Model ecological restoration of submontane forest in Kenya

Brackenhurst Botanic Garden
Tigoni, Kenya

www.brackenhurstbotanicgarden.org

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Ecological restoration in practice

- The context in Kenya
- Principles of restoration in relation to FLR
- The process on site
- Environmental education
- A forest in more than trees: trophic levels

The context

Threats to biodiversity and ecosystems in Kenya


Rate of total destruction
(land use change)
>> rate of restoration

Very poor security; collusion with forest officials.

Land use choices: wildlife conservation vs. agriculture. Livestock numbers preclude range rehabilitation

Threats: Degradation (irrecoverable in the short term)

Threats: land use change, smallholder agriculture; urbanization, plantation crops

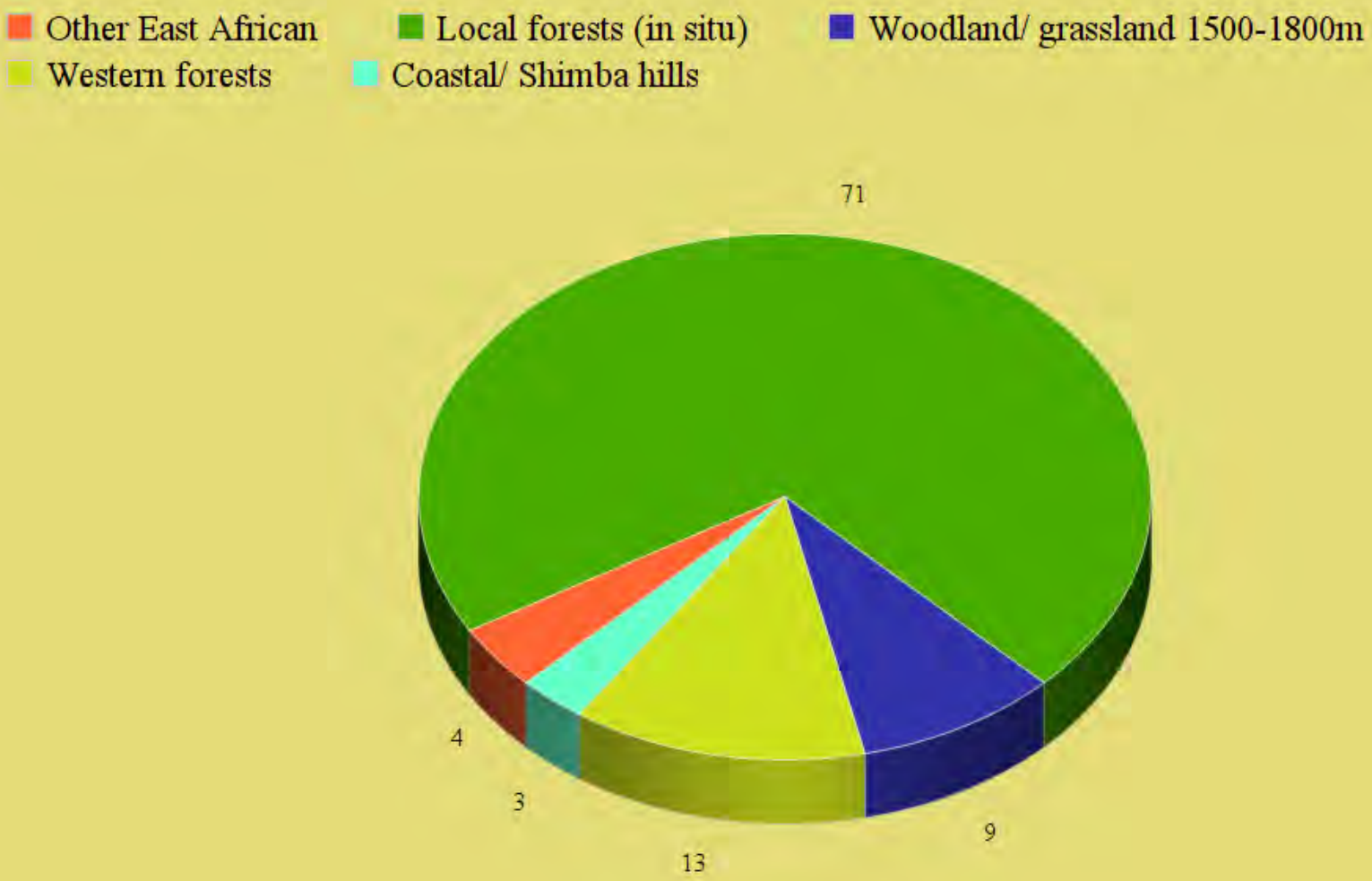
Tea country (1800-2000m): plantations of wattle, eucalyptus, Grevillea; windbreaks of Hakea; scattered indigenous trees. Valleys dry for 6 months a year.

