Climate Change Impacts on Agriculture

CalCAN
California Climate & Agriculture Network

CALIFORNIA AGRICULTURE is uniquely vulnerable to climate change. Rising temperatures, constrained water resources, and increased pest and disease pressure are among the climate change impacts that threaten to fundamentally challenge California agriculture in the coming years and decades[1].

Significant investments in research, technical assistance and financial incentives will be needed to keep California agriculture viable and assist the industry in adapting to climate change.

Here we provide a brief review of the anticipated impacts of climate change on California agriculture.

Changing Water Patterns and Supply

Changing climate and weather patterns are predicted to significantly affect water availability in the state. As temperatures rise, precipitation will increasingly fall to earth as rain rather than snow during the winter months[2]. Consequently, the Sierra Nevada snowpack—the state's primary water storage—will drop below historical levels. This decrease will likely result in reductions in runoff and shifts in timing of water releases, subsequently decreasing water supplies. Some research has suggested that snowmelt runoff could occur up to two months earlier than it does under current averages[3].

Warmer temperatures will allow for longer growing seasons in the near term, increasing water requirements for crops at a time when water supply reliability is decreased[4,5]. Reduced runoff during peak planting season in late spring and early summer will also increase demand for irrigation and likely lead to heightened competition between urban, agricultural and environmental uses[6,7]. Moreover, warmer temperatures will increase demand for electricity, while at the same time reduced water supply will hamper hydropower generation[8]. Constrained water resources will be among the most challenging effects of climate change for California agriculture.

Reduced Winter Chill Hours

Warming temperatures are already threatening fruit and nut crops, some of the most lucrative sectors in the state's agricultural economy, and climate models predict that this trend will worsen. Proper setting of fruit requires between 200 and 1200 winter chill hours (i.e., temperatures below 45°F) per season. Chill hours have been decreasing since the 1950s and climate models predict that up to two-thirds of chill hours may be lost in parts of the Central Valley—the state's primary fruit and nut tree growing region—by the end of this century.

Crops such as apples, cherries and pears that require long chill hours may have extremely limited growing ranges by 2050[9]. A number of perennial crops in the state may be particularly hard-hit, including avocadoes, nuts[10], grapes[11] and stone fruit[12]. Though warmer nights have benefited oranges[13] and wine grapes in some cases[14], continued warming will create conditions unfavorable for production of many wine grape varieties in the future[15]. A 2011 study by Stanford researchers concluded that production of premium grape varieties in Napa could be cut in half by the year 2040[16].

Continued production of many of these fruits may require farmers to change the cultivars they plant or move production further north and/or "upslope" to higher elevations. Each of these scenarios presents its own challenges, including increased costs of production and a loss of some capital investments already made in these permanent orchard crops.

Decreased Crop Yields

Warmer temperatures will likely extend the growing season and increase crop yields in the near term, but such benefits will be limited. Longer growing seasons will put additional pressure on resource use, and new evidence suggests that many crops may face yield losses in the long term. The U.S. Climate Change

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Science Program noted that annual crops including rice, corn and sorghum will likely have notable decreases in crop yields in the coming decades[17]. Temperature increases may also negatively affect tomato yields[18]. Current U.S. growing regions for corn, soybeans and cotton may have yield decreases of 30 to 46 percent by the end of the century under the slowest predicted warming scenario and decreases of 63 to 82 percent under the most rapid warming scenario[19].

As described in Figure 1, California climate models suggest that even the slowest warming scenario (scenario B1) will affect crop yields for a variety of annual plants. Cotton, maize, sunflower, and wheat yields may decrease an average of three to eight percent by 2050. Cotton and sunflower will face even greater yield losses as soon as 2025 and may decrease by as much as 29 percent before the end of the century[20].

