CAQSIS-2018 UMR PIAF, Clermont-Ferrand, 27 - 29 mars 2018

Croissance et qualité des bois agroforestiers : problématique, état des lieux des connaissances et premier énoncé de questions de recherche

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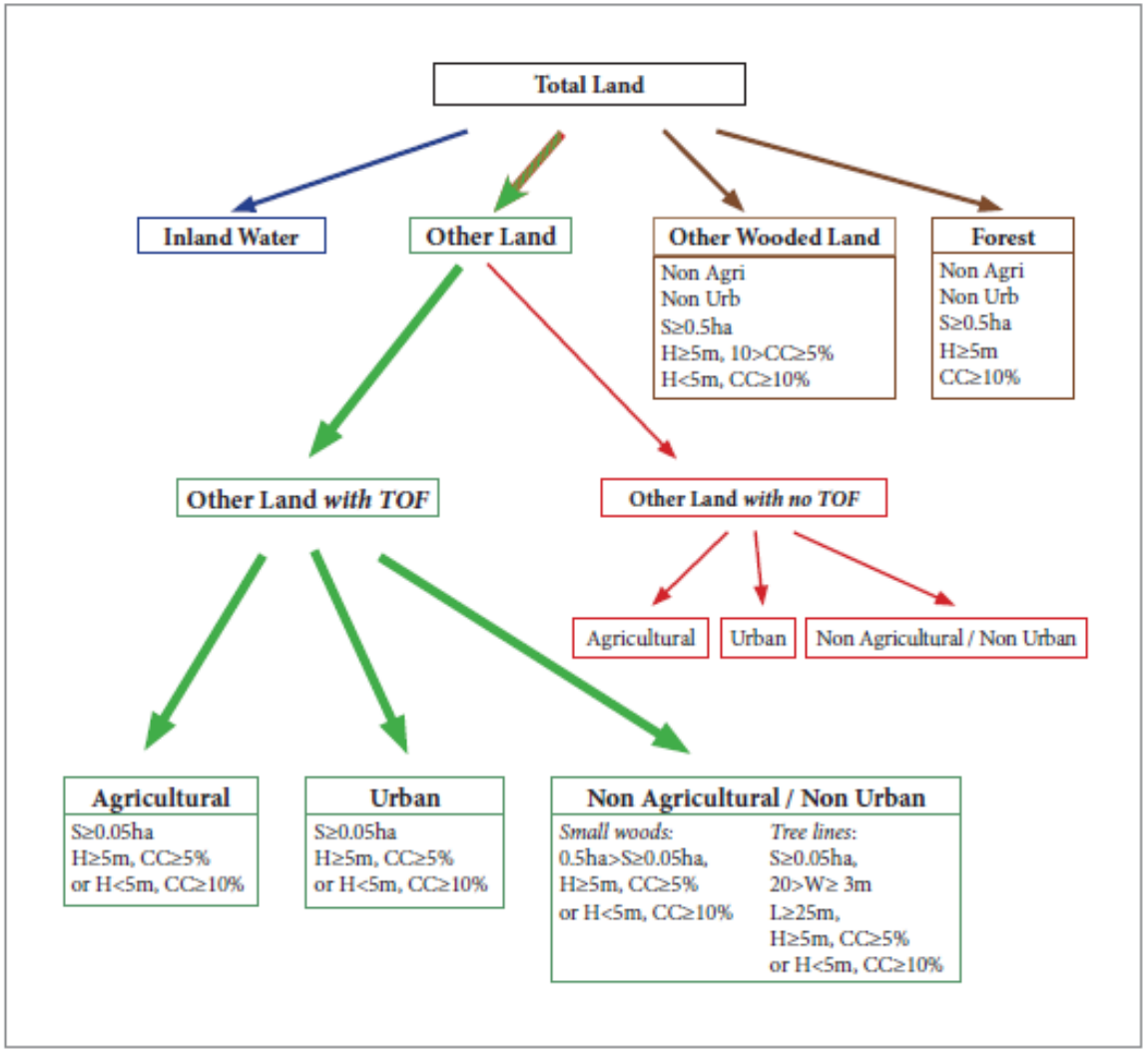
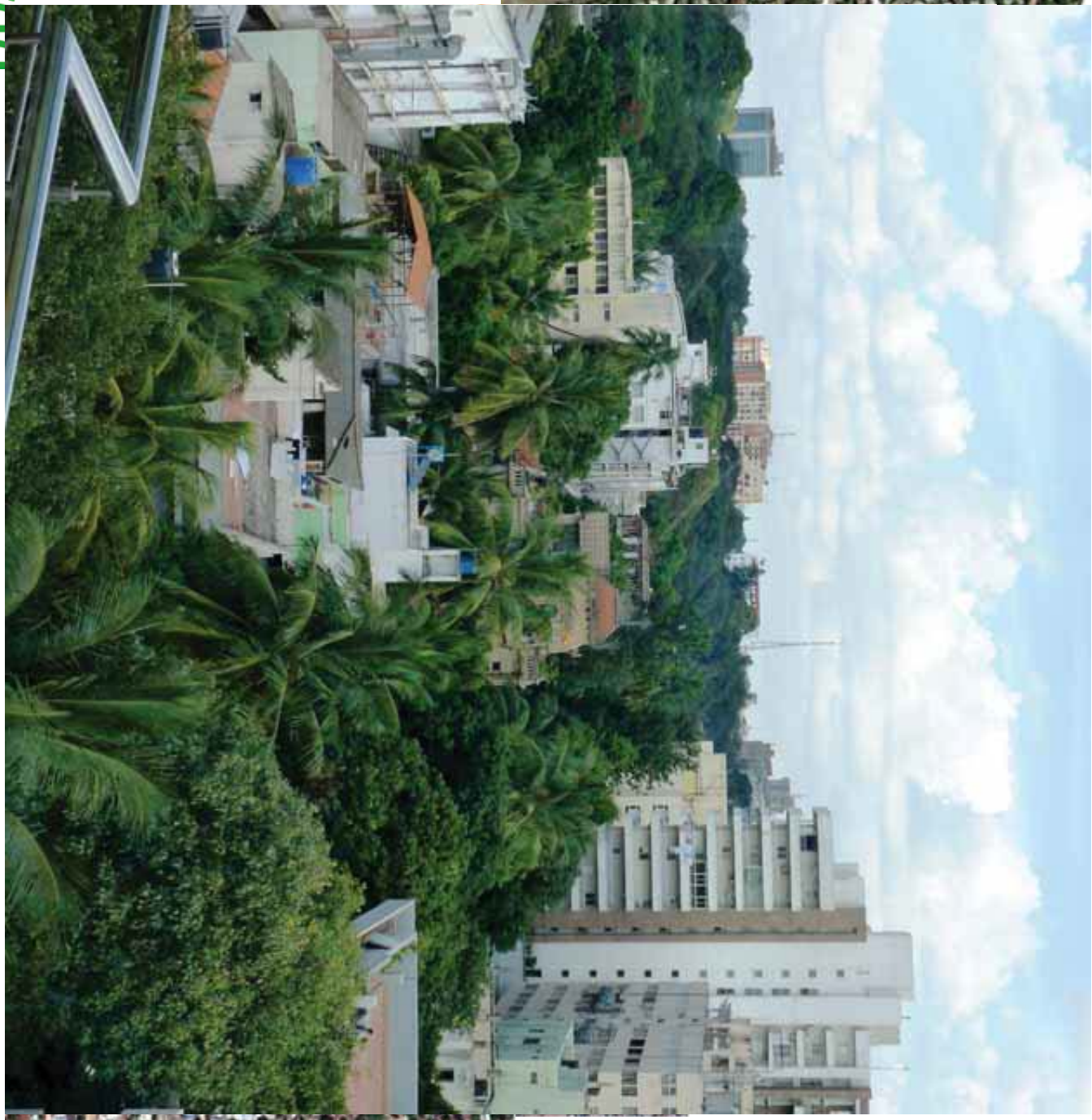
- Contexte
  - Les TOF
  - Le cas particulier des agroforesteries
- La qualité des bois d'agroforesterie
  - Typologie de la bibliographie
  - Un exemple d'étude comparative QB Forestier / QB Agroforestier sur peuplier I214, Restinclières, 34
  - La programmation contractuelle actuelle
- Les questions de recherches Caqso-compatibles
- Discussion



