Survey of genetic diversity in European Populus breeding programs

Véronique Jorge, Arnaud Dowkiw, Patricia Faivre-Rampant, Marc Villar, Marie Pegard, Vincent Segura, Vanina Guérin, Marijke Steenackers, Lorenzo Vietto, Catherine Bastien

BioForA

INRA
SCIENCE & IMPACT

Survey of genetic diversity in European Populus breeding programs

CONTRIBUTORS to the present work :

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INRA Experimental unit GBFOR

GBFOR
Génétique et Biomasse Forestières
Unité Expérimentale ORléans

GENTREE

Unit BioForA

Our research objective

Management of forest genetic resources for sustainable timber production in a changing climate context

Individuals

Theme A
Better understand the construction of phenotypes of complex traits

Wood formation | Resistance to diseases | Reproduction (sexual/asexual)

Populations

Theme B
Analyse responses of populations under natural or artificial selection to a changing environment

Management Units (Conservation, Breeding)

Theme C
Optimize sustainable management of genetic diversity in natural and breeding populations

Genetic Resources for research

in- & ex-situ Conservation

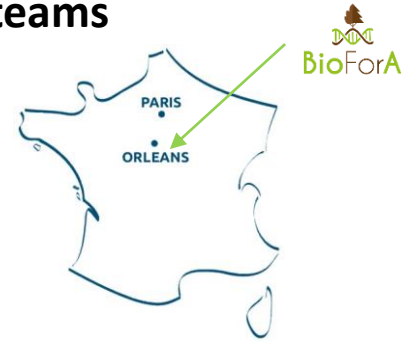
Breeding programmes

Operational Pole « Genetic Resources »

FRM production engineering.

Guidelines for FRM Use

- **Joint unit between INRA and ONF** (French National Forest Service)
- **~50 persons (40 perm.)**
- **4 teams**



Species studied : Poplars, Douglas Fir, Scot Pine, wild cherry, larches, ash

SUMMARY

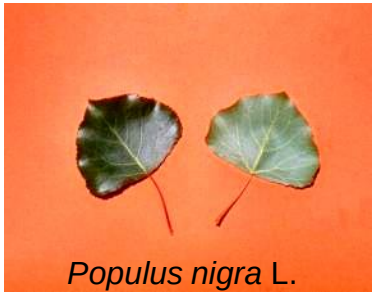
1. Poplars and poplar cultivars
2. Objectives of the study
3. Material and methods
4. Genotyping quality and discrimination between species
5. Diversity of genitors used in poplar breeding programs
6. Relatedness between cultivars
7. Diversity in multi-clonal varieties
8. Conclusions

1. Poplars and poplar cultivars

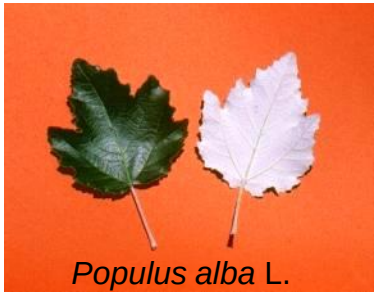
Poplars (genus *Populus*)

6 sections et 29 species
Dioecious

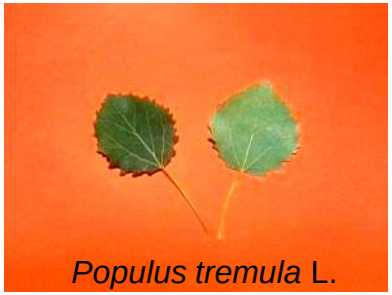
Populus nigra var 'Italica'



Populus nigra L.



Populus alba L.



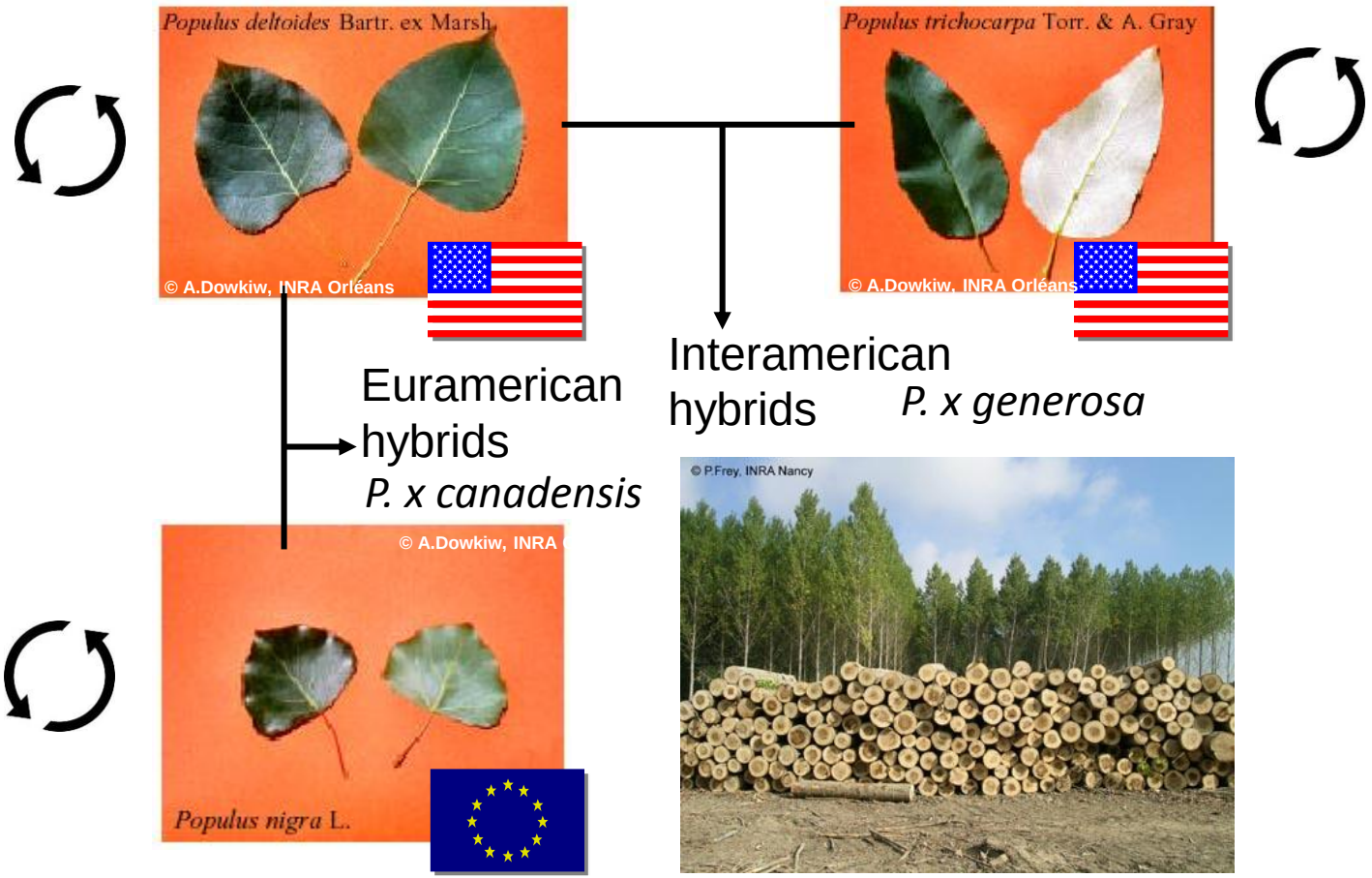
Populus tremula L.

