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Survey of genetic diversity in European Populus breeding programs

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BioForA



Survey of genetic diversity in European Populus breeding programs

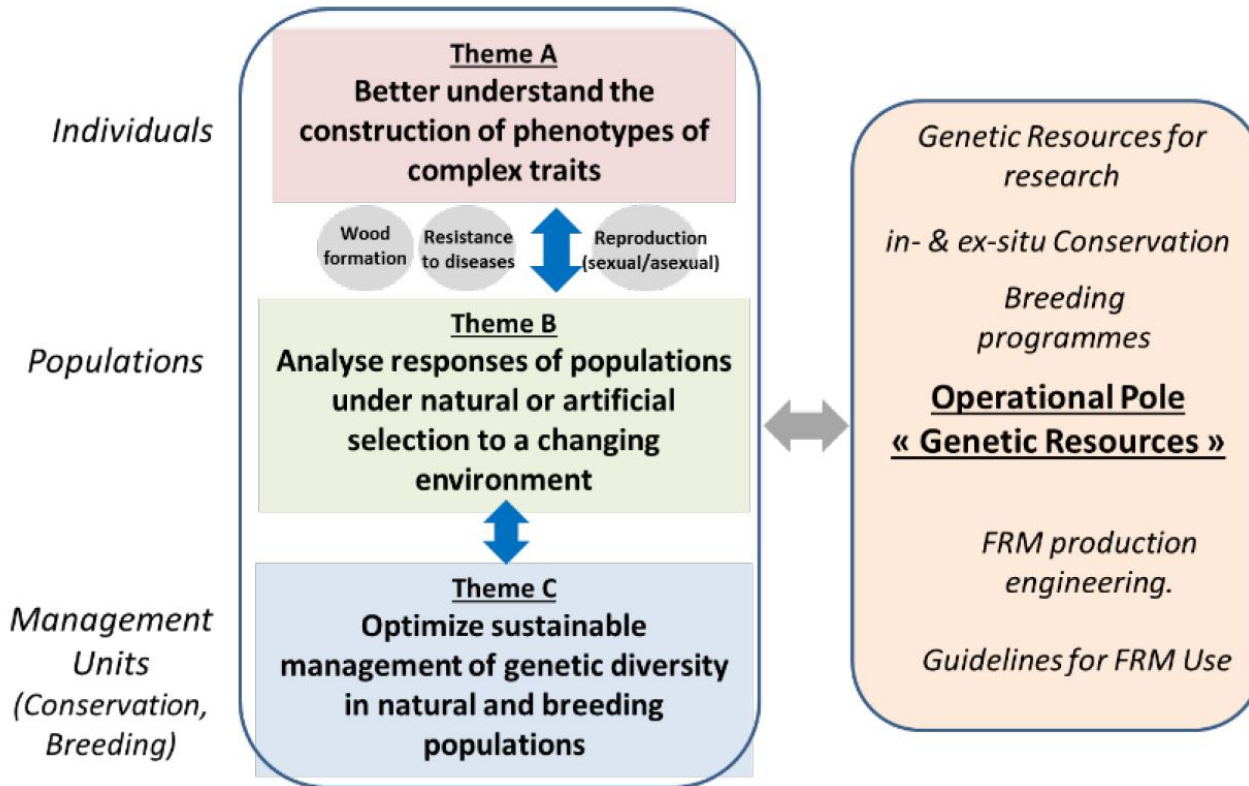
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INRA Experimental unit GBFOR



Our research objective

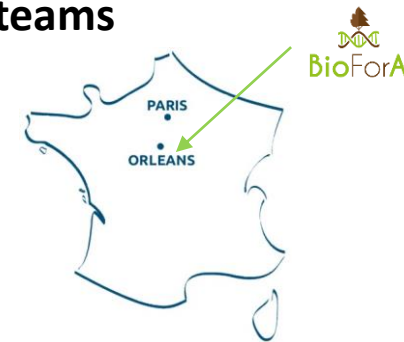
Management of forest genetic resources for sustainable timber production in a changing climate context



- **Joint unit between INRA and ONF** (French National Forest Service)



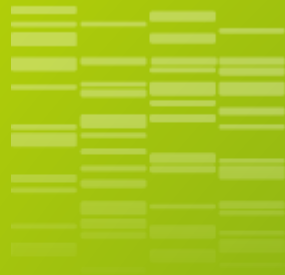
- **~50 persons (40 perm.)**
- **4 teams**



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

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.