Collecting sites

- Loima
- Marsabit
- Mt. Kulal
- Ndotos
- Matthews
- Kakamega
- Cherangani
- Aberdares
- Mt. Kenya
- Nairobi
- Mara/ Loita/ Nguruman
- Chyulu Hills
- Kilimanjaro (Kenya)
- Kitui (Mutha/ Endau)
- Taita hills/ Kasigau

Brackenhurst forest

- Altitude: 2050-2200m; ±1200mm rainfall
- Ecologically degraded area, now reverting to a natural submontane forest ecosystem
- 110,000 woody native plants grown (5 year survival rate is 90%). NO natural regeneration
- Also collect from dryland, rainforest (from W. Kenya), woodland and grassland species all *ex situ* and many disappearing naturally
- 1500 plant species (>500 woody species of trees, shrubs & climbers; >140 families)



Sources of taxa

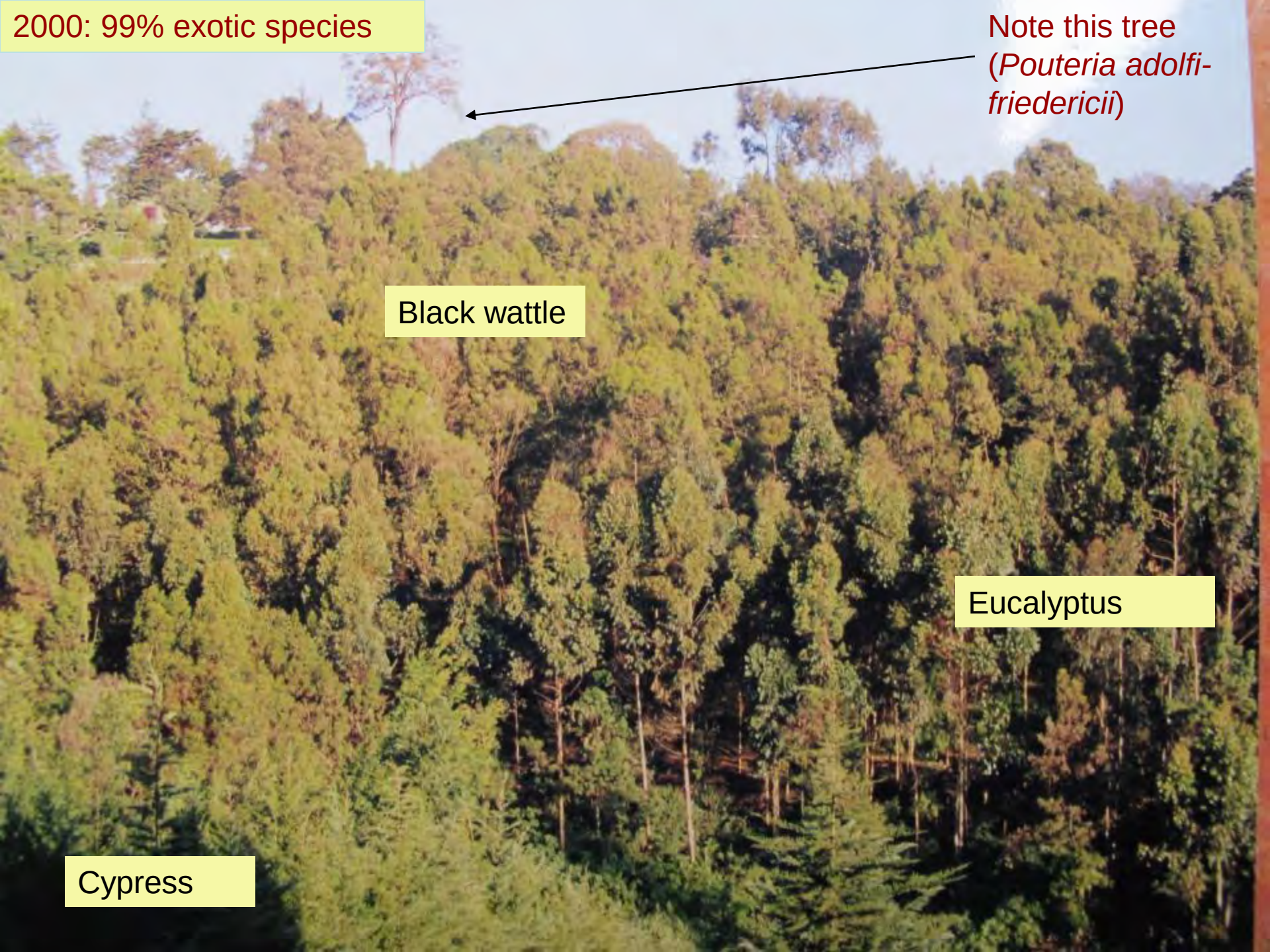
Cassine schlechteranum
from dry forest

Ex situ conservation

Cylicomorpha parviflora

Ex situ conservation:

Widdrintonia whytei & *W. cedarbergensis*


2000: 99% exotic species
Note this tree (*Pouteria adolfi-friedericii*)
Black wattle
Eucalyptus
Cypress

Brackenhurst Botanic Garden in 2017

Ecological restoration project 2000-2030 (99% indigenous)

Our aim: to recreate a ‘natural’ forest

2010 from Government land: note cattle and wetland barrier

General restoration principles

1. Restoring is not restoration: Bonn challenge mentions 150m ha RESTORED by 2020, and 350 m ha by 2030.
2. e.g. Kenya target is 5m ha. Ethiopia "*will have RESTORED*" 15m ha by 2020.
3. International/ national commitments are necessary but should be realistic and achievable.
