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WELCOME...

Welcome to the Summer Issue of the Environmental Monitor. The weather is warming up and we've got all the hot new gear you might need. Cool off with our look at new research into the melting patterns of Alpine snowpacks and Peruvian glaciers. There's also the world's only cranberry bog surrounded by water and a struggle for dominance on the Texas savanna. Don't miss how an innovative river monitoring system prevented disaster after a train wreck in Pennsylvania.

Located in Beavercreek, Ohio, Fondriest Environmental is the trusted partner you can turn to for help with environmental monitoring projects. We can assist in everything from planning and monitoring to systems integration, equipment calibration and even staff training. Our application engineers assemble, integrate, and calibrate all equipment – when you get it, it's ready to use. Our specialists have years of experience developing and deploying remote systems and working with leading suppliers such as YSI, Hach, Thermo Scientific, In-Situ, Solinst, NexSens, and many more.

Cover Photo by Mike Voellmecke

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EM ONLINE RECENT FEATURES

Monitoring Allegheny Headwaters

By Jeff Gillies

In this tale of a watershed group's plan to track non-point source pollution, a data logger disappears after Hurricane Irene washes out a stream bank stabilization project. Two weeks later and two miles downstream, a volunteer finds it washed ashore, still recording specific conductivity every 15 minutes.

Researching Karst Aquifers

By Audrey Carson

By identifying how toxins flow through underground aquifers in a West Virginia cave, a WVU professor and graduate student could help save lives a world away in Puerto Rico where high preterm birth rates are linked to poor water quality. PROTECT, the Puerto Rico Testsite for Exploring Contamination Threats will incorporate WVU's transport models to study aquifers in Puerto Rico.

Waterfall Sediment Transport

By Jeff Gillies

A waterfall plunge pool in the middle of a storm is great place to measure sediment transport but a dangerous place to wade. A student of geological and planetary science gets around this problem with depth-sensing sonar equipment that could provide new insights on how landscapes evolve as water carves through rock.

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Melting Glaciers and Peru's Water Supply

By Jeff Gillies

With the help of restored stream monitoring stations, a group of university researchers has determined that a country depending on melting glaciers for water now faces a shrinking supply of the resource.

Peru depends on water that flows down from the Cordillera Blanca mountains on its way to the Pacific Ocean. The water irrigates expansive agriculture on the country's coast and drives some of the hydro power stations that supply 80 percent of the country's electricity.

"The geography is fascinating in Peru because you have this desert coast and a lot of its water resources are coming from mountains that are glacier covered," said Bryan Mark, associate professor of geography at Ohio State University. "It's a major population relying on water from these mountains."

Peru is the world's leading exporter of asparagus. Also popular are sugarcane and other crops that would be impossible to grow without the irrigation water drawn from the Rio Santa, according to Mark.

But a warming climate has the mountains' glaciers in a state of constant retreat. And while an ever-shrinking glacier initially sweats an increasing supply of water into mountain watersheds and streams, that doesn't last forever. It's just a short-term pulse into the system, Mark said.

In a recent study of the water supply of Peru's mountain glaciers, Mark and other researchers determined that the initial increase of meltwater is over. From now until the glaciers melt completely, Peru will have to adapt to a dwindling supply of mountain water.

"Here's a real change in the landscape that people haven't seen ever in their cultural history," Mark said. "These are some real important fundamental human development questions."

To determine the change in water supply, the researchers used historical data from a network of stream discharge monitoring stations along the Rio Santa. The stream gauges were originally operated by the Peruvian government, but many were shut down when the electrical utilities were privatized in the 1990s. To get recent discharge data to compare with the historical record, the researchers had to get those old monitoring sites back online.

Beginning in 2008, Ohio State University, McGill University, the French Institut de Recherche pour le Developpement, and the Peruvian glaciology unit of the Autoridad Nacional del Agua joined together on a project to install water level loggers at 13 sites along the Rio Santa, including five sites that were part of the historical monitoring network.

Before the new stations could start making automated discharge measurements, the equipment had to be calibrated with manual stream flow measurements. The crew used the Sontek RiverSurveyor M9, an acoustic Doppler current profiler that can be towed back and forth across a stream while it sends discharge data over a wireless Bluetooth connection to a computer on the bank..

Discharge measurements are often made by measuring water velocity while wading across a stream. That would have been too dangerous in the rushing waters of the steep mountain rivers Mark and his colleagues were studying.

"We can measure discharge in small streams pretty readily, but it's the big flowing rivers that are a challenge," Mark said. "That's where the M9 has been really good."

The next extension of Mark's work in the watershed will look at water quality. Mining is a leading industry in Peru's economy, but it often leaves the country's rivers vulnerable to pollution from dumped tailings or spillover from leachate ponds.

"If you think about impact, quantity is one part of the equation," Mark said. "But quality becomes ever more important as you have less of the water." JG

Researchers towed the RiverSurveyor accross the Rio Santa, gathering discharge data to calibrate a network of stream gauges.

All Photos: Bryan Mark

Let It Rain

By Jeff Gillies

A rain garden on the GVSU campus soaks up stormwater and feeds an irrigation pond, keeping runoff from the ravines.

In a strip of land between the Grand River and Grand Valley State University's Allendale, Mich. campus, a system of ravines puts a significant wrinkle in the otherwise flat landscape. For Peter Wampler, an associate professor of geology who came to Grand Valley in 2004 from the mountains of Oregon, the folded hills of the ravines were welcome relief in a topographically challenged state.

"The ravine systems are really incredible," Wampler said. "They're unique. They're really steep. There are parts you can barely walk up."

The ravines, which drop 120 feet over a short distance, have given sanctuary to diverse plants and wildlife for thousands of years. But in the 1960s, the ravines gave university planners a convenient place to dump the stormwater that drains from campus after a heavy rain -- a strategy has left the ravine floors scoured and slopes unstable.

Now, an effort to preserve this fragile natural feature has launched a campus-wide push for progressive stormwater management and monitoring.

Since the school opened in the '60s, its drainage network has concentrated stormwater into a few outflow pipes that send torrents rushing down the ravine floors, washing away soil and potentially collapsing banks. Soil that washes out of the ravines ends up in the Grand River, where it can cloud the water and smother habitat for fish and other aquatic organisms. Summer 2011 saw the first round of sediment sampling in the river, which gave researchers a look at how big the problem is.

"We have good numbers now, and they're pretty staggering numbers, the amount of sediment that's being generated by that system," Wampler said.

Not all the erosion is unnatural. The system has likely always moved some sediment into the river — that's what formed the ravines in the first place. But the university's past stormwater management practices have made it worse.

"I think we've certainly accelerated the process," he said. "The erosion has gotten more dramatic, more flashy and more episodic than it probably was historically."

Since 2006, a network of monitoring gauges that continuously record flow or stage height throughout the ravines has helped characterize just how flashy the runoff has become. One way Wampler has done this is by calculating lag times, or the amount of time it takes for runoff to reach its peak flow after a rain event. Lag times in natural, undeveloped watershed tend to be relatively long because water is absorbed by plants and soil, slowing its movement through the system. Lag times in urbanized watersheds are relatively short because paved surfaces and pipes speed the water along.

Rainfall and stage height data collected during a storm in 2006 show a lag time of around 50 minutes in one of the runoff-impacted ravines. Similar data from an off-campus, undeveloped creek monitored as a control found a lag time between 250 and 1,400 minutes.

Though the data describing the problem are fairly recent, the school has been rethinking its stormwater management since the 1990s after a massive pipe failure and conspicuous erosion. By 2002 they had a new stormwater plan and launched erosion-control efforts in the ravines. They installed structures to slow the velocity of water as it blasted from the outflow pipes. They laid down a layer of rocky riprap on ravine floors to secure the soil.

But the erosion persisted. Water found its way around the dams and limestone riprap was breaking down. "They spent a lot of money for a lot of years trying to put Band-Aids on this gaping wound down there," Wampler said. "And really, none of it has worked and it's still not working."

By trying to line the ravines with rock and slow the water once it was already in the ravines, the fixes were already too late. Instead, they needed to keep the water out of the ravines in the first place.

That goal has been at the center of a sea change in stormwater management at Grand Valley over the past decade. In 2006, the university created a committee called the Stormwater Advisory Group, whose members include students, faculty and representatives from Facilities Services, the university department responsible for planning and maintenance. The group created a new comprehensive management plan that guides stormwater control. Wampler credits the turnaround to improved data and communication, and especially the initiative of Facilities Services to make the problem a priority.

"The thing driving all this is that Facilities has made a conscious, verbal and public commitment to return the campus to 1960s runoff levels," he said. "Any new construction on campus, the runoff control will actually turn back the clock."

Facilities is meeting that commitment through best management practices like building green roofs that absorb water and parking lots of porous asphalt that allow rain to seep through. On the grounds of the LEED-certified Laker Turf Building, which was built in 2008 for student recreation, stormwater is directed into a 9,000 square-foot rain garden that takes a big bite out of the runoff.

Another series of monitoring gauges helps show how well the rain garden works. A hydrograph generated from the data shows that during a 2009 rain event, water flowing into the rain garden hit a peak of 1,200 gallons per minute. The outflow never rose above 200 gallons per minute.

"It's amazingly effective," Wampler said. "I was a bit skeptical, to be honest, about these rain gardens. But I was proven wrong, especially with this one."

In the rain garden, much of the water percolates into the ground or is taken up by native plants. Water that manages to escape the garden is captured by a pond and used for irrigation.

The single biggest change in campus stormwater management is a constructed wetland completed in the summer of 2011. Around 25 percent of the runoff flowing into one of the ravines has been diverted into the wetland, which Wampler sees as the next target for monitoring gauges if funding becomes available.

In the meantime, the university's advancements in curbing runoff have been an important educational opportunity for students to learn about environmental processes and planning. Dozens of classes have implemented some manner of stormwater component, and Wampler said he takes almost every class he teaches on a "ravine romp" and rain garden tour. Some classes get a chance to evaluate rain garden data and gauge its effectiveness themselves.

"It's great for students. They really appreciate seeing real problems and real solutions being applied," he said. "And it's an evolving story, so I can tell them how things have changed and how things are progressing from where they were." JG

Severe erosion in a rare ravine system led to Grand Valley State University's pledge to cut campus runoff through modern stormwater management and monitoring.

