CZO | CRITICAL ZONE OBSERVATORIES
U.S. NSF NATIONAL PROGRAM

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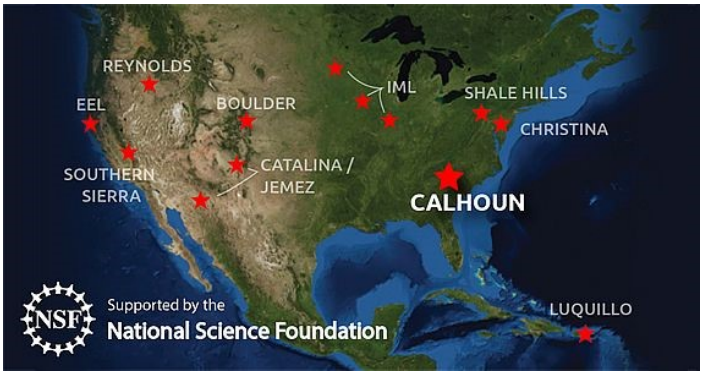
Objective

Wherever people live, we tend to accelerate soil erosion. This activity familiarizes students with the environmental and human factors that increase soil erosion, using the southern Piedmont as a case study. The goals are to: (1) develop skills and knowledge that relate soil erosion to land cover, slope, and land management and (2) draw attention to the role of Critical Zone (CZ) science in understanding social and environmental processes that shape managed landscapes.

Materials

- Computer with internet access
- Paper and pen or pencil

The Critical Zone



The Critical Zone extends from the tops of the vegetation to depths at which fresh groundwater freely circulates. This is the zone where nearly all terrestrial life resides, including humanity. Soil, one of the most essential Earth materials, lies at the heart of the CZ. Critical Zone Observatories (CZOs) are platforms for studying the processes occurring in the CZ and how these processes change through time (see criticalzone.org). The Calhoun CZO (CCZO) is located in the Sumter National Forest in upstate South Carolina (criticalzone.org/calhoun/). This region was severely impacted by soil erosion that occurred when forests were cleared for agriculture from about 1800 to the early 1900s. By the mid-20th century, more than 25 million acres of once-productive land had been severely eroded. These high rates of erosion reduced the soil's capacity to grow crops and impacted water quality in streams. Many farms were abandoned or sold as struggling farmers migrated to urban areas or to more productive farmlands. The USDA Forest Service began purchasing some of these properties in the 1930's to create the Sumter National Forest and later established the Calhoun Experimental Forest to study ways to manage soils on such fragile and eroded land. The CCZO builds upon this long history of research to examine how agricultural degradation and reforestation change CZ processes such as soil productivity, hydrology, mineralogy, water quality, and carbon exchange. Together, research at the Calhoun Experimental Forest and the CCZO provide a 70-year window into how the CZ of this region has both influenced and responded to human management.

Land management, soil erosion & conservation

Humans are entirely dependent on soil. Food, clean drinking water, and many other ecosystem services all depend on the complex interactions between soil, atmosphere, water, and living organisms that occur at Earth's surface. Yet, this invaluable Earth material is continually eroded by the forces of water, wind, gravity, and most recently humans, the dominant erosive factor on the planet. Environmental factors such as the amount and intensity of rainfall, the slope (steepness) of the land, and the erodibility of the soils themselves can all impact rates of soil erosion. For example, water will flow faster, and have greater erosive power, when running down a long, steep hill rather than across a flat field.

Photo credits: USDA Forest Service

Human management practices such as removing vegetation, plowing along slopes, or construction that causes water to run across the land surface can increase rates of erosion above background rates. Without proper management, a single rainstorm can wash away 100's of years of soil development! Fortunately, we can also conserve soil through practices that slow water and hold soil in place.

For an illustrated guide to the CCZO, visit
criticalzone.org/national/blogs/post/what-is-the-calhoun-critical-zone-observatory/

Classroom Activity: Humans and Soil Change

The CCZO experienced severe soil erosion due to human management. Even today, the combined history of erosion and later efforts to conserve and restore the soil continue to shape the landscape.

1. Open Google Earth and visit 34.6118°, -81.7102°. Zoom out so that the camera is ~ 10,000 m and north is at the top. What land uses do you observe? Use the 3D view and the elevation profile (Fig. 1) to describe the topography. Where do different land uses occur along the elevation profile?

2. The Piedmont ("foothill") of South Carolina is characterized by weathered bedrock and gently rolling hills dissected by streams. (a) Describe the general pattern made by stream valleys in the CCZO. How do steeper and flatter areas correspond to the location of streams? (b) What do these patterns suggest about how water shapes the land? (c) Based on slope, which areas have a potential for future soil erosion? Why?

3. Visit: criticalzone.org/calhoun/news/story/czo-agi-2020 and examine images of two soil profiles. The soils at the CCZO are ancient, deep, and highly weathered. The darker colors at the surface indicate higher levels of soil organic matter, which is important in storing plant nutrients. Which parts of the soil profile are most impacted by erosion? What effect might this have on the future ability of the soil to store nutrients and grow plants?

