Wetland Wire

The Newsletter of the Duke University Wetland Center, Nicholas School of the Environment and Earth Sciences

Volume 9, Number 1 Autumn 2007

DUWC Dedicates Stream and Wetland Assessment Management Park (SWAMP)

Duke University officials dedicated the Stream and Wetland Assessment Management Park (SWAMP) on Wednesday, May 2, 2007. SWAMP is located along a stretch of Sandy Creek in Duke Forest, near the Al Buehler Cross Country Trail and just a stone's throw across N.C. 751 from Duke's West Campus.

The site is designed to help protect the region's drinking water supply by controlling contaminant-laden storm runoff from Duke's campus and 1,200 surrounding acres of Durham. It also functions as an outdoor teaching and research laboratory for undergraduate and graduate students in environmental studies and engineering.

Scientists and students at the Duke University Wetland Center have worked for more than three years on the first three phases of the restoration. They have recontoured and replanted Sandy Creek's formerly silt-clogged streambed and banks, restored a riparian wetland along the floodplain, built a wetland and built a new storm water reservoir and earthen dam to replace an old dam.

"The changes we're observing–not only in the restored stream-wetland-lake complex itself but also in water quality downstream from it–are extremely encouraging," said Curtis J. Richardson, DUWC's director and professor of resource ecology at the Nicholas School of the Environment and Earth Sciences.

The new dam at the Stream and Wetland Assessment Management Park near Duke University's West Campus is part of a wetland and stream project that has restored areas of bottomland hardwood wetlands and provided much-needed research facilities. The project, also designed to improve the quality of regional drinking water, was officially dedicated in May 2007.

Photo by Mengchi Ho

Storm runoff containing heavy concentrations of sediment, nitrogen, phosphorus and other urban pollutants drains into Sandy Creek. The stream is a tributary of New Hope Creek, which meets state pollution standards when it enters northern Durham County, but often has been in violation by the time it left southern Durham County bound for Jordan Lake, part of the Raleigh-Durham area's drinking water supply.

Tests conducted prior to SWAMP's restoration and one year after its completion show that nitrate pollution downstream has been reduced substantially, Richardson said.

"Rapid declines in nitrate concentrations between testing stations immediately above and below the site suggest significant ecosystem metabolism is taking place within the restored stream-wetland complex," he said. "It is once again functioning as a wetland should."

Nitrate levels at testing stations along the creek have been well below

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On The Inside

From The Director

Greening the Blue Devil–DUWC's SWAMP and Duke's Plans for Campuswide Stormwater Control

In the late 1990s, Masters and Ph.D. students in my Wetland Ecology classes surveyed water quality and storm flows in the streams on 8,500 acres of the Duke campus and nearby sections of Duke Forest. This survey showed that the University campus and the City of Durham were both major contributors of nutrients, organics, sediments and storm water runoff going into these streams then directly on to Jordan Lake, a manmade lake completed in 1983 that serves as a drinking water reservoir for much of the Raleigh-Durham area in central North Carolina. Moreover, analysis of the existing wetlands and streams done by my graduate class on Wetland Restoration revealed that most of these streams on the Duke site were highly incised and that the surrounding wetlands no longer functioned as filters, transformers, or sinks for pollutants on the landscape.

Armed with several years' worth of data, I proposed to the Clean Water Management Trust Fund (CWMTF), a North Carolina state agency that sponsors construction projects to improve water quality, that the Wetland Center would restore Sandy Creek, a stream in Duke Forest near Duke's West Campus and a major tributary funneling waters from the city and University campus into Jordan Lake. Our main selling point was that we would quantify the effects of restoring riparian wetland functions on water quality and create a sustainable functioning wetland/stream complex that would not only improve water quality and reduce sedimentation downstream, but also create a diversity of new aquatic and wetland habitats.

With over a million dollars from the state (CWMTF) and federal funding from EPA Section 319 Program administered by the NC Division of Water Quality, the USDA Natural Resources Conservation Service, and NSF-along with $500,000 of Duke University contributions-we have completed a major portion of the Sandy Creek restoration, built a lake/wetland stream complex, and recently constructed a treatment wetland to address the highest levels of runoff from the campus.

