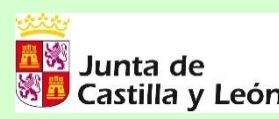




PINEA SPOT CONGRESS
LISBON 2023
21 TO 23 NOVEMBER

The impact of secondary fellings on growth and survival of *P. pinea* natural regeneration in the Spanish Northern Plateau

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Natural regeneration of the forests is a main key element for Sustainable Forest Management



- Emulate natural processes
- Mimic natural patterns
- Better locally adapted
- Natural selection
- Structural heterogeneity
- Cheaper

- High dependence on random events
- Diffiult to program on time
- Common failures
- Multiple bottlenecks
- Require early interventions



Necessary scientific based knowledge on

- Method of cutting
- Intensity of cutting
- Timing for each intervention



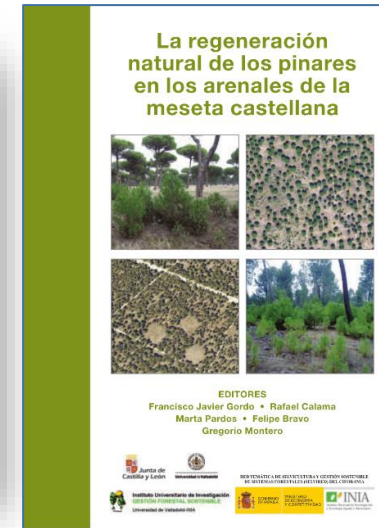
Natural regeneration in *Pinus pinea* forests

Up to 1980s



- Traditional method
- Strip clearcutting + sowing
- Criticism

From 1990s

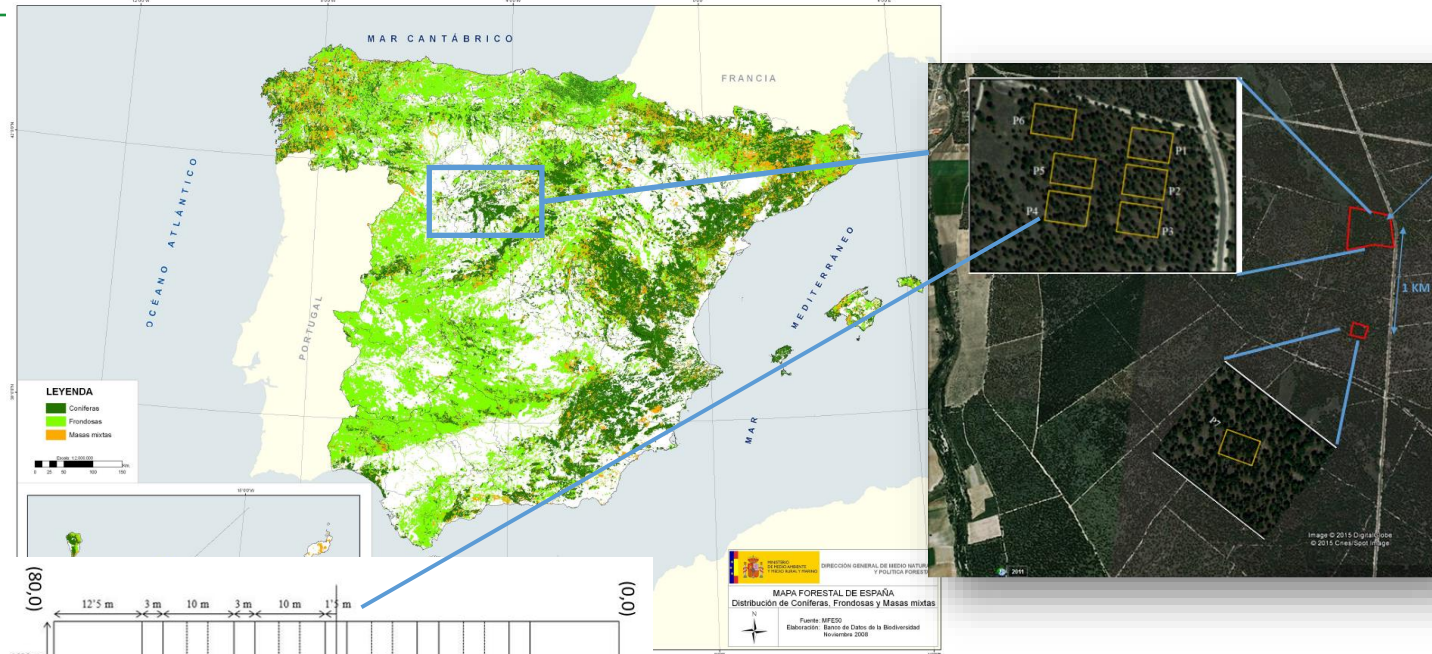


Uniform Shelterwood System: well known initial phases but little known on last phases

Question 1. Impact of secondary fellings on seedling height growth and mortality?

