Saving our soil: How to extend US breadbasket fertility for centuries

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UMass Amherst geosciences professor Isaac Larsen standing on the erosional escarpment at Stinson Prairie, Iowa. Credit: UMass Amherst

The Midwestern United States has lost 57.6 billion tons of topsoil due to farming practices over the past 160 years, and the rate of erosion, even following the U.S. Department of Agriculture's guidelines, is still 25 times higher than the rate at which topsoil forms.

Yet, we need not despair: researchers from the University of Massachusetts Amherst recently reported in the journal *Earth's Future* that no-till farming, which is currently practiced on 40% of cropland acres in the Midwest, can extend our current level of soil fertility for the next several centuries. This has implications for everything from food security to climate-change mitigation.

The vast majority of the food we all eat is grown in topsoil, that carbon-rich, black earth that nurtures everything from watermelons to brussels sprouts. What most of us call topsoil, scientists call A-horizon soil, and these A-horizon soils, whose fertility has developed over eons, are susceptible to erosion.

"When most people think of erosion, they think wind or water," says Jeffrey Kwang, currently a postdoctoral fellow at the University of Minnesota who completed this research as part of his postdoctoral studies in Isaac Larsen's Geomorphology Research Group at UMass Amherst and is lead author of the paper. "It turns out that the far greater driver of soil erosion in the midwestern U.S. has been conventional agriculture."

But what that current rate of erosion is has been very difficult to pin down precisely, though, as the Geomorphology Research Group has shown over the past few years, soil erosion in the U.S.'s breadbasket is far greater, and occurring at a far faster rate, than had previously been suspected.

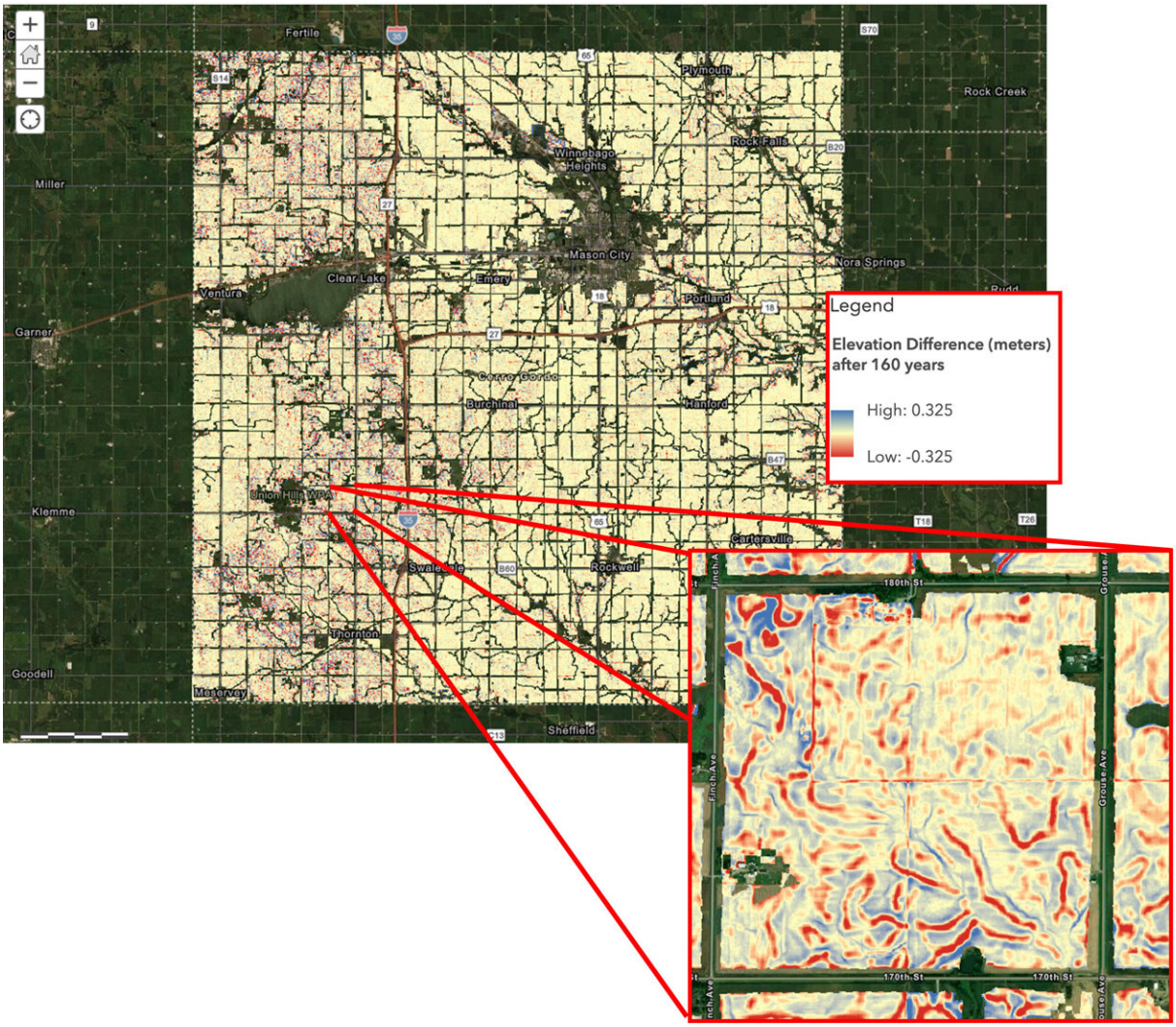
A brief history of soil loss in the Midwest

