# SOD-BASED ROTATIONS AND GLOBAL WARMING

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## INTRODUCTION

Global warming is the largest and most dangerous impact on the environment that humans have ever made. Some expected effects will be rising ocean levels and displacement of over ½ of the 150 million people in Bangladesh, exposure of over 500 million additional people to malaria, shortened growing seasons in Europe due to a collapse of the Gulf Stream, more intense droughts in the grain belt of the United States, and more intense storms originating in the Atlantic and Pacific. This is but another challenge to our survival. We have already effectively reduced acid rain, virtually eliminated small pox and polio, reduced lead poisoning in children to nearly insignificant levels, and greatly reduced air pollution in many of the major cities of the world.

The main cause of global warming is the increase in greenhouse gasses in the environment. The principal gas contributed by humans, on a mass basis, is carbon dioxide ($CO_2$) resulting from the burning of plant biomass and petroleum fuels. The carbon pools and fluxes have been estimated (Table 1). The major carbon (C) pool is carbonate rock at approximately 60,000,000 Gt (Gt = 1.1 billion tons) of C as compared to 750 Gt in the atmosphere (Flach et al 1997).

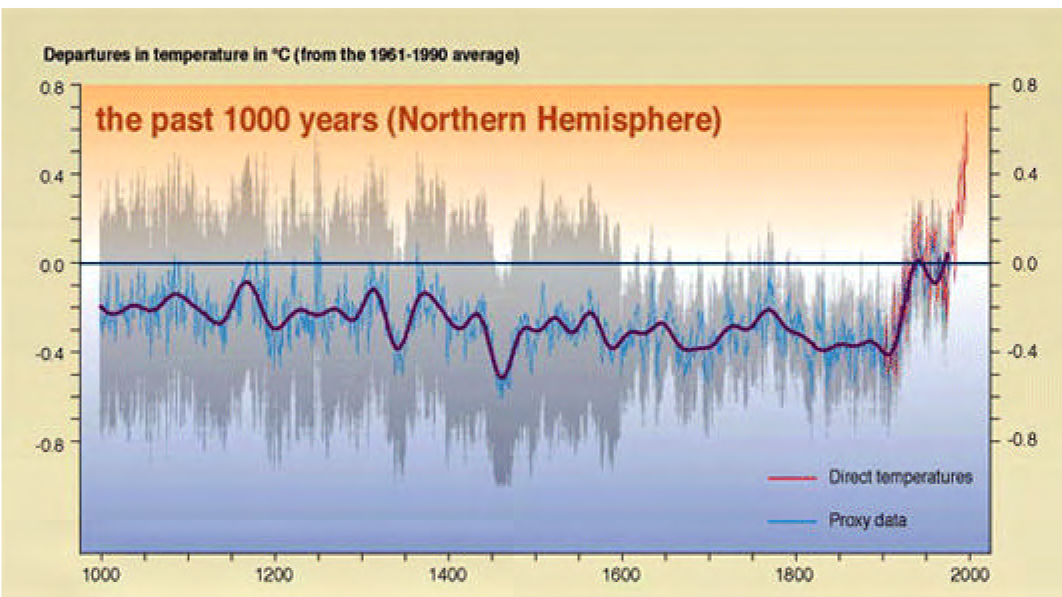
Table 1. The major carbon pools of the world (after Flach et. al. 1997)

| Reservoir | Carbon (Gt) (Gt=1.1 billion tons) |
|---|---|
| Carbonates | 60,000,000 |
| | |
| Organic carbon | |
| Sedimentary rocks | 10,300,000 |
| Recoverable fossil fuels | 4,000 |
| Vegetation | 760 |
| Soil | 1,400 |
| | |
| Oceans | 34,000 |
| Atmosphere | 750 |

Atmospheric C fluxes is well documented. It is estimated that the atmospheric C is increasing on average of 3 Gt per year (Table 2). As a result, the rate of temperature rise is greater than in any known historic or prehistoric time (Fig 1).

