Optimization of wood production in bioenergy plantations: 1. through the use of adequate plant material in terms of resource use efficiencies

Julien Toillon, Bénédicte Rollin, Erwin Dallé, Jean-Charles Bastien, Franck F. Brignolas, Nicolas Marron

CREFF
Cost Reduction and Efficiency Improvement of Short Rotation Coppice

SYLVABIOM

Intens&Fix

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Through the use of adequate plant material in terms of resource use efficiencies

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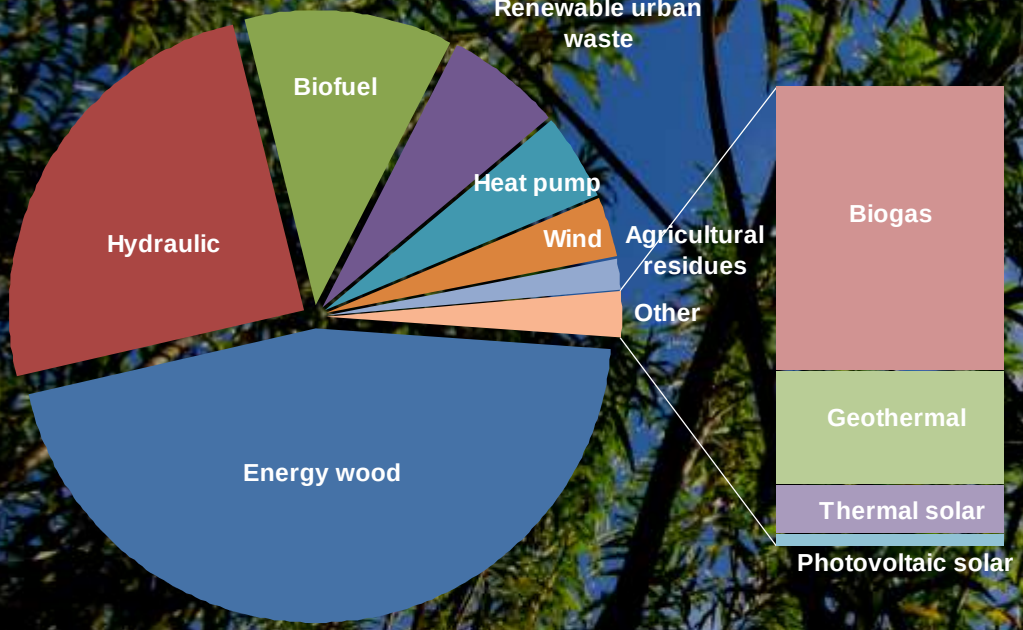
Why? How? Where? What?



European directive : 20% of produced energy have to be renewable

➔ 7.9% in France in 2009

➔ 45% from wood (forest and SRC)

➔ Need of 8 to 10 millions hectares to reach the objectives…

➔ … avoiding concurrence with food agriculture

European directive : 20% of produced energy have to be renewable

- ➔ 7.9% in France in 2009
- ➔ 45% from wood (forest and SRC)
- ➔ Need of 8 to 10 millions hectares to reach the objectives…
- ➔ … avoiding concurrence with food agriculture
- ➔ Use of suboptimal lands
- ➔ Optimization of wood production while reducing inputs
- ➔ Use of plant material using efficiently water and nitrogen

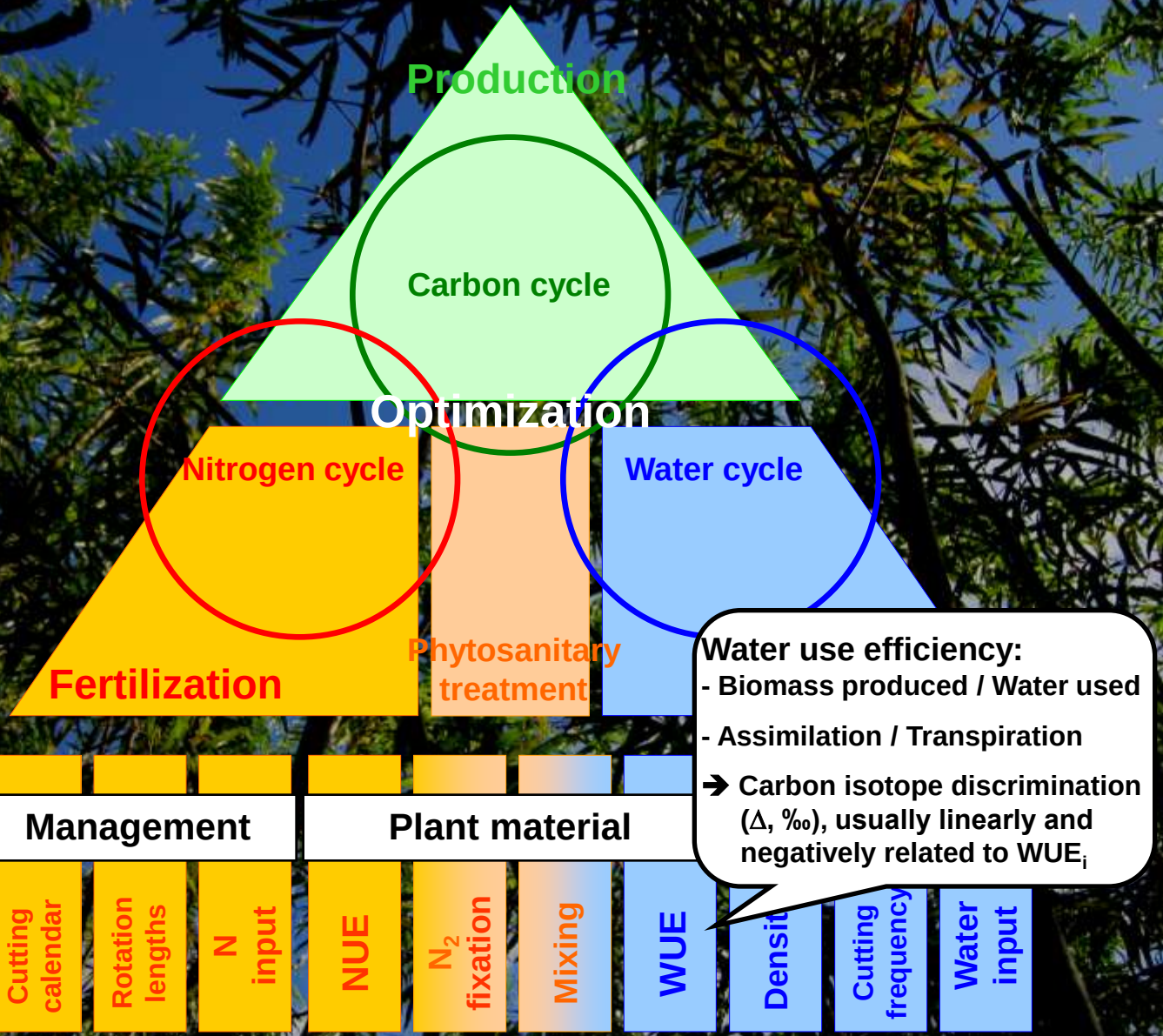
Most frequently used tree species in Europe:

