



Introduction

Rubber agroforests are a major part of the landscape in Sumatra and these harbor a large share of the original forest plant and animal species of lowland Sumatra. There is a continuum of management intensities affecting species richness [monoculture rubber (MR), simple rubber agroforests (SRA) and complex rubber agroforests (CRA) or “jungle rubber” that resemble forests]. Efforts are underway to get market recognition for the forest-like production conditions through eco-certification. Any form of certification, however, requires a clear operational definition of species-rich rubber agroforest. Using available data, we aim to provide quantitative criteria that are:

- easy to understand
- easy to measure
- reliable

Candidate Criteria

This review suggests the following candidate criteria may be used to distinguish different RAF species and their floristic structural complexity. We reviewed the available data for forest, abandoned old RAF, currently tapped RAF and monoculture rubber (MR).

- Number of tree species more than 10 cm dbh (diameter at breast height or 1.3 m above ground) in an 8 m circle around a random starting point.
- Relative rubber basal area, measured as a percentage of the total sum of diameter² of all trees in a sample area.
- Number of large trees (>40 cm dbh).
- Number of seedlings (shrubs, woody plants <2 m height) and sapling (woody species with DBH <10 cm and height >2 m) species in a defined sample area.

1. Number of tree species in a circle of 8 m radius

For forest plots the lowest value found was 5, while the highest value for the rubber monoculture was 3. Hence, we propose a threshold of 4 trees per plot. Nearly 20% of the rubber agroforest plots did not make the mark on this criterion.

