Session B: Forest genetic resources (FGR) and adaptation to climate change

Response to selection in an aerial conifer seed bank

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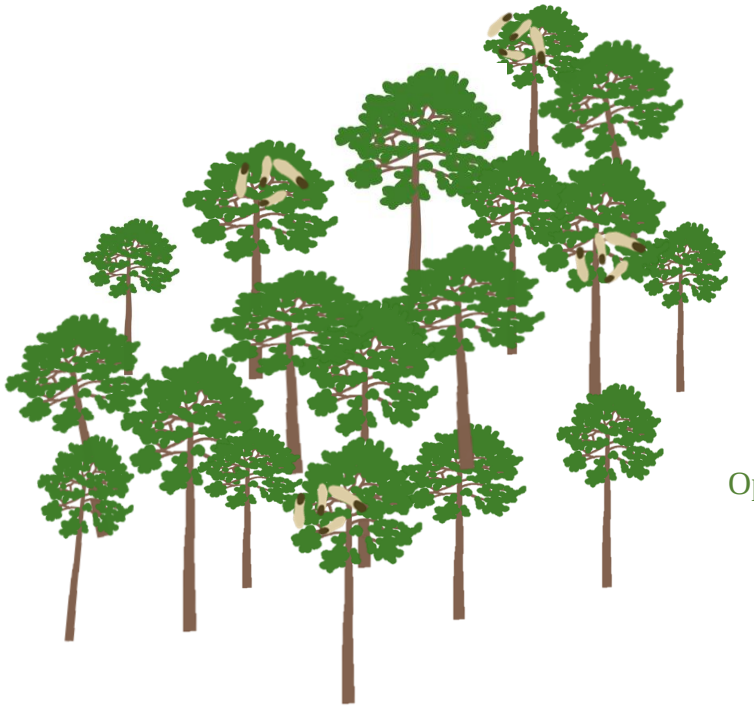
Context of the study

How do plants modify their phenotypes according to the environment?

Genotype × Environment Interaction

Different responses in each species will depend on a variety of factors such as the intensity and direction of environmental change, the type of life history traits and the genetic variability of the populations of a species.

