Production and Biodiversity Responses to Extreme Climatic Events Across a Heterogeneous Landscape

Debra P.C. Peters[1], Jin Yao[2], and Osvaldo Sala[3]

[1]Jornada Basin LTER and USDA ARS, Las Cruces, NM; [2]Adams State College, Alamosa, CO; [3]Brown University, Providence, RI

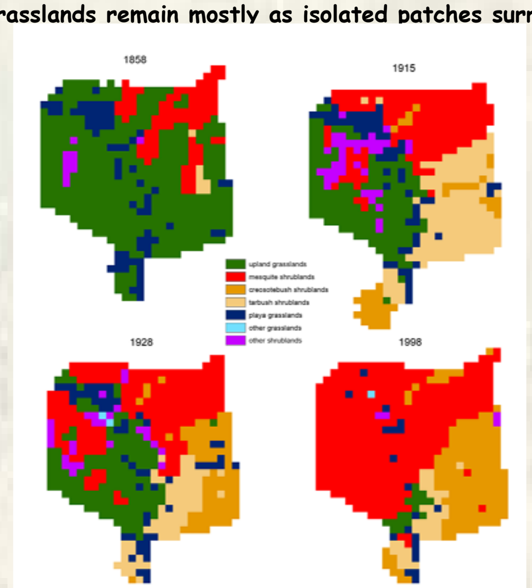
Introduction. Temperatures are increasing globally, but the magnitude and trajectory of localized changes in precipitation are uncertain. This uncertainty in climate results in uncertainty in predictions of future ecosystem dynamics. We used 18 years of ecosystem responses that included a series of both dry and wet years to predict future dynamics of a heterogeneous landscape under directional changes in climate. We compared these dynamics with long-term (140 year) historical trends in vegetation to determine if climate change provides opportunities for shrublands to revert to grasslands located in different parts of the landscape.

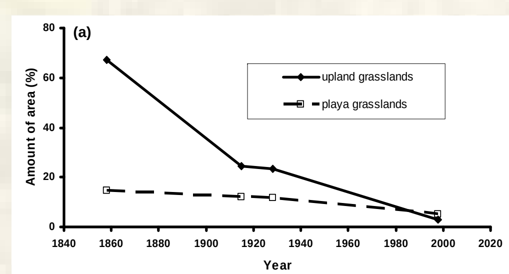
Study site. Sampling was conducted in the northern Chihuahuan Desert at the Jornada Basin USDA-LTER site in southern NM, USA (32.5N, 106.45W). Climate is arid to semiarid with an 80 year average of 23 cm of annual precipitation occurring mostly during the summer-fall monsoon period. Average monthly temperatures range from 6°C in January to 26°C in June.

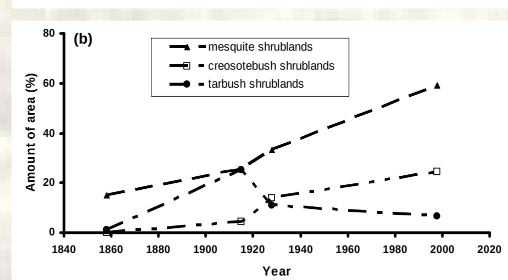
Methods. Three sites were selected for each of five ecosystem types: upland or playa grasslands, and creosotebush, mesquite or tarbush shrublands. Livestock grazing has been excluded since at least 1989. Within each site, a systematic grid of 48 or 49 1 m^2 permanent quadrats with 10m buffers were established in 1989. Plant biomass is estimated by individuals and species three times a year using non-destructive measurements ANPP is measured as the positive increment in biomass in a quadrat between late winter and fall. Richness is obtained by counting the number of species in each quadrat in the fall.

Historical trends

Most of the 100,000 ha of the Jornada was dominated by grasslands (81%) in 1858 (green, blue on map). Similar to arid and semiarid regions globally, perennial grasslands have converted to shrublands through time. Most of the area is now dominated either by mesquite (red) or creosotebush (brown). Grasslands remain mostly as isolated patches surrounded by shrublands.

