

## An Expert's Take: Marsh Restoration after Oil Spills

By Barrett Kays

**D**r. Stephen W. Broome came to N.C. State to study soil science and later became an internationally recognized expert in establishing, restoring and mitigating damages to coastal marshes. Broome grew up in the tiny town of Aurora and later gladly found himself professionally stuck solving coastal issues. And “stuck” is just about right on target, as he’s focused much of his work on restoring coastal marshes damaged with crude oil spills.

Broome has done so much work on coastal salt and brackish water marshes along the North Carolina coast that he says he is familiar with just about every bit of the barrier islands, every inlet, and all of the extensive sounds in the state.

In 1978, as a young research associate in the Department of Soil Science working with Dr. Ernie Seneca of the Botany Department, Broome was sent to Cotes-d’Armor, France, to re-establish coastal marshes damaged by the Amoco Cadiz super tanker oil spill.

At the time it was the largest oil spill in history and impacted 45 miles of the French coastline with 69 million gallons of crude oil. In route from the Persian Gulf to Rotterdam, Netherlands, the tanker Cadiz got caught



**Fire boat response crews battle the blazing remnants of the offshore oil rig Deepwater Horizon in April 2010.** (Photo courtesy U.S. Coast Guard)

in the English Channel under strong winds. The super tanker was driven across the Channel and grounded on the French coast, resulting in a ripped hull that caused the supertanker to split in half and sink.

Since the early 1970s the N.C. State team has been leaders in the study of coastal marsh management, successfully creating and restoring coastal salt marshes. So, it was natural for France to invite the N.C. State team over to Europe in 1978 immediately after the super

*(continued on page 7)*

# Welcome!

From the Department Head

I've spoken before of the remarkable breadth and depth that our discipline expertise extends, including the innate ability residing with our own department regarding important issues in North Carolina and beyond. This issue of *Soil Science Solutions* highlights the positive role played by the Department of Soil Science in realms that might not be apparent to those less familiar with our far-reaching capabilities.

Faculty, staff and graduate students have made significant contributions over many years in a myriad of dimensions that directly impact and improve our understanding of environmental issues. Concern for the environment will continue to be of paramount importance in our lives.



One has only to look at the major oil spill in the Gulf of Mexico last year to be acutely aware of ramifications emanating from an event of this magnitude. Not only has this unfortunate event had obvious and still unknown consequences for people and the environment in the region; but it has also captured the attention and concern of individuals, scientists, and policy makers across the country and around the world.

Moreover, this seemingly distant event from North Carolina has relevance to research activities of faculty in our Department. In this issue of *Soil Science Solutions*, you'll learn of the coastal marshes restoration work conducted by Dr. Stephen Broome for nearly three decades. Also note the research of Dr. John Walker, an atmospheric and soil scientist studying nitrous oxide emissions, who is a graduate of our Department and now an adjunct faculty member. Their soil science expertise has enabled them to play important roles in addressing environmental concerns within North Carolina and well beyond state boundaries.

Closer to home, you'll learn how faculty and staff are using both conventional methodology and cutting-edge technology to assist in forensic investigations. This relatively new 'CSI' involvement is made possible by the analytical capacity of two service labs in the Department, one devoted to chemical analyses and the other to soil physical characteristics, along with the excellent supervision provided by Dr. Wayne Robarge and Dr. Michael Vepraskas, respectively.

Collectively, these stories shine a light on the ever-expanding contributions made by the Department of Soil Science as we strive to have impact on issues of consequence to North Carolina and the larger community beyond our border.

We are committed to continue addressing a broad array of current issues of import, while also seeking opportunities to become engaged in emerging concerns relevant to North Carolina citizens. These leadership efforts will invariably serve the world community – a responsibility we openly embrace.



