



HAL
open science

Response to artificial selection in the maritime pine breeding program

Laurent Bouffier

► **To cite this version:**

Laurent Bouffier. Response to artificial selection in the maritime pine breeding program. Aurora Conference, Nov 2015, Bordeaux, France. hal-02792446

HAL Id: hal-02792446

<https://hal.inrae.fr/hal-02792446v1>

Submitted on 7 Oct 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution - NonCommercial 4.0 International License

Aurora meeting – November 4th, 2015



Response to artificial selection in the maritime pine breeding program

Laurent Bouffier

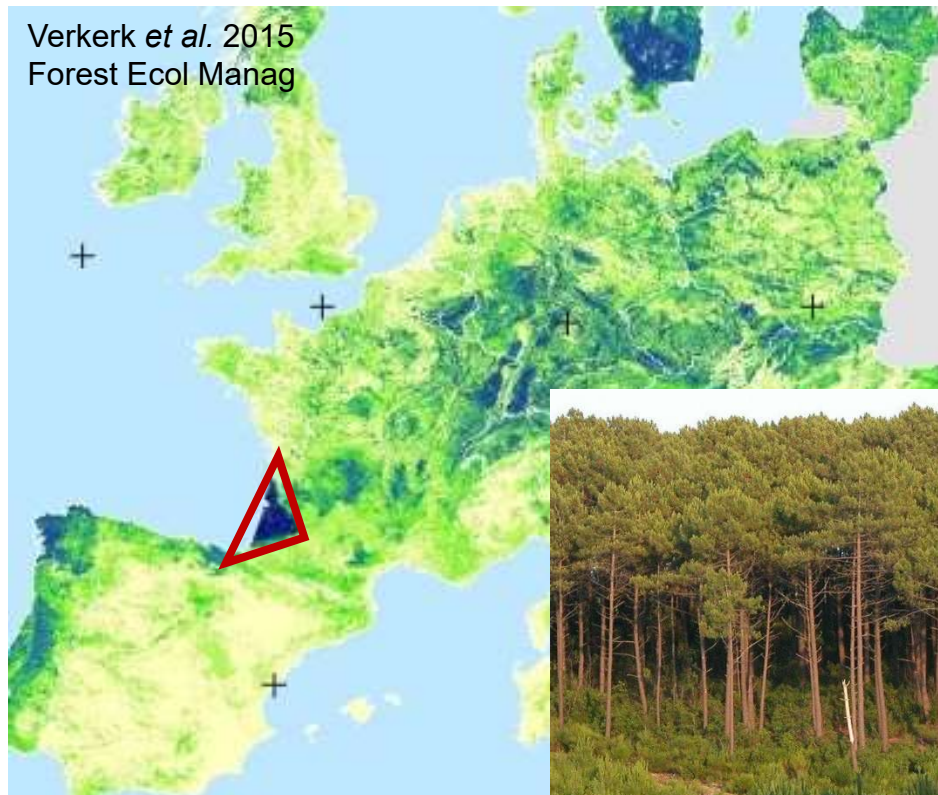


- The maritime pine breeding program
- The current genetic evaluation system
- Genetic gains in improved varieties
- Evolution of genetic variation in successive breeding populations



Maritime pine in France

Maritime pine in France



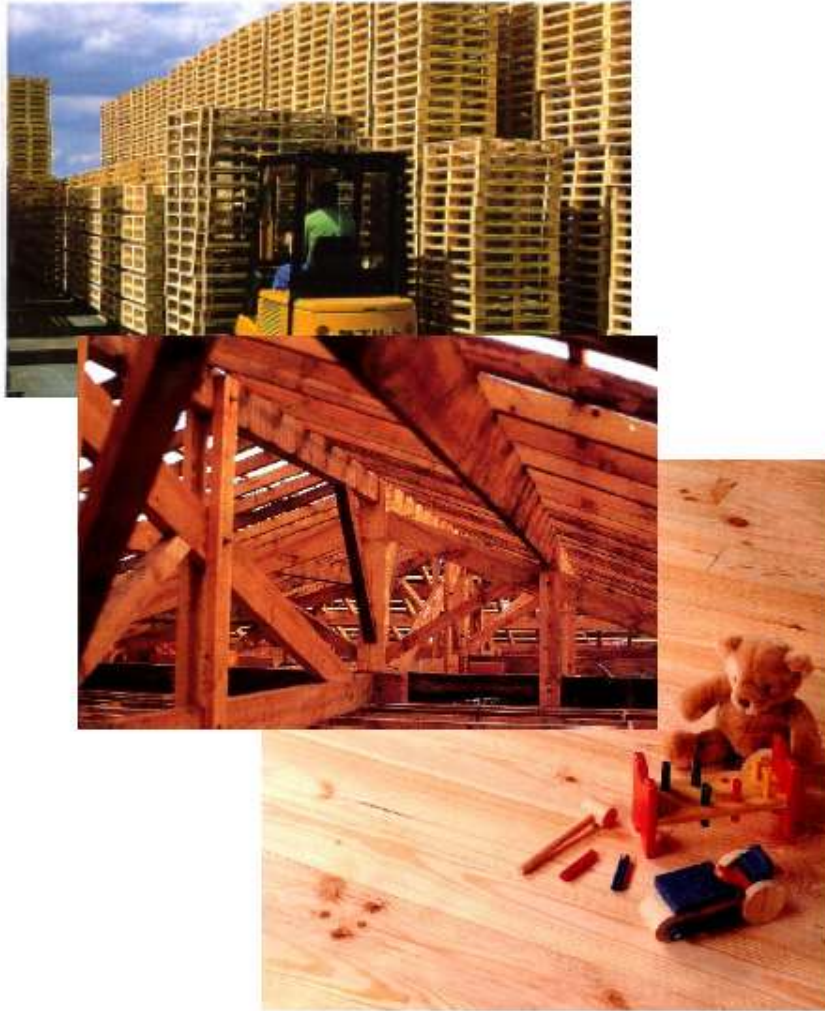
- Main plantation species
 - 10% of French forests
 - 24% of the harvest



- In Aquitaine
 - 0.8 million ha
 - 11 m³/ha/year
 - 8.5 M m³ harvested /year



60% : Sawtimber



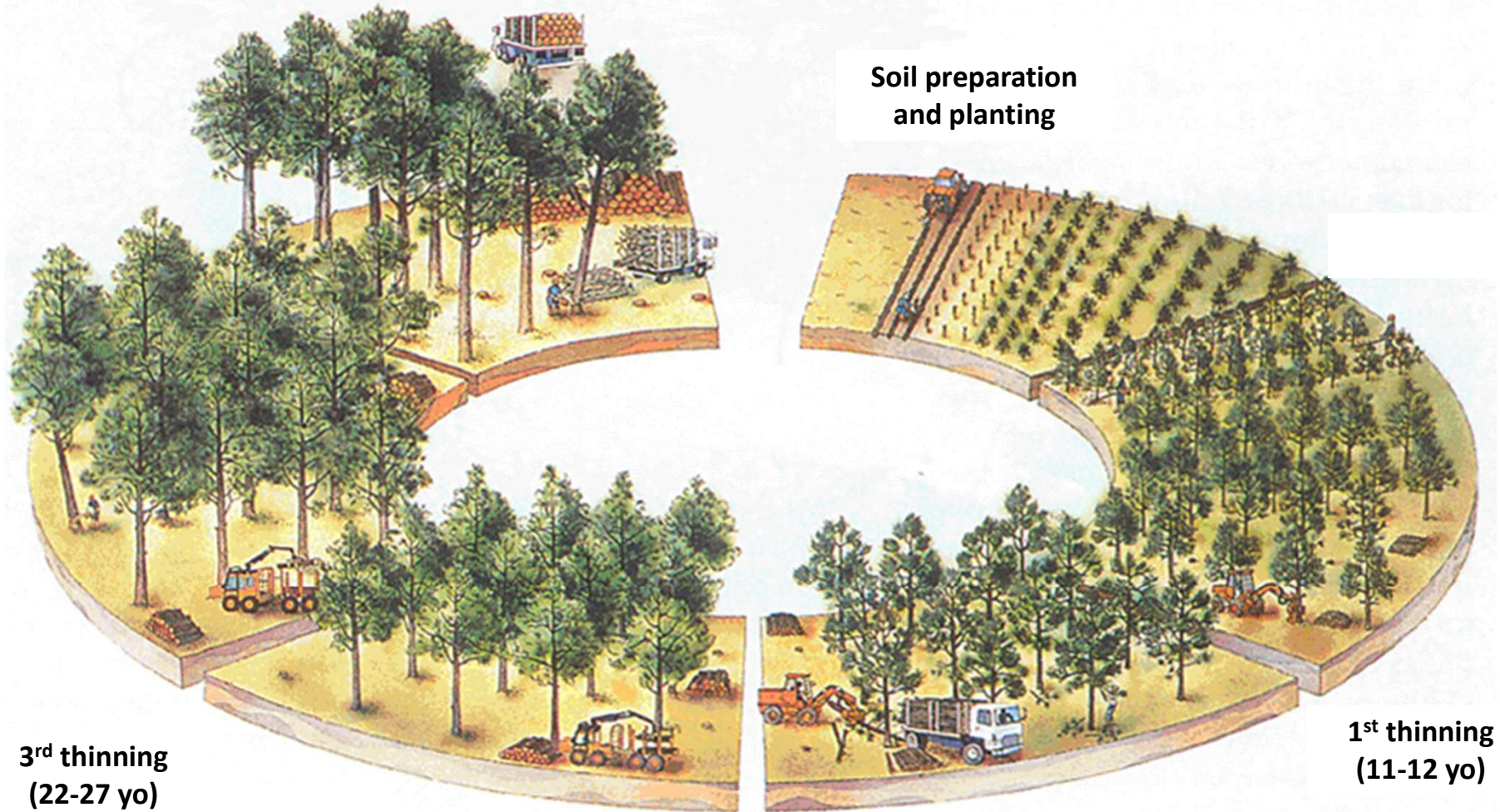
40% : Industrial wood



Maritime pine plantations

clear-cutting
(35-40 yo)

