wetland science & practice

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FROM THE EDITOR'S DESK

It's been a busy time for me over the past months as it probably has for many of you. Getting field work done before the onset of winter while trying to also ready things on the home front for cold weather (e.g., putting wood up in the shed and getting other wood ready for cutting and splitting). On my drive back from New Jersey last night (November 13), I encountered the first real sign of winter – a light snow that could be seen when the headlights were on high. Nothing was sticking to the ground yet but by morning there was a thin blanket of snow over the ground. My NJ work involved revisiting permanent plots established in 2009 to monitor long-term changes in sea-level rise. Since then Hurricane Sandy came through and had a significant impact on the vegetation of some plots (I'll report on my findings in a future issue of *Wetland Science and Practice*).

Ralph Tiner
WSP Editor

We've been getting more interest in submission of articles for WSP. In this issue, you'll find papers presenting the results of studies involving changes in a neighboring forested wetland from the use of rapid infiltration beds intended to improve local water quality (Koning and Bell), an assessment of wetlands in a Lake Ontario embayment (Gefell and others), and the use of kites for acquiring aerial photos (Andresen and others). The December issue also includes an article by Rob McInnes about the RAMSAR Convention and international wetland conservation inviting SWS members to contribute to the cause, letters from the SWS and the Consortium of Aquatic Science Societies to EPA on the proposed definition of "waters of the US," and another article presenting an example of an outstanding personal commitment to wetland conservation by Paul and Cathy Keddy. In the research section, we have the first student profile describing Wes Hudson's project examining restoration of forested wetlands in Virginia and outlines of two research projects in Mexico by Carlos Troche.

With the New Year approaching, we often reflect on the past year and set goals for the next. You might have completed a project with findings that would be of interest to SWS members, so please consider writing a summary of your work or observations for a 2015 issue of WSP. Our next issue comes out in March and for that I'll need your drafts by the middle of January. Also consider recording any observations of plant growth or the return of wildlife in your neighboring wetlands for those of you in the Northern Hemisphere and for those in the Southern Hemisphere, documenting the departure of birds and the last flowers in your wetlands for our "Notes from the Field" section. "Notes" submissions can be received by the last week in February.

Finally, World Wetlands Day is February 2 (see page 31). This year a photo contest will be held from February 2 to March 2 - see http://www.worldwetlandsday.org/ for details. So consider participating in the contest or celebrating wetlands in other ways on that special day.

Wishing you all a happy holiday season and New Year! ■

CONTENTS

Vol. 31, No. 4 December 2014

Cover photo:
Pondside swamp after first heavy snowfall in Massachusetts
(R. Tiner photo)

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SOCIETY OF WETLAND SCIENTISTS
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PRESIDENT'S MESSAGE

As the saying goes, it has been a busy few months. However, I believe the most important thing that we have seen these past several months has been our (SWS's) response to the proposed EPA/COE changes in the definition of "Waters of the US".

James E. Perry, PhD, PWS
SWS President

Some of you may know that several past court cases have muddied the water where the Clean Water Act's (CWA) definition of waters of the United States is involved (think SWANCC and Rapanos). To that end the Environmental Protection Agency (EPA) and the Corps of Engineers (COE) proposed a rule to "define the scope of waters protected under the clean water act…." (33CFR Part 328). The proposed changes were seen as necessary in order to provide for consistency and predictability in enforcement of the Clean Water Act (CWA) and to increase the "…clarity and scope of "waters of the United States"" (33CFR Part 328 pg 22188). In June of 2014 I asked an ad-hoc committee comprised of Drs. Joy Zedler, Daniel Larkin, and Carter Johnson to review the proposed rule change and to prepare a position paper for SWS.

In short, the EPA and COE have proposed to define jurisdictional "waters of the United States" as: "Traditional navigable waters; interstate waters, including interstate wetlands; the territorial seas; impoundments of traditional navigable waters, interstate waters, including interstate wetlands, the territorial seas, and tributaries, as defined, of such waters; tributaries, as defined, of traditional navigable waters, interstate waters, or the territorial seas; and adjacent waters, including adjacent wetlands" (33CFR Part 328 pg 22188-22189).

Perhaps the most significant portion of the rule is the determination that "other waters", that is those waters that do not fit easily into the above definition, may be determined jurisdictional on a case-specific basis. They would be jurisdictional if "…they have a "significant nexus" to a traditional navigable water, interstate water, or the territorial seas." (33CFR Part 328 pg 22189). Wetland ecological functions that the agencies may use to foster the determination of a significant nexus include "…sediment trapping, nutrient recycling, pollutant trapping or filtering, retention or attenuation of flood waters, runoff storage, export of organic matter, export of food resources, and provision of aquatic habitat." (33CFR Part 328 pg 22213). Interestingly, it is not necessary to prove a hydrologic connection of "other water" to prove that they have a "significant nexus" since many of the functions presented above may take place in a wetland without hydrologic connectivity. The agencies further note that the definition "…is significantly based on data, science, the CWA, and case law." (33CFR Part 328 pg 22189).

Those areas that were exempt from jurisdictional overview, particularly those established to protect farmers, have not changed. They include waste treatment systems, prior converted cropland, ditches

continued on page 11

wetland science & practice

SWS NEWS

Recognize your fellow colleagues by nominating them for an SWS award

Do you know an SWS member who has made a real impact in wetland science, restoration or conservation? Perhaps you want to recognize someone for their dedication and service to SWS over the years. Here's your chance! SWS is offering four awards this year and will recognize recipients at the SWS 2015 Annual Meeting held in Providence, Rhode Island, U.S.A., May 31 - June 4, 2015. Visit the SWS website for complete award descriptions, nomination instructions and a listing of past award winners. All nominations are due by Monday, Feb. 9, 2015 and must be submitted through our online submission system which can be accessed by selecting the awards below.

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

Lifetime Achievement Award
The Lifetime Achievement Award honors individuals who have achieved special distinction in their career through contributions to wetland science and management, specific to research, education or policy. The award also comes with a Lifetime membership in the Society.

Merit Award
The Merit Award recognizes individuals demonstrating outstanding original research, achievement, or contribution to wetland science while inspiring future efforts. The award comes with a three-year membership in the Society.

International Travel Awards
The International Travel Awards provide financial assistance to wetland scientists from developing countries that are disadvantaged through regional economic conditions to enhance their participation in Society activities through a travel grant to the Annual Meeting. The award includes a complimentary membership for three years with SWS. ■

Attention students!

You are now invited to apply for an SWS Student Research Grant! SWS will provide up to $1,000 to support wetland-related research conducted by qualified undergraduate and graduate students from an accredited college or university worldwide.

Applicants
A student is eligible to apply for a research grant if they are conducting undergraduate or graduate-level research in wetland science at an accredited college or university worldwide. Please note that the student applicant must be a member of SWS to be eligible. The application deadline is Monday, Feb. 9. Apply today by completing a form and proposal document through our online submission system.

Reviewers needed
Each application is reviewed by a team of wetland scientists. If you would like to participate as a reviewer or are thinking about it, please contact David Bailey, SWS Student Grants Subcommittee Chair for details (David.E.Bailey2@usace.army.mil). Thanks for your help! ■

SAVE THE DATE!

2015
SOCIETY OF WETLAND SCIENTISTS
Changing climate. Changing wetlands.
Providence, Rhode Island

May 31 - June 4, 2015

Registration opens in mid-December.

Watch your email for news on the SWS 2015 Annual Meeting and the call for abstracts.

Start preparing now!

Field Trips & Workshops
Dig deeper into your research interests by participating in one of the many field trips or workshops at the SWS 2015 Annual Meeting. Visit www.swsannualmeeting.org for more information and find out what piques your interest.

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.

Letter to the EPA regarding the proposed rule on Waters of the United States

To: EPA
From: James Perry, President of the Society of Wetland Scientists (SWS)
Re: EPA-HQ-OW-2011-0880. SWS Comment on the EPA proposed rule on waters of the US, compiled by SWS members Joy Zedler, Daniel Larkin, and Carter Johnson

SWS is an international membership organization of more than 3,000 wetland professionals dedicated to fostering sound wetland science, education, and management.

SWS supports the EPA proposed rule on waters of the US as follows:

• **The proposed rule is science-based,** following EPA's review of over 1,000 peer-reviewed papers on the physical, chemical, and biological connections by which streams, wetlands, and open-waters affect downstream waters such as rivers, lakes, and oceans. The review is comprehensive, clear, technically accurate, and it summarizes solid science. The proposed rule correctly addresses the provision of clean water, which is a well-known function of wetlands. Here, we emphasize and expand on the following topics:

A. The quality of downstream waters depends on materials that are (or are not) discharged upstream in the watershed and carried by streams to wetlands that can remove materials and cleanse the water.

B. The system of connected streams and wetlands includes wetlands that perform in aggregate, both synergistically and cumulatively. We illustrate this for the Prairie Pothole Region (PPR).

C. Because water quality is degraded during and after flooding, SWS supports the need to protect wetlands to reduce flood risk.

A. The quality of downstream waters depends on materials that are (or are not) discharged upstream in the watershed and carried by streams to wetlands that can remove materials and clean the water.

- *Isolated wetlands* can improve water elsewhere in a landscape by trapping and retaining surface or groundwater discharges that would otherwise carry pollutants downstream.

- Non-isolated streams and wetlands are often *connected as a system*, either via surface water or groundwater. Wetlands that are connected improve water quality by performing *complementarily* along the water's flow path, with sequential contributions to the removal of solid and dissolved materials depending on the quality (e.g., particle size and weight) of the materials and the condition of the wetland (frozen or thawed, nutrient starved or eutrophic, deep or shallow, etc.). *The arrangement of wetlands on the landscape (size, density, position, etc.) influences water quality variables and flooding. The system is complex* and modelers now see the need to consider wetlands in aggregate (Zhang et al. 2012).

Quoting Zhang et al (2012) further:

"Understanding the implications of wetlands on downstream lake phosphorus concentration requires detailed landscape and hydrological information about the catchments of individual wetland units (Tompkins et al. 1997)."

"When inflow phosphorus concentration of a wetland is very high, it is likely that the wetland's effect on phosphorus retention exceeds its effect on consuming water and thus makes the phosphorus concentration lower at the outlet of wetland."

- *Larger areas* of wetland in a watershed *remove larger amounts of materials*. Johnston et al. (1990) found a threshold effect—reduced water quality where watershed area dropped below10%. This non-linear relationship indicates a synergism, not a simple addition.

- Water quality services are *not just a linear/additive function* of wetland area. High-quality water requires large wetland complexes and small wetlands dispersed across watersheds. Landscape heterogeneity and wide scattering of wetlands across the landscape are positive predictors of water quality (Moreno-Mateos et al. 2008). 'Scattered and numerous wetlands are better than few and aggregated ones, because within the whole catchment they will increase landscape complexity (patch density and heterogeneity) and accordingly reduce the amount of TDS in water" (ibid.; TDS = total dissolved solids).

- Detenbeck et al. (1993) showed that, for 33 watersheds near Minneapolis, downstream lakes had higher water quality where there were upstream wetlands in *close proximity* to the downstream lake. Similarly, Newbold (2005) found that "Targeted site selection in four small watersheds in the Central Valley resulted in predicted levels of nitrogen attenuation two to eight times greater than that from maximizing wetland area without consideration of the location of the restoration sites." This modeling study indicated high sensitivity to wetland *distribution*, not just wetland *area*.

B. The system of connected streams and wetlands includes wetlands that perform in aggregate within watersheds and/or landscapes (the latter being a more appropriate concept for flat topography, as in the prairie pothole region). Materials added to small streams and/or small wetlands, in aggregate, have cumulative effects downstream. The concept of performing in aggregate pertains to spatial and temporal frameworks. Small amounts of material added to many waters upstream adds up to a large loading downstream, as do small amounts of material added frequently over time. The early understanding of cumulative impacts and functioning in aggregate has withstood the test of rigorous research.

- Wetlands in aggregate can function <u>*synergistically*</u> (i.e., the whole is greater than the sum of the parts). For example, vernal pools support "meta-populations" of plants and animals. Meta-populations are sustained even if one more more sub-portions decreases; the probability of at least one sub-population persisting is greater where propagules can easily move from one pool to another. Several pools in close proximity can sustain populations (e.g., an annual plant or amphibian) better than fewer pools located at greater distances from one another.

- The concept that <u>*wetlands perform in aggregate*</u> over space and time was embodied in early predictions that the effects of losing multiple wetlands or that degradation across many wetlands would need to be considered in a <u>*cumulative impact assessment*</u> (Brinson 1988, Hemon and Benoit 1988, O'Brien 1988, Preston and Bedford 1988, Siegel 1988, and Winter 1988). Their advice 25 years ago still holds: functions of wetlands should not be viewed independently; the cumulative function of all wetlands in a watershed may differ from simply adding the functions of individual wetlands.

Quotes from Johnston et al. 1990:

"The relationship between basin storage (as percentage of basin area in wetlands and lakes) and relative flood flow is non-linear in the empirical models developed by Jacques & Lorenz (1988), so that our data yielded a critical threshold at about 10%. Small wetland losses in watersheds with < 10% wetlands could have a major effect on flood flows. A similar threshold was found for wetlands in Wisconsin watersheds by Novitzki (1979).

"Cumulative impact assessment differs substantially from the approach used by existing wetland evaluation systems (Reppert et al. 1979; U.S. Army Corps of Engineers 1980; USFWS 1980; Adamus 1983) because it evaluates the collective function of a group of wetlands, rather than the contribution of an individual wetland.

"Our results indicate the importance of considering wetland position in the landscape when evaluating cumulative function. All wetlands in a watershed do not behave alike with regard to water quality function, which may explain why previous attempts to relate percent wetland to

Letter from the Consortium of Aquatic Science Societies

October 23, 2014

To Whom It May Concern:

We are writing today on behalf of CASS (the Consortium of Aquatic Scientific Societies), a group of scientific societies including the American Fisheries Society, the Association for the Sciences of Limnology and Oceanography, the Phycological Society of America, the Society for Freshwater Science, and the Society of Wetland Scientists. Our societies founded CASS in recognition of the integration among all aquatic systems. While water, and the scientists who study it, can sometimes be categorized by terms such as "lake", "river" or "ground water", our societies and scientists acknowledge the fundamental integration of aquatic ecosystems. The goal of CASS is to promote scientific study, education, and outreach about aquatic ecosystems. Our member societies represent more than 12,000 professional aquatic scientists from academia, government agencies, private industry, NGOs, and elsewhere. Most of the leading freshwater scientists in the United States belong to at least one of our societies.

We thank you for the opportunity to comment on the proposed definition of the "Waters of the United States" (Docket identification (ID) No. EPA-HQ-OW-2011-0880). This definition is central to the protection of the ecological quality of our waters and the benefits that they provide to the citizens of the United States, and we appreciate the care and time that has been put into developing the proposed definition. We agree that it would be highly desirable to have a definition that would allow for transparent, predictable, and consistent application of the Clean Water Act, and we applaud the critical and extensive use of scientific information in preparing the new rule.

In general, we believe that the proposed definition is reasonable, and is well supported by scientific studies, many of which are cited in the proposed rule. In particular, we strongly support many aspects of the proposed definition. Here are our specific comments on the proposed rule.

- **We strongly support inclusion of headwater streams, including intermittent or temporary streams that do not have perennial flow.** There is now ample scientific evidence (much of it cited in the proposed rule) that there are strong and varied physical, chemical, and biological connections between headwater streams, whether they have perennial flow or not, and downstream navigable or interstate waters. This clearly satisfies the requirement for "significant nexus". Furthermore, the proposed use of the presence of bed, banks, and an ordinary high-water mark to identify stream channels that should be included seems both practical to apply in the field and consistent with the scientific evidence regarding strong connections.

- **We strongly agree that is important to include some "ditches" as "Waters of the United States."** We acknowledge it may be politically necessary to exclude "ditches that are excavated wholly in uplands, drain only uplands, and have less than perennial flow" and ditches that do not contribute water to jurisdictional waters from "Waters of the United States" (but see our next comment). However, "ditches" that have perennial flow or that currently drain or formerly drained wetlands or lakes in many cases were built to modify or replace existing natural drainage features that would have qualified as "Waters of the United States", and typically are well connected with downstream waters, thereby satisfying the "significant nexus" criterion.

