Enrichment of Central African logged forests with high-value tree species: testing a new approach to regenerating degraded forests

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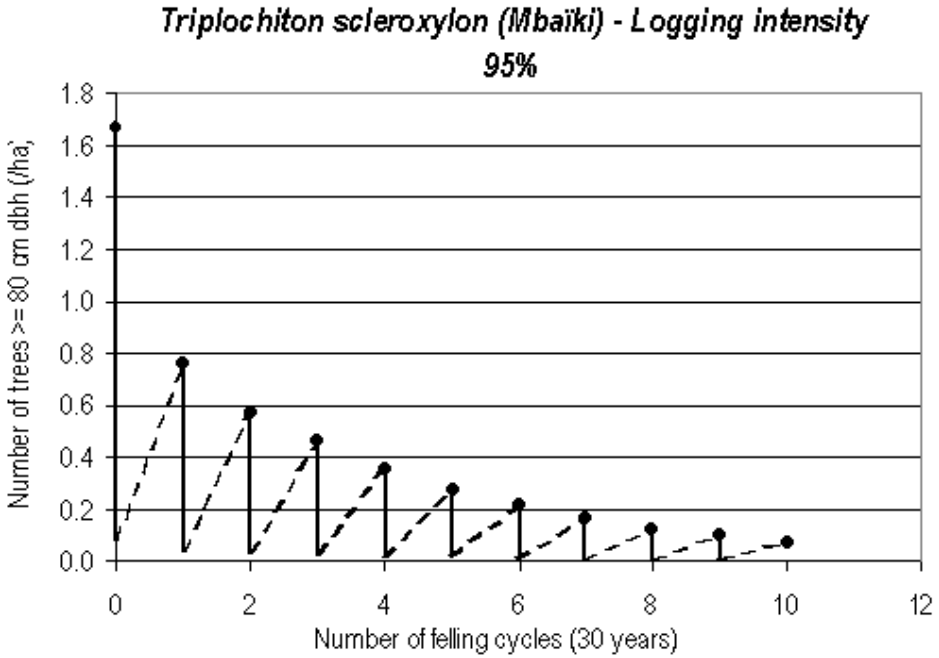
Context

- Moist forests cover 180,000,000 ha in Central Africa
- 26 % licensed to logging companies (De Wasseige et al., 2012)
- national regulations (e.g. minimum cutting diameters, cutting cylces)
- management plan (e.g. trees inventories, recovery rates)

- Studies on long term recovery show dramatic decrease of trees available for logging
- Mostly for light demanding species, e.g. ayous (obeche, wamba, wamba)



Source:
Karsenty & Gourlet-Fleury (2006)

In this context, enrichment of the forests is definitely needed

Objectives

Main objective:

To test a pragmatic enrichment technique of degraded forests with high-value species

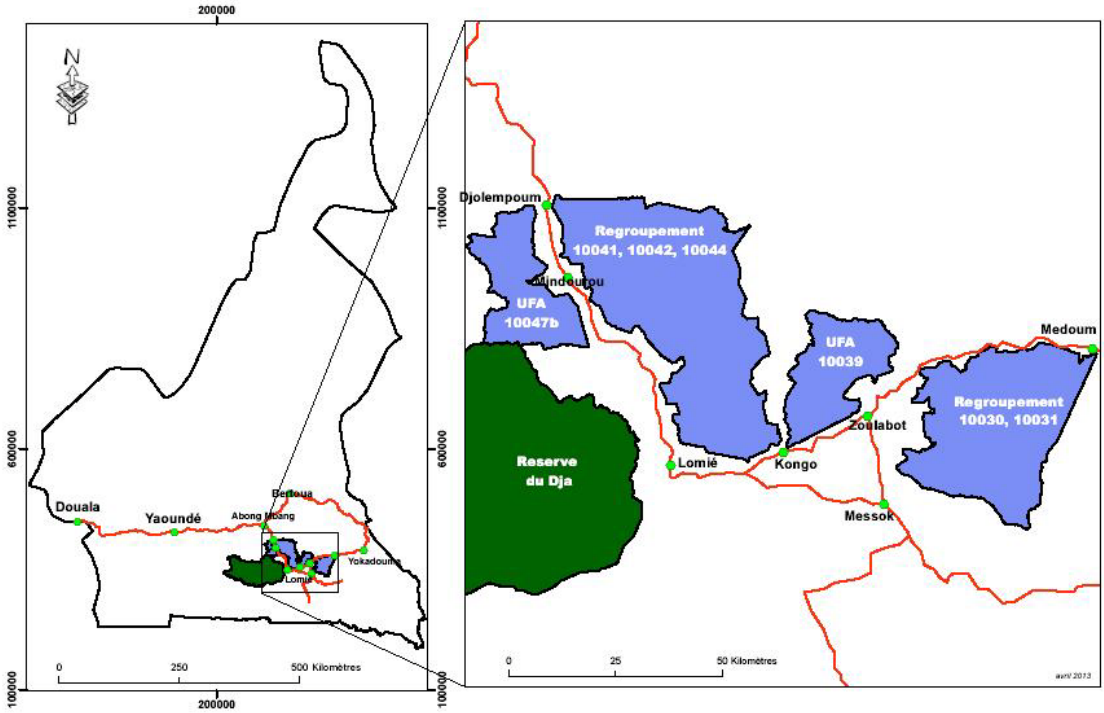
Secondary objectives:

1. To compare species behavior in the early stage of plantation (<5yrs) in order to identify the best candidate species (growth/survival)
2. To search for relationships between traits and performance of the species
3. To estimate the cost of mixed-species plantations

Methods

Study site

- Implementation since 2009 in Cameroon
- FMU Pallisco & partners
- 360,000 ha
- Old secondary semi-deciduous forest
- ferralsols
- 1,700 mm



Enrichment technique

- Selection of the most open forest areas along permanent established roads

Enrichment technique

- Identification and protection of high-value species and all trees with dbh > 50 cm

Enrichment technique

• Clear cutting of the understory with machetes by a team of ten workers, felling of some trees (e.g. *Musanga cecropioides*) with a chain saw

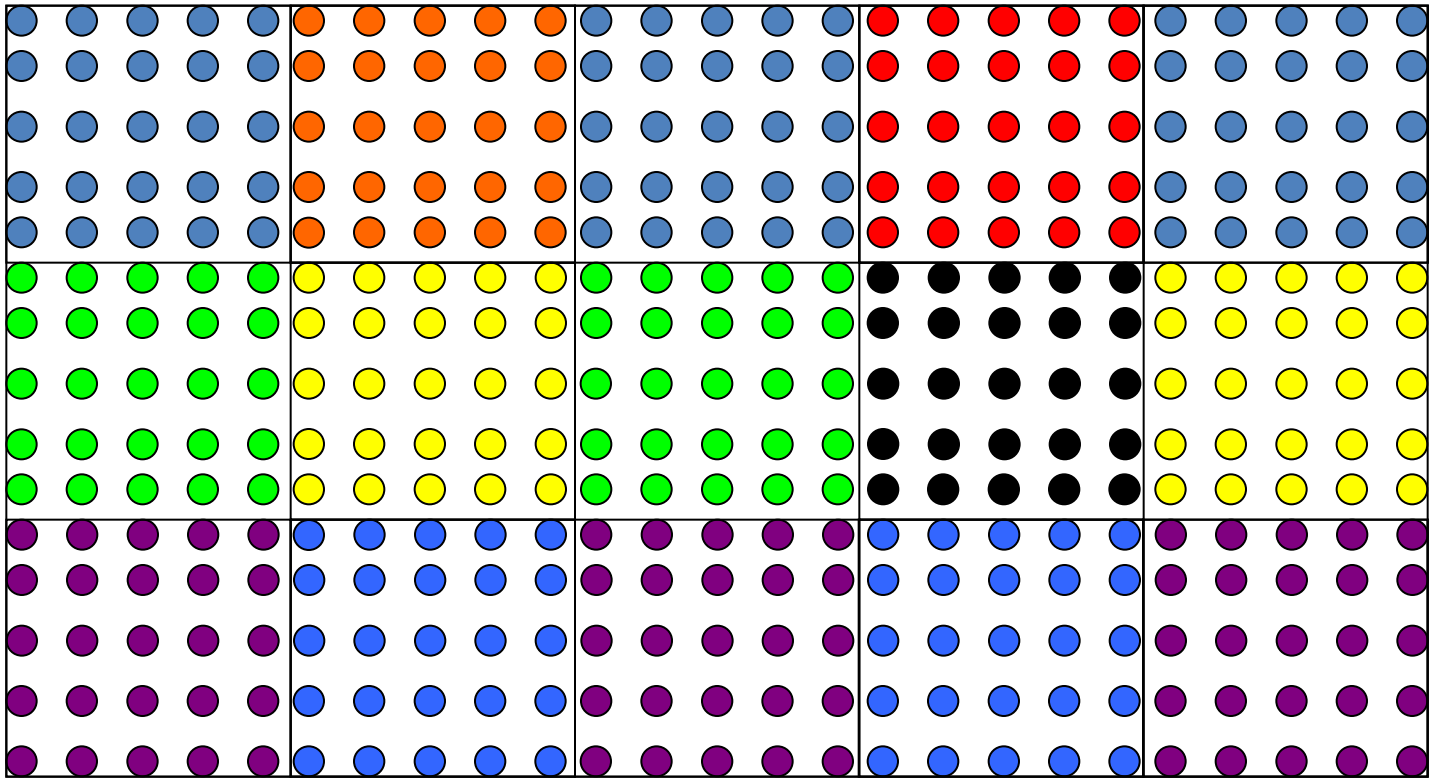
Enrichment technique

• Selection of several species in a nursery based on their tolerance for the various amount of light penetration throughout the plantation area.

