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Assessing shrub encroachment in a grassland-shrubland desert ecotone using the relationship between remote sensed phenology of vegetation and precipitation

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Climate change and the massive alteration of natural habitats are major drivers of land degradation. Their effects may be especially significant in drylands, where ecosystems are particularly sensitive to degradation, usually involving largely irreversible landscape changes. A paradigmatic case of catastrophic vegetation shift is the shrub-encroachment process that has been taking place over the last 150 years in the Chihuahuan Desert, where large areas of grasslands dominated by perennial grass species (black and blue grama) have shifted to shrublands dominated by woody species (creosotebush and mesquite) accompanied by accelerated water and wind erosion. An array of mechanisms are involved in this process, including external triggering factors such as precipitation and land-use variations, and endogenous amplifying mechanisms brought about by soil erosion-vegetation feedbacks. We track landscape changes at a 20 km2 grasland-shrubland ecotone in the northern edge of the Chihuahuan Desert (McKenzie Flats, Sevilleta LTER site, New Mexico) by studying the relationship between long-term (2000-13) records of medium-resolution remote sensing of landscape phenology (MODIS NDVI) and precipitation. We hypothesize that grass and shrub life-forms exhibit important differences in phenology and water use. Our analysis indicates that herbaceous vegetation (grasses and forbs) shows quick growth pulses associated with short-term (previous 2 months) precipitation, while shrubs show a slow response to medium-term (previous 5 months) precipitation. We use these relationships to (a) determine the broad-scale spatial distribution of herbaceous vegetation and shrubs in our study site, and to (b) decompose and transform the NDVI signal into partial NPP components for herbaceous vegetation and shrubs. We further analyze the influence of inter-annual variations in seasonal precipitation on remotely sensed NPP data. Plant growth for herbaceous vegetation is particularly synchronized with monsoonal summer rainfall. For shrubs, NPP is better explained by winter plus summer precipitation, overlapping the monsoonal period of rain concentration. Our results suggest that a precipitation drift driven by reductions in monsoonal summer rainfall and increases in winter precipitation may enhance the shrub-encroachment process in the desert grasslands studied in the American Southwest.