- **We are concerned that the requirement for ditches excavated wholly in and draining only uplands to have perennial flow (p. 22203, 22219 of the Federal Register listing) is too restrictive**. This requirement seems more restrictive than the guidance from Rapanos that ditches should have "relatively [emphasis added] permanent flow of water" to be included under "Waters of the United States", and at odds with the scientifically supported recognition elsewhere in the proposed rule of the importance of tributaries having non-perennial flow. We suggest that ditches excavated wholly in and draining only uplands be included in "Waters of the United States" if they contain flowing water more than 75% of the time. *continued . . .*

drainage basin water quality have generally been unsuccessful (Whigham & Chitterling 1988).

"Therefore, the position of wetlands in the watershed appears to have a substantial effect on water quality, particularly with regard to sediment and nutrients."

Additional relevant points by wetland scientists:

"Understanding the relationship between wetland cover in the watershed and coastal marsh water quality is important not only for the purpose of predicting natural variation in water quality, but also for understanding the implications of wetland loss that often occurs as a result of human development (Wolter and others 2006). Like Johnston and others (1990), we found wetland cover to be a significant factor determining COND levels [specific conductivity]. Wetlands have the ability to filter dissolved ions and nutrients in surface runoff (Hemond and Benoit 1988; Johnston et al. 1990) and can therefore help reduce ionic concentrations. As expected, we also found that greater wetland cover is related to lower levels of TNN in marshes at the watershed outflow. This is consistent with a large body of literature that outlines the importance of wetlands in the nitrogen cycle." (DeCatanzaro et al. 2009) (TNN = total nitrate nitrogen)

"Regional landscape setting influences local wetland relationships with TP and color through cross-scale interactions, and lake TP and color are controlled by both local-scale wetland extent and regional-scale landscape variables." (Fergus et al. 2011)

Complex effects of upstream wetlands on downstream waters: The following *Prairie Pothole Region* (PPR) case study illustrates one clear finding from the EPA/COE science review and proposed rule, namely, there is great complexity in the ways that upstream wetlands influence downstream waters. The complexity of processes involved and their highly variable influence in space and time make it difficult to assign level or degree of connectivity to any given wetland, wetland complex, or even watershed. This difficulty in turn makes the regulatory mission challenging.

- *Four main functions of wetlands in the PPR produce interconnectedness: fill and spill; recharge/discharge; biodiversity inoculum; groundwater flux*. As detailed below, three of these functional connections (fill-spill; recharge-discharge; biodiversity inoculum) between pothole wetlands and downstream waters are supported by solid, peer-reviewed, science. All functional pothole wetlands fill with water and contribute biodiversity inoculum; a large percentage of pothole wetlands spill water that often joins downstream waters; virtually all functional pothole wetland complexes contribute to recharge and discharge that lengthens the hydroperiod of more permanent wetlands and increases the chance that surface water spills and enters downstream waters; movement of water from pothole wetlands to deep groundwater that then enters downstream surface waters is likely to occur but is difficult to determine from field studies. Parsing out which pothole wetland provides each of the four functions and documenting how often each occurs is not tractable from a research perspective. The few uncertainties should not be the enemy of the far more numerous certainties. *The dominant message from the EPA science review and this SWS assessment is that connections between pothole wetlands and downstream waters are strong and undeniable.*

1. Fill and spill. Perhaps the clearest hydrological connection between prairie wetlands and downstream waters is their capture and storage of rainstorm and snow pack runoff (fill function). Calculations presented in the science review show that substantial amounts of water can be held back from streams and rivers by pothole wetlands, thus reducing flood magnitude and frequency. In a large proportion of prairie wetlands, however, especially in easterly parts of the prairie pothole region (PPR) with moderate to high rainfall (Millett et al. 2009), wetlands cannot capture and hold all water inputs. In these areas, integrated drainage networks have formed over time from spilled water (spill function), and connectivity between wetland basins and downstream waters is direct and observable. While spilling is more likely and voluminous in wetter regions, it can occur in drier, more westerly PPR regions during periods of deluge such as those observed in the 1990s (Winter and Rosenberry 1998). Most of the ten wetlands at Orchid Meadows, a long-studied wetland complex in eastern South Dakota (central PPR), overflowed frequently and contributed substantial volumes of water via channel outflow to a deep, recreational lake (Johnson et al. 2004, van der Kamp and Hayashi 2009). *Both fill and spill functions occur in prairie wetlands across the PPR*; the spill function is more evident in the integrated drainage network of the central and eastern PPR.

2. Recharge/discharge. A second well-studied process identified in the science review, termed recharge/discharge, connects members of a wetland complex to each other hydrologically. *However, the physical connection between less permanent pothole wetlands and downstream waters was not identified or discussed in the EPA science review*. In the PPR, topographically higher wetlands (usually those classified as temporary or seasonal in permanence category) recharge shallow groundwater that discharges into lower semi-permanent wetlands. This topographically driven, regional-local flow system functions when water percolates through fracture cracks in the glacial till beneath wetland basins. The permeability of the tills depends on the degree of fracturing that is best developed in surface soils. The amount of water that discharges from higher wetlands into lower ones can be sufficient to lengthen the hydroperiod of receiving wetlands and to shift them from seasonal to semi-permanent. The water budgets of wetlands in complexes do not balance in mathematical models without accounting for the recharge function (Johnson et al. 2010). In this way, in-

vestigators have found a link between the more ephemeral wetlands, often occurring in higher landscape positions, and downstream water. More specifically, recharge maintains deeper semi-permanent wetlands increasing the frequency and volume of spilling into downstream waters after snow melt and rain storms. *This physical connection between less permanent pothole wetlands and downstream waters is a useful addition to the EPA science review.*

3. Groundwater flux. Major questions raised in the EPA science review were: How connected are pothole wetlands to deeper groundwater? Do pothole wetlands directly recharge downstream streams, river, and lakes via deeper ground water? *It is well established that water movement among wetlands is part of the shallow groundwater system* (van der Kamp and Hayashi 2009). Deeper tills, however, generally have low hydraulic conductivity allowing only very slow movement of water. But there are exceptions. In the more rugged parts of the PPR, where most functional wetlands remain, the till underlying or adjacent to wetlands includes materials varying in coarseness and permeability, ranging from cobble and gravel through sand to heavy clay. The sands and gravels occur as extensive sheets, long narrow buried-valley deposits, and many small deposits of local extent (van der Kamp and Hayashi 2009). The deposits can function as aquifers that distribute recharge water from "leaky" wetlands to deeper groundwater, and then possibly to down gradient surface waters. Because aquifers are encountered frequently when coring, it is likely that some wetlands do feed surface waters through deeper groundwater pathways. Research into the complex "black box" of groundwater movement in the glacial tills in the PPR has yet to prove and quantify the occurrence of such flow paths. However, known passage of salts from wetlands into deep groundwater storage has been determined (van der Kamp and Hayashi 2009).

4. Biodiversity inoculum. The EPA science review lays out a clear case that pothole wetlands contribute biodiversity inoculum to downstream waters. Some forms of the inoculum, such as seeds and whole plants, are transported directly by water that spills to downstream streams, rivers, and lakes. Other organisms, such as amphibians that live and reproduce in pothole wetlands, depend on spillage flow pathways and other surface water sources to disperse and recolonize new sites downslope. Still others, such as migratory waterfowl that breed in pothole wetlands, complete their breeding cycle in late summer by moving to more permanent downstream waters. A countless number of species from single celled organisms to vertebrates move from pothole wetlands to downstream waters in a myriad of ways in time and space to complete their life cycles and to colonize new sites as a means to maintain and expand their populations. Pothole wetlands play a major role in the ability of plants, animals, and microbial communities to remain functional and diverse in glaciated prairie landscapes.

• **The criteria for determining that waters in riparian areas and floodplains are "adjacent waters" and therefore included in the "Waters of the United States" look reasonable, and are well supported by scientific research showing that waters in these areas have strong ecological connections to jurisdictional waters or their tributaries.** A key question raised by this definition is how to define "floodplain" in terms of return intervals or other criteria (p.22209 of the Federal Register listing). The suggestion that the extent of the floodplain be determined "by best professional judgment" seems problematic, and allows for considerable uncertainty and inconsistency in the delineation of "adjacent waters", which seems incompatible with your broad goal of transparency, predictability, and consistency. We suggest that you adopt a more uniform approach, and choose a standard return interval (we suggest 100 years, because 100-year floodplains are widely mapped, and because bodies of water within the 100-year floodplain usually have obvious connections to jurisdictional waters) with which to define floodplains, perhaps allowing this standard to be overridden in exceptional cases by best professional judgment. Alternatively, if floodplain extent is to be determined by best professional judgment, the rule should more explicitly state what considerations are to be taken into account in applying this best professional judgment.

• As the draft rule notes, some "other waters" outside of waters that will be included by rule do in fact have a significant nexus with jurisdictional waters, particularly when certain kinds of these "other waters" (e.g., prairie potholes, Carolina bays) are considered in combination with other similarly situated waters. **We encourage the USEPA to sponsor research to develop better indicators of ecological connectivity that allow for easier identification of significant nexus and therefore less case-by-case analysis of these "other waters".**

• **The definition of "In the Region" (p. 22212 of the Federal Register listing) could be problematic and should be modified.** The current definition ("in the region" [means] the watershed that drains to the nearest traditional navigable water, interstate water, or the territorial seas through a single point of entry.") would seem to imply that if a body of water along a small tributary of a navigable water were being considered, only the watershed of that small tributary would be considered to be "the region". It would seem more natural, and more in keeping with the remainder of the proposed rule, to define "the region" as the watershed of the navigable water rather than the tributary.

• **Finally, we are disappointed that the proposed rule fails to recognize the strong and ecologically vital connections between ground waters and surface waters.** Ground water, shallow aquifers, and hyporheic waters (those immediately below streams, lakes and wetlands) are connected to those surface waters and determine their flows during dry periods. Essentially, such ground waters are underground tributaries of lakes, streams, rivers, and wetlands. Groundwater upwelling is crucial for successful spawning of trout and salmon in lakes, and creates cool-water refuges in summer for juvenile and adult salmonids as well as warm-water refuges in winter when streams and lakes are ice covered. Ground water inputs are critical to most wetlands, lakes and streams, as well as spatially intermittent streams, and thereby affect the quality and quantity of those waters and the biota and fisheries that surface waters support. Inadequately regulated mining, fossil fuel extraction, agriculture, and industrialization have all contributed to groundwater depletion and contamination. Therefore exempting ground waters from "Waters of the United States" makes no sense from a scientific perspective.

Thank you for your attention. Please do not hesitate to contact us if we may be of assistance. We may be reached via David Strayer (strayerd@caryinstitute.org), or through our current CASS coordinator, Dr. Adrienne Sponberg (sponberg@aslo.org).

Sincerely,

Douglas J. Austen, Ph.D., Executive Director, American Fisheries Society
James J. Elser, Ph.D., President, Association for the Sciences of Limnology and Oceanography
John W. Stiller, Ph.D., President, Phycological Society of America
David L. Strayer, Ph.D., President, Society for Freshwater Science
Jim Perry, Ph.D., President, Society of Wetland Scientists

C. Because water quality is degraded during and after flooding, SWS supports the need to protect wetlands to reduce flood risk, which will be increasingly important during future climates with more frequent, more extreme streamflow events. Here are relevant sections of recent scientific publications.

• Floods, like water quality, relate to the built environment. A study from Texas, which consistently has the nation's greatest impacts of flooding, concerned 423 flood events from 1997 to 2001 and identified impacts of several measures, including wetland alteration, impervious surfaces, and dams. Their results support the important role of naturally occurring wetlands in mitigating flood damage (Brody and Zahran 2008).

• It is conventional wisdom that losing wetlands increases flood risk. However, *it is novel to quantify cumulative impacts at a watershed scale*: Ahmed (2014) estimated a 4% increase in the 100-year flood as a result losing non-provincially *significant wetlands* (6% of basin area; PSW are provincially significant wetlands recognized by Ontario)… Adding non-PSWs (combined total = 15% of basin area) and assuming similar hydrological functions regardless policy-related class, peak flood attenuation was estimated to improve 9-10%. Removal of non-PSWs will increase the value of the 1-day flow by up to 50%.

• "…federal permits issued to alter a naturally occurring wetland exacerbate flooding events in coastal watersheds along the Gulf of Mexico… importance of our findings for planners and policy makers interested in reducing the adverse impacts of coastal flooding is that flood events are regulated not solely by the effect of permit counts, but by the type of permit granted. First, as expected, IP [individual permits] significantly increase flooding because they signify development projects requiring large amounts of wetland (>0.5 acres) to be disrupted. These projects usually involve the addition of impervious surfaces… Decision makers should carefully monitor the number and location of IP granted within a watershed to ensure the hydrological system remains relatively intact… Second, while we expect large development projects and associated impervious surfaces to increase the rate of flooding, the even stronger positive effect of GP [general permits] is somewhat surprising. This result indicates that *relatively small-scale wetland alteration such as with the case of residential development have more serious "cumulative impacts" on flooding over time*. GP may be indicative of sprawling development patterns where each individual project may not cause a severe impact, but the total sum of all small disruptions to a watershed unit results in loss of hydrological function and resulting increased flood events. This '*death by a thousand cuts*' phenomenon should be a primary concern for environmental and hazard mitigation planners. *Officials need to steer their focus away from site-based review and incremental decision making toward the watershed level where cumulative impacts are more easily detected*. (Brody et al. 2007a)

Wetland loss is the primary driver of increased flood risk. "Although the total amount of impervious surface in an area is often cited as the culprit for increased flooding and associated property damage, these may result more from exactly where these surfaces are, and how they affect the natural environment… by separating the variable measuring wetland development from the variable measuring impervious surface, we eliminate from the latter from what may be its most important adverse hydrological impact: loss of wetlands. We noticed the same trends in related studies of floods at both the local jurisdiction scale and the watershed scale (Brody, Highfield, et al., 2007; Brody et al. 2008).

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President's Message continued from page 3

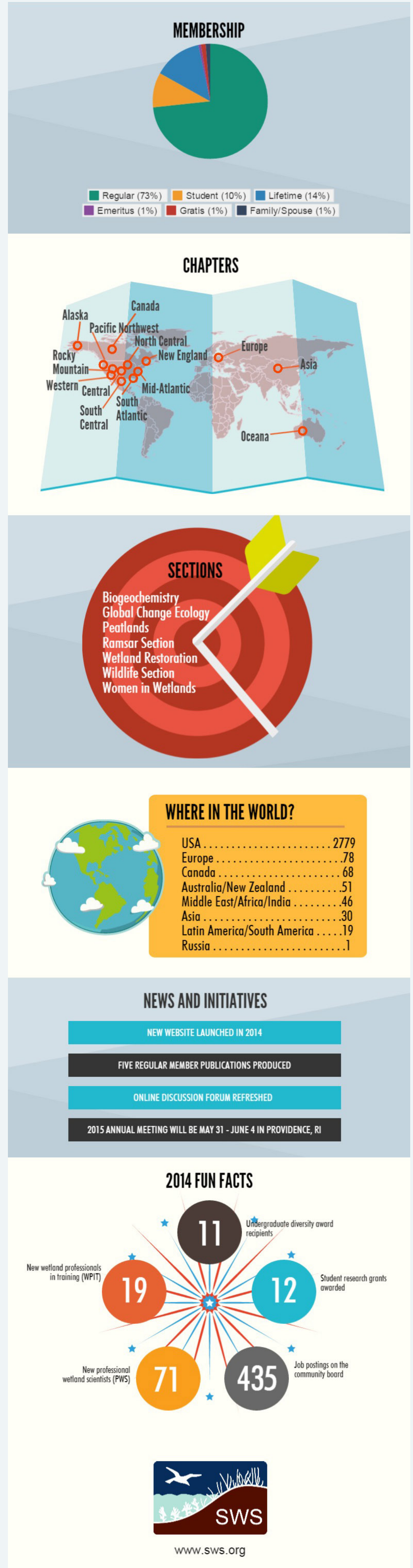
(those excavated in uplands and those that do not contribute flow), artificially irrigated areas, etc. (see 33CFR Part 328 pg 22188 for complete list).

Their report, presented elsewhere in this edition of WSP, was approved by the SWS Board of Directors at our Nov. 5th conference call and submitted electronically to the EPA on Nov. 6, 2014.

On other fronts; Planning for the Providence 2015 meeting is moving at a very rapid, and smooth, pace. The South Central Chapter is currently working with our business partners to set up a 2016 meeting in Texas, and we are looking at the possibility of a meeting in Puerto Rico in 2017.