Question 2. Impact of within-patch competition?

Question 3. Effect of seedling age => Timing of interventions



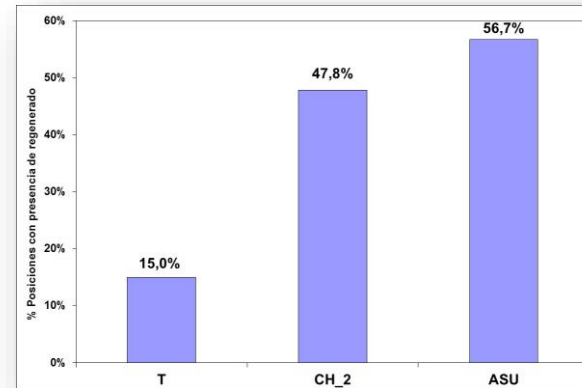
- Installed in 2003
- 120 years-old even-aged stand
- Seven 0.48 ha plots
- Three treatments:
 - Shelterwood (USS): 80 stems ha⁻¹ BA: 12
 - Two step clearcutting(2CC): 40 stems ha⁻¹ BA: 8
 - Control (C): 150 stems ha⁻¹ BA: 18
- 32 subplots (9 m²)/plot

2003 - 2015

Main findings by 2015

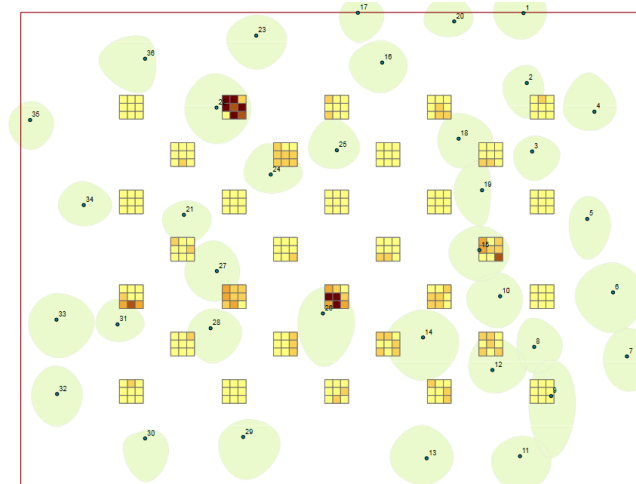


Annual monitoring emerged seedlings
 Seedling survival and growth
 Different essays



Trat	Seedlings ha-1		
	Emerged 2003-2013	Established 2015	Mean height (cm)
2CC	53900	922	61,2
USS	54800	6277	51,8
C	3600	0	-

Three regeneration events: 2002, 2007 and 2011
 Failure in 2CC: big gaps and summer seedling survival
 Success of USS method



Clustered distribution
 Dense patches below crown
 Non-regenerated gaps



Secondary felling in USS: 40 stems ha^{-1} , BA: 6-8 $\text{m}^2 \text{ha}^{-1}$
Very light cuttings in 2CC (2-3 per plot)
Aiming to release and put into light the regenerated patches

February 2016

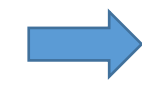
Predictor1: Intensity of secondary fellings



2016-2023: Annual monitoring of height growth and survival on already established seedlings (572)