Soil preparation
and planting



3rd thinning
(22-27 yo)

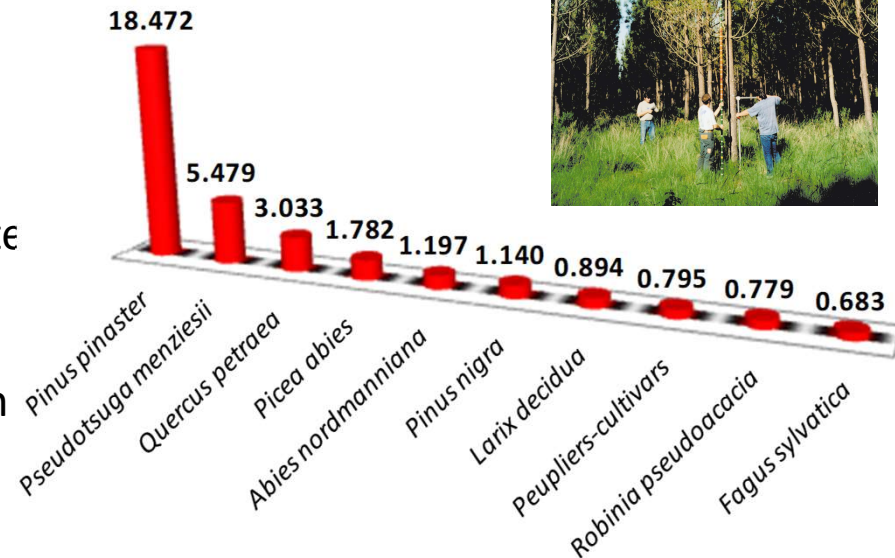
2nd thinning
(17-19 yo)

pruning

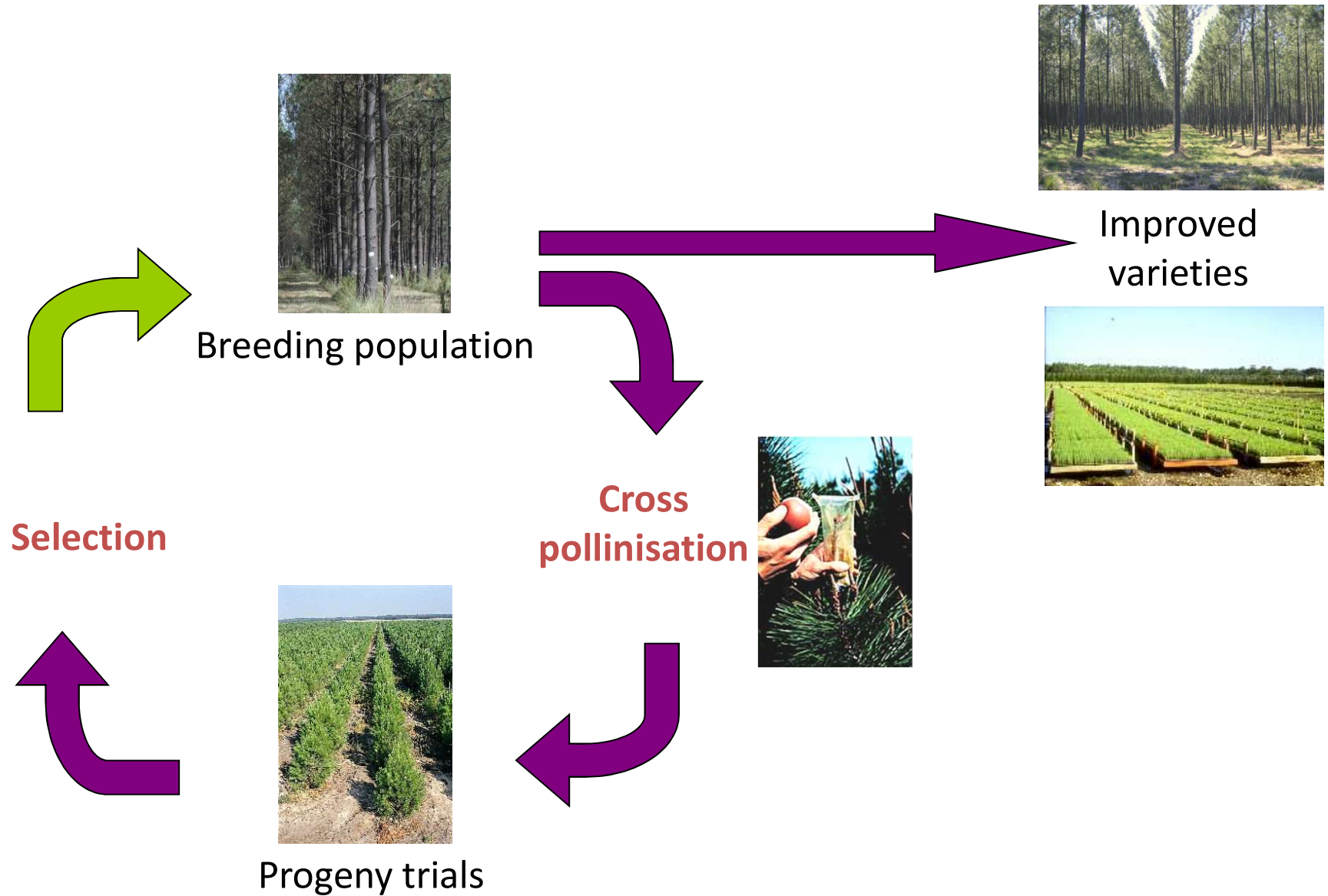
1st thinning
(11-12 yo)

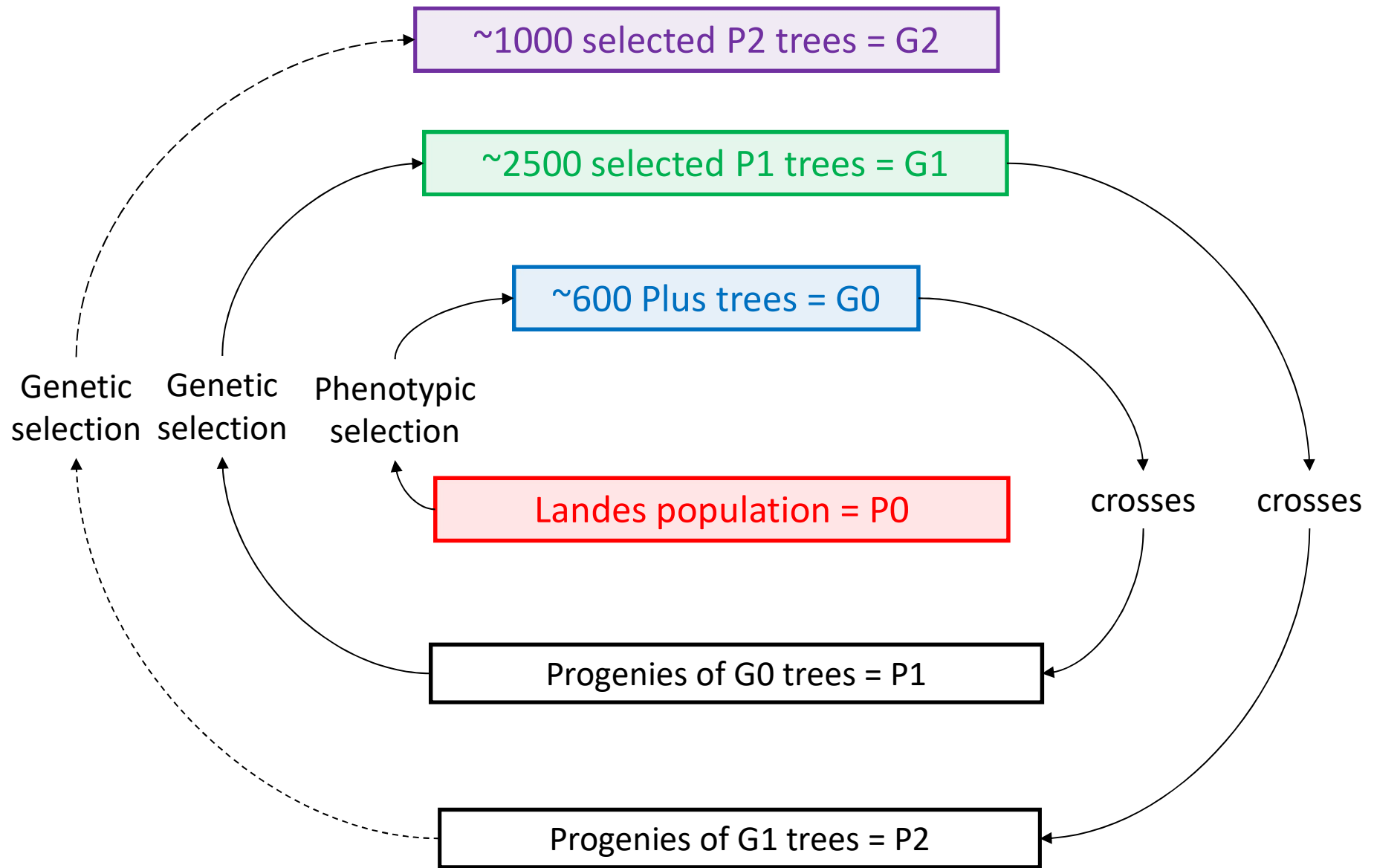
Maritime pine breeding program

- Initiated in the 60's :
 - Base population ~600 plus trees selected in the Landes forest
 - Recurrent selection scheme
 - Managed by a public – private consortium (GIS « Pin Maritime du Futur ») since 1995
- Selection criteria
 - Evaluation at 10 – 12 years old
 - Volume (growth)
 - Wood quality (stem straightness)
- Seed orchards:
 - Generalist varieties from open pollinate seed orchards established with 40-50 genotypes
 - Improved varieties = 90% reforestation



Recurrent selection scheme





Large initial maritime pine breeding population...