The graduate students in my wetlands courses have made important contributions to many design features of the Sandy Creek restoration. In fact, the incorporation of these projects into each semester's Restoration class has proven to be one of the most exciting aspects of our teaching program here in the Nicholas School.

As noted in this issue's front-page story, the University administration has recently incorporated the Sandy Creek project into their long-term plans to "green" the Duke Campus. The newly dedicated wetland stream complex, now called SWAMP (Stream Wetlands Assessment Management Park) is now an integral part of the University's long-range plan to improve water quality. The goal is to completely restore all the streams and wetlands on campus. The Duke University Wetland Center will work closely with the University planners and architects to incorporate green designs into all the water features on campus. Importantly, because our SWAMP site treats 1,200 acres of runoff from the city, this project is supported by the city of Durham and sponsored by the Durham Soil and Water Conservation District.

SWAMP is also central to the Wetland Center's research and education plans for the future, providing an outdoor laboratory for research and education. In autumn 2007 alone, 250 undergraduate students visited the site in addition to students from local high schools and the Life and Science Museum, Durham, NC. Wetland Center staff are leading tours and training sessions for a number of local and state agencies who are working to address new ecological approaches to stream and wetland restoration.

This greening of the Blue Devil has brought together faculty, staff, students, and administrators in the Duke community; local, state and federal agencies; and other local groups and organizations. Our future success will be built on this cooperation.

—Curtis J. Richardson
Director, Duke University Wetland Center

Wetland Wire

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Back in the summer of 1999, masters students Sarah Watts, Dan Berlin, and Evie Turley drilled sampling wells to monitor the water table at the new Sandy Creek wetland restoration site. In the eight years since this picture first appeared in an early issue of *WetlandWire*, many students in the Nicholas School of the Environment and Earth Sciences have contributed to the success and ongoing progress of the SWAMP project and the greening of the Duke Campus.

Photo by Mengchi Ho

DUWC Dedicates “SWAMP” Wetland Restoration Project

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the North Carolina water quality standard of 10 milligrams per liter every month since restoration was completed. Prior to restoration, nitrate levels in the creek exceeded state limits four times during the test period of July 2003 to July 2004.

Species richness in the restored ecosystem also is improving. Field surveys done prior to and after restoration show that the stream today provides habitat for two new orders and five new species of aquatic insects, with a total of 89 species..

"The return of macroinvertebrates is one of the first signs that you've done the job right," Richardson said.

In addition to its roles as a pollution buffer and wildlife habitat, the restored ecosystem serves as an outdoor classroom, training center and field laboratory.

Hundreds of students from the Nicholas School, Duke's Pratt School of Engineering, the University of North Carolina at Chapel Hill, the North Carolina School of Science and Mathematics and other area schools, as well as staff members from the North Carolina Museum of Life and Science, attend classes and take part in hands-on training sessions there.

Researchers from numerous local institutions use the site to conduct studies on biological diversity, hydrology, water quality, mosquito control, invasive plant species and other issues.

"What we learn here will benefit wetland and stream restoration projects nationwide," Richardson said. "SWAMP provides a unique opportunity to train students on real-world restoration techniques and modern hydrologic modeling approaches, as well as basic principles of stream, lake and wetland ecology."