Tree Outside Forest (TOF)

Urbanforestry



Agroforestry

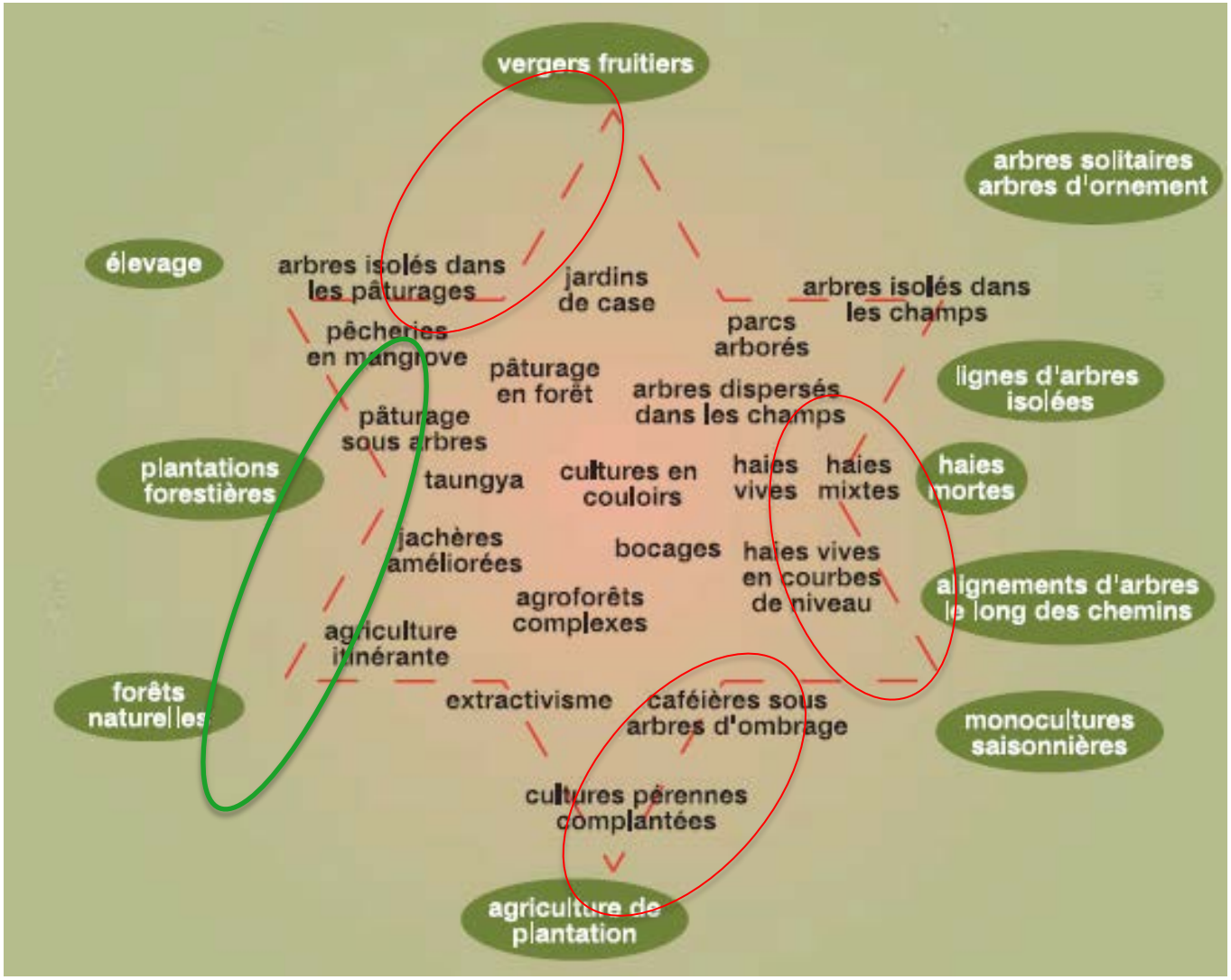
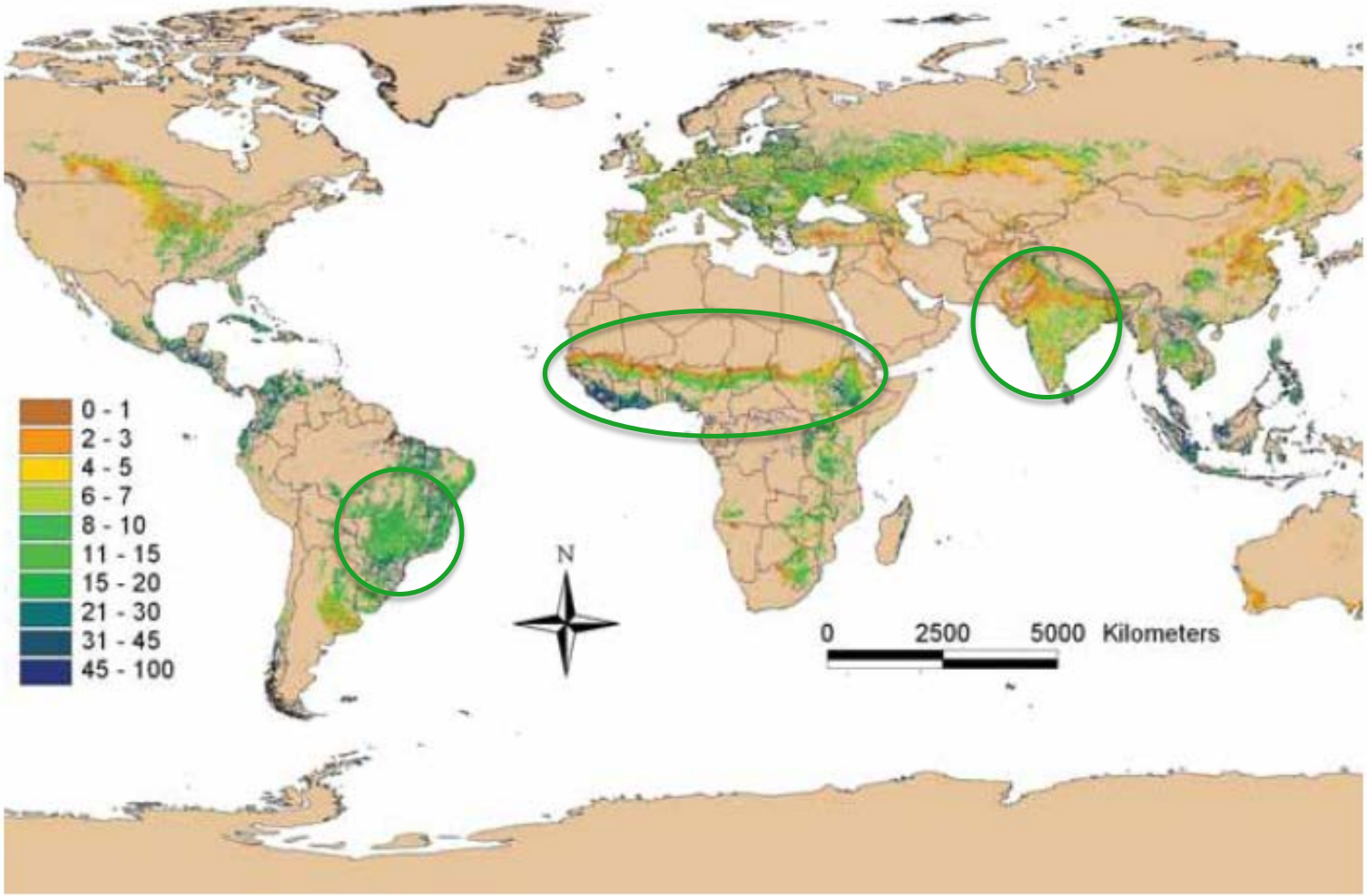


Figure 1. À la périphérie, les ovales représentent des situations non agroforestières. Au centre, le domaine flou de l'agroforesterie est délimité par des tirets indiquant les passages vers ce qui n'est pas de l'agroforesterie. Les caractéristiques agroforestières augmentent vers le centre.

d'après Torquebiau et al. 2002

Tree Cover on Agricultural Land - Global



Source: Zomer, R. J., A. Trabucco, et al. 2009. *Trees on Farm: Analysis of Global Extent and Geographical Patterns of Agroforestry.* ICRAF Working Paper 89. Nairobi, World Agroforestry Centre: 72.