Since 2021, members of Larsen's research group, including Kwang, Evan Thaler, Caroline Quarrier and others, have been breaking new ground in the world of soil science.

The group's initial study showed that more than one-third of the Corn Belt in the Midwest—nearly 30 million acres—has completely lost its carbon-rich topsoil, that rich A-horizon layer. Furthermore, the team showed that the erosion was likely due to contemporary tillage practices, in which plows are dragged through fields, moving topsoil from higher to lower elevations. Unfortunately, the USDA's own assessments don't include erosion due to tillage, and so the agency has missed a major driver of erosion.

A year later, the team discovered that the Midwest has lost 57.6 billion metric tons of soil since Euro-American cultivation of the region began, approximately 160 years ago. This historical rate of loss, which is mostly due to tillage, is nearly double the rate which the USDA considers sustainable.

Finally, the team recently showed that Midwestern soil is eroding between 10 and 1,000 times faster than it did in the pre-agricultural era, and that the USDA's current upper-limit of sustainable erosion—1 mm per year—is an average of 25 times more than what is actually sustainable.



Cerro Gordo County, Iowa and detail of individual farms (inset) soil loss over next 160 years under a conventional plowing scenario. Dark red areas show soil loss of 32.5 cm (12.8 inches); blue show gain of 32.5 centimeters. Credit: Jeffrey Kwang

Modeling the future

"We already discovered how the history of erosion in the U.S. has shaped our present reality," says Isaac Larsen, associate professor of

earth, geographic and climate sciences at UMass Amherst and the paper's senior author. "But what's going to happen in the future?"

For this latest research, Kwang, Larsen and the Geomorphology Research Group relied on the insights of their earlier work into historical rates of erosion to predict future scenarios. Their first breakthrough was to finally determine the current rate of tillage-driven soil erosion. It turns out that the Midwest loses 1.1 kilograms of soil and 12 grams of soil organic carbon (SOC) per square meter every year, which far outpaces the rate at which new topsoil is created.

But no one knows what the future will look like. "Since we don't know how farming practices and policy will change," Larsen says, "we've used the current erosion rate to model a few different future scenarios."

"We looked at the current business-as-usual method, under which approximately 40% of the midwestern U.S."s acres are no-till farmed, all the way up to 100% adoption of no-till methods. We then modeled the erosional rates under each scenario for the next century," says Kwang.

Their initial finding was that, if the U.S.'s current agricultural practices remain largely unchanged, approximately 8.8 billion metric tons of soil and 170 million metric tons of soil organic carbon will be lost over the next century alone.

When the team modeled the impact of a 100% no till scenario, the picture turned rosier. Much rosier.

"Approximately 95% of the erosion we see under the business-as-usual scenario over the next century would be prevented," Kwang says.

Put another way, the soil savings are so significant that if the U.S. adopts no-till practices now, it would take 10,000 years to see the same level of

soil and SOC loss that would occur in only a century if our agricultural practices do not change.

Furthermore, the rate of loss decreases over time: the more soil and SOC there is, the faster we lose it, and the rates of loss taper off as there's less to lose. "This means there's real incentive to act now," says Kwang, "when we'll see the most long-term benefit."

Soil and climate

It's no surprise that topsoil is crucial for agriculture; but most forecasts for greenhouse gas emission and plans for climate mitigation also need to account for topsoil loss, because soil is the largest pool of terrestrial carbon. Scientists hypothesize that accelerated soil erosion alters this carbon pool enough to influence the global carbon cycle.

However, Kwang says, "most models that look at soil and its effect on climate don't account for erosion rates slowing down over time. We need to get this right if we're to prepare effectively for the future—and know we have a rate that can help inform predictions of what the future climate might be."

More information: The Future of Soils in the Midwestern United States, *Earth's Future* (2023). DOI: 10.1029/2022EF003104. agupubs.onlinelibrary.wiley.co … 10.1029/2022EF003104

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