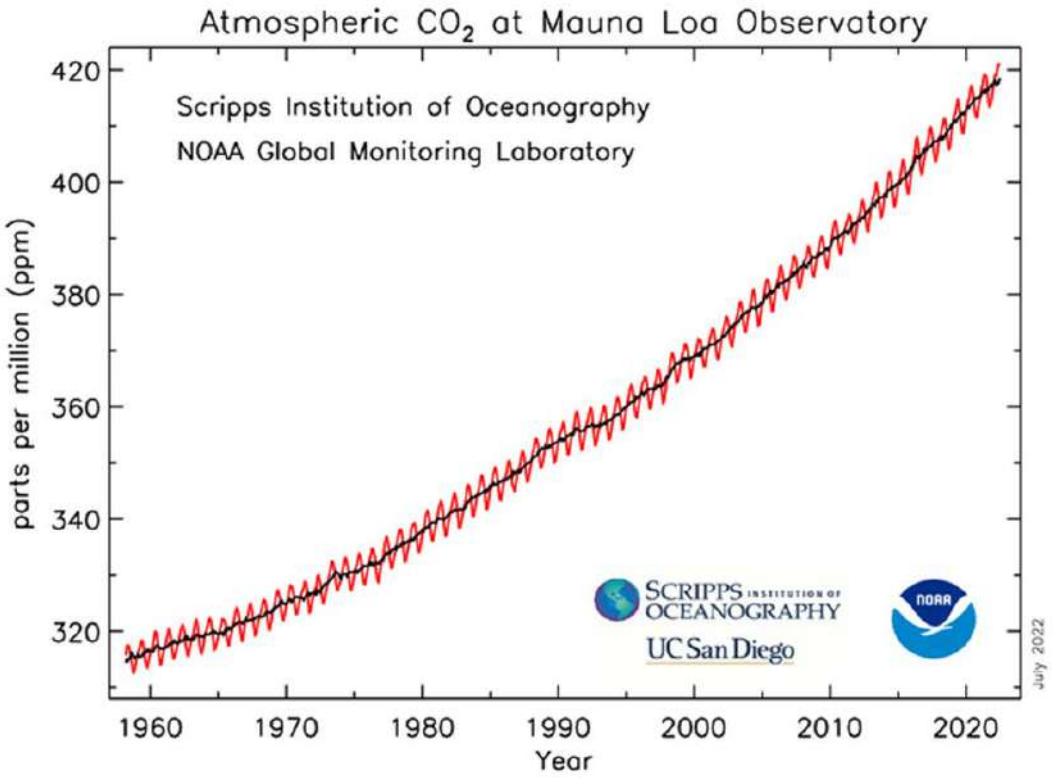
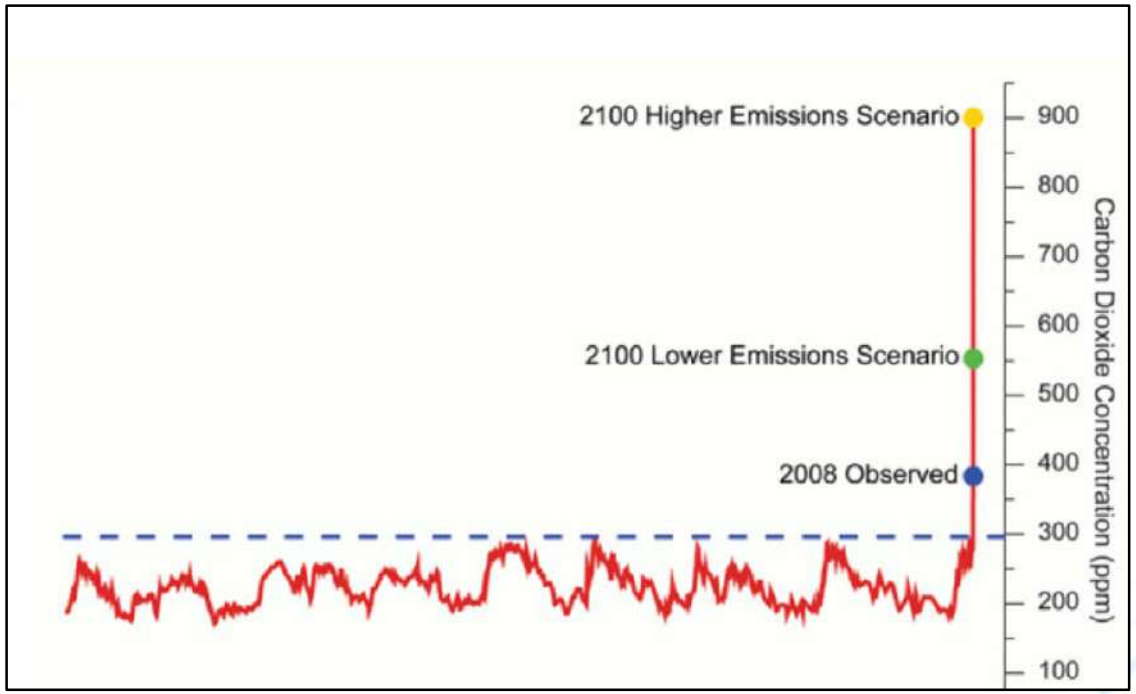
Innovative agroforestry designs for oil palm-dominated landscapes