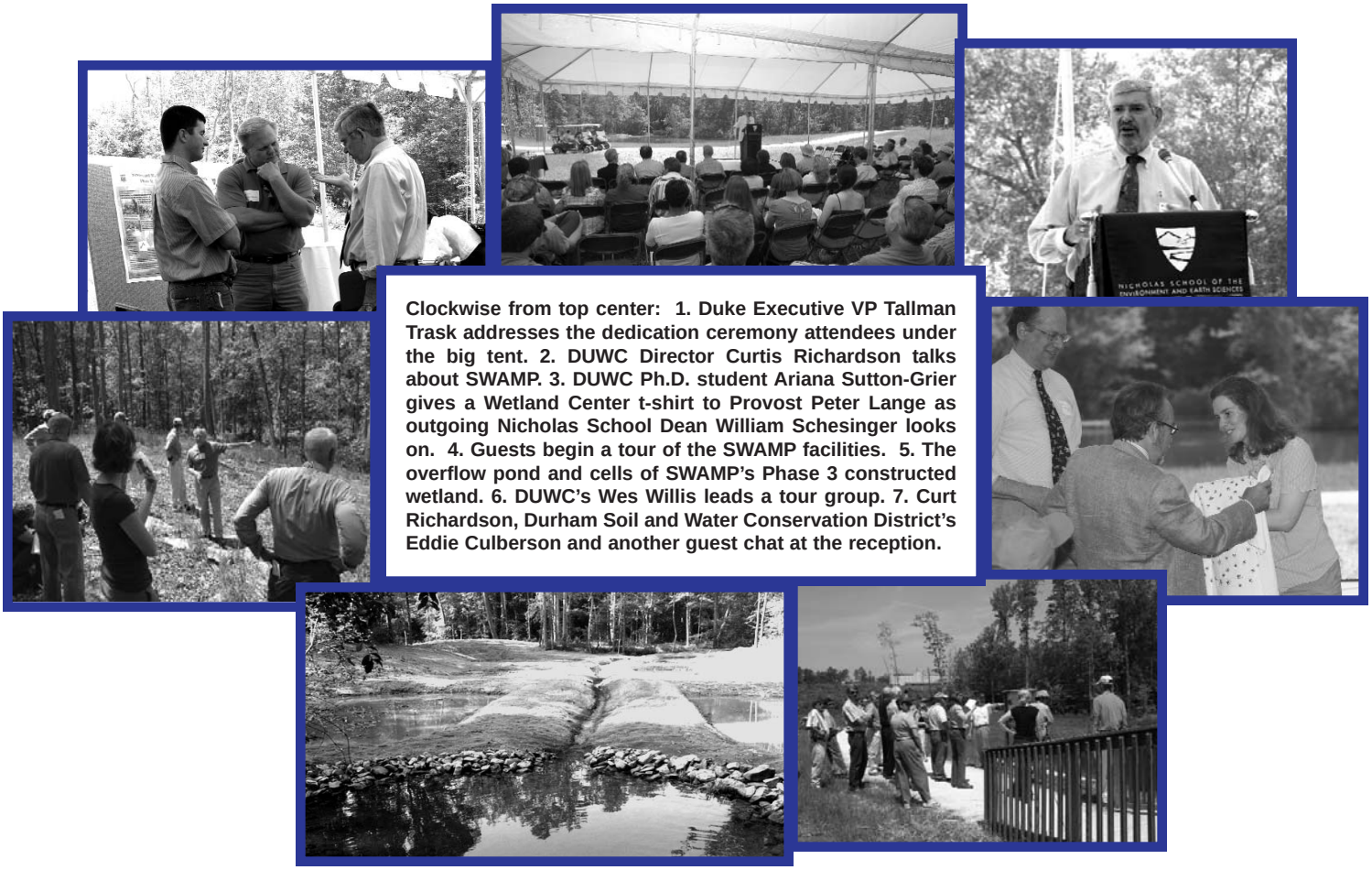
Signs along the Al Buehler Trail, which crosses and then parallels a section of SWAMP, educate the public about the role wetlands play in environmental health. Boardwalks will be built to provide opportunities to view plants and wildlife.

Plans call for restoring a second tributary of Sandy Creek, upstream from the current project, beginning in 2008. After that, Richardson hopes to investigate the possibility of expanding the project to two additional tributaries so that the entire Upper Sandy Creek watershed eventually is included.

"Our goal is to 'green' the entire stream-wetland system on campus and aid the City of Durham and Durham County in improving water quality," Richardson said.

The dedication program, hosted by Richardson, included remarks by Duke Provost Peter Lange, Executive Vice President Tallman Trask III, and outgoing Nicholas School Dean William Schlesinger. After the ceremony, DUWC members led guests on walking tours of the dam site, stream, and research areas.

Tim Lucas
Nicholas School of the Environment and Earth Sciences



Clockwise from top center: 1. Duke Executive VP Tallman Trask addresses the dedication ceremony attendees under the big tent. 2. DUWC Director Curtis Richardson talks about SWAMP. 3. DUWC Ph.D. student Ariana Sutton-Grier gives a Wetland Center t-shirt to Provost Peter Lange as outgoing Nicholas School Dean William Schesinger looks on. 4. Guests begin a tour of the SWAMP facilities. 5. The overflow pond and cells of SWAMP's Phase 3 constructed wetland. 6. DUWC's Wes Willis leads a tour group. 7. Curt Richardson, Durham Soil and Water Conservation District's Eddie Culberson and another guest chat at the reception.

