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Oak Forest Responses to Episodic-Seasonal-Drought, Chronic Multi-year Precipitation Change and Acute Drought Manipulations in a Region With Deep Soils and High Precipitation

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Implications of episodic-seasonal drought (extremely dry late summers), chronic multi-year precipitation manipulations (±33 percent over 12 years) and acute drought (-100 percent over 3 years) were evaluated for the response of vegetation and biogeochemical cycles for an upland-oak forest. The Quercus-Acer forest is located in eastern Tennessee on deep acidic soils with mean annual temperatures of 14.2 °C and abundant precipitation (1352 mm y-1). The multi-year observations and chronic manipulations were conducted from 1993 through 2005 using understory throughfall collection troughs and redistribution gutters and pipes. Acute manipulations of dominant canopy trees (Quercus prinus; Liriodendron tulipifera) were conducted from 2003 through 2005 using full understory tents.

Regional and severe late-summer droughts were produced reduced stand water use and photosynthetic carbon gain as expected. Likewise, seedlings and saplings exhibited reduced survival and cumulative growth reductions. Conversely, multi-year chronic increases or decreases in precipitation and associated soil water deficits did not reduce large tree basal area growth for the tree species present. The resilience of canopy trees to chronic-change was the result of a disconnect between carbon allocation to tree growth (an early-season phenomenon) and late-season drought occurrence. Acute precipitation exclusion from the largest canopy trees also produced limited physiological responses and minimal cumulative growth reductions. Lateral root water sources were removed through trenching and could not explain the lack of response to extreme soil drying. Therefore, deep rooting the primary mechanism for large-tree resilience to severe drought. Extensive trench-based assessments of rooting depth suggested that 'deep' water supplies were being obtained from limited numbers of deep fine roots.

Observations of carbon stocks in organic horizons demonstrated accumulation with precipitation reductions and drying, but no change in mineral soil carbon pools attributable to changing precipitation. Measured changes in nitrogen and other element pools suggested that long term immobilization of elements with chronic drying would lead to reduced growth, but that deep rooting access to the key base cations would moderate such effects by providing a source of minerals to be cycled in near surface soils. Cumulative changes in canopy foliar production were evident over time showing sustained or even increased production with chronic drying. This unexpected response is hypothesized to result from the retention of nutrients in highly-rooted surface horizons made available for plant uptake during spring mineralization.