Effects of Precipitation and Climate on Streamflow and Temporal Variability of Nutrient Concentrations

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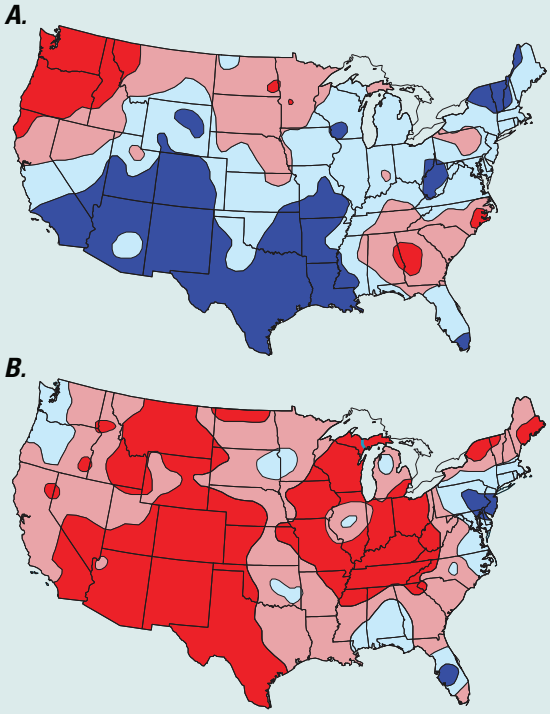
Daily, seasonal, and long-term changes in climate can affect streamflow, which in turn affects nutrient variability in streams. Specifically, daily variability in surface temperature, light availability, and precipitation can contribute to short-term (minutes to days) changes in local hydrologic processes such as runoff, snowmelt, and evapotranspiration, that in turn affect streamflow. Seasonal changes (weeks to months) in large-scale weather patterns can bring seasonal dry or wet periods and the start and end of growing seasons. Longer changes (years) are tied to "El Nino" events in the tropical Pacific, which yield a recurring pattern of winter precipitation that favors a wetter-than-normal Southwest and Florida and a drier-than-normal Northwest. The opposite of an El Nino in the tropical Pacific is a "La Nina," which reliably yields wetter-than-normal winters in the Northwest and drier-than-normal winters in the Southwest. Changes that last for decades at a time, such as prolonged droughts, are related to climatic fluctuations over the North Pacific and North Atlantic (fig. 2-11).



Positive values are shaded red, and negative values are shaded blue. Darker shades indicate stronger correlation (>0.4 or <-0.4).

Figure 2-11. Areas of the conterminous United States where long-term droughts (several years to decades) are positively correlated (red) or negatively correlated (blue) with changes in ocean temperature in the North Pacific (*A*) and the North Atlantic (*B*). (Modified from McCabe and others, 2004.)

Additional multi-decadal streamflow variability may be related to long-term climate change in response to increasing greenhouse-gas concentrations in the global atmosphere, or to naturally occurring variability in winter and spring temperatures and in the form and timing of precipitation. Warming has occurred across the West, upper Midwest, and Northeastern United States, while the Southeast has actually cooled overall. Warmer winters and springs in the Western United States have contributed to widespread hydrologic changes, including trends towards more precipitation as rain rather than as snow, less snowpack overall, earlier greening of vegetation, and earlier snowmelt (fig. 2-12).

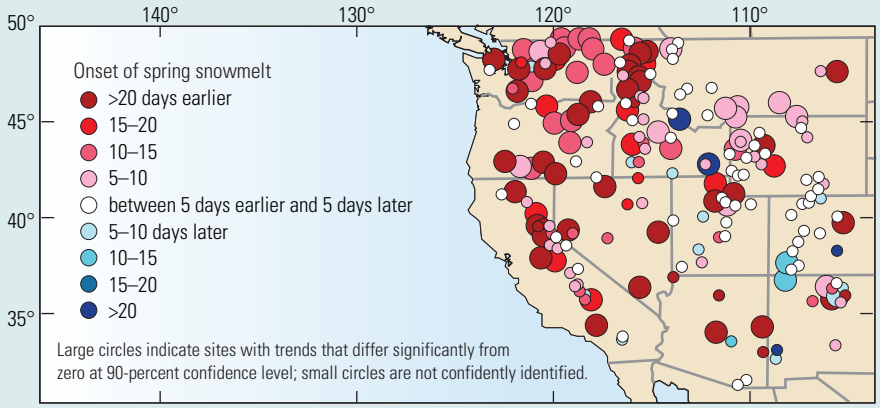


Figure 2-12. Spring snowmelt onset—the date on which snowmelt runoff adds a large initial surge to rivers—occurs a week to almost three weeks earlier now than in the middle of the 20th century in the West (Dettinger, 2005). Changes in the timing of streamflow have implications for agricultural water management and hence nutrient transport.

Nutrient concentrations respond to these short-term and longer-term temporal changes in streamflow. Specifically, nutrient concentrations can change throughout the year and over a 24-hour period in response to changes in light availability, temperature, and in turn, biological productivity (Kent and others, 2005; Peterson and others, 2005). Concentrations in some areas are highest during spring and summer wet periods following fertilizer application. Concentrations in other areas are highest during winter low-flow periods because of groundwater inflow and reduced biological uptake. Finally, annual and decadal changes in precipitation can lead to long-term changes in surface runoff or instream dilution, contributing to long-term changes in nutrient concentrations in streams.