wetland science & practice
published by the Society of Wetland Scientists
Vol. 33, No. 1 Mar 2016

FROM THE EDITOR'S DESK

Greetings to all as spring is approaching. It's been a strange winter…I think we only had a few weeks of real winter weather and the snow held off locally until February. Today it's raining. I've heard the maple sugaring started early this year, but the sap stopped flowing when faced with a short run of bitter cold.

Ralph Tiner
WSP Editor

March is the sugaring season as the typical season in Massachusetts runs from late February to early April. So the sugar houses should be up and steaming by the time this issue comes off the press. Given the warmer weather it could be a short season for making syrup, since the sap flows when the weather has freezing nights and warm days. The days may fit the equation, but the nights may be warming up sooner. Time will tell…and we know how predictable weather is.

I've been consumed updating my *Wetland Indicators* book (scheduled for release later this year) and have added a chapter on wetland formation and hydrology. I've received great cooperation from researchers who have shared their monitoring results from a wide variety of wetlands. Very interesting material, but I'm ready to get some outdoor activity on a regular basis; too much cabin fever and computer screen time. I'm looking forward to some good weather for cycling and motorcycling plus seeing a green landscape.

In this issue we have a report of the trip to Taiwan by Gillian Davies, Kim Ponzio, and Wei-Ta Fang complete with photos – looks like an exciting trip and will continue to open up opportunities for wetland scientists from both countries. We have one article in this issue – a very interesting contribution from Joy Zedler based on her weekly observations of the growth of tussock sedge (*Carex stricta*) in a Wisconsin wet meadow. It's amazing how many data points she has; must have been a great place for a Sunday walk. She managed to collect data in the growing season for 11 years – quite an accomplishment! We also have two research briefs from two students at Indiana University and Doug Wilcox's cartoon – From the Bog. Thanks to all contributors.

We continue to encourage folks to contribute articles on their projects to let others know what you've found. I'm still hoping to get chapters to submit summaries of their activities so other chapters can see what others are doing. If you have questions about possible submissions, please feel free to contact me at rtiner@eco.umass.edu. In the meantime, enjoy the coming of Spring in the Northern Hemisphere and get ready for winter activities in the Southern half of the planet.

Happy Swamping! ■

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Cover photo:
A wet meadows dominated by Care stricta tussocks Madison, Wisconsin U.S.
Photo by Joy Zedler

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

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

PRESIDENT'S MESSAGE

Spring has sprung! Well, at least down here in Florida! However, there are many of you who may say, "What happened to our winter?", "Why did it start so late?", "Why so much precipitation?" or "When will this winter end?". The occurrence of extreme winter events, whether it be increased precipitation or drought, could be due to a "super" El Niño, in part driven by climate change. A detailed understanding of how global climate changes affect global weather patterns like El Niño is being studied by many climate scientists. Now… I am not a climate scientist, but I do know some people who are. SWS has linked us in with researchers and policy makers that are actively involved in trying to bring wetlands to the forefront of the climate conversation. Keep reading if you'd like to know more.

Kimberli Ponzio, PWS
SWS President

COMMUNICATION & EDUCATION

Speaking of climate change, I hope you caught the webinars in our last quarter that focused on just that. Lisa Fernandez, with the Yale Program on Climate Change Communication, kicked things off with a webinar on "Climate Change in the American Mind". In February, we focused on the importance of wetlands in the global carbon cycle with Bill Moomaw from Tufts University and Nigel Roulet from McGill University. And, in March, Cristina Eisenberg focused on climate change effects on faunal communities and creating resilient wetlands. We will wrap up our 'Climate Change and Wetlands' series in April with Gail Chmura of McGill University introducing the topic of climate change and the future of blue carbon. We will then begin to focus on wetlands in the coastal areas of Texas as an introduction to the types of things you will see when we meet in Corpus Christi in May.

A new SWS initiative is taking shape that will allow international students to interact and participate in wetland science research in other countries. Bianca Wentzell (sub-committee Chair) and a stellar team of SWS members are forging the way for a *Wetland Ambassadors Program* with a mission to develop an international student exchange program in which graduate students will participate in a visiting research fellowship at a university outside of their home country that features rigorous wetland science research opportunities. This initiative is expected to not only provide top-notch educational opportunities for future wetland scientists around the globe, but also to enhance international networking, wetland science information exchange, and communication among members of SWS.

On Feb. 2nd, SWS members around the world were involved in a number of activities to celebrate World Wetlands Day (WWD) in order to raise public awareness of wetland values, benefits and importance. Activities included lectures, clean-ups, wetland walks, photo contests, wetland planting, and a teleconference of the U.S. National Ramsar Committee. This WWD also marked the first anniversary of the enactment of landmark wetland legislation in Taiwan known as the Taiwan Wetlands Conservation Act that protects designated wetlands of Inter-

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wetland science & practice

Join us at next year's Annual Meeting

SWS2016

Corpus Christi — May 31 - June 4

Protecting wetland ecosystem services.
Promoting stronger economies.

Field Trips and Workshops Promise Exploration, Deep Learning

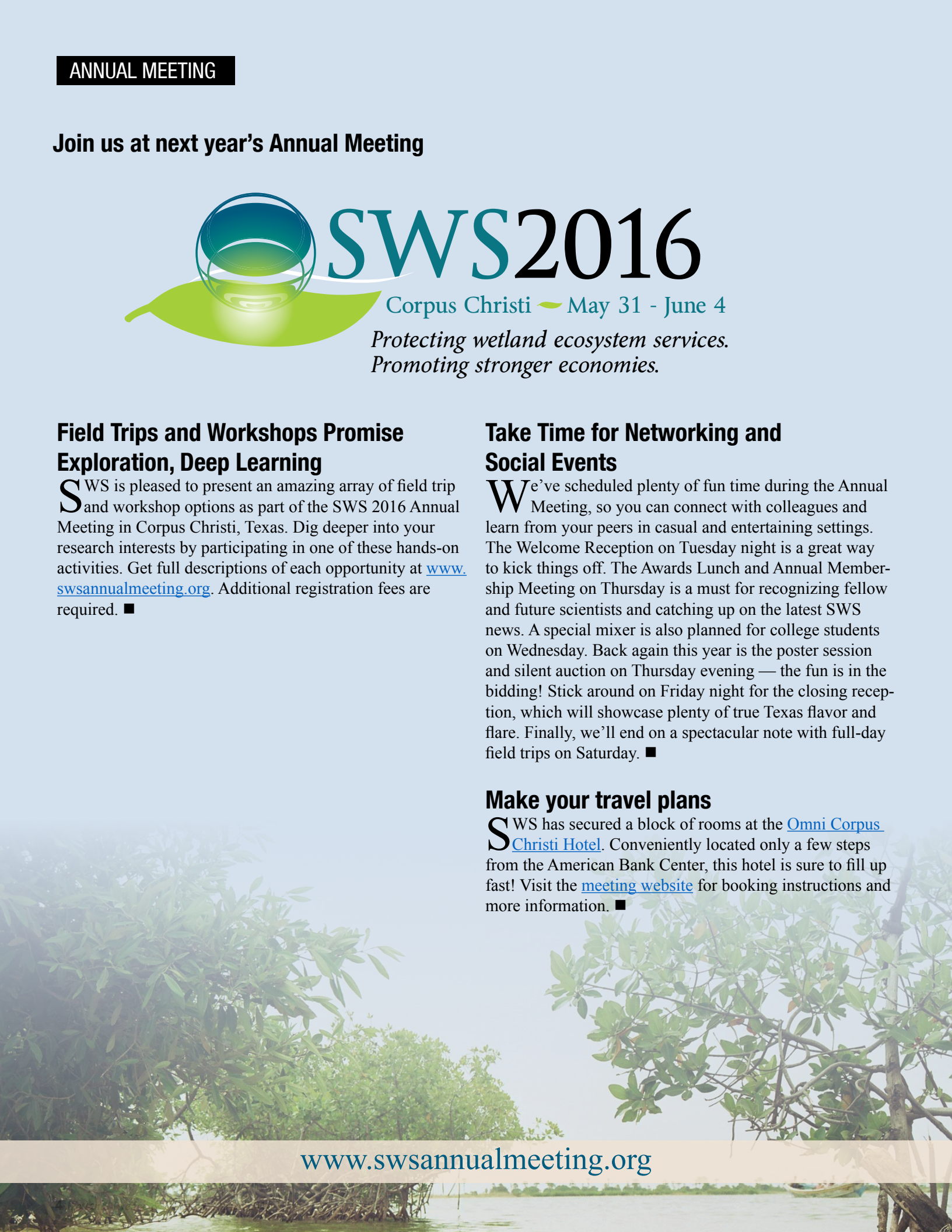
SWS is pleased to present an amazing array of field trip and workshop options as part of the SWS 2016 Annual Meeting in Corpus Christi, Texas. Dig deeper into your research interests by participating in one of these hands-on activities. Get full descriptions of each opportunity at www.swsannualmeeting.org. Additional registration fees are required. ■

Take Time for Networking and Social Events

We've scheduled plenty of fun time during the Annual Meeting, so you can connect with colleagues and learn from your peers in casual and entertaining settings. The Welcome Reception on Tuesday night is a great way to kick things off. The Awards Lunch and Annual Membership Meeting on Thursday is a must for recognizing fellow and future scientists and catching up on the latest SWS news. A special mixer is also planned for college students on Wednesday. Back again this year is the poster session and silent auction on Thursday evening — the fun is in the bidding! Stick around on Friday night for the closing reception, which will showcase plenty of true Texas flavor and flare. Finally, we'll end on a spectacular note with full-day field trips on Saturday. ■

Make your travel plans

SWS has secured a block of rooms at the Omni Corpus Christi Hotel. Conveniently located only a few steps from the American Bank Center, this hotel is sure to fill up fast! Visit the meeting website for booking instructions and more information. ■



www.swsannualmeeting.org

SWS2016

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Sponsorship Opportunities

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

CONTRIBUTING LEVEL — $500

Help make the SWS 2016 Annual Meeting a success by making a general contribution. Sponsor's logo will be featured on the meeting website with a link to their corporate page, on signage at registration and in the meeting mobile app.