All Photos: Amanda Pitts

River Guardians

ORSANCO's Organic Detection System watches over the Ohio River

By Audrey Carson

On October of 2006, a train derailment sent 23 tank cars full of ethanol off the tracks. Three of them spilled their contents into the Beaver River, a tributary of the Ohio River that enters at mile 25. What could have been an environmental disaster was avoided by the quick reaction of a novel river monitoring system.

The Ohio River Valley Water Sanitation Commission (ORSANCO)'s Organics Detection System focuses on cooperating with water utilities along the river to detect organic compounds spilled along any of its 981 miles. It has detected volatile contaminants from many unreported chemical spills and releases. The ODS program ultimately protects drinking water by addressing pollution at the source.

In the case of the Beaver River derailment, the ODS was able to track the ethanol's denaturing compounds, beginning at the Weirton, W.Va. site, 40 miles from where the spill entered the river.

"Source water protection, very shortly, is protecting the directing water utilities that make drinking water by protecting the source water they draw from," said Jerry Schulte, ORSANCO's Manager of Source Water Protection and Emergency Response.

Photo: Craig Hanchey

To keep a finger on the pulse of the Ohio River's water quality, ORSANCO, based in Cincinnati, has 15 monitoring sites at drinking water utilities and industrial partners from just above its beginning near Pittsburgh to Paducah, Kentucky at River Mile 930. The Ohio River is unique in that it has a definitive starting point at the confluence of the Allegheny and Monongahela Rivers in Pittsburgh, making it easy to number by river miles – and easy for ORSANCO to place ODS sites along its length.

"Basically, we have the whole river bugged," Schulte said.

Predating the United States Environmental Protection Agency and the Clean Water Act, ORSANCO was established in 1948, a year when the river's water quality was, as Schulte put it, "abysmal."

Since that time and through the combined efforts of the eight states that created ORSANCO, the organization has made tremendous strides in the water quality of the 204,000 square mile Ohio River watershed. The water quality has improved so much that there are now more than 130 different species of fish living in the Ohio River. The river has hosted both the Bassmasters and the FLW Outdoors national bass tournaments in recent years.

Rail cars filled with ethanol plunge into the Beaver River in 2006.

The Ohio River confluence at Pittsburgh, PA.

Photo: Pennsylvania Department of Environmental Protection (PADEP)

Photo: Jim McCollum

> "Basically, we have the whole river bugged."
>
> -Jerry Schulte

At a bare-bones minimum, each participating facility must process one raw water sample every day of the year to check for the presence of organic compounds. Most sites perform several tests daily; last year, participating facilities analyzed 4,228 raw river samples. At least one sample a day has been processed since 1978, when the ODS program began after a massive unreported carbon tetrachloride spill contaminated drinking water intakes from Huntington, W.Va to Louisville, Ky.

ORSANCO is in the process of updating the ODS equipment, adding automated sampling to its sites, allowing 24-hour monitoring so facility operators can evaluate data received after a full night's rest.

To receive automated data quickly, NexSens Technology installed iSIC data loggers at each ODS site along the Ohio River and at the ORSANCO headquarters. The iSICs use DSL and cellular telemetry, a significant upgrade from the dial-up ORSANCO was using, cutting download time from an hour to approximately 10 seconds. The iChart software installed on site computers interrogates the data loggers and stores measurements in a database that can be accessed by any other project sites or from an operator's home.

"The amount of support we need to provide to each site is unique so having that two-way capability is ideal for a system that runs a 1,000-mile long river," Schulte said.

Each site uses gas chromatography to identify and quantify organic chemicals in the water. This process separates the compounds out by weight with the results resembling an EKG machine graph. Each peak in the chromatogram represents a different compound and, depending on the peak, an event that may require immediate action from ORSANCO or the drinking water utility.

Many chemicals the ODS program tests for have Maximum Contaminant Levels (MCLs) established by the EPA. Detection levels for all regulated volatile organics detected by the ODS are well below the MCLs. If a chemical is detected above its MCL, the drinking water utility is required to contact ORSANCO. Schulte or another ORSANCO member can access that site's data and verify if the detection is valid – as advanced as the technology is, humans cannot be replaced.

"A litany of things can cause a false positive," Schulte said.

Schulte explained that their current detection system can only report what it has been calibrated to report. As part of the ODS upgrade, the gas chromatogram with mass spectrometer will be replaced with a mass spectrometer which will give system operators a percent confidence level for each detected compound. This will reduce the amount of guesswork needed from the human side of the operation.

In addition to detecting unreported releases, the ODS program can also track reported chemical releases so drinking water facilities know when the chemical plume will hit their location – and implement countermeasures. In these cases, ORSANCO usually knows what chemical they are looking for because it has been reported. Such was the situation in the Beaver River train derailment.

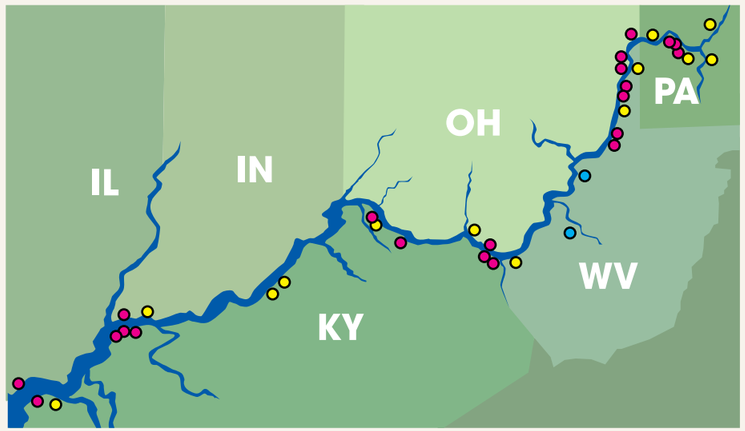
ORSANCO staff used river velocity information from the National Weather Service to predict the progress of the contaminant plume and communicated the time of travel to the downstream water utilities. Because of this, drinking water utilities were able to implement additional treatment steps or close their intakes until the plume passed. The ODS equipment tracked the ethanol plume for approximately 300 miles until it was diluted by a heavy rain near Huntington, W.Va.

The great success of the ODS program is partially due to the cooperation among and between the drinking water utilities. Larger utilities will often run water tests for smaller utilities with a lower capacity to run complex tests in a contamination event. The cooperation also allows facilities to treat the water as it comes in, often powered with activated carbon. The ODS program is envied worldwide, Schulte said.

"This is one of the premier systems in the world for source water protection," Schulte said. "At least every month I get a call from a drinking water utility in the United States asking about our system, what we've done and how we've put this together."

He's also traveled to China and the Netherlands to talk about the ODS program. For many, it serves as a deterrent to draining and dumping into the river. At times, Schulte said, system operators and commission staff have gone out in a boat after a detection event and identified the specific pipe from which the contaminant was flowing and stemmed the flow.

"When you have that ability, a detection system like this is a deterrent and people are inclined to not do things," Schulte said. AC



ODS LOCATIONS

- Drinking water intakes
- Drinking water intakes and ODS sites
- Industrial water intakes and ODS sites

Modern Mission

By Jeff Gillies

Tygart Dam is one of 16 flood control dams where the Army Corps' Pittsburgh District also monitors water quality.

In the unseasonably warm March of 1936, the Northeast's snowpack melted quickly and joined with a heavy rain to send water rushing down the Allegheny and Monongahela rivers toward Pittsburgh. The rivers rose 21 feet above flood stage in what became known the Great St. Patrick's Day Flood.

In the city, the flood killed 45 and caused $250 million in damage (equivalent to $4 billion today). Throughout the Ohio River Valley, the totals were even higher. Across the nation, the disaster brought a big change to the way governments protect people from floods. It helped motivate Congress to pass the Flood Control Act of 1936, which made corralling rising rivers the job of the federal government and assigned the task to the U.S. Army Corps of Engineers.

Fast forward 75 years and millions of dollars in construction projects later, the Army Corps' Pittsburgh District manages 16 dams and reservoirs throughout Pennsylvania, Ohio, West Virginia and New York. All told, the projects cost around $500 million to build and are estimated to have prevented as much as $10 billion in flood damage since the first dam was completed on West Virginia's Tygart River in 1938.

The dams are still serving their original purpose: A 2004 flood would have risen nearly eight feet higher if it weren't for the runoff-storing capacity of the reservoirs. But the Congressional authorization under which the dams are built and operated gives the Corps responsibility for more than just controlling floods. Depending on location, the reservoirs and downstream waters are also managed for water quality, water supply, conservation of fish and wildlife, and recreation.

The Corps' dams in the Mahoning River watershed were built as much to help water quality as they were for curbing floods, said Rose Reilly, a biologist with the Pittsburgh District.

"Steel manufacturing facilities and support industries would reuse the river water three or four times before it reached the mouth of the Mahoning," Reilly said. "Before we built our headwater reservoirs, river water temperatures during the summer could reach as high as 130 degrees Fahrenheit."

The Corps built dams in the Mahoning River's upper reaches and tributaries to keep downstream water temperatures below 100 degrees. Water stored in the reservoirs and released during the summer helped bolster the season's low flows and buffer the effects of industrial discharges.

Though water quality in the watershed has improved dramatically since the heyday of steel manufacturing and the passage of the Clean Water Act, the additional flow from the reservoirs continues to help streams meet cleanliness standards by diluting pollution.

Photo: Fondriest Environmental

Though some of the dams were built to address World War II-era problems, today the District is taking a 21st century approach to its water-quality mission. A modern monitoring system is an important part of that. At 12 of their 16 reservoirs, a buoy-supported sensor string is continuously measuring temperature at every three feet in the water column and relaying the data back to their offices. Dissolved oxygen, specific conductivity and pH are measured at three buoys.

Temperature data collected at multiple depths shows water managers a picture of reservoir stratification patterns. Monitoring is particularly important at the district's selective withdrawal dams, which have intake gates for drawing reservoir water at multiple depths. As stratification progresses throughout the summer, metals, nutrients and other pollutants concentrate in the reservoir's cooler bottom layer. Water managers can choose to release higher quality from the reservoir surface water or to blend releases from multiple gates so that highly anoxic and reduced waters with high concentrations of dissolved metals and nutrients are not being released downstream.

