a flaw in the index, per se. Rather, the discrepancy arises from the prevalence-test *rule* which set the threshold value for hydrophytic determination at exactly 3.0. Thresholds are not inherent, but are chosen empirically (see National Research Council 1995, p. 129). In their original paper, Wentworth et al. (1988) noted that PI values within 0.5 units of the 3.0 threshold might also be indicative of hydrophytic vegetation (owing to the underlying variance of the estimate), but their point was not fully appreciated at the time. In very simplistic terms, the index can be thought of as having a mathematical "rounding" issue – as does any average value. For example, a vegetation sample consisting of many abundant FAC species plus a few low-cover FACU species is clearly hydrophytic, but it would have a PI slightly greater than 3.0. The PI is the average species "score", which implies a whole number. A PI of 3.05 or 3.15 is still basically 3 (FAC) when rounded. From that viewpoint, site LW2 could also pass the prevalence test.

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[2] Terms follow the usage of Lichvar and Gillrich (2014a, b)

[3] Any equal-interval scale could have served for the purpose. For example, the 5 wetland-indicator scores could have been 1, 3, 5, 7, and 9. Likewise, the ordinal scale could have been inverted (OBL = 5 to UPL = 1). In the first example, a prevalence-rule might require a PI less than or equal to 5 (the FAC score) for a positive determination; in the second example, a rule would require a PI > 3 (instead of < 3).

Table 1. Demonstration of conceptual analogy between the Prevalence Index (PI) and Hydrophytic Cover Index (HCI)

PI is an average score (from 1 to 5) weighted by species relative coverages

HCI is an average "score" (from 0 to 1) weighted by species relative coverages, where 1 = hydrophyte and 0 = not

Site	Species	Wetland-Indicator Rating†	PI score	Species percent cover (%)	PI score weighted by % cover		HCI Score	HCI score weighted by % cover
LW2	A	OBL	1	1.9	1.9		1	1.9
LW2	B	OBL	1	0.8	0.8		1	0.8
LW2	C	FACW	2	1.5	3.0		1	1.5
LW2	D	FACW	2	0.9	1.8		1	0.9
LW2	E	FACW	2	0.1	0.3		1	0.1
LW2	F	FACW	2	8.3	16.5		1	8.3
LW2	G	FACW	2	2.6	5.3		1	2.6
LW2	H	FACW	2	0.8	1.5		1	0.8
LW2	I	FAC	3	0.8	2.3		1	0.8
LW2	J	FAC	3	0.1	0.4		1	0.1
LW2	K	FAC	3	9.0	27.0		1	9.0
LW2	L	FAC	3	4.1	12.4		1	4.1
LW2	M	FAC	3	5.3	15.8		1	5.3
LW2	N	FAC	3	7.1	21.4		1	7.1
LW2	O	FAC	3	18.8	56.3		1	18.8
LW2	P	FACU	4	32.6	130.5		0	0.0
LW2	Q	FACU	4	0.4	1.5		0	0.0
LW2	R	UPL	5	0.1	0.6		0	0.0
Totals				95.0	298.9			61.9

† OBL = Obligate Wetland, FACW = Facultative Wetland, FAC = Facultative, FACU = Facultative Upland, UPL = Upland

Sum of cover-weighted PI scores (all species) = 298.9
Total cover (all species) = 95.0%
Cover of hydrophytes (P.I. scores '1–3' only) = 61.9%
Prevalence Index = (298.9/95.0) = 3.15

Cover of hydrophytes (= sum of cover-weighted HCI scores) = 61.9%
Total cover (all species) = 95.0%
Hydrophytic Cover Index = (61.9/95.0) = 0.65 (65%)

In hindsight, it appears that the decision to use a PI threshold value of 3.0 was somewhat conservative and thus could yield some ambiguous field determinations. Figure 1 illustrates this idea for a dataset of 63 field sites having a range of relative abundance of hydrophyte species, where PI and HCI values for each site are compared. Note that a PI threshold of 3.0 would essentially define hydrophytic vegetation as needing at least 60–65% relative hydrophytic cover (not 50%) for any positive determination. Conversely, nearly all sites with a PI of 3.2 or less would satisfy the HCI rule. This example suggests that a PI threshold of about 3.2–3.3 might give fewer incorrect determinations; however, it would be difficult to redefine a prevalence-test threshold without exploring a large sample of validation datasets, and impractical to work with a fractional threshold. As an alternative, the HCI is framed to be consistent with the original concept of hydrophytic vegetation (Environmental Laboratory 1987) as having more than 50% representation of hydrophytic species.

Like the PI, the HCI presents a few practical issues. A hypothetical sample with 50% OBL cover and 50% UPL cover (however improbable in the field) would have a PI of exactly 3.0 and an HCI of exactly 50%; that sample would pass the current PI rule but fail the HCI rule. A "rounding" question also remains: does an HCI of 50.1% satisfy the "greater than 50%" rule? Examining validation datasets (as in Figure 1) could help to clarify these issues.

In summary, the two indices emphasize different aspects of vegetation data. The HCI is a metric of species relative cover, whereas the PI is a metric of the "average" species type (i.e., OBL, FACW, FAC, FACU, or UPL). Note that the scatterplot in Figure 1 truncates as relative hydrophytic cover approaches 100%. This occurs because a site with 100% hydrophytic cover could have (hypothetically) all OBL species, or all FACW species, or all FAC species. The PI can distinguish those cases, while the HCI does not. As noted by Lichvar and Gillrich, the Hydrophytic Cover Index has advantages for wetland determination situations in being a direct metric of the relative coverage of hydrophytes, thus it is simpler to understand and apply

for yes/no decisions. The Prevalence Index describes which types of species are predominant, thus it may be useful as an index of species composition in evaluations of vegetation condition for ecological or monitoring studies. ■

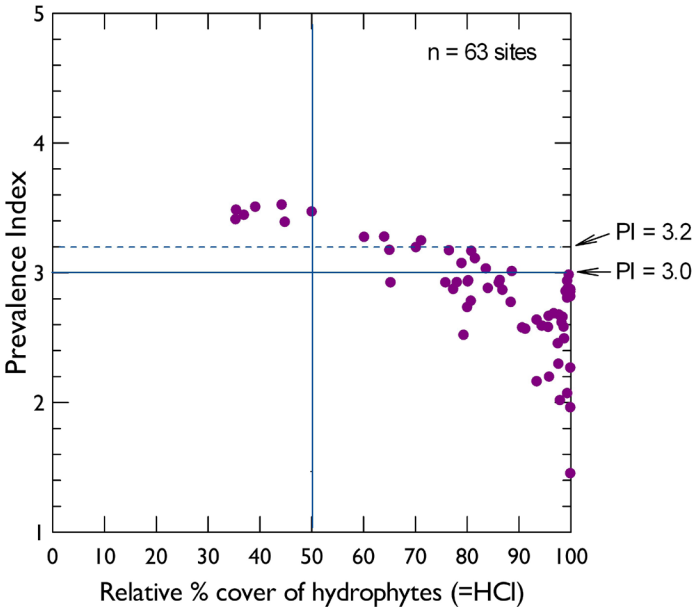

Figure 1. Values of the Prevalence Index vs. the Hydrophytic Cover Index for 63 field sites. Solid blue lines are the respective thresholds for defining hydrophytic vegetation (3.0 for the PI, 50% for the HCI); dotted blue line is for a PI threshold of 3.2. Ten sites with HCI $>$ 50% have a PI greater than 3.0, but only three have a PI greater than 3.2. All sites with HCI $\leq$ 50% have PI values $\geq$ 3.4.

