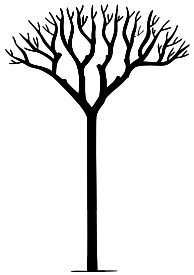
Xtrawood: refining estimation of tree above ground biomass using wood density variations and tree structure

Romain Lehnebach, Hélène Morel, Julie Bossu, Jacques Beauchêne, Eric Nicolini
Jean-François Barczi, Sébastien Griffon

Tree Above Ground Biomass (AGB)

tree AGB = Tree volume X Whole-tree Basic density

Perfect tree AGB estimate !!



$$\frac{\text{Tree Dry mass}}{\text{Tree Green volume}}$$

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tree AGB = Tree volume X Whole-tree Basic density

Perfect tree AGB estimate !!

$$\frac{\text{Tree Dry mass}}{\text{Tree Green volume}}$$

tree AGB = Result of Allometrical equations (DBH, H and **Species-level wood density** value)

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Perfect tree AGB estimate !!

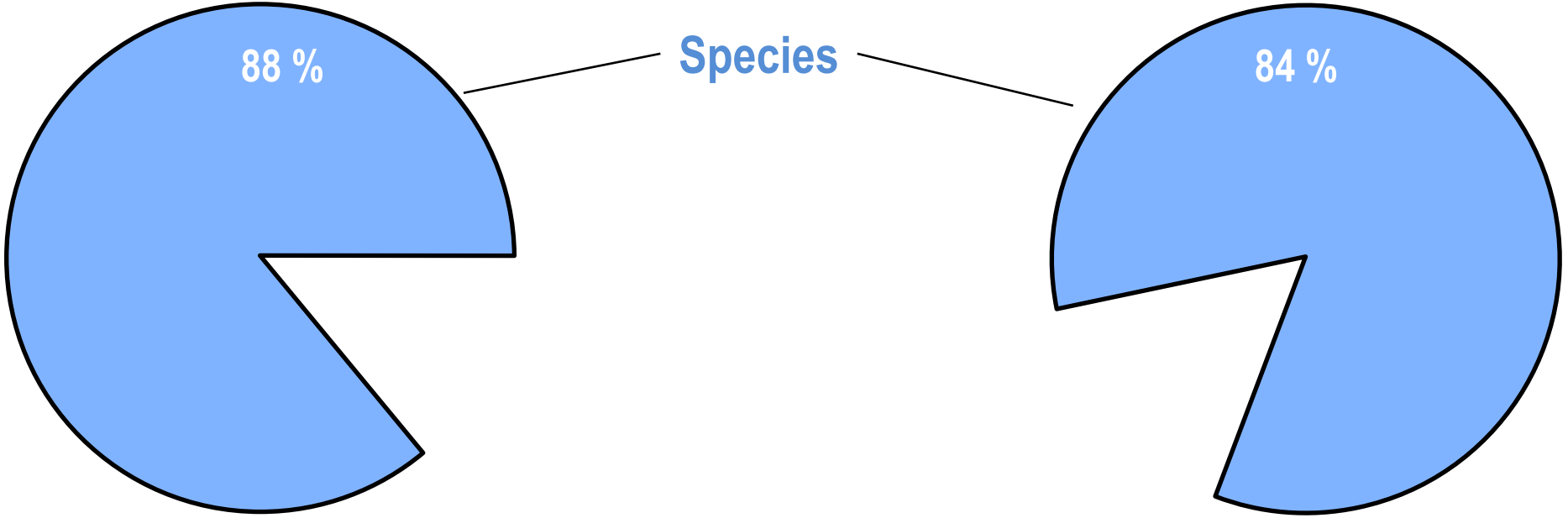
$$\text{Whole-tree Basic density} = \frac{\text{Tree Dry mass}}{\text{Tree Green volume}}$$

tree AGB = Result of Allometrical equations

(DBH, H and **Species-level wood density** value)

Biased or unbiased tree AGB ??