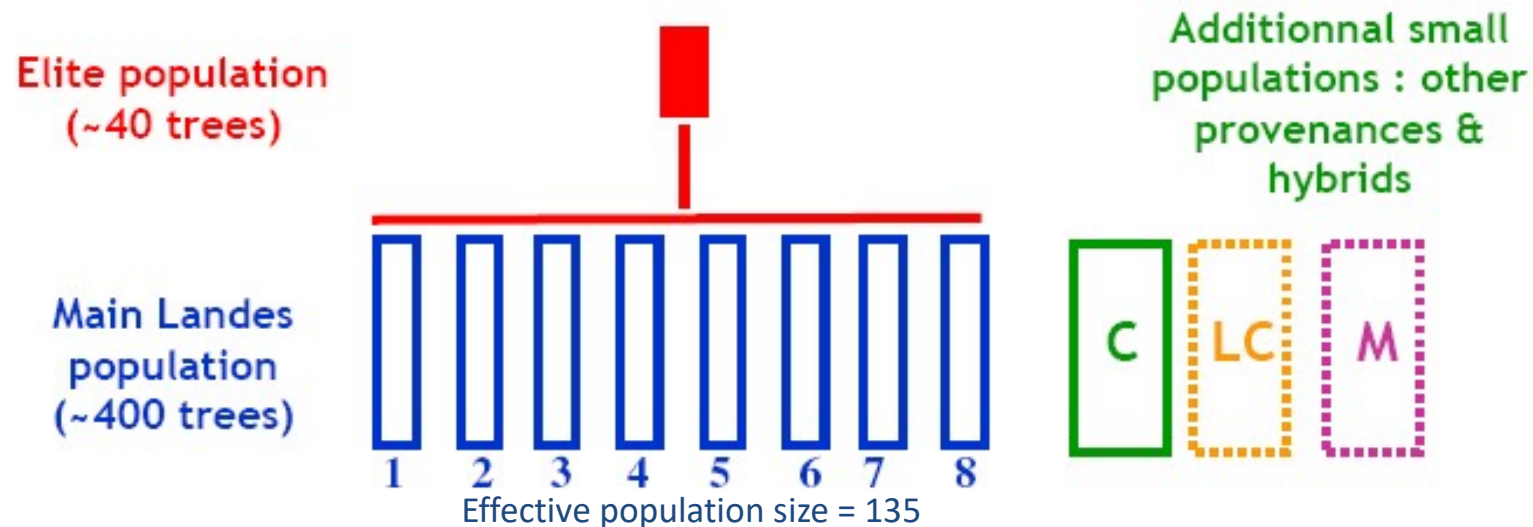
~ 600 G0 (« plus trees »)

~ 2600 G1

~ 1000 G2

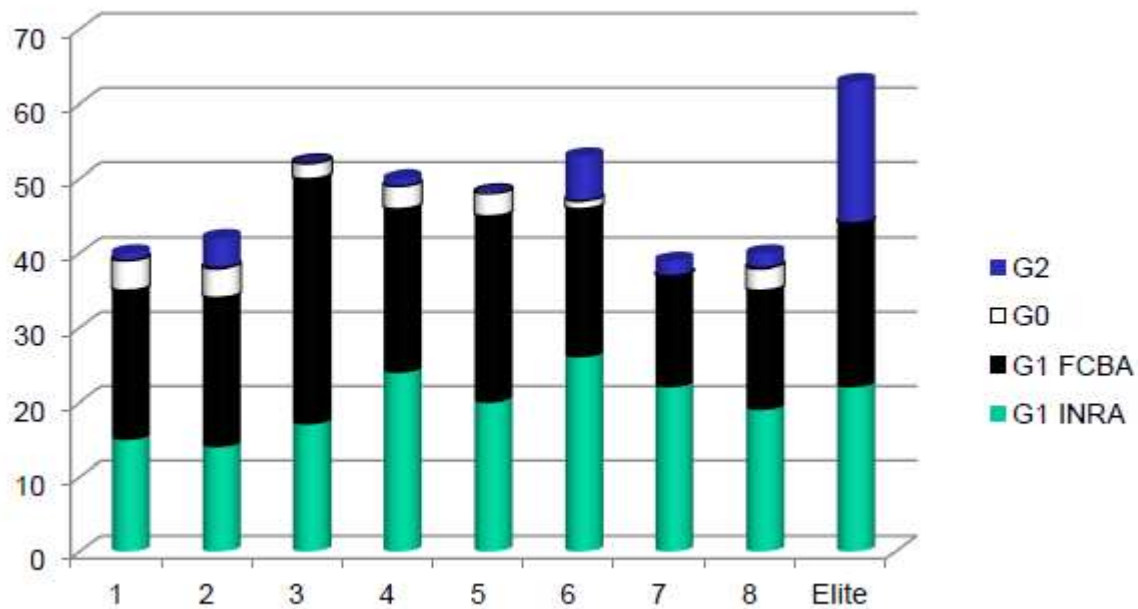
- phenotypic selection of plus trees in the 60's
- recurrent selection based on growth and straightness
- selection of G1 by INRA and FCBA (high level of relatedness between G1 trees)
- selection of G2 by INRA

... now structured into sublimes



➤ sublining to control pedigrees:

- coancestry is controlled by subdivision of the breeding population into non-related sublimes
- OP seed orchards will be constituted with selected trees from non-related sublimes



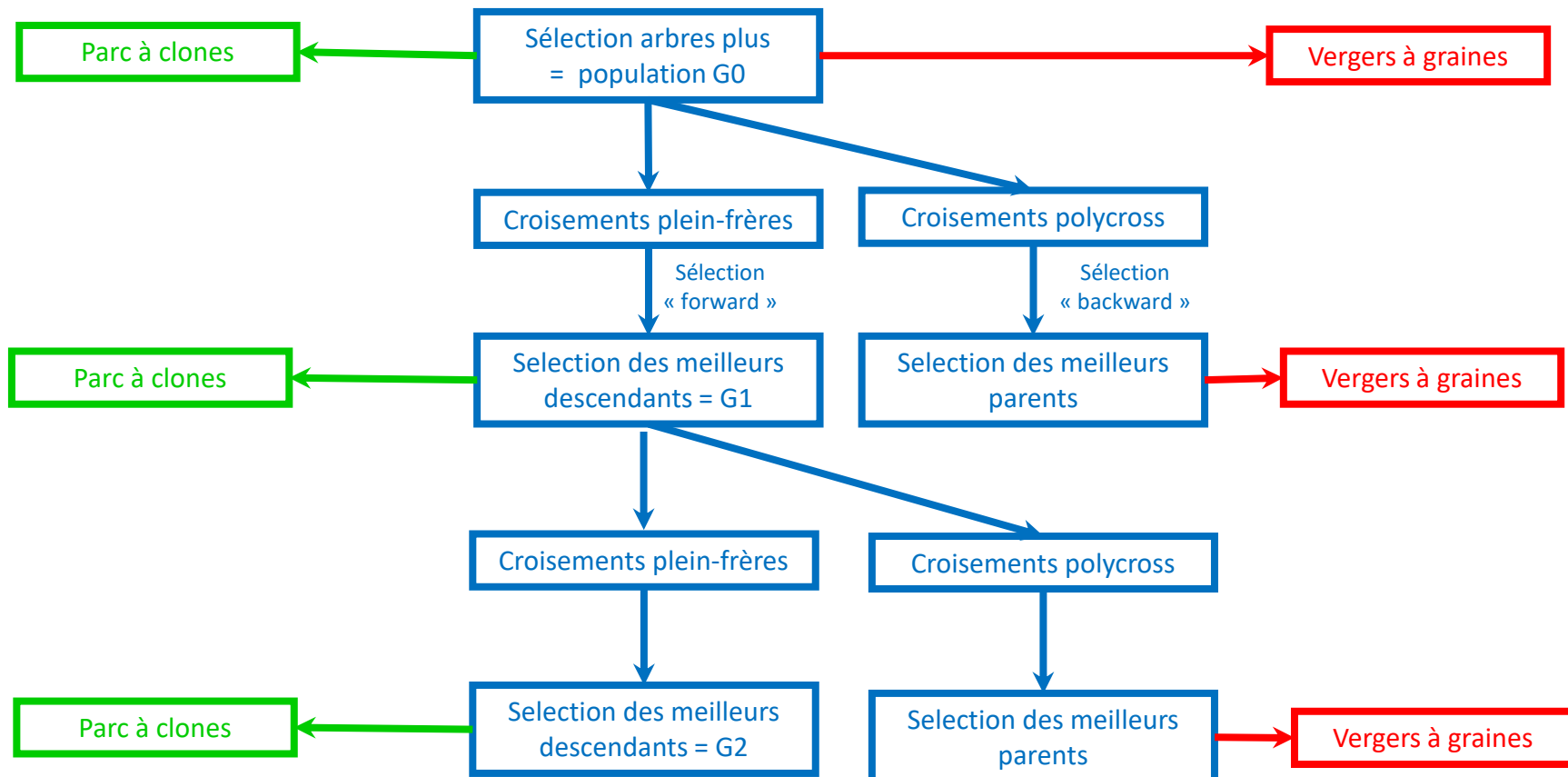
Taille actuelle :
 364 individus dans
 8 lignées
 (en moyenne 45,5),
 et 63 dans la pop élite