- Poplar
- Willow
- Eucalyptus
- Black locust (*Robinia*)

➔ 1500 to 12 000 trees / ha

➔ 2 to 8 year rotations

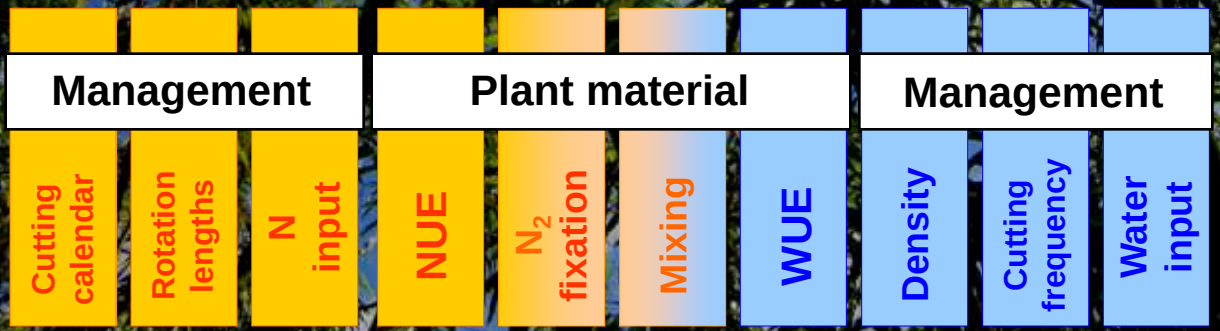
Why? | **How?** | Where? | What?



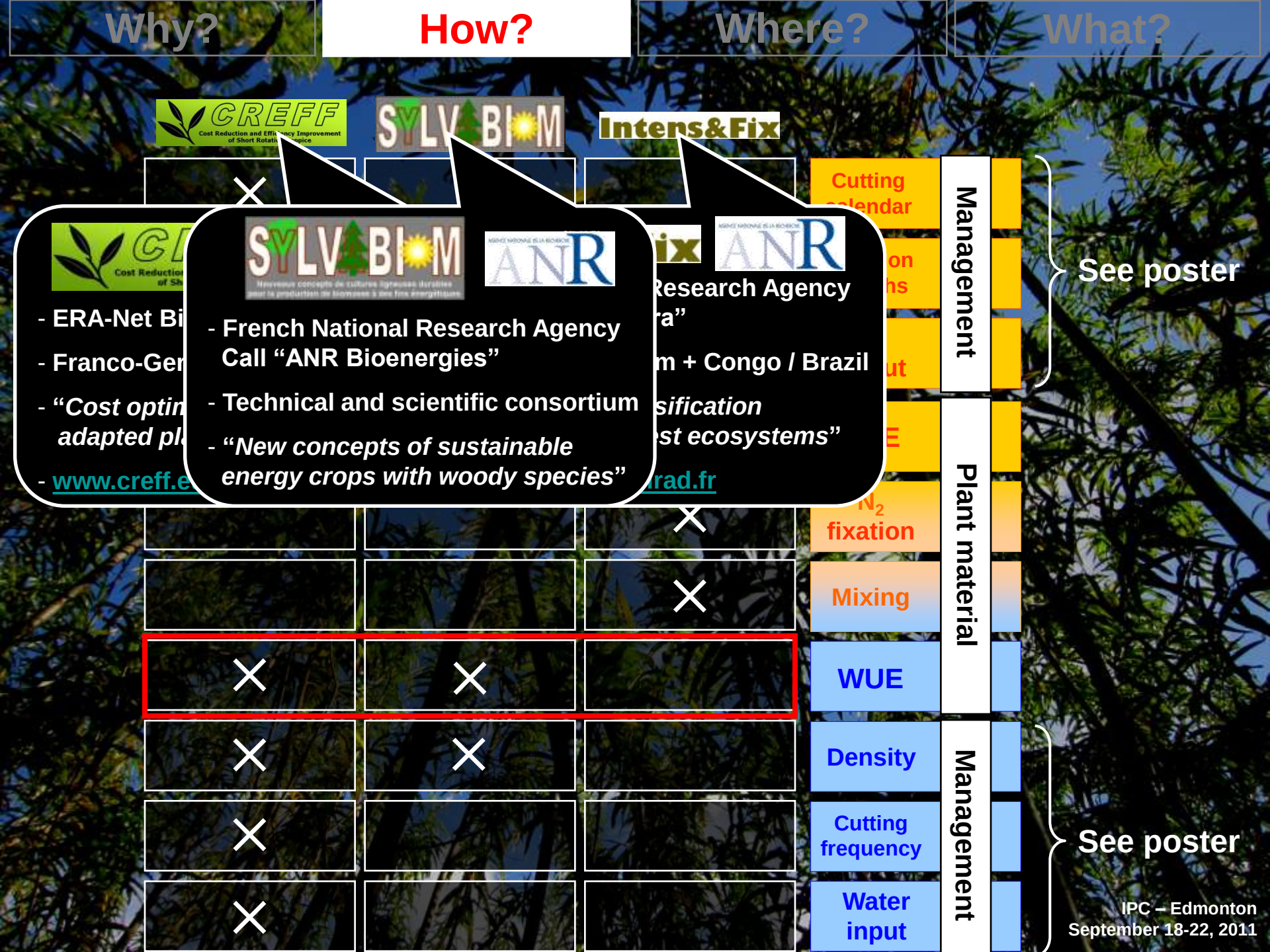
Water use efficiency:

- **Biomass produced / Water used**
- **Assimilation / Transpiration**

➔ **Carbon isotope discrimination (Δ, ‰), usually linearly and negatively related to WUE_i**


Management
Plant material
Management
Cutting calendar
Rotation lengths
N input
NUE
N_2 fixation
Mixing
WUE
Density
Cutting frequency
Water input

Why? | **How?** | Where? | What?



Why? | How? | **Where?** | What?