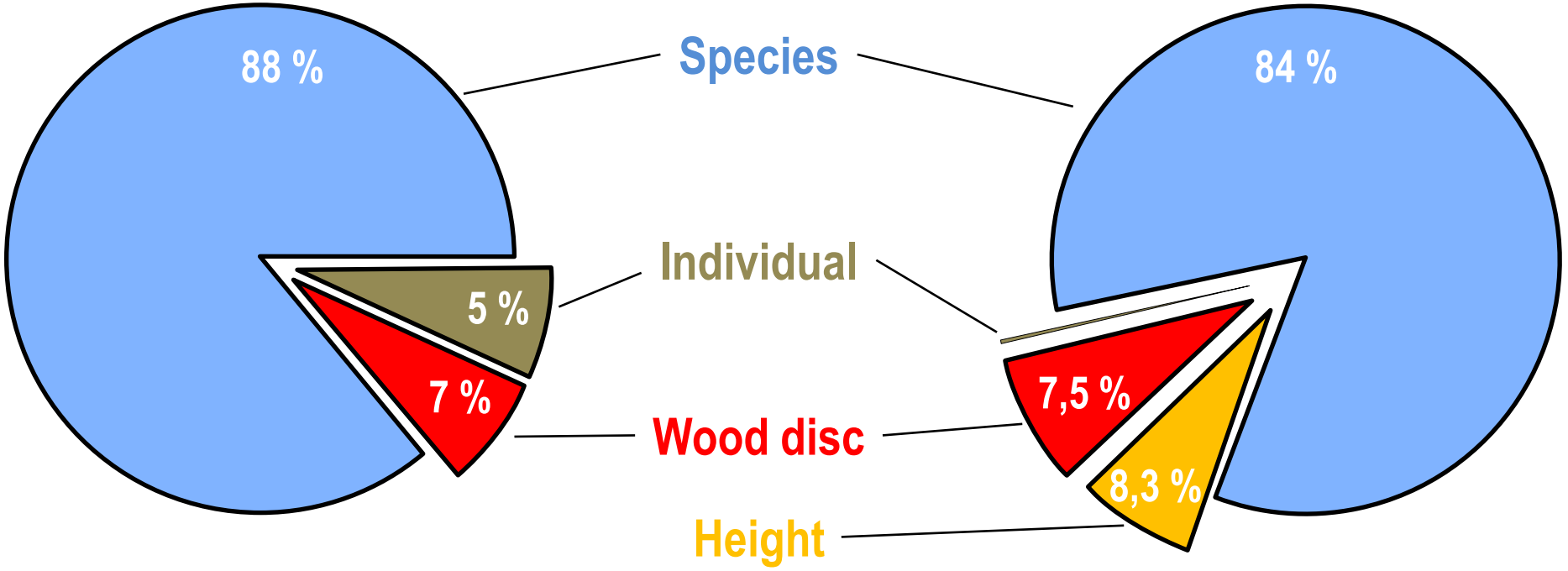
Variance partitioning of wood density



Osazuwa et al. 2014

Lehnebach, 2015

Variance partitioning of wood density



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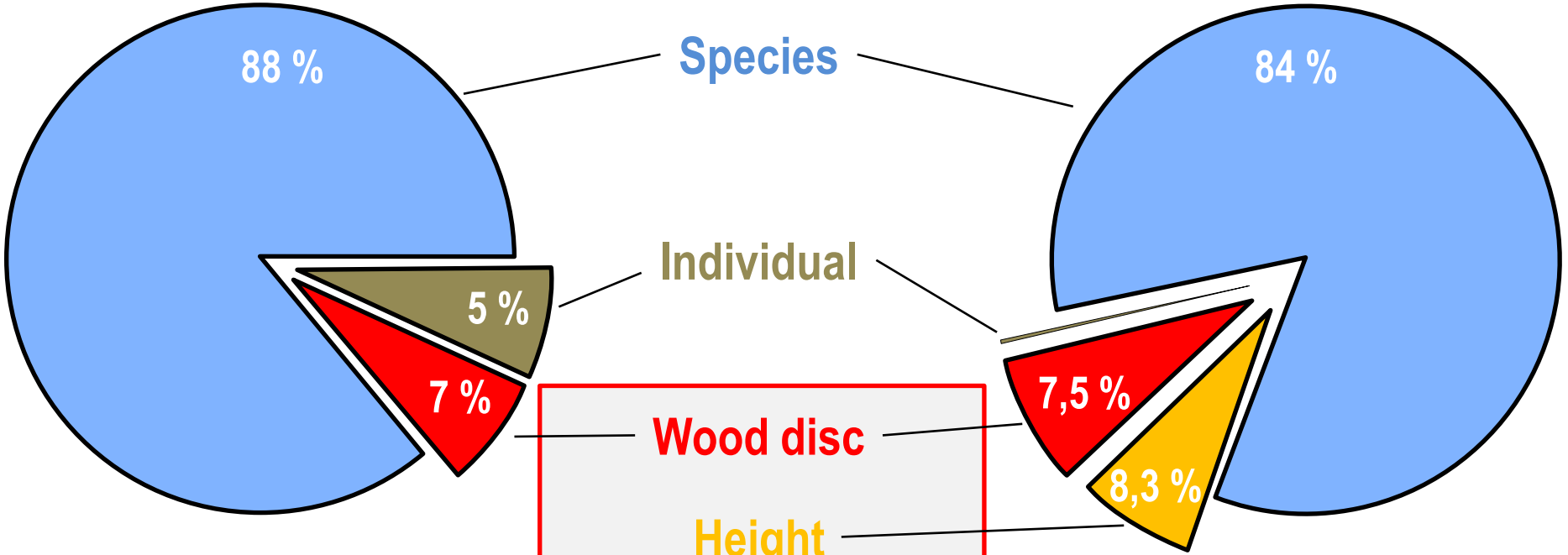

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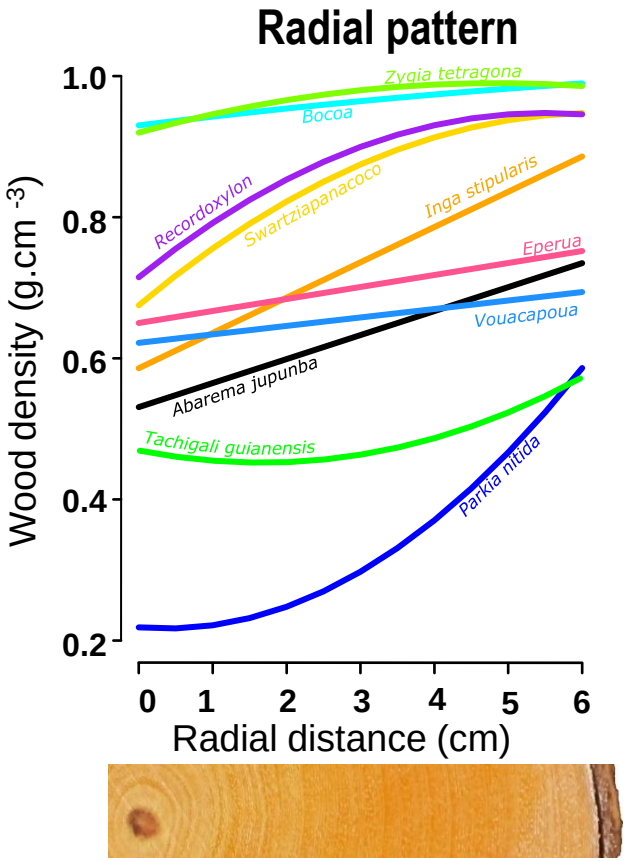
7 to 15% explained to the within-tree level !!