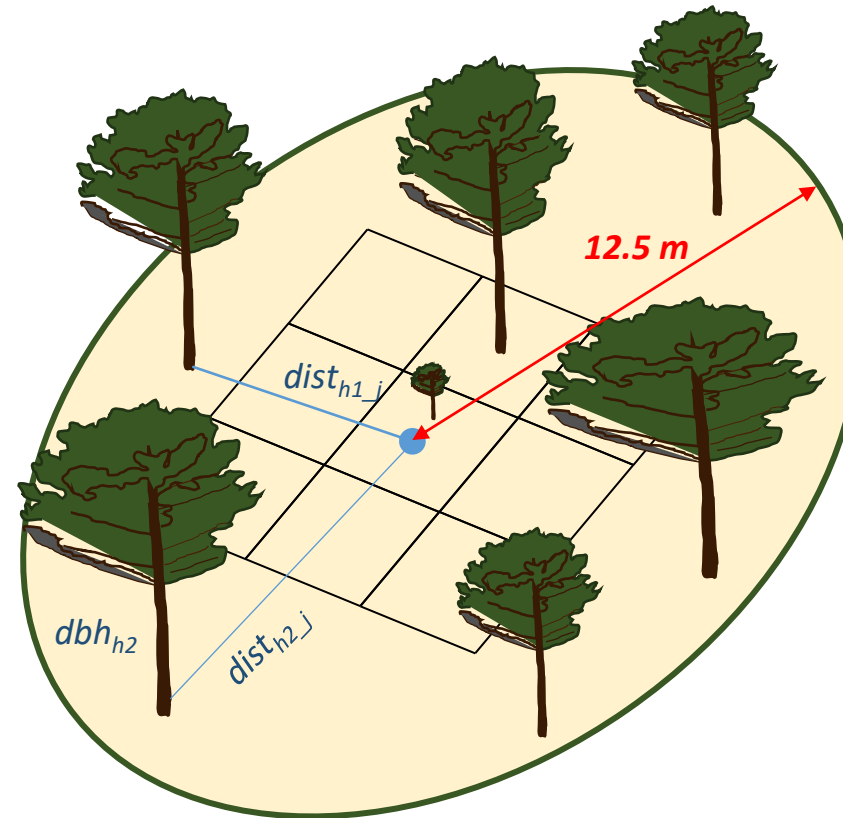
- δH_{16_23} (cumulative)
- Mortality: M_{16_23} (0,1)

$$GPOT_j = \prod_{h=1}^{n_j} \left(1 - \frac{dbh_h}{dbh_{max}} e^{[-0.25 dist_{hj}]} \right)$$



1 = Max competition
 0 = No competition

$$IPOT_j = 1 - GPOT_j$$



Before : $IPOT15_{pre_j}$
 After felling: $IPOT15_{post_j}$

$$Release_j = 1 - \frac{IPOT15_{post_j}}{IPOT15_{pre_j}}$$

Predictor2: Within-patch competition



Number of seedlings within the 1 m² position: Nw

Predictor3: Seedling cohort



Cohort 2002
h₁₅ - h₂₃: 113 - 325 cm
30 plants
Rate mortality: 0%



Cohort 2007
h₁₅ - h₂₃: 51 - 178 cm
515 plants
Rate mortality: 6.2%



Cohort 2011
h₁₅ - h₂₃: 15 - 57 cm
27 plants
Rate mortality: 51.9%

Modelling approach: linear (δH_{16_23}) and generalized linear (M_{16_23}) mixed models
Comparison between different combination of predictors (LRT)
Separately fitted for each cohort

