CALIFORNIA FIRE SCIENCE CONSORTIUM

Research Brief for Resource Managers

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Modeling Desert Shrubland Changes with an Invasive Grass Introduction and Climate Change

Yu, K., G.S. Okin, S. Ravi, and P. D'Odorico. 2016. Potential of grass invasions in desert shrublands to create novel ecosystem states under variable climate. Ecohydrology 9:1496-1506. DOI: 10.1002/eco.1742

Management Implications

- Invasive grasses are a huge problem for desert shrublands, changing the community composition and the fire regime.
- Invasive grasses create a frequent, surface fire regime. The introduced regime will eradicate many native desert shrubland species that are not adapted to fire.
- Increased climate change variability will speed the grass-fire, positive feedback cycle, leading to an un-vegetated, resource-poor scabland state, a collapsed ecosystem.

As is true for many ecosystems globally, invasive grasses are changing desert shrublands. Invasive grasses do this by altering the local community composition and interspecies competition dynamics of the ecosystem, as well as by making communities more flammable. For desert shrubland species that have evolved without fire, the introduction of a grass-fire, positive feedback cycle is particularly problematic.

In this paper (Yu et al. 2016), the researchers modeled exactly how problematic the grass-fire cycle could be for non-fire-adapted desert shrublands under three sets of climate conditions. Specifically, three different degrees of inter-annual precipitation variability (i.e., none, medium, and extreme climate change variability; sigma = 0 to 0.8) and related invasive grass cover biomass was modeled to theoretically induce land degradation.

The results showed that depending on the climate change variability level, vegetation transition would lead to one of three stable states: a new *grassland steady-state* with low climate variation (Fig.1-**III**), a new *shrubland steady-state* with intermediate climate variation (Fig.1-**I**), or a novel *scabland state* with extreme climate variation (Fig.1-**IV**). The intermediate transition state of grasses and shrubs together was considered unstable (i.e., transitional) because of the introduced fire pressure dynamics (Fig.1-**II**). Soil resource availability and biomass were projected to parallel shrub biomass with intermediate to high levels of climate

variability. The decrease in overall biomass parallels the decrease in soil resources.

This process-based model structure explored the interplay among grass, shrub, climate, and soil availability dynamics by calculating the probabilities for reaching one of the three steady states (i.e., Grass, Shrub, or Bare Soil) within 3000 time steps. Using the native shrub state as the initial state, and introducing a one-time grass invasion toward the beginning of each simulation (i.e., at step 250), 1000 iterations were run for each level of climate variability and for different random values of grass and shrub carrying capacities.

The model assumed: (i) shrubs and grasses are in competition for the same soil and water resources; (ii) in absence of fire and climate fluctuation, shrubs are more competitive than grasses; and (iii) fires are a source of disturbance for this non-fire-adapted, desert shrub population.

Overall, this modelling effort demonstrates how the combination of grass invasion, fire dynamics, erosion, and drought can convert desert shrublands either to exotic grassland or to novel scabland states.

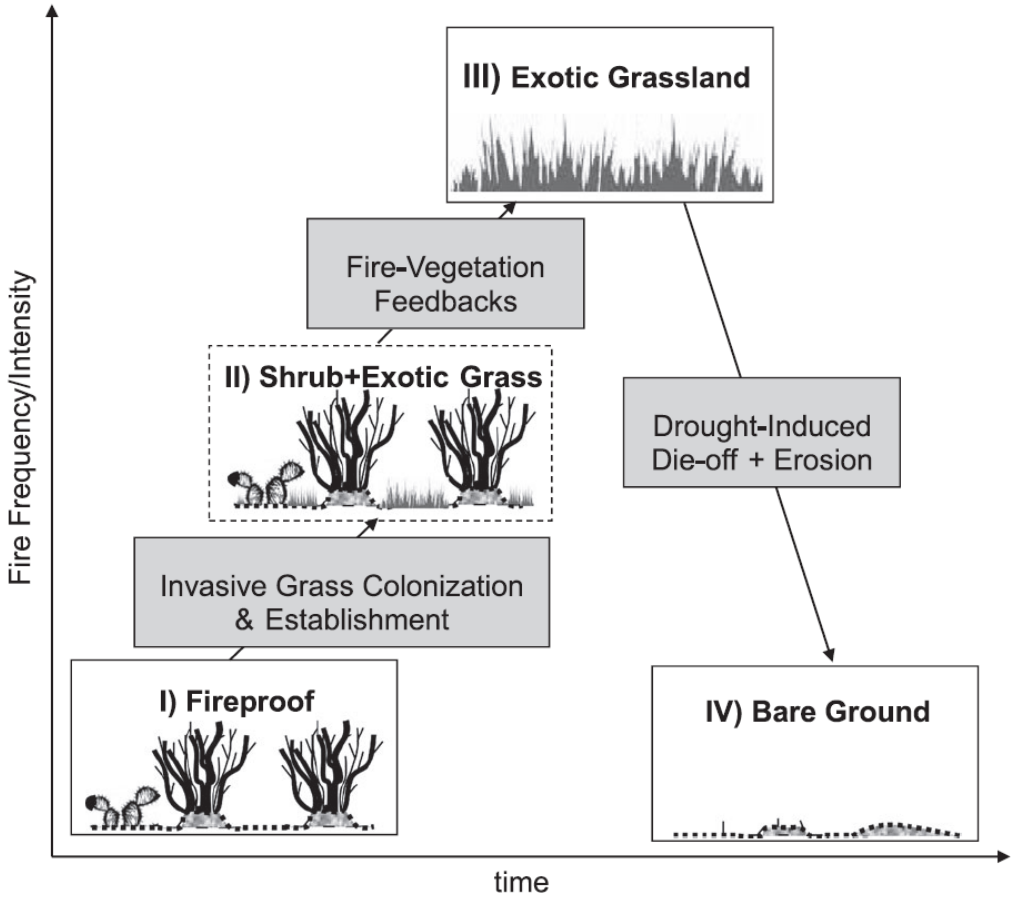

Figure 1. A conceptual representation of the possible four stages of vegetation transition in desert scrublands affected by grass invasions.