# COVER CROPS: A COST-EFFECTIVE TOOL FOR CONTROLLING EROSION

## The Cost of Soil Erosion

Erosion remains one of the premier threats to United States agriculture. Soil is valuable, and productive soil is very valuable. It is quite difficult to calculate the exact value of soil because of the many factors that affect soil productivity as well as the variety of ecosystem services that soil provides. The price of bulk topsoil can offer a crude estimate of soil value. For example, topsoil can sell for 40 dollars per ton in Missouri. However, soil health and soil type can have a considerable effect on the value and productivity of soil. Furthermore, the variety of ecosystem services provided by soil should be considered when assessing its value.

Calculating the cost of erosion is even more complicated than the value of soil because one must consider not just the loss of soil, but also the impacts of that lost sediment in other areas. Rivers need to be dredged, ponds have to be re-excavated, and water quality must be improved after erosion occurs, all of which costs money. We lose on average about 12 tons per acre per year from agricultural soils.[2] Most soil lost to erosion is topsoil, which is the most productive and valuable part of the soil profile. Even without having detailed costs for all erosion impacts, the value of soil and the need to reduce erosion are apparent.

## Current Erosion Control Practices

There are a number of methods used to limit erosion. Many are old, if not ancient, ideas that can be employed to greater effect when combined with modern technology. Farming along contours, terracing, no-till and cover crops are all examples of old ideas refurbished with modern technology. Agricultural technology remains a dynamic field, and some of the most exciting technology, from an erosion perspective, allows farmers to harness biological processes that used to seem incompatible with large scale agriculture.

**Gully erosion on a field after soybeans with no cover crop (Photo credit: Joe LaRose)**

Erosion is sometimes thought of as a physical process that requires mechanical solutions and a bulldozer. Terraces, waterways, and retention ponds are valuable tools for reducing erosion; however, biological solutions are also effective while offering additional economic and environmental benefits. Grassed waterways, buffer strips, no-till, and cover crops are examples of biological solutions to erosion. No-till and cover cropping in particular has enormous potential to control erosion as well as providing other valuable environmental and economic benefits. Fortunately, a growing number of farm operators and owners are recognizing that potential. The 2017 Census of Agriculture reported that cover crop use in Missouri more than doubled from 2012 to 2017, increasing by 116 percent to 842,178 acres. Over 6,000 farm operations in Missouri were using cover crops in 2017. The picture for no-till is even more encouraging, with a total of 4.6 million acres of reported no-till in 2017, up 15.6 percent from 2012. However, there are about 10.1 million acres of row crop production in Missouri, so no-till is still less than half the acreage and cover crops are less than 10 percent of the

*Authored Joe LaRose and Rob Myers, Center for Regenerative Agriculture, University of Missouri.*

acreage. There is a need for additional attention on how these practices can be implemented.

## What Are Cover Crops?

Cover crops are plants used to protect and improve the soil that are not grown for harvest. Cover crops can fit into any cropping system that leaves soil without a living root for part of the year. There were 15.4 million acres of cover crops planted in the United States in 2017 [3]. The typical corn-soybean rotations of the Midwest certainly have room for cover crops, with nearly a nearly seven-month window between harvest and planting. A typical example of cover crops in this system would be cereal rye planted immediately after corn harvest before beans, then a mix of oats, radishes, or crimson clover after soybean harvest and before corn again.

Technically, any herbaceous plants could be used as a cover crop, but there are certain traits that make for good cover crops. Cover crop species that establish easily, grow quickly, and have affordable seeds are very desirable. Cover crops also need to be killed at some point to allow cash crops to grow, a process referred to as "termination." Some plants species are more easily terminated than others. Cover crops such as oats and radishes will be killed by cold winter temperatures when planted in the fall. Other species such as cereal rye or hairy vetch will survive the winter and grow more in the spring. These winter-hardy cover crops must be terminated by herbicides, rolling, mowing, or tilling. Cover crops that belong to various plant families often serve different purposes. Grasses are often used to scavenge nutrients and suppress weeds. Legumes like crimson clover fix nitrogen and can support beneficial insects. Brassicas such as canola can be used for cover crop grazing and pest control. Regardless of the family, all cover crops are useful for controlling erosion to some extent. To understand how they can be an integral part of erosion control, it is important to understand the process of erosion.

