

## Climate Change and Agriculture

Climate scientists project that over the next several decades the accumulation of greenhouse gases will continue to raise temperatures and change established precipitation patterns across the world. The Intergovernmental Panel on Climate Change (IPCC) has found that temperature increases and other changes have already occurred and are projected to continue over the next century. Global climate changes raise several issues for California agriculture: (a) adaptation to new climate patterns in California, (b) adaptation to new market developments driven by climate change and climate change policy in other regions, (c) responses to policies designed to mitigate climate change by reducing emissions of greenhouse gases from agriculture and (d) responses to policies designed to reduce greenhouse gas (GHG) emissions in other sectors.

The United States is currently (Summer 2009) in the midst developing a climate change mitigation strategy, while California is implementing laws and regulations designed to reduce GHG emissions within the state. Adjustment of agricultural practices has the capacity to contribute to GHG reduction in California and globally. Agricultural production methods can be modified to reduce harmful emissions and sequester carbon that might otherwise contribute to climate change.

Agricultural production releases each of the three main greenhouse gases: carbon dioxide, methane, and nitrous oxide. Carbon dioxide is the main focus of many GHG reduction efforts because it is by far the most pervasive of the gases, but in terms of destructive potential for the ozone, methane is 21 times more powerful than carbon dioxide, while nitrous oxide is 300 times more powerful. To measure global climate change impact, these gases are put on a scale that weights emissions by climate change impact. In California, agriculture accounts for about six percent of weighted GHG emissions and about one percent of economic output and employment.

In 2006, governor Schwarzenegger signed the California Global Warming Solutions Act (AB32) to address emissions through market incentives and government regulations. Among other policies, AB32 will impose a cap and trade system for GHG emissions in California. Agriculture is not scheduled to be capped under this system, but if farms are able to show that they have reduced emissions they are likely to be in a position to sell GHG reduction credits to firms in other industries. Important issues for agriculture are the emission reduction credits that are attributed to specific agricultural practices and the potential prices for emission reduction credits.

Agriculture releases greenhouse gases in many ways and this suggests reduction strategies. Tilling the soil releases carbon dioxide, as soil is exposed to oxidation, therefore reduced tillage, employed on less than 2 percent of California cropland, can reduce GHG emissions (NRCS 2008). Carbon can be sequestered by planting cover crops including trees. Agriculture accounts for about 70 percent of nitrous oxide emissions (NRCS 2008) in the United States, largely from the application of fertilizers, so reduced use of nitrogen fertilizer use can reduce emissions. Nationally, agriculture accounts for one-third of methane emissions (NRCS 2008). Livestock operations contribute substantial methane emissions through digestive processes and decomposition

of animal waste. Rice production contributes to methane releases through anaerobic (underwater) decomposition of biomass, and changes in practices for flooding or post harvest straw handling can reduce methane releases. Finally, agriculture can also contribute to climate change mitigation through reduced use of energy such as fuel for transport and tillage equipment and irrigation.

The greatest impact to agriculture and the greatest demands for adaption will come from rising temperatures. As an example of historical trends, figure 1, shows that average minimum temperatures in the San Joaquin Valley have risen by about 2.5 degree Fahrenheit (almost 1.4 °C) from the 1930s to the first years of this century. Climate scientists project California will experience a temperature rise of 3.6 to 5.4 degrees Fahrenheit (2 to 3 °C) through 2050 (Cayan et al. 2006) and about 5.4 to 7.2 degrees Fahrenheit (3 to 4 °C) through

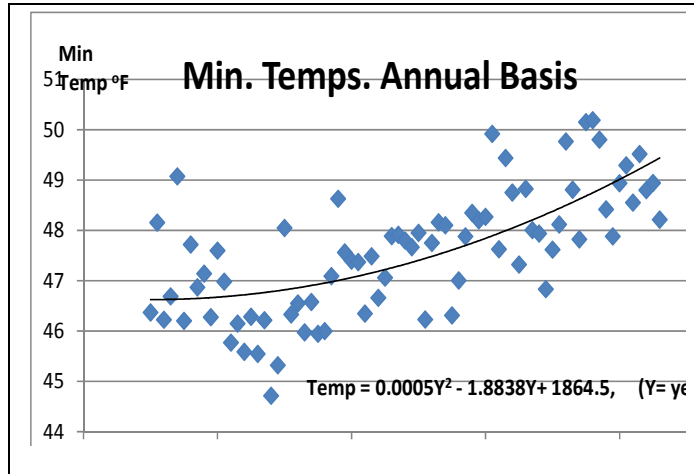


Figure 1: Temperature change in the Central Valley since 1930, average minimum temperatures on an annual basis. (Bar-Am 2009)

2080 (Lobell 2006). Warming implies fewer frost days and more heat waves (Weare 2009), which will affect crops that require a certain number of chill hours. Changes in precipitation are more difficult to project, but models indicate reductions in precipitation over much of the Western United States. The winter mountain snowpack will be smaller since more precipitation will fall as rain rather than snow. In addition, snowmelt will occur earlier. To counteract potential flooding, lower average reservoir storage will lead to less water available for summer irrigation in the more frequent dry years (Weare 2009). These changes imply increased demands for additional water storage facilities.

Climate change will affect agriculture through several channels in addition to the direct increase in mean temperatures. Concerns include challenges such as changes in geographic ranges for pests and diseases, shifts in precipitation patterns, including less snow and earlier snow melt and additional or more severe wildfires. On the positive side, although relationships are complex, increased concentration of carbon dioxide generally stimulates plant growth and is projected to increase yields of many crops.

Agricultural input and output market conditions will be affected by global climate change and climate change policies. For example, energy and fertilizer prices will rise as a part of higher taxes or cap and trade policies and irrigation water may become more scarce and expensive in regions outside California too. On the output side, a multitude of adjustments will determine if prices for important California crops such as grapes, almonds, lettuce and other fruits and vegetables important here will rise or fall given climate change in competitive regions. Although results of these complex market interactions cannot be well projected now, they have the potential to be among the most

important implications of global climate change for California agriculture. Clearly the myriad effects of climate change and associated policies will likely demand substantial innovation by California agriculture over the rest of this century.

Not all implications of climate change are negative for all agricultural enterprises, but all change demands adaptations. Adaptation will likely involve shifts in many agricultural practices including which crops are grown where. California agriculture has made massive adjustments over the past century and with climate change many more changes are coming.

– University of California Agricultural Issues Center, July, 2009

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