

Promoting species diversity: understanding Sweet Chestnut within regeneration of Scots pine stands

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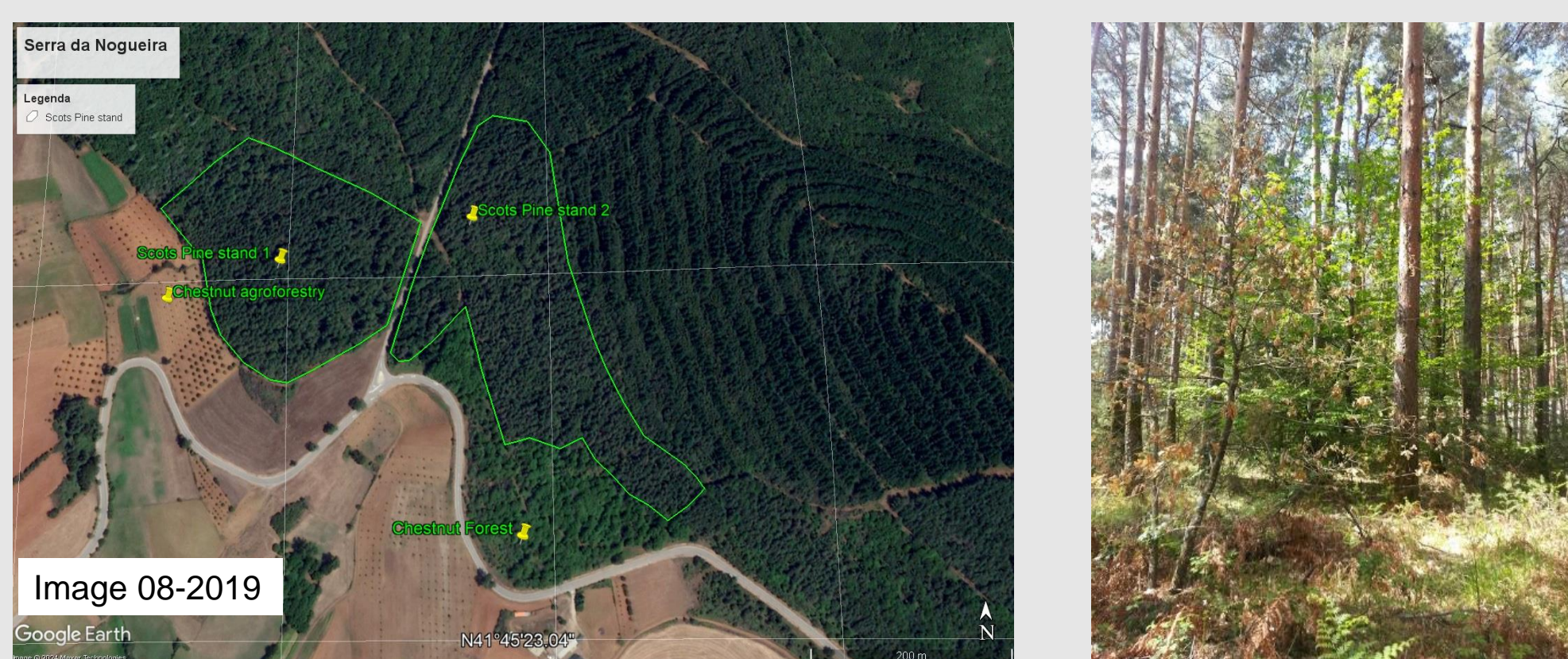
Introduction

Pine forests exhibit a natural gradual transition to mixed plantations, where hardwoods like sweet chestnut (*Castanea sativa* Mill.) and oaks begin to establish as ecological succession progress. However, the persistence of chestnut in conifer stands depends heavily on surrounding chestnut stands and light availability.