Alain Rival

M. Ancrenaz, I. Lackman, S. Burhan, P. Guizol and M. Djama

The rising CO_2 context





Plantation labour in recurrent crisis

The Malaysian Reserve
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Labor shortage to cost Malaysia palm oil sector RM20b

BUSINESS TIMES

20 pct of oil palm unharvested due to labour shortage

By Bernama - October 17, 2023 @ 3:44pm

South China Morning Post
Celebrating 120 years

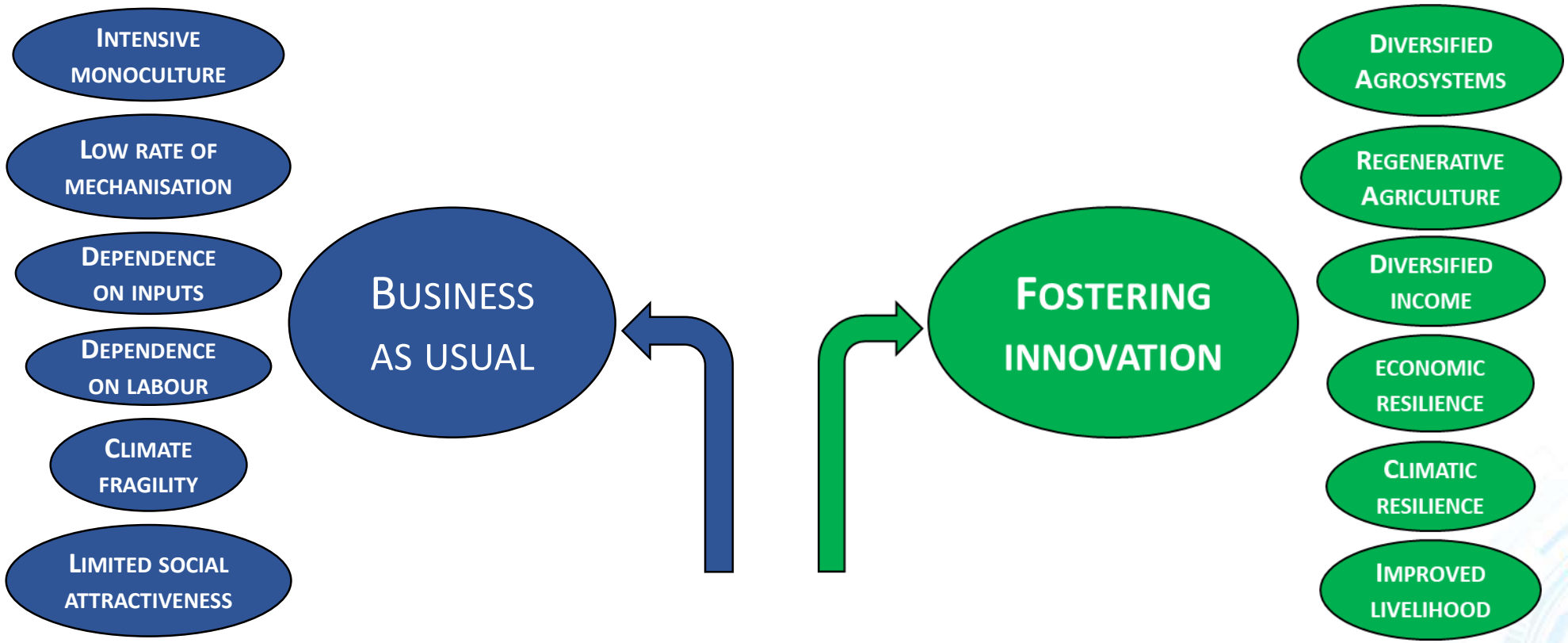
In palm-producing regions of Malaysia and Indonesia, where the pandemic led to a critical shortage of the manual labour on which the industry depends, an army of farmers has been postponing the inevitable. Squeezed by high costs and falling yields, many smallholders argue they can't replant – and have no choice but to keep going.