As always, we at SWS hope you have a joyful holiday season and a peaceful new year. ■

Society of Wetland Scientists BY THE NUMBERS



SWS NEWS

The Ramsar Convention and SWS – Delivering wetland conservation at a global level

R. J. McInnes[1], SWS Ramsar Section Chair; RM Wetlands & Environment Ltd, Littleworth, Oxfordshire, UK

In early 1971, following almost a decade of discussions, non-governmental organisations (NGOs), government officials and wetland scientists met in the Iranian city of Ramsar on the shores of the Caspian Sea to finalize the text and terms of an international treaty. The treaty, the Convention on Wetlands of International Importance Especially as Waterfowl Habitat, was concluded on February 2, 1971, making it the first of the modern global intergovernmental treaties (sometimes termed multi-national environmental agreements – MEAs) on the conservation and sustainable use of natural resources. The popular name for the convention, the Ramsar Convention, just as with other treaties such as the Kyoto Protocol or the Geneva Convention, is therefore derived from a location and is not an acronym. A full account of the origins and early development of the Convention is provided in Matthews (1993) and more information can be found at www.ramsar.org.

The Ramsar Convention provides a framework for international cooperation and national action for the conservation and wise use of wetlands (Gardner and Davidson 2011). The Convention's mission is the "*conservation and wise use of all wetlands through local and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world.*" The countries that are signatories (known as *Contracting Parties*) commit to the delivering on the three pillars of the Convention, namely:

Designation of suitable wetlands for the list of Wetlands of International Importance (the Ramsar List) and ensuring their effective management;

Working towards the wise use of all their wetlands through national land-use planning, policies and legislation, management actions and public education; and

Cooperation internationally on transboundary wetlands, shared wetland systems, shared species, and development projects that may affect wetlands.

Obligations on the Parties

The Convention text establishes procedural options and sets out the obligations of the Contracting Parties. Adopting an inclusive approach, Article 1.1 of the Convention text defines wetlands as "*areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres*". Article 2 of the Convention text states that each Contracting Party "*shall designate suitable wetlands within its territory for inclusion in a List of Wetlands of International Importance*." The Convention provides guidance on the designation process and nine criteria have been established for identifying a Wetland of International Importance (commonly known as *Ramsar Sites*; Table 1).

Ramsar Sites

As of late September 2014 there were 168 Contracting Parties. Globally, the Parties have designated 2,186 Ramsar Sites covering an area in excess of 208 million hectares (mha). The sites are not evenly distributed across the six Ramsar regions with the largest number of sites designated in Europe (n=1,059) and the lowest number of sites in Oceania (n=79) (Figure 1). Similarly, the spatial extent of Ramsar Sites is not uniformly distributed across the six regions (Figure 2). Africa supports the largest area of internationally important wetlands with some 90.67 mha of land designated as Ramsar Sites, including the world's largest Site, Ngiri-Tumba-Maindombe (6.569 mha) in the Democratic Republic of Congo. There are only 215 Ramsar Sites designated in North America with 37, 142 and 36 in Canada, Mexico and the United States, respectively. The North American Ramsar Sites cover some 23.584 mha with more than a quarter of this area comprising Queen Maud Gulf Ramsar Site in Canada (6.278 mha). Members of the U.S. National Ramsar Committee have pledged that efforts need to be made to increase the number of Ramsar Sites in the US in acknowledgement of the country's outstanding history in wetland science, management and protection (Wetland Science & Practice 2014).

Wise Use

The Convention defines the wise use of wetlands as "*the maintenance of their ecological character, achieved through the implementation of ecosystem approaches, within the context of sustainable development*". Put simply,

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this means the conservation and sustainable use of wetlands and all the services they provide, for the benefit of people and nature. In the context of the Convention, wise use applies to all wetlands irrespective of their designation at a local, national or international level or their importance for maintaining species of conservation concern. This aspect of wise use is often conveniently neglected in decision-making. Finlayson et al. (2011) investigated this dimension further by posing the question whether after more than forty years of Parties practising wise use has implementation achieved the intended outcomes for the world and its people? Drawing on *inter alia* the conclusions in the Millennium Ecosystem Assessment (2005) their analysis suggested that this had not been the case as the loss and degradation of wetlands has continued at a pace greater than for any other ecosystem, a view substantiated by a recent review by Davidson (2014) which suggests that up to 87% of wetlands have been lost since the beginning of the 18th century. Paradoxically, the desire of governments to drain, pollute, convert and impact wetlands in the name of

Table 1. Criteria for identifying and designating Ramsar Sites (Ramsar Convention Secretariat 2010a).

Group A. **Sites containing representative, rare or unique wetland types**		**Criterion 1** A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.
Group B. **Sites of international importance for conserving biological diversity**	*Criteria based on species and ecological communities*	**Criterion 2** A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.
		Criterion 3 A wetland should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.
		Criterion 4 A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.
	Specific criteria based on waterbirds	**Criterion 5** A wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds.
		Criterion 6 A wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird.
	Specific criteria based on fish	**Criterion 7** A wetland should be considered internationally important if it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/ or values and thereby contributes to global biological diversity.
		Criterion 8 A wetland should be considered internationally important if it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.
	Specific criteria based on other taxa	**Criterion 9** A wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of wetland-dependent non-avian animal species.

economic growth and development, including ambitions to eradicate poverty and to feed an ever-growing human population, fundamentally degrades functioning wetlands that, largely for free, provide immense value to human society through the delivery of ecosystem services (Finlayson et al. 2011). To rectify this situation demands that governments have access to the relevant skills, science and knowledge and build the capacity to implement sustainable solutions in the pursuit of delivering on the wise use of wetlands.

International Cooperation

The Ramsar Convention has published guidelines on the multiple components which comprise international cooperation (Ramsar Convention Secretariat 2010b). Cooperation can be on many levels (Navid 1989) including the management of transboundary wetlands or shared watersheds, the protection, monitoring and management of shared wetland-dependent species along flyways or other migratory routes, stemming the spread of alien invasive species or the trade in endangered species, or assisting in the pursuit of joint funding and financing initiatives. There is also a key role in the sharing and exchange of knowledge. This can include the sharing of indigenous knowledge or promoting better management practices through the application of new science across the many fields which wetland managers are required to embrace.

A key component in the sharing of knowledge is the Convention's Scientific and Technical Review Panel (STRP). As a subsidiary body of the Convention, STRP provides scientific and technical guidance to the various bodies of the Convention including the Parties, the Standing Committee, and the Ramsar Secretariat. Working to a triennial programme between the Conferences of the Contracting Parties (COP), the STRP's work plan for each triennium is built around the priority tasks determined by the Standing Committee, which are based upon requests from the COP by means of its Strategic Plan and Resolutions. The STRP comprises a chairperson, appointed members, representative of each of the five International Organization Partners (IOPs) and National STRP Focal Points from the Contracting Parties. In addition, representatives of other convention secretariats, convention subsidiary scientific bodies, and scientific organizations as officially Invited Observer Organizations, invited experts, consultants, and organizations are asked to participate as required. The Society of Wetland Scientists (SWS) has been formally recognized as an Invited Observer Organization since 1999 and members of SWS have made, and continue to make, a significant contribution to the technical and scientific work of the Convention.

Regional Priorities

At the 18th Meeting of the STRP held in Gland, Switzerland in September 2014, the Ramsar Secretariat's Senior Regional Advisors (SRAs) from the six Regions outlined the priorities in their region for scientific and technical support over the coming triennium (2015-2018). These are summarised in Table 2.

Fundamental and applied research is required across many areas and relevant information exchange is vital to enhance capacity building and practical delivery of the goals of the Convention. Improved understanding and application of knowledge around wetlands and their ecosystem services represented the only universal priority. However, the needs around ecosystem services are also linked to requests for capacity building and detecting, reporting

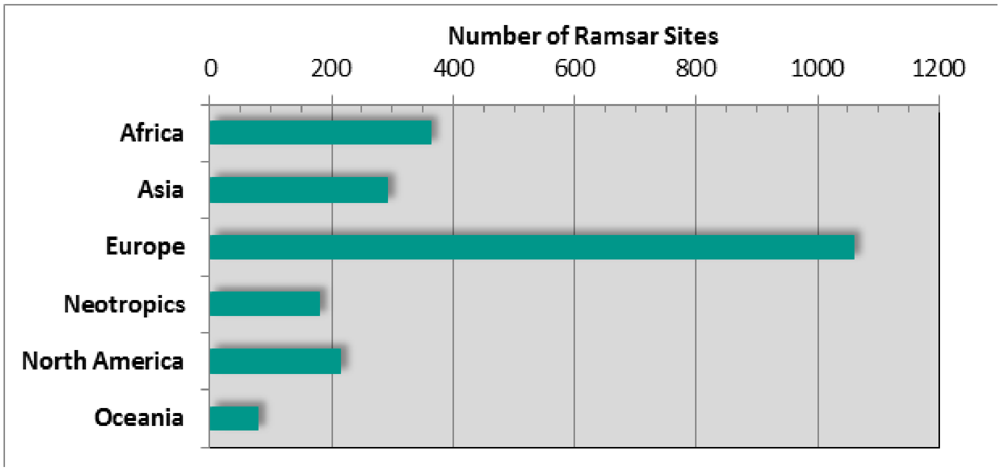

Figure 2. Number of Ramsar Sites in the six Ramsar regions (as of 24th September 2014).

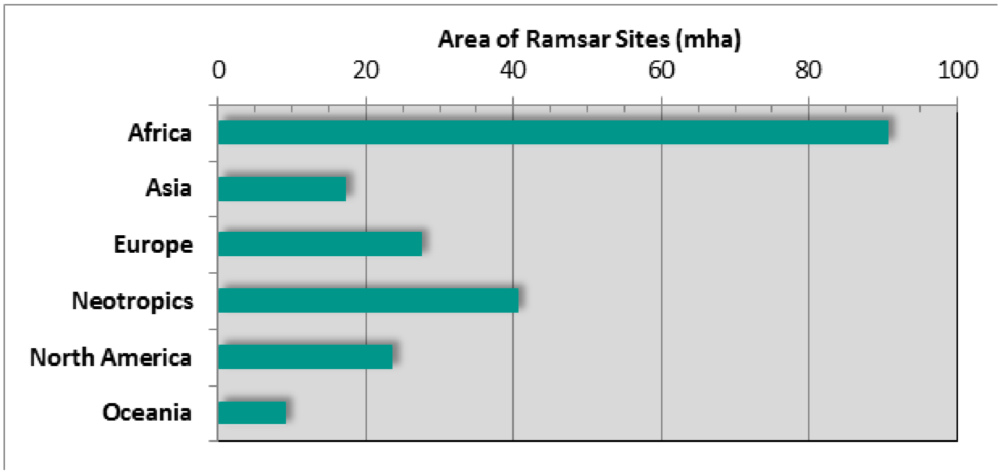

Figure 3. Area of Ramsar Sites in the six Ramsar regions (as of 24th September 2014).

Table 2. Regional scientific and technical priorities for the Ramsar regions, September 2014. (Note the priorities for the Neotropics and North America were combined by the SRA.)

	Africa	Asia	Europe	Americas (Neotropics and North America)	Oceania
Wetland inventory, assessment, monitoring and reporting	✓		✓		
Wetlands and ecosystem services, including economic valuation	✓	✓	✓	✓	✓
Detecting, reporting and responding to changes in ecological character	✓			✓	✓
Wetland and urbanization	✓				
Wetlands and poverty reduction	✓			✓	
Wetlands and water resource management		✓			
Wetlands and climate change		✓	✓		
Wetlands and invasive species					✓
Integrating social science expertise			✓		
Environmental flows				✓	
Capacity building		✓		✓	✓
Synergies in implementation of biodiversity MEA's					✓
REDD+ for forested wetlands					✓
Groundwater and wetlands	✓				
Assistance with Ramsar Information Sheets					✓
Wetland engineering	✓				

and responding to changes in ecological character. Numerous region-specific scientific and technical priorities were also identified including issues relating to urbanization (Africa), water resource management (Asia), integration of social science (Europe), environmental flows (Americas) and invasive species (Oceania). Many of the these priorities are already being addressed though the current STRP work plan, but efforts must be increased to ensure that these global wetland issues receive appropriate scientific and technical consideration and that information and knowledge are passed on to relevant organizations and wetland managers.

The role of the Society of Wetland Scientists

Through the many roles that they play, SWS members already make a significant contribution to the delivery of the goals of the Ramsar Convention. Across the globe, SWS members include active participants in the work of the STRP, national delegates to COP or members of National Ramsar Committees. The mission of the Society (to promote understanding, conservation, scientifically based management and sustainable use of wetlands throughout the world) mirrors the goals of the Convention. As wetland scientists and practitioners there are multiple opportunities for individuals to strengthen the bonds between the two organisations. The Ramsar Section of SWS acts as one of the bridges between the two organisations. The Section routinely holds a symposium at the Annual Meeting of the Society focussing on a key topic of relevance to the Convention (Figure 3); seeks experts to contribute to elements of the STRP work plan including conducting research or reviewing documentation; and assists Parties in identifying relevant experts or knowledge holders in their country or region.

If SWS members wish to become more involved in

Figure 3. Psovka Stream Ramsar Site, Czech Republic. Visited by SWS Ramsar Section members during the 2011 SWS International Meeting in the Czech Republic.

Ramsar related matters, please join the Ramsar Section or contact the author for more information, especially regarding the regional priorities presented in Table 2. If any US-based members wish to assist with promoting the goals of the Convention within their State or are interested in considering further sites for designation please contact the Chair of the U.S. National Ramsar Committee (wmitsch@fgcu.edu). ■

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Impact of Rapid Infiltration Beds on Hydrology, Vegetation and Chemistry of a Forested Wetland

Catherine Owen Koning[1], Franklin Pierce University, Rindge NH; Jennifer Bell, Plymouth State University, Plymouth, NH

Pearly Pond, a 142-acre lake in southwest New Hampshire, has become eutrophic as a result of phosphorus loading (i.e., experiencing harmful algae blooms and decreased dissolved oxygen). Consequently, the lake does not meet its water quality goals, which include primary contact recreation and support of aquatic life (VLAP 2012). The Rindge campus of Franklin Pierce University (FPU) sits on the northern edge of Pearly Pond, and historic wastewater discharges have contributed to the phosphorus loading of this shallow lake. The University has addressed this problem through the installation of Rapid Infiltration Beds (RIBs) for tertiary wastewater treatment. However, monitoring of wetland systems indicate that these infrastructure changes may not be as effective as expected.

Since the University's establishment at this location in 1968, wastewater was treated on site and discharged directly into the surrounding wetland system (Figure 1). Thirty years of wastewater discharge exceeded the natural capacity of the wetlands to take up phosphorus. In 1998, the New Hampshire Department of Environmental Services (NHDES) classified Pearly Pond as impaired and identified wastewater as a primary source of excess phosphorus (NHDES 2010). To address this impairment, the University improved its wastewater treatment process by augmenting the chemical treatment with aluminum sulfate to remove phosphorus. In addition to this and other upgrades, the University also installed two RIBs in 2008. The RIBs are composed of mounded sand underlain by crushed stone on fractured bedrock (Figures 2 and 3). By design, RIB systems release effluent wastewater atop the mounds, then flows downward where pollutants are adsorbed to the sand, thereby leaving clean water to recharge the groundwater.

While land-based discharge systems such as RIBs are becoming more common, several studies suggest that they are not effective at removing nutrients such as phosphorus and nitrogen over the long term (Delaware Geological Survey 2014). After observing increased water levels and vegetation changes in the adjacent wetland (Northeast of the RIBs, Figure 1) in the years following their installation, we set out to test the hypothesis that Franklin Pierce University's RIBs are affecting water levels, water chemistry, and vegetation in the adjacent wetland system.

