A Watershed Moment for Soil Science

Big changes have occurred since the last issue of Soil Science Solutions. NC State’s College of Agriculture and Life Sciences has unveiled a game-changing plan to improve collaboration and productivity. Our current 13 departments will join one of our four new functional ‘systems’ – Plant; Animal; Food, Biochemical & Process; and Human & Resource – beginning July 1, 2016.

Soil Science and Crop Science have merged, and will be part of the new Plant Systems. The new department will be the largest in the college. With approximately 74 faculty, it will be as large as any of the other three Systems.

We are using the working title “Crop and Soil Sciences” for our group, with a final decision anticipated in August. Dr. Jeff Mullahey leads the merged department. Dr. Deanna Osmond is the associate head. Dr. David Crouse will serve as the undergraduate coordinator. I will return to teaching and research after a two-year stint as interim head.

The main changes are governance of the new department and sharing our administrative staff. The merger should have little impact on current Soil Science programs or our faculty, staff and students activities. Undergraduate programs will be merged – but the graduate programs will be managed separately as in the past. Integration of graduate programs is not possible today, given the differences in requirements. No changes are expected in Soil Science academic majors at either the graduate or undergraduate levels. We already share IT support with Crop Science and of course hold a joint graduation.

We have lost eight faculty over the past three years due to budget cuts and retirements. We thank Dave Lindbo, Ron Gehl, Julie Grossman, Alan Meijer, Greg Hoyt, Wayne Robarge, Mike Hoover and Michael Wagger for their good work. Jot Smyth has just begun his three-year phased retirement. We will add two positions – soil nutrient management for extension, and organic or sustainable agricultural systems. In addition, we will fill a new position in “rhizosphere” science which will study the soil-root interface and its effect on the plant. So, on balance we are beginning a rebuilding phase after years of decline.

I believe these are positive changes for Soil Science at NC State. We’ll be part of a large department, which can be influential in increasing faculty positions and maintaining strong undergraduate and graduate programs. I want to encourage our alumni feel optimistic, and to give us your thoughts and recommendations. We continue to appreciate and count on your generous support.

Dr. Mike Vepraskas, Former Interim Department Head and William Neal Reynolds Distinguished Professor
NC State’s Soil Scientists.
Who we are, and what we do.

Our mission is to prepare students for well-paying careers in land development, environmental management and agriculture.

Mike Vepraskas, William Neal Reynolds Distinguished Professor
In addition to department head, Mike teaches a class on wetland soil to NC State students and trains professionals throughout the U.S. to identify wetland soils.

Aziz Amoozegar, Professor
Aziz invents devices to measure water flow in soils, soil strength and the sizes and density of soil particles. He just invented a new soil penetrometer for soldiers to use to test landing sites for planes in hostile areas. Aziz also teaches a graduate class on environmental soil physics and assists with the introductory soil science class.

Rob Austin, Extension Associate
Rob makes maps for agricultural and environmental projects using the latest computer models along with data from satellites and drones.

Steve Broome, Professor
Steve develops methods to restore wetlands that improve water quality and decrease erosion of coastal shorelines. He teaches the soils classes for the Agricultural Institute, along with a graduate and undergraduate class in wetland soils. Steve is also the department’s director of undergraduate programs.

David Crouse, Associate Professor
David teaches students that without soils they would be hungry, homeless and naked through the introductory soils class in both the Spring and Fall semesters. He also develops tools that guide farmers in applying nutrients to fields in amounts that are increase yields and do not break state laws.

Carl Crozier, Professor
Carl teaches farmers the best ways to apply plant nutrients to improve profits and reduce runoff of nitrogen, phosphorus and sediment into rivers and reservoirs. His research shows that if nitrogen fertilizer use was reduced by 10% on farms, growers would save over $3.3 million per year.