RESEARCH REPORT

Cattail Removal and Habitat Restoration in a Costa Rican Wetland

Doctoral candidate and DUWC student Michael Osland was in Costa Rica from September 2006 to July 2007 conducting research funded by a Fulbright U.S. Student Scholarship in Ecology/Environmental Studies. Osland was one of only 1,200 U.S. citizens who traveled abroad for the 2006-2007 academic year through the Fulbright Student Program. In this article, Osland (seen at right in a Costa Rican wetland) writes about his research project on cattail expansion in the region.

In the last two decades, Costa Rica has become an extremely popular destination for U.S. and European travelers interested in visiting the country's various national parks and viewing the diverse tropical flora and fauna. For birdwatchers, a visit to the wetlands of Palo Verde National Park (PVNP) during the dry season can be spectacular. Between December and April, tens of thousands of migratory and residents birds are easily observed in these wetlands. An especially dramatic resident is the Jabiru Stork (*Jabiru mycteria*) which can be 1.5 m tall (Figure 1). However, few visitors realize that the presence of most of these birds is the result of over 25 years of cattail (*Typha domingensis*) removal and avian habitat restoration efforts.

With the support of a Fulbright Grant and a research fellowship from the Organization for Tropical Studies, I conducted research this past year in the wetlands in and around PVNP, a Ramsar Wetland of International Importance and also a wetland listed on the Montreux Record, a register of endangered/threatened Ramsar sites. PVNP is located in the northwest portion of Costa Rica (see map in Figure 2), a part of the country that is characterized by two very distinct seasons (a 6-month dry season and a 6-month wet season). The wetlands within PVNP receive surface water inputs that fill the wetlands during the wet season to a maximum depth of about 1.5 m. Once the rainy season ends, high evapotranspiration rates result in a gradual drop in water level that continues until most of the wetlands have no standing water by the end of the dry season. This seasonality is very pronounced and strongly influences the ecosystem processes and community structure present in these wetlands. PVNP contains roughly 12,000 ha of wetlands and is part of a regional floodplain that contains an estimated 100,000 ha of wetlands[1]. The wetlands of PVNP have a history that is common to tropical seasonal wetlands. Prior to becoming a park, these wetlands were subject to more than a century of intense cattle grazing; during the dry season, wetlands in tropical seasonally dry areas become prime grazing land due to the presence of water in an otherwise very dry landscape. In the late 1970s, the area was expropriated by the Costa Rican government and later turned into a national park in order to protect the wetlands and adjacent dry forest. Upon creation of the park/wildlife refuge, the cattle were considered anthropogenic components of the ecosystem and removed from the park.

Figure 1. A Jabiru Stork in a rice field near Palo Verde National Park, Costa Rica. ***Photo by Anna Osland.***

Figure 2. Map of Costa Rica showing the location of Palo Verde National Park.

At roughly the same time, cattail began to expand into PVNP wetlands. The most common hypothesis is that with the loss of the competitive release provided by the cattle via grazing, cattail (which is actually native to the region) was able to outcompete other plants and form dense monotypic stands. Another prevalent hypothesis is that the quantity, timing, and salinity of hydrologic inputs to the wetland have changed due to regional and local land use changes. However, neither of these hypotheses has been adequately tested. In PVNP, cattail has expanded into at least 1500 hectares of wetlands in the last 25 years. The consequence of the cattail expansion has been a reduction of open water, bare sediment, and aquatic plant diversity. Management efforts in the last 25 years have been directed towards controlling the cattail expansion and restoring plant and avian diversity. Today, cattail growth in Palo Verde Marsh is locally controlled through a combination of mechanical disturbance and flooding. During the dry season, mechanical disturbance is used to reduce cattail biomass and vigor. The mechanical disturbance is called *fangueo* in Costa Rica and consists of using a tractor with metal paddle wheels to crush and pull up cattail culms (Figure 3). After *fangueo*, rapid flooding associated with the initial rains of the wet season (typically in May) kill the already weakened and now oxygen-deprived cattail shoots. Where the soils permit, *fangueo* is a cheap ($40–60 per ha), fast (one tractor can crush 6–10 ha/day), and effective cattail control technique. These management efforts have resulted in an increase in plant and avian diversity in the restored sections of the marsh. However, the impact of these efforts has never been assessed or communicated in the form of replicated experiments.