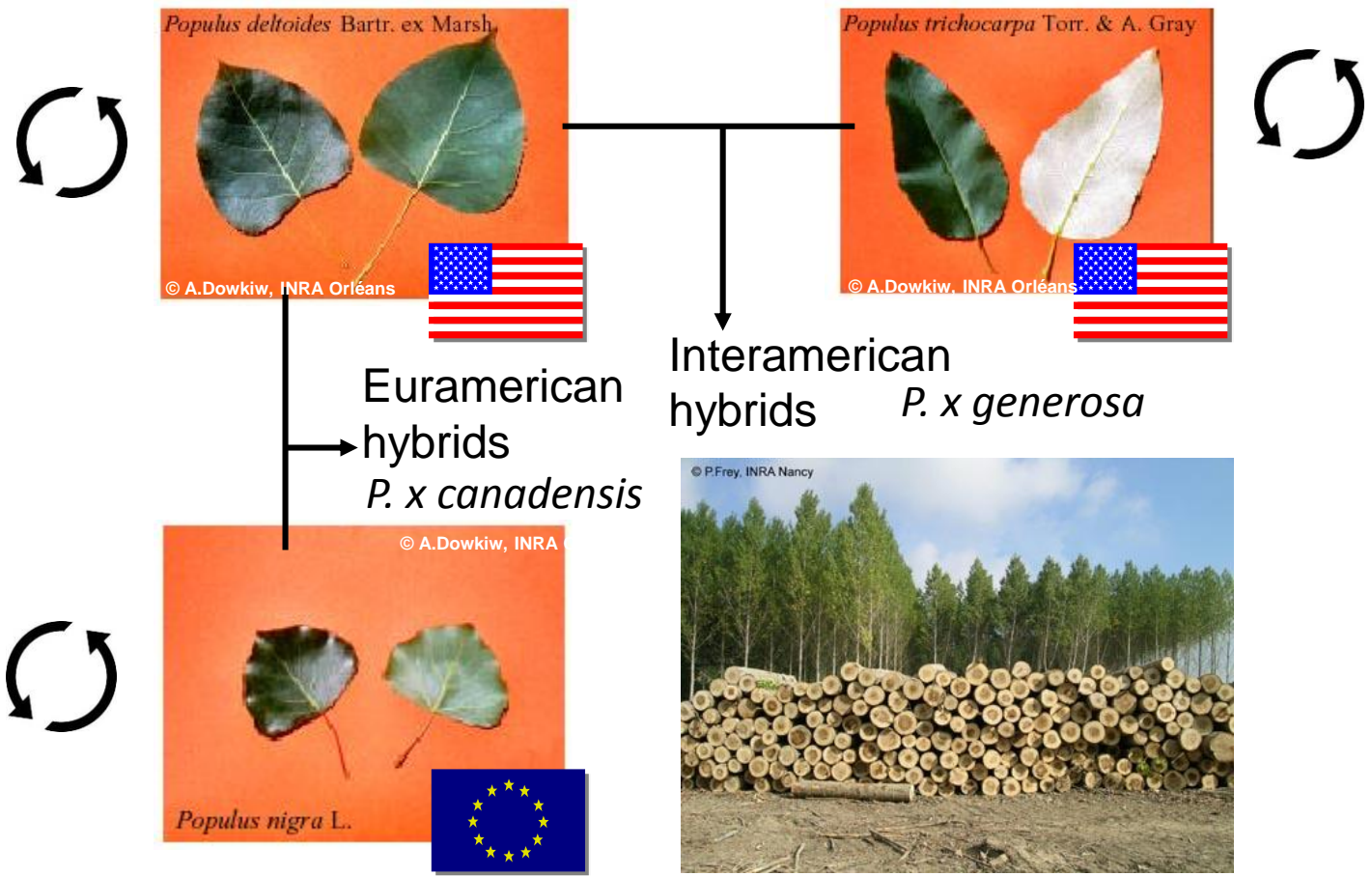
Populus trichocarpa Torr. & A. Gray



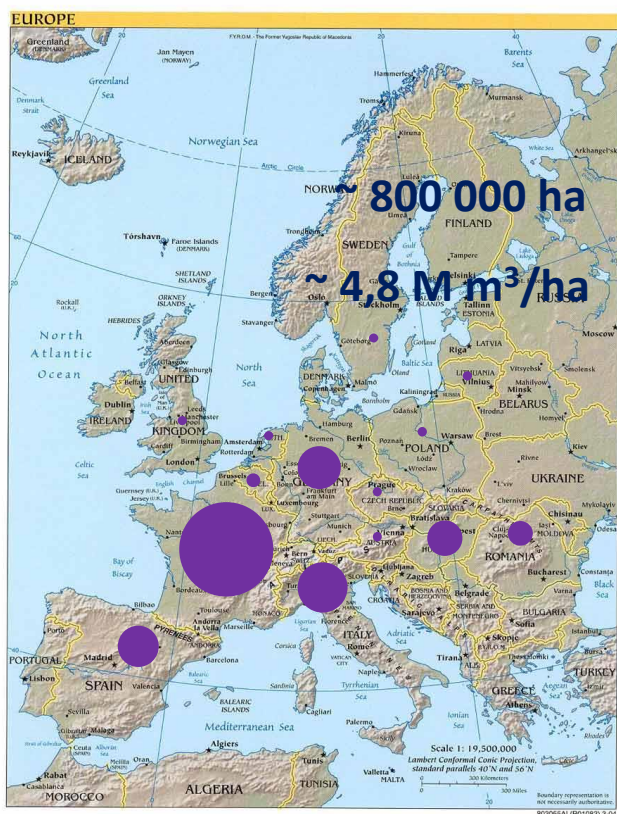
Populus deltoides Bartr. ex Marsh.

Breeding poplars

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



Poplar cultivation and consequences



Figures from TreeBreedX Monography contributions

List of registered material (2014)

- 172 mono-clonal 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%)

