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Kenyan Experiences Using the Miyawaki Method to create Mini urban Forests

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Miyawaki Restoration in Urban Landscapes

- Miyawaki forests are common feature in Japanese urban spaces and have been proven to create resilient natural systems in the face of disasters such as tsunamis, by creating barriers to fires and floods and have also prevented total structural collapse of infrastructure such as raised highways.

- Urban spaces in most countries world over have a major limiting factor in the spatial extent that can be implemented and sustained as green spaces. Most often than not, urban green spaces have been shrinking at an alarming rate

- Green spaces not only moderate climate factors but also offer many ecosystem services to nature and human beings

- A most important ecosystem service in urban areas is carbon sequestration and also the aesthetic component which enables many urban dwellers to enjoy quality green spaces as urban parks and small forest islands.

Miyawaki Forest Approach…..

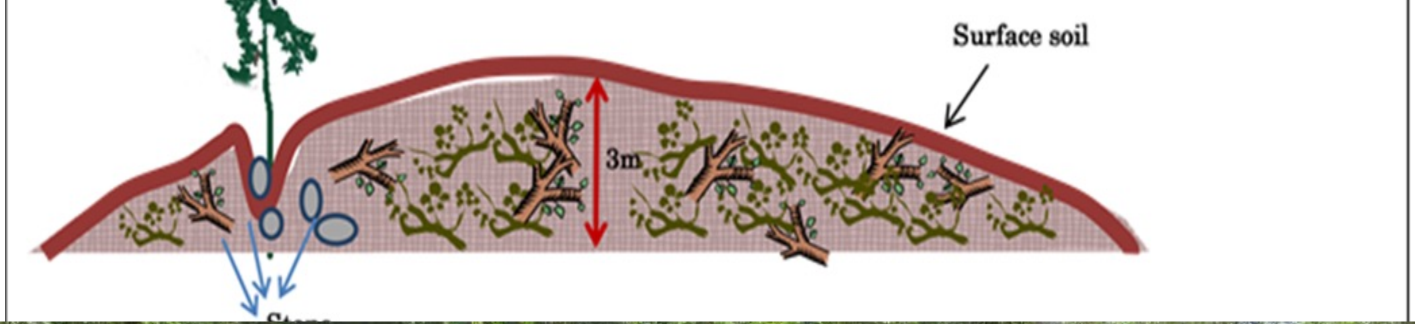
An important aspect of Miyawaki method is understanding the tree community structure in climax vegetation, species selection in appropriate ratios and planting seedlings at high density (3 seedlings/m2)

The 'Miyawaki method' has been instrumental in restoration of potential natural vegetation in Japan and many parts of the word since the 1970's (Miyawaki 1993, 1996, 1998, 2004)

In addition,

- why plant?
- how to plant,
- when to plant and

Diagram of mound incorporating wood to provide carbon for growing seedlings



Actual mound construction

Maintenance (mulching, weeding & replacement of dead seedlings) is done for 3 years post planting after which canopy should be closed and high enough due to fast growth from light competition. This reduced light penetration beyond the canopy layer and therefore suppresses new undergrowth (weeds).