4. Have the indicators of restoration been spelled out? Restoration is NOT about numbers of trees planted.

5. Dryland reforestation is much more challenging because of vicissitudes of climate.
6. Two types of forest restoration:
   a) Enrichment (active or passive), OR
   b) Land use change back to original ecosystem (TOTAL & ACTIVE restoration.

Most projects are about enrichment

7. Livestock (wildlife?) are major handicaps in successful restoration.
8. A forest is more than trees

Native forest restoration

1. Is FLR about native forest restoration or land restoration?? If it is land restoration, what is the endpoint?
2. Is it ignoring the rangelands and GRASS? The major causes of rangeland degradation are overgrazing and gradual removal of woodland species.
3. Total forest restoration takes TIME & MONEY. We set a target of 30 years (2000-2030) for restoring a 40 ha patch of forest.
4. A block of one or two species of indigenous tree may be a forest but is NOT ecological restoration

5. Our project is the creation of a natural forest…is this an oxymoron?
6. FLR, as we interpret it, should be ecological restoration of:
   - NATIVE plant and animal biodiversity
   - trophic levels
   - ecosystem services
   - edaphic factors: S.O.M., fertility, structure, water infiltration rates
7. Know your biodiversity, because you cannot restore if you don't
8. In our forest we set a goal of >250 identified plant species per 2ha. block (>50 spp. of trees), inclu. herbs, Poaceae, Pteridophyta, Bryophyta etc


