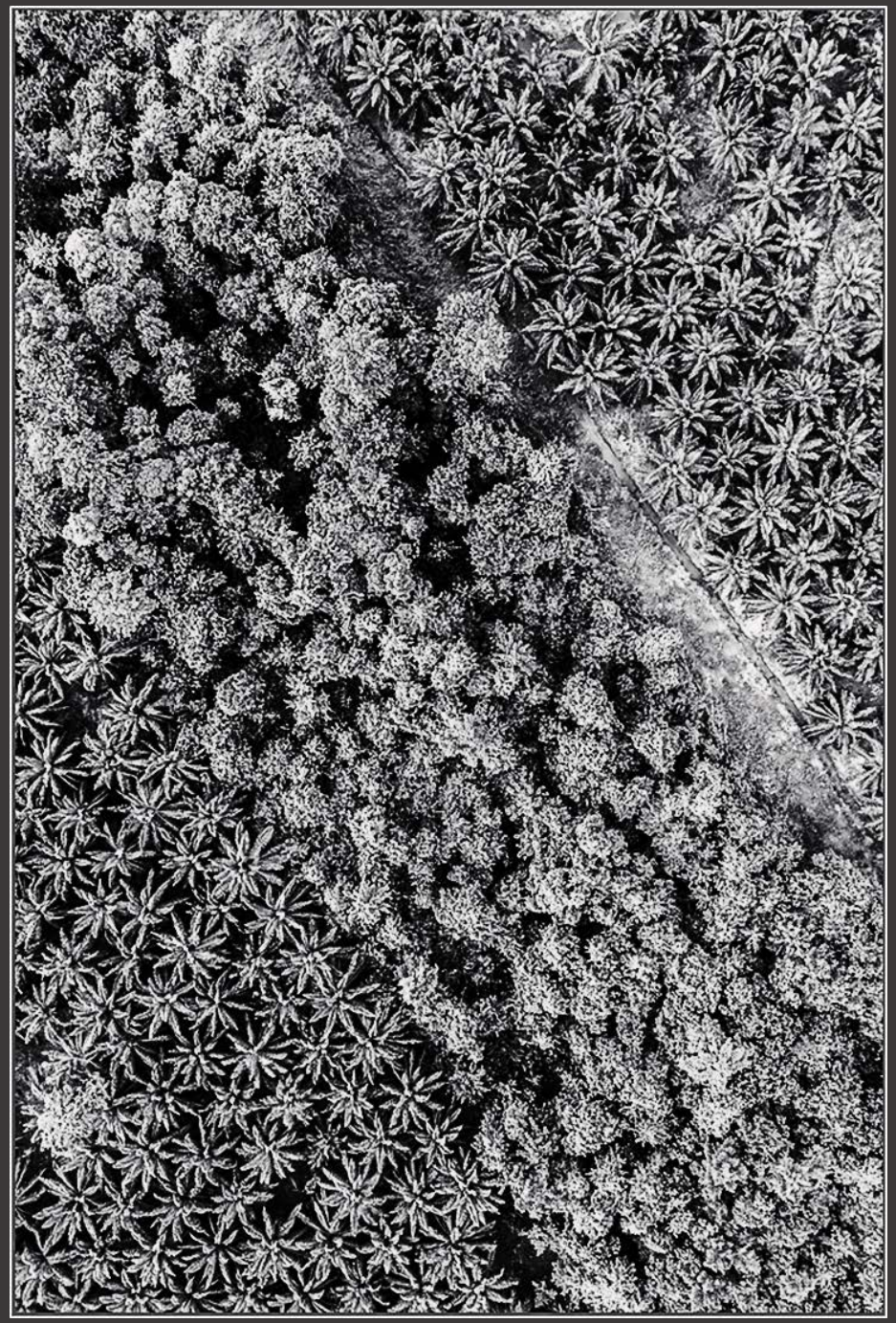

Agroforestry in the Agroecology Transition
Institute of Tropical Agriculture and Food Security - University Putra Malaysia