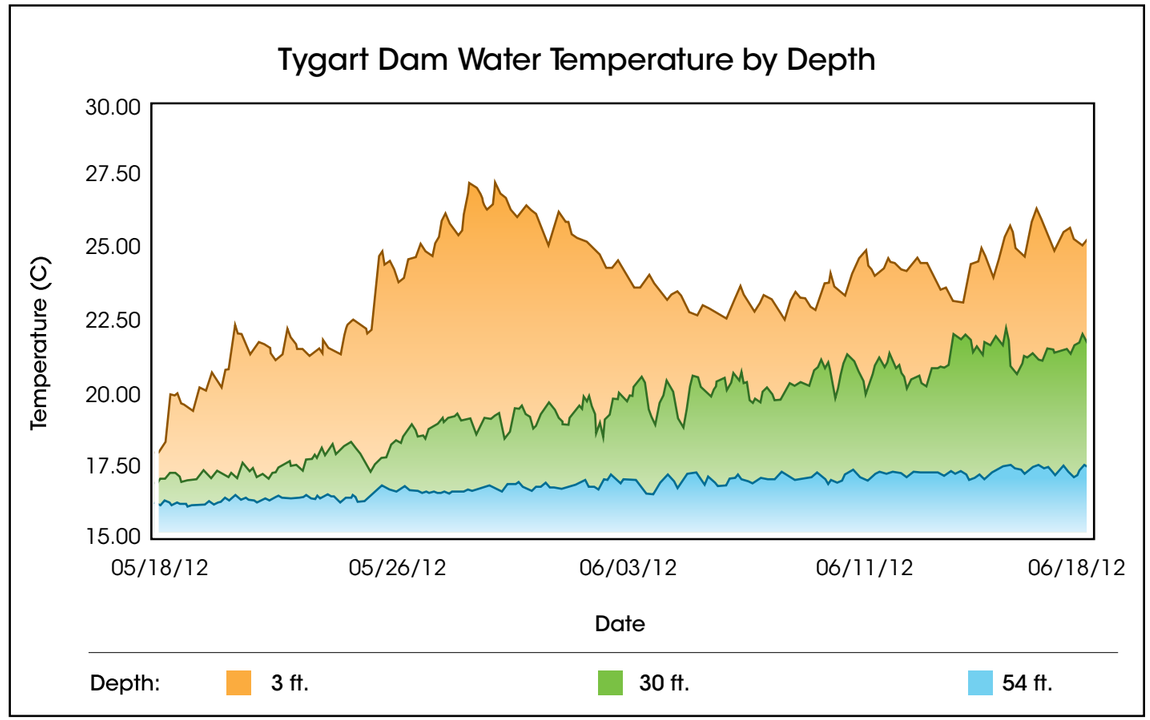
Selective withdrawal intakes also allow water managers to regulate downstream water temperatures to support fisheries or improve water quality. "In essence, the upper and lower intakes are used like cold and warm water spigots that allow blending to meet downstream temperature objectives," Reilly said.

Though water managers follow prescribed schedules which dictate how much and when water passes through each dam, they can make subtle adjustments based on environmental and hydrologic conditions, using real-time data. "So water managers follow schedules but have some flexibility to modify operations to optimize water quality and aquatic life benefits. For example, the amount of flow released or timing of the release can be modified slightly to better support a fish spawn."

The Pittsburgh District's 16 dams will be doing that job for the foreseeable future, despite a nationwide trend that has seen such structures increasingly targeted for removal. More than half of the dam removals in U.S. history have occurred since 1999, according to data from American Rivers, a non-profit group that tracks and advocates for removals. Work on the world's biggest-ever dam removal project started in 2011 when crews dismantled the Elwha Dam on the Elwha River, which flows from Olympic National Park in Washington out to Puget Sound. A few miles upstream, demolition of the Glines Canyon Dam is underway. It will be the tallest dam ever removed.

The science that describes the environmental degradation associated with dams is relatively new, Reilly said. It appears that the Corps is unlikely to turn to new dams to solve water resource problems; the Pittsburgh District's most recent dam was finished in 1988. Meanwhile, the districts dams aren't on the table for removal.

"Our projects have Congressional authorizations for flood control, water quality, navigation, water supply and water quality," Reilly said. "If the dams were removed, these benefits would be lost and there would be a significant change in the quality of life for the folks who live in the watersheds." JG



Ohio's Cranberry Bog

By Audrey Carson

Betty Martin, 96, led the tourist group off the bus in Buckeye Lake, Ohio and walked down a dock to an old pontoon boat where three Buckeye Lake Historical Society members welcomed her with open arms.

"Well, bless your heart, my dear, welcome aboard the Queen of the Lake!" exclaimed Lois Holler, a guide specialist with the historical society.

Martin and other members from a local tour group came out on a sunny afternoon to see a unique treasure – the only cranberry bog in the world completely surrounded by water. It's a good thing Martin came when she did because she may outlive the bog. By the time she is a century old, it may no longer exist.

The cranberry bog made its way to Ohio when a glacier pushed a belt of Canadian forest south, eventually creating a mat of sphagnum moss. Bog plants, including the namesake cranberry, thrived in the sphagnum moss. When engineers constructed the Erie Canal in the 1820s, they flooded the valley where the bog was, creating a reservoir for the canal. Only 50 acres of the sphagnum moss mat remained on the surface of the water. The result was the only known bog in the world to be completely surrounded by water. Typical cranberry bogs are akin to wetlands in that they are a marshy area on land.

The bog mat in what became Buckeye Lake has since dwindled in size. It turns out that deciduous trees do not thrive well in sphagnum moss because it releases hydrogen ions, resulting in a pH of 4 and few nutrients. When the large trees on the bog die, they fall over, taking a hunk of the mat with them and over time reducing the acreage of the bog. It is now down to 10 acres from the original 50.

"We are extremely careful because [the bog] is extremely delicate and we know it," Holler said.

J-me Braig, director of the historical society, urged the tour group not to touch any of the plants as members walked from the boat to the boardwalks that snaked through the bog. As Braig walked through cranberry plants, the sphagnum moss gave with each step, making it look as though she was walking on a trampoline. Braig pointed out not only cranberry plants, named for their white flowers that look like cranes, but carnivorous pitcher plants and sundew as well.

Its fragile nature is why a trip to the bog is a rare opportunity – it must be on a scheduled tour or on Cranberry Bog Day, the third Saturday in June of each year. In previous years, only the first 400 people drawn from a lottery could visit the bog on this day. However, since the Buckeye Lake Historical Society took over management of the bog from the Ohio Department of Natural Resources in November 2011, Cranberry Bog Day is now open to everyone. It attracts more visitors than locals.

"Most of the people who come are fascinated," said Charlotte Bennet, pilot of the Queen of the Lake. "People come from far and wide to see it, but people who live here have never seen it."

It wasn't always that way. On the boat ride, Braig passed around an old photograph of Buckeye Lake Park, a small amusement park that was a popular choice for company picnics. The park closed in 1970 and the cranberry bog became a state nature preserve three years later.

With the Buckeye Lake Historical Society now managing the bog, it is in the hands of people from multiple fields, including those who have seen its evolution over a lifetime. Braig has directed the society for six years, taking over the position from her mother, Donna, who founded the society. Though the future of the bog is uncertain, the historical society is working to enforce a no wake zone near the bog and to reduce wave action in the vicinity to give it every chance for long-term survival for more generations to enjoy. AC

Photo: Melissa Elkins

Prickly Situation

By Jeff Gillies

"The prickly pears are so abundant that we could scarcely find room to lye," wrote Meriwether Lewis in a July 20, 1805 journal entry as he and William Clark crossed Montana on their journey back from the Pacific coast. The site where Lewis penned that lament falls today within Lewis and Clark County, and the cactus that troubled him is the namesake of Prickly Pear Creek, one of the lakes and streams under the care of the county's Water Quality Protection District.

The unspoiled waters plied by the members of the first U.S. transcontinental expedition now face impacts from abandoned and operating mines, septic tanks, timber harvests and grazing livestock. Meanwhile, parts of the district have seen rapid residential development while demand for water sometimes exceeds the supply.

"We're in the middle of quite a complicated scenario," said Jim Wilbur, the Water Quality Protection District's coordinator. "So that's why we're at least trying to develop the data so planners and policy makers can have informed decisions."

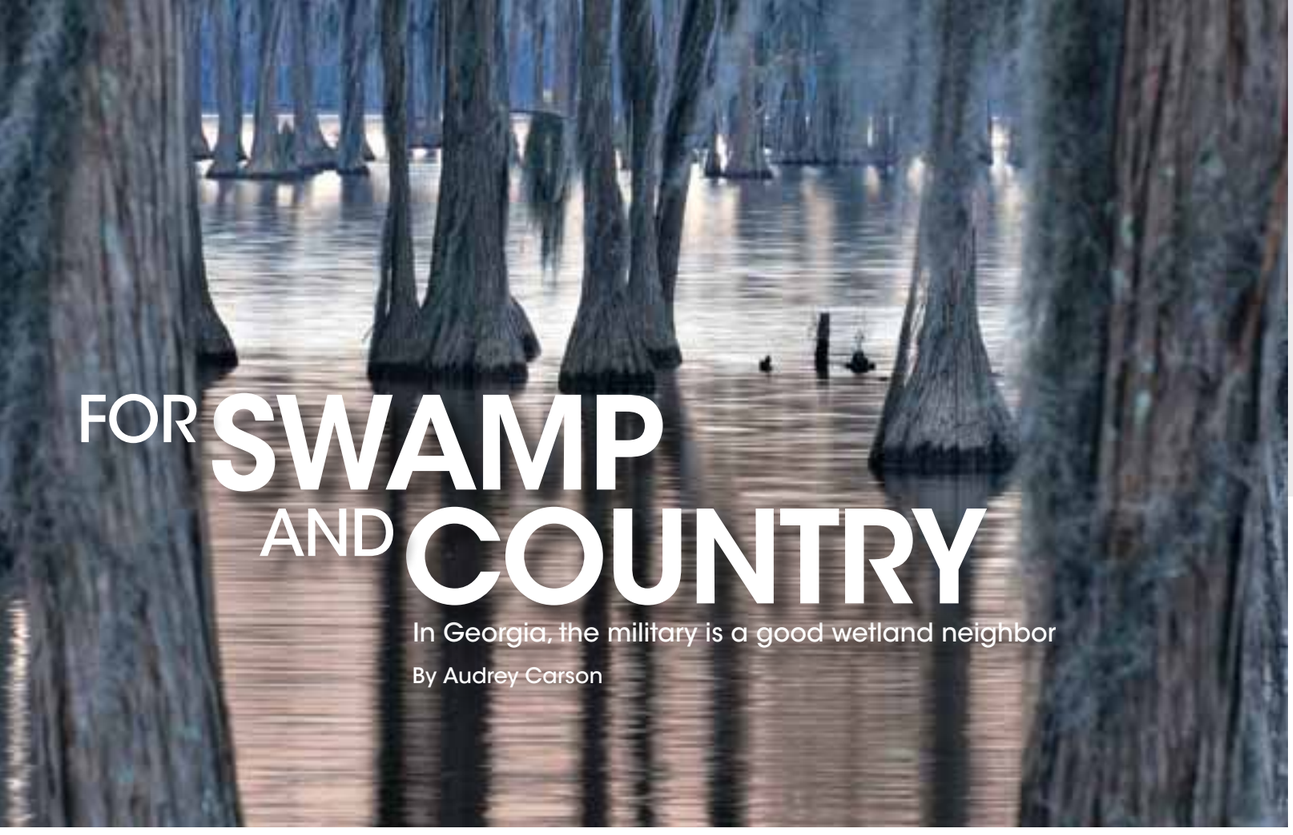
That data development includes a study of how groundwater and surface water interact. They've installed piezometers to measure shallow groundwater at several sites where they're also monitoring streams. Though the link between surface and groundwater has been long accepted by scientists, the Montana Supreme Court acknowledged the connection only recently. Before that decision, the state managed surface water and groundwater rights through separate programs.