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References

Environmental Laboratory. 1987. *Corps of Engineers Wetlands Delineation Manual*. Technical Report Y-87-1. Vicksburg, MS: Environmental Laboratory, US Army Corps of Engineers Waterways Experiment Station.

Lichvar, R., and J. Gillrich. 2014a. Evaluating methods for analyzing vegetation and determining hydrophytic vegetation for wetland delineation. *Wetland Science & Practice* 31(2): 9-10.

Lichvar, R.W., and J. J. Gillrich. 2014b. *Examining Discrepancies Among Three Methods Used to Make Hydrophytic Vegetation Determinations for Wetland Delineation Purposes*. ERDC/CRREL TR-14-2. Hanover, NH: US Army Engineer Research and Development Center.

National Research Council. 1995. Wetlands: characteristics and boundaries. National Academy Press, Washington, DC.

U.S. Army Corps of Engineers. 2010. *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Atlantic and Gulf Coastal Plain Region.* Eds. J.S. Wakeley, R. W. Lichvar, and C. V. Noble. ERDC/EL TR-10-20. Vicksburg MS: U.S. Army Engineer Research and Development Center.

Wentworth, T.R., G. P. Johnson, and R. L. Kologiski. 1988. Designation of wetlands by weighted averages of vegetation data: a preliminary evaluation. *Water Resources Bulletin* 24:389-396.

Wetland Ecogenomics – The Next Generation of Wetland Biodiversity and Functional Assessment

Joel F. Gibson[1], Eric D. Stein[2], Donald J. Baird[3], C. Max Finlayson[4], Xiaowei Zhang[5], Mehrdad Hajibabaei[1]**

Wetlands are among the most productive and important ecosystems on Earth, yet they have been subject to repeated and dramatic historical losses, and continue to be at risk of degradation and destruction (Millennium Ecosystems Assessment 2005; Cuiabá Declaration 2008). In coastal areas worldwide, it is estimated that 50% of salt marshes and 35% of mangroves have either been lost or degraded, with the proportion exceeding 90% in some areas, such as the West Coast of the United States (Barbier et al. 2011). Arguably, inland areas have seen more rapid and extensive attrition with an areal loss of 64-71% since 1900 (Davidson 2014). Dahl (1990) estimated that over 100 million acres (40 million ha) of wetlands were lost in the coterminous United States between the time of European settlement and 1980, mostly due to ditching, draining and conversion for agricultural purposes. In China, it is estimated that 57% of coastal wetlands and 73% of mangrove forests have been lost since the 1950s, primarily due to land reclamation and other anthropogenic impacts (Qiu 2011). Although loss rates have slowed in some countries (e.g., United States), global wetland loss continues to occur, primarily in less-developed countries (Davidson 2014). For example, 55% of newly urbanized areas in Chile between 1975 and 2000 occurred through wetland conversion (Pauchard et al. 2006). In addition to outright loss, wetland degradation continues as a function of urban and agricultural encroachment, resource extraction, excessive use, pollution, hydrologic alteration, and invasion by aggressive non-native species (Millennium Ecosystem Assessment 2005; Silliman et al. 2009). Looking to the future, climate change effects, particularly sea level rise will pose increasingly significant risks to coastal wetlands. Blankespoor et al. (2014) estimate that a 1m sea-level rise would affect 68% of coastal wetlands in 86 developing countries and territories, with extensive loss occurring in Europe and Central Asia, East Asia, and the Pacific, as well as in the Middle East and North Africa.

International multi-lateral efforts aimed at protection and restoration of wetlands and the promotion of stewardship and conservation include: a) the Ramsar Convention on Wetlands, which provides a framework for national action and international cooperation for the conservation and wise use of wetlands and their resources (McInnes 2014; Box 1) and b) the European Union's Water Framework Directive, which includes a general objective to restore functioning and biodiversity of aquatic ecosystems, with a goal of achieving 'Good Ecological Status' for rivers, lakes, and estuarine and coastal waters. In addition to multi-lateral efforts, many countries have bilateral arrangements that also seek to support the conservation of wetlands. Many individual nations have enacted programs and policies aimed at protecting and managing wetlands in a more sustainable manner. In Australia (Environment Australia 1997), wetlands policy promotes conservation, restoration, and sustainable use. Within North America, individual states, provinces, and territories have legislated to restrict wetlands loss and promote remedial and restoration actions. In China, the development of National Wetland Parks at the county level have been promoted and relevant provisions on wetland park management have been enacted.

Arguably, the hallmark of national wetland regulatory protection is the United States' Federal Clean Water Act, which aims to protect and restore the chemical, physical, and biological integrity of wetlands. Implementing regulations for the Clean Water Act stipulate a process of avoiding and/or minimizing wetland impacts to the maximum extent practicable, and compensating for all unavoidable losses. The Clean Water Act, along with other federal and state regulations, promotes dual goals of short-term no net loss of wetlands and long-term gains in wetlands.

Each of the national and international wetland polices includes language relating to the protection and restoration of not only wetland area, but also wetland functions, values, and services. Despite this universal tenet, no program prescribes *specific* methods for assessing such functions and values, leading to a plethora of options for conducting such assessments.

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Assessing Wetland Ecosystem Functions and Services

Literally hundreds of functional assessment methods have been used in wetlands over the past 30 years (e.g., Bartoldus 1999, Carletti et al. 2004). Functions generally describe the fundamental ecological processes that occur in wetlands (Novitsky et al. 1996; Smith et al. 1995), whereas services specifically refer to ecosystem attributes and processes that support the well-being of human populations (Costanza 2000, MEA 2005). Often, the distinction between functions and services is blurred and, as a result, assessments almost invariably include elements of both function and service evaluation (Table 1). Since functions and services generally involve processes occurring over time, their evaluation requires repeated measurements to quantify process rates. Despite this, most wetland assessment methods measure a combination of cultural, physical, and biological attributes at a single moment in time, providing a snapshot of the status of a wetland that is used to *infer* the degree, or capacity, to which certain functions or services are being performed. To date, an efficient and robust approach to measuring actual functions or services remains one of the most desired, yet elusive goals in wetland management.