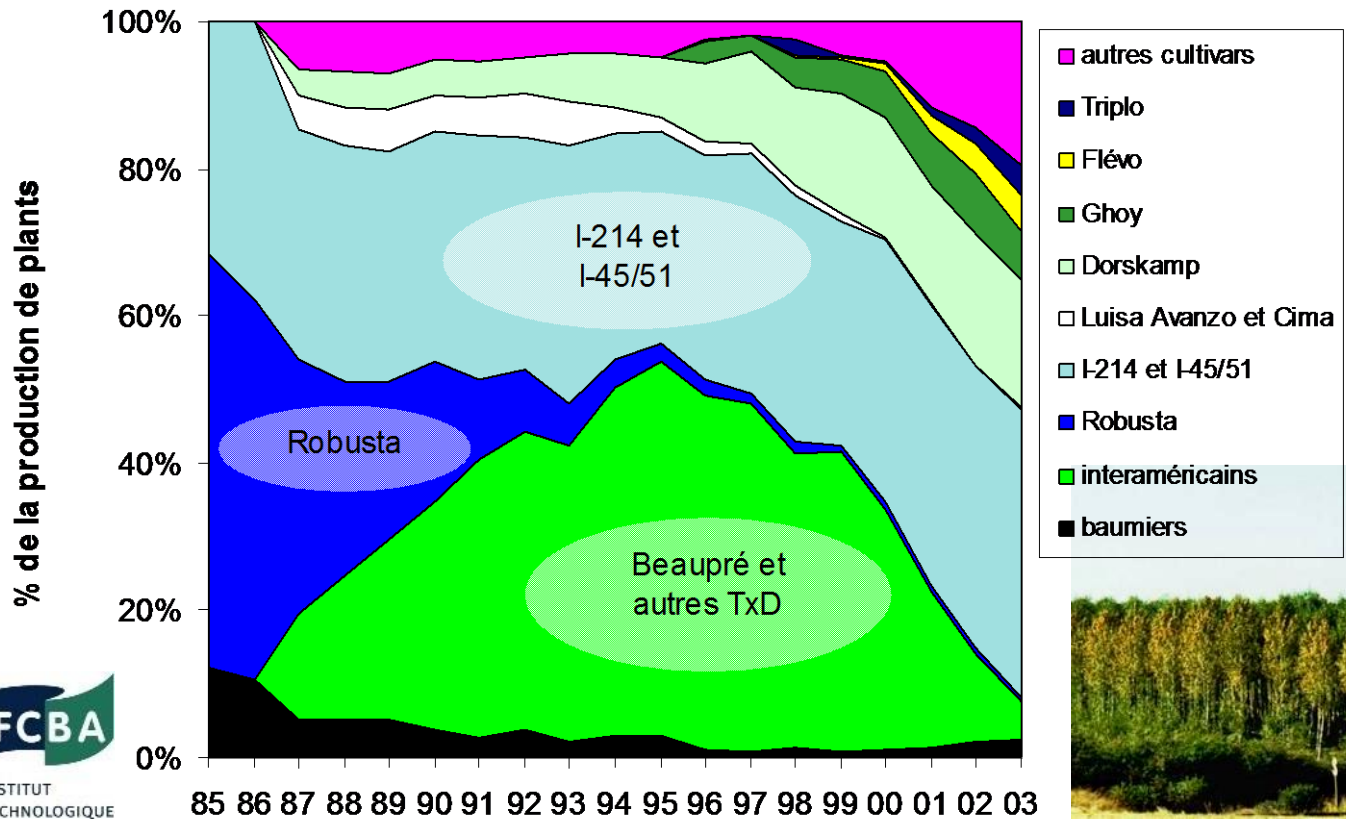


Poplar cultivation and consequences

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



©S. Bisoffi



Poplar cultivation and consequences

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



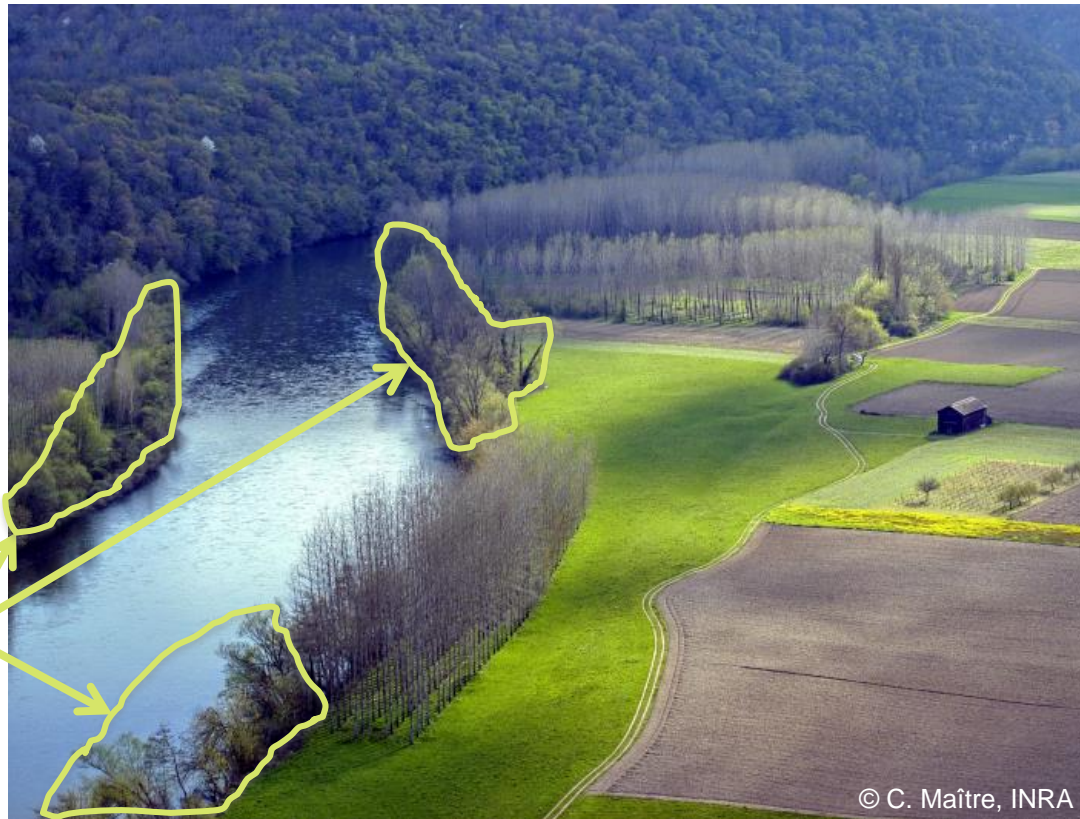
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Poplar cultivation and consequences