BRONZE LEVEL — $1,000

- **DAILY PLENARY SPEAKER.** The SWS 2016 Annual Meeting will feature three highly renowned plenary speakers who will present the latest wetland research. Three opportunities available.
- **DAILY MORNING & AFTERNOON REFRESHMENTS.** Attendees will enjoy light snacks and beverages during daily morning and afternoon refreshments. Six opportunities available.

SILVER LEVEL — $2,500

- **STUDENT MIXER.** This special reception will provide students the opportunity to exchange ideas and network with expert wetland professionals. All attendees welcome.
- **AWARDS LUNCH & ANNUAL MEMBERSHIP MEETING.** Meeting registrants will be invited to attend this special event to honor SWS award winners and catch up on the latest SWS initiatives.
- **POSTER SESSION & SILENT AUCTION RECEPTION.** The 2016 poster session will showcase the latest wetland research and will provide an opportunity for all meeting attendees to network. The South Central 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 — $7,500

- **MOBILE APP.** Attendees will be able to access the meeting program, general meeting information and session details via their smart phones and the web. The sponsor's logo will be featured on the homepage of the app.
- **WELCOME RECEPTION.** The SWS 2016 Annual Meeting will kick off with a special Welcome Reception.

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

**Prices are quoted in US dollars.*

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

President's Message continued from page 3

national, National, and local importance and went into effect on Feb. 2nd, 2015. I encourage all of you to post your WWD pictures on the SWS Facebook page and start planning for next year's celebration. This is OUR big day to highlight wetlands and show the world what it's all about.

PARTNERSHIPS

As part of our new collaborative relationship with the Association of State Wetland Managers (ASWM), we were invited to participate in their Wetland Training Workgroup with a mission to define and implement strategies for providing high quality wetland training programs. Thanks go out to SWS Members, Matt Schweisberg and Marleigh Sullivan, for being part of that team. Also, kudos go to Matt for agreeing to become our SWS representative to ASWM in order to enhance our collaborative efforts to encourage sound science in wetland research, management, restoration, policy, and conservation.

Since 2008, the Asia Chapter, lead by Wei-Ta Fang, has been working with a number of entities to bring SWS Presidents to Taiwan to foster collaboration among our groups and to exchange wetland information. In December, Gillian Davies (SWS President-elect) and I traveled to Taiwan to present wetland research, to develop a Memorandum of Understanding with two Taiwanese governmental groups, and to start the conversation about a student exchange program. Our report is featured in this article of the WSP – check it out!

In January, I accepted an invitation to serve on the Scientific Committee for the INTECOL (International Association for Ecology) meeting in China, Sept 2016 [http://www.intecol-10iwc.com/EN/Index.aspx]. As a committee member, along with numerous other SWS members serving INTECOL (including Co-Chair, Eugene Turner), I will assist in gathering meeting sponsorship, generating awareness and support, ensuring the scientific program reflects the meeting theme and identifying important topics to be covered. My hope is that participation on the Committee will strengthen the ties between SWS and INTECOL and will result in a collaborative annual meeting in the future.

SWS has continued to work with CASS (Consortium of Aquatic Scientific Societies) to partner on policy initiatives, specifically a document for the next administration highlighting policy issues for fisheries and aquatic ecosystems, and to host a booth at the USA Science and Engineering Festival this coming April. As a SWS representative to CASS, Jane Rowan, and former SWS president, Mary Kentula, provided input to help CASS communicate with legislators concerning the current condition of wetlands, lakes and streams in the U.S. Specifically, Kentula provided documents and expertise on the EPA's National Aquatic Resource Surveys and the National Wetland Condition Assessment.

The Human Diversity Committee, with Chair Alani Taylor, continues their fine program to engage under-represented groups in an outreach effort this spring in Jacksonville, FL. SWS will host a booth at the MANNRS (Minorities in Agriculture, Natural Resources and Related Sciences) conference that is intended showcase wetland science as premier option for students interested in natural resource-related education and careers.

FINANCES

The financial status of SWS is strong and we are realizing nice returns on our investments. The Ways and Means Committee, lead by SWS Treasurer Julia Cherry, will be evaluating our investment performance annually to ensure that we are staying on track. In order to fund our new initiatives and to maintain funding for all the great programs we have historically supported, we are investigating new, 21st-century funding avenues, such as Amazon Smile. In addition, one of our SWS student associations, the University of Florida Wetlands Club, is testing the waters by raising funds through a crowd-funding site to support student travel to the Annual Meeting in Corpus Christi [http://ufwetlandsclub.blogspot.com/2016/02/help-fund-our-trip-to-sws-national.html]. Finally, we look forward to the submission of proposals to our Chapter Development Grants to boost membership and expand programs of smaller chapters or international chapters.

MEMBERSHIP

As of 12/31/15, SWS had nearly 3,300 members from over 62 countries. Please don't let your membership lapse - renew right now [http://www.sws.org]. And stay tuned as we roll out the results from our membership survey in the coming months.

ANNUAL MEETING

The abstract submission deadline has passed and registration for the Annual Meeting in Corpus Christi, TX on May 31 – June 4, 2016 is in full swing. Make sure to register early to select your favorite field trip option on the Tuesday prior to and the Saturday following the meeting. The meeting theme of "Protecting wetland ecosystem services. Promoting stronger economies." promises to offer some interesting topics for an engaging meeting. This will be the first time we are offering a Journalism Fellow Award to foster communication with the public through the extension of a journalist's opportunity to gain an in-depth understanding of wetlands and to explore the complexities of the role wetlands play in the economy. Hope to see you there!

Finally, I wish you a delightful spring as you venture out into the wetlands to continue your wetland scientific investigations. Here's a thought about the restorative nature of wetlands on those whose hearts it warms:

"When I would recreate myself, I seek the darkest wood, the thickest and most impenetrable and to the citizen, most dismal, swamp. I enter a swamp as a sacred place, a *sanctum sanctorum*. I "fancy that it would be a luxury to stand up to one's chin in some retired swamp a whole summer, scenting the wild honeysuckle and bilberry blows, and lulled by the minstrelsy of gnats and mosquitoes!"
— Henry David Thoreau ■

Society of Wetland Scientists Visits Taiwan

Gillian T. Davies, PWS, NHCWS, Registered Soil Scientist, CESSWI President Elect, Society of Wetland Scientists, Senior Ecological Scientist, BSC Group, Inc., Worcester, MA, USA

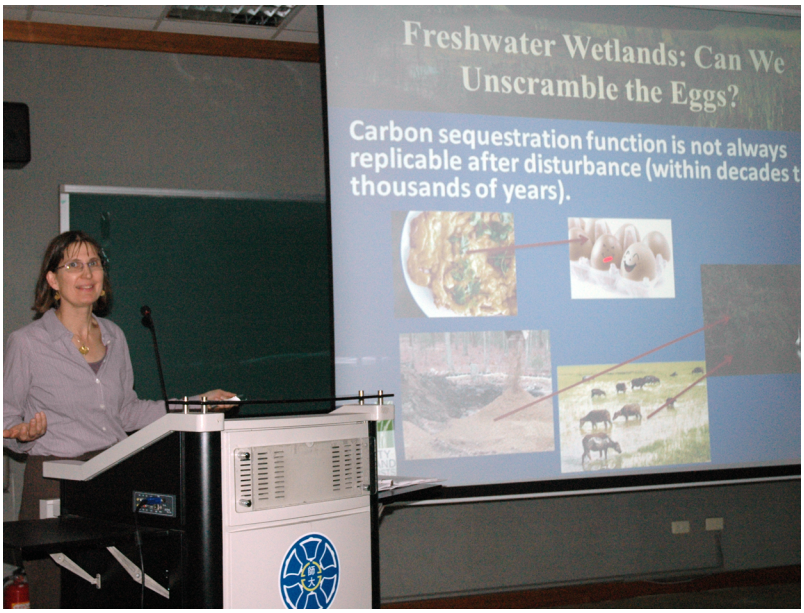
Kimberli J. Ponzio, M.S., PWS, President, Society of Wetland Scientists, St. Johns River Water Management District, Environmental Scientist IV, Bureau of Water Resources, Palatka, FL, USA

Wei-Ta Fang, Ph.D., Regional President, Society of Wetland Scientists Asia Chapter, Associate Professor, Graduate Institute of Environmental Education, National Taiwan Normal University, Taipei, Taiwan

We would like to extend our concern and care to all of the Taiwanese who have suffered in the recent February 5th 2016 earthquake, especially to those who have lost family and friends in this tragedy. Thankfully, we have heard that our colleagues and their families are unhurt.

Last December, Kim Ponzio (current President of the international Society of Wetland Scientists (SWS)) and Gillian Davies (President Elect of SWS) had the exciting opportunity to visit Taiwanese wetlands, wetland scientists and dignitaries, and to give presentations at the National Taiwan Normal University (NTNU) (Photo #1) in Taipei, and at the International Forum on Coastal Wetlands, at the Chigu Center in Tainan County. The trip was generously sponsored by Dr. Mei-Li Hsueh, Director of the Endemic Species Research Institute/Chigu Center, and Professor Monica Kuo, Chair of the Digital Earth Research Center and the Department of Landscape Architecture at the Chinese Culture University. The primary host and organizer of the trip was SWS Asia Chapter President, Dr. Wei-Ta Fang, of NTNU, who was assisted by wetland scientist Cheng-Hsiang Liu. Wetland scientist Dr. Jungchen Huang, professor at Shanghai Jiao Tong University in Shanghai, China and former Ph.D. student of Dr. Bill Mitsch, graciously served as our interpreter when we gave our presentations. For the past seven years, our Taiwanese colleagues, supported by the Taiwanese government, have been sponsoring SWS presidents and/or president-elects to visit their country for international scientific exchanges concerning wetlands.

PHOTO 1. Gillian Davies speaking at the National Taiwan Normal University.



Taiwan is a large, mountainous, and densely populated island located in the Pacific Ocean, north of the Philippines and south of Japan, with mainland China to the east. A steep spine of volcanic mountains divides the heavily populated west side of the island from the much less developed, Pacific-facing, eastern side. Jade Mountain (also known as Mount Morrison, and locally called "Yushan"), Taiwan's highest peak, reaches 12,966 feet above sea level.

Taiwan's climate is sub-tropical in the north, and tropical in the south. Northern Taiwan typically receives 260cm of rainfall annually (that's twice as much as Florida, US), but is experiencing reduced rainfall due to climate change. The island is subject to periodic typhoons and earthquakes. Although lowlands are densely developed and heavily farmed, mountainous areas are relatively undeveloped, due to steep and landslide-prone terrain.