In this case-study of Serra da Nogueira, Portugal – a region characterized by a mosaic of habitats formed by mountain agriculture, with extensive Pyrenean oak forests interspersed with some stands of other hardwoods and conifers, including scots pine (*Pinus sylvestris* L.) - chestnut persists in the natural regeneration of these stands largely due to existing forest and agroforestry chestnut stands.

Advanced regeneration in the understory of Scots pine stands suggests that the chestnut can persist in the natural regeneration dynamics, contributing to the formation of more resilient and biodiverse mixed stands.

Location of study area - (41°45'34"N, 6°54'53"W, 980 m a.s.l.)



Plots establishment and data collection (scots pine stands near 65 years old)



Generalized linear models (GLM) and generalized additive models (GAM) were used to explore the influence of potential explanatory variables related to stand structure, crown cover, and degree of shrub cover (SC) on the abundance of chestnut and other species of natural regeneration.

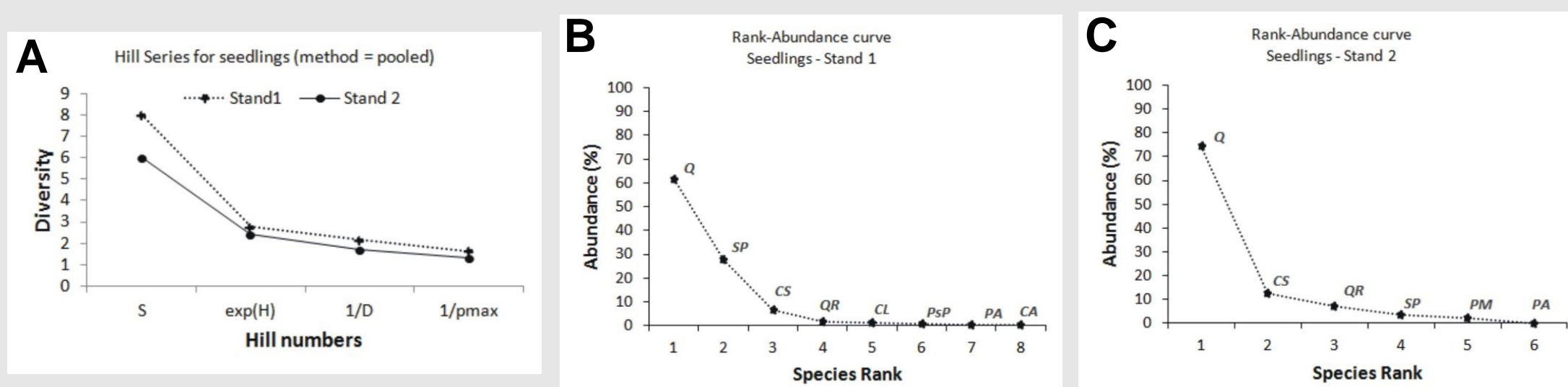
Objectives

- Evaluate the diversity of regeneration within two scots pine stands in Serra da Nogueira, NE Portugal.
- Analyze the abundance and resilience of chestnut throughout different phases of natural regeneration.
- Explore the relationship between the abundance of chestnut and other species that make up natural regeneration with variables such as stand structure, canopy cover, and shrub cover.