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



Black poplar



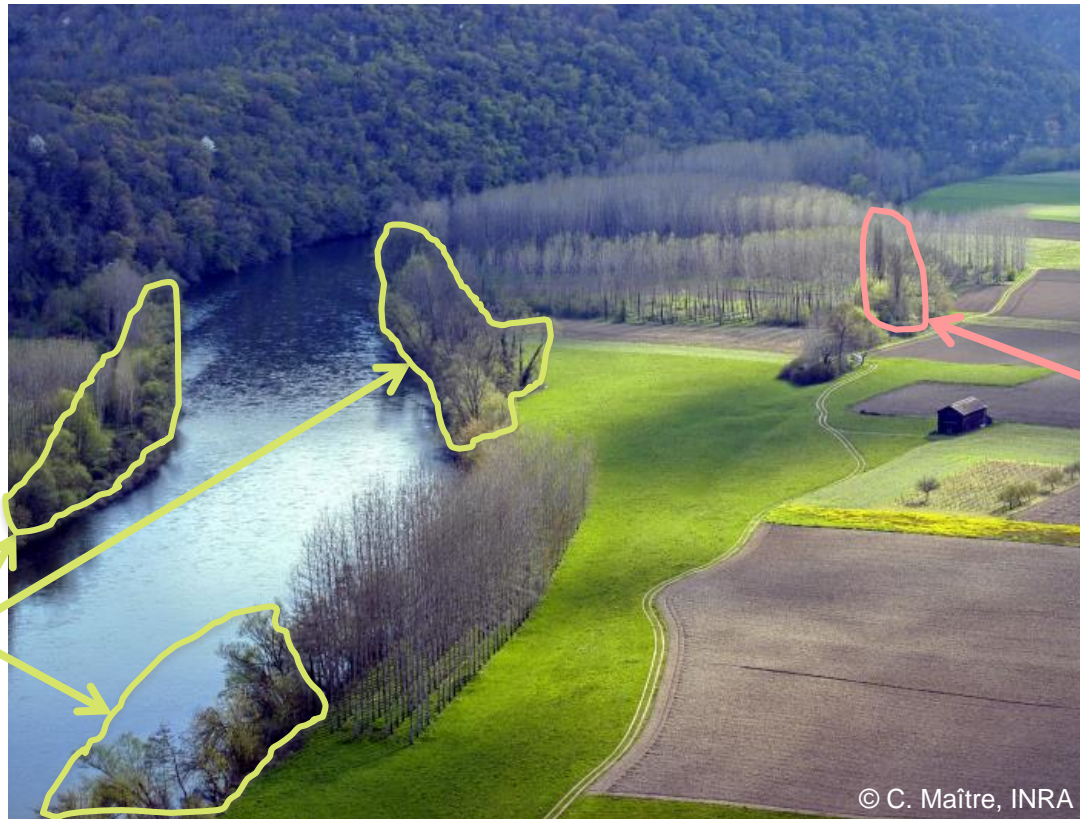
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Poplar cultivation and consequences

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Black poplar



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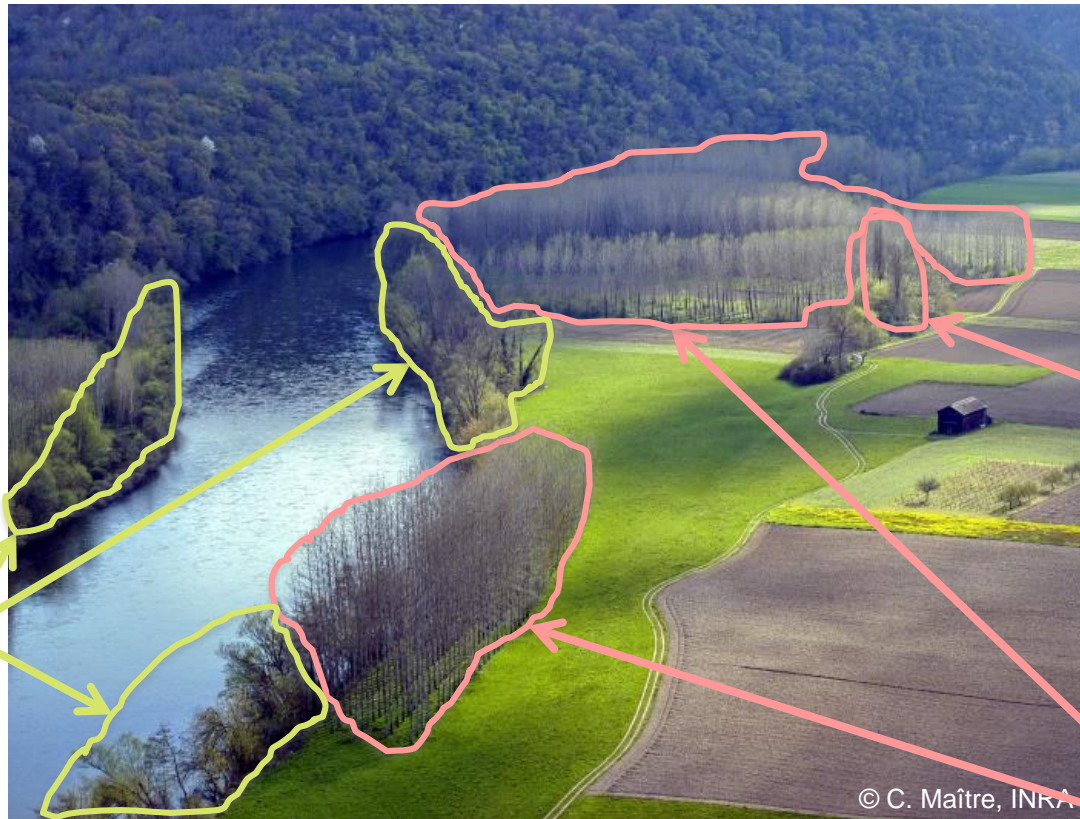
Lombardy poplar
« Italica »

Poplar cultivation and consequences

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- Introgression as a potential risk for natural resources



Black poplar

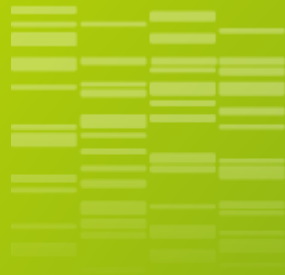


Lombardy poplar
« Italica »



**cultivated
poplars
stands**

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2. Objectives of the study

Gentree (H2020) project – WP2

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

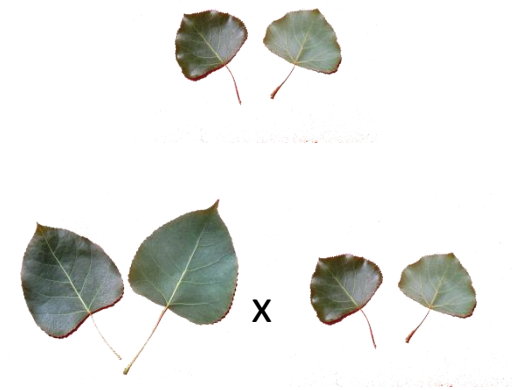
WP2 – Innovative breeding strategies based on the rational use of forest genetic resources

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* resources





3. Material and methods

Plant material

➤ Cultivars

incl. 'Bellini', Italian cultivar !

