Crop and Soil Responses to Topsoil Replacement in Eroded Landscapes

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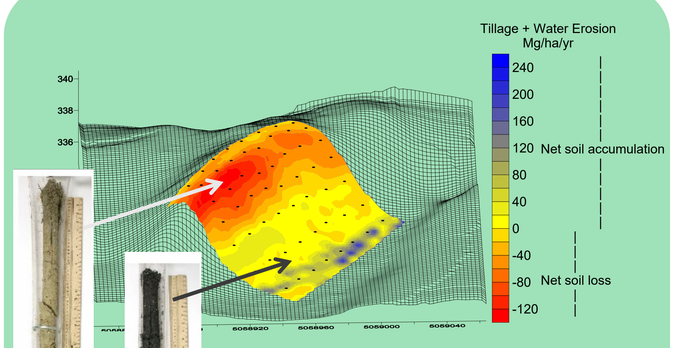
Key Findings

- In a hilly landform that has been cultivated for many years, erosion had removed virtually all topsoil from the upper slope and deposited topsoil in the lower slope.
- We reversed erosion by moving 15-20 cm of soil from the lower slope to the upper slope.
- Soil addition increased soil organic carbon content, plant nutrients, water infiltration, and soil water content during crop emergence, resulting in 12-59% higher corn and soybean yields.
- Removing soil did not drastically change most measured soil properties but crop yields were sometimes lower in areas of soil removal.

Background

In hilly agricultural landscapes, soil properties and crop yields vary throughout the field and often reflect the pattern of soil movement resulting from the combined erosive effects of tillage and water. Areas of high convexity tend to have a shallow A horizon depleted in soil organic matter, plant-essential nutrients, and available water; these areas are typically low-yielding, especially in dry years. In contrast, concavities tend to have deep topsoil accumulation, with soils high in organic matter and nutrients; these areas are high-yielding in dry years but can be low-yielding in years with excess moisture.

Reversing the erosion process by replacing translocated topsoil (soil-landscape rehabilitation) is one method to improve the productivity of eroded land.



a

b

In the landscape we studied, tillage is the dominant erosive force. Under intensive tillage, soil loss rates were as high as 130 Mg per ha (58 tons per acre) per year in the most convex landscape positions (shoulder and upper backslope). Soil accumulation occurs in concave positions.

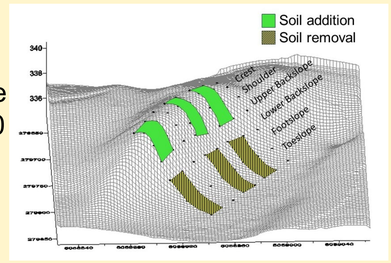
Soil profiles show the effects of topsoil redistribution. In areas of high soil loss (profile a), the surface soil is low in organic matter. Subsoil material that is light in color and high in calcium carbonate has been mixed into the surface soil in the upper slope. In the lower slope (profile b), approximately 46 cm of depositional material (moved by erosion from higher slope positions) overlies the original topsoil, so that high-organic-matter soil extends to 68 cm deep.

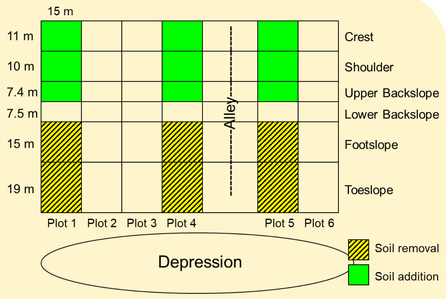
Objective

Investigate relationships between key soil physical, chemical, and biological factors and crop growth and grain yield in eroded and rehabilitated landforms

Methods

Earth moving equipment was used to remove 15-20 cm of soil from the footslope and toeslope and add 15-20 cm of soil to the crest, shoulder, and upper backslope of the same plot.





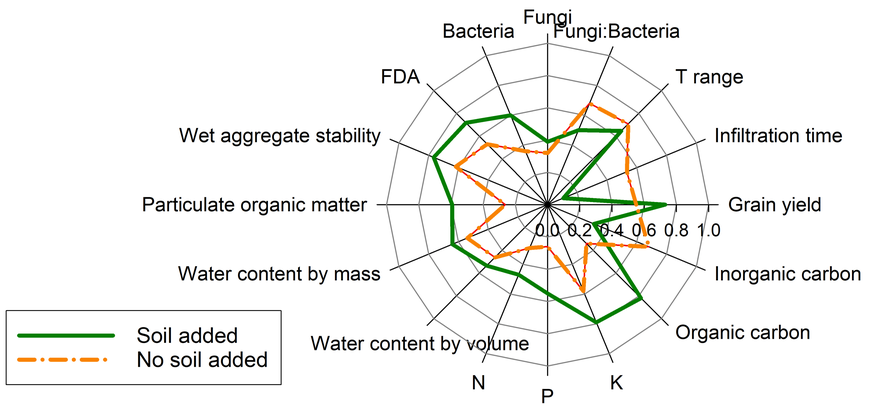
Soil was moved in 3 plots; another 3 plots remained in their eroded condition.