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Challenges

- Food Security
- Energy Security
- Slum Clearance
- *And limitation of*
  - *Pioneer Front (deforestation)*
  - *Degradation of soils*
  - *Loss of biodiversity*

Answers

- Agroecological transition
- Short supply chain
- Balanced management of « Natural » forests *quite expensive (harvesting, transport, loggingcollateral damages)*
- Planted forests for energy and/or materials production *but genetic erosion, possible introduction of invasive species, chemical inputs (fertilizing, pesticides…)*

=> An invitation to

revisit AGROFORESTRY

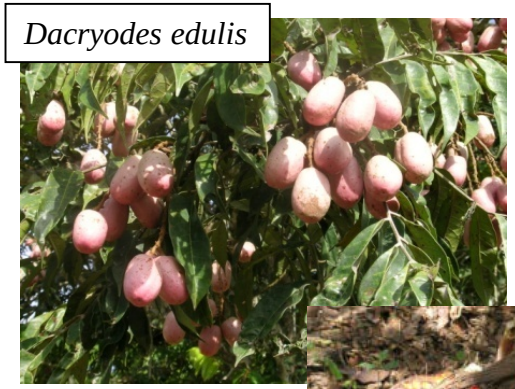
Example of Cocoa Plantation In Central Cameroon

Triplochyton scleroxylon

Timber production

Cocoa production

Dacryodes edulis



Fruits production

Morinda lucida

Medicinal use

Elaeis guineensis

Nuts and wine-palm production

Petersianthus macrocarpus

Host plant of *Imbrasia ertli.* (caterpillar consummed by some populations of Cameroon)

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+ Vegetable productions, etc…

… and lots of other services

Ceiba pentandra

Shading and keeping soil fertility

ETC….

Cola nitida

Social function

Ficus mucoso

Soil protection, water cleaning

Elaeis guineensis

Theobroma cacao

Property lines

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Savanna afforestation accelereted by human activities

Happy, 1998, Jagoret, 2007, Michel 2010

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En France métro

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- How to **design new AFS** to be integrated into wood value chain (energy & materials)?
- How to **encourage farmers** to invest in trees, the return on investment being in medium term?
- **Which tree species** to introduce or to keep there (compromise *auxiliary for agriculture / wood production / non invasive species / nitrogen-fixing species*, …)?
- For given species, how to **predict** and assess wood quality compared to « wellknowned » wood characteristics from natural forests or plantations ?

Agroforestery as a new wood supplier system for industry?

1. Qualification de bois d'essences utilisées en **plantation** et potentiellement utilisables en agroforesterie (e.g. *Glencross and Nichols 2008, Glencross and Nichols 2013)*
2. Qualification de bois issus d'un ou plusieurs types de systèmes agroforestiers et **comparaison entre SAF et avec données QB bibliographiques** de plantations (e.g. *Shanavas and Kumar 2006, Skukla & Viswanah 2014, Reza Taghiyaril & Efhami Sisi 2012).*
3. **Influence des cultures intercalaires** et pratiques agricoles sur QB (e.g. *Cutter and Garrett 1993)*
4. Comparatif QB agrofo/QB plantation et-ou /QB bois de forêt naturelle sur **dispositifs dédiés** (rarissime, voir plus loin)

Qualité des bois agroforestiers : typologie de la bibliographie (1)

5. Essences à **croissance rapide** réputées pour leur bonne durabilité et bonne mécanique
6. Souvent « **forte » densité de peuplement** (> 200 arbres/ha)
7. **Arbres jeunes** (<15 ans) => encore manque de recul
8. Essences **feuillues** tempérées (*Populus nigra, Juglans nigra),* tropicales ou sub-tropicales *(Tectona grandis, Acacia Mangium, Acacia auriculiformis, Grevillea robusta, Terminalia catappa, nombreuses essences de la rain forest Australienne, etc…)*
9. Partout : Inde, Iran, Australie, Océanie, USA, Europe, Afrique
10. Résultats : **pas de constat de franche dégradation** (ou de franche amélioration - eg densité du bois ; volumes produits / arbre)

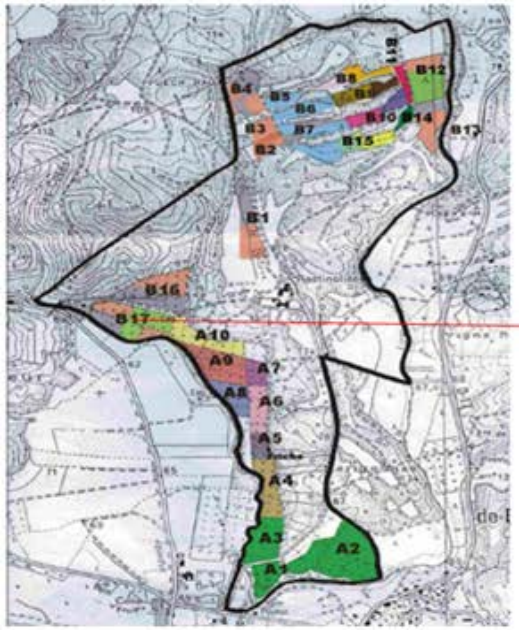
Qualité des bois agroforestiers : typologie de la bibliographie (2)

11. Situations agroforestières extrêmement contrastées *(conditions pédoclimatiques, cultures intercalaires, bandes en herbe, nombre de strates, mélanges d'essences, densités de plantation, …)* et données souvent très « mal comparées » => difficulté à faire émerger des tendances claires et d'avancer sur le **déterminisme des QB**

=> Nécessité de disposer de dispositifs permettant des comparaisons toutes choses égales par ailleurs *: exemple du domaine de Restinclière INRA_UMR System ; 250 ha avec culture, agroforesterie, témoins forestiers ; peuplier, noyer, cormier, paulownia, etc…*

Qualité des bois agroforestiers : typologie de la bibliographie (3)

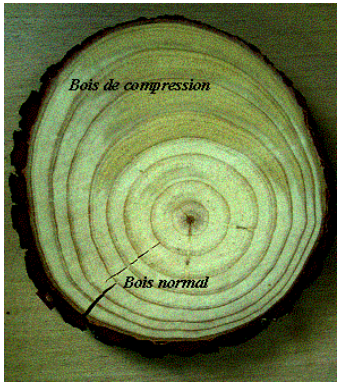
- Site description *(creation : 1994)*
  - Restinclières Domain, France (near Montpellier) ; 250 ha
  - Average annual temperature : 14°C ; rainfall : 880 mm ; 60 very windy days (65 % W / 25 % N / 10 % S)
  - Agroforestry Plot (AF): 119 trees/ha i.e. 57 trees planted 14m x 6m ;
  - Forest Control Plot (TF): 400 trees/ha i.e. 156 trees planted 5m x 5m
  - 19 years old trees_cultivar I214

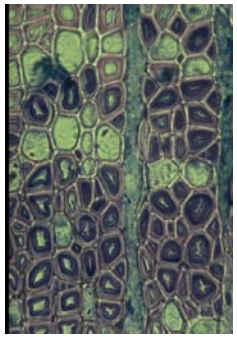


An example: Poplar I214

Lower density of plantation *(exposure to light & wind - less competition between trees - interaction trees /crops) => ?*