"Now they're kind of a combined program," Wilbur said. "If you want a groundwater right in our area, and it has some ability to impact water supply to the streams, you have to basically retire an older surface water right to get that."

The district monitors groundwater levels at over 100 wells to help track the region's bedrock and valley alluvium aquifers. Water supply issues are a big concern, Wilbur said, and the region just came out of a 10-year drought that saw some wells going dry. But 2011 brought abundant snow pack, rains and flooding.

"So we're seeing the other side of that coin," Wilbur said. "By measuring water levels, you get groundwater directions and how the aquifer responds to those change in climate." JG

Photo: Dallas Krentzel



FOR SWAMP AND COUNTRY

In Georgia, the military is a good wetland neighbor

By Audrey Carson

It's rare that more than one entity involved in a wetland wants to keep it natural. The Grand Bay and Banks Lake (GBBL) wetland complex in South Georgia has four organizations looking out for its best interests, including one that oversees national security. The 18,000 acre complex, consisting of seven large, loosely connected wetlands, is co-owned by Moody Air Force Base, the Georgia Department of Natural Resources, U.S. Fish and Wildlife Service and The Nature Conservancy. It's also protected by the United States Department of Defense (DOD).

Sitting in the middle of the wetland complex is Moody Air Force Base, which owns the greatest share of the wetlands. In 2003, after a report by The Nature Conservancy revealed a rapidly growing local population was threatening the quality of the wetlands, the DOD issued a Legacy Grant to spearhead a management plan for the land. This included collecting baseline data of the hydrology and ecology of the area as well as a map of the current and historic vegetation within the wetlands. Moody Air Force Base wildlife biologist Gregory Lee said the base has always been interested in maintaining the natural state of the wetlands.

"Our job is to integrate the military mission with the management of the ecosystem," Lee said.

The sentiment is reflected across all military branches. Though the GBBL wetland complex is unique in its composition and organization involvement, it is a mere 18,000 of 30 million acres managed by the DOD. At 420 species, the DOD also has more threatened or endangered species under its wing than any other federal land management agency.

"If you look at the Department of Defense as a whole, [it] does an outstanding job of managing its natural resources," Lee said.

Moody Air Force Base instigated its plan of attack by creating the Grand Bay Banks Lake Council, a partnership group comprised of members from landowning organizations with an interest in the integrity of the wetlands. The council developed a cooperative stewardship plan with goals to create a database for the GBBL ecosystem while keeping in mind human use of the wetlands. Among priority objectives were enhancing the habitats of wading birds, including the endangered wood stork, limiting logging of hardwood hammocks that shelter many endangered species and prohibiting commercial and residential development within 150 meters of wetlands and aquatic systems. To fulfill the grant, the council then needed to collect baseline hydrological and ecological data.

To begin hydrologic monitoring, the base consulted the Joseph W. Jones Ecological Research Center in Newton, Ga. to conduct a preliminary hydrologic evaluation of the Grand Bay and Banks Lake area including a water quality evaluation.

"It's honorable on their part to want to understand the water quality and how their activities and how other activities around these wetlands may be impacting the quality of the wetlands," said Woody Hicks, Jones Center hydrologist. "It's part to their advantage and it's also being a good steward and neighbor."

Hicks and Brian Clayton, Jones Center monitoring technician, installed monitoring platforms throughout the complex. The platforms are wooden docks equipped with six YSI 6600EDS V2 sondes to measure temperature, dissolved oxygen, specific conductivity, pH, and turbidity. Five platforms incorporate OTT Thalimedes sensors to measure surface water level. The equipment records water quality data every hour and Hicks and Clayton check the data every two months. The water quality information collected within the Legacy Grant year was included in The Nature Conservancy report on project results.

Sandhill cranes and American alligators are often found in Grand Bay.

After the grant expired in 2006, Lee and Hicks did not feel they had enough information to capture a hydrological or biological snapshot of the GBBL wetland complex – in fact, Lee wanted a photo album. Using funds allocated to the Air Force base from the DOD, the base asked The Jones Center to perform a five-year study of the wetlands system beginning in 2008. The Jones Center now provides Moody Air Force Base with a yearly report of wetland hydrology and any changes in water quality or ecology that have occurred.

"It's essentially been a discovery project in the beginning and now it's a long-term monitoring project," Hicks said.

The monitoring will keep a finger on the pulse of a thriving wetland complex that reaches far beyond the Air Force base. The complex facilitates a wide array of activities including fishing and water recreation opportunities in the section maintained by the U.S. Fish and Wildlife service. The Banks Lake area includes a deep water wetland where public fishing is permitted.

The Grand Bay area features a wetland education center operated by the Georgia Department of Natural Resources that is booked nearly every day by school groups, Hicks said. Visitors can walk across the half-mile boardwalk and view the wetlands from a 54-foot observation platform. The natural history museum provides information about rare local species including gopher tortoise, wood storks and the indigo snake. These species are heavily considered when wetland management decisions are made.

Hicks, Clayton and Lee all mentioned what good condition the GBBL wetlands are in – something you may need to hear three times to believe after all the bad news about wetlands lately.

"They are carefully maintained and controlled because of their various conservation interests to the organizations that own them," Hicks said. "All of the partners are eager to keep the wetland healthy."

The timing of the proactive stewardship plan was also ideal.

"Most people usually wait til it's bad to start studying things," Clayton said.

However, not even the DOD can control Mother Nature, who has been stingy with rainfall over the past year in South Georgia, among many areas in the United States. All involved said they hope the rain comes soon in this third year of the five-year project to produce a true reflection of the area's ecological parameters. In the meantime, it's in good hands.

"The military has been a good steward of this resource," Lee said. "The water leaving this base is just as clean as the water that falls on this base." AC

All Photos: Tom Wilson

Pursuing Ecology's 'Digital Revolution'

Profiling in the Poconos

By Jennie Brentrup

I arrived at Miami University in the fall of 2011 after completing my undergraduate work in biology at Colby College in Maine. I knew that a PhD in Zoology working with Dr. Craig Williamson in the Global Change Limnology Lab would be both rewarding and challenging, but I had no idea how exciting the opportunity would be.

Dr. Williamson's interests in ultraviolet radiation, climate change, and his desire to delve deeper into the study of alpine lakes as sentinels for the environment has lead his research team around the world. Project sites include northeastern Pennsylvania, Alaska, Lake Tahoe, the Beartooth Mountains, Canadian Rockies, Argentina and New Zealand.

As part of the National Science Foundation's Integrative Graduate Education and Research Training (IGERT) program at Miami University, I decided to pursue an internship with Fondriest Environmental. The focus of my IGERT program is on Environmental Aquatic Resource Sensing (EARS), so an internship with Fondriest Environmental was an excellent opportunity to work with a company advancing the field of sensor technology.

This summer's project will center on water and climate monitoring on Lake Lacawac, a small and very pristine Pocono Mountain lake in northeastern Pennsylvania.

Our research team decided to custom-build a profiling buoy to capture fine resolution water quality data throughout the water column and near lake meteorological parameters. This type of buoy will allow us to investigate long-term changes in the water clarity of Lake Lacawac, as well as the effect of increased episodic storm events, such as hurricanes, on ultraviolet (UV) transparency and lake mixing properties.

In order to take many different measurements associated with changes in weather and water quality parameters, a stable buoy design was required to support an array of sensors and power capabilities. The floating platform builds off of the work of a former graduate student in our lab, Dr. Kevin Rose, who developed a similar system in 2009 for research in the Beartooth Mountains in Montana. Using three pods, the weight of the buoy is spread out over a larger surface area to enhance stability and improve buoyancy. On top of the three pods sits a tower with a solar panel that allows the buoy to run completely on solar radiation by continuously charging batteries that power the sensors.

A weather station, photosynthetically active radiation (PAR), and net solar radiation sensor are all attached to the tower so accurate rain, wind, and solar data can be gathered in the same location as the underwater sensors. The tower also houses a smart winch and motor, which allows the underwater sensors to move vertically in the water column. The smart winch consists of a single lay wheel inside a plastic housing that only requires one thin cable for the instruments to profile. It's configured with WiFi capabilities, so it can receive data from the sensors once the underwater data logger returns to the water surface at the completion of a profile and then transmit the data to a computer on shore.

This technology is a large advancement over previous buoys that had trouble profiling with multiple cables. The smart winch can be controlled through an iPhone app or on any laptop with WiFi capabilities, allowing easy checks on its performance and maintenance. The data will also be available online for anyone to view, allowing for greater community involvement and cooperation among researchers at different institutions.

As hurricanes hit the east coast with greater frequency and duration, researchers are relying more heavily on high-frequency data from sensors to better predict and understand the implications of storm events.

