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Carbon Sequestration: Position of the Soil Science Society of America

C. Lee Burras

Iowa State University, lburras@iastate.edu

John M. Kimble

United States Department of Agriculture

Rattan Lal

Ohio State University - Main Campus

Maurice J. Mausbach

United States Department of Agriculture

Goro Uehara

University of Hawaii at Manoa

See next page for additional authors

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Abstract

Increased long term (20-50 year) sequestration of carbon in soils, plants and plant products will benefit the environment and agriculture. Crop, grazing, and forestlands can be managed for both economic productivity and carbon sequestration. In many settings this dual management approach can be achieved by applying currently recognized best management practices such as conservation tillage, efficient nutrient management, erosion control, use of cover crops and restoration of degraded soils. In addition, conversion of marginal arable land to forest or grassland can rapidly increase soil carbon sequestration. Research is needed that better quantifies carbon sequestration obtained by these practices; this research should culminate in a scientifically defensible soil carbon sequestration accounting system that also would be suitable to the business sector, should soil carbon become a marketable commodity. Implementation of these practices will integrate a wide range of disciplines in the basic, agricultural, silvicultural, and environmental sciences as well as in the social, economic and political sciences. SSSA advocates a global increase in soil organic matter as a timely benefit to global well being by reducing the rate of increase in atmospheric CO₂ and increasing the productivity of soil, particularly in many areas with degraded soils.

Keywords

grazing, forestlands, economic productivity, carbon sequestration

Disciplines

Agronomy and Crop Sciences | Soil Science

Comments

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Authors

C. Lee Burras, John M. Kimble, Rattan Lal, Maurice J. Mausbach, Goro Uehara, H. H. Cheng, David E. Kissel, Robert J. Luxmoore, Charles W. Rice, and Lawrence P. Wilding

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Increased long term (20-50 year) sequestration of carbon in soils, plants and plant products will benefit the environment and agriculture. Crop, grazing, and forestlands can be managed for both economic productivity and carbon sequestration. In many settings this dual management approach can be achieved by applying currently recognized best management practices such as conservation tillage, efficient nutrient management, erosion control, use of cover crops and restoration of degraded soils. In addition, conversion of marginal arable land to forest or grassland can rapidly increase soil carbon sequestration. Research is needed that better quantifies carbon sequestration obtained by these practices; this research should culminate in a scientifically defensible soil carbon sequestration accounting system that also would be suitable to the business sector, should soil carbon become a marketable commodity. Implementation of these practices will integrate a wide range of disciplines in the basic, agricultural, silvicultural, and environmental sciences as well as in the social, economic and political sciences. SSSA advocates a global increase in soil organic matter as a timely benefit to global well being by reducing the rate of increase in atmospheric CO₂ and increasing the productivity of soil, particularly in many areas with degraded soils.

What is carbon sequestration?

Carbon sequestration refers to the storage of carbon in a stable solid form. It occurs through direct and indirect fixation of atmospheric CO₂. Direct soil carbon sequestration occurs by inorganic chemical reactions that convert CO₂ into soil inorganic carbon compounds such as calcium and magnesium carbonates. Direct plant carbon sequestration occurs as plants photosynthesize atmospheric CO₂ into plant biomass. Subsequently, some of this plant biomass is indirectly sequestered as soil organic carbon (SOC) during decomposition processes. The amount of carbon sequestered at a site reflects the long-term balance between carbon uptake and release mechanisms. Many agronomic, forestry, and conservation practices, including best management practices, lead to a beneficial net gain in carbon fixation in soil.

What is the relationship between carbon sequestration, land management and other environmental factors?

The implementation of effective land management practices, especially through stewardship activities such as the Conservation Reserve Program, Wetland Reserve Program, Forestry Incentive Program and conservation tillage, lead to both increased above ground carbon sequestration and to increased SOC. Soils gaining SOC are also generally gaining in other attributes that enhance plant productivity and environmental quality. Increases in SOC generally improve soil structure, increase soil porosity and water holding capacity, as well as improve biological health for a myriad of life forms in soil.

In general there is a favorable interplay between carbon sequestration and various recommended land management practices related to soil fertility (e.g., adding mineral

fertilizers, manures, sludges and biosolids), tillage, grazing, and forestry. Recommended agronomic, grazing land and forestry practices also enhance land sustainability, wildlife habitat and water quality. In most locations, especially environmentally sensitive settings, these practices also result in decreased water and wind erosion that degrade soil carbon stocks. The same positive relationship that exists between carbon sequestration and recommended land management can, in some settings, improve water quality and aid wildlife habitat restoration.

Why include soils in carbon sequestration?

