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

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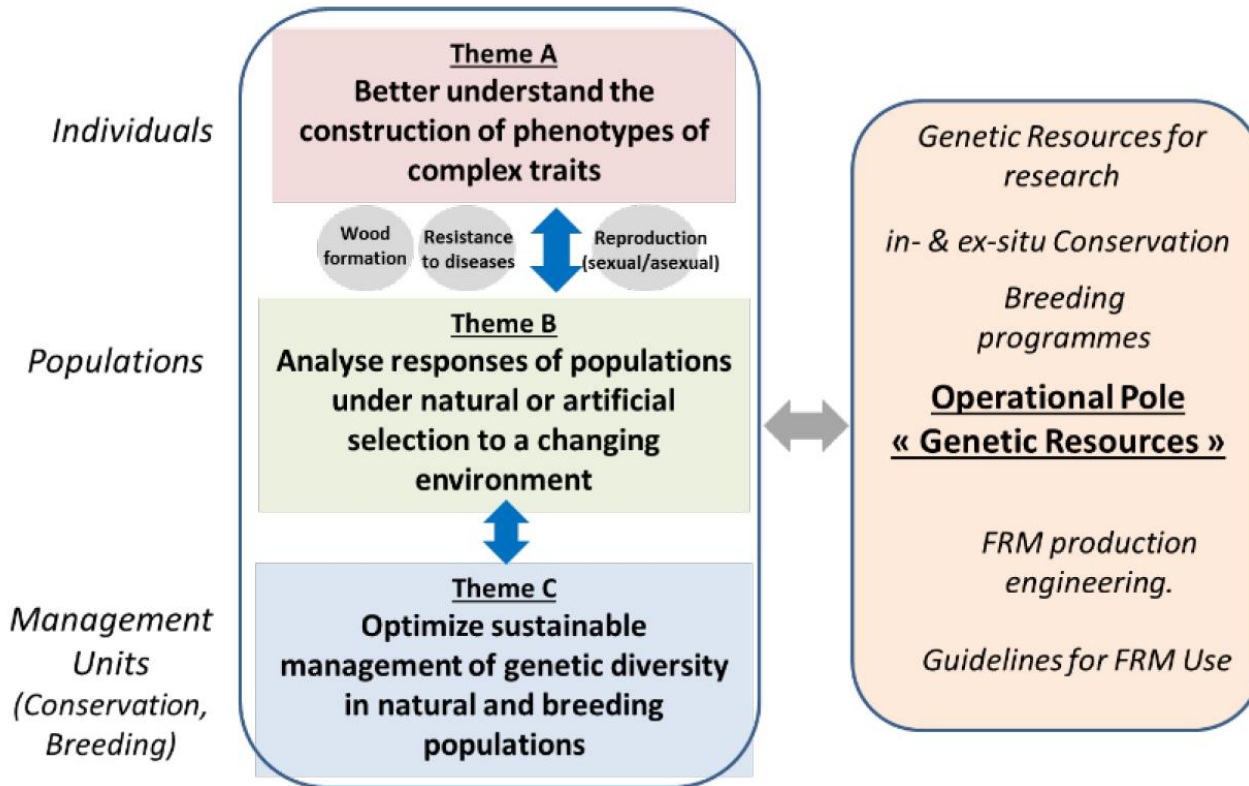# Survey of genetic diversity in European Populus breeding programs

CONTRIBUTORS to the present work :
V. Jorge, A. Dowkiw, P. Faivre-Rampant, M. Villar, M. Pegard, V. Segura, V. Guérin, M. Steenackers, L. Vietto, C. Bastien
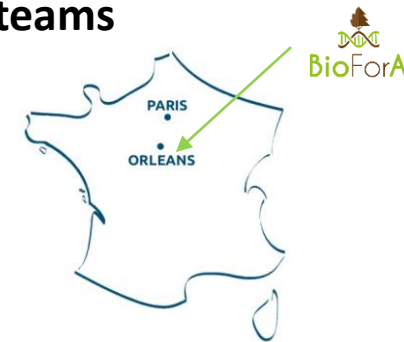INRA Experimental unit GBFOR

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

Theme A
Better understand the construction of phenotypes of complex traits

Individuals

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)

Office National des Forêts

- **~50 persons (40 perm.)**
- **4 teams**

BioForA

PARIS

ORLEANS

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

INRA SCIENCE & IMPACT

GENTREE

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**
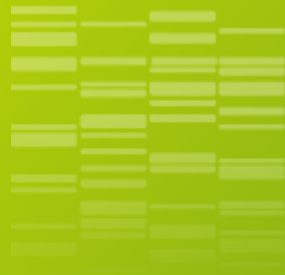
8. **Conclusions**

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.