Association d'Initiatives Locales pour l'Energie et l'Environnement

Institut National de la Recherche Agronomique

Forêt, Cellulose, Bois-construction, Ameublement

Chambres d'Agriculture

Institut pour le Développement Forestier

Laboratoire des Interactions Microorganismes Minéraux Matière Organique dans les Sols

Poplar clonal test (60 clones) + Willow clonal test (20 clones)


Pleyber-Christ
Lamballe
Saint-Gilles
Saint-Ségal
La prénessaye
Kerdavic
Kerguéhennec
Gennes sur Seiche
Les Cormiers
Guémené-Penfao
Saint-Sulpice -des-Landes
Nouzilly
Blois
Vatan
Saint-Cyr-en-Val
Brinon-sur-Sauldre
Amagne
Fleury
Semuy
Moyenvic
Champenoux
Darnieulles
Padoux
Attigny
Sélestat

Robinia clonal test (30 clones) + 8 willow + 1 poplar clone


T°C : 16.7°C
Rainfall : 148 mm
OM : 39.5 g kg^{-1}
N : 1.7 g kg^{-1}

8 willow clones


T°C : 17.0°C
Rainfall : 257 mm
OM : 9.9 g kg^{-1}
N : 0.6 g kg^{-1}

Poplar clonal test (60 clones) + 6 willow clones


T°C : 17.4°C
Rainfall : 382 mm
OM : 62.1 g kg^{-1}
N : 3.2 g kg^{-1}

Brittany | **Centre** | **Bourgogne**

Growing conditions

Poplar 'Dorskamp'

Robinia 2 provenances

Willow 8 clones

The 3 species at the same site

Close Δ / WUE values for leaves and wood

Close Δ / WUE values for poplar and willow…

… but inferior for black locust

➔ Black locust more efficient to use water than poplar / willow?

➔ Or due to extreme conditions at this site in 2010?

More precisely for each species…

Robinia clonal test (30 clones) + 8 willow + 1 poplar clone

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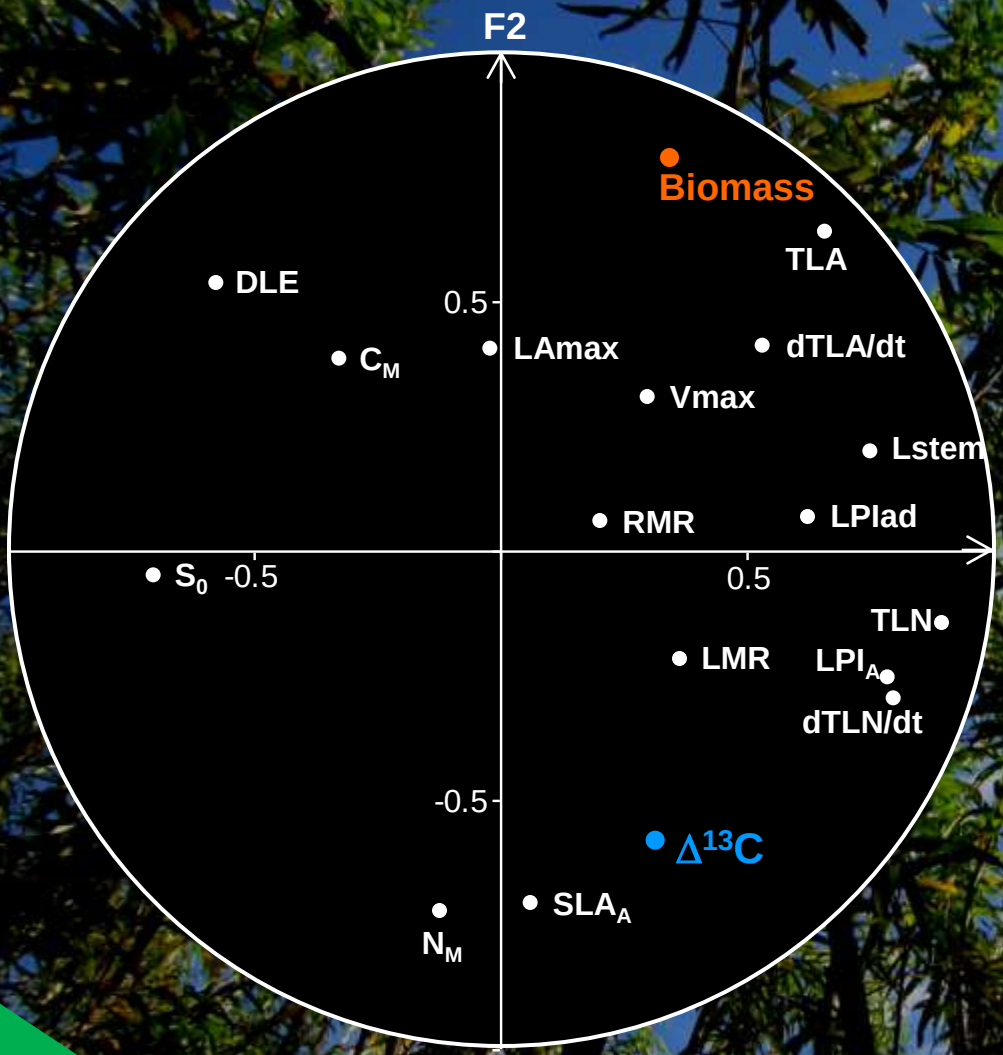
Rainfall : 148 mm