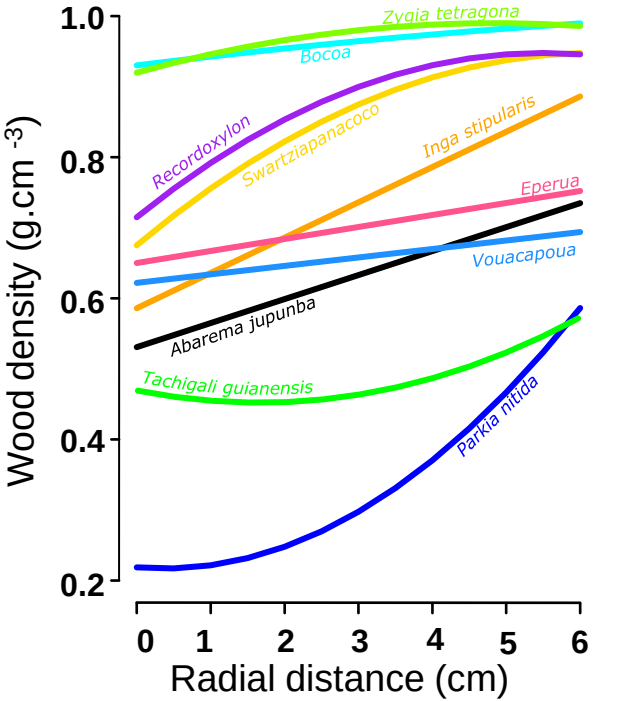
Lehnebach, 2015

Radial and Longitudinal pattern of Wood density variations

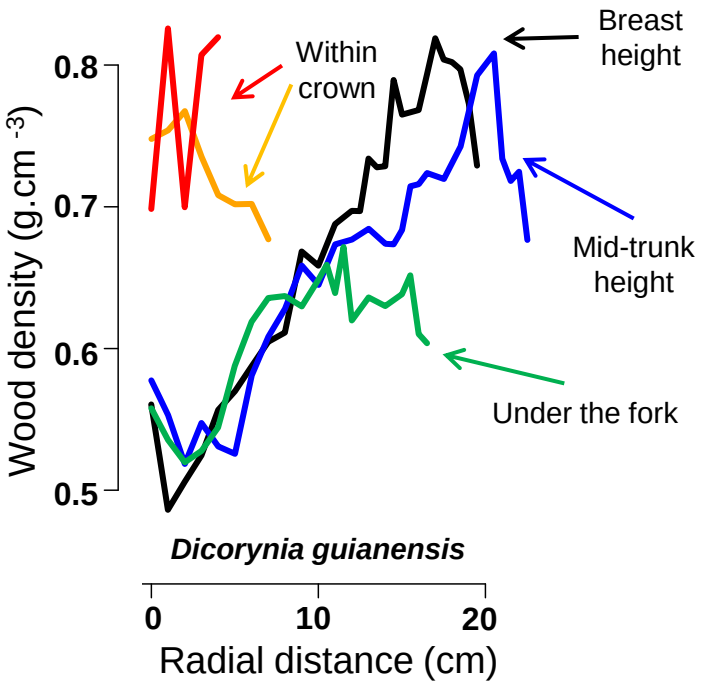


Radial and Longitudinal pattern of Wood density variations

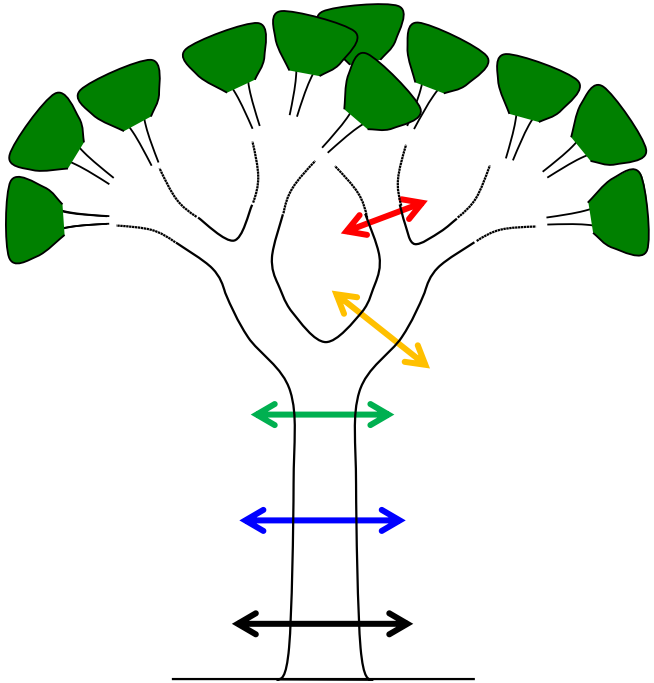
Radial pattern



Longitudinal pattern



Linking Tree structure and Wood density variations
In theory …



Tree structure data
Stems dimensions and topology

Linking Tree structure and Wood density variations
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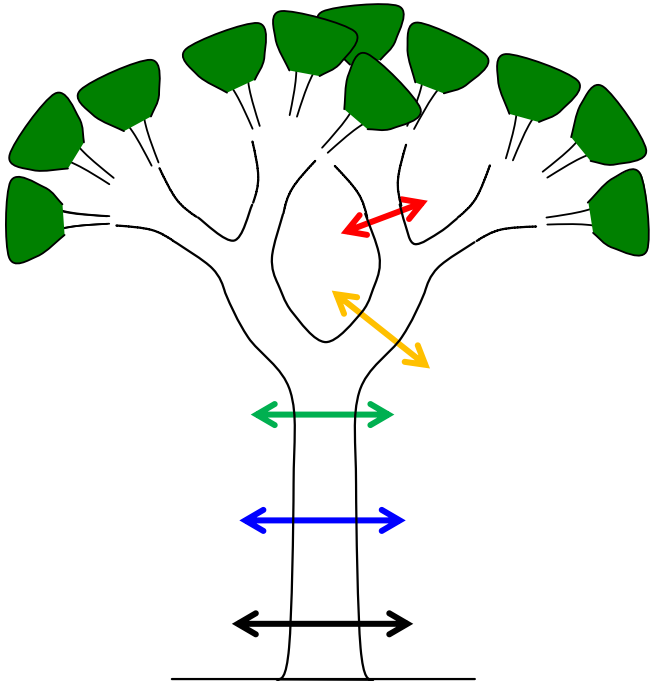

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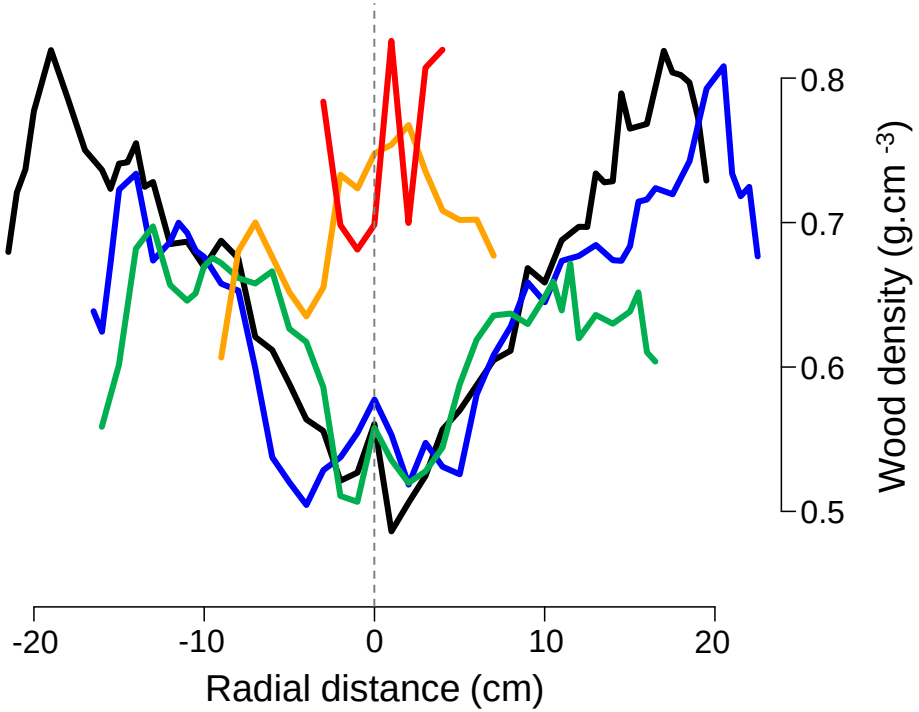

Wood density data
Radial and Longitudinal references

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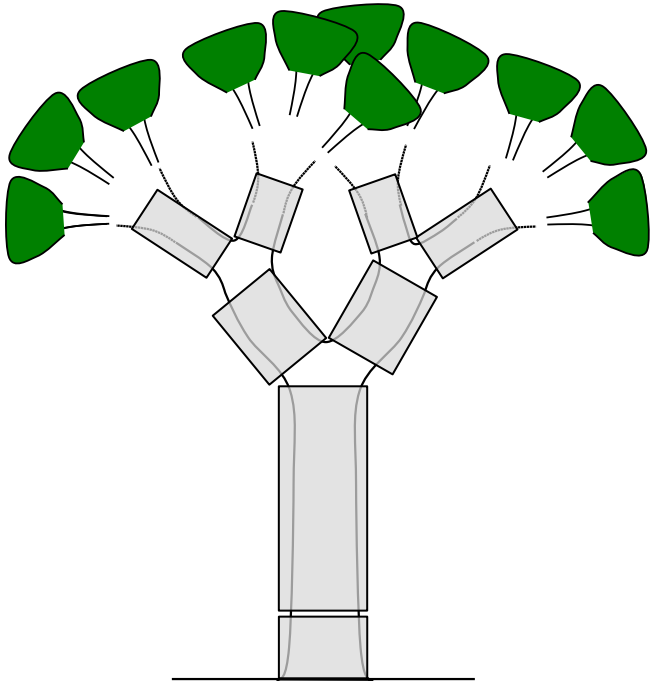
In practice…



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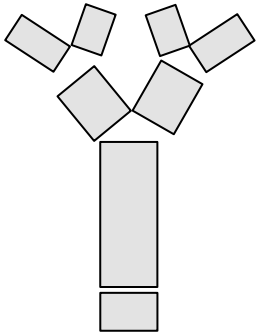
In practice…

ENTITY-CODE			Line	Length	Basal diameter	Distal diameter
/I1			1			
	/A1		2			
	^/U1		3	130	80	80
	^<U2		4	1850	80	60
		+A21	5			
		^/U1	6			
		…				
	^<U3		10	70	30	25
		+A21	11			
		…				
		^/U1	14	330	25	10
		…				



Tree structure data
Multiscale Tree Graph (MTG)
(Godin & Caraglio, 1998)

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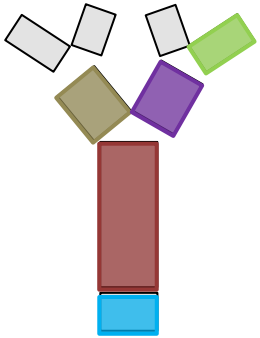