Populus trichocarpa Torr. & A. Gray

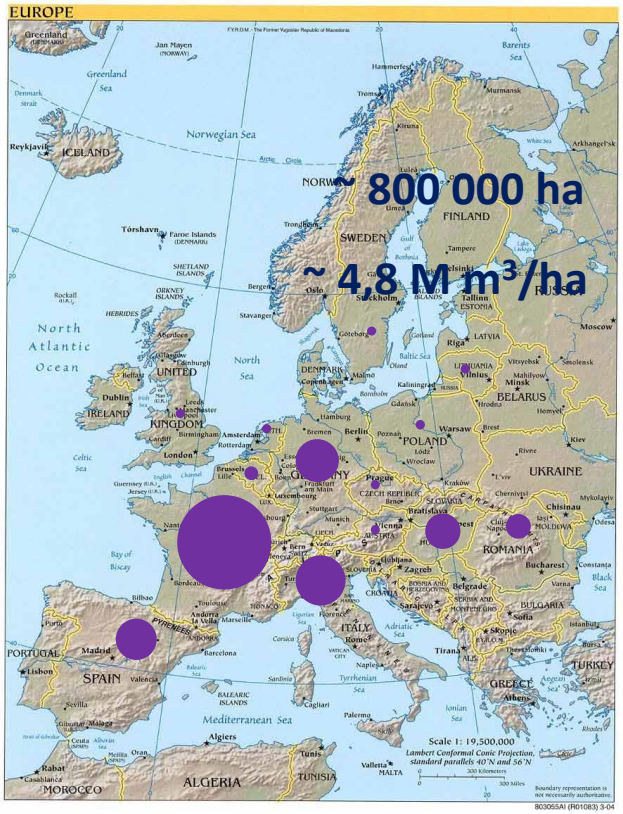
Populus deltoides Bartr. ex Marsh.

Breeding poplars

- Recurrent selection at intraspecific level
- Interspecific hybrids => hybrid vigour



Poplar cultivation and consequences



Figures from TreeBreedeX Monography contributions

List of registered material (2014)

- **172 monoclonal cultivars**
- **10 multi-clonal varieties**

But only few cultivars used by European countries …

Nb of clones representing 90% of planting stock (2007) :

France : 9 clones, I-214 (24%) - Triplo (10%)
Italy : 7 clones, I-214 (77%) – Villafranca (3%)
Belgium : 16 clones, Koster (23%) - Unal (1%)
Spain : 5 clones, I-214 (70%)

Poplar cultivation and consequences

- Monoclonal stands
- Few cultivars used with « fashion » effect
- Diseases outbreaks in a *P. deltoides x P. trichocarpa* context

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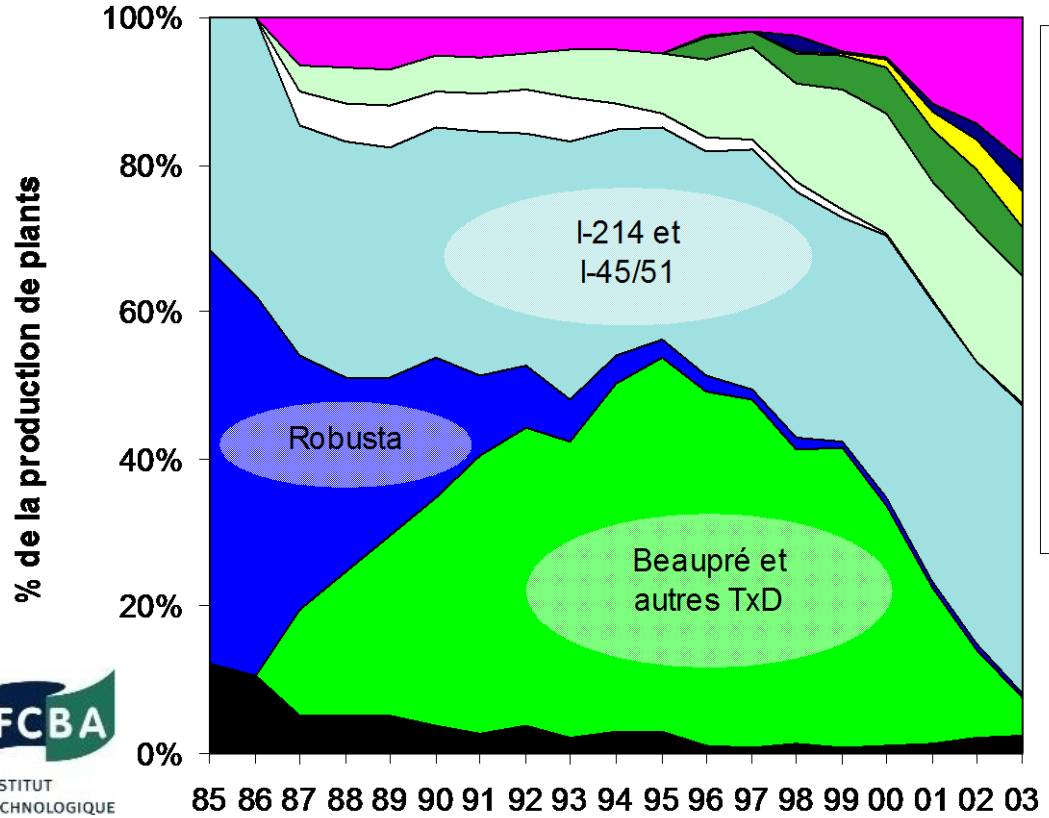

