

# Gestão do subcoberto no montado: impactos na árvore e na cortiça.

▶ Resultados de um caso estudo com 12 anos  
(+ 6 anos)

- ▶ Sónia Pacheco Faias,
- ▶ Paulo Firmino,
- ▶ Joana Amaral Paulo,
- ▶ Margarida Tomé



# Questões abordadas

- ▶ Considerando duas práticas comuns de gestão do subcoberto :
  - ▶ Será similar o incremento em diâmetro na madeira/cortiça?
  - ▶ Qual a interação entre a idade de crescimento da cortiça e o momento de aplicação destas práticas de gestão?
- ▶ Qual o impacto da vegetação espontânea no incremento anual da cortiça?



# Ensaio experimental

Estabelecido em 2003 e monitorizado durante 12 anos (até 2015).

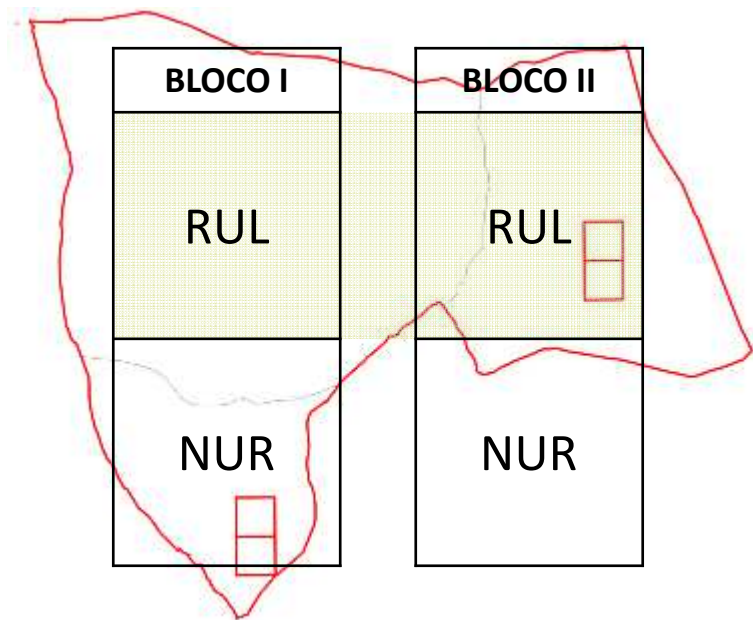
- Povoamento irregular com densidade média: 132 arv/ha
- 2 blocos casualizados, 2 parcelas por bloco, cada com 2 ha e 20 m bordadura
- Vegetação arbustiva dominada por *Cistus salvifolius*, *Lavandula pedunculata*, *Ulex aircensis*
- Gestão tradicional com remoção periódica do subcoberto
- Solos: Podzol, textura arenosa

## ***RUL – Remoção do subcoberto com tremocilha***

Remoção da vegetação no subcoberto com incorporação da matéria orgânica no solo, seguida de sementeira de tremocilha (2003, 2007, 2009)

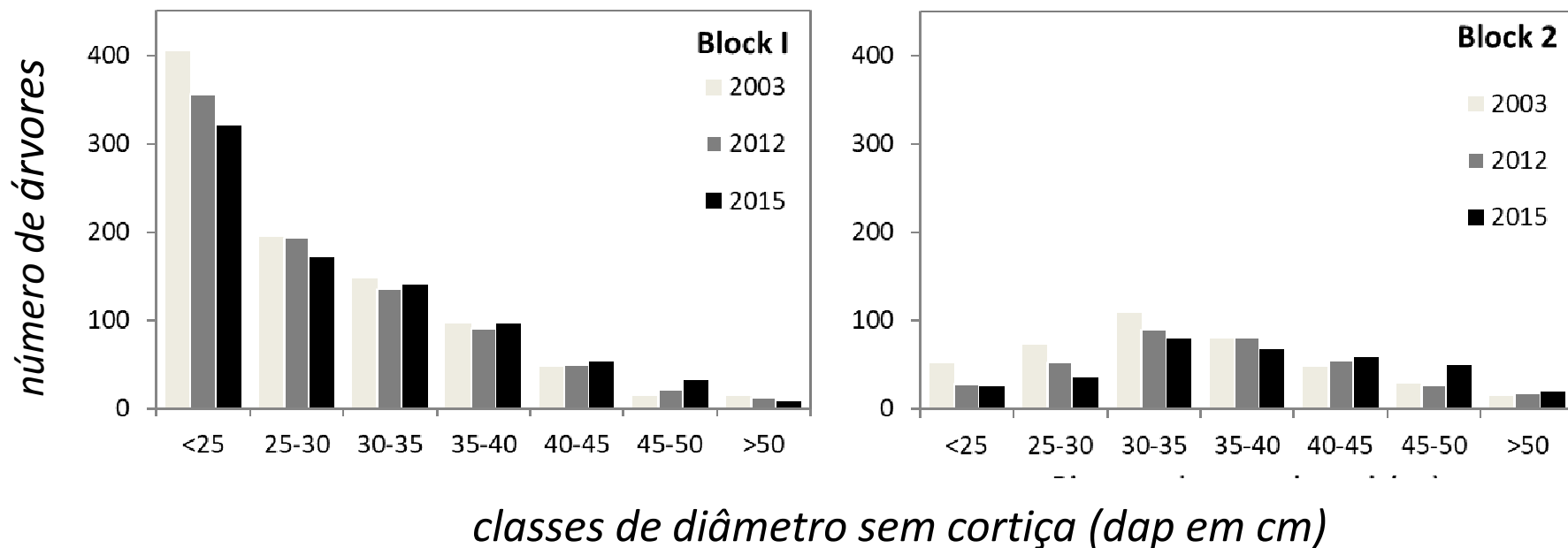
## ***NUR – Manutenção da vegetação espontânea***

durante um período de 9 anos (2003 - 2012)



