

wetland science & practice

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Greetings and welcome "Spring" to New England. It's been quite rainy and on the cool side recently in Massachusetts, but things are quite green and warming up – it's supposed to be in the 70s today. The indigo bunting, ruby-throated hummingbirds, and phoebes are back and



Ralph Tiner
WSP Editor

“I'm sure that many of you attended our annual meeting in Corpus Christi. For those of you who have given presentations, please consider writing a brief article for Wetland Science & Practice.”

article for Wetland Science & Practice. It should be relatively easy to take your presentation and convert it to a 5-page summary paper for WSP. This would give your project more exposure, put it in a published form to inform other SWS members not attending of your work, and eventually reach the general populace when the issue is available online via the internet worldwide. If you have any questions, please contact me at rtiner@eco.umass.edu.

Meanwhile, enjoy the summer in the Northern Latitudes and the winter in the Southern Hemisphere.

Happy Swamping! ■

Note to Readers:

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

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Cover photo:
Spring peeper, *Pseudacris crucifer*
by Ralph Tiner

www.sws.org

SOCIETY OF WETLAND SCIENTISTS
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Well...my term as SWS President has come to an end. I have to say that this has been one of the most rewarding experiences of my professional life. The relationships I have built over the last year with SWS leaders, staff, members, and collaborators have been amazing. I consider it an honor to have had the opportunity to shape the Society and to have it shape me as a leader. It's with much pleasure and confidence that I hand over the reins to my esteemed colleague, President-elect, Gillian Davies. I know she brings an incredible enthusiasm for leading the Society and we are all in good hands! As we make this transition and share in leadership of SWS, we will share the latest and greatest things that have been happening in this address.



Kimberli Ponzio, PWS
SWS President
2015-2016

ELECTIONS

We offer our congratulations to Arnold van der Valk on being elected SWS President-elect and we welcome him to the team. We would also like to thank Darold Batzer for putting his hat in the ring and for continuing to serve SWS by agreeing to help the Local Program Committee plan for our 2017 Annual Meeting.

ANNUAL MEETING

As we write this, the Annual Meeting in Corpus Christi, TX on May 31 – June 4, 2016 is just around the corner. With a theme of “Protecting Wetland Ecosystem Services, Promoting Stronger Economies” we have 91 symposia talks, 212 individual presentations, 7 field trips and 6 workshops scheduled to take place.



Gillian Davies
SWS President
2016-2017

We hope you were able to attend the meeting and found it educational, engaging and enlightening. If you were unable to attend, hopefully you participated virtually by viewing the first-ever live streaming of the plenary talks. Now we look forward to our 2017 Annual Meeting that will be held in beautiful, sunny San Juan, Puerto Rico on June 3-8th, 2017. Make sure to arrange your schedule to be there and also pencil in 2018 for a meeting in the Rocky Mountain Chapter in Colorado.

Finally, the SWS Board of Directors approved the Future Meetings Committee's proposal for Rotational Geographic Sectors that helps us determine when and where we will hold our Annual Meetings. The plan will allow chapter leaders, the Executive Board and SWS Staff to plan proactively at least 2 years ahead of time.

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- ASIA / [Wei-Ta Fang](#)
- CANADA / [Gordon Goldborough](#)
- CENTRAL / [Luke Eggering](#)
- EUROPE / [Jos Verhoeven](#)
- INTERNATIONAL / [Elijah Ohimain](#)
- MID-ATLANTIC / [Jason Smith](#)
- NEW ENGLAND / [Jennifer Karberg](#)
- NORTH CENTRAL / [David Mushet](#)
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COMMITTEES

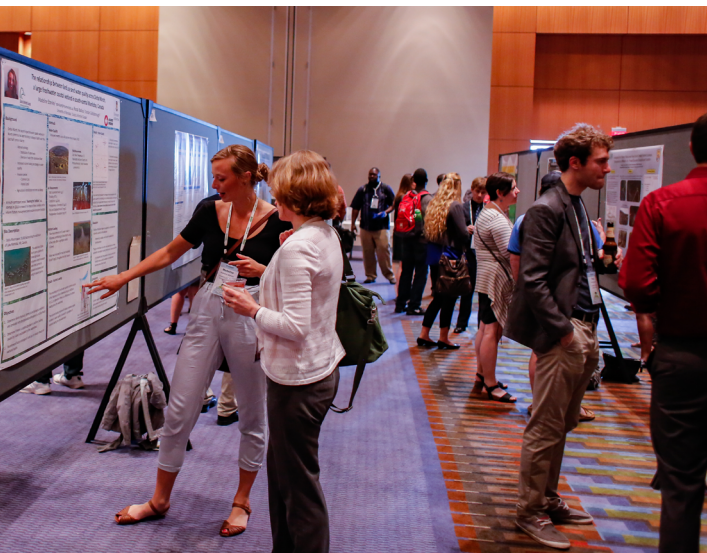
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- RAMSAR / [Nick Davidson](#)
- STUDENT / [Rose Martin](#)
- AIBS / [Dennis Whigham](#)

ANNUAL MEETING

SWS 2016 ANNUAL MEETING WAS FANTASTIC - WE HAD A GREAT TIME CONNECTING WITH EVERYONE, CATCHING UP ON ALL THE LATEST IN WETLAND SCIENCE RESEARCH FINDINGS AND GETTING OUT IN THE FIELD ON FIELD TRIPS! VIEW MORE PHOTOS ON THE SOCIETY OF WETLAND SCIENTISTS FACEBOOK PAGE. 



THANK YOU TO SWS 2016 SPONSORS



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WE CAN'T WAIT TO SEE YOU ALL NEXT YEAR IN PUERTO RICO. PLEASE PLAN TO JOIN US!

Society of Wetland Scientists Annual Meeting

SWS2017
Puerto Rico
June 5-8

Celebrating Wetland Diversity
Across the Landscape:
Mountains to Mangroves



RESOURCES

SUBSCRIBE TO WETLAND BREAKING NEWS

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

VIDEO AVAILABLE TO AID IN USING WETLANDS MAPPER

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

PAST ISSUES OF WETLAND SCIENCE & PRACTICE

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

SWS FREE MONTHLY WEBINAR SERIES

Take advantage of your SWS membership by participating in outstanding educational opportunities without leaving your desk! SWS is pleased to provide a [webinar series](#) on wetland science topics of interest. The convenience and flexibility of SWS webinars enables you to educate one or a large number of employees at once, reduce travel expenses, and maintain consistent levels of productivity by eliminating time out of the office. Webinar registration is a complimentary member benefit. A limited number of spots are available for each webinar. If you're unable to participate in the live webinar, all webinars are recorded and [archived](#) for complimentary viewing by SWS members. ■

Also, please see the *Wetland Bookshelf* section at the end of this publication.

President's Message continued from page 29

COMMUNICATION & EDUCATION

We want to offer our congratulations to Bill Morgante for receiving the SWS President's Award for leading the Education and Outreach Committee, ushering in some amazing new initiatives, and for mentoring and equipping new leaders on E&O subcommittees. Here are some of the accomplishments he helped to realize.

Have you caught the new SWS Webinar Series? We finished this quarter (Apr-Jun) by wrapping 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. In May, Sean Charles, of Florida International University, started the conversation about coastal wetlands in the Gulf of Mexico to focus our attention on the types of things you will see when we meet in Corpus Christi. And finally in June, Bill Mitsch of Florida Gulf Coast University, will broaden the geographic scope by talking about the U.S. National Ramsar Program.

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 (subcommittee 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.

After many years of work by Abbey Tyrna's team and SWS Staff, we are excited to roll out the first-phase launch of the Wetland Treasures Initiative as part of our American Wetlands Month activities. The goal of the Initiative is to raise public awareness of and interaction with wetlands and their many benefits to human health and environmental quality by creating a one-stop-shop for information about wetlands across the nation. Stay tuned as the team selects and announces the first-ever certified Wetland Treasures this July.

It's time to get out your cameras and take some wetland shots to submit to our 2nd Annual Photo Contest for the 2017 SWS International Wetlands Calendar. Be ready to send in your entries starting in June.

STUDENTS

Did you know that we now have eight (8) SWS Student Associations? If you saw the recent World Wetlands Day

activity list, our students were the ones leading the way. The culture of student engagement in SWS is, as always, kicking into high gear. We have a number of valuable student programs such as our SWS undergraduate minority mentoring program (now called SWAMMP), our Student Research and Travel Grants Program, and soon to come... our Wetland Ambassadors Exchange Program. In addition, we are engaged in reaching out to students of all ages with our Human Diversity Committee hosting a booth in Jacksonville, FL at the MANNRS (Minorities in Agriculture, Natural Resources and Related Sciences) conference and our Education and Outreach Committee (together with our CASS partners) hosting a booth at the 4th USA Science & Engineering Festival in Washington, D.C.

PARTNERSHIPS

Just in case you weren't aware, we now have a number of productive partnerships with a number of entities.

- **Association of State Wetland Managers (ASWM)**
Memorandum of Cooperation
SWS Representative: Matt Schweisberg
Our newest action was to appoint SWS Member, John Bourgeois, to ASWM's Workgroup on Wetland Restoration and have Bill Morgante attend the ASWM Conference last March in West Virginia.
- **Consortium of Aquatic Scientific Societies**
Memorandum of Understanding
SWS Representative: Jane Rowan
As a group, we recently decided to bring CERF (Coastal Estuarine Research Federation) back into the fold with our 5 member organizations - ASLO, AFS, PSA, SFS and SWS. We are tentatively planning to hold another Joint Aquatic Sciences Meeting in 2022. Many thanks to Jane for serving all these years - we are seeking a new representative.
- **Ramsar Scientific Technical Review Panel**
Memorandum of Cooperation
SWS Representative: Nick Davidson
We plan to sign a renewal of our MOC in the near future and hope to coordinate the term of the agreement with the Triennial meeting of the Ramsar Convention of the Parties.
- **American Institute of Biological Sciences**
Member Organization
SWS Representative: Dennis Whigham
Dennis attended an AIBS workshop on "Addressing Biological Informatics – Workforce Needs" in Washington D.C. and reported to the Board of Directors on the topics that were discussed and suggested ways that SWS could address the issues.

- **Taiwan Construction and Planning Agency & Taijiang National Park**

Memorandum of Understanding

SWS Representative: Wei-Ta Fang

We signed a renewal of our agreement with Taijiang National Park in Oct 2014 and we plan to sign a renewal of our MOU with the Taiwan CPA in Sept 2016 during the Asia Chapter Meeting in Taipei. Several SWS presidents and members have been invited by the CPA and are attending the meeting prior to the INTECOL meeting in China the following week. We hope to recruit members, build collaborations, engage student interested in Wetland Ambassadors Program, and further internationalize SWS.