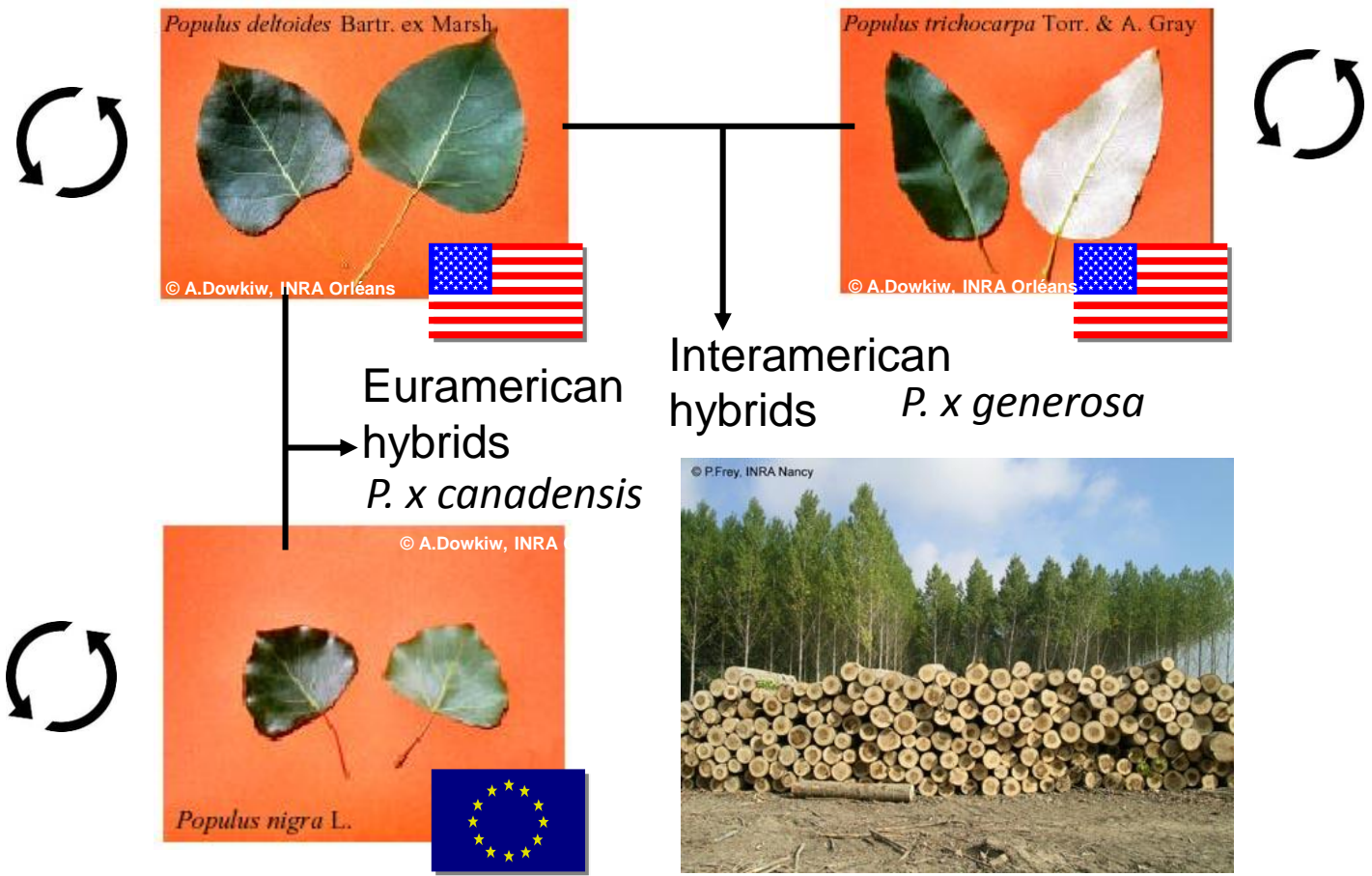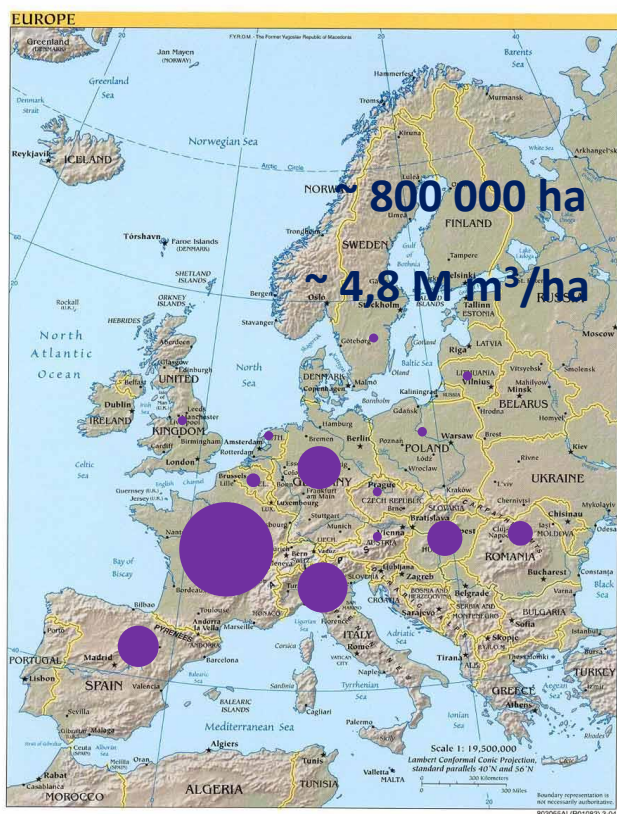*Populus trichocarpa* Torr. & A. Gray

Populus deltoides Bartr. ex Marsh.

Breeding poplars

> ➢ **Recurrent selection at intraspecific level**
> ➢ **Interspecific hybrids => hybrid vigour**

Populus deltoides Bartr. ex Marsh

© A.Dowkiw, INRA Orléans

Populus trichocarpa Torr. & A. Gray

© A.Dowkiw, INRA Orléans

Euramerican hybrids
P. x canadensis
© A.Dowkiw, INRA O

Interamerican hybrids

P. x generosa

© P.Frey, INRA Nancy

Populus nigra L.

