Modeling the shrub encroachment in the Northern Chihuahuan desert Grasslands using a Cellular Automata model

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Arid grasslands of southwestern North America have changed dramatically over the last 150 years as a result of the shrub encroachment, i.e. the increase in density and biomass of indigenous shrubby plants in grasslands. Numerous studies have documented the expansion of shrublands in the southwestern America Grasslands; in particular the encroachment of shrubs in american deserts has strongly occurred in the Chihuahuan deserts from 1860.

The Sevilleta National Wildlife Refuge (SNWR), located in the northern Chihuahuan desert shows a dramatic encroachment front of creosote bush (i.e. shrub) into native desert grassland. This encroachment has been here simulated using an Ecohydrological Cellular Automata Model, CATGraSS.

CATGraSS is a spatially distributed model driven by spatially explicit irradiance and runs on a fine-resolution gridded domain. In the model, each cell can hold a single plant type or can represent bare soil. Plant competition is modeled by keeping track of mortality and establishment of plants, both calculated probabilistically based on soil moisture stress. For this study, the model is improved with a stochastic fire and a grazing function, and its plant establishment algorithm is modified.

CATGraSS is implemented in a small area (7.3 km2) in SNWR, characterized by two vegetation types: grass savanna and creosote bush. The causes that have been considered for the encroachment in this case study are: the fire return period increase, the grazing increase, the seed dispersal caused by animals, the role of wind direction and the shrub-grass inhibition effect.

The model is able to reproduce the encroachment occurred in the SNWR basin, simulating an increasing of the shrub from 2% in 1860 to 42% (i.e. current shrub percentage) in 2010 highlighting as more influent factors the reduced fire frequency and the increased grazing intensity. For the future management and encroachment control, the reduction of the fire return period and the grazing removal could be the best actions to reduce and control the encroachment.