- **SWS Professional Certification Program**

PCP Board Representative

SWS Representative: Scott Jecker

For the first time, SWS and PCP are co-hosting the Welcome Reception at the Annual Meeting in Corpus Christi to help strengthen the ties between our two organizations and to allow members of both groups to interact.

FINANCES

The financial status of SWS is strong and we are realizing nice returns on our investments. The Ways and Means Committee, led by SWS Treasurer Julia Cherry, will be evaluating our investment performance annually to ensure that we are staying on track. In addition, we are surveying Chapter leaders to determine how Chapter investments will be handled in order to provide much needed funds for their activities and functions. Since we approved the SWS 2016 Budget last November, we have started two new initiatives - *Chapter Grant Funding* and *Chapter Outreach*. Both are designed to help boost membership and expand programs of smaller chapters or international chapters. A call for Chapter Grant Funding proposals was rolled out this January and we are pleased to announce that the Europe Chapter is being awarded the first grant for approximately \$5,000, with disbursements spread over three years. The award for the first year will be \$2,500, with additional money granted over the ensuing two years, based on first-year results. The European Chapter submitted a detailed and persuasive grant application, documenting their financial need and specific chapter-building initiatives



that they wish to fund, which engendered strong support for their proposal.

The Chapter Outreach Program was kicked off by Gillian Davies participating in the Rocky Mountain Chapter meeting in April to help build enthusiasm for the Annual Meeting in 2018, to assist in the recruitment of the Local Planning Committee, and to vet the venue and possible field trip locations for that meeting. In May, I attended the Europe Chapter meeting to participate in the wetlands management and policy themed meeting, to help build SWS membership, to meet with collaborators who drafted the State of the Resource paper for the Studentchishta wetland in Macedonia, and to open the conversation with other like-minded organizations about possible collaborations or cooperative agreements. Thanks goes out to the ad hoc committee headed up by Jim Perry for drafting guidelines and reporting procedures for our Chapter Outreach activities.

MEMBERSHIP

The membership of SWS continues to grow and we now have over 3,500 members worldwide. As we build momentum in internationalizing, the percentage of our membership from Chapters outside of the United States is increasing and is now at 11%. We also continue our Gratis Membership program for eligible members in developing countries and as of Dec. 2015, there were 65 members representing 28 countries (India and Nigeria having the greatest number). As evident by our member renewal rate of 82%, we continue to strive to keep membership value high and are happy to hear any new ideas you may have on doing so!

KIM'S FAREWELL ADDRESS

Once again, I thank you all for the opportunity to serve as the 2015-2016 SWS President. And having just visited Germany during the Europe Chapter meeting, I would like to leave you with a couple of German quotes - one from noted German naturalist and scientist, Alexander von Humboldt, that should encourage us in our pursuit to understand nature and one ancient German proverb that simplifies that understanding and drives home the point of why we study and protect wetlands:

"I shall collect plants and fossils, and with the best of instruments make astronomic observations. Yet this is not the main purpose of my journey. I shall endeavor to find out how nature's forces act upon one another, and in what manner the geographic environment exerts its influence on animals and plants. In short, I must find out about the harmony in nature."

~Baron Alexander von Humboldt (1769-1859)

"Where there are no swamps, there are no frogs."

~Ancient German proverb

GILLIAN'S WELCOME ADDRESS

As I begin my SWS presidency, I would like to thank outgoing President Kim Ponzio, and outgoing Past-President Jim Perry for their excellent leadership, mentorship and friendship, and to welcome Arnold van der Valk to the Executive Board as our newly elected President-elect. Arnold's qualifications are impressive, and I am confident that he will make a substantial contribution to SWS leadership over the next few years. Our 2016-2017 Executive Board will, I am sure, provide a continuation of the strong and collaborative leadership that has characterized the EB in recent years, and will enjoy top-tier support from our highly capable SWS staff, led by the incomparable Michelle Czosek. Our SWS staff at AMPED facilitates and accelerates the work that we do as volunteers, with the overall effect of expanding our organizational capabilities. Our success in launching new initiatives and strong Annual Meetings rests in part upon having a reliable and highly competent organizational staff.

As your new President, I hope to build on the success of the past few years, where SWS has seen continued growth in membership, dynamic Annual Meetings, and expansion of important programs, as outlined above. Over the past year, I have watched our organization improve in the ability to provide valuable benefits to members, such as the development of the webinar program, to expand capacity to support and develop the next generation of wetland scientists, to support chapters, and to internationalize. We also have responded to several requests for input, and/or support for, emerging national and international wetland issues, and look forward to honing our capacity in this area.

As we head further into the 21st century, the predictions for climate change seem to mount. We are now hearing, based on improved modeling, that we are likely to experience as much as 6 feet of sea level rise by the end of the century, due to accelerated melting of Greenland and Antarctica ice sheets. Because wetlands are transitional ecosystems, not quite fully terrestrial, not quite fully aquatic, they are particularly sensitive to changes in hydrology and temperature. In addition, they play an outsized role in the global carbon cycle and in providing climate resiliency ecosystem services. Most of the world still does not fully understand how significant wetlands are. As an international wetland organization, and as individual wetland scientists, we are in a position to bring wetlands to the attention of those who look at climate change through the lens of human society, or terrestrial ecosystems, or fully aquatic ecosystems, and to promote the use of sound wetland science as policies and practices are formed. I look forward to meeting this challenge with the entire SWS community. ■

Studenchishte Marsh as an Integral Part of Ancient Lake Ohrid: Current Status and Need for Protection

Nadezda Apostolova^{1,2}, Daniel Scarry¹, and Jos T.A. Verhoeven³

INTRODUCTION

This article describes the past and current state of Studenchishte Marsh, the last remaining 50-ha wetland bordering Lake Ohrid, Macedonia, in the context of plans for developing tourism infrastructure along the lake's shores. These plans have raised concerns among regional stakeholders and organizations promoting wetland protection. Lake Ohrid is one of the largest and deepest, and certainly the oldest lake in Europe (Wagner et al. 2014). It has a large number of endemic species (Albrecht and Wilke 2008) and is still predominantly pristine (Veljanoska-Sarafiloska et al. 2011). Studenchishte Marsh purifies inflowing surface and ground water to Lake Ohrid and provides habitat for important biodiversity elements in the area.

Agricultural activities already influence the wetland, but the current plans for urban development would result in greater deterioration because they include complete drainage of the area. Our goal is to describe this unique wetland by giving information on the past and current state of the ecosystem and to make a plea for its conservation and protection. Before focusing attention on the Studenchishte Marsh, the article begins with a general review of the services wetlands provide, wetland degradation and impacts, and an overview of the Lake Ohrid ecosystem.

WETLANDS AND ECOSYSTEM SERVICES

As defined by RAMSAR, wetlands are coastal or inland surfaces inundated or saturated with fresh water or salt water (www.ramsar.org). They include many types of natural wet habitats and human-made wetlands (e.g., rice paddies and impoundments). Marshes are one type that is frequently or continually inundated, having mostly mineral soil and characterized by emergent soft-stemmed vegetation adapted to saturated soil conditions. Marshes can be categorized as non-tidal and tidal, with the former being widely distributed in Europe where they are associated with streams, lakes, ponds and rivers. In contrast to marshes, fens have organic soils (peat at least 40 cm thick), receiving water from both surface and groundwater sources that greatly influences their soil-water chemistry.

Wetlands represent some of the world's richest and most productive ecosystems. They are particularly important for carbon sequestration. While covering less than 10% of Earth's surface, they contain about 35% of global terrestrial carbon (Ramsar Convention Secretariat 2013). Wetlands facilitate the horizontal and vertical transport of carbon and nutrients between ecosystems, especially through their hydrologic connections to streams and overland flow; these connections are essential for the functioning and integrity of complex floodplain-river-lake systems. Wetlands provide numerous other services such as provisioning and purification of water and floodwater detention. Their services are also important for socioeconomic reasons, offering fishery and forestry resources as well as recreational and tourism opportunities. Located between the upland and large coastal areas, wetlands are a key landscape component. Wetland loss and degradation undermine the services and benefits that they provide, negatively impacting human welfare and contributing to species extinction.

The majority of biogeochemical reactions in wetlands occur in the underlying, highly organic and mineral-rich (sand, silt and clay) soil (Mitsch and Gosselink 2015). Links between substrate characteristics and ecological functioning are receiving increased attention because the associated processes are important providers of goods and services that benefit human health and well-being. Due to high nutrient levels, freshwater marshes are among the most productive ecosystems on Earth, frequently sustaining a diversity of life disproportionate to size. Beyond their considerable habitat value, non-tidal marshes: 1) mitigate flood damage by storing water after heavy rain or snowmelt; 2) alleviate drought as they recharge groundwater supplies and moderate streamflow; and 3) filter excess nutrients from surface runoff which is fundamental to the maintenance of the water quality in the watershed. Consequently, wetland degradation often detrimentally affects nearby surface water bodies in terms of hydrology, climate and ecology (Mitsch and Gosselink 2015; Verhoeven 2014).

WETLAND DEGRADATION AND ITS WIDER CONSEQUENCES

Over 60% of European wetlands were lost before the 1990s. Although drainage of wetlands has been common for centuries, its extent spiked in the past century leading to a

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substantial decline in number, size and quality of wetland habitats across the European landscape. According to a recent European Environment Agency (EEA) report, 73% of assessments for European Union (EU) wetlands demonstrate unfavorable conditions (European Environment Agency 2012). Over the past century, Europe's landscapes have undergone substantial changes: "Core natural" landscape patterns have transitioned to mosaics of "mixed" (semi-natural) and/or "some natural" patches. Recently, this trend has increased in the Republic of Macedonia (hereafter Macedonia) (European Environment Agency 2015), which has undergone increased industrialization, infrastructure development and urbanization. Such modifications have largely compromised the distribution and quality of wetlands.