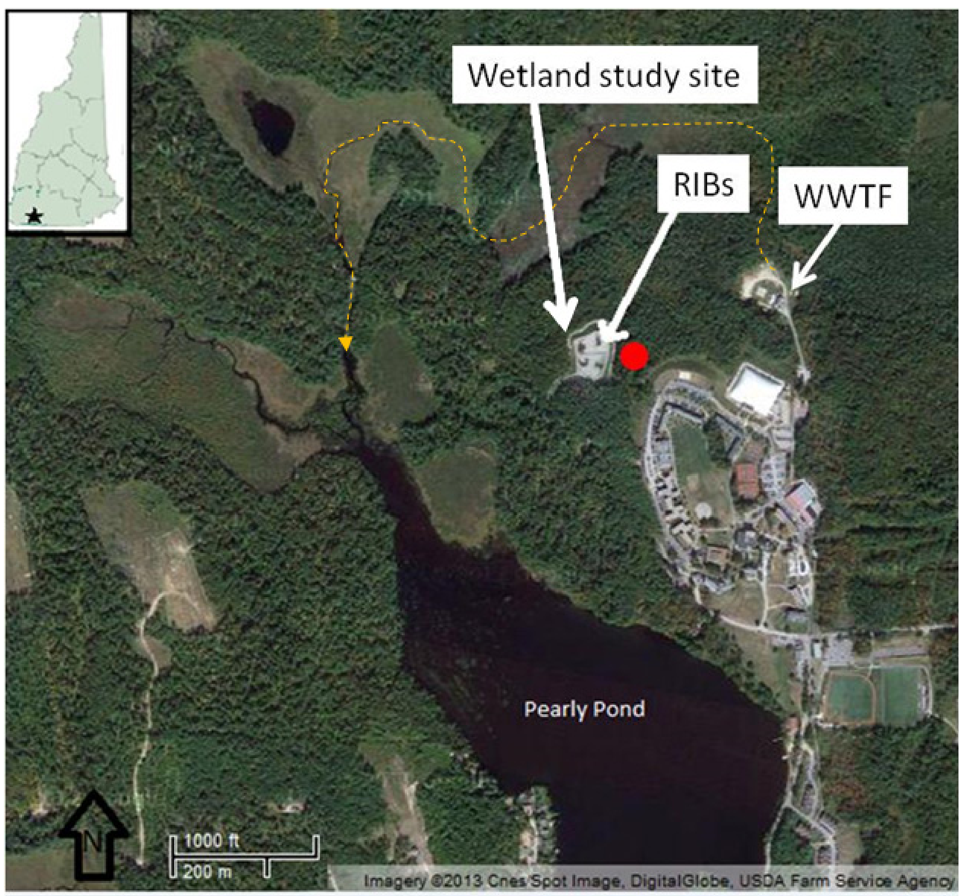

Figure 1. Study Location. Red dot marks University's official surface water monitoring location, located about 80 m southeast of the wetland study site. Orange line shows path of former effluent discharge prior to construction of RIBs.

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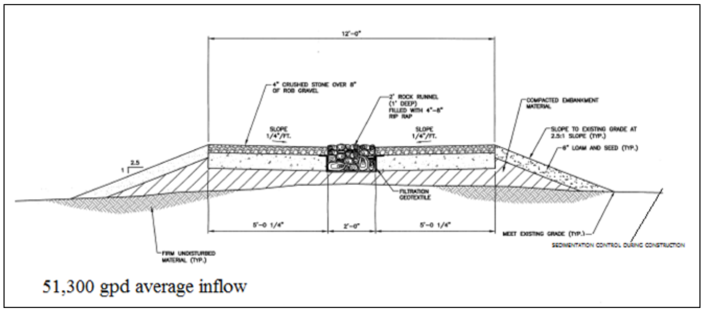

Figure 2. Schematic diagram of Rapid Infiltration Bed

Study site

The wetland is a 0.36 ha (0.9 acres) red maple–*Sphagnum* basin swamp in Rindge, NH. Its small size and geographically isolated position precluded its mapping based on aerial photography, so it is not found on the National Wetlands Inventory map. Soils in the area are Monadnock fine sandy loam, very stony, and Beckett fine sandy loam, very stony. The soil in the wetland area is mapped as Adams loamy sand; these soils are typically well-drained, 60-80" deep (NRCS Websoil survey). Underlying geology of this area consists of a Silurian metamorphic schist/quartzite, Rangeley formation, overlain with drumlins of glacial till (Lyons et al. 2006). The study area drains into Pearly Pond, which empties into Tarbell Creek, a second-order tributary of the Connecticut River.

Methods

Piezometers were installed in the wetland in 2005 and have been used to record piezometric head levels and hydraulic gradients intermittently. Water levels, water quality, and vegetation survey data from the years before the facility's installation and startup (2005, 2006, 2007) were compared to data collected after installation in 2009 (2011 and 2012).

Piezometer A is shallow (52 cm below ground) while Piezometer B is deeper (124 cm below ground). Piezometers were constructed of 3.175 cm (inside diameter) schedule 40 PVC pipes, with 30 cm screens and 0.254 cm slots. Piezometers were backfilled with native materials, and sealed at the top with 5-10 cm of bentonite. A stage gage installed in a 0.6 m deep unlined well was used to determine depth to water table. For this study, piezometric data that were collected before RIB installation (2005-2007) were compared to data collected in 2011-2012. Hydrologic data from 2011-2012 that did not have temporally corresponding data (by month) in 2005-07 were omitted from the analysis.

Specific conductance and pH were monitored and recorded three times per year in 2005 and biweekly from May to November in 2012; again, only data from the same months was used for comparison. Specific conductance and pH were measured using a YSI 30 conductivity meter and a Hanna 9025 pH meter. Surface water samples were taken from within the wetland on three occasions in 2012, stored in acid-washed bottles and frozen until analysis for total phosphorus at the University of New Hampshire water quality lab using an alkaline persulfate digestion followed by colorimetric measurement of phosphate (EPA method 365.1). One surface water sample was also taken from the wetland outflow in 2014, and analyzed at the NHDES Water Quality Lab in Concord (EPA method 365.2). In addition, water quality reports from 2008-2013 provided by FPU's wastewater treatment facility were also used to characterize the surface water taken from an area adjacent to the RIB, about 80 m southeast of the wetland (Figure 1). These samples were analyzed for total phosphorus by Eastern Analytical Inc. of Concord NH, using EPA method 365.1, as well as for pH, dissolved oxygen, total Kjehldahl nitrogen (EPA 4500N_{org} C/N) and nitrate (EPA method 353.2). Before and after data were compared statistically using a t-test in Microsoft EXCEL.

Vegetation assessments of the wetland were done in 2005 as a part of a larger study, and again in 2012 using a nested plot design. For the survey of the herbaceous layer, four 1 m^2 plots were laid out in the four cardinal directions two meters from Piezometer A. All species within the plots were identified and percent cover was estimated. The shrub layer was surveyed in four 25 m^2 plots in the same manner. Trees were surveyed in a 400 m^2 plot with Piezometer A at the center. Again, all species were identified and percent cover estimated. Diameter at breast height was measured for each tree within the 400 m^2 plot. A list of species present in the wetland before and after the RIB installation was compiled by walking through the entire wetland and recording all species until no new species were found.

Results

Piezometric head levels in Piezometer A increased from an average of 37.24 cm (std. dev. 23.53 cm) below ground to an average of 13.96 cm (std. dev. 2.38 cm) above ground after installation (Figure 4). Similarly, levels in Piezometer B increased from an average of 42.11 cm (std. dev. 50.73 cm) below ground to an average of 21.2 cm (std. dev. 3.21

Figure 3. Franklin Pierce University Rapid Infiltration Bed, south basin.

cm) above ground after installation. Annual discharge from the wastewater treatment plant did not change significantly, averaging 15.3 million gallons per year (std. dev. 0.23 MG/yr) in 2005-2007 and 15.7 (std. dev. 1.25 MG/yr) in 2011-2012. Stage gage data show high water levels, similar to those of the piezometers, in the period after RIB installation as well. Not only did head levels increase substantially, but there was far less variability in head levels in both the shallow and deep piezometers after the RIBs were installed, as indicated by the smaller standard deviation (Figure 5). Water levels increased sufficiently during the study period enough that a surface flow outlet that had rarely seen any outflow was observed to contain flow much more often. A change in precipitation could not explain this difference since annual precipitation was slightly lower in the years after installation (i.e., averaging 115.78 cm, std. dev. 26.7 cm compared to 121.9 cm, std. dev. 18.3 cm in the years before installation; Figure 4). The impact of this change in water levels on the wetland can be seen in Figures 5a and 5b.

Prior to installation, relative head levels in piezometers A and B indicated a pattern of weak recharge gradients in dry periods, alternating with weak discharge gradients in wetter periods. After installation of the RIBs, head levels were higher in Piezometer B than in Piezometer A, indicating a weak but consistent pattern of groundwater discharge gradients (Figure 4).

Water sampling in the wetland shows that specific conductance increased from an average of 50 uS (std. dev. = 6.4) in 2005-2006 to 937 uS (std. dev. = 236.9) in 2012, while pH, using the geometric mean, has also increased from an average of 3.75 (std. dev. 0.2) to 6.0 (std. dev. 0.3). Surface water samples taken directly in the wetland only in 2012 and 2014 show very high total phosphorus levels: 1.09 mg/l (std. dev. = 0.84) in 2012, and 0.207 mg/l (n=1) in 2014.

Surface water monitoring from 2006-2012 taken from an area 80 m southeast of this wetland for required monitoring shows a statistically significant increase in pH, nitrate, and dissolved oxygen, but a significant decrease in total Kjeldahl nitrogen and no significant difference in total phosphorus (Figure 6).

The wetland vegetation showed corresponding changes as well. As shown in Figure 7, the wetland was dominated by *Sphagnum* moss, facultative and facultative wetland species in 2006, but in 2012 the wetland is dominated by obligate and facultative wetland species, and the *Sphagnum* moss has been lost to inundation. The average vegetation cover in the wetland has decreased while dominance of obligate wetland plants has increased (vascular plants, excluding mosses). Table 1 lists new species that were observed after the RIB installation, including obligates *Typha latifolia* and *Lemna minor* and the invasive *Phragmites australis*. Further evidence of wetland degradation was the observation of many dead or dying trees of *Acer rubrum, Tsuga canadensis* and other species.

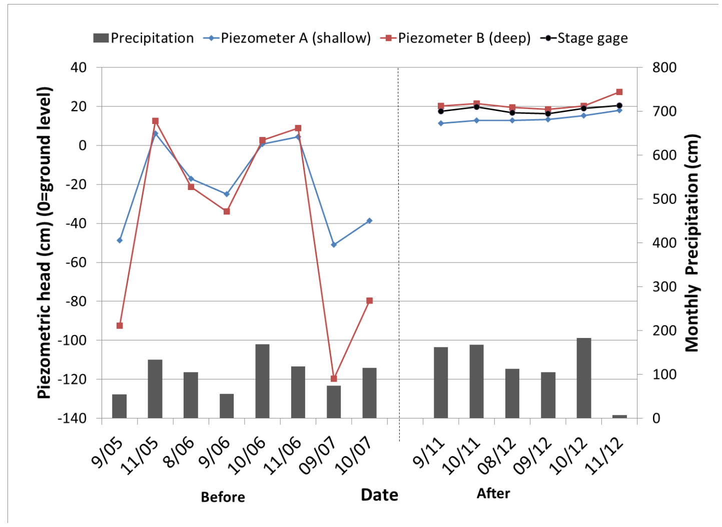

Figure 4. Wetland head levels in Piezometer A (shallow) and B (deep) before and after installation of the RIBs. Stage gage data were not available from the before period. Monthly precipitation is shown by the bars corresponding to the secondary axis.

Figure 5. Wetland from same point before RIB installation and after. Note higher water levels after and the presence of duckweed, Lemna minor) on the water's surface.

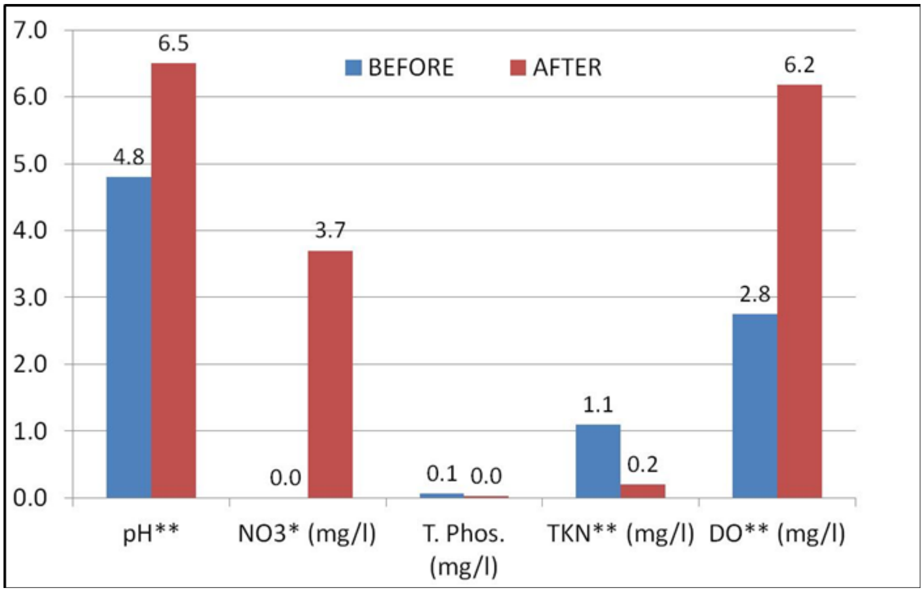

Figure 6. Water chemistry in surface water samples in adjacent wetland area before and after RIB installation. *=significant difference at p<0.01; **=significant difference at p<0.001.

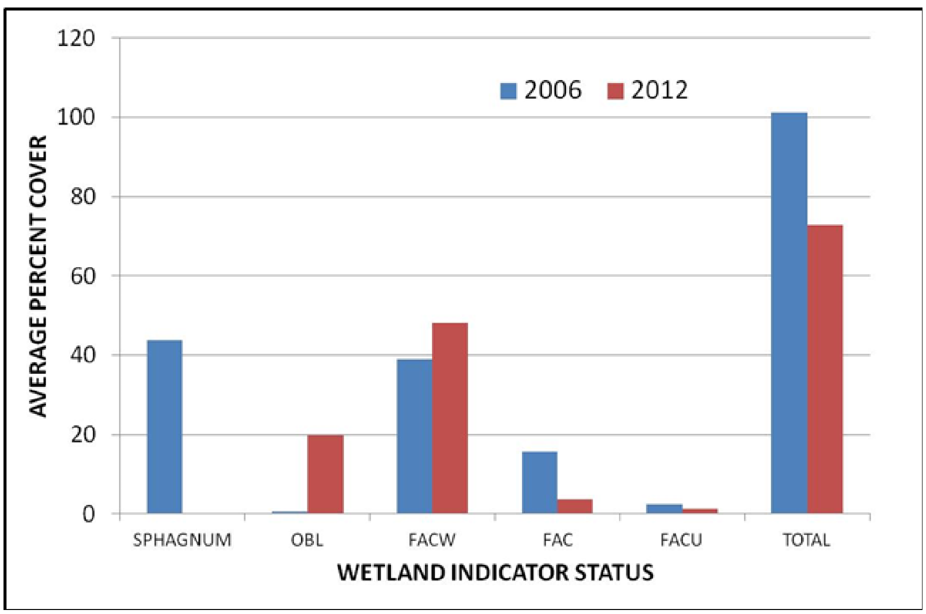

Figure 7. Wetland indicator status of plants in the wetland in 2006 (before RIB installation) and 2012 (after).

Table 1. New plant species found in the wetland after RIB installation.

Scientific name	Common Name	Wetland Indicator Status
Bidens connata	Common beggarticks	OBL
Gaultheria procumbens	Eastern teaberry	FACU
Lemna minor	Duckweed	OBL
Phragmites australis	Common Reed	OBL
Triadenum virginicum	Marsh St. John's wort	OBL
Trillium undulatum	Painted trillium	FACU
Typha latifolia	Broad-leaved cattail	OBL

Discussion

Moura et al. (2011) found that phosphorus levels in soil and groundwater tend to increase in and around RIB systems. In that study, the older systems showed a greater increase. In addition, they found large spatial variability in the phosphorus concentrations in soils around the RIBs, indicating large heterogeneity in subsurface soils. This may explain why phosphorus levels seem to be much higher in the wetland study site here, relative to the University's official shallow surface water monitoring site 80 m southeast of the wetland study site, or the differences may be an artifact of different labs used for water testing or of insufficient sample sizes. The US EPA guide to RIBs indicate that RIB systems rarely fail (EPA 2003), with most failures due to inaccurate site evaluation prior to construction. The FPU site consists of shallow soil over bedrock, necessitating a mounded system, which may have limited the effectiveness of the facility. This geologic setting is less desirable than those of the systems studied by Andres and Sims (2013). These authors found that, despite deep soils high in iron oxides and organic matter, which should favor phosphorus adsorption, the soils in the RIBs showed phosphorus saturation and surrounding groundwater showed high nitrogen and phosphorus levels. In this case, preferential flow paths allowed for faster flow and less effective treatment than was expected.