Calanthe sylvatica


Eulophia stenophylla

Oplismenus hirtellus

Oplismenus undulatifolius

Euphorbia prostrata

FERNS OF BRACKENHURST FOREST









Picture & design by Herbert Migiro

Low biodiversity

Total restoration

The process

NO regeneration of native trees as the area had been a gum. Cypress or wattle forest for > 60 years

In 2000, Brackenhurst had <20 indigenous trees but a nearby forest has about 50 woody species. Common species include:

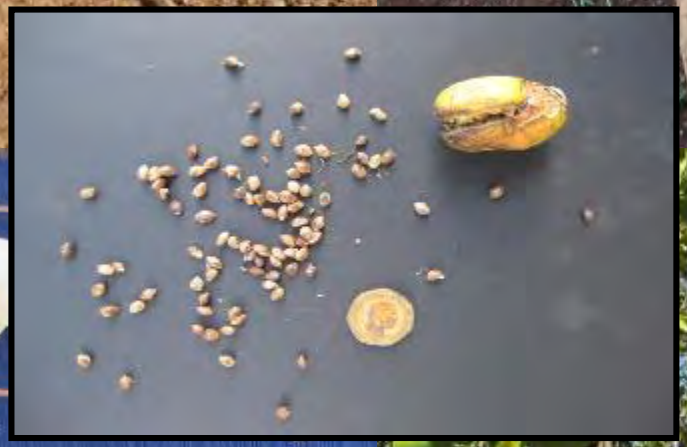
Araliaceae:	*Polyscias kikuyensis*
Clusiaceae:	*Garcinia volkensii*
Euphorbiaceae:	*Croton megalocarpus/ C. macrostachyus*
Euphorbiaceae	*Macaranga kilimandscharica*
Lauraceae:	*Ocotea keniensis (O. usambarensis* extirpated?)
Malvaceae:	*Cola greenwayi*
Meliaceae*:*	*Ekebergia capensis*
Moraceae:	*Ficus thonningii*
Olacaceae:	*Strombosia scheffleri*
Phyllanthaceae	*Margaritaria discoidea*
Rosaceae:	*Prunus africana*
Rubiaceae:	*Psychotria mahonii/ P. fractinervata*
Rutaceae:	*Zanthoxylum gillettii / Clausena anisata*
Rutaceae	*Vepris simplicifolia*
Salicaceae:	*Casaeria battiscombei*
Sapotaceae:	*Pouteria adolfi-friedericii*
Sapotaceae:	*Chrysophyllum gorungosanum*

Why we prefer scientific names

Croton megalocarpus

- Eng: none
- Luhya: Musine
- Boran: Napo
- Kikuyu: Mukinduri
- Maa: Olmergoit
- Tugen: Ortuet
- Samburu: Lameruguet
- Kamba: Muthulu/ Kithulu
- Pokot: Korelach

- Nandi: Masineitet
- Taita: Mukigara
- Gabbra: Nyaap’po
- Luganda: Nkulumire
- Buddu: Mbula
- Rukiga: Mutakura
- Rutoro: Munyabakuru
- Runyankore: Mutagunda




Note grass, woodland spp. (acacia [*S. xanthophloea*])

Reforestation under former cypress: no regrowth, no invasives, easy to restore if understory plants proactively planted

Replanting on land formerly under gum & wattle very difficult

Former gum plantation: no active understory planting but invasives cleared. Trees fine, light shade.

Basella alba

60 years under wattle: S.O.M. >2- 3%

17 years under indigenous forest;
S.O.M. just below leaf litter layer ± 24%

Environmental education

Three main targets:

- The Youth
- Women
- Professionals

Environmental education: Global initiative service Summit: visit to Brackenhurst Feb 23rd 2013

Lack of knowledge of plant identification, ecology & taxonomy

- In 2017 we had a training course on ecological restoration: 29 attendees from 2 govt. institutions and 7 NGOs.
- We quizzed them on 25 less common species asking for Family, Genus, Species & vernacular name (Max. 100 marks)
- Median score 7/100 (one person got 34)

N.B. Regional training course in 2017/18 on plant identification

Loss of indigenous knowledge leads to loss of indigenous biodiversity

Which of the following 6 simple, lobed leaves is ecologically the odd one out?