Schéma de sélection recurrente

Population de conservation

Population d'amélioration

Population de multiplication





Genetic evaluation system

Previous methodology

- Phenotypic data adjusted for environmental effects
- Only simple pedigree relationships were taken into account (half-sib families for example)
- Analyses carried out trial by trial

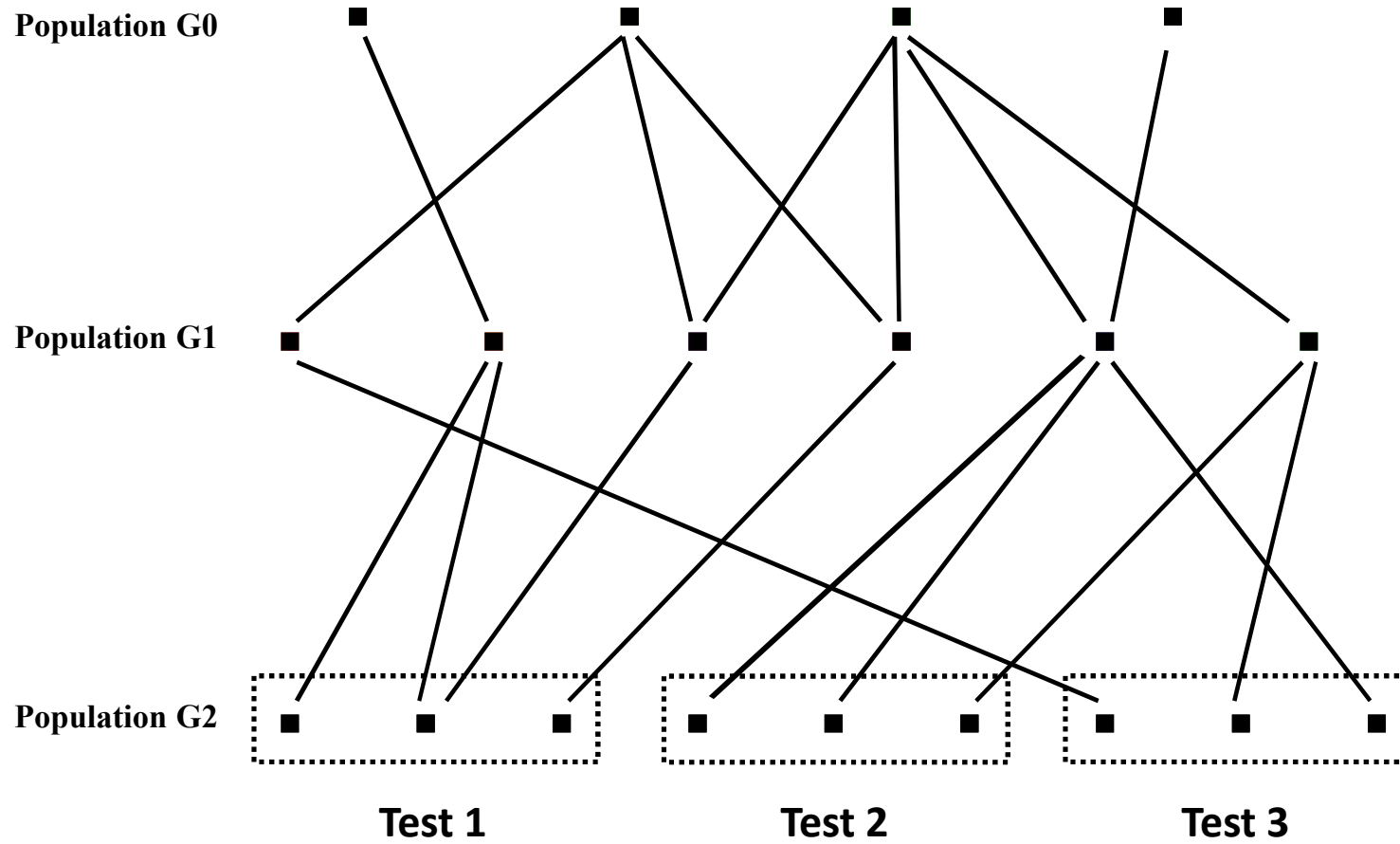
Limitations

- Breeding values from different trials are not comparable
- Informations from different trials were not combined

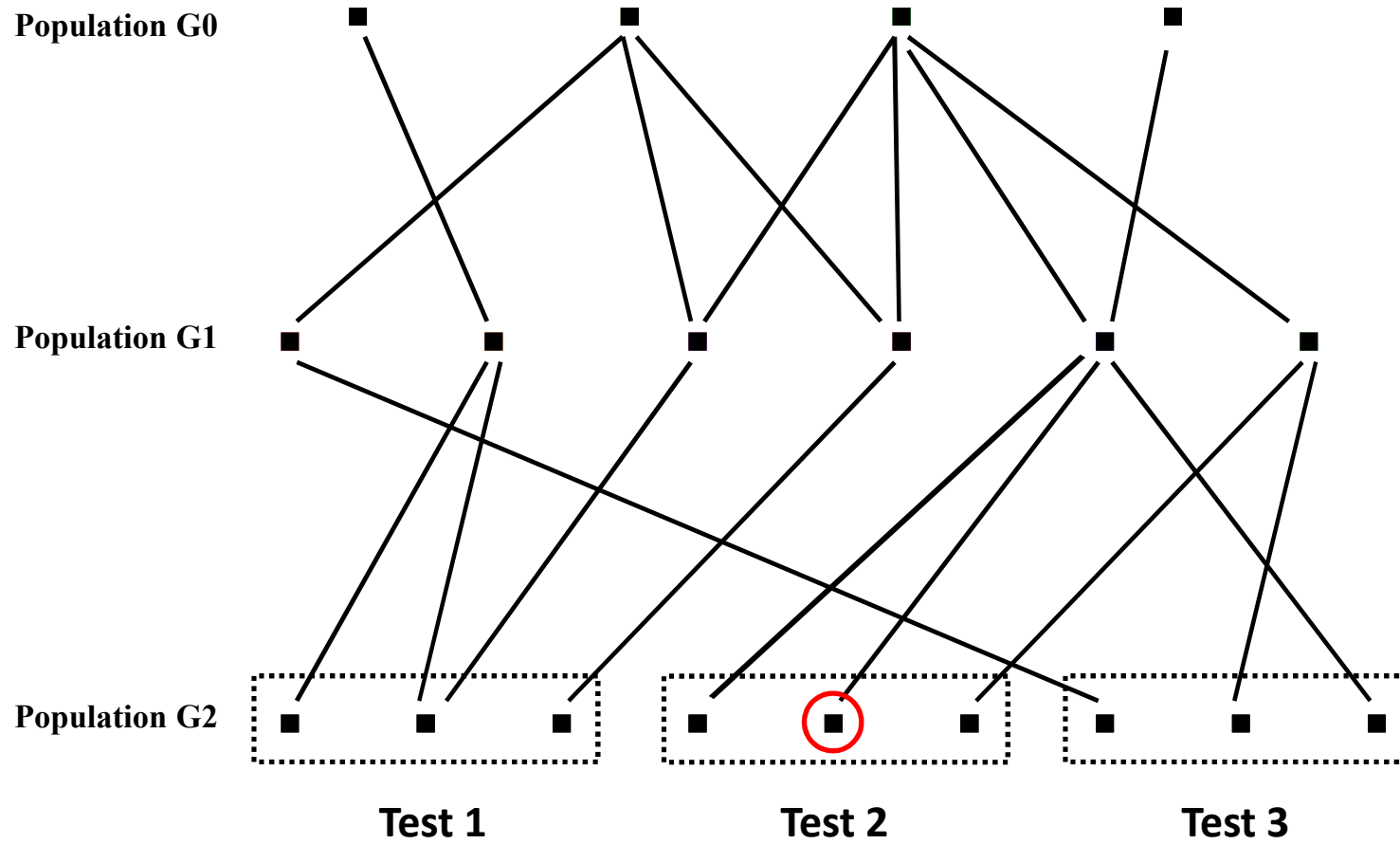
Individual model

- Mixed model: fixed effects (environmental components) and random effects (genetic components)
- Phenotypes are linked by a genetic relationship matrix computed from the pedigree
- Effects estimated simultaneously by maximum likelihood (ASReml software)
- All the pedigree information is taken into account to accurately estimate both the genetic parameters and the breeding values
→ Best Linear Unbiased Predictor (BLUP)