Table 2. Carbon fluxes to and from the atmosphere. (after Flach et. al. 1997)

| Source | Carbon (Gt) |
|---|---|
| From Atmosphere to | |
| Vegetation (photosynthesis) | 100-120 |
| Ocean | 100-115 |
| Land (silicate weathering) | 0.06 |
| To Atmosphere from | |
| Ocean | 100-115 |
| Plant respiration | 40-60 |
| Decay of residues | 50-60 |
| Fossil fuels | 4 |
| Land use change | 2 |




source: Intergovernmental Panel on Climate Change, www.ipcc.ch

Figure 1. The increase in average world temperature over time as compared to 1961-1990 average.

North America is currently a net source of $CO_2$ to the atmosphere, contributing to the global buildup of greenhouse gases in the atmosphere and associated changes in the earth's climate. In 2003, North America emitted nearly twp billion tons of C to the atmosphere as $CO_2$, mostly (80%) from the United States combustion of fossil fuels. The conversion of fossil fuels to energy (primarily electricity) is the single largest contributor, accounting for approximately 42% of North American fossil emissions in 2003. Transportation is the second largest, accounting for 31% of total emissions. There are additional globally important carbon sinks in North America. In 2003, vegetation in North America removed approximately 530 million tons of C per year (±

50%) from the atmosphere, storing it as plant material and soil organic matter. This land sink is equivalent to approximately 30% of the fossil fuel emissions from North America. The imbalance between the fossil fuel source and the sink on land is a net release to the atmosphere of 1468 million tons of C per year (± 25%) (Fig. 2). Approximately 50% of North America's terrestrial sink is in the re-growth of forests in the United States on former agricultural land that was last cultivated decades ago, and on timber land recovering from harvest. Other sinks are relatively small and not well quantified. The future of the North American terrestrial sink is also highly uncertain. The contribution of forest re-growth is expected to decline as the maturing forests grow more slowly and take up less carbon dioxide from the atmosphere. But, this expectation is surrounded by uncertainty because forests re-growth and other sinks responses to changes in climate and $CO_2$ is largely unknown (King et al, 2007).

