CZO | CALHOUN
CRITICAL ZONE OBSERVATORY

NATIONAL CZO PROGRAM

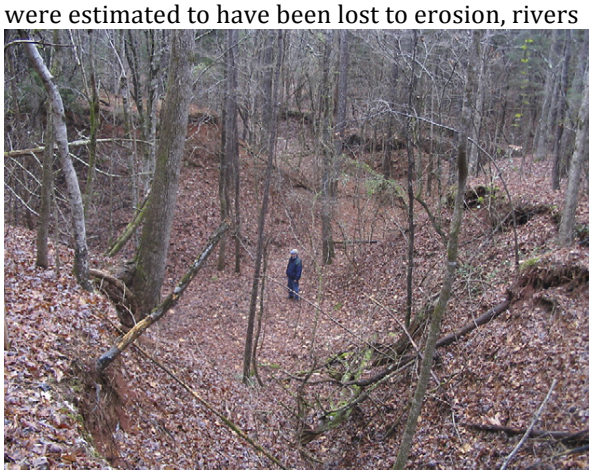
An observatory that integrates human and natural forcings of Earth's Critical Zones and the sciences of water, mineral, and organic matter cycles

A new CZO. The Calhoun CZO seeks to understand how Earth's Critical Zones (CZ) respond to severe soil erosion and land degradation. Re-instrumented catchments measure and help model changes in ecohydrology and biogeochemistry of interfluves, hill slopes, and terraces that were historically subject to accelerated erosion and deposition. Because CZs are integrated systems from upper plant-canopies to water in deep aquifers, research focuses on how land use stresses networks and processes that connect the CZ's surface and subsurface systems. Researchers will use historic and contemporary data of vegetation, soil, catchments, and sensor networks to help hindcast and forecast CZ dynamics and evolution across temporal and spatial scales.

USDA Forest Service Calhoun Experimental Forest Photo: ~1948

Location and Current Investigators. The Calhoun CZO is located in the USA's Southern Piedmont that extends from Virginia to Alabama. The new Calhoun CZO leverages more than 60 years of USDA Forest Service and Duke University research on land and water degradation and soil change based at the Forest Service's Calhoun Experimental Forest in the Sumter National Forest. The CZO investigators include researchers and educators from Duke University, University of Georgia, Georgia Tech, University of Kansas, Mississippi State University, Roanoke College, as well as the USDA Forest Service.

Critical Zone Evolution on the Piedmont. The Calhoun CZO aims to improve understanding of the dynamics and evolution of biota, landforms, soils, saprolites, hillslope hydrology, stream channels, and sediments that comprise CZs with belowground systems that are ancient (>10^6 y), deep (~30 m on interfluves), and of advanced-weathering stage, often with no weatherable primary minerals for many meters in depth. These attributes suggest CZs that are highly vulnerable to human alteration, and indeed, much of the Southern Piedmont including the Calhoun Experimental Forest has a history that involves some of the most serious agricultural land and water degradation in the nation. By the mid-20th century, nearly 18-cm of soil over more than 10 million ha were estimated to have been lost to erosion, rivers

