News from the CLIMAS El Niño-Drought Initiative

END InSight

February 2003

THE UNIVERSITY OF ARIZONA.

Is Spring Coming Earlier to the Southwest?

Evidence is mounting that the western United States, along with the rest of the planet, has warmed measurably within the past few decades. However, rising temperatures are not evenly distributed across the globe; nor are they evenly distributed through time, leading to uncertainty about their impacts on particular regions and ecosystems. To shed light on the relevance of this issue to the Southwest, this article will focus on a particular aspect of rising temperatures: the lengthening of growing seasons caused by earlier warming in the spring and its effects on plants, animals, and water supplies in the Southwest.

Minimum temperatures are warming about twice as fast as maximum temperatures, causing the freeze-free periods in most mid- and high-latitude regions to lengthen. This shift towards earlier last spring frost dates in the Southwest is particularly important as it coincides with the major growing season of plants, which rely on winter and early spring moisture to begin their annual growth cycle, and has implications for animal species as well. The hydrology of the Southwest also may be affected, because a large proportion of the region's water supplies come from snowpack melt.

Less Frost in New Mexico & Arizona
Regional evidence supports a trend toward longer frost-free periods. In Albuquerque, for example, temperature records from the airport since 1931 indicate that, on average, the last spring freeze date occurred 8 days earlier and the first fall free date, 8 days later at the end of the 20th century compared to earlier periods. Overall, the average growing season in Albuquerque has increased by approximately two weeks since 1991 (1).

Frost dates in southeastern Arizona indicate an even more pronounced lengthening of the growing season. CLIMAS researchers Melissa Chavez and Gregg Garfin examined the dates for the last frost of the spring and the first frost of the fall in the towns of Willcox and Safford, Arizona. By examining trends in temperature records from 1959 through 2001 for both locations, they concluded that last spring frost is occurring earlier and first frost is occurring later in the year. The trend projects that by the early 2000s, the last spring frost will occur 4–5 weeks earlier than in 1959; however, there is great variability in last spring frost date from year to year (2).

Difficulties in Tracking Early Spring
Identifying early spring temperature shifts might seem like a simple process, wherein researchers simply look at temperature records and identify trends toward earlier warming. However, it's not that simple for several reasons. Chavez and Garfin's study notes one of the caveats in tracking the trend toward early spring: the greater decrease in frost days in Willcox may be attributed to "urban heating effects," meaning that developed areas tend to store heat longer and thus less freezing occurs. The temperature gauge used for the Safford data is located in a less built-up area, at the University of Arizona Safford Agricultural Center, which may explain part of the difference between the sites. Given the rapid urbanization taking place in the Southwest, this factor could be affecting temperature readings at many gauges, giving the appearance of earlier spring that is not borne out by other indicators, such as faster snowmelt and observed changes in plant and animal behavior.

A further difficulty in delineating seasonal temperature shifts in the Southwest is the fact that precipitation may be a more significant constraint in determining plant growth cycles than temperature. After dry winters, plant growth may be slowed until more moisture is available, regardless of temperature conditions. This means that climatic patterns such as El Niño-Southern Oscillation (ENSO) introduce precipitation-related variability into growth records that is difficult to separate from temperature fluctuations. Chavez and Garfin, for example, noted a tendency for more frost days in La Niña years, due to generally drier conditions and clearer skies, which allow for greater nighttime cooling.

Another hindrance to understanding whether or not spring is indeed com-

continued on page 2

Early Spring, continued

ing earlier is the brevity of historical temperature records. In many locations, records are available from the late 1800s or early 1900s, but stations may have changed locations or recording methods or experienced urban heating effects. Even those sites with 100 or so years of solid data have recorded only a tiny fraction of the total climate record, making it difficult to discern short-term anomalies from much longer-term trends that can be attributed to phenomena such as global warming.

Tree-ring data have been used to expand the climate record in the Southwest. Researchers at the Laboratory of Tree-ring Research at the University of Arizona have reconstructed temperature and precipitation records over the past 1,000 years, based on the annual growth rings present in tree samples taken across the Southwest, and have created an index of past tree-growth cycles to compare with more contemporary specimens (3).

