AGRICULTURE PRACTICES TO SEQUESTER CARBON IN SOILS

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Why?

Since the late 1800's fossil fuel use, expansion of cultivated agriculture, and forest clearing have led to an increase in atmospheric CO_2 from 260 ppm to current levels >370 ppm (IPPC, 1995) (Fig. 1). Most of the recent increase in CO_2 has been attributed to combustion of fossil fuels for energy and transportation, but changes in land use also contribute to atmospheric CO_2. This increase in atmospheric CO_2 potentially impacts climate, as it is a greenhouse gas.

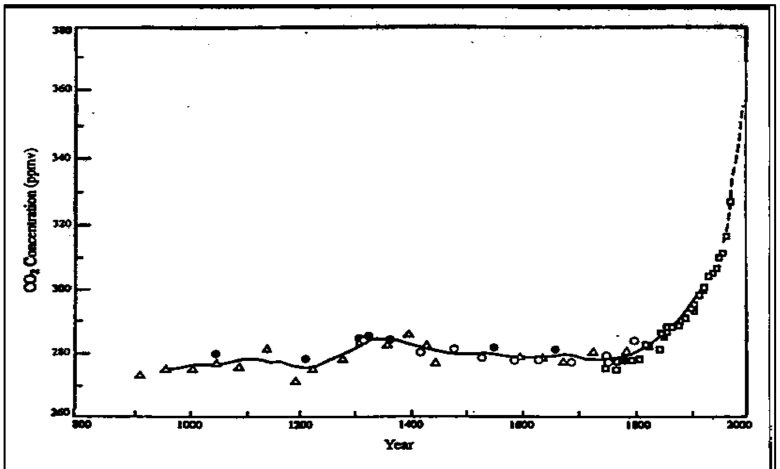


Figure 1. Temporal changes in atmospheric concentration of CO_2 (IPCC, 1995).

How? Agriculture's Role!

The impact of soil and crop management is illustrated in Fig. 2. As noted earlier, agriculture in the 1800 and early 1900's relied upon the plowing the soil with low crop yields and crop residues were often removed. This combination of agricultural practices resulted in reducing the replenishment of organic material (carbon) to the soil. Approximately 50% of the soil organic carbon (soil organic matter) has been lost from soil over a period of 50 to 100 years of cultivation (Fig. 2). However, this loss of soil carbon also represents the potential for storage of C in agricultural soils. Carbon sequestration by soils occurs primarily through plants. Plants convert CO_2 into tissue through photosynthesis. Upon their death, plant tissues decompose, primarily by soil microorganisms, and the carbon in the plant material is eventually released back into the atmosphere as CO_2. However some of the C in plant material forms soil organic matter sometimes referred to as "humus." Some of this carbon can persist in soils for hundreds and even thousands of years.

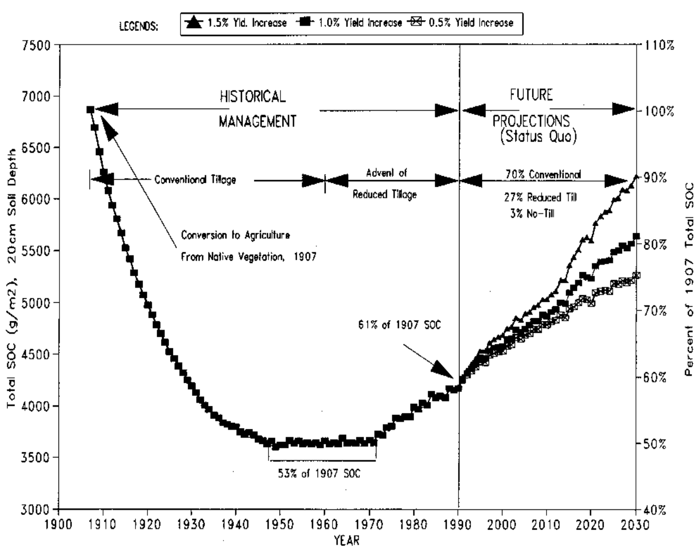


Table 1 lists several practices affecting the soil's ability to sequester C (Lal et al., 1998). Comparisons of no-tillage with spring plow have projected 20 to 80% higher soil C with no-tillage after 40 years (Donnigian et al., 1994). At Kansas State University, we have shown an increase in soil C of approximately 0.15 tons C/a/y. This is equivalent to an increase of 1.5 ton C/acre over a 10-year period. Cropping sequences can also affect soil C. In Kansas, intensifying cropping systems by conversion from wheat-fallow rotation to wheat-grain sorghum-fallow rotation in western Kansas increased soil C levels (Havlin et al., 1990). Combinations of high intensity cropping with no-tillage gave maximum benefits modeled for several locations in the North American prairies (Paustian et al., 1998).