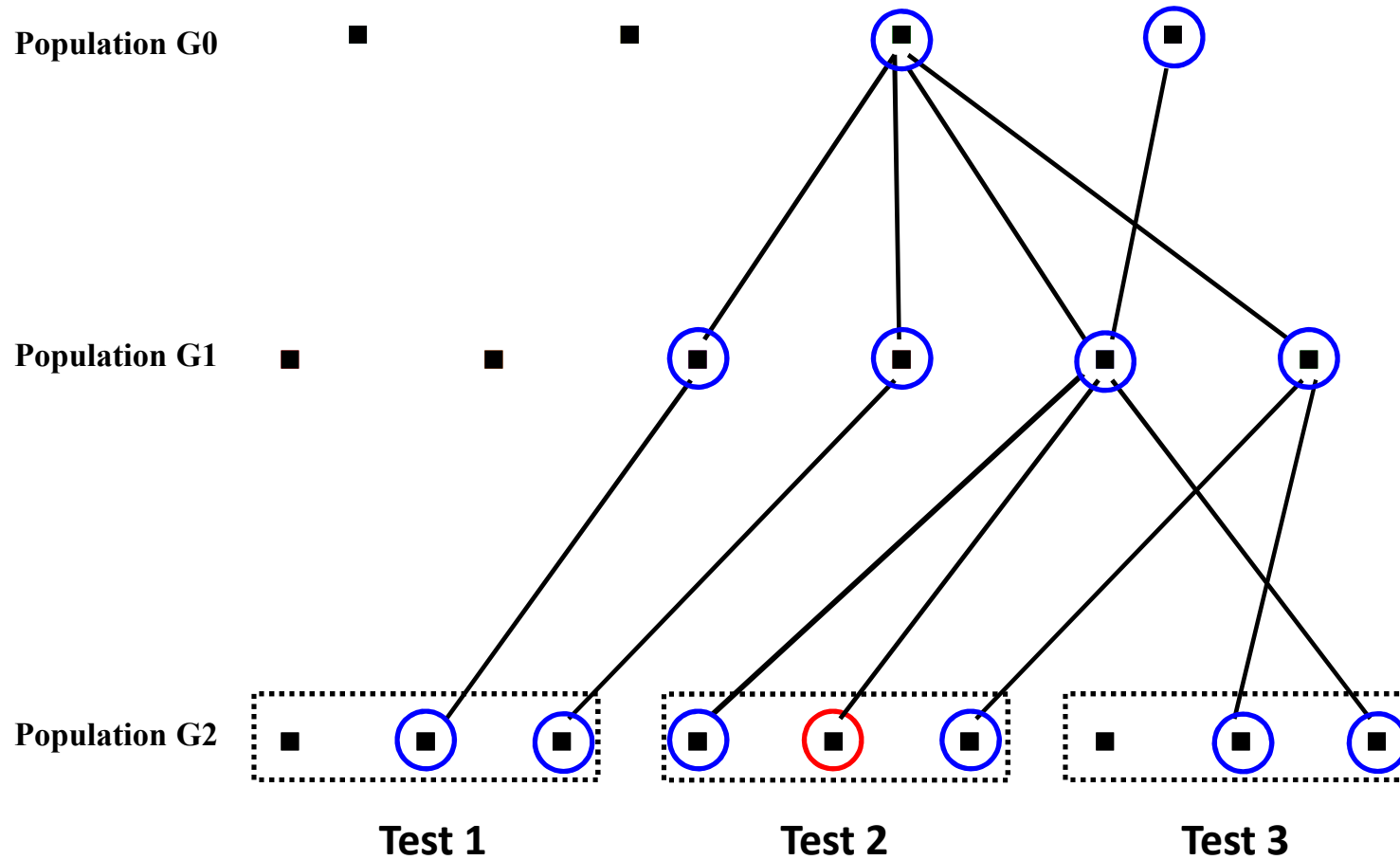
BLUP evaluation

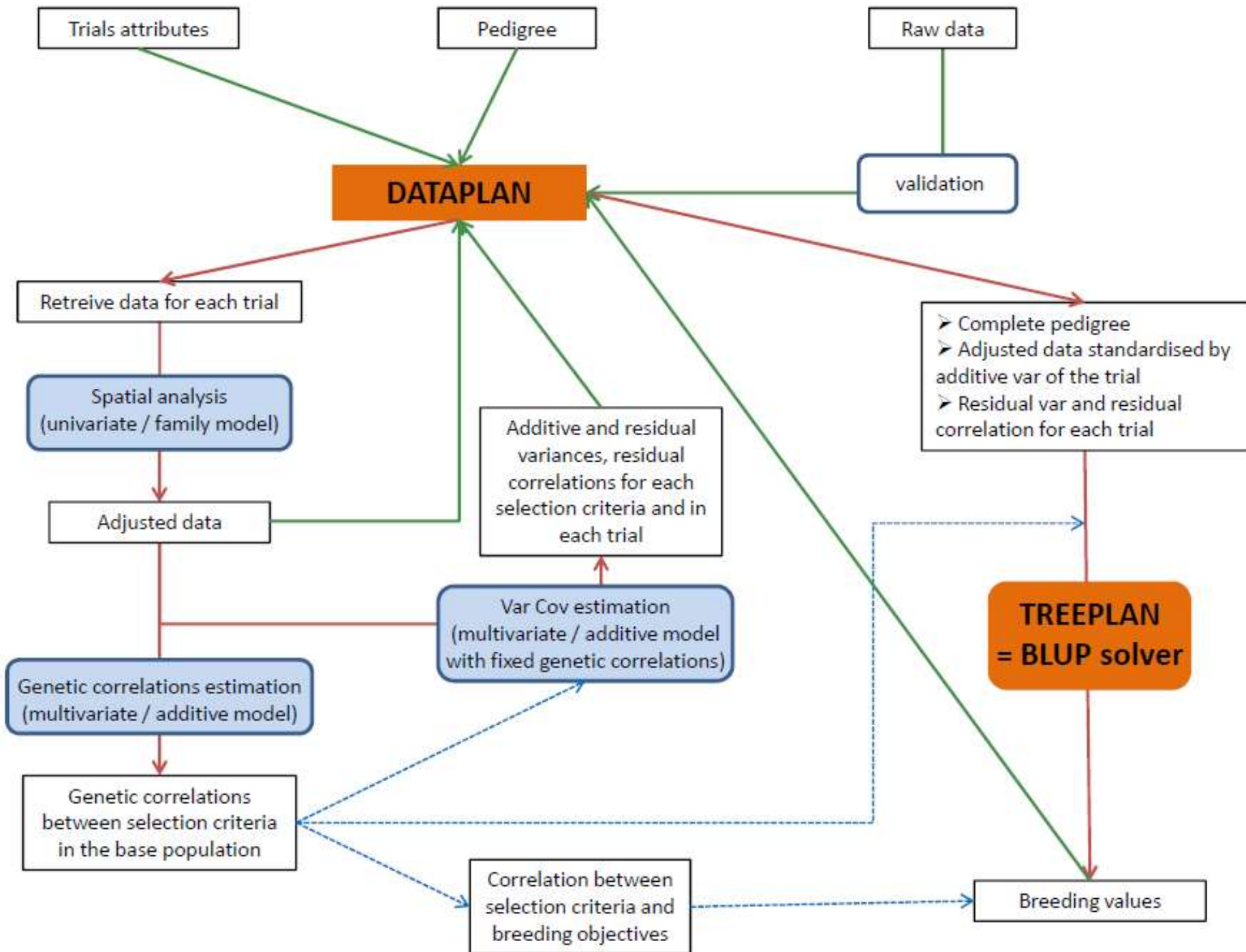


BLUP evaluation



BLUP evaluation





Maritime pine breeding values

More than 500,000 trees in the database

Pinus pinaster

Home Pedigree Trials Documents TREEPLAN Inventory

Home : Pedigree : Genotypes : Show

Retrieve Download Bookmark Add genotype Import genotypes Import attributes

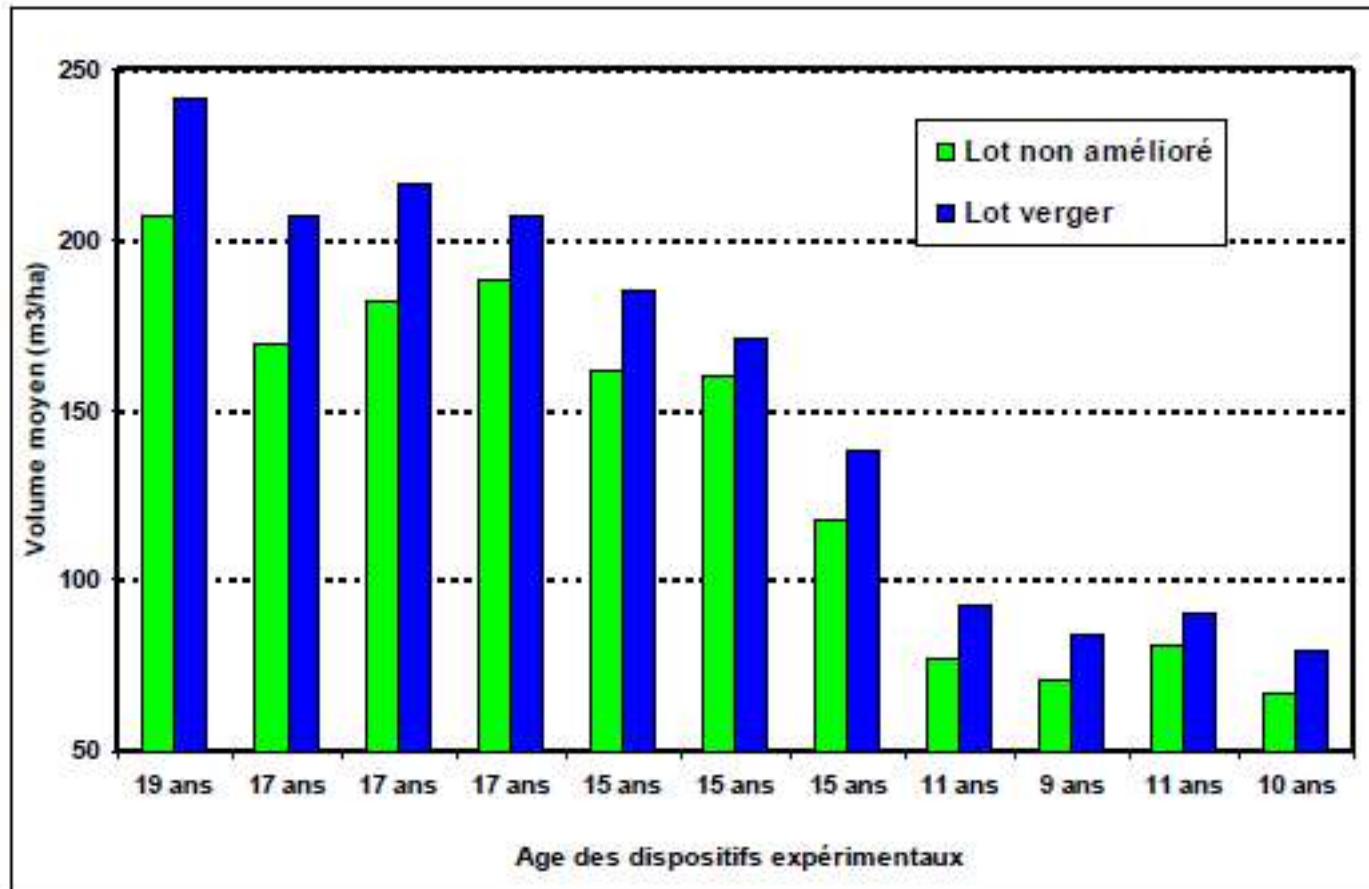
GENOTYPE ID	GENOTYPE NAME	FAMILY ID	FAMILY NAME	MUM ID	MUM NAME	DAD ID	DAD NAME	CIR 12 EBV	CIR 12 EBV ACC	CIR 12 EBV SE	EV 08 EBV	EV 08 EBV ACC	EV 08 EBV SE
3786068	F1.2324	67949	1317x0003	3710004	1317 (Genotype)	3709890	0003 (Genotype)	1.0446	0.9537	0.3006	-0.5973	0.9640	0.2659
3786053	F1.1733	68101	0024x0152	3709906	0024 (Genotype)	3752274	0152 (Genotype)	1.1644	0.9477	0.3192	-1.9987	0.9514	0.3080
3786034	F1.1714	68347	1321x3814	3710007	1321 (Genotype)	3710070	3814 (Genotype)	0.7364	0.9470	0.3213	-0.9296	0.9515	0.3076
3786001	F1.1681	68345	1901x3814	3710039	1901 (Genotype)	3710070	3814 (Genotype)	2.0242	0.9472	0.3208	-0.6769	0.9513	0.3084
3785998	F1.1678	68348	3110x3814	3710048	3110 (Genotype)	3710070	3814 (Genotype)	2.4634	0.9242	0.3819	-1.6435	0.9588	0.2841
3785989	F1.1669	68294	0056x3111	3709919	0056 (Genotype)	3710049	3111 (Genotype)	2.0742	0.9473	0.3203	-0.1338	0.9515	0.3075
3785913	F1.1587	68039	0161x0108	3709969	0161 (Genotype)	3709942	0108 (Genotype)	2.1362	0.9463	0.3234	0.0752	0.9522	0.3055
3785907	F1.1580	68292	4301x3110	3710104	4301 (Genotype)	3710048	3110 (Genotype)	2.5012	0.9430	0.3327	-0.1998	0.9459	0.3245
3785880	F1.1548	68026	0041x0022	3752236	0041 (Genotype)	3709904	0022 (Genotype)	1.4977	0.9544	0.2985	-1.1036	0.9638	0.2665
3785866	F1.1533	68274	3113x1902	3710051	3113 (Genotype)	3710040	1902 (Genotype)	1.1818	0.9486	0.3165	-1.3258	0.9516	0.3072