A large portion of my research focuses upon assessing the impact of mechanical disturbance and grazing upon cattail dominance and plant community development in Palo Verde Marsh (a wetland within PVNP). I have established an experiment that consists of a single factor, cattail management, applied at three levels (control, mechanical disturbance, and a combination of mechanical disturbance and grazing) with 15 replicates. (See Figure 4 for an illustration of an individual block of the experimental design.) The response variables include plant community composition/structure, soil properties, and avian diversity. I also conducted a seedling emergence study to identify species found in the seed bank and determine the establishment requirements of each seed bank species. The ultimate goal is to create a filter-based assembly rules model than can be used to illustrate the impact of disturbance and flooding regimes upon the plant community in Palo Verde Marsh. I recently returned from Costa Rica and am in the process of analyzing the data and the soil and plant tissue samples. Hence, the results of this study are not yet ready for formal communication. However, preliminary analyses indicate that the most common post-disturbance plant species include the following: (1) rooted free floating species– *Neptunia natans* and water lilies (especially *Nymphaea amazonum* and *N. pulchella*); (2) free floating species– duckweed (*Lemna aequinoctialis* and *Wolffiella welwitschii*) and water hyacinth (*Eichhornia crassipes*); (3) submerged species– bladderwort (*Utricularia gibba*); and (4) emergent species– bent alligator flag (*Thalia geniculata*), *Echinodorus paniculatus*, jointed flatsedge (*Cyperus articulatus*), grasses (*Hymenachne amplexicaulis*, *Paspalum distichum*, *Echinochloa colona*, and *Paspalidium geminatum*), cattail (*T. domingensis*), and sensitive jointvetch (*Aeschynomene sensitiva*).

In addition to investigating the impact of disturbance and grazing upon the plant community, I also studied the impact of nutrient-rich agricultural runoff into a nearby wetland, La Bocana Marsh. La Bocana was once a seasonal wetland with a diverse plant and avian community. However, an irrigation project upstream of the marsh now channels nutrient-rich agricultural runoff to La Bocana throughout the year. The change is dramatic; La Bocana is now dominated by extremely dense and monotypic stands of cattail. Some parts of the marsh have cattail culms that are over 5 m in height (as compared to the 2–4 m culms

Figure 3: The tractor and wheels used to crush and pull up cattail culms at Palo Verde (called *fangueo* in Costa Rica). *Photo by Mike Osland.*

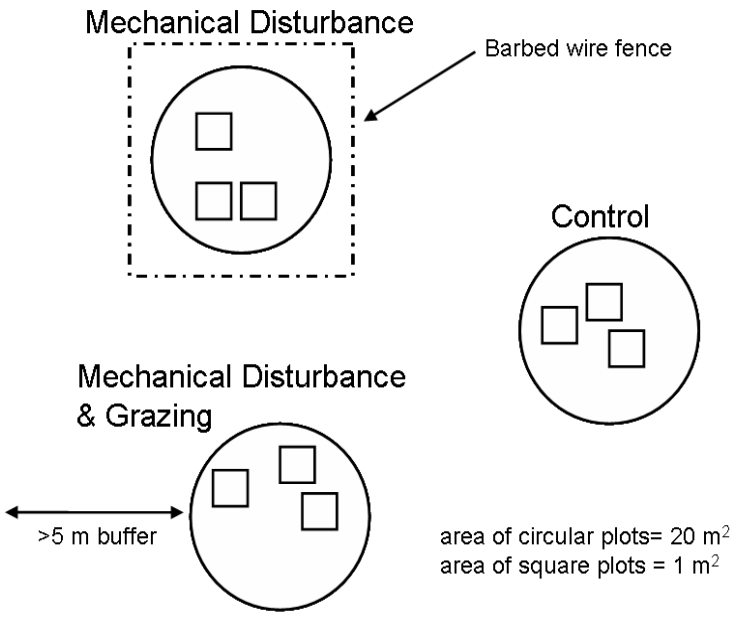


Figure 4: Illustration of an individual block of the experimental design.