Conclusion

Water levels in the wetland have clearly increased and shifted from alternating weak groundwater recharge and discharge gradients to weak but steady discharge year-round. The wetland is now connected to adjacent wetlands by surface outflow, so what may have been a "geographically isolated" wetland has gained a more substantive surface flow connection. Elevated specific conductance and pH indicate effluent wastewater may be entering the wetland and changing water chemistry. The plant community has transitioned from a palustrine forest with a dense canopy and an understory of mostly facultative species and *Sphagnum* to a more open canopy forest with an understory of an obligate emergent and floating leaved community. New species found in the wetland included as duckweed, cattails and common reed, all of which are known to respond to very wet, high-nutrient conditions (Farnsworth and Meyerson 2003; Bastlova et al. 2004; Tulbure and Johnston 2010; Ray et al. 2014).

In light of our findings, future plans for the Franklin Pierce University system include greater efforts at phosphorus removal upstream via chemical treatment with aluminum sulfate in the wastewater treatment system, as well as the potential for iron filings to be added to the RIBs when the time comes to replace the sand, and measures to reduce overall water use on campus.

In summary, the results indicate that Franklin Pierce University's RIBs are affecting water levels, water chemistry, and vegetation in the adjacent wetland system. These changes mark a significant shift in the wetland's functions and values and its role within the larger wetland system. While the water quality problem in Pearly Pond is being addressed at a watershed scale by these RIBs and other measures, it is important to quantify the local impacts of RIBs. The potential for the local impacts of RIBs to affect the surrounding ecosystem indicate a need for continued monitoring at this location as well as others. Since RIBs clearly have the potential to alter the functions and values of adjacent wetlands, more attention should be given to site characteristics when planning the use of RIBs for water quality improvement. ■

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Wetland Habitat Assessments at the Rochester Embayment Area of Concern on the South Shore of Lake Ontario, USA

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Wetlands in urban areas along Lake Ontario have been subject to various forms of degradation. The Great Lakes Water Quality Agreement (GLWQA) of 1972 between the United States and Canada was initiated to address the degradation of the physical, chemical, and biological integrity of the Great Lakes. The GLWQA of 1987 (Annex 2) identified locations that have serious contamination and other degradation issues to a greater degree than the rest of the Great Lakes basin, and designated these locations as Areas of Concern (AOCs). AOCs are assessed through preparation of remedial action plans (RAPs) to determine which of 14 "beneficial uses" related to human and intrinsic values of the ecological system remain impaired, and to identify actions that will restore beneficial uses. The Rochester Embayment is one of several areas designated as an AOC. The RAP for the Rochester Embayment Area of Concern (REAOC) provides investigation and remediation strategies for 12 beneficial use impairments (BUIs) including the "Loss of Fish and Wildlife Habitat" BUI (Beal and Stevenson 1997; MCDPD 1993; MCDPH 2011; USEPA 2014). Among BUI removal criteria and recommended

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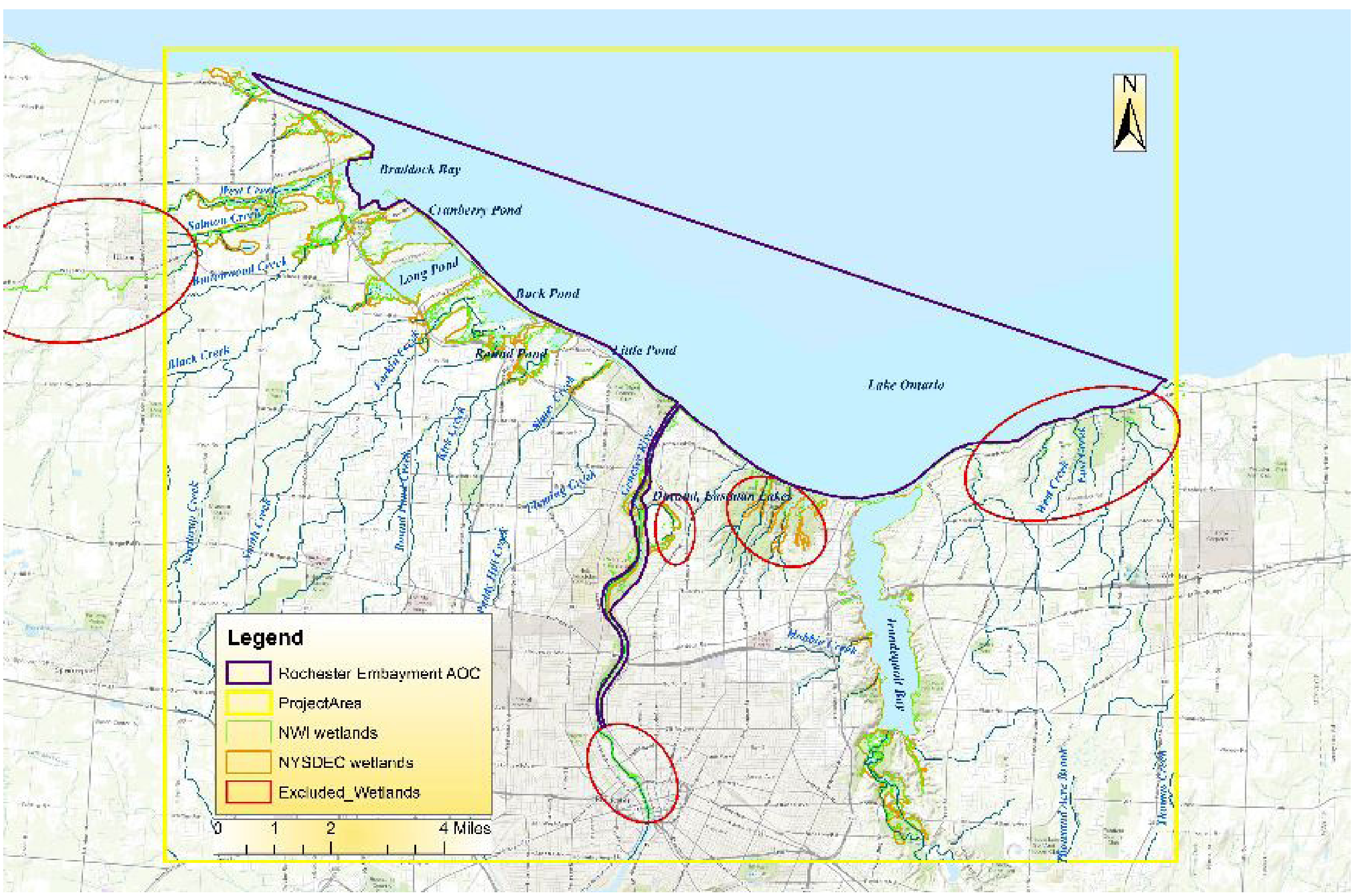

Figure 1. Project area for the USFWS wetland assessment at the Rochester Embayment Area of Concern. Indicated wetlands were excluded because associated waterbodies are small, constructed, and/or are not contiguous with the REAOC proper.

actions for the habitat loss BUI are requirements to assess trends in wetland size and condition, and rank wetland habitats for protection and restoration (E&E 2011; MCDPH 2011). In 2012, the U.S. Environmental Protection Agency (USEPA) Great Lakes National Program Office (GLNPO) requested that the U.S. Fish and Wildlife Service (USFWS) New York Field Office (NYFO) conduct these assessments under Great Lakes Restoration Initiative funding.

In 2012-2013, NYFO conducted assessments in wetlands associated with waterbodies in the immediate vicinity of the REAOC. The project area was defined by the extent of New York State Department of Environmental Conservation (NYSDEC) and USFWS National Wetlands Inventory (NWI) mapped wetlands in the REAOC, and contiguous wetlands in connected waterbodies (Figure 1). The project addressed the following objectives: (1) determine whether (a) wetland extent or (b) wetland quality is in decline at the REAOC; and (2) rank current habitat condition of the wetlands for restoration and preservation prioritization. The final report – "Wetland assessment in the Rochester Embayment Area of Concern in support of the Loss of Fish and Wildlife Habitat BUI Removal Evaluation" is available on the NYFO web site (http://www.fws.gov/northeast/nyfo/ec/glri.htm). This article summarizes key findings.

Change in Emergent Wetland Extent

Change in wetland extent was evaluated in 14 waterbodies by comparing emergent marsh delineations from 1951 aerial imagery against 2011 delineations. The analysis focused on emergent wetlands, since delineation of the historical extent of submerged wetlands and many wooded wetlands was not possible using historical aerial photographs alone. Delineations and interpretations using aerial imagery were conducted consistent with methods used by the National Wetlands Inventory (NWI).

Historical wetland signatures were delineated from October 1951 black and white aerial photographs, with other imagery used to assist in interpretation where necessary. Existing data compiled by the University of Massachusetts from 2011 color infrared imagery served as the base delineation for current wetland extent. Where the 2011 CIR coverage was incomplete, we used 2011 orthographic true color imagery to fill in gaps (ArcGIS 10.0 Bing base map, June 2011). The most recent leaf-off imagery (e.g., 2009 orthographic aerials and 2005 CIR) was also consulted for reference as needed.

The project area experienced a total net loss of approximately 280 acres of emergent wetland from 1951 (2,263 acres) to 2011 (1,982 acres). Both losses and gains were

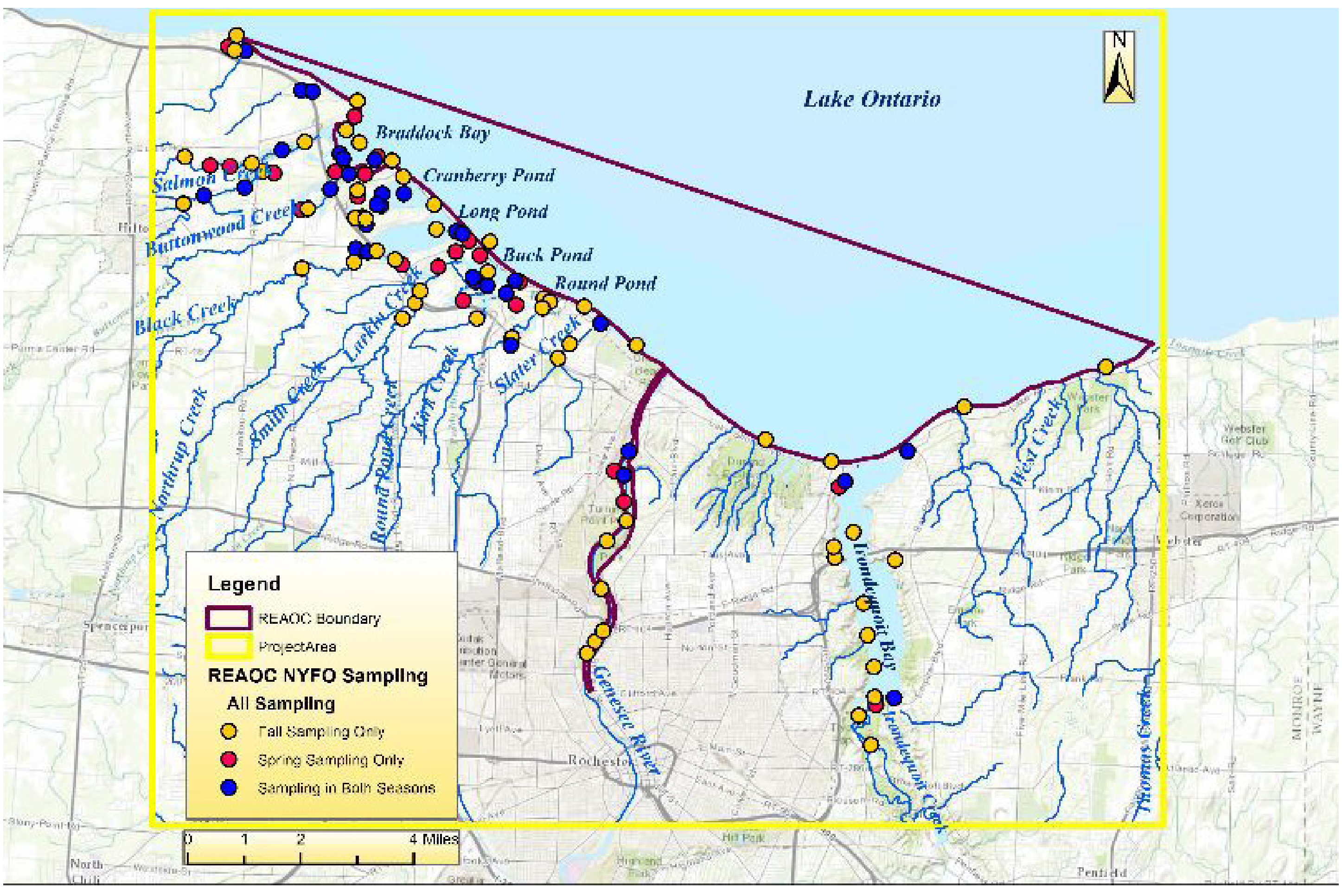

Figure 2. Distribution of 112 stations sampled in fall 2012 or spring 2013 for structural and vegetative habitat, water quality, and/or animal communities in order to rank wetland quality among waterbodies in the immediate vicinity of the REAOC. Points are differentiated by sampling season.

observed in different areas within most waterbodies. Net losses ranging from 1 to 121 acres were seen in 11 of the 14 waterbodies evaluated, while net gains ranging from 11 to 40 acres were observed in three of the waterbodies (Table 1). Most of the lost acreage was due to road construction and other development, erosion potentially resulting from water level regulation in Lake Ontario initiated in the 1960s, and natural dynamic shifts at wetland margins (Table 2).

Change in Wetland Quality

Change in wetland quality was explored in 16 waterbodies through evaluation of 19 individual metrics characterizing structural habitat condition, water quality, and animal communities. Trend analysis of time series data was conducted for water quality (1991-2009) and animal community metrics. Animal community metrics of wetland habitat quality were derived using existing guidance (Burton 2008; Grabas et al. 2008; GLC 2008; Timmermans et al. 2008) from call count data for both birds and amphibians collected within the project area during 1995-2011 by the Great Lakes Marsh Monitoring Program (BSC 2000). High variability typical of water quality and animal call count data was dampened by computing mean values for each metric by waterbody for each year sampled. Mean values were plotted over time, and apparent trends were statistically evaluated using the Mann-Kendall non-parametric trend test (Gilbert 1987; Nielson 2006). Change in structural habitat was interpreted by comparing current to historical aerial imagery (2011 to 1951) at a total of 79 stations distributed across the project area. Three structural habitat metrics indicative of habitat resiliency and complexity were evaluated: Percent of Assessment Area (AA) with a Buffer, Buffer Width, and Patch Mosaic Complexity. These metrics are included in the USA Rapid Assessment Method (RAM) (USEPA 2011), as applied for the National Wetland Condition Assessment.

There was no overall temporal trend in wetland quality in the project area as a whole, although obvious trends were detected within individual waterbodies (Table 3). Both improvements and declines in quality were observed in each waterbody considered, depending on the specific metric observed. Water quality improved in seven of the

Wetland Complex	Waterbody	Emergent Wetland Acreage in 1951	Emergent Wetland Acreage in 2011	Net Change in Emergent Wetland Acres since 1951*	Acres Lost	Acres Gained	% Change since 1951 in Emergent Wetland Extent
Braddock Bay	Braddock Bay	290.63	223.42	-67.21	-100.13	32.92	-23.13%
	Salmon Creek**	99.80	140.26	40.46	-8.63	49.09	40.54%
	West Creek**	24.70	35.65	10.95	-1.77	12.72	44.32%
	Buttonwood Creek	151.08	136.34	-14.74	-15.85	1.10	-9.76%
Buck/Round	Buck Pond	626.90	505.43	-121.47	-124.25	2.78	-19.38%
	Round Pond	222.22	201.25	-20.98	-29.76	8.79	-9.44%
Cranberry/Long	Cranberry Pond	209.13	193.85	-15.28	-16.93	1.65	-7.31%
	Long Pond	88.13	64.16	-23.97	-30.83	6.87	-27.20%
Genesee River		130.25	83.85	-46.40	-59.10	12.70	-35.62%
Irondequoit	Irondequoit Bay	63.24	52.62	-10.62	-37.29	26.68	-16.79%
	Irondequoit Creek and Eastern Trib**	195.08	208.53	13.45	-36.59	50.05	6.90%
Bogus Point	Bogus Pond Marsh	36.16	35.26	-0.90	-2.88	1.98	-2.49%
	Payne Beach Marsh	105.48	89.57	-15.91	-15.91	0.00	-15.08%
Slater Creek		20.59	11.65	-8.94	-12.90	3.96	-43.43%
REAOC Overall		**2263.38**	**1981.83**	**-281.55**	**-492.84**	**211.29**	-12.44%

*Submerged aquatic vegetation was not considered due to the difficulty of accurately measuring historic extent of aquatic beds. Only areas with high certainty of cover type in both sets of imagery were utilized to calculate change in emergent wetland extent.