4. Plant roots help to hold a soil in place. Compare rooting patterns in the forested and agricultural soil profiles. Based on the photos, how might erosion potential change if a forested area were converted to agriculture? If agricultural lands were planted with trees? If all vegetation were removed?

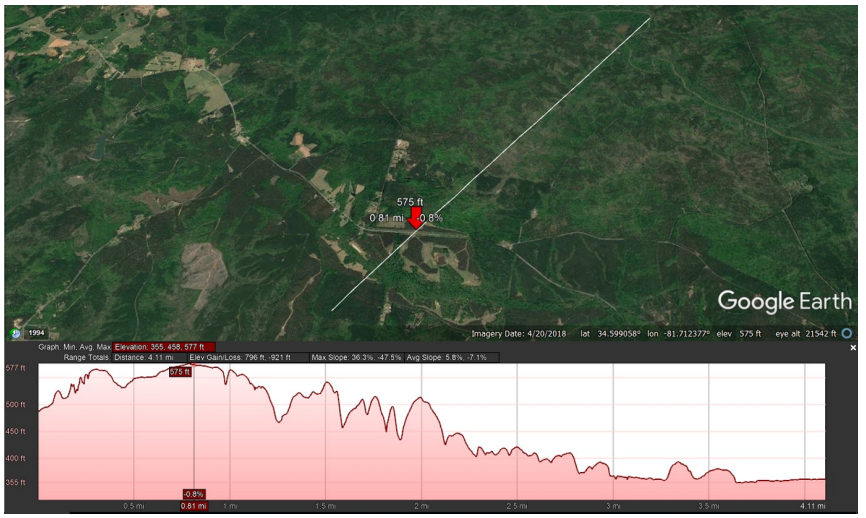


Figure 1. Land cover and elevation profile along a transect at the CCZO.

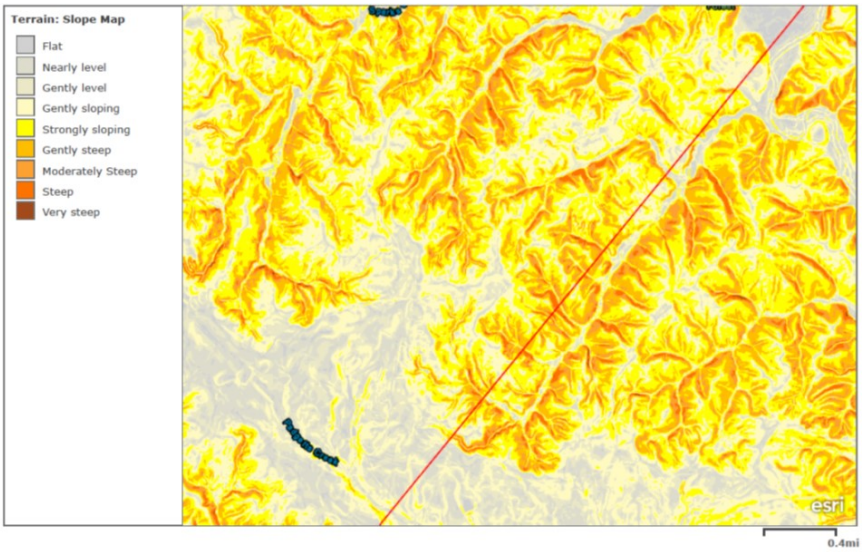


Figure 2. Slope along a transect at the CCZO. The lines in Figs 1 and 2 may be used as references.

5. Native American agriculture was well-developed and primarily located in the flat bottomlands near streams and rivers. Early European and African-American settlers first farmed bottomlands but then began farming the broad, relatively flat areas between the streams ('interfluves'). As populations increased, later small farmers, both European and African-American, cleared forests on upper slopes and converted them to agriculture (yellow areas of Fig. 2). (a) Create a cross-sectional diagram of a stream valley. (b) Use the diagram to interpret how changes in agricultural management could have impacted soil erosion.

6. Surface materials eroded by human activity are carried away in streams and eventually deposited as sediments lower in the watershed. These sediments are called "legacy sediments" because they reflect the legacy of human activity. What do legacy sediments indicate about the effects of erosion on nutrients and organic matter across the larger landscape? Are the impacts the same on erosional and depositional areas of the landscape? Explain.

7. Imagine that you are a resource manager for the USDA Forest Service. What management practices would you suggest to reduce future rates of soil erosion in the lands around the CCZO? Explain your reasoning.

Teacher's Notes: Additional information about the CCZO may be found at http://criticalzone.org/calhoun. 1) The topography of the CCZO has a pronounced dendritic drainage pattern with stream valleys separated by broad, relatively flat interfluves. Roads, towns, and many agricultural lands tend to be located on flatter parts of the landscape. 3) The upper portions of the soil profile erode, leaving the clay-rich subsoils near the surface. Heavily eroded soils are less able to support agriculture. 4) The rooting in the forested soil is more extensive and deeper than in the agricultural soil. 6) Soil organic matter and nutrients removed from erosional areas are deposited in other portions of the landscape. Although there is a net loss in nutrients and organic matter from one part of the landscape, other areas may experience a net gain. 7) Examples could include: planting vegetation, stabilizing slopes, plowing or building forest roads along elevation contour lines.