OM : 39.5 g kg^{-1}

N : 1.7 g kg^{-1}

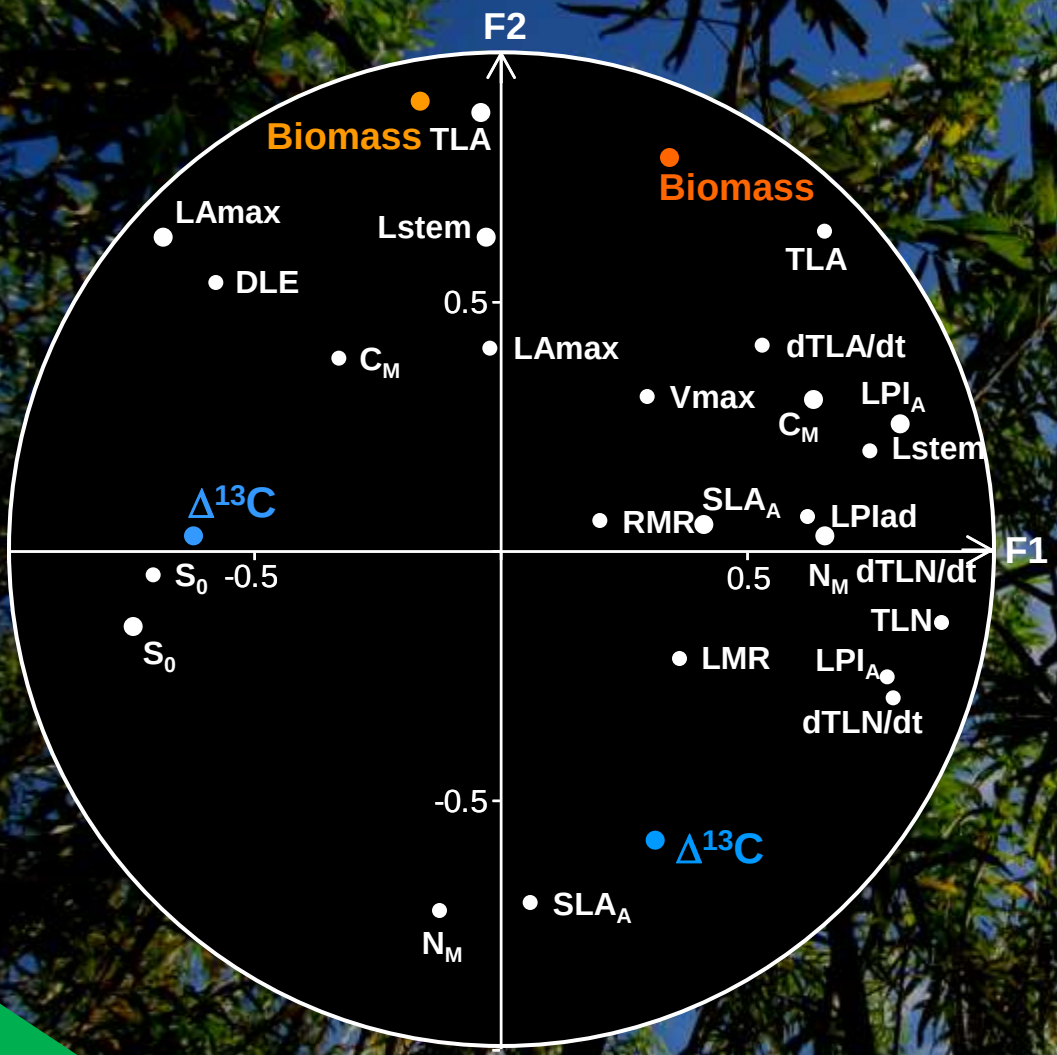
European poplar clones (Italy / Netherland / Belgium / France / Hungary)



Marron *et al.* 2005

Poplar

European poplar clones (Italy / Netherland / Belgium / France / Hungary)



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Monclus *et al.* 2005

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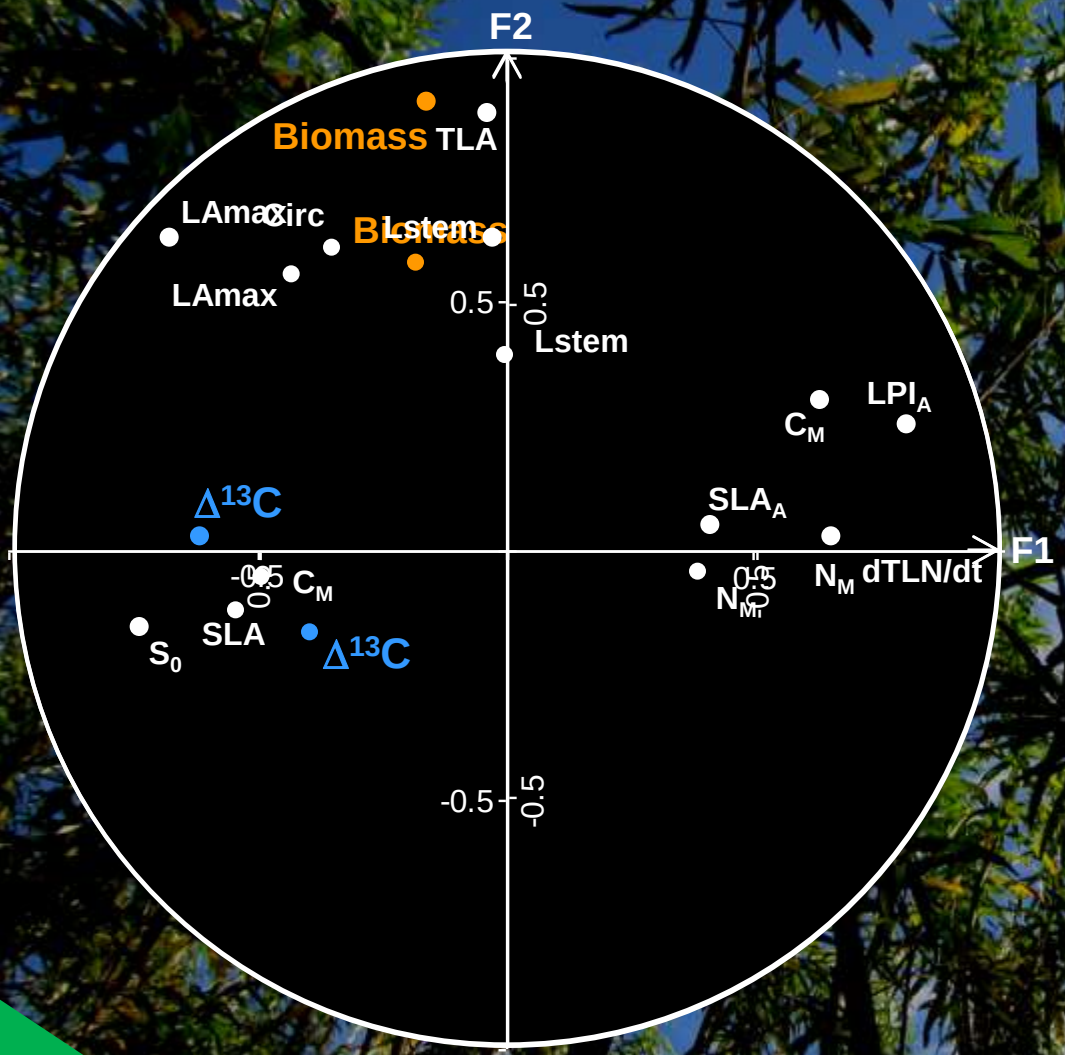