Worldwide, SOC in the top 1 meter of soil comprises about 3/4 of the earth's terrestrial carbon; nevertheless, there is tremendous potential to sequester additional carbon in soil. For example, many cropland soils of the United States have lost as much as 50% of their original SOC due to the effects of land clearing and tillage. Such conventional farming practices "burn" SOC just as we burn fossil fuels today. However, in the case of SOC this historical decline can be reversed, which is not the case for fossil fuel reserves. With proper management the US can put back much of the SOC depleted over the past two centuries. Improved management of crop, grazing, and forest lands is estimated to potentially offset 30,000-60,000 million metric tons of the carbon released by fossil fuel combustion over the next 50 years.

What else do we know today about US emissions and US sequestration of carbon?

CO₂ emissions make-up more than 80% of all greenhouse gas emissions in the US with the annual input of C in the atmosphere being about 1,900 million metric tons. Most of this C is a product of burning fossil fuels (from USDOE).

US forestlands currently fix about 250 million metric tons of atmospheric C each year (from USDA-FS and USDOE).

US cropland can sequester about 75-200 million metric tons of atmospheric C per year by using current best management practices. US grazing land can sequester 30-90 million metric tons of atmospheric C annually by controlled grazing, fire management, and by use of fertilizers and improved cultivars (from USDA Global Change Fact Sheet).

Progressive research on carbon sequestration is ongoing and a priority in a number of federal and state agencies as well as many universities with soil science, agronomy, forestry and allied departments.

What still needs to be known?

Improvement in monitoring and verification protocols for carbon sequestration in soil-plant ecosystems is needed for quantitative economic and policy analyses. These protocols need to be quantitatively defensible and readily applicable to fields and watersheds with differing land uses and weather conditions. Such protocols must be acceptable, both domestically and internationally, to scientists, policy makers,

landowners, and business groups. These protocols must be suitable for use by employees of government agencies and licensed professionals.

Practical techniques to quantify the overall net beneficial impact of agricultural and silvicultural practices on all greenhouse gases, including methane (CH₄) and nitrous oxide (N₂O), are needed. Other beneficial services derived from improved land practices, such as changes in soil quality, productivity, water and air quality, and erosion must also be recognized and evaluated. Recommended carbon sequestration practices must show benefit for the total environment from a whole ecosystem accounting perspective.

Plant breeders and physiologists must be involved to insure that cultivars developed for economic and biological yields also improve soil. The biological yield of above and below ground biomass should have properties, such as elevated lignin and suberin contents that promote accumulation of stable carbon forms in soil and in plant products.

The potential impact of climate variability on the stability of sequestered carbon in soils and long-lived plants must be evaluated. Determination of suitable land management practices is needed to minimize risk of carbon release from soil in response to changes in regional weather patterns such as El Niño and La Niña.

Long-term studies are needed to insure that currently effective carbon sequestration practices result in stable carbon forms for the long term (at least 20-50 years).

A soil carbon economy: A timely opportunity for all Nations

The economic value of soil carbon needs to be assessed with consideration for both onsite and offsite effects. Procedures are needed for a defensible soil carbon accounting system, and policies need to be established that provide incentives for net soil carbon sequestration at the global scale. Such policies can provide financial incentives for the restoration of degraded and impoverished soils, while achieving reductions in the rate of buildup of atmospheric CO₂ levels. Enhancing the SOC pool through global and national policy incentives may be especially beneficial to improving agronomic productivity, enhancing food security and reducing poverty in countries with degraded soils, thus providing splendid benefits to humankind. The dynamics of carbon sequestration processes must be evaluated in the context of local soil and crop attributes including biogeochemical cycles and soil spatial variability. Accounting for variability of soil and plant processes is needed at a range of scales from fields to watersheds and from regional to continental scales. Spatial and temporal variability of soil C is known to be high in many areas. Any soil C commodity price structure will need to be conservatively discounted for soil C variability.

Incentives and plans for adoption of sound technical practices are needed for farmers, ranchers, foresters and other land managers. Implementation of such plans will require better understanding of rural society and the market incentives needed for adopting changes in farming, grazing, and forestry practices that benefit all sectors of society.

Advancement in knowledge through targeted research will permit refined quantitative assessment of the total carbon sequestration potential of the US and our global partners.

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Lee Burras, Iowa State University (Chair)	H.H. Cheng, University of Minnesota
John M. Kimble, USDA-NRCS	David E. Kissel, The University of Georgia
Rattan Lal, The Ohio State University Laboratory	Robert J. Luxmoore, Oak Ridge National Laboratory
Maurice J. Mausbach, USDA-NRCS	Charles W. Rice, Kansas State University
Goro Uehara, University of Hawaii	Lawrence P. Wilding, Texas A&M University

Approved by SSSA Board of Directors

<u>Robert J. Luxmoore</u>	<u>October 25, 2001</u>
SSSA President	Date