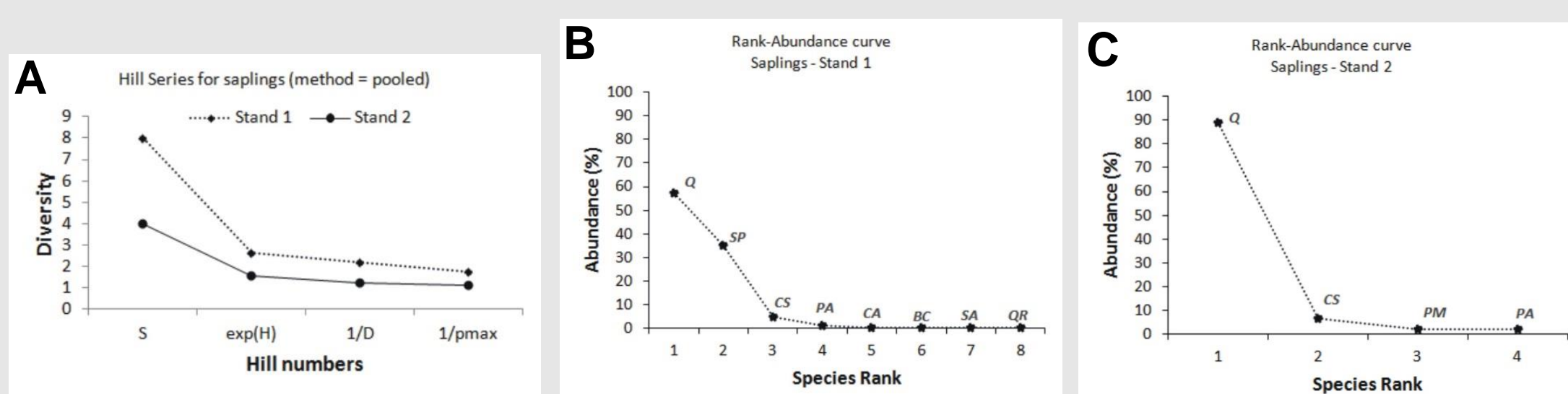
Methodology:

- Systematic sampling using circular concentric plots.
- Natural regeneration ($d < 10$ cm):
 - Two strata:
 - ✓ height ≤ 2 m;
 - ✓ height > 2 m;
 - Concentric circular plots:
 - ✓ Seedlings: 100 m²;
 - ✓ Saplings: 200 m²;
- Abundance and diversity indices:
 - ✓ Modified Shannon and Simpson indices;
 - ✓ Inverse Berger-Parker index;
 - ✓ Species richness.

Seedlings strata ($d < 10$ cm, $h < 2$ m)