Oil palm-based agroforestry systems: lessons learned and perspectives

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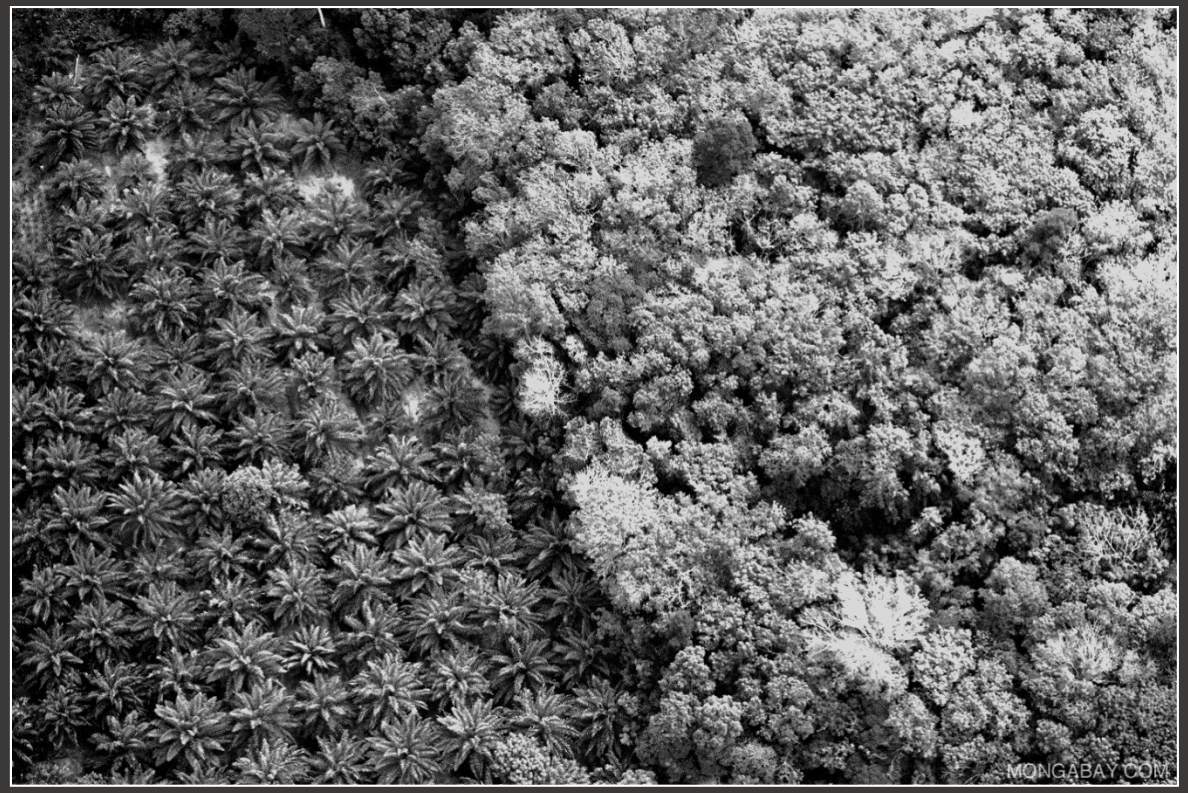
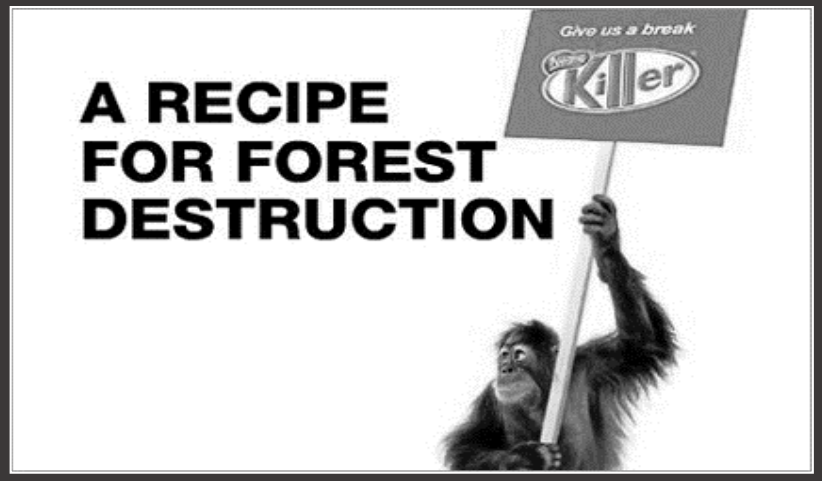
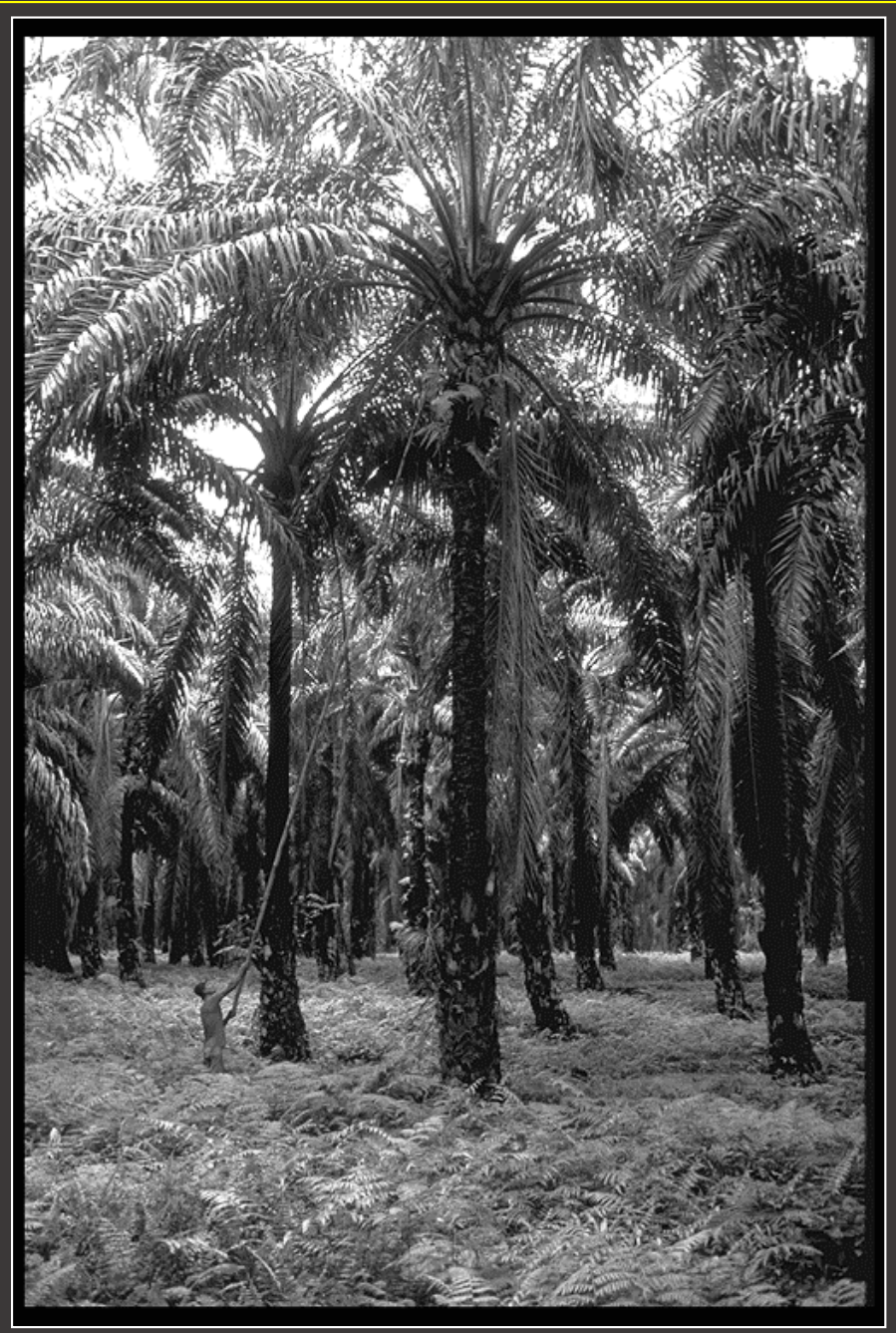
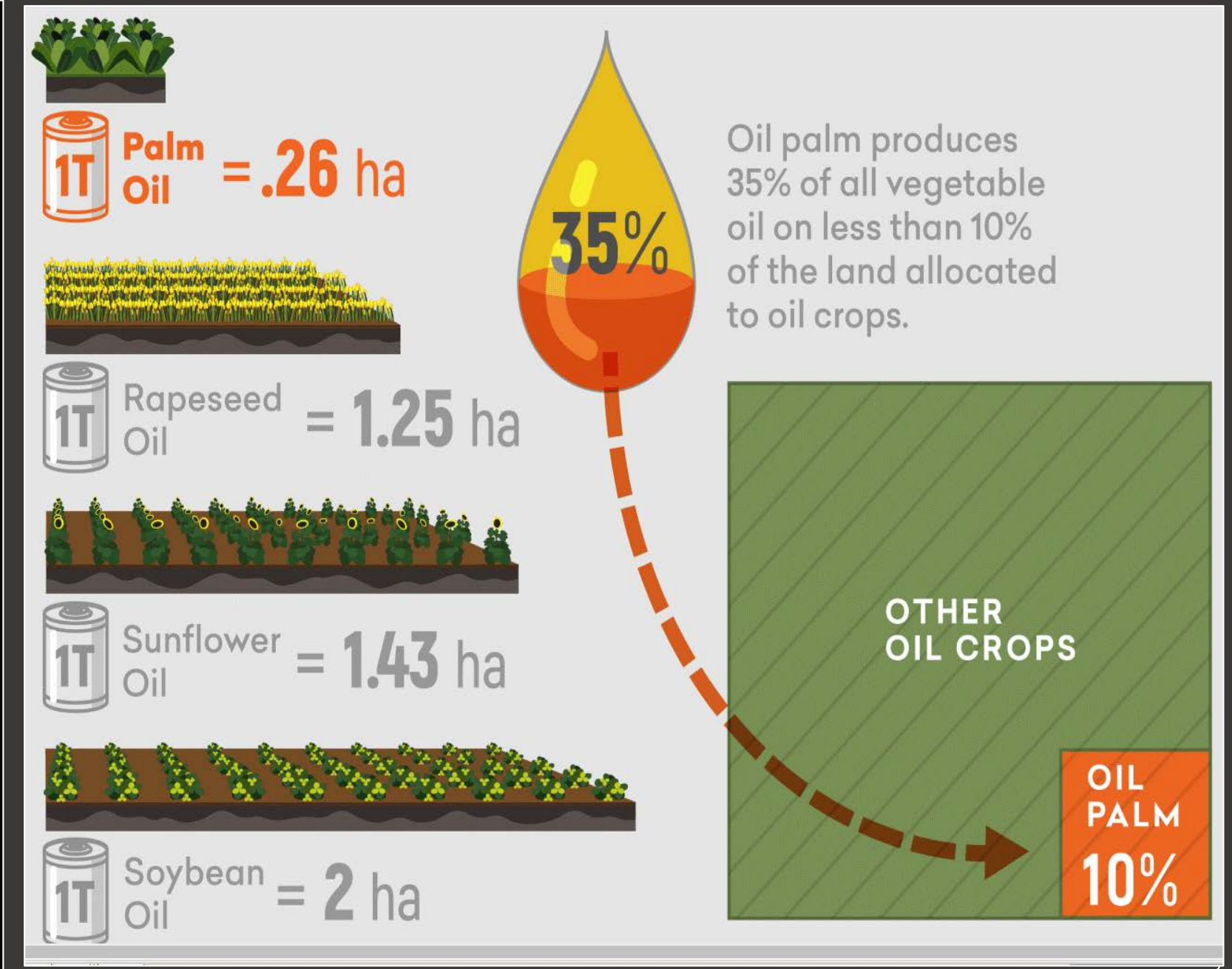
Oil palm is in the public debate





Key factors of attractivity (1)





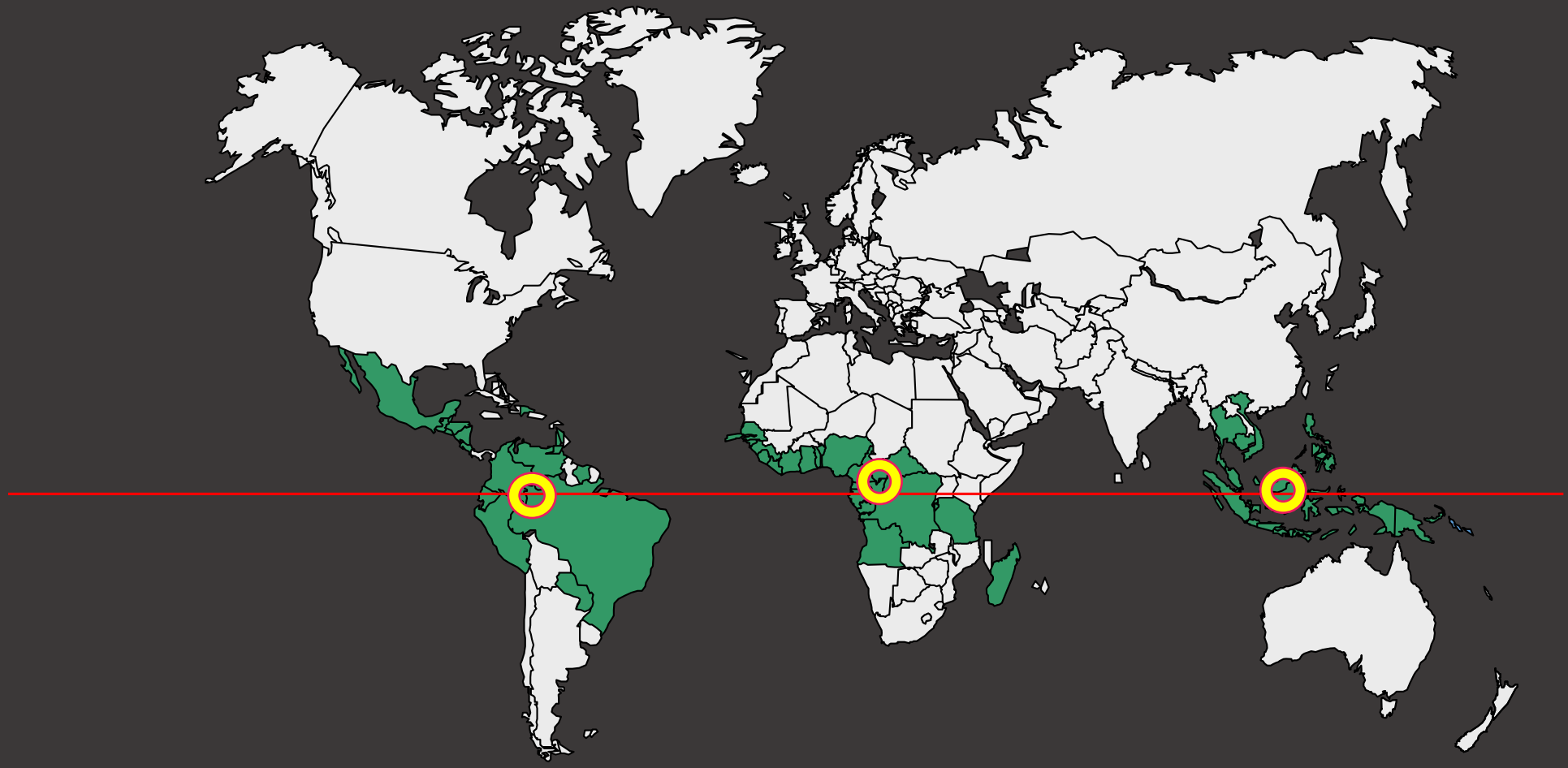
Key factors of attractivity (2)

Crop	Land productivity (€/cultivated hectare)	Work productivity (€/man.day)
Oil palm	2,100	36
Rubber (clonal plantation)	1,600	17
Rubber (agroforestry)	1,300	21
Cultivated rice	200	1.7





Preserving hotspots



Why agroforestry?

