Climate Change

AGRICULTURE AND CLIMATE CHANGE — KBS researchers discovered and quantified how different crop management practices can interact to provide novel opportunities for greenhouse gas mitigation by agriculture. These discoveries inform agricultural greenhouse gas policies worldwide.

Since 1992 scientists at the KBS LTER site have studied fluxes of the major, naturally occurring greenhouse gases — carbon dioxide (CO₂), methane, and nitrous oxide — in a variety of cropped and natural ecosystems. A 2010 update of research originally published in 2000 continues to show how different cropping strategies can have markedly different effects on greenhouse gas fluxes from both annual and perennial cropping systems. Twenty years of research show that on average, conventional cropping methods have an annual global warming impact (GWI) of about 110 CO₂-equivalents per square meter. Careful analysis reveals that nitrous oxide production is responsible for more than half of this impact, with the remaining half the combined effect of fuel and agrochemical use, including commercial fertilizer, agricultural lime, and pesticide inputs.

However, KBS results also suggest that almost all of the GWI of farming can be mitigated by changing management strategies. No-till cultivation led to soil carbon storage that almost completely offset the GWI of other activities. Planting leguminous cover crops, such as red clover, to reduce the need for nitrogen fertilizer and agricultural lime also substantially reduced cropping system GWI. Taken together, results suggest that not only could row-crop agriculture be CO₂-neutral, but crop production could help to mitigate greenhouse gas production in general — sufficient even to offset the annual increase in U.S. GWI from the emission of fossil fuel CO₂. Comparison of cropland to natural communities at KBS showed further that ecosystems that had been abandoned from agriculture 10 to 50 years previously had a higher mitigation potential (a more negative GWI) than any of the cropping systems, and greater even than late successional forest. Placing marginal cropland into conservation easements could thus be an additional strategy for mitigating greenhouse gas production elsewhere in the economy — especially if the biomass produced in these easements was then used for biofuels that offset fossil fuel use.

Many ecosystem processes change slowly. Any change in soil carbon over less than a decade is very difficult to detect. For example, one difference that has emerged only recently from the KBS LTER is that the organic system has become net-mitigating, i.e. it now has a negative GWI due to soil carbon storage that was undetectable 10 years after establishment. Short-term changes in the annual fluxes of nitrous oxide and methane are equally difficult to detect, in this case because of year-to-year climatic variability. Only long-term observations and experiments can reveal important trends.

Global warming impact analyses of these cropped and natural ecosystems were not anticipated when KBS LTER measurements were first initiated. But an ecosystems approach to taking measurements and a commitment to long-term sampling meant that when crucial measurements were needed for complete GWI analysis — measurements of fuel use and soil nitrogen levels, for example — they were available. Detection of such trends at an LTER site means also that experimentation can be initiated to explain the reasons for long-term trends.

For Further Reading


Robertson et al. 2000


The net global warming impact (GWI) of different types of cropped and unmanaged ecosystems at the KBS LTER site. A negative GWI indicates mitigation of greenhouse gas emissions. Row crops included corn, soybean, and wheat rotations. These cropped systems were compared with unmanaged fields and forests that were abandoned from agriculture years ago and are undergoing natural succession (change) toward becoming the native deciduous forest of the region. Source: Gelfand and Robertson 2010, unpublished, based on update of data in Robertson et al. 2000.