LAKE OHRID – A NATURAL SANCTUARY

The Ohrid-Prespa region in the southwest of the Balkan Peninsula is one of the world's most ancient inland watershed systems, formed during the late Miocene (Albrecht and Wilke 2008). Lake Ohrid (Table 1) is recognized as Europe's oldest inland water, with age estimates ranging from 2 to 5 million years (Albrecht and Wilke 2008), while

Lake Macro Prespa (or simply Prespa) may be just as old (Wagner and Wilke 2011). Lakes Ohrid and Prespa are only 10 km apart, separated by the 2,255 m high Galichica Mountain, whose karstic subterranean channels connect the two (Vogel et al. 2010). According to the World Wildlife Fund Conservation Science Program's Freshwater Ecoregions of the World, the Ohrid-Prespa area belongs to the Ecoregion "Southeast Adriatic Drainages" (Hales 2015) which is characterized by very high endemism. For freshwater fishes, it is one of the world's richest areas with more than 8 species per 10⁴ km² (Abel et al. 2008) and a rate of endemism greater than 50%. Lake Ohrid, a United Nations World Heritage Site since 1980, is a "museum of living fossils", providing sanctuary for Tertiary Period creatures that died out elsewhere during the ice ages (Stankovic 1960). It contains at least 200 endemic species that have evolved in isolation over millions of years, including at least 7 of its 17 native fish species, such as "belvica" (*Salmo ohridanus*), Ohrid roach (*Rutilus ohridanus*), summer trout (*Salmo ap-helios*), Pestani or Ohrid trout (*S. letnica*), Struga trout (*S. balcanicus*), and lumi trout (*S. lumi*) (Kottelat and Freyhof 2007). Lake Ohrid is also noted for its exceptional inverte-

TABLE 1. Main geographic and hydrologic characteristics of Lake Ohrid.

| | | | |
|----------------|--|----------------------------------|--|
| Location | 41°05' N; 20°45' E | Shore line | 87.53km (56.02 belong to Macedonia) |
| Type | Tectonic | Surface area | 358.18km ² (2/3 belong to Macedonia) |
| Elevation | 693.17m above sea level | Dimensions | Maximal width: 14.8km Maximal length: 30.37km |
| Age | 3-5 million years (recognized as ancient lake) | Littoral zone width | 1-2km in the southern and northern part and much more narrow on the western and eastern shore (less than 10m at some points) |
| Depth | Max: 288.7m Average: 163.7m | Volume | 58.64 km ³ |
| Trophic state | Oligotrophic | Average phosphorus concentration | 4.5 µg/L |
| Climate | Average air temperature registered in the period 1951-2009: 11.3°C. Insolation: Total number of daylight hours: 4,399 h/year, (2,257 h/year with sunshine - 56% of the maximal daylight duration). Cloud cover per annum: 4.9 tenths of the sky-dome Average air humidity: 70% Average wind speed per annum: B=1.8m/sec; Average wind frequency per annum expressed by promille is 297‰, and blows in a northerly direction with an average calmness C=138‰. | | |
| Catchment area | 1,487 km ² after it was artificially enlarged in 1962 by 460 km ² when the River Sateska, previously a tributary of River Crni Drim, was diverted into the lake near the town of Struga. The effective size is substantially larger because several springs along the shores are supplied from Lake Prespa providing approximately 46% of the inflow of water to Lake Ohrid. | | |
| Water level | Regulated since 1963 (intergovernmental agreement between the Republic of Albania and the former Yugoslavia). Acceptable oscillations: minimal and maximal elevation of 693.10m and 693.75m asl respectively (water layer difference of 65cm). | | |

brate endemism (89% of gastropod species, two-thirds of crustaceans and 71% of flat worms are endemic) (Albrecht and Wilke 2008) and is internationally recognized as an Important Bird and Biodiversity Area for its ornithological significance (over 40,000 water-bird individuals during winter; Birdlife International 2016).

Lake Ohrid is oligotrophic according to Carlson’s Trophic State Index (Carlson 1977) for lakes which is based on Secchi Disc transparency, chlorophyll and total phosphorus (Veljanoska-Sarafiloska et al. 2011). Nevertheless, parts of the littoral zone are under substantial anthropogenic pressure: areas where the rivers Sateska, Koselska, Velogoska and Cherava discharge into the lake display water pollution and changes in trophic status (Kostoski et al. 2010). Disturbed trophic conditions are evidenced by an absence of charophytes, low biomass or absence of other aquatic plant species in tributary inflows, and by changes in the density and composition of benthic fauna, with an altered ratio between cosmopolitan and endemic species (Trajanovski et al. 2015). Concerns exist that Lake Ohrid could become eutrophic, leading to summer stagnation and dangerously low oxygen levels. The main source of pollu-

tion is untreated sewage produced by the resident lakeside population which is now estimated at about 200,000 people (Avramoski et al. 2006). Its growth has been accompanied by the massive development of tourism infrastructure. The population around the lake multiplies several-fold during summer, far beyond the capacity of regional infrastructure, drinking water supplies, and waste disposal (Kostoski et al. 2010). Several projects once inspired hopes for the protection of Lake Ohrid water quality such as the primary collector and wastewater treatment plant on the Macedonian side of the lake (1988) and the bilateral Lake Ohrid Conservation Project with Albania (1998). Unfortunately, neither has proved a satisfactory solution and a great volume of untreated water from the catchment reaches the lake (Kostoski et al. 2010). Water pollution is probably the main threat to the lake’s ecological stability given the lake’s long water-retention time (60 years). The second major source of eutrophication is inflow of nutrients from erosion and agricultural run-off including fertilizers and herbicides. About 150 tons of dissolved phosphorus are estimated to enter the lake each year, and, with this, the total phosphorus load may be 3 to 5 times greater than it should be to keep the lake in an oligotrophic state (Avramoski et al. 2006).

FIGURE 1.

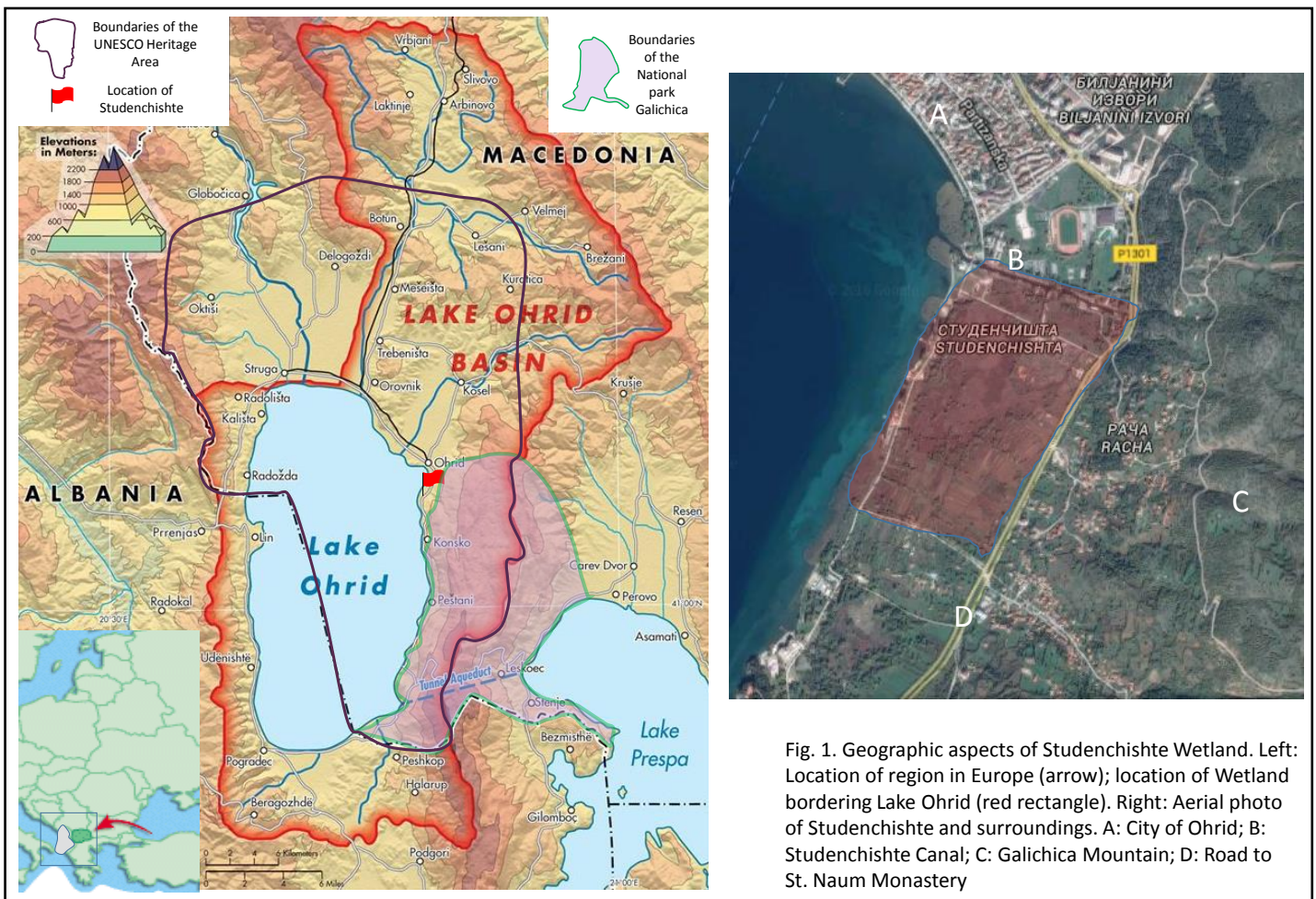


Fig. 1. Geographic aspects of Studenchishte Wetland. Left: Location of region in Europe (arrow); location of Wetland bordering Lake Ohrid (red rectangle). Right: Aerial photo of Studenchishte and surroundings. A: City of Ohrid; B: Studenchishte Canal; C: Galichica Mountain; D: Road to St. Naum Monastery

STUDENCHISHTE MARSH LOCATION

In the past, there were several wetlands around Lake Ohrid, most of which have been drained and converted to agricultural and urban land. Presently, only one wetland remains: Studenchishte Marsh (hereafter Studenchishte) (Figure 1). It is located 694–696 m above sea level to the lake’s north-east (41°06’08” north and 20°48’49” east), on lowland, narrow terrain bordered on the north by Studenchishka River (now Studenchishte Canal), on the south by the Racha River, on the west by the shore of Lake Ohrid, and on the east by a regional road. This road represents a geomorphological boundary, with the terrain rising steeply at the foothills of Galichica Mountain. A survey using Google Earth in 2010 revealed that wetlands in this area occupied 50 ha with marshy and peaty habitats extending over 25 ha (Spirovska et al. 2012). The total inundated area fluctuates depending on precipitation patterns and on lake levels. The altitudinal gradient feeding the wetland with water spans 965 m, between Gjafa Mountain, and where Biljanini Springs flow into the lake (Figure 1). This gradient extends over a 4.6 km distance and has a 21% slope. However, during heavy rainfall only mild landslides occur in small rivulets and watercourses (Spirovska et al. 2012).