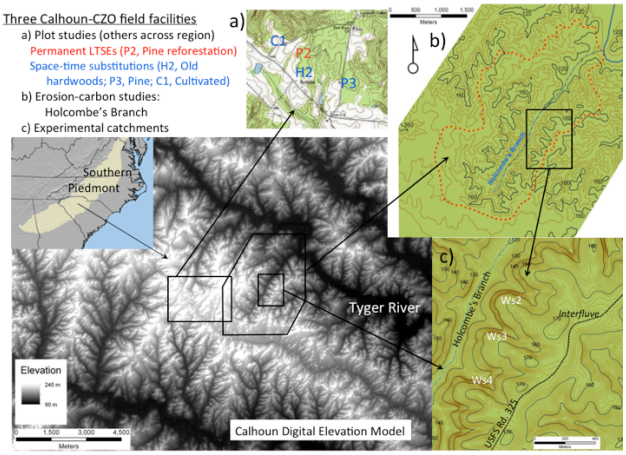


Calhoun Experimental Forest photo, ~2006 James et al. Catena

carried enormous sediment yields, cultivation-based crops were no longer viable, and large numbers of farmers had abandoned the land. Remarkably, by the late 20th century, the eroded and often abandoned Piedmont farmland had been extensively reforested, motivating many to adopt the perspective that the degraded land had been restored in a matter of decades by a process known as "old-field succession." *Our team has a more critical perspective, and is guided by a hypothesis that the impressive local and regional reforestation masks fundamental alterations in CZ hydrology, geomorphology, biology, and biogeochemistry and that post-disturbance CZ evolution may not so much recover as restabilize in altered states*. Given all this, the Calhoun-CZO provides an important opportunity for meeting the growing need to understand CZs "in the face of land use change … to inform strategies for sustaining a wide range of human activities" (from NSF's CZO Program Solicitation, NSF 12-575).

Critical Zone Science at the Calhoun CZO. We live in a time in which over half of the Earth's CZs are

affected by natural *and* human forcings, and a key objective of the Calhoun-CZO is to help integrate humanity into CZ science. To that end, we see Calhoun CZ science to be transformational in exploring the CZ's lower boundary conditions and processes, and the CZ's evolution following land degradation. The CZO is organized by research questions motivated by the concept that natural CZs are integrated systems from upper plant-canopy boundary layer to the water in the deepest aquifers and that human forcings typically accelerate CZ processes associated with vegetation, atmosphere, and surface hydrology and soils, thus stressing temporal and spatial networks that connect surface and deep subsurface components of the CZ.



Three Calhoun CZO field facilities located on topo and DEM maps..

The questions that organize Calhoun CZO research build directly on past research at the site and span multiple scales of time and space:

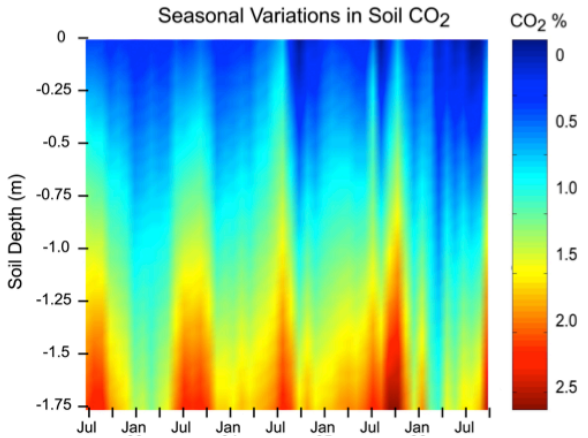
1) Do land-use change, land degradation, and erosion decouple upper and lower CZ systems, by destroying macroporosity networks that are conduits of gas and water exchange? How rapidly can re-forestation recover CZ porosity and re-network the CZ into an integrated system?

2) How has the legacy of severe erosion redistributed and altered organic carbon dynamics on both eroded uplands and in anoxic alluvium filled with historic sediment?

3) How do human-forced changes in the CZ interact with human livelihoods, adaptation, and governance?

4) Can human-forced CZs enter new steady states, complete with positive feedbacks and attractors that resist recovery?

Re- and up-instrumented catchments, first instrumented by hydrologists in the late 1940s, will allow investigators to measure, experiment, and model ecohydrologic and biogeochemical dynamics from interfluves to a variety of hill slopes to toe slopes and terraces, all across multiple temporal and spatial scales. Sensors connected by wireless networks and samplers of gases and water will be co-located along transects and in depth-dependent arrangements to examine the recovery of integration in the degraded Critical Zone systems. Interdisciplinary models are being coupled with radiocarbon and stable isotope analyses to hindcast and forecast system hydrology, soil properties and processes, and overall CZ biogeochemistry.



Deep CO_2, soil solid and solution data will be greatly expanded in Calhoun-specific and Cross-CZO studies.

Broader Impacts of CZO Science. The Calhoun-CZO is a center for research *and* education. The CZO is linked to a Duke University IGERT-training center on intelligent sensor networks, annual CZO science meetings will have oral and poster presentations, discussions, and training sessions that involve scientists and students as fundamental members of the CZO team. We plan a range of outreach efforts to local, regional, and national publics with multi-media science, history, and community-based components, using field days, hardcover books, op-eds, Facebook, and Twitter. An important focus of the CZO is on undergraduate research and education, and we are developing a set of classroom-tested, web-based laboratory and classroom activities for undergraduates and advanced high school students based, in part, on real-time and historic data from the Calhoun CZO.

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