Enrichment technique

- Plantation done according to the species regeneration guild,
- 25 seedlings of a particular species,
- 3 x 3 m,
- alternation of species to prevent parasitism and predation

Schematically



Maintenance

Year	N maintenance cuttings
1	3
2	2
3	1

- Afterwards, thinning will be necessary

Studied species

- High-value species : IUCN red list, e.g. CR Mukulungu *Autranella congolensis*

Studied species

- High-value species : CITES appendix, e.g. Assamela (kokrodua) *Pericopsis elata*

Studied species

- High-value species : NTFP, e.g. Moabi *Baillonella toxisperma*

Permanent plot design

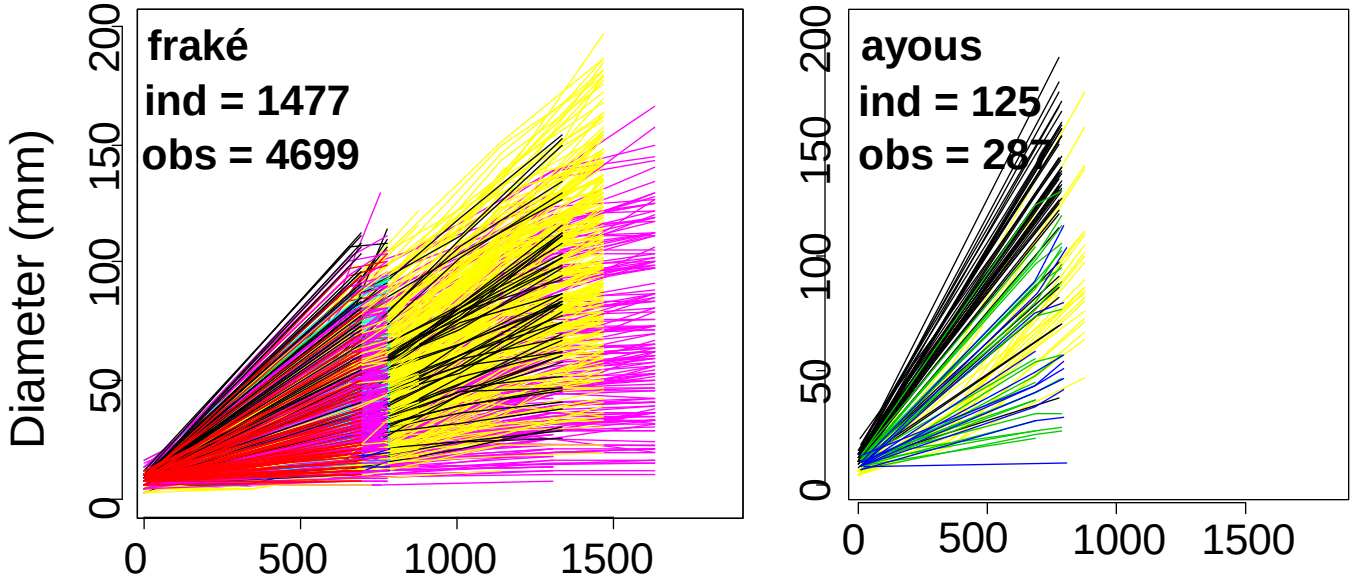
- 14 plots planted from 2009 to 2012
- Remaining forest canopy cover after plantation: 30 %
- 0.2 to 1 ha
- +- 5000 marked seedlings, 23 different species,
- Annual monitoring (H, d10, dbh, social status) for 2-5 years