GEOPHYSICAL AND HYDROLOGICAL CHARACTERISTICS

Geological Composition. The Ohrid-Prespa region belongs to the West-Macedonian zone and is part of the Dinaric system characterized by Paleozoic, Triassic, Cretaceous, Neogene and Quaternary geological formations (Hoffmann et al. 2010). The Paleozoic rocks are the oldest and form the base, whereas the largest portion is made of Triassic rocks with substantial facial diversity. Studenchishte contains materials belonging to the Neogene basin, mainly divided into three sediment series (basal, productive and

upper layer) as well as Quaternary sediment formations. Alluvial sediments are the most common (Spirovska et al. 2012). The sediments consist of sands and marly-clay materials, which lay unevenly and are often unconsolidated. Quaternary lake-marshy sediments are represented by mud and very fine materials. Geological formations of the Quaternary-Diluvial are terraced lake and river sediments, moraine materials, fluvial-glacial materials and karst detritus. The alluvial sediments along the lake which are part of the loose Quaternary sediments display high water porosity. Here, 30 m-deep wells provide medium and high water potential. Under this layer, loosely-tied rock masses of capillary porosity have been found (clay, marly-clay and marl), which constitute hydro-geologic insulators (Spirovska et al. 2012).

Hydrology. The subterranean aquifer at Studenchishte is dense with a level of free groundwater running northeast to southwest (Spirovska et al. 2012). The terrain abounds with water: the hydraulic head of the groundwater is high (above 10 m) and discharge is constant. The amount of discharging water depends on the grain sizes of the Quaternary sediments and the resultant porosity as well as on the amount of precipitation. Unconsolidated sediments make the terrain at Studenchishte highly porous; hence, the filtration index is quite high. The upper 20 m of sediments are loose materials, enabling rapid water infiltration. The semi-bound rocky masses below can act as hydro-geological conductors. The surrounding terrain contains Triassic limestone with a low filtration index yet this occurs only at depths greater than 30 m at Studenchishte (Spirovska et al. 2012).

The hydrographic network of the catchment that discharges into Studenchishte consists of a single surface stream called Dlabok Dol (Spirovska et al., 2012). However, the wetland borders Biljanini Springs, an important

source of water that discharges into Lake Ohrid and Studenchishte. Groundwater discharging into Studenchishte mainly originates from atmospheric precipitation filtered through the highly porous, karstic Galichica massif. Water levels of Lake Ohrid also influence hydrologic conditions in the wetland. During high-water extremes such as in 1963 and 2010, the wetland fully merges with the lake. Importantly, the contact between the groundwater inputs to Studenchishte, its influence

TABLE 2. Plant associations present in Studenchishte Marsh.

| | |
|------------|---|
| Marsh | Class PHRAGMITETEA Tx. et Preis. 1942 Order Phragmitetalia eurosibirica W. Koch 1926 Union Phragmition 1. Association Scirpeto-Phragmitetum W. Koch 1926 2. Association Oenantheto-Roripetum Lohm. 1950 Union Sparganio-Glycerion Br.-Bl. et Siss. 1942 3. Association <i>Sparganio-Glycerietum fluitantis</i> Br.-Bl. 1925 Union <i>Magnocaricion</i> W. Koch 1926 4. Association <i>Caricetum elatae</i> W. Koch 1926 Sub-association lysimachietosum Mic. 1959 5. Association <i>Cyperetum longi</i> Mic. 1957 |
| Wet meadow | Class MOLINIO-ARRHENATHERETEA Br.-Bl. et Tx. 1943 Order <i>Trifolio-Hordeetalia</i> H-ić 1963 Union <i>Trifolion resupinati</i> Mic. 1957 1. Association <i>Trifolietum nigrescentis-subterranei</i> Mic. 1957 |

on the lake and the movement of groundwater between the lake and the wetland have not been adequately studied (Spirovska et al. 2012).

Soils. Studenchishte soils are mainly organic (histosols) and, less extensively, swampy-gley soils (Filipovski 1999). In Macedonia, histosols are not common, covering just 700 ha or 0.03% of the entire territory. This figure includes the former Struga Marsh (500 ha) adjacent to Lake Ohrid, which was drained for agriculture in the 1940s. Currently, the total area of histosols around Lake Ohrid is 90 ha, mainly in the proximity of the city of Ohrid (Filipovski 1999). Studenchishte's histosols are of the lowland type, which is formed near lakes, in depressions or in groundwater discharge areas. Lowland peats in Macedonia usually belong to the category of lowland peat soils, i.e., histosols whose organic-horizon is relatively thin. With a maximum peat depth of 300 cm and averaging 220 cm, Studenchishte's histosols are an exception (Filipovski 1999). This wetland is regarded as having the largest and most representative remnant of the lowland peat histosol type in Macedonia, worthy of protection in its own right. The major part of Stu-

denchishte can therefore be classified as fen wetland, which is exceptionally rare in the region.

Climate. The climate in the Ohrid region including Studenchishte, is moderate–continental (Table 1), modified by air currents from the Adriatic Sea via the river Crni Drim, which, combined with the lake influence, induces a specific thermal and pluvio-metric regime that is characterized by small air-temperature changes throughout the year and autumn/winter concentrations of heavier rain.

BIODIVERSITY

In this section, some major components of the biodiversity of Studenchishte are described with an emphasis on flora and fauna groups for which there is available information (Figure 2). The major plant associations in the wetland are discussed and information on the diatom flora is also provided. A number of invertebrate fauna groups are briefly discussed, such as *Odonata* (dragonflies), *Lepidoptera* (butterflies) and *Coleoptera* (beetles), along with vertebrate groups including fishes, amphibians and other animals characteristic for the wetland.

FIGURE 2. Characteristic flora and fauna of Studenchishte Marsh. (A) *Caricetum elatae*, (B) *Utricularia* sp., (C) *Plegadis falcinellus*, and (D) *Rorippa amphibia*



Plantlife. *Vascular plants.* Although relatively small in size, Studenchishte contains 6 plant associations (Table 2). Several habitat types are present including natural alkaline marshes and fens, one semi-natural wet meadow, and several

anthropogenic habitats: orchards, fields, gardens, houses and infrastructure facilities. Alkaline marshes and fens are humid habitats that receive water and nutrients from sources other than precipitation. For Studenchishte, these sources

TABLE 3. Plant species in Studenchishte Marsh (SM), most of which are common in European wetlands but are considered rare for the Republic of Macedonia.

| | |
|-----------------------------------|---|
| <i>Carex elata</i> All. | Disappeared from SM |
| <i>Ceratophyllum submersum</i> L. | In danger of extinction from SM |
| <i>Nymphaea alba</i> L. | Probably disappeared from SM |
| <i>Nuphar lutea</i> L. (Sm.) | Reintroduced and revitalized in Mazija by the Macedonian Limnological Society |
| <i>Myosurus minimus</i> L. | Disappeared from SM |
| <i>Polygonum amphibium</i> L. | In danger of extinction from SM |
| <i>Leucojum aestivum</i> L. | Probably disappeared from SM |
| <i>Senecio paludosus</i> L. | Disappeared from SM |
| <i>Ranunculus lingua</i> L. | Disappeared from SM |
| <i>Cyperus longus</i> L. | In danger of extinction from SM |

TABLE 4. List of Odonata species in Studenchishte that are on the International Union for Conservation of Nature's Global Red List. LC (least concern), NT (near threatened).

| Species | IUCN Global Red List | EU Habitats Directive |
|--|----------------------|-----------------------|
| <i>Aeshna isocetes</i> (Müller) | LC | |
| <i>Calopteryx splendens</i> (Harris) | LC | |
| <i>Coenagrion mercuriale</i> (Charpentier) | NT | Annex II |
| <i>Coenagrion puella</i> L. | LC | |
| <i>Cordulegaster bidentata</i> (Selys) | NT | |
| <i>Cordulia aenea</i> L. | LC | |
| <i>Enallagma cyathigerum</i> (Charpentier) | LC | |
| <i>Erythromma lindenii</i> (Selys) | LC | |
| <i>Lestes barbarus</i> (Fabricius) | LC | |
| <i>Orthetrum albistylum</i> (Selys) | LC | |
| <i>Orthetrum brunneum</i> (Fonscolombe) | LC | |
| <i>Orthetrum coerulescens</i> (Fabricius) | LC | |
| <i>Platycnemis pennipes</i> (Pallas) | LC | |
| <i>Sympecma fusca</i> (Vander Linden) | LC | |
| <i>Sympetrum sanguineum</i> (Müller) | LC | |

are the springs at the foothill of Galichica and groundwater movement. Alkaline fens differ from bogs in that they have less acidic conditions and higher nutrient levels, and can therefore support far greater plant and animal diversity. Studenchishte has 4 plant associations that develop in alkaline conditions. Marsh habitats are characterized by mineral-rich substrates and a constantly submerged portion that does not accumulate organic matter. This habitat in Studenchishte is represented by the association *Sparganio-Glycerietum fluitantis* that develops in the canals and is linked to the reed association (*Scirpeto-Phragmitetum*) in the lake's littoral zone. The alkaline fen habitats are characterized by the association *Caricetum elatae*, although only a small area of this community remains. In the part of the lake adjacent to the wetland - Mazija and Ajvan Beach, 11 vascular hydrophytes and 6 fringe associations can be found (Talevska 2005). Wet meadows are the only type of semi-natural habitat in Studenchishte. Macedonian wet meadows are not registered as priority habitats in Annex I of the European Union (EU) Directive 92/43/EEC. However, similar habitats phytocoenologically belonging to the alliances *Molinion W. Koch* and *Molinio-Holoschoenion Br.-Bl.* (semi-natural wet meadows with high herbaceous plants—code 6410 and 6420 of Annex I of the EU Directive 92/43/EEC—and the alliance *Arrhenatherion Koch*—circum-Mediterranean mesophilic meadows, code 6510) are considered endangered in Europe (<http://ec.europa.eu>). Farmlands, mainly used for corn cultivation, are the anthropogenic habitats that occupy the largest proportion of the land in Studenchishte. Unlike farmlands, the orchards (apple, pear, plum and walnut) do possess certain significance in terms of biological diversity as several bird species use them for nesting (*Lanius minor*, *Pica pica*, and *Corvix cornix*).

Diatoms. Eighty-nine species of *Diatomeae* are reported for the wetland, of which

TABLE 5. Species of beetles (Coleoptera, Carabidae) found in Studenchishte considered rare for the Republic of Macedonia.

| Coleoptera (beetles) species |
|---|
| <i>Agonum lugens</i> and <i>A. piceum</i> |
| <i>Amara convexiuscula</i> |
| <i>Stenolophus skrimshiranus</i> and <i>S. proximus</i> |
| <i>Brachinus elegans</i> |
| <i>Pterostichus elongates</i> |
| <i>Oodes helopioides</i> and <i>O. gracilis</i> |

4 are rare (present in 2-5 localities in Macedonia) and 11 endemic to Lake Ohrid as described in the assessment of the condition of the wetland elaborated in 2012 by a Macedonian interdisciplinary team of experts (Spirovska et al. 2012). Interestingly, Studenchishte's *Diatomeae* include both those characteristic for oligotrophic conditions (springs) such as *Amphora*, and others found typically in wetlands - *Gomphonema*, *Stauroneis*, *Navicula*, and *Nitzschia*.