In addition to migrants from mainland China and other nations, who have arrived over the past several hundred years, the island is home to indigenous people, referred to as the Original People, who have been inhabiting the island for thousands of years. Peoples who have inhabited and/or controlled Taiwan include 14th – 16th century Chinese and Japanese pirates, early waves of migrants from mainland China, the Dutch, the Spanish, the Japanese, and most recently, mainland Chinese who arrived with

the Koumintang (KMT) and Chiang, Kai-Shek at the end of World War II as Mao, Tse-Tung consolidated Communist control over mainland China. From 1947 – 1987, the KMT government maintained martial law throughout the country. Currently, Taiwan is a thriving democracy, with lively elections. On January 16, 2016, Taiwan's first female President (Photo #2), was elected. Dr. Ing-Wen Tsai, a former law professor and lawyer with degrees from The London School of Economics and Cornell University, and current President of the Democratic Progressive Party (DPP) will be inaugurated on May 20, 2016. The healthy rotation of two parties over the past couple of decades reflects the political diversity and balanced values of democracy in Taiwan's presidential elections. From a wetland perspective, the net result of this history is that lowlands have been densely inhabited and farmed for hundreds of years, with essentially all freshwater wetlands being converted to rice paddies or development, according to our hosts. Natural wetlands persist in undeveloped mountainous areas, and possibly in some coastal areas.

The wetland scientists and political dignitaries with whom we met actively promote wetland protection, restoration and creation, as well as climate resiliency. We met with Professor Charles Chin-Rong Lin, the highly energetic Deputy Mayor of Taipei, who is promoting numerous wetland restoration/creation projects as part of Taipei Vision 2050, including a plan to restore an extensive area of floodplain wetlands within Taipei (Photo #3). The objective of these activities is to regain lost wetland functions and to help create a more climate-resilient city. Professor Lin, a university associate professor at National Chiao Tung University who spent a year as a visiting scholar at MIT, is taking four years off from academia to serve as Deputy Mayor.

Taipei, like so many major cities, is coastal, and was built on the banks of major rivers. There is a proposal to move a regional airport (Songshan Airport), currently located adjacent to the Keelung River in the northern sector of Taipei, to another location. If the airport moves, Professor Lin advocates converting the riverside portion (162 hectares) of the airport footprint to a wetlands park that would be larger than New York's Central Park, and would offer city residents unparalleled urban access to green and open space. Extensive riverine floodplain wetlands would be restored, reducing urban flood hazards associated with our warming climate, and increasing Taipei's climate resiliency.

Professor Lin suggested that the City of Taipei would be able to co-sponsor the SWS Asia Chapter meeting that will be held in Taipei from September 13 through 18, 2016, and also proposed establishing a Memorandum of Understanding between the City of Taipei and SWS. We will be following up on these proposals over the coming months. Dr. Wen-Je Ko, the Mayor of Taipei and a former medical doctor, has launched the "Adaptive City 2016" and "Velo City" campaigns, as well as an international climate resiliency design contest. "Velo City" translates to "Bicycle City", as can be seen in Photograph #4, which shows the Mayor holding a bicycle, on a subway billboard.

PHOTO 2.
Campaign billboard for Dr. Ing-Wen Tsai, first female President of Taiwan, elected on January 16, 2016.

PHOTO 3.
Photo 3 Deputy Mayor, Dr. Charles Lin, points out the location of the planned wetland park at the current location of the Songshan Airport.

We enjoyed numerous multi-course banquets, adventurously enjoying spicy goat back stew, thousand-year-old eggs, hot pot, octopus, squid, and spicy jellyfish. One such evening was spent with Taiwan's Construction and Planning Agency (CPA) Section Chief Terrence Lee, as well as our sponsor Monica Kuo, and others. The CPA is the governmental agency that is responsible for spatial resource planning, use and management. Sustainability, protection of natural resources and biodiversity, and green building are central to their mission. SWS is in the process of renewing its 5-year Memorandum of Understanding with Taiwan CPA, which should be ready for signatures at the SWS Asia Chapter meeting in September 2016.

At the Guandu Nature Park, an approximately 57-hectare constructed wetland on the outskirts of Taipei (located at the confluence of the Tamshui and Jilong Rivers), Nelson Chen, the CEO of the park, took us on a tour (Photo #5). Taiwan is a major stopover location for migrating birds on flyways from Japan, Korea, China, Mongolia, and Russia, as they travel on routes known as The East Asia/Australasia Flyway, to southern destinations in Southeast Asia, Australia and New Zealand. Approximately 200 species of birds come to Guandu, including the endangered black-faced spoonbill (*Platalea minor*), and a beautiful endemic bird, the Black-naped Monarch flycatcher (*Hypothymis azurea*), despite the proximity of Taipei and heavy usage by park visitors. On the day we were there, a large group of birders, armed with huge cameras, was excitedly stalking the Black-naped Monarch flycatcher. The extensive boardwalk system allows 150,000+ people to enjoy the wetland system and nature park each year, while protecting the wetlands from such heavy traffic. Educational signage abounds, as well as art installations made from natural materials (Photo #6). Each year, the park hosts an art exhibition, as a way to attract visitors and support the arts. The one requirement is that the artwork must be constructed from natural materials that will decompose without harming the ecosystem. This park is exceptional in its capacity to provide diverse ecosystem services, ranging from pollution/nutrient attenuation, water quality improvement, water storage and flood control, and wildlife habitat, to recreation, education, and art space, and is clearly highly valued by the citizens of Taipei and beyond.

At the Taijiang National Park, which was established in 2009, we met with Park Director

PHOTO 4.
Subway billboard showing Taipei Mayor, Dr. Ko Wen-ji, advocating for bicycles.

PHOTO 5.
Overlooking Guandu constructed wetland. Pictured left to right Gillian Davies, Nelson Chen, Kim Ponzio, and Wei-Ta Fang.

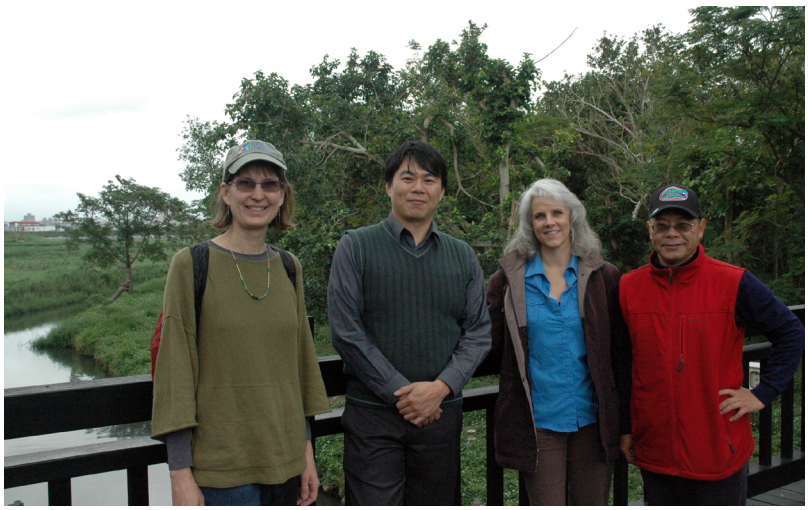


PHOTO 6.
Sculpture constructed from natural materials and installed in wetland at Guandu Nature Park.

PHOTO 7.
Black-faced Spoonbills during sunset over Taijiang National Park.

PHOTO 8.
Children participating in beach cleanup at Chigu Center on the Taiwan Strait.

PHOTO 9.
SWS President Kim Ponzio, ESRI Director Mei-Li Hsueh & others participating in beach cleanup.

PHOTO 10.
Jhouzai constructed wetland (10 hectares) adjacent to Lotus Lake.

Wei-Chuan Chang, and heard about their project to track black-faced spoonbills (Photo #7) using satellite tracking in cooperation with scientists in Korea and Japan. Approximately 60% (about 2,400 individuals) of the global population of black-faced spoonbills spends a portion of their annual life cycle in Taiwanese wetlands. Director Wei-Chuan Chang discussed the recent passage of Taiwan's Wetland Conservation Act, which went into effect on World Wetlands Day, February 2, 2015. This landmark legislation protects two Wetlands of International Importance, forty Wetlands of National Importance, and forty-one temporarily designated Wetlands of Local Importance. Local counties are being asked to designate and enforce the protection of the locally important wetlands. Taijiang National Park includes two Wetlands of International Importance and two Wetlands of National Importance, including the Chigu Salt Pan and an area designated as a black-winged stilt (*Himantopus himantopus*) restoration area. In addition, areas adjacent to Taijiang National Park host wetlands of importance, identifying the overall area as very significant to wetland resources and their ecosystem services. The park provides an outdoor education curriculum to children in grades K - 12, which includes wetland curriculum and time spent outdoors. The Director is interested in incorporating climate change resiliency into the work at the park.

At the Chigu Center, our sponsor, Dr. Mei-Li Hsueh, led a beach cleanup (Photos #8 & 9) on a barrier beach facing the Taiwan Strait (also known as Formosa Strait). We joined kindergarten through 5th grade students and adults from the community and Chigu Center, filling trash and recycling bags with debris on the ocean side of the barrier beach. It was heart-breakingly easy and quick to fill the bags. With more than 50 volunteers armed with one or two large sacks apiece, we could carry no more after a mere half hour of collecting. When we looked backwards to see our impact, it was hard to tell we had been there. The volume of plastic bottles, trash, Styrofoam, and tangled fishing nets was staggering. Dr. Mei-Li Hsueh

is studying the trash, with several years' data on where it comes from. On our single half hour of collecting, we brought back materials from Taiwan, China, Japan, Korea, the Philippines, and Vietnam. The Chigu Center is the winter home of a substantial part of the world's population of black-faced spoonbills. Following the clean-up, we held an International Forum on Coastal Wetlands with speakers including Dr. Wei-Ta Fang, Kimberli Ponzio, Gillian Davies and SWS member Dr. Hsiao-Wen Wang from National Cheng Kung University.