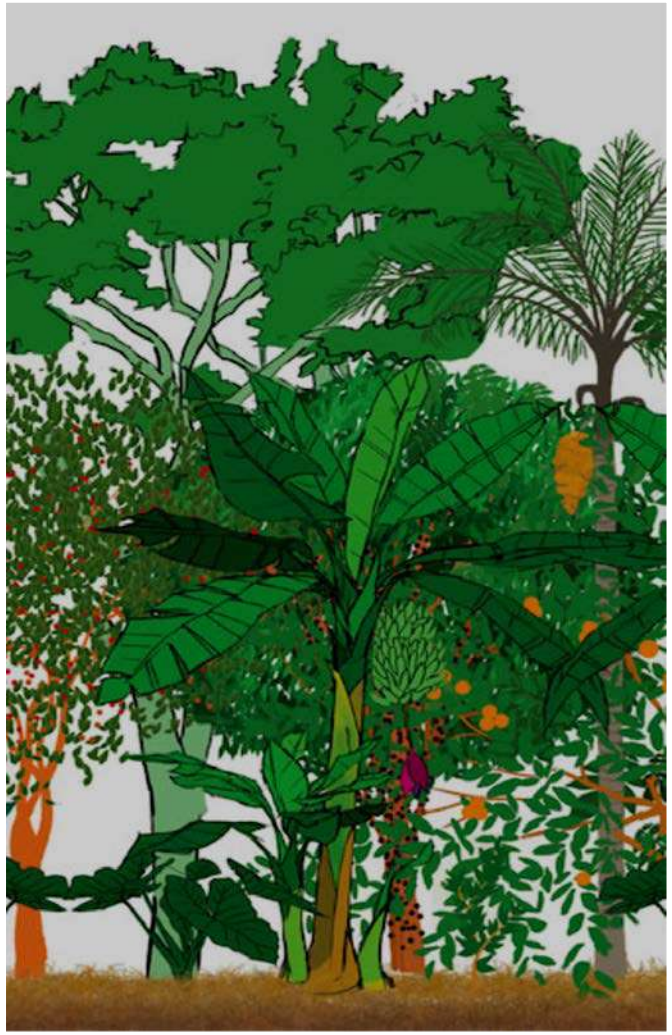
THE BORNEO POST

Labour shortages critical challenge for Sabah development – IDS

Which way to go?

