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Soil seed-bank structure and seed-germination dynamics contribute to pulsed shrub encroachment in a grassland-shrubland Chihuahuan ecotone

Mariano Moreno de las Heras, Laura Turnbull, and John Wainwright
Durham University, Department of Geography, Durham, United Kingdom

Shrub encroachment is pervasive in many arid and semi-arid landscapes worldwide. Large areas of desert grasslands in southwestern USA have shifted to sparse shrublands dominated by woody species over the last 150 years, accompanied by accelerated soil erosion. A complex range of mechanisms has been suggested to explain the occurrence of this phenomenon, including land-use change, climate variations, and soil erosion feedbacks of vegetation change. An important step to understand patterns in species dominance at desert grassland-shrubland transitions is the understanding of limitations on plant establishment imposed by the shrub-encroachment process. We analyze the structure of soil seed banks and the environmental limitations for seed germination (i.e. soil-water availability and temperature) of dominant species (black grama and creosotebush) across a Chihuahuan grassland-shrubland ecotone (Sevilleta National Wildlife Refuge, New Mexico). Seed density in soils across the ecotone is generally low (200-400 seeds m-2), although is largely concentrated in vegetation clumps (reaching peaks up to 800-1200 seeds m-2 in grass and shrub patches). Species composition in the soil seed-bank is strongly affected by shrub encroachment, with seed densities of grass species (and particularly for black grama) sharply decreasing in shrub-dominated areas. Optimal temperature for seed germination of both black grama and creosotebush (20-25ºC) suggests synchronization of plant establishment with the summer monsoonal period. Water-level limitations for seed germination are similar for the two species (about 8-10% soil moisture), although creosotebush seeds need a longer time under optimal water-availability conditions for germination (about 12 days) than black grama seeds (about 7 days). Analysis of temporal series of field-based and simulated soil-moisture levels suggests that creosotebush requires very strong monsoonal precipitation for plant establishment, and therefore shrub encroachment is likely to take place in the form of low-frequent discrete pulses driven by the coupling of shrub dynamics at the seedling establishment and adult plant stages. Reestablishment of black grama is strongly limited by the lack of viable seeds in shrub-dominated areas.