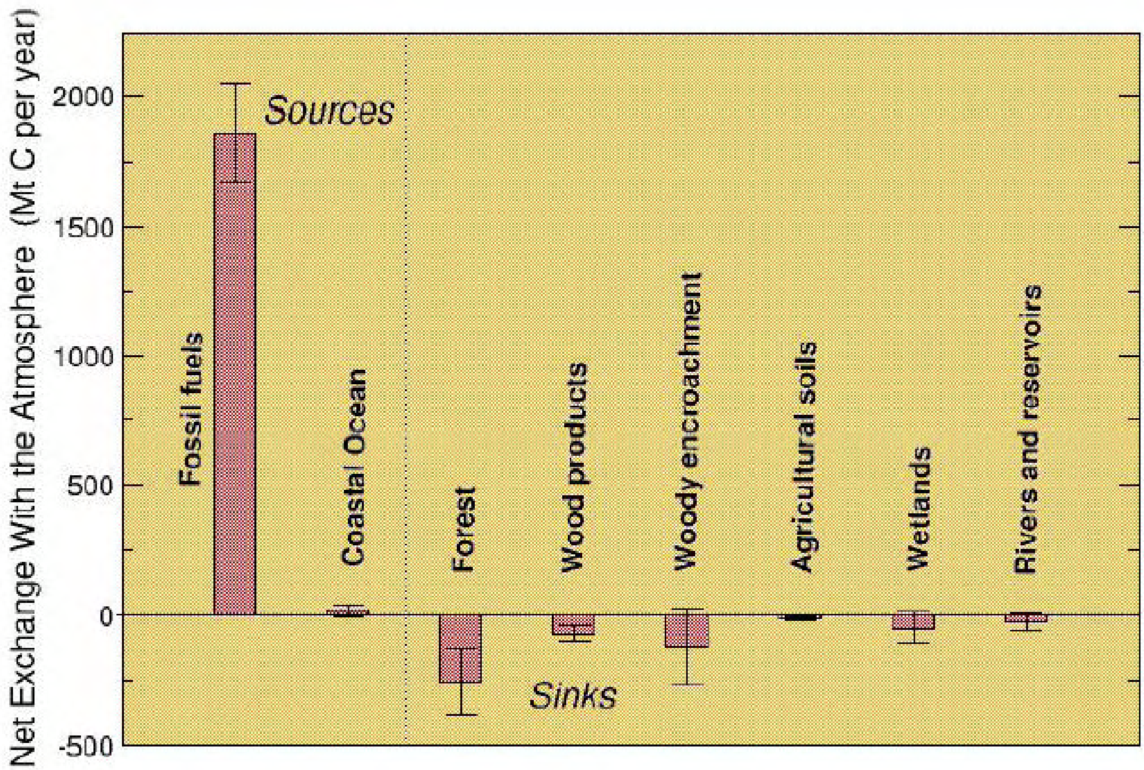



Fig. 2. North American carbon (C) sources and sinks (million tons of C per year) circa 2003. Height of a bar indicates a best estimate for net carbon exchange between the atmosphere and the indicated element of the North American carbon budget. Sources add carbon dioxide to the atmosphere; sinks remove it. Error bars indicate the uncertainty in that estimate, and define the range of values that include the mean value with 95% certainty. (From King et al, 2007).

One obvious solution to the rapidly increasing concentrations of atmospheric $CO_2$ is to sink the C in other areas. The terrestrial pool (Table 1) contains the vegetation pool (760 Gt of C) and the soil organic matter (SOM) pool (1400 Gt of C) and is about three times greater than the atmospheric pool of of 750 Gt of C. Since the flux between the terrestrial and atmospheric C pool is large, terrestrial systems can have a significant impact on the total amount of C in the atmosphere.

How can the ability of soil to accumulate C be manipulated such that atmospheric C is reduced and thus possibly reducing the current rate of global warming? It is known that changes in soil management can have a tremendous impact on soil organic carbon (SOC). In the classic Rothamsted experiments it was found that C storage in soil increased to 40 tons/acre when 15.6 tons/acre/year of farmyard manure were applied to the soil (Flach and Cline, 1954). The SOM continued to increase for over 140 years and is currently 3 times greater than the non-manure amended but fertilized soils. The non-manured and non-fertilized plots lost SOC over time.

In large part, the loss of soil organic matter can be attributed to one major event – the invention of the plow. The original wooden plow (an "ard") developed in the fertile crescent evolved to the "Roman plow" with an iron plowshare. In the 8th century the inverting plow was developed. The moldboard plow was designed by Thomas Jefferson in 1784 and patented in 1796 by Charles Newfold. A cast iron version was marketed in the 1830's by John Deere. Coupled with the "steam horse" the widespread plowing of the Midwest led to severe soil erosion and SOC loss, ultimately resulting in the dust bowl in the 1930's. With the development of 2,4-D after World War II came no-till, which is presently practiced in 235 million acres globally (Lal et al, 2007).

The SOC is also impacted by crop species, especially when comparing annual row crops to perennial grasses. For example, in one study using warm season grasslands, the SOC in the surface 6 inches averaged 2.24 %, whereas croplands averaged 1.98 % (Omonode, et al 2006). They estimated that warm season grasses sequestered an average of 1 ton of C per acre per year. more than the corn-soybean rotation. Similar conclusions were made by Sainju et al (2006) for the humid southeastern United States. They concluded that cover crops and N fertilization can increase the SOC in tilled and no-tilled soils. They found that a biculture of legume and non legume crops (vetch and rye) in a notill situation sequestered nearly 300 lbs of C per acre per year.

The objective of this study was to examine a 4 year no-till, sod-based rotation (bahiagrass, bahiagrass, peanut, cotton) for its potential effect on SOC and its possible role in sequestering carbon using environmentally and economically sustainable farming practices.