# Estrutura do povoamento

## Evolução da densidade do povoamento por bloco

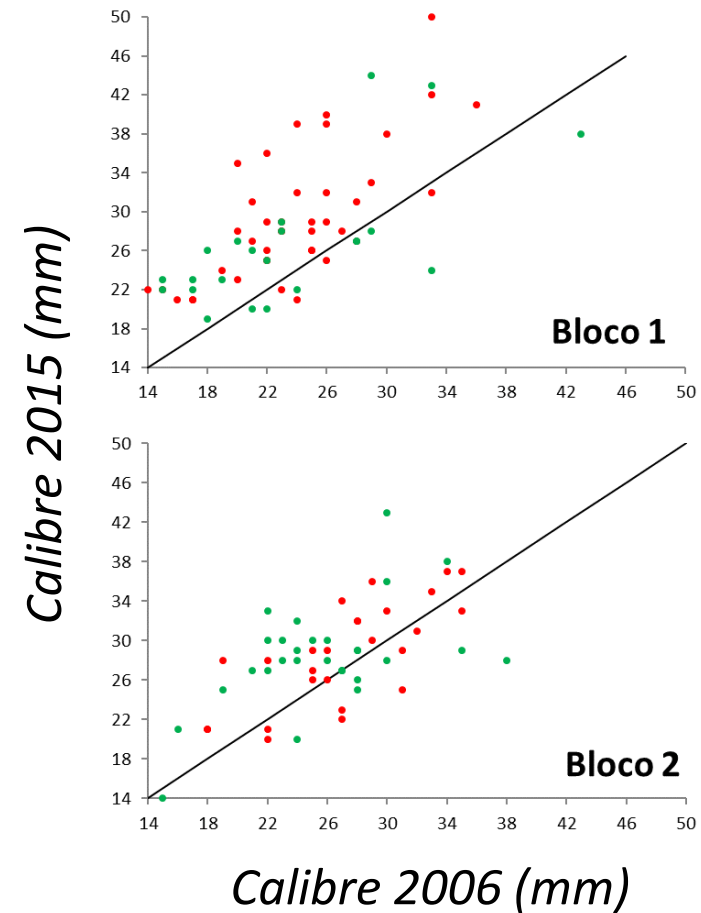
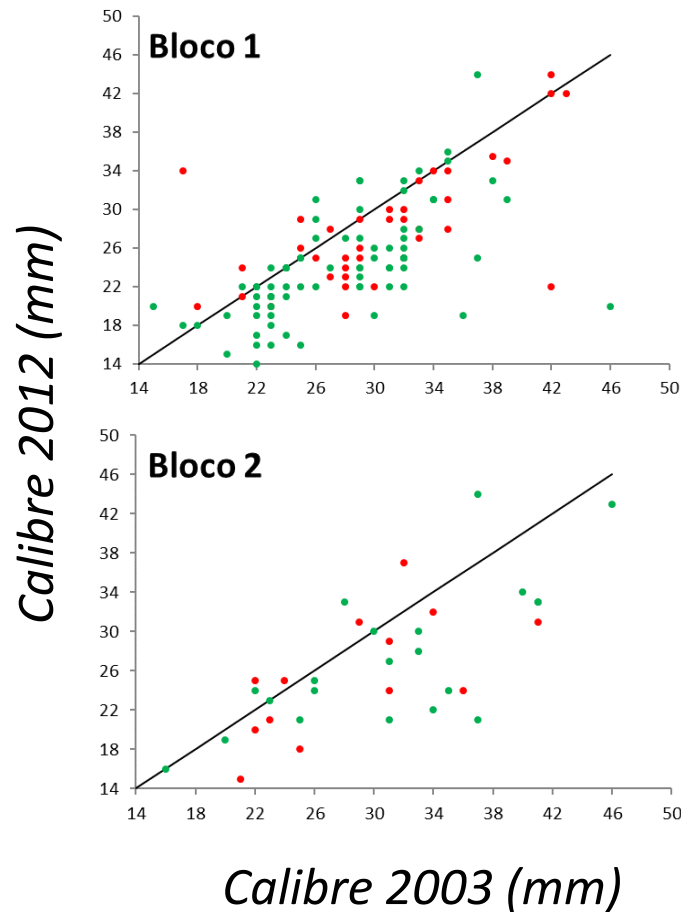