Box 1

The Ramsar Convention on Wetlands

The Ramsar Convention on Wetlands has designated over 1,900 wetlands on its List of Wetlands of International Importance. These wetlands are found in 160 different nations and total over 186 million hectares. As a part of its Strategic Plan for 2009-1015, the Ramsar Convention outlined a number of strategies to achieve its overarching goal of ensuring the Wise Use of wetlands (Ramsar Convention Secretariat 2010). These strategies include "wetlands inventory and assessment", "global wetland information", "science-based management of wetlands", "wetland restoration", and "control of invasive alien species" in order to maintain the ecological character of all wetlands. Each of the strategies proposed by this international body require large volumes of high-resolution biodiversity data.

In particular, ecogenomics can contribute to the requirements under the Convention to list wetlands of international importance based on the composition and abundance of their biodiversity, as well as tools to assess changes in the ecosystem functions and biogeochemical processes that support the biodiversity and the ecosystem services that they provide. The absence of adequate data on the biodiversity and functions and processes that characterize wetlands is seen as a major limitation on maintaining their ecological character, including measuring the success of restoration efforts.

Table 1: Commonly assessed wetland services (left) and functions (right). Although developed somewhat independently, there is substantial overlap between functions and services.

Wetland Ecosystem Services (MEA 2005, Barbier et al. 2011)	**Wetland Functions (Smith et al. 1995, Novitsky et al. 1996)**
Provisioning Services Food production Fresh water storage and retention Fiber and fuel production Biochemical extraction of medicines and other materials Genetic materials	**Functions associated with Water Quality Improvement** Removal/transformation of nutrients Removal of metals and toxic organics Removal of sediment
Regulating Services Source of and sink for greenhouse gases, carbon sequestration Water regulation (hydrological flows) groundwater recharge/discharge Water purification and waste treatment retention Erosion regulation, retention of soils and sediments Natural hazard regulation flood control, storm protection, coastal erosion Pollination- habitat for pollinators	**Functions associated with Habitat** Habitat for plant communities Invertebrate species habitat Vertebrate species habitat Maintenance of wildlife diversity and abundance Support primary production and export
Cultural Services Spiritual and inspirational source Recreational and tourism opportunities Aesthetic values Educational opportunities	**Functions associated with Hydrology/Water Quantity** Reduction in peak flows Decrease in downstream erosion, sediment stabilization Maintenance of low flows to streams during dry season Ground water and aquifer recharge
Supporting Services Soil formation sediment retention and accumulation of organic matter Nutrient cycling storage, recycling, processing, Fisheries maintenance	

Although simple in concept, functional assessment is a challenging proposition. Existing structural measures remain limited in scope, and do not fully reflect the dynamic processes that occur in wetlands. By nature, wetlands are temporally variable and spatially heterogeneous largely due to variations in biotic communities and hydrologic conditions that can fluctuate over diel, tidal, seasonal, inter-annual, and decadal time scales. Many assessment methods rely on measurement of "characteristic" or "diagnostic" plant or animal communities, such as plants, amphibians, fish, birds, or invertebrates as indicators of condition. Despite their utility and some success at large scales, surveys of multiple taxonomic groups across ecosystems have suggested that no single group can be used effectively to predict variation in the biodiversity of other taxonomic groups, thereby undermining the assumptions of indicator taxa as measures of overall ecosystem condition or function (Heino 2010; Mandelik et al. 2012). Moreover, many groups involved in the performance of key functions (e.g., microbial assemblages) are poorly captured in conventional assessments, as no simple, practical methods exist for their observation and quantification of their functional attributes.

Advances in wetland functional assessment depend on our ability to develop tools that can capture the trophic interactions, food web complexity/diversity, and biogeochemical processes that drive wetland health/condition. These tools should support routine application in a consistent and repeatable manner so that they can be easily incorporated into regulatory and management programs. They must be relatively simple and inexpensive to facilitate their application at scales that capture spatial and temporal patterns in wetland condition. In addition, they should be taxonomically and phylogenetically more 'complete', extending beyond a limited number of indicator taxa.

Wetland Ecogenomics

Existing and newly developed molecular tools provide promise for fulfilling the needs for "next generation wetland functional assessment." The use of standardized DNA sequence markers – DNA barcodes – has become a common, standard practice in many areas of biodiversity assessment (Hajibabaei et al. 2007a, 2007b). Customized, public databases of DNA barcodes and other marker gene sequences (e.g., BOLD, GenBank) contain representative DNA barcodes for hundreds of thousands of animal, plant, fungal, and microbial taxa. Comparison of DNA barcodes recovered from unidentified specimens can be used to provide species-level identification for a wide range of organisms. In addition to DNA barcode regions, molecular methods have also been employed to investigate functional gene regions of both prokaryotes and eukaryotes (Pujolar et al. 2012; Mason et al. 2012).

Next-generation sequencing (NGS) has been established as a powerful and practical means for generating millions of DNA sequences across broad phylogenetic groups from bulk environmental samples (Hajibabaei et al. 2011; Shokralla et al. 2012; Gibson et al. 2014; Shokralla et al. 2014). This use of NGS to extract DNA sequence data for biodiversity analysis from mixed environmental samples has been termed metasystematics (Hajibabaei 2012). The types of environmental samples that have been employed in metasystematic research include organisms such as benthic invertebrates (Hajibabaei et al. 2011), terrestrial insects (Gibson et al. 2014), and diatoms (Kermarrec et al. 2014).