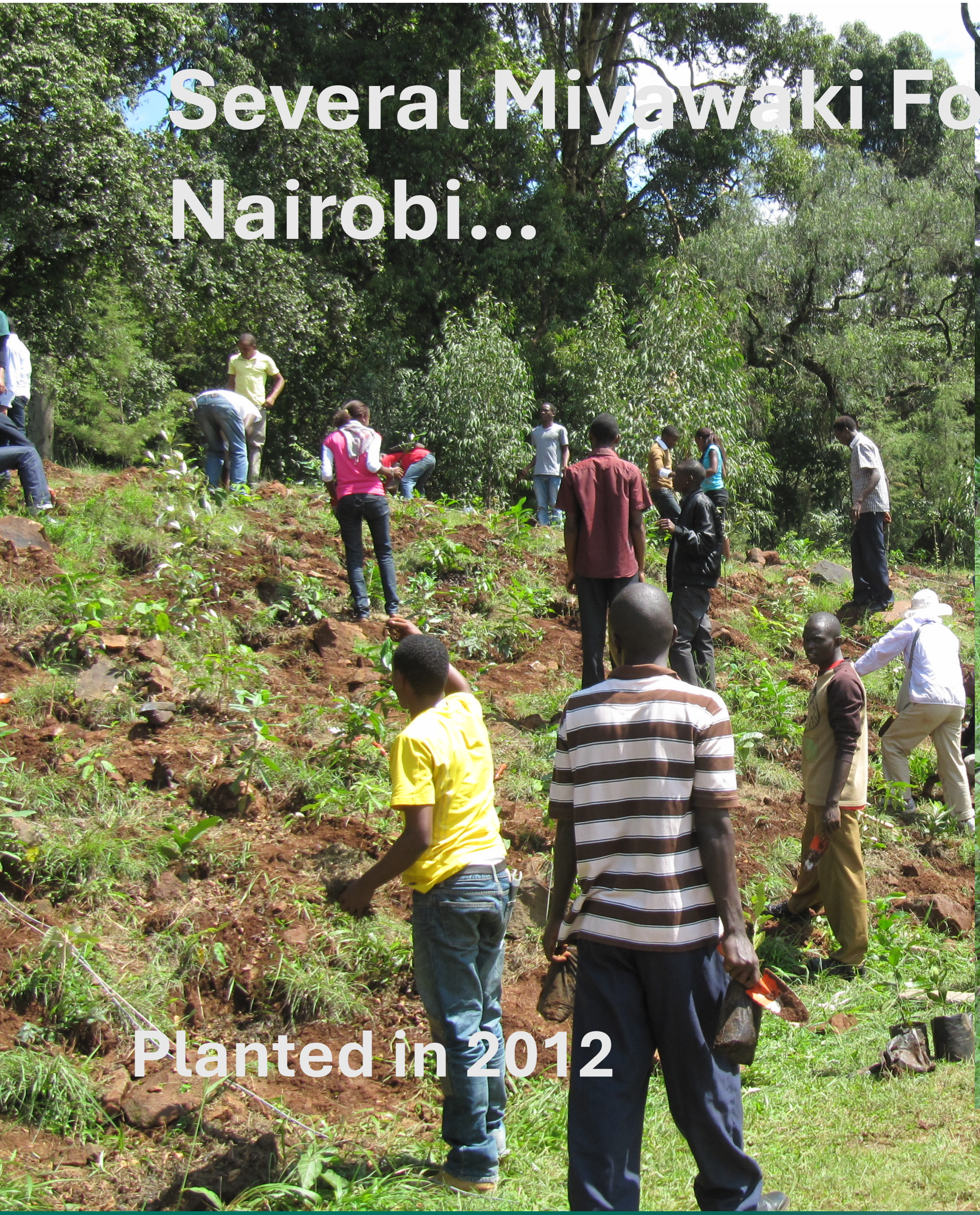
Development of Miyawaki Mini Forests at the University of Nairobi

- Several and extensive studies were conducted in the upland dry forests of Kenya to understand the plant community structure and composition.
- The upland dry forests around Nairobi are Karura, Ngong Road, Oloolua and Ngong hills.
- Data from these forests was collected and enabled species selection for restoration at the University of Nairobi's Chiromo campus
- A total of 16 species were selected comprising of *Shrebera alata, Rawsonia lucida, Cassipourea malosana, Vepris simplicifolia, Drypetes gerrardii, Elaeodendron buchananii, Croton megalocarpus, Brachylaena huillensis, Calodendrum capense, Ficus thonningii, Warburgia ugandensis, Olea europea* ssp. *africana, Olea capensis* ssp. *hochstetteri, Ehretia cy* *Markhamea lutea* and *Cordia africana*