FCBA INSTITUT TECHNOLOGIQUE

Poplar cultivation and consequences

- Cultivated (exotic, ornemental clones) and native poplars often coexist in the landscape
- Introgression as a potential risk for natural resources

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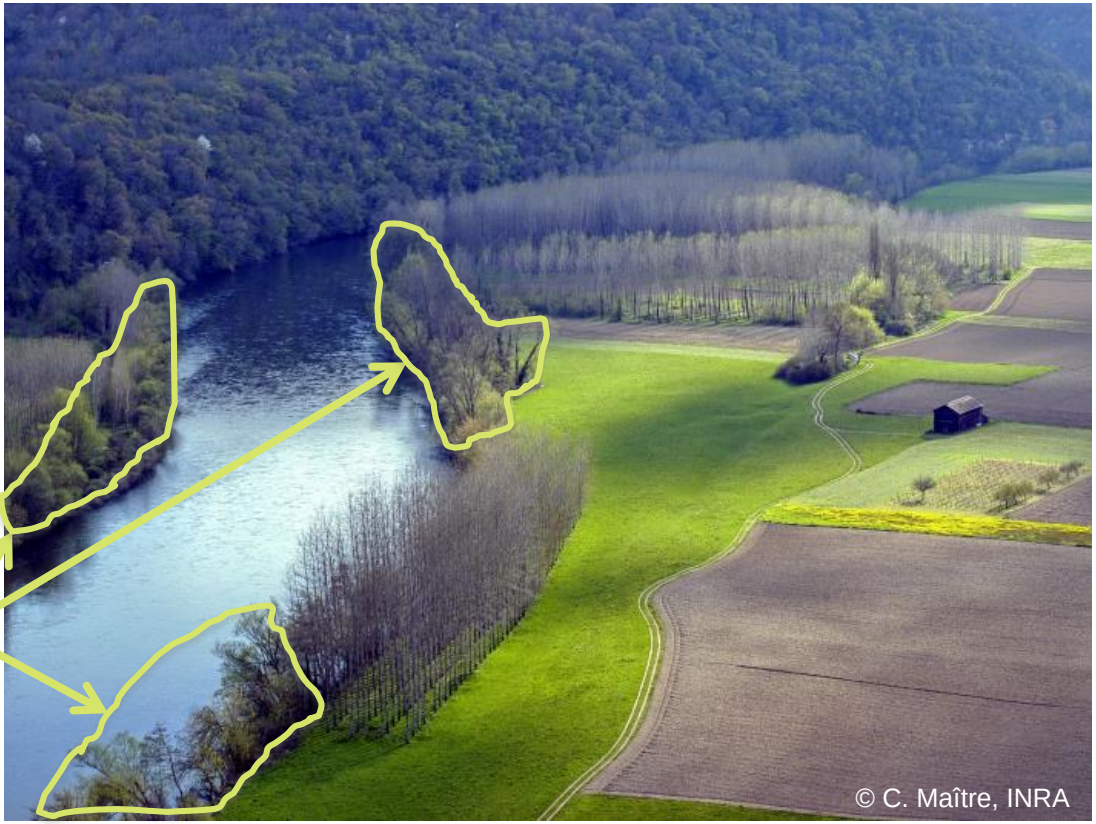
Black poplar



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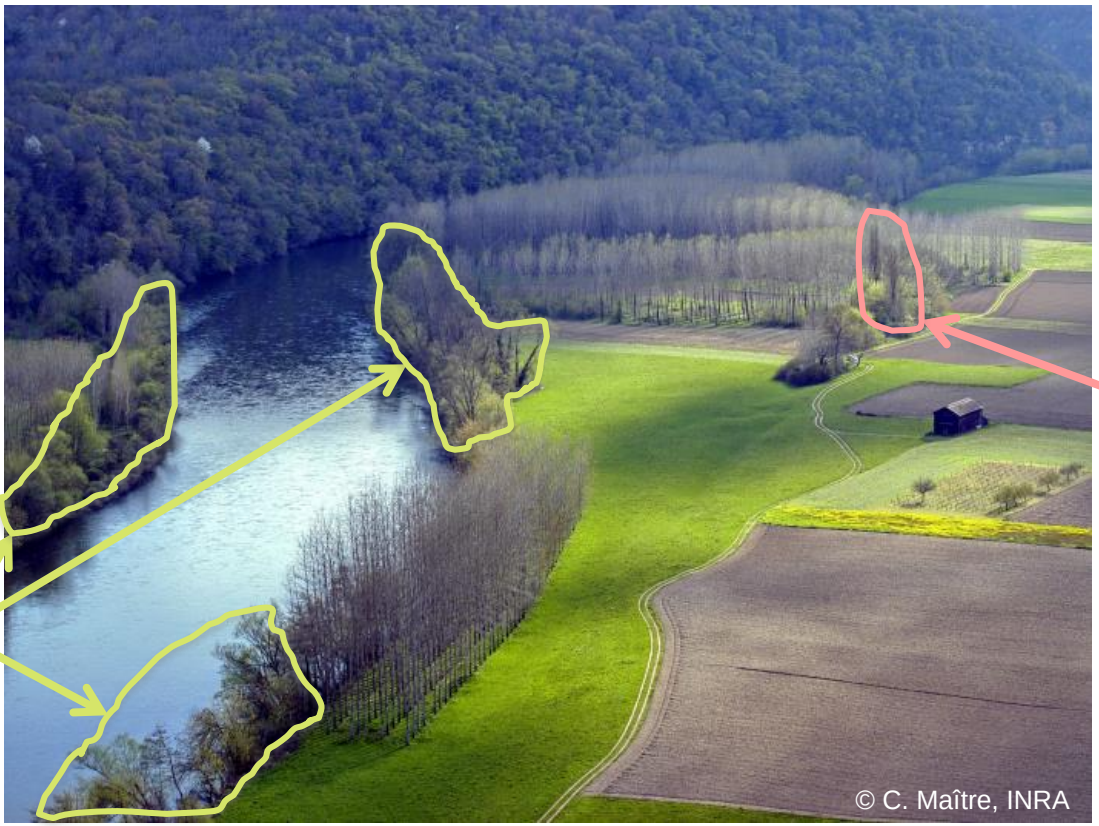