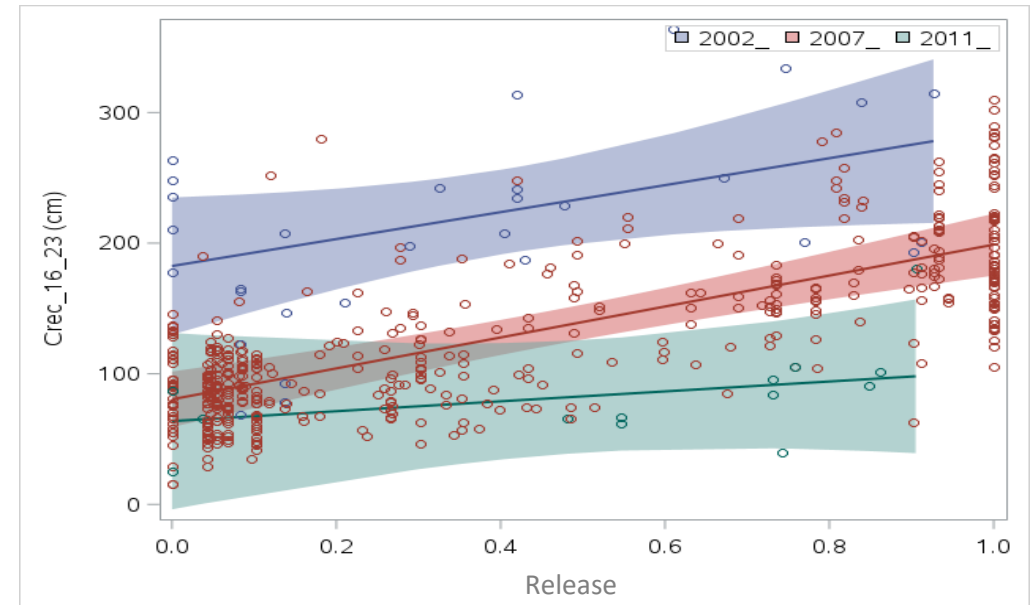
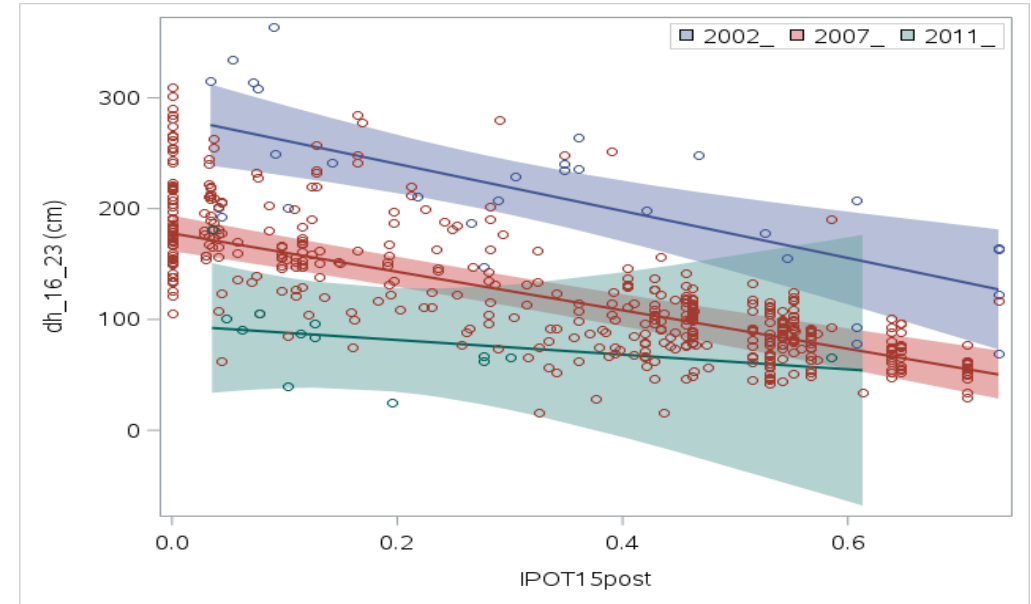
Model for height increment

IPOST15post	Reelase	Nw	2002	2007	2011
X	X	X	314,9	4539,2	117,8
X		X	315,0	4552,5	118,4
X	X		318,1	4554,2	117,8
	X	X	319,6	4581,9	117,8
X			318,4	4546,1	118,4
	X		326,3	4595,5	
		X	326,1	4630,1	119,2
			330,8	4631,2	119,2

IPOST15post (-), Reelase (+) and Nw (-) have significant effects on δH_{16_23} for 2002 and 2007 cohorts
 No effect on 2011 cohort



Secondary felling has a positive effect on height growth for older seedlings
 Within patch thinning will promote height growth in older seedlings