Methodology

- Species selection done and planted as indicated earlier
- Strips of vegetation were planted across contours in a formerly landscaped area of the campus in 2012 and 2013, and on artificial mounds created for flood mitigation along a river running through the campus (planted in 2014, 2016, and 2018)
- Plots of 5x5 meters were established after planting and each seedling was geotagged and measurements of crown diameter, height and subsequently DBH (after attaining 1.3 m height) taken at least once an year (for 3 to 7 years after establishment)
- We used linear regression models to describe growth dynamics for height, DBH and wood volume

Several Miyawaki Forests Established Around Nairobi...



Planted in 2012

How It Looks Today….


April 2013 after planting

How It Looks Today….

Planted in 2014

.....after 18 months

Planted in 2016

How it Looks Today….


2018
2019
2021

We assumed the growth to be in an initial quasi constant growth that can be described by a linear regression model:

$$\hat{h} = \alpha + \beta t$$

where $\hat{h}$ is the estimated species height in cm, t is the time after plantation in days, while the parameters of the model are α representing the mean tree height at plantation, and β is the slope of the line representing the growth rate (cm d^{-1}). The same model was applied to wood volume growth.

For the estimation of wood volume, we the equation below adapted from Magnussen and Reed (2015).

$$\hat{v} = \pi \cdot \frac{rcd}{200} \cdot 2 \cdot \frac{h}{100} \cdot D$$

where $\hat{v}$ is the estimated wood volume in m^3, *rcd* is the root crown diameter in cm, *h* is the tree height, also in cm, and *D* is a calibration parameter, which have been empirically set 0.42 (Magnussen and Reed, 2015).

