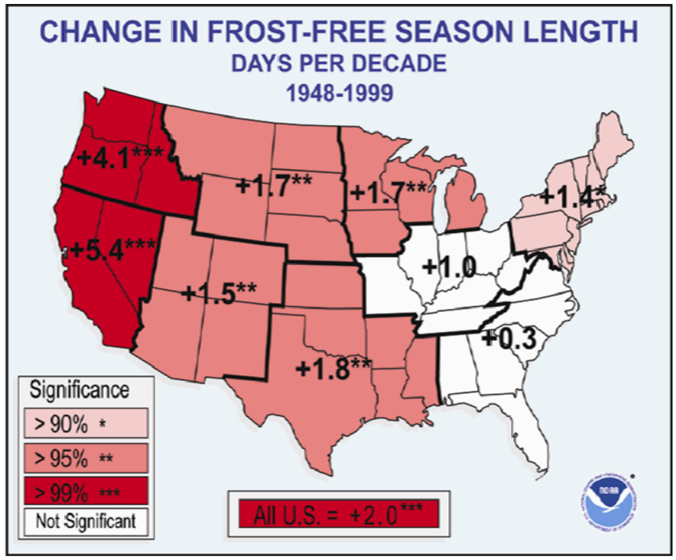
Earth Gauge
A National Environmental Education Foundation Program

Climate Change and Agriculture

Learn about some of the interactions between climate and agriculture in North America.

PHENOLOGY

Changes in seasonal temperatures can cause changes in the timing of crop budburst, pollinator life-cycles, or both. Because crops and pollinators need each other, unless they adjust to climate changes in tandem, both can suffer population declines. In California's Central Valley, butterflies pollinate major cash crops including cotton, peas, wheat, and sugar beets. A study of 23 of the region's butterfly species conducted between 1972 and 2003 revealed a general advance in the dates of their spring pollinating flights by an average of 24 days, which reflects the three degree Fahrenheit rise in springtime temperature that happened over the same period.



Earlier hatching and flight of California's butterflies is related to a 5.4 day increase in the length of California and Nevada's frost-free growing season, or the period from the last frost in spring to the first frost in fall or winter. The image at right shows regional changes in the frost-free season that occurred between 1948 and 1999.

CARBON DIOXIDE (CO_2) CONCENTRATIONS

Many crops grow differently under elevated atmospheric CO_2 levels, which have risen from 280 parts per million in pre-industrial times to over 385 parts per million today. The interactions between increased CO_2 and changes in temperature and moisture availability can be complex. For example, a 50 percent increase in atmospheric CO_2 results in a 26 percent increase in wheat yields (usually measured in tons per acre). Yet, if this increase in CO_2 is accompanied by an increase in temperature, which increases moisture loss and decreases yield, there is actually a slight decrease in yields.

Higher CO_2 concentrations can also alter the chemical composition of many crops. For example, higher CO_2 concentrations make strawberries sweeter, more aromatic, and antioxidant rich. On the other hand, higher CO_2 concentrations cause some crops to produce less protein. Experiments conducted under CO_2 levels that are about twice those seen today resulted in wheat, barley, and rice producing 10-15 percent less protein; potatoes producing about 14 percent less protein; and soybeans producing about 1.4 percent less protein.

Increased CO_2 levels cause plants to close their stomata, the tiny openings usually found on the undersides of leaves that regulate how much gas goes in and out of a plant. When plants close their stomata, less water goes from the soil, through the plant, and into the atmosphere, and more water stays in the soil and ultimately drains into the oceans. This decrease in evaporation from plants has likely partially counteracted the increase in evaporation resulting from higher temperatures. This helps to mitigate drought, but also increases the risk of floods, as when a soil's water content reaches a certain point, any additional rainfall flows over land and into surface waters.

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INCREASED EROSION

Heavy rains are a major agent of erosion. In central Oklahoma, the largest two percent of rainstorms accounted for 60 to 85 percent of total soil loss between 1977 and 1999. In the United States over the 20th century, the proportion of rainfall events that fell into the "extreme" category, which is defined as a rainfall event where more than two inches fall in a 24-hour period, increased from nine to 11 percent. The amount of rain that falls during the heaviest one percent of U.S. rainfall events has increased by 20 percent over the last 100 years, and the upper Midwest has experienced a 50 percent increase in the number of days where it rains more than four inches.

LIVESTOCK STRESS

Each year, even with heat abatement efforts, extreme heat costs America's livestock industries (dairy, beef, swine, and poultry) a collective 1.7 billion dollars. These losses come in the form of increased mortality, decreased appetite, decreased milk and egg production, and decreased reproductive fitness. A variety of factors impact losses. Cattle, for example, are like humans in that hot and humid days are the hardest on their systems, and cool nights provide a break from the heat. Cattle can handle a certain "heat load." If the cows get a break from the heat, some of the heat load is removed, and they can bear another hot day. Without a break from the heat, the load from one day can carryover into the next and "overload" the cattle.


Photo Courtesy of ARS USDA

In North America over the last 50 years, average nighttime low temperatures have risen faster than average daytime high temperatures. There has been a 50 percent increase in the number of unusually warm nights, and nights with temperatures that would have fallen into the top tenth percentile during the 1950's now fall into the top 15th percentile. Almost all of this increase has occurred since 1975.

CASE STUDY: CALIFORNIA'S ORANGES AND AVOCADOS

Crops grown in California bring in 13 percent of America's agricultural income and account for half of our domestically consumed produce. In California between 1980 and 2003, orange yields increased and avocado yields decreased. These changes in yield have been linked to recent climate change.


Photo Courtesy of ARS USDA

California produces two types of oranges: navel oranges, which are harvested from November to May, and Valencia oranges, which are harvested from May to October. Warm Decembers (which reduce frost damage) and wet Mays (which give the growing Valencias a boost) are conducive to increased yields. Years when the December temperature was 3.6 degrees Fahrenheit warmer than average produced crop yields that were five tons per acre larger than average. Wet Mays (Mays where rainfall is about one centimeter above average) would on average result in a 20 ton per acre yield increase over years when rainfall was average. Over the last 30 years, November through January temperatures in California increased by 1.8 degrees Fahrenheit. Average May precipitation remains largely unchanged. Over this period, orange yields increased by 9.3 percent.

While increases in average May daily low temperatures help avocado production to some degree, once this value exceeds 53.6 degrees Fahrenheit, the yields go down at a rate of about ten tons per acre for every 1.8 degree Fahrenheit increase in daily low temperature. Over the last 30 years, temperatures in the region increased by three degrees Fahrenheit during April, May, and June. There also appears to be a link between August daily maximum temperatures exceeding 87 degrees Fahrenheit and a drop in yields. Over the last thirty years, average July, August, and September temperatures on the southern California coast have increased by 1.8 degrees Fahrenheit.

CALIFORNIA'S WATER STRESS

Seventy-five (75) percent of the West's water resources originate from snow and ice melt. During the past century, glaciers in the Sierra Nevada Mountains, which provide water for California's agriculture, have retreated by 55 percent. Rapid retreat occurred between 1920 and 1970, and again from the 1980's until today. This retreat has been accompanied by a one degree Fahrenheit rise in temperature and a nine percent drop in winter precipitation, which occurred in the Sierra Nevada Mountains over the 20th century.

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