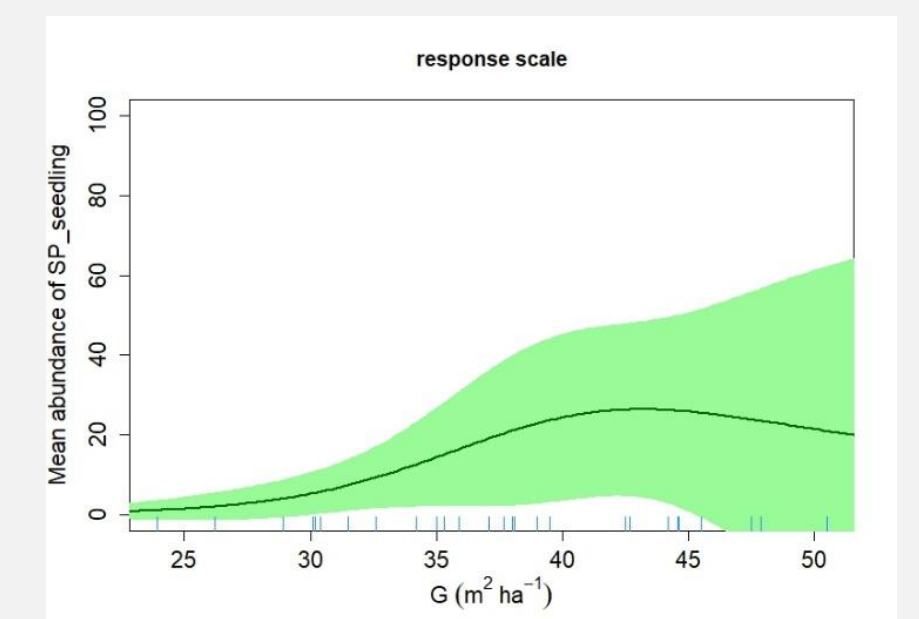
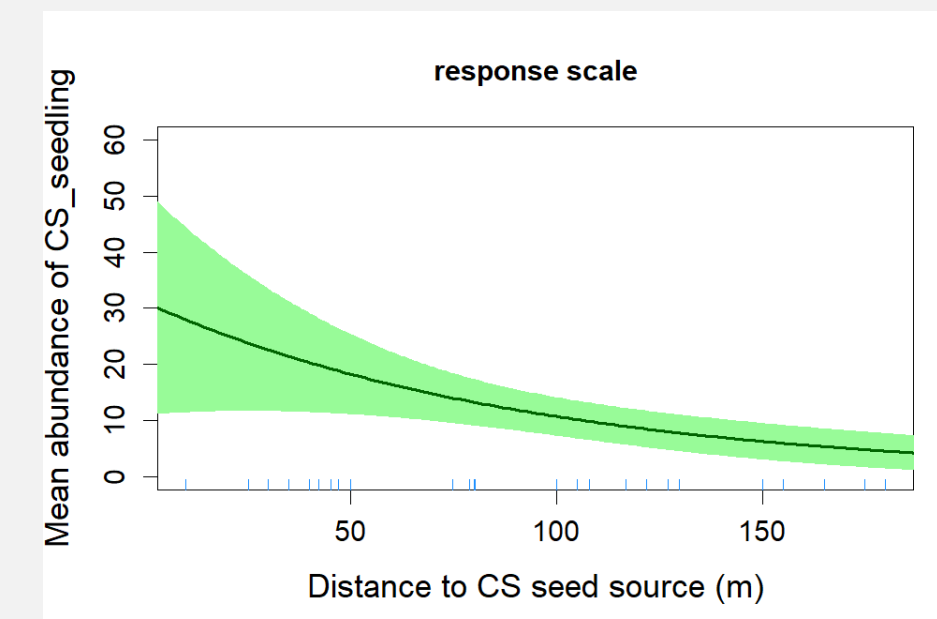
Saplings strata ($d < 10$ cm, $h > 2$ m)