## The Erosion Process

Erosion happens when soil moves. Wind, water, and ice can all cause erosion. This bulletin mainly deals with water erosion, therefore we will generally refer to erosion in this section as when water moves soil downhill. There are three factors that interact to produce erosion: **rainfall**, **infiltration**, and the **water holding capacity** of the soil. The infiltration rate is simply how fast water sinks into the soil. If at any time rainfall exceeds infiltration rate, the excess water unable to enter the soil will become runoff and erosion is possible. When infiltration rates are higher than rainfall, however, water enters the soil and no runoff or erosion occurs. Water will infiltrate until soil has reached its water holding capacity. Water holding capacity refers to how much water the soil can hold before it is fully saturated. Eventually, soils become saturated and runoff will be produced regardless of how quickly water can infiltrate the soil.

**A raindrop displacing soil particles (Photo credit: USDA-NRCS)**

Despite the importance of infiltration and water holding capacity, many past erosion efforts focused on controlling erosion by mitigating the speed of runoff, rather than preventing it. This is perhaps due to the fact that infiltration is an almost invisible process, while runoff is highly visible. Erosion at its most obvious occurs at the bottom of slopes where runoff has picked up speed and volume. This is called gully erosion, and it is very recognizable. Grassed waterways can be effective at holding soil in areas of high runoff and reducing gully erosion. Grassed waterways may help trap some soil before it leaves the field completely, but they cannot stop erosion from starting in a field to begin with.

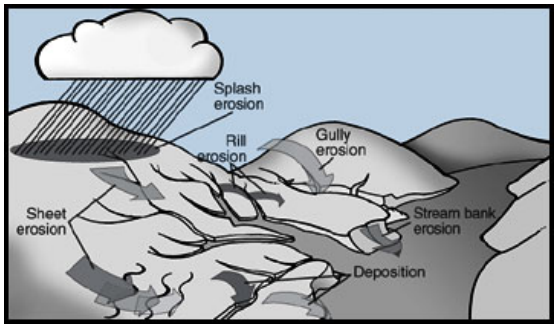
Rill erosion resembles miniature gullies, and it also happens when moving water scours a path through the soil. The steeper the slope of a field, the faster

water can move and the more soil it can displace. Terraces are one tool for reducing gully and rill erosion. Terraces can slow runoff after it has already started, but they still do not stop sediment-filled runoff from forming because they do not change the infiltration rate or water holding capacity of soil. This is a key to stopping erosion, and the reason cover crops are so useful.

## Cover Crops and Erosion

Cover crops can limit erosion before it begins by protecting soil from raindrops and increasing infiltration. The least visible types of water erosion are called sheet and splash erosion. Although it is difficult to see evidence of sheet and splash erosion, they can still move vast amounts of soil. They are also the precursor for rill and gully formation. Sheet and splash erosion start with a raindrop. Raindrops are tiny but pack a big punch. A raindrop smashing into unprotected soil blasts apart soil aggregates, which are groups of soil particles and organic matter. The soil particles are then more easily carried away by runoff.

Even the soil particles that do not immediately runoff can lead to further erosion through a process called crusting. Soil particles that do not aggregate form a structure-less layer, or a crust, when the bare soil dries, effectively sealing the surface. Further rainfall can no longer infiltrate the soil and instead moves downhill as runoff, carrying more suspended soil particles with it.




