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Land degradation patterns induced by biological invasions: Untangling the climate-soil-vegetation feedback.

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Dryland degradation associated with rapid shifts in vegetation composition (e.g. encroachment of woody plants in to grassland, exotic grass invasion) is of critical concern due to its impact on climate, water cycle, environmental quality and food security. Here we present a novel desertification paradigm driven by exotic grass invasion of stable desert shrublands. Invasion by exotic annual grasses can increase fire frequency, shrub mortality, and resource redistribution, thereby destroying the heterogeneity of resources typical of desert shrublands and favoring the conversion into exotic grasslands. However, long-term persistence of grass cover is restricted due to recurrent droughts that displace the invasive grasses. This drought-induced loss of vegetation cover is expected to be followed by higher soil erosion rates and irreversible losses of soil resources. We support this framework using a combination of extensive field monitoring in shrub-grass ecotones in North American deserts (fire-soil erosion feedbacks), laboratory experiments (ecophysiological responses, mortality), and modeling (patch scale feedbacks to regional scale). Our results provide evidence to support the proposed land degradation pathway involving a climate-soil-vegetation feedback. The mechanism we propose suggests that biological invasions and climate change may act in concert and amplify each other's effect on vegetation cover and soil resources. In the degradation mechanism described here, climate change and biological invasions are acting in concert to induce land degradation. This framework also indicates that the process of land degradation can be facilitated both by heterogeneity (shrub encroachment) and homogeneity (exotic annual grass invasion) of soil resources, depending on the plant functional type inducing the change in resource distribution.Climate models predict that many arid regions around the world will become affected more frequently by recurrent droughts and experience warmer conditions. The shrub - invasive - crash state transitions can be thought to be driven by chance events, and because of predicted changes in climate (e.g. precipitation variability) we can expect more chances.