Table 2: Potential ecogenomic approaches that could be used to assess various wetland functions

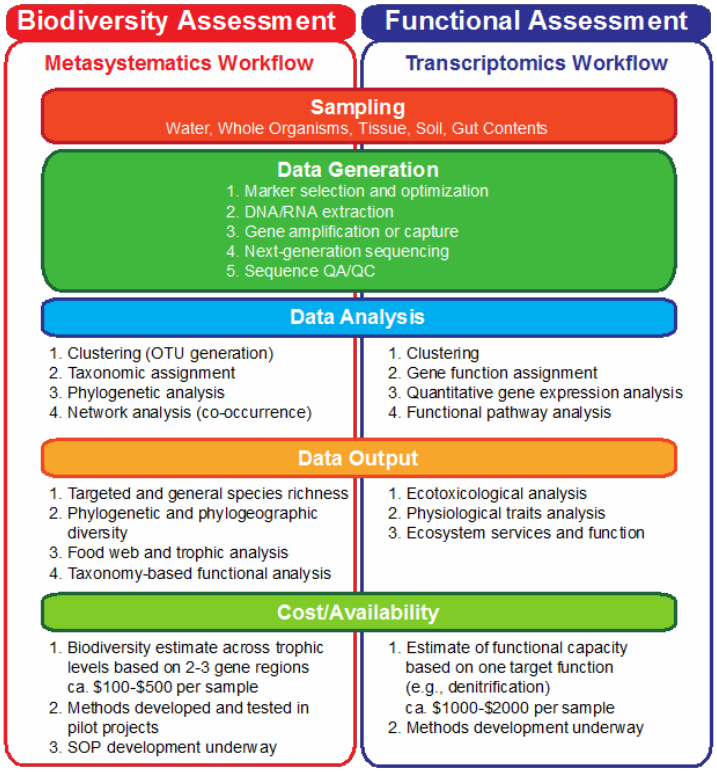
Wetland Functions (Smith et al. 1995, Novitsky et al. 1996)	**Potential Wetland Ecogenomics Assessment Approach**
Functions associated with Water Quality Improvement	
Removal/transformation of nutrients	Microbial diversity; functional gene and metatranscriptome expression
Removal of metals and toxic organics	Microbial diversity; active microbial community
Removal of sediment	Detection of presence of sediment tolerant or intolerant taxa
Functions associated with Habitat	
Habitat for plant communities	Plant diversity via tissues or propagules
Invertebrate species habitat	Invertebrate diversity
Vertebrate species habitat	Vertebrate diversity via tissue or eDNA
Maintenance of wildlife diversity and abundance	Pan-taxonomic diversity and/or phylogenetic diversity
Support primary production and export	Microbial and plant diversity
Functions associated with Hydrology/Water Quantity	
Reduction in peak flows	Detection of taxa adapted to specific flow or inundation conditions
Decrease in downstream erosion, sediment stabilization	Detection of presence of sediment tolerant or intolerant taxa
Maintenance of low flows to streams during dry season	Detection of taxa adapted to specific flow or inundation conditions
Ground water and aquifer recharge	

Other metasystematic studies have been able to extract DNA from fluids such as ethanol preservative used for sampling benthic invertebrates (Hajibabaei et al. 2012) and filtered water samples (Pilliod et al. 2013; Turner et al. 2014). The use of any of these sources of environmental DNA (or eDNA) includes extracting cellular-bound or exogenous DNA from a water or tissue sample as way of capturing information about resident organisms or processes occurring in a wetland.

The integration of NGS, eDNA, and metasystematics for wetland assessment we term "***wetland ecogenomics***." Wetland ecogenomics is already opening new avenues for wetland assessment by allowing for efficient assessment of multiple trophic levels, functional genes, and taxonomically comprehensive community composition as measures of wetland function. Example applications of wetland ecogenomics for wetland assessment include the following (Table 2):

- Evaluation of trophic complexity and food web energetics through reconstruction and observation of community composition across multiple trophic levels from primary producers to top consumers (Peralta et al. 2010).
- Overall biodiversity assessment (from microbes to mammals) through cataloguing richness and phylogenetic diversity in multiple taxa and functional guilds simultaneously.
- Development of advanced bioassessment tools through improved taxonomic resolution that allows identification of taxa sensitive to specific environmental stressors (e.g., Dafforn et al. 2014). This may also facilitate use of trait-based assessment through either species identification or direct measure of functional genes.

Figure 1: Wetland ecogenomics workflow for biodiversity and functional assessment



- Rapid detection of target species of interest, such as invasive species, species of primary management interest, or sensitive, rare, threatened, or endangered species (Zhan et al. 2013).
- Direct evaluation of the effects of changes in water quality. Microbial communities may be highly sensitive to even small fluxes of contaminants in the environment (Sims et al. 2013; Gardham et al. 2014).
- Measurement of the putatively active community (via RNA) and/or the ratio of relative abundance of RNA to DNA. Capture of the active microbial community using a 16S rRNA approach provides significant information about the potential activity of the microbial community in glacier-fed streams (Wilhelm et al. 2014). Such approaches could also be applied in other wetland communities, including phytoplankton and zooplankton.
- Measurement of ecosystem functions and biogeochemical process, such as denitrification, sulfate reduction, or methanogenesis and methanotropy. This may occur through either measurement of microbial communities responsible for these processes or through detection of functional genes that indicate the level to which these processes are occurring (Eaton et al. 2011, 2012).
- Linkage of high-resolution biodiversity information with stable isotope and observational data to delineate food web structure (e.g., Gray et al. 2014).

Future Prospects

Wetland ecogenomics provides a potential new frontier in assessment of wetland functions and biodiversity. A number of stages are necessary for the successful implementation of an ecogenomic approach to wetland research (Figure 1; Box 2). Further operational implementation of ecogenomic approaches will require additional development and testing of each of these stages. Based on Bohmann et al. 2014 and Rees et al. 2014, some specific technical issues that must be addressed include:

- Refining wetland sampling methods to be both field-efficient and DNA-friendly.
- Automating the bioinformatics process with tools and methods for consistent and easily applied data processing.
- Improving methods to minimize false positives and pseudo-absences.
- Developing approaches to recover biomass and/or abundance information from bulk DNA samples.
- Cataloguing and understanding the processes and variables that affect eDNA half-life and persistence in the environment.
- Improving our understanding of the dispersive properties of eDNA in various environments and partitioning between different environmental compartments (e.g., soil vs. water).
- Building and populating reference libraries to support assignment of taxonomic names to DNA sequences.

- Revising the conceptual approach to ecological reference definitions and index construction to incorporate the use of operational taxonomic units as opposed to (or in addition to) Linnaean taxonomy.

Wetlands have been consistently undervalued by society, and, arguably, this indicates a failure on the part of advocates of wetland conservation to present a convincing policy case for their protection, coupled with the reluctance of governments to implement international commitments for wetland conservation and wise use (Finlayson 2012). Part of the challenge in developing compelling policy arguments to support wetland protection is the sheer diversity of reasons motivating conservation practitioners, which are often in conflict. For example, wetlands are unique reservoirs of biodiversity, yet they are also valued for their ability to filter or otherwise retain contaminants in situ - yet it is unclear how these two conflicting goals can be easily reconciled (Baird et al. 1995). Clearly, we need to greatly improve our understanding both of the capacities of wetlands to regulate and support societal conservation and environmental management goals, while also protecting their ability to provide ecosystem services without significant degradation of their key ecological functions, and supporting biodiversity structure. The Ramsar Convention on Wetlands has developed structures and guidance for the wise use of wetlands in support of these goals (Finlayson et al. 2011), but the success of implementation measures at a national level is questionable (Finlayson 2012). Wetland ecogenomics can provide an appropriate set of tools to establish a new, systematic approach to wetlands functional assessment. This, in turn, offers the possibility to develop a more focused wetlands conservation research paradigm, where specific wetland management options can be evaluated using a knowledge-based framework, constructed on a more holistic understanding of how the various biodiversity components and their functions support key wetland functions and service. High-throughput genomics can provide access to rapid, dynamic information on the deep structure of wetland communities - particularly those areas of 'dark diversity' that until now have proved resistant to practical observation. What is even more exciting is the prospect of linking these structural observations to broad-scale observations of function at the assemblage level - made possible by functional transcriptomics. While these methods are currently in their infancy, their potential to revolutionize wetlands observation, and to support science-based policy for wetlands management is clear.