Choices, risks and consequences…

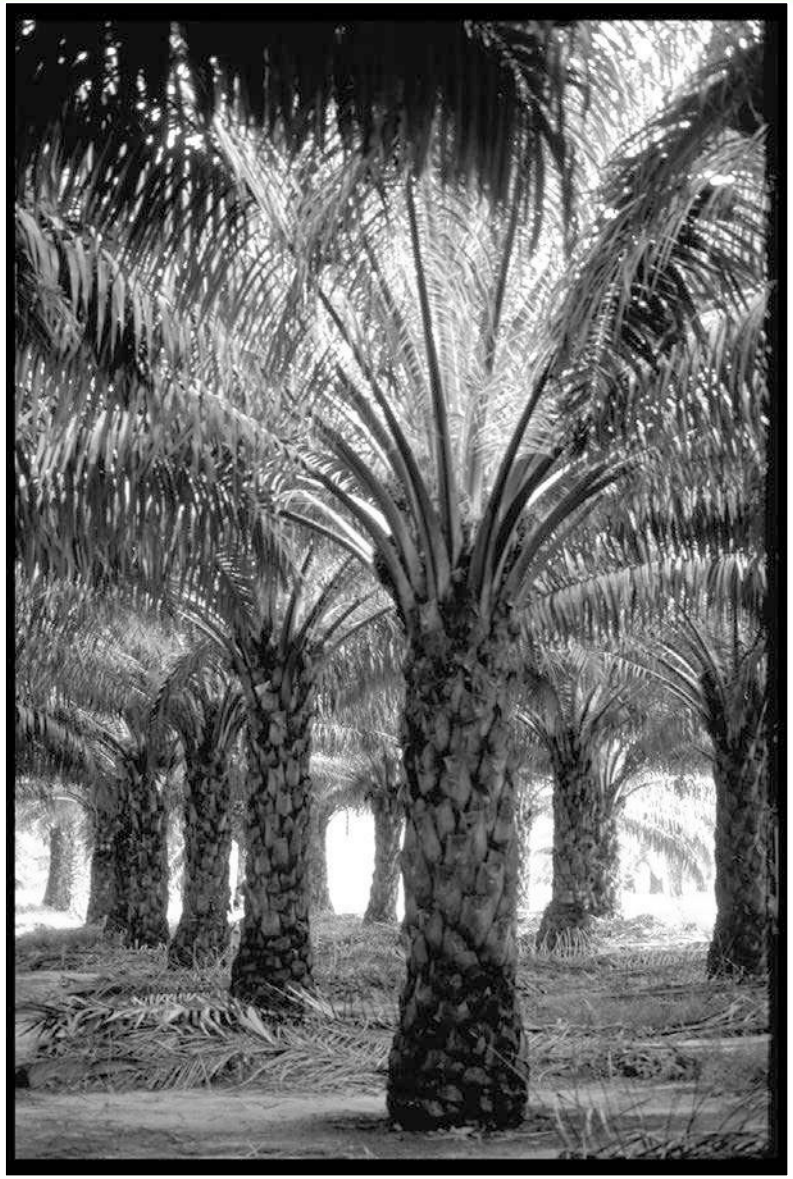




Why agroforestry?

- 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.

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?

- After millennia of polyculture, intensive monoculture became 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 also revealed several weaknesses (need for mechanization, labor shortages).
- Diversified systems are more able to resist to price volatility (more stable income from multiple activities

Biodiversity hotspots

The EFForTS Project

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) worked for 12 years in close cooperation,
- 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/.