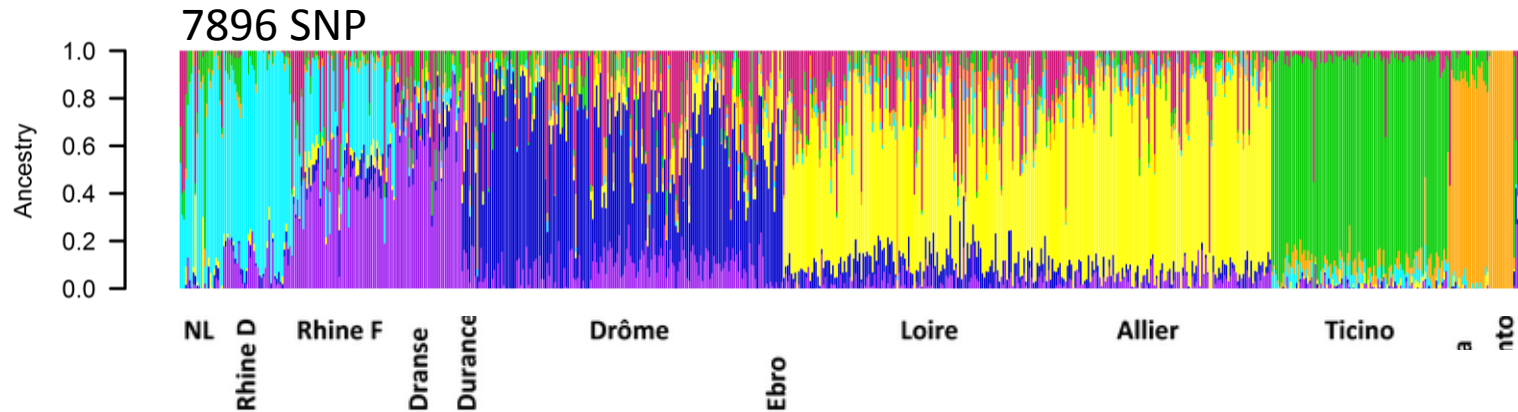
➤ Genitors from active breeding programs (BE, FR, IT)

➤ Multi-Clonal Varieties

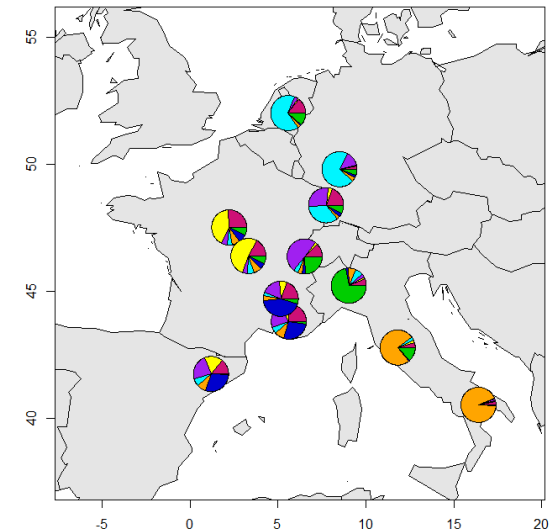


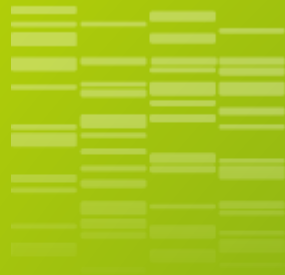
type	origin	#
Cultivars <i>P. nigra</i> , ornamental		Italica, Thevestina
Cultivars <i>P. nigra</i> registered	F/I, NL	Jean Pourtet, Vereecken
Cultivars <i>P. x canadensis</i>	Belgium	5
	France	5 (old cultivars)
	Hungary	2
	Italy	29
	NL	5
	Poloni	6
Genitors	Alasia (Italy)	10 (DN)
	CREA (Italy)	28
	GIS (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



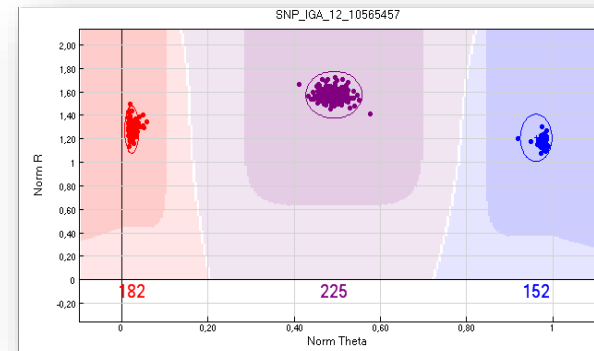
- ❖ Diversity structured according to drainage systems.
- ❖ An **ancestral** cluster clearly admixed in almost all predefined populations.
- ❖ Introgression from cultivated stands ?





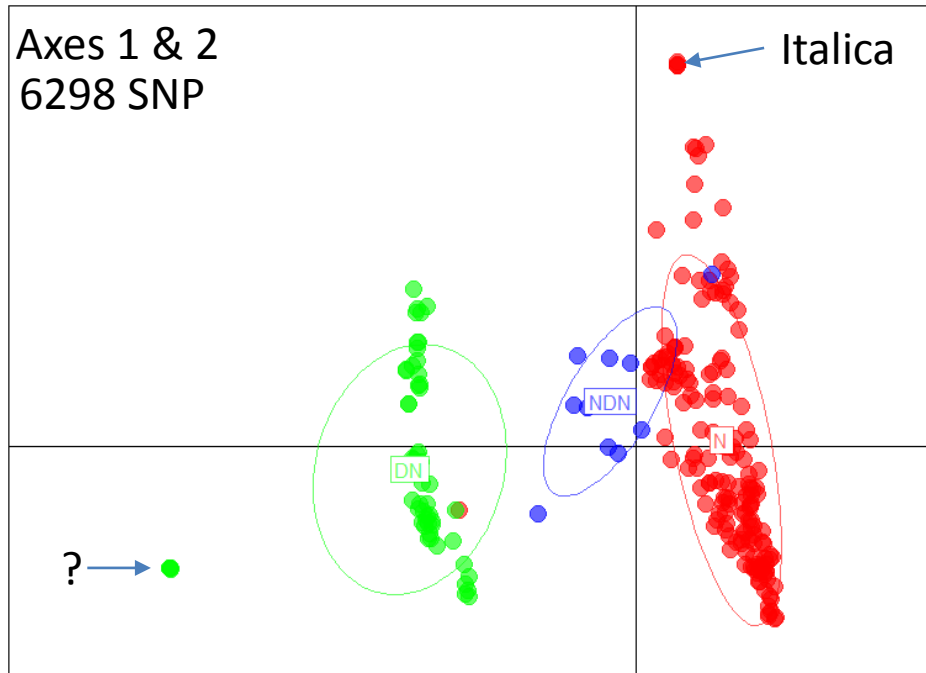
4. Genotyping quality and discrimination between species