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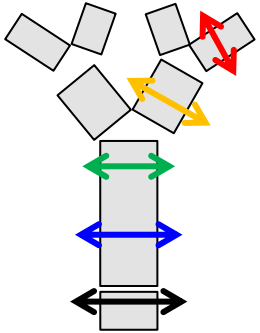
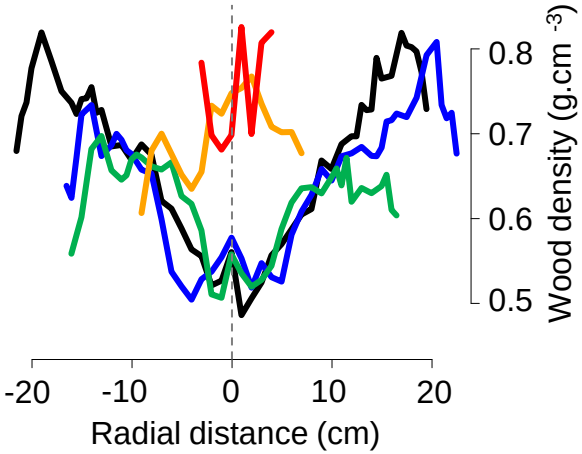
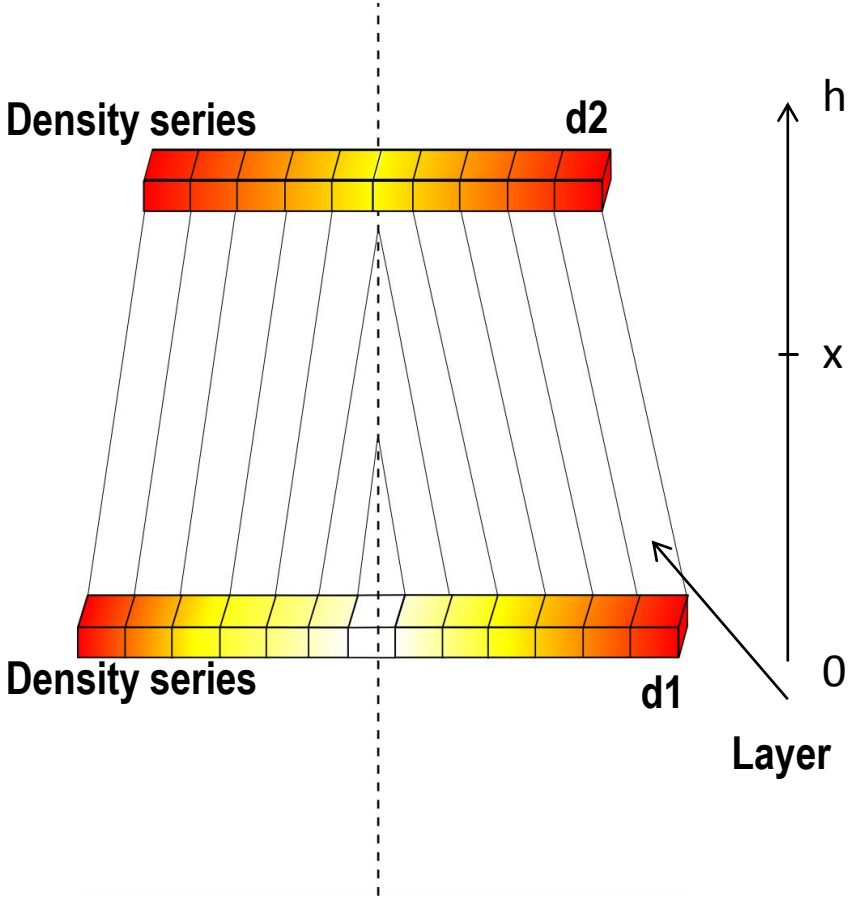




Wood density data

Ind	hclass	height	distance	WD
…	…	…	…	…
1	1	270	-1	0,525
1	1	270	0	0,558
1	1	270	1	0,484
…	…	…	…	…
1	1	270	19	0,770
1	2	1200	-2	0,535
1	2	1200	-1	0,552
1	2	1200	0	0,575
1	2	1200	1	0,551
…	…	…	…	…
1	2	1200	16	0,714
1	3	2250	-2	0,508
1	3	2250	-1	0,504
1	3	2250	0	0,556
1	3	2250	1	0,533
…	…	…	…	…
1	3	2250	16	0,608
1	4	2701	-2	0,799
1	4	2701	-1.5	0,777
1	4	2701	1.5	0,805
1	4	2701	2	0,799
…	…	…	…	…
…	…	…	…	…

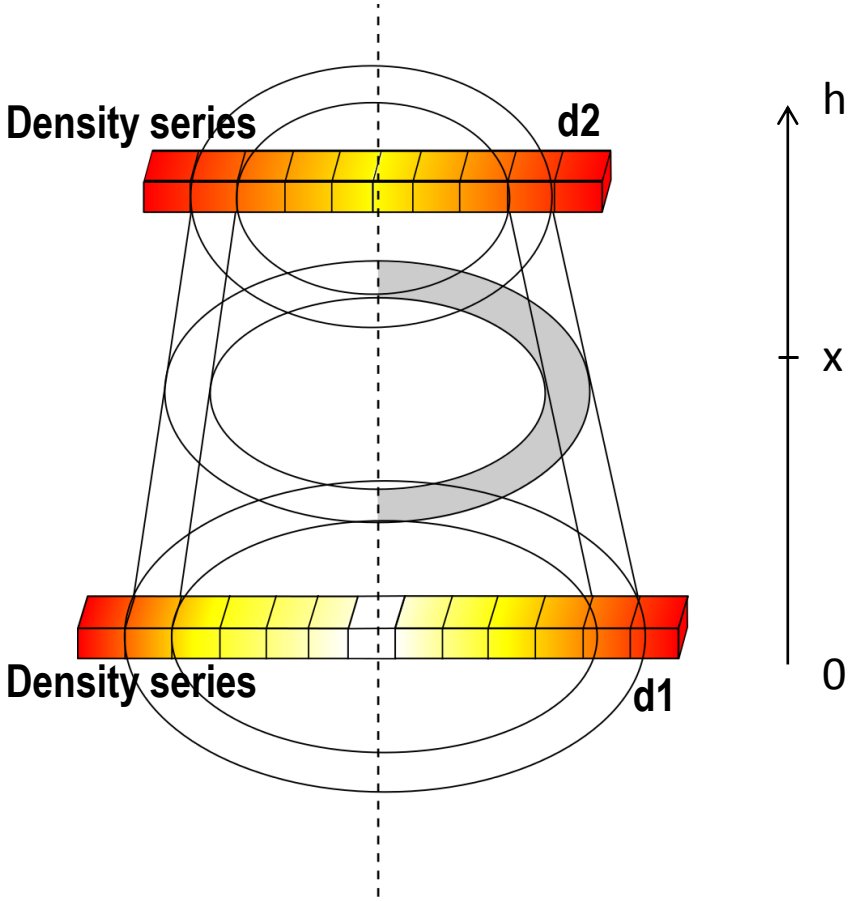
Mass calculation of layers, stem segment and tree



