USDA NRCS

United States Department of Agriculture
Natural Resources Conservation Service

Conservation Resource Brief

Soil Quality

February 2006 Number 0601

Key Points:

- The amount of cropland managed using methods to improve soil organic matter increased by 46 million acres between 1982 and 1997.
- Soil organic matter plays a key role in the physical, chemical, and biological health of soils.
- Residue Management is the primary practice for increasing organic matter.
- Residue Management reduces fuel consumption by an average of 3.5 gallons per acre.
- Increased surface residue forms a physical barrier to wind and water erosion
- Soil organic matter holds 10 to 1,000 times more water and nutrient than the same amount of soil minerals.
- A 1 percent increase in organic matter can add nearly 2 acre-inches more water holding capacity.
- Crops are better able to withstand drought when infiltration and water holding capacity improve.
- Organic matter may bind pesticides and reduce their impact on surface and groundwater.
- Wildlife habitat improves when residue management improves.

Contact:

NRCS Web site at www.nrcs.usda.gov.

Helping People Help the Land

Issue

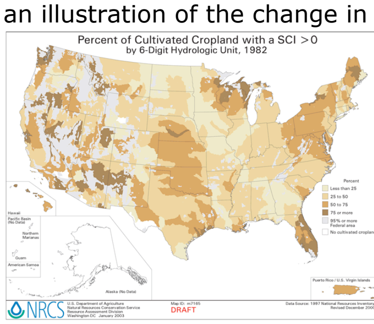
Soil conservation policy in the United States stems from the devastating erosion events of the 1920s and 1930s. Due to concern for preserving agricultural productivity, the concept of tolerable soil loss and the creation of the T factor–the maximum annual soil loss that can occur on a particular soil while sustaining long-term agricultural productivity was developed. Conservationists focused on reducing soil loss to T by applying practices, such as terraces, contour strips, grassed waterways, and residue management.

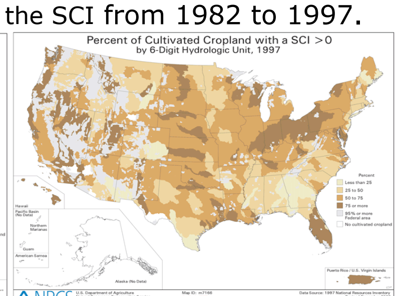
By the end of the century, concern about air and water quality became as important as agricultural productivity. To address these environmental goals and maintain the land's productive potential, we must now go beyond erosion control and manage for soil quality. How soil functions on a farm–not just in buffers or waterways–affects erosion rates, agricultural productivity, air quality, and water quality. The most practical way to enhance soil quality is to promote better management of soil organic matter or carbon. In short, we should go beyond T and manage for C (carbon).

Many soil properties impact soil quality, but organic matter deserves special attention. It affects several critical soil functions, can be manipulated by land management practices, and is important in most agricultural settings across the country. Because organic matter enhances water and nutrient holding capacity and improves soil structure, managing for soil carbon can enhance productivity and environmental quality. Organic matter can reduce the severity and costs of natural phenomena, such as drought, flood, and disease. In addition, an increase in soil organic matter levels can reduce atmospheric CO_2 levels that contribute to climate change. Inherent to managing for carbon is a reduction in tillage, which reduces fuel consumption and emissions.

Natural Resource Trends

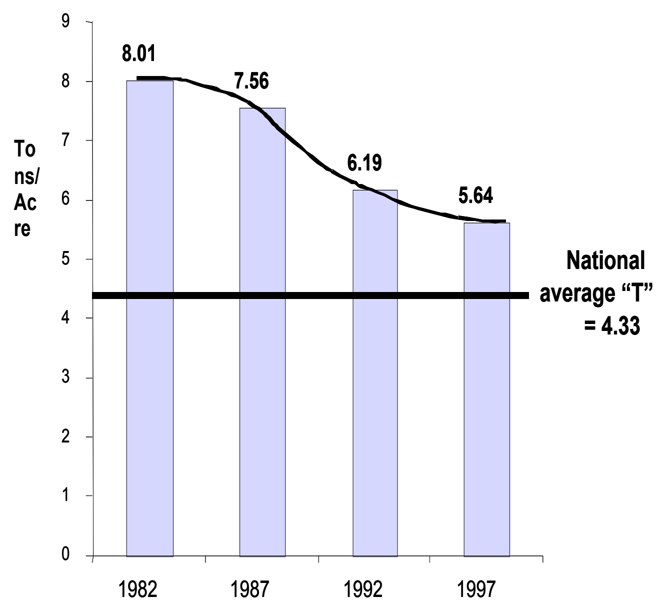
The Soil Conditioning Index (SCI) predicts the effect of cropping systems on soil organic matter levels. A positive SCI indicates a cropping system that is likely to result in increasing levels of soil organic matter. Below is an illustration of the change in the SCI from 1982 to 1997.





Go beyond T–Manage for C

The goal of reducing soil erosion to T (tolerable soil loss rates) generated remarkable improvements in the nation's natural resources (figure 2). However, the pace of erosion control has slowed as we approach the goal of managing to T. As of 1997, 1.8 billion tons of soil are lost from cropland, and 120 million acres are eroding at rates greater than T. We can achieve a new level of soil conservation by focusing on building soil organic matter or soil carbon (C).