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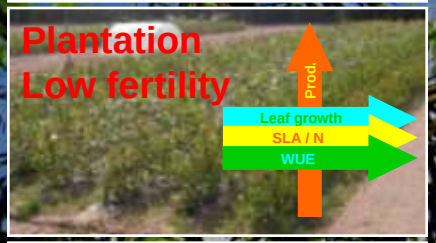
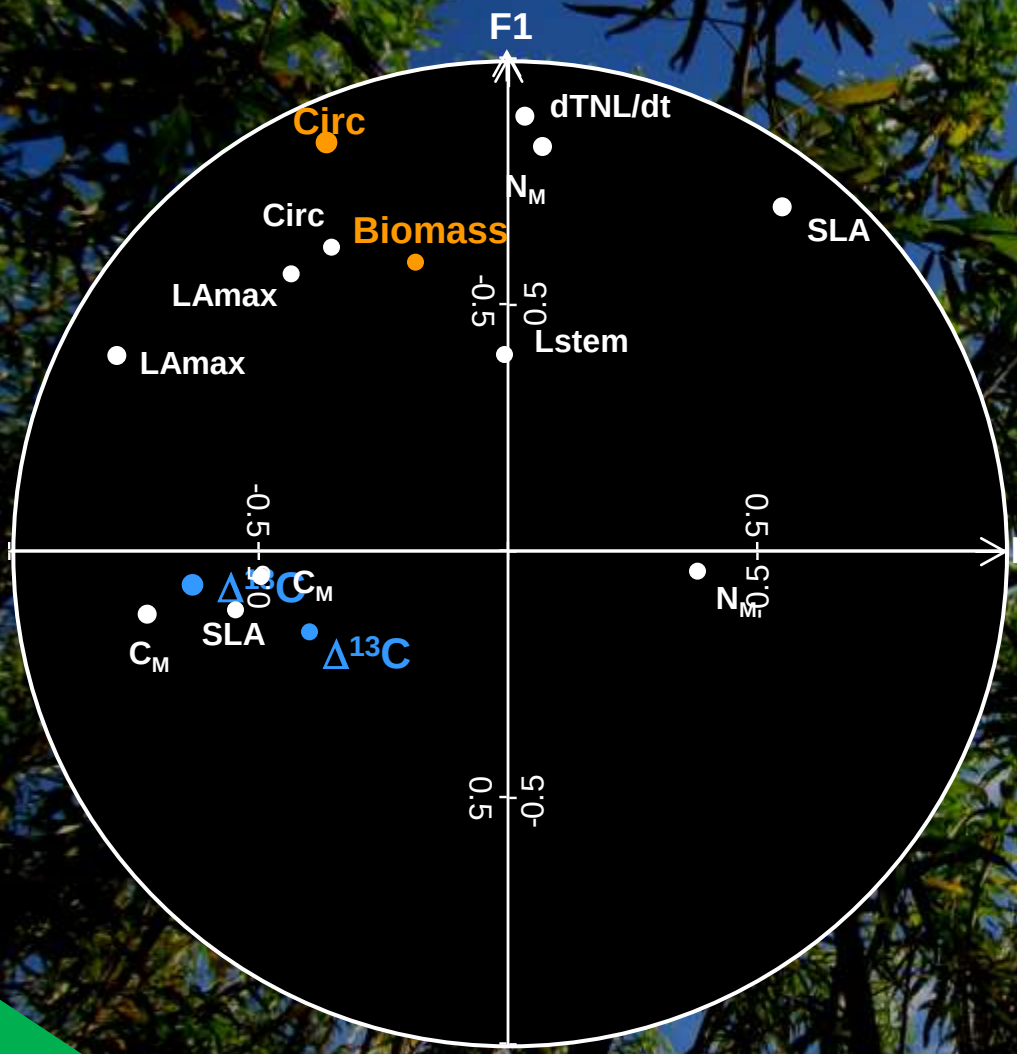


Monclus *et al.* 2005

Monclus *et al.* 2006

Poplar

European poplar clones (Belgian F1)



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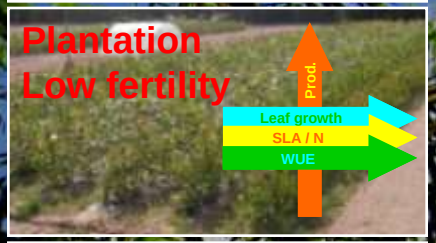

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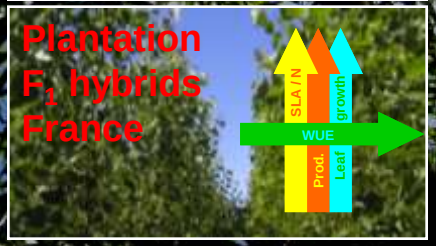

Marron and Ceulemans 2006

Dillen *et al.* 2011

Poplar

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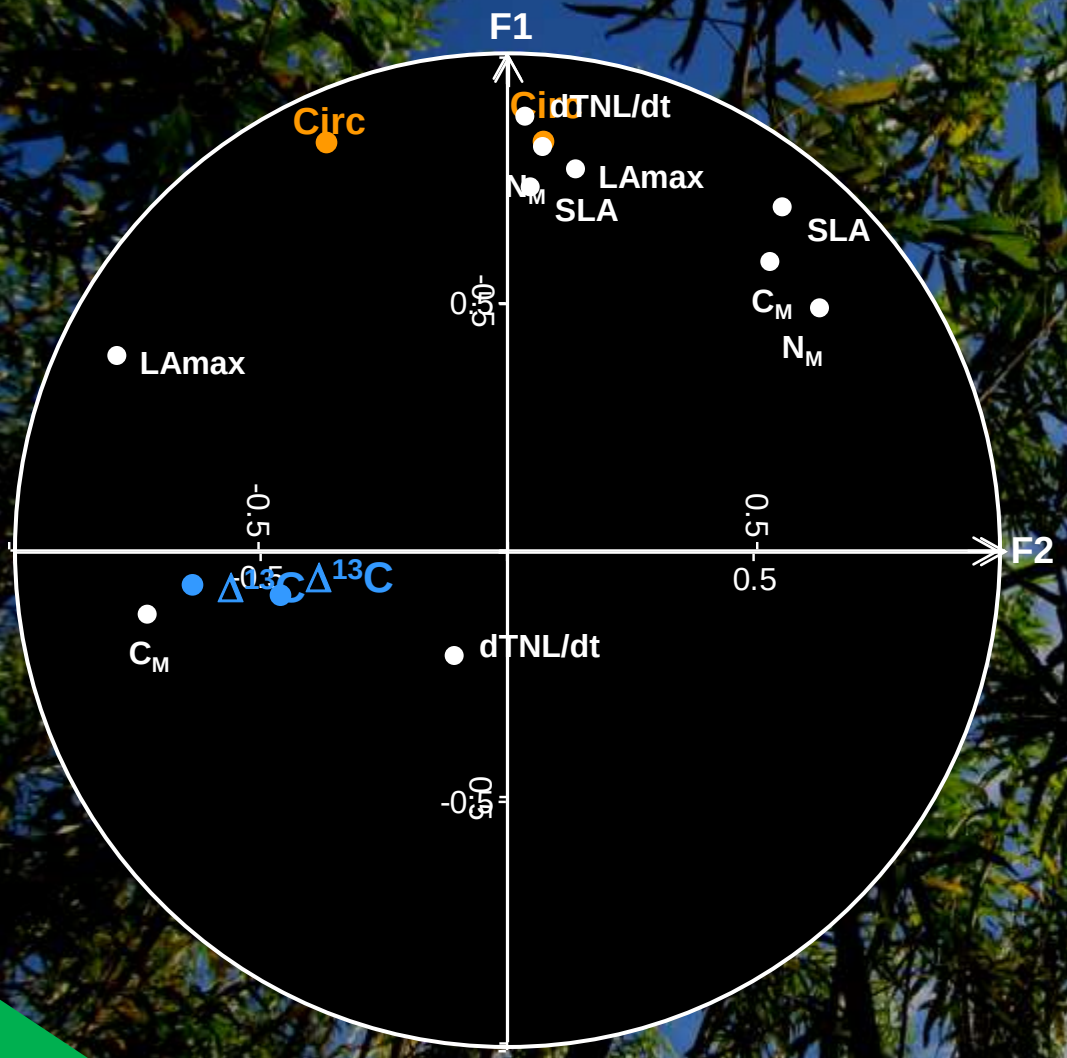

