Grassland-shrubland state transitions in arid rangelands: competition matters

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INTRODUCTION

• Desertification in arid rangelands is often synonymous with transitions from grassland states to degraded states dominated by shrubs and bare soil.
• Traditional desertification models emphasize abiotic feedbacks that modify the physical environment to promote shrub proliferation and impede grass survival. These models assume biotic interactions (competition, facilitation) have little bearing on state transition dynamics.
• We hypothesized that biotic interactions could modify rates and dynamics of state change. We tested this hypothesis along a Bouteloua eriopoda grassland to Prosopis glandulosa shrubland transition on the Jornada Experimental Range in the northern Chihuahuan Desert (Fig. 1).

METHOD: Selective Removal (SR) Experiments

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Focal Plant</th>
<th>Neighbor</th>
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<tbody>
<tr>
<td>SR1</td>
<td>Grass</td>
<td>Shrub</td>
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<tr>
<td>SR2</td>
<td>Shrub</td>
<td>Grass</td>
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<tr>
<td>SR3</td>
<td>Shrub</td>
<td>Shrub</td>
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SR1: Shrub within 5 m of focal grass patches were left intact (controls) or killed with foliar herbicide.
SR2: Focal shrubs had their immediate (3x canopy diameter) grass neighborhoods left intact or neutralized.
SR3: Shrubs within 5 m of a conspecific focal individual were left intact or killed.

Focal plant aboveground ANPP was estimated at peak biomass (Sep-Oct) by harvesting in SR1, or via allometric equations in SR2 and SR3.

RESULTS AND CONCLUSIONS

Grasses responded positively to shrub removal in all years (Fig. 3A). ANPP differences (control v. treatment) were greater following consecutive years of high PPT (Fig. 2).

Conclusion: Biotic interference by shrubs on grasses can reinforce and magnify abiotic feedbacks during grassland-shrubland transitions.

Small shrub (< 50 cm diam.) ANPP responded positively to grass removal in years with above-average PPT, a result not evident in larger shrubs (> 50 cm diam.) or in dry years (Fig. 3B).

Conclusion: Grasses can slow rates at which shrubs attain the size needed to modify the physical environment in self-promoting ways.

Shrub ANPP response to conspecific neighbor removal was comparable, regardless of shrub size or PPT (Fig. 3C).

Conclusion: Maximum shrub cover is constrained primarily by abiotic variables rather than shrub-shrub competition.

MANAGEMENT IMPLICATIONS

• Grassland and shrubland states represent alternative basins of attraction in arid rangelands, with shrubland more resistant to change than grassland (Fig. 4).
• The competitive influence of shrubs on grasses (Fig. 3A) helps explain observations of shrub encroachment into arid grasslands where grazing pressure has been reduced and/or in the absence of disturbances such as fire. This interaction promotes the shrubland state.
• The competitive suppression of small shrubs by grasses (Fig. 3B) lengthens the time frame during which brush management may be an effective strategy for maintaining a grassland state. Reductions in grass biomass (e.g. by drought or grazing) would ostensibly hasten grassland-shrubland state transition and shorten this window.
• Contrary to expectations, interference between shrubs appears to not influence rates of grassland-shrubland state transition (Fig. 3C). Rather, shrub density and cover may be constrained by physiological limitations and abiotic constraints imposed by resource (e.g. soil water) availability.

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