Liz Driscoll, Extension Associate
Liz works with students of all ages to get them to appreciate agriculture and possibly choose it as a career. Her extension program conducts workshops for 4-H, Junior Master Gardener, Junior Horticultural Association and FoodCorps, among others. Liz’s teaching activities include beekeeping and butterfly rearing for second graders.

Owen Duckworth, Associate Professor
Owen identifies the chemicals that plants and microbes use to dissolve metals from soil minerals to use for their growth. Plants may eventually be bred to produce these chemicals in large amounts and used to clean water and soil of contaminating metals.

Alan Franzluebbers, USDA Professor
Alan’s principal interest is improving soil quality. A current focus studies how microbes increase the amount of nitrogen in soils. Improving soil quality and storing soil organic carbon will help develop sustainable agricultural systems.

Terrence Gardner, Assistant Professor
Terrence develops new ways to use micro-organisms to remove contaminants from water and soil. He also teaches a class on soil microbiology.

Jonathan Godfrey, Extension Associate
Jonathan trains professionals in the latest technologies for disposing of household waste onsite in safe, legal manners. His training extends state-wide. Jonathan is self-funded through his fee-based courses.
Alexandria Graves, Associate Professor
Alex identifies organisms that live in soil and move through water and air that cause diseases in people. She teaches an undergraduate class in environmental microbiology, and has served as the college’s Assistant Dean for Diversity, Outreach and Engagement.

John Havlin, Professor
John teaches the importance of plant nutrients in our everyday lives through his undergraduate and graduate soil fertility classes. John worked to get the “DigIt: The Secrets of the Soil” display into the museum of Natural Sciences in Raleigh, which was viewed by over 60,000 people in just 60 days.

Josh Heitman, Associate Professor
Josh studies the interactions of heat and water in soils to accurately predict the amounts of water lost by evaporation in soils. Models are being developed to use for climate change predictions that will tell us how much irrigation water crops in N.C. will need in the years ahead. Josh also teaches undergraduate and graduate classes in soil physics.

Dean Hesterberg, Reynolds Professor
Dean studies how phosphorus moves through soils to get more of it into plants and less into move into streams. This improves fertilizer use efficiency, saves farmers money and improves water quality. He also is working with contaminants such as arsenic, copper, zinc and lead in soils and wastes to make them non-toxic to humans and plants. Dean teaches a graduate class in soil chemistry.

Rich McLaughlin, Professor
Rich studies the how quality of drinking water decreases when eroded soil moves into streams and reservoirs from construction sites. His program develops economical techniques that keep eroded soil on-site using plants, chemicals, filters and ponds. Rich also teaches an undergraduate class on soil management.

Deanna Osmond, Professor
Deanna develops nutrient management and conservation practices that allow farmers to reach high crop yields – without polluting our drinking water with excess fertilizer or eroded soil. This work is saving farmers millions of dollars each year. Deanna currently serves as the department’s director of extension programs.

Matt Polizzotto, Assistant Professor
Matt studies how contaminants such as arsenic, manganese and mercury in the environment can affect human health. He develops methods to remove such contaminants from drinking water. Matt also teaches an undergraduate class on environmental soil chemistry.

Wei Shi, Professor
Wei investigates ways of changing the types of micro-organisms in the soil to better control carbon and nitrogen reactions. Such changes may allow farmers to use less fertilizer without reducing crop yields. Wei also teaches a graduate class on soil microbiology.

Jot Smyth, Professor
Jot develops better ways to apply plant nutrients that will improve a farmer’s profits while reducing runoff of nitrogen, phosphorus and sediment into rivers and reservoirs. Biofuels is also another area of active research for him. Jot serves as the department’s director of graduate programs and teaches a graduate level class on soil fertility.

Joni Tanner and Kathryn Luxford, Extension Associates
Joni and Kathryn coordinate training programs for professionals in the areas of waste management, nutrient management and erosion control. These fee-based programs cover their salaries as well as maintenance of the training facilities.