- Wood density at height x :

$$d(x) = ax + b, \qquad a = \frac{d2 - d1}{h}, b = d1$$

Mass calculation of layers, stem segment and tree



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- Half-ring area at height x :

$$S(x)$$

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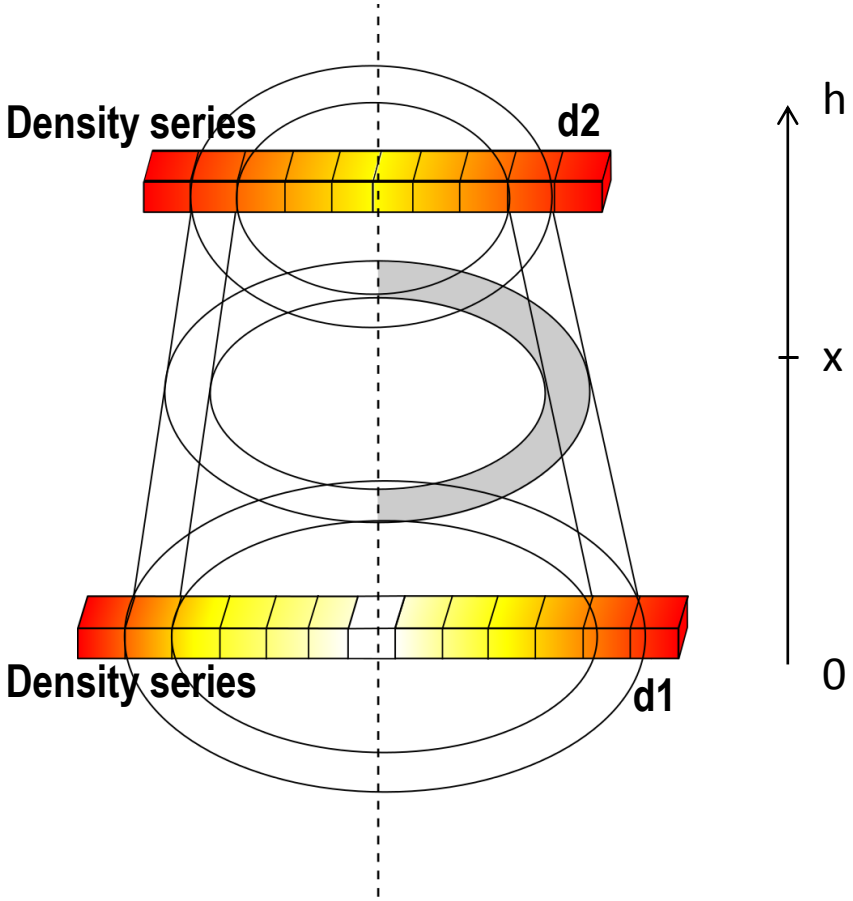

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- Layer mass :

$$m_l = \int_0^h S(x).d(x).dx$$

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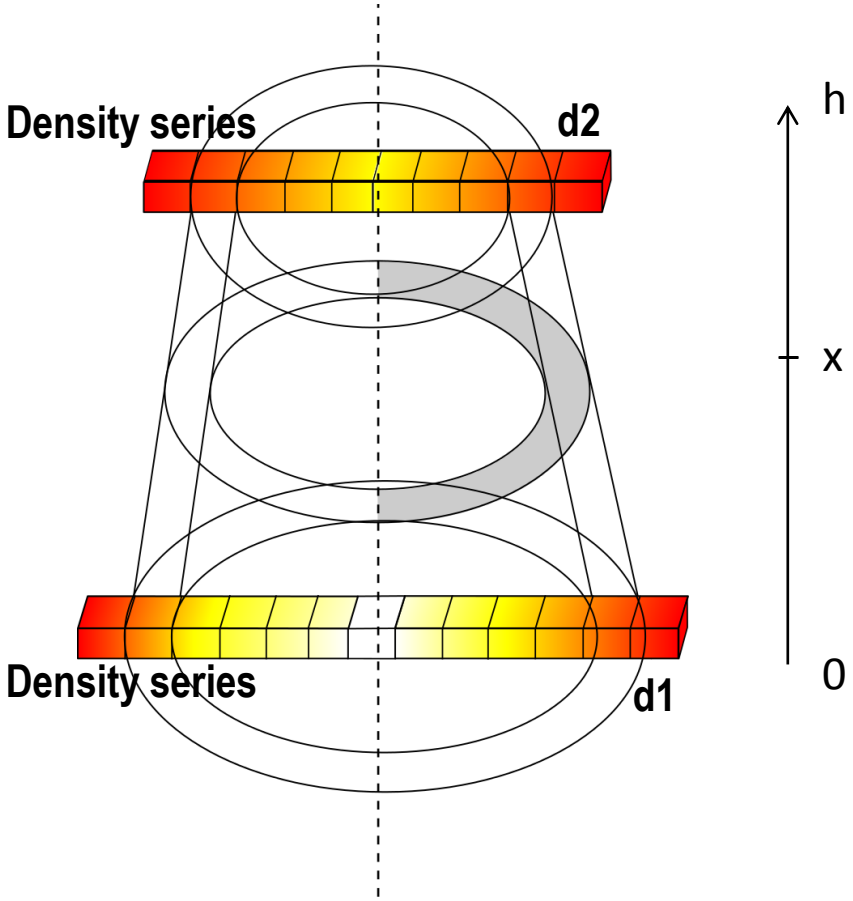

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- Layer mass :

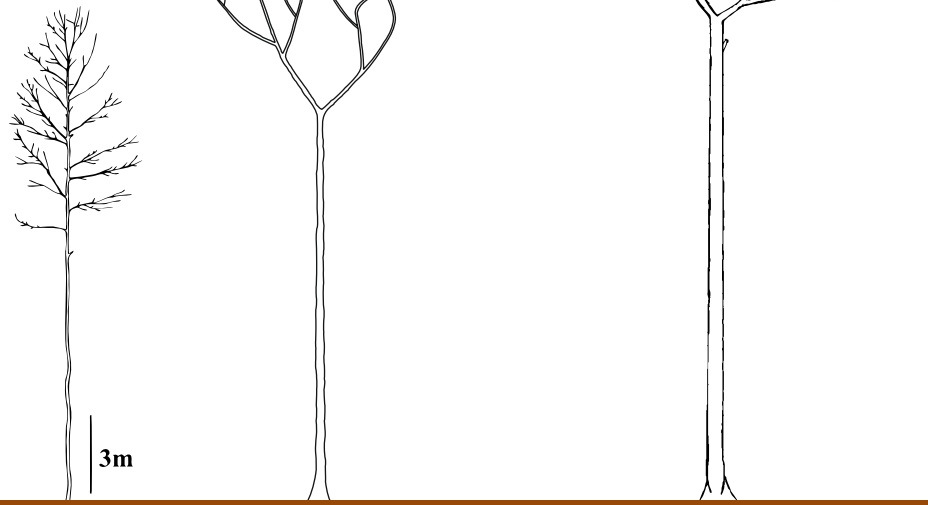
$$m_l = \int_0^h S(x).d(x).dx$$

- Stem segment mass :

$$m_s = \sum_{i=0}^{i=n} \left(\int_{x=0}^{x=h} S_i(x).d_i(x).dx \right)$$

Computing biomass and visualizing wood density variations
The example of *Dicorynia guianensis*

Hyper-accumulating carbon species (Fauset, 2015)



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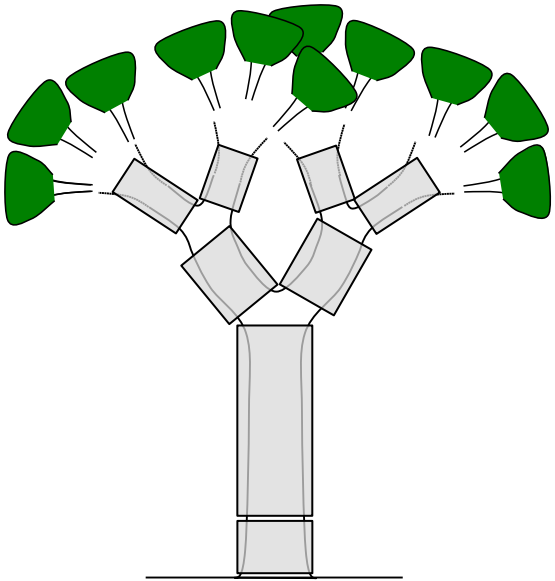