- High productivity comes at a cost: soil that is depleted or eroded, watercourses that are polluted or drying up, and a food system that produces 20–40% of greenhouse gas emissions
- We urgently need to transform the food system, including agriculture.
- Agroforestry, as a nature-based approach to production and land use, will play an important role in this transformation.
- Agroforestry is land use that combines trees with crops, trees with livestock, or trees with both crops and livestock.
- This mix of components creates an agroforestry system in which the components interact in a beneficial manner, improving agriculture in many ways.

Gassner A and Dobie P. eds. 2022. Agroforestry: A primer. Design and management principles for people and the environment. Bogor, Indonesia: Center for International Forestry Research (CIFOR) and Nairobi: World Agroforestry (ICRAF).

Why oil palm-based agroforestry?

- Intensive monoculture has been the norm for most of plantation crops
- This system relies on abundant arable land and docile work force.
- The 2015 El Nino episode demonstrated the poor climatic resilience of intensive monocrop systems.
- The CoVid pandemics has revealed several weaknesses (need for mechanization, labor shortages).
- Diversified systems are more able to resist to price volatility and attract young farmers (stable income from multiple activities).

The Biodiversity Enrichment Experiment

- The EFForTS project is for Ecological and Socioeconomic Functions of Tropical Lowland Rainforest Transformation Systems (Sumatra, Indonesia)

- In the EFForTS project, more than 160 researchers from the University of Göttingen in Germany and the Indonesian universities IPB University (Bogor), UNTAD (Tadulako University, Palu) and UNJA (University of Jambi) work in close cooperation, representing a wide range of disciplines including ecology, forestry, agriculture, remote sensing, economics, human geography, and cultural anthropology.

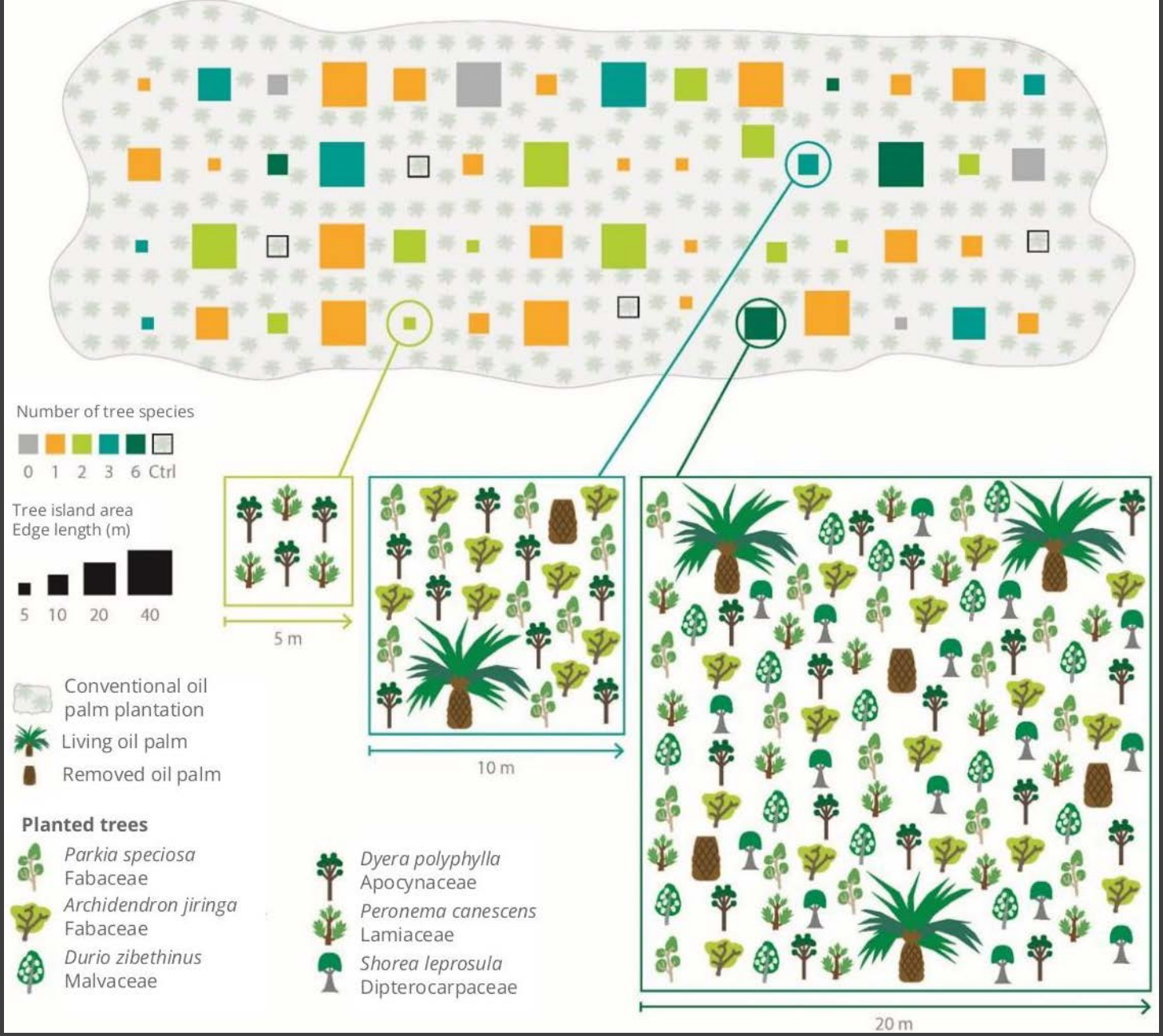
- EFForTS-BEE is part of the global network of 323 tree diversity experiments *TreeDivNet* - https://treedivnet.ugent.be/.

The Biodiversity Enrichment Experiment

- In December 2013, 52 experimental plots (i.e. tree islands) were established in a conventional 140 ha oil palm plantation.
- Experimental design followed a random partition plot area (25, 100, 400 and 1600 m2) and tree species diversity (0, 1, 2, 3 and 6 species).
- Six different tree specieswere planted:
  - *Archidendron jiringa (Fabaceae)* fruits
  - *Parkia speciosa* (Fabaceae) fruits
  - *Durio zibethinus* (Malvaceae) fruits
  - *Dyera polyphylla* (Apocynaceae) fruits
  - *Shorea leprosula* (Dipterocarpaceae) timber
  - *Peronema canescens* (Lamiaceae) timber
- Species are native to the region and widely used for their fruits, timber or latex.

Zemp et al (2022) Tree islands enhance biodiversity and ecosystem functioning in oil palm landscapes. Nature (in press)

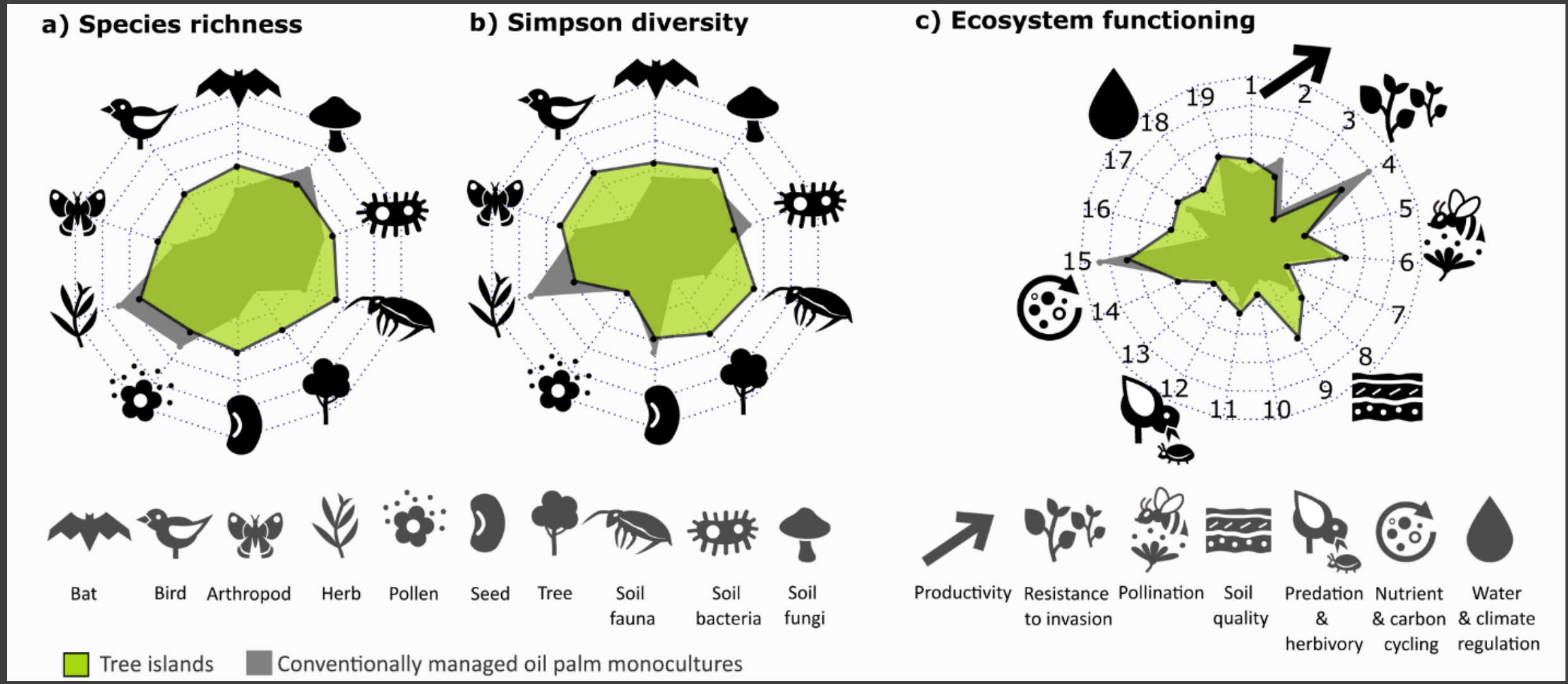
The Biodiversity Enrichment Experiment



- This experimental design tests the restoration outcomes of tree island establishment in oil palm dominated landscapes.
- Tree islands vary in area (25 - 1600 m2) and planted tree diversity (0 - 6 species), with a total of 52 tree islands established in an industrial oil palm plantation in Sumatra, Indonesia.
- Control plots (ctrl) represent conventionally managed oil palm 284 monocultures.