Box 2

Continuing the Wetland Ecogenomics Discussion at SWS 2015 in Providence

A series of events will be included in the program of the SWS Annual meeting to be held in Providence, RI, May 31-June 4, 2015. Please make plans to join us for both to continue our shared progress on the development of these technologies.

"Incorporating Genomic Technologies into Wetland Research"
Sunday, May 31st, 1-5pm
This workshop, conducted by the authors and other collaborators, will introduce participants to the essential components of a genomics-based wetlands research and monitoring program. The goal of the workshop will be to assist participants in operationalizing their own plans for genomic research and monitoring of wetlands. Please see the meeting website (swsannualmeeting.org) for registration and location details. Pre-registration will be required for this event.

"Monitoring and assessing changing wetlands using new genomic tools"
Date and time TBA
This symposium, co-chaired by the authors, will cover ongoing uses of genomic technologies to investigate changing wetland conditions. The talks included in this symposium will present results from research in wetland genomics, as conducted in wetland systems from the Arctic to the tropics. Participation in this event is included in your meeting registration. Please come to hear these fascinating talks and join in the discussion.

References

Baird, D.J., Finlayson, C.M. and Camilleri, C. 1995. Ecological impacts of contaminants on wetlands: towards a relevant method of risk assessment. In C.M. Finlayson (editor). *Wetland Research in the Wet-Dry Tropics of Australia.* Supervising Scientist Publications, Commonwealth of Australia. pp. 242-246.

Barbier, E.B., Hacker, S.D., Kennedy, C., Koch, E.W., Stier, A.C. and Silliman, B.R. 2011. The value of estuarine and coastal ecosystem services. *Ecological Monographs* 81(2):169–193.

Bartoldus, C.C. 1999. *A comprehensive review of wetland assessment procedures: A guide for wetland practitioners.* St. Michaels, Maryland: Environmental Concern, Inc.

Blankespoor, B., Dasgupta, S. and Laplante, B.. 2014. Sea-level rise and coastal wetlands. *Ambio* 43(8):996-1005.

Bohmann, K., Evans, A., Thomas, M., Gilbert, P., Carvalho, G.R., Creer, S., Knapp, M., Yu, D.W. and de Bruyn, M. 2014. Environmental DNA for wildlife biology and biodiversity monitoring. *Trends in Ecology & Evolution* 29(6):358-367.

Carletti, A., De Leo, G.A. and Ferrari, I. 2004. A critical review of representative wetland rapid assessment methods in North America. *Aquatic Conservation-Marine and Freshwater Ecosystems* 14:S103-S113.

Costanza, R. 2000. Social goals and the valuation of ecosystem services. *Ecosystems* **3**:4–10.

Cuiabá Wetlands Declaration. 2008. *Wetland Science and Practice* 25:20-23.

Dafforn, K.A., Baird, D.J., Chariton, A.A., Sun, M.Y., Brown, M.V., Simpson, S.L., Kelaher, B.P. and Johnston, E.A. 2014. Faster, higher and stronger? The pros and cons of molecular faunal data for assessing ecosystem condition. *Advances in Ecological Research* 51:1-40.

Dahl, T.E. 1990. *Wetlands losses in the United States 1780's to 1980's.* Washington, D.C.: U.S. Department of the Interior, Fish and Wildlife Service, 13 pp.

Davidson, N.C. 2014. How much wetland has the world lost? Long-term and recent trends in global wetland area. *Marine and Freshwater Research* 65(10): 934-941.

Eaton, W.D., McDonald, S., Roed, M., Vandecar, K.L., Hauge, J.B. and Barry, D. 2011. A comparison of nutrient dynamics and microbial community characteristics across seasons and soil types in two different old growth forests in Costa Rica. *Tropical Ecology* 52:35-48.

Eaton, W.D., Anderson, C., Saunders, E.F., Hauge, J.B. and Barry, D. 2012. The impact of *Pentaclethra macroloba* on soil microbial nitrogen fixing communities and nutrients within developing secondary forests in the Northern Zone of Costa Rica. *Tropical Ecology* 53:207-214.

Environment Australia. 1997. *Wetlands policy of the Commonwealth of Australia*. Canberra, Australia.

Finlayson, C.M., Davidson, N., Pritchard, D., Milton, G.R. and MacKay, H. 2011. The Ramsar Convention and ecosystem-based approaches to the wise use and sustainable development of wetlands. *Journal of International Wildlife Law and Policy* 14:176-198.

Finlayson, C.M. 2012. Forty years of wetland conservation and wise use. *Aquatic Conservation: Marine and Freshwater Ecosystems* 22:139-143.

Gardham, S., Hose, G.C., Stephenson, S. and Chariton, A.A. 2014. DNA metabarcoding meets experimental ecotoxicology: advancing knowledge on the ecological effects of copper on freshwater ecosystems. *Advances in Ecological Research* 51:79-104.

Gibson, J., Shokralla, S., Porter, T.M., King, I., van Konynenburg, S., Janzen, D.H., Hallwachs, W. and Hajibabaei, M. 2014. Simultaneous assessment of the macrobiome and microbiome in a bulk sample of tropical arthropods through DNA metasystematics. *Proceedings of the National Academy of Science USA* 111: 8007-8012.

Gray C., Baird, D.J., Baumgartner, S., Jacob, U., Jenkins, G.B., O'Gorman, E., Lu, X., Ma, A., Pocock, M.J.O., Schuwirth, N., Thompson, M. and Woodward, G. 2014. Ecological networks: the missing links in biomonitoring science. *Journal of Applied Ecology* 51:1444-1449.

Hajibabaei, M. 2012. The golden age of DNA metasystematics. *Trends in Genetics* 28:535-537.

Hajibabaei, M., Singer, G.A., Clare, E.L. and Hebert, P.D.N. 2007a. Design and applicability of DNA arrays and DNA barcodes in biodiversity monitoring. *BMC Biology* 5:24.