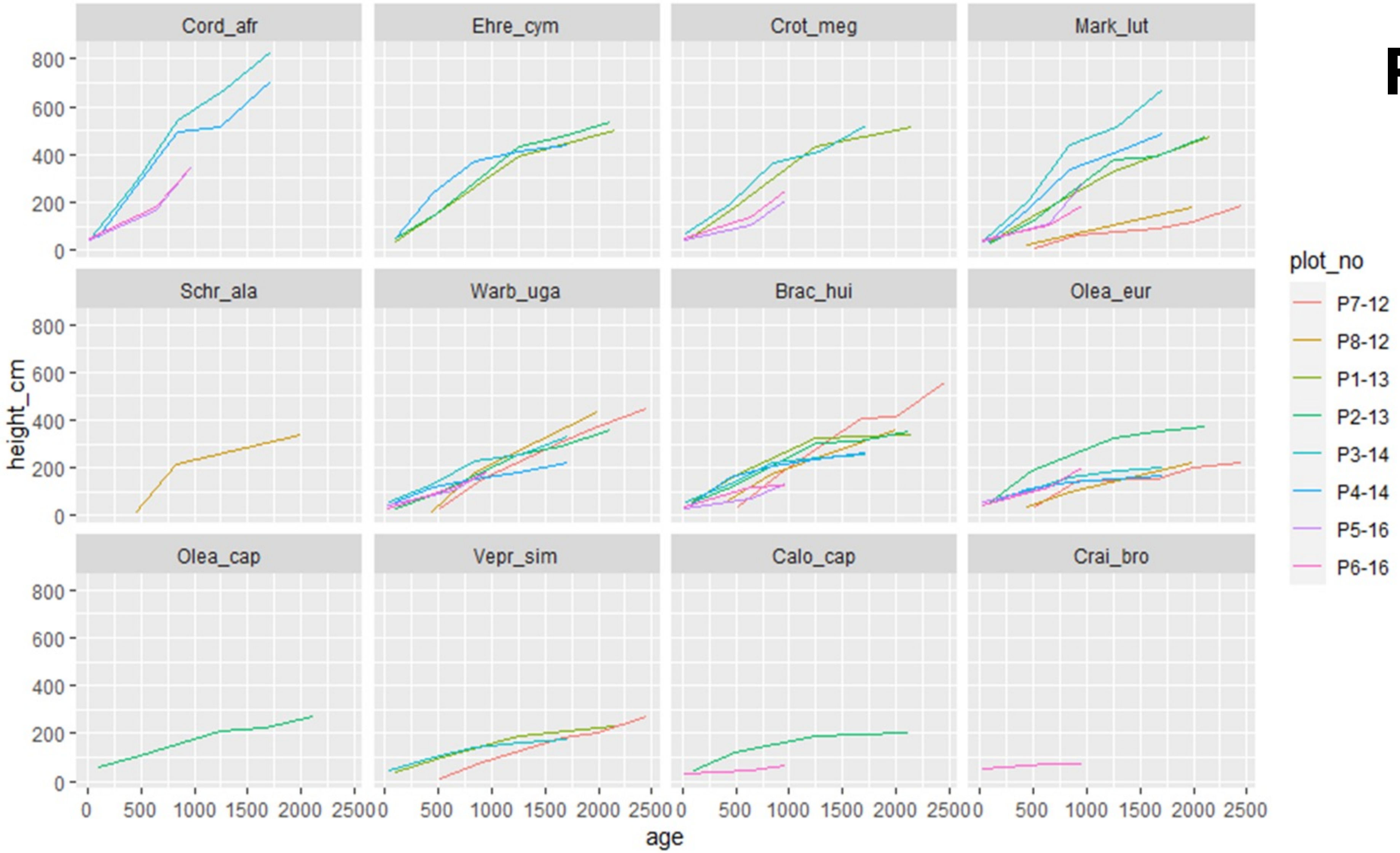
RESULTS

Height Growth Rates

- The growth rate of each species was not uniform across the different plots planted in the different years between 2012 and 2016. Some species such as *Cordia africana* and *Markhamea lutea* showed faster growth in the 2014 plots than the plots planted in 2012 and 2016.

