Shifts in soil bacterial populations linked to wetland restoration success

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A new study led by Duke University researchers finds that restoring degraded wetlands -- especially those that had been converted into farm fields -- actually decreases their soil bacterial diversity.

But that's a good thing, say the study's authors, because it marks a return to the wetland soils' natural conditions.

"It sounds counter-intuitive, but our study shows that in restored wetlands, decreased soil bacterial diversity represents a return to biological health," said Wyatt H. Hartman, a Ph.D. candidate in wetlands and environmental microbiology at Duke's Nicholas School of the Environment.

"Our findings are novel because they are the opposite of the response seen in terrestrial ecosystems, where restoration improves conditions from a more barren, degraded state," said Curtis J. Richardson, director of the Duke University Wetland Center and professor of resource ecology at the Nicholas School. Richardson is Hartman's faculty adviser.

Their report on the study will be published online this week by Friday in the *Proceedings of the National Academy of Sciences*.

Soils in undisturbed wetlands present harsh conditions, with elevated acidity and low oxygen and nutrient availability in which fewer bacterial groups can survive and grow, they explained. In comparison, former wetlands that have been drained, limed and fertilized for farming host greater soil bacterial diversity because they present conditions more suitable for bacterial growth.

"The bacterial communities in these fields almost resemble those found in wastewater treatment plants," Hartman noted.

Soil bacteria are essential to wetland functions that are critical to environmental quality, such as filtering nutrients and storing carbon. "The mixture of bacterial groups in wetland soils can reflect the status of wetland functioning, and the composition of these populations is as telling as their diversity," Richardson said.

Measuring whether the right mix of bacteria is returning to a restored wetland can be a valuable biological indicator scientists can use to evaluate restoration success, he added.

"We found that one of the simplest and most promising indicators of restoration success was the ratio of Proteobacteria, which have the highest affinity for nutrient-rich environments, to Acidobacteria, which have the highest tolerance for poor conditions," Hartman said.

The researchers determined soil bacterial composition and diversity within restored wetlands, agricultural fields and undisturbed wetlands across North Carolina's coastal plain. They sampled these paired land-use categories across three distinct types of wetlands: pocosin bogs, floodplain swamps and backwater swamps that were not connected to streams.

Samples were also taken from sections of the Everglades, the largest wetland in the United States, where a $10.9 billion effort is now underway to remediate the effects of agricultural runoff.

"We identified bacterial groups by their evolutionary relationships, which were determined by sequencing DNA extracted from soils," Hartman said. "This approach allowed us to capture a much greater diversity of bacteria than would be possible using conventional laboratory culturing, which works for only a small fraction of the 10,000 to 1 million species of bacteria that can be found in a single cubic centimeter of soil."

Previously, researchers have used genetic techniques to target known organisms or bacterial groups in wetland soils, he said. "But this study is unique in that we used these methods to capture the full range of bacterial groups present, and determine how their composition shifts with land-use changes and restoration."

"These types of findings can only be obtained in studies done on sites that have been restored and studied over a number of years and assessed with these modern techniques," Richardson said.

Wetlands filter and reduce nutrients and pollutants from agricultural and urban runoff as well as improve water quality and store around 25 percent of the world's soil carbon, while covering only 4 to 6 percent of its land mass.

More than half of original wetland acreage in the U.S. has been destroyed or degraded, but some has been restored in recent decades under the federal government's "no net loss" policy.

"Re-establishment of microbial communities indicates a restoration of the biological functions of soils. This study across a wide range of wetlands is the first to establish that shifts in soil bacteria populations may be a key marker of restoration success," Richardson said.

Source: Duke University