**Water level in 1951 imagery for Salmon, West, and Irondequoit Creeks appeared higher than in 2011 imagery, leading to calculated wetland gains.

Table 1. Estimated acreage and summary of changes in emergent wetland extent from 1951 to 2011, by waterbody in the REAOC project area.

eight waterbodies considered, but absolute nutrient levels remained excessively high in a few of those waterbodies despite improving trends. Patterns in structural habitat and animal community trends were less clear, except in a few waterbodies. Among the clearest patterns were net declines in wetland quality in Irondequoit Creek and West Creek, and a broad improving tendency in Irondequoit Bay, Buck Pond, and Cranberry Pond. Specific metrics that declined most consistently across waterbodies were patch mosaic complexity, bird species diversity, bird focal species richness, and bird index of biological integrity (IBI).

Ranking Current Wetland Quality

Wetlands were ranked for restoration and preservation prioritization using metrics of structural habitat condition, water quality, and/or animal communities (Table 4). Metrics were derived from data collected in 2012 and 2013 at a total of 112 sampling stations distributed across the project area. Standardized field methods were selected that were: designed for extensive sampling across large areas, rapidly implemented, and readily repeatable. Structural habitat quality was assessed using the USEPA's USA Rapid Assessment Method, which has been utilized in

Loss Type	Loss Cause[1]	Acreage by Cause
Mowed	Development	0.42
Fill	Development	57.31
	Uncertain	2.17
	Road	63.15
	Stream Channelized	5.03
Hydrological shift	Development	0.47
	Road	15.48
Hydrological change with Fill	Uncertain	26.21
Made Land	Development	30.04
	Road	24.29
Residential	Development	6.39
	Stream Channelized	3.90
Shift	Delineation	0.03
Shoreline	Erosion	2.89
Conversion of wetland to water	Development	26.72
	Dredge	16.11
	Dynamic shift	93.38
	Erosion	82.85
	Road	20.76
	Stream Channelized	3.25
	Water Level	11.99
TOTAL of LOSSES		**492.84**

Table 2. Loss in wetland acreage between 1951 and 2011 across entire REAOC project area, tallied by attributed cause.

Waterbody	Structural Habitat			Water Quality			Bird Community								Amphibian Community				
	% AA With Buffer	Buffer Width	Patch Mosaic	Total P	SRP	TSS	Total Call Count	NAF Call Count	MNO Call Count	Total Species Richness	Focal Species Richness	AMNO Species Richness	Diversity Index	Index of Biotic Integrity	Total call count	Total Species Richness	Woodland Species Richness	Diversity Index	Index of Biotic Integrity
Bogus Pond	NT	NT	NT																
Payne Beach Marsh	NT	NT	I																
Braddock Bay	I	I	D	I	I	NT													
West Creek	NT	NT	I				D	D	D	NT	NT	NT	NT	NT	NT	NT	D	NT	D
Salmon Creek	NT	I	NT																
Buttonwood Creek	I	I	I				NT	NT	D	D	D	D	D	NT	NT	NT	NT	NT	NT
Cranberry Pond	I	I	I	I			I	I	I	I	D	D	NT	D	I	NT	I	NT	I
Long Pond	I	NT	D	I	I	NT									D	D	D	D	D
Northrup Creek	NT	D	D	I															
Buck Pond	I	I	D	I			I	I	NT	I	D	D	D	NT	I	I	I	I	I
Larkin Creek	NT	NT	NT																
Round Pond	I	I	D																
Slater Creek	NT	NT	NT																
Genesee River	NT	D	D	I	I	I									D	NT	NT	I	NT
Irondequoit Bay	D	D	I	I	I	NT	I	I	I	I	I	I	NT	NT	NT	NT	NT	NT	I
Irondequoit Creek	D	D	D	NT	D		I	I	NT	NT	D	NT	NT	D	I	D	D	NT	NT

Table 3. Summary of changes in mean values of wetland habitat quality metrics[1] (D=Decline, I=Increase, NT=No Trend, blank=data insufficient to evaluate trend). Associated waterbodies are listed approximately west to east. 1. *Acronym definitions are provided in the on-line final report.*

Structural Habitat	Water Quality	Animal Communities	
		Birds	Amphibians
Percent of Assessment Area having a Buffer	Total Phosphorus	Species Diversity Index	Species Diversity Index
Buffer Width	Total Suspended Solids	Index of Biological Integrity	Index of Biological Integrity
Stress to the Buffer Zone	Total Dissolved Solids	Species Richness (All)	Species Richness (All)
Topographic Complexity	pH	Focal Species Richness	
Patch Mosaic Complexity	Dissolved Oxygen		
Vertical Complexity	Nitrite		
Plant Community Complexity	Ammonia		
Stress to Water Quality			
Alterations to Hydroperiod			
Habitat/Substrate Alterations			
Percent Cover of Invasive Species			
Vegetation Disturbance			

Table 4. Metrics used to rank current wetland quality in the REAOC project area.

System	Structural Habitat EPA RAM	Water Quality YSI/grab	Animal Communities MMP	
			Birds	Herps
Lentic	Long Pond	Long Pond		Long Pond
	Buck Pond	Buck Pond	Braddock Bay	Braddock Bay
	Irondequoit Bay	Round Pond	Irondequoit Bay	Irondequoit Bay
Lotic	Genesee River	Genesee River		Genesee River
	Irondequoit Creek	Irondequoit Creek	Irondequoit Creek	Irondequoit Creek
	Braddock Bay Tributaries	West Creek	Buttonwood Creek	

Table 5. Summary showing the lowest ranked waterbodies in each habitat assessment category; the colors link waterbodies to a common watershed.

the National Wetland Condition Assessment. Water quality parameters were measured consistent with a 2011 QA/QC protocol of the analytical lab. Bird and amphibian communities were characterized using the Marsh Monitoring Protocol (BSC 2000).

Both metrics and waterbodies were ranked. Low-ranking metrics provided guidance to restoration planning by identifying which wetland attributes scored lowest, hence most in need of improvement. For example, a low score for patch mosaic complexity indicated that increasing the interspersion of habitat types would be an appropriate restoration objective. Ranking habitat quality by waterbody identified where restoration and protection are most needed.

Factors consistently found to be responsible for driving down wetland quality scores across waterbodies included ammonia, total phosphorus, and dissolved oxygen (DO) levels, and the following structural habitat metrics: patch mosaic complexity, stress to the buffer zone, topographic complexity, vertical (plant strata) complexity, and plant community (taxonomic) complexity. This set of low-scoring habitat metrics indicated a degradation of overall habitat complexity and resiliency. We deconstructed the lowest scoring structural habitat metrics to identify specific field indicators most responsible for driving down habitat quality scores across the project area; specific restoration recommendations were based on this analysis.

Poor structural habitat complexity broadly translated into limited habitat edge and low habitat diversity, hence, limited capacity for robust and diverse plant and animal communities. This interpretation was supported in the trend analysis of animal community metrics, which identified broadly declining trends in marsh bird diversity, focal species richness, and IBI scores across waterbodies in the project area. These findings suggested that activities for restoring habitat should focus on improving structural and vegetative complexity, and where feasible, mitigating up-gradient nutrient loadings and rehabilitating degraded buffers as well as protecting intact buffers.

Weight-of-evidence analysis identified principal candidate waterbodies for wetland habitat restoration within the project area: Braddock Bay and its tributaries, Long Pond, Genesee River, Irondequoit Bay, Irondequoit Creek, and Buck Pond (Table 5). Cranberry Pond was the best candidate for wetland protection, as it ranked relatively high across assessment metrics.

Ongoing Activities

We are now coordinating construction projects and efficacy monitoring in consultation with interagency technical advisors based on the findings from this wetland assessment, in order to improve habitat for diverse wetland wildlife within the project area. ■

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Kite-based Aerial Photography (KAP): A Low Cost, Effective Tool for Wetland Research

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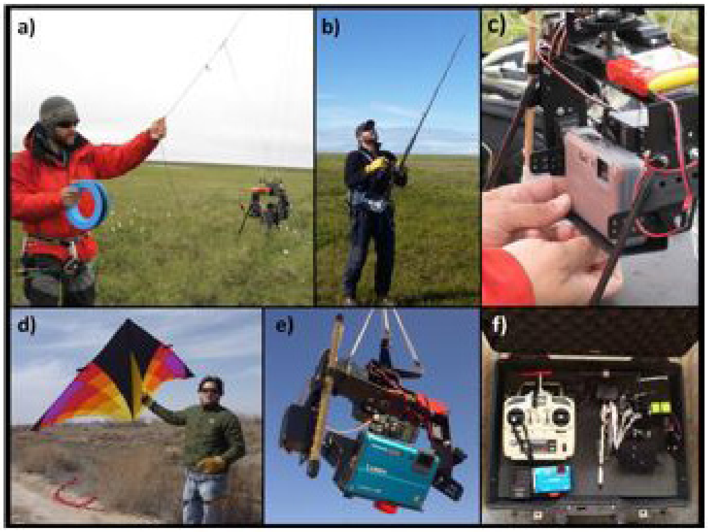

Figure 1. KAP equipment used for the studies featured in this article. a) Deployment of KAP rig with hand reel and waist harness for line attachment, b) Rod and reel for high altitude image acquisition (>200m), c) Camera setup on KAP rig, d) Delta style kite (9ft), e) KAP rig and picavet auto-levelling system, f) and carry case with the KAP radio control, camera, rig, tools, and spare parts.

The development and utilization of new technologies in wetland research is key for advancing knowledge, conservation, and management of these important ecosystems. While satellite-based remote sensing has proven valuable for understanding mostly regional to continental scale changes in wetlands (Ozesmi and Bauer 2002, Rebelo et al. 2009), the high spatial heterogeneity of wetland plant communities and landscape units has proven challenging to characterize with the use of satellite technologies (e.g., Kim et al. 2012). The use of aerial photography to link or scale plot scale measurements to those made by satellites has long been recognized (e.g., Harris and Bryant 2009). More recently, the increasingly popular use of unmanned aerial vehicles to acquire low altitude high resolution imagery and other data at relatively low cost has reinforced the utility of aerial remote sensing platforms. When most researchers think of UAVs, they think of scaled down airplanes (Rango et al. 2006), blimps (Marzolff and Poesen 2009), and helicopters or quad/octocopters (Rosnell and Honkavaara 2012). Few researchers think of kites as a capable, affordable, and efficient platform for acquiring aerial imagery - kite-based aerial photography (KAP) (Aber et al. 1999, Dandois and Ellis 2010), despite kites being used to acquire among the first airborne imagery ever captured (Beaufort and Dusariez 1995). Furthermore, unlike most of the other UAVs listed above, KAP systems are less restricted by general aviation regulations in most countries. Previous studies have shown the feasibility of KAP as an valuable tool for a wide variety of environmental observations including land degradation (Marzolff et al. 2002), surface hydrology (Andresen and Lougheed in review), high mountain ecosystem research (Wundram and Löffler 2007), biocontrol assessment (Aber et al. 2005), forest ecology (Aber et al. 2002), and bird colony census (Fraser et al. 2010). Given that many wetland landscapes typically experience windy conditions, KAP represents a suitable platform for acquiring high spatial resolution aerial imagery of these ecosystems. This article introduces kite-based aerial photography to the wetland scientific community as an inexpensive, user-friendly remote sensing technique that has numerous applications in wetlands research.

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Methodology and Equipment

A typical KAP system consists of a kite, a kite line and a camera rig suspended from the kite line (Aber et al. 1999). For the case studies presented in this article, a relatively simple light-weight single-camera rig system lifted by a delta style kite was utilized (Figure 1). The rig allows users to pan, tilt and trigger the camera via a remote transmitter that is typically used by model airplane enthusiasts (4 channel R/C system). This system permits users to acquire images of a given region of interest from various perspectives. Cameras included relatively standard point-and-shoot and small DSLR models. For low altitude flights, a 100-250 lb-test Dacron or braided line was used, while for high altitude flights (>200m), a large-line capacity (500-1000m) fishing reel and rod was used to make line control more efficient and comfortable for the user. It is advice to always wear heavy-duty gloves for hand protection from line.

Prior to flying it is important to know the size of the area of interest in order to calculate the desirable flying height. Optimal flying heights can be estimated based on the viewing angle of the camera using basic trigonometry and users are advised to conduct pre-flight calculations of line length vs flying angle. Several websites also facilitate the calculation of optimal flying heights given camera specifications (e.g., http://www.aerogis.de/eng/gsdcalculator.html; http://www.grc.nasa.gov/WWW/k-12/airplane/kitehigh.html). During high altitude flights, considerable bow can persist in the kite line and we have found that attaching a transmitting GPS to the KAP rig aids in calculating both the horizontal distance the KAP rig is away from the user and if the KAP rig is positioned optimally over the region of interest (ROI). When combined with measurement of flying angles of the kite relative to the observer using a clinometer, flying height can easily be calculated using formulae in the links provided above. It should be noted that fluctuations in wind speed and turbulence can alter camera rig height rapidly so it is wise to be conservative in the calculations of the camera footprint and either oversample the ROI and/or fly at a higher altitude to ensure a larger sampling footprint.

Image Processing

In recent years, advances in photogrammetric and digital image processing software have substantially improved capacities for deriving environmental characteristics from photographs. Images can be incorporated into Geographical Information System (GIS) software using geometric corrections based on ground control points (GCPs) distributed throughout the site or by image to image rectification with existing high resolution satellite or aerial imagery. When study sites are larger than the camera's footprint, images can be mosaicked and color balanced in a range of image processing software (e.g. ERDAS Imagine, ENVI, Agisoft, PhotoScan, etc.). After geometric correction and/or mosaicking, images can be used for multiple purposes including delineation of features of interest, production of land cover maps, estimation of area or distance, and calculating vegetation greenness indices that are proxies for vegetation productivity (Richardson et al. 2009, Migliavacca et al. 2011). In addition, recent advances in digital photogrammetry, image processing, and computing has allowed for 3D spatial data to be derived for ROIs captured with multi-view imagery that is suitable for the production of digital elevation and hydrographic surface models (e.g., Snavely et al. 2010). Below, we present two case studies that showcase the potential of KAP in wetlands research.

KAP Case Studies

The Rio Bosque Wetlands Park is a 372-acre mitigation site near El Paso, TX that includes a seasonally waste-water irrigated wetland (Rodriguez and Lougheed 2010). Management of invasive species such as tumbleweed (*Salsola* spp.) and saltcedar (*Tamarix* spp.) can be aided by the production of detailed land-cover classifications using ENVI

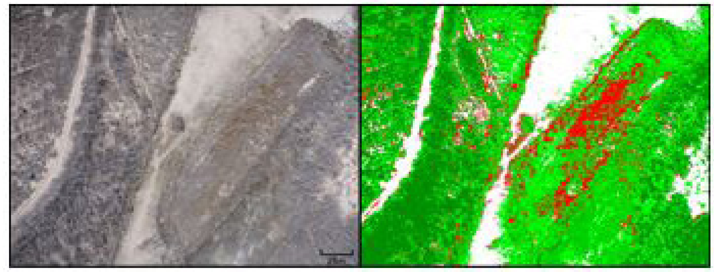

Figure 2. Winter KAP image of Rio Bosque Wetland Park (left) and supervised land-cover classification (right) depicting invasive species in red (mostly tumbleweed), and native plant communities (green).