Poplar cultivation and consequences

~ 800 000 ha

~ 4,8 M m³/ha

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%)
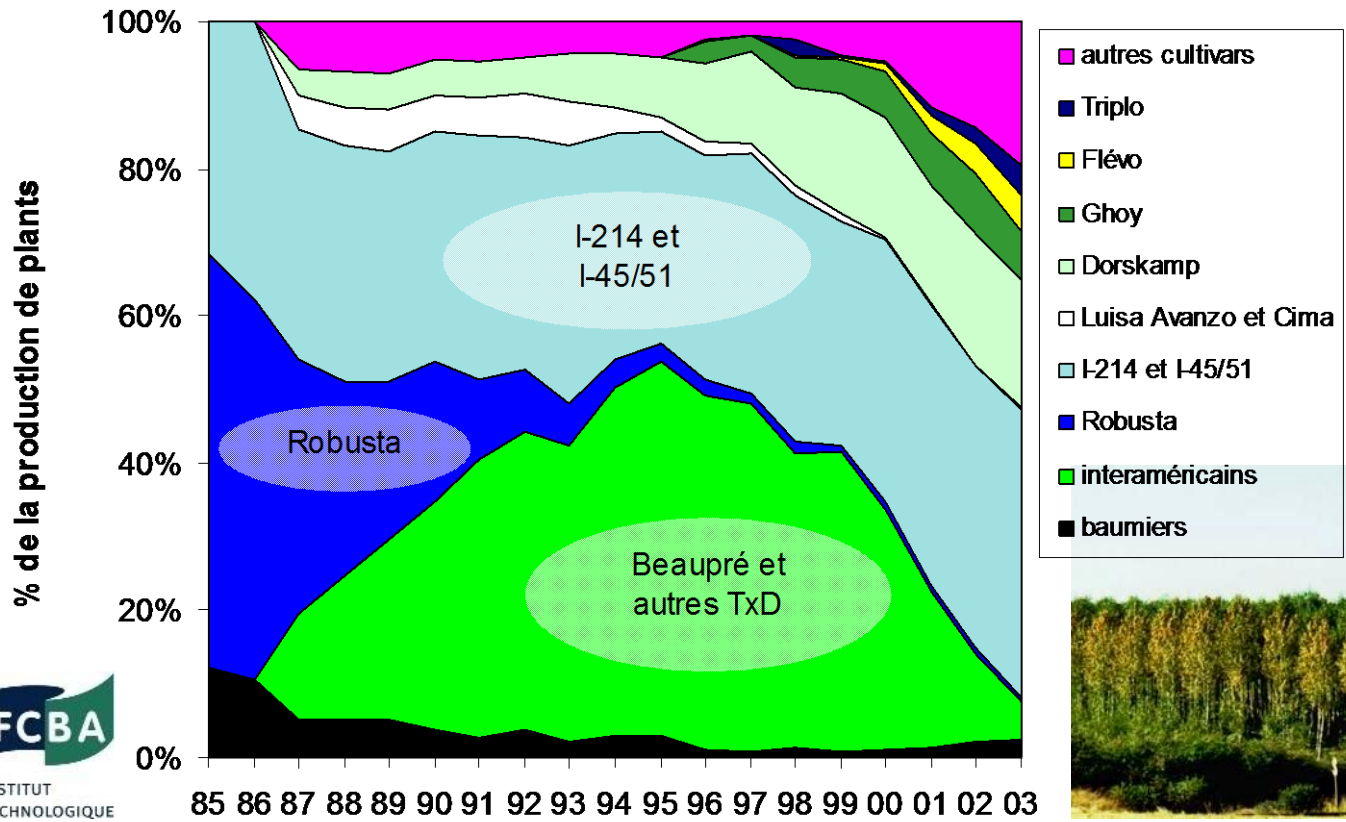Belgium : 16 clones, Koster (23%) - Unal (1%)
Spain : 5 clones, I-214 (70%)

Poplar cultivation and consequences

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

©S. Bisoffi

% de la production de plants

Legend:
- ■ autres cultivars
- ■ Triplo
- ■ Flévo
- ■ Ghoy
- □ Dorskamp
- □ Luisa Avanzo et Cima
- ■ I-214 et I-45/51
- ■ Robusta
- ■ interaméricains
- ■ baumiers

Chart labels:
- I-214 et I-45/51
- Robusta
- Beaupré et autres TxD

X-axis: 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03

Année

Poplar cultivation and consequences

➢ **Cultivated (exotic, ornemental clones) and native poplars often coexist in the landscape**

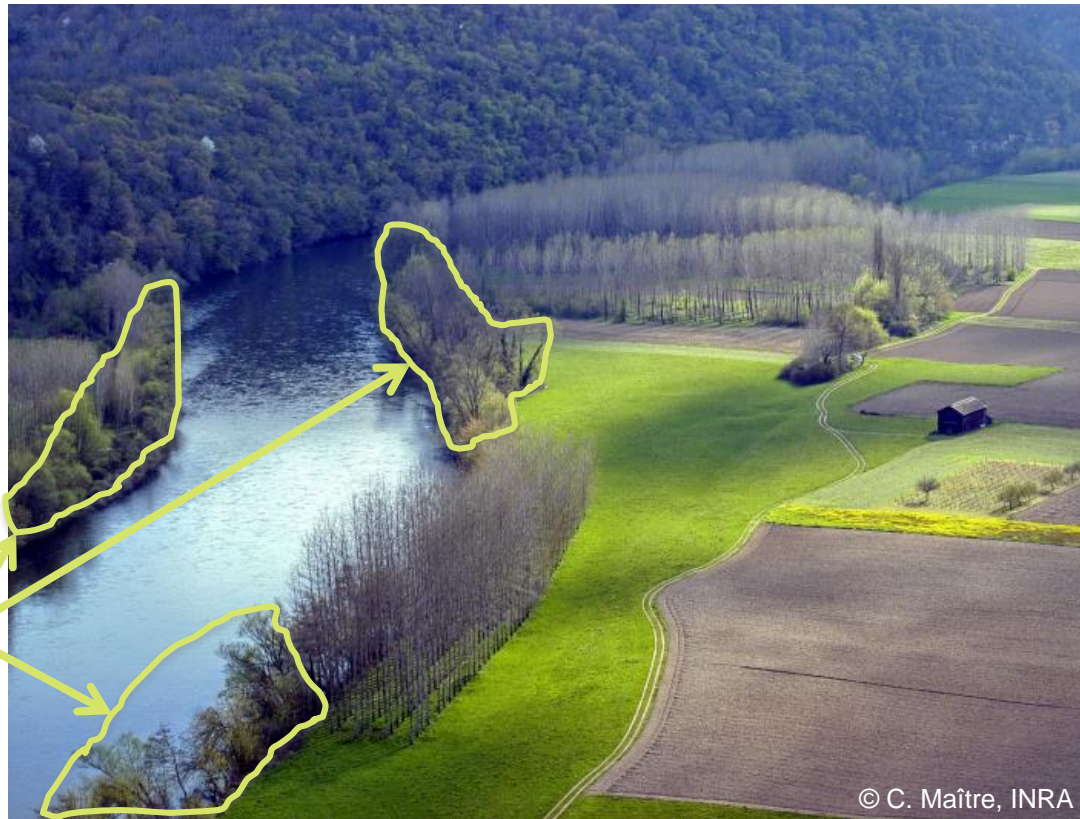➢ **Introgression as a potential risk for natural resources**

