



## **Co-limitation of primary productivity by water and nitrogen along regional gradients of mean annual precipitation**

H. Epstein (1), J. Paruelo (2), G. Piñeiro (2), W. Lauenroth (3), I. Burke (3) and J. Barrett (4)

(1) University of Virginia, USA, (2) University of Buenos Aires, Argentina, (3) Colorado State University, USA, (4) Dartmouth College, USA

Primary productivity in semiarid ecosystems is co-limited by soil moisture and plant-available nitrogen. It had commonly been thought that, along spatial gradients of mean annual precipitation in grassland systems, water is more limiting in drier areas and nitrogen is more limiting in wetter areas. Recent syntheses of various studies suggest that this may not be the case and that these resources may more equitably limit primary productivity at all points along rainfall gradients. An adequate theory for why this is true has not been proposed. One theory states that along gradients of increasing mean annual precipitation, water availability, nitrogen availability and plant demand for nitrogen all increase similarly; therefore the expected plant response to changes in soil moisture or nitrogen would not vary along the gradient. However, new data demonstrate that plant-available nitrogen does not increase to the same degree as water availability with increasing mean annual precipitation; in fact, it may not increase at all along precipitation gradients. To accommodate this, we suggest that nitrogen availability does not vary substantially along precipitation gradients, but neither does plant demand for nitrogen; this would explain the fact that wetter grassland ecosystems are no more limited than drier grassland ecosystems by nitrogen. We also hypothesize that ecosystems most limited by nitrogen and water occur at intermediate levels of mean annual precipitation, where vegetation transitions are present, such as the transition between shortgrasses and tallgrasses, or between grasses and shrubs. New field experiments and remote sensing analyses have been proposed to test these hypotheses.