The next day we visited the Jhouzai Wetland Park (Photo #10), adjacent to Lotus Lake in Kaohsiung. Our guide Wen-Chi Huang taught us that the 10-hectare wetland had been created fifteen years ago, from former rice paddies, as a means of treating the eutrophied water of Lotus Lake. Lotus Lake is a major recreational destination, with dramatic temples, pagodas, statues, and walking paths on its banks (Photos #11 & 12). Although eutrophied conditions persist, water quality has improved at Lotus Lake since construction of the wetland. Additionally, the wetland provides important habitat for many water birds. While visiting the park, we saw the endangered pheasant-tailed jacana (*Hydrophasianus chirurgus*), as well as grey heron (*Ardea cinerea*), little egret (*Egretta garzetta*), great egret (*Ardea alba*), and gallinule coot (*Gallinula galeata*). Unfortunately, Jhouzai Wetland Park also provides a haven for

PHOTO 11.
Lotus Lake.

PHOTO 12.
Dragon and Tiger Pagodas at Lotus Lake.

PHOTO 13.
Invasive African tree snails at the night market.

PHOTO 14.
Making traditional Amis fish soup, using rocks and a bark pot.

PHOTO 15.
Boy Scout and Dad doing community service in FataanMataian constructed wetland.

PHOTO 16.
Temple in Taroko National Park gorge.

the invasive African tree snail (*Achatina fulica*) in upland areas. The African tree snail was introduced by the Japanese in 1908 as a food source, and is now a problematic invasive. However, it continues to remain a food source for humans, as we saw at the ubiquitous night markets (Photo #13).

After a short flight across the steep spine of mountains that divides eastern and western Taiwan, we enjoyed a delicious meal of roasted fish and fish soup, cooked according to the traditional methods of the Amis original people (Photo #14), at a traditional Amis restaurant. We then visited the adjacent Fataan/Mataian constructed wetland, which was packed with tourists, and once again, accessible by boardwalk. Both Kim and Gillian have participated in the Boy Scouts of America with their sons, so they really enjoyed running across a Taiwanese scout outing, where boy scouts and girl scouts were doing a community service project to remove nuisance weeds from the wetland ponds (Photo #15). The troop leader, Alfred Wang, a banker from Taipei, informed us that great camping opportunities exist in the mountains. He was clearly enjoying the opportunity to introduce the next generation to an understanding and appreciation of wetlands. The Fataan/Mataian wetland is a 100-hectare area, owned by a government utility company that uses the groundwater. In order to maintain the groundwater supply, they have left this area undisturbed since 1910, with the exception of the period of Japanese occupation. All other lowland wetlands in the area have been converted to rice paddies.

The grand finale to our trip was a long and winding ride up through the Taroko National Park gorge Photo #16, where we ultimately crossed a suspension footbridge (Photo #17), squeaked past a fence, and cautiously made our way down a dilapidated stairway to the river and some hot springs. Somehow, veteran bathers were able to tolerate, and even enjoy, the sulfurous and scorching hot spring water. Gillian, Kim, and fellow wetland scientists Cheng-Hsiang Liu and Dr. Chung-Hsin Juan, were just barely able to soak our feet on the outskirts of the hot spring, where plenty of icy river water moderated the temperature. On one of the stops as we drove up the gorge, we noticed a large troop of monkeys decorating a few of the trees. They took little notice of us, as they progressed in their efforts to remove and eat the trees' leaves (Photo #18).

The generosity of our Taiwanese hosts was unparalled, and Gillian and Kim gained interesting insights into wetland issues in a landscape very different from their home ecosystems in New England and Florida. International exchanges, such as this trip, build bridges between geographic regions, which leads to a variety of initiatives and insights. For instance, SWS rekindled our relationship with

the Taiwan CPA and will be renewing our MoU with them in September 2016. During our trip, the Taiwan CPA and the City of Taipei committed to co-sponsorship of the SWS Asia Chapter meeting in Taipei, which will occur from September 13 through 18, 2016. In addition, the City of Taipei initiated a Memorandum of Understanding with SWS. SWS is launching a student exchange program, and Dr. Hsiao-Wen Wang, one of the wetland scientists with whom we met, is serving on our Wetland Ambassadors Committee and collaborating with other SWS members, including Dr. Marinus Otte (Professor at North Dakota State University) and Dr. Jim Perry (Professor at Virginia Institute of Marine Sciences), on student exchanges between universities. One of Dr. Marinus Otte's undergraduate students, Aaron Kaip, is going to be the first exchange student at National Taiwan Normal University (NTNU) from February to June during 2016. Last year, Past President Jim Perry extended his stay in Taiwan long enough to teach courses on river restoration and fluvial morphology at National Cheng Kung University in Tainan. This year, we were able to discuss future SWS events and collaborations with numerous wetland scientists, and contribute to scientific exchanges at a Taiwanese university and research center. SWS looks forward to future collaborations with our Taiwanese colleagues, and we wish to thank all who contributed to making our trip such a resounding success. ■

PHOTO 17.
Suspension footbridge and gorge at Taroko National Park.

PHOTO 18.
Wild monkeys in Taroko National Park.

Phenology of *Carex stricta*: It pays to be tall!

Joy Zedler, Botany Department and Arboretum, University of Wisconsin-Madison

INTRODUCTION

Southern Wisconsin tussock meadows are greatly diminished in area relative to pre-settlement times (Zedler and Potter 2008; Figure 1), and restoration is warranted. The geographically-widespread sedge, *Carex stricta,* is considered a "superplant" for restoring southern Wisconsin's wet meadows because it is readily grown from both ramets (vegetative propagules) and seeds (Leaflet 22; see arboretum.wisc.edu/leaflets). Young plants can be tailored to different restoration sites by manipulating water and nitrogen (Gallagher 2009). Also, the species is easy to outplant in restoration sites, and canopies rapidly expand to create dense cover (Gallagher 2009, Lawrence and Zedler 2011, Doherty and Zedler 2015).

FIGURE 1.
A wet meadows dominated by *C. stricta* tussocks reveals their distinctive microtopography in winter, after canopies have collapsed but not decayed. This tussock meadow is an unplowed remnant in the University of Wisconsin-Madison Arboretum.

Once established, *C. stricta* provides valued ecosystem services, including carbon storage. Most graminoids store carbon belowground, but tussocks do so both above- and belowground (Lawrence and Zedler 2011, 2013; Lawrence et al. 2013). In seven Wisconsin *C. stricta* meadows, the number of tussocks averaged 4.9/m^2, with a mean volume of 1160 cm^3 and height of 15 cm; tussocks were predominantly organic (74–94% of total dry mass) and composed of leaf bases (46–59%), fine roots (10–31%), and duff (5–13%) (Lawrence and Zedler 2011). Five Upper Midwest remnant tussock meadows had tall (17 cm), large (4,113 cm^3) tussocks consisting of up to 95% carbon and comprising 41–62% of total biomass carbon; the tussocks in three reference sedge meadows contained 843–1,697 g C/m^2 making them second only to soil in C storage (Lawrence and Zedler 2013).

Carex stricta supports biodiversity, including several associates recommended for introduction after the *C. stricta* matrix is well established in restoration sites (Johnston and Zedler 2012). Tussocks add surface area (40% more with 15-25 cm-tall tussocks; Werner and Zedler 2002), provide topographic heterogeneity, and grow early in spring, allowing temporal segregation (Peach and Zedler 2006; this study). Other wetland dominants suppress and exclude subordinate species (Lord and Lee 2001; Werner and Zedler 2002; Peach and Zedler 2006; Frieswyk et al. 2007; Johnston et al. 2008).

With few remnant *C. stricta* meadows, there are limited data on phenology. Does interannual variability exceed that of tussock size? A warm year might increase *C. stricta* growth, but so might a tall tussock. Monitoring and nondestructive sampling were called for. An obvious trait to monitor would be tussock height. However, tussocks accumulate mass slowly, beginning with loosely-organized mats of adventitious roots (apparent within 2 yrs of continuous flooding) leading to dense, solid mass, as found in an 11-yr-old restoration site with 15-20-cm tall tussocks (Lawrence and Zedler 2011, 2013). An early report of 1.2-m-tall tussocks (Costello 1936) does not state whether that was just the pedestal (tussock, herein), or if it included the canopy (plant height, herein). I have seen 50-cm tussocks in mature sedge meadows, but none over a

meter. Estimates from ^{14}C dating indicated that 16-18-cm tall tussocks in three remnant sedge meadows were ~52 years old in the 1960s (peak ^{14}C emissions from atomic bomb tests; Lawrence and Zedler 2013). Tussocks grow too slowly to measure annual rates.

Ramets and leaves are difficult to count, but the tallest leaves can characterize herbaceous wetland plants (Vernescu and Ryser 2009). Maximum leaf length (MLL) on a tussock is easily measured for *C. stricta*, and when the leaves curve, the resulting canopy height can be assessed. Flowering and the abundance of inflorescences are also readily recorded, as are heights of co-existing forb species.

My aim in monitoring *C. stricta* heights and flowering was to track growth over time, relative to forbs, and to compare interannual variation with differences among tall and short tussocks.

METHODS

Several areas with groundwater seepage support *C. stricta* tussock meadows near headwater springs in Dunn Township, Dane County, Wisconsin. One tussock meadow (~0.1 ha) is adjacent to a shallow, 4-m wide, perennial cold-water spring (42.9° N. -89.4° W.) and readily accessible. It receives continuous groundwater discharge (visibly wet soil) of constant temperature (54°F). Rainfall is unnecessary for growth, and there is no watershed to supply surface water runoff. The study site is not pristine as remnants of rusty barbwire fencing indicate past grazing, probably by cattle.

I established an 8-m-long trail within the tussock meadow and added five short (~1-m) planks to stabilize the wet soil and mark the path. My path connected eight taller *Carex stricta* tussocks and six that were shorter (Figure 2).

I measured tussock height by placing a meter stick vertically on the side away from my path. Nearly every Sunday during 11 growing seasons (late April through early Nov., 2005-2015), I assessed the same 14 tussocks, placing the m stick on top of each, stretching the handful of leaves, and recording the longest leaf (in cm). I counted the number of inflorescences when present, then measured canopy height (to the nearest 5 cm above the pedestal). When a canopy had split (part decumbent, part taller), I recorded both heights and used the average. This aspect of variation was not anticipated and, although uncommon, it and the 5-cm intervals make canopy height an imprecise attribute. As leaves began to senesce, I tried measuring maximum tip necrosis, necrosis of the longest leaf, and then selected the maximum extent of green leaf tissue as the most repeatable measure, because dry dead tips broke easily. I recorded the identity and height of the tallest forb that was shading a tussock (measuring from the tussock top, as for canopy height).