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



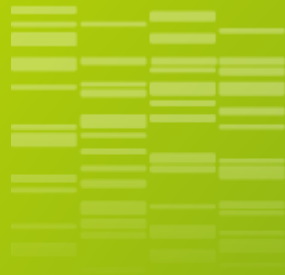
- Potential of the genotyping tool to discriminate *Populus* species and hybrids (axe 1).
- Impact of ornamental *Populus nigra* cv (Italica, axe 2).

Perspectives :

Development of discriminant markers for axe 1 and axe 2

« hybrid » cultivars
+ others DN, DNxN

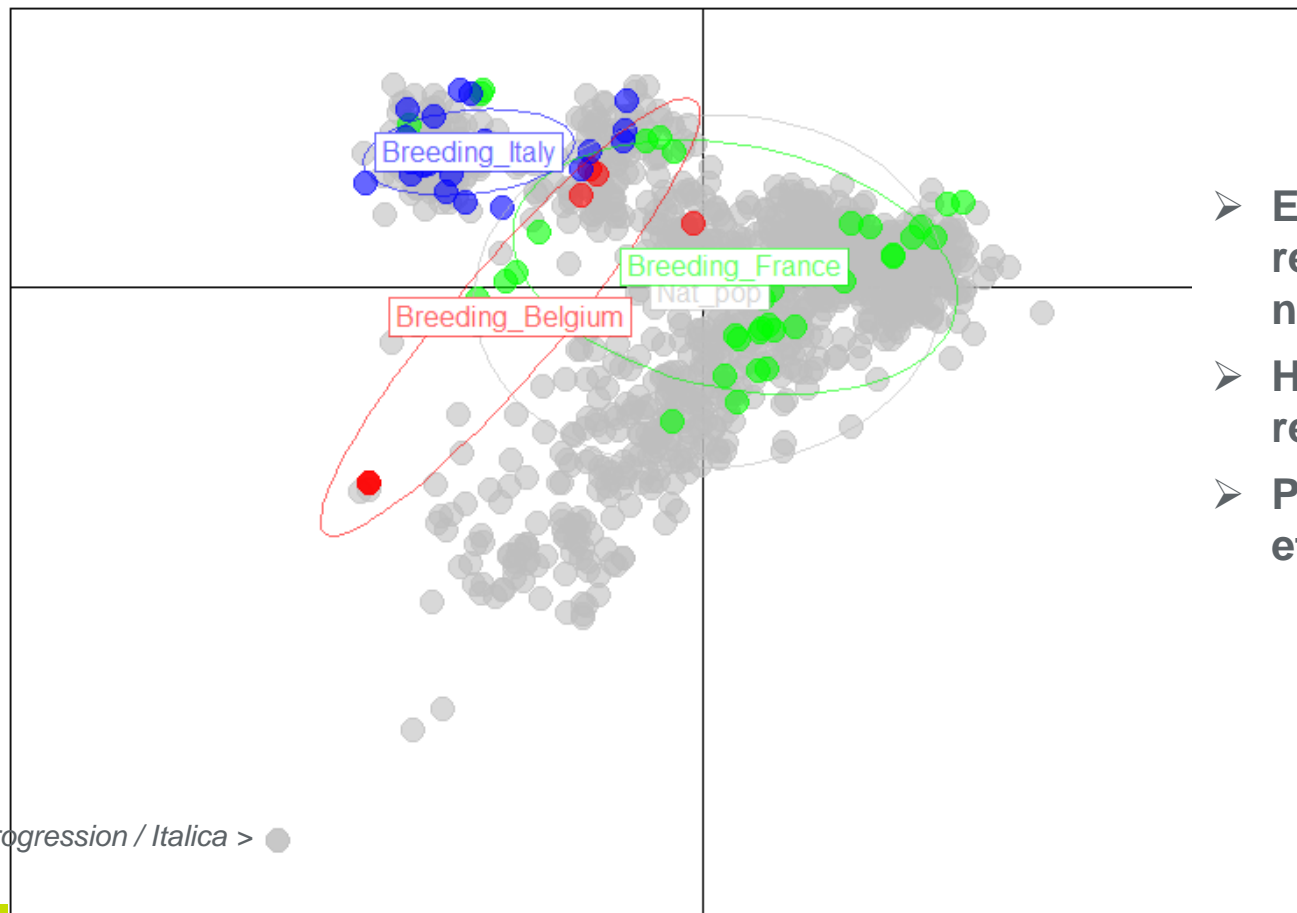
P. nigra genitors
+ VMC



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

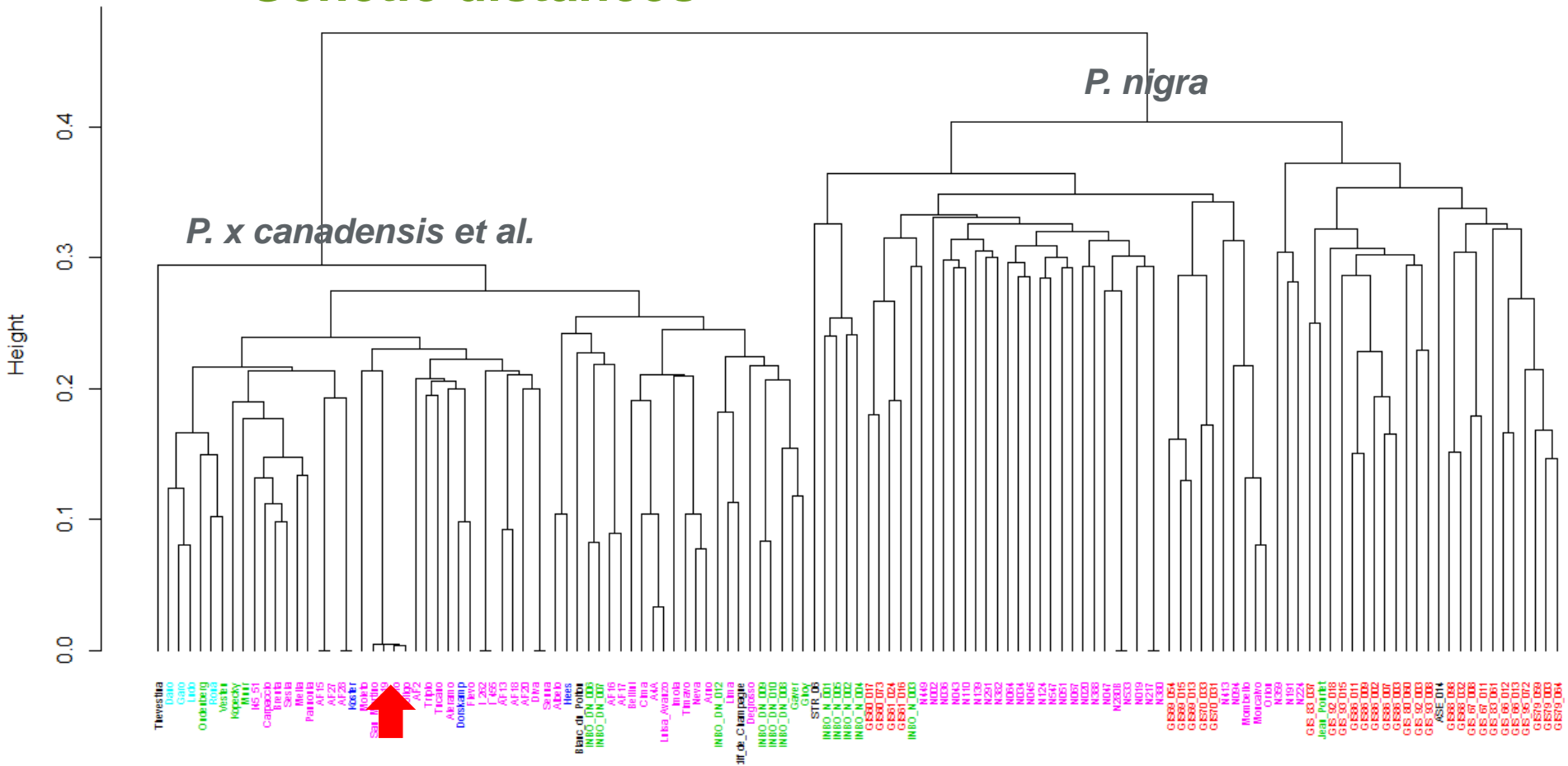