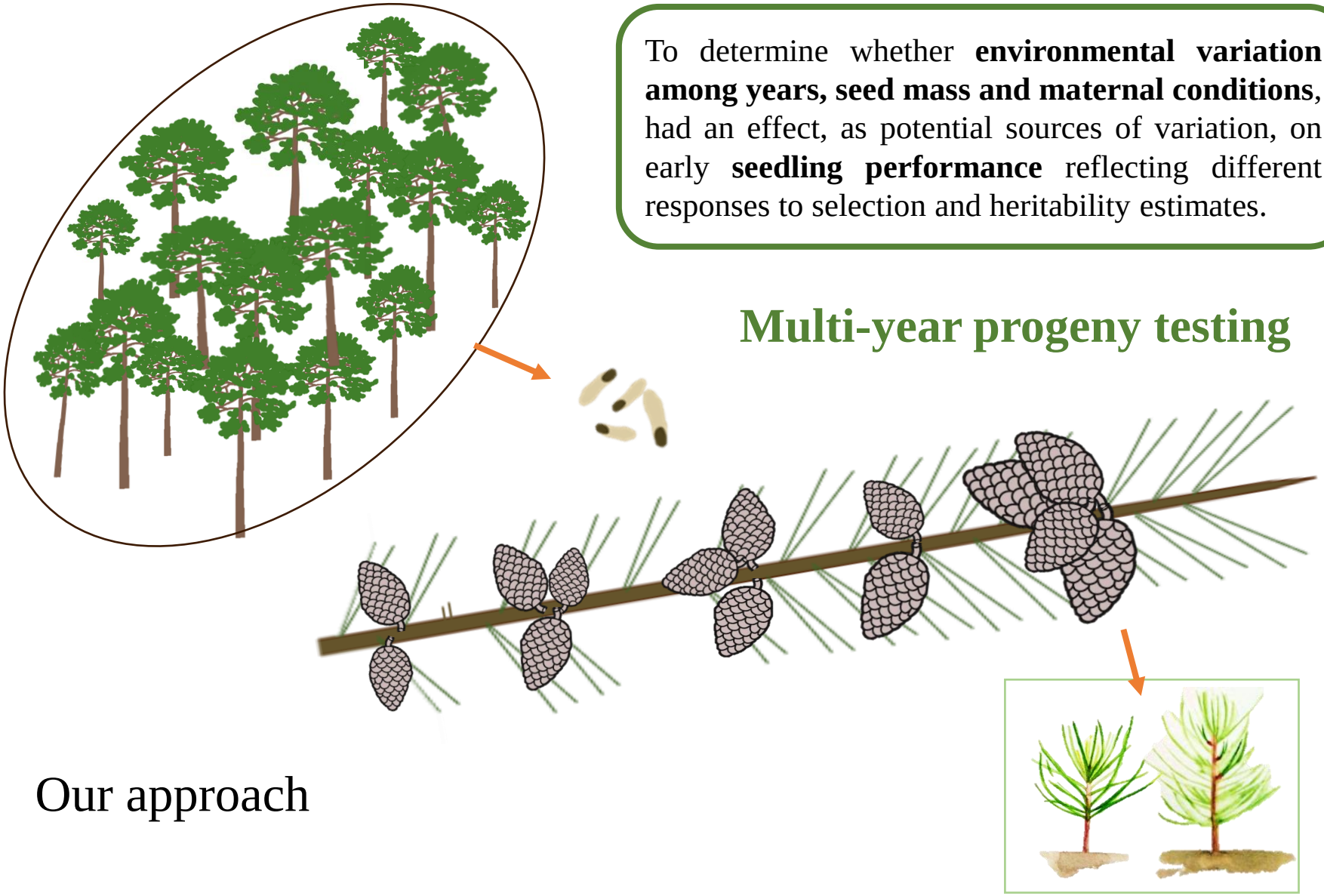


Open-pollinated progeny trials

Context of the study

Objective

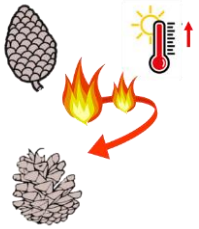
To determine whether **environmental variation among years, seed mass and maternal conditions**, had an effect, as potential sources of variation, on early **seedling performance** reflecting different responses to selection and heritability estimates.