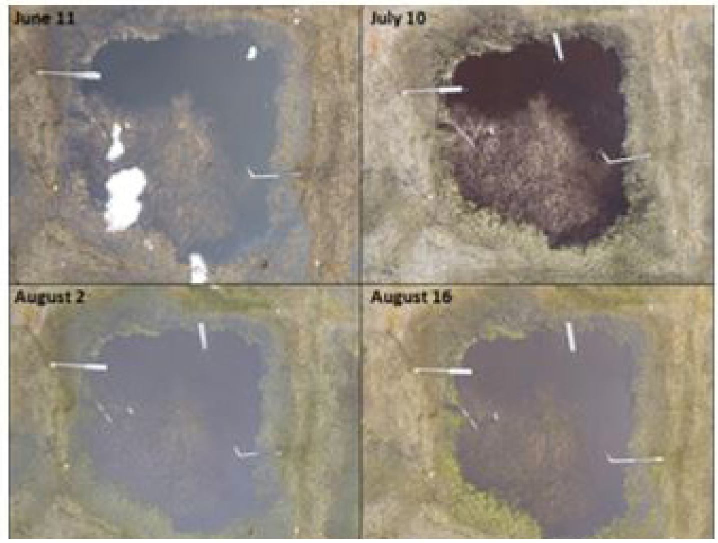

Figure 3. Kite-based aerial imagery of an Arctic tundra pond showing seasonal changes in pond water depth and plant cover during the growing season in 2011 (Site: IBP-J 71.293626N, -156.70144W). Infrastructure for accessing the ponds can be seen in all photographs and snow/ice can be seen in the image acquired on June 11th. Imagery was acquired with a point and shoot camera at an approximate height of 80m.

Figure 4. KAP panoramic image composite of the International Biological Program wetland ponds near Barrow, Alaska acquired with a DSLR camera at an approximate height of 100m.

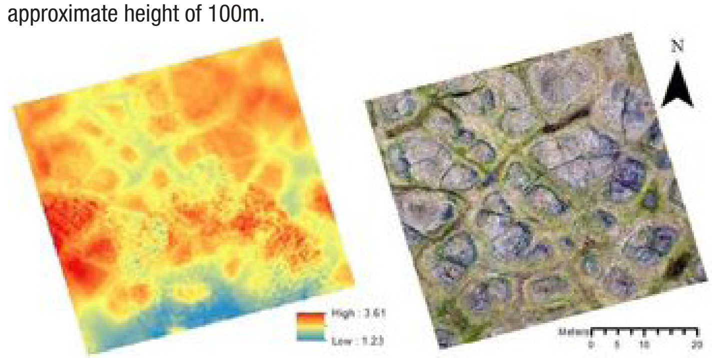

Figure 5. Interpolated DEM surface model (left, meters above sea level) and corresponding georeferenced kite aerial image (right) for polygonal tundra near Barrow, Alaska. DEM derived from 200 multi-view angle images at a height of 50m approximately.

and KAP imagery acquired with a point and shoot camera flown at approximately 80m (Figure 2). Ground surveys suggest that the classification given in Figure 2 allows for the identification of tumbleweed plants that are as small as 15cm in diameter.

For Arctic Tundra Wetland research on the North Slope of Alaska (Lougheed et al. 2011), the KAP system was used to document seasonal landscape-level changes and spatial and temporal greening trends of small tundra ponds, generally less than 40m across (Figure 3). In addition, the KAP was used to obtain composite image mosaics for larger wetlands, oblique-view panoramas (Figure 4) and digital elevation models (DEMs) (Figure 5). Greening trends can then be calculated using georeferenced repeat photography and greenness indices that are proxies for plant phenology and carbon fluxes (e.g. Richardson et al. 2009; Migliavacca et al. 2011). DEMs were derived from multi-view imagery that were processed with Agisoft PhotoScan.

KAP Advantages and Challenges

We tested the KAP system in a variety of wetlands situated in extreme environments such as the Arctic tundra and the Chihuahuan desert. This low-cost remote sensing system has proven to be a cost effective and reliable tool for acquiring high-spatial resolution aerial imagery of research sites. The advantages of KAP over other small format aerial photography platforms such as the UAVs listed above, include lower cost, longer flight times (including sustained stationary acquisitions), ease of operation and few legal constraints. The relatively low cost of a KAP system is one of the major advantages over remote sensing platforms. The systems we typically deploy cost $500 - $1,000 US depending on the camera and altitude we are flying. One of the major limitations of drones is their short flight time, which is directly related to the battery life, design, and payload. In contrast, KAP systems can be flown for a couple of hours depending mainly on wind strength and battery life of the camera and servos on the KAP rig. In addition, the simplicity of KAP over drones and other systems makes it a better option for inexperienced or infrequent users and/or users deploying systems in remote areas where there is limited access to specialist components. Piloting drones is technically demanding and usually requires extensive maintenance in comparison with KAP systems. We typically 'fly blind' in that we do not usually telemet video footage from the KAP rig to the user on the ground. As a result, the user and, where possible, observers position the KAP rig over a given ROI by careful judgment. We have found that experience improves target accuracy and that it is only for high altitude KAP that the need for a real time video feed would be useful. Nonetheless, following a flight, we always carefully view images on site and repeat the flight if we are dissatisfied with initial results.

As with most aerial remote sensing platforms, there are challenges to KAP. Although kites of varying sizes and multi-kite configurations can be used to sustain flight during varying wind conditions, including turbulent conditions downwind of ridgelines and infrastructure, winds of less than 7mph typically prevent flight. When flying a 1kg KAP rig, small delta kites (8-12ft) are well suited to strong winds (15+ mph) and bigger kites (12-16ft) for lighter winds (7-15 mph). In some cases, wind direction can be problematic if obstacles prevent overflight of a target downwind of the user. Forests and vegetation can be problematic especially with canopy taller than 10m. It is advice to launch the kite in open areas free of obstacles such as power lines and large trees. Flying the kite at higher altitude helps gain kite stability by avoiding canopy and terrain wind turbulence. A preflight analysis of the research site is highly encouraged to address questions of wind speed and direction as well as launching area and potential obstacles. In addition, several bad experiences hasten us to caution users that weather conditions can change quickly at times and that appropriate scenarios for responding to such adversity should be planned before any flight. We also encourage users to fly responsibly and abide by flight restrictions enforced by local and general aviation authorities. ■

Acknowledgements

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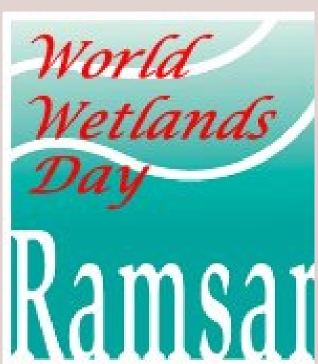
World Wetlands Day Coming

Every year the international community celebrates wetlands around the globe on February 2. This day marks the anniversary of the signing of the Convention on Wetlands of International Importance in Ramsar, Iran in 1971 (see the article by Rob McInnes in this issue of Wetland Science and Practice for more information on the treaty). On World Wetlands Day, governments and non-government organizations sponsor events (e.g., nature walks and lectures) to increase public awareness of wetland values and benefits and promote wetland conservation. For a list of U.S. Ramsar sites where events may be happening, check out the website of the U.S. National Ramsar Committee: http://usnrc.net/.



WETLAND SCIENCE RESEARCH NEWS

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).

Carlos Troche has shared summaries of two ongoing wetland research projects in Mexico that he is involved with. One of them at CONABIO (a government agency) and the other one at the Centro de Investigaciones en Geografía Ambiental of the Universidad Nacional Autonoma de Mexico.

Mexican Wetlands: Assessment and Spatial Monitoring

Study by the National Commission for Knowledge and Use of Biodiversity (CONABIO)

Objectives:
1. develop a remote sensing method to identify, delimit and characterize four
4. mexican wetlands;
2. generate land use / land cover maps;
3. examine seasonal changes in waterbodies in wetlands; and
4. explore the relationship between wetland vegetation (biomass) and passive/active optical sensing data.

Expected completion: December 2015
Contacts: Dr. Rainer Ressl (rressl@conabio.gob.mx) and Carlos Troche (ctroche@conabio.gob.mx)

Geo-ecological Assessment of Coastal Wetlands as Carbon Sinks

Research at the Centro de Investigaciones en Geografía Ambiental *of the Universidad Nacional Autonoma de Mexico*

Objectives:
1. determine the composition, structure, distribution and differences in coastal wetland landscapes at 1:250000 and 1:50000 scales;
2. examine the relationship between the heterogeneity of landscapes of coastal wetlands in the Gulf of Mexico, their vertical structure and storage capacity of soil carbon; and
3. establish the relationship of landscapes and biomass estimated from geographic object-based Image analysis.

Expected completion: August 2018
Contacts: Carlos Troche (ctroche@pmip.unam.mx) and Dr. Ángel Priego Santander (apriego@ciga.unam.mx) ■

This is a new subsection of the Wetland Science section of WSP that allows students to provide a little background on themselves and highlight their ongoing projects. The first contribution comes from Wes Hudson a Ph. D candidate at the Virginia Institute of Marine Sciences, College of William & Mary, Gloucester Point, VA, USA. Other students interested in summarizing their work should send their profiles to the WSP Editor (rtiner@eco.umass.edu).

Seeking Improvements in Forested Wetland Restoration

Herman W. Hudson III

My current research is an outgrowth of my master's thesis that focused on the drivers of natural tree colonization into post agricultural restored wetlands in southeastern Virginia (Christopher Newport University under Dr. Robert Atkinson). Heavy colonization (>90,000 stems/ha) by pioneer species decreased exponentially as distance from the forest edge increased and stem density was also positively correlated with the size of the trees in the surrounding forest. When tree planting is necessary for the success of a restoration project, deciding what species and stocktype[1] to plant can be a challenge and little information is available to guide practitioners. Few studies have investigated how species and stocktype choice can influence the development of ecosystem functions in forested wetlands. This gap in knowledge drove my interest in forested wetland restoration and is the basis for my dissertation for the Doctorate in Marine Science with Dr. James Perry at the Virginia Institute of Marine Science (VIMS).

My dissertation is a large-scale field experiment that was planted with 2,772 trees in 2009. Seven species were planted: *Betula nigra* (river birch), *Liquidambar styraciflua* (sweetgum), *Platanus occidentalis* (American sycamore), *Quercus bicolor* (swamp white oak), *Quercus palustris* (pin oak), *Quercus phellos* (willow oak) and *Salix nigra* (black willow). Three stocktypes of each species were used: bare-root, tubeling, and 1-gallon containers. The trees were planted in three cells where the hydrology was manipulated using an aboveground irrigation system to include: (1) an ambient cell (a minimum 2.5cm irrigation or rain per week), (2) a saturated cell (kept saturated at a minimum of 90% of the growing season within the root-zone), and (3) a flooded cell (inundated above the root collar at least 90% of year). The environmental conditions in the wettest treatment (flooded cell) represented conditions that could exist in a recently restored forested wetland. They

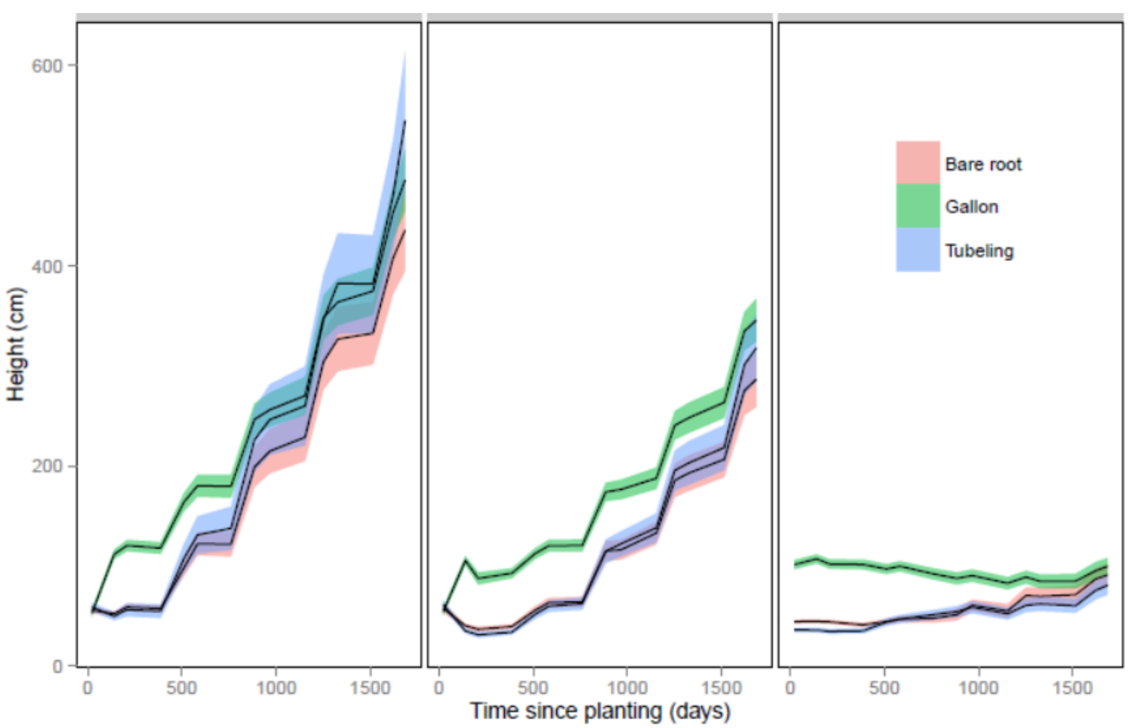


Figure 1. Height of stocktypes in 3 cells over 5 years. Solid line represents mean and colored ribbons represent 95% confidence interval.

1. Stocktype is a loose term that refers to the culmination of various nursery production techniques.

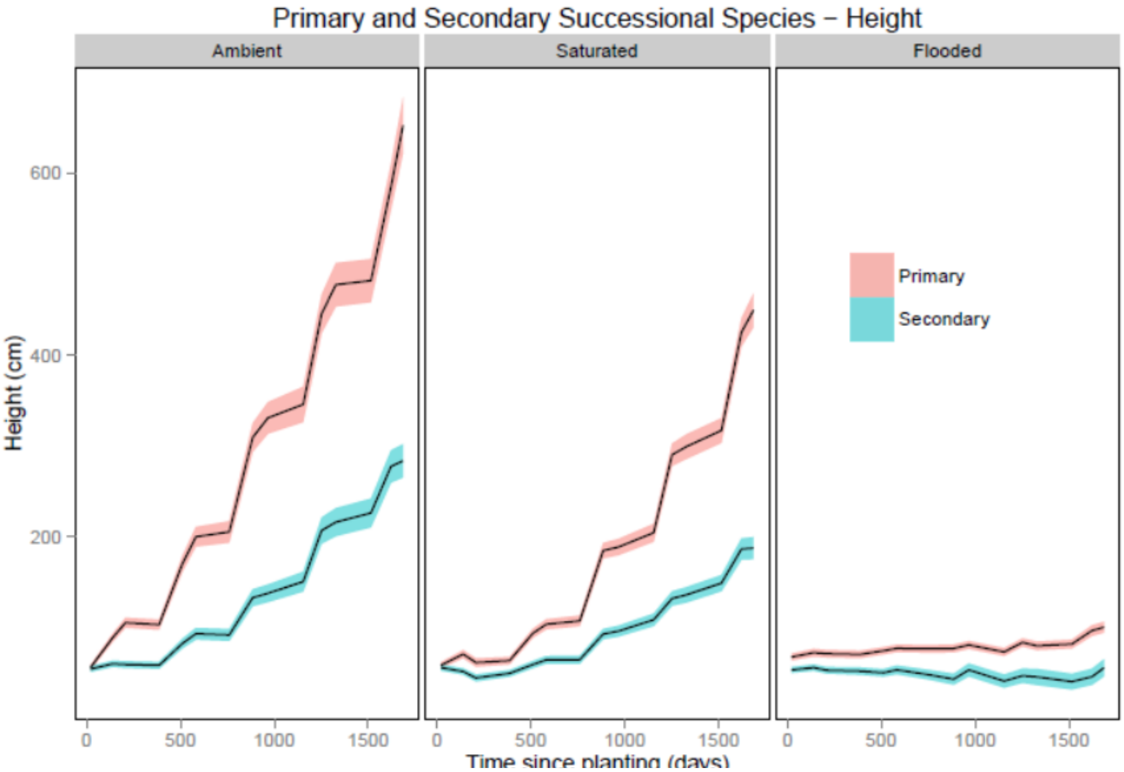


Figure 2. Height of primary and secondary successional species in 3 cells over 5 years. Solid line represents mean and colored ribbons represent 95% confidence interval.

were more stressful than those of the ambient and saturated cells due to uncontrolled herbaceous vegetation competition, higher soil bulk density, lower soil nutrient content, and higher clay content. More than 200 citizen volunteers helped monitor the survival and growth (stem diameter, height, and canopy diameter) of the planted trees for five years. Above- and below-ground biomass of 560 trees were harvested and measured to develop equations relating the biomass to morphological traits, which will quantify biomass accumulation and carbon sequestration functions.