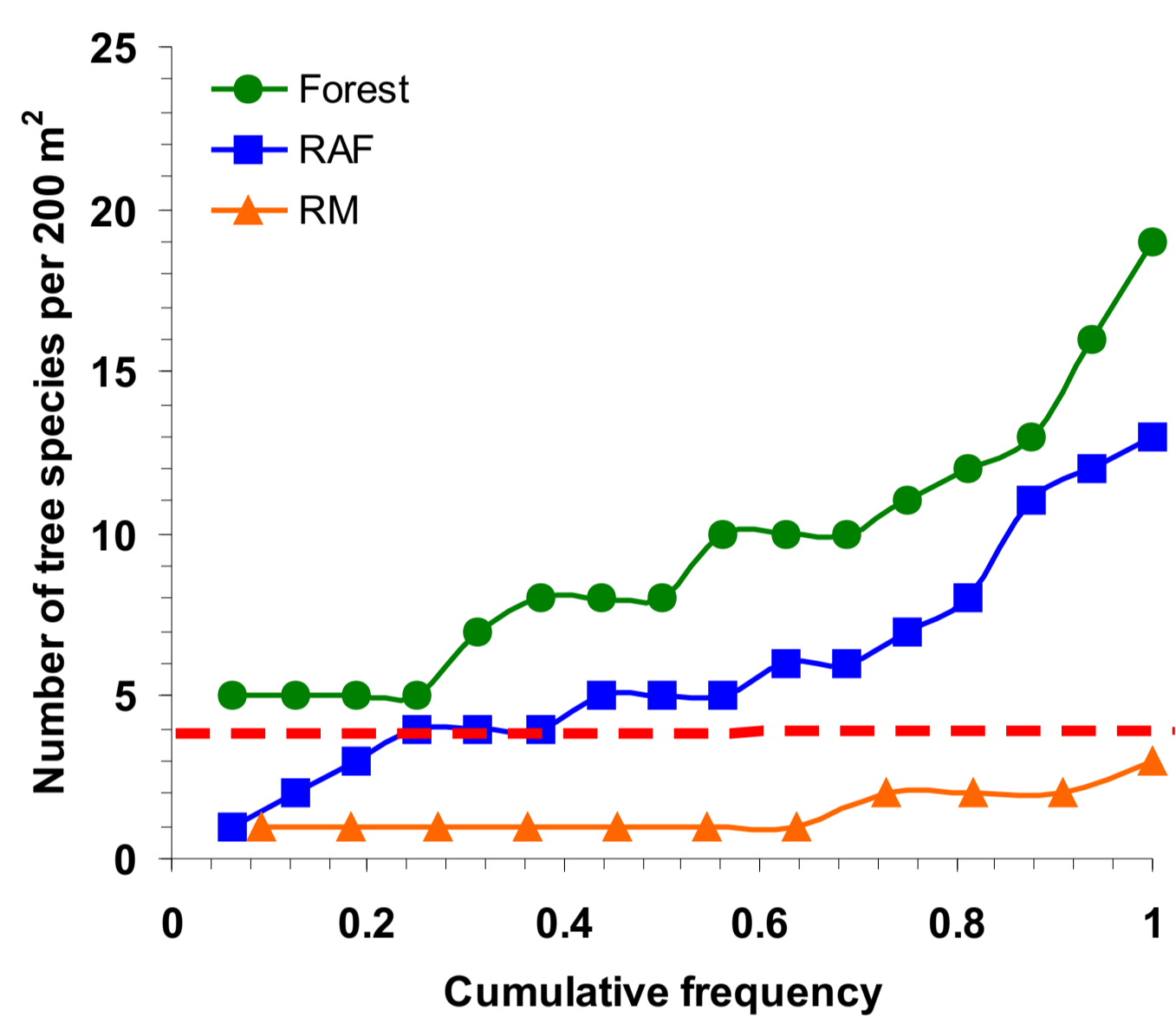


Figure 1. Number of tree species inside forests, RAF and monoculture rubber plots in Bungo, Jambi