Hajibabaei, M., Singer, G.A.C., Hebert, P.D.N. and Hickey, D.A. 2007b. DNA barcoding: how it complements taxonomy, molecular phylogenetics and population genetics. *Trends in Genetics* 23:167-172.

Hajibabaei, M., Shokralla, S., Zhou, X., Singer, G.A.C. and Baird, D.J. 2011 Environmental barcoding: a next-generation sequencing approach for biomonitoring applications using river benthos. *PLoS One* 6:e17497.

Hajibabaei, M., Spall, J.L., Shokralla, S., and van Konynenburg, S. 2012. Assessing biodiversity of a freshwater benthic macroinvertebrate community through nondestructive environmental barcoding of DNA from preservative ethanol. *BMC Ecology* 12:28.

Heino, J. 2010. Are indicator groups and cross-taxon congruence useful for predicting biodiversity in aquatic ecosystems? *Ecological Indicators* 10(2):112-117

Kermarrec, L., Franc, A., Rimet, F., Chaumeil, P., Frigerio, J.-M., Humbert, J.-F. and Bouchez, A. 2014. A next-generation sequencing approach to river biomonitoring using benthic diatoms. *Freshwater Science* 33:349-363.

Mandelik, Y., Dayan, T., Chikatunov, V. and Kravchenko, V. 2012. The relative performance of taxonomic vs. environmental indicators for local biodiversity assessment: a comparative study. *Ecological Indicators* 15:171-180.

Mason, O.U., Hazen, T.C., Borglin S., et al. 2012 Metagenome, metatranscriptome and single-cell sequencing reveal microbial response to Deepwater Horizon oil spill. *The ISME Journal* 6:1715-1727.

McInnes, R.J. 2014. The Ramsar Convention and SWS – delivering wetland conservation at a global level. *Wetland Science & Practice* 31(4):12-16.

Millenium Ecosystem Assessment. 2005. *Ecosystems and Human Well-Being: Wetlands and Water Synthesis*. Millennium Ecosystem Assessment Series. Washington DC: World Resources Institute. 68 pp.

Novitski, R.P., Smith, R.D. and Fretwell, J.D. 1996. Wetland functions, values, and assessment. In J.D. Fretwell, J.S. Williams and P.J. Redman (editors). National Water Summary on Wetland Resources, USGS Water-Supply Paper 2425. Washington DC: U.S. Department of the Interior, U.S. Geological Survey. pp. 79-86.

Pauchard, A., Aguayo, M., Pena, E. and Urrutia, R. 2006. Multiple effects of urbanization on the biodiversity of developing countries: The case of a fast-growing metropolitan area (Concepcion, Chile). *Biological Conservation* 127(3):272-281

Peralta, A.L., Matthews, J.W. and Kent, A.D. 2010. Microbial community structure and denitrification in a wetland mitigation bank. *Applied and Environmental Microbiology* 76(13):4207–4215

Pilliod, D.S., Goldberg, C.S., Arkle, R.S., Waits, L.P. and Richardson, J. 2013. Estimating occupancy and abundance of stream amphibians using environmental DNA from filtered water samples. *Canadian Journal of Fisheries and Aquatic Sciences* 70:1123-1130.

Pujolar, J.M., Marino, I.A.M., Milan, M., et al. 2012. Surviving in a toxic world: transcriptomics and gene expression profiling in response to environmental pollution in the critically endangered European eel. *BMC Genomics* 13:507.

Qiu, J.N. 2011. China faces up to 'terrible' state of its ecosystems. *Nature* 471(7336):19.

Ramsar Convention Secretariat. 2010. *The Ramsar Strategic Plan 2009-2015: Goals, strategies, and expectations for the Ramsar Convention's implementation for the period 2009 to 2015*. Ramsar Handbooks for the Wise Use of Wetlands, 4th edition, vol. 21. Ramsar Convention Secretariat, Gland, Switzerland.

Rees, H.C., Maddison, B.C., Middleditch, D.J., Patmore, J.R.M. and Gough, K.C. 2014. The detection of aquatic animal species using environmental DNA – a review of eDNA as a survey tool in ecology. *Journal of Applied Ecology* 51:1450–1459.

Shokralla, S., Spall, J.L., Gibson, J.F. and Hajibabaei, M. 2012. Next-generation sequencing technologies for environmental DNA research. *Molecular Ecology* 21:1794-1805.

Shokralla, S., Gibson, J.F., Nikbakht, H., Janzen, D.H., Hallwachs, W. and Hajibabaei, M. 2014. Next-generation DNA barcoding: using next-generation sequencing to enhance and accelerate DNA barcode capture from single specimens. *Molecular Ecology Resources* 14:892-901.

Silliman, B.R., Grosholz, T. and Bertness, M.D. 2009. Salt marshes under global siege. In B.R. Silliman, T. Grosholz and M.D. Bertness (editors). *Human impacts on salt marshes: a global perspective*. Berkeley, CA: University of California Press. pp. 103-114.

Sims. A., Zhang, Y., Gajaraj, S., Brown, P.B. and Hua, Z. 2013. Toward the development of microbial indicators for wetland assessment. *Water Research* 47:1711-1725

Smith, R.D., Ammann, A., Bartoldus, C. and Brinson, M.M. 1995. *An approach for assessing wetland functions using hydrogeomorphic classification, reference wetlands and functional indices*. Technical Report TR-WRP-DE-9, Waterways Experiment Station, Army Corps of Engineers, Vicksburg, MS. http://www.wes.army.mil/ el/wetlands/pdfs/wrpde9.pdf.

Turner, C.R., Barnes, M.A., Xu, C.C.Y., Jones, S.E., Jerde, C.L., Lodge, D.L. and Gilbert, M. 2014. Particle size distribution and optimal capture of aqueous macrobial eDNA. *Methods in Ecology and Evolution* 5:676-684.

Wilhelm, L., Besemer, K., Fasching, C., Urich, T., Singer, G. A., Quince, C., and Battin, T.J. 2014. Rare but active taxa contribute to community dynamics of benthic biofilms in glacier-fed streams. *Environmental Microbiology* 16(8):2514-2524.

Zhan, A., Hulák, M., Sylvester, F., et al. 2013. High sensitivity of 454 pyrosequencing for detection of rare species in aquatic communities. *Methods in Ecology and Evolution* 4:558-565.

This section is intended to inform readers about ongoing wetland research by various universities, government agencies, NGOs and others. When studies are completed, WSP invites short articles that address key findings, while more technical papers are submitted to Wetlands or other peer-reviewed journals. Researchers interested in posting short or more detailed summaries of their investigations are encouraged to contact the WSP editor (please include "WSP Research News" in the email subject box).