Our approach

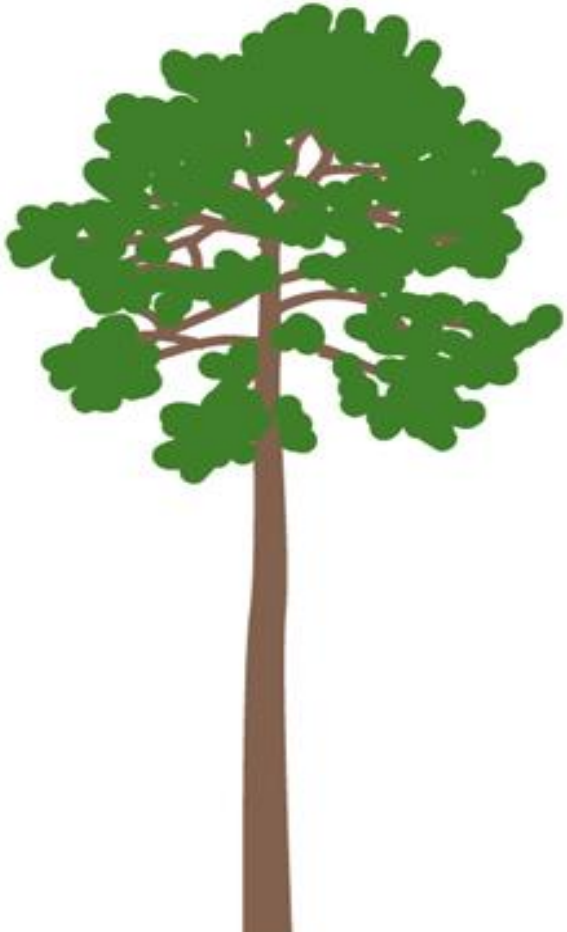
Context of the study

Serotiny



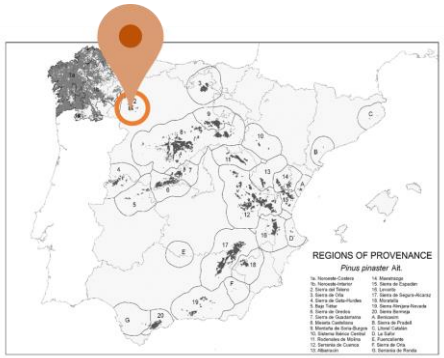
Consists in the ability to retain seeds in temporarily closed cones (serotinous cones) to form an aerial seed bank that can be released after an environmental trigger, normally fire.

Lamont *et al.*, 2020



Retrospective analysis

Pinus pinaster



Natural population
Tabuyo del Monte
Northwestern Spain.

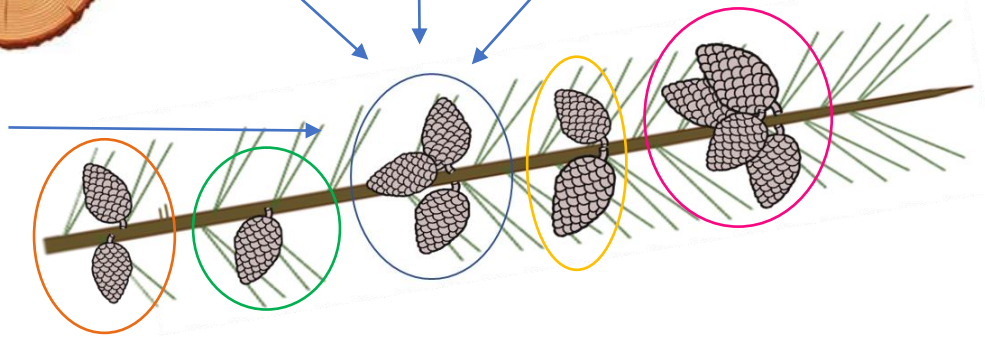
20

Basal diameter

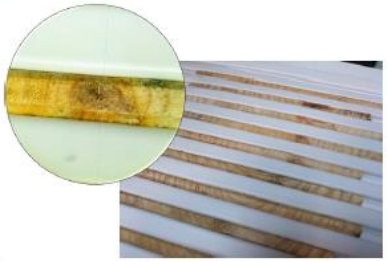
Tree ring width

SPEI

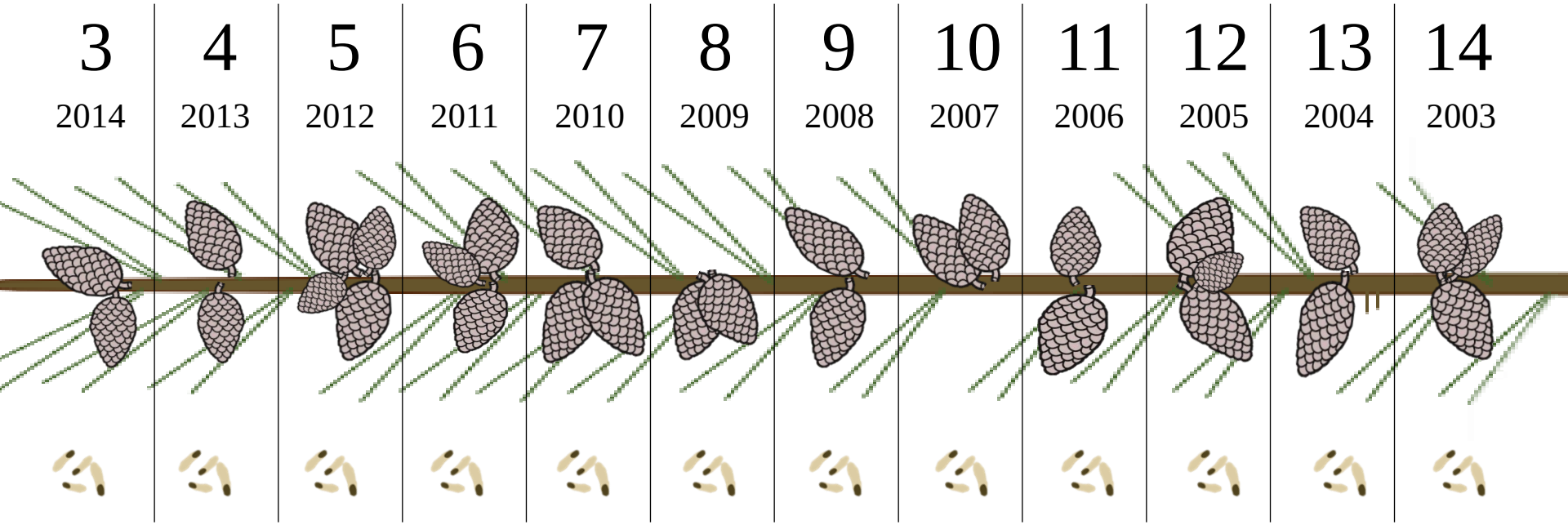
Vicente-Serrano *et al.*, 2010. *Journal of Climate*