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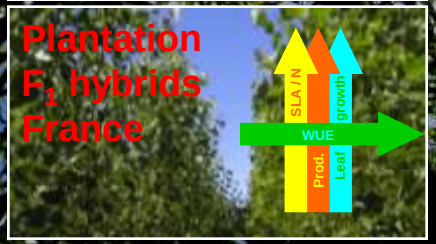

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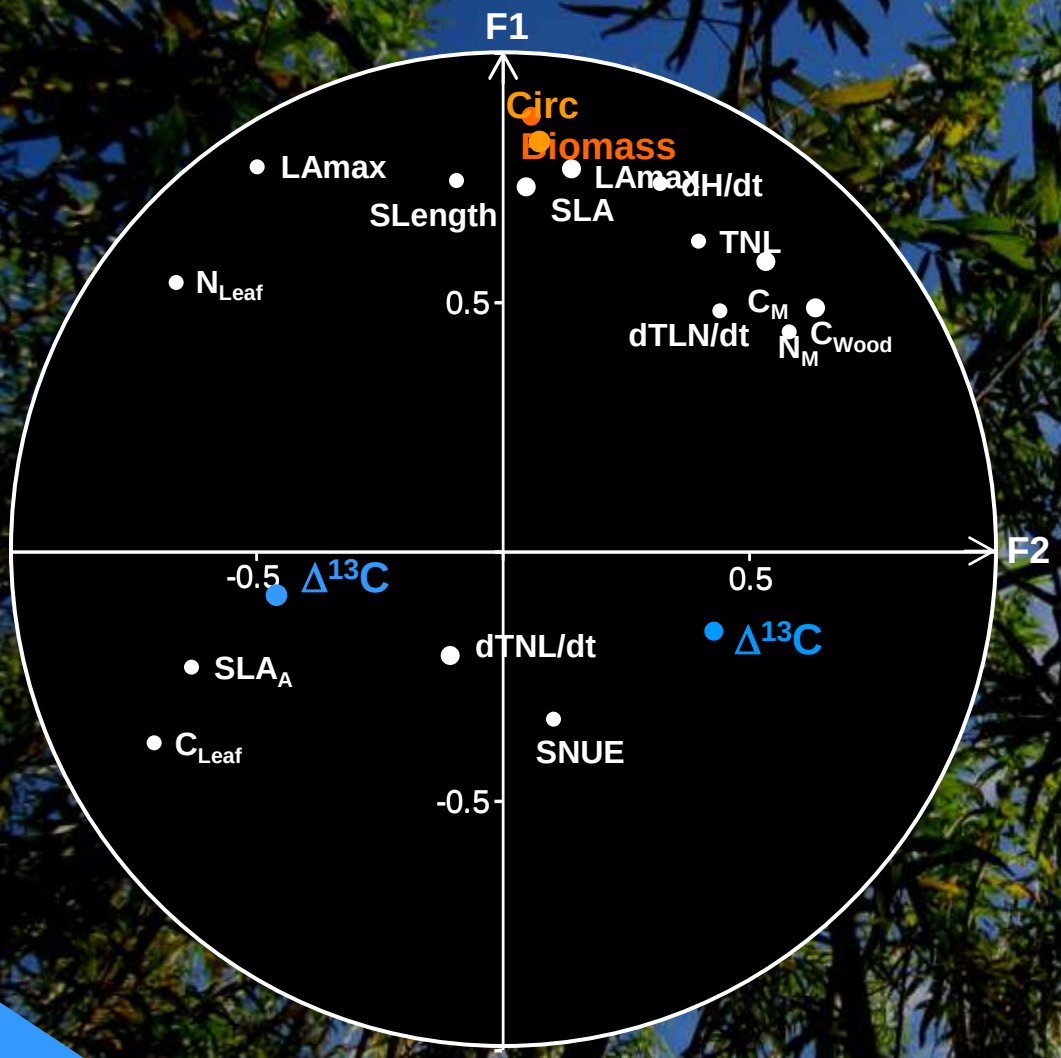
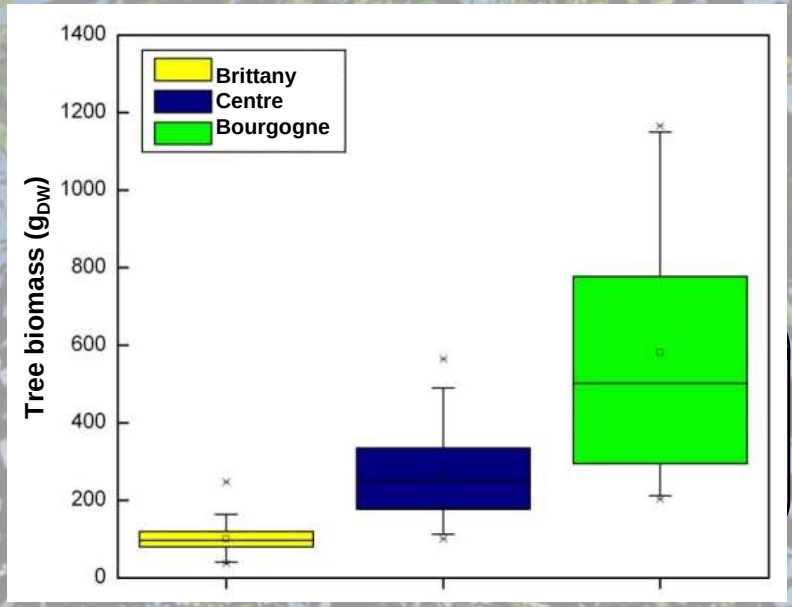
Poplar