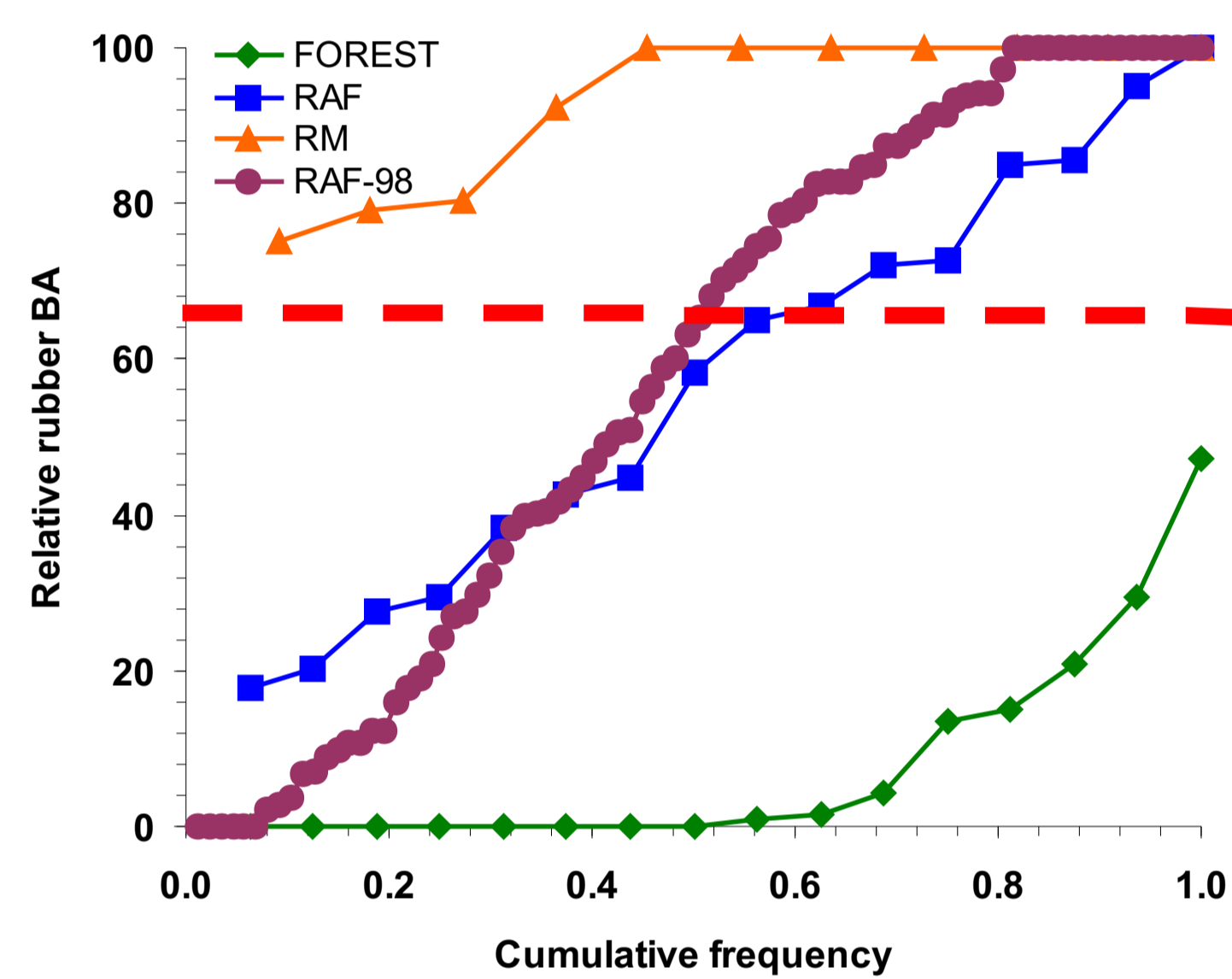


Figure 2. Relative basal area of rubber trees in forest, RAF and monoculture rubber in Bungo

2. Relative basal area of rubber

The lowest relative basal area (BA) of rubber trees inside monoculture plots was about 75% of total BA. We propose a threshold of 2/3 or 67% for SRAF. (Figure 2)



3. Combination of rubber basal area and tree diversity

The tree diversity (number of tree species) can be easily measured. Hence,

- **Simple Rubber Agroforest (SRA)** refers to those plots with rubber trees occupying less than 67% of the total BA, and with average of >4 tree species in 8-m circle plots or >6 tree species in 400m² sample plots.
- Species-rich **Complex Rubber Agroforest (CRA)** can be used to refer to plots with rubber basal area of <1/3 of the total BA and average of >8 tree species in an 8-m circle plots or >12 tree species in 400m² sample plots.

Relative rubber basal area would need to be measured only in borderline diversity cases.

Farmers' perspective on forest and rubber agroforest and monoculture rubber

- Forests and rubber monocultures are different land use systems, and rubber agroforests fall between these two systems, both in terms of vegetation structure species diversity
- Traditional RAF usually starts with land clearing and rubber planting the young rubber gardens gradually develops into old rubber agroforests.

Table 2. Farmers' description of rubber systems and forest

Attributes	Forest	Complex (old) Rubber Agroforests (Kebun Karet Tua)	Simple Rubber Agroforests (Kebun Karet Muda)	Monoculture Rubber
Plant species diversity	Highest (late succession species)	High (some succession species)	Medium (pioneer species)	None
Tree size	large	large	medium	medium
Useful non-rubber trees	Many (local quality timber and fruit species)	Many (local timber and fruit species)	local fruit trees	None
Other products	rattan, honey, saps	rattan, honey, saps		
Tree spacing	irregular	irregular	some regular	regular
Latex productivity	None	Low	Medium	High
Watershed function	high	high	medium	low
Source of rubber propagules	NA	wildlings	wildlings or clones	Clones

Data Sets

A number of available datasets of rubber agroforests collected in Jambi (Sumatra, Indonesia) from previous studies were used to explore thresholds:

- ASB2 surveys lead by Dr. Suryo Hardiwinoto (Gadjah Mada University, Yogyakarta) in Rantau Pandan, Muara Kuamang, Sepunggur, Muara Buat and Pintas Tuo 1998 – 16 transects (87 plots),
- Surveys for the Belowground Biodiversity project in Rantau Pandan, Muara Kuamang and Kuamang Kuning (Bungo district, Jambi); Total area of forest, RAF and MR surveyed were 0.32 ha, 0.32 and 0.20 ha, respectively. Other data (incl. PhD Thesis Saida Rasnovi) did not use full characterization of the tree flora.