Lombardy poplar
« Italica »

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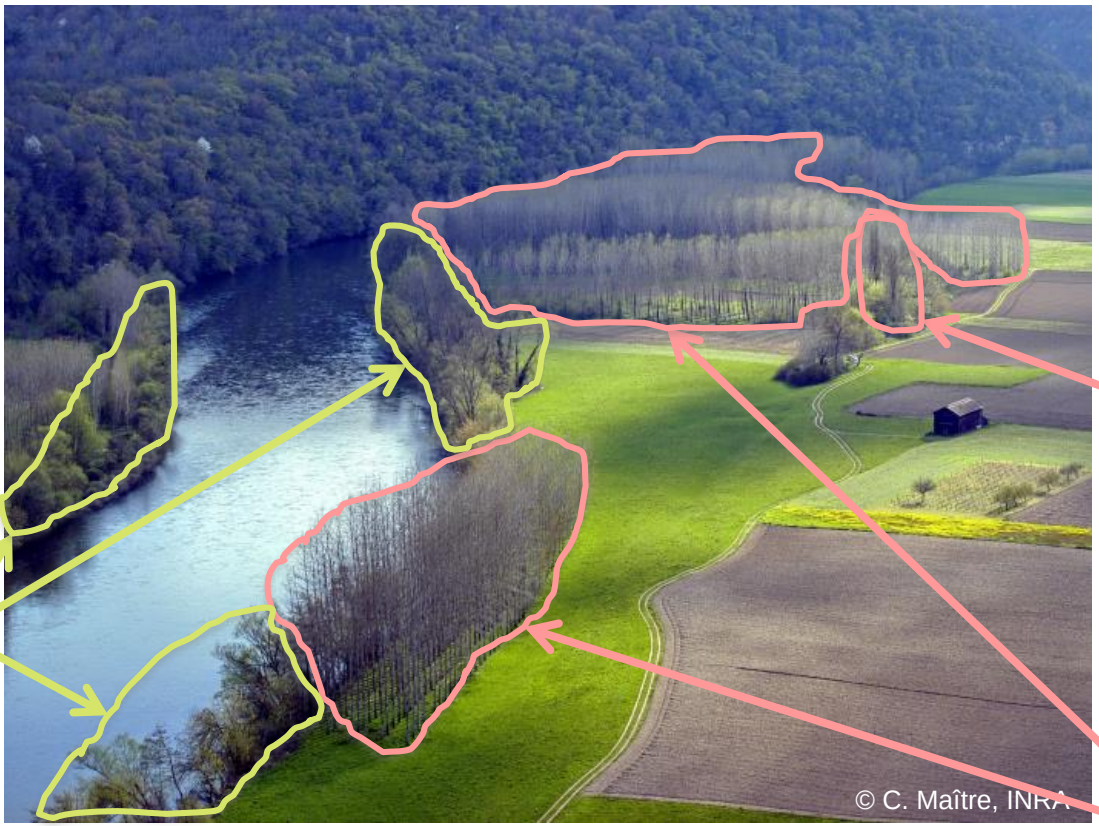


Lombardy poplar
« Italica »

cultivated poplars stands

2. Objectives of the study

Gentree (H2020) project – WP2

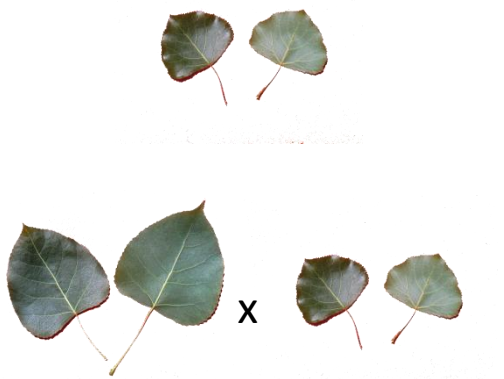
Optimising the management and sustainable use of forest genetic resources in Europe

WP2 – Innovative breeding strategies based on the rational use of forest genetic resources

Task 2.2:

Design and Implementation of allele and genotype sampling strategies to enrich breeding populations

- Comparative analysis of genetic diversity in natural / breeding populations: ***Populus nigra*** in EU breeding programmes
- ***P. deltoides*** *x* ***P. nigra*** cultivars with high tolerance to pests and diseases and high productivity even in northern conditions : take value of large genetic diversity available from natural *P. nigra* ressources