The preliminary results suggest that under stressed conditions (flooded cell) similar to those found in recently restored forested wetlands, stocktypes with larger initial size survive, grow and accumulate biomass more that the smaller stocktypes (Figure 1). Primary successional species (especially *S. nigra*) exhibited greater survival than secondary successional species (*Quercus*) in stressed environmental conditions while the survival of the secondary species equaled or exceed the survival of the primary species in less stressful conditions. The growth and biomass accumulation of the primary successional species was greater than secondary species under all environmental conditions (Figure 2).

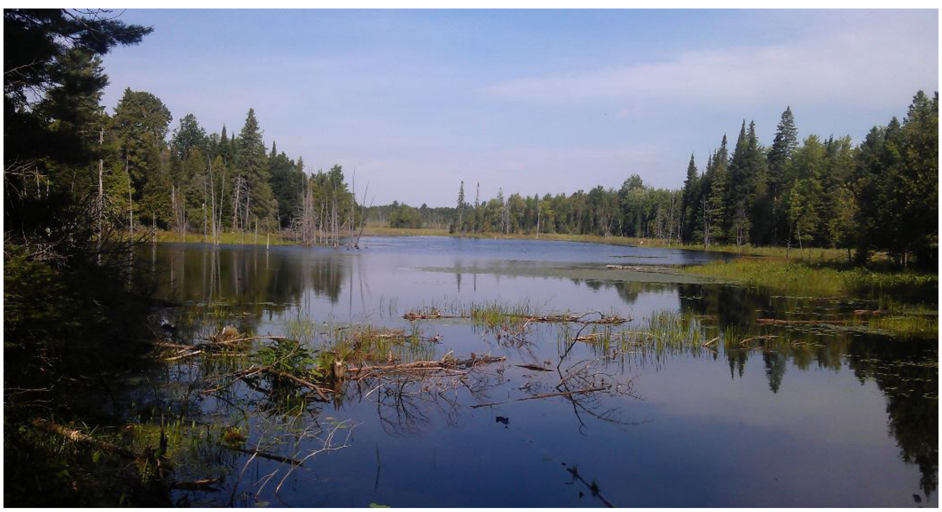
These preliminary findings suggest that species and stocktypes need to be selected to match the conditions present at the restoration site or, failing that, primary successional species should be planted using larger stocktypes to ensure the return of ecosystem functions (habitat, productivity, carbon sequestration, etc.). Where the environmental conditions are less stressed, small stocktypes could be used to reduce the cost associated with planting and both primary and secondary species could be used to enhance biodiversity and return gradients of ecosystem functions.

The future goals for this research are to quantify the amount of carbon sequestered by these species and to investigate the role competition/facilitation may have on tree survival and growth. Other research has shown that early successional species could facilitate natural colonization or survival and growth of planted late successional species. My hope is that this research will help improve the practice and ecological understanding of forested wetland restoration.

For additional information on the research, please contact Wes at: hwhudson@vims.edu or via Twitter: @hwhudson3. ■

An Outstanding Example of a Personal Contribution to Wetland Conservation

While many of us contribute time and/or money to causes and organizations that support land conservation, it is also possible to go one step further by purchasing land for conservation and working with land trusts to protect land for future generations. Anyone working in wetlands should be familiar with Dr. Paul Keddy's contributions to science. He has over 150 publications to his credit, with his *Wetland Ecology: Principles and Conservation* winning the Society of Wetland Scientists' Merit Award in 2006. While recognized for his writings and teaching, Dr. Keddy has also practiced what he has preached in terms of wetland conservation. He has bought land…and given it away.



Long Pond is the largest pond in Keddy Nature Sanctuary, Drummond-North Elmsley Township, Ontario.

As Aldo Leopold wrote so many years ago in *A Sand County Almanac*, biologists spend too much of their life watching beautiful places ruined. Even in their twenties, Paul and Cathy were fed up at seeing natural places they loved, including so-called protected areas, being violated. They decided to buy at least one piece of forest that they could enjoy. As graduate students at Dalhousie University in Nova Scotia in the 1970s, Paul and his future wife, Cathy found, a thousand miles away near Ottawa, 100 acres that included a great blue heron rookery. They decided to buy it. For years they camped on the land and explored adjoining lands. Of course, once you explore adjoining lands, you find new attractions. There was the source of the stream for the heronry, and a patch of orchids in a nearby seepage area. If only they could own that land too! But money was tight. The first of two parcels was purchased only after it was logged, recognizing that the land, in time, would recover. The second parcel was purchased later after logging had commenced, but they were able to buy out one of the loggers to keep a portion of the land in its natural state. Eventually their property encompassed just over a square mile (about 640 acres). The full property included a wide array of natural features: a ridge with ancient hemlock trees, the northern-most occurrence in Canada of *Peltandra virginica*, nesting turkey vultures, and more than ten beaver ponds with populations of snapping turtles, bullfrogs and spotted salamanders.

Back when they bought the first property, there was little protection for wetlands, but now there is a wetland evaluation program in Ontario. Their property, and more adjoining land, has been designated a Provincially Significant Wetland Complex.

When Paul left his endowed professorship in Louisiana, he took up a new position — Independent Scholar (www.drpaulkeddy.com) and forest warden. He says it's much like being a professor – but without the interminable meetings and without exams. Of course, the pay is minimal, but then St. Francis of Assisi lived in a forest for many years in similar circumstances. Paul's first project at this location was the new edition of *Wetland Ecology* mentioned above. He is now preparing a new edition of his other text book, *Plant Ecology*. Paul's office overlooks the property, and he can see beavers, muskrats, herons and kingfishers without moving from his desk!

But what happens to such properties when you die? Paul said that if killed by a logging truck on the highway, or swallowed by an alligator, he did not want his forest being wrecked. This is where a local land trust stepped into picture. The Mississippi Madawaska Land Trust (MMLT) accepted a gift combining property and development rights to establish the Keddy Nature Sanctuary which is now one of five properties under their stewardship. The effort of the Keddys is an excellent example of how you can take your commitment to wetland conservation to another level. Most regions of North America now have land trusts. For more information on the Keddy Nature Sanctuary, see the April 2014 edition of the MMLT newsletter (http://mmlt.ca/wp-content/uploads/April-2014-Newsletter.pdf). ■

U.S. Army Corps Releases Online Questionnaire for Improving National Wetland Plants List

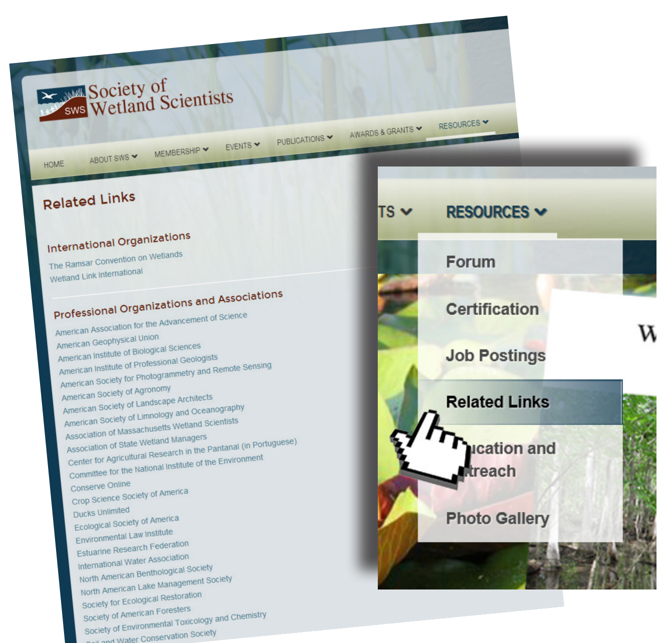
In 2012, an extensive update of the National Wetland Plant List (NWPL) was finalized. In an effort to continue improving the quality of wetland ratings on the NWPL, the NWPL's national panel is releasing an online questionnaire designed to identify those plant species for which wetland ratings may need revision, as well as species that should be considered for addition and/or deletion from the list. The questionnaire is being distributed to all four NWPL collaborating federal agencies—the U.S. Army Corps of Engineers, the Environmental Protection Agency, the U.S. Fish and Wildlife Service, and the Natural Resources Conservation Service—and is being announced by the Society of Wetland Scientists, the Association of State Wetland Managers, and others. The questionnaire is open to any agency, institution, or individual who cares to submit information on one or more plant species with wetland ratings that may need further review. Questionnaires will be accepted November 10, 2014 through January 31, 2015. The questionnaire requires the respondent to identify the species in question, the wetland region(s) and/or sub-region(s) in which its wetland rating needs to be reviewed, the current wetland rating, and the proposed wetland rating change. Additionally, the respondent will be asked to provide some supporting documentation (literature citations, regional floras, herbaria records, and personal observations) and to summarize the rationale for the requested wetland rating change based on the supporting information provided. Once the questionnaires have been received, a list of all wetland ratings that need to be reviewed and all suggested additions and deletions will be compiled and evaluated by the NWPL panel members. Based on submitted documentation, available literature, and the panel members' experience, the panel will make decisions on proposed changes to the NWPL. The results will be posted on the NWPL web site and any changes to wetland ratings will be included in the 2015 NWPL update. A link to the questionnaire and an example of a completed questionnaire for an individual plant species can be found on the NWPL website at: http://wetland_plants.usace.army.mil/. If you have any questions or concerns related to the questionnaire or the process for plant ratings, please contact Robert Lichvar 603-646-4657 or email NWPL@usace.army.mil. ■

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.**



This section is devoted to recording seasonal observations of plant and animal activity in wetlands. For this issue most of the observations are from my travels since our normal contributors had nothing to report. Perhaps spring and early summer observations are more interesting for most people to make and record observations after the long winter. If you would like to participate in recording your observations of life in the wetlands, please let me know by email (rtiner@eco.umass.edu); please put "WSP Nature Observations" in the subject box and in your response please indicate your geographic area and specific interest. For this issue, special thanks to John Lowenthal for his observations from North Carolina.

NORTHEAST

Observations from Massachusetts

During the last week of September, at higher elevations in Franklin County, peak color was observed in red maple swamps, while *Acer rubrum* at lower elevations was, as expected, a bit behind.

Observations from Connecticut

On October 27 at Barn Island (New London County), all the leaves were gone from *Nyssa sylvatica*, while *Acer rubrum* still had some red or yellow leaves present.

Observations from New Jersey

On October 17 in wetlands at Assunpink Wildlife Management Area (Monmouth County), flowers present on *Polygonum amphibium*, rose hips on *Rosa palustris* (leaves beginning to turn yellow), and berries on *Ilex verticillata* (leaves still green). *Cephalantus occidentalis* shrubs have lost nearly all their leaves. At Colliers Mills Wildlife Management Area (Ocean County), fronds of *Osmunda cinnamomea* were golden, leaves of both *Gaylussacia frondosa* and *Rhododendron viscosum* were turning yellow and red, those of *Vaccinium corymbosum* were mostly red, and those of *Vaccinium macrocarpon* in a small bog were still green.

On November 12, green basal rosettes of *Samolus valerandi* ssp. *parviflorus* were evident in a brackish marsh at Forsythe National Wildlife Refuge (Ocean County) while this year's growth was all brown and barely noticeable. In a neighboring freshwater lowland swamp, leaves of *Magnolia virginiana* were still present but turning yellow and leaves of *Ilex verticillata* were yellow.

Rose hips of Swamp Rose (*Rosa palustris*), Ralph Tiner

Ditch Stone-crop (*Penthorum sedoides*), Ralph Tiner

Chincoteague Salt Marsh in the Fall, Ralph Tiner

MIDWEST

Observations from Illinois

During the week of September 15 in DuPage County, the following plants were still in flower: *Actinomeris alternifolia*, *Bidens aristosa*, *Bidens cernua*, *Eupatorium serotinum*, *Lycopus uniflorus*, *Polygonum amphibium*, *Solidago* spp., *Symphyotrichum lanceolatum*, and *Verbena hastata*. Plants that have gone to seed included: *Asclepias incarnata*, *Chelone glabra*, *Juncus torreyi*, *Lycopus uniflorus*, *Penthorum sedoides*, *Polygonum virginianum*, *Schoenoplectus fluviatilis*. Berries were observed in *Arisaema triphyllum*.

SOUTHEAST

Observations from Virginia

During the first week of September, the salt marshes at Chincoteague National Wildlife Refuge displayed their autumn gold color with *Spartina alterniflora* in seed. Other marsh plants that had gone to seed included *Distichlis spicata*, *Setaria parviflora*, *Panicum virgatum*, and *Schoenoplectus robustus*. Some plants were still flowering: *Pluchea purpurascens* and *Limonium carolinianum* in the salt marsh, *Mikania scandens* and *Baccharis halimifolia* along the marsh border, and *Conoclinium coelestinum* in an adjacent palustrine forested wetland.

Observations from North Carolina

John Lowenthal reports:

In July observed four carnivorous species in flower in the eastern part of the state: *Dionaea muscipula*, *Drosera intermedia*, *Sarracenia flava*, and *S. purpurea* plus the federally listed *Lysimachia asperulaefolia*.

Observations from Florida

In late November in Lee and Collier Counties, as one would expect, there was still plenty of green understory in south Florida swamps, especially ferns including *Blechnum serrulatum*, *Campyloneurum phyllitidis*, *Nephrolepis exaltata*, *N. cordifolia*, and *Osmunda regalis*. Many of the swamp trees were festooned with *Pleopeltis polypodioides*, many green, others mostly brown depending on recent precipitation. Red berries were observed on *Ilex cassine*. Some plants still in flower in the marshes included *Peltandra virginica*, *Pontederia cordata*, *Sagittaria lancifolia*, and *Thalia geniculata*, while *Baccharis halimifolia* was seen in both flower and seed. *Symphyotrichum carolinanum* was still in flower while exhibiting its climbing habit. *Andropogon glomeratus* was in seed looking quite fluffy along the edges of the wet prairie. Open water areas in Corkscrew Swamp were covered with *Salvinia minima* or *Pistia stratiotes* (latter dominated "Lettuce Lake"), with *Thalia* also common. In Six Mile Cypress Slough Preserve (Lee County), leaves of *Taxodium distichum* were turning yellow, some orange, while others have been shed. Most *Fraxinus carolinana* have shed their leaves, only a few trees retained some leaves.

With the onset of colder weather, manatees (*Trichechus manatus*) have begun to migrate upstream in coastal rivers. About 20 were seen at Manatee Park (Lee County) in the warm water discharge canal from the local power plant.

Changing color: Leaves of Bald Cypress (*Taxodium distichum*), Ralph Tiner

Manatee (*Trichechus manatus*), Ralph Tiner

Texas coastal marsh on Galveston Island, Ralph Tiner

SOUTHWEST

Observations from Texas

In late October in Galveston County, *Solidago sempervirens*, *Baccharis halimifolia*, and *Conoclinium coelestinum* were observed in flower in and bordering coastal wetlands on the barrier island. In the salt marshes, *Suaeda* sp. and *Salicornia bigelovii* have turned red. Seed pods of *Cynanthum angustifolium* were seen dangling from a shrub along the edge of a brackish marsh. ■

Get involved! SWS now seeking nominees for 2015 President-Elect and Treasurer

Nominations to serve on the SWS Executive Board are now being accepted. The President-Elect serves for a three-year cycle (President-Elect, President, and Immediate Past President). The Treasurer serves a three-year term. Please note that current Treasurer Julia Cherry will stand for re-election. If you'd like to serve on the SWS Executive Board or nominate someone to serve, please email Steve Faulkner, Nominations Committee Chair, at faulkners@usgs.gov no later than Tuesday, Dec. 30. Below are the descriptions of the duties of the President-Elect and Treasurer.

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 shall complete the President's remaining term and then complete his term as President for which he 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 his duties, and any other duties delegated by the Bylaws of the Society or designated by Board of Directors from time to time.

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.

WETLAND BOOKSHELF

The following are a list of some new and recent publications that may be of interest. 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 Research Technology Center

- 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

- 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

- 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

Publications by Other Organizations

- 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

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/

The Sedge/Grass Meadow Game Show

- 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

- 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

See additional books and resources 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.