3785839	F1.1505	68260	3823x1317	3710077	3823 (Genotype)	3710004	1317 (Genotype)	0.9123	0.9422	0.3351	-0.0923	0.9497	0.3133
3785833	F1.1498	68027	1307x0022	3709995	1307 (Genotype)	3709904	0022 (Genotype)	1.4056	0.9488	0.3160	-1.0792	0.9508	0.3099
3785817	F1.1482	68027	1307x0022	3709995	1307 (Genotype)	3709904	0022 (Genotype)	1.0735	0.9236	0.3835	-1.4722	0.9592	0.2828
3785789	F1.1453	68261	3112x1317	3710050	3112 (Genotype)	3710004	1317 (Genotype)	1.1250	0.9486	0.3164	-0.8143	0.9516	0.3072
3785783	F1.1447	68026	0041x0022	3752236	0041 (Genotype)	3709904	0022 (Genotype)	1.6430	0.9382	0.3460	-1.5745	0.9681	0.2506
3785782	F1.1446	68026	0041x0022	3752236	0041 (Genotype)	3709904	0022 (Genotype)	1.1764	0.9444	0.3289	-1.8604	0.9661	0.2582
3785764	F1.1428	68026	0041x0022	3752236	0041 (Genotype)	3709904	0022 (Genotype)	0.8769	0.9203	0.3913	-2.0129	0.9568	0.2909
3785702	F1.1359	67842	1329x0105	3710015	1329 (Genotype)	3709940	0105 (Genotype)	0.9335	0.9489	0.3156	-1.1484	0.9515	0.3076
3785560	F1.0790	68240	3110x1309	3710048	3110 (Genotype)	3709997	1309 (Genotype)	1.4834	0.9672	0.2542	-0.4687	0.9742	0.2256
3785547	F1.0777	68168	1319x0243	3710005	1319 (Genotype)	3709979	0243 (Genotype)	1.6486	0.9749	0.2228	0.1237	0.9783	0.2072

First <<Prev 1 2 3 4 5 6 7 8 ... Next>> Last | All 818 rows

A photograph of a forest with tall, straight tree trunks and a ground covered in fallen leaves and ferns. The text "Genetic gains in improved varieties" is overlaid in the center.

Genetic gains in improved varieties

Traits under selection



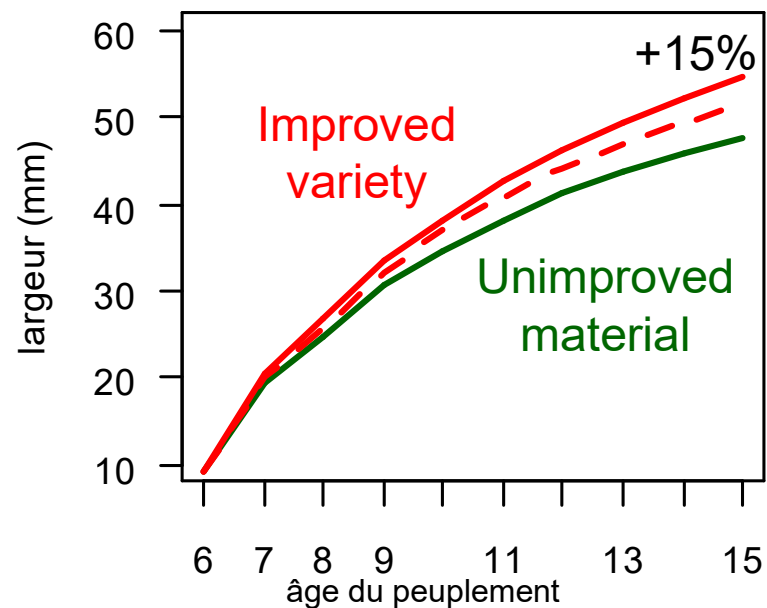
- First generation improved varieties: +15% for volume and stem straightness (but very variable depending on site characteristics)
- +30% is expected for second generation improved varieties

What are the consequences of growth selection on wood density in the French maritime pine breeding programme?