On the profiling buoy, multiple sensors collecting high-frequency data are attached to an underwater cage, which allows our research team to study changes occurring at different depths in Lake Lacawac at time scales never before possible. With advanced sensor technology on buoys, we are able to fill in the holes of what is occurring in lakes in between traditional manual sampling that typically occurs on a weekly or monthly time frame.

A YSI sonde and Turner Designs C6 multi-platform, as well as two Li-COR PAR sensors are profiling underwater as many as four times a day.

As a leading expert on the effects of climate change on lakes, Dr. Craig Williamson's focus on applying research to current environmental issues fit with my desire to be involved in aquatic ecology research that is relevant beyond the scope of the scientific community and could help inform policymakers.

Often climate change is mostly thought of in terms of increases in temperature. Although temperature is a significant aspect, rainfall has also increased, but it has typically come in the form of episodic storm events, such as hurricanes that cause significant damage with heavy rainfall and severe wind.

If these storm events continue, considerable changes will occur in lakes with yet unknown consequences. With the ability to gather data at different depths, the profiling buoy will allow us to take a peek into the future to better understand our changing climate. JB

TRIAL RUN

To verify performance, the profiler was deployed in the Miami University dive pool. With a WiFi connection to an iPhone, researchers were able to exercise the smart winch, sending the underwater platform up and down on command. The topside atmospheric sensors and a complete set of water quality sensors collected data during the pool trials. After two successful dive pool tests, the research team was confident that the system was ready for field deployment in the Pocono mountain lake.

WIRELESS Wetland

By Alexandra Hazlett

On a muggy day in January, 2012, researchers waded into the south Florida wetlands to install a monitoring tower. Located near Big Cypress Swamp, the equipment will take hourly measurements and report back on the water quality of the wetlands.

The long-term goal is to help restore the area, according to project's leader, Dr. Li Zhang, assistant director of the Everglades Wetland Research Park. First, they need to know the baseline conditions — hence the wading trip.

"We need scientific data to support [restoration efforts]," she explains.

The Everglades Wetland Research Park is part of the Kapnick Center, located on the campus of the Naples Botanical Garden. The research park, which is a Florida Gulf Coast University facility, was created to "provide teaching, research, and service related to wetland, river, and coastal science and ecological engineering."

South Florida's ecosystem needs all the help it can get. Unaware of the hugely important niche occupied by wetlands, successive generations attempted to drain and control the area.

In 1948, Congress authorized the Central & Southern Florida Project (CSF), an ambitious and mostly successful effort to tame and control the floodwaters that continually ravaged South Florida. About 1,000 miles of levees, 720 miles of canals, and nearly 200 miles of water control structures were built to "provide water supply for municipal, industrial, and agricultural uses, prevention of saltwater intrusion, water supply for Everglades National Park, and protection of fish and wildlife resources," according to the Comprehensive Everglades Restoration Plan.

The CSF was passed in response to decades of difficulties with the South Florida landscape. The area's interior was barely habitable. Droughts threatened the fresh water supply and floods destroyed homes. Unfortunately, while the CSF fueled South Florida's development, it worsened the Everglades' serious problems.

While the ecosystem used to be the domain of alligators, panthers and countless flocks of migratory birds, the wildlife dwindled as the human population rose from 500,000 in

the 1900s to its current level of 6 million. The term "Everglades" generally is shorthand for Everglades National Park, but the "River of Grass" used to cover nearly all of South Florida. The whole ecosystem of the area has been impacted by development.

Now (as before), the area suffers from droughts and overabundance of water, usually at the wrong times of the year. Development caused water to run off too quickly, draining into the ocean and reducing the water available to the ecosystem. What water did enter was of poor quality, and it no longer moved freely throughout the system.

Over the past decades, the world has come to appreciate the beneficial role that wetlands play in the larger ecosystem. The Ramsar Convention on Wetlands lists flood control, groundwater replenishment, shore stabilization and storm protection, water purification, and climate change mitigation and adaptation among the benefits of wetlands — the same benefits that draining was supposed to provide. The convention classifies the Everglades as a "Wetland of International Importance," in addition to its designations as a World Heritage Site and International Biosphere Reserve.

The Water Resources Development Acts of 1992 and 1995 started a process of reexamining the CSF, and the creation of an ambitious long-term initiative – the Comprehensive Everglades Restoration Plan – to renew the health of the ecosystem. One of the goals of the plan is to capture most of the 1.7 billion gallons of water that are discharged daily and use it to supply the natural system and the needs of the population. More than 240 miles of project canals and internal levees will be removed to lift barriers to water movement.

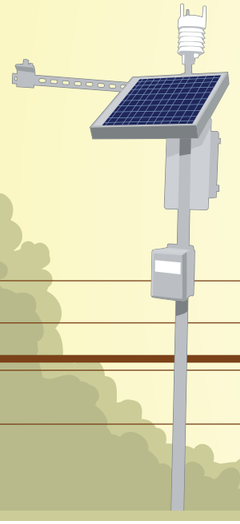
Long marginalized, the Everglades are finally being appreciated, but Zhang's research won't stop at the South Florida border. The restoration project has larger goals than local development. Collaboration with international scholars is planned, as well as inquiry into how wetlands can help mitigate the effects of climate change.

"Wetlands are a very important landscape," Zhang says. AH

SYSTEM DESCRIPTION

The centerpiece of the FGCU wetland monitoring station is the NexSens 4100-MAST Radio Data Logging System. This system includes a 4100-iSIC data logger with radio modem, 20-Watt solar charging kit and high-powered Yagi radio antenna mounted to a 1-1/2" stainless steel pipe. This pipe telescopes from a 2" stainless steel pipe and has two height settings – the lower setting for access and maintenance and the higher located above flood stage to protect the logger and maximize the radio signal.

The iSIC data logger records data hourly from a vented water level sensor and YSI multi-parameter water quality sonde equipped with temperature, conductivity, pH, turbidity and dissolved oxygen (DO) sensors. Data is transmitted wirelessly from the monitoring site to Dr. Zhang's office in the Kapnick Center. There, a PC running NexSens iChart software retrieves and displays the data in real-time to staff and visitors on a 55" flat screen monitor. Data is also pushed to a web datacenter hosted by NexSens for 24/7 access from any web browser.



WEATHER on the SAVANNA

Scientists at Texas A&M search for the causes of woody encroachment

By Alexandra Hazlett

South Texas is a brutal landscape. For weeks on end each year, it's possible to have high temperatures hovering above 100 degrees Fahrenheit, and lows that don't dip under 90. The state, which has both large cities and vast rural areas, is extremely water-stressed.

"It's really torturous," says Darrin Moore, a research associate with the Department of Ecosystem Science and Management at Texas A&M University.

Moore should know - he and his team have been studying the local weather patterns for years, the latest in a long line of science that has come out of area. Their most recent project is a remote weather station at La Copita Research Area.

La Copita was donated to Texas A&M in 1981 to "address the multi-faceted problems of grazing land and natural resources management in South Texas," according to the university's website dedicated to the area. Meaning "little cup" in Spanish, the 2,726-acre tract of land is located about 15 miles south and west of Alice, Texas.

Local accounts hold that the area was primarily used for cattle grazing, and a small cattle and goat herd are still kept for research purposes. In conjunction with another experimental range in College Station, La Copita functions as a place to monitor environmental changes and test out theories of land management.

The landscape of La Copita is considered a subtropical savanna - an ecosystem characterized by grass, with some trees openly spaced so the canopy is not closed. Savanna environments generally experience rainfall variation from year to year (usually concentrated in one season) and wildfires in the dry season. The amount of wood shrubs or trees can vary in a savanna, but lately, woody encroachment, as the shift away from a preponderance of grassland is known, has become a concern. Not just for La Copita, but for many savannas.

"The topic of woody encroachment into grassy areas is one of concern, " Moore says.

The precise causes of woody encroachment in a savanna are unknown. The ecosystem is incredibly fragile - probably as fragile as a desert, says Moore, since it's such a narrow band across the state.

Scientists are studying the problem from all angles - grazing, climate, season, precipitations, chemicals such as herbicides, fire, etc.

What is known is that clusters of woody plants, namely Mesquite, are becoming more frequent, edging out the grasses and altering the landscape to be more hospitable to their arboreal brethren.

"Is it the chicken or the egg - did the shrubs move in because the grass could no longer compete?...[We're] trying to find what is the key source for woody encroachment into the grasslands," says Moore.

Take precipitation, or the lack thereof, as a place to start. The proliferation of mesquite clusters could be caused by more frequent droughts. The lack of water may be giving the tree a competitive advantage over the grass. Or the ecosystem is changing in response to the water stress and the resulting mechanism favors the growth of more trees. The trees could also be a passive beneficiary of the situation, perhaps it's the grasses that are being pummeled and can no longer outcompete the trees.

The effects of controlled burns and forest fires are similarly hard to pin down. According to the Encyclopedia of Earth, low-intensity fires keep the growth of woody species in check. But as cattle grazing has become widespread, the herds have reduced the fuel load (grasses), making fires less frequent, and providing an opening for woody encroachment. Wildlife grazing, in contrast, tends to keep such shrubbery in check.

The phenomenon of woody encroachment, which seems to be a new development, may actually reflect natural cyclical changes in vegetation. Early descriptions of the area do not mention trees, though the exact makeup of the environment is unclear.

Illustration: Nate Christopher

Absent a good historical record, it is difficult to comprehend the extent and novelty of the changes currently being observed.

A salient question in the middle of all this is: Do these changes matter? Is woody encroachment on savanna grasslands actually a problem? As with most issues, says Moore, it depends on who you ask.

Ranchers need grass to graze cattle, so tree encroachment represents a negative for them. But for browsing deer and birders, the changes are welcome.

"From a scientific point of view, from a botanist point of view, we're just interested in the change, and why that's occurred," Moore says.

Land management is a tricky issue in Texas, which, unlike other states, doesn't have vast tracts of land controlled by the Bureau of Land Management (BLM). Ranchers have full control over their spreads, which may cover hundreds of square miles. Such decentralized control has not been a problem, says Moore, until a prolonged drought started 3-4 years ago.

The expansiveness of the ranches and the unpredictability of climate change can exacerbate unintentional mismanagement by individual owners. The cumulative effects of those decisions -- digging new wells, cutting down trees -- can add up.