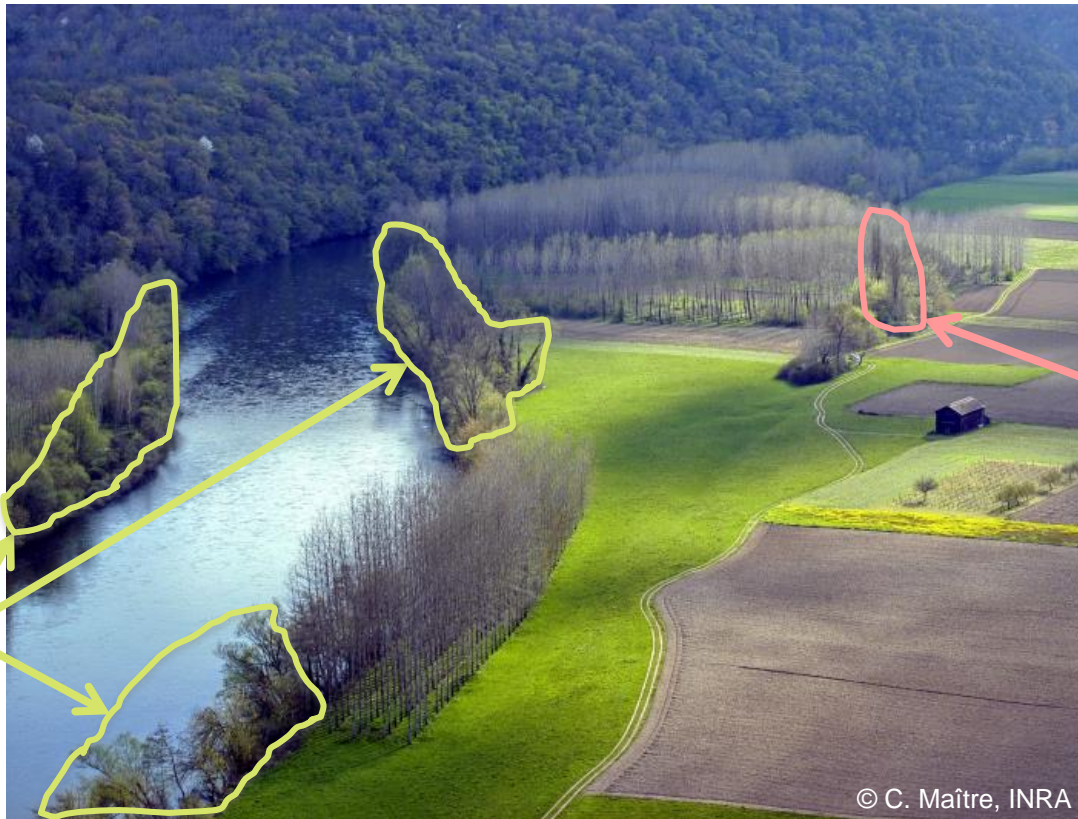© C. Maître, INRA

Poplar cultivation and consequences

➢ **Cultivated (exotic, ornemental clones) and native poplars often coexist in the landscape**

➢ **Introgression as a potential risk for natural resources**


Black poplar

© C. Maître, INRA

Poplar cultivation and consequences

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➢ **Introgression as a potential risk for natural resources**

Black poplar

Lombardy poplar
« Italica »

© C. Maître, INRA

Poplar cultivation and consequences

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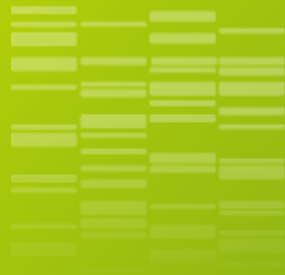

Black poplar
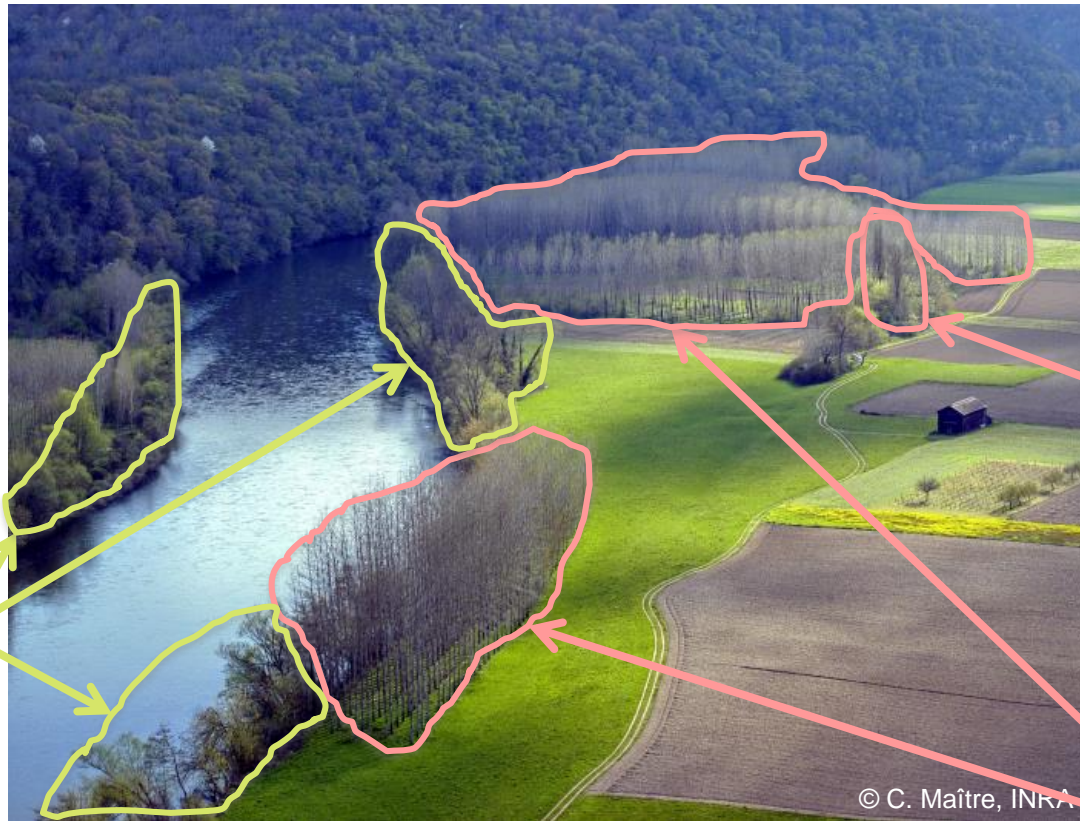
Lombardy poplar
« Italica »

cultivated poplars stands

© C. Maître, INRA

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
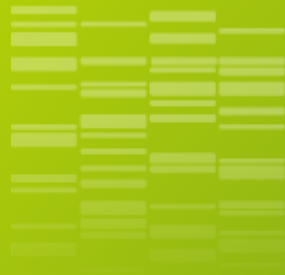
Task 2.2:

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**
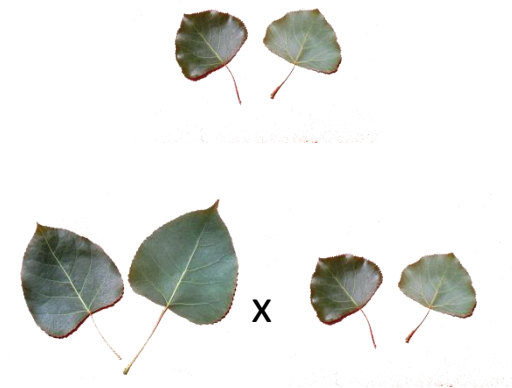
3. Material and methods

