Interspecific facilitation and critical transitions in arid ecosystems

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Abstract

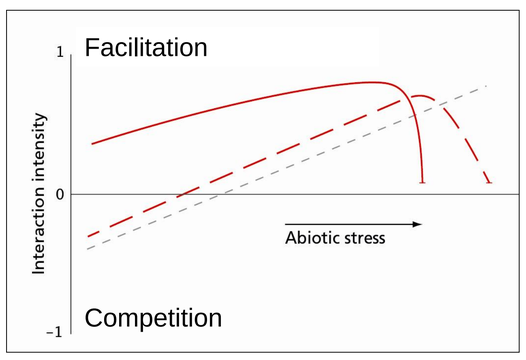
Climate change and intensified land-use may result in rapid and irreversible degradation of arid ecosystems. To prevent such critical transitions it is crucial to detect early warning signals. Increased 'patchiness' – smaller and fewer vegetated patches – is thought to be such a signal. Facilitation between plants is known to be an important mechanism driving the patchiness of the vegetation, but we lack understanding of how interactions between plants change in response to combined effects of drought and consumer pressure. Most recent synthesis predicts a decline in facilitation intensity at the high end of a drought stress gradient. We hypothesize that adding consumer pressure may result in even earlier and faster declines in facilitation intensity. So far, studies on critical transitions and plant-plant interactions have developed separately. Here, we show how the relation between stress and facilitation intensity could be incorporated into the critical transition framework, to improve our ability to predict critical transitions.[1] Moreover we present first results from two fieldwork studies in SE Spain aimed at investigating plant-plant interactions under high drought stress and grazing pressure.

Shape of the Stress Gradient Hypothesis

Plants may facilitate neighbours by for example shading, increasing nutrients or protecting against herbivores.

Facilitation intensity is the net effect of total facilitative and competitive interactions between plants and may change with stress.

- Shading
- More nutrients/infilltration
- Protection against herbivores
- Root competition



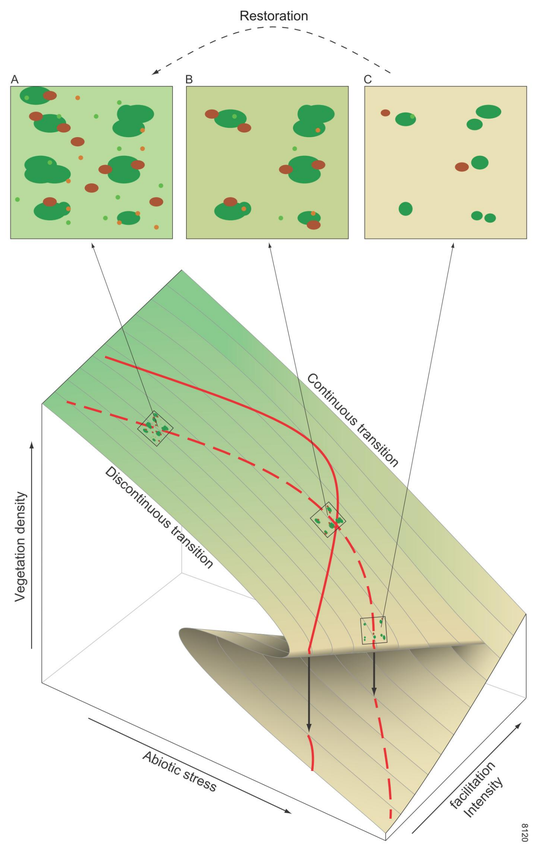
Stress Gradient Hypothesis(2): Increase in facilitation intensity with higher abiotic stress **(grey dotted line)**

Revised SGH arid ecosystems(3) Increase in facilitation intensity with higher stress, but at extreme stress facilitation intensity wanes. **(red dotted line)**

Key knowledge gap: How do plant-plant interactions change when both water stress and herbivory act simultaneously?

Hypothesis: decline in facilitation strength at the high end of an abiotic stress gradient will be earlier and faster when herbivory is considered (1, red solid line).

Plant interactions and critical transitions



This conceptual model[1] aims at integrating the relation between stress and facilitation intensity into the critical transition framework.

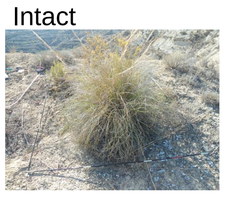
- Facilitation intensity may determine position of critical transition treshold[4]
- Declines in facilitation intensity with increasing stress may speed up degradation.
- Field observations on facilitator recruitment and spatial association strength may serve as additional warning signs (panel A, B, C).

Removal experiment

Study site: Murcia precipitation: 301 mm/y; goat and rabbit grazing.

Design: At 6 hills (3 goat grazed/ 3 ungrazed) 30 saplings of *Anthyllis cytisoides* were selected in three microsites: intact *Stipa tenacissima* patch, bend Stipa patch and open. Survival, growth and microclimate are monitored since April 2012.

Intact



Shading ++
Grazing protect. ++
Root competition -

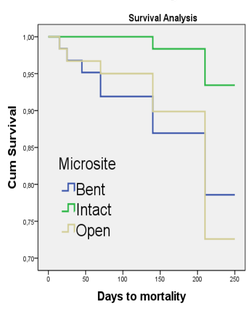
Bend

Shading +
Grazing protect. 0
Root competition -

Open

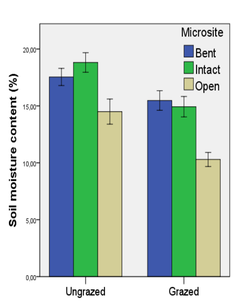
Shading 0
Grazing protect. 0
Root competition 0

Preliminary results



Higher sapling survival in intact stipa patch.

More browsing damage in open and bent treatments

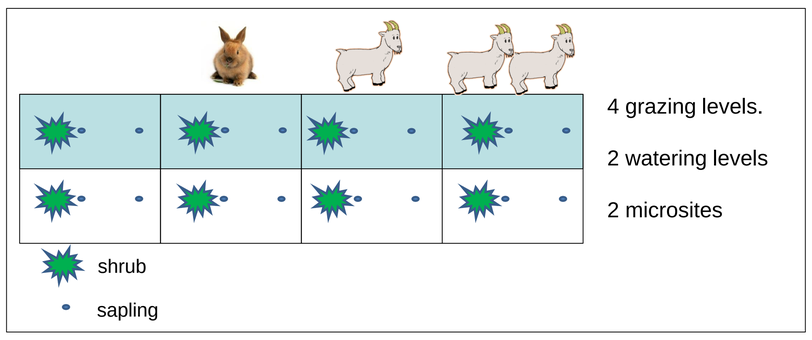


Lower soil moisture in open microsite.

Difference enhanced by grazing

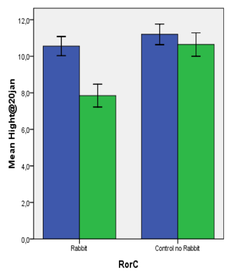
Planting experiment

Design: 1280 *Anthyllis cytisoides* saplings were planted at four fenced terraces. Every fence was divided into four compartments to mimic grazing levels. Saplings were planted with and without protection of an unpalatable shrub *(Artemisia herba-alba)*. Survival, growth and microclimate are monitored from January 2013 onwards.



X 4

Preliminary results



Within two weeks after initiating experiment: differences were found between open (green bar) and shrub (blue bar) microsites. **Higher average sapling height** for saplings **under shrubs.** Also higher survival under shrubs

References:

[1] Verwijmeren, M., *et al.* 2012. Interspecific facilitation and critical transitions in arid ecosystems. - *Oikos*: in press.
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