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Damaged Land, Buried Carbon
Erosion and Deposition Constitute a Net Carbon Sink

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Everybody knows erosion is bad, but one of the bad things everybody "knows" may be a bum rap: that erosion is a source of increased carbon dioxide entering the atmosphere. Is erosion really a carbon source, or might it be a carbon sink?

In a new study and analysis, a team of scientists at UC Berkeley, Berkeley Lab, and the US Geological Survey (USGS) reports that soil erosion and deposition form a significant carbon sink, which potentially offsets as much as 10 percent of global fossil-fuel emissions of CO_2.

From left, Margaret Torn, John Harte, and Asmeret Asefaw Berhe (photo Roy Kaltschmidt). On right, Jennifer Harden.

"Erosion is a serious problem, but there's a silver lining," says the report's lead author, terrestrial biogeochemist Asmeret Asefaw Berhe, a postdoctoral fellow in UC Berkeley's Department of Earth and Planetary Sciences and a guest in Berkeley Lab's Earth Sciences Division (ESD). "By conserving lands that have stored this eroded carbon, we can continue to keep that carbon from re-entering the atmosphere as CO_2."

Berhe is from Eritrea, where as a young woman she studied soil and water conservation at Asmara University. She earned her master's degree in resource development (political ecology) at Michigan State University and at Berkeley focused on erosion and the soil carbon cycle for her doctoral studies.

"It is not our intention to put a positive spin on soil erosion but to contribute to a proper accounting of carbon," she says of the team's findings. "If anything, we stress the need to continue programs for conserving marginal lands."

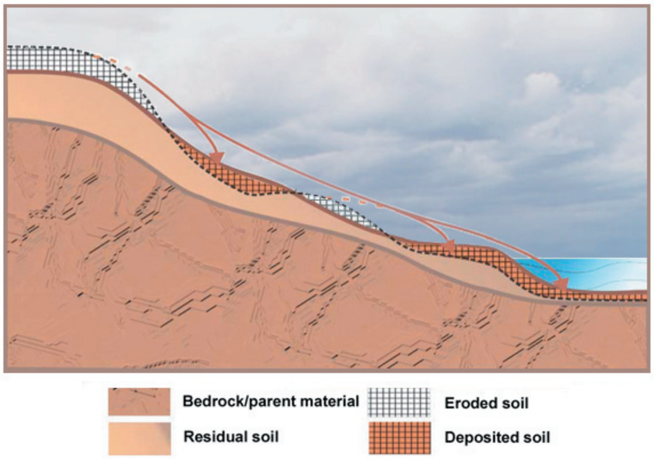
Berhe's coauthors are ecologist John Harte of UC Berkeley, soil scientist Jennifer Harden of the USGS, and biogeochemist Margaret Torn of Berkeley Lab and UC Berkeley. They conclude that it's necessary to revise past estimates of how much the historic increase in atmospheric CO_2 concentration is caused by land-use changes. If some eroded areas are carbon sinks, there's an even greater impetus to conservation.

Torn, who heads ESD's Climate Change and Carbon Science program, says, "Whether and where soils constitute a net carbon sink or a net source of atmospheric CO_2 is an unresolved question, but it clearly depends on local conditions." Proper accounting is essential because, as she and Harte have shown, loss of the carbon presently stored in soils could contribute to feedback loops that accelerate global warming.

Unnatural erosion

Most erosion is caused by deforestation, biomass burning, and poor agricultural practices. Even landmines are a significant cause of land degradation in some countries, including Berhe's native Eritrea. Costs to the environment are severe, and human welfare is directly impacted by loss of productive agricultural land, increased flooding, silting of reservoirs, and other damage. The same human activities that cause erosion increase the amount of carbon dioxide in the atmosphere. It's estimated that land-use changes since the Industrial Revolution have released CO_2 equal to three-quarters of the CO_2 from fossil fuel emissions.

"Because erosion is such a pressing environmental problem, anything positive associated with it is almost impossible to perceive," says Berhe. "This may be one reason why the question of whether soil erosion is a net carbon source or sink has been a subject of fierce debate among Earth scientists."



Erosion moves soil and organic carbon downslope to be deposited in basins. If undisturbed, some depositional basins serve as a significant carbon sink.

Much of the carbon that plants take out of the atmosphere cycles through the soil. Decomposing organic matter releases carbon back into the atmosphere. Erosion affects both processes, positively and negatively.

In eroded soils, plant productivity and carbon input are reduced. Some nutrient losses can be offset by good farming practices and fertilizers; fuel to make fertilizer and run farm machinery is a carbon source, however.

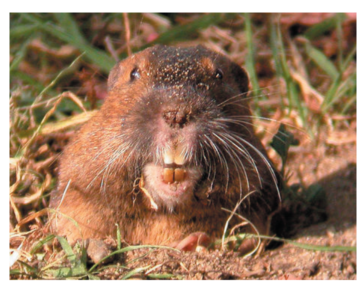
As eroded soil is transported downslope, decomposition may be accelerated, releasing more carbon; however, when the soil is deposited and buried, especially in flooded, low-lying areas, decomposition slows.

"Our goal was to understand not only how much carbon is transported and deposited by erosion, but what mechanisms stabilize this carbon in the soil where it is deposited," Berhe says. "In particular we were interested in how stable the carbon is in the depositional settings, as compared to the carbon that remains on the eroding slopes."

To assess the carbon balance, the researchers studied two different watersheds. One, the Tennessee Valley in the Marin Headlands, has been relatively undisturbed for many years, and erosion there occurs naturally—the chief cause being vigorous burrowing by pocket gophers. The erosion rate is low.

The second site was studied by coauthor Harden as part of the USGS Mississippi Basin Carbon Project. The Nelson Farm in northern Mississippi was cleared from a hardwood forest in 1870 and has been intensively cultivated ever since, with crops like soybeans and hay; rates of erosion are high, although the land continues to be productive because of fertilizer use.

The researchers found that only a small part of the atmospheric carbon taken up by growing plants ends up in the erosion-induced terrestrial carbon sink—about one percent of the net primary production (plant growth), and about a sixth of all the carbon transported by erosion. The carbon sink at the agricultural site was proportionally bigger than at the wild site, storing 15 times more carbon because of greater erosion and deposition. Most carbon deposited by erosion never leaves its watershed.



A pocket gopher rearranges the soil in Tennessee Valley.

How much eroded carbon is decomposed, during erosion and after it is deposited in different kinds of basins, remains an important unanswered question. The authors argue strongly for controlling erosion in flood-prone areas, degraded soils, and other eroding landscapes by improving agricultural practices. A good cover of undisturbed vegetation increases the soil's potential to store carbon.

"As a result of erosion, a significant amount of carbon is stored in the soil by burial and aggregation, which prevents it from being released back to the atmosphere," Berhe says. But there's a caveat: "If this sink is disturbed"—for example by dismantling earthen dams, which store a great deal of carbon—"potentially a lot of carbon could be released into the atmosphere. Consequently, conservation lands should be perpetuated to protect those carbon stocks."

This is an edited version of an article appearing in the April 2007 edition of Science@Berkeley Lab, the online science magazine of Lawrence Berkeley National Laboratory. The full-length version, including links to further information, may be accessed at http://www.lbl.gov/Science-Articles/Archive/sabl/2007/Apr/05-erosion.html.