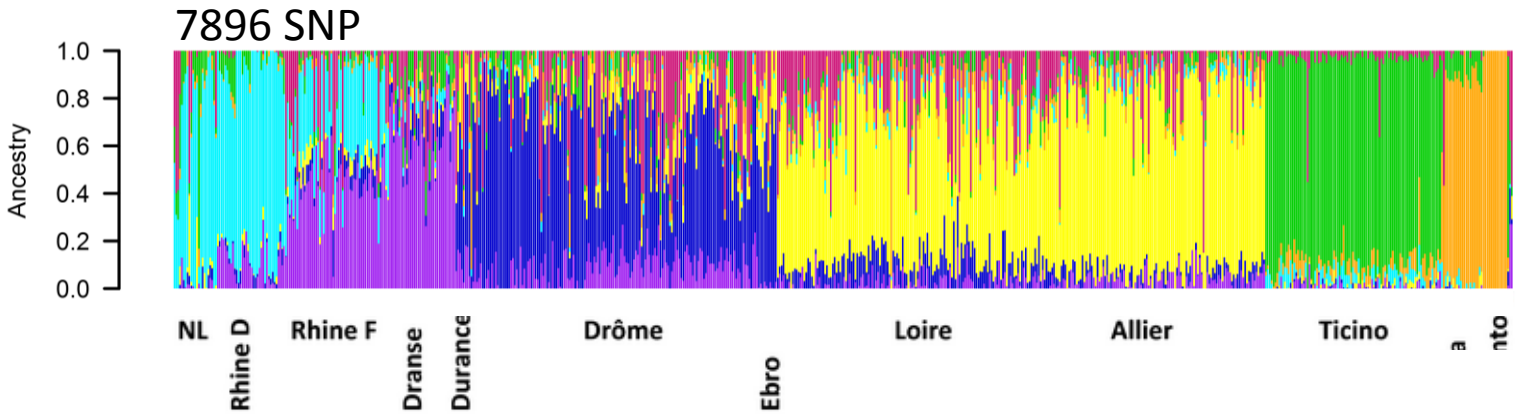
3. Material and methods

Plant material

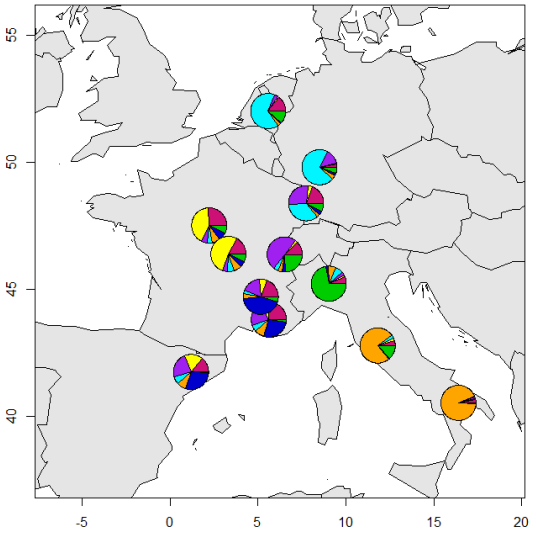
- **Cultivars**
  incl. ‘Bellini’, Italian cultivar !
- **Genitors from active breeding programs** (BE, FR, IT)
- **Multi-Clonal Varieties**

type	origin	#
Cultivars *P. nigra*, ornemental		Italica, Thevestina
Cultivars P. nigra registered	F/I, NL	Jean Pourtet, Vereecken
Cultivars *P. x canadensis*	Belgium	5
	France	5 (old cultivars)
	Hungary	2
	Italy	29
	NL	5
	Poloni	6
Genitors	Alasia (Italy)	10 (DN)
	CREA (Italy)	28
	GIS (France)	39
	INBO (Belgium)	11 (6 DN; 5 N)
Multiclonal Varieties (MCV)	France	2 (25 ind. each)

10 K SNP array used characterise genetic diversity in *P. nigra* at European scale

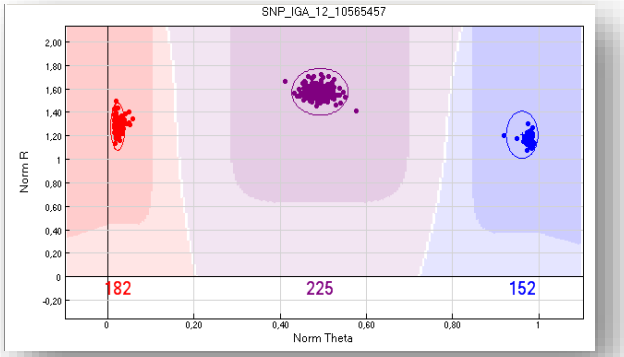


- Diversity structured according to drainage systems.
- An **ancestral** cluster clearly admixed in almost all predefined populations.
- Introgression from cultivated stands ?



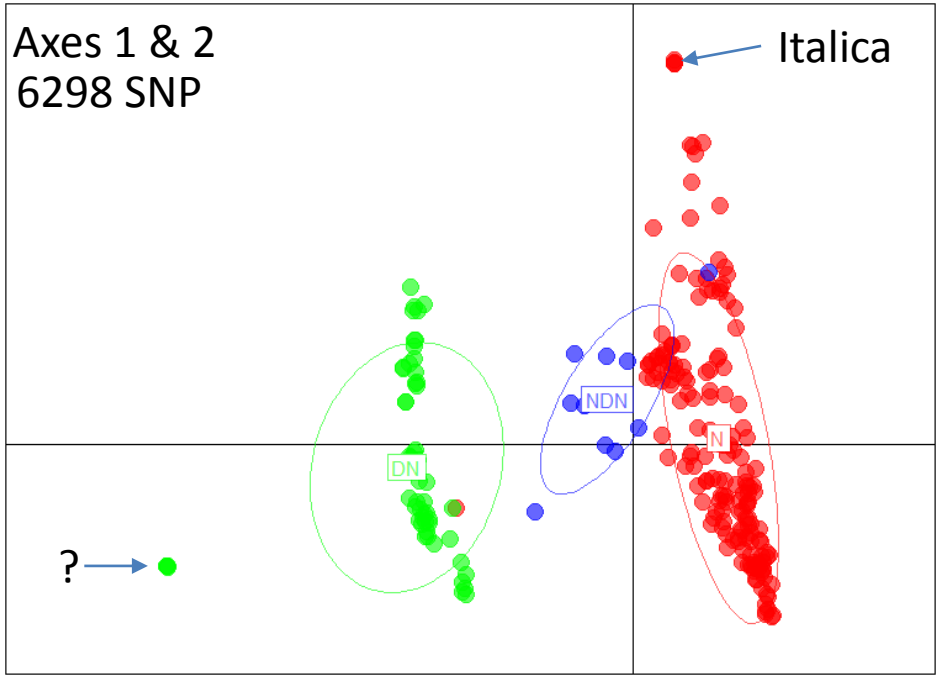
4. Genotyping quality and discrimination between species

Genotyping quality



- Quality of initial genotyping : **11% SNP failed** => 9 127 SNPs to use
- Overlap with 2 previous genotyping campaigns including natural populations => **6 298 SNPs**
- Selection of SNP to answer different questions :
  - **~1 200 SNP** selected evenly distributed on the genome to describe diversity in poplar breeding programs.
  - Remark : Only **802 SNP** showed 3 genotypic classes in the set of *P. deltoides x P. nigra* cultivars => those SNP polymorphic in *P. deltoides.*