# Amostras de cortiça: 4 descortiçamentos

12345678										12345678									
RUL	<div>19951996199719981999200020012002</div> <div><math>n = 18</math></div> <div>19981999200020012002200320042005</div> <div><math>n = 27</math></div> <div>20042005200620072008200920102011</div> <div><math>n = 26</math></div> <div>20072008200920102011201220132014</div> <div><math>n = 29</math></div>								2003 2006 2012 2015		<div>19951996199719981999200020012002</div> <div><math>n = 24</math></div> <div>19981999200020012002200320042005</div> <div><math>n = 29</math></div> <div>20042005200620072008200920102011</div> <div><math>n = 23</math></div> <div>20072008200920102011201220132014</div> <div><math>n = 27</math></div>								RUL
NUR	<div>19951996199719981999200020012002</div> <div><math>n = 38</math></div> <div>19981999200020012002200320042005</div> <div><math>n = 15</math></div> <div>20042005200620072008200920102011</div> <div><math>n = 43</math></div> <div>20072008200920102011201220132014</div> <div><math>n = 18</math></div>								2003 2006 2012 2015		<div>19951996199719981999200020012002</div> <div><math>n = 16</math></div> <div>19981999200020012002200320042005</div> <div><math>n = 27</math></div> <div>20042005200620072008200920102011</div> <div><math>n = 22</math></div> <div>20072008200920102011201220132014</div> <div><math>n = 27</math></div>								NUR
Bloco I										Bloco II									