European willow clones (Sweden / Ireland)



Six willow clones at 3 contrasting sites

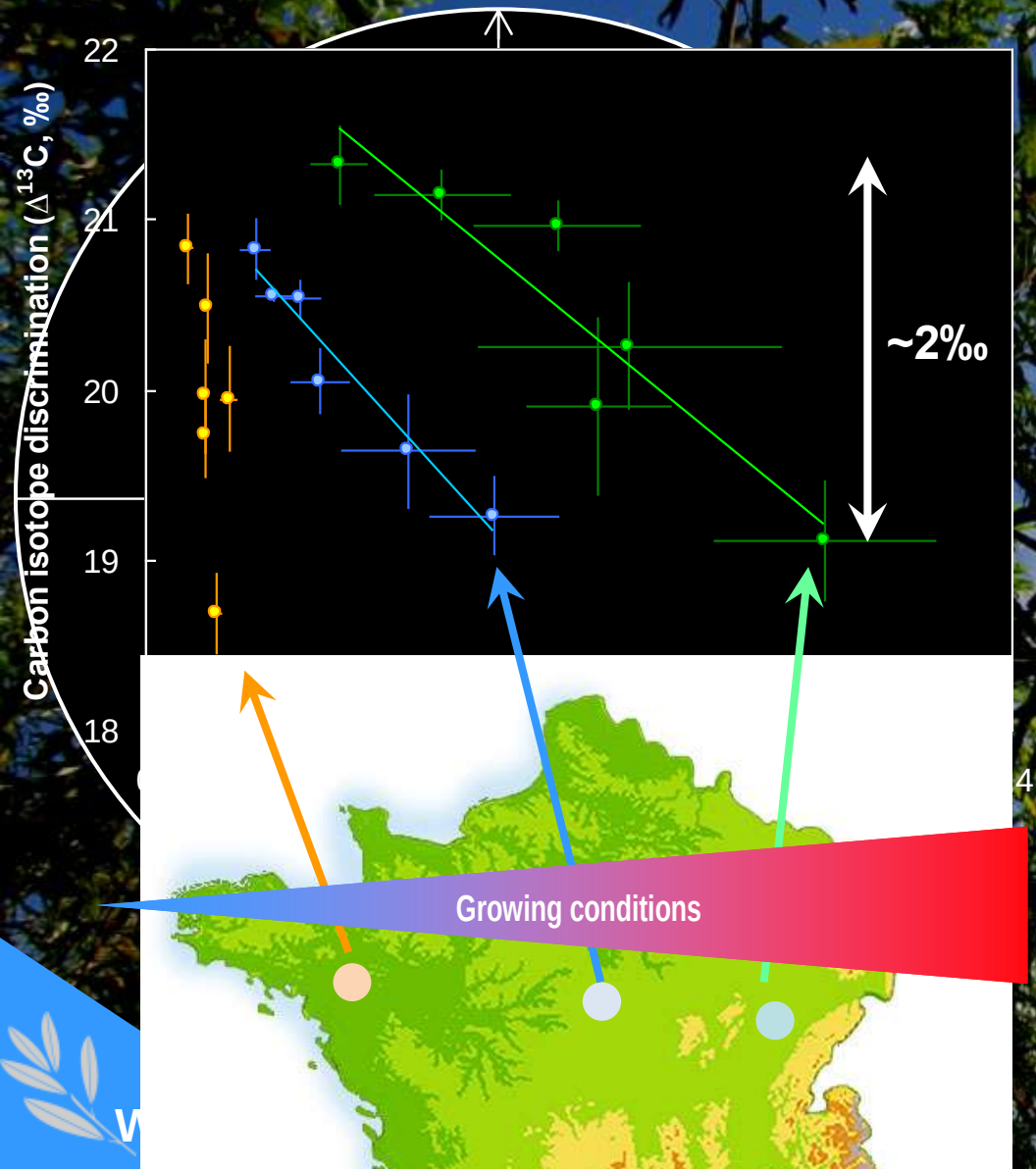


For willow as well, it seems that there is no relationship between productivity and Δ / WUE

But…

Willow

European willow clones (Sweden / Ireland)



… when studied site by site…

Around 30% variation in Δ among willow clones

Clone ranking stable among sites

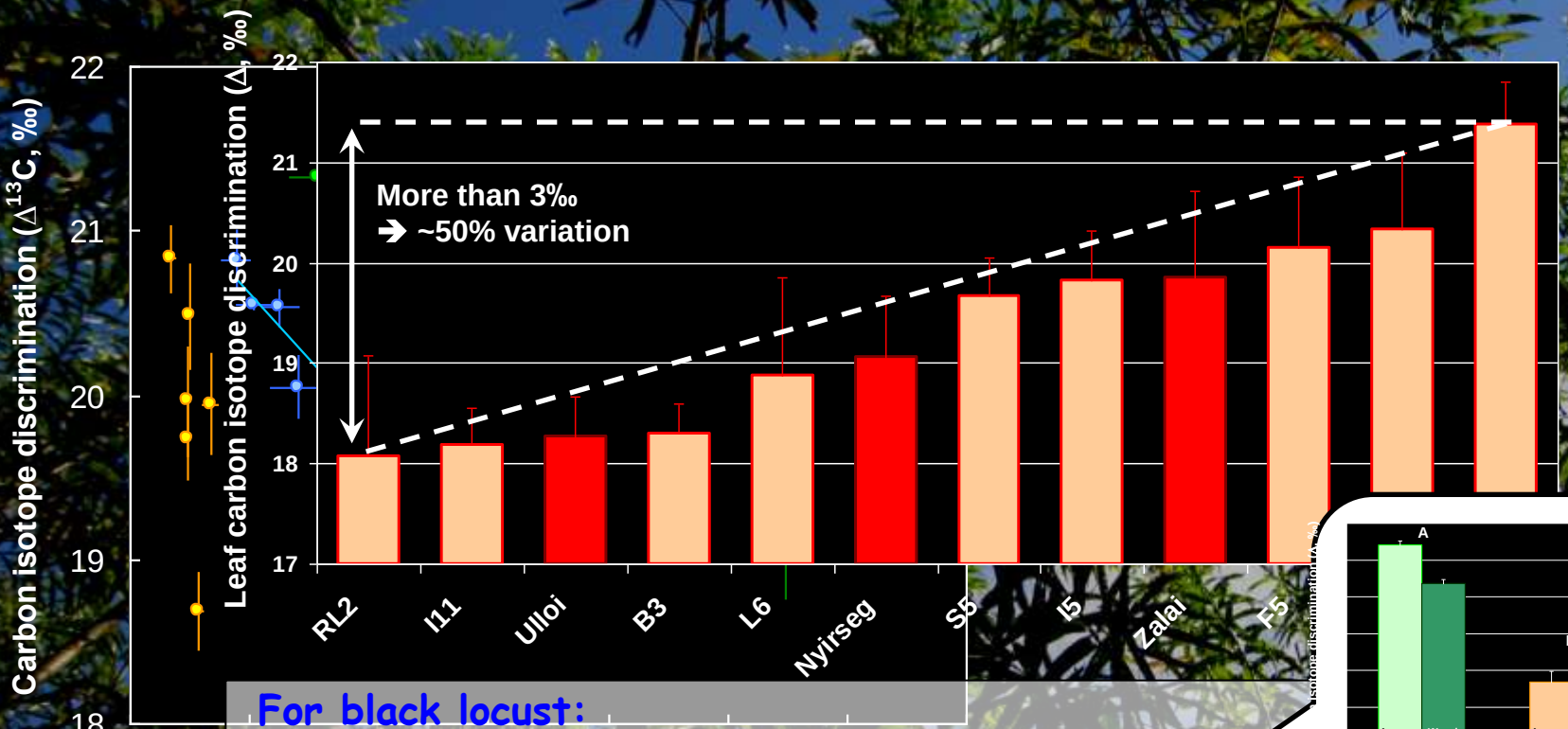
➔ Quite wide variation enabling selection