- Higher proportion of juvenile wood
- Higher proportion of reaction wood
- Higher growth stresses
- Higher rates of lignin
- Higher (or lower) rates of extractives / durability
- Higher transverse shrinkages
- Lower mechanical properties in L direction
- More branches (knots)
- Degraded trunks/logs shape (=> decrease of recoverable volume)





AF Wood Quality: some hypothesis

Distance to the river

LE LEZ

■ Lack of trees

○ Sampled trees

Vers SUD-EST

Ripisylve

								7	6	5					L15
					10	9	8	7	6	5	4				L14
		13	12	11	10	9	8		6	5	4	3	2	1	L13
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	L12
15	14	13	12	11	10		8	7	6	5	4	3		1	L11
15	14	13	12	11	10	9	8	7	6	5	4	3	2		L10
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	L9
15	14	13	12		10	9	8	7	6	5	4	3	2	1	L8
15	14	13	12	11	10	9	8	7	6	5	4	3	2		L7
	14	13	12	11	10		8			5	4		2		L6
15		13	12	11				7	6	5					L5
15	14	13	12	11	10	9	8	7		5	4	3	2		L4
	14	13	12												L3
15	14	13	12			9		7	6	5	4	3	2	1	L2
	14		12							5	4			1	L1

Fossé

Témoin agricole (et passage obligatoire pour les engins)

Vers NORD-OUEST

Fossé écoulement vers le Lez et séparation A10 et B17

Bordure cultivée

L7		1	2	3	4	5	6	7		9				Ligne Cormiers =>		
Allée cultivée <14>																
L6	1	2	3		5	6	7		8				12	Ligne Cormiers =>		
L5			3	4	5	6	7	8			10		12	Ligne Cormiers =>		
Allée cultivée <14>																
L4	1	2	3	4		6	7	8	9	10				Ligne Cormiers =>		
Allée cultivée <14>																
L3		2	3	4	5			8		10		12		14	15	Ligne Cormiers =>
L2	1	2		4	5	6	7	8	9					Ligne Cormiers =>		
L1		2	3	4	5	6	7	P	P	P	11	P	P	14	Ligne Cormiers =>	

EP

Bordure non cultivée

Fossé

Chemin vers source du Lez

20 trees sampled (10 + 10)

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- Dendrometric measurements

  . Total height

  . Diameter (DBH)

  . Ovality

  . Volume

- # Modulus of Elasticity (MoE) measured on standing trees

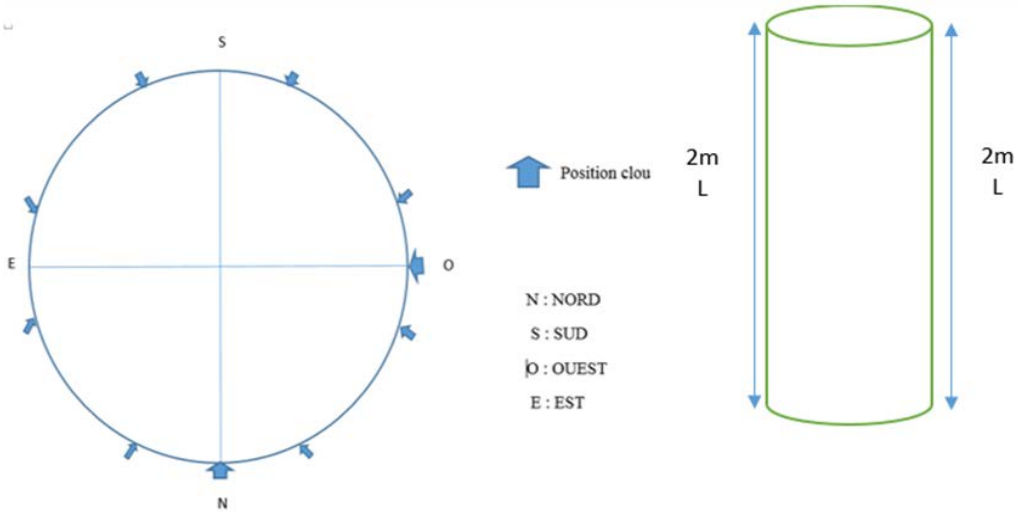
. in orthogonal (R, T, L) & compass directions (N, E, S, W) using WISiS system (non destructive method)

. MoE = ρ(L/t)2 (ρ : density ; L : nails distance ; t : propagation time)

Accéléromètre

Conditionneur pour accéléromètre et marteau instrumenté + carte d'acquisition

Nails positioning



- Growth-stresses measurement using DRLM System (longitudinal residual deformations of maturation) in the 4 compass directions

❑ Fixing the transducer between two reference points

❑ Drilling between these reference points

❑ Reading the longitudinal deformation

❑ Converting these data into strain value

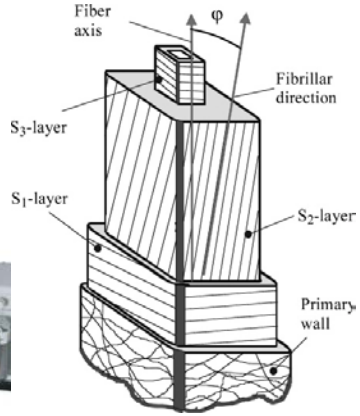





- Measurements on N/S increment cores

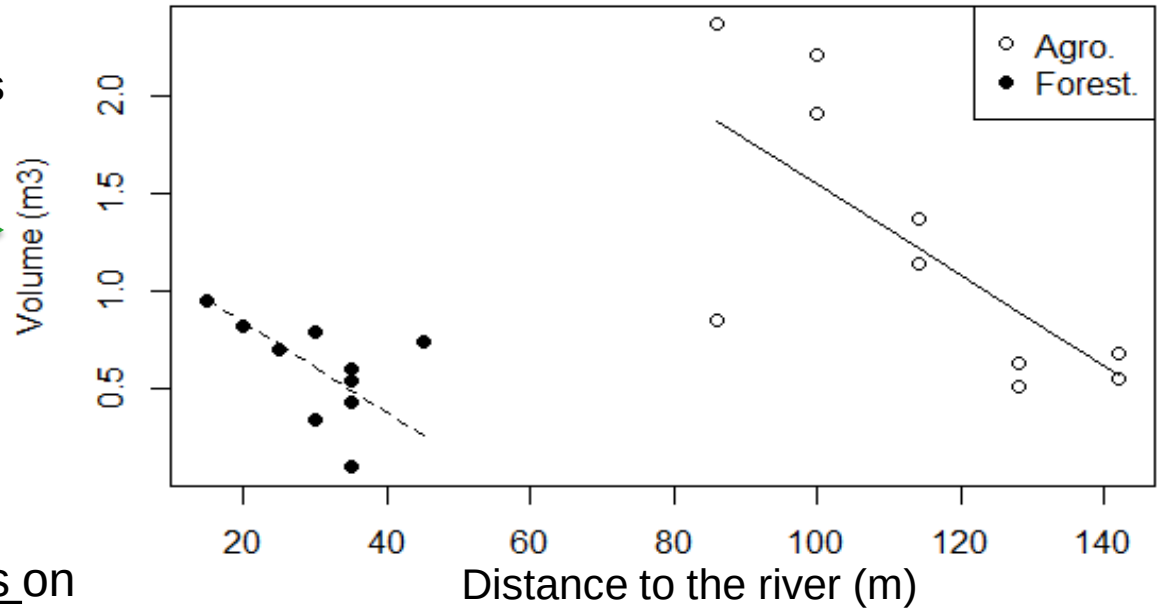
. one Ø 5mm increment core / tree using a Pressler auger (moisture content & density)

. one Ø 10 mm increment core / tree using a motorized drill (microfibril angles for each ring by X-ray diffractometry / Lignin content using Klason lignin method)



Results (1)

- Sylvicultural treatment
  - Significant effect on
    - trees slenderness
    - trees volume