## MATERIALS AND METHODS

A 6-yr irrigation x rotation sod-based rotation study was initiated in the summer of 2000 on a Dothan sandy loam (fine, loamy siliceous, thermic Plinthic Kandiudult) at the University of Florida's North Florida Research and Education Center in Quincy, FL (84°33' W, 30°36' N). A two-year old bahiagrass sod was used to ensure good ground coverage and vigorous growth of the succeeding crop. An oat cover crop followed harvested peanut and cotton each fall. The percent soil organic matter (SOM) was determined from 2003-2006 in the cotton crop – which followed 2 years of bahiagrass then one year of peanuts. For the 2003 sample the plots were in bahiagrass, bahiagrass, peanut, then cotton. For 2004 the plots were in cotton, bahiagrass, bahiagrass, peanut, cotton. The 2005 plots were in peanut, cotton, bahiagrass, bahiagrass, peanut, cotton, and the 2006 plots were in bahiagrass, peanut, cotton, bahiagrass, bahiagrass, peanut, cotton. Crop management practices for the rotations, which included bahiagrass and peanut management, are described in more detail in Katsvairo et al., 2007.The percent SOM was converted to SOC by the relationship SOM = SOC X 1.727 (Stevenson, 1994) (conversion values typically range from 1.5-2).

## RESULTS

The SOM in the cotton following bahiagrass was 1.29% in 2003 and increased to 1.60% in 2006 (Fig. 3).