4. Large Tree Density (number of trees >40 cm dbh)

Old rubber agroforests normally include large trees that may have been left when the land was initially cleared, or that have grown since then. Generally biodiversity of birds, mammals, insects and epiphytes is largely associated with big trees. The density of trees of >40 cm dbh inside RAF ranged from 6 trees/ha (1 tree/plot of 20x100 m transect, or circular plot of 25 m radius) in Muara Kuamang (MK) to 25 trees/ha (4 trees/plot of 20x100 m transect or circular plot of 25 m radius) in Rantau Pandan (RP).

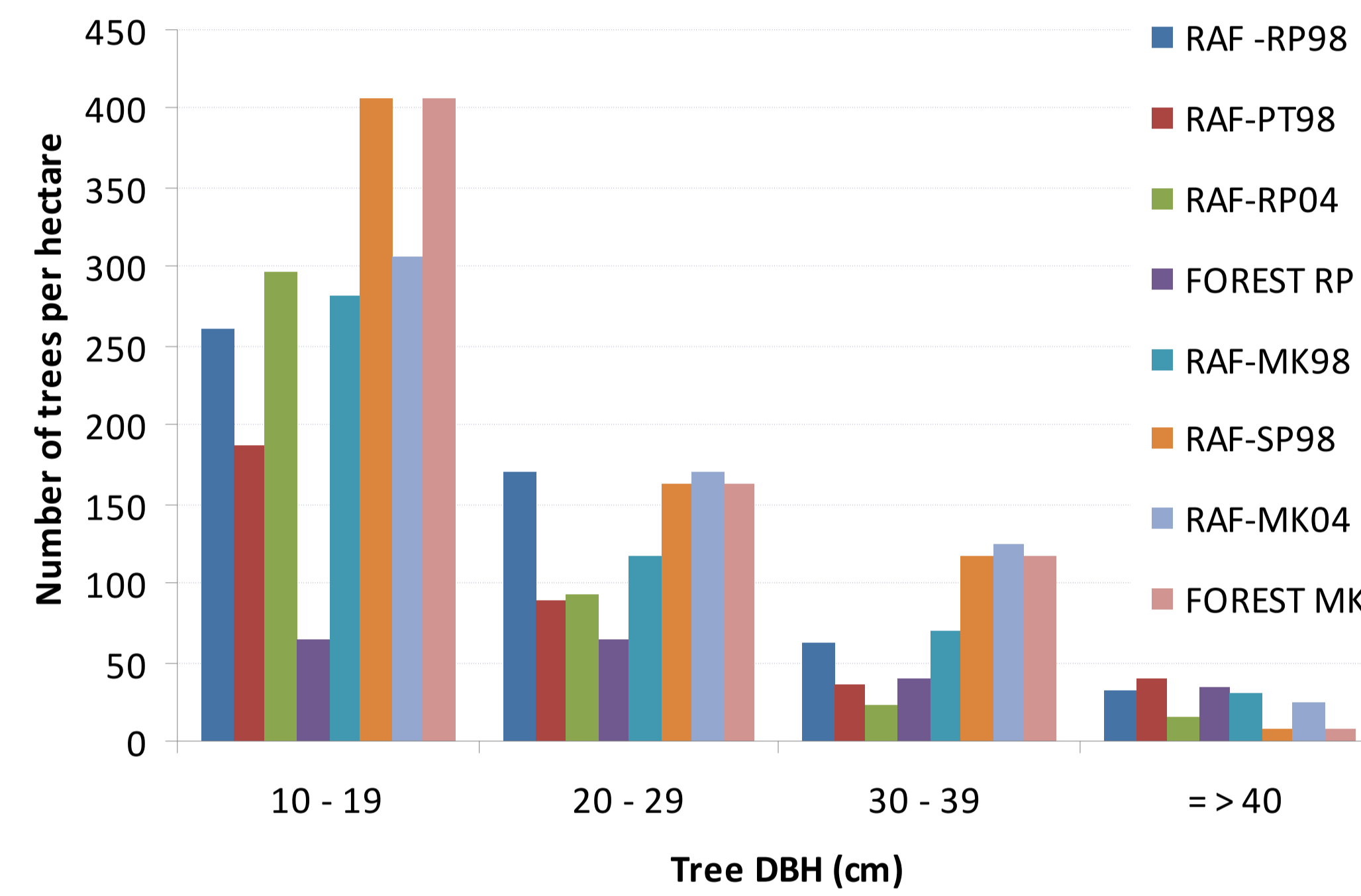


Figure 3. Distribution of trees in the forest and RAF of Rantau Pandan (RP) and Muara Kuamang (2004) and RAF of RP, MK, Pintas Tuo (PT) and Sepunggur (SP) (1998).