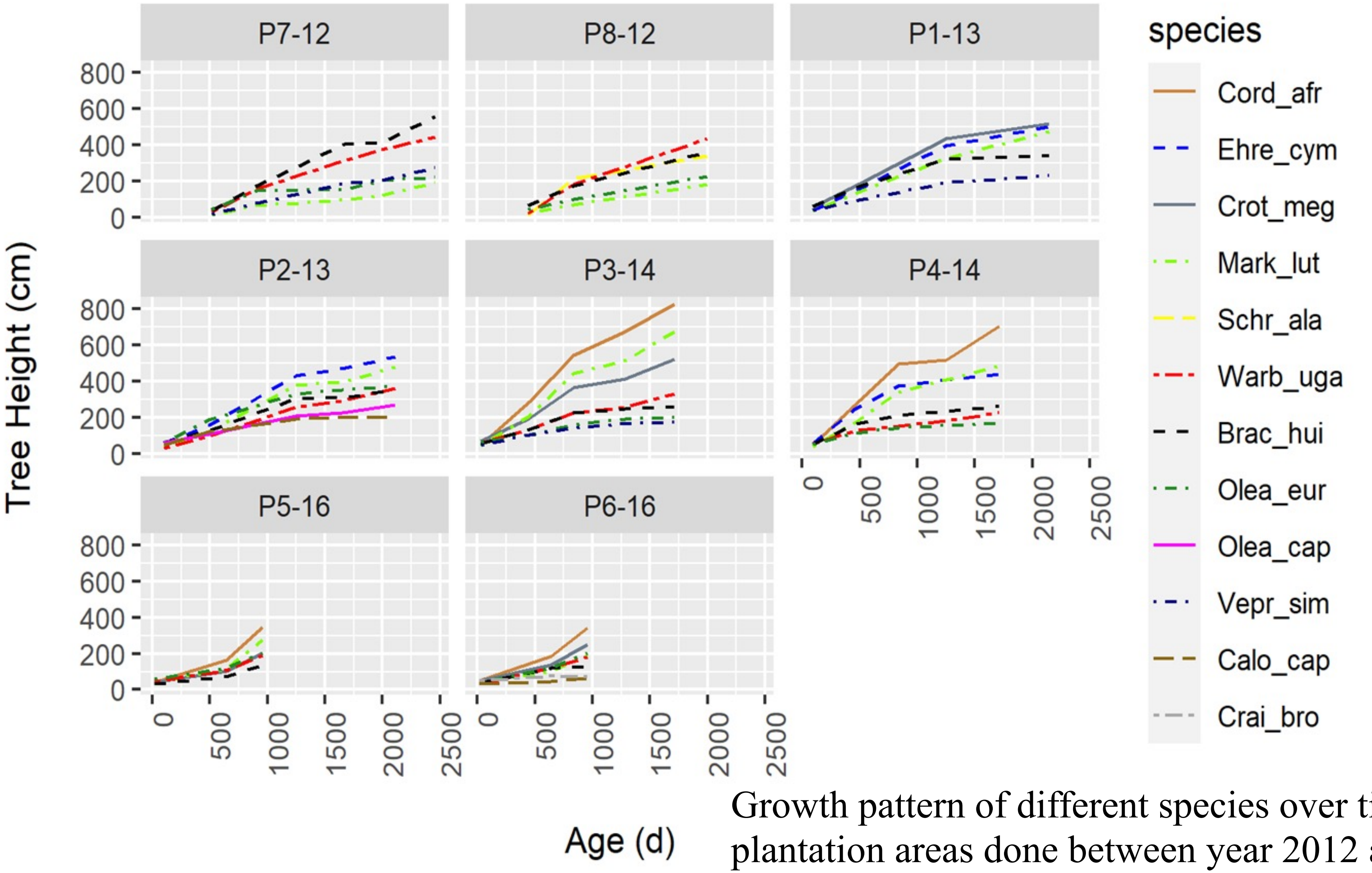
- When the species growth rate is looked at per plot, *Cordia africana* had the best growth rates in the plots where it was present, that is year 2014 and 2016 plots. This was irrespective of the age at which the measurements were made.

RESULTS



Growth rates of different species across the different plots planted between the years 2012 and 2016.

RESULTS



Growth pattern of different species over time for plantation areas done between year 2012 and 2016

Height Growth Rates

Considering the average slopes in the growth models per species, height growth ranged from 0.028 cm d^{-1} in *Craibia brownii* to 0.365 cm d^{-1} in *Cordia africana*, which represent an approximated annual growth 0.1 to 1.33 m y^{-1}, respectively.

Tree species assessed in regeneration experiments ordered by average height growth rates (in cm d^{-1}).

Scientific Name	Family	Average growth Rate (cm/day)	Individuals
Cordia africana	Boraginaceae	**0.365**	35
Ehretia cymosa	Boraginaceae	**0.235**	35
Croton megalocarpus	Euphorbiaceae	**0.216**	25
Markhamia lutea	Bignoniaceae	**0.207**	95
Schrebera alata	Oleaceae	**0.187**	3
Warburgia ugandensis	Canellaceae	**0.170**	81
Brachylaena huillensis	Compositae	**0.147**	48
Olea europaea ssp. *cuspidata*	Oleaceae	**0.116**	78
Olea capensis	Oleaceae	**0.105**	3
Vepris simplicifolia	Rutaceae	**0.100**	13
Calodendrum capense	Rutaceae	**0.055**	11
Craibia brownii	Leguminosae	**0.028**	7

Diameter at Breast Height (DBH)