found in unenriched marshes in the region). Although, at first glance, this account sounds similar to the expansions of *T. domingensis* that have occurred in the Everglades and freshwater marshes throughout the Caribbean, there are some very important differences. Perhaps most importantly, the wetlands in PVNP are not as oligotrophic and P limited. In fact, soil N:P ratios in PVNP wetlands imply N limitation. These wetlands are also seasonal and receive large surface water inputs (in contrast to the precipitation-dominated inputs of the Everglades). The soils in these wetlands are mineral (many are vertisols) not organic and decomposition during the dry season is probably very rapid. I conducted a fertilization experiment this year to assess the extent of nutrient limitation. I am also comparing plant community composition, cattail stand structure, and both soil and foliage N:P ratios along a potential eutrophication gradient in La Bocana in order to assess the impact of the nutrient-rich agricultural runoff. The process of analyzing data and samples is still ongoing; thus, the results of this study are not yet ready for formal communication. The broad objective of this investigation is to quantify the changes in both diversity and ecosystem functions that are caused by the nutrient-rich and non-seasonal permanent surface water inputs into these wetlands.

In closing, I would like to encourage wetland scientists and students to consider visiting or conducting research in the PVNP wetlands. The Organization for Tropical Studies has a field station adjacent to Palo Verde Marsh (the Palo Verde Biological Station) and is eager for additional research in these interesting and unique wetlands.

—Michael Osland
Duke University Wetland Center

Reference

[1]Jiménez, J. A. 2001. pp. 90-95 in *La Cuenca del Río Tempisque: Perspectivas para un Manejo Integrado* (eds. J.A. Jiménez and E. González). San Jose, Costa Rica: Organización para Estudios Tropicales.

DragonflyTV Visits North Carolina Wetlands

DUWC doctoral candidate Ariana Sutton-Grier (far left) writes about her recent experiences during filming for PBS TV children's science programming. Joining Ariana in a tour of wetlands in Eastern North Carolina were her fellow television "stars" (left to right) Sarah, Valencia, and Sophia.

My adventure in television began with a phone call out of the blue from *DragonflyTV* producer Gloria Bremer at the end of September. *DragonflyTV*, a program in the PBS Kids television lineup aimed at the 9 to 12 year old audience, shows that science is exciting and something everyone can do.

It turned out that Gloria's phone call was not quite as random as I thought. During summer 2006 I had worked with the North Carolina Museum of Life and Science helping to teach their tour guides about the museum's on-site wetland exhibit and leading field trip sessions in Duke Forest with middle school students in the museum's wetlands camps. The museum staff had recommended me to Gloria and the *DragonflyTV* staff as a source for wetland information.

At first Gloria just wanted my advice about wetlands around the Raleigh-Durham area as well as what kinds of questions kids could ask about wetlands on a TV segment. But as we talked, we realized it would be fun to do a segment on the diversity of North Carolina wetlands. This would involve a trip down east to the coast to see cypress swamps, salt marshes, and pocosins.

Before I knew it, I was signed up to go on a weekend-long excursion with three middle school girls, two moms, two TV producers (including Gloria), a sound guy, and a cameraman!

We all had the chance to meet each other at a local restaurant the Thursday before we were to leave. I was immediately impressed by Sarah, Sophia, and Valencia (nicknamed "V"), the three middle school girls who were going to be the "stars" of the show. They were articulate and exuberant, and they already knew a lot about science. I also really liked the producers, parents, and crew. I headed into the weekend knowing we were going to have a great time.

We gathered in Durham very early on Saturday morning, October 14, 2006. It was a gorgeous day, sunny and cold. We first drove south to Rhodes Pond in Cumberland County, where an outdoor guide met us with four canoes. We headed out on the water and toured the cypress swamp there for about four hours. Sarah and "Soph" had some trouble steering their canoe and ended up taking a bunch

of detours, which caused them to have fits of laughter. Along the way we saw a couple of rare orchids and a beaver dam, and we had a wonderful time. On the way back we sang camp songs with our voices echoing through the swamp.