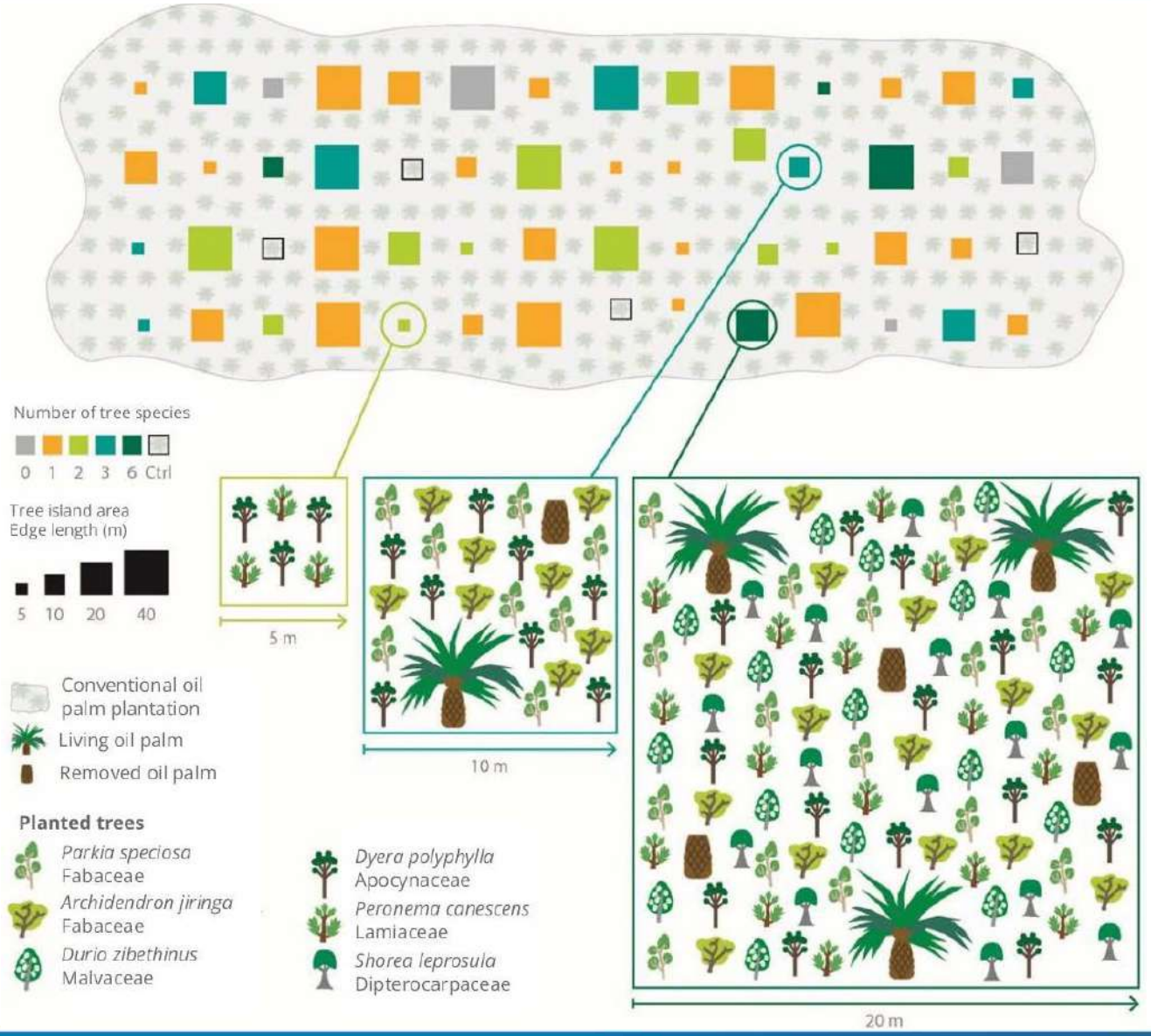
The Biodiversity Enrichment Experiment

- 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 species were 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