Soil samples were collected before soil movement in the fall of 2005 and annually after soil movement. We evaluated soil properties and crop responses from 2006 to 2011. The site was farmed as part of the larger field, according to regional practices implemented by the landowner.

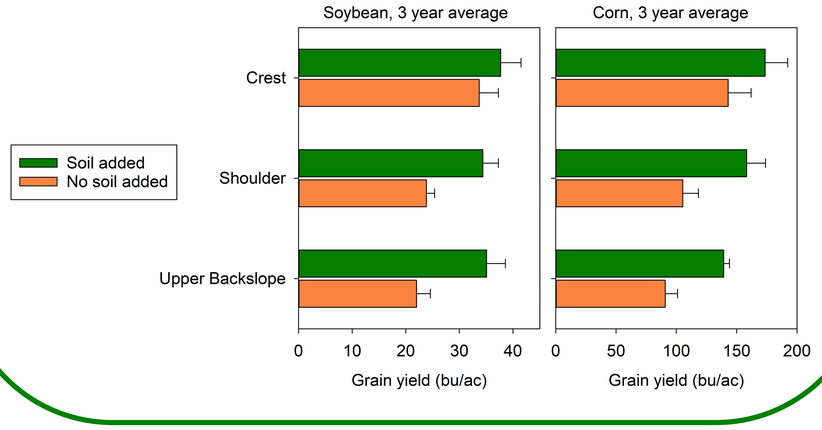
Results

Upper slope:

Surface soils in areas of soil addition had 2-3 times higher organic carbon and higher nutrients, water content, and other properties compared with areas with no soil added.

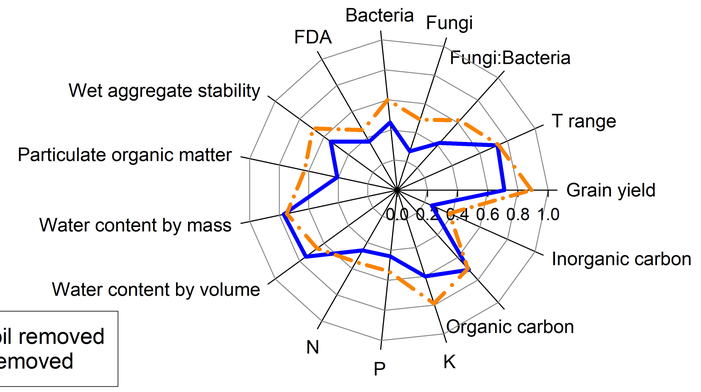


Corn yields were 21-53% higher and soybean yields were 12-59% higher in areas of soil addition, with the largest yield increases observed in the most eroded landscape positions.

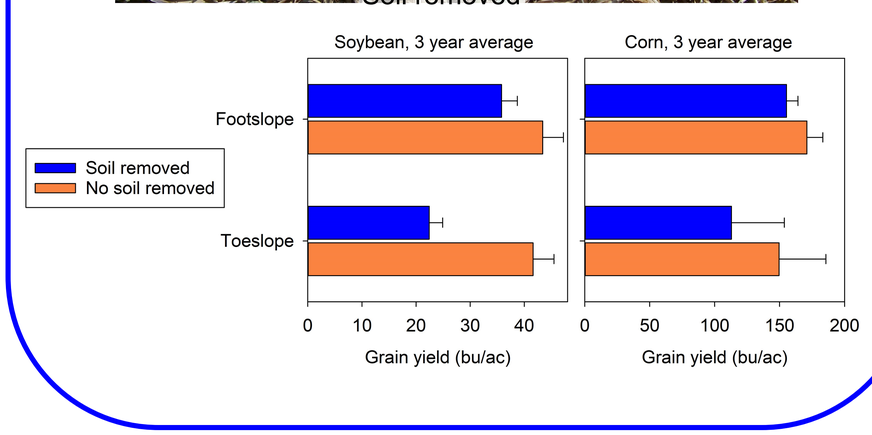


Lower slope:

Because of the deep accumulation of topsoil in the lower slope, removing 15-20 cm of soil did not result in a large change in most soil properties. Soil biological indicators were lower in areas from which soil was removed.



Corn and soybean yields were lower where soil was removed. The largest yield reduction was in the lowest landscape position, which was affected by excessive moisture in wet years.



Further Findings and Next Steps

- We conducted numerous experiments at this severely eroded site in addition to the work presented here. We also found
  - Crop yield increases were not due to increased stand.
  - Soil addition increased corn grain protein and test weight.
  - Soil movement did not worsen weed issues.
- Similar experiments in a moderately eroded landform showed only marginal yield increases.
- Follow-up studies evaluated whether a soil amendment (dairy manure solids from an aerobic digester) could improve soil properties and crop yields in a manner similar to adding soil. A separate study evaluated yield responses when adding different depths of topsoil.

Acknowledgements

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