**Water erosion processes (Illustration credit: University of Missouri Extension Guide G1509)**

The first step to stopping splash erosion is to protect the soil from raindrops by keeping it covered. True to their name, cover crops can do an excellent job of covering the soil and intercepting rain drops, especially if they are allowed adequate growth. Cover crops intercept rain drops by themselves as well as by keeping post-harvest crop residue in place. Without a living plant stems, crop residue can be moved by wind or water into clumps, leaving soil exposed and vulnerable. The stems of cover crops prevent this from happening. Keeping residue in place also slows runoff during heavy precipitation, allowing water to infiltrate the soil.

Cover crops protect the soil while growing, and residue left from a cover crop can also provide a protective blanket for a period of time after the cover crop is terminated. Cover crop plants also feed the soil ecosystem, which results in a healthier soil with higher infiltration rates. The secretions and bodies of soil microbes encourage better soil aggregation, which increases infiltration. Soil invertebrates can have very positive impacts on infiltration. Night crawlers, one type of earthworm, are the most important of these in Midwestern soils. Night crawlers excavate long vertical tunnels that rapidly transport water from the soil surface to several feet below. Cover crops can boost earthworm populations by as much as three-fold[6] by providing food and improving soil structure.

During large rainfall events, precipitation can eventually exceed infiltration or water holding capacity, leading to runoff. On soil with little cover, runoff usually leads to significant soil loss. With cover crops, however, sediment soil loss can remain very low even when runoff is significant. Cover crops reduced sediment loss by 83 percent in a tomato production system even though runoff was only reduced by 44 percent.[7]

Cover crops may also affect the water holding capacity of the soil. It can be hard to separate infiltration from holding capacity. The drought resistance associated with cover crops is sometimes attributed to water holding capacity when it may be due to infiltration. An increase in organic matter is usually the reason given for increased water holding capacity under cover crops. Although cover crops can increase soil organic matter, the relationship between organic matter and water holding capacity requires further investigation.

## Combining No-Till and Cover Crops

Those familiar with conservation tillage probably recognize some of the benefits of soil cover attributed to cover crops above. Conservation tillage is one way to reduce erosion and support soil health by leaving at least 30 percent crop residue. No-till does this even better, minimizing soil disturbance and leaving all the crop residue at the soil surface. When no-till and conservation tillage were first popularized, they were widely believed to be lasting solutions to erosion. Yet despite the success of no-till and conservation tillage in reducing erosion, these practices still occur at less-than-sustainable rates and are not sufficient during large precipitation events. The missing factor is a living root, which cover crops provide. Roots prevent erosion by keeping soil aggregated. Plants secrete exudates through their roots that feed bacteria and fungi. Those exudates, along with substances produced by bacteria and fungi, such as glomulin, help soil particles stick together and to the root, even when water is flowing over the soil. The emphasis on soil cover, although important, can predispose people to discount the impact of cover crops that have not put

**Adjacent fields photographed on the same day. Left: no cover crop and soil is blowing. Right: cover crop and no blowing soil. (Photo credit: Bruce MacKellar, Michigan State University)**

on much top-growth in the fall. Some farmers refrain from planting covers late in the fall because cover crops would only be a few inches tall with little soil coverage. They reason that they would get little erosion benefit from such little coverage. However, the roots still manage to hold soil in place.

## Cover Crops and Wind Erosion

Wind erosion is typically more of a concern in semi-arid or arid regions of the Great Plains. However, wind is still a source of erosion in other cropland areas, including Missouri. Not only can soil be lost from a field by wind, but blowing soil can be a hazard for motorists and an irritant to people outdoors. Cover crops are effective at reducing wind erosion both by adding "roughness" to the soil surface, reducing soil surface wind speed, and anchoring the soil in place with roots.

## How to Use Cover Crops to Control Erosion

There are numerous publications and resources that cover the specifics of how to use cover crops in every kind of cropping system. To maximize erosion control, there are a few practices to keep in mind regardless of the system.

