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Perturbing Nature: Will a Small Change in the Timing of Snowmelt Lead to Big Shifts in Soil-Plants-Microbes and Watershed Behavior?

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In temperate mountain watersheds, snowmelt is a major hydrologic event associated with large annual fluxes of nitrogen among soils-plants-microbes, as well as a major driver of nitrogen export from watersheds. Plant phenology has historically been triggered by loss of winter snow and air temperature in spring. Plant production and nutrient uptake occurs after snowmelt and is coupled with microbial biomass turnover and soil nutrient mobilization. The coupling likely enhances ecosystem nitrogen retention; however, rising winter and spring air temperatures, dust-on-snow, and reduced winter snowfall is causing snowmelt to take place earlier with increasing frequency in the mountainous western U.S. We hypothesize that early snowmelt will disrupt coupled plant-microbial behavior, resulting in temporal asynchrony between microbial biomass turnover, nutrient release, and the timing of plant leaf expansion. Therefore, a subtle shift in the timing of plant growth due to earlier snowmelt could substantially affect watershed behavior.

Winter 2017 was typical of winters past in the Colorado Rocky Mountains with high snowfall and late-lying snow into June and July. Lower elevations in the East River watershed began greening in mid-May, approaching 100% species with leaves expanded in early June. Drought conditions followed, so that full leaf color change for the early-greening species began in mid-June at lower elevations. Synchrony in greening across a hillslope was greater at lower than higher elevations, where snow cover is more spatially variable. Also, due to high snowfall in 2017, elevations above 11,000 feet began greening nearly three weeks after lower and mid elevation regions of the watershed. This threshold behavior across elevation in the watershed may be a critical watershed behavior that shifts in years with earlier snowmelt. In 2017, at lower elevations, overwinter soil microbial biomass production was triggered by snowmelt infiltration, which occurred more than 60 days prior to soils becoming snow-free. Soil bacterial and fungal community composition, determined by amplicon-sequencing, exhibited striking shifts in the abundance and distributions of taxa and functional guilds. Changes in soil bacterial and fungal community structure was initiated by snowmelt infiltration and persisted through the complete loss of snow in spring. Immediately following snowmelt, NO₃ - concentrations in soil pore water and soil extracts increased dramatically, suggesting release of nitrogen from microbial biomass. These data provide an incredible baseline to compare to this year, 2018, and subsequent years, in which there is a high probability of lower snowfall, earlier snowmelt, and in which earlier snowmelt experiments will take place.