This issue highlights research and related wetland activities at Old Dominion University, Norfolk, Virginia. Special thanks to Frank Day for assembling this contribution. Also see monthly issues of *Wetland Breaking News* for news clips on wetland research (http://www.aswm.org/news/wetland-breaking-news/892-current-issue#science).

Coastal freshwater/brackish marshes as blue carbon ecosystems.
Wetlands play an important role in global carbon sequestration. Carbon sequestered in tidal systems has been termed "blue carbon" and most of the research in this area has focused on sea grass beds, mangrove communities, and salt-water marshes. On the barrier islands along the Atlantic seaboard, freshwater/brackish marshes are common in the interdunal swales. The water within these marshes is fresh much of the time, but they receive salt-water input from storm and overwash events. We are quantifying the carbon budgets in these marshes on Hog Island (Virginia Coast Reserve LTER Site) to evaluate their potential role as "blue carbon" ecosystems. Emily Adams and Nathan Sedghi are compiling an initial carbon budget for these marshes. Contact: Frank Day, fday@odu.edu

State change thresholds across a dune/swale landscape.
The landscape on a barrier island can be quite varied with regard to system states, which consist primarily of forested and grass dominated dunes and interdunal swale marshes and shrub thickets. We are attempting to characterize state transitions across the barrier island landscape and quantify factors that mediate these transitions. The fluctuating groundwater free surface, as well as accretion and erosion of these islands, can lead to substantial ecological changes. We are studying various ecosystem processes along a swale wetland to dune upland transect in an attempt to determine thresholds of change. Matt Smith is currently looking at belowground root decomposition rates along this wetland to upland gradient. Contact: Frank Day, fday@odu.edu

Carbon storage in tidally influenced bald cypress swamps in the Mid-Atlantic region.
Bald cypress (*Taxodium distichum*) occurs near its northern limit on Virginia's coastal plain. Bald cypress swamps improve water quality within the Chesapeake Bay watershed by reducing erosion and trapping sediments and nutrients. Bald cypress regeneration and productivity are greatly influenced by hydrology. Also, productivity at the northern and southern limits of community ranges are typically less than that found midrange. Sea level rise and changes in the frequency of flood pulses and the duration of inundation associated with global climate change are expected to have substantial impacts on these communities. Leah Gibala-Smith is estimating productivity of bald cypress in two of Virginia's tidal bald cypress communities, a southern, wind-driven tidal bald cypress forest and a northern lunar tidal bald cypress forest. Contact: Leah Gibala-Smith, leahgibala@hotmail.com

Hydrogeological factors that influence pitcher plant bog viability.
Working in the Joseph Pines Preserve in Sussex County, Virginia, John McLeod evaluated the long-term viability of groundwater flow to pitcher plant bogs in this Coastal Plain setting. The stratigraphic and topographic position of thick clay beds within the sand and clay beds beneath the watershed controlled spring locations. Within the managed long-leaf pine savanna at the 80 hectares Preserve, water withdrawal by plants is approximately half that which occurs in adjacent loblolly pine forests. Model results suggest that spring flow during single dry or very dry years will probably provide sufficient water to sustain the bog, but multiple drought years may not. This project is supported by Wetland Studies and Solutions, Inc. (WSSI). Contact: Rich Whittecar, (rwhittec@odu.edu)

Groundwater contributions to toe-slope wetlands.
Working in the crystalline Piedmont of central Virginia with WSSI, Kerby Dobbs evaluated the stratigraphy and hydrology of two toe-slope wetlands at the edges of valley bottoms. Mill pond deposits and other historical legacy sediments strongly control flow paths at these two sites. Dobbs concluded groundwater seepage from saprolite-dominated hillsides can be significant, typically ranging between 20-40% depending upon annual and seasonal hydrology. He also determined that the Effective Monthly Recharge (W_{em}) calculations and the overall package of wa-

ter-budgeting tools embedded in the new Wetbud software accurately estimated water levels in the wetlands. Contact: Rich Whittecar, (rwhittec@odu.edu)

Hydrogeologic variations across a barrier island that influence the hydrology of interdunal wetlands.
False Cape State Park, southeastern Virginia, contains several wetlands in interdunal swales. Matthew Richardson's analyses of annual-scale groundwater variations using a MODFLOW-based package showed that the height of the asymmetric freshwater lens depended mostly upon spatial variation in permeability and recharge. Synthetic hydrographs developed from weather data using W_{em} calculations indicate that the swales have experienced wetland hydrology nearly every year since 1983. Contact: Rich Whittecar, (rwhittec@odu.edu)

Hydrology of wetlands in northern Virginia.
Two ongoing projects in northern Virginia are testing the applicability of the Wetbud package developed with the support of WSSI and in cooperation with Virginia Tech faculty and students. Stephen Stone is working at Huntley Meadows Park in Alexandria to model the effects upon the surrounding wetlands of elevated water levels in the central pond. He will also be comparing results of ET estimates made from diurnal water table fluctuations with Bowens Ratio estimates made in the central wetland. Ben Hiza is studying the hydrogeologic controls on the wetlands in the Julie J. Metz Wetlands Bank along tidal Neabsco Creek. Contact: Rich Whittecar, rwhittec@odu.edu

Ecology of Isoetes in the southeastern United States.
Peter Schafran continues his doctoral research on the evolution and ecology of the genus *Isoetes* in the southeastern United States. This region has suffered severe insults to its hydrology for 200 years allowing formerly isolated taxa to occupy new habitats and hybridize. As a result, there is extensive reticulate evolution in the group with some species rapidly expanding their range while others adapted to pristine habitats have shrinking populations and even face extirpation. Contact: Lytton Musselman, lmuselm@odu.edu

Wetland restoration in Tidewater Virginia.
In collaboration with the Elizabeth River Project, the Kaplan Orchid Conservatory is propagating wetland species to be used in restoring communities along the Elizabeth River. Contact: Marcus Jones, m1jones@odu.edu

Development of wetland delineation videos.
As a member of the National Technical Committee on Wetland Vegetation, Lytton Musselman has been working with the committee on the development of short instructional videos to help wetland delineators evaluate vegetation to identify wetlands and establish their boundaries. This is under the aegis of the U S Army Corps of Engineers; the videos will be posted on YouTube. Contact: Lytton Musselman, lmusselm@odu.edu

Riverine vegetation in Brunei.
In Brunei Darussalam Lytton Musselman is part of an expedition surveying pristine rainforest habitat, including riverine vegetation, in the Keraja region that is being considered as a rainforest preserve. This work is through the Institute of Biodiversity and Environmental Research of the Universiti Brunei Darussalam and supported in part by a Fulbright award. Related work in Brunei includes research on the biology of parasitic plants associated with the wetlands in the karangas vegetation, a highly threatened coastal forest. Contact: Lytton Musselman, lmusselm@odu.edu