Michael Waggoner  
Head

## Soil Science *Solutions*

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On the cover: **A marsh in the south-  
eastern Coastal Plain.** (Photo courtesy  
National Biological Information Infrastructure)

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# Tracing Pollution and Contamination in the Gulf of Mexico

By Barrett Kays

**D**r. John T. Walker has been studying nitrous oxide emissions from both terrestrial and aquatic ecosystems. So what happens when a tropical storm encounters your research vessel in the Gulf of Mexico? Well, Walker learned to just go with the flow of the storm.

He continued to collect nitrous oxide emission data as the storm waves battered his vessel; with the data ultimately reflecting that nitrous oxide emissions spiked during the storm event. After a couple of days of pounding from the storm and holding on for dear life, John says his “sea sickness just seemed to go away because he got so excited with the unusual research data. Those waves just didn’t seem so daunting any more”.

Walker got his start in atmospheric science and later came down to earth studying terrestrial ecosystems in the Department of Soil Science during his graduate research and since as senior chemist at the U.S. EPA National Risk Management Research Laboratory in Research Triangle Park, N.C.

Walker is one of those unique out-of-the-box thinkers who combines the study of terrestrial, aquatic and atmospheric systems to assess risk and develop strategies to mitigate environmental damages such as the recent oil spill in the Gulf of Mexico. He was recognized with the U.S. EPA Science and Technology Award in 2005 and 2009, and the U.S. EPA NRMRL Award in 2009.

Since Walker is both an atmospheric and soil scientist, he studies the production and emission of nitrous oxide, a potent greenhouse gas, in natural and agricultural systems. His study of nitrous oxide emissions from the Gulf of Mexico hypoxic zone has led to a broader understanding of its biogeochemistry. Observation of the large emission pulse generated by the storm highlights the importance of incorporating transient events in global budgets of trace gas emissions from biogenic sources.

The hypoxic zone in the northern Gulf of Mexico refers to an area along the Louisiana-Texas coast in which water near the bottom of the Gulf contains less than 2 parts per million of dissolved oxygen, causing a condition referred to as hypoxia.

Hypoxia can cause fish to leave the area; while resulting in stress or death to bottom-dwelling organisms that



**Research vessel Pelican in the Gulf of Mexico.** (Photo courtesy Louisiana Universities Marine Consortium)

can’t move out of the hypoxic zone. The root cause of hypoxia is believed to be excess nutrients delivered from the Mississippi River, in combination with seasonal stratification of Gulf waters. Excess nutrients promote algal and attendant zooplankton growth.

The associated organic matter sinks to the bottom where it decomposes, consuming available oxygen. Stratification of fresh and saline waters prevents oxygen replenishment by mixing of oxygen-rich surface water with oxygen-depleted bottom water.

It is important to know the spatial pattern of the pollution before mitigation plans are formulated. Walker has advanced some unique approaches based upon his research, including how best to trace nitrous oxide levels in Gulf waters. Similar approaches may aid in determining the spatial pattern of oil pollution.

Pollution often can be mitigated by the use of microorganisms, so it’s important to know what nutrients are limiting the growth of the microorganisms. Nitrogen is often a limiting factor, therefore Dr. Wayne Robarge, Walker’s major professor, thinks that the concept of fertilizing the oil contamination in the marshes or perhaps fertilizing the oil pollution in the Gulf may be an effective approach to mitigation of the contamination.

As of yet, Walker is not sure if he will be assigned to the Gulf to help with the mitigation of the thousands of square miles of oil contamination in the marshes and open waters. He is eager to study the changes to the hypoxic zone from the oil contamination.

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*Dr. Walker’s research in the Gulf was supported by U.S. EPA and NOAA.*

# Forensic Soil Science Investigations

By Barrett Kays



Jordan Glenn Peterson was convicted of first degree murder on March 22, 2010, due in part to soil scientists and geologists matching soil on his clothes and shoes to the soils where the victim was found.

It was just like you have seen on the “Crime Scene Investigation” television series. In this case, Raleigh Police Department detectives asked N.C. State to conduct an independent scientific investigation to determine if soil material from the suspect’s clothes was similar to the crime scene soil.