1. Maximize growth period: The longer a cover crop has to grow, the more top growth there will be to protect the soil from raindrops and the more root growth there will be to hold the soil during excessive rainfall. This means planting as early as possible and terminating as late as possible. Cover crops that have time to root more extensively will also help improve soil structure and create more macropores, aiding rainfall infiltration.
    a. Early establishment: Many farmers plant cover crops immediately after fall harvest, which may leave little establishment time before winter dormancy. An alternative is to interseed the cover crop into a commodity crop before harvest to give it more time to grow. Cover crops can be broadcast into standing corn, soybeans, or cotton with an airplane or by a high clearance broadcast seeder. The tradeoff from earlier broadcast seeding is that rain is needed for establishment. If the cash crop will be harvested in early fall, it can be better to wait and use a drill or row crop planter to seed the cover crop immediately after harvest.
    b. Termination: Spring is when much of the erosion occurs in the Midwest. Any gap between cover crop termination and cash crop emergence has potential to lead to erosion. Farmers are terminating cover crops closer to planting, and an increasing number wait to terminate the cover crop until after planting their summer cash crop, a process called "planting green." Current

planting technology allows for planting corn, soybeans, cotton or other crops into living cover crops, which can be terminated by spraying or rolling after the cash crop is planted.

c. Growing cover crops in the summer: In much of the Midwest, the summer is currently reserved for cash crops. However, summer cover crops can produce abundant root and top growth that can greatly benefit soil health and resistance to erosion. Summer cover crops can be planted after a small grain is harvested in the late spring or early summer. Small grains themselves are beneficial for erosion reduction. Foregoing cash crops in the summer is an economic conundrum because cool season crops like wheat are not currently very profitable in much of the Midwest. Integrating livestock can make including a small grain into the rotation more feasible. Summer cover crops can produce abundant, high quality forage for livestock at a time when many cool-season pastures are dormant.

2. Cover crop selection: Cover crops with dense masses of fine roots are best at holding soil. Grasses are usually the best for erosion control, though other cover crop species can still be helpful. Although grasses like cereal rye may be the best for erosion, diverse mixes that include some grasses offer a host of other benefits for soil health that should be considered as well. Another consideration is winter-hardiness. Cover crops that survive through the winter are able to hold more soil in the spring than winter-killed cover crops such as oats.

## Why Cover Crops Should Be a Priority for Helping Prevent Erosion

### *Cost-effectiveness*

Cover crops can be very effective at controlling erosion. Grass cover crops after no-till soybeans reduced soil loss by 87 to 96 percent in Missouri.[8] In Mississippi, cover crops reduced soil loss by 97 to 99 percent after no-till cotton.[9] Compared to terraces, which can be costly to install and require maintenance and eventual renovation, cover crops are less expensive. National average cost of seed and seeding from the SARE/CTIC cover crop survey in 2012 to 2013 was 37 dollars per acre; some farmers have found ways to do cover crops for half that, while others such as organic farmers may spend more to include legumes in the mix. Cover crops can pay for themselves over time with improved soil health and gradually improved yields. They can also pay quickly in particular management situations, such as when herbicide-resistant weeds or soil compaction is present, or when livestock are integrated into row-crop operations[10]. Grazing winter cover crops can reduce the need for hay and supplemental feed during the winter.

### *Other impacts*

Cover crops have more ancillary benefits than any other practice. Besides reducing erosion and improving soil health, cover crops can decrease soil compaction, build drought resistance, increase yields, and over time may save on the cost of fertilizer, weed, and pest control. When combined with no-till, cover crops can allow farmers to plant and harvest earlier than conventional farmers. Cover crops can also help support pollinators and wildlife.

Cover crops' ability to help reduce erosion also pays dividends for water quality. Gulf hypoxia, the eutrophication of water bodies, and problems with drinking water have all drawn attention to agricultural runoff and leaching. By increasing rainfall infiltration and reducing field runoff, cover crops help keep field nutrients and pesticides in place, rather than being lost with sediment leaving agricultural fields as runoff.