**RUL** – Remoção do subcoberto com tremocilha ; **NUR** – Manutenção da vegetação espontânea

# Calibre das amostras de cortiça

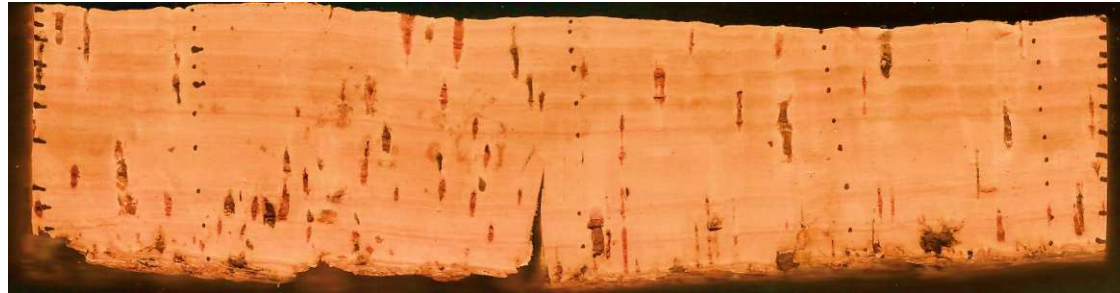


• Tremocilha

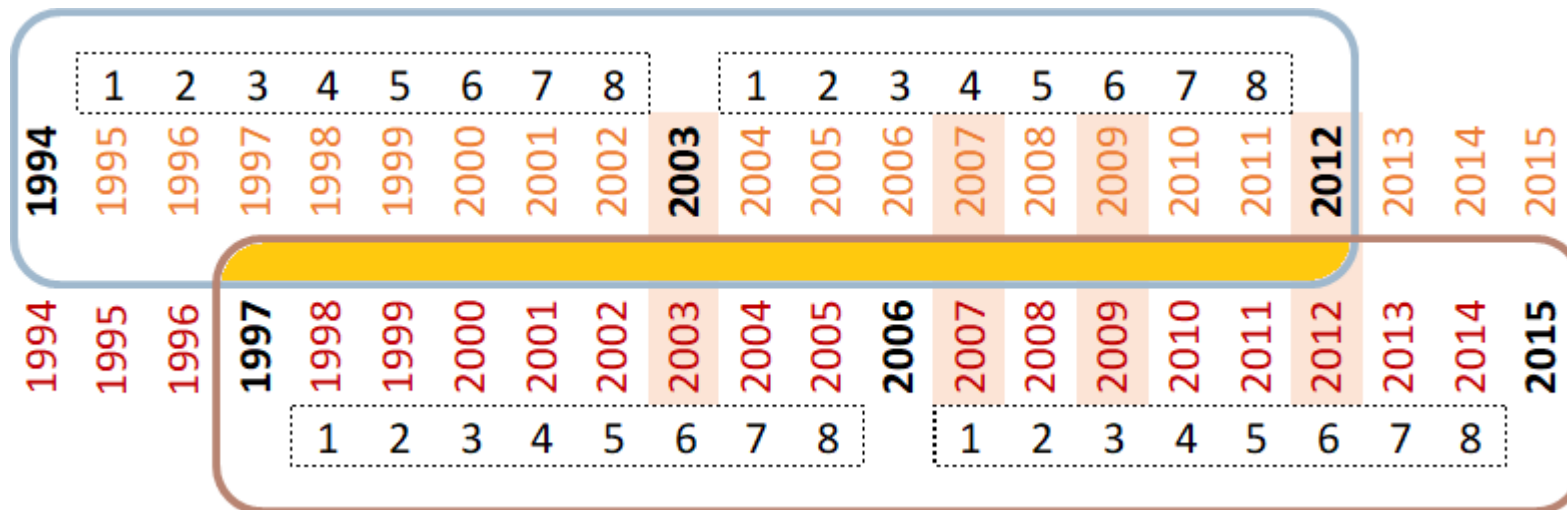
• Testemunha

# Medição de anéis de crescimento

8 Anéis de crescimento

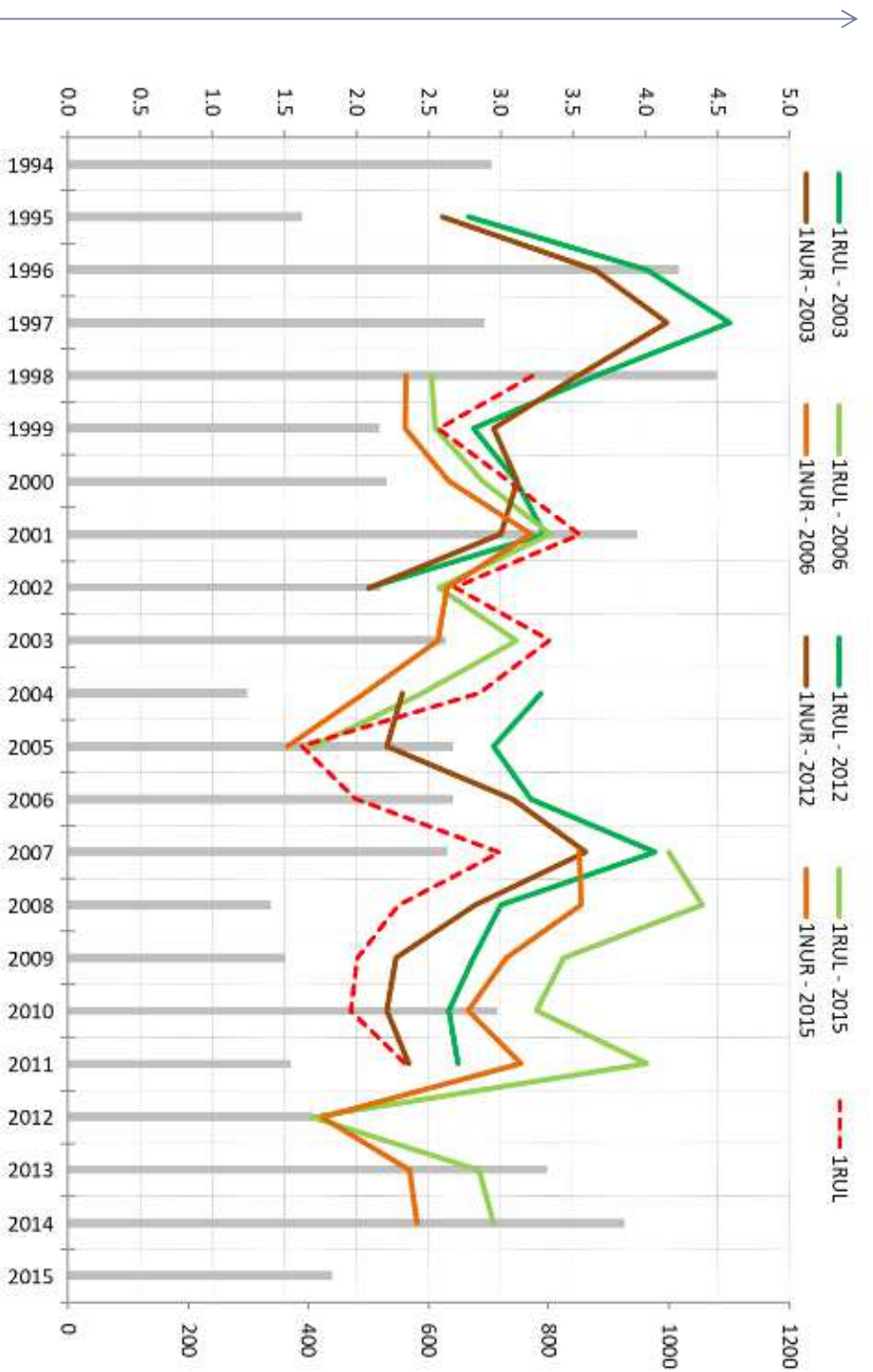


2 períodos de descortiçamento



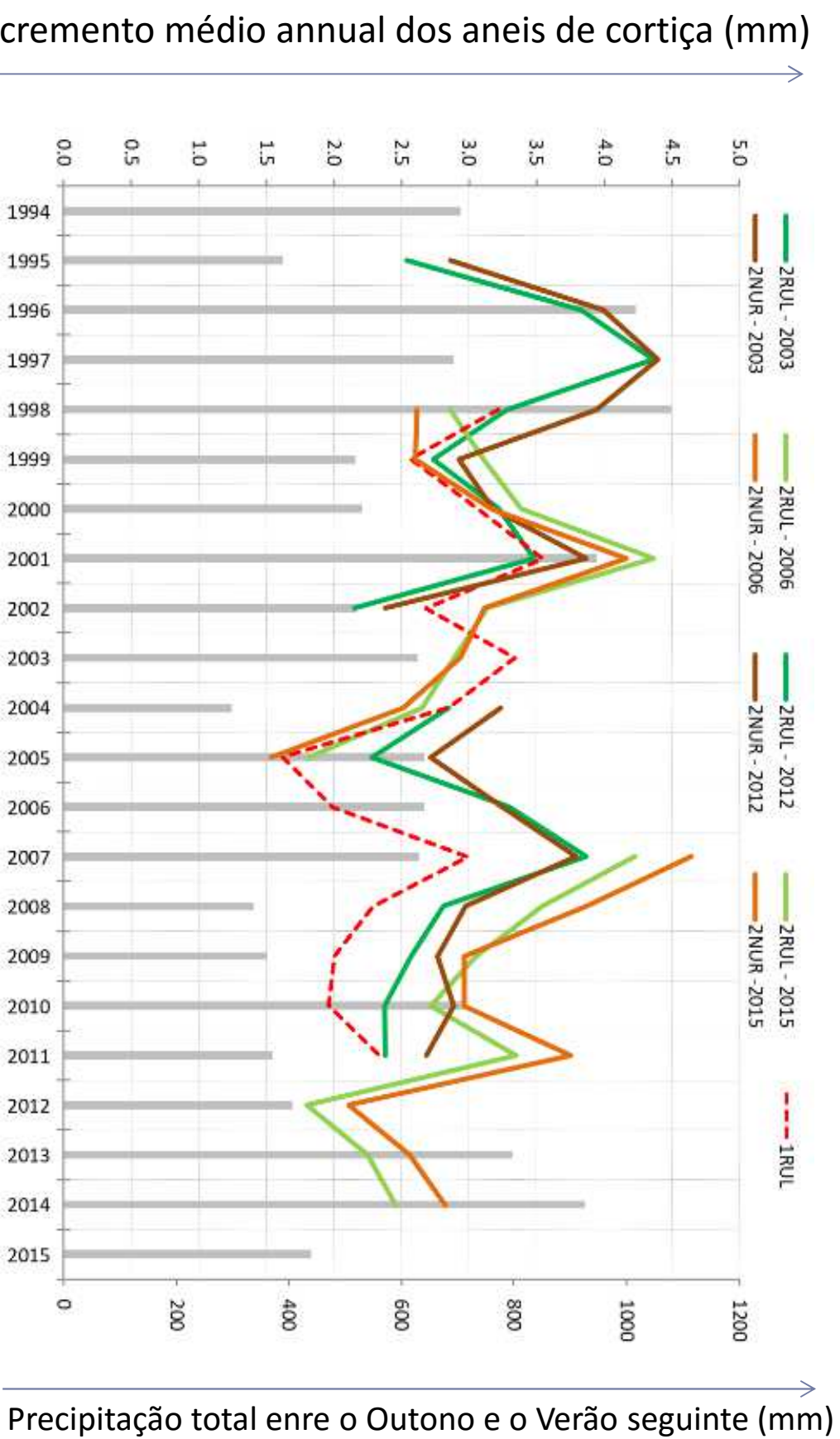


# Anéis de crescimento em cortiça – bloco I





# Anéis de crescimento em cortiça – bloco II



# Métodos aplicados

- ▶ Teste não-paramétrico : Krushal-Wallis
- ▶ Modelo linear misto:
  - ▶ índices de competição dependentes da distância (CI)
  - ▶ variáveis que caracterizam a gestão do subcoberto (Tr)



$$rw_{ijt} = (\mu_{0j} + \beta_0) + \beta_1 tc_{ijt} + \beta_2 Pr_t + \beta_3 CI_{ij} + \beta_4 Tr_{jt} + \beta_5(tc_{ijt} \times Tr_{jt}) + \varepsilon_{ijt}$$

**tc** idade do anel de cortiça (anos); **Pr** precipitação anual (mm)  
**i** índice da árvore ; **j** índice da parcela; **t** índice da idade do anel (anos)

# Estudos publicados



RESEARCH ARTICLE

## Understory effect on tree and cork growth in cork oak woodlands

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### Abstract

**Aim of study:** Cork oak is one of the main forest tree species in Portugal that typically occurs in *montado*, where operational practices oriented to the tree, crop or animal management may influence several of the ecosystem components. This study aimed at contributing to fulfil the lack of knowledge on the effect of those practices on the cork and wood growth, by comparing the wood diameter growth and the annual cork increment under two different understory management options.