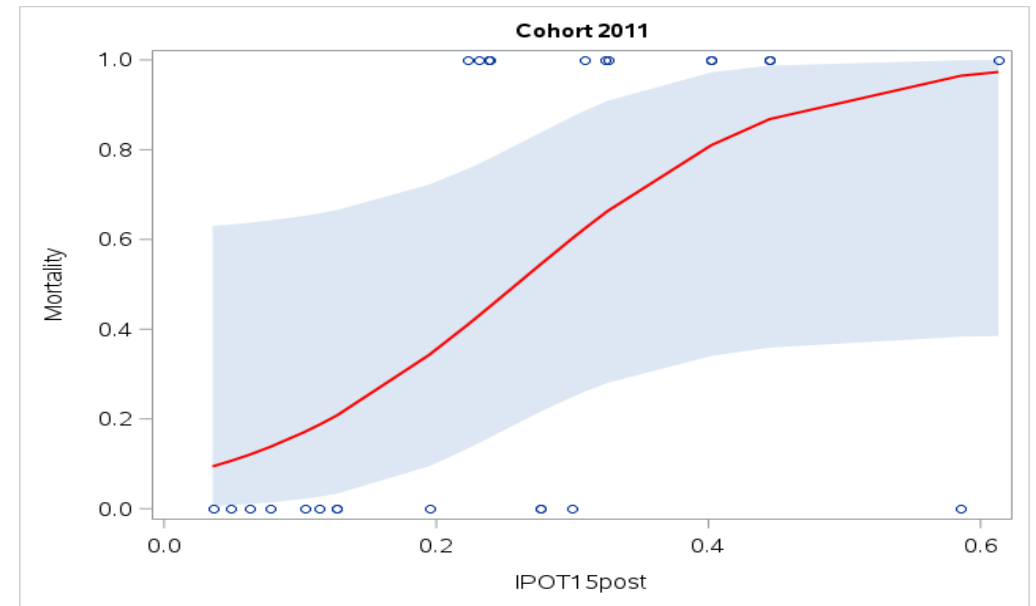
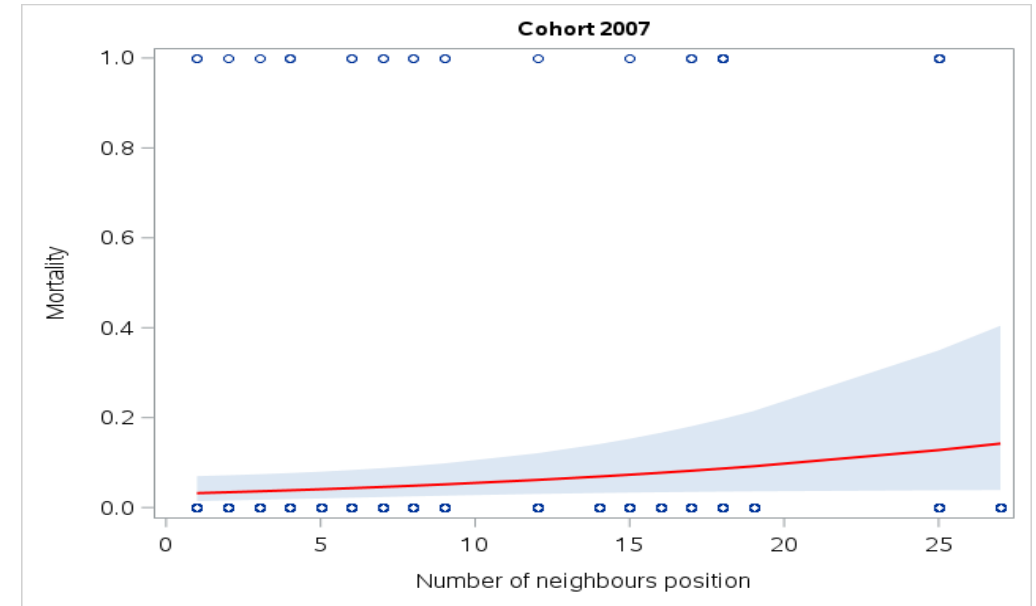
Model for seedling mortality

IPOT15post	Free	Nw	2007	2011
X	X	X	239,5	30,3
X		X	238,3	32,2
X	X		242,8	28,3
	X	X	237,6	29,7
X			242,6	30,6
	X		241,7	28,9
		X	241,6	39,8

Nw has significant (+) but slight effect on the mortality for seedlings in 2007 cohort
 IPOT15post (+) a Release (-) have significant effects on the mortality in seedlings of 2011 cohort



Secondary felling has a positive effect on reducing the mortality for young seedlings
 Within patch thinning will reduce mortality in older seedlings





A delay in the application of secondary fellings lead to increased mortality in young seedlings and a reduction in height growth in older ones

Secondary fellings should be applied when seedling height is over 50 cm and plants show adult needle

Early thinnings should be applied on dense patches when height is < 1 - 2 m

CONGRESSO PINEA SPOT LISBOA 2023

21 A 23 DE NOVEMBRO

Thank you very much!
Obrigado!
Muchas gracias!

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