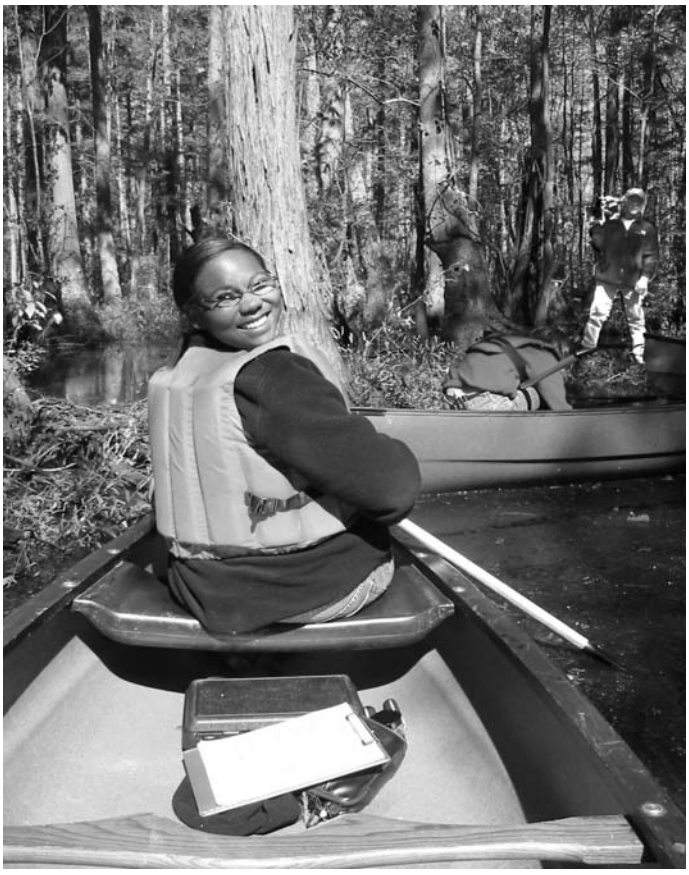
We grabbed a late lunch and then stopped to do some filming of us packing up the van as if getting ready to start our trip. I learned that in TV production there is a lot of stopping and starting and doing things out of order so the final narrative can run smoothly.

We drove to the coast and arrived late Saturday evening at Morehead City. All the men, tired from the day's work, went off to bed, but all the women went out for dinner at a seafood restaurant. We chatted all through the meal and had such a good time!

Sunday morning we were up early and ready to go. We headed to Bear Island, part of the Hammocks Beach State Park, to see a salt marsh. A very helpful park ranger took us out on a boat to the island.

We put on our waders and hopped off the boat, only to get absolutely, completely stuck in the mud within moments. First Sarah got a little stuck. Next, Soph got so stuck she fell over and got all muddy. Then she fell again and nearly took V with her. Trying to help them, I got stuck too. Gloria had to come rescue all of us. We were all in fits of giggles! Despite the fun, the crew reminded us that our microphones would stop working if they got too muddy (ah, the details of television), so the ranger got us back on the boat and took us to a less muddy area.

We saw the kinds of crabs and little fish that live in the marshes, and we tasted the saltiness of the glasswort plants that grow there. The girls found everything exciting in the way only young people can.



In the afternoon we headed to the Croatan National Forest to see a pocosin. A forester took us to a tall pocosin, where we looked at the peat soils and dense vegetation. The mosquitoes ate us alive, and we tried to avoid the fire ants. We also hoped we would not run into any of the rattlesnakes that live in that habitat. We left the forest, and our excursion ended with an evening drive back to Durham.

Monday morning we met on the Duke campus. I showed the girls around the Duke Forest restoration project at the Wetland Center's SWAMP (Stream and Wetland Assessment Management Park) site, and I talked about my research there. We took a few soil samples and water samples and then took them back to the Wetland Center lab so the girls and the TV crew could see how we analyze field samples.

That's where my TV filming experience came to an end. It was such fun! I loved talking to Sarah, Soph, and V, knowing that what we were saying would be heard by thousands of kids. I loved getting to share my knowledge about wetlands and my excitement about the diversity and uniqueness of wetland ecosystems. It was an exhausting weekend, but every moment was worth it and so much fun! I would do it again in a heartbeat.

This fall, in September 2007, the day before our *DragonflyTV* show premiered in North Carolina, there was a wonderful red carpet-like event at the North Carolina Museum of Life and Science in which Sarah, Soph, V, and I were the stars. We got to talk about our experience filming the show, and the audience–which was full of little kids–asked all sorts of questions, including which wetland was our favorite, which wetland animals we liked best, and what was the funniest moment during filming. The museum's premiere event was so delightful and gratifying; it gave me just a little taste of celebrity. And our producer, Gloria, did mention to me that I was very good on camera and she could see me hosting my own kids' science show. Who knows? Maybe if academic life doesn't end up suiting me, I'll think about a life in TV!