Fruiting biology of cane.
Like many bamboos, cane (*Arundinaria tecta*) fruits once then dies. During the past few years there has been two fruiting incidents, the first recorded for the region in over a century. We are monitoring the establishment of seedlings from this fruiting in the Great Dismal Swamp National Wildlife Refuge. Contact: Lytton Musselman, lmusselm@odu.edu

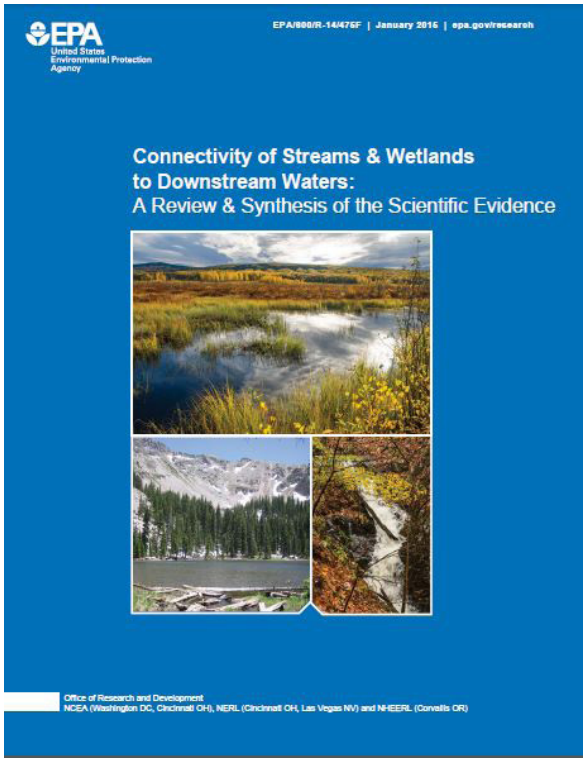
Population genetics of mosquitofish in southeastern United States wetlands.
The two most common and aggressive species of mosquitofish in North American wetlands are the eastern mosquitofish (*Gambusia holbrooki*) and the western mosquitofish (*G. affinis)*. Even though these two species can interbreed and are nearly indistinguishable in appearance, previous work has suggested that *G. holbrooki* have more advantageous life-history traits when compared to *G. affinis* and may be expanding their range westward past Mobile Bay (Alabama) which has long been considered a division between the two species. We intend to use microsatellites and fin ray counts to determine if populations west of Mobile Bay are now dominated by *G. holbrooki*, due to their ability to outcompete *G. affinis*. An invasion of *G. holbrooki* into western wetlands surrounding the Gulf of Mexico may have important evolutionary and conservation ramifications for native species. Contact: Rebecca Walawender, rwilk010@odu.edu ■

EPA Finalizes Report on Connectivity of US Waters

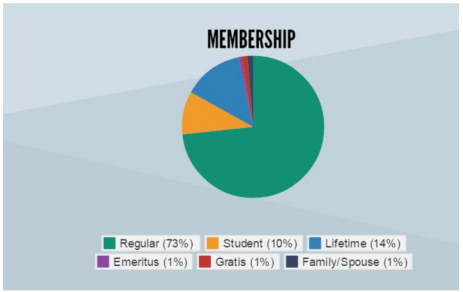
The Environmental Protection Agency's (EPA) Office of Research and Development (ORD) has published a science report entitled "Connectivity of Streams and Wetlands to Downstream Waters: A Review and Synthesis of the Scientific Evidence." The report summarizes the current scientific understanding about the connectivity and mechanisms by which streams and wetlands affect the physical, chemical, and biological integrity of downstream waters. The report addresses three main questions related to connectivity:

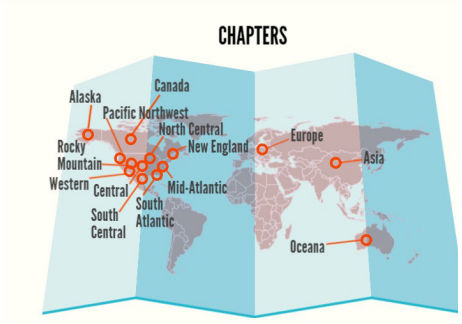
1. What are the physical, chemical, and biological connections to, and effects of,ephemeral, intermittent, and perennial streams on downstream waters?
2. What are the physical, chemical, and biological connections to, and effects of,riparian or floodplain wetlands and open waters on downstream waters?
3. What are the physical, chemical, and biological connections to, and effects of,wetlands and open waters in non-floodplain settings on downstream waters?

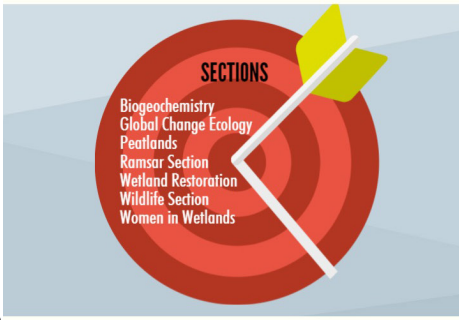
The findings can be used to inform policy and regulatory decisions, including the proposed Clean Water Rule being developed by EPA's Office of Water and the U.S. Army Corps of Engineers. The report may be downloaded at http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=296414. ■

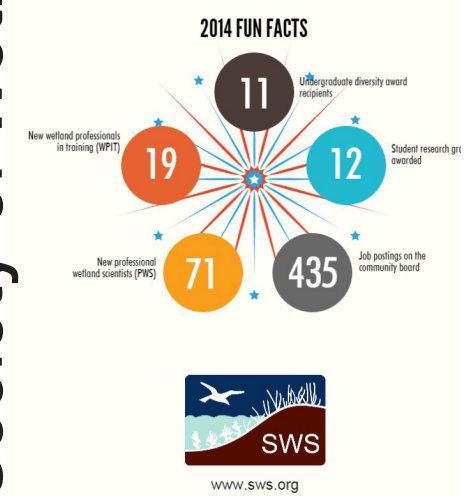


Society of Wetland Scientists BY THE NUMBERS









The following are a list of some new and recent publications (2013-2014) that may be of interest. The latest entries are marked by an asterisk. If you know of others please send the information to the WSP Editor for inclusion in future editions of Wetland Science and Practice.

BOOKS

- 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

- 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

- 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

- 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

The following is a list of journals and newsletters that contain material on wetlands. If you have additions to recommend, please send the name and links to the WSP editor.

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 **at sws.org**.

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

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.