Discrimination between species



« hybrid » cultivars
+ others DN, DNxN

P. nigra genitors
+ VMC

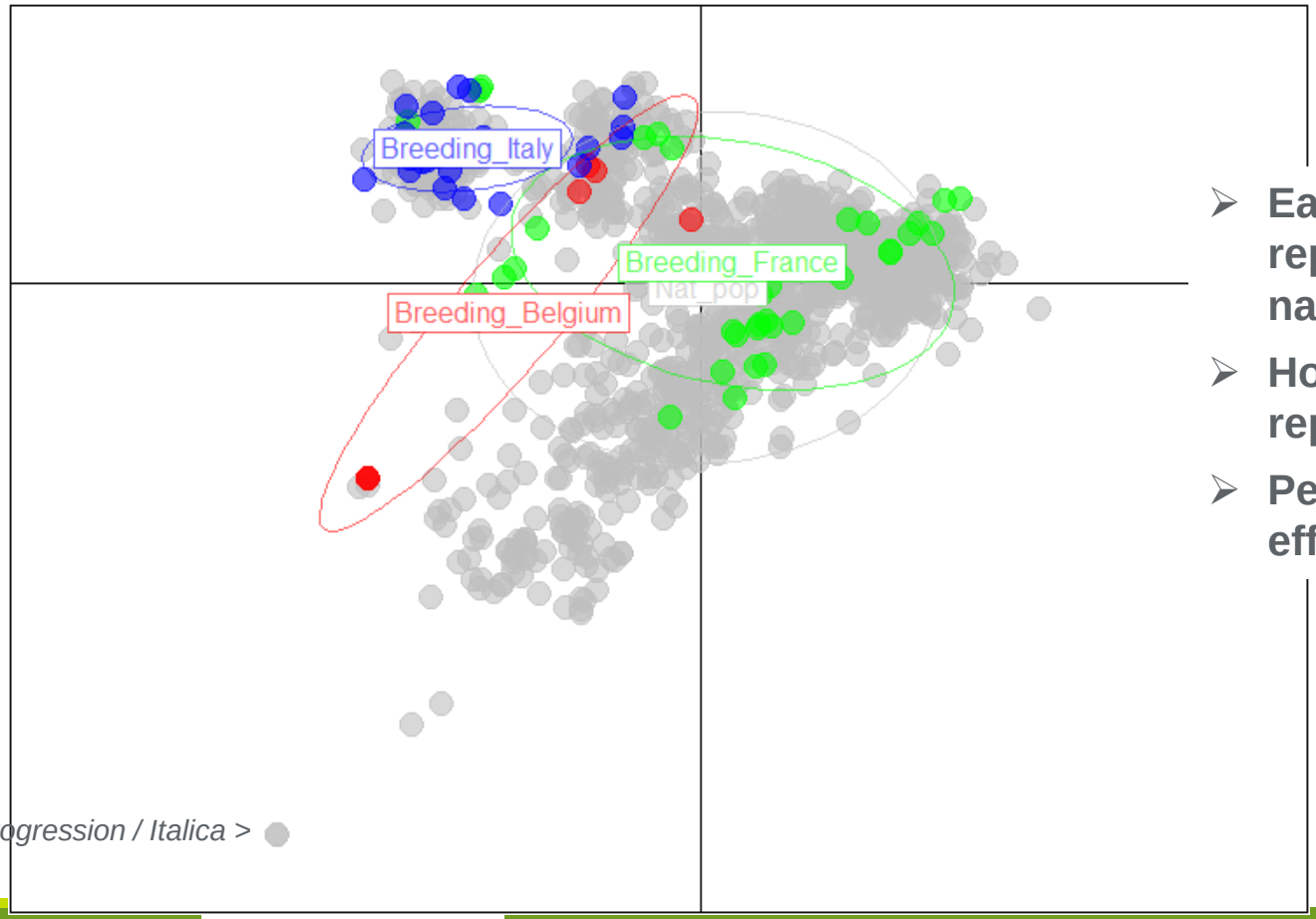
- Potential of the genotyping tool to discriminate *Populus* species and hybrids (axe 1).
- Impact of ornamental *Populus nigra* cv (Italica, axe 2).

<u>Perspectives</u> :
Development of discriminant markers for axe 1 and axe 2

5. Diversity of genitors used in poplar breeding programs

Large diversity and low introgression / Italica, except for Belgium breeding population