5. Number of Seedlings and Saplings

Presence of seedlings and saplings in a system implies its regeneration potential. The diversity of seedlings and saplings inside MR was lower than in forests and RAF, but plot-to-plot variability was high. Seedlings (both count and species diversity) are also abundant inside MR and often as high as in RAF. Most of the seedlings often fail to reach the sapling stage due to diverse reasons. The diversity of saplings inside MR is lower than in forests and RAF. Sapling diversity is important as it indicates the conduciveness of the system for further tree growth. High sapling diversity is also important as the structural canopy diversity provides niche habitats for faunal diversity.

Based on the data available, we propose a threshold of average 4 species of saplings (>2 m high and <10 cm dbh) inside circular plots of 8 m radius.

Table 1. Number of species, individual plants and families of seedling and sapling strata present at forest, RAF and MR

Strata	Forest		RAF		RAF-98		RM	
Seedlings:								
Number of species	15.4	5.2	15.4	5.2	4.23	2.5	7.2	3.4
Number of individual plant	45.6	5.3	47.8	5.4	15.27	15.2	9.7	29.0
Number of plant families	54		47				43	
Saplings:								
Number of species	10.9	5.3	10.4	5.8	5.01	3.83	1.8	1.7
Number of individual plant	17.7	9.9	18	12.9	8.70	6.48	4.2	8.9
Number of plant families	50		42				8	