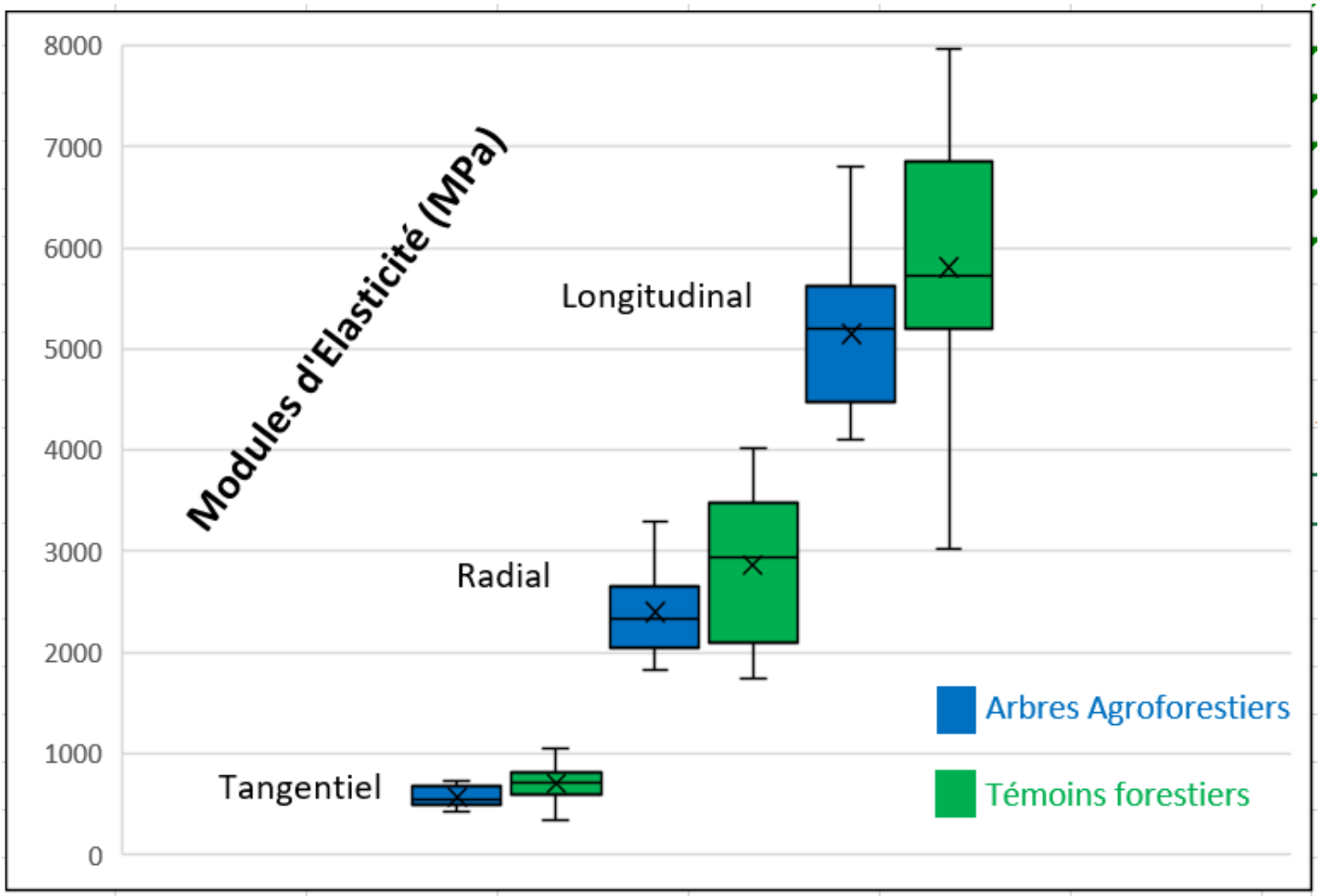


- *Agroforestry trees less slender than forest trees (0,42 vs 0,29)*
- *Agroforestry trees bigger than forest trees*

  - No significant effects on
    - ovality, tree height, tree diameter
      (All the trees are almost cylindrical and almost straight in each plot)
    - growth stresses
    - wood mechanical properties
    - MFA, %Lignin

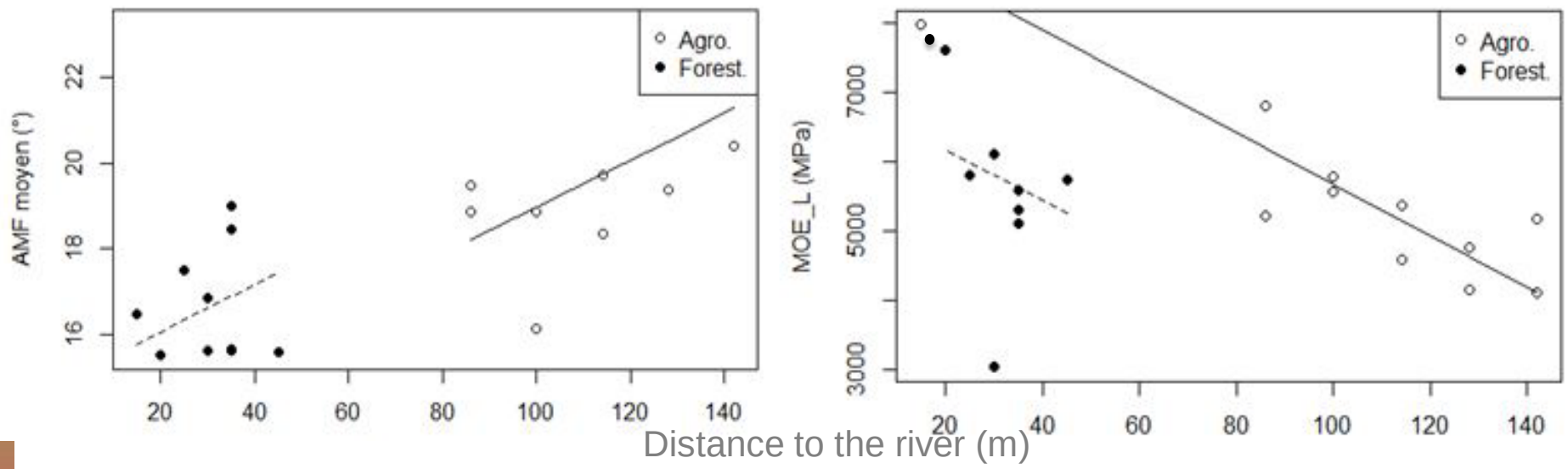
Results (2)

A slight trend of MoE (values & variability) decrease in Agroforestry trees



Results (3)

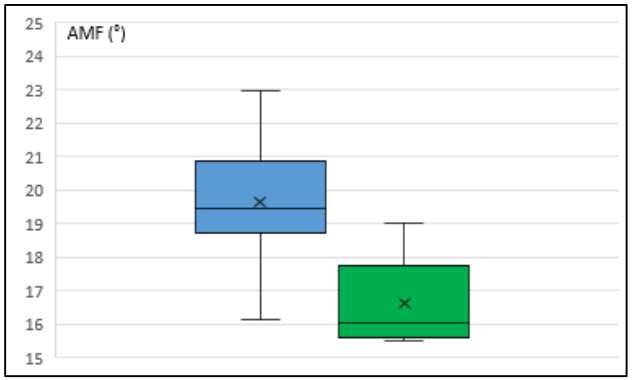
BUT significant effects of the distance to the river
both on MFA (>0) & MoE_L (<0)

