



# Burned and devoured – Or how do introduced herbivores and fire influence the endemic high-elevation flora of La Palma, Canary Islands?

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## Background



Caldera de Taburiente, La Palma

Introduced mammalian herbivores are considered one of the major threats to native island ecosystems and biodiversity. Environmental isolation is exceptionally high in high-elevation ecosystems on oceanic islands, thus, resulting in a high proportion of endemic plant species. As a consequence of the evolutionary history in the absence of mammalian herbivores endemic plant species are considered poorly adapted to herbivory. Here, we present data from an 11-year enclosure experiment in the high-elevation ecosystem of La Palma, Canary Islands, where rabbits and goats have been introduced but do not naturally occur. Our aim is to investigate the effect of herbivory and fire on seedling establishment and species diversity.



Ice covered shrubs after a winter storm

## Methods



Example: enclosure 57

The high-elevation ecosystem of La Palma is found above the thermal inversion layer created by humid NE trade winds and has only an area of approx. 15 km<sup>2</sup>. The system is dominated by endemic shrub and dwarf shrub species. Many species are single island endemics restricted to the small high-elevation ecosystem of La Palma.

The *no herbivory* treatment was installed in 24 fenced enclosures (20x20m) established by the NP Caldera de Taburiente in 2000 (Fig. 1). The enclosures are organized in four aspect transects reaching from 1800 to 2400 m a.s.l.

Four enclosures were damaged in 2005 by a wildfire (*fire* treatment), while in four others rabbits were temporarily present (*rabbit* treatment). Seedling richness and species were recorded. Growth heights of all individuals of the four main shrub species were measured. Next to each enclosure a plot of the same size was affected implementing the same measurements (*full herbivory* treatment). Statistical methods included linear models, mixed effect models and Mann-Whitney-U-Tests.

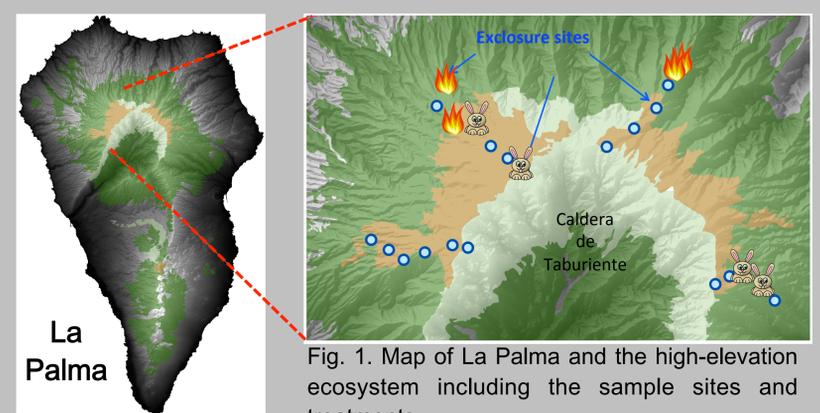


Fig. 1. Map of La Palma and the high-elevation ecosystem including the sample sites and treatments.

## Results & Discussion

The presence of introduced herbivores, also only temporarily, had a significant negative effect on shrub performance and seedling richness, while the opposite was true for post-fire conditions:

**Endangered species** such as *Chamaecytisus proliferus* ssp. *proliferus* or *Genista benehoavensis* seem better adapted to the harsh climatic conditions than *Adenocarpus viscosus* ssp. *viscosus*, a single island endemic shrub species, which is virtually mono-dominant in the high-elevation ecosystem of La Palma (Fig. 2). The presence of introduced herbivores prevents the establishment of other shrub species than *A. viscosus* ssp. *viscosus* resulting in a nearly (global) extinction of several single island endemic plant species.

**Seedling richness is strongly reduced under herbivore presence** (Fig. 3). In combination with the (now abandoned) goat herding the presence of rabbits has likely lead to a vegetation shift in this system. It is assumed that phytochemical defense compounds within dominant species such as *A. viscosus* ssp. *viscosus* or *Bystropogon origanifolius* make them less susceptible to browsing, whereas the endangered species seem to lack comparable compounds (Fig. 4). However, as almost all species are endemic to some degree the selective browsing by introduced herbivores seems independent of endemism.

**Post-fire conditions have a positive effect on seedling richness**, even under full herbivory conditions, compared to non-fire sites (Fig. 3). Evidently, species are well adapted to reoccurring fire events, some even might be considered obligate pyrophytes.

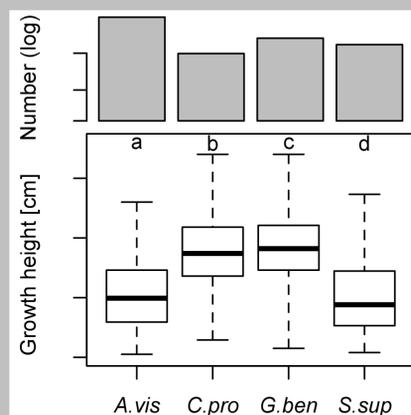


Fig. 2. Mean growth height and frequency of the four major shrub species. Letters indicate significant differences. (from: Irl et al., 2012)

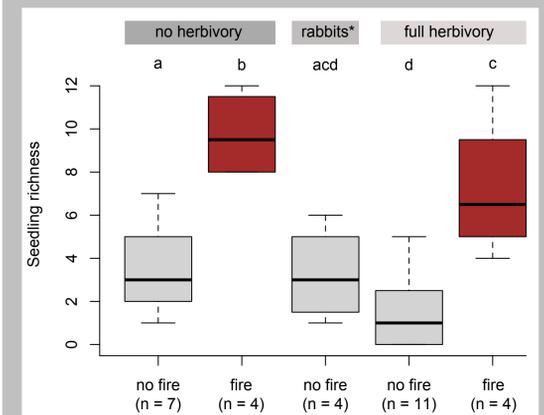


Fig. 3. Seedling richness under varying herbivory treatments (no herbivory, rabbit and full herbivory) and fire. Letters indicate significant differences. (from: Irl et al., submitted)



Fig. 4. Examples of a vital individual of the single island endemic *Genista benehoavensis* inside the enclosure (a) and an individual of the same species unfortunately highly damaged by browsing on the outside (b). (from: Irl et al., submitted)

## Conclusion

Probably, only the total eradication of introduced herbivores will allow the recuperation of the 'natural' vegetation and long-term preservation of endangered endemics often confined to the small area of the high-elevation ecosystem. However, it is still debated what the 'natural' vegetation actually looks like. In addition, eradication programs are cost and labor intensive and rely on the full support of the local population.

1. Irl SDH, Steinbauer MJ, Babel W, Beierkuhnlein C, Blume-Werry G, Messinger J, Palomares Martínez Á, Strohmeier S, Jentsch A (2012) An 11-yr enclosure experiment in a high-elevation island ecosystem: introduced herbivore impact on shrub species richness, seedling recruitment and population dynamics. *Journal of Vegetation Science*.
2. Irl SDH, Steinbauer MJ, Messinger J, Blume-Werry G, Palomares Martínez Á, Beierkuhnlein C, Jentsch A. Burned and devoured – Introduced herbivores, fire and the endemic flora of the high-elevation ecosystem on La Palma, Canary Islands, submitted