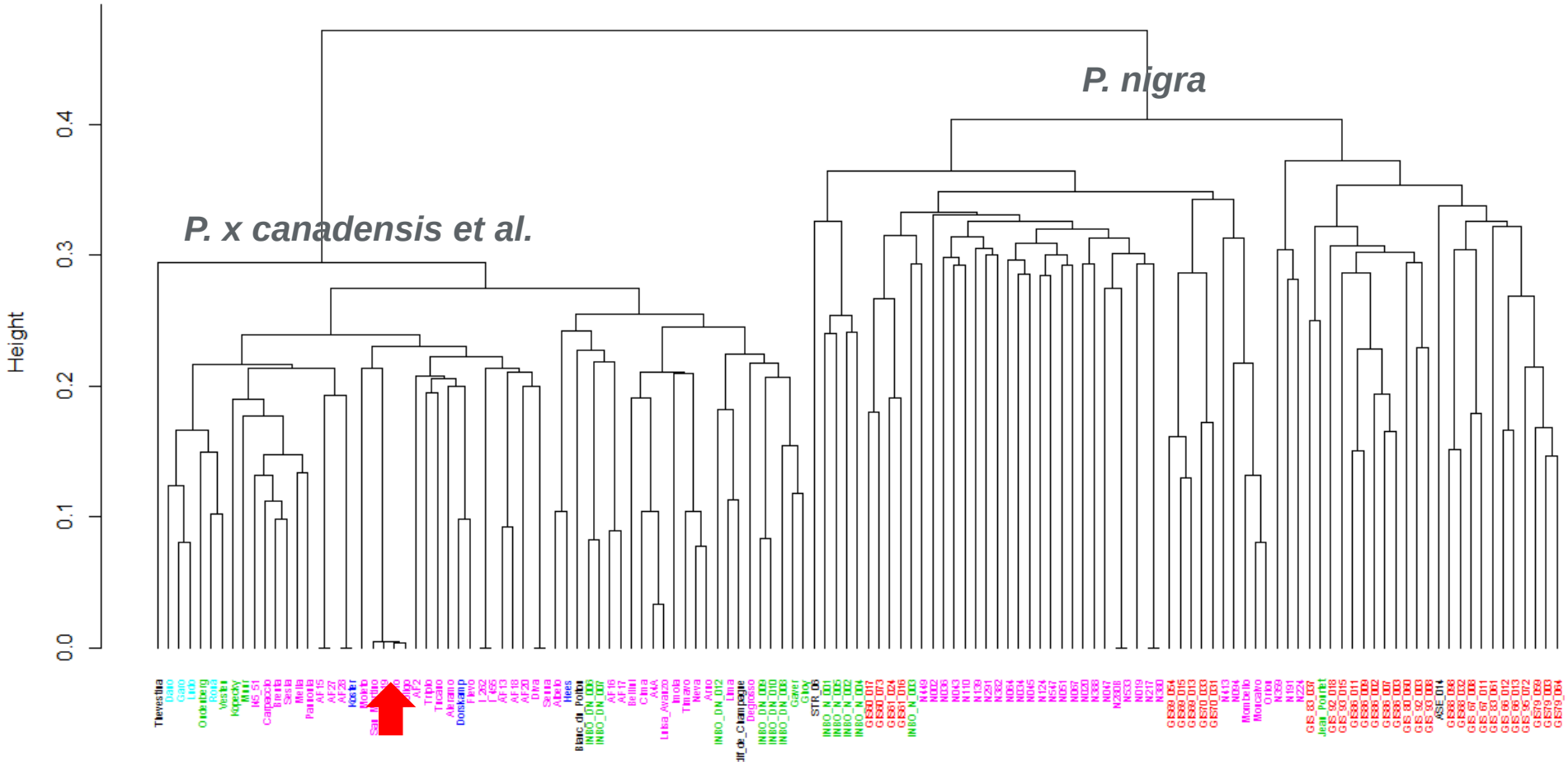
P. nigra genitors vs. Natural populations (in grey)
PCA axes 1 & 2, 1128 SNP



- Each breeding population representative of the local natural population
- How much this diversity is representative ?
- Perspectives: compare effective population size.

6. Relatedness between cultivars

Genetic distances

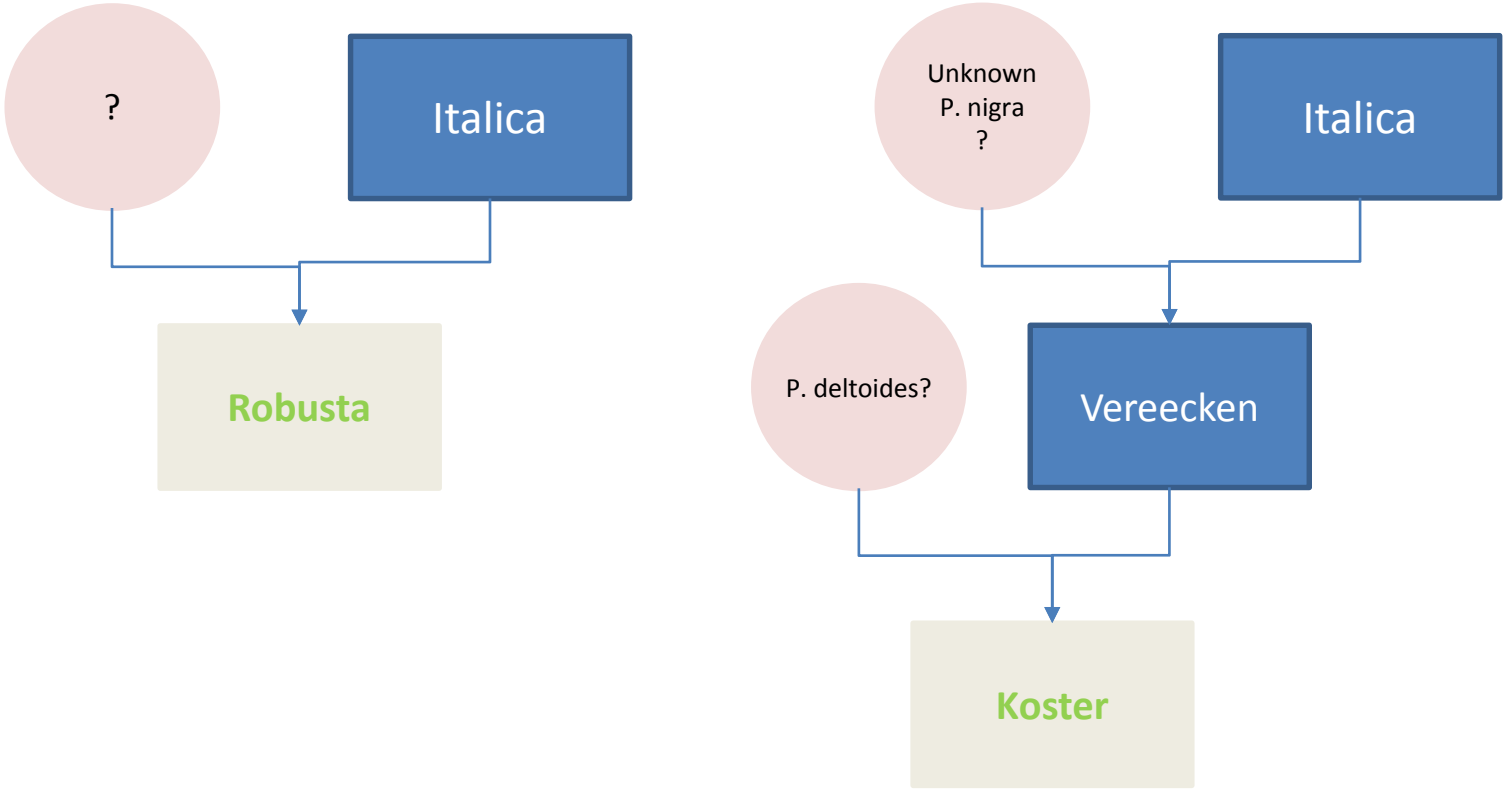


- Confirmation of previous conclusions : distinction between taxa, genitors pooled/breeding programs
- Different levels of relatedness inside breeding programs
- Close relationship between some cultivars
- Pure *P. deltoides among declared P. deltoides x P. nigra hybrids ?*

1128 SNPs
Belgium
France (GIS, Poloni)
Italy
Netherland
+ old cultivars

Evidence of the use of Italica in poplar breeding

- Resolving pedigree of some culitvars.