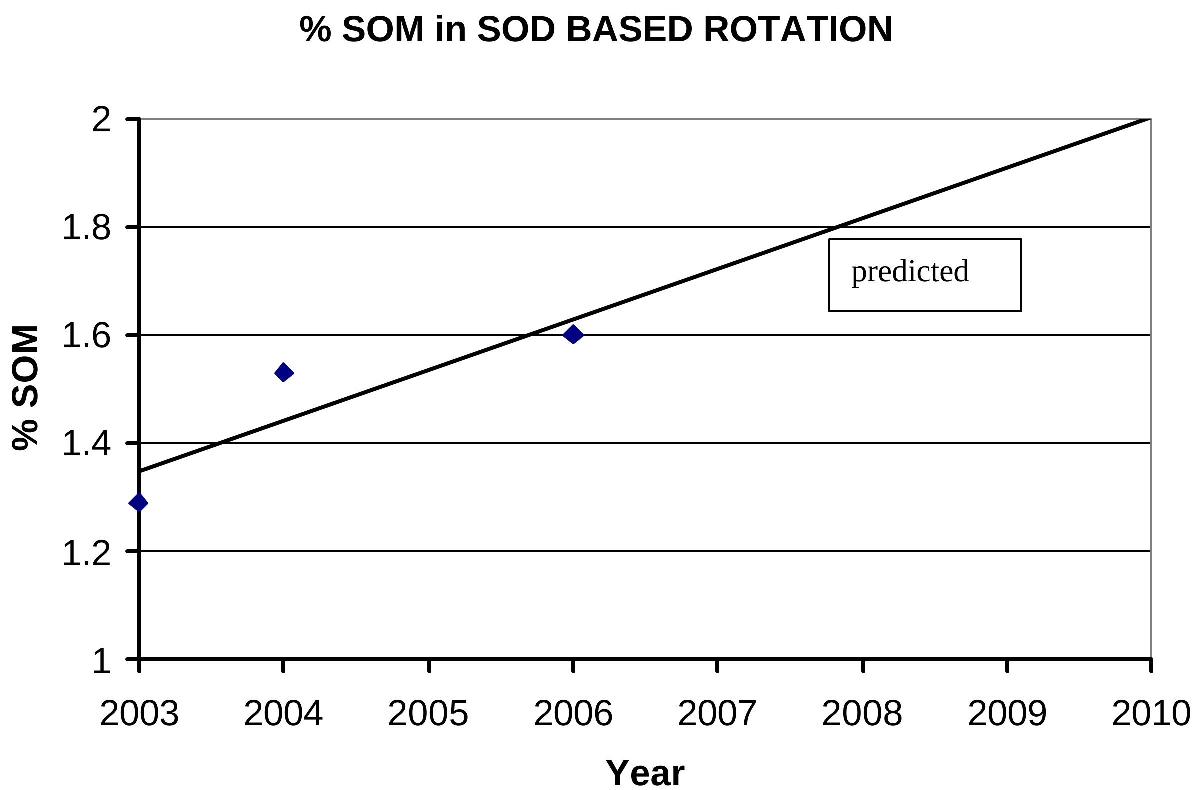



Fig. 3. The increase in SOM in cotton in a rotation of bahiagrass-bahiagrass-peanut-cotton.

## DISCUSSION

The data thus far indicate that the SOM in the sod-based rotation is increasing over time at a rate of approximately 0.1% per year. If this trend were to continue until 2010, the field plot SOM will reach approximately 2%. The following discussion considers what the impact might be on North America's C budget if the sod-based rotation were widely practiced in the southeast. For the purpose of this discussion we assume that 1,000,000 acres will be under this practice.

Approximately 1468,000,000 tons of C released into the atmosphere in North America is not sequestered and is responsible in part for the increase in greenhouse gasses. If 1,000,000 acres of sod-based rotation were established, this unsequestered C might be reduced by about 0.05% (Fig. 4).