Scientific Name	DBH (cm)	Age (d)	Plot
Cordia africana	15.6	1,712	P3-14
Ehretia cymosa	8.6	489	P1-13
Warburgia ugandensis	8.1	437	P8-12
Brachylaena huillensis	8.1	437	P8-12
Markhamia lutea	7.9	2,149	P1-13
Croton megalocarpus	6.4	2,149	P1-13
Schrebera alata	6.0	437	P8-12
Olea europaea ssp. cuspidata	3.6	2,111	P2-13
Craibia brownii	2.9	644	P6-16
Calodendrum capense	2.5	2,111	P2-13
Vepris simplicifolia	2.5	2,457	P7-12
Olea capensis	2.0	2,111	P2-13

Growth in diameter at breast height is highly dependent on the species and the local conditions in regeneration plots. The maximum reached values range from 1.96 cm for *Olea capensis* to 15.6 cm for *Cordia africana*

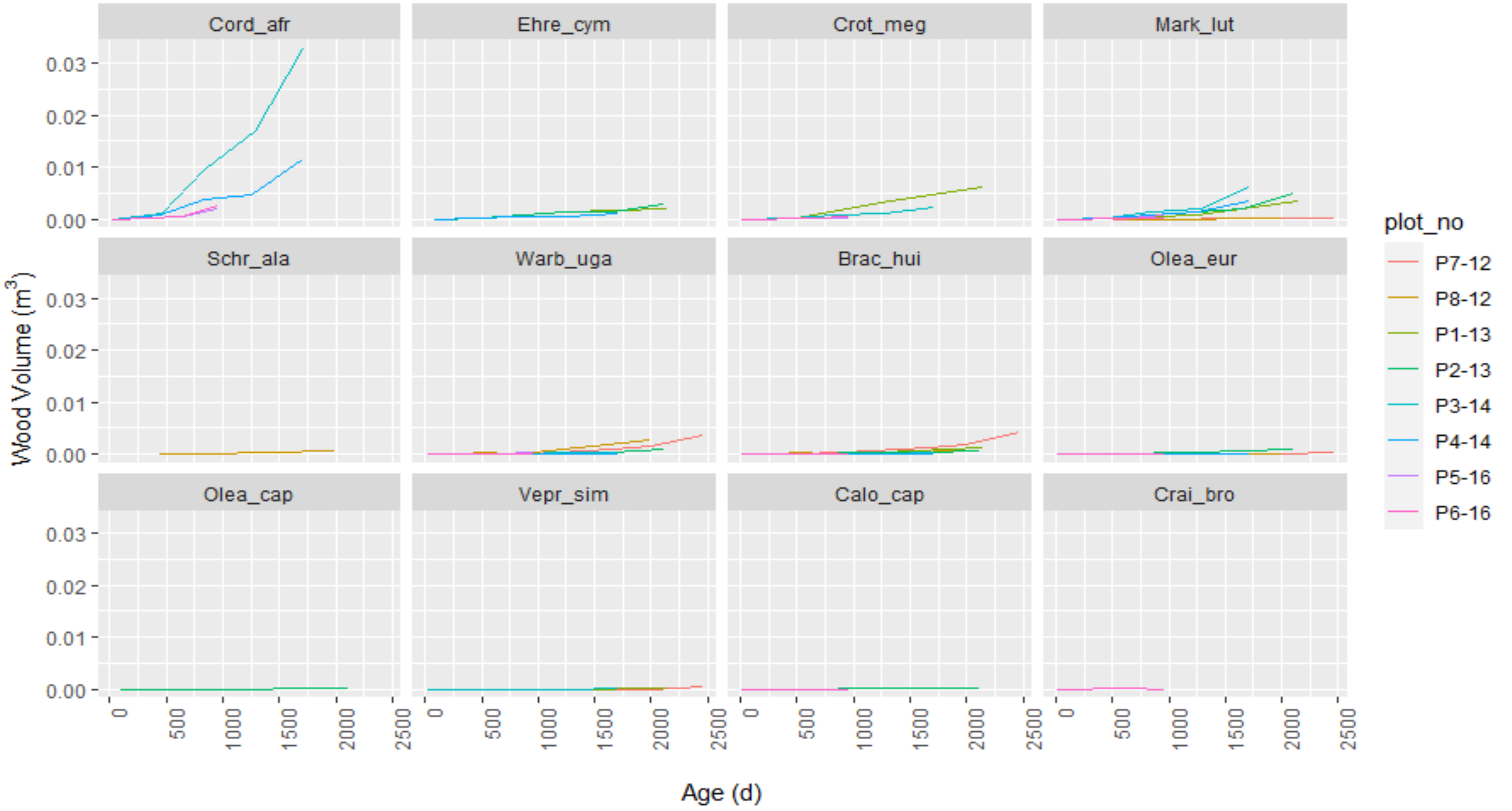
Maximum diameter at breast height observed