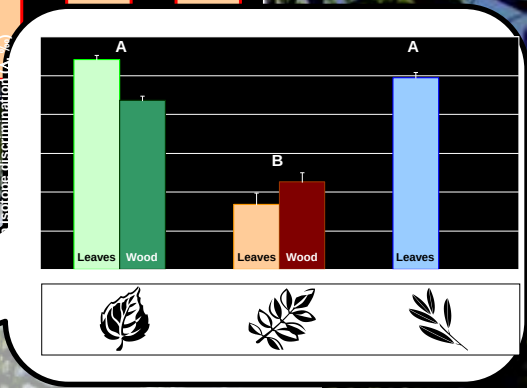
Relation Δ / biomass stronger when conditions are favorable

➔ Δ driven by assimilation at the "good" sites

➔ Δ driven by stomatal conductance at the "bad" site

European black locust clones (Hungary / France)





For black locust:

- Large clonal variation available in French and H
- But difficulties to propagate it clonally
- Contradiction between seedling Δ (17.2‰) and cutting Δ (19.5‰)

➔ Need to describe in more details this promising species for bioenergy

Black locust

In summary:

Variation

- Large Δ / WUE variation for the three species…

… but highly dependant on growth conditions

Clonal rankings usually stable whatever conditions

Relation with productivity

Poplar / Robinia: no link between Δ and production has been shown

Willow: negative link Δ / production (positive WUE / prod.)

➔ In any case, possibility to select for both traits together

➔ To be completed…


Thank you…
… and to the people
contributing to these projects

Carbon isotope discrimination during photosynthesis and W_i: simple model

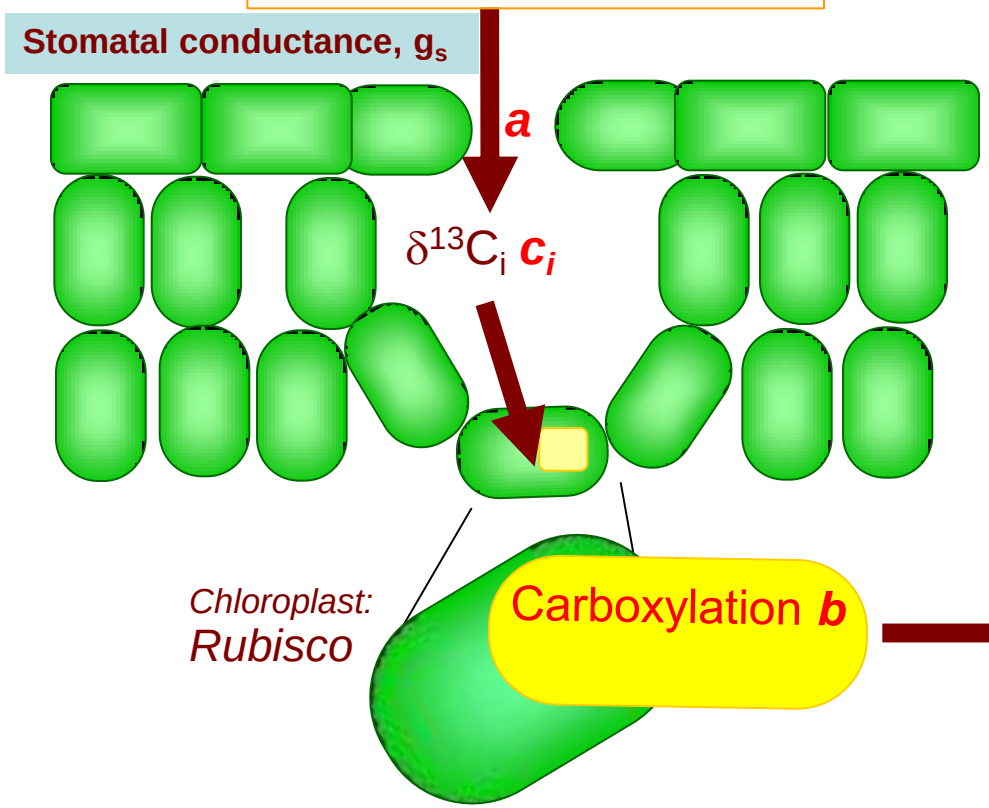
$$\Delta^{13}C \approx \delta^{13}C_{air} - \delta^{13}C_p$$

$$W_i = \frac{c_a}{1.6}\left(\frac{b - \Delta^{13}C}{b - a}\right)$$

Farquhar *et al.* 1984

Source: atmospheric CO_2
$\delta^{13}C_{air}$ c_a

Stomatal conductance, g_s



Product: photosynthates $\delta^{13}C_p$

C_a : atmospheric CO_2 concentration

C_i : intercellular CO_2 concentration

C_c : chloroplastic CO_2 concentration

Discrimination factors:

a : 4.4‰

b : 27‰

$\delta^{13}C_{air}$: carbon isotope composition of atmospheric CO_2 (≈-8‰)

$\delta^{13}C_p$: carbon isotope composition of photosynthates