8 trees
15 to 60 cm DBH
Measured by climbers

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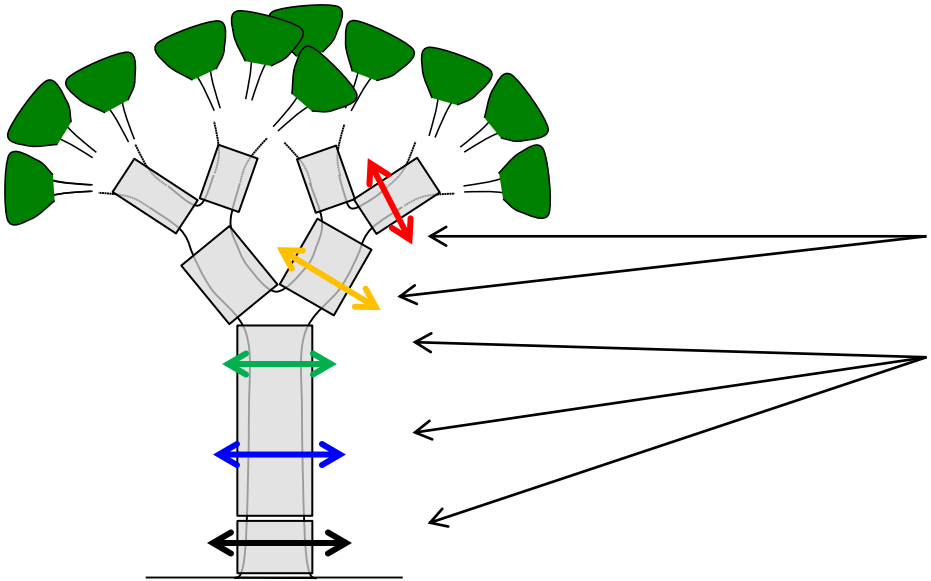

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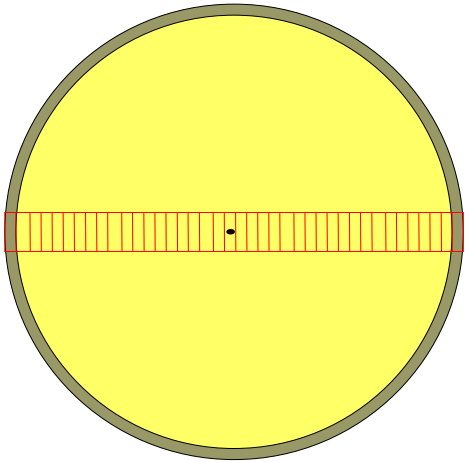

One density measurement each ½ cm

Computing biomass and visualizing wood density variations
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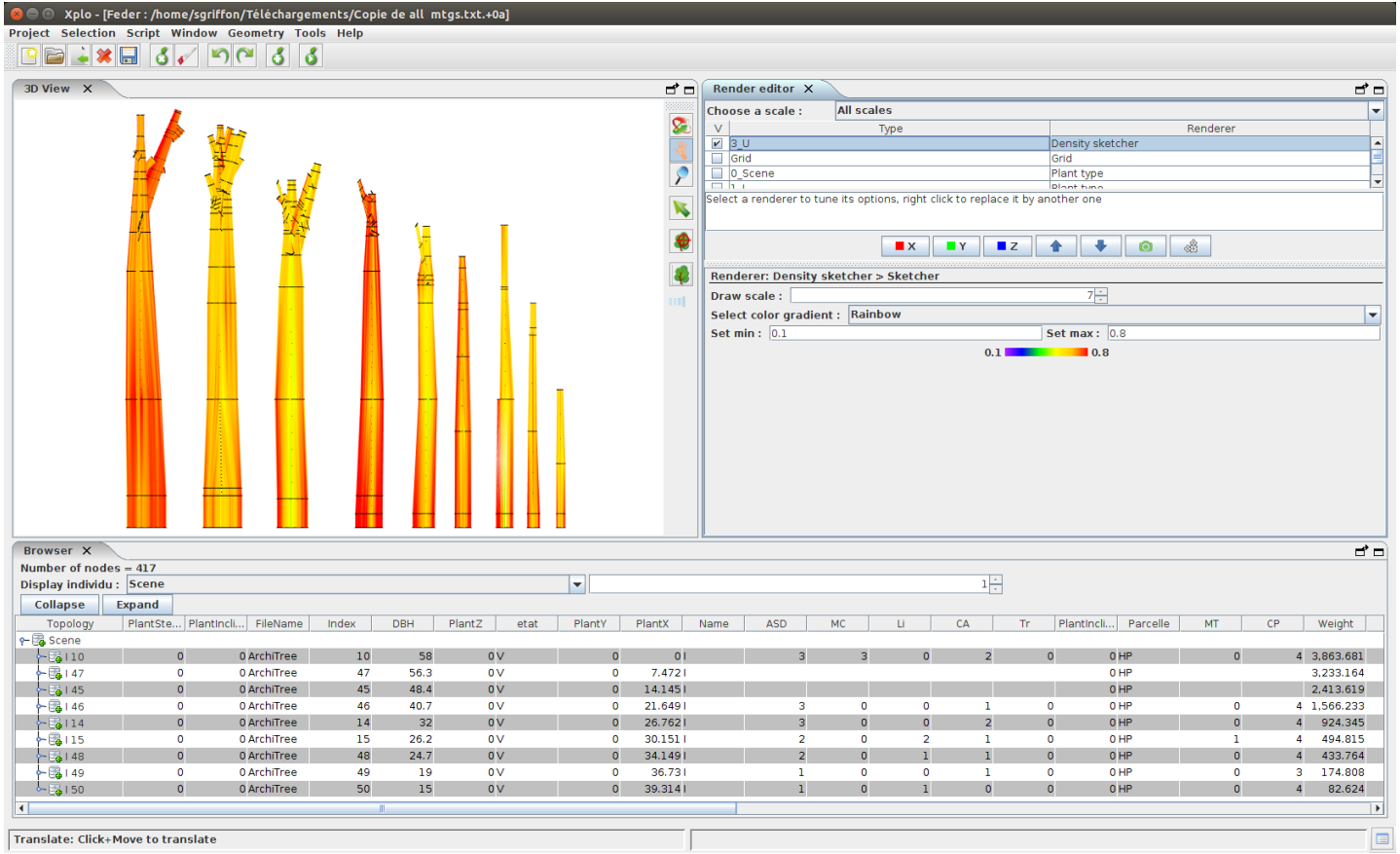
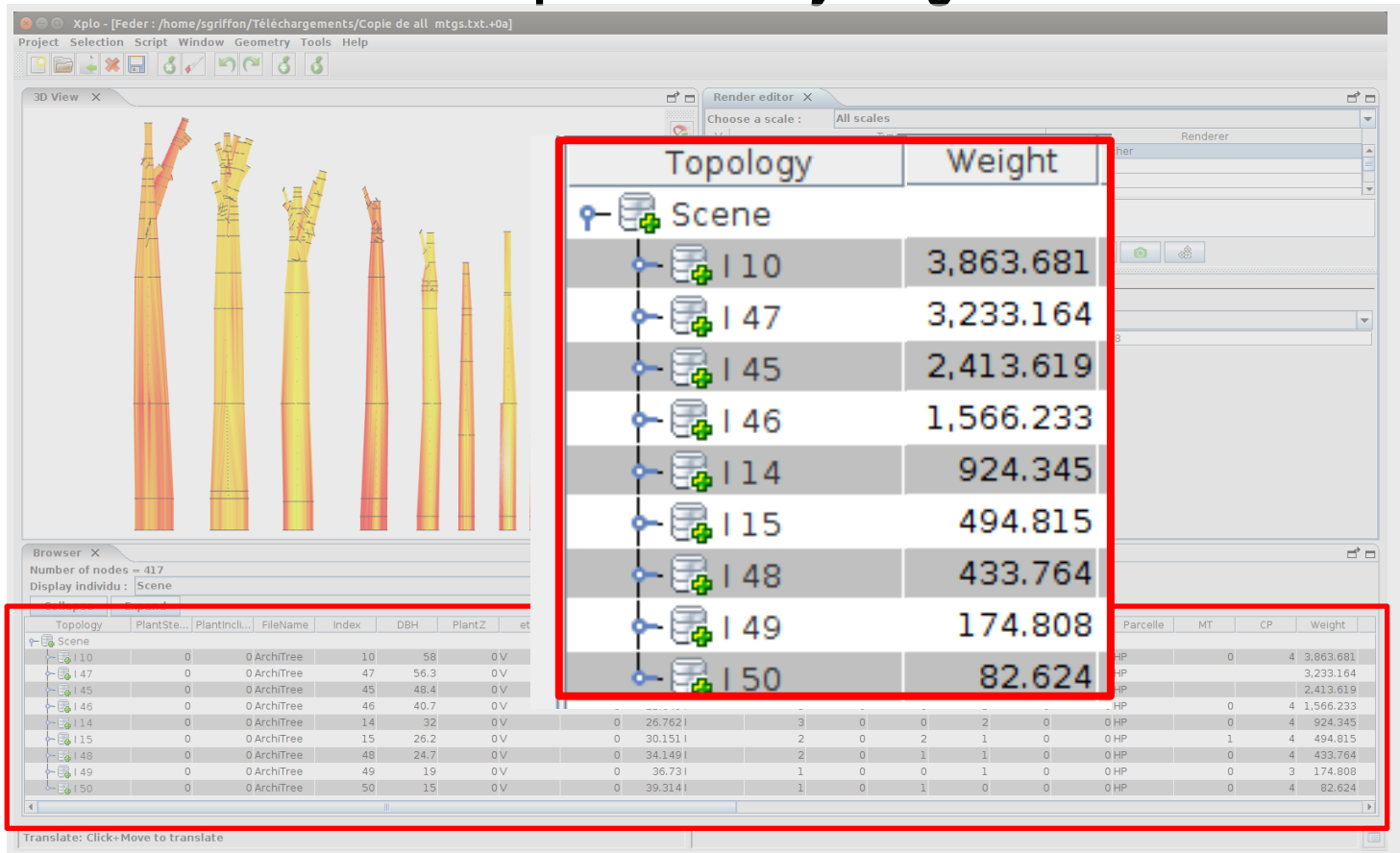