Fauna. Invertebrates. Studenchishte has a specific invertebrate fauna, differing fundamentally from that of Lake Ohrid. Hence, despite its comparatively limited area, the wetland needs to be regarded as a vital contributor to the biodiversity of the Lake Ohrid region. The wetland and other coastal waters contain 16% of the Gastropoda, 20% of the Tricladida (Smiljkov and Shapkarev 1998), 35% of the Oligochaeta (Shapkarev 1966) and 22.5% of the Chironomidae (Smiljkov and Shapkarev 1998) that are found in Lake Ohrid. Dragonflies and damselflies (*Odonata*) display both widespread European species (81%) and Southern European species (19%) (Zawal et al. 2010) and the latest report specifies 34 species in Studenchishte (Table 4). Recent-

ly, 39 species of beetles (*Coleoptera*) have been recorded in Studenchishte, some of which are rare for Macedonia and found only in this location (Spirovska et al. 2012; Table 5). Studies on daylight butterflies (*Lepidoptera*) include 138 species for the Ohrid region (Scheider and Jakšić 1989), but there are no data specific to the Studenchishte Marsh. In the Biljanini Springs region of the wetland, 5 chironomids (*Diptera, Chironomidae*) have been identified: *Ablabesmya monilis*, *Thienemannimyia lentiginosa*, *Pothastia gaedi*, *Eukiffériella quadridentata*, and *Cricotopus inaequalis* (Smiljkov and Shapkarev 1998) as well as 9 species of planarians (*Plathelminthes, Turbellaria, Tricladida*), most of which are endemic to the springs in the coastal area of Lake Ohrid or to the lake itself (Kenk 1978; Krstanovski 1994). Lastly, Ikonov provides data on 10 species of mayflies (*Baëtidae, Ephemeroptera*): *Baëtis pumilus*, *B. rhodani*, *B. carpatica*, *B. vernus*, *B. tenax*, *B. bioculatus*, *B. tricolor*, *Cloëon dipterum*, *C. praetextum*, and *Procloëon bifidum* (described as *P. lychnidense*), as well as *Heptagenia macedonica* (*Ecdyonidae*) (Ikonov 1962; Ikomonov 1963).

Vertebrates. Due to proximity and direct connection to the lake, the aquatic vertebrate fauna of the wetland has historically been considered to be part of the lake. Therefore, little data relates specifically to Studenchishte. Owing to its low water level, presently, the wetland does not contain dense fish populations. However, 17 fish species can be found in Studenchishte Canal (14 native and 3 alien) (Spirovska et al. 2012). In the past, before most of the marsh and fen were drained, Lake Ohrid and Studenchishte were directly connected and many lake species would enter Studenchishka River and its spring branches (Stankovic

TABLE 6. Categorization of the current threats to the existence of Studenchishte Marsh.

| | |
|----------|--|
| A | Poor level of protection, without clear regulatory support. Lack of system for sustainable management. |
| B | Drainage of the marsh and conversion of parts to cultivated land and urban areas. This includes the construction of road infrastructure. |
| C | Non-functional communication between the marsh and Lake Ohrid. Prior to the marsh's significant size reduction, a large number of Lake Ohrid's fish species spawned in the marsh. The construction of the road along the coastline (landfilling and paving) severed the direct communication between the marsh and Ohrid Lake. |
| D | Dumping of waste. Over the past 20 years, huge amounts of construction waste have been dumped in the marsh, covering nearly 6 ha of wet meadows and other marsh habitat, at the expense of the relict association <i>Caricetum elate</i> . |
| E | Inappropriate maintenance of the grass areas in wet meadows Mechanized methods for maintaining the grass areas represent a possible threat. |
| F | Utilization of the beaches. In the past 15 years, beaches have been "urbanized"; the reed areas have been decreasing and the willow belt near the coast has been completely destroyed. |
| G | Pollution. Wash off and degradation of dumped solid waste from various origins (generally mixed waste and inert construction waste) and the utilization of chemical pesticides and mineral fertilizers for agricultural activities that are conducted in the marsh and its surroundings have polluted the marsh. The plant nursery, which is operational in the area of the marsh, is a serious and significant threat due to the high use of fertilizers and other pesticides. |

1960). A large number of Ohrid's fish fauna used to spawn in the wetland, primarily in the group *Cyprinidae* (*Cyprinus carpio*, *Scardinius erythrophthalmus*, *Phoxinus phoxinus*, *Pachychilon pictum*, *Rutilus ohridanus*, and *Alburnus alburnus arborella*). Today, fish spawning no longer occurs and instead, permanent populations of Eurasian minnow (*Phoxinus phoxinus* L.) and stone loach (*Nemachilus barbatulus sturanyi* St.) are present in the Studenchishka Canal.

At least 9 amphibian species have sustainable populations in the wetland, all of which are classified as strictly protected or protected fauna species (according to Annexes II and III of the Bern Convention (BC; <https://www.cbd.int/>). The most important ones at the European level are the Macedonian crested newt (*Triturus macedonicus*) and the yellow-bellied toad (*Bombina variegata*). Regarding reptiles, at least 4 snake species have been found in Studenchishte: *Emys orbiculari*, *Elaphe quatuorlineata*, *Natrix natrix*, and *Natrix tessellata* (Spirovska et al. 2012), which are also listed in Annexes II and III of the BC.

Studenchishte was previously considered one of the primary nesting sites for waterbirds along Lake Ohrid's shores, but its significance has decreased. Presently only a few species rear young: some warblers (*Acrocephalidae*), waterfowl (*Anatidae*), and the little bittern (*Ixobrychus minutus*). It remains, however, one of Macedonia's few nesting locations for the mute swan (*Cygnus olor*). Around 50 other bird species, including 15 rated as 'rare or endangered' in Annex I of the Birds Directive (http://ec.europa.eu/environment/nature/legislation/birdsdirective/index_en.htm), can be found migrating and foraging in Studenchishte (herons, ibises, godwits, harriers and ducks). The little bittern is the only Annex I species observed nesting (Spirovska et al. 2012).

Mammal reliance on Studenchishte cannot be assessed due to insufficient study. Particularly striking is the lack of data on bat fauna, one of the more important and endangered groups. Species present include otter (*Lutra lutra*), fox (*Vulpes vulpes*), European polecat (*Mustela putorius*), white-breasted marten (*Martes foina*), and several rodent species (Spirovska et al. 2012).

STUDENCHISHTE - PAST AND PRESENT

Connected by multiple channels, Studenchishte was once an integral part of Lake Ohrid (Cvijic 1911). At that time, it occurred within a much larger wetland that has now been lost, and was considered a biodiversity hotspot and regarded as vital for the maintenance of the water level of the lake. Over the past 30 years, however, the wetland has become the last remaining part of the buffer zone between the lake and upland areas. This remnant wetland continues to be subject to direct and indirect intervention that have resulted in extensive ecological degradation. Today only remnants of the original channels and various springs remain to provide hydrologic inputs to the wetland. Large portions of the wetland have been drained and converted

to farmland (fields, meadows and orchards) or impervious surfaces (buildings, a helipad, and local roads). Meanwhile, the coastal area adjacent to the city of Ohrid has undergone massive construction in line with the rapid development of tourism facilities. Along the border between the wetland and the lake, recreation facilities, beach platforms, bars, and even car parks have been built.

Over the past decades, there have been several attempts to provide specific legislation for the protection of Studenchishte. The 1979 Basic Urban Plan for the city of Ohrid granted the wetland protected status as a special-purpose area. Studenchishte was part of the city territory covered by the Master Urban Plan of 1987, and various categories of protection were proposed. The 2006 General Urban Plan (GUP) suggested categorization for the wetland as a landscape with outstanding natural features and established it as a protected area (51.55 ha) to be used for basic education and specific kinds of recreation. Since 2004, the Spatial Plan for Macedonia has proposed the category of Special Nature Reserve, yet the protection level in accordance with Macedonia's Law on Nature Protection has not been defined. Moreover, recent plans for "protection" within the GUP (2002-2012) and the modification of the GUP for 2014-2024 are so contradictory that they allow part of the coastal strip along Studenchishte Canal and its estuary to be converted to a water sports centre with accompanying facilities (hotels, shops, and restaurants) and the rest of the nearby coast used as an urban beach. The latest GUP also includes measures to improve the supply of drinking water which would inevitably affect the integrity and viability of the wetland. Overall, although a series of documents are aimed at protection for Studenchishte, subsequent plans and actions are contradictory, and it is clear that the wetland has not been, and will not be, protected adequately. The long-term lack of proper care (Table 6) endangers the wetland ecosystem, compromising some of the most important values of Lake Ohrid (Spirovska et al., 2012) such as elevated rates of biodiversity in niche habitats, the maintenance of specific lacustrine conditions to which unique species have evolved, and the harbouring of relict and locally endemic species.

Several construction activities have been particularly detrimental: 1) a plant nursery "Rasadnik" (in the '90s) destroyed large portions of the relict association *Caricetum elatae*—the only site for this community in Macedonia, 2) the sports center "Biljanini Springs" (inaugurated in 1998) caused the disappearance of a large share of *Senecio paludosus* and *Ranunculus lingua*, and 3) construction of army and police facilities eliminated the rare plant *Myosurus minimus*. Anthropogenic pressure has likely led to the disappearance or danger of extinction of floating plants such as white water lily (*Nymphaea alba*), yellow pond lily (*Nuphar lutea*), and longroot smartweed (*Polygonum amphibium*), as well as the area's white willow, the reed-belt, and the association of *Cyperetum longi* (Spirovska et al. 2012).