The dataset generates new hypotheses and quantifies earlier observations, e.g., the temporal shift from sedge dominance in spring toward forbs in fall (Peach and Zedler 2006). I avoided statistical tests, because the path and its 14 tussocks were not chosen randomly. While this limited analysis, it was clear that confining my sample to a single, short transect also confined trampling effects. Weekly walking compressed the organic soil, affected tussock height measurements, and appeared to encourage wildlife to use the same path and bed down on top of some shorter tussocks. As in the Heisenberg principle, I changed the ecosystem by trying to describe it. Random sampling would have spread the damage, but would not eliminate disturbance.

I consulted weather data for Madison (www.usclimatedata.com/climate/madison) to explore variations in mean monthly high and low temperatures and total precipitation, including the last spring snowfall >1 inch. Gorham (1974) suggested that a site's highest monthly mean temperature (in his example, 9-22°C) was a reliable predictor of its productivity, based on 11 *Carex* meadows from 41° to 52° N. Latitude in North America and Europe, with 170 to 1470 g/m^2 canopy biomass. However, Curtis Prairie's canopy biomass (354 g/m^2 in August 2008, Doherty and Zedler 2014) and Madison's highest monthly mean temperature of 28°C do not fit Gorham's curve. Still, Gorham's findings suggest that unusually warm or cold air temperatures in March or

FIGURE 2.
Study site in mid-May 2005. The log was a useful landmark after canopy closure obscured the trail.

April months could accelerate vegetative resprouting of *C. stricta*, and unusual weather in April and May could affect flowering. Snowfall >1" continued into April only in 2007 (5.3" on 11Apr) and 2011 (1.3" on 19Apr). Mean monthly minimum temperatures were near normal in both of those years, so there was little evidence to support a late-snowfall effect.

RESULTS AND DISCUSSION

Data are for 294 Sundays (mean 27/yr; range: 19 in 2005 to 37 in 2010), with over 4,000 MLL and 4,000 canopy measures, plus counts of inflorescences in May-June and heights of adjacent forbs into November. Means are presented as ± standard errors.

Tussock heights. Measures of tussock height were imprecise, because both the soil base and tussock top (with leaves and attached litter) were compressible. The 2005 heights included litter, so I assessed litter in 2012 by measuring tussock height with and without applying moderate pressure with a meter stick. I then recalculated the 2005 tussock heights (mean without litter = 32 ±5.7 cm). Still, re-measures in 2012 (mean 22±4.6 cm, range 2-45) and 2015 (mean 21±4.4 cm, range 0-42) documented substantial decline since 2005. Two tussocks (T#6, T#11) near the path were no longer present in 2015, following disturbances that included my trampling and probable deer bedding.

I used the average of the 2012 and 2015 measurements (19.8 cm) as a criterion to separate tussocks into two subgroups. Thus, six above-average tussocks (20-42 cm) were considered tall, leaving eight in the short subgroup (Table 1).

The ratio of largest to smallest mean MLL was 1.1, both between height subgroups (Table 1) and years (Table 2). However, the other ratios of trait means were greater for height subgroups than for years: canopy height (1.5 vs. 1.2), flowering tussocks (3.6 vs. 1.8) and total inflorescences (9.7 vs. 3.5). On average, the six tall tussocks produced longer leaves, taller canopies (without considering tussocks, not just when added to tussock heights), and more inflorescences. Just how widely these differences might

TABLE 1.

Attributes of tall vs. short tussocks (data are ranges and means for 6 tall and 8 short tussocks). T = tussock; # = number from south to north along an 8-m path; ht = height; max = maximum; MLL = maximum leaf length; spikes were also noted on 1Nov2015. MLL and canopy heights are summed to yield plant heights only for 2015, when tussock heights were last measured.

Height subgroup	T# from tall to short	Tussock height in 2015 (cm)	Max height of spikes 9Nov2014 (cm)	MLL on 17May 2015 (cm)	MLL in all of 2015 (cm)	Max canopy height 2015 (cm)	Plant ht (tussock + its canopy) (cm)	# yrs a tussock flowered (of 11)	11-yr total inflorescenses produced
Tall	9, 7, 13, 12, 3, 2	18-42	2-3	40-60	138-158	65-80	88-115	8-10	53-153
Mean		**30.5**	**2.5**	**51.3**	**150.8**	**71.7**	**102.2**	**9.0**	**102.8**
± s.e.		3.2	0.3	3.5	3.6	2.1	3.7	0.4	17.3
Short	1, 14,4, 10, 8, 6, 11, 5	0-15	1-3	0-60	0-160	0-65	0-80	0-6	1-41
Mean		**8.6**	**1.7**	**41.5**	**113.8**	**46.6**	**55.3**	**2.5**	**10.6**
± s.e.		2.1	0.2	6.5	18.5	8.0	9.1	0.8	5.1

TABLE 2.

Attributes of *C. stricta* over 11 years of monitoring (n = 14 tussocks). Abbreviations as in Table 1. Grand means (N = 11 yrs) ± s.e. were: MLL = 137.0±1.3 cm; canopy height (excluding the tussock) = 68.0±1.3 cm; inflorescences per tussock = 6.6±0.4, and total inflorescences produced annually by all 14 tussocks = 64.7±6.5.

Attribute	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Mean MLL (cm)	135.1	136.6	136.6	133.7	135.7	138.9	141.2	128.4	142.0	144.2	134.5
Standard error	2.1	3.3	3.3	3.9	3.7	5.3	5.5	5.2	5.1	3.6	6.5
Mean canopy height (cm)	77.1	70.1	66.1	65.0	63.8	64.3	66.6	63.6	68.4	74.2	68.3
Standard error	1.7	1.5	2.8	3.0	1.8	1.7	4.1	3.8	3.4	3.4	3.0
Number that flowered	7	7	9	8	7	8	6	5	5	5	6
Total inflorescences	26	80	63	92	89	69	44	91	48	53	57

be generalized awaits data suitable for statistical analysis. These 14 tussocks support a light-limitation hypothesis, i.e., leaves higher in the canopy absorb light first and produce more biomass. In 2015, tall plants (tall tussocks + tall canopies; mean = 102.2±3.7 cm) averaged 1.8 times taller than short plants (short tussocks + short canopies; mean = 55.3±9.1 cm). Leaves of the shortest plants were often shaded by taller *C. stricta* canopies.

Overwintering spikes. As early as October, tussock tops had produced short, sharp shoots that overwintered and grew early in spring. Their triangular shoot base made them sturdy, and while they were difficult to see, they felt like nails ("spikes" hereafter). Spike MLL was 1-3 cm on 9 November 2014 (Table 1). The spikes often have a white powdery coating that persists when the shoots begin elongating (Figure 3). Overwintering spikes could confer an advantage by responding early to snow melt or warm days. A late frost, however, could override any early-melt advantage. According to Bernard and Solsky (1997) and Bernard et al. (1988), many other *Carex* species also have overwintering spikes, and their high concentrations of N, P, and K, allow an early-growth advantage that leads to flowering. Photographic evidence indicates that *C. stricta* inflorescences can elongate nearly as fast as green shoots (Figure 4). A 2016 study will focus on overwintering shoots and their role in flowering.

Leaf elongation. Despite emerging early in the season, shoots of *C. stricta* grow slowly for the first 6-7 weeks when nights are still cold. Once leaves reach about 25 cm in May, they elongate at a near-linear rate of ~15 cm/week, then slow to reach maximum leaf length (grand mean 137 cm) near the summer solstice (Figure 5). Because the leaf tips are often at the bottom of the canopy, their necrosis is understandable. By lifting and measuring leaves to obtain MLL, I likely affected rates of tip necrosis.

The leaves senesced gradually as measured by maximum green leaf (Figure 6). Mean MLL increased from 8 March through 5 July and mean maximum green leaf length decreased from 5 July through 1 November. Often, a single leaf retained some green tissue, so this trait overestimates whole-plant condition.

Mean monthly high and low temperatures identified 2012 as unusually warm throughout the growing season, and 2003 and 2014 had unusually cold weather in March. The mean high temperature for March 2012 was 40.4°F compared to normal (25°F). April was just 2°F above the 57°F norm, but May had the highest mean temperature in 11 years at 51.6° F (norm = 46°F). That year, *C. stricta* shoots exceeded 15 cm MLL on 25 March (one month "ahead of schedule"), and inflorescences were abundant in early April.

This early advantage (early height growth to 15 cm) was lost for the stand as whole, however. Shading by skunk cabbage (*Symplocarpus foetida)* occurred by 20 May when it was the tallest forb with leaves extending to 30-75 cm above nearby short tussocks, including T#11. By June 10, T#11 was reduced to a single stem; later it was covered by *S. foetida'*s large dead leaves. I also caused damage by adding planks that I stepped on weekly, by removing Canada thistle (*Cirsium arvense*) within easy reach, and even by lifting sedge leaves to select and measure the longest ones changed their position relative to adjacent canopies. I blame deer, however, for other damages. I saw browsed leaves on T#10 on 6 May (my only observation of consumption) and a flattened canopy on T#14 on 13 May. On 7 February 2016, I happened to observe four deer romping in my study site; their hoof-prints in recent snow showed that they followed my path and avoided tall tussocks but not necessarily short ones. My direct and indirect impacts could explain tussock height declines from 2005-2015.

FIGURE 3.
Whitish-green shoots (here, ~10 cm tall) emerge from overwintering spikes (1-3-cm tall) that are easier to feel than see among the tussock-top litter (12 April 2005 photo).

FIGURE 4.
On 8 May 2005, black inflorescences were visible on tussocks with mean MLL = 34 cm). An equally tall leaf of reed canary grass (*Phalaris arundinacea*) is also visible, along with its litter from 2004.

Given multiple disturbances, the mean MLL for 2012 (128 cm) was well below the 11-year mean of 137 cm, despite potential for extraordinary growth that year, with the highest mean maximum temperatures of 11 years in June, July and August. Still, a few undisturbed tussocks appear to have experienced a "year effect." Four tussocks grew leaves >140 cm by 1 July, and growth continued to a record 160 cm. Increased growth under high temperature is consistent with the findings of He and Holaday (2011), who compared *C. stricta* photosynthetic rates with temperature treatments administered in spring, summer and autumn. Their greenhouse data are relevant; they used seed from my Wisconsin population to grow their experimental plants.