**Material and methods:** An experimental trial implemented on an uneven-aged cork oak pure stand during a cork rotation period of 9 years, was established with the specific goal of comparing understory management options: a yellow lupine pasture versus spontaneous vegetation. Cork samples were taken at the beginning and end of the period and were used to measure cork thickness and annual cork rings. The differences between treatments were assessed performing a non-parametric test and a more robust approach using linear mixed model. Precipitation and treatment levels were jointly considered on the analysis.

**Main results:** A slight effect was found on the cork thickness regarding the treatment with lupine application. However, no distinct effect was found, regarding wood and the annual cork increment pattern. Additionally, annual cork ring width showed a positive correlation with precipitation and a negative correlation with ring age.

**Research highlights:** The results of this study indicate no distinct pattern regarding the annual cork and wood increment when comparing the understory effect of yellow lupine pasture versus spontaneous vegetation.

**Additional keywords:** *Quercus suber*, cork thickness, cork ring, lupine, shrubs, linear mixed model.

**Abbreviations used:** AIC (Akaike information criterion); Co (crown cover percentage); da (diameter at breast height under cork); dkg (quadratic diameter at breast height under cork); diu (wood diameter increment); KW (Kruskal-Wallis); M (percentage of dead trees); MSE (mean square error); N (number of trees per hectare); NUR (no understory removal); OM (organic matter); RUL (understory removal with lupine seeding); rw (annual cork ring width).

**Authors' contributions:** Conceptualization, design and implementation of the trial: MT and JAP. Data collection and analysis: SPF and JAP. Drafting of the paper: SPF and JAP. Revision of the intellectual content: MT and JHNP. All authors read and approved the final manuscript.

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**Competing interests:** The authors have declared that no competing interests exist.