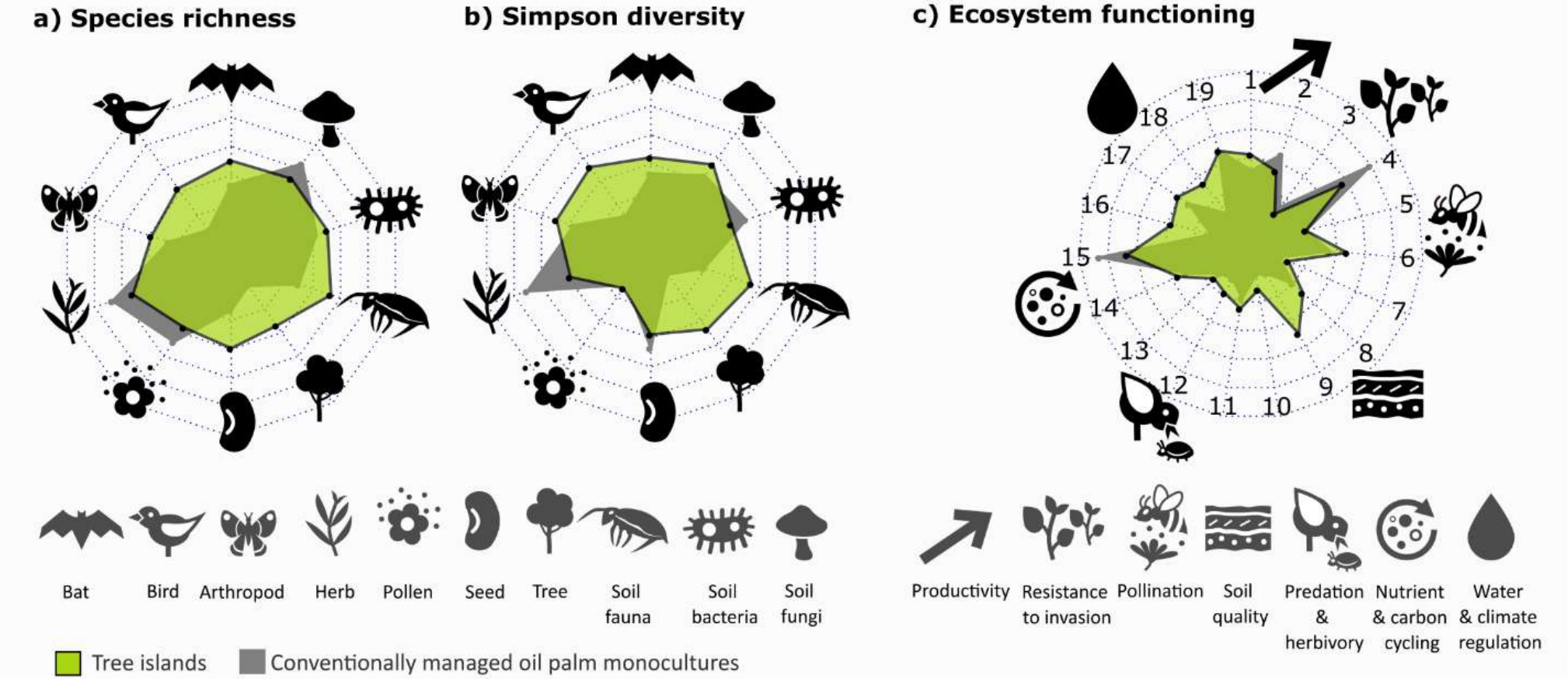
- Species are native to the region and widely used for their fruits, timber or latex.



- 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 represent conventionally managed oil palm monocultures.

Zemp, D.C., Guerrero-Ramirez, N., Brambach, F., Darras, K., Grass, I., Potapov, A., Röll, A., Arimond, I., Ballauff, J., Behling, H. and Berkelmann, D., 2023. Tree islands enhance biodiversity and functioning in oil palm landscapes. Nature, pp.1-6.