We would like to thank our good friend and associate Dr. Barrett Kays for his good work conducting and preparing the faculty interviews in this publication.

For our latest news visit soil.ncsu.edu
Osmond leads the way in agricultural nutrient management

When it comes to helping farmers adopt appropriate, affordable and effective ways to keep agricultural nutrients from becoming water pollutants, Dr. Deanna Osmond has been leading the way for three decades.

Osmond focuses on practical questions at the complicated intersection of water quality, agricultural production and conservation practices. An award-winning NC State professor and the Soil Science Department’s extension leader, she has played a particularly important role in developing research-based educational programs and tools enabling North Carolina farmers to meet environmental rules to reduce nitrogen rates in some of the state’s most important rivers and lakes.

Nitrogen can enter streams, lakes and rivers from multiple sources, including fertilizers, animal manure and wastewater treatment systems, Osmond explains. An overabundance of nitrogen can lead to the overgrowth of aquatic plants and algae, which, in turn, can kill fish and clog water intakes. Not only that, because commercial fertilizers cost money, every bit of nitrogen that farmers lose to the environment cuts into their bottom lines.

One of Osmond’s first projects when she joined NC State’s faculty was to lead the development of an easy-to-use, computerized nitrogen loss estimation worksheet. In 1998, new state regulations called for all pollution sources to reduce nitrogen loading into the Neuse River by 30 percent, and a tool was needed to allow the state’s Department of Environmental Quality make annual assessments of farmers’ compliance.

Osmond and her colleagues have since conducted multifaceted research to support that compliance. They have, for example, looked at best management practices, such as riparian buffers, to find out how effective they are at reducing nitrogen. And they’ve worked to keep the nitrogen loss tool up-to-date as crop genetics – and thus optimum nitrogen rates – have changed.

She’s also helped create Cooperative Extension programs designed to help farmers comply with water-quality rules. As a result, about 6,000 farmers and green-industry personnel in the Neuse and other regulated water basins have learned more about nutrient management techniques.

More recently, Osmond has studied the effectiveness of using exclusion fencing to keep wastes from grazing cattle out of streams and is currently looking at whether slow-release fertilizers and fertilizer additives actually generate greater yields.

“I think it’s really important we continue this work for a couple of reasons: We have to ensure that … the scientific numbers within these tools are accurate, because otherwise these tools are not going to give us the confidence we need,” Osmond says. “The second thing is that it’s important to farmers to optimize their nitrogen use because commodity prices are so low right now. Fertilizing appropriately saves money, and it protects the environment at the same time.”

A native of Wichita, Deanna Osmond earned bachelor’s degrees in anthropology, agronomy and soil science at Kansas State University before earning a master’s degree in soil science from NC State. She went on to work as a U.S. agricultural development project officer in the Democratic Republic of the Congo, then completed a doctoral degree in crop, soil and environmental sciences at Cornell University. She returned to NC State and worked as water quality extension specialist in the Department of Biological and Agricultural Engineering before becoming an assistant professor in the Soil Science Department in 1997. She is a fellow with the Soil Science Society of America and the American Society of Agronomy.
Shi’s research breaks new ground

You could call Dr. Wei Shi’s research groundbreaking, both literally and figuratively: The NC State University soil scientist is not only digging to learn more about the microbes that make up soil, she’s also shaking up conventional beliefs about their role in emission of a significant greenhouse gas.

While nitrous oxide is naturally present in the air as part of the Earth’s nitrogen cycle, human activities such as agriculture, fossil fuel combustion, wastewater management and industrial processes increase the amount in the atmosphere. As a greenhouse gas, nitrous oxide is believed to contribute to global warming, which has significant implications for agricultural and environmental health. It also contributes to ozone depletion.

Scientists long believed that bacteria were largely responsible for converting nitrogen in soils into nitrous oxide. But in recent scientific papers, Shi and her colleagues have shown that other microbes – fungi – account for a large portion of total soil N2O production in a variety of agricultural ecosystems.