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Article

## Drivers for Annual Cork Growth under Two Understory Management Alternatives on a Podzolic Cork Oak Stand

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**Abstract:** Understory management practices and stand density characteristics allow one to distinguish a cork oak traditional silvopastoral system (known as a *montado*) from a cork oak forest system. Although understanding the manner in which different management practices affect cork growth is imperative, there are still only a few outputs from experimental research that contribute to this knowledge. The effect of potential drivers on annual cork growth was analyzed using a linear mixed model approach. Two dimensions of drivers were considered: intraspecific competition, assessed by tree level distance-dependent indices; and interspecific competition, assessed by variables characterizing understory management. The present dataset was collected from an experimental trial established on a cork oak stand in Podzolic soil on the Tagus river basin, covering two different cork growth cycles over the period from 2003 to 2015. The adjusted models considered two understory management alternatives: spontaneous shrubs maintenance and forage application. In both models, annual precipitation displayed a positive effect on annual cork growth, as expected. However, no significant effect of intraspecific competition was found. Additionally, there was a positive effect on annual cork growth associated with the spontaneous shrubs growth and a negative effect associated with lupine presence; both effects linked to different cork ring ages' thresholds. The study main contributions are the following: (i) the introduction of the interaction between cork growth cycle stage and understory management practices, only possible with cork sample collections from different cork rotation cycles; (ii) the finding that there was no significant effect of intraspecific competition on cork growth.

**Keywords:** *Quercus suber* L.; *montado*; distance-dependent competition index; cork ring; shrubs; lupine

# Contribuições gerais

- ▶ Foi confirmada a presença de correlação positiva da precipitação e a correlação negativa do ano de crescimento da cortiça.
- ▶ Não foi encontrado um efeito da competição intraespecífica no crescimento anual da cortiça.
- ▶ Não foi encontrado um padrão distinto entre tratamentos no crescimento anual da cortiça e no crescimento radial da madeira, ao longo de um período de descortiçamento de 9 anos.
- ▶ Foi encontrado um efeito positivo no crescimento anual da cortiça associado a um período de manutenção da vegetação arbustiva espontânea (6 anos).
- ▶ Foi encontrado um efeito negativo associado aplicação da tremocilha durante um período inicial de crescimento anual da cortiça (5 anos).



# Manutenção do ensaio

Instalado em **2016** em monitorização até **2019**

## ***RUF – Remoção do subcoberto***

Remoção da vegetação no subcoberto com incorporação da matéria orgânica no solo

## ***NUR – Manutenção da vegetação espontânea***

*Desde 2012*

## ***RUF – Remoção do subcoberto com fertilização***

Remoção da vegetação no subcoberto com incorporação da matéria orgânica no solo, seguido de fertilização NP (2016, 2018).



# Medições

## Monitorização mensal do incremento em diâmetro

- 10 árvores com boa vitalidade por ciclo descortiçamento (Yd) e por tratamento (Tr)

## Monitorização sazonal do teor nutrientes nas folhas

- 5 árvores com boa vitalidade por Yd e Tr
- Folhas jovens do ano: na Primavera, antes das primeiras chuvas de Outono, e no inverno

Ano	Meses											
2016						6	7	8	9	10	11	12
2017	1	2	3	4	5	6	7	8	9	10	11	12
2018	1	2	3	4	5	6	7	8	9	10	11	12
2019	1	2	3	4	5	6	7	8	9	10	11	12

amostagem de folhas

fertilização NP



# Métodos

Para os dois tipos de resposta da árvore:

- ▶ Variação do teor de nutrientes (NPK) nas folhas jovens

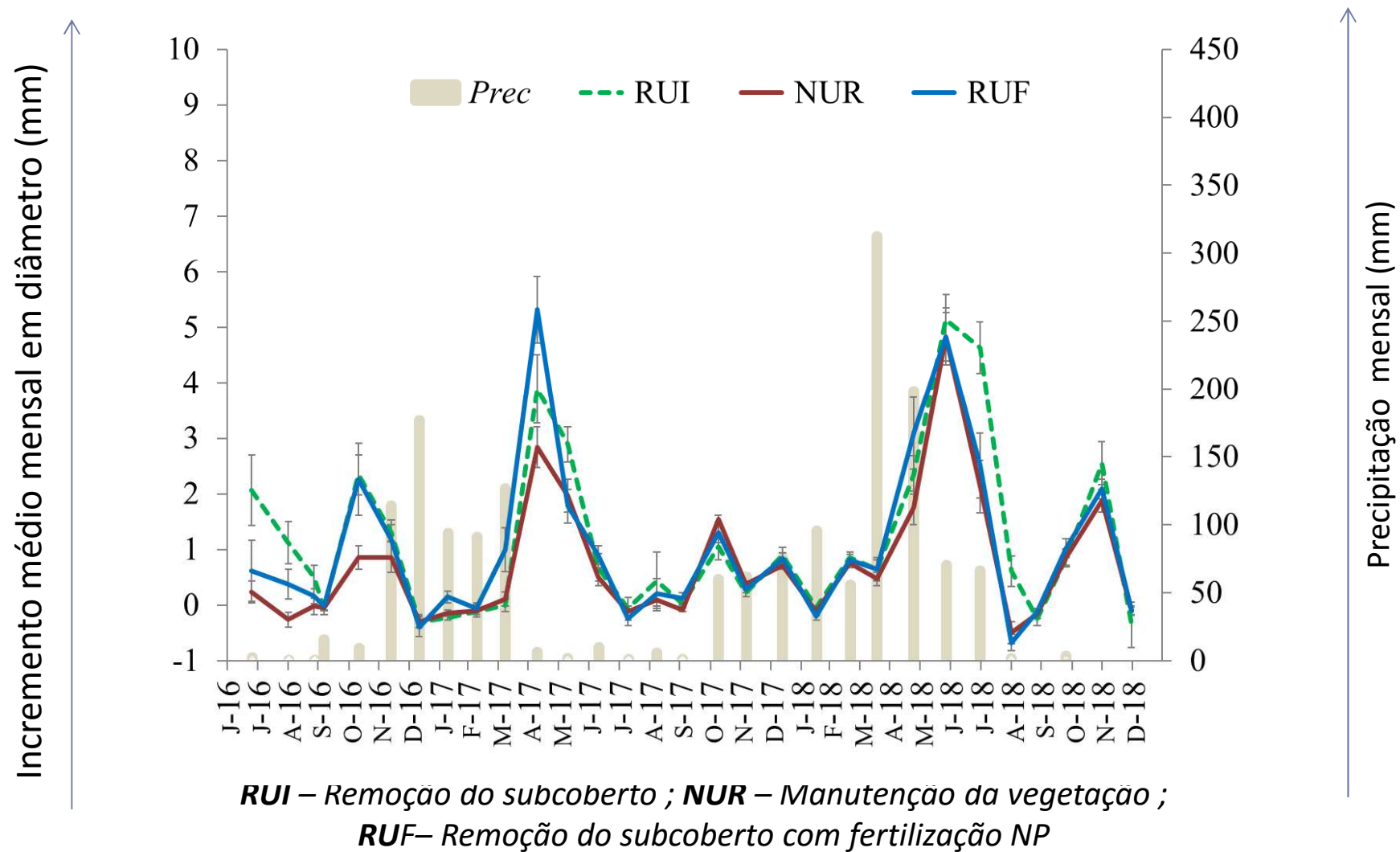
ANOVA 3 Fatores:

