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Book Documents Recent Changes to Ancient Southeast Soils

A new book coauthored by Duke University's Daniel Richter documents the extraordinary history of soils of the southeastern United States, where fields of a former vast cotton belt are now covered by rapidly growing pines.

The book describes how these soils -- among the world's oldest -- formed over about 70 million years, and how human use transformed them over the past two centuries in ways that provide valuable lessons for the world's land managers, said Richter, a professor of forest soils and ecology at Duke's Nicholas School of the Environment and Earth Sciences.

The new work, *Understanding Soil Change* (August 2001, Cambridge University Press), draws on records from Richter's and co-author Daniel Markewitz's outdoor laboratory in South Carolina's Calhoun Experimental Forest. There, with U.S. Forest Service colleagues, the pair has documented how soils were altered when primeval woodlands were turned into cotton fields that were eventually abandoned and have since regrown as pine forests.

Markewitz, Richter's former graduate student, is now a University of Georgia assistant professor.

"Given the importance of soils, there are surprisingly few long-term soil sites in which we can look at change in a scientific way, and I think this is a very important missing piece of science's ecological understanding," Richter said.

The Calhoun Forest, he noted, is particularly valuable for its record of how four decades of tree growth have altered soils in a number of important and sometimes surprising ways. At the Nicholas School, Richter and Markewitz are preserving an unusually complete archive of Calhoun soils collected seven times between 1962 and 1997. They hope to make another collection in 2002.

The Calhoun Forest soils provide insights for southern ecosystems as well as for a large part of the tropics that share similar soils and are currently undergoing rapid land-use transformations, Richter added.

"As we approach a 10-billion-person world, soils are being managed with an intensity and at a geographic scale never before attempted," he said. Yet, "we know so little about how management

changes soils. And this despite the fact that soils provide the basis of the world's food and fiber production, biodiversity, water supplies, and terrestrial and aquatic ecosystems."

According to Richter, soils in the southern U.S. "have formed mainly under forests that have controlled the natural breakdown of underlying bedrock since the time of the dinosaurs.

Over such a long period, the action of percolating rainwater has extended many southeastern soil covers to great depths -- more than 30 feet in the Calhoun forest and more than 100 feet at similar research sites near Duke's campus.

Leaching rainwater also acidifies and depletes the fertility of such soils. Given those inhospitable conditions, scientists have wondered how records could show cotton cultivation flourishing in South Carolina's inland Piedmont section by the early 1800s, and how cotton could become what Richter called "a South-wide phenomenon" by the 1830s.

Richter suggests one important reason cotton thrived was the "fertilizer effect" induced when settlers' cut and burned forests. Analogous to "slash and burn" land clearing practices in the tropics, nutrients accumulated in trees over long periods of time were suddenly returned to the soil, dramatically improving soil fertility for at least the initial series of crops.

This new found fecundity dwindled over decades of cotton growing so that farmers increasingly relied on chemical lime to reduce acidity, and nitrogen and phosphorus fertilizers to replace the nutrients crops had removed.

During the 1920s, fields were seriously affected by soil erosion and boll weevil infestations, and lime and fertilizers were unable to sustain the soil's former productivity. Farming was abandoned in much of the region by the mid-20th century. After that began "the modern part of this story that is so remarkable," Richter said, as those eroded but fertilizer-enriched soils supported the re-establishment of pines.

Scientists have found that native loblolly and short leaf pines make the most of available plant nutrients. Depleted but hardly "dead," the former farmland soils were able to grow pines "in part supported by fertilizers added by nearly forgotten share croppers and tenant farmers," Richter said.

Today southern forests, most growing in former farm soils, produce more wood than any other timber-growing region in the world. "We can readily demonstrate that land uses such as modern forestry have less impact on soils than former ecosystems such as cotton," the researchers said. "But what we really want to understand is the long-term ability of soils to sustain forest growth."

For instance, without agricultural lime the soils have re-acidified in ways mimicking pre-settlement conditions. But about 40 percent of the new acidity in upper soil layers is actually attributable to acid rain from human-caused air pollution, the authors estimated.

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