- Each breeding population representative of the local natural population
- How much this diversity is representative ?
- Perspectives: compare effective population size.



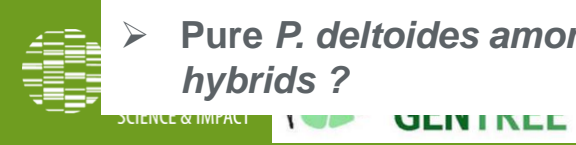
6. Relatedness between cultivars

Genetic distances



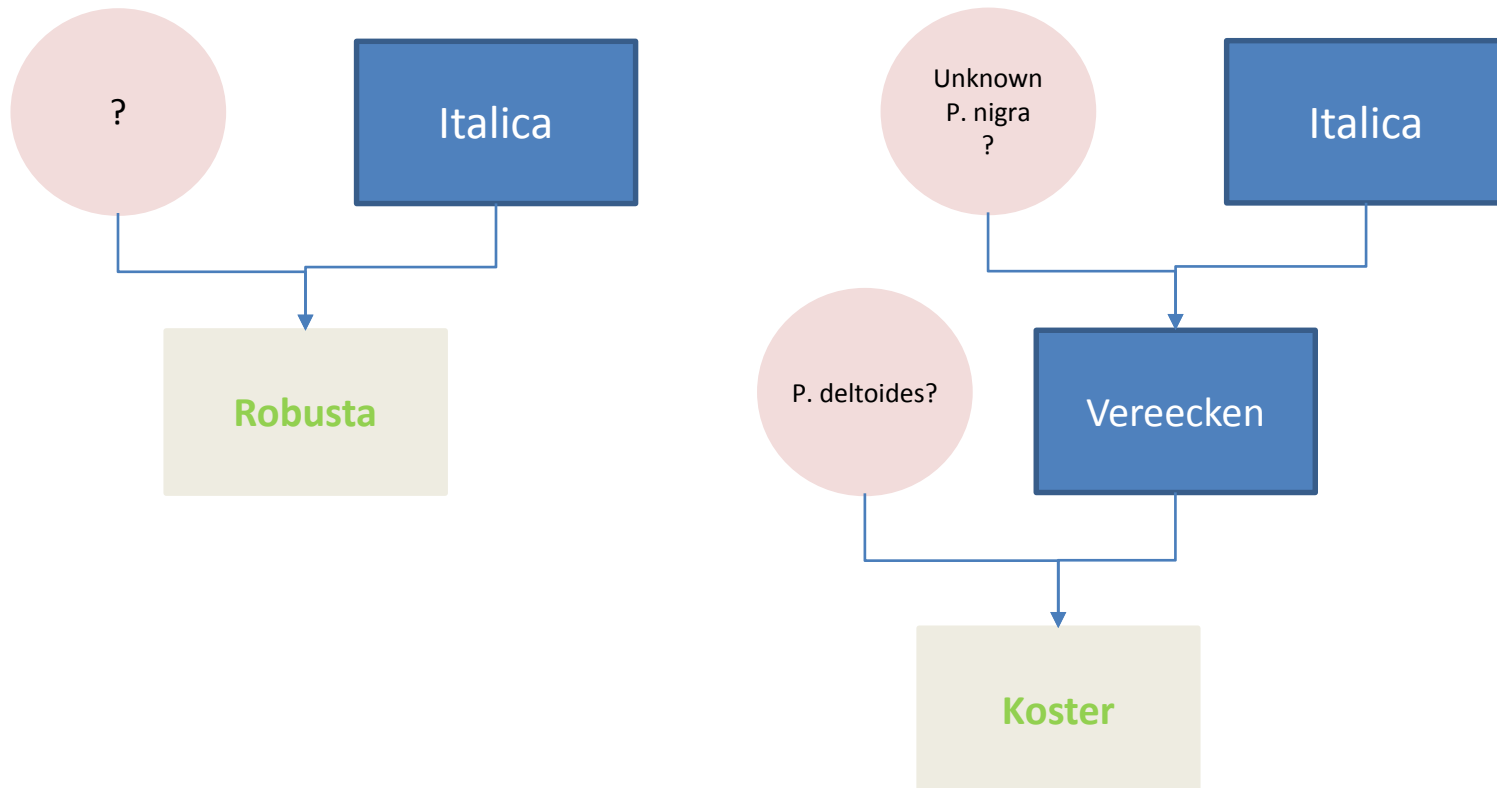
- Confirmation of previous conclusions : distinction between taxa, genitors pooled/breeding programs
- Different levels of relatedness inside breeding programs
- Close relationship between some cultivars
- Pure *P. deltoides* among declared *P. deltoides* x *P. nigra* hybrids ?