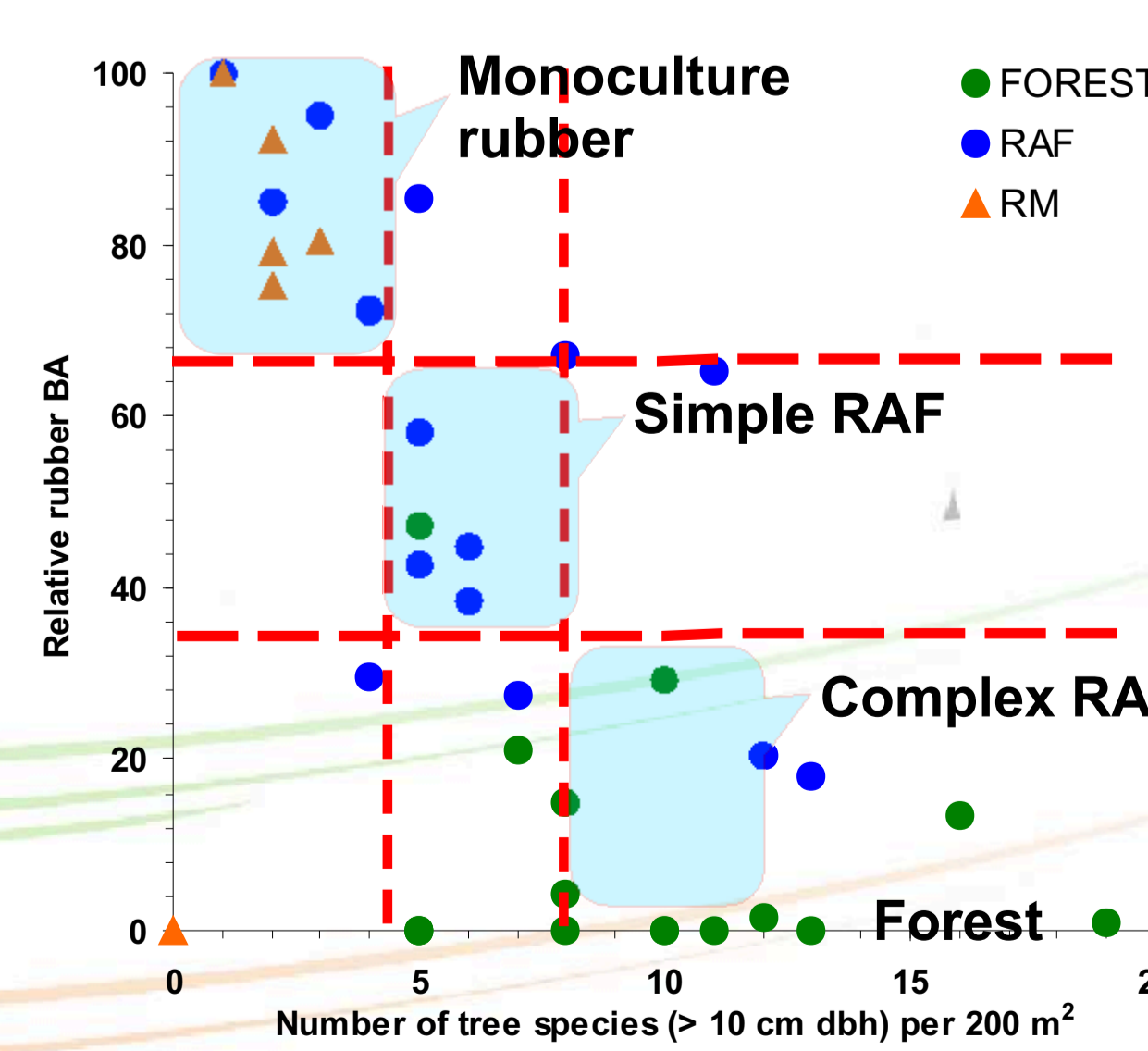
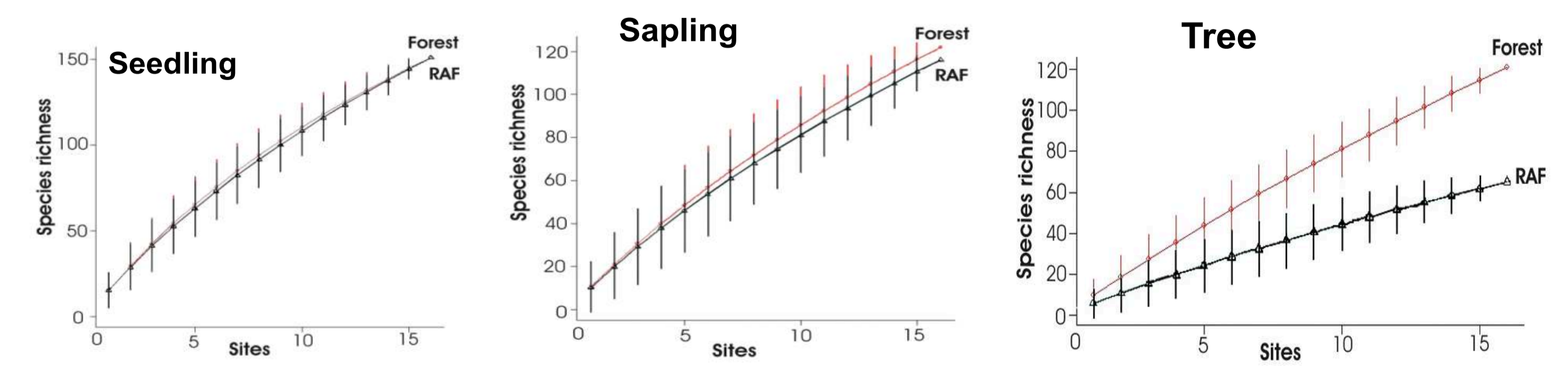


Figure 4. Number of tree species versus relative BA rubber in the forest, RAF and MR plot

Operational definitions for SRA and CRA

Simple Rubber Agroforest (SRA)

Rubber trees occupy <2/3 of total basal area
and Average >4 tree species per 200m² sample plots
and Old trees: minimum 1 tree >40cm dbh/200m² plot
and Saplings: >4 sapling species/200m²

Complex Rubber Agroforests (CRA)

Rubber trees occupy <1/3 of total tree basal area
and Average >8 tree species per 200m² sample plots
and Old trees: minimum 1 tree >40cm dbh/200m² plot
and Saplings: >4 sapling species/200m²