Trees do most of their growing, including adding the majority of wood to their trunks, during the early spring. At higher elevations, this season of rapid growth is bounded by below-freezing temperatures earlier in the year and lack of moisture as late-spring aridity increases. However, according to Julio Betancourt of the U.S. Geological Survey, scientists have noted that trees at higher elevations are increasingly adding wood earlier in the season. “The growth we’re seeing is just off the scale, unprecedented compared to anything that’s taken place in the past,” Betancourt notes. Betancourt and others attribute this early growth to higher nighttime temperatures occurring earlier in the year at higher elevations, which extends the trees’ growing season.

Warmer Temperatures Affect Species

Because of the difficulty in isolating early spring temperature shifts, researchers look for widespread temperature-related changes in natural events, such as the timing of snowmelt runoff pulses (discussed below) or changes in plant and animal distributions or behaviors (such as the tree growth example discussed above). There are four ways that species may react to warming temperatures: 1) the density of species in different locations can change, and their range can shift either towards the poles or to higher elevations; 2) species may experience phenological changes, or those that affect the timing of cyclical events such as migration, flowering, or egg laying; 3) species may exhibit morphological changes in body size or behavior; and 4) the frequencies of genetic traits affected by temperature can change within species (4).

Temperature changes affect different organisms in different ways. For example, 39 species of butterflies in Europe and North America have shifted their ranges northward by up to 200 km (125 mi) over the past 27 years. Plant species in the same areas, on the other hand, cannot shift their ranges as quickly to respond to changing temperatures and thus lag behind (5). Another factor that inhibits species from responding to climate change by shifting to cooler areas is the expanding human population in many areas; habitats are fragmented or destroyed and migration routes blocked by human land uses.

Any and all of these responses may affect the ecological balance between species in a given area and alter ecological communities in ways that may be devastating to particular species. When faced with higher minimum temperatures, some species may invade new areas and out-compete existing species. Disease-carrying organisms, such as mosquitoes, may shift their ranges due to both temperature and humidity changes and be introduced into new areas by climate shifts.

Tracking the effects of temperature shifts on particular species’ ranges is made more difficult by the fact that some species’ distributions fluctuate naturally in tune with climatic conditions, such as ENSO episodes. However, the impacts and intensity of ENSO episodes have increased during the last century and may well continue to do so. This could have serious impacts for organisms such as coral species, which cannot tolerate temperature rises of greater than 1 degree Celsius for longer than six weeks. The 1997–1998 El Niño episode brought some of the warmest ocean temperatures ever recorded, contributing to the demise of an estimated 16 percent of the world’s reef-building corals (5).

Early Spring Impacts on Water Supplies

Early spring also can have important effects on water supplies in the Southwest; indeed, a recent study of the timing of runoff in California noted that, “The timing of snowmelt runoff from the mountains…plays almost as great a role in water supply management as does its quantity and quality” (6).

Snowfall is estimated to provide 50 to 80 percent of the West’s annual water supply, and most of it is stored in natural reservoirs of snowpack in high mountain ranges through the winter season and into the spring and summer. Much of the water in the Colorado River and other river systems in Arizona and New Mexico is produced by snowmelt. However, satellite data show a 10 percent decrease in snow cover and ice extent in the northern hemisphere since the late 1960s, much of it potentially due to warmer temperatures, which lead to smaller runoff flows.

Snowpack conditions on April 1 form the basis for runoff estimates and forecasts. When warm spring temperatures cause snow to melt earlier, water flows into reservoirs sooner and is exposed to evaporative losses for a longer period of time. Gradual snowmelt over several months, on the other hand, creates moderate flows that extend into the late spring and summer. Trends toward earlier spring snowmelt streamflow have been observed in

continued on page 3

Early Spring, continued

western North America. The first pulse of snowmelt streamflow has occurred approximately two days earlier each decade during 1945–1993 (7). The operation of reservoirs, irrigation water availability, and flood-control management all depend to a great extent on the timing of runoff.

Conclusion

Whether or not spring is coming earlier to the Southwest is a difficult question to answer, given the brevity of climate records and the difficulty of separating decadal-scale climate changes from longer-term trends and precipitation effects from those caused by temperature, as well as the lack of adequate and unbiased temperature records. However, it is a factor likely to have important impacts on ecological communities and water supplies in the near future. Better monitoring and understanding of the mechanisms causing early spring trends will help Southwest water resource, land, and wildlife managers to cope with future climate-driven management challenges.

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