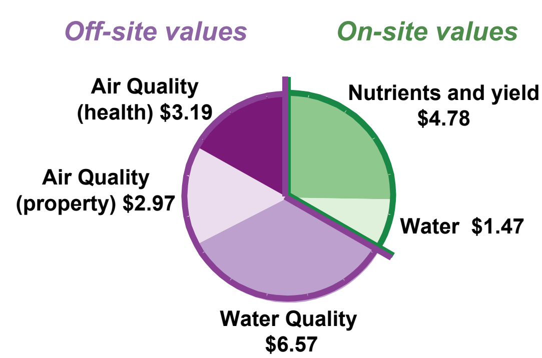


- By emphasizing organic matter management technology, soil loss can be reduced on those lands that still suffer excessive erosion.
- Even moderate erosion rates can harm air quality, water quality, and wildlife habitat.
- Improving soil organic matter levels can further stabilize soil within fields and protect environmental quality.
- Keeping soil in place is only the beginning of soil conservation. Soil also has to function well.
  It must hold nitrogen, phosphorus, and pesticides in place and keep them out of surface water.
  Soil must deliver nutrients and water to plants as they need them.
  Soil should minimize the effects of floods and droughts.
  Organic matter helps soil perform all these functions.

What does this mean for conservation?

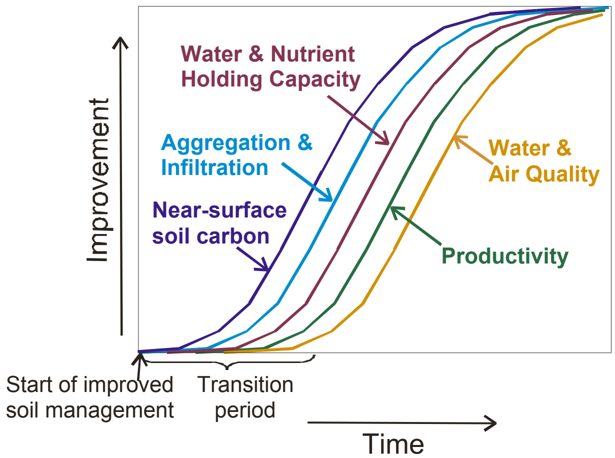
Managing for C means using well-known technology in a new way. By addressing conservation issues from the perspective of soil organic matter instead of erosion, we will focus on enhancing the soil as opposed to managing for tolerable degradation. Managing for C provides additional on-site benefits and incentives for the landowner, creating greater motivation for the person making the decisions about managing the Nation's natural resources. Managing for soil carbon also requires that farmers, ranchers, conservationists, and policymakers understand how organic matter works and the time required to realize its full benefit. It also requires an understanding of the value of soil and the environmental and production costs associated with its loss. (For further explanation of the pie chart see Appendix A.)

What is the topsoil worth?



How does organic matter work?

Once a farmer or rancher begins working towards enhancing soil organic matter, a series of soil changes and environmental benefits follow. The rate and degree of these changes and the best suite of practices needed to achieve results vary with soil, climate, and previous management history. Initially, managing for greater soil organic matter may require higher pesticide, herbicide, or nutrient applications. For grazing lands, it may require changes in grazing schedules, stocking rates, exclusion areas, or re-seeding. In time, productivity and environmental quality will be enhanced.



Apply practices that enhance soil organic matter:

- **Diverse, high biomass crop rotations or species diversity on grazing lands**
- **Cover crops**
- **Reduced tillage**
- **Rotational grazing**
- **Prescribed grazing**
- **Manage traffic; equipment, livestock, and recreational vehicles**

Organic matter dynamics change:

- **Increased surface residue forms a physical barrier to wind and water erosion.**
- **Higher residue rotations and cover crops contribute more organic matter and nutrients to the soil.**
- **Less soil disturbance means lower organic matter losses.**

Soil properties change:

- **Surface structure becomes more stable and less prone to crusting and erosion.**
- **Water infiltration increases and runoff decreases when soil structure improves.**
- **Soil organic matter holds 10 to 1,000 times more water and nutrients than the same amount of soil minerals.**
- **Beneficial soil organisms become more numerous and active with diverse crop rotations and higher organic matter levels.**
- **Air quality, water quality, and agricultural productivity improve**
- **Dust, allergens, and pathogens in the air immediately decline.**
- **Sediment and nutrient loads decline in surface water as soon as soil aggregation increases and runoff decreases.**
- **Ground and surface water quality improve because better structure, infiltration, and biological activity make soil a more effective filter.**
- **Crops are better able to withstand drought when infiltration and water holding capacity increase.**
- **Organic matter may bind pesticides, making them less active.**
- **Soils managed for organic matter may suppress disease organisms, which could reduce pesticide needs.**
- **Crop health and vigor increase when soil biological activity and diversity increase.**
- **Wildlife habitat improves when residue management improves.**

Managing for Soil Quality

Each combination of soil type and land use calls for a different set of practices to enhance soil quality. Yet, several principles apply in most situations.