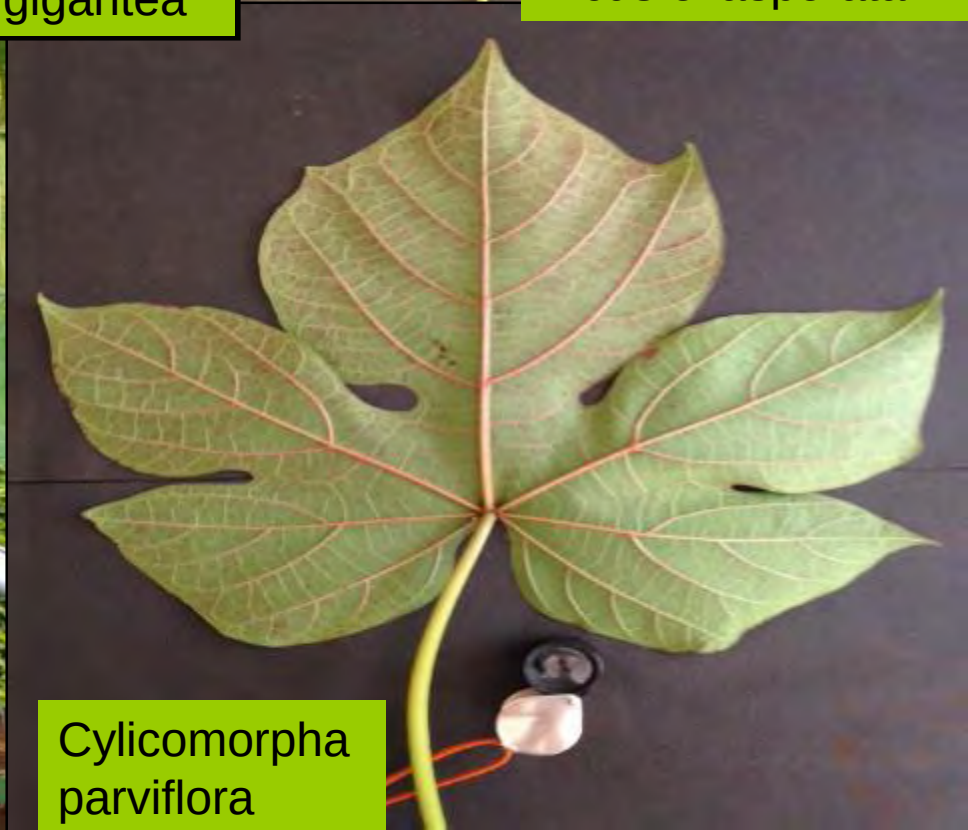
Obetia radula

Cola gigantea

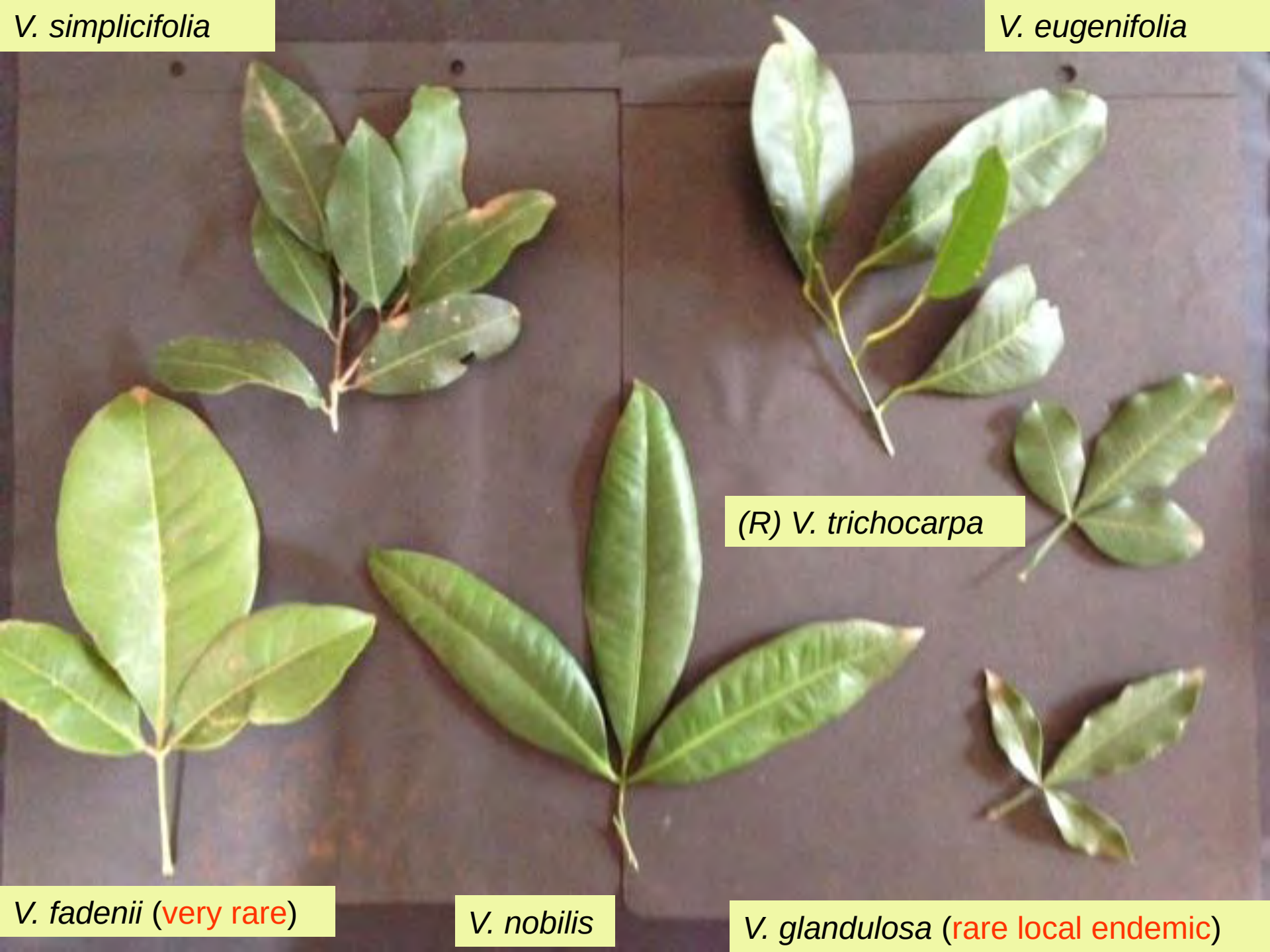
X

Ficus exasperata

Macaranga schweinfurthii



Cylicomorpha parviflora


V. simplicifolia
V. eugenifolia
(R) V. trichocarpa
V. fadenii (very rare)
V. nobilis
V. glandulosa (rare local endemic)

A new species of *Prunus* (Rosaceae) from Kakamega Forest in western Kenya

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Background

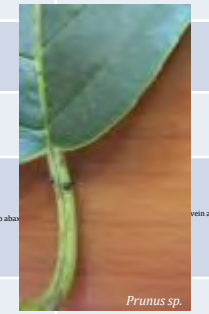
Prunus africana (Hook. f.) Kalkman has been generally recognized as the only native species of *Prunus* on the African continent, with a second named species, *P. crassifolia* (Hauman) Kalkman, accepted in some sources (Hauman, 1952) but often considered only an extreme form in leaf fleshiness of *P. africana* (Graham, 1960; African Plant Database, 2017). A *Prunus* species found in Kakamega Forest differs from *P. africana* in several morphological characters. About 250 seedlings have been distributed to other gardens and forests.