Wood Volume growth rates

- *C. africana* had different patterns of wood increase in different plots over time
- *M. lutea* and *C. megalocarpus* also showed some variation between the years.
- Other species showed some rather flat curves meaning that there was consistent increases in wood volume for each species despite the plot and time when they were planted
- However, *S. alata*, *O. capensis*, *V. simplicifolia*, *C. capense* and *C. brownii* had flat lines close to zero showing that their wood volume remained very low irrespective of time of planting or plot.

Maximum diameter at breast height observed

Wood Volume growth rates



Wood volume for each species in the different plots

Wood Volume ….

- On average the volume growth ranges from 0.044 $mm^3\ d^{-1}$ for *Craibia brownii* to 7.692 $mm^3\ d^{-1}$ for *Cordia africana*
- Considering the wood volume growth plot by plot, there are big differences, where the plots planted in 2014 (P3-14 and P4-14) together with P1-13 (planted in 2013) have growth rates over 1 $mm^3\ d^{-1}$.
- As in the case of height growth, high values for volume growth rates are also associated to high variability on the respective growth values.

Scientific Name	Volume Growth Rate ($mm^3\ d^{-1}$)	Individuals	Plots
Cordia africana	7.692	35	4
Markhamia lutea	1.310	95	8
Croton megalocarpus	1.235	25	4
Ehretia cymosa	0.943	35	3
Warburgia ugandensis	0.635	81	7
Brachylaena huillensis	0.427	48	8
Schrebera alata	0.337	3	1
Olea europaea ssp. *cuspidata*	0.141	78	7
Vepris simplicifolia	0.083	13	3
Olea capensis	0.068	3	1
Calodendrum capense	0.052	11	2
Craibia brownii	0.044	7	1

Tree species used in regeneration experiments, ordered by average volume growth rates.

Discussion

- In a preliminary exploration of growth rates both on height and volume, there was no evidence of change in growth rates (not much deviation in the linear model) and therefore our assessment by linear regression models is well justified.
- *Cordia africana* had the highest growth rates in almost all the plots where it was present. This ability of fast growth makes of *C. africana* one the best suitable species for a fast recovery among the tested ones, at least in the initial stages.
- Remarkable performance was observed for *Ehretia cymosa*, *Croton megalocarpus*, and *Markhamia lutea*.

Discussion…

Species selection created a natural multi-layered vegetation with slow growing, shade tolerant species such as *Vepris simplicifolia*, *Olea europapaea* ssp *africana* surviving and creating good successional vegetational matrix

General Conclusions

- While *C. africana* is able to overtake all other species in terms of growth speed, site conditions appear to be very decisive in terms of recovery capacity of forest stands by using the Miyawaki's Method.
- Species selection is an important criteria for scientific based restoration programs when using potential natural vegetation.
- Urban landscapes can be successfully restored with islands of natural vegetation and achieve conservation goals while maintaining spatial aesthetics in urban green spaces.
- Considerations should be made for species that can tolera shading during the initial recommended 3 year maintenanc period.

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Thank You.