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

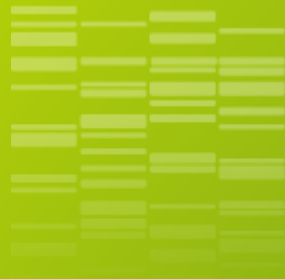


Evidence of the use of *Italica* in poplar breeding

❖ Resolving pedigree of some cultivars.



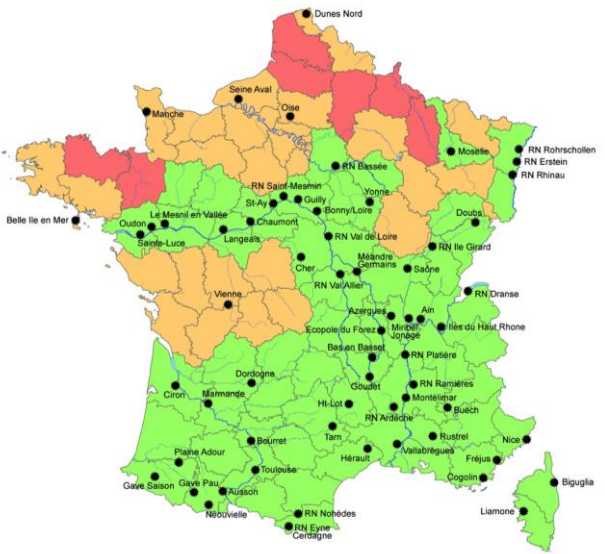
Results from Colony, Jones & Wang 2010



6. Diversity in multiclonal varieties

Multi-Clonal Varieties of *Populus nigra*

Target in deployment = ecological restoration of river banks



Occurrence 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

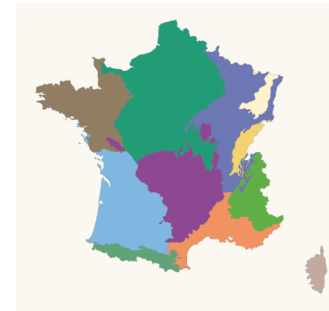
One variety per river basin & large ecological regions

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 competition
 - Branching patterns: avoid fastigate

Populus nigra var. *Italica*



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

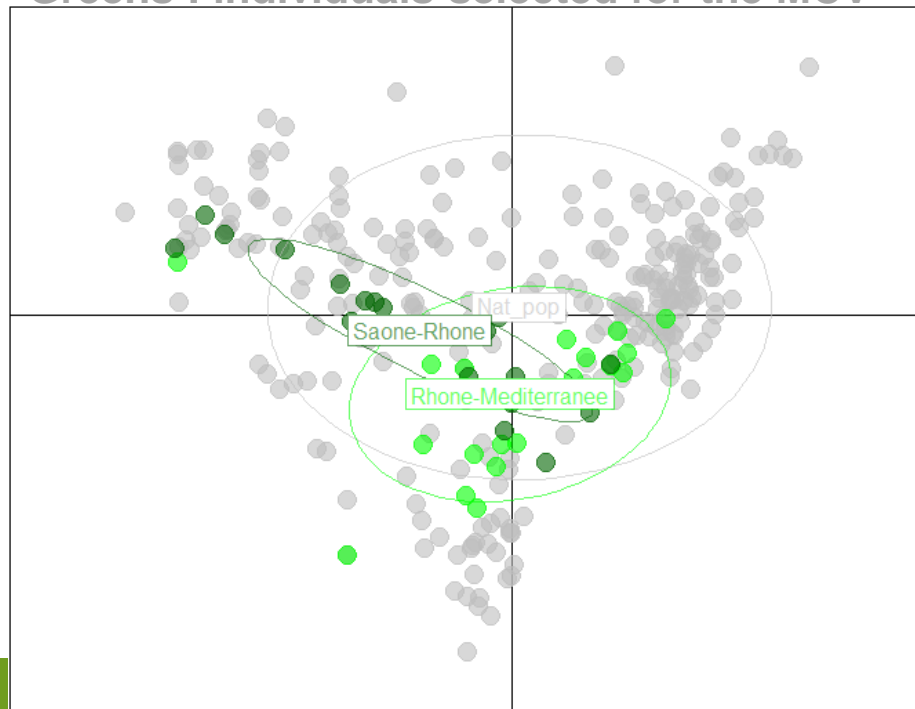


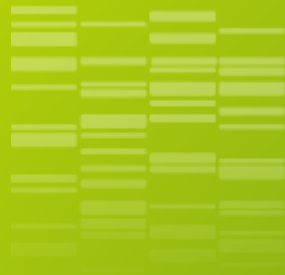
Populus nigra multiclonal variety: 2 yrs-old plants

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



INRA Selgen project
Breed2Last



Partners

GIS peuplier



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