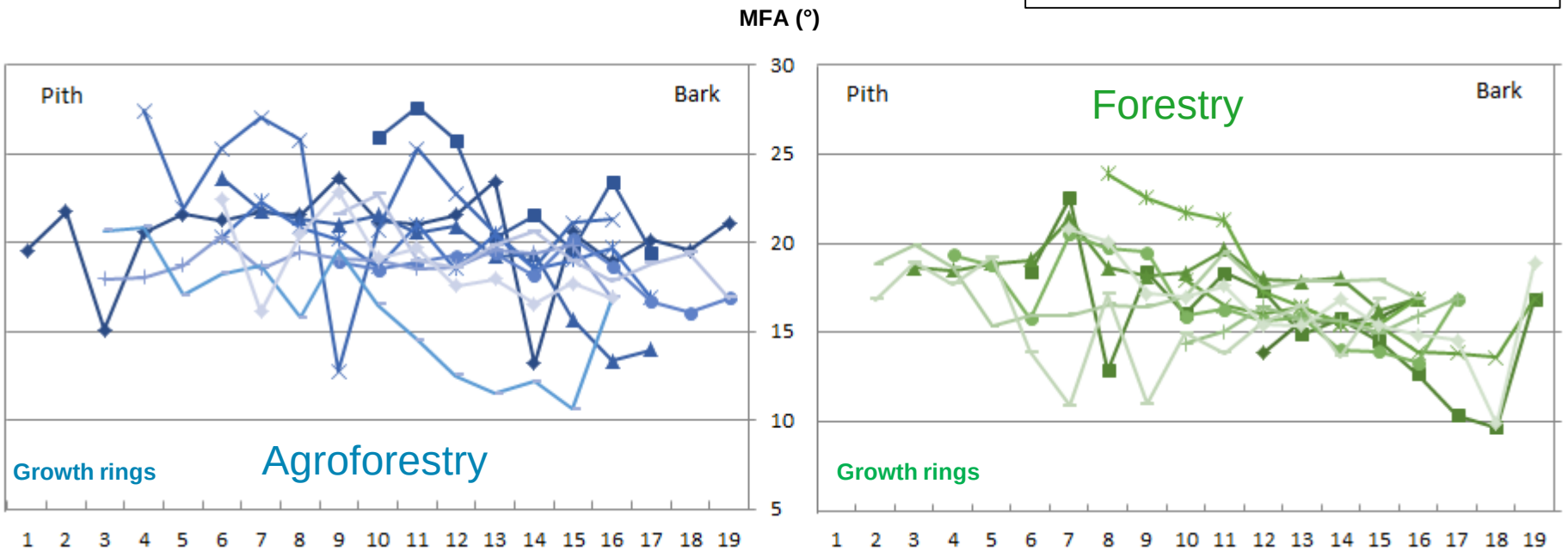


=> Interaction between the two factors « sylviculture »
& « distance to the river »

Results (4)

An trend of MFA increase in Agroforestry trees





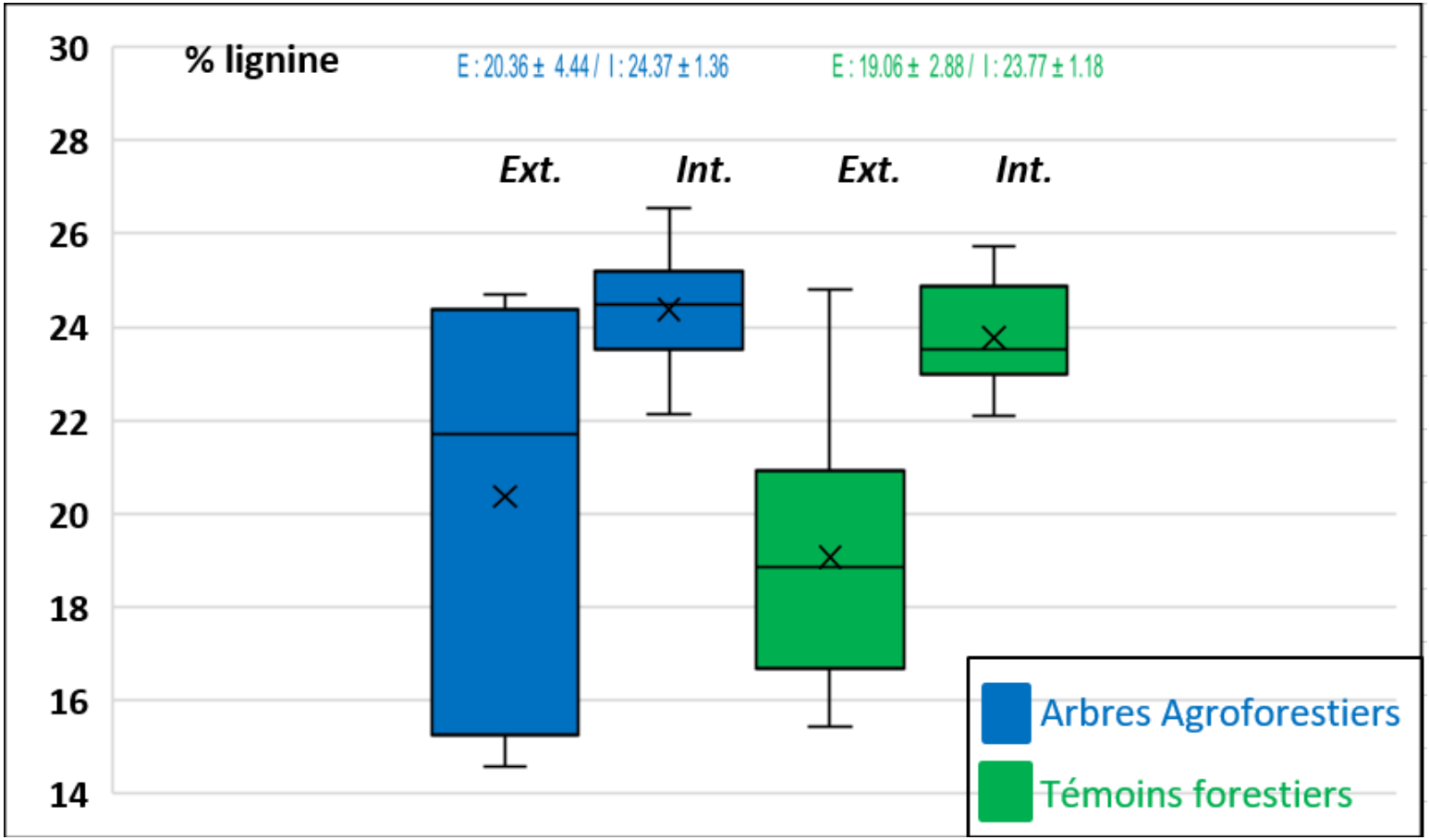
MFA vs cambial age

Mean MFA : 19.65 ° / Mean sd : 2.40°

Mean MFA : 16.62 ° / Mean sd : 2.05°

Results (5)