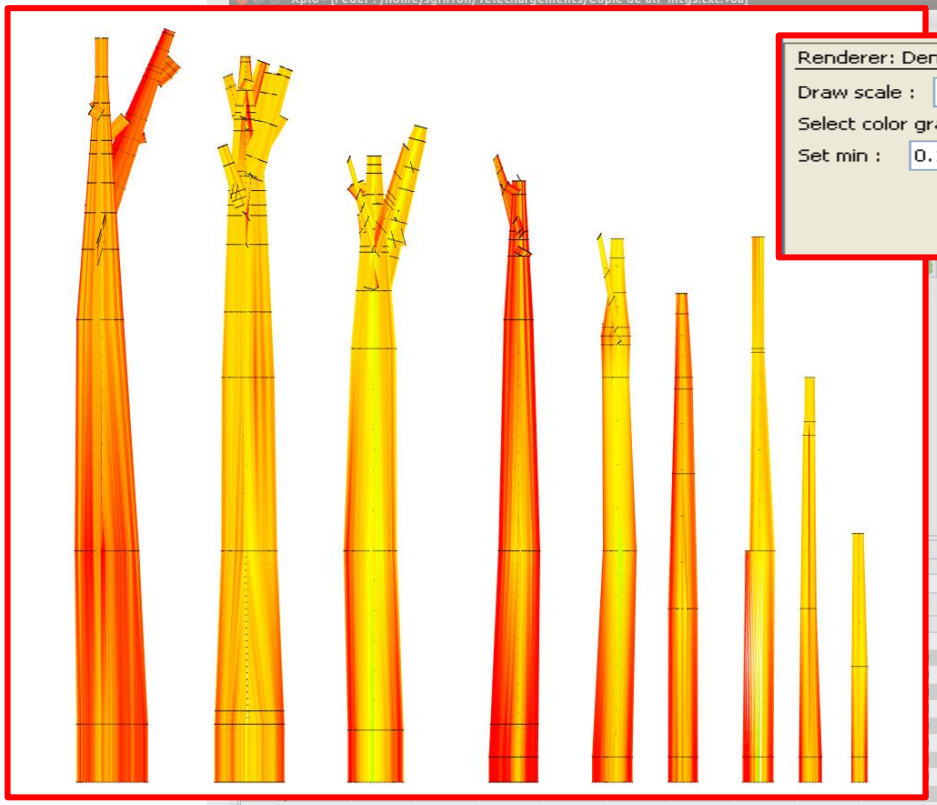
Topology	PlantSte...	PlantIncli...	FileName	Index	DBH	PlantZ	etat	PlantY	PlantX	Name	ASD	MC	Li	CA	Tr	PlantIncli...	Parcelle	MT	CP	Weight
Scene																				
I 10	0	0	ArchiTree	10	58	0	V	0	0	I	3	3	0	2	0	0	HP	0	4	3,863.681
I 47	0	0	ArchiTree	47	56.3	0	V	0	7.472	I						0	HP			3,233.164
I 45	0	0	ArchiTree	45	48.4	0	V	0	14.145	I						0	HP			2,413.619
I 46	0	0	ArchiTree	46	40.7	0	V	0	21.649	I	3	0	0	1	0	0	HP	0	4	1,566.233
I 14	0	0	ArchiTree	14	32	0	V	0	26.762	I	3	0	0	2	0	0	HP	0	4	924.345
I 15	0	0	ArchiTree	15	26.2	0	V	0	30.151	I	2	0	2	1	0	0	HP	1	4	494.815
I 48	0	0	ArchiTree	48	24.7	0	V	0	34.149	I	2	0	1	1	0	0	HP	0	4	433.764
I 49	0	0	ArchiTree	49	19	0	V	0	36.73	I	1	0	0	1	0	0	HP	0	3	174.808
I 50	0	0	ArchiTree	50	15	0	V	0	39.314	I	1	0	1	0	0	0	HP	0	4	82.624

Computing biomass and visualizing wood density variations
The example of *Dicorynia guianensis*