Tree Age



Retrospective analysis



Common garden experiment (semi-natural conditions)

Plant Height (mm)

Plant Height (mm) at the ontogenetic stage 4

Statistical analyses

- ✓ Variance estimation. BLUPs estimation.
- ✓ G×E interaction: **LMM**

General Model → Model 1: Seed mass → Model 2: Seed mass Maternal covariates

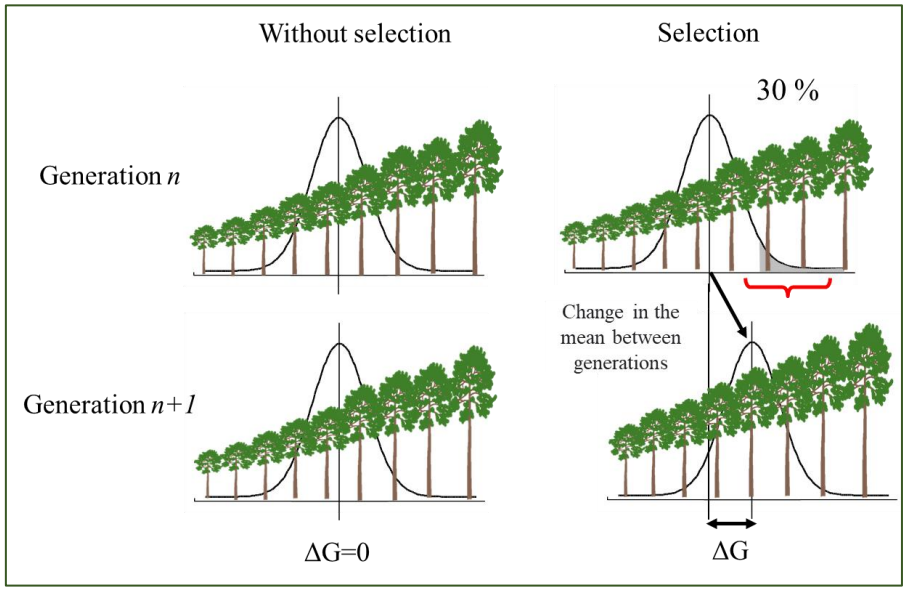
- ✓ Ketata's ranking.