With soil samples from five agricultural systems – conventional farming, organic farming, integrated crop and livestock production, plantation forestry and a naturally regenerating, abandoned agricultural field – they found that fungi were just as significant as bacteria when it comes to producing nitrous oxide.

They have also identified and characterized N2O-producing fungi and determined how they responded in the lab to soil changes in organic matter, pH and oxygen levels. Because altering soils changes the amount of N2O produced, the research implies it may be possible for scientists could find ways that farmers can lower those emissions.

That’s a fact, she says, that can’t be ignored if we are to find sustainable ways to increase agricultural production while protecting the environment.

“In the past, fungi have been completely overlooked as a player in N2O production. Now that we better understand the sources and the control factors, we can find ways to better manage agricultural systems to minimize nitrous oxide emissions.”

Dr. Wei Shi grew up in Shenyang, an industrial town in northeast China, and earned a bachelor’s degree in biology from Liaoning University in Shenyang; a master’s degree in ecosystem ecology from Shenyang University, and a doctoral degree in soil microbiology from Utah State University. Her research involves the biochemical, ecological and physiological functioning of soil and environmental microorganisms. Her current focus is on soil carbon and nitrogen sequestration, soil nitrogen transformation kinetics and microbial community structure and function.
Finding ways to keep vineyards in the Goldilocks zone of appropriate moisture – not too little and not too much – can be a challenge. But in laboratory, field and modeling experiments, Dr. Joshua Heitman is gaining the kind of insight that will lead to better water management strategies for North Carolina’s burgeoning winegrape industry.

Heitman is a soil physicist in NC State University’s Department of Soil Science. His research focuses on how soil properties and dynamics affect water availability. Such research has ramifications for agriculture, the environment and – particularly in the case of his vineyard experiments – the economy.

In North Carolina, the wine and grape industry supports 7,600 jobs and has an estimated $1.28 billion annual economic impact. While the native muscadines grown in the eastern part of the state are well adapted to the climate, the same isn’t true of the European varieties grown in the state’s other regions.

“North Carolina is on the wet end of the spectrum when it comes to the places that these varieties are grown. So we have a bit of a challenge,” Heitman says. “On the one hand, we want to be sure there’s enough water to produce the crop, and on the other hand, we want to make sure there’s not too much water, because that has downsides.”

If there’s too much water, Heitman explains, plants get what folks in the industry call “overly growthy” – and that lowers the grapes’ sugar content and thus the overall quality of wine produced from the grapes. Not only that, humidity also favors disease, which means growers have to spend more time and money on pesticides and other disease management techniques, he says.

Heitman knew a better understanding of how water is flowing through the vineyard system could help scientists develop strategies for conserving water in dry years and for managing it during wetter years. He teamed with scientists in the temperate U.S. and in much more arid Israel as he began that work.

The researchers started by figuring out ways to measure and model the evaporation and transpiration processes taking place overall in vineyards and also among the various vineyard components – namely, the vines, the soil and, in the U.S., the grass that grows between vine rows.

He and his colleagues have also looked at specific ways that the grass that lies between the rows might be altered to produce better growing conditions: How does, for example, the type of grass affect the amount of water available to the plants? And would varying the size of that grass strip reduce or increase transpiration in ways that affect disease pressures in the vineyard?

What Heitman and his colleagues are learning has implications far beyond the vineyards they are working in. Mechanisms by which combined moisture and energy transfer occur in soil are poorly understood and difficult to predict, so the sensors, measurement techniques and theories he develops have significance for other crops as well as rangelands, forests and urban areas.

“In our lab, we work on lots of different things related to water: It can be urban or agricultural or it can be basic science trying to understand the fundamental processes of how water moves through the soil,” he says. “As we better understand how water is being partitioned between favorable uses and nonfavorable uses – or losses that we don’t want to happen – we can modify our systems to be more efficient.”