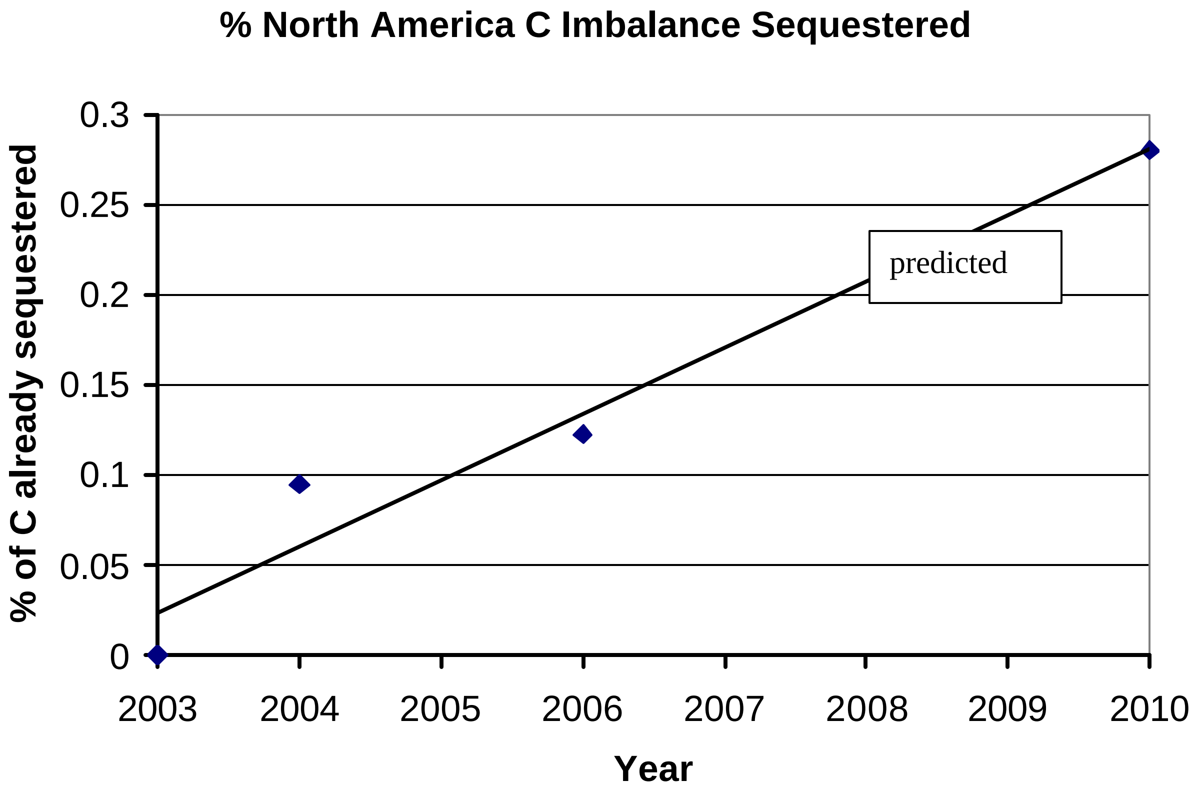



Fig 4. The impact of 1,000,000 acres of sod-based rotation in the southeast on the North America C imbalance.

At present, about 30% of the C released into the atmosphere is captured in plant growth. If the sod-based rotation were to be used on 1,000,000 acres, there could be an increase of about 0.1% per year more C sequestered in the soil reservoir (Fig. 5).

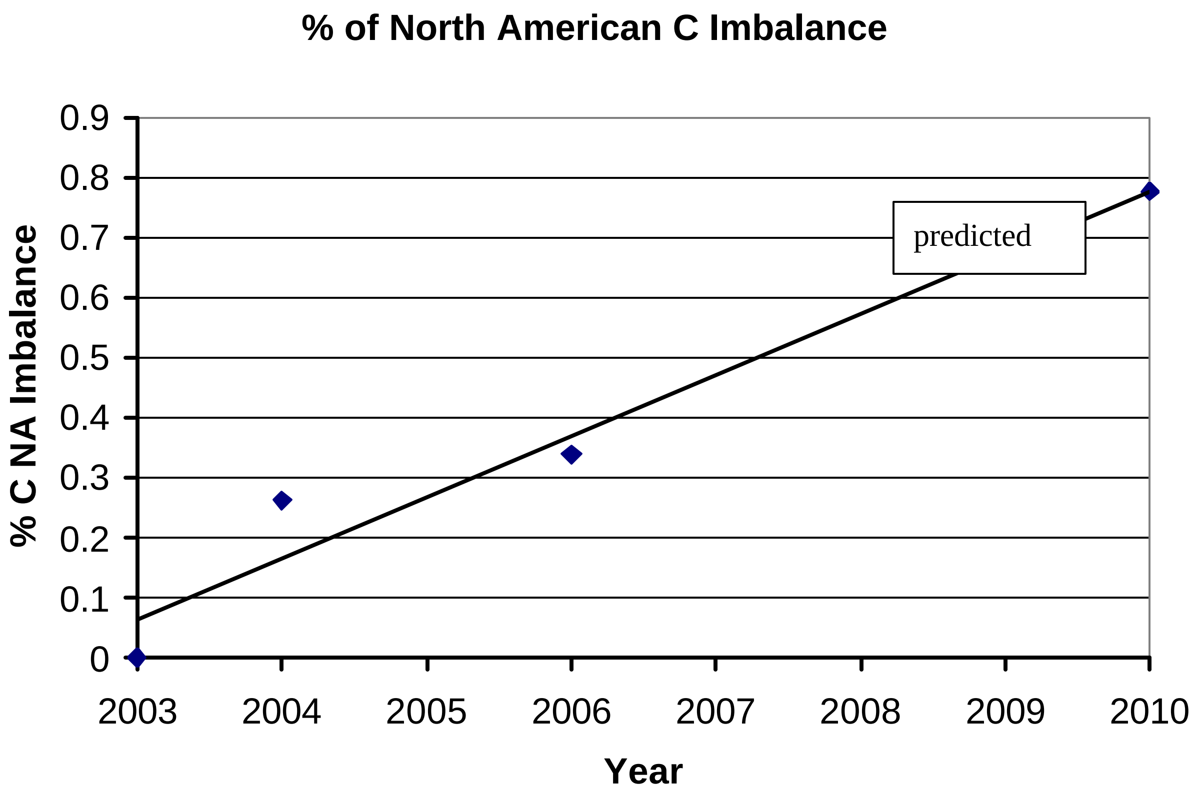



Fig 5. The impact of 1,000,000 acres of sod-based rotation in the southeast on the North America C imbalance.