Zemp et al (2022) Tree islands enhance biodiversity and ecosystem functioning in oil palm landscapes. Nature (in press)

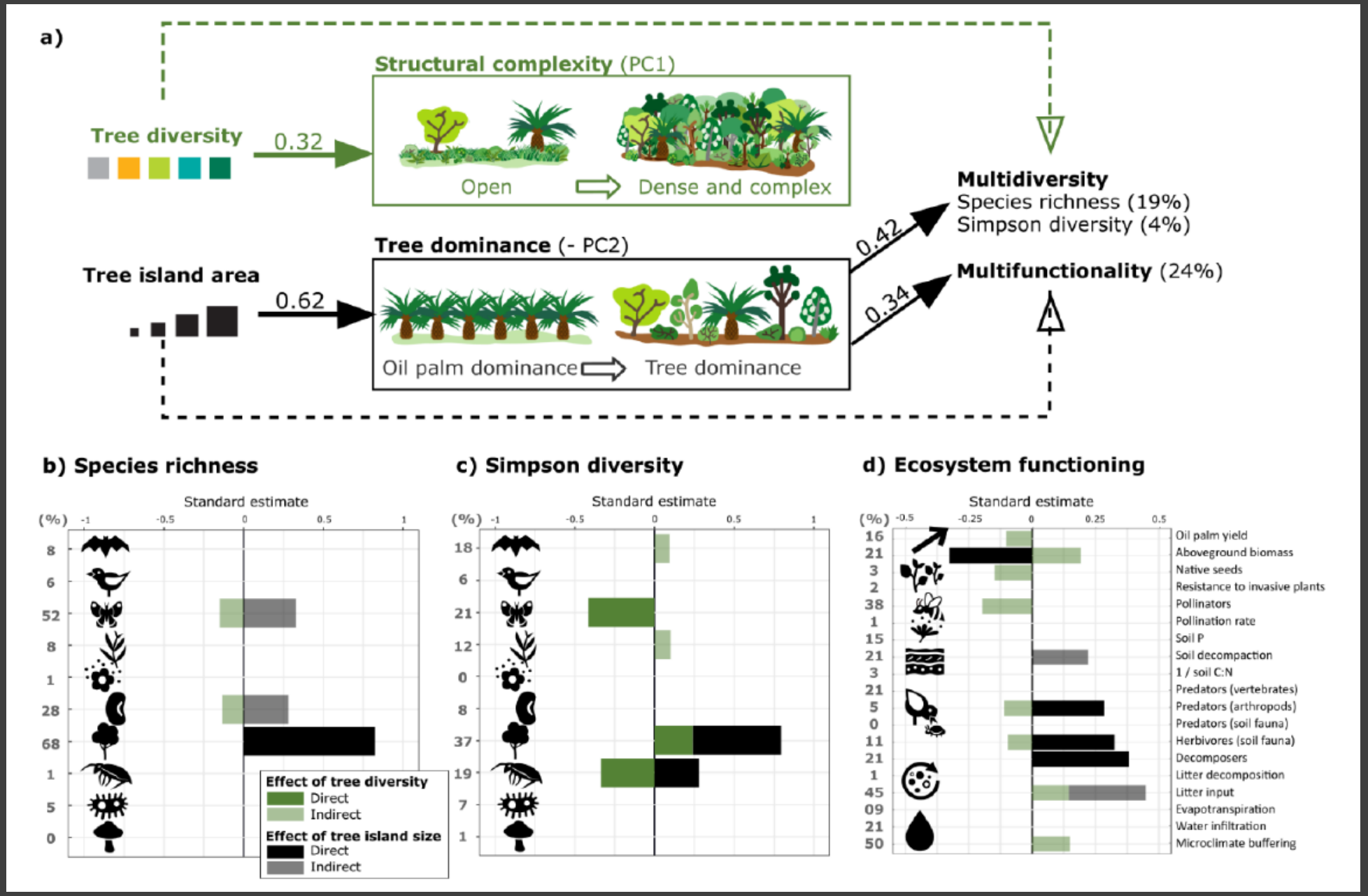
Key findings



Indicators of biodiversity calculated (a) as species richness and (b) Simpson diversity, which emphasizes the contribution of abundant species and (c) ecosystem functioning across 52 tree islands (green polygons) compared to oil palm monocultures (grey polygons). Polygon vertices represent median values for each indicator. The areas delimited by the polygons illustrate (a-b) multidiversity and (c) multifunctionality.

Zemp et al (2022) Tree islands enhance biodiversity and ecosystem functioning in oil palm landscapes. Nature (in press)

Key findings



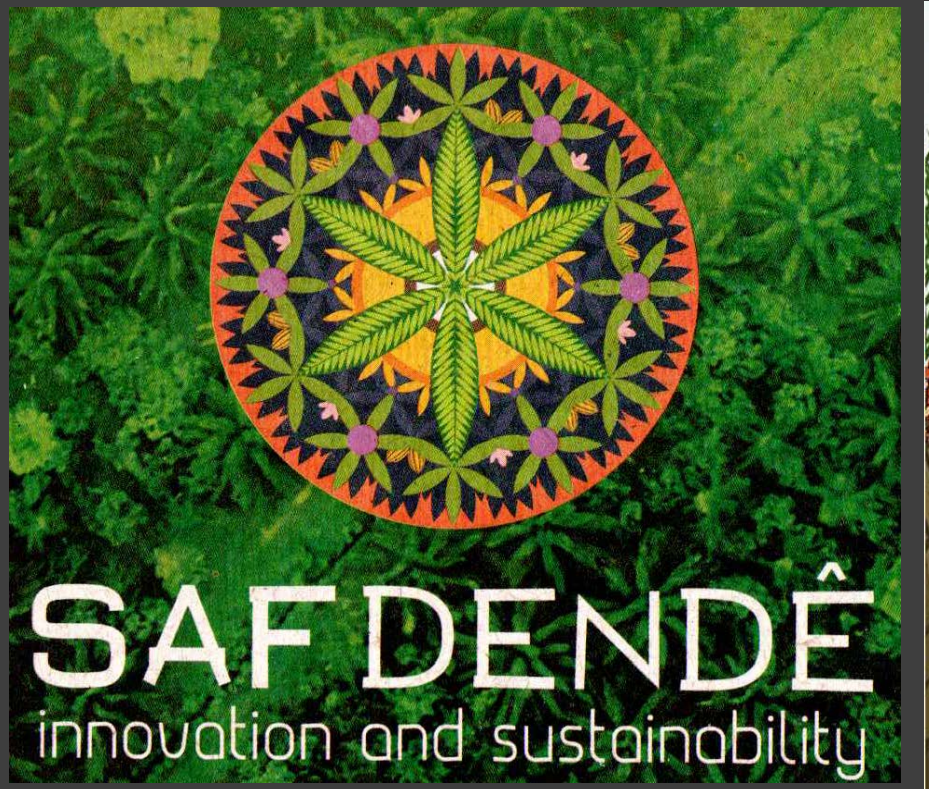
Zemp et al (2022) Tree islands enhance biodiversity and ecosystem functioning in oil palm landscapes. Nature (in press)