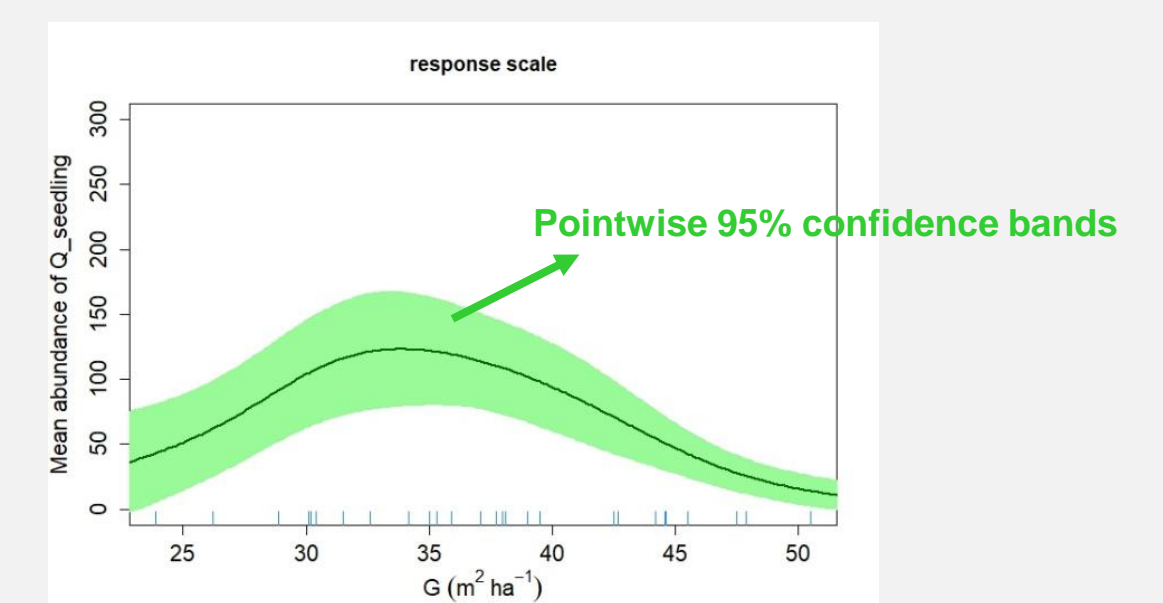
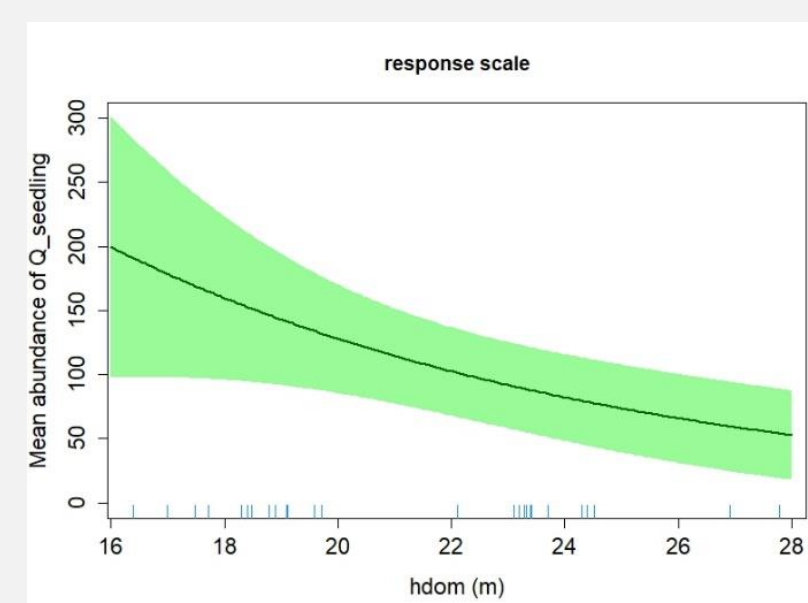
A: numbers of Hill series (S – species richness, exp(H) – modified Shannon index, 1/D – modified Simpson index, 1/pmax – reciprocal of Berger-Parker index). **B** and **C:** Rank-Abundance curves in stands 1 and 2, respectively (Q – Pyrenean oak, SP – scots pine, CS – chestnut, QR – holm oak, CL – cypress, PsP – blackthorn, PA – cherry, CA – cedar).

Results:

- Chestnut (CS) - seedlings
- Scots pine (SP) - seedlings



- Pyrenean oak (Q) - seedlings



GAM negative binomial with linear effect of dominant height and nonlinear effect of basal area (*deviance explained* = 59%)

- ✓ Chestnut regeneration within Scots pine stands reflects the positive net flow of chestnut from adjacent stands. **Distance to chestnut seed sources negatively affects the average number of chestnut seedlings.**
- ✓ Seedling regeneration is relatively abundant. However, the number of individuals that progress to the sapling stratum is considerably reduced.
- ✓ **Chestnut is the second most common species observed in regeneration, and sometimes the third, in both seedlings and saplings.**
- ✓ Basal area (G) significantly affects the abundance of natural regeneration. Basal areas around 40 m² ha⁻¹ favor Scots pine regeneration, while basal areas of 30-35 m² ha⁻¹ favor Pyrenean oak regeneration. **No specific relationship was found for chestnut.**
- ✓ **Developed shrub cover in gaps prevents chestnut regeneration.**
- ✓ **To achieve more biodiverse stands with the inclusion of hardwoods such as chestnut and oak, shrub cover and basal area must be managed appropriately.**

- Close monitoring of chestnut and other broadleaf species in Scots pine stands is crucial for optimizing management. Their native status and ability to enrich ecosystems ensure future biodiversity and resilience.

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