Nationwide agricultural greenhouse gas emissions sources, scenarios, and mitigation potential

California Environmental Associates has been working over the last few months on behalf of the Packard Foundation to answer the following questions:

1) What was the range of plausible scenarios for US agriculture GHG emissions and sequestration between 2008 and 2020 and what trajectory are we following?
2) What are the sources of GHG from agriculture in the US?
3) What are the most promising opportunities for US agriculture to mitigate climate change?
4) What was the range of plausible scenarios for nitrogen pollution associated with US agriculture between 2008 and 2020 and what trajectory are we following?
5) What are the sources of nitrogen pollution from agriculture in the US?
6) What are the most promising opportunities for US agriculture to mitigate nitrogen pollution?

Amy Dickie, Senior Associate at CEA, will present preliminary findings from this study, focusing primarily on sources of emissions and mitigation potential of agricultural greenhouse gas in the US. A draft summary of the findings to date follows.

Agriculture contributes approximately 6% of US greenhouse gas emissions on an annual basis, a rate that has been fairly constant for the last few decades. Although overall emissions are relatively small, the technical potential for mitigation is larger than might be expected given that there is significant un-tapped potential to sequester carbon in agricultural soils (both in grazed lands and cropped lands).

Greenhouse gas emissions from agriculture have been rising at a very modest pace in recent years, with the only notable growth coming from manure management – both from dairy cattle and swine as an increase in large scale confinement operations have changed common practices for manure management. Agricultural emissions are split roughly 60/40 between livestock and crops. Livestock emissions are primarily driven by methane released from the digestive function of animals, particularly cattle, though emissions from manure and grazed lands are also notable. As a percentage of overall US agricultural emissions, enteric fermentation (digestion) accounts for 30%, and manure and grazed lands both account for approximately 14%. Cropland emissions are almost entirely driven by nitrous oxide (~33% of total US agricultural emissions), released from both synthetic fertilizer application and crop biological fixation. Soil carbon in cropped and grazed lands can function as either a source or a sink, depending on weather, usage patterns, and management of the land. Soil carbon from croplands has served as a net sink in recent years.

Considering the breakdown of emissions sources by region and commodity can be quite instructive. Texas, California, and Iowa lead the country in terms of state agricultural emissions, accounting for 10%, 7%, and 7%, respectively of US emissions. Emissions in Texas are driven primarily by enteric fermentation from its large beef cattle population (Texas accounts for nearly 15% of all emissions from enteric fermentation in the US). In Iowa, emissions are split about evenly between cropland emissions and emissions from livestock, both swine and beef cattle. Approximately 2/3rds of California's emissions are attributable to its dairy cattle (both enteric fermentation and manure), and 1/3rd to nitrous oxide from its croplands.

Looking across the country, livestock emissions are dominated by cattle – approximately 60% of livestock emissions are from beef and approximately 25% are from dairy. An additional 10% are from swine. On a per head basis, dairy cattle have by far the largest emissions because they are more commonly housed in feedlots (vs. grazed systems for beef), and on average are much larger, productive animals (larger animals eat more and therefore create more methane). Dairy cattle emissions are more than two times that of beef cattle on a per head basis, yet beef cattle populations dwarf those of dairy cattle and thus beef cattle dominate aggregate emissions. Interestingly, California's emissions per head for dairy cattle are much higher than that of other states that rely more heavily on pasture systems than feedlot systems.

Cropland emissions are dominated by corn, thanks to both its high fertilizer requirement – corn receives nearly 45% of all nitrogen fertilizer in the US – and the fact that it accounts for more acres of cropland than any other crop. Corn accounts for approximately 40% of all cropland emissions, soy accounts for roughly 20%, and "non major crops" account for an additional 18%. The dominance of corn leads to a predictable concentration of cropland emissions from the MidWest, though California ranks high as well on a state-by-state comparison.

Greenhouse gas mitigation opportunities have an extensive literature, split roughly into two categories – those that document the mitigation potential on a per ha basis for specific practices in specific locations, usually from field level studies, and those that apply sectoral economic models to determine the economic potential of different broad categories of practices (e.g. afforestation, forest management, conservation management practices, nutrient management, biofuel production), depending on different prices of carbon. The former tend to be difficult to be widely applicable, and the latter may be too aggregated in their application to assess the nationwide biophysical potential of some individual practices.

The recent publication of the Nicholas Institute's (T-AGG) "Greenhouse Gas Mitigation Potential of Agricultural Land Management in the United States: A Synthesis of the Literature" provides an extremely useful data set. This report provides mean estimates as well as high and low ranges for the soil carbon sequestration potential, methane and nitrous oxide emissions reductions potential, and process and upstream emissions reductions potential on a per hectare basis for 42 mitigation practices, as well as an assessment of the maximum area available for each mitigation practice. According to this report, on a CO_2e per hectare basis some of the leading practices include set aside and management of histosol cropland (i.e. protecting organic soils), application of biochar, restoring wetlands, switching to short-rotation woody crops, and agroforestry. When we consider the applicable hectares for these practices, however, some of the opportunities that are more widely applicable, such as conservation tillage, winter cover crops, and grazing lands management, appear more compelling. That said those opportunities that are widely distributed and have a smaller per hectare opportunity may be more difficult to implement. Further many practices with large potential compete for the same land, forcing the farmer to choose between practices and therefore, limiting the potential of any single practice. Biochar application ranks high both in terms of it's per hectare potential and its applicable hectares, however there are still basic questions regarding longevity and mitigation potential, lifecycle concerns and economic factors that need to be further studied. Another important consideration is the indirect land use impacts of those mitigation practices that take land out of production (e.g. set-asides) and/or significantly change cropping patterns (e.g. agroforestry, short rotation woody crops, perennials). Several studies, including the Nicholas Institute's recent report, "The Net Global Effects of Alternative U.S. Biofuel Mandates", have found that taking land out of production, and or diminishing yields in the US leads to a net gain in GHG emissions on a global basis because the demand for agricultural commodities is fairly inelastic and production just moves elsewhere. Mitigation practices that do not change land use or cropping patterns, but rather change the GHG intensity of production, may be the best option. Further study of their technical and economic mitigation potential on a national and regional basis will help guide policy and intervention efforts.

CEA’s report is still in process and additional findings will be forthcoming, including an analysis of sources and mitigation opportunities of nitrogen pollution.