The two "cool years" had below-average March monthly mean high temperatures (2013 = 18.4; 2014 =18.3; "normal" = 25°F) and below-average monthly mean low temperatures of 34.7°F and 37.4°F, respectively (normal = 43°F). Subsequent months were near normal, yet both years achieved above-average mean MLL (142 and 144, respectively). In 2014, leaves exceeded the grand-mean MLL a

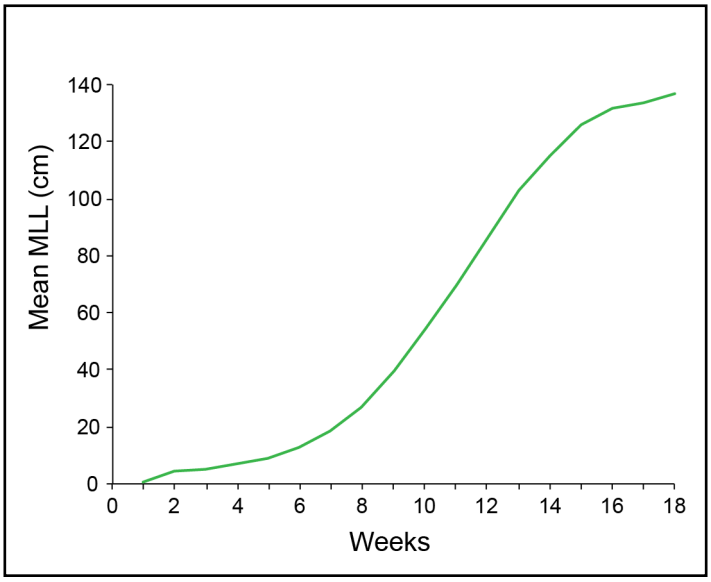


FIGURE 5.
Maximum leaf lengths (MLL, in cm, N = 11 years) aligned on their greatest value (mean±s.e. = 137.0±1.3, at week 18). Thereafter, leaf tips experienced necrosis and it became easier to measure maximum green leaf (Figure 6).

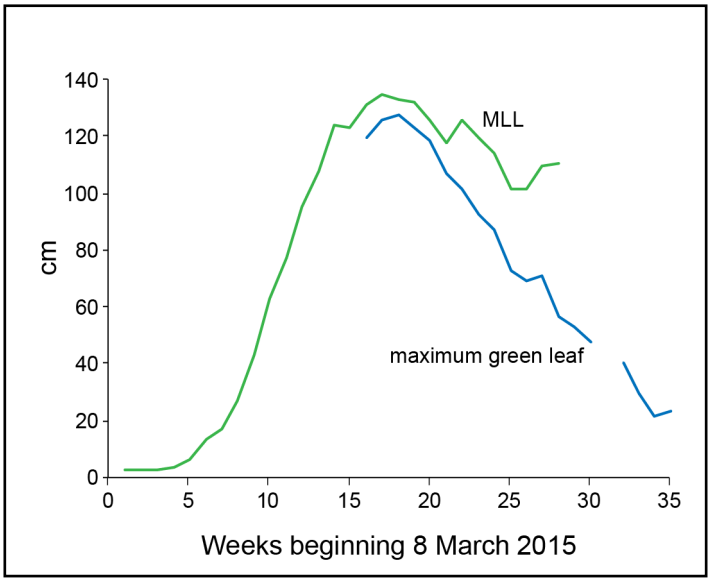


FIGURE 6.
Data from 2015 show that MLL (including necrotic tips) extends beyond the maximum green leaf tissue on a tussock (lower curve). No green remained on 15 November (T#5 and T#11 were absent in 2015 and T#6 and T#14 lost all live leaves mid-season). Break in curve = no data.

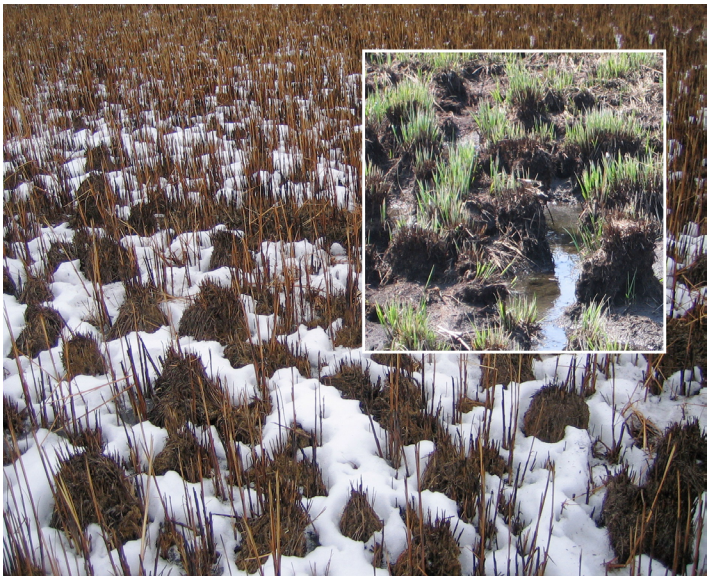


FIGURE 7.
Bare black tussocks in Cherokee Marsh in winter 2008 after a controlled burn (to manage shrub invasion) in fall 2007. Inset shows young shoots after snow melt. This sedge meadow is one of Madison's Conservation Parks (www.cityofmadison.com/parks/cherokeenorth/).

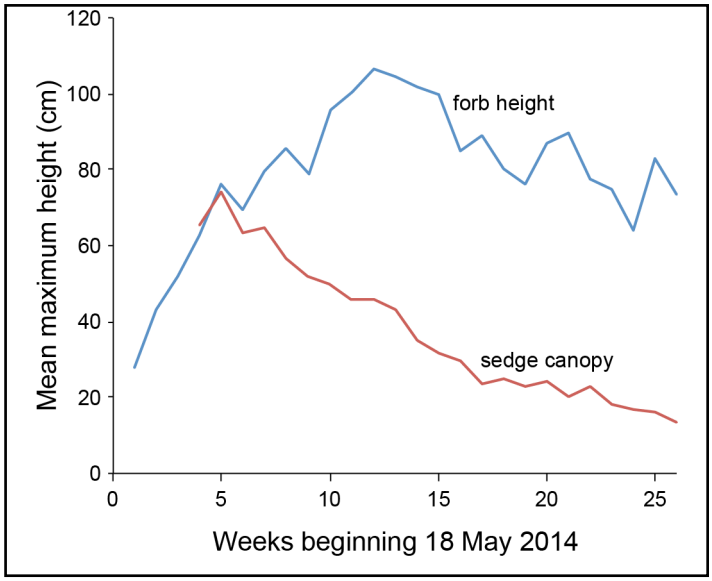


FIGURE 8.
Forbs (upper line) overtop the *C. stricta* canopy (lower line) in summer. Sedge data are for 14 tussocks and forb data are for the tallest forb that shaded a tussock (N ≤ 14, since some tussocks were not always shaded by forbs). Plots are heights above tussock tops.

month before their peak MLL, but not in 2013. These early high MLL data were not consistent with warmer temperatures, seen in 2012. Monthly temperature data did not explain high MLLs in cool years.

Inflorescences. *C. stricta* flowered (i.e., produced at least one inflorescence) in May and released seed in June. Flowering occurred in all 11 years, and all but one tussock flowered at least once (Table 2). I counted 712 inflorescences for 14 tussocks over 11 years. On average, a tussock flowered 5.3 times in 11 years and those that flowered averaged of 9.6±1.1 inflorescences per flowering event (N = 74) or 4.6±3.1 per year, including zeroes (N = 154). The largest number of inflorescences for a single tussock was 38 in 2008; that tussock (#9, in the tall subgroup) skipped two years, then produced 16 and then 34 inflorescences (the 2nd highest number per tussock). Tussock #9 was the top reproducer, based on total inflorescences. The top year for number of flowering tussocks was 2007 with nine plants producing inflorescences--but the top year for the number of inflorescences was 2008 with a total of 92. As observed by Post et al. (2008), not all life history events are equally responsive to environmental variation. Frequency of flowering and inflorescence production were correlated (R = 0.77) and both were less predictable than leaf elongation.

Tussock flowering did not display a boom-and-bust pattern; rather, high- and low-production was associated with height subgroups (Table 2). The six tall tussocks produced the most inflorescences over 11 years and flowered most often. Reproductive advantages of a tall tussock should include improved chances of widespread wind pollination and potential for long-range seed dispersal.

Other factors known to correlate with *C. stricta* flowering are hydroperiod and nutrients. In 72 outdoor mesocosms, 91% of 3-yr-old *C. stricta* seedlings produced inflorescences; more were produced under wetter hydroperiods and 40% more when N and P were added (Lawrence & Zedler 2011). In contrast, Costello (1936) stated "Examination of thousands of tussocks over a period of more than six years in the Milwaukee region has yielded comparatively few fruiting specimens. Seedlings of *Carex stricta* were never found during this period."

C. stricta seeds might be adapted to germinate on dark substrates, which I observed in a small sedge meadow where tussocks were bulldozed to divert agricultural runoff. The bare black soil produced many volunteer seedlings. Also, in trays of seeds given shallow water and full sun, *C. stricta* germinated in black but not white trays. Both of these observations are explained by experimental results that *C. stricta* seeds need high temperatures to germinate (Kettenring and Galatowitsch 2007). The sun's warming of disturbed, black soil likely stimulates both germination and seedling growth. The same might be true of fire-scorched tussocks (Figure 7).

Canopy height. Canopies exhibit temporal segregation during the growing season. Canopies measured above the tussock (ignoring differential tussock heights) achieved peak height in July and gradually declined thereafter (Figure 8, lower curve). The seasonal sequence of dominant green cover thus begins with mosses in early spring, at least where there are openings in the litter layer (Figure 3), followed by closure of the sedge canopy in June, and then overtopping of sedges by tall, conspicuous forbs.