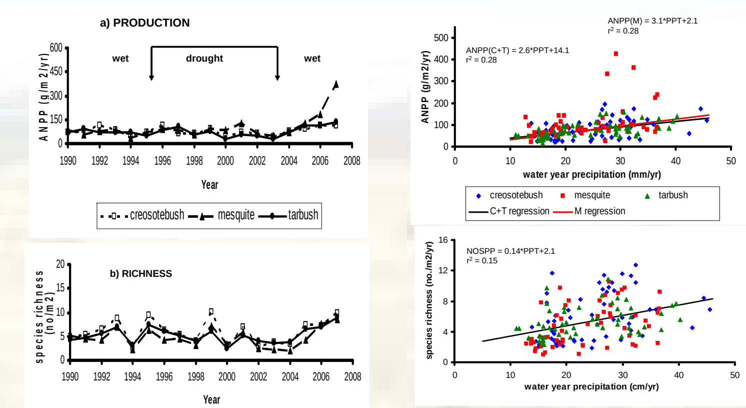




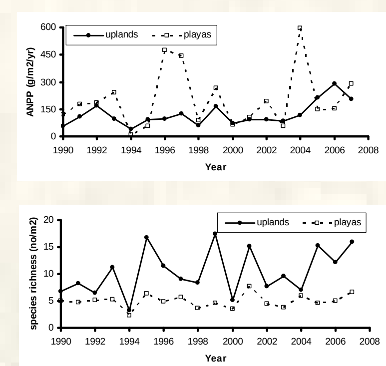


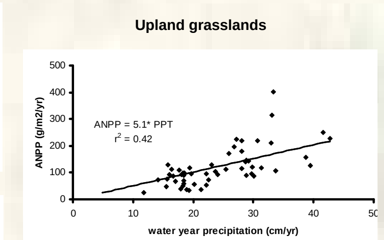
Responses to precipitation

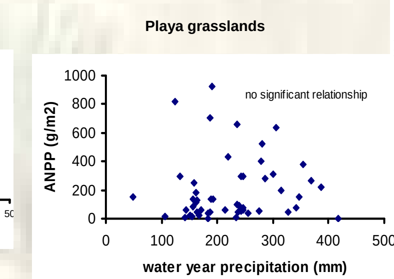
In shrublands, both production and richness were low throughout the 10-y drought. A series of wet years (2004-08) resulted in an increase in both variables as a result of increasing density and cover of herbaceous species. Thus, future drought will maintain low productivity shrublands whereas future wet periods are expected to promote herbaceous cover in all 3 shrubland types.

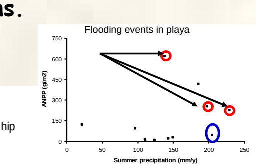


In grasslands, uplands and playas responded differently to precipitation. Production of upland grasslands was linearly related to precipitation while richness was highly variable. Thus, these grasslands will likely remain susceptible to shrub invasion in droughts and may be maintained under wet periods. In contrast, production in playa grasslands was highly variable while richness remained low throughout the 18-y time period. Production of playa grasslands is related to contagious processes: flooding events either result in high or low values depending on the timing of the event relative to plant growth. Playas may be maintained in wet periods if connectivity with upslope positions remains.









Future trajectories

Our data suggest that a long-term decrease in precipitation will accelerate current desertification trends with continuing loss of grasslands. On the contrary, a multi-year increase in precipitation can act to: (a) decrease the rate of grassland to shrubland conversion and (b) convert degraded shrublands to savannas containing mixtures of shrubs and grasses, and potentially a return to grasslands in the future. Because this regime shift reversal is not predicted based on historical drivers, our assumptions about ecosystem dynamics in the face of global change need to be re-examined, and new strategies need to be developed to take advantage of opportunities provided by future climates.