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
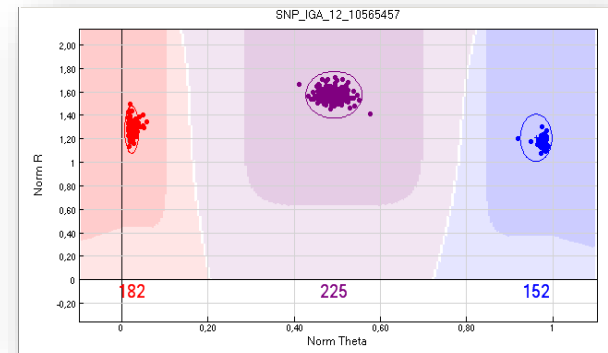
7896 SNP
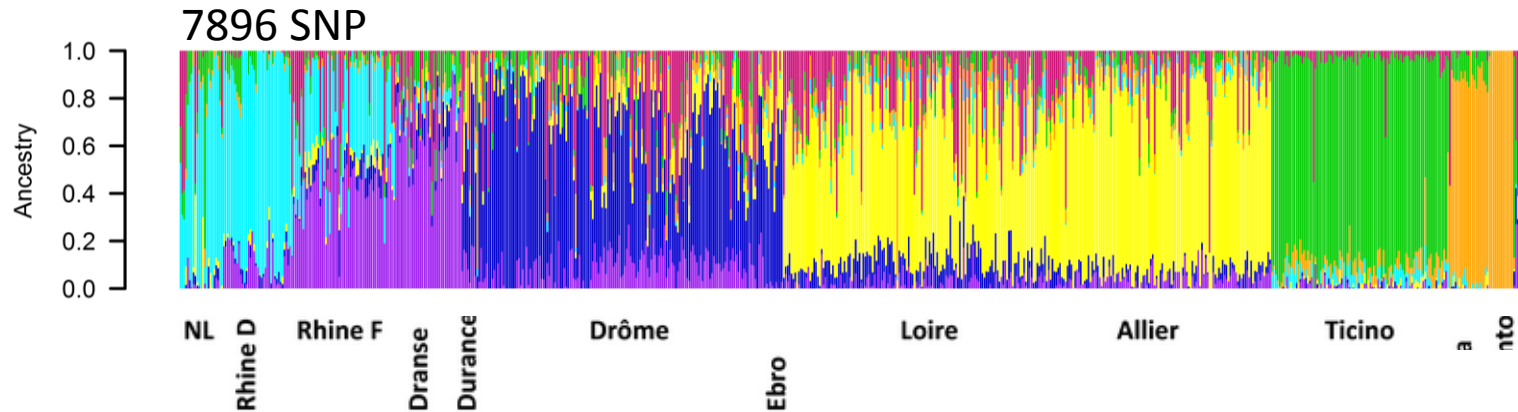
- ❖ **Diversity structured according to drainage systems.**
- ❖ **An ancestral cluster clearly admixed in almost all predefined populations.**
- ❖ **Introgression from cultivated stands ?**
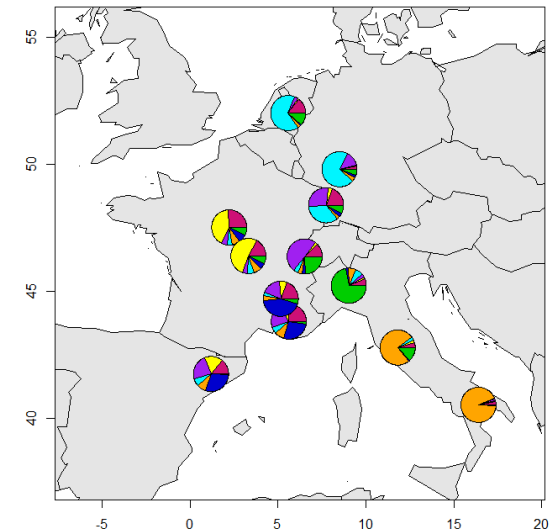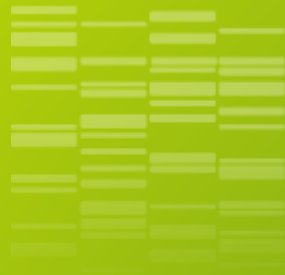
4. Genotyping quality and discrimination between species

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*.**
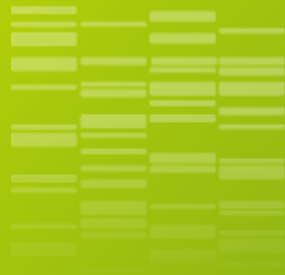
Discrimination between species

Axes 1 & 2
6298 SNP
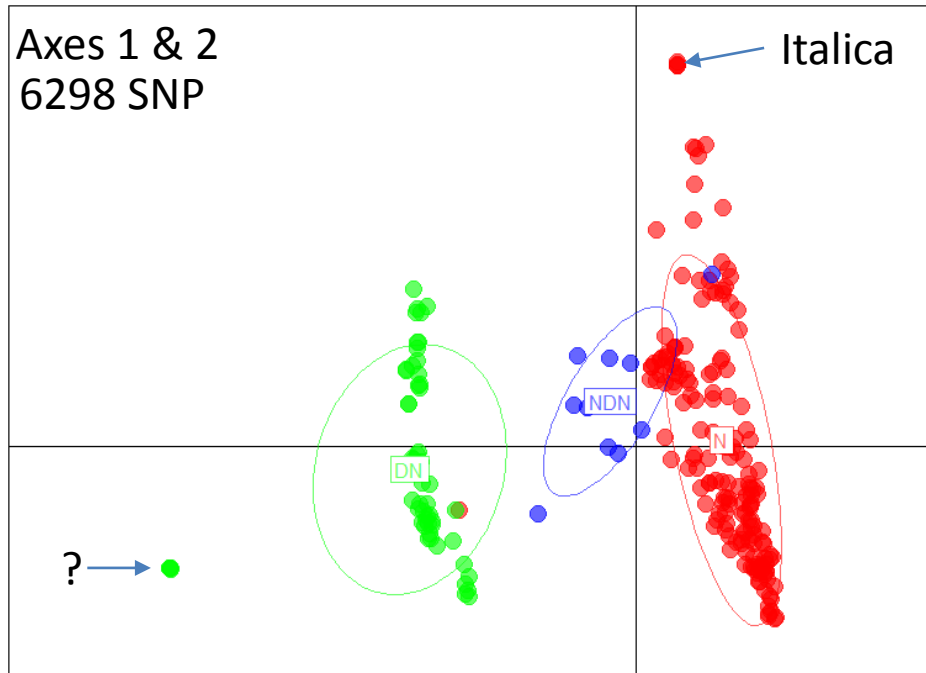
- **Potential of the genotyping tool to discriminate *Populus* species and hybrids (axe 1).**