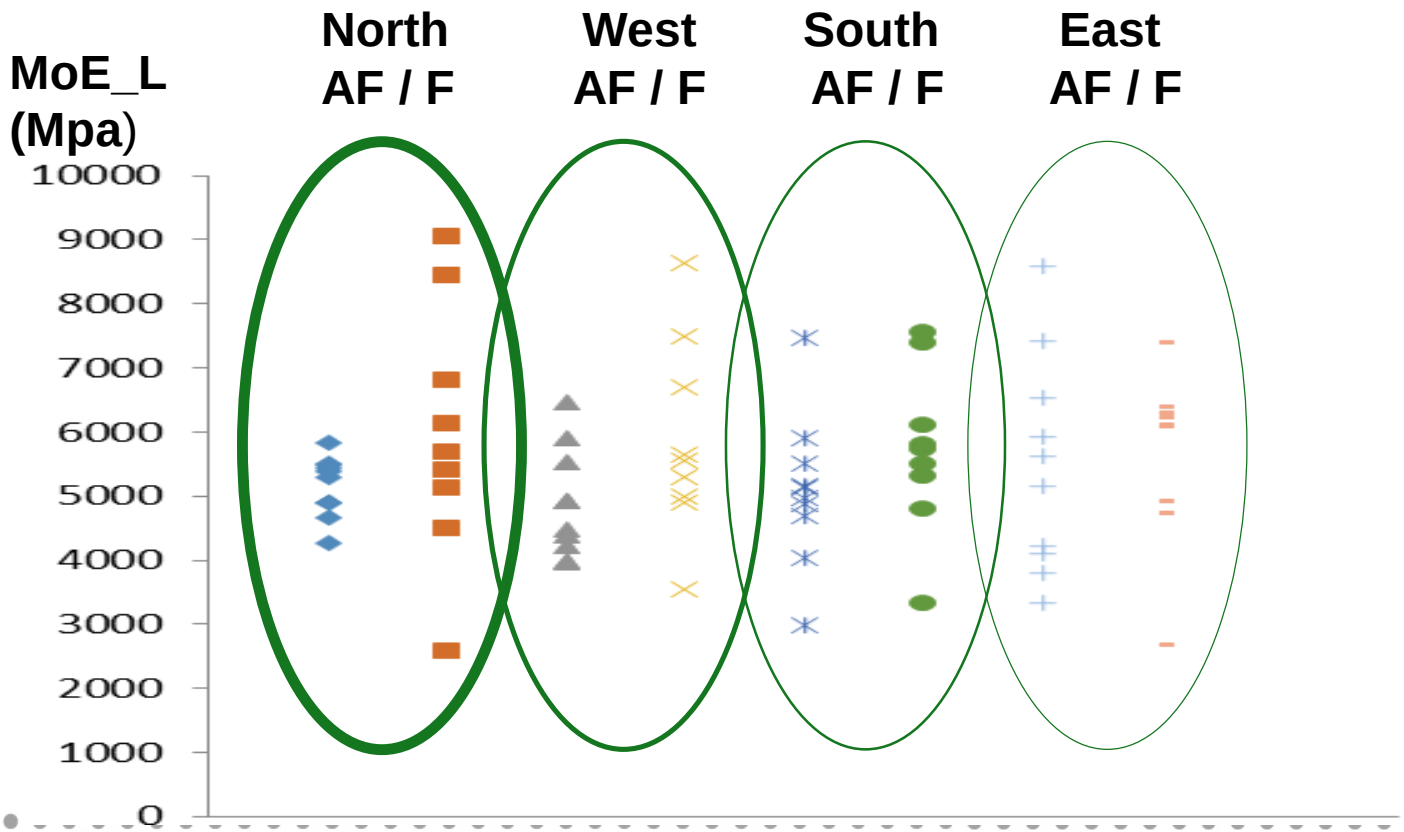
A slight trend of % Lignin increase in Agroforestry trees



Ext = Extérieur (supposé être du bois adulte) Int = intérieur (supposé être du bois juvénile)

Results (6)

No significant effect of cardinal orientation on mechanical properties



To sum up…

- Difficult to generalize results because of the small sampling and of the interaction sylviculture/distance to the river
- Trends of small degradations (statistically not significant) of material properties in AFS (MFA, Lignin, MoE) but less variability of mechanical properties in agroforestry plot
- Access to water is a very important factor to explain variabilities

But, roughly, intrinsic poplar wood quality coming from agroforestry seems equivalent to the quality of wood produced into “forest” conditions…

To be done:

- Measurement of tension wood on disks
- Confirmation of these results on a larger sample, other localisations, other cultivars

1. **Poplar I214** UMR System in Restinclière (phenotype, cc, br, perf méca) – CD Hérault
2. Branch valorisation **Oak and Chestnut** (bocage), **Poplar and Walnut** (intra-parcel) - Graine Ademe
3. **Landa, Bunbinga, Padouk** (mecha., durability) in cocoa plantation, Centre Cameroon – FFEM/AFD
4. Which species to design new cocoa AFS in Ivory Cost? – FFEM/AFD
5. Reintroducing « Old » Mediterranean **Poplar** cultivars (6 countries) into the field to ensure perennial supplies of wood industries (+Low J/M transition age) - ENI_EU
6. AFS integration into wood sector (French Guyana) – Labex CEBA

Other projects in progress

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- **Déterminisme de la qualité des bois (**y.c. aspects biochimiques**) dans les différents compartiments des TOF ?**
- **Quelles influences (i) des élagages houppier et réductions racinaires des arbres (ii) des cultures intercalaires et interventions humaines associées sur la xylogénèse des TOF ?**
- **Quelles spatialisations** (y.c. densité de peuplement) **et quelles mixités d'essences** (niveau de biodiversité) **pour une production de bois de qualité bien articulée avec les autres services écosystémiques?**
- **Quelles relations architecture arbre / QB ?**
- **Quelles gestions des compromis agro/fo/bois?**

Questions de recherche (1)

- Comment se réapproprier les savoirs autour des valorisations traditionnelles des produits ligneux agroforestiers (éthno) ?
- Quels retours pour le petit paysannat ?
- Comment concevoir les nouveaux SAF pour intégrer la ressource ligneuse dans les filières bois d'œuvre, bois énergie et chimiques
- Comment faire travailler ensemble forestiers et paysans ?

Questions de recherche (2)

A suivre… (coopérations)

MERCI !

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1937-2017
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INTERNATIONAL UNION OF FOREST RESEARCH ORGANIZATIONS

DIVISION 1 - SILVICULTURE

1.04.00 - AGROFORESTRY

Coordinator:
Swoyambhu Man Amatya, Nepal

Deputies:
Gert Nyberg, Sweden
Clement Akais Okia, Uganda
Alvaro Sotomayor Garretón, Chile

Unit 1.04.00

- Activities and events
- Publications and references
- Expertise offered by Unit

DIVISION 6 - SOCIAL ASPECTS OF FORESTS AND FORESTRY

6.07.00 - URBAN FORESTRY

Coordinator:
David Nowak, United States

Deputies:
Marcus Hedblom, Sweden
Cecil C. Konijnendijk van den Bosch, Canada
Sreetheran Maruthaveeran, Malaysia

Unit 6.07.00

- Activities and events
- Publications and references
- Expertise offered by Unit
- Toolbox
- Unit Noticeboard

ABOUT UNIT

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UNIT NOTICEBOARD

2018-01-09
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forestry will be explore
By learning from one a
will highlight excellent
We are also looking fo

http://www.iufcvancouv

DIVISION 5 - FOREST PRODUCTS

5.06.00 - PROPERTIES AND UTILIZATION OF PLANTATION WOOD

Coordinator:
Roger Meder, Australia

Deputies:
Yafang Yin, China

Unit 5.06.00

- Activities and events
- Publications and references
- Expertise offered by Unit
- Toolbox

ABOUT UNIT

The move by many countries to develop forest plantation is a key step towards conserving and managing the natural forest sustainably. Increasingly, more and more tree species have been introduced into forest plantation programmes.
A major concern of this Research Group is to document and make available information on the properties and utilization of newly introduced and exotic plantation woods through discussions, linkages, networks and other means. It is hoped that such actions would enable the utilization of such data for successful forest plantation programmes thus contributing to sustainable forest management.