TABLE 7. Intrinsic ecological and economic significance of Studenchishte Marsh.

| Features of Ecological and Conservation Importance | |
|---|--|
| 1. Geological significance | The histosols of Studenchishte Marsh are the deepest and most representative of lowland histosols in the Republic of Macedonia, amounting to 3 m depth. |
| 2. Ecosystem services | (1) Storage of carbon in its 5,000-year peatlands, (2) water quality improvement, and (3) habitat provision. Historically, services also included habitats for spawning of major fish species. |
| 3. Habitats | The area has 3 characteristic wetland habitats: alkaline marshes, alkaline swamps, and wet meadows. |
| 4. Plant associations and plant associations with limited dissemination | 5 marsh plant associations. This is a real treasure because Studenchishte Marsh includes 50% of the total diversity of marsh associations recorded in the Republic of Macedonia. In the Republic, the plant association <i>Caritum elatae</i> is found only in Studenchishte and thus its protection is of particular importance. It could serve as a source for <i>Carex elata</i> individuals to repopulate other nearby sites, e.g., Struga Marsh. |
| 5. Biodiversity | The marsh ecosystem is a habitat for rare and endemic species. 34 spp. of <i>Odonata</i> (some are extremely rare), 39 spp. of beetles, 23 spp. of water insects, and 9 spp. of amphibians (all included in the Bern Convention). |
| - General | |
| - Rare plant and animal species | 5 rare plant spp. (<i>Carex elata</i> , <i>Ceratophyllum submerse</i> , <i>Nymphaea alba</i> , <i>Nuphar lutea</i> and <i>Myosurus minimus</i>). Only 1 species —the yellow lotus—has been reintroduced near the marsh. 9 spp. of beetles in Macedonia are known to exist only in Studenchishte, and this site is also home to several hygrophilic species. |
| - Endemic species | 11 diatom species are endemic or rare in the Republic of Macedonia. The highest rate of endemism is found among planarians (most of the 9 known species are endemic for the springs by the lake). |
| - Endangered species | The Odonata of the marsh contain several rare species. 15 spp. of <i>Odonata</i> are included on the Global Red List of the IUCN (13 of which are least concerned and 2 near threatened). 1 species (<i>Coenagrion mercurial</i>) is listed in Annex II in the European Union Habitats Directive; it is also listed in the Bern Convention. |
| - Species and habitats with a conservational significance for the European Union | 6 spp. of amphibians, 3 spp. of reptiles, 15 spp. of birds, 1 sp. of <i>Odonata</i> and 1 sp. of butterfly have this significance. Regarding habitats, the most important are those with the plant associations <i>Caricetum elatae</i> and <i>Cyperetum longi</i> (<i>Magnocaricion</i>) that are included in the Habitats Directive. |
| - Refugium | Relict presence identifies Studenchishte Marsh as a safe haven where species have been able to cling to existence through the environmental flux that erased their existence in other parts of their one-time range. This is no doubt correlated with the local climate, which moderates extremes of both hot and cold. A protected Studenchishte Marsh would continue to fulfil this role. This is particularly important in the Balkans where certain species exhibit high genetic diversity, both a driving factor for evolution and a reducer in terms of extinction exposure. |
| Features of social/economic importance | |
| 1. Uniqueness | The marsh ecosystem is strongly interconnected with the lake ecosystem. Studenchishte is the only remnant of the once extensive wetlands along the coastline of the lake. Despite its area being reduced, it still features various natural phenomena and ecological processes. |
| 2. Research | It represents a unique ecosystem that needs to be preserved for future generations. It is a valuable site for scientific research of natural conditions and processes. Investigations are needed into the taxonomy and habitat preferences of animal groups not previously studied in this region. |
| 3. Tourism and recreation | The proximity of the city of Ohrid, its connection to the sports-recreation centre, “Biljanini Springs,” and the lakeshore provide ideal conditions for the marsh to be used for educational purposes and for selective tourism - hiking, birdwatching, landscape photography, relaxation and “educational tourism.” |
| 4. Landscape | The harmonious landscape makes this site naturally beautiful; it constitutes an important landmark that bestows Ohrid Lake with particular beauty and authenticity. |

STUDENCHISHTE – WIDER IMPORTANCE AND RECOMMENDATIONS

Studenchishte Marsh matters from two perspectives: its own significance and its role in the resilience of the wider ecosystem of Lake Ohrid. These call for immediate and appropriate conservation and protection.

The significance of the wetland itself resides in its hydrological and geomorphological characteristics, soil composition, and the abundance and diversity of plants and animals (Table 7). Moreover, the wetland cleans raw sewage and other pollution flowing from the Ohrid region into the lake and functions as a carbon storage system. Since the entire of Studenchishte was recognized as contributing to the outstanding natural qualities that saw the Ohrid region enshrined on the World Heritage List in 1980, the wetland further requires protection in accordance with the Convention on the Protection of the World Cultural and Natural Heritage of UNESCO - the most important international convention relevant to spatial planning in the Ohrid region.

Studenchishte should also be considered in the context of ancient Lake Ohrid. Of the 117,000,000 lakes on Earth (Verpoorter et al. 2014), only a few have been concretely identified as ancient, of which Lake Ohrid is one (Albrecht et al. 2006). These inland waters have been in extended isolation, leading to unique evolutionary and speciation pathways. Indeed, Lake Ohrid may present an almost globally unique opportunity for interdisciplinary research due to its long existence, freshwater biodiversity, accessibility, and well-defined physicogeographical boundaries (Albrecht et al. 2006; Lorenschat and Schwalb 2014; Hauffe et al. 2011). By buffering against pollution and contributing to the maintenance of the specific water composition that enables Lake Ohrid's ecosystem to thrive, Studenchishte is providing a service of great value to humankind.

Another consideration is that Studenchiste is the last remaining site of a once large wetland complex along the borders of Lake Ohrid. Although its functioning is known in general terms, many of the detailed interactions remain largely unexplored, among them, the surface water and groundwater flows, soil biogeochemical functioning, and their significance for the biota in the wetland as well as Lake Ohrid as a whole. Future developments should lead to plans to restore the vast wetland areas around the lake to better protect its immensely important biodiversity and ecological integrity. It is of the utmost importance to have a functioning wetland system in place to serve as a blueprint for the systems to be restored.

CONCLUSIONS

Freshwater ecosystems occupy only 0.8% of Earth's surface, but harbor nearly 6% of all known species (Dudgeon et al. 2006). Currently, freshwater habitats are among the world's most endangered and their future is not promising. In the past, wetlands such as marshes were regarded not only useless wastelands but also as serious hazards

to human health due to mosquito breeding. Nowadays, a paradigm shift is overdue: wetlands must be reevaluated as ecological assets with benefits ranging from water-quality improvement and flood attenuation to aesthetics and recreational opportunities. In the past, these values alone have not been sufficient to protect them. Concerted efforts are urgently needed by local and state decision-makers to develop effective policies that protect biodiversity and work for agricultural producers, consumers, tourists and outdoor enthusiasts. Studenchishte Marsh is the only surviving wetland on Lake Ohrid's shore. Despite its recognized importance, authorities in Macedonia have so far avoided implementation of measures for its proper protection. As Studenchishte gradually disappears, policy initiatives aimed at protection are now more urgently needed than ever before. Proper protection of Studenchishte would require a moratorium on all lakeshore construction, and the establishment of an independent expert consultation unit, preferably of international composition, whose role is to review and assess regional development proposals including commercial and tourism infrastructures as has been proposed by two international researchers in an article for the Macedonian magazine "Fokus" (Albrecht and Wilke 2015). The overall objective should be strong and permanent regional and international cooperation, efficient and responsible management of Studenchiste Marsh, as well as a solid legal basis for the protection of its many values. ■

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REFERENCES

- Abell, R., M.L. Thieme, C. Revenga, M. Bryan, et al. 2008. Freshwater Ecoregions of the World: A New Map of Biogeographic Units for Freshwater Biodiversity Conservation. *BioScience* 58(5): 403-414.
- Albrecht, C., S. Trajanovski, K. Kuhn, B. Streit, and T. Wilke. 2006. Rapid evolution of an ancient lake species flock: Freshwater limpets (Gastropoda: Ancyliidae) in the Balkan Lake Ohrid. *Organisms Diversity & Evolution* 6(4): 294-307.
- Albrecht, C. and T. Wilke. 2015. Lake Ohrid: A paradise in peril. In: Fokus, Media Plus Fokus – Skopje. Available via <http://fokus.mk/lake-ohrid-a-paradise-in-peril/>
- Albrecht, C. and T. Wilke. 2008. Ancient Lake Ohrid: biodiversity and evolution. *Hydrobiology* 615: 103-240.
- Avramoski, O., S. Kycyku, T. Naumoski, D. Panovski, et al. 2005. Lake Ohrid Experience and Lessons Learned Brief for the Lake Basin Management Initiative. Available via <http://iwlearn.net/iw-projects/1665/experience-notes-and-lessons-learned/view>.
- Birdlife International 2016. Important Bird and Biodiversity Area factsheet: Lake Ohrid. In: Birdlife International, Sites – Important Bird and Biodiversity Areas (IBAs). Available via <http://www.birdlife.org/datazone/sitefactsheet.php?id=126>