The City/County Bureau of Identification had collected trace soil evidence from the site, clothes and shoes of the suspect. Dr. Billy Oliver of the N.C. State Program for Forensic Science advised detectives to contact Dr. Wayne Robarge, professor of soil physical chemistry, and laboratory technician Kim Hutchison, in the Department of Soil Science. Heather Hanna and Phil Bradley, geologists with N.C. Geologic Survey, and geochemist Dr. Steven Singletary from Fayetteville State

University (FSU) also were part of the team.

Huchinson explains it was like solving a complicated puzzle to determine distinctive soil characteristics that could be used to compare the trace soil samples.

After visiting the crime scene and studying the soil samples, they decided to investigate the elemental composition of the mica that was found in all of the samples. The team asked Singletary, director of the Southeastern N.C. Regional Microanalytical and Imaging Center at FSU, to join them. The team used a Joel Hyperprobe Field Emission Electron Probe Microanalyzer to produce high-resolution analyses of submicron areas on the samples.

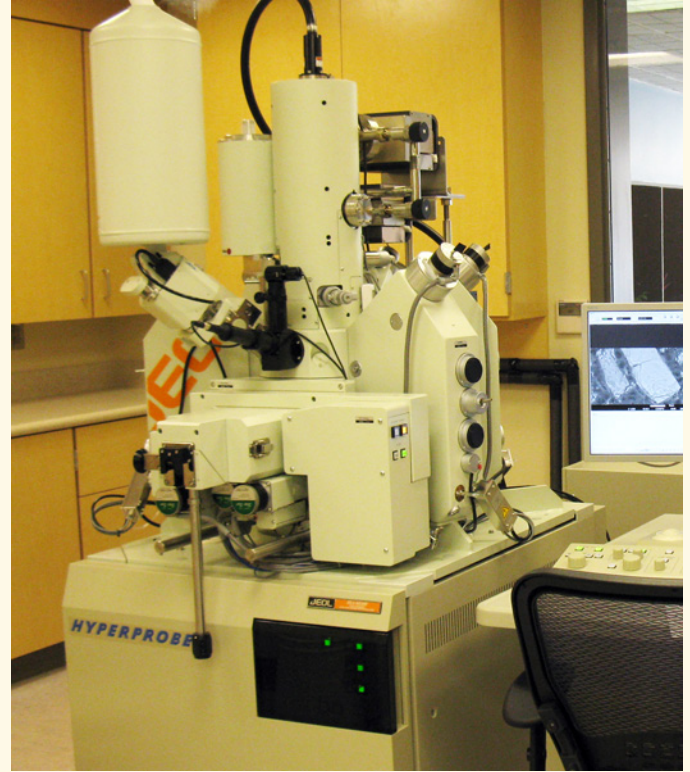
They were able to determine that the soil samples from the suspect’s clothes and shoes were consistent with soil samples collected at the crime scene.

Moreover, they were able to determine that mica composition was unique to the crime scene by comparing the results to another location in the N.C. Piedmont.



**Mass spectrometer at the N.C. State University Soil Science Analytical Spectrometry Services Laboratory (left).** (Photo courtesy Kim Hutchison)

**Japan Electron Optics Laboratory (JEOL) hyperprobe at Fayetteville State University (below).** (Photo courtesy Heather Hanna)



It was enough evidence to place the defendant at the specific site where the shooting victim was found by the Raleigh Police Department.

Hanna testified in superior court, establishing the fact that mica from the defendant's clothes and shoes were matched to the site. The analysis of the mica provided the best forensic evidence in the case and was the primary reason that the jury convicted the suspect.

Over the years, Department of Soil Science faculty and technicians have served various governmental and private investigators in conducting forensic laboratory analyses for both criminal and civil cases in state and federal courts.