In conclusion, the potential impact of sod-based rotation on global warming through reducing greenhouse gasses may be minimal. However, taken at a local level, lets suppose that a farmer has 500 acres and is interested in converting his farm to the sod-based rotation. Assuming that burning 1 gallon of gasoline releases 7.5 lb of C into the atmosphere, the farmer would be able to sequester the C from nearly 700,000 gallons of gasoline over 8 years of the rotation, or about 100,000 gallons per year (Fig. 6).

Think Globally, Act Locally.

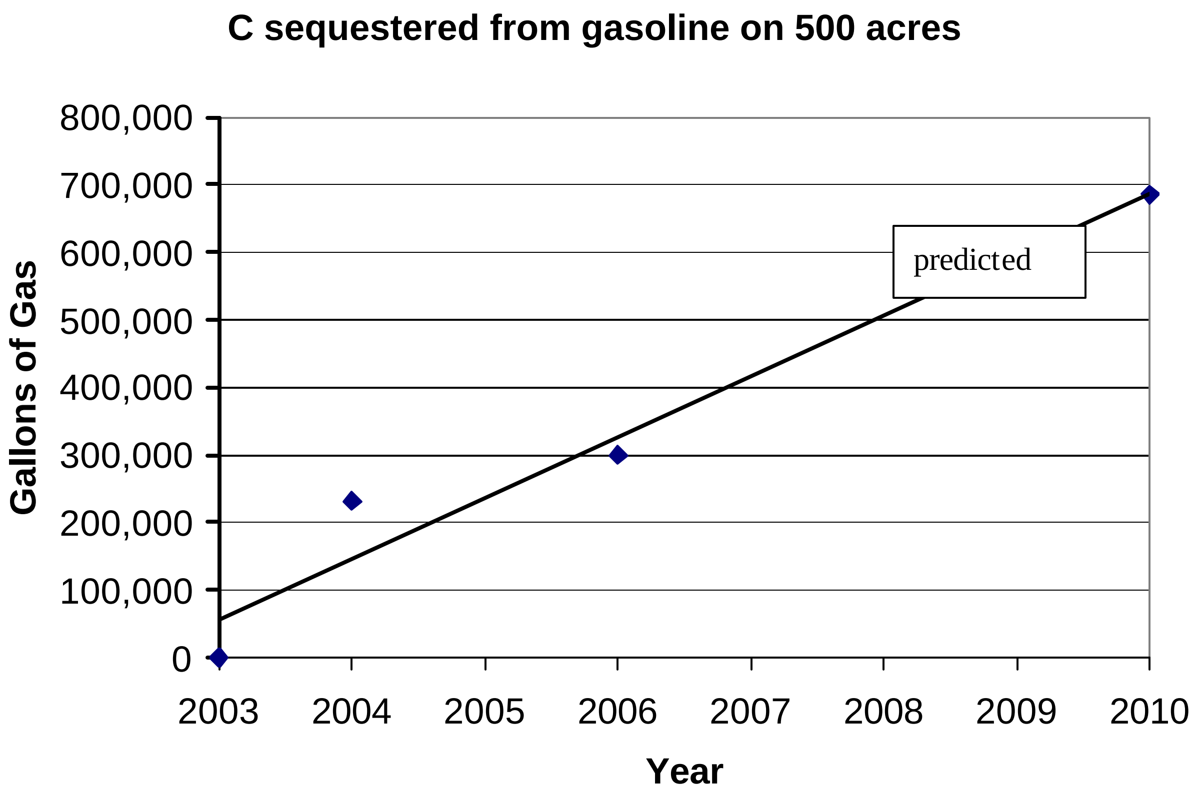



Fig. 6. C from gasoline sequestered on a 500 acre farm in the sod-based rotation.

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