- Costs and yields of plantation estimated

Results

Growth and mortality

Seedlings alive at the end of the monitoring
(n=4621 trees, 17794 observations, 2-5 years)

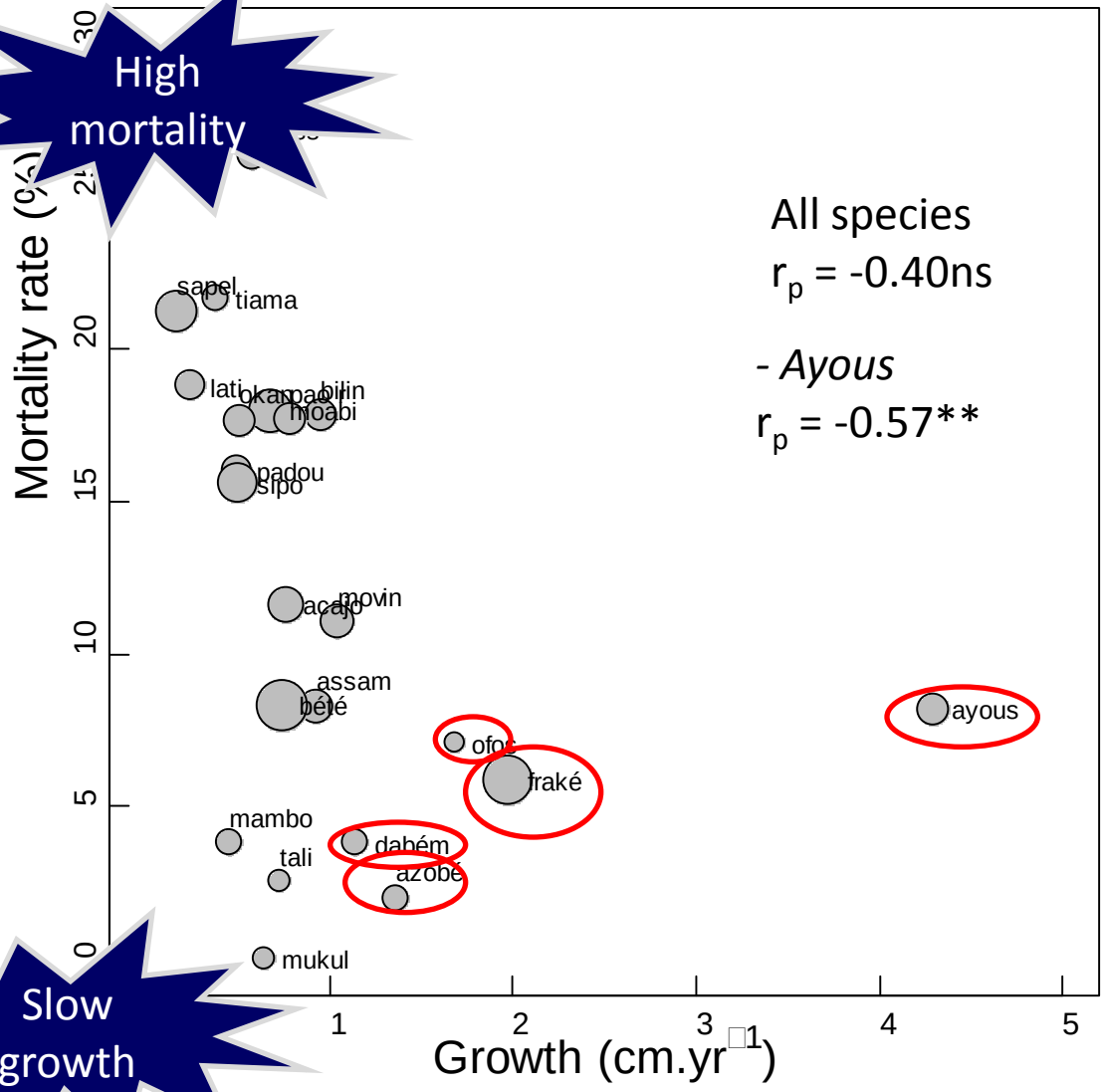


Variability among species and between plots, linear growth

$$D_{is} = a_s + c_s \times Time + \beta_{is} \times Time + \varepsilon_{is}$$

Name	Species	Growth. (mm) max (10 %)	c_s Growth (mm)	Growth sd
Ayous / wawa / samba/ obeche /	*Triplochiton scleroxylon*	65,96	42,90	0,75
Fraké / limba / korina	*Terminalia superba*	33,50	19,80	0,22
Ofos	*Pseudospondias microcarpa*	21,74	16,77	1,87
Azobé / Ekki	*Lophira alata*	18,73	13,64	1,15
Dabéma / Dahoma	*Piptadeniastrum africanum*	19,41	11,42	1,07
Movingui / Ayan	*Distemonanthus benthamianus*	21,16	10,46	0,73
…	…	…	…	…
Sapelli / Sapele / Mahogani	*Entandrophragma cylindricum*	5,10	1,71	0,48
Iroko / odum	*Milicia excelsa*	2,83	1,67	1,34

