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Predicting sudden land degradation in response to overgrazing and climate change

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Drylands and human population

Drylands cover about 40% of the land surface, these areas are prone to desertification due to intensified land use and climate change. Degradation of drylands affects both local populations and food security at the local and global scale.

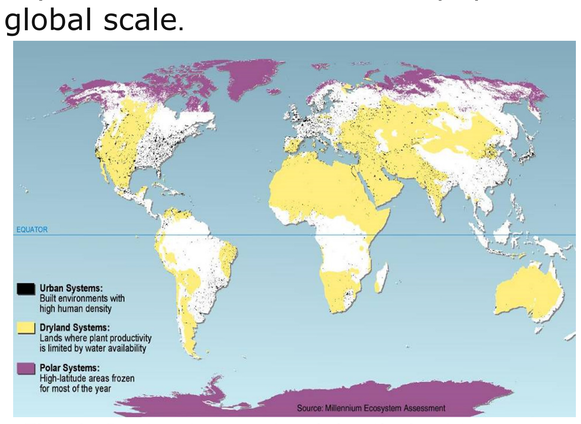
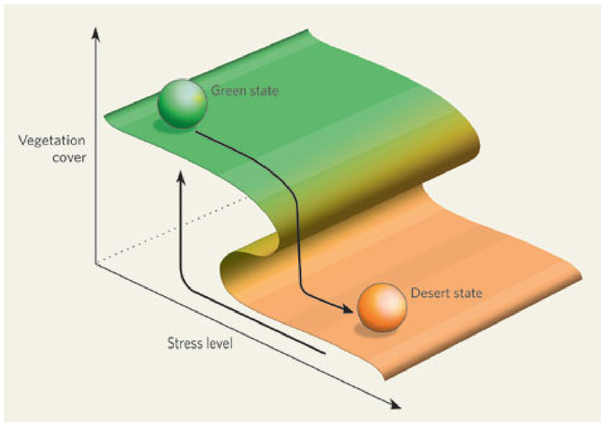


Fig. 1. Drylands: productivity limited by water.

Fig 2. Local land users depending on vegetation

Sustainable use of drylands: avoid sudden degradation

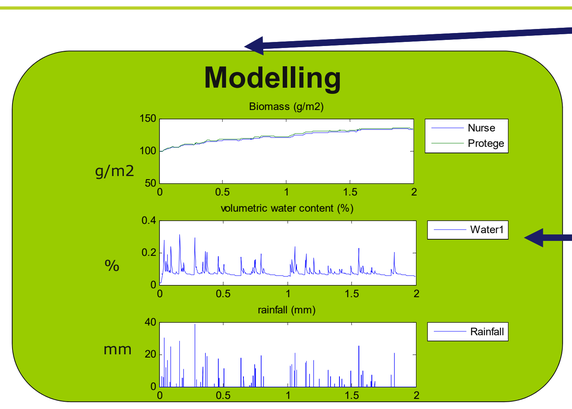


Intensified land-use and climate change may result in rapid and irreversible degradation of arid ecosystems. Positive plant-plant and positive plant-soil interactions are crucial processes in upholding ecosystem stability. We studied these processes in two semi-arid sites to increase understanding about how these processes evolve along environmental gradients.

Fig. 3. Drylands can undergo hard to reverse transitions when positive interactions between plants or between plants and soil are at play.

Integrative approach

We combine and integrate knowledge from field data, modelling and local knowledge. This approach is needed to understand complex sustainability problems.



Research area: South East Spain, Cabezo de la Plata

We performed a planting experiment to assess how plant-plant interactions change when both grazing and aridity stress are at play. Young palatable plants were transplanted under a nurse shrub or sole standing along a combined gradient of drought stress and grazing pressure to investigate how facilitation changes with increased environmental pressure.

Fig. 4. Shrubs or tussock grasses can effectively shelter young plants from being grazed.

Results Spain: plant-plant interaction

We found neutral interations between plants under no grazing, but positive interactions under low goat grazing pressure. Under high grazing pressure positive interactions waned again (Fig 5). This shows that the interactive effects of grazing and drought will act to accelerate degradation of arid ecosystems

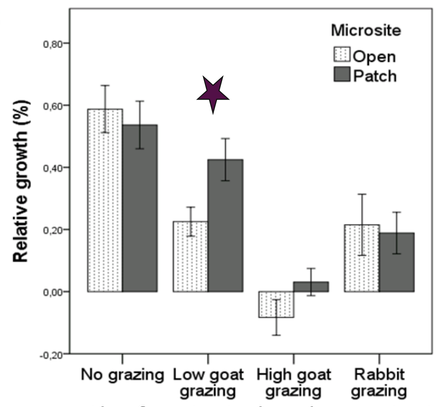


Figure 5: relative growth of protected and unprotected young plants under four different grazing regimes.

Model results plant-plant interactions

We used experimental data on plant growth as an input for a ecoydrological model consisting of three coupled differential equations mimicking soil water content and plant growth of two species. Model results showed that facilitation decreases with an increase in drought but that grazing leads to overal positive interactions along a drought gradient.

Research area: Cyprus, Pissouri

The Pissouri was once extensive pine woodland, but during recent history almost all the pines have been removed. Current land degradation is associated with overgrazing by goats. Here we study the interaction between grazing (fig 6) and both soil erosion and plant water stress (fig 7).

Fig. 6. goat farm in Pissouri

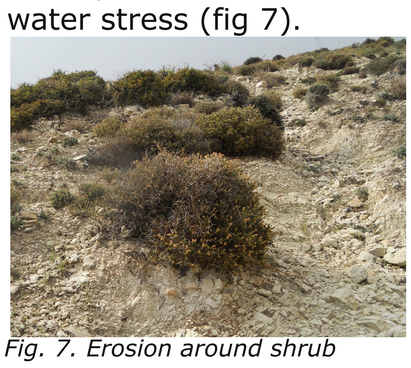


Fig. 7. Erosion around shrub

Results Cyprus: plant soil interactions

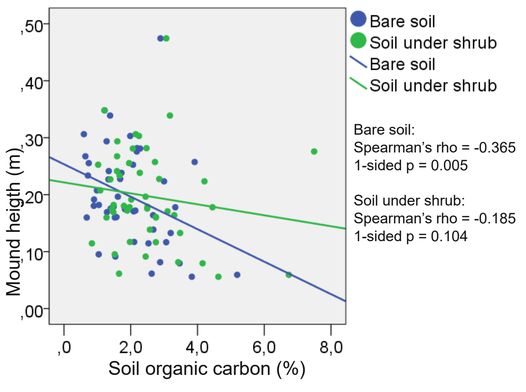


Fig 8. Mounds under shrubs decreases when the surrounding soil is more fertile

Preliminary results indicate that mound height under shrubs increases when organic carbon of the soil surrounding the shrub decreases (Fig 8), and water stress increases. This suggests that the fertility of the bare soil surrounding shrubs is a better early warning signal for degradation compared to the fertility of the soil under the shrubs.