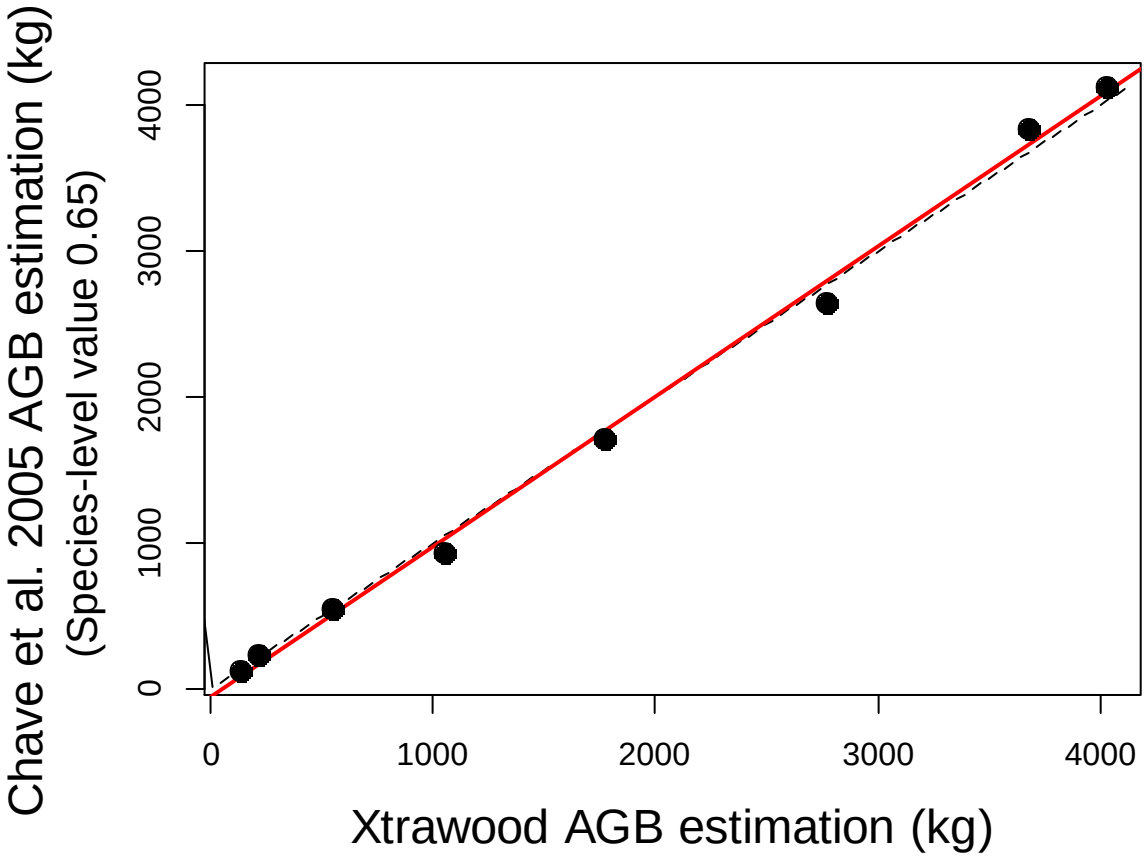


Topology	Weight
Scene	
I 10	3,863.681
I 47	3,233.164
I 45	2,413.619
I 46	1,566.233
I 14	924.345
I 15	494.815
I 48	433.764
I 49	174.808
I 50	82.624

Computing biomass and visualizing wood density variations
The example of *Dicorynia guianensis*



Xtrawood AGB estimate VS Allometrical AGB estimate



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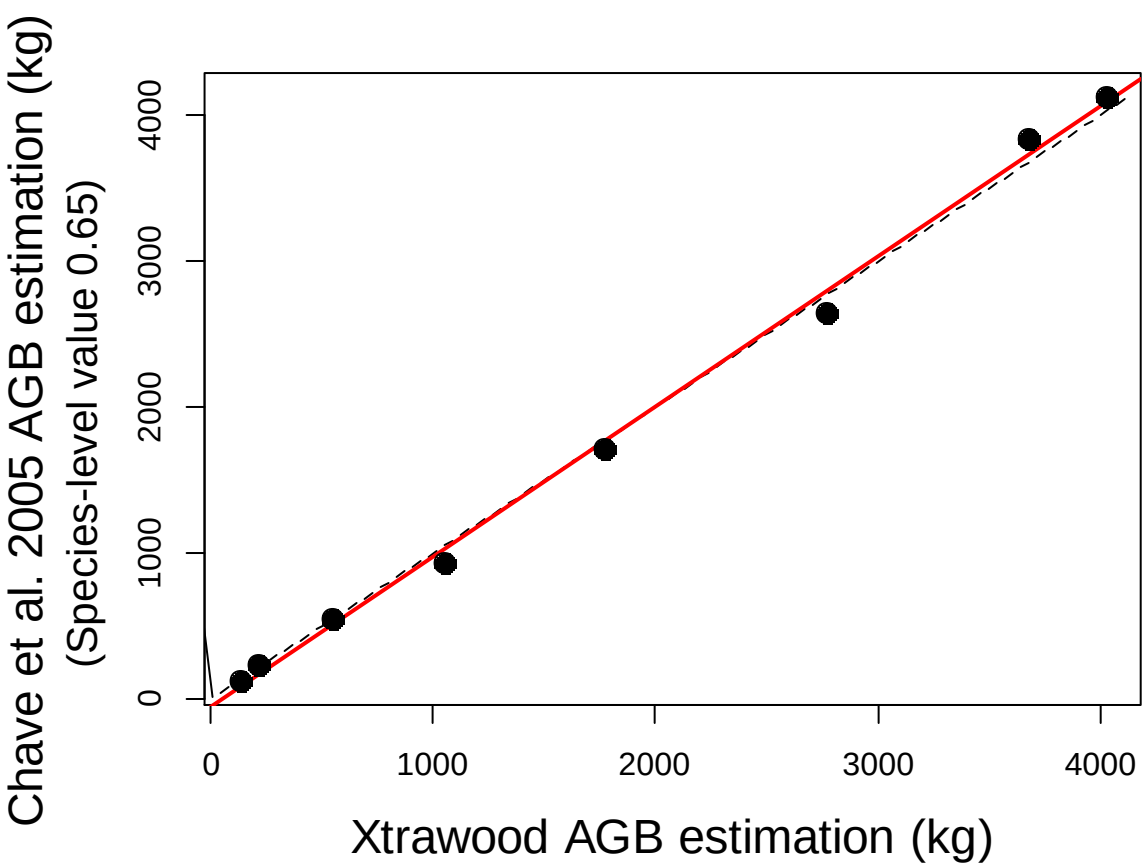

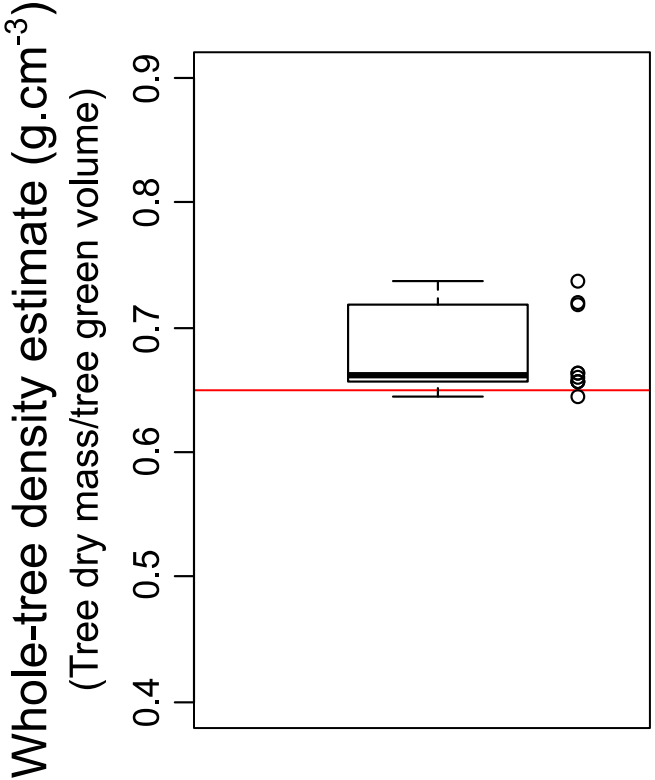

Conclusions

Xtrawood produces biomass estimates taking into account wood density variations

Xtrawood allows the visualization of wood density within tree

Xtrawood is not dedicated to forest managers !!
…. but is reliable tool to develop efficient sampling strategies
(cross-validation, Whole-tree density estimation)

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…. but is reliable tool to develop efficient sampling strategies
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What happens next ?

Integration of heartwood amount …

Dynamics of biomass accumulation … taking into account tree structure and wood density variations

Xtrawood is always under development ! Comments ? Advices ? Requests ?

Informations

Website: **amapstudio.cirad.fr/soft/xplo/start**

Multi-platforms: **Windows, Linux, Mac OS X**

Language : **Java**

Licence : **LGPL**

Developper: **Sébastien Griffon** (sgriffon@cirad.fr)

Thank you very much for any kind of attention !!!