High mortality



Slow growth

Best candidate species (obj. 1):

Ayous : *Triplochiton scleroxylon*

Fraké : *Terminalia superba*

Ofos : *Pseudospondias microcarpa*

Azobé : *Lophira alata*

Dabéma : *Piptadenistraum africanum*

Relationships with traits (obj. 2)

Quantitave traits	Range	Growth	Growth max	Mortality
Wood density (g/cm³)	0,33 - 0,88	**r = -0,41 (p = 0,057)**	**r = -0.48 (p = 0,029)**	r = -0.08 (p=0,716)
Dbh max (mature) (cm)	0,65 - 3,00	r=0.01 (p = 0.947)	r = 0.02 (p = 0.92)	r = 0.16 (p = 0.472)
Seed length (cm)	0,1 - 5	r = -0.32 (p = 0.168)	r = -0.31 (p = 0.181)	r = 0.05 (p = 0.847)
Leaf area (cm²)	4,4 - 17	r = 0.22 (p = 0.316)	r = 0.18 (p = 0.405)	r = -0.04 (p = 0.84)

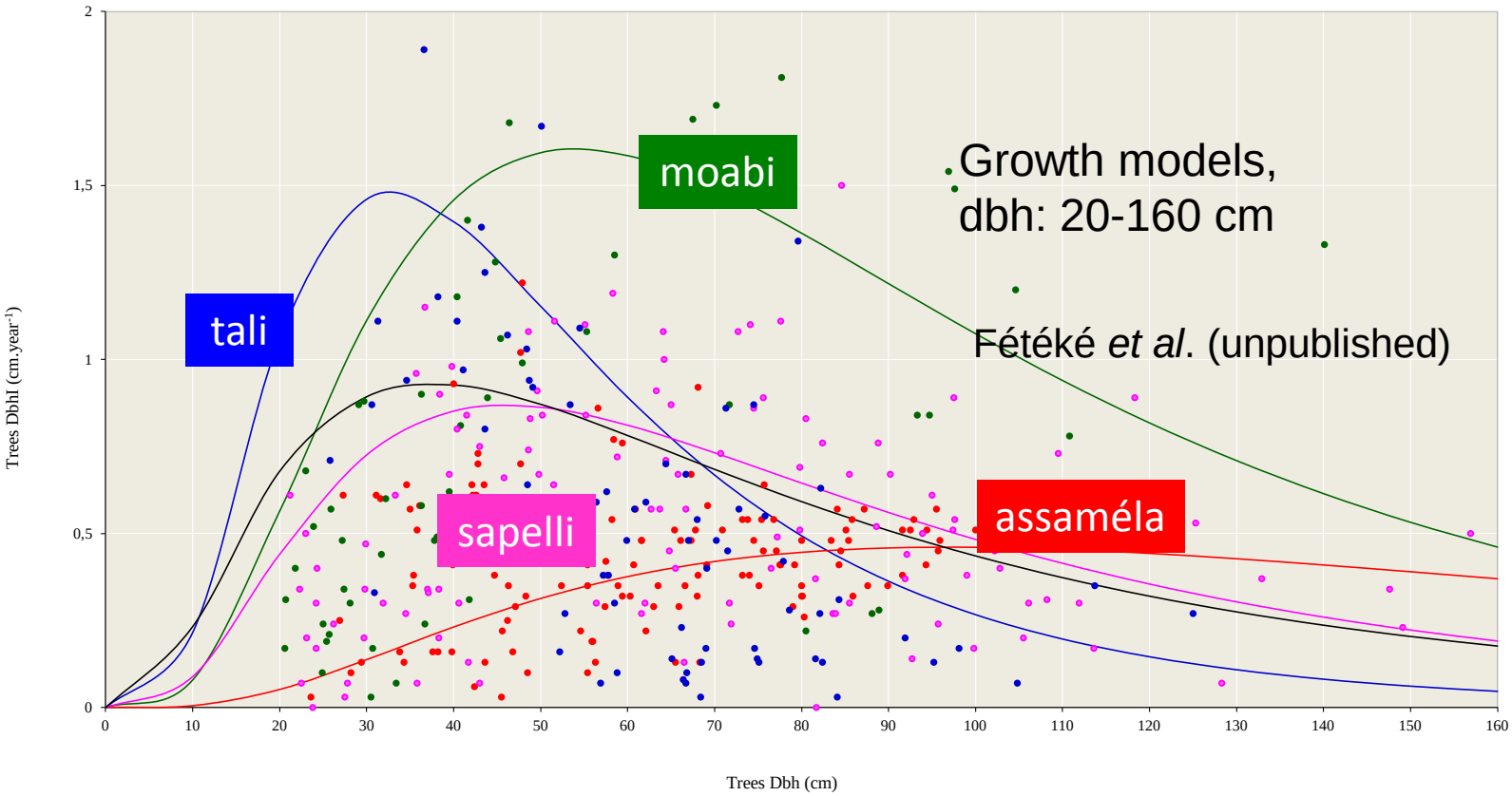
Qualitative traits	Categories	Growth	Growth max	Mortality
Guild	P, NPLD, NA	p = 0.124	p = 0.242	p = 0.255
Deciduousness	Evergreen, deciduous, NA	p = 0.307	p = 0.444	p = 0.233
Dispersal mode	Animal, Wind, Unassisted	p = 0.901	p = 0.501	p = 0.332