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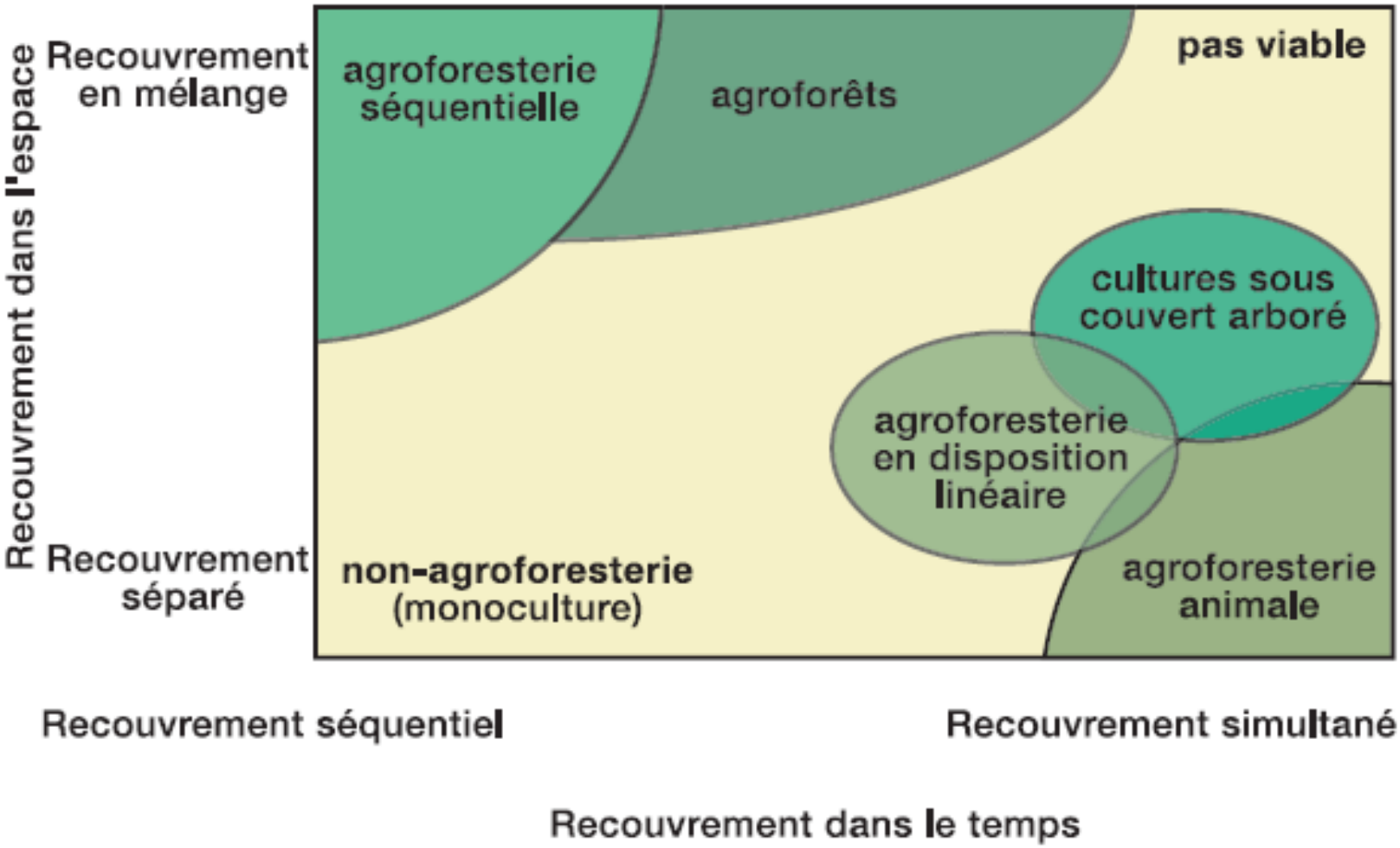

Figure 2. Classification de l'agroforesterie fondée sur le degré de recouvrement spatial et temporel entre les arbres et les cultures (VAN NORDWIJK, PURNOMOSIDIH, 1995, modifié).

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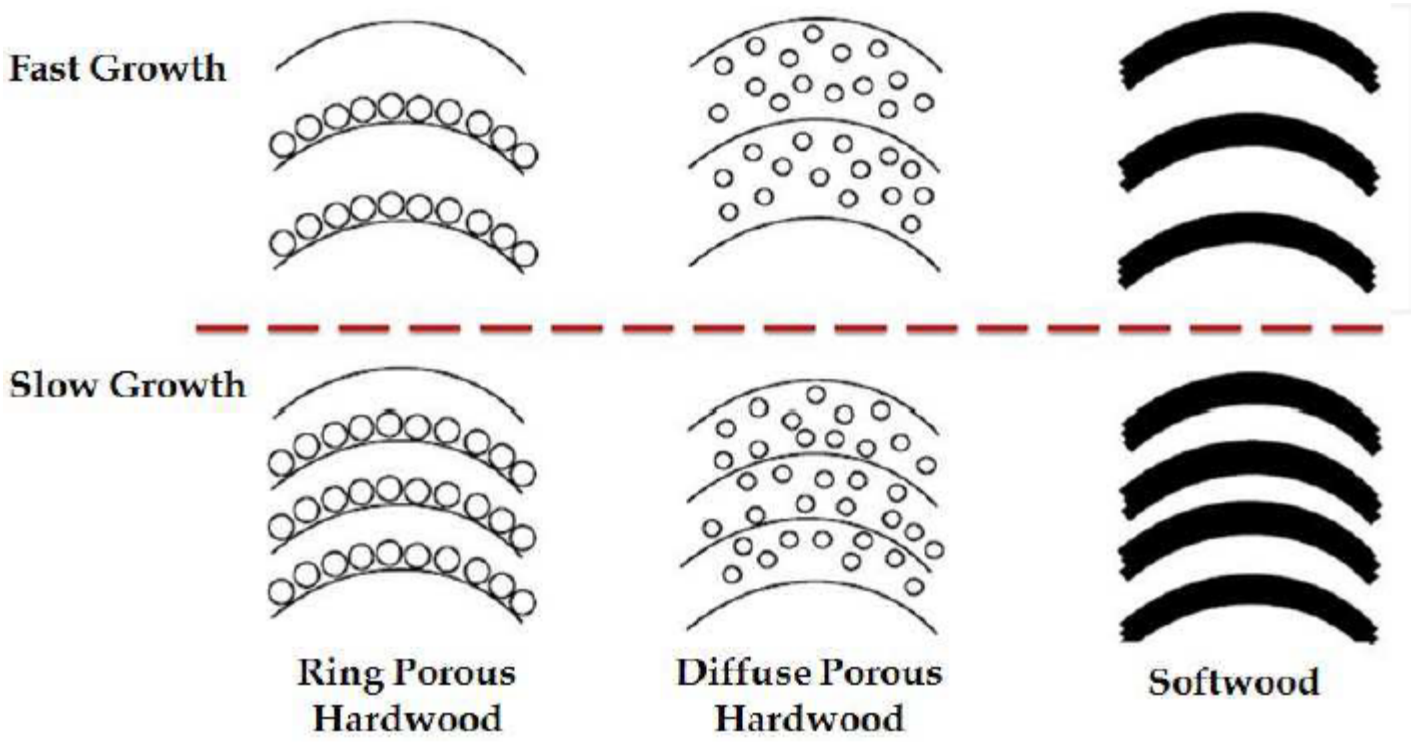

Influence de la vitesse de croissance sur la structure des cernes
(d'après Taghiyari et Sisi 2012)

TO SUM UP…

Productions

- ✓ Cocoa, coffee, cereals, etc.
- ✓ Fruits
- ✓ Cattle
- ✓ Medical products
- ✓ Beverage
- ✓ Wood for cooking, energy
- ✓ **Lumber, high diversity of wood materials**
- ✓ Biomolecules
- ✓ Fibres, Oils, Resins
- ✓ ….

Other services

- ✓ Soil protection (against erosion, limiting chemical inputs, maintaining fertility, nutriment cycling, …)
- ✓ Habitat for natural predators of crop pests
- ✓ **Conservation of biodiversity / ecological corridors**
- ✓ Microclimate
- ✓ Carbon sequestration
- ✓ Cultural role
- ✓ Demarcation of parcels
- ✓ Quality of life improvement

Resilience / Forest <-> agriculture revesibility / Alternative to pioneer fronts / Savanna afforestation / Healthy production / Short chain supply / Autonomy

Multifonctionality of AFS

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Introducing **biodiversity** into the plantation or into the fields

⇒ Well understanding of relation ***growth conditions / growth interactions between species / wood properties*** for different tree species

⇒ Take advantage of **a much more various offer**

Upstream sorting of **biodiversity** to supply hight value *niche product systems* **(«picking» biodiverse qualities into the fields)** taking advantage of **natural optimisations**

⇒ to developp specific tools for Non Destructive Characterisation into the fields…

Notion of Material Biodiversity Management

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…whereas now, two main industrial ways to manage wood variability

- Standardisation of wood products (dimension, mechanical grading, …)
- Deconstruction of solid wood to rebuilt Engineering Wood Product

A third way, remembering the initial fonctions of wood into the trees

VS

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=> An invitation to

revisit AGROFORESTRY ?

Of course yes,

but some challenges for wood industries

- How to adapt industrial tools to wood variability, **not any more only reducing it** (standardisation) but also **taking advantage of it**?
- How to integrate agroforest wood into the value chain supply?

=> Also an invitation to

revisit WOOD INDUSTRIES

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