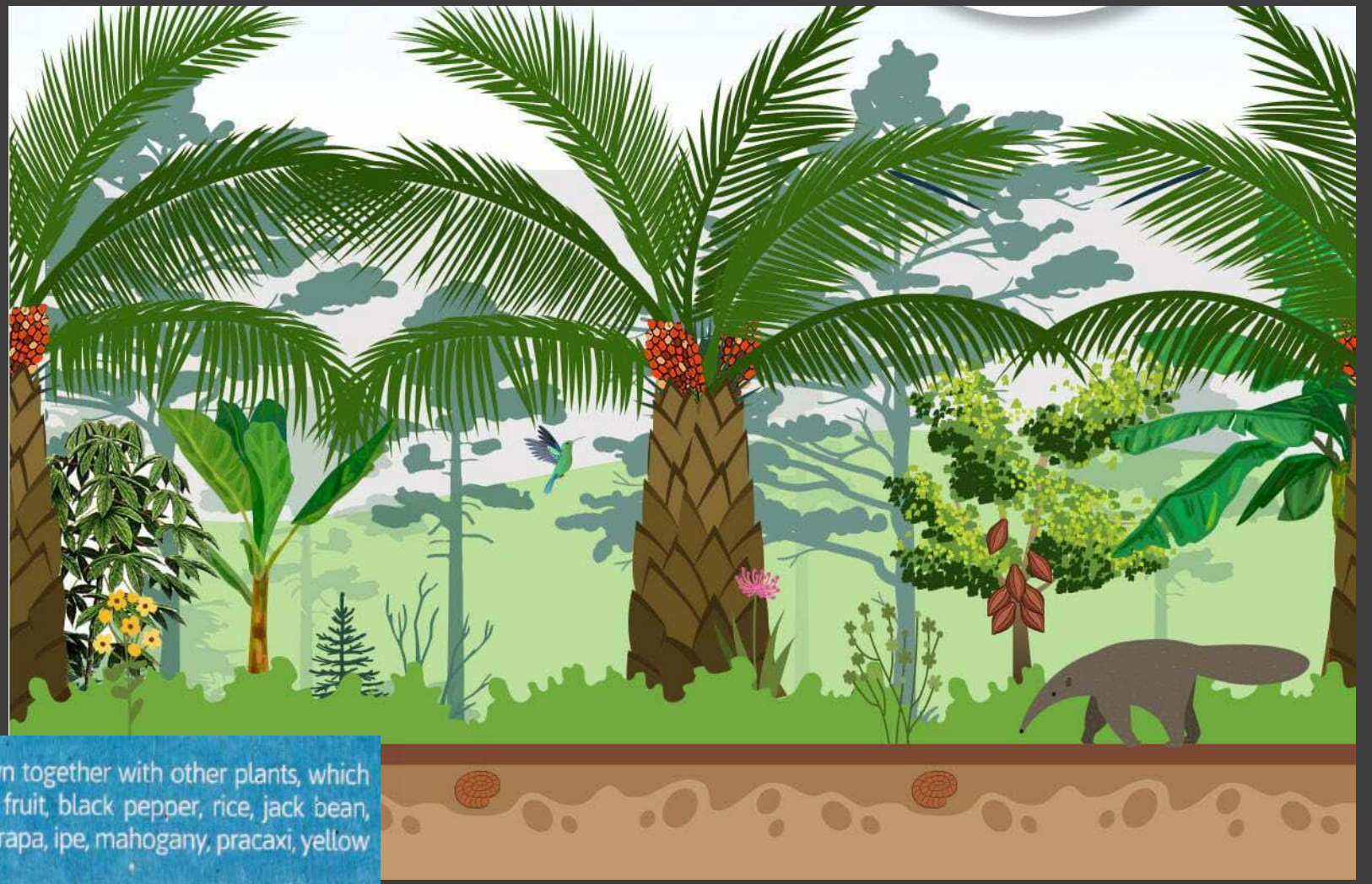
Conclusions

- A large-scale, five-year ecosystem restoration experiment in an oil palm landscape enriched with 52 tree islands, encompassing assessments of ten indicators of biodiversity and 19 indicators of ecosystem functioning.
- Tree enrichment enhanced multidiversity by 250% and ecosystem multifunctionality by 75% compared to conventional monocultures.
- Therein, larger tree islands led to higher multidiversity and multifunctionality gains via changes in vegetation structure.
- Tree enrichment did not significantly decrease landscape-scale oil palm yield.
- Such results demonstrate that enriching oil palm-dominated landscapes with tree islands is a promising ecological restoration strategy.

Zemp et al (2022) Tree islands enhance biodiversity and ecosystem functioning in oil palm landscapes. *Nature* (in press)

SAF DENDE - Brasil

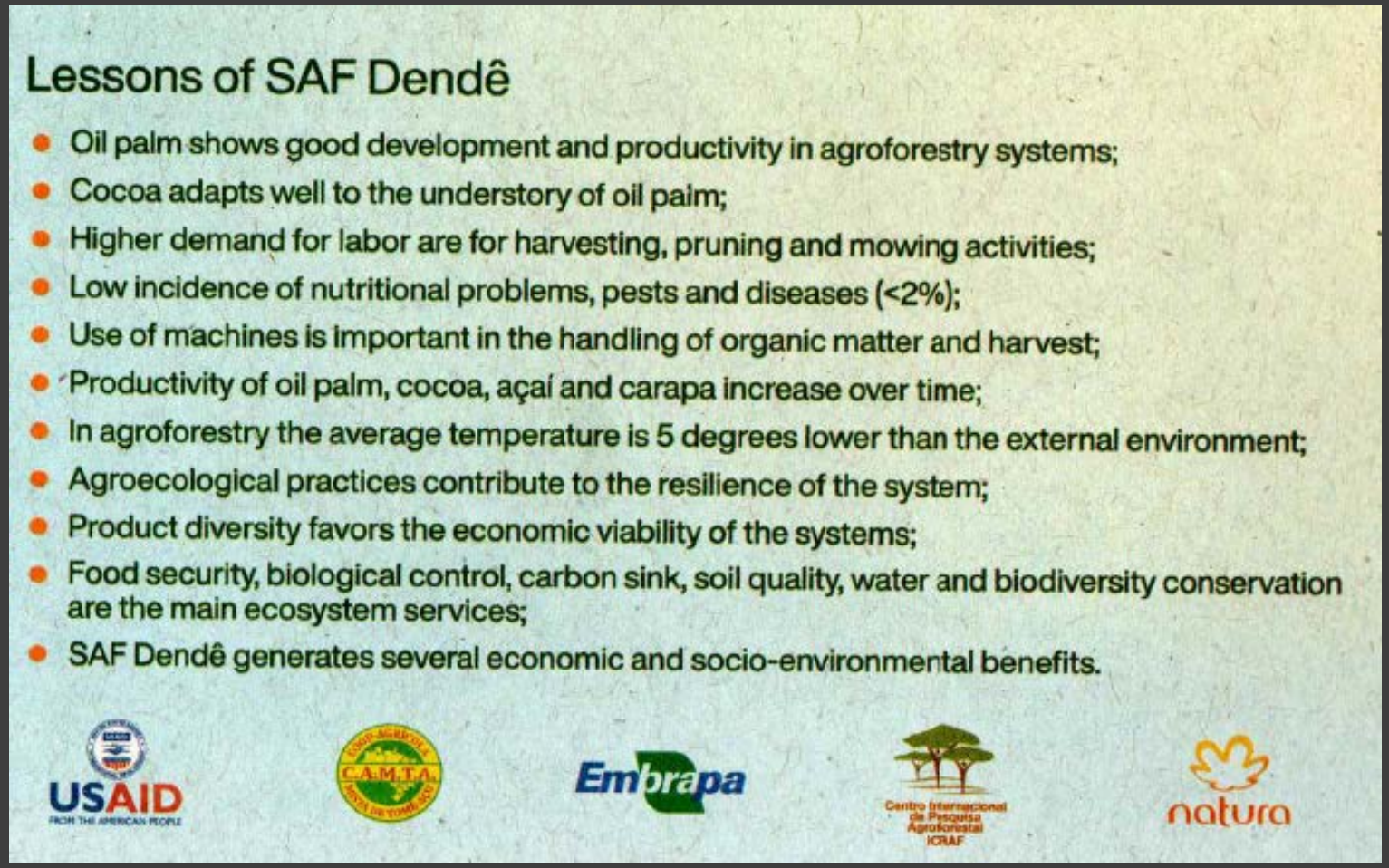




SAF Dendê is an agroforestry production system where oil palm is grown together with other plants, which can be used food or even wood production. Cassava, banana, passion fruit, black pepper, rice, jack bean, pigeon pea, tree marigold, inga, gliricidia, achiote, cocoa, açaí, bacaba, carapa, ipe, mahogany, pracaxi, yellow mombin and ucuuba were part of these systems with oil palm.

In partnership with local farmers, this participatory study showed that the cultivation of oil palm in agroforestry systems (SAF Dendê), with high biodiversity, presents good growth and productivity, generates different products, increases income and benefits for families without harming the environment, being an example for the world.

SAF Dendê: Lessons



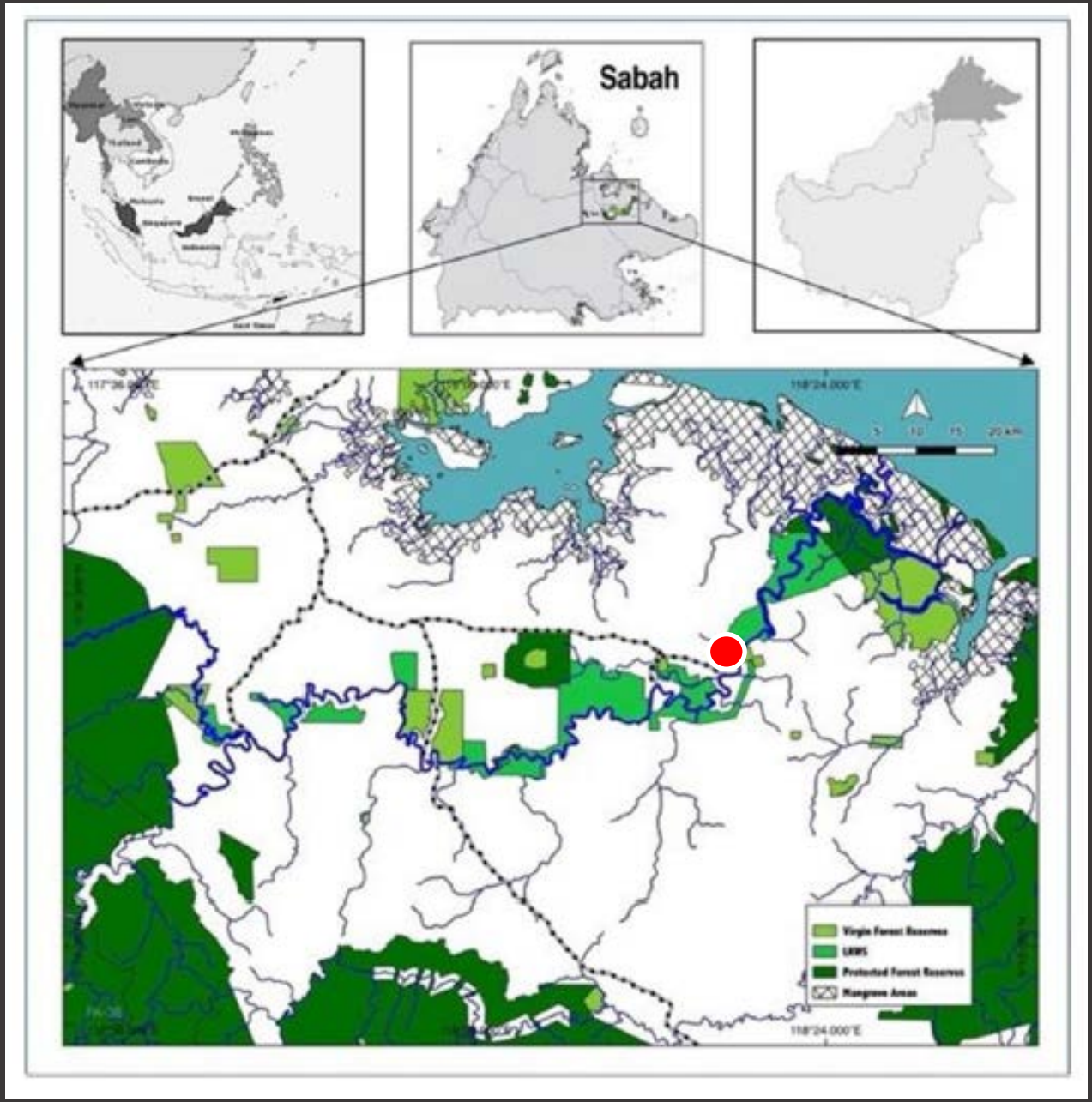
- First plantation: 2008
- 81 to 99 palms/ha
- 2008: 6 Agroforestry systems amounting 18ha in total
- 2019: 18 demonstration units in 61 ha
- SAF DENDE generates 3 X more environnemental services than monoculture