- ✓ Heritability

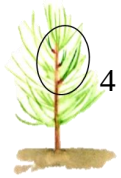
$h^2 = V_A / V_P$ Half-sibs family

$V_A = 4 \times V_F$

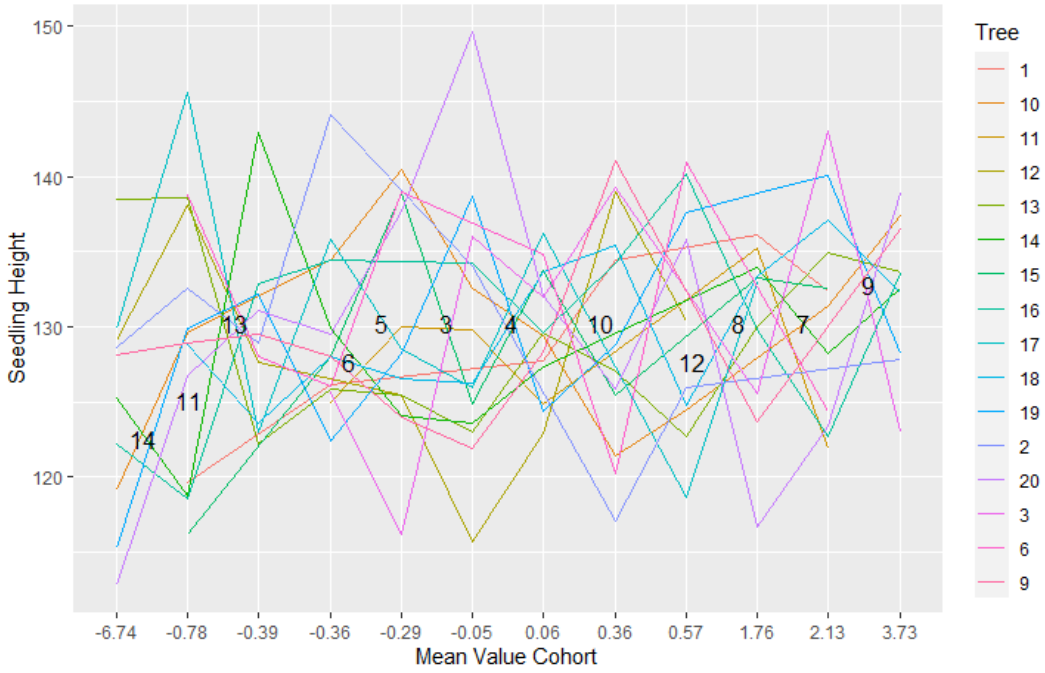
- ✓ Response to selection →



G×E interaction



Groups	Variance	Std. Dev.	LRT	Df	Pr(>Chisq)
Seedling Height					
Mother Tree	113.96	10.675	45.655	1	<0.001
Cohort	12.28	3.505	1.875	1	0.1709
Mother Tree*Cohort	87.95	9.378	77.892	1	<0.001
Block	111.84	10.575	223.198	1	<0.001
H4					
Mother Tree	141.4	11.89	44.464	1	<0.001
Cohort	0.0	0.0	0.000	1	0.9999
Mother Tree*Cohort	114.6	10.71	66.763	1	<0.001
Block	188.8	13.74	238.335	1	<0.001