Juniper, for instance, is often removed from the banks of rivers in order to raise aquifer levels and leave more water for plants and animals. While a rancher may remove those trees, and then see a water level increase in the aquifer, Moore says there's no proof that cutting down the tree actually helped. Often, a similar native species will move into the niche left by the juniper, keeping an environmental status quo.

"You take out a Tamarisk and you get a Cottonwood," says Moore.

Getting buy-in for altered land-management practices is an ongoing campaign. In some areas, demonstration fields are used to test new procedures and prove their effectiveness as a way to spread knowledge through the local population.

Large-scale environmental shifts may also have an effect on climate change - which, like everything else, is unclear. Different types of plants alter the microclimate of the soil in which they live. This process has implications for the amount of nitrogen in the soil (Mesquite is a nitrogen-fixer — taking the element from the air and storing it in its roots). Dry environments, Moore says, tend to be low in nitrogen.

Another key question is whether the vegetation shift will have an effect on underground carbon sequestration, and if so, what will it be. Scientists are still trying to determine the full amount of carbon stored underground in soil all over the world. This unknown variable plays a major role in global warming models because carbon dioxide acts as a multiplier for the effects of warming, speeding up the cycle. Understanding the soil microclimate and how it is changing is a key goal of Moore and his team's research.

While the team begins to assess the incoming data, ongoing experimentation at the range in College Station may provide some insight. Researchers set up different plots of trees, each planted in a particular matrix. They then used heaters to raise the temperature of the mini-ecosystems, and also manipulated the rain cycle. The goal was to observe how the trees grew, and how different species grew together. The initial findings, Moore explains, showed that monoculture did not do as well under heat and water stress.

Monitoring will continue, as will the search for answers, and the larger trends behind the change in the savanna landscape.

"We're just trying to determine the connectedness of everything and where that connectedness lies," says Moore. AH

GEAR UP

Hach 2100Q

Have complete confidence in your measurements with Hach's 2100Q portable turbidity meter. This compact device will provide accurate turbidity readings every time, no matter the environment or application.

In full calibration mode, the 2100Q walks the user through the calibration process step-by-step and automatically verifies accuracy. The meter measures to an accuracy of 0.01 NTU based on the Environmental Protection Agency Method 180.1 design criteria.

For low turbidity situations (nothing exceeding 40 NTU) the 2100Q offers the convenience of "RapidCal," a faster calibration process that only requires use of a single standard.

The turbidimeter automatically stores 500 measurements for easy access and stress-free backup, including date, time, operator ID, reading mode, sample ID, sample number, units, calibration time, calibration status, error messages and the measurement result.

NexSens MB-100

The versatile NexSens MB-100 Portable Data Buoy will withstand years of use in both surface and sub-surface monitoring applications. Weighing just over 30 pounds as a complete system, a single person can easily deploy the MB-100 from any size vessel.

Experts designed the data buoy with a sturdy stainless steel frame and polymer coated, cross-linked foam hull for exceptional durability. All sensor connections are concealed below the surface with rugged waterproof connectors. A wireless radio-to-shore, cellular, or Iridium satellite transmitter can be positioned above the water but hidden and protected under the buoy hood.

NexSens Fast T-Node

Build a network of NexSens Fast T-Node temperature sensors to accelerate your next monitoring project. Newly released from NexSens Technology, the improved Fast T-Node boasts quicker responses, higher accuracy and greater interface capabilities for precise temperature measurements in an addressable and connectorized assembly.

The Fast T-Node's accuracy is +/- 0.05 C, offering more precise readings within seconds rather than minutes. Explore additional features including industrial standard Modbus interface, accommodating direct connection to SCADA systems without an expensive controller. RS-485 interface also increases string length capability as well as the number of nodes that can reside on the same temperature string.

YSI EXO1

YSI's state-of-the-art EXO Sonde is a smart, field-ready monitoring device that truly "breaks the sonde barrier." Two models of the EXO are available with a wide range of capabilities, each ideal for use in natural freshwater and saltwater aquatic environments.

The EXO1 features four universal sensor ports, while the EXO2 contains six sensor ports plus a central port for an anti-fouling wiper. Each model is secured within high-impact Xenoy Housing. Parameters include temperature, dissolved oxygen, pH, ORP, conductivity, depth, total algae (phycocyanin and chlorophyll), turbidity, and fluorescent dissolved organic matter (fDOM). The sonde also provides four calculated parameters including specific conductance, salinity, total dissolved solids (TDS) and total suspended solids (TSS).

The sonde sensor ports are 'smart' ports with active monitoring that detects sensors and any damage to them. The port will automatically shut down if damage has occurred.

The EXO Handheld has an IP67 rating, providing wireless connection with EXO sondes. KOR Interface Software offers users the ability to manage field data collected from EXO sondes easily and efficiently. It provides interface for fast-calibration and configuration, designed specifically for long-term monitoring.

YSI ProODO

Spend more time researching and less time maintaining your dissolved oxygen (DO) meter. Low-maintenance optical technology eliminates the need for cleaning electrodes and changing solutions.

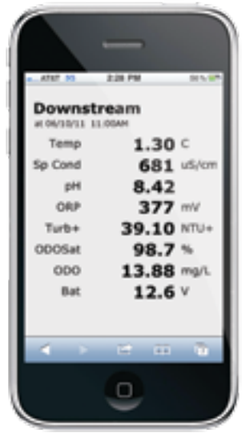
Luminescent detection does not consume oxygen while sampling. No stirring is needed and external gases are prevented from disrupting the sample. The 'smart sensors' can also store calibration data and be placed on any ProODO instrument without re-calibration.

With field durable cables, MS-8 connectors, rubber over molded IP-67 waterproof case, the ProODO is suitable for rugged field applications.

NexSens WQData

NexSens WQData is a secure online datacenter, providing a Web interface for real-time environmental data.

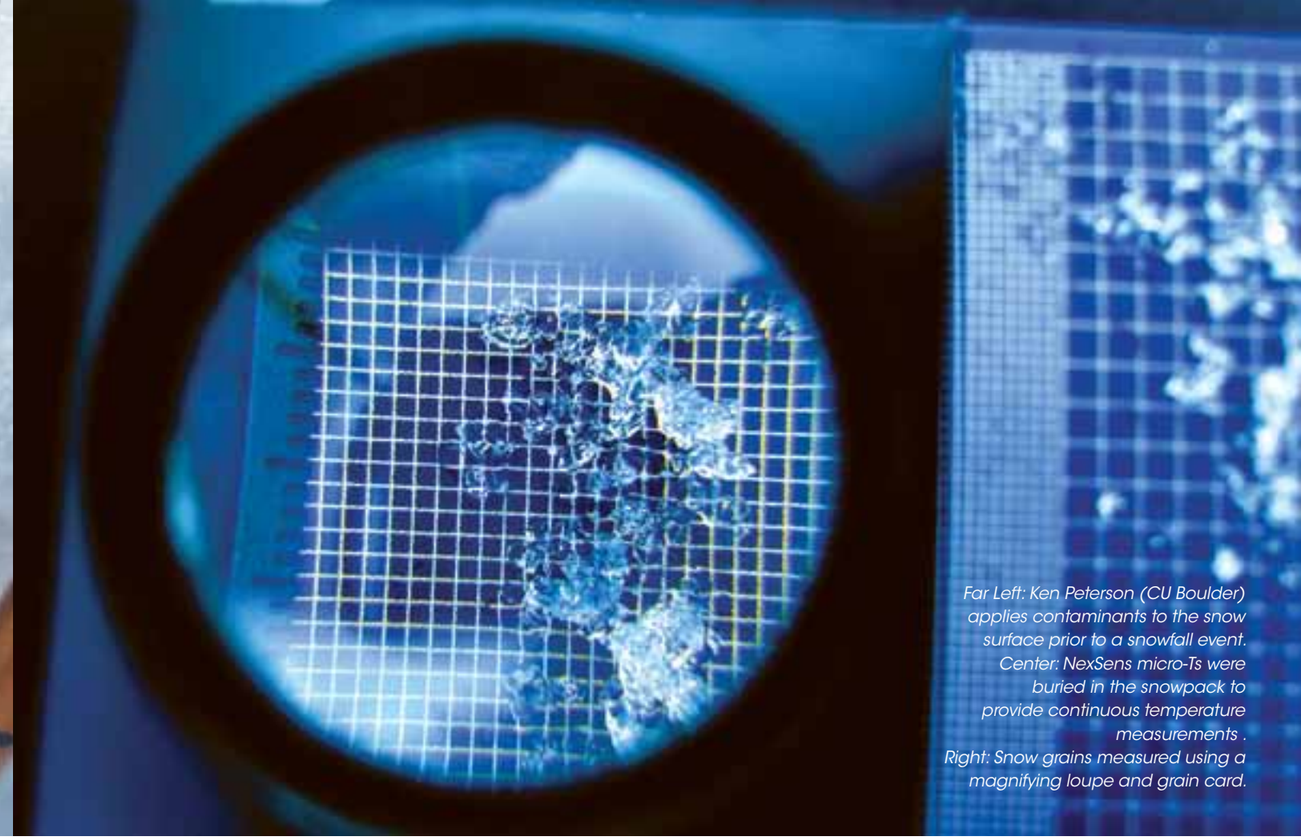
Visitors can interact with the project's maps by zooming for a detailed look at any monitoring location. Each WQData site is automatically generated by NexSens iChart software and posted to the web at a user-defined interval. Visitors can view project data in real time via WQData's mobile app, offering 24/7 instant access using any internet browser.



WQData allows for comparison of multiple monitoring sites instantly using a graphical, easy-to-use interface for quick view of project maps, creation of statistical summaries, or interaction on the community forum.

ROCKY MOUNTAIN FEVER

By Audrey Carson



Far Left: Ken Peterson (CU Boulder) applies contaminants to the snow surface prior to a snowfall event. Center: NexSens micro-Ts were buried in the snowpack to provide continuous temperature measurements . Right: Snow grains measured using a magnifying loupe and grain card.

A skiing enthusiast, Danielle Perrot has understandable concern for the condition of her recreational surface. If the snow is too dirty, it sticks to the skis. If it melts too early, the ski season ends prematurely. If the mountain pine beetle infestation spreads, trees fall on the slopes, hopefully missing skiers. There is a lot to think about other than enjoying the slopes.