Methods

In 2006 seed was collected from a tree ca. 20 m high in Kakamega Forest and propagated in Brackenhurst Botanic Garden. Flowering and fruiting material was collected from the cultivated individuals in 2011 and compared with published descriptions and herbarium specimens to determine its taxonomic status.

Data from MO herbarium African specimens and literature

	Flora of Tropical East Africa (Graham, 1960) & Flora Zambesiaca (Mendes, 1978)	Flora of North America (Rohrer, 2014) & McVaugh (1951)	Specimen data from Nicholson
	Prunus africana (Hook. f.) Kalkman	Prunus serotina Ehrh.	Prunus sp.
Leaves: Size	4-15 x 2-5.5 cm	2-13.5 x 1.1-6.5 cm	16-19 x 9-9.2 cm
Shape	lanceolate, lanceolate-elliptic, elliptic-oblong, ovate, obovate,	lanceolate, lanceolate-elliptic, elliptic-oblong, ovate, obovate, lance-ovate	ovate
Length : width ratio	1.6-2.9	2.3-3	1.6-2.3
Color			
Sheen			
Pubes		midrib abax	vein axils
Base	shortly cuneate, rounded	cuneate, rounded	rounded
Apex	obtuse, acute, acuminate, long-acuminate	acute, acuminate (caudate)	acute, acuminate
Margin	crenate, serrate	crenate, serrate, glandular	serrate, serrulate
Laterals	not distinct or distinct	not distinct	distinct
Petiole	1-1.4 cm	0.2-3 cm, dulcred	2-2.2 cm, green



Kakamega Forest is a tropical rainforest situated in the Kakamega and Kisumu counties of Kenya, northwest of the capital Nairobi, and near to the border with Uganda. It abuts the eastern side of Kakamega town in Western Province of Kenya. The forest is located between 0°08´N to 0° 22´ N and 34° 46´ E to 34° 57´ E. The forest lies in Lake Victoria Basin, about 150 km west of the Great African Rift Valley, from which it is separated by highlands stretching from Cheranganis in the North to the Mau Escarpment in the South. To the East it borders North Nandi forest atop the Nandi Escarpment (at over 2200 m), while it borders South Nandi forest towards the South-east.

Kakamega Forest is Kenya's only tropical rainforest and is generally considered the eastern-most remnant of the lowland Congolean rainforest of Central Africa. It is dominated by central African lowland species, but due to its elevation (predominantly between 1500–1600 m) and proximity to the formerly contiguous Nandi Forests it also contains highland elements.

The forest including reserves encloses about 238 square kilometers, a little less than half of which currently remains as indigenous forest. The Kakamega Forest is very wet, with an average of 1200–1700 mm of rain per year. Rainfall is heaviest in April and May ("long rains"), with a slightly drier June and a second peak roughly in August to September ("short rains"). January and February are the driest months. Temperature is fairly constant

Results

The inflorescences and fruit of the *Prunus* species from Kakamega are distinctly different from *Prunus africana* and resemble the New World *P. serotina* Ehrh., but the latter species has black rather than red fruit when ripe. The flowers of *P. africana* are borne in shorter and less dense racemes than those of the Kakamega tree, and the fruits of *P. africana* are oblate (wider than long), while those of the Kakamega tree are spherical. Furthermore, the leaf blades of *P. africana* are consistently shorter and narrower than those of the Kakamega tree, and the petiole of *P. africana* is shorter.

Conclusion

Several morphological characters of the Kakamega *Prunus* fall outside the known range of *Prunus africana*. Pending final investigation we suggest that it may represent a new species to science.

All photos courtesy of Mark Nicholson

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Monitoring tree growth

5000 trees planted in 2012: 50 species in 4 plots. (Repeated in 2013 using three replicates).

We measure dbh, height and canopy width.

3 arbitrary categories of growth rates:

1. Rapid >1.5 m/yr (*Olea welwitschii*, *Milletia dura*, *Vitex keniensis*, *Rauvolfia caffra*, Polyscias spp.)
2. Medium 0.5-1.5m/yr (Prunus, Sapotaceae)
3. Slow <0.5m/yr (Gardenia,Garcinia/ Strombosia): some as slow as 10 cm/yr.