In 2018, new areas were implemented in Tomé-Açu with the support of ICRAF, totaling 15 new demonstration units, on 30 hectares. New farmers, new arrangements and new species associated with oil palm.
The first plantations of SAF Dendê occurred in 2008, with the Cooperativa Agrícola Mista de Tomé-Açu (CAMTA), Natura Inovação and Embrapa (Eastern Amazon and Western Amazon). 6 agroforestry systems with oil palm were implemented, totaling 18 hectares in 3 demonstration units (degraded pasture, early secondary forest (capoeira) and abandoned orchard).
product and income diversification
start of oil palm production
SAF Dendê generates 3x more environmental services than monoculture
biodiversity
18 DEMONSTRATION UNITS in 61 ha
2011
2015
2008
2019
81 to 99 oil palm pl/ha
harvesting of food crops
oil palm production peak
CFF weight/plant: 180 kg
biodiversity conservation
soil conservation
water conservation
organic matter conservation
nutrient cycling
human capital
local development
use of renewable sources

The TRAILS Project, Malaysia (Sabah)

- TRAILS project builds on a complementary partnership.
- TRAILS links academics, NGO, private and public stakeholders.
- TRAILS relies on long term expertise and multidisciplinary approaches from various science fields.
- TRAILS deals with agronomy, forestry and conservation sciences.

Location



- TRAILS is located within the 500,000 ha Kinabatangan floodplain region of Eastern Sabah, Malaysia.
- Today, 85–90% of the land is a mature oil palm landscape interspersed by 41,103 ha of fully protected but largely disconnected forest fragments ranging in size from 100–7,330 ha
- New oil palm plantation development decreased sharply from 2006
- Since 2010, forest loss for oil palm agriculture has tapered off even further, but conversion continues when new land can be acquired

International Journal of Primatology
https://doi.org/10.1007/s10764-022-00288-w

Objectives

- To install oil-palm-based agroforestry inside the oil palm plantation
- To undertake mixed planting in real-life conditions, using selected oil palm seedlings and 15 different native forest species
- To monitor the dynamics of wildlife recolonization (abundance, diversity, and mobility) in selected areas : mixed-planting, riparian corridors, and pure oil palm plantations.
- To comparatively study oil palm performance in these different systems: growth and development, fruit yields and bunch characteristics will be measured.

Objectives

- To understand key characters of climatic resilience and the bioclimatic condition of the agroforestry parcels
- To assess the ability of mixed planting at providing environmental services
    - photosynthetic capacity,
    - soil health,
    - water quality
    - abundance of pollinators
- To analyse the socioeconomic impact of the transition from oil palm monospecific plantation to complex agroforestry systems.