Conveniently, Perrot is an alpine researcher at the University of Colorado-Boulder studying the effects of dust and pine needles on snowmelt. Pure white snow easily reflects solar rays, preventing it from melting quickly. When debris falls on snow, it reduces the snow's albedo, a measure of the snow's ability to reflect light. Reducing the albedo increases the amount of energy absorbed rather than reflected, which causes the snow to melt more quickly. Aside from cutting the ski season short, it affects hydrology in nearby streams and rivers.

In the western United States, including the Rocky Mountain region and California, a majority of the water flowing in rivers and streams originates from snowmelt. Normally, thick snowpack acts as a drip irrigation system, slowly melting and releasing water from the natural reservoir. Those who depend on this water, such as farmers in California and Arizona, expect a high flow in June and July, as this is when most of the snow is melting. However, when snow melts sooner, reservoirs downstream are not expecting the sudden influx of water. Water schedules are thrown out of sync, affecting soil moisture, productivity, and biologic activity.

Perrot's research will study how dust and pine needle contaminants affect the timing of snowmelt. It will eventually be incorporated into snow models that currently lack snowpack contamination data.

"Everybody thinks albedo is really high in snow and that this high albedo lasts long into the season," said Evan Pugh, a member of Perrot's research team. "Almost everywhere we've looked in Colorado there is stuff in the snow. During snowmelt, most snow surfaces are not as pure as conceptual models predict. "

Impurities come from both local and distant sources. In recent years, western states have been fighting with an outbreak of the mountain pine beetle. The native beetles burrow into pine trees and lay their eggs in the bark, feeding off the trees. Though they are no bigger than a fingernail, these beetles kill millions of acres of trees during outbreaks. These dead trees drop their needles, littering the snow and lowering its albedo. In Pugh's research, he found that snow under dying trees melted one week earlier than snow under live trees.

Dust from the Southwest United States is also a culprit in reducing snow's albedo. Perrot is one of the first researchers to study the effects of dust deposition on snowpack in subalpine forested areas, though she said many people know about it.

To study the effects of this debris on snowmelt, Perrot and her team created a plot in a clearing near Boulder, Colorado. Snowpack is measured in four different 1 meter by 15 meter areas: needle contamination, dust contamination, needle and dust contamination and a control area with no contamination.

All Photos: Danielle Perrot

The team collected some of the dust by crushing their own rocks; some of it came from a local landscaping company.

The team placed NexSens micro-T temperature loggers in pits at each corner and two midpoints of the plot to record long-term temperature measurements. In each pit, a micro-T was placed near the surface, halfway down and three-fourths the distance from the surface of the pit for full-profile temperature data. They also placed loggers in nearby dead trees at varying heights to record air temperature. The micro-Ts will record temperatures every hour, telling Perrot exactly when the snow starts melting and when it becomes isothermal at 0 degrees Celsius.

To measure albedo, the team used an albedometer. This is a contraption made of two pyranometers that measure shortwave radiation. One faces up to measure radiation from the atmosphere while the other faces down to record radiation reflected by the snow. Albedo is calculated as the ratio of reflected radiation to incoming atmospheric radiation. The team assumes that radiation not reflected by the snow is absorbed, heating the snow and starting the melting process.

From preliminary observations, Pugh and Perrot said the plot that contains both dust and needles is melting the fastest. They will know actual temperatures when they dig up the micro-Ts later this year.

"It'll be like Christmas!" Perrot said. "We've been patient all season and now I want my data."

Perrot will use the data from this winter to create a computer model of the field manipulation experiment. This year, Perrot will not collect as much data as she was hoping to due to the "funky" snowfall. There was very little precipitation in Boulder during the month of March. She and the team will perform the experiments over the next few years to accumulate different data for an average.

"Nature's always tough," Pugh said. "When you're working in a natural system, [research] depends on when it snows, if the temperatures are average or abnormally warm or if a moose walks across the field site and leaves footprints."

The team did install a fence around the plot to discourage Pugh's third research variable. Perrot will incorporate the snow contamination data into existing models, providing a more accurate model of snowmelt. From these models, water managers in the western U.S. will have a better idea of how to distribute water over the summer so municipalities and farmers won't go dry in September. The National Oceanic and Atmospheric Administration and Intergovernmental Panel on Climate Change could also use the modeling in their weather and climate data.

It's also useful information for recreational companies, including rafting organizations and, of course, ski resorts.

"Anyone that uses water in the western states should care about when the snow melts," Pugh said.

A Green Innovation

By Jeff Gillies

There isn't a lake in Puerto Rico that doesn't sit behind a dam. Since 1913, this land of no natural lakes has been stopping up rivers to store water to generate electricity, irrigate crops and supply 65 percent of the population's drinking water. Today, most of Puerto Rico's man-made lakes face man-made problems.

According to data reported in 2010 to the U.S. Environmental Protection Agency by the Puerto Rico Environmental Quality Board, 17 of 18 reservoirs were falling short of Clean Water Act standards for dissolved oxygen needed to support aquatic life. The report listed pollution from agriculture and septic systems as common causes.

Thanks to a settlement between the U.S. Environmental Protection Agency and a water utility, a small water conservation company is engineering a man-made solution in an attempt at the island's the first-ever lake restoration.

The restoration will target Lake Toa Vaca, a reservoir built originally to supply irrigation water to sugarcane crops on Puerto Rico's southern coastal plain, which receives less rainfall than the rest of the island. But the plan changed when the dam was finished in 1972 and it became primarily a public water supply. As early as 1983, just 11 years after the 1,740-foot-long, 215-foot-tall Toa Vaca dam was finished, the reservoir had high levels of total nitrogen and total phosphorus, a harbinger of eutrophication.

In 2010, Toa Vaca was among the reservoirs failing to meet federal dissolved oxygen standards for supporting aquatic life. While the reservoir was meeting federal water quality standards for public drinking water sources, the local water treatment plant is only drawing water from its two shallowest intake pipes, according to Carlos González, CEO of Green Innovations Technologies, Inc., a water conservation company based in Puerto Rico.

Eutrophication has deprived the reservoir's lower layer of dissolved oxygen, spurring a number of reactions that have fouled the water near the deeper intakes and made it too costly to treat.

González's company has a chance to fix that. In 2010, the Puerto Rico Aqueduct and Sewer Authority agreed to pay $2.5 million to improve water quality on Toa Vaca as part of a settlement with the EPA over violations at 129 drinking water treatment plants. The sewer authority commissioned Green Innovations Technology to address the problems that come along with low dissolved oxygen, including a buildup of hydrogen sulfide generated by anaerobic bacteria.

Hydrogen sulfide is toxic to fish, and its removal will be the first and most sensitive step towards restoration, González said. Green Innovations will install a series of ceramic diffusers on the lake bottom, a step required by the EPA settlement. Air pumped through the diffusers will create a plume of bubbles that will push tainted water from the bottom of the lake up to the surface where the gas can escape.

But it's not a matter of blasting the gas out of the water as quickly as possible. While hydrogen sulfide is bad for aquatic life, it can also cause nausea, dizziness and headaches in people. And it reeks of rotten eggs. To keep human exposure to a safe level, a monitoring buoy floating in the lake will measure the emissions every five minutes and post the data online every 30 minutes. Those measurements will quickly let project staff know if they need to ease back on the bubblers and release the gas more slowly. If the measurements exceed 0.5 parts per million near the buoy, pumping will be reduced.

Once enough hydrogen sulfide has been released, the restoration will deal with the excess iron and manganese that resulted from the anaerobic conditions and affect the taste and smell of the water. They'll also add beneficial bacteria and enzymes to speed up the process.

According to González, all of Puerto Rico's reservoirs could benefit from similar treatment. Though new dams have been the answer to the commonwealth's water problems since 1913, that will only work for so long. The island covers just 3,500 square miles, and its rivers have already been aggressively dammed. Large dam construction on Puerto Rico peaked in the 1950s, a decade before peaking in Europe and two decades before South America. This is the island's first shot at lake restoration, and it could become an important strategy for protecting their current drinking water supplies. JC

The 10 HP compressors above pump air into the diffusers located at the bottom of lake Toa Vaca, moving around 150,000 gpm.

About Green Innovation Technologies

Green Innovation Technologies Inc. (GIT) is a consulting firm based out of Puerto Rico, focused on providing customers with technologies for process control, operational costs reduction and water conservation.

Under the direction of CEO Carlos González, GIT offers sensors, instruments, software, and data collection platforms for water quality monitoring and testing for many applications and bodies of water, including natural and manmade lakes, dams and reservoirs.