**Dr. Joshua Heitman grew up on a large farm and ranch in north central Kansas and earned a bachelor’s degree in agronomy and natural resources and a master’s degree in agronomy from Kansas State University. At Iowa State University, he earned a doctorate in soil science and environmental science. He joined NC State’s faculty in 2007. Heitman is an associate professor and University Faculty Scholar.**
Duckworth digs for answers

Dr. Owen Duckworth’s research may focus on the smallest of worlds, but it has big implications for solving both agricultural and environmental problems.

Duckworth is a biogeochemist in the Department of Soil Science, and he investigates the molecular-level interactions of soil-borne organisms, mineral surfaces and trace metals, such as arsenic, manganese and iron. The goal of his research is to determine the factors that control the fate, transport, speciation and uptake of nutrient and contaminant metals in soils, natural waters and engineered systems.

This basic research can yield important clues that could help us find effective ways to better manage nutrients for agricultural crops, protect ground water and surface waters, and to clean up polluted sites.

He points to his research involving NC State University’s former toxic waste site near Carter-Finley Stadium as an example of a basic research project with practical implications. In the 1970s, the university disposed of solvents, pesticides, heavy metals and other chemicals there. Then in the 1980s, the U.S. Environmental Protection Agency targeted the area as a high priority for clean up, a Superfund site.

Several years ago, naturally occurring manganese oxide deposits led to a shutdown of a water treatment system at the site. Though the manganese oxides were causing a problem at the site, Duckworth was intrigued, because he knew that they could also be useful in breaking down organic pesticides, solvents and other potentially toxic chemicals. The manganese was being turned from its soluble form into minerals by soil-borne fungi that were thriving in the toxic environment. Could those organisms be somehow incorporated into a clean-up system that works with minimal interaction from people?

Figuring out the answer would require fundamental information about both the organisms and the manganese oxides, and so Duckworth, along with Drs. Matt Polizzotto and Dr. Terrence Gardner in the Soil Science Department and Dr. Leslie Sombers in the Chemistry Department, went to work.

“The first thing we did was characterize the organisms,” he says, “We basically look at the properties and structure of the manganese oxides to try to understand how they bind metals and how that metal bonding affects the redox reactivity – which controls how they break down organic matter.”

Because the fundamental factors that Duckworth focuses on have such importance to the environment, he is often drawn into research with an applied aspect. For example, he’s worked with Dr. Dean Hesterberg to study how metals were being released from coal fly ash spilled in Tennessee. With Dr. Deanna Osmond and Dr. Michael Burchell, of the Department of Biological and Agricultural Engineering, he’s researched how nitrogen is transformed in riparian buffers, or vegetated areas along streams and rivers. And with Polizzotto, he’s looked at the interactions between manganese and iron and how they relate to arsenic contamination in Cambodian ground water.

Polizzotto says that Duckworth is a particularly valuable collaborator. “Owen is the nuts-and-bolts guy who makes everything work,” he says. “He is the glue that makes the research team bond, so that it can ask really tough questions and find really unusual discoveries.”

Duckworth says his work is always driven toward a goal. “We can do really cool molecular science,” he says, “and at the same time we focus on doing things that can support others – and that matter.”

A native of Richmond, Va., Dr. Owen Duckworth joined NC State in 2007 as an associate professor of soil biogeochemistry after serving as a postdoctoral scholar at the University of California, Berkeley. He holds a bachelor’s degree in chemistry and geology from the College of William and Mary, a master’s degree in environmental science from the University of North Carolina at and a doctorate in environmental engineering and applied science from Harvard University. The project studying manganese oxides is supported by a grant from the National Science Foundation (ECS-1407180).
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For information on how to join the Friends of Soil Science, please visit soil.ncsu.edu or contact Chris Cammarene-Wessel at 919.515.7678 or chris_wessel@ncsu.edu