- **Impact of ornamental *Populus nigra* cv (Italica, axe 2).**

Perspectives :
Development of discriminant markers for axe 1 and axe 2

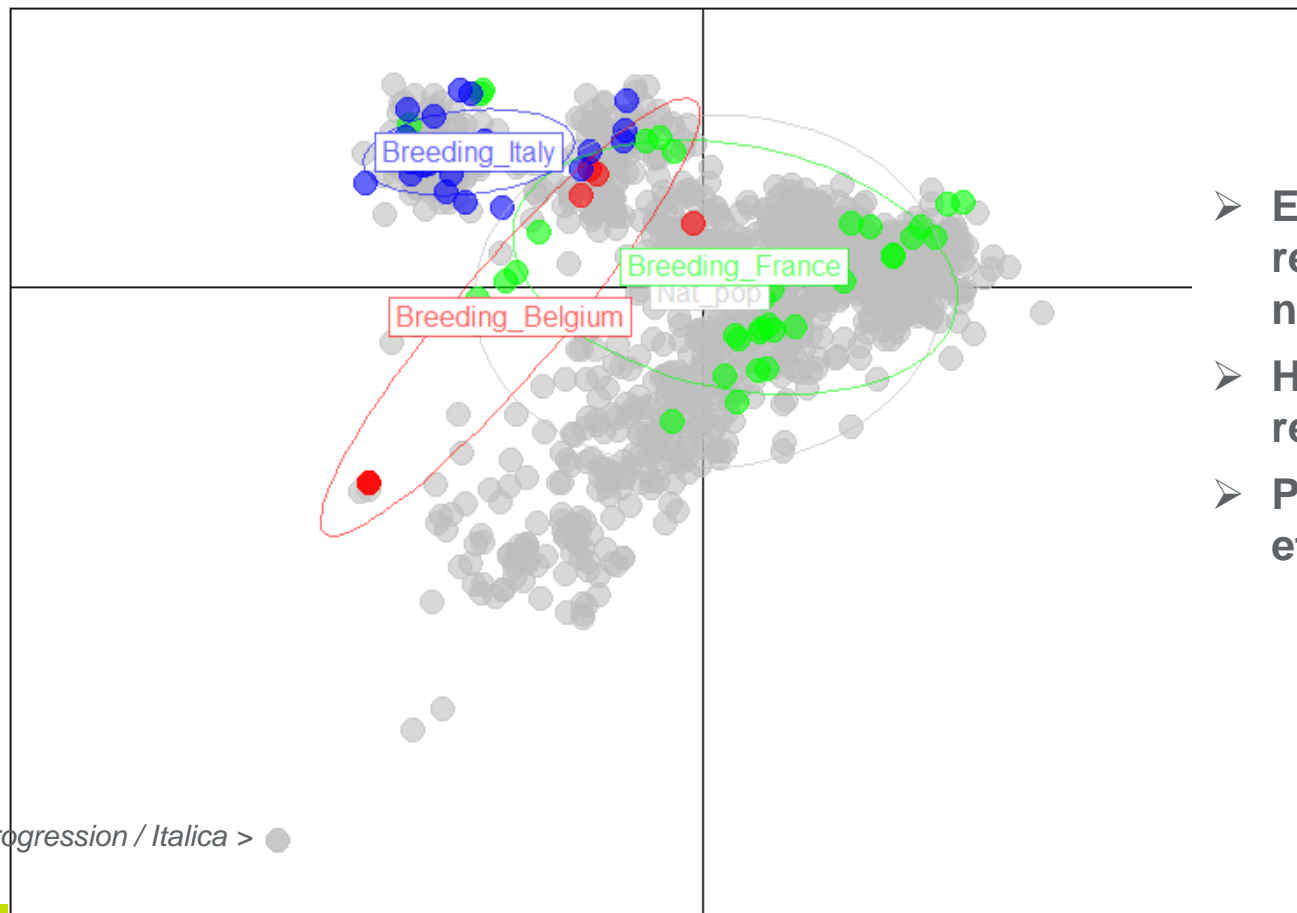**« hybrid » cultivars**
+ others DN, DNxN
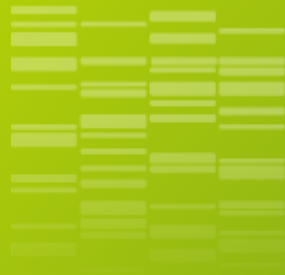
P. nigra genitors
+ VMC