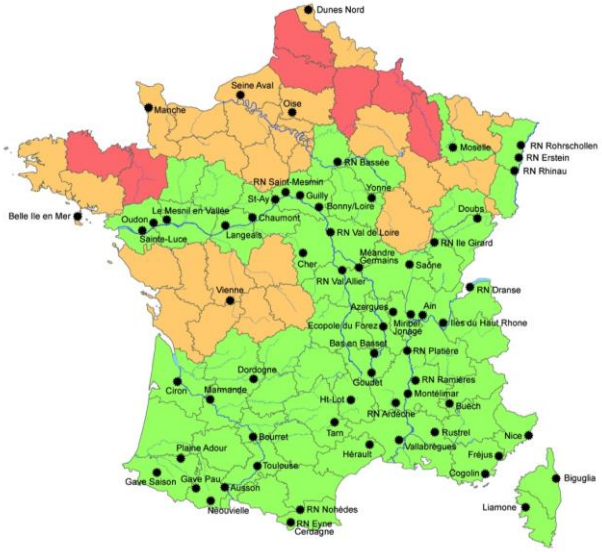


Results from Colony, Jones & Wang 2010

6. Diversity in multiclonal varieties

Multi-Clonal Varieties of *Populus nigra*

Target in deployment = ecological restoration of river banks



Occurence of the species:

- Present in riparian forests
- Present as isolated trees
- absent

General rules of a MCV of black poplar

- Individuals of the species *Populus nigra !*
- Variety by river basin (six in France)
- Largest diversity as possible (geographic, ecologic and genetic), representative of the river basin
- Choice of 25 genotypes per variety

Development of cost- and time-effective breeding methods = T2.3 of GenTree project

Multi-Clonal Varieties of *Populus nigra*

Actual methodology

Species descriptors and introgression

- In situ phenotype : tree shape, bark characteristics, stem characteristics, leaf shape, bud shape, male and female catkins
- SSR markers

Populus nigra var. Italica

One variety per river basin & large ecological regions

GRECO : 'large ecological regions' of the French National Forest Inventory

Largest diversity as possible

- Sex ratio
- No clone (SSR markers)

Traits evaluated in trials :

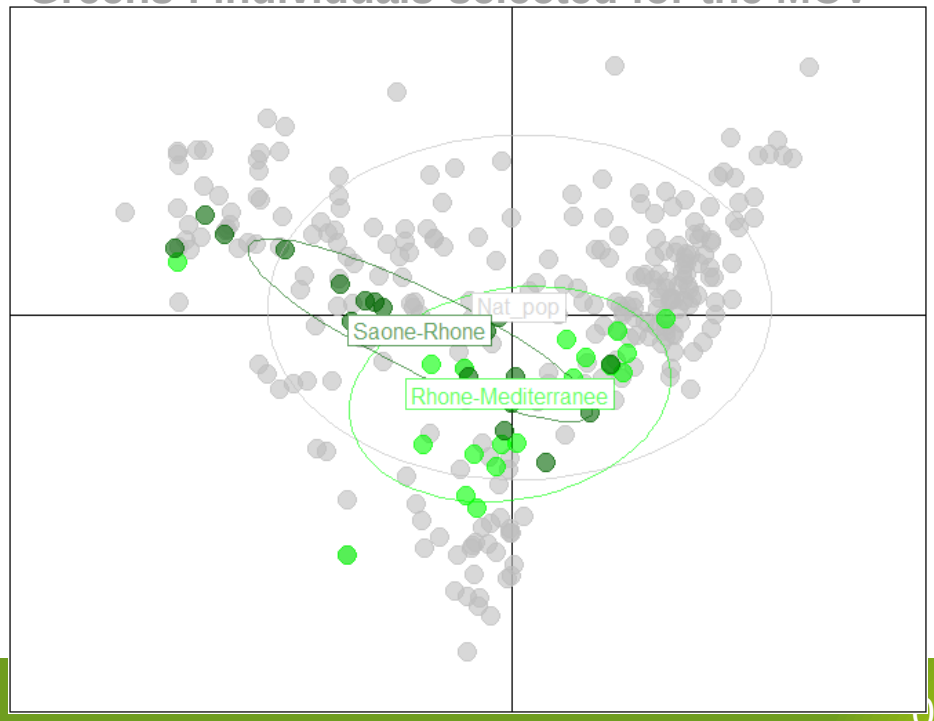
- Phenology: max. variability
- Height and diameter: eliminate extremes to avoid competiton
- Branching patterns: avoid fastigiate

Multi-Clonal Varieties of *Populus nigra*

- **Registration** on French national register of 2 new multi-clonal varieties of *Populus nigra* for the Rhône river basin
- Validation of the low-cost strategy with SNP genotyping

Populus nigra multiclonal variety: 2 yrs-old plants

1128 SNPs
Grey : Rhone natural populations
Greens : individuals selected for the MCV



8. Conclusions

Conclusions

- 10K SNP array valuable tool to evaluate diversity in *P. nigra* but limited for *P. deltoides* (but not nul ?)
- Actual breeding programs used local *P. nigra* diversity => but hybrid cultivars bred are registered at European level
- Validation of a low-cost selection methodology for MCV

How to design and implement allele and genotype sampling strategies to enrich breeding populations ?

GenTree Task 2.4

Improvement of genetic diversity management in intensive breeding programmes

Genomic Selection
explicite management of genetic diversity
Optimisation introduction new diversity

Graciès !

Projects

NovelTree

GENTREE

INRA Selgen project
Breed2Last

Partners

GIS peuplier

irstea

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