Table 1. Land Use for C Sequestration (Lal et al., 1998)

Management Strategies		
Land Use	Soil Management	Crop Management
• Cultivation • Forestry • Rangeland	• Tillage • Fertility • Water Management • Erosion Control	• Varieties • Crop Rotations • Cover Crops • CRP

Grassland systems also can contribute to C sequestration when properly managed. Research at Kansas State University has shown that under elevated atmospheric CO_2 the soil contained 6% more C to a depth of 15 cm compared with ambient conditions (Rice et al., 1999). The increased in soil C was due to increased plant production followed by incorporation into the soil. The amount of C sequestered over the 8-year experimental period was equivalent to 2 tons C/acre. Proper fire management also increases soil C. We have reported a 5 % increase in soil C with annual burning compared to unburned tallgrass prairie (Rice et al., 1999). This is equivalent to 2 tons C per acre for a 10-year period.

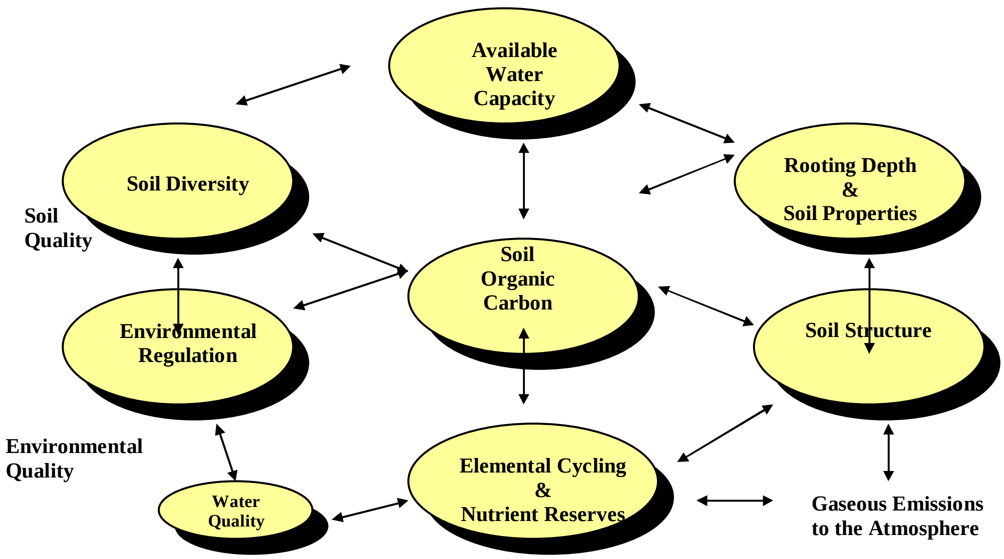
Table 2. Estimates of C sequestration potential of agricultural practices of U.S. cropland (Lal et al., 1999).

Agricultural practice	(Tons C/a/y)
Conservation Reserve Program	0.15 – 0.30
Conservation tillage	0.10 – 0.20
Fertilizer management	0.02 – 0.07
Rotation with winter cover crops	0.05 – 0.15
Summer fallow elimination	0.05 – 0.15

Economic analysis suggest that soil carbon sequestration is among the most beneficial and cost effective options available for reducing greenhouse gases, particularly over the next 30 years until alternative energy sources are developed and become economic feasible. Soils do not have an infinite capacity to store carbon; therefore long-term reductions carbon emissions must come from changes in energy technologies, such as alternative fuels.

Additional benefits

Managing agricultural soils for sequestering C will result in additional benefits.



Increasing soil organic C include increased crop productivity and enhanced soil, water, and air quality. In addition, management practices that increase soil C also tend to reduce soil erosion, reduce energy inputs, and improve soil resources.