Costs (obj. 3)

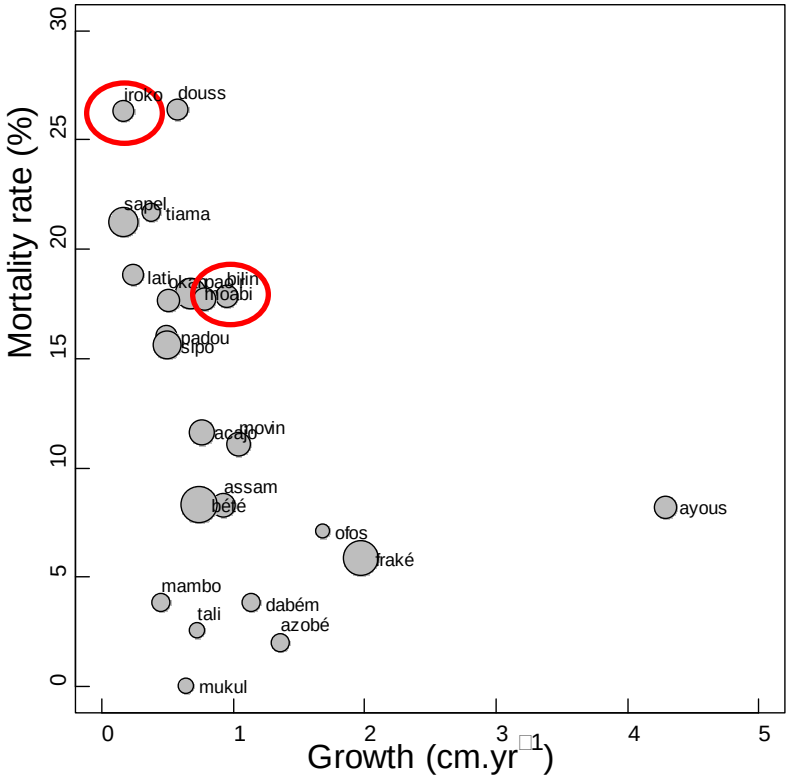
- Team of 13 people (includes 2 nurserymen,1 supervisor) plant 10 ha and manage (maintenance, thinning) 60 ha per year.
- Total cost : 5585 EUR (7,038 $) per ha includes labor, transportation and material.
- Number of mature trees expected per ha : 44
- Total cost estimated of raising a mature tree from seed: 127 EUR (160 $)

Discussion & conclusion

- Highly promising growth rates for some species (ayous, fraké, …) but cannot be extrapolated since the growth is not linear over longer period



- For some species, the morality rate was very high. For such species, other regeneration techniques should be recommended.
- By comparison with our previous studies for two of these species (moabi *Baillonella toxisperma*, iroko *Milicia excelsa*), enrichment of logging gaps gave better results at lower costs (Doucet *et al*., 2009 ; Dainou *et al*., 2012).



Cost = crucial issue! Total cost for a mature tree = 1m³ of round wood!

But this may be the price to be paid for maintaining the long term productivity and biodiversity of the African moist forests.