TRAILS in numbers

Allocated area : 100 ha

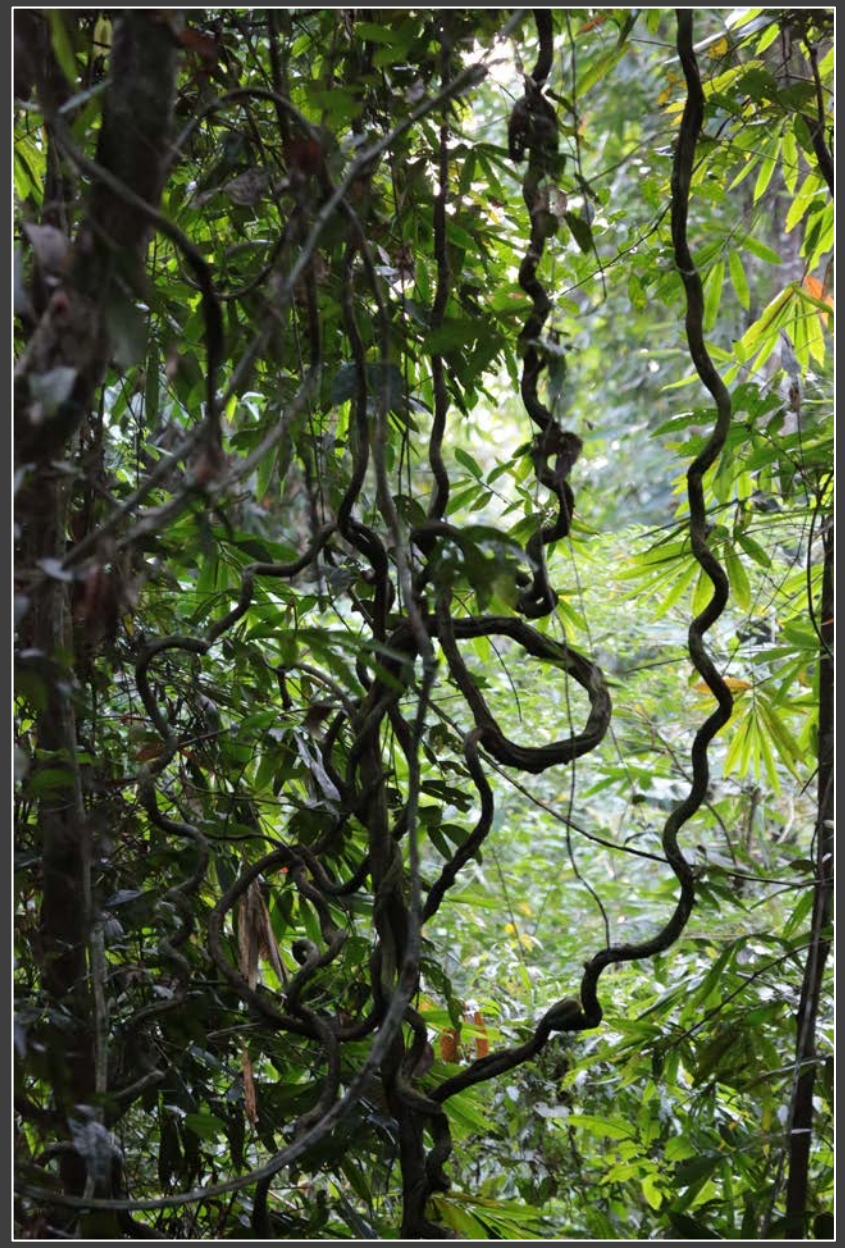
Present planted area : 22 ha

Planted forest species : 15

Planted trees : 3,000

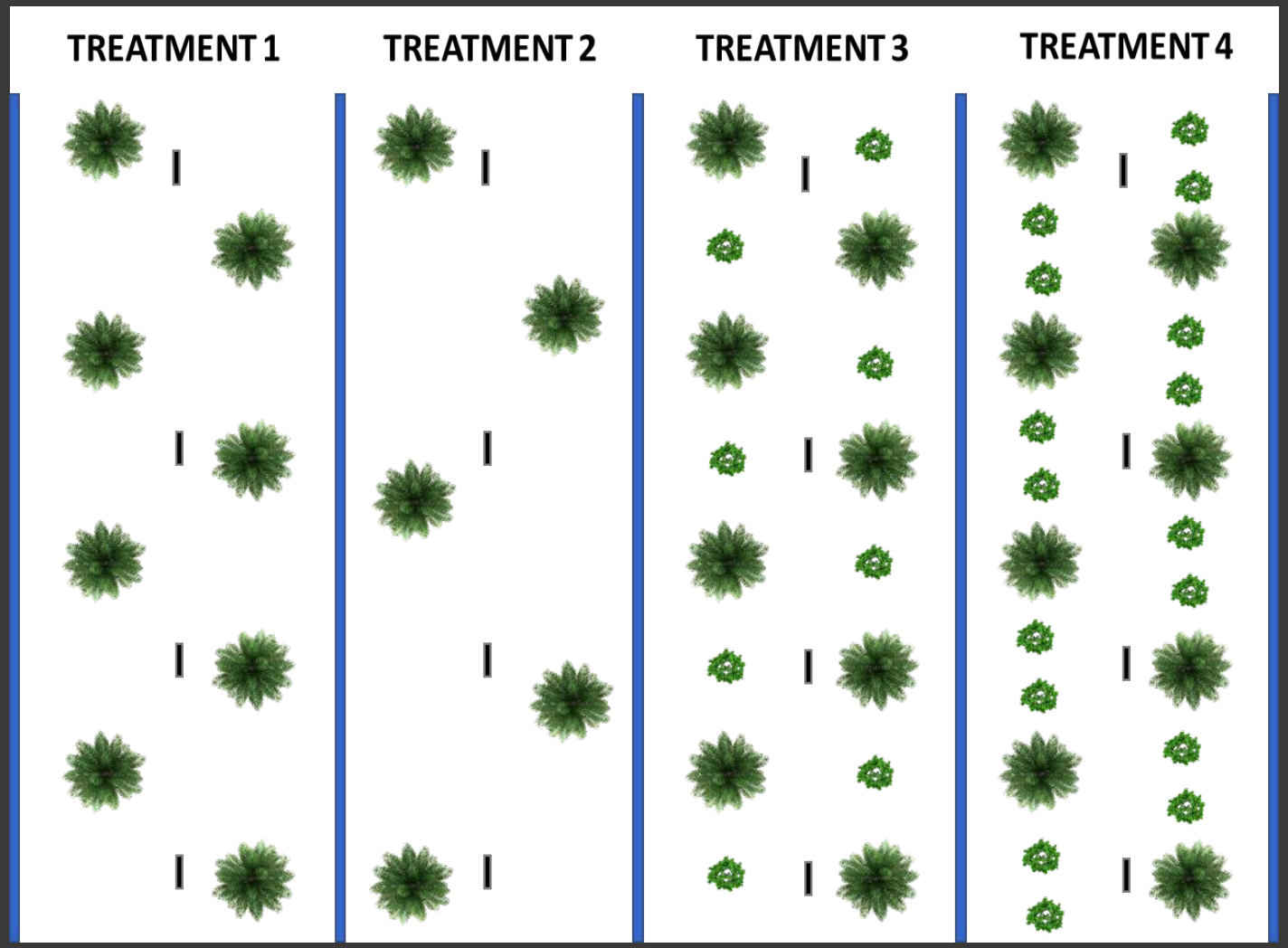
Specific planting designs : 3

TRAILS in numbers -27 native species



Family	Species	Vernacular name
Anacardiaceae	Koordersiodendron pinnatum	Ranggu
Anacardiaceae	Pentaspadon motleyi	Pelajau
Anacardiaceae	Dracontomelon sp.	Sengkuang
Annonaceae	Meiogyne sp.	Karai
Combretaceae	Terminalia catappa	Ketapang Paya
Dilleniaceae	Dillenia borneensis	Simpoh Gajah
Dilleniaceae	Dillenia excelsa	Simpoh laki
Ebenaceae	Diospyros sp.	Kayu Malam
Euphorbiaceae	Croton oblongus	Lokon
Euphorbiaceae	Mallotus muticus	Mallatus Paya
Euphorbiaceae	Glochidion borneensis	Obah Nasi
Euphorbiaceae	Excoecaria indica	Apid Apid
Lauraceae	Cinnamommum spp	Tiga urat
Malvaceae	Pterospermum javanicum	Bayor
Meliaceae	Toona sureni	Limpaga
Moraceae	Ficus septica	Lintotobu
Moraceae	Ficus benjamina	Lamba - banyan
Myrtaceae	Eugenia cerassiformis	Obah Jangkang
Myrtaceae	Eugenia sp.	Obah Putih
Myrtaceae	Syzygium malaccense	Makopa
Myrtaceae	Eugenia cerasiformis	Obah merah
Rubiaceae	Nauclea subdita	Bangkal aiskrim / kuning
Rubiaceae	Nauclea orientalis	Bangkal Daun Besar
Rutaceae	Murraya paniculata	Kemuning
Tiliaceae	Microcos crassifolia	Kerodong Damak-damak
Verbenaceae	Vitex pinnata	Kulimpapa

1 - Oil palm-based interplanting



Expected results

- Impact of the reduction of oil palm density (143 to 93 palms/ha)
- Effect of forest trees co-planting on oil palm productivity
- Changes in biodiversity parameters
- Changes in biophysics parameters (soil, water, plant)

Design

- One single trial made of 5 blocks
- Forest species: *Nauclea subdita*
- a fast growing native species generating light shading.

2 - Assessment of native forest species

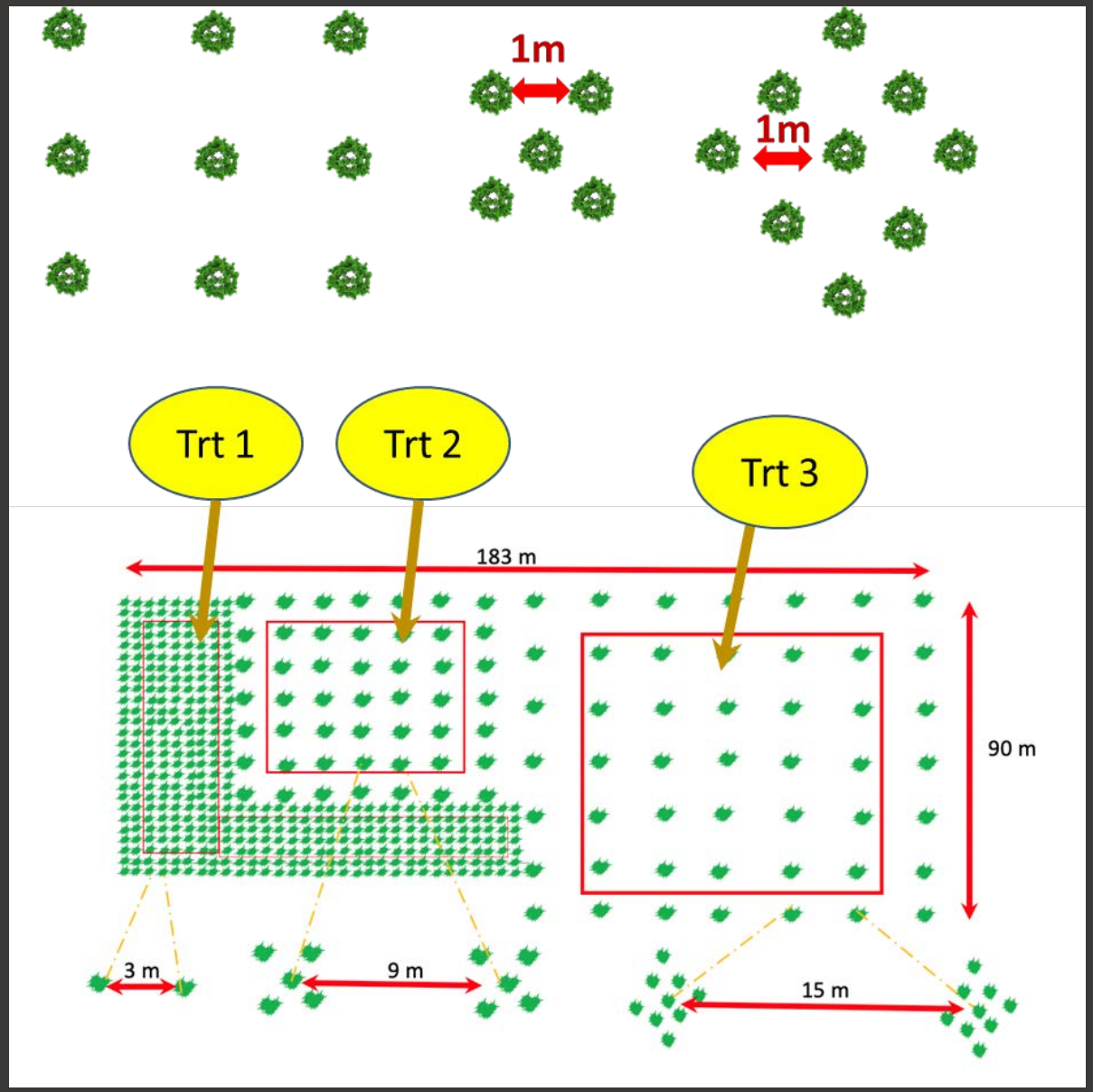
Expected results

- Suitability of native forest species to be part of agroforestry plantations
- Monitoring of the ability of each forest species to grow in association
- Assessment of the nucleus-type regeneration strategy

Design

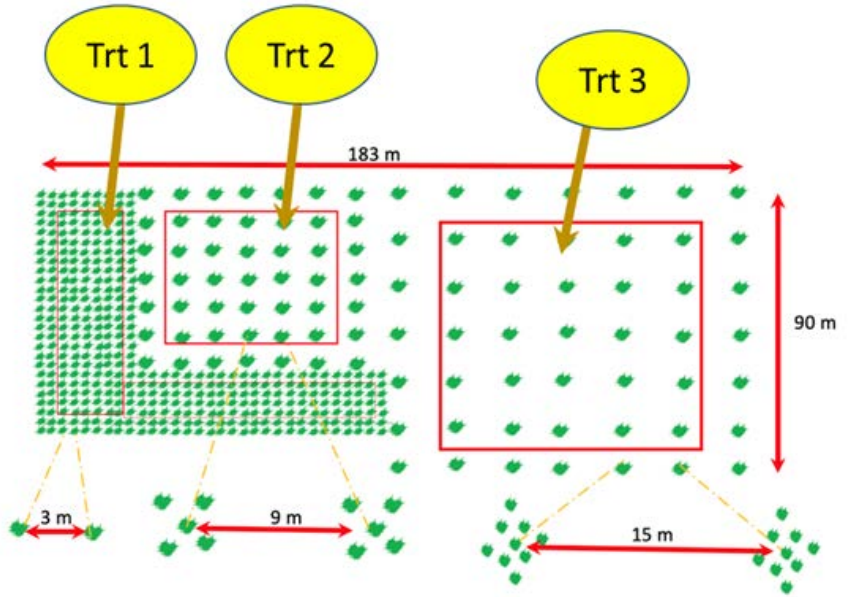
3 treatments

- Treatment 1 : 10 species 3 X 3 m, comparison of species ; 25 trees per species needed for measurements.
- Treatment 2 : 5 trees per nucleus 1 X 1 m , spacing between nuclides is 9 m.
- Treatment 3 : 9 trees per nucleus 1 X 1 m, spacing between nuclides 15 m.