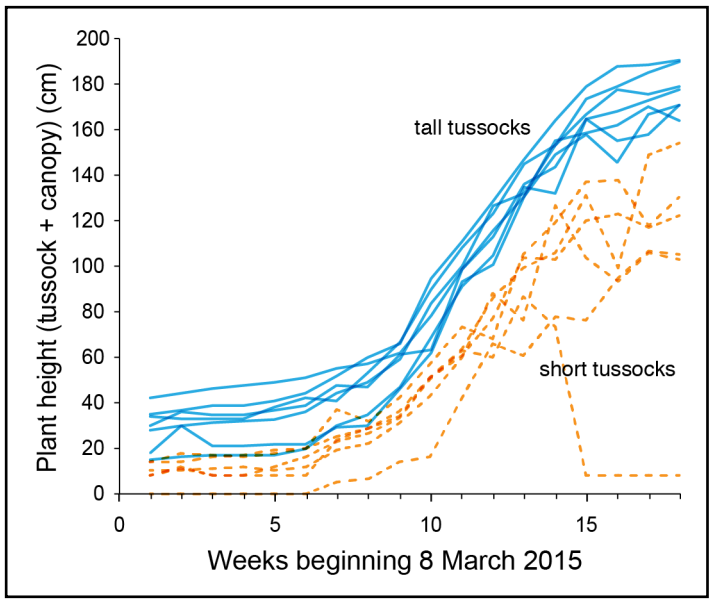


FIGURE 9.
Plant heights (tussocks + canopies) for tall (left) vs short (right) tussocks. In 2015, the intermediate T#1 resembled tall tussocks and is included in the left graph.

FIGURE 10.
Photo of the study on 24 June 2006. The *C. stricta* canopy is continuous and intermittent forbs overtop.

Whole plants (tussocks + canopies). The six tall tussocks were about 0.5-1.3 m apart, and their canopies rarely overlapped. They did, however, shade the shorter plants. The combined *C. stricta* canopies expanded to ~100% cover soon after the summer solstice (Figures 9-10).

Forbs on or near the 14 tussocks. Forbs grew rapidly from late May to over a meter above tussock tops by early July (Figure 10). The most common tall forbs were goldenrod (*Solidago canadensis*) and New England aster (*Symphotrichum novae-angliae*). Usually, an unbranched forb stem with leaves <10 cm long provided <20% cover. Forb stems remained upright through October, either live or as standing dead.

Forb heights increased with stem growth but decreased with several variables, e.g., wilting, heavy dew (as on 24 May 2015), senescence, leaning or breakage, and occasional insect damage. Heights could increased again with short-term recovery or with the appearance of a different forb leaning over a tussock. Although the tussock canopy declined (Figure 7), tall forbs were not likely the cause, because they never cast heavy shade. Instead, the *C. stricta* canopy collapsed as its leaves senesced (maximum green leaf shortened; Figure 5). An exception was *S. foetidus* which has large leaves on upright petioles (Figure 11). In May 2013, its leaves extended to 85 cm tall and overtopped short tussocks (T#4, 5, 10, 11), which "went missing" in 2014. *S. foetidus* leaves sometimes inhibited short, but not tall, tussock sedges.

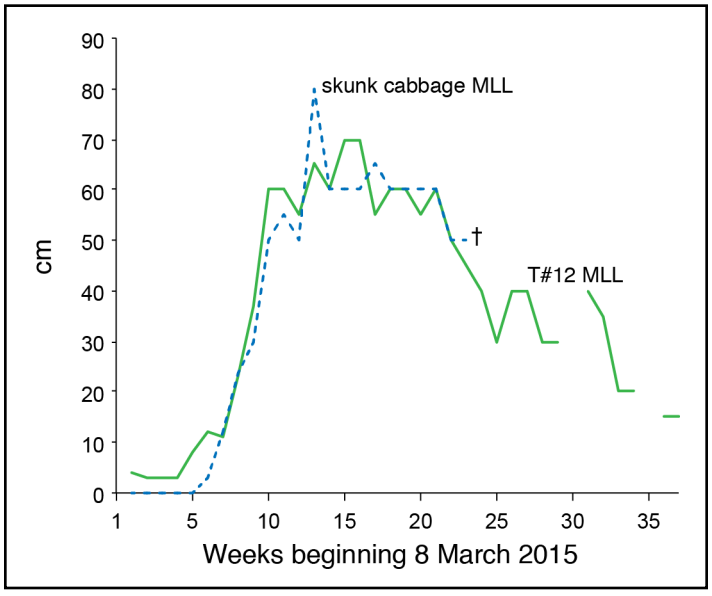


FIGURE 11.
Height in 2015 of the tallest leaf of *Symplocarpus foetidus* that cast significant shade on *C. stricta* T#12 until that leaf senesced (16 August 2014) and collapsed. Both data sets are for heights above the 14-cm *C. stricta* tussock. Figure 2 shows *S. foetidus* among *C. stricta* at the study site in mid-May 2006.

CONCLUSIONS, HYPOTHESES AND RECOMMENDATIONS

The phenology of *C. stricta* was consistent for 14 tussocks over 11 years of weekly monitoring. Shoots overwintered and began elongating in March-April, then lengthened ~16 cm/week from mid-May to mid-June. Leaves > 43 cm long curved and formed a canopy (mean = 64-77 cm) above tussock tops from June 9-24. After the summer solstice, leaves achieved maximum length (grand mean = 137 cm; range = 128-144 cm). Leaves senesced from leaf tips to bases, from mid-May to early November. Dead leaves remained attached to tussocks and persisted through the next growing season. Flowering occurred in late April–May, with seed rain in June. From 2005 through 2015, tussocks that flowered produced 9.6±1.08 inflorescences on average (N = 74).

Results support two hypotheses: H_1 - interannual variation of flowering and canopy heights is less than differences between tall vs. short plants and H_2 - flowering varied more than vegetative traits. Inflorescences ranged from 0-38/tussock, but six tall tussocks (> 22 cm) reproduced the most dependably and produced 11-yr totals of 52-153 inflorescences, while eight shorter tussocks produced 0-41. Six tall tussocks remained tall for 11 years, while shorter tussocks and their canopies were vulnerable to trampling and wildlife, e.g., deer bedding.

It pays to be tall. The advantages likely include greater productivity, ability to shade subordinates, and resistance to being trampled. A positive feedback might be that tall tussocks with long leaves and high canopies accumulate biomass readily, adding height and storing reserves for seed production.

Monitoring can degrade the ecosystems we try to conserve. Further research is needed to identify effects of direct (trampling) and indirect human impacts (creating paths that deer follow). To reduce effects of monitoring, sampling can shift to targeted dates, based on a year of weekly data on overwintering spikes, linear leaf elongation, flowering time, peak canopy height and declining length of green tissue on leaves. Critical times are mid-May (for MLL and # inflorescences per tussock), 2 weeks in mid-June (for MLL to calculate elongation rate) and canopy height in early July and September to document tall forbs.

Further research is needed to quantify overwintering spikes (presence, nutrient content, production of inflorescences), the effects of late-winter frosts on photosynthesis, and local stressors (e.g., frost on tussock tops) as weather becomes more variable. ■

ACKNOWLEDGMENTS

I thank Ralph Tiner for encouraging this submission, and the Town of Dunn, Wisconsin, for protecting tussock meadows using conservation easements on private lands.

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National Wetlands Inventory Produces Wetlands Mapper App for Phones

A new version of the Wetlands Mapper has been developed to run on mobile devices. When accessing the Wetlands Mapper from a mobile device, the user will now be automatically directed to this new mobile friendly version. When the mobile device's GPS location services are on, the user can simply touch the screen and the mapper zooms to the location of the user. This ability greatly enhances the possible use cases and user experience by bringing the interactive wetland data to the field. Use your mobile device to access the new version of the Wetlands Mapper at: http://www.fws.gov/wetlands/Data/Mapper.html

Note that the zoom to location will not work on your mobile device unless the location services are turned on. Each device may have different ways to accomplish this. For Apple devices follow this link. For Android devices follow this link. Certain browsers have specific location settings: for Safari follow this link; for Chrome follow this link.

If you have never used the Service's Wetland Mapper, view this 3 minute video, *How to find and use the U.S Fish and Wildlife Service's Wetlands Mapper*: https://www.youtube.com/watch?feature=player_detailpage&v=CB398gj3O04 ■

Association of State Wetland Manager's NWI+ Web Mapper Back Online

A modified version of the NWI+ mapper that is back online through the Association of State Wetland Manager's website – Wetlands One-Stop Mapping (http://www.aswm.org/wetland-science/wetlands-one-stop-mapping), thanks to Virginia Tech's Center for Geospatial Information Technology. The online mapper offers hydrogeomorphic-type classifications of mapped wetlands by landscape position, landform, water flow path, and waterbody type (LLWW descriptors). This information has been coupled with standard NWI classification to create an expanded wetland database, which has been used to predict 11 wetland functions. The mapper can display wetlands by NWI type, landscape position, landform, and water flow path, as well as by each of the 11 functions. While originally designed for color displays, this interim mapper presents data in shades of gray as a cost-cutting mechanism until funding can be secured to upgrade the technology. A "codes" function is offered that allows users to click on "dots" on a wetland that are linked to a drop-down table showing the classification by NWI type and LLWW type. The data posted are for select areas only, as this was not a standard product for the U.S. Fish and Wildlife Service's National Wetlands Inventory Program. Several states have posted their data through this website including Connecticut, Delaware, Georgia, Pennsylvania, and New Mexico. In some places, additional data layers are available for display, includng potential wetland restoration sites and "p-wet areas" (undeveloped hydric soil areas that were not mapped as wetland due to a lack of a reliable signature). The ASWM website has links to summary reports for many of the larger areas where this specialized inventory was performed. These reports will give readers a good idea of how the data are created and how they enhance and expand upon existing wetland inventory data. ■

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).

Student Research at Indiana University

Two graduate students from Indiana University, working under the direction of Dr. Christopher B. Craft, have submitted information on their ongoing research. Feel free to contact them for details.

Measuring the response to sea level rise in a tidal freshwater forested wetland on the Altamaha River, Georgia

Accelerated sea level rise driven by global warming will lead to greater inundation and salt water intrusion into coastal wetlands. Tidal freshwater forests are especially susceptible to salt water intrusion and even low levels of salinity stunt growth and lead to tree mortality. I measure forest structure (species richness, habitat diversity) and function (litter fall, woody increment) and soil accretion in a healthy tidal forest on the Altamaha River, Georgia, to characterize ecosystem dynamics under normal flow conditions to aid in predicting their response and resilience to sea level rise and climate variability (e.g. drought).