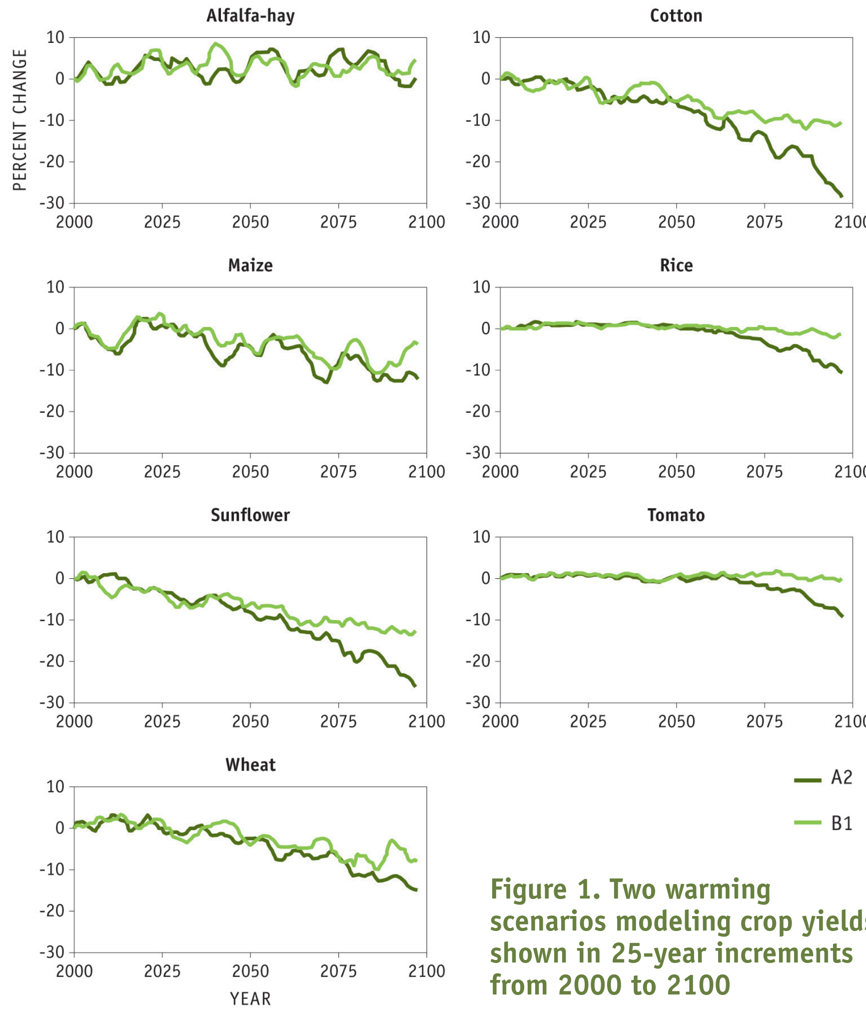

Figure 1. Two warming scenarios modeling crop yields, shown in 25-year increments from 2000 to 2100

Weeds, Pests and Disease

Although increased atmospheric concentrations of carbon dioxide, the most prevalent greenhouse gas may stimulate plant growth, weed and pest populations are also predicted to increase[21]. Crops grown under elevated carbon dioxide levels can have up to twice as many insects and higher levels of insect damage compared to control groups[22]. Warmer temperatures will likely lead to the northern migration of invasive species and weeds.

As weed growth intensifies, herbicide and pesticide use may also increase. Research predicts that glyphosate, the most widely used herbicide in the United States, will continue to lose efficacy as overuse causes more weed species to develop resistance to it. In response, some growers may increase the volume, types and potency of chemical applications in the future, which could raise production expenses and exacerbate water and air quality issues related to synthetic agrochemicals[23].

Vulnerabilities of Livestock Agriculture

Livestock operations make up a significant portion of California's agricultural economy, and California is the top dairy-producing state in the nation. Livestock and livestock products cash receipts totalled $7.8 billion in 2009[24].

Livestock production may be heavily affected by changes in climate as a result of increased pests and diseases. Elevated temperatures could increase the persistence and dispersal of animal pathogens[25]. Warmer temperatures can cause increases in mortality and/or decreases in productivity as a result of physiological stress and lower feed consumption. In feedlots, higher temperatures will likely increase the production of methane, ammonia and other gases associated with ruminants. Moreover, increased heat waves and rising temperatures will likely lead to overall reductions in meat, egg and dairy production, as well as decreased reproductive capability of livestock[26].

Extreme Weather Events

Climate change has the potential to increase the number and intensity of extreme weather events in the state[27], which may have profound short-term impacts on agriculture. Flooding in the Delta and Central Valley farmland is likely to increase from the combination of rapid snow melt resulting from warmer temperatures in the Sierra Nevada and increased winter and spring rainfall[28].

The greatest weather-related cause of agricultural loss has historically been excess moisture, but heat waves are poised to cause the most economic damage in coming years[29]. The magnitude and persistence of droughts are also expected to increase, with some climate models suggesting increasingly frequent moderate droughts in the state and other models suggesting less frequent but more severe droughts[30].

Extreme temperatures may further exacerbate difficult agricultural conditions. Particularly for flowering crops, vulnerabilities to heat may negatively affect growth. Existing research suggests that tomatoes suffer losses as a result of extreme temperature events, including heat waves and late frosts. Heat waves may also place additional demands on water and irrigation, further restricting available supplies[31].

Importantly, extreme heat events could have devastating health consequences for farmworkers, the backbone of California agriculture, who are employed at peak numbers during the hottest months of the year. Farmworkers are generally economically vulnerable and often lack health insurance, further exacerbating their risks of exposure to extreme weather conditions[32].

Economic Impacts

All of the changes summarized above have economic implications and widespread consequences. Agricultural products are important contributors to the state's economy, earning nearly $35 billion in 2010 for production on 81,500 farms and ranches. The agricultural sector in California provides an average of about 385,000 jobs in farming[33], with many more jobs dependent on the agricultural industry. While comprehensive research estimating the economic impact of climate change on California agriculture is still ongoing, early estimates demonstrate significant potential losses.

Moreover, agriculture is one of the most vulnerable sectors to water shortages, and annual costs of nearly $200 million could be incurred by agriculture if water availability is reduced to 20 percent below current demand levels[34]. Decreased water availability could produce losses of up to $1,700 an acre[35].

Preparing for Climate Change

California is already experiencing the effects of climate change, including warming temperatures, rising sea levels, longer fire seasons and shifts in precipitation[36]. Efforts to reduce greenhouse gas emissions and avoid the worst effects of climate change are needed, but they will not be enough to avoid all expected impacts of climate change. California agriculture will have to adapt to a changing climate and resources will be needed to make that possible. A report by CalCAN illustrates that California agriculture lacks adequate climate-specific research, technical assistance and financial support for growers, and is ill-prepared to face the challenges of climate change[37].

Additional California-specific research can assist scientists and agricultural producers in understanding the adaptation options available to them. Technical assistance and financial incentives will translate research findings into practice and support a broad base of California producers in making transitions. Investments must be made, using innovative policies and funding at the state and federal levels, to ensure that agriculture contributes to climate protection efforts and remains a diverse and vibrant contributor to the economy and culture of California. ■

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The California Climate & Agriculture Network

The California Climate and Agriculture Network (CalCAN) is a collaboration of California's leading sustainable agriculture organizations advocating for policy solutions at the nexus of climate change and agriculture. We cultivate farmer leadership to face the challenges of climate change and to serve as California's sustainable agriculture voice on climate change policy.

CalCAN
www.calclimateag.org
(916) 441-4042 or
(707) 823-8278
info@calclimateag.org

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