*ciclo descortiçamento, tratamento, data de recolha*

- ▶ Crescimento anual em diâmetro

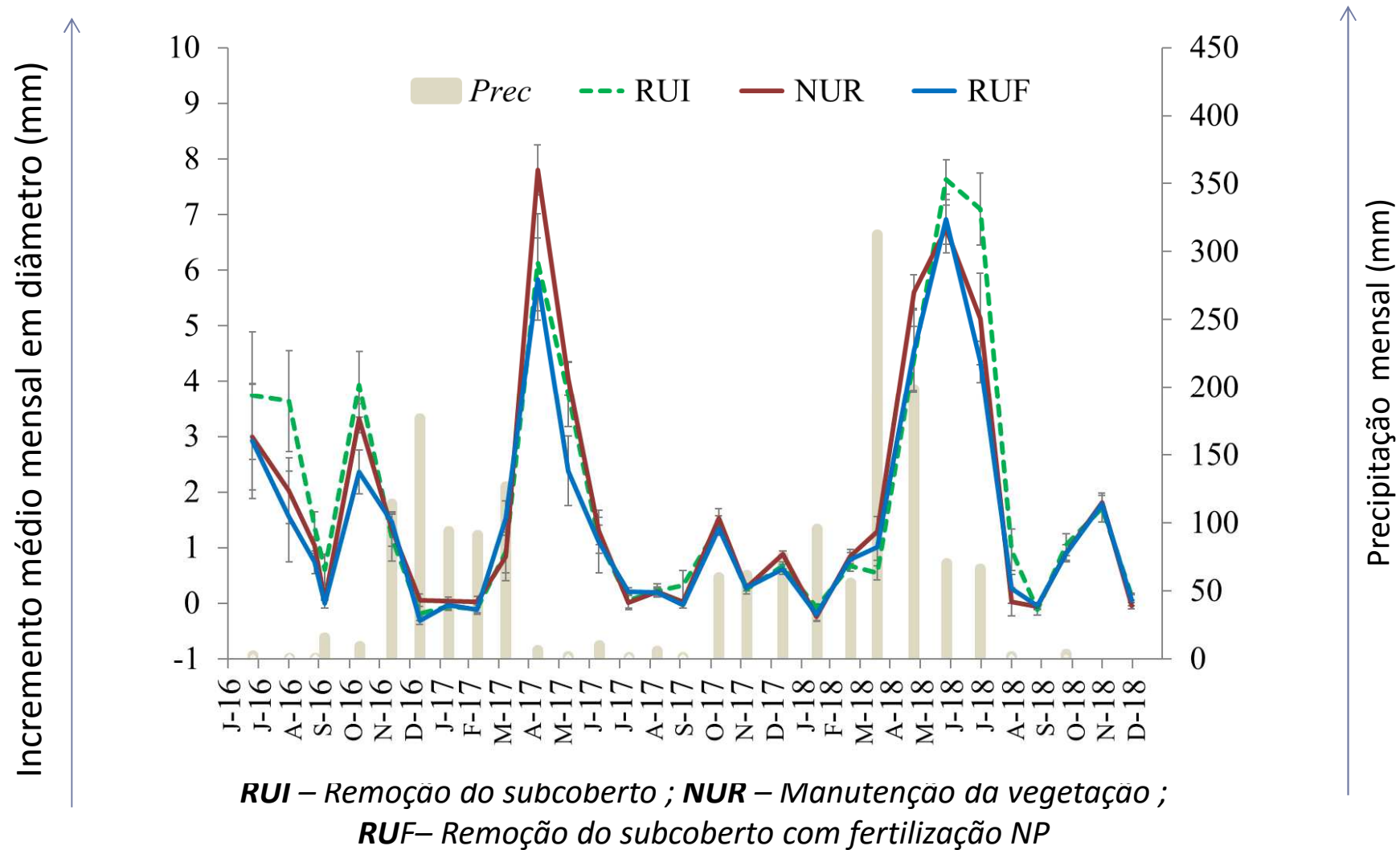
Modelo linear misto

# Incremento em diâmetro – 2003/2012





# Incremento em diâmetro – 2006/2015



# Poster

<http://hdl.handle.net/10400.5/17901>

## Resumindo

Os resultados obtidos pela análise dos dados de 2 anos de monitorização indicam um diferença no tratamento com fertilização ... trabalho em progresso

### Intra-annual tree diameter increment and seasonal leaves nutrients in cork oak species under three understory management alternatives

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**Background:** In *montado*, anthropogenic interventions in the understory layer are a common management practice, that may potentially affect tree growth and regeneration, but also soil functions and nutrient availability.