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

Breeding_Italy

Breeding_France
Nat_pop

Breeding_Belgium

Introgression / Italica >

➤ **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

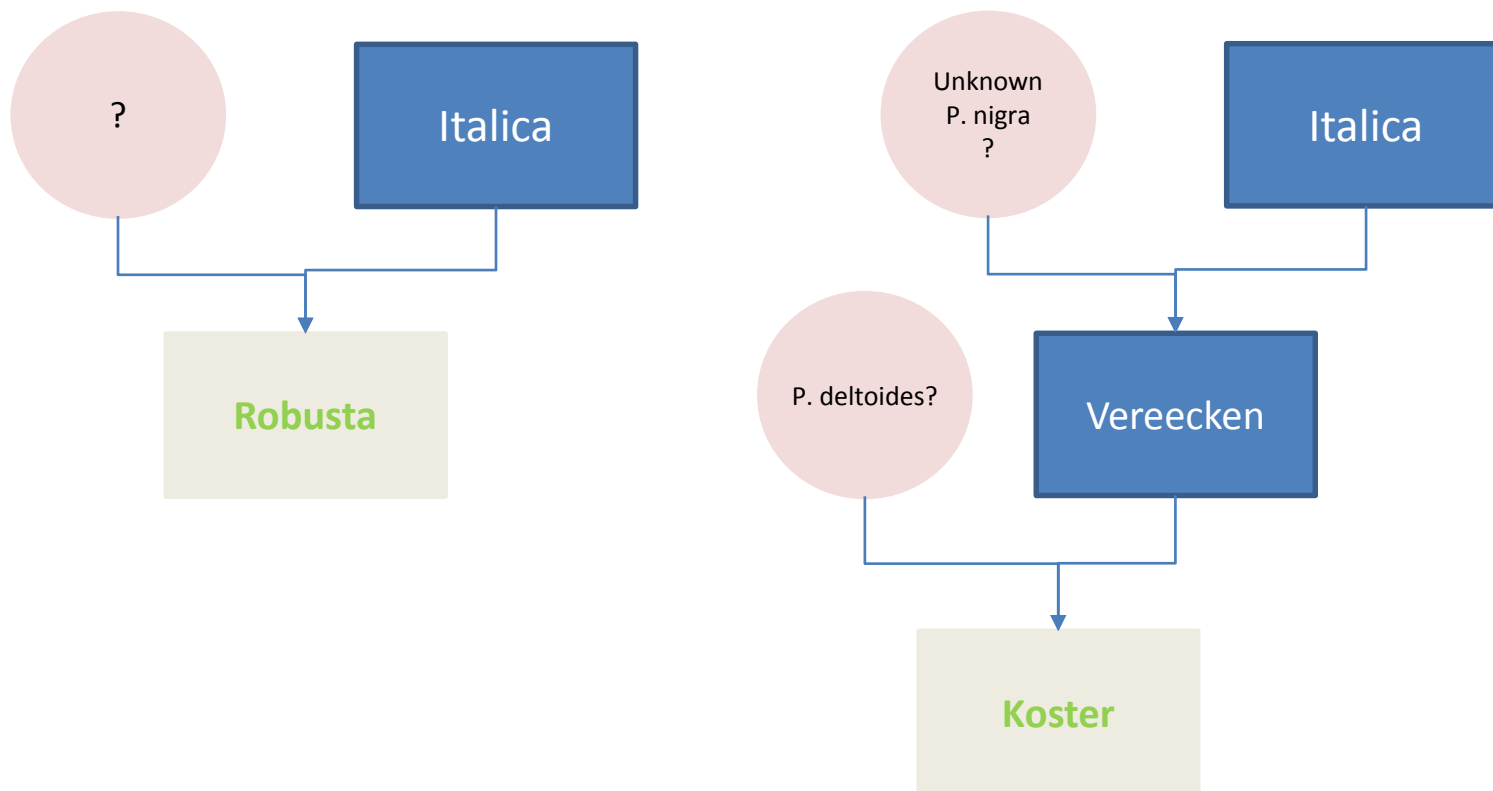

P. nigra

P. x canadensis et al.
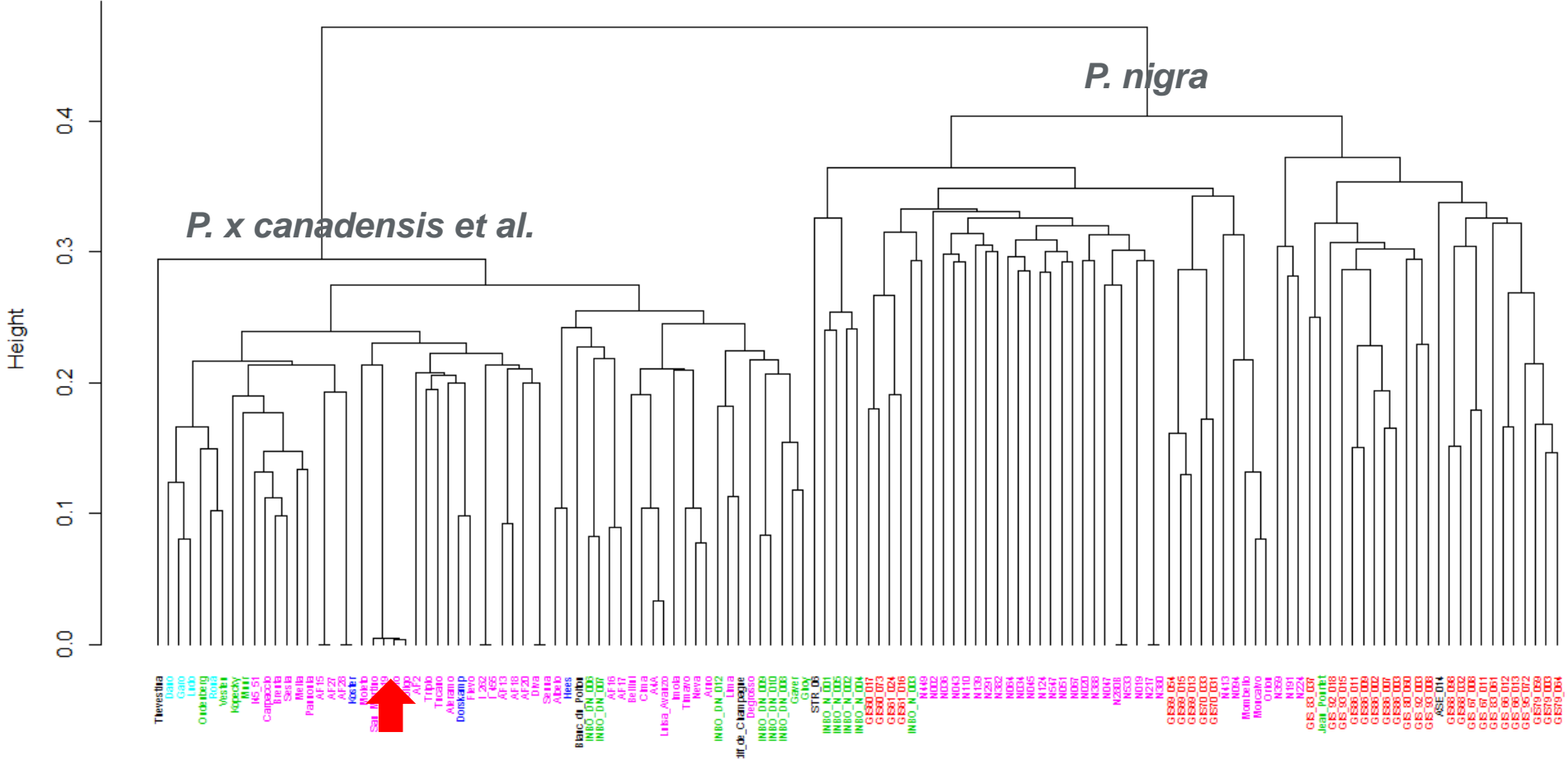
- ➤ **Confirmation of previous conclusions : distinction between taxa, genitors pooled/breeding programs**
- ➤ **Different levels of relatedness inside breeding programs**
- ➤ **Close relationship between some cultivars**
- ➤ **Pure *P. deltoides* among declared *P. deltoides* x *P. nigra* hybrids ?**
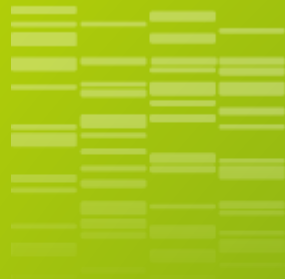
1128 SNPs
Belgium
France (GIS, Poloni)
Italy
Netherland
+ old cultivars

