Plant functional response to desertification in semi-arid Mediterranean woodlands

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Introduction

•**Desertification and land-degradation** are increasingly affecting drylands, seriously compromising critical ecosystem services. Since these areas support over 38% of the human population, there is an urgent need to prevent the crossing of irreversible degradation thresholds. Among them, **semi-arid areas** are the most vulnerable and increased human-pressure together with climatic change scenarios can boost the ongoing DLD process [1].

•Plant **functional diversity** has been acknowledged as a better and more universal predictor of ecosystem productivity and vulnerability than species diversity alone [2], and is thus a **good candidate** to be used **as a DLD indicator**.

Objectives

i. Study **plant functional response** along a DLD gradient and identify shifts in functional patterns;

ii. Develop a **functional ecological indicator** to monitor vulnerable areas where mitigation actions should focus.

Methods

• The study was performed during spring 2012 in a mainly semi-arid area dominated by Holm-oak (*Quercus ilex* L.) open woodlands - *Montado* - in the south of Portugal, under Mediterranean climate (Fig. 1).

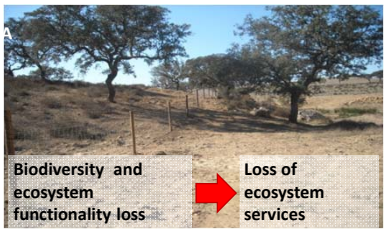


Fig. 1 (A,B). *Montado*, a semi-natural system with a long history of anthropogenic management.

- **34 sampling sites** with similar conditions (land use, altitude, slope, lithology, and soil pH and no fire recently) were selected randomly along a **climatic gradient**, with long-term average precipitation (1950-2000) ranging from 521 to 634 mm.
- The **point–line intercept transect** method was used to survey the herbaceous community (six 20m-transects each with 41 points spaced every 50cm per local).

Fig. 2. Sampling sites (black dots).

Conclusions

• We found **increased plant cover and richness** with increasing **short-term** precipitation (former year), evidencing a limiting effect due to water shortage in the study area.

• At medium to long-term, we found a **shift in the functional composition** of the plant community near 600mm of mean annual precipitation. A higher relative cover of **perennial graminoids and annual N-fixing species** was observed in **wetter sites**, while annual grasses dominated almost exclusively the drier ones. The reduction on the cover of these groups in the drier sites, particularly of N-fixing species, reveals a **functional impoverishment** which limit certain ecosystem processes.

• A variation along the gradient was also found for **continuous traits** (e.g. *T. barbata* specific leaf area), revealing a **non linear pattern** and a shift near the same precipitation threshold.

•We found that **plant functional groups can be used as early warning indicators** of the desertification process.

Future research

•Analyze more sites;

•Explore further the functional response in sites with high shrub cover;

•Analyze other functional traits

Results

•Herbaceous understory was **dominated by annual grasses and forbs**, with few perennial herbaceous and low shrub species. Total plant cover and species richness increased consistently with increasing precipitation in the former winter-spring (Spearman's r=0.61* and r=0.41*, respectively).

Species distribution

The first axis of an NMDS differentiates sites dominated mainly by shrubs (Fig. 3). Sites with a higher shrub cover have also a higher slope (Spearman's r=0.48*), differing in humidity values and runoff. The second axis is correlated with mean annual precipitation (1950-2000). Sites with higher precipitation have higher relative cover of perennial graminoids and annual N-fixing species; sites with low precipitation are mainly composed of annual graminoids and biennials.

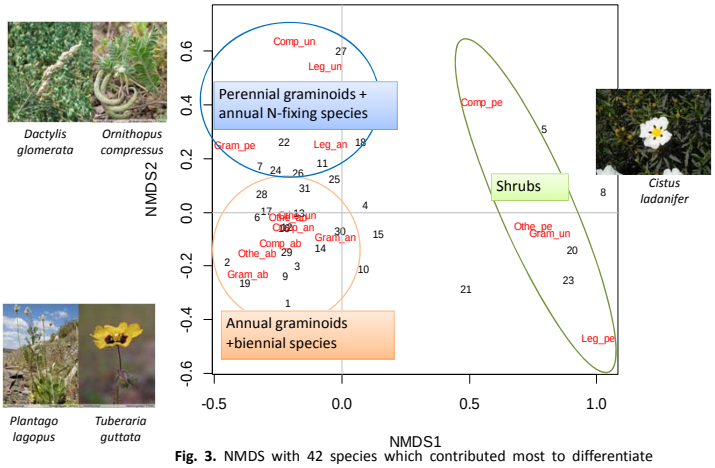
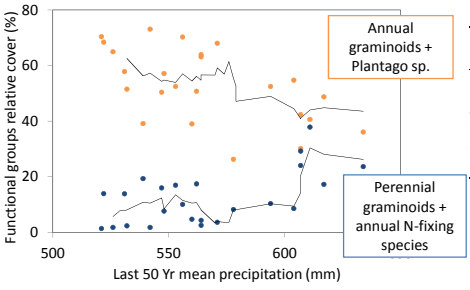


Fig. 3. NMDS with 42 species which contributed most to differentiate sites (up to 80% of average dissimilarities - SIMPER analysis).

Functional groups' shifts

Plant functional composition changes along the desertification gradient: in **drier sites**, plant community is composed almost **exclusively by annual grasses**, while in **wetter sites perennial graminoids and annual N-fixing** species increase their relative cover (Fig. 4).

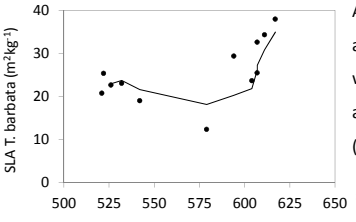


Tab. 1. Spearman correlations

	Mean annual precip. (50 yrs)
Plant cover (%)	0.38*
Number of species	-
Annual graminoids (%)	-
Annual N-fixing (%)	0.44*
Perennial graminoids (%)	0.57*

Fig. 4. Relative cover of functional groups and mean annual precipitation (1950 – 2000).

Functional traits' shifts



A consistent variation along the gradient was also found for *Tolpis barbata* **specific leaf area**, with lower values in the drier sites, approximately below 600 mm of precipitation (Fig. 5).

Fig. 5. *Tolpis barbata* specific leaf area.

[1] Millennium Ecosystem Assessment (2005) Ecosystems and Human Well-Being: Desertification Synthesis (World Resources Institute, Washington, DC).

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[3] Cornelissen, J.H.C., Lavorel, S. *et al.* (2003) Handbook of protocols for standardized and easy measurement of plant functional traits worldwide. Australian Journal of Botany, 51, 335–380.

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