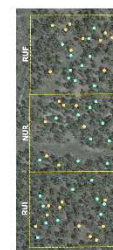


How cork oak trees respond to distinct understory management alternatives?



**Overview:** An experimental trial implemented on a pure uneven-aged cork oak stand, in Podzol soil, with the specific goal of comparing understory management alternatives, was monitored between 2003 and 2015. The stand understory layer is composed by spontaneous vegetation dominated by *Cistus salvifolius*, *Lavandula pedunculata* and *Ulex alicensis*. Cork samples from two distinct cork rotation cycles (2003 to 2012 or 2006 to 2015), taken at the beginning and end of the debarking period, were analyzed regarding cork ring width (Faias *et al.* 2018, Faias *et al.* 2019). Results suggest a different effect on cork annual growth depending on whether the operations are performed at the middle or at the beginning of the cork rotation cycle. Under the CorkNeighbors research project, this trial was continuously monitored and analyzed between 2016 and 2019 (Faias 2019).

#### Trial Description



#### Understory management alternatives (UMA):

- **NUR:** spontaneous understory vegetation maintenance (as control);
- **RUI:** understory removal with biomass incorporation into the soil;
- **RUF:** understory removal with simultaneous NP fertilization.

Along 2 years, 30 trees selected by UMA and YD (cork rotation cycle: 2012, 2015), were monitored, regarding the tree variables:

- **Monthly diameter increment**, with band dendrometers;
- **Current-year leaves nutrient variability**, samples taken in the end of spring, before the first rain and in the winter.

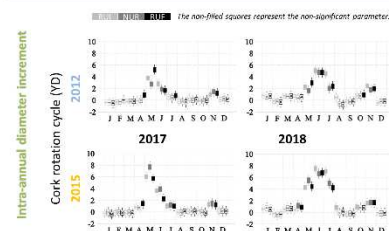


**Methods:** Two distinct approaches were defined considering both tree response variables:

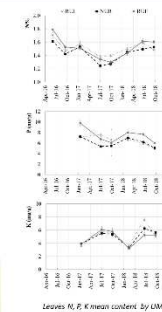
- Specific leaf area (SLA) and nutrient contents (NPK), comparison between UMA, were assessed with a ANOVA 3-factor: season, YD, UMA.
- A linear mixed model approach was applied for the monthly diameter increment data. The random effects considered trees inside plots, and the fixed effect focus in the interaction between: UMA, YD, measurement year (YM) and month.

$$y_{ijlm} = \mu + \beta_{i(j)} + \gamma_l + \tau_m + x_i + (x|y)_{ijlm} + e_{ijlm}$$

where  $y_{ijlm}$  is the diameter increment of tree  $i$  at plot  $j$  at measurement  $l$  (mm);  $\mu$  is the general mean;  $\beta_{i(j)}$  is a tree random effect within each plot;  $\gamma_l$  is a month fixed effect;  $\tau_m$  is a year fixed effect;  $x_i$  is related to the cork debarking cycle and understory management variables (single or combined) and  $e_{ijlm}$  is residual error.



The fixed effect parameters interval regarding 3 factors interaction (UMA|YD|YM), suggest an effect on RUF in the spring after NP fertilization, on the trees with older cork age (2012).



#### Leaves seasonal variability

Results from ANOVA (p value) for the leaves seasonal variability regarding specific leaf area (SLA) and nutrients contents (N, P, K), where YD relates the cork cycle in 2012 or 2015 and season is the time of taking the sample within the year.

Effect	SLA	N	P	K
	mm <sup>2</sup> /g	%	mg/g	mg/g
UMA	0.0000	<0.0001	<0.0001	0.7319
YD	<0.0001	<0.0001	0.0021	0.0240
Season	<0.0001	<0.0001	<0.0001	<0.0001
UMA*YD	0.0114	0.0144	0.0174	0.0003
UMA*Season	0.0007	0.0008	<0.0001	0.0005
YD*Season	0.0034	0.7401	0.5563	0.4955
UMA*YD*Season	0.0197	0.1431	0.0009	0.1972

The leaves P content was higher on RUF, in the two years after performing understory operations, while the leaves N content was higher in the second year.

**References:** Faias S. 2019. Using dendrometer-based measurements to monitor cork oak growth and yield under dry, Podzol soils. MSc thesis, Instituto Superior de Agronomia, Universidade de Lisboa. Faia S, Neves Firmino P, Tomé M, Moreno G, Amaral Paulo J. 2019. Dendrometer-based measurements to monitor cork oak growth and yield under dry, Podzol soils. Forest Ecology and Management 438:1181-1191. Faia S, Neves Firmino P, Tomé M, Moreno G, Amaral Paulo J. 2019. Dendrometer-based measurements to monitor cork oak growth and yield under dry, Podzol soils. Forest Ecology and Management 438:1181-1191.

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Contexto

Dados

Métodos

Resultados

Conclusões

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