Top performing tree species

Height (cm) at 5 years; n=10 per species; $\bar{x}$ (cm) $\pm$ S.E.)

1. *Millettia dura*	480 ±44.7
2. *Trema orientalis*	467 ±41.4
3. Polyscias kikuyuensis	413 ±31.8
4. Vitex keniensis	399 ±20.4
5. Dombeya torrida	388 ±40.3
6. Rauvolfia caffra	344 ±20.7
7. Hagenia abyssinica	341 ±18.1
8. Erythrina abyssinica	297 ±12.1

Top performing tree species

5 year dbh ([cm]; n=10 per species; $\bar{x} \pm$ S.E)

1. *Hagenia abyssinica*	17.1 ±0.89
2. *Dombeya torrida*	15.7 ±0.51
3.Trema orientalis	15.1 ±2.29
4. *Polyscias kik./ P. ful*	7.74 ±0.66
5. *Rauvolffia caffra*	6.78 ±0.51
6. *Erythrina abyssinica*	5.73 ±1.02
7. *Vitex keniensis*	5.73 ±0.28
8. *Millettia dura*	5.1 ±0.43

What is the fastest growing species?

Winner on height

1. *Millettia dura*
2. *Trema orientalis*
3. *Polyscias kikuyuensis*
4. *Vitex keniensis*
5. *Dombeya torrida*
6. *Rauvollfia caffra*
7. *Hagenia abyssinica*
8. *Erythrina abyssinica*

Winner on dbh

1. *Hagenia abyssinica*
2. *Dombeya torrida*
3. *Trema orientalis*
4. *Polyscias kik./ P. ful*
5. *Rauvolffia caffra*
6. *Erythrina abyssinica*
7. *Vitex keniensis*
8. *Millettia dura*

Which is the fastest growing species?

None of the above!

	cm (5 yrs)	m (23 yrs)
Olea welwitschii	700	27 (n=4)
Croton macrostachyus	*410*	29 (n=1)

(cf. *Millettia dura* 480)

So why didn't we measure *O. welwitschii* or Croton?? Olea ALL eaten. Croton does not like wind so we did not plant it on the hill

Antelope damage: *Vangueria* resprouting from base

What can we can conclude from these data?

1. It excludes trees that were eaten by antelope (100% of *Olea welwitschii, Bridelia micrantha* etc were eaten)
2. No replicates in first trial. In sheltered damper area, trees will grow faster than this.
3. We planted what we had.
4. These trees were planted in a grass field. In a real forest, seedlings are competing and many other spp. may be there e.g. Sapots, Diospyros, Prunus, Ocotea, Nuxia, Anthocleista etc.
5. So are we just measuring pioneers?
6. *Croton macrostachyus* is a woodland sp., not a forest sp. Nor, arguably, is Hagenia.

White-tailed Mongoose, Black-tipped mongoose, Genet Cat, Civet Cat, African Clawless Otter, African Palm Civet, Black-backed Jackal, African hedgehog, Grey Duiker, Black & White Colobus, Sykes Monkey, Bush Pig, Porcupine, Fruit & insectivorous Bats

Chrysomelidae: leaf miner; larva lives on Neoboutonia

Trophic levels 2 & 3

Heteracris brevipennis

Coccinellidae


Colobus guereza: Left the site in 1939, returned naturally 2015

A forest is more than trees

(Trophic level 2)

Atelerix albiventris: trophic level 3

A forest is more than trees

Kikuyu Three-horned Chameleon (*Chamaeleo jacksoni*)


Von Hoehnel’s chameleon
(*Chameleo hoehnelii*)

What do bats pollinate? What pollinators are we missing?

Trophic level 4: the predators that eat the hedgehogs & bushbabies

project that aspires to influence NGO and parastatal reforestation initiatives.

Thanks for listening !

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