Heritability

			General Model			Model 1			Model 2		
	Cohort	Nr. Seedlings	h^2	s.e.	CV_A	h^2	s.e.	CV_A	h^2	s.e.	CV_A
Seedling height	3	316	0.91	0.0099	30.1	0.36	0.0059	17.4	0.41	0.0080	18.7
	4	308	0.29	0.0052	16.5	0.14	0.0039	11.2	0.17	0.0048	12.4
	5	266	0.61	0.0084	26.3	0.49	0.0076	23	0.58	0.0104	25.3
	6	309	0.48	0.0068	20.4	0.46	0.0068	19.9	0.51	0.0081	21.2
	7	232	0.53	0.0083	21.6	0.56	0.0089	22.3	0.75	0.0122	26.4
	8	245	0.41	0.0070	18	0.3	0.0062	15	0.44	0.0085	18.7
	9	218	0.06	0.0027	6.8	0.04	0.0028	5.8	0.02	0.0033	3.9
	10	279	0.1	0.0032	9.4	0.07	0.0029	7.5	0.05	0.0033	6.3
	11	286	0.68	0.0087	28.6	0.49	0.0076	23.7	0.56	0.0090	25.3
	12	194	0.54	0.0093	22.4	0.3	0.0070	15.8	0.36	0.0010	17.4
	13	234	0.16	0.0043	12	0.07	0.0033	8	0.22	0.0064	14.2
	14	158	0.26	0.0066	18	0	0.0028	0	0	0.0051	0
	Mean		0.42			0.27			0.34		
	C.V		60.9			74.0			72.4		
	Cohort	Nr. Seedlings	h^2	s.e.	CV_A	h^2	s.e.	CV_A	h^2	s.e.	CV_A
H4	3	251	1.11	0.0113	27.4	0.57	0.0085	18.2	0.6	0.0094	18.6
	4	225	0.19	0.0051	11.7	0.09	0.0038	7.8	0.11	0.0042	0.87
	5	204	0.76	0.0102	24.5	0.47	0.0083	18.4	0.51	0.0091	19.5
	6	226	0.35	0.0064	14.2	0.34	0.0064	13.8	0.37	0.0073	14.5
	7	173	0.55	0.0090	17.6	0.48	0.0095	16.3	0.54	0.0103	17.5
	8	183	0.28	0.0067	11.9	0.24	0.0063	10.9	0.28	0.0068	11.8
	9	183	0.05	0.0033	5.2	0.07	0.0038	6	0.04	0.0034	0.46
	10	221	0.14	0.0041	9.3	0.16	0.0049	9.9	0.17	0.0051	10.3
	11	218	0.52	0.0081	18.8	0.43	0.0075	17	0.48	0.0085	18
	12	148	0.75	0.0117	20.8	0.58	0.0107	17.6	0.45	0.0102	15.3
	13	183	0.18	0.0051	10.2	0.12	0.0047	8.1	0.12	0.0048	0.83
	14	118	0.25	0.0076	12.9	0	0.0039	0	0.02	0.0045	0.36
	Mean		0.43			0.30			0.31		
	C.V		74.2			70.1			68.1		

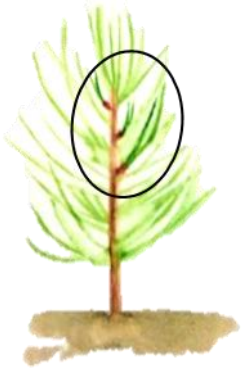
h^2: heritability

Mean and C.V: coefficient of variation.

CV_A: coefficient of evolvability.

Suárez-Vidal *et al.*, 2021

Response to selection



	Gen Model	Model 1	Model 2
	R (%)	R (%)	R (%)
Seedling height	1.88	1.38	1.01
	0.32	0.11	0.07
	2.11	2.67	1.86
	0.05	0.98	0.87
	0.38	-1.85	-2.59
	1.61	-0.88	-0.91
	0.02	0.21	0.03
	-0.5	0.24	-0.01
	3.49	2.58	1.64
	0.11	0.03	-0.13
	-0.09	0.00	-0.04
	-0.72	0.00	0
	0.72	0.46	0.15
	138.6	285	793.6
H4	R (%)	R (%)	R (%)
	7.07	3.63	3.05
	0.01	-0.03	0.00
	1.63	1.22	0.99
	-0.24	0.00	0.02
	0.75	1.07	0.93
	-0.39	-0.25	-0.23
	-0.03	0.04	-0.03
	-0.61	-0.63	-0.48
	1.10	0.68	0.56
	2.12	1.54	0.94
	-0.21	-0.23	-0.18
	0.13	0.00	0.02
	0.94	0.59	0.47
	223.2	199.4	205.3

Different responses between cohorts.

Variability to face possible future scenarios.

Pujol *et al.*, 2018. *Trends in ecology & evolution.*.

Take home messages

We found a strong and widespread **interaction between mother trees and cohorts** for **seedling size and ontogeny** , which implies that the effects of the maternal genotypes were different depending on the year when seeds were formed.

When **discounting maternal effects**, h^2 values were more stable.

The most informative part of these results is the **variation** present across **cohorts**.

Transgenerational effects, by promoting phenotypic differentiation, could have a role in **stabilizing selection**.

¡Thank you!

Muito obrigada