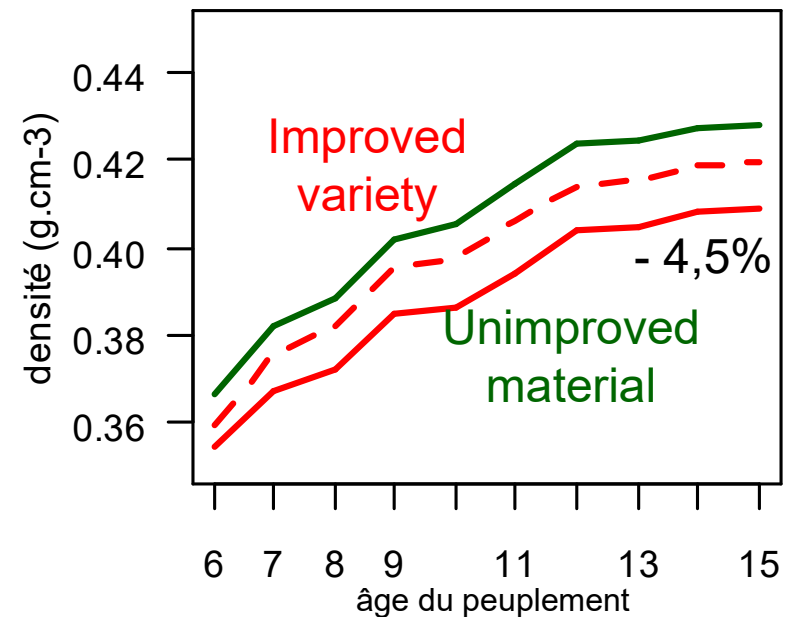
Laurent Bouffier • Annie Raffin • Philippe Rozenberg •
Céline Meredieu • Antoine Kremer

Tree Genetics & Genomes (2009) 5:11–25
DOI 10.1007/s11295-008-0165-x

Ring width



Wood density



Improved varieties: genetic gain for growth associated with a slight decrease of wood density

Correlations between wood density and selection criteria in the breeding population

	Corrélation phénotypique	Corrélation génétique
circonférence - densité	-0,09 (0,04)	-0,21 (0,19)
hauteur - densité	0,00 (0,04)	-0,08 (0,16)
écart à la verticalité - densité	0,00 (0,04)	0,08 (0,17)

Estimation à partir des tests Hermitage et Pissos (1150 arbres)



Evolution of genetic variation in successive breeding populations

Heredity (2008) 101, 156–165
© 2008 Nature Publishing Group All rights reserved 0018-067X/08 \$30.00

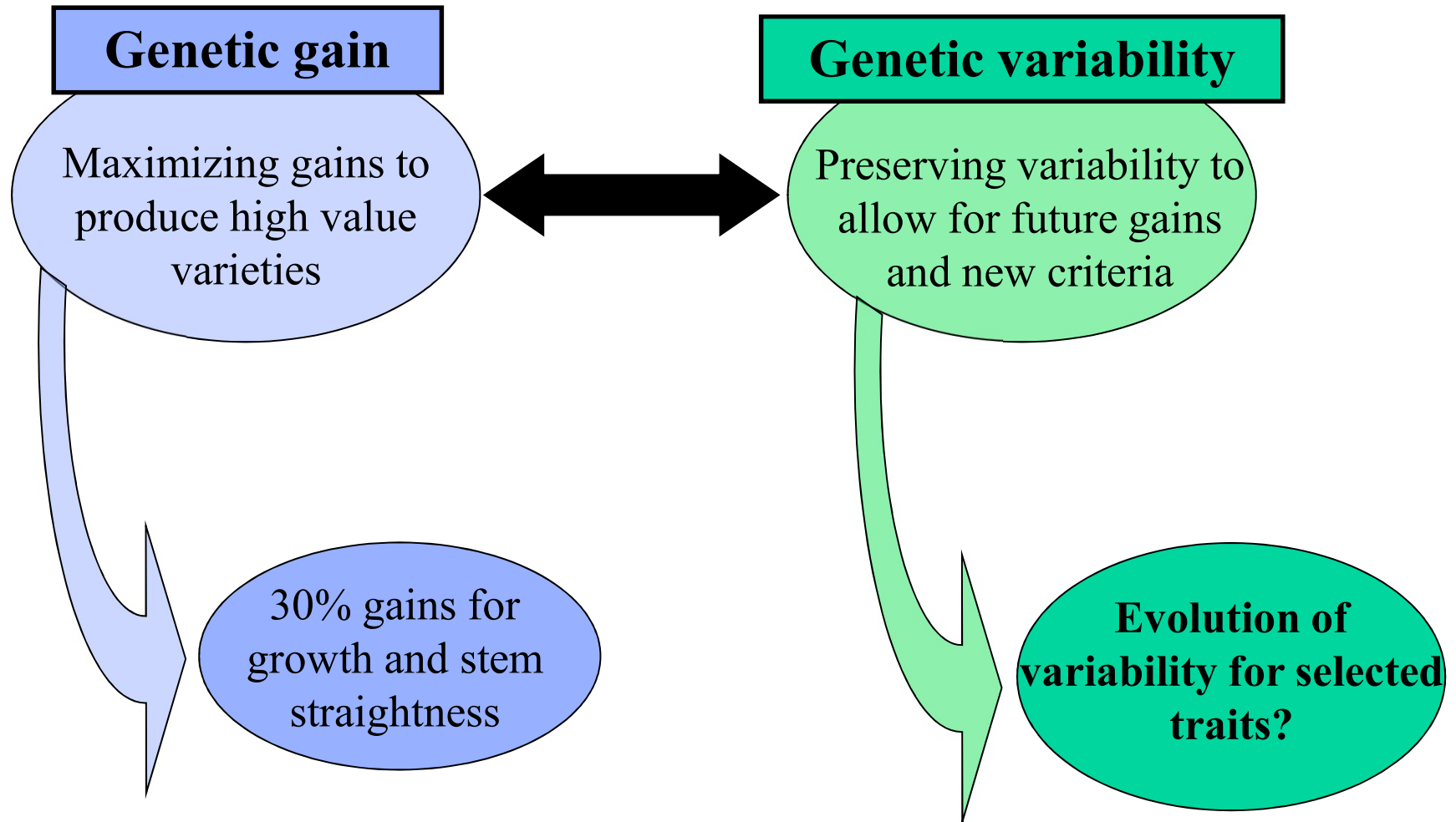
www.nature.com/hdy

ORIGINAL ARTICLE

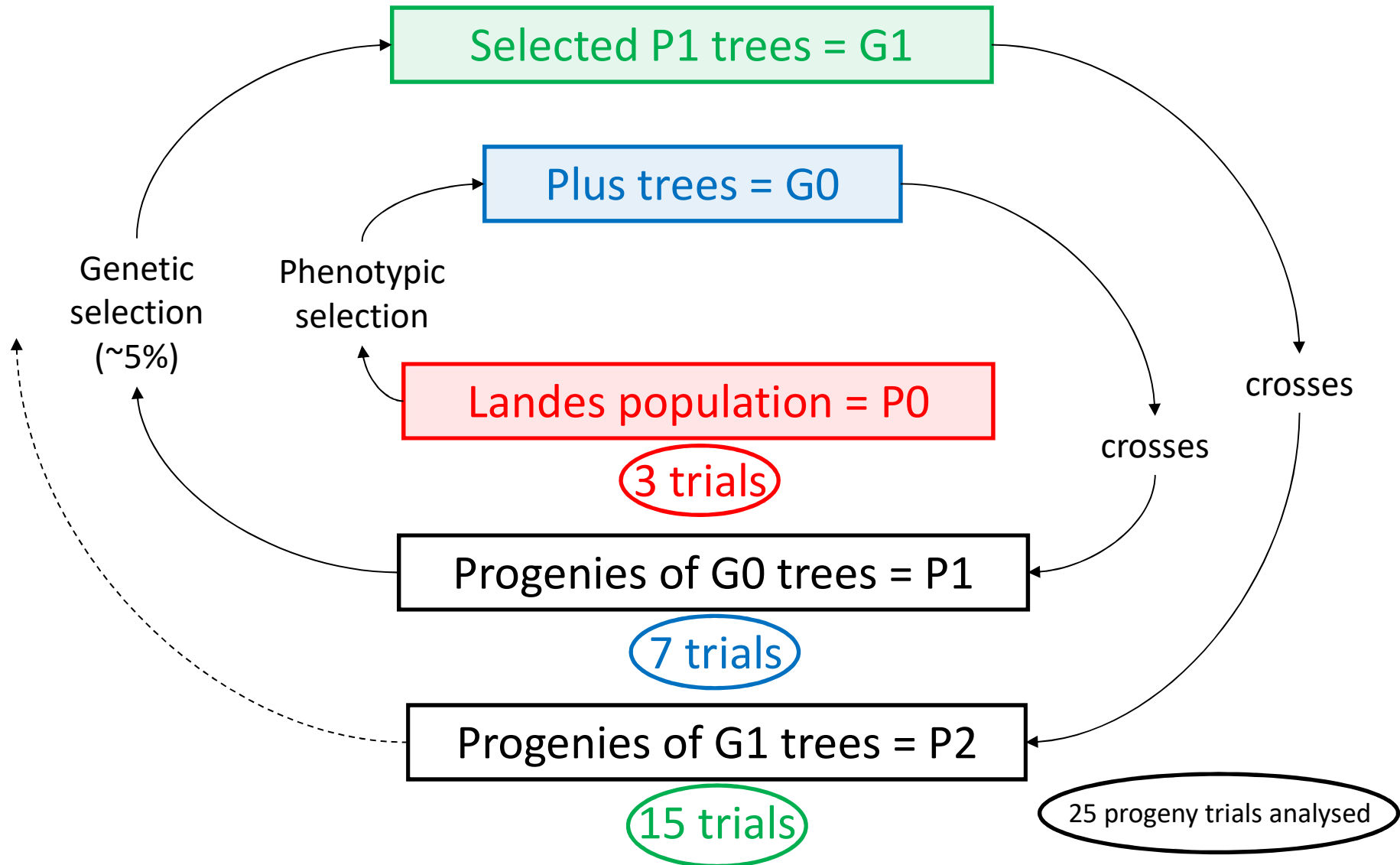
Evolution of genetic variation for selected traits in
successive breeding populations of maritime pine