Ariana Sutton-Grier
Duke University Wetland Center

The North Carolina wetlands segment of *DragonflyTV* is currently airing on PBS affiliates nationwide.

MORE INFORMATION ONLINE!

DragonflyTV
http://pbskids.org/dragonflytv

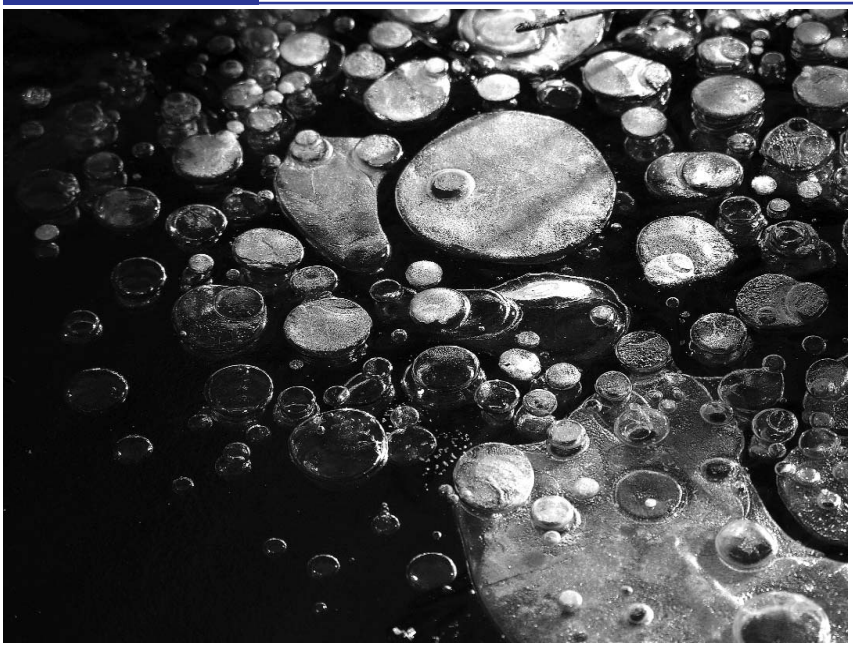
The Museum of Life and Science, Durham, NC
http://www.ncmls.org/

DUWC SWAMP site
http://www.env.duke.edu/wetland/swamp1.htm

V flashes a smile as the *DragonflyTV* group pauses near a beaver dam at Rhodes Pond, a cypress swamp in Cumberland County, NC. Sarah is bending over in her canoe to gather up supplies while the TV cameraman stands in the background ready to begin filming.

Photo by Ariana Sutton-Grier

Freeze Frame–DUWC Researcher's Photos in Environmental Art Show



***TURTLE BREATH*. The bubbles from a submerged turtle's exhalations are frozen in the early morning ice covering Duke Forest's Sandy Creek, forming a subtle abstract pattern.**
Photo by Mengchi Ho

DUWC researcher and data manager Mengchi Ho is among sixteen artists who have been invited to display artwork in a multimedia exhibition entitled *Water–Our Most Precious Resource*.

Jointly sponsored by the Orange County (NC) Arts Comission and the Friends of the Carrboro Branch Library, the exhibit runs from October 2007 until January 15, 2008 at the Carrboro Branch Library/ McDougle Schools Media Center, 900 Fayetteville Road, Chapel Hill, NC.

The exhibition will be open during regular library hours, which are posted at the Carrboro Branch Library's website, http://www.co.orange.nc.us/library/carrboro/index.htm

The exhibit explores the natural beauty of water in the environment as well as aspects of the often problematic human stewardship of this basic necessity.

Ho often finds subjects for his photography while doing fieldwork, studying plants, and collecting soil and water samples. His six photos on display in the art exhibit exemplify a variety of wetland and aquatic habitats across North Carolina.

The Duke University Wetland Center is dedicated to providing sound scientific knowledge that will lead to sustainable wetland functions and values for the nation and for the world. The center works towards this goal by conducting, sponsoring, and coordinating research and teaching on critical wetlands issues.

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