- Carlson, R.E. 1977. A trophic state index for lakes. *Limnology and Oceanography* 22: 361-369.
- CBD/Ramsar/STRP, Water, wetlands, biodiversity and climate change, p. 42.
- Cvijic, J. 1911. Basics of the Geography and Geology of Macedonia and Old Serbia, Book 3, Royal Serbian Academy, Belgrade, pp. 689-1272.
- Dudgeon, D., A.H. Arthington, M.O. Gessner, Z. Kawabata, et al. 2006. Freshwater biodiversity: importance, threats, status and conservation challenges. *Biol Rev Camb Philos Soc* 81(2): 163-182.
- European Commission DG Environment. 2013. Interpretation Manual of European Habitats. Available via http://ec.europa.eu/environment/nature/legislation/habitatsdirective/docs/Int_Manual_EU28.pdf
- European Environment Agency (EEA). 2012. Conservation status of habitat types of European Union interest in wetland ecosystems. In: EEA website. Available via <http://www.eea.europa.eu/data-and-maps/figures/conservation-status-of-habitat-types-4/#parent-fieldname-title>
- European Environment Agency (EEA). 2015. Fragmentation of natural and semi-natural areas. In: EEA website. Available via <http://www.eea.europa.eu/data-and-maps/indicators/fragmentation-of-natural-and-semi-1/assessment-1>.
- Filipovski, G. 1999. Types of Soil in the Republic of Macedonia, vol. IV. Macedonian Academy of Science and Art.
- Hales, J. 2015. Southeast Adriatic Drainages. In: Freshwater Ecoregions of the World. Available via http://www.feow.org/ecoregions/details/southeast_adriatic_drainages
- Hauffe, T., C. Albrecht, K. Schreiber, K. Birkhofer, S. Trajanovski, and T. Wilke. 2011. Spatially explicit analysis of gastropod biodiversity in ancient Lake Ohrid. *Biogeosciences* 8: 175-188.
- Hoffmann, N., K. Reicherter, T. Fernandez-Steege, and C. Grutzner. 2010 Evolution of Ancient Lake Ohrid: a tectonic perspective. *Biogeosciences* 7: 3377-3386.
- Hristovski, S. 2007. New records of ground beetles (Coleoptera, Carabidae) for the fauna of the Republic of Macedonia. *Acta Entomologica Slovenica* 15(1): 87-92.
- Ikonomov, P. 1962. Baëtidae (Ephemeroptera) of Macedonia. *Annual Anthology of Biology* 13: 83-140.
- Ikonomov, P. 1963. Mayflies (Ephemeroptera) of Macedonia. Family: Heptagenia (Ecdyonuridae). *Annual Anthology of Biology* 14: 155-156.
- Lorenschat, J. and A. Schwalb. 2013. Autecology of the extant ostracod fauna of Lake Ohrid and adjacent waters - a key to paleoenvironmental reconstruction. *Belgian Journal of Zoology*, 143(1): 42-68.
- Kenk, R. 1987. The Planarians (Turbellaria: Tricladida Paludicola) of Lake Ohrid in Macedonia. Smithsonian Contributions to Zoology, Nr. 280, Smithsonian Institution Press, City of Washington, 56 pp.
- Kostoski G., C. Albrecht, S. Trajanovski, and T. Wilke. 2010. A freshwater biodiversity hotspot under pressure - Assessing threats and identifying conservation needs for ancient Lake Ohrid. *Biogeosciences* 7: 3999-4015.
- Kottelat, M. and J. Freyhof. 2007. Handbook of European Freshwater Fishes. Cornol, Switzerland: Publications Kottelat.
- Krpač, V.T. and B. Mihajlova. 1997. *Gonepteryx cleopatra* (Linnaeus 1767), a new species of the butterfly fauna in Macedonia (Lepidoptera: Pieridae). *Acta Entomologica Slovenica* 5(1): 113-116.
- Krstanovski, Z. 1994. Biosystematic and ecological analysis of the planarians of Lakes Ohrid, Prespa and Dojran, and their coastal waters. Doctoral dissertation. SS. Cyril and Methodius University, Faculty of Natural Sciences and Mathematics, Institute for biology.
- Matzinger, A., M. Schmid, E. Veljanoska-Sarafiloska, S. Patceva, et al. 2007. Eutrophication of ancient Lake Ohrid: Global warming amplifies detrimental effects of increased nutrient inputs. *Limnology and Oceanography* 52(1): 338-252.
- Mitsch, W.J. and J.G. Gosselink. 2015. Wetlands. Fifth edition: New York, John Wiley and Sons, 456 pp.
- Ramsar Convention Secretariat. 2013. The Ramsar Convention Manual: a guide to the Convention on Wetlands (Ramsar, Iran, 1971), 6th ed. Ramsar Convention Secretariat, Gland, Switzerland. Available via <http://www.ramsar.org/sites/default/files/documents/library/manual6-2013-e.pdf>
- Scheider, P. and P. Jakšić. 1989. The Butterflies of Yugoslav Macedonia, Selbstverlag Paul Scheider. 227 pp.
- Shapkarev, J. 1966. *Oligochaetae* fauna of Ohrid Lake (Part 2). *Annual Anthology of Biology* 16: 115-177.
- Smiljkov, S. and J. Shapkarev. 1998. Taxonomic research on the *Choronomidae* larvae fauna (Diptera: Choronomidae) in the waters of the lowland regions of the Ohrid valley. *Annual Anthology of Biology* 51: 44-49.
- Spirovska, M., et al. 2012. Integrated study on the state of the remaining of Studenchishte Marsh and measures for its revitalization. Dekons-Ema. Društvo za ekološki consulting. Available via http://www.ohrid.gov.mk/Ekologija/Proekti/Ekologija%20arhiva/Menka-Blato-13_02_2012%20%20lektorirano-final.pdf
- Stankovic, S. 1960. The Balkan Lake Ohrid and its Living World, Faculty of Sciences, Monographia Biologicae, Vol. IX. Uitgeverij Dr. W. Junk, Den Haag, Netherlands, 357 pp., 1960.
- Šapkarev, J. 1977. The fauna of earthworms of Macedonia. 7. The earthworms (*Oligochaeta: Lumbricidae*) of Ohrid-Struga valley. Godisen Zbornik (Annuaire de la Faculté de Biologie de l'Université "Kiril et Metodij" de Skopje), 30: 27-45.
- Talevska, M. 2005. Biomass, production and mineral materials among the clasping leaf pondweed *Potamogeton perfoliatus* L. of Ohrid Lake. Doctoral dissertation. SS Cyril and Methodius University, Faculty of Natural Sciences and Mathematics, Institute of Biology.
- Talevska, M. 2011. Distribution of *Elodea canadensis* in Lake Ohrid. International Conference on Carstic waterbodies in Albania (Albakes'11). Elbasan, R. Albania. Book of abstracts: 49.
- Trajanovski, S., B. Budzakoska Gjoreska, S. Trajanovska, and K. Zdravski. 2015. Habitat change-driving force for endemic/cosmopolitan ratio perturbation in the benthic fauna of ancient Lake Ohrid and its watershed. Review of the Hydrobiological Institute Ohrid. Macedonia. ISSN 1409-9373. pp 116-130.
- Veljanoska-Sarafiloska, E., M. Jordanoski, T. Stafilov, and M. Stefova. 2011. Study of organochlorine pesticide residues in water, sediment and fish tissue in Lake Ohrid (Macedonia/Albania). *Macedonian Journal of Chemistry and Chemical Engineering*, 30 (2): 163-179.
- Verhoeven, J.T.A. 2014. Wetlands in Europe: Perspectives for restoration of a lost paradise. *Ecological Engineering* 66: 6-9.
- Verpoorter, C., T. Kutser, D.A. Seekell, and L. Travník. 2014. A global inventory of lakes based on high-resolution satellite imagery. *Geophysical Research Letters* 41(18): 6396-6402.
- Vogel, H., M. Wessels, C., Albrecht, H.-B. Stich, and B. Wagner. 2010. Spatial variability of recent sedimentation in Lake Ohrid (Albania/Macedonia). *Biogeosciences* 7: 3333-3342.
- Wagner, B. and T. Wilke. 2011. Preface "Evolutionary and geological history of the Balkan lakes Ohrid and Prespa". *Biogeosciences* 8: 995-998.
- Wagner, B., T. Wilke, S. Krastel, G. Zanchetta, et al. 2014. More than one million years of history in Lake Ohrid cores. *Eos, Transactions, American Geophysical Union*, 95(3): 25-26.
- Zawal, A., S. Stojanovski, and S. Smiljkov. 2010. Preliminary investigations on *odonata* from the lake Ohrid (Macedonia). Second Balkan Conference on Biology, 2010, Plovdiv, 50 years University of Plovdiv. Biotechnol. & Biotechnol. eq. 24/2010/se, Special edition/on-line, 636-638.

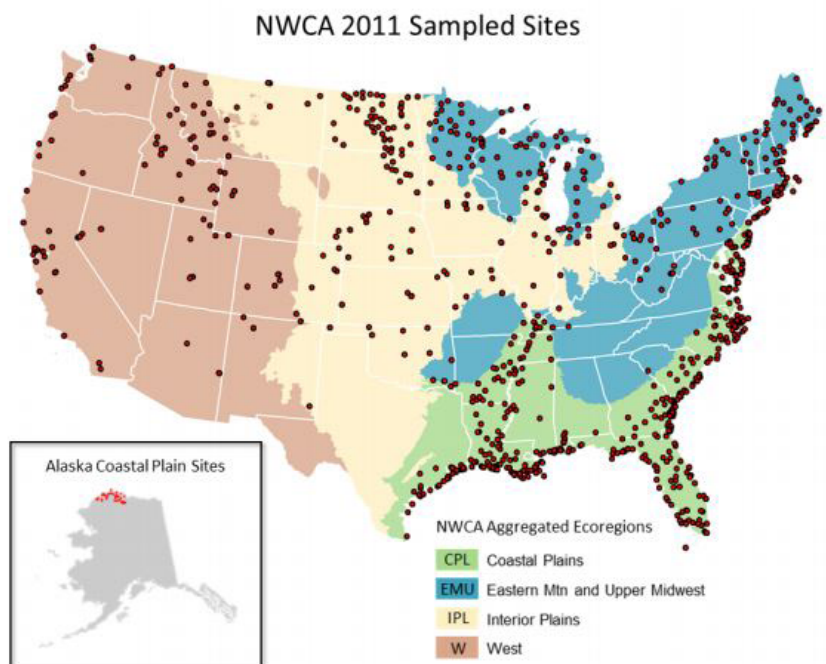
U.S. EPA Finds that 48% of U.S. Wetlands are in Good Health

On May 11, 2016, the EPA released its 2011 National Wetland Condition Assessment Report (https://www.epa.gov/sites/production/files/2016-05/documents/nwca_2011_public_report_20160510.pdf). The assessment found that nationally, 48% of the wetland area is in good condition, while 20% is in fair condition and the rest (32%) is in poor condition (see report for details).

The study involved nationwide field sampling of sites intended to account for the distribution of wetlands across the country (Figure 1). Some areas have far fewer wetlands than others so that, even in areas of the country where there are few sample sites (e.g. southern Appalachian Mountains), regional and national results still apply to the broader target population.

Many agencies and organizations collaborated with EPA to produce this assessment. During the spring and summer of 2011, more than 50 field crews sampled wetlands across

FIGURE 1.
NWCA sampled sites including those on the North Slope of Alaska.



THE FOLLOWING IS EPA'S MAY 11 NEWS RELEASE ON THE ASSESSMENT:

The U.S. Environmental Protection Agency (EPA) today released the first-ever National Wetland Condition Assessment, showing that nearly half of the nation's wetlands are in good health, while 20 percent are in fair health and the remaining 32 percent in poor health.

The National Wetland Condition Assessment is part of a series of National Aquatic Resource Surveys designed to advance the science of coastal monitoring and answer critical questions about the condition of waters in the United States.

"America's wetlands are vital for reducing water pollution, reducing flooding, providing habitat for fish and wildlife, offering recreational opportunities, and

contributing goods to economy," said Joel Beauvais, deputy assistant administrator for EPA's Office of Water. "We know that protecting our wetlands is a critical component of adapting to climate change impacts like flooding and managing pollution and nutrients damaging our country's water quality,"






Physical disturbances to wetlands and their surrounding habitat such as compacted soil, ditching, or removal of plants, are the most widespread problems across the country, and nonnative plants are also an issue particularly in the Interior Plains and West.

EPA conducted the National Wetland Condition Assessment in partnership with state environmental agencies and

the country. Each crew used standardized field protocols to record vegetation, soils, hydrology, algae, water chemistry, and potential stressors at each site. Most sites were selected using a random sampling technique so that the results of the survey reflected the range of wetlands across the country. Data collected at these randomly selected sites were used to produce national and regional estimates of wetland condition (Table 1). ■

TABLE 1.