Evidence of the use of Italica in poplar breeding

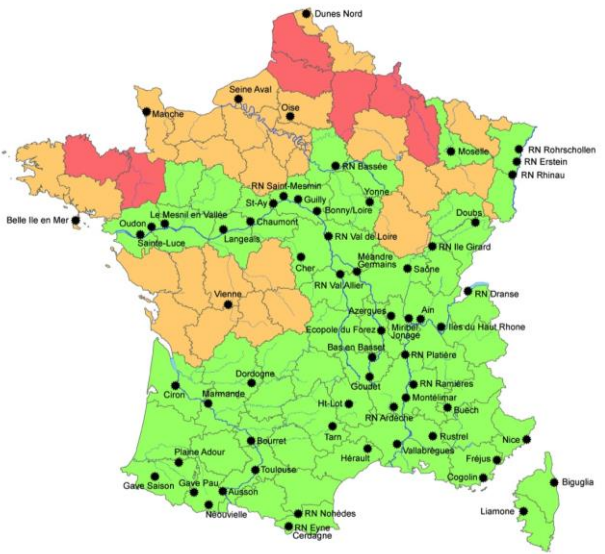❖ **Resolving pedigree of some culitvars.**

Results from Colony, Jones & Wang 2010

6. Diversity in multiclonal varieties

<u>M</u>ulti-<u>C</u>lonal <u>V</u>arieties of *Populus nigra*

Target in deployment = ecological restoration of river banks

Occurence of the species:
- **Present in riparian forests** (green)
- **Present as isolated trees** (orange)
- **absent** (red)

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

After M. Villar, coord. National Conservation Programme of *Populus nigra*

.027

INUPRAG June 3 > June 4, 2018

Multi-Clonal Varieties of *Populus nigra*

Actual methodology

Species descriptors and introgression

➢ In situ phenotype : <u>tree shape</u>, bark characteristics, stem characteristics, leaf shape, bud shape, male and female catkins
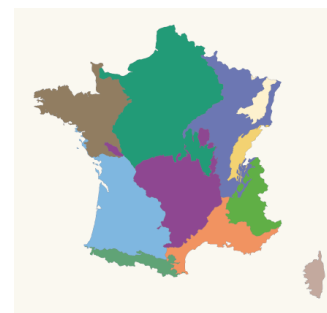
➢ SSR markers

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

Populus nigra var. Italica

After M. Villar, coord. National Conservation Programme of *Populus nigra*

.028

INUPRAG June 3 > June 4, 2018

<u>M</u>ulti-<u>C</u>lonal <u>V</u>arieties of *Populus nigra*

➢ **Registration** on French national register of 2 new multi-clonal varieties of *Populus nigra* for the Rhône river basin

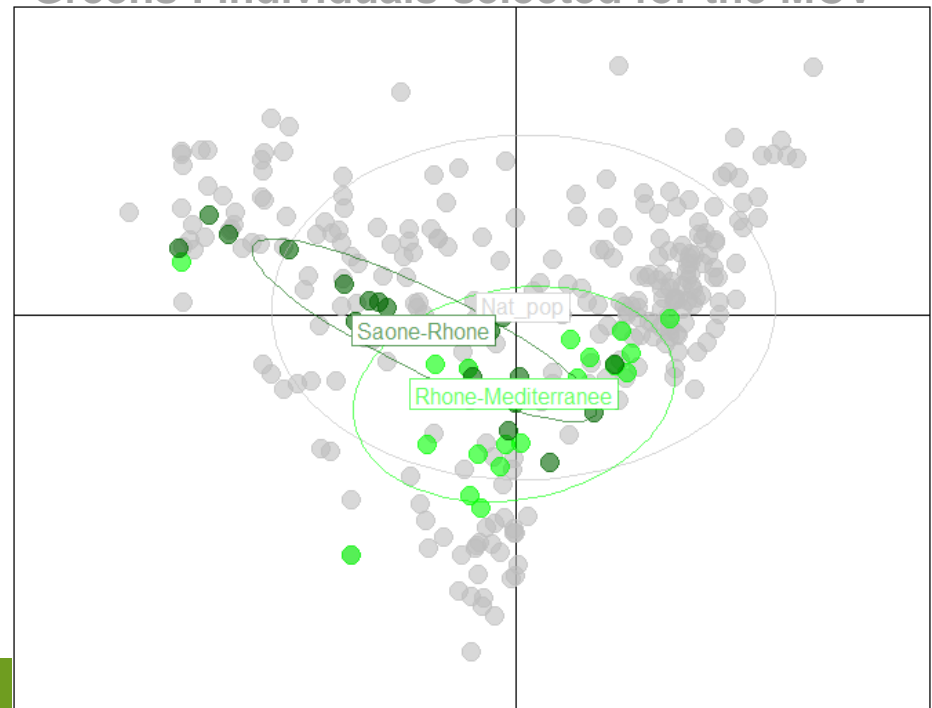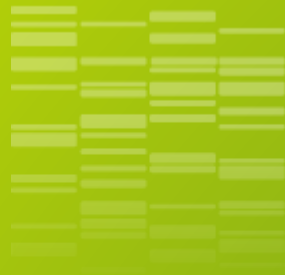➢ Validation of the low-cost strategy with SNP genotyping

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

Populus nigra multiclonal variety: 2 yrs-old plants

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
> explicit management of genetic diversity
> Optimisation introduction new diversity

Graciès !

Projects

Partners

INRA Selgen project
Breed2Last

GIS peuplier