L Bouffier, A Raffin and A Kremer
INRA, UMR1202 Biodiversity Genes and Communities, Cestas, France

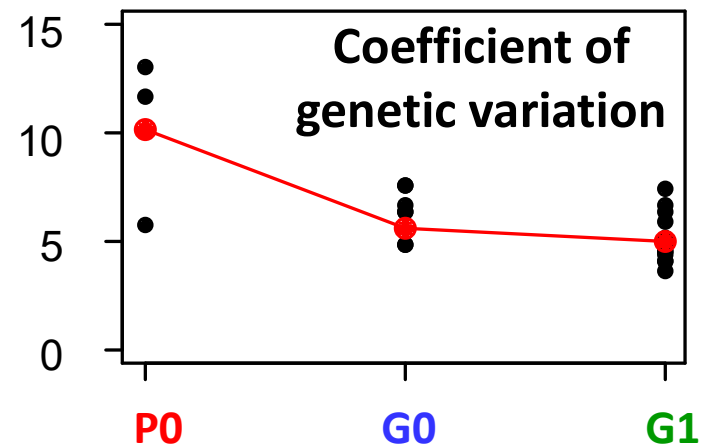
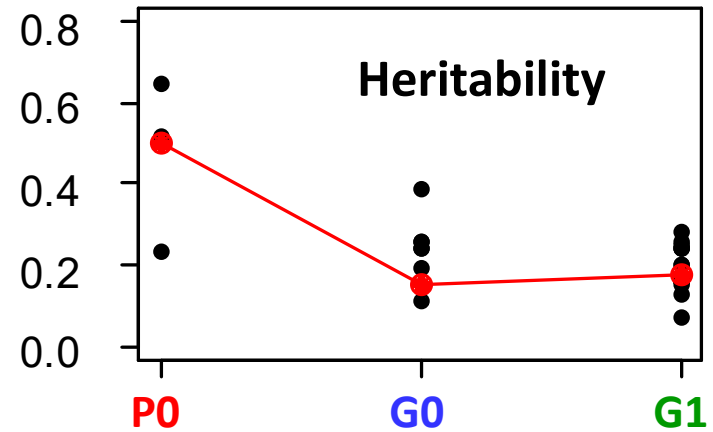
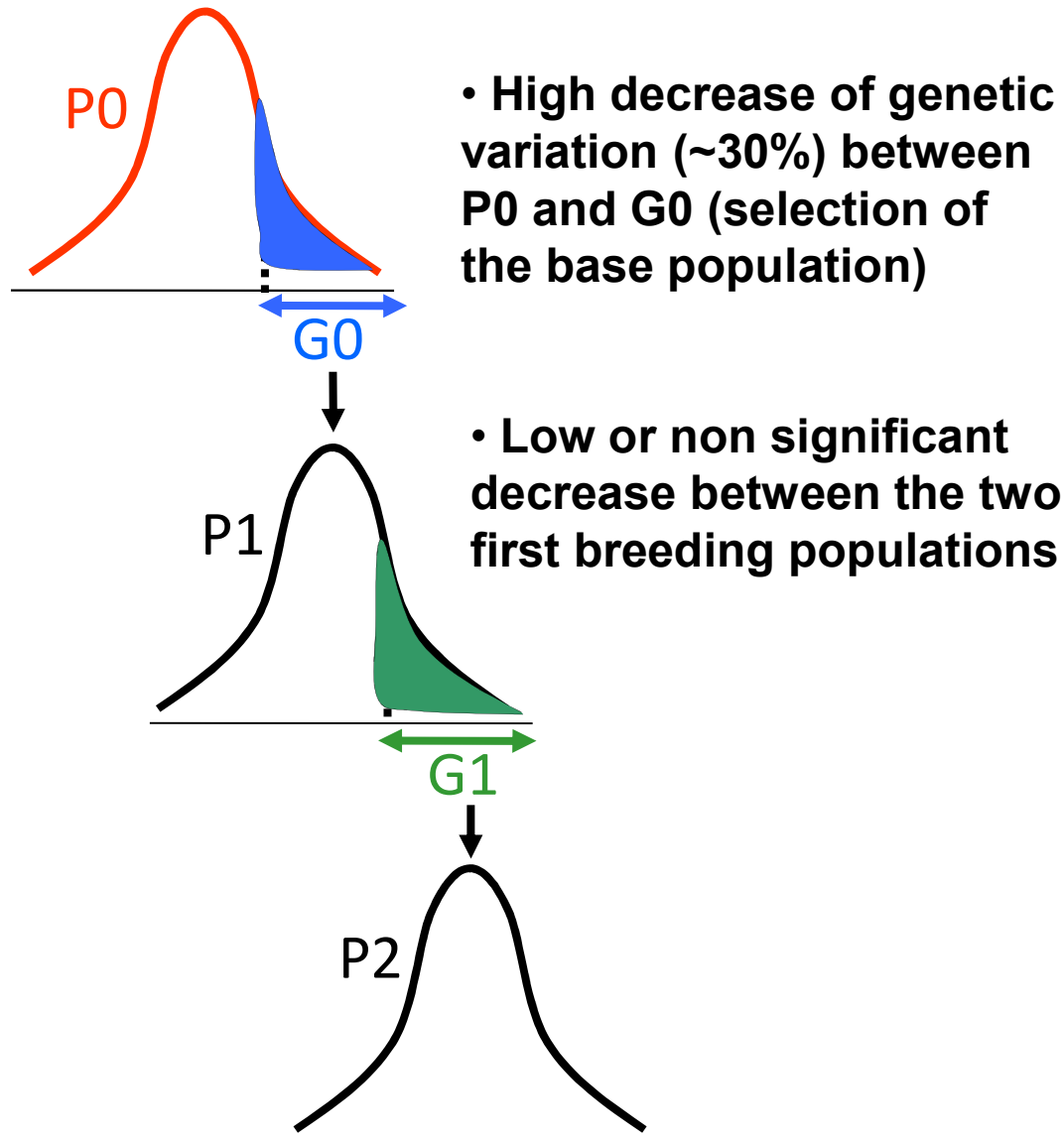
Trade-off between gain and variability



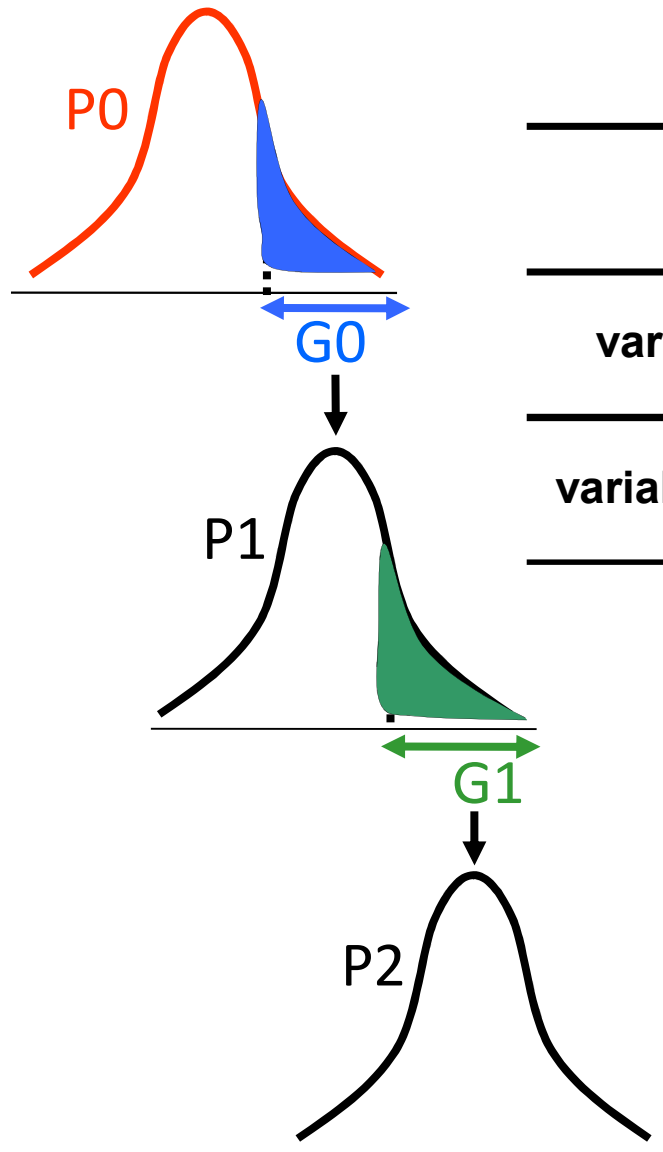
Breeding populations and progeny trials studied



Evolution of genetic variation for selection criteria



Evolution of genetic variation for wood density



		Densité du bois
héritabilité	population P0	0,53 (0,18)
	population G0	0,45 (0,09)
variabilité génétique	population P0	5,5% (1,0)
	population G0	5,1% (0,6)
variabilité phénotypique	population P0	7,5% (0,3)
	population G0	7,5% (0,2)

- Non significant decrease of genetic variation for wood density between P0 and G0

Evolution of mean
(varieties)

Growth

Wood density



Evolution of genetic
variation
(breeding population)



from P0 to G0
Stable or low decrease
between G0 and G1

Stable



Future genetic gains



New selection criteria