The N.C. State Soil Science Analytical Spectroscopy Services Laboratory provides method development and consultation services regarding elemental analysis, metal speciation and sample digestion of unusual sample matrices for research faculty, staff, graduate students and the professional community. Robarge is the supervisor for the laboratory. The laboratory has been used in the following recent criminal cases:

- State of North Carolina vs. Jordan Glenn Peterson before Wake County Superior Court, NC, regarding homicide of Anthony Markice Bowling, 2010.
- Investigation in homicide of Jonathan Blackwell for Rockingham County District Attorney, NC, 2007.

The N.C. State Soil Science Soil Physical Properties Laboratory, under the supervision of Dr. Michael Vepraskas, analyzes samples for research projects from N.C. State, as well as other universities, private sector and governmental agencies. The laboratory conducts particle size analysis and soil water retention analyses. The laboratory has been used in the following recent environmental and construction cases:

- Cheyenne River Sioux Indian Tribe vs. United States of America and U.S. Army Corps of Engineers Omaha District before U.S. Federal Court of Claims regarding 45 square miles of sedimentation damages allegedly caused by the construction on the Missouri River of the Oahe Reservoir in South Dakota, 2007.
- Henderson County Drainage District #3, et al. vs. United States of America and U.S. Army Corps of Engineers Rock Island District before U.S. Federal Court of Claims regarding flooding of crop lands in eleven agricultural drainage districts along the Mississippi and Illinois rivers in Illinois and Missouri with damages allegedly caused by the construction of the lock and dam systems on the rivers, 2004.
- Battery Park City Authority of New York vs. Carr, Lynch, Hack & Sandell Inc. before New York Supreme Court, Borough of Manhattan, NY, regarding alleged ineffective soil drainage caused during the construction of the Nelson B. Rockefeller Hudson River Park, NY, NY, 2001.

# Distance Education Gaining Traction and Impact

By Michael Vepraskas

The Department's distance education (DE) activity continues to grow. We now serve approximately 150 students from around the country each year, including both working professionals and full-time students.

The introductory soils class taught by David Crouse is our largest online class, and it is capped at 30 students per semester. We currently have 12 students enrolled in the online Masters of Soil Science program, which comprises 30 percent of our graduate student total. These students are advised by eight faculty members.

A total of 10 DE classes are now offered in our undergraduate and graduate programs, as well one class in the Agricultural Institute. Our classes include introductory soil science, soil fertility, soil classification, soil microbiology, wetland soils and environmental applications. Some of these classes are taught at both the graduate and undergraduate level. Our newest addition is a graduate-level soil physics class that will be taught this fall by Aziz Amoozegar and Josh Heitman.

Another recent addition to our DE program is the Certificate in Soil Science. This program is designed for people who are interested in becoming licensed soil scientists, but who do not have the interest or time to get a masters degree. The certificate will be awarded when 15 credits in soil science have been earned. Credits can be earned entirely online or by a combination of online and face-to-face instruction.

Distance education is generating additional resources for the University, the College and Department that are proving critical at this time.

Many in the Department are now benefitting from these resources, as just last year, the Soil Science program alone received nearly \$150,000 through its DE program. The money enabled support for faculty stipends, part-time IT staff, computer hardware used for the entire department, as well as development costs for the new soil physics class.

In addition, much-needed computer upgrades were provided to faculty working with old machines, and new desks were purchased for about two-thirds of the graduate students.

The DE program in Soil Science will continue to grow. Alumni are encouraged to consider DE classes should they want to enhance their careers. We also encourage alumni to suggest new classes that would be of particular interest to them.



**All students completing the Master of Soil Science degree through distance education are required to complete two hours of field classes to obtain practical skills, such as developing and interpreting a soil profile description. This and many other practical skills are taught over four to five days as part of SSC620: Soil Geomorphology Field Experience.**

## Marsh restoration *(continued from page 1)*

tanker sank.

The French Army put so many boots and heavy equipment on the ground that they simply dug up the marsh soil and root mat in many areas in order to remove the oil. Broome and the N.C. State team established research plots to test the planting and fertilization techniques they had first applied to stabilizing dredge spoil at Oregon Inlet in North Carolina for the U.S. Army Corp of Engineers beginning in 1969.

