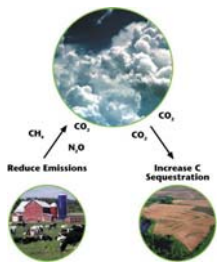


Climate Friendly Farming™: Managing the farm for carbon



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Washington State University helping farmers develop and implement agricultural systems and practices that mitigate global climate change.

Agriculture & Greenhouse Gases

The atmospheric levels of key greenhouse gases (carbon dioxide CO₂; methane CH₄; nitrous oxide N₂O) have increased exponentially in the past century, with human activity being the primary contributor (Figure 1). **Agriculture is a significant contributor to all three gases**, with CO₂ from soil organic matter oxidation, methane from rice culture and ruminant livestock, and N₂O from fertilizers enriching the nitrogen cycle. **Agriculture can help mitigate greenhouse gases (GHG) by reducing current emissions, sequestering atmospheric CO₂ in soil, and providing bioenergy** (which is essentially CO₂ neutral) to reduce fossil energy use.

Figure 1

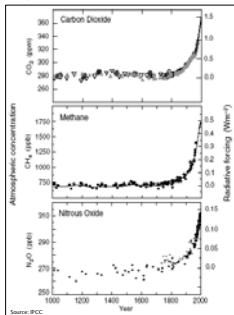


Figure 2

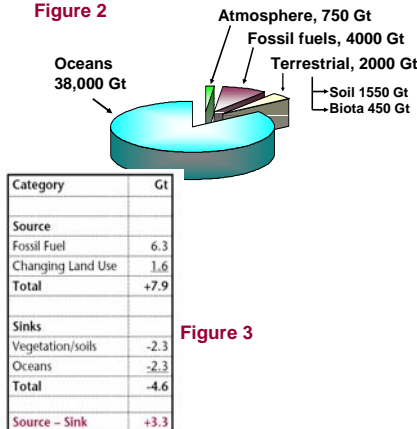


Figure 3

The earth's carbon is divided into *pools* (see figure 2). A relatively small amount of the global carbon is found in pools that create the delicate carbon cycle which affects the climate and life on the planet. On an annual basis, carbon is exchanged between terrestrial, atmospheric and surface ocean systems in "flux" (ie. growing plants fix carbon from the atmosphere into biomass, decaying vegetation releases carbon from biomass back to the atmosphere). Before the industrial revolution, this flux actually decreased the atmospheric carbon pool because terrestrial and ocean systems fixed more carbon from the atmosphere than they released. **Pre-industrial atmospheric concentration of CO₂ – which creates our climate baseline – was approximately 280 parts per million (ppm).**

The fossil fuel carbon pool was a geologically stable pool until human use made it part of the annual carbon cycle. Fossil fuel combustion in the past 150 years has dramatically changed the global carbon budget, leading to an annual carbon budget deficit (increasing atmospheric carbon concentration) of 3.3 Gt annually (see figure 3). **The current atmospheric concentration of carbon is approximately 380 ppm**, which has been linked with climate change and increasing variability in the past 150 years (especially acute in the last 30 years). Climate experts estimate that a doubling of atmospheric carbon concentrations from pre-industrial levels (ie. ~ 540 – 560 ppm) could lead to severe climate change. Current trends, under a business as usual approach (~3% increase in carbon emissions annually), would mean that atmospheric concentration of carbon would reach 1,100 ppm by the end of the century.

Agriculture is not the solution to climate change. The only *solution* to climate change is shifting from fossil carbon based energy and products to carbon neutral energy and products. **However, agriculture can provide some tools useful for near-term mitigation** which can help us buy the time necessary to make the transition to a carbon-neutral energy economy which will allow the time necessary to re-balance the earth's carbon pools and restore a stable climate system over the next few centuries.

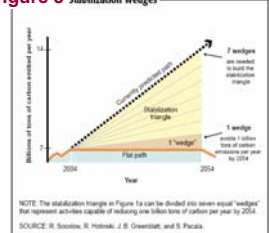
How much carbon can we mitigate?

Pacala and Socolow (2004) from Princeton University's Climate Mitigation Initiative describe the immediate challenge of greenhouse gas mitigation as an issue of "stabilization", or taking actions to cap greenhouse gas emissions such that the ultimate concentration of atmospheric carbon peaks at approximately 500 ppm by mid-Century. In order to accomplish this goal, they have suggested the concept of "stabilization wedges" (see figures 4 & 5) – ie. greenhouse gas mitigation actions / technologies currently available at less than \$100 / ton CO₂. Examples of these technologies include: energy efficiency and conservation, geological sequestration of carbon, more fuel efficient vehicles, nuclear, wind and photovoltaics, reforestation, conservation tillage, and biomass used for energy and products.

Figure 4 Historical carbon emissions with two potential pathways for the future



Figure 5 Stabilization wedges



Specific actions and technologies which could contribute to an agricultural mitigation wedge include:

Reducing GHG emissions from cropland
Reduce tillage, Precision N management

Increase soil C sequestration
Control erosion and topsoil losses, Reduce tillage, Soil-building cropping systems, More biomass, Green manures, Legumes, Roots!, Optimal irrigation and fertilization
Recycle organic materials: sewage sludge (biosolids), animal manure, crop residues, food processing wastes, composts

Offset fossil fuel use
Bioenergy, biofuels, and bioproducts; Biological N; More local food systems (average food item travels 1500 miles); Perennial cropping systems

How can I get paid to manage carbon on my farm?

Global markets for carbon are rapidly emerging in response to the Kyoto Protocol (US is not a participant), state legislation (California, Northeast state), and the desires of many companies and individuals for responsible environmental stewardship. The concept of a "carbon credit" is that when an emissions cap is placed on a business, that business can either spend money to reduce its emissions or pay someone else for their activities to do so. A farm that sequesters soil carbon or captures methane from manure in an anaerobic digester, can theoretically sell their credits to an emitter.

The European market for carbon credits is more developed than the US market, and prices have ranged from \$12-38 per metric ton of CO₂ recently. In contrast, prices on the Chicago Climate Exchange (a voluntary, but binding market) have ranged from \$3.50-4.00, reflecting the absence of US participation in an agreement such as Kyoto (see figures 6 and 7). Methane and nitrous oxide are 23 and 300 times as potent as CO₂ respectively and represent emissions permanently avoided, and therefore reductions of these two greenhouse gases are potentially far more valuable than CO₂. Methane is now being traded in some carbon markets, but nitrous oxide is not. Pacific Northwest farmers provided two key "firsts" in carbon trading: The Pacific Northwest Direct Seed Association (PNDSA) aggregated carbon credits from member farmers and negotiated the first agricultural carbon credit trade in the US. The Vander Haak Dairy in Lynden, Washington (a Climate Friendly Farming partner) sold the first methane reduction credit in the US. Carbon credits can theoretically apply to everything from GHG reductions and carbon storage to reduced diesel consumption– but very few protocols have been established for verification and trading of the credits. **Carbon credits may also be extended to biofuels, but end user of the fuel will likely be the recipient of the credit, not the farmer or biofuel producer.**

Figure 6



Figure 7

