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a southern forest story

Soil Opens Window to the Past and the Future
by *Scottee Cantrell*



In a South Carolina forest, where deer wander through stands of loblolly pines grown tall in old cotton fields, the land is eroded and gullies sometimes run deep. Cotton farming depleted and degraded the soil by the 1920s, so that when you step in some forest areas today, it is the subsoil that your foot touches. The topsoil - some experts say as much as six inches from Virginia to Georgia - was carried off downstream leaving behind fields too eroded to farm and rivers filled with sediment.

The soil that remains underneath the South's pines and hardwoods has an important story to tell about the history of old Southern agriculture and about modern rapidly growing forests and their sustainability, says the Nicholas School's Daniel D. "Dan" Richter. But to fully understand this story, there have to be permanent soil plots like those at the Calhoun Experimental Forest in South Carolina, where repeated sampling has been conducted for four decades, and for which a soil archive contains nearly all samples collected and carefully stored for periodic analysis.

"There are a number of long-term studies of forest change, but practically none of these include observations of how soils change through time," says Richter, professor of forest soils and ecology.

Richter credits Dr. Carol G. Wells of the U.S. Forest Service for originating the Calhoun study in 1957 and for continuing it through 1982. The site, located in a remote area of upstate South Carolina near Spartanburg, was originally an old cotton field that Wells' colleagues planted in pine, a very common practice in the mid-20th century.

When Wells retired, Richter expanded the Calhoun soil archive with help from his students. The archive is stored in a striking oak cabinet that dominates a second floor hallway at the Duke's Levine Science Research Center. Behind its doors are drawers labeled by year – starting in 1962 and continuing through 1997 at about five-year intervals – each containing dozens of little jars that together tell a forest history.



Calhoun Soil Profile



Although he speaks softly, it is with a great deal of enthusiasm that Richter talk about the richness of the Calhoun project, one of the world's longest soil studies, and the important part it can continue to play in providing new insights into soils, forests, and history.

• *The site, for example, is an ideal laboratory for observing effects from acidrain. "Whereas most environmental studies have modeled acid rain effects on soil with few if any field observations, we have coupled our soil-chemistry models with direct observations of soil acidification to better understand the acid dynamics of a forest," says Richter.*

Using observations and models, Richter and Dan Markewitz, a 1996 Nicholas School Ph.D. graduate and now assistant professor of forest soils at the University of Georgia, estimated that about 40 percent of the acidification of

Dan Richter (right) and Associate in Research Michael Hofmockel with soil archive Calhoun soils was attributable to acid rain and about 60 percent to natural forest processes. "One of the hardest problems in understanding the acid rain problem was to quantify the pollutant inputs of acids relative to natural contributions," Richter says.

The study has contributed special data to other issues of environmental significance, namely how much acid rain and other air pollutants have altered calcium, nitrogen, and lead in eastern forest soils. According to Richter, these issues have been contentious in the past because of the notable absence of direct observations of how soils change over time scales of decades.

- "The Calhoun experiment also is helping to solve the riddle of the carbon cycle, literally one of the great scientific issues of our age," says Richter. Carbon dioxide is increasing in the world's atmosphere mainly due to fossil fuel burning and will perhaps double in concentration by the end of the 21st century. This has raised keen interest in how the world's forests incorporate a portion of the excess carbon dioxide into tree biomass and soil.

Since the Calhoun Experiment includes such an extensive soil archive, much about the forest-carbon cycle is contained within the archive's collection of small jars, including the story of "bomb carbon." Bomb carbon – carbon that weighs 14 rather than 12 grams per mole – was greatly increased by above-ground testing of nuclear weapon in the 1950s and 1960s, about the time the Calhoun forest was being established. This meant that bomb carbon "labeled" the carbon that was added and stored in the forest, and can be used to follow it into and out of the forest ecosystem.

Richter led a study to investigate bomb carbon within the Calhoun ecosystem from 1957 to 1997, which resulted in a report published in the scientific journal, *Nature*, in 1999.

The study estimates the rapid rate with which the whole forest (trees and soil) can store carbon and quantifies the soil-carbon cycle like few other long-term ecological studies.

- The more Richter and Markewitz studied the Calhoun, the more they were interested in how the long history of cotton had altered the soil. In addition to assembling the chain of deeds for the Calhoun fields back to royal grants in the 1750s, they sought out for comparison four uncultivated soils that remained intact under old stands of oak and hickory. These are hardly "virgin forests," says Richter, "as they were undoubtedly used for timber, grazing, and fuelwood. On the other hand, the soils in these hardwood stands are relatively intact compared with the majority of the Piedmont landscape, which has been cultivated and cropped by many generations of farmers."

Not only have these hardwood forests provided insights into the carbon cycle, the uncultivated soils have proven to be remarkably acidic and infertile. Richter suggests that the natural acidity possessed by many soils of the Southeast has been underestimated, as has the degree to which historical Southern agriculture enriched soils with fertilizer nutrients and lime. "Not a small fraction of the nutrients cycled by the modern southeastern forest originated from fertilizers added by long-forgotten sharecroppers and tenant farmers," says Richter.

In an effort to increase the number of research sites available for long-term studies of soil, Richter is developing an initiative with the Southern Center for Sustainable Forests to network long-term research sites across the southern forest. This will allow researchers to better document changes in long-term productivity and in soil fertility.

Richter is one of three co-directors of the Southern Center, a research center formed in 1997 by Duke, North Carolina State University, and the North Carolina Division of Forest Resources to conduct research on controversial issues related to forests.

Richter says he is awed by increases in human demands on soils across the South, but also throughout the world. "Nowhere is it easy to use soil without damaging it, and we are clearly challenged by how to make the most of the soils we have inherited." Richter says he would like to do his part in helping to improve management of the earth's soil, a task that depends on understanding how we are changing what he calls the "central processing unit of the earth's environment."

Information is available online for the Calhoun Experimental Forest at <http://sedimentary.env.duke.edu/research/Calhoun/indexcalhoun.html>, and for The Southern Center for Sustainable Forests at <http://www.env.duke.edu/scsf/>.