Number of probability sites sampled nationally and within each of the NWCA Aggregated Ecoregions and acres of wetland area these sites represent. Number of sites sampled and the acres represented are also shown for the aggregated wetland types used in NWCA.

| Region | Sampled Sites in Population | Acres Represented by Sampled Sites, (% of Population) | NWCA Wetland Type | Sampled Sites in Population | Acres Represented by Sampled Sites, (% of Population) |
|---|-----------------------------|---|----------------------|-----------------------------|---|
|  National | 967 | 62,156,199 (100%) | Estuarine Herbaceous | 258 | 4,987,824 (8%) |
| | | | Estuarine Woody | 69 | 497,821 (1%) |
| | | | Inland Herbaceous | 302 | 13,599,611 (22%) |
| | | | Inland Woody | 338 | 43,070,943 (69%) |
|  Coastal Plain | 513 | 30,893,305 (50%) | Estuarine Wetlands | 288 | 5,283,489 (9%) |
| | | | Inland Herbaceous | 62 | 3,750,551 (6%) |
| | | | Inland Woody | 163 | 21,859,265 (35%) |
|  Eastern Mtn & Upper Midwest | 152 | 19,956,668 (32%) | Estuarine Wetlands | 14 | 29,173 (0.04%) |
| | | | Inland Herbaceous | 55 | 3,762,089 (6%) |
| | | | Inland Woody | 83 | 16,165,406 (26%) |
|  Interior Plains | 156 | 7,659,166 (12%) | Estuarine Wetlands | 0 | 0 |
| | | | Inland Herbaceous | 115 | 4,598,831 (7%) |
| | | | Inland Woody | 41 | 3,060,335 (5%) |
|  West | 146 | 3,647,060 (6%) | Estuarine Wetlands | 25 | 172,985 (0.3%) |
| | | | Inland Herbaceous | 70 | 1,488,139 (2%) |
| | | | Inland Woody | 51 | 1,985,936 (3%) |

other federal agencies, including the Natural Resource Conservation Service and U.S. Fish and Wildlife Service. The assessment supplements the U.S. Fish and Wildlife Service's Status & Trends program, which has been documenting changes to the extent of wetland area in the U.S. for more than 30 years. EPA's collaboration with states and other federal agencies on the National Wetland Condition Assessment catalyzed and dramatically accelerated state efforts to monitor and assess wetlands.

Taken together, these surveys increase understanding of these dynamic, extremely important ecosystems that were once actively removed throughout much of the U.S. With new insight gained over time, the assessment will enable EPA and partners to more effectively manage and protect

existing wetlands and hopefully restore some of those that have been lost.

EPA is also launching the National Wetland Condition Assessment Campus Research Challenge today to encourage graduate students to identify and use the data to address one or more key and innovative questions and hypotheses on water quality, wetland health, or wetland ecology. The research may examine relationships nationally, eco-regionally, or for other subpopulations of interest. The challenge closes January 2017 and the winners will be announced March 17, 2017. More information on the assessment: <http://www2.epa.gov/national-aquatic-resource-surveys>. ■

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).

EARTHWORMS BUILDING HUGE MOUNDS IN TROPICAL WETLANDS

From EurekAlert!

http://www.eurekalert.org/pub_releases/2016-05/p-ebh051216.php

Researchers have found a seasonal wetland in Colombia and Venezuela dotted with mounds that can reach as high as 2 meters tall and 5 meters wide. The ecology of the mounds was little known, and some researchers have proposed that these patterned arrays result from erosion. The earthworm (*Andiorrhinus* sp.) grows up to 1 meter long. It feeds in shallow flooded soil and deposits casts to build a small “tower” of dry habitat, where it breathes. The tower may eventually become a mound surrounded by a moat. The researchers proposed that as neighboring mounds grow, they fill the intervening basins and form larger mounds, creating the *surales* pattern (seen below).

The authors of this study investigated the origin and extent of the *surales* landscapes by comparing earthworms and soil properties at sites with and without mounds, as well as analyzing aerial images obtained from drones and Google Earth. For a copy of the article: <http://dx.plos.org/10.1371/journal.pone.0154269>. Zangerlé A, Renard D, Iriarte J, Suarez Jimenez LE, Adame Montoya KL, Juilleret J, et al. 2016. The *Surales*, Self-Organized Earth-Mound Landscapes Made by Earthworms in a Seasonal Tropical Wetland. *PLoS ONE* 11(5): e0154269. doi:10.1371/journal.pone.0154269. ■



Aerial view of the *surales* mounds.
(Photo by Delphine Renard; Creative Commons Attribution License).

U.S. GEOLOGICAL SURVEY WETLAND RESEARCH

The USGS has posted online brief summaries of ongoing wetland projects being conducted through their Wetland and Aquatic Research Center at: <https://www.usgs.gov/centers/wetland-and-aquatic-research-center-warc/science-topics/wetlands>. The topics include the ecology of tidal freshwater forested wetlands in the Southeast, the effect of sea-level rise on coastal wetlands, soil properties and geochronology in Barataria Basin (LA), hydrodynamics and sediment transport in deltas and coastal wetlands, ecology of tropical dry wetlands at Palo Verde National Park (Costa Rica), mangrove migration, and climate change effects on coastal marsh foundation species. The site links interested readers with publications and researchers for detailed information. ■

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

BOOKS

- Wetland 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 North-central 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/ntcwg.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](http://erdc/el-tr-13-1)
- Hydrogeomorphic (HGM) Approach to Assessing Wetland Functions: Guidelines for Developing Guidebooks (Version 2) [ERDC/EL TR-13-11](http://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](http://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-one-stop/5044-nwi-reports>
- Preliminary Inventory of Potential Wetland Restoration Sites for Long Island, New York http://www.aswm.org/wetland-sonestop/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/nwip-lus_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/%28ISN%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>

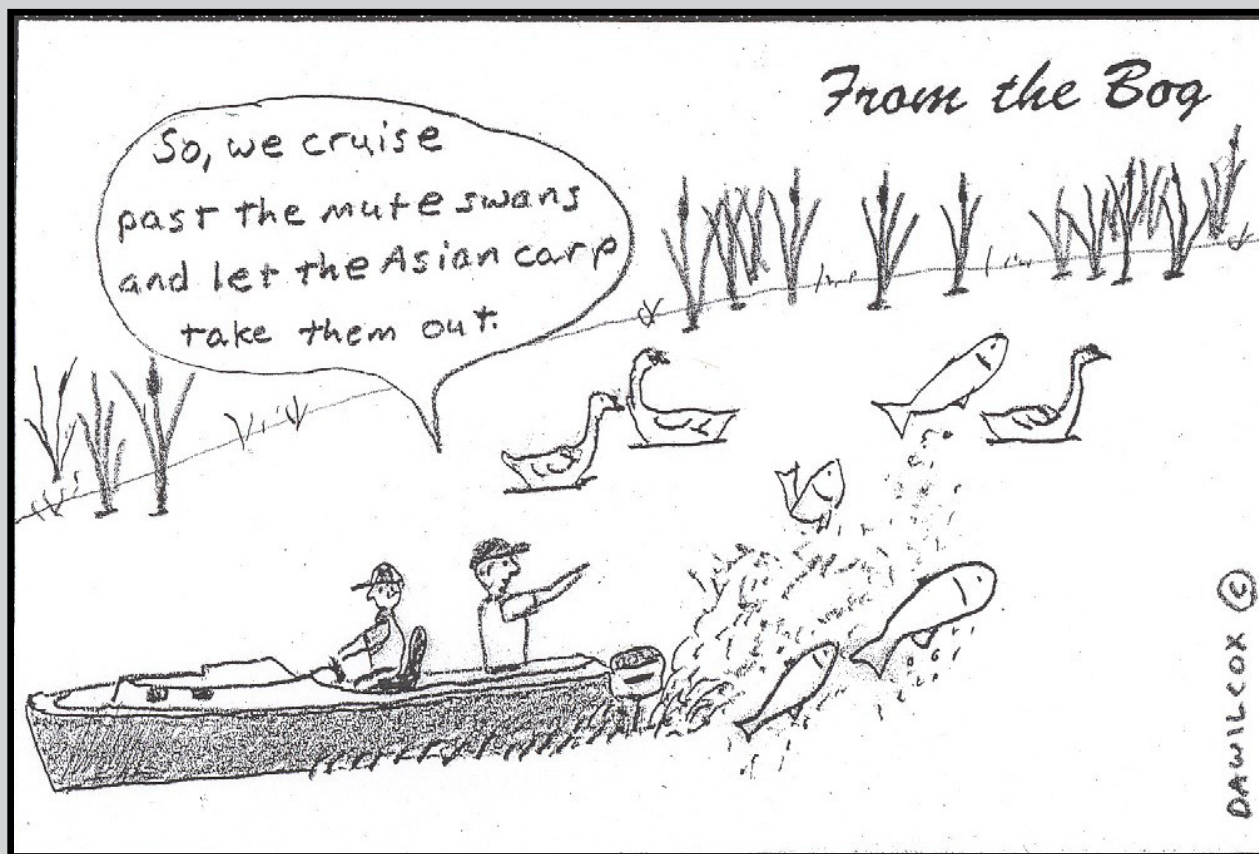
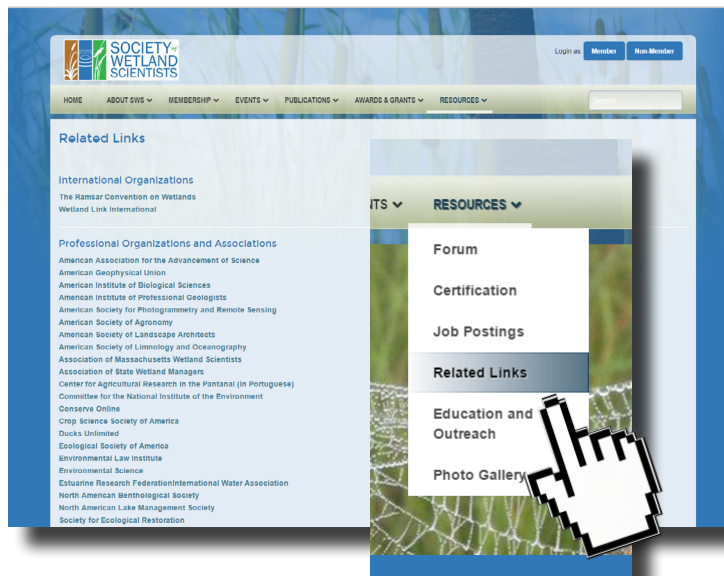
NEWSLETTERS

- 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>

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](http://sws.org).



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.