Objectives:

- Measure aboveground net primary production using dendrometers and litter fall traps
- Measure carbon, nitrogen, and phosphorus content in leaf litter
- Determine changes in elevation using Surface Elevation Tables (SETs)
- Calculate soil accretion rates by analyzing ^{137}Cs and ^{210}Pb gamma counts
- Measure carbon, nitrogen, and phosphors content in soil

Expected Completion: May 2017

Contacts:

MSES Candidate McKenna Stahl mestahl@indiana.edu and Dr. Christopher Craft ccraft@indiana.edu. ■

The impact of human alteration of sediment supply on coastal wetland vulnerability to sea level rise

Mineral sediment is an important source of material supporting vertical accretion in coastal wetlands. The decline in sediment delivery in rivers over the past few decades can lead to reduced accretion and wetland submergence. Our study will assess how have accretion rates in coastal wetlands responded to changes in sediment delivery in three Southeast estuaries: Cape Fear, NC, Edisto, SC and Altamaha, GA.

Objectives:

- Determine whether mineral sediment supply is an important factor contributing to marsh accretion by measuring variable accretion rates in three study sites.
- Determine the rates of accretion and mineral deposition using radiometric dating measurements.
- Analyze soil organic carbon to estimate carbon sequestration rates.
- Measure above- and below-ground plant biomass at each sampling location to determine relationships between vertical accretion, plant biomass and sediment supply.
- Employ modeling approaches (Marsh Equilibrium Model, Sea Level Affects Marshes Model) to predict vulnerability of Southeast tidal marshes to current and future rates of sea level rise.

Expected completion: August 2018

Contacts:

Elena Solohin, PhD Student in Environmental Sciences, Indiana University (esolohin@indiana.edu) and Dr. Christopher Craft (ccraft@indiana.edu). ■

WETLAND BOOKSHELF

In this edition you'll find three new entries – two books "*Wetland Soils: Genesis, Hydrology, Landscapes, and Classification*" edited by M.J. Vepraskas and C.B. Craft and "*Creating and Restoring Wetlands: From Theory to Practice*" by C.B. Craft and an online US Army Corps of Engineers regional guidebook for functional assessment in the Northcentral and Northeast Region.

BOOKS

- Wetland Soils: Genesis, Hydrology, Landscapes, and Classification https://www.crcpress.com/Wetland-Soils-Genesis-Hydrology-Landscapes-and-Classification/Vepraskas-Richardson-Vepraskas-Craft/9781566704847
- Creating and Restoring Wetlands: From Theory to Practice http://store.elsevier.com/Creating-and-Restoring-Wetlands/Christopher-Craft/isbn-9780124072329/
- Salt Marsh Secrets. Who uncovered them and how? http://trnerr.org/SaltMarshSecrets/
- Remote Sensing of Wetlands: Applications and Advances. https://www.crcpress.com/product/isbn/9781482237351
- Wetlands (5th Edition). http://www.wiley.com/WileyCDA/WileyTitle/productCd-1118676823.html
- Black Swan Lake – Life of a Wetland http://press.uchicago.edu/ucp/books/book/distributed/B/bo15564698.html
- Coastal Wetlands of the World: Geology, Ecology, Distribution and Applications http://www.cambridge.org/us/academic/subjects/earth-and-environmental-science/environmental-science/coastal-wetlands-world-geology-ecology-distribution-and-applications
- Florida's Wetlands http://www.pineapplepress.com/ad.asp?isbn=978-1-56164-687-6
- Mid-Atlantic Freshwater Wetlands: Science, Management, Policy, and Practice http://www.springer.com/environment/aquatic+sciences/book/978-1-4614-5595-0
- The Atchafalaya River Basin: History and Ecology of an American Wetland http://www.tamupress.com/product/Atchafalaya-River-Basin,7733.aspx
- Tidal Wetlands Primer: An Introduction to their Ecology, Natural History, Status and Conservation https://www.umass.edu/umpress/title/tidal-wetlands-primer
- Wetland Landscape Characterization: Practical Tools, Methods, and Approaches for Landscape Ecology http://www.crcpress.com/product/isbn/9781466503762
- Wetland Techniques (3 volumes) http://www.springer.com/life+sciences/ecology/book/978-94-007-6859-8

ONLINE PUBLICATIONS

U.S. ARMY CORPS OF ENGINEERS

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

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

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

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

U.S. FOREST SERVICE

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

U.S. GEOLOGICAL SURVEY, NATIONAL WETLANDS RESEARCH CENTER

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

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

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

PUBLICATIONS BY OTHER ORGANIZATIONS

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

ARTICLES OF INTEREST FROM VARIED SOURCES

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

LINKS TO WETLAND-RELATED JOURNALS AND NEWSLETTERS

JOURNALS

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

NEWSLETTERS

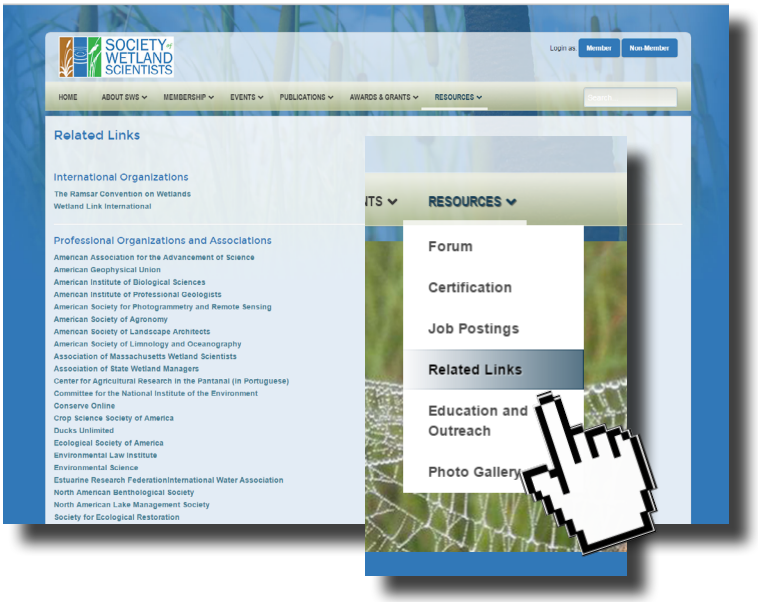
- Biological Conservation Newsletter (this monthly newsletter contains a listing of articles that include many that address wetland issues – current and others back to 1991 in the "Archives") http://botany.si.edu/pubs/bcn/issue/latest.htm#biblio
- Wetland Breaking News (Association of State Wetland Managers)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

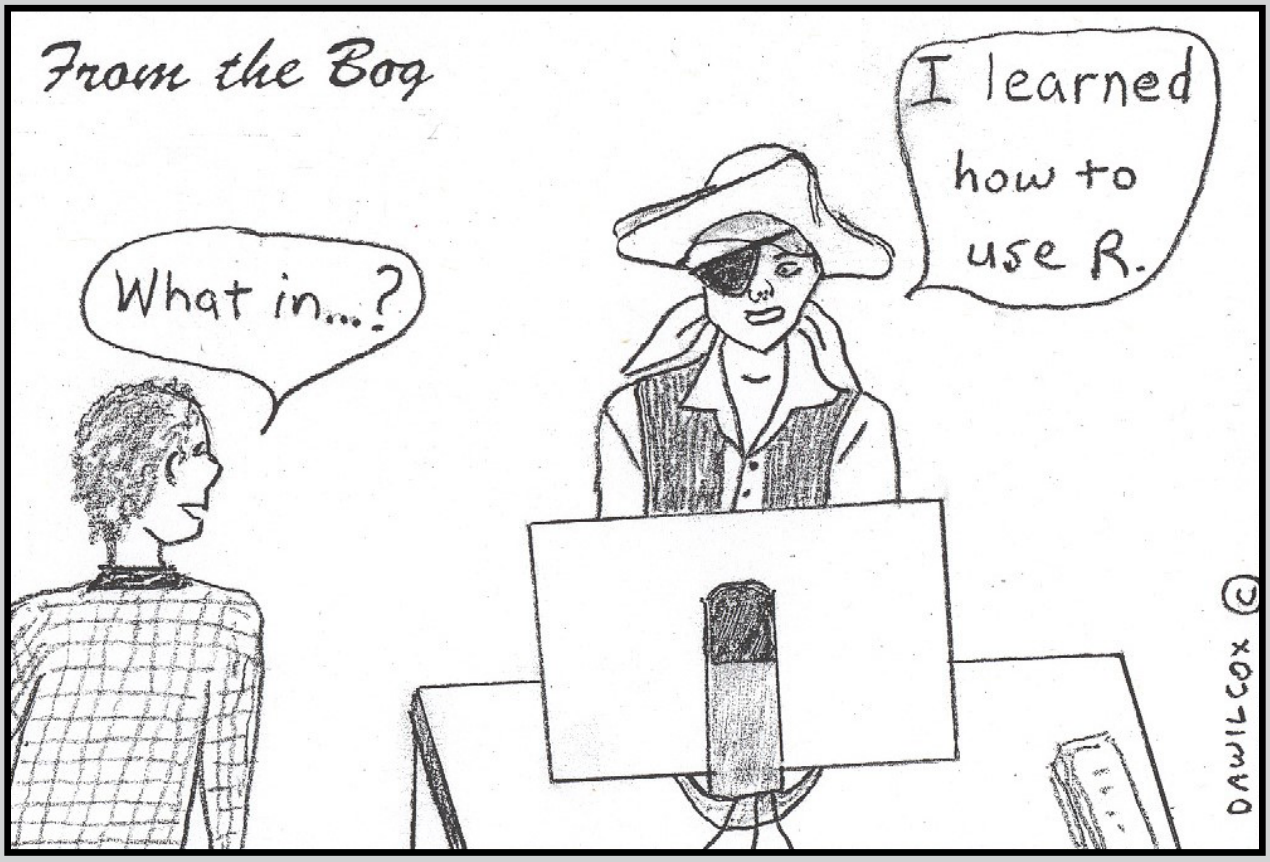
WEB TIP

Resources at your fingertips!

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

Find them on the Related Links page **at sws.org.**





Aargh!

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.