1) Add organic matter -- Regular additions of organic matter are linked to many aspects of soil quality. Organic matter may come from crop residues at the surface, roots of cover crops, animal manure, green manure, compost, and other sources. Organic matter, and the organisms that eat it, can improve water holding capacity, nutrient availability, and can help protect against erosion.
2) Avoid excessive tillage -- Excessive organic matter degradation, disrupts soil structure, and can cause compaction. For more information about conservation tillage, visit the Conservation Tillage Information Center (http://www.ctic.purdue.edu/CTIC/CTIC.html).
3) Carefully manage fertilizer and pesticide use - In this century, pesticides and chemical fertilizers have revolutionized U.S. agriculture. In addition to their desired effects, they can harm non-target organisms and pollute water and air if they are mismanaged. Manure and other organic matter also can become

pollutants when misapplied or over-applied. Fertilizer can increase plant growth and the amount of organic matter returned to the soil.

4) Increase ground cover - Bare soil is susceptible to wind and water erosion, and to drying and crusting. Ground cover protects soil, provides habitats for larger soil organisms, such as insects and earthworms, and can improve water availability. Cover crops, perennials, and surface residue increase the amount of time that the soil surface is covered each year. Increase plant diversity - Diversity is beneficial for several reasons. Each crop or range species contributes a unique root structure and type of residue to the soil. A diversity of soil organisms can help control pest populations, and a diversity of cultural practices can reduce weed and disease pressures.
5) Diversity across the landscape and over time can be increased by using buffer strips, small fields, contour strip cropping, crop rotations, and by varying tillage practices. Changing vegetation across the landscape or over time increases plant diversity, and the types of insects, microorganisms, and wildlife that live on your farm.

For Grazing Lands:

1) Properly manage grazing, fire, and vehicle use.
2) Increase or maintain plant production.
3) Improve plant cover and minimize bare spaces
4) Promote the growth of species with high root production and promote a mix of species with different rooting depths and patterns.
5) Protect soil from erosion by maintaining or increasing plant cover.
6) Minimize grazing, recreational use, and vehicular traffic when soils are wet.
7) Do not harvest hay when soils are wet.
8) Use only designated trails or roads; reduce the number of trips.

Additional Soil Quality Concerns

Compaction:

Soil compaction occurs when the soils physical properties have been degraded and soil particles are pushed together by pressure exerted by traffic from equipment or animals. A few of the consequences of compaction are:

1. Restricts rooting depth, decreasing water and nutrient utilization.
2. Decreases water infiltration and therefore increases the risks of erosion and flooding.
3. Decreases pore size, causing the soil to warm more slowly and have a larger proportion of water-filled pores at field capacity, reducing aeration.

Controlling traffic and improving the soils’ ability to resist compaction with organic matter are two of the most effective means of combating soil compaction.

Salinity:

Soil salinity occurs when the water soluble salts accumulate in the soil. A few of the consequences of salinity are:

1. Restricts the plants ability to take up water.
2. Degrades the soils structure making it more prone to erosion losses.
3. Degrades the quality of shallow groundwater and surface water resources.

Salinity is best managed by managing water. Managing recharge waters diverting surface water, maintaining water tables below root zone, irrigate to keep salts below root zone, reduce summer fallow, utilize deep-rooted salt tolerant plants to remove excess moisture from seeps, and improve water retention of the soil by increasing soil organic matter.

NRCS Program Funding, Soil Management 2002-2005
(Funding reflects expenditures for all Soil Resource concerns not just Soil Quality)

Program	Financial Assistance Funding 2002-2005	Technical Assistance Funding 2002-2005	% of FA	% of TA
Conservation Technical Assistance (CTA)	$0	$856,800,000		79%
Environmental Quality Incentives Program (EQIP)	$462,473,163	$101,790,731	48%	9%
Ground & Surface Water Conservation (GSWC)	$12,257,274	$1,419,291	1%	0%
Conservation Innovation Grants (CIG)	$1,422,435	$7,046	0%	0%
Conservation Security Program (CSP)	$56,875,908	$8,531,387	6%	1%
Resource Conservation & Development_ (RC&D)	$0	$19,995,961		2%
Wildlife Habitat Incentives Program (WHIP)	$2,095,013	$421,327	0%	0%
Agricultural Management Assistance (AMA)	$5,485,505	$1,281,059	1%	0%
Grassland Reserve Program (GRP)	$93,175,490	$24,124,509	10%	2%
Farm and Ranch Lands Protection Program (FRPP)	$320,755,450	$9,514,229	34%	1%
Conservation Reserve Program (CRP)	FSA Provides FA	$53,248,123		5%
Watershed Protection and Flood Prevention Program (WP&FPP)	$2,332,400	$999,600	0%	0%
Total	$956,872,638	$1,078,133,263	100%	100%

The RC&D program provides benefits for a multiple number of resource issues. Dollar amounts given reflect a percentage of total program funding for RC&D for FY 2002-2004. This figure is pro-rated based on data analysis conducted for the national program evaluation conducted in FY2004 & FY 2005. Soil management is captured under the land conservation element in the RC&D statute.