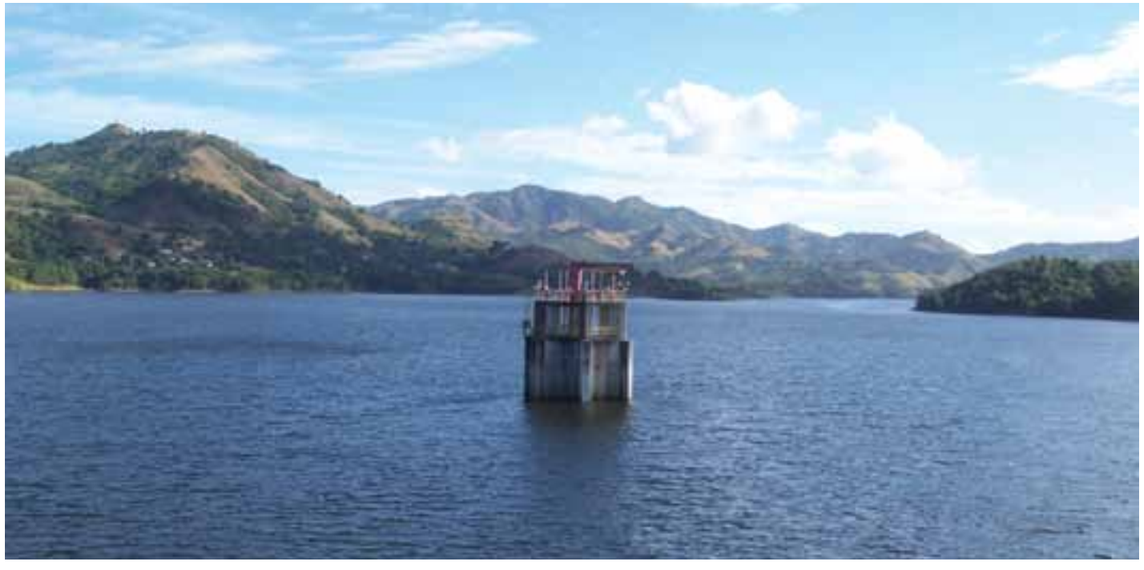


Photo: Carlos González

Photo: Gloria Archilla

TECHNOLOGY UPDATE

Fluorescence Detection of **CDOM**

By Jennie Brentrup

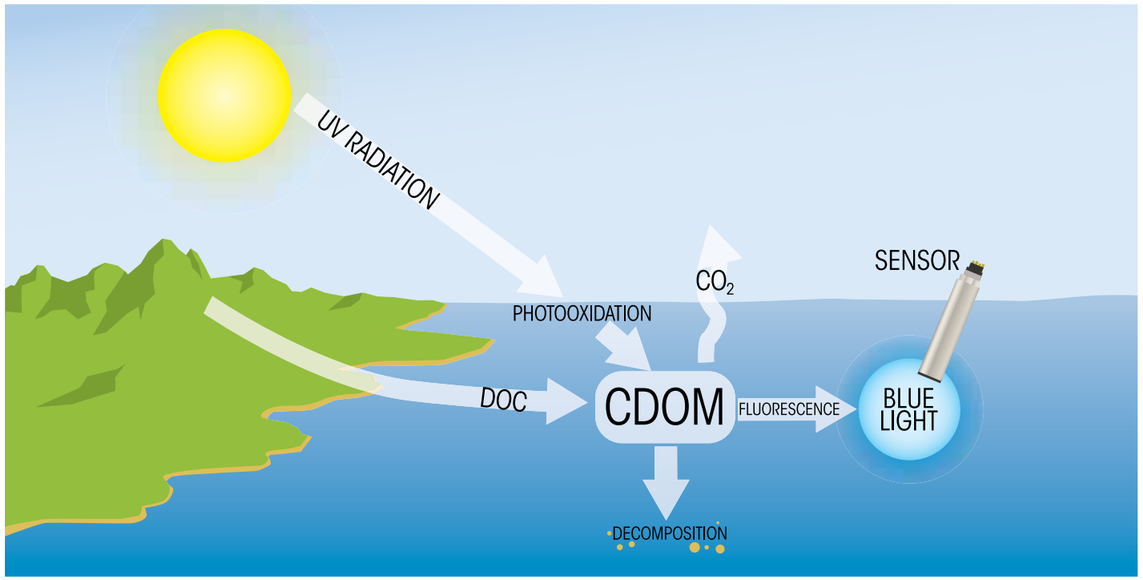
Monitoring chromophoric or colored dissolved organic matter (CDOM) in a variety of marine and freshwater environments can be extremely useful for quantifying changes in water clarity. CDOM is the portion of dissolved organic carbon (DOC) that absorbs solar radiation. As a major component of total DOC, CDOM is what gives bogs and wetlands their characteristic tea color. In freshwater and coastal marine systems, the major source of DOC entering the water is from terrestrial inputs of decaying plant material, as well as byproducts from the decomposition of animals and microbes. Different sources and varying concentrations of CDOM can cause water color to range from pale yellow to dark brown.

Across the northeastern US and regions of northern Europe, DOC concentrations have increased significantly over the past twenty years. In order to better understand this phenomenon and its environmental impacts, scientists have turned to sensors to measure CDOM in-situ. When CDOM absorbs ultraviolet radiation, it releases energy as photons of visible blue light, making fluorescence detection the easiest and fastest means of estimating the DOC quality. Fluorescence of CDOM in natural water can be measured without the need to conduct extractions or other sample preparations.

Scientists have developed numerous methods for using CDOM fluorescence sensors to enhance their understanding of a variety of biological, chemical and physical processes. In aquatic ecosystems, one result of increasing DOC concentrations is decreased light availability for phytoplankton to use for photosynthesis. CDOM fluorescence can be used to investigate how changes in DOC quality impact primary production rates. As a major food source for aquatic organisms, phytoplankton populations have a disproportionate impact on the rest of the aquatic food web. And with less light available, a large reduction in phytoplankton populations could negatively affect fish and other organisms.

At Hubbard Brook Experimental Forest in New Hampshire, researchers are using CDOM sensors to estimate the sources and sinks of carbon in terrestrial ecosystems. With the help of a CDOM sensor, scientists were able to map estimates of DOC concentrations throughout the entire watershed. A novel finding was that the effect of torrential rain from a hurricane caused the CDOM fluorescence to decrease, suggesting a shift in the quality of DOC following high rain events.

Fluorescence detection with the Turner Designs Cyclops-7 Submersible Fluorometer is more sensitive, faster and less expensive than other qualitative measures and effectively brings the lab to the sample. The compact sensor can be integrated with NexSens data loggers, YSI multi-parameter sondes, and other 3rd party data collection platforms using a 0-5 VDC analog output. JB



INDUSTRY PROFILE

Q&A Steve **RUBERG**

Q Where are some of your buoys located, and what's the common thread that you're trying to study?

A On western Lake Erie, we're deploying a number of systems that provide insight into why harmful algal blooms have been increasing in intensity and frequency. In the case of the buoy near Cleveland we're looking at providing observations of low oxygen events, known as hypoxia, that affect drinking water.

We also have another system that's looking at a variety of parameters related to native fish and ecosystem health in the Thunder Bay National Marine Sanctuary, which is also a NOAA archaeological preservation site for historic shipwrecks. And there's another in Lake Michigan that looks at rip currents.

The common thread of Saginaw Bay, western and central Lake Erie is the Great Lakes Restoration Initiative. We're looking at phosphorus levels, optical parameters (things that give us insight into the algal blooms), and oxygen levels near the bottom of the lake.

Q Is this problem consistent across the Great Lakes?

A The difference between Lake Erie and Lake Michigan or Huron, is they might all have 10-15 meters of warm water in the summer. But with Lakes Michigan or Huron, you might have 15-16 meters of warm water over 90 meters of cold water. Lake Erie is 15-16 meters of warm water over 4 meters of cold water and so there is less oxygen for use by biological organisms.

Q What's the main challenge in these bodies of water?

A One of the things that complicates monitoring is that the oxygen levels below about 15-16 meters deep are very low and the water temperature is low. That section of low-temperature water is called the "hypolimnion." The cold water layer can move independently of the warm water layer and it can get up into the intakes [for drinking water]. In the long run, we want to provide information on the movement of that cold water layer to water intake managers.

The basin [where the buoy is installed] is larger than the size of the state of Delaware. The water densities are different, and so they don't mix. That's the reason the oxygen goes low — because the density is lower in that cold water layer than the warm water layer. The oxygen that mixes into the upper layer from winds can't penetrate down to the cold layer. If the winds push the warm water layer west, the cold water layer might go east.

Q Have you seen any results so far from the buoys?

A Encouraging results. We've been able to provide warning to the water intakes at Cleveland that oxygen levels are low and conditions are deteriorating and they can change how they treat the water. They're seeing everything in real time. As soon as they see the results, they can react. This is giving them insight into what's happening in the deeper parts of the lake, their source drinking water. AH

Steve Ruberg
Observing Systems Researcher
Great Lakes Environmental Research Lab

Latest Research:
Steve Ruberg's work with the Great Lakes Environmental Research Lab (GLERL) involves setting up networks of observation systems around the Great Lakes. Many of these are year-round meteorological stations and often include web cams for real-time access. The goal, he says is to try to extend networking technology across the Great Lakes, all the way to the bottom of the lake.

Background:
Steve Ruberg has been working at GLERL, part of the National Oceanic and Atmospheric Administration, for 18 years. He earned his bachelor's degree at the University of Kentucky and his master's degree in Systems Engineering at Wright State University. Before working at NOAA, he worked first for the United States Navy, followed by the Air Force at Wright Patterson Air Force Base.

SHARE YOUR PROJECT

Many of our features come directly from our customers — their ideas, projects, needs, and solutions. If you have a project you're proud of or new research we should know about, get in touch with us! We're always on the lookout for ideas. We write the Environmental Monitor to inform and entertain our readers, and we couldn't do it without your input.

"Rocky Mountain Fever," the Colorado Snowmelt article in this issue, was a project a customer shared with us — we appreciate the contribution, and hope to feature more great customer stories in the future!

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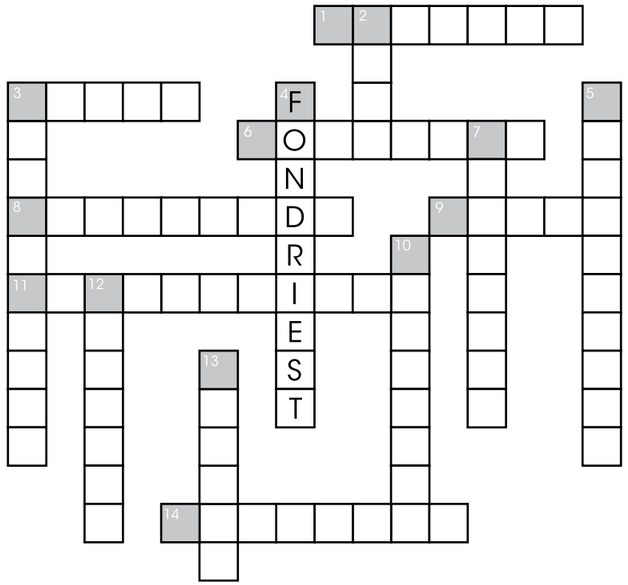
Rivers of the **U.S.**

Across

1. View the Washington DC monuments from this river
3. Runs through Grand Teton National Park
6. Flows through the Grand Canyon
8. Forms part of the US-Mexico border
9. Recent site of world's largest dam removal
11. Earthquakes temporarily reversed it
14. Largest river in the Pacific northwest

Down

2. Longest tributary of the Mississippi
3. Source waters rise in California's volcanic plateaus
4. Where to buy river monitoring equipment
5. Connects the Great Lakes to the Atlantic
7. Entire boundary between NJ and PA
10. Longest river in North America
12. Links Lake Superior to Lake Huron
13. Captain "Sully" Sullenberger landed here



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