Starting in 1990, Broome served as scientific advisor to New York City in dealing with the aftermath of a massive Exxon pipeline spill into the New York harbor area. The rupture in the pipeline spilled fuel oil into the estuary near Newark Liberty International Airport and then washed along the Newark, Raritan and Kill van Kull Bays which connect to the New York harbor. Only 25 percent of the 567,000 gallons spilled were recovered during the clean-up operation. Broome worked with the city to re-establish the marshes and the adjacent William T. Davis Wildlife Refuge.

So, what lessons has Broome learned that can apply to the Gulf Coast marshes?

First, the clean-up teams should carefully assess the effect of oil on the marsh vegetation and soils at each location. The root mat and marsh soils should be left in place whenever possible, and heavy traffic should be avoided to reduce compaction. In time the oil will disperse and decompose and the marsh vegetation is likely to recover.

In heavily oiled areas where the soil is saturated with oil and marsh plants die, it may be necessary to remove the soil and root mat. In such cases, restoration of the marsh may require soil amendments and planting with native vegetation that was present on the site.

Of course every site will have unique logistical, hydrologic and soil problems that will make successful restoration challenging. And the sheer magnitude of the amount of needed marsh restoration in the Gulf Coast is simply staggering.

Broome's techniques may be used to mitigate damages to the Gulf Coast wetlands caused by the unprecedented BP Deepwater Horizon spill in April 2010. Do not be surprised if he shows up in the Mississippi delta; it will not be Broome's first trip to the Gulf Coast marshes and probably not his last.

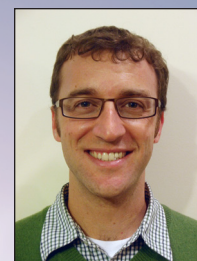
### Ten Largest Oil Spills

Location	Year	Vol. Spilled (million gallons)
Kuwait	1991	520
Gulf of Mexico/U.S.	2010	185
Mexico	1980	100
Trinidad and Tobago	1979	90
Russia	1994	84
Persian Gulf	1983	80
South Africa	1983	79
France	1978	69
Angola	1991	51
Italy	1991	45
Alaska/Exxon Valdez (#34)	1989	10

## Department Highlights

### New Faculty

Dr. Matthew Polizzotto joined the Department as Assistant Professor of Soil Hydrogeochemistry. Matt received a B.S. in Environmental Science from the University of Rochester and Ph.D. in Geological and Environmental Sciences from Stanford University. Prior to joining the Department, Matt was a Postdoctoral Scholar in Environmental Earth System Science at Stanford University. Matt's research focuses on the interaction of water with contaminated soils. He also will teach a newly developed graduate course on the impacts of science on environmental remediation, management and policy practices.



**Matthew Polizzotto**

### New Undergraduate Program

A new major in Soil and Land Development has been approved by the UNC Board of Governors. The B.S. program will prepare students seeking career opportunities in the consulting industry and/or real estate development. Students will be trained in *both* land evaluation techniques as well as in the legal and financial aspects of real estate development.

## Soil Science Solutions

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## *You're invited to join the Friends of Soil Science!*

The Friends of Soil Science is a community devoted to the economic support and expansion of the Department of Soil Science at North Carolina State University. Your membership will help enhance the Department in a number of ways:

- guide future economic growth
- create a land development undergraduate program
- expand research programs
- augment professional training programs
- foster the development of partnerships with industry, business and government organizations

**Gifts of any size are appreciated. All gifts are tax-deductible.**

For information on how to join the Friends of Soil Science, please visit [www.soil.ncsu.edu/give](http://www.soil.ncsu.edu/give) or contact Chris Cammarene-Wessel at 919-515-7678 or [chris\\_wessel@ncsu.edu](mailto:chris_wessel@ncsu.edu)

*We hope you'll join us!*