## The Importance of Stacking Erosion Control Practices

Cover crops may be the most economical practice to reduce erosion and certainly deserve investment, but they are not an erosion silver bullet. Complete reduction in erosion will require a combination of practices, especially for 50- and 100-year precipitation events. Stacking erosion control practices is more than additive, and may be more cost-efficient in the long-term. Terraces frequently have a life of less than 30 years, with periodic maintenance procedures necessary to keep them in

working condition. Adding cover crops and going no-till may extend the life of terraces and decrease maintenance costs. Terraces also present an excellent opportunity to add perennial cover within a field. Strips of deep-rooted grasses, like those employed in the Prairie STRIPS project at Iowa State University, can be integrated into terracing, further reducing erosion and extending the life of the terrace.

**A terrace with perennial conservation plants in a cover cropped field (Photo credit: Edwin Remsberg)**

Cover crops and no-till are one of the best marriages of erosion control practices. Together, they have been shown to reduce erosion by as much as 88 percent.[11] An ideal system for reducing erosion would include cover crops as part of a diverse rotation that included a small grain and a summer cover. Tillage should be eliminated or greatly reduced to minimize soil disturbance. Terraces on steeper slopes should be planted with deep-rooting perennial grasses and native plants that extend the life of the terraces and provide other ecosystem services. Waterways should have a dense grass stand, and field borders can benefit from perennial cover as well to help trap moving soil. Ultimately, an integrated conservation approach that includes cover crops is the best way to keep valuable topsoil in place and ensure the next generation will have the same opportunity to farm.

## Citations


1. Duffy, M. Value of Soil Erosion to the Land Owner. (2012).

2. Ghabbour, E. A. et al. National Comparison of the Total and Sequestered Organic Matter Contents of Conventional and Organic Farm Soils. Adv. Agron. **146,** 1–35 (2017).

3. 2012 census of agriculture. Volume 1, Geographic area series. Part 14, Indiana, state and county data. ([Washington, D.C.] : United States Department of Agriculture, National Agricultural Statistics Service, 2014., 2014).

4. CTIC. Report of the 2016-17 National Cover Crop Survey. Joint publication of the Conservation Technology Information Center, the North Central Region Sustainable Agriculture Research and Education Program, and the American Seed Trade Association (2017). doi:10.3929/ethz-a-007116300

5. Myers, R. & Watts, C. Progress and perspectives with cover crops: Interpreting three years of farmer surveys on cover crops. J. Soil Water Conserv. **70,** 125A–129A (2015).

6. Schmidt, O. & Curry, J. P. Population dynamics of earthworms (Lumbricidae) and their role in nitrogen turnover in wheat and wheat-clover cropping systems. Pedobiologia (Jena). **45,** 174–187 (2001).

7. Smukler, S. & Jackson, L. E. Assessment of best management practices for nutrient cycling: A case study on an organic farm in a Mediterranean-type climate. J. Soil Water Conserv. **67,** 16–31 (2012).

8. Zhu, J. C., Gantzer, C. J., Anderson, S. H., Alberts, E. E. & Beuselinck, P. R. Runoff, Soil, and Dissolved Nutrient Losses from No-Till Soybean with Winter Cover Crops. Soil Sci. Soc. Am. J. **53,** 1210 (1989).

9. Mutchler, C. K. & McDowell, L. L. Soil loss from cotton with winter cover crop. Trans. ASAE **33,** 432–436 (1990).

10. Schomberg, H. H. et al. Grazing winter rye cover crop in a cotton no-till system: Yield and economics. Agron. J. **106,** 1041–1050 (2014).

11. Angle, J. S., Mc Clung, G., Mc Intosh, M. S., Thomas, P. M. & Wolf, D. C. Nutrient Losses in Runoff from Conventional and No-Till Corn Watersheds1. J. Environ. Qual. **13,** 431 (1984).



*Development of this publication was supported by a grant from the Missouri Department of Natural Resources funded through the Parks, Soils and Water Sales Tax.*

*July, 2019*