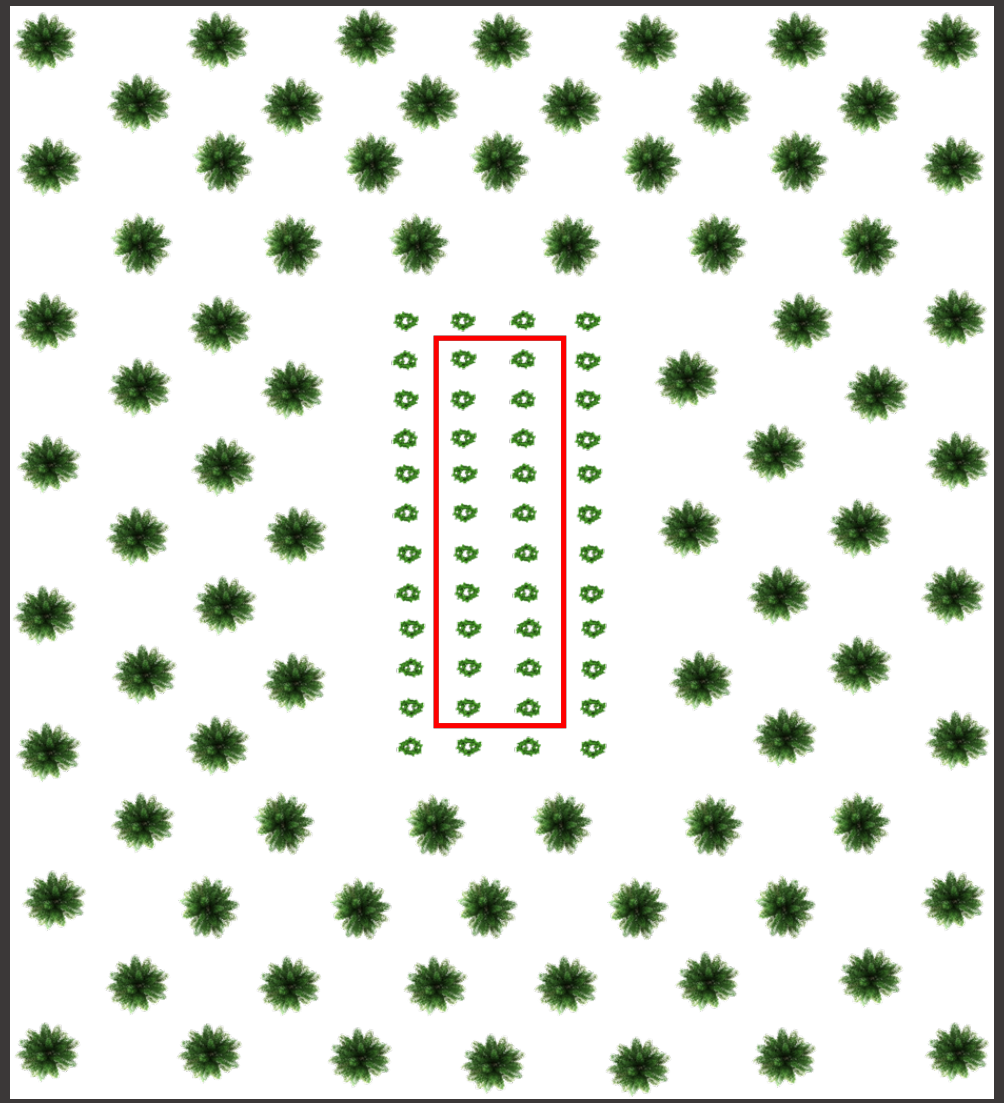


2 - Assessment of native forest species

3	LINTOTOBU
4	BAYOR
7	OBAH JANGKANG
11	OBAH PUTIH
12	RANGGU
14	KERODONG DAMAK-DAMAK
19	LIMPAGA
22	MALLASTUS PAYA
26	APID-APID
27	OBAH MERAH



3 - Forest Islands



Goal

To document the interactions between palms and specific tree species

Specific objectives

- To assess the productivity of palms around the islands
- To assess the changes in microclimate inside and around the islands
- To assess possible contamination or symbiosis through the microflora (*Ganoderma*)

Forest species

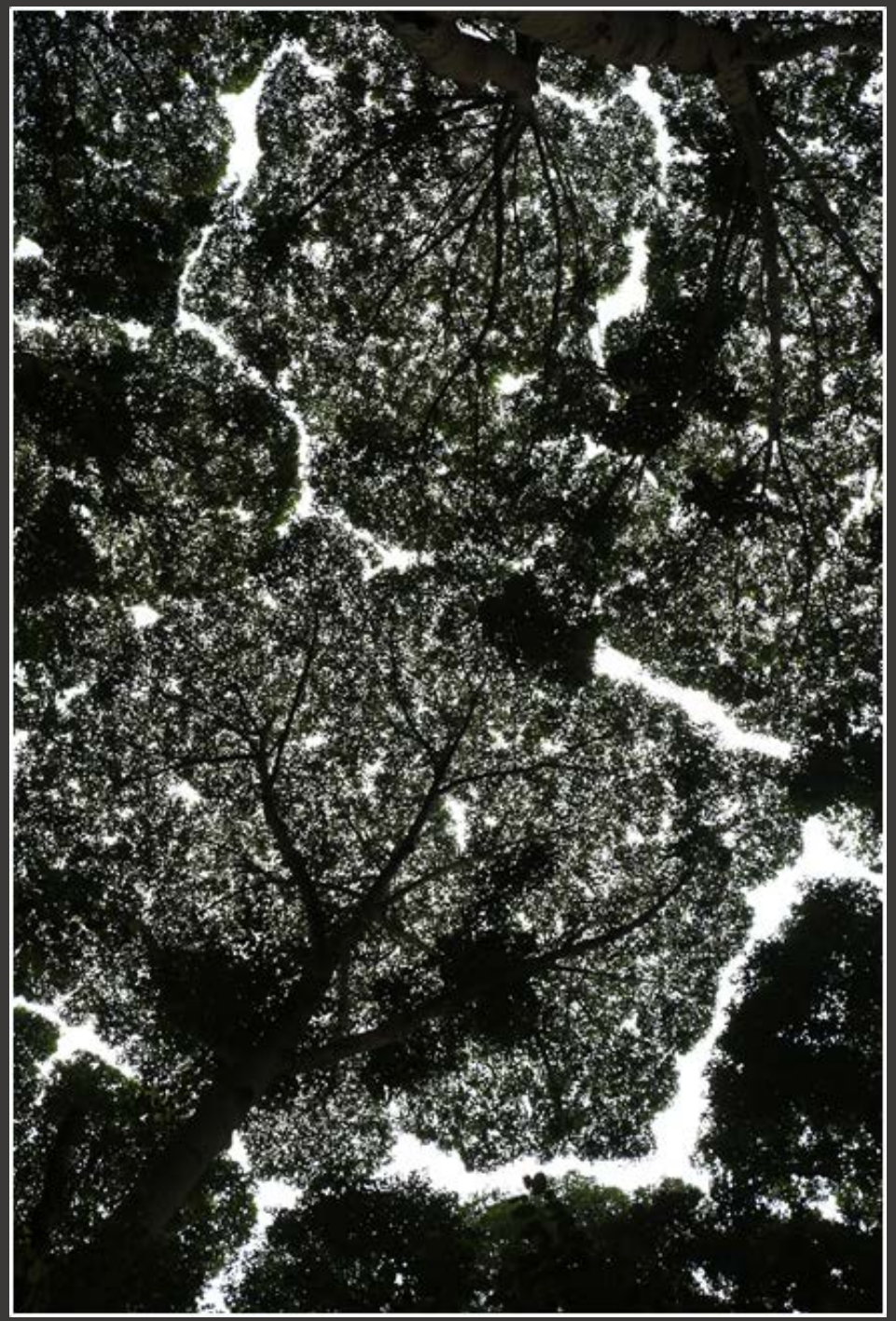
5 replicates x 48 trees = 240 trees per species

Uncertainties

- Knowledge gaps
  - Plant pathology
  - Organisation of work/cropping system
  - Constraints of organic palm oil production
  - Architectural/physiological plasticity of the oil palm
- Partnership gaps
  - Readiness to embrace changes and risks
  - Is “so far so good” still an option?
  - Private plantation sector has long been the driver of innovation : is it ready for more?
- Financial incentives
  - Governments
  - Agencies (state, province, local)
  - Carbon credits

10-years work plan

PROJECT PHASE	YEARS	ACTIVITIES	BUDGET
TRAILS 1	2020 - 2022	• Construction of partnership • Baseline Assessment • Planting Design • Socioeconomic Studies	• 1,000 k€ • 2 years • Private/Public funding
TRAILS 2	2023 - 2026	• Protocols for evaluation - Agronomy • Protocols for evaluation - Biodiversity • Establishing participatory research • Protocols for statistical analysis • Data Collection • Data Treatment (Statistical Analysis) • Training (4 PhDs) • Publications	• 2,000 k€ • 4 years • Private/Public funding
TRAILS 3	2027 - 2030	• Data Collection • Data Treatment (Statistical Analysis) • 2 Post Doctoral Fellows • Publications • Recommendations	• 2,000 k€ • 4 years • Private/Public funding



Thank you.
Terima Kasih.
Merci.

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