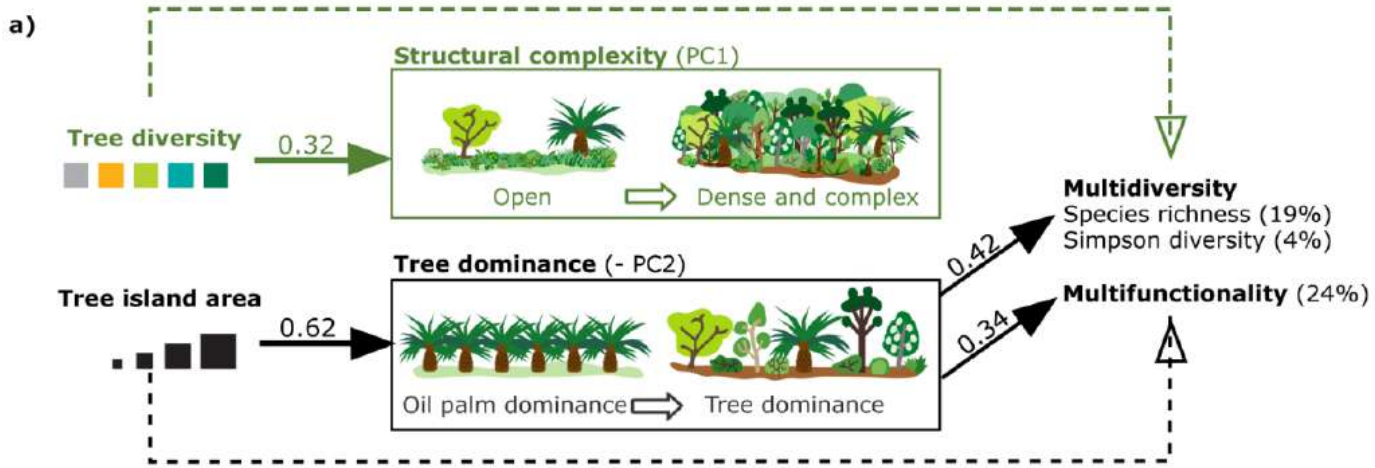
Key findings

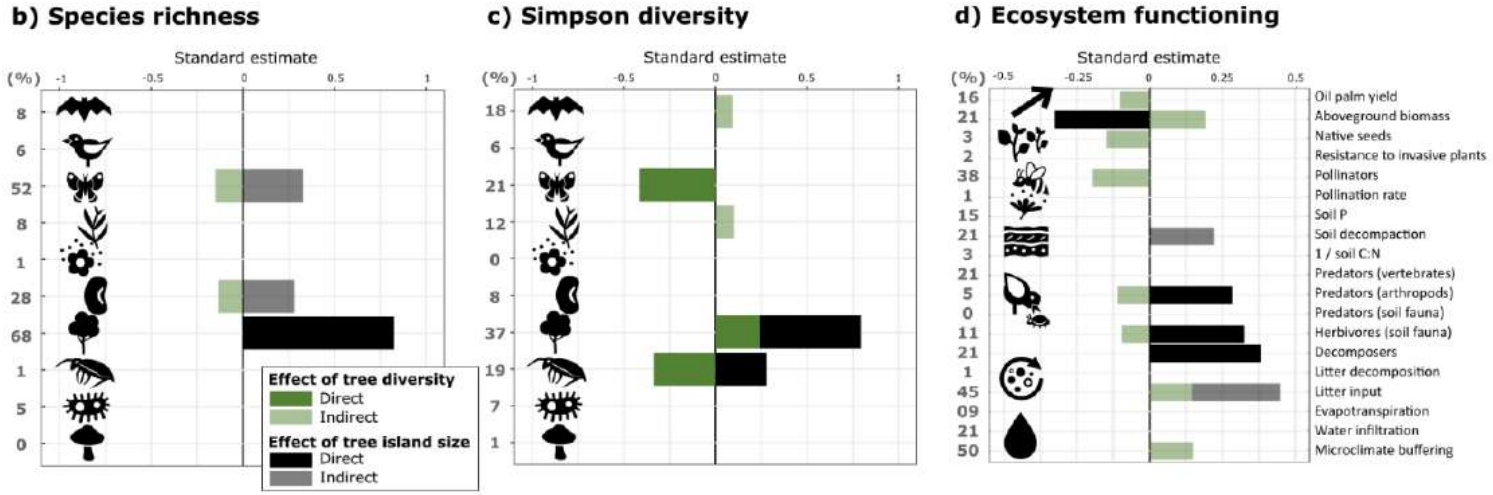


Indicators of biodiversity calculated (a) as species richness and (b) Simpson diversity, which emphasizes the contribution of abundant species and (c) ecosystem functioning across 52 tree islands (green polygons) compared to oil palm monocultures (grey polygons). Polygon vertices represent median values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

Simpson's Diversity Index is a measure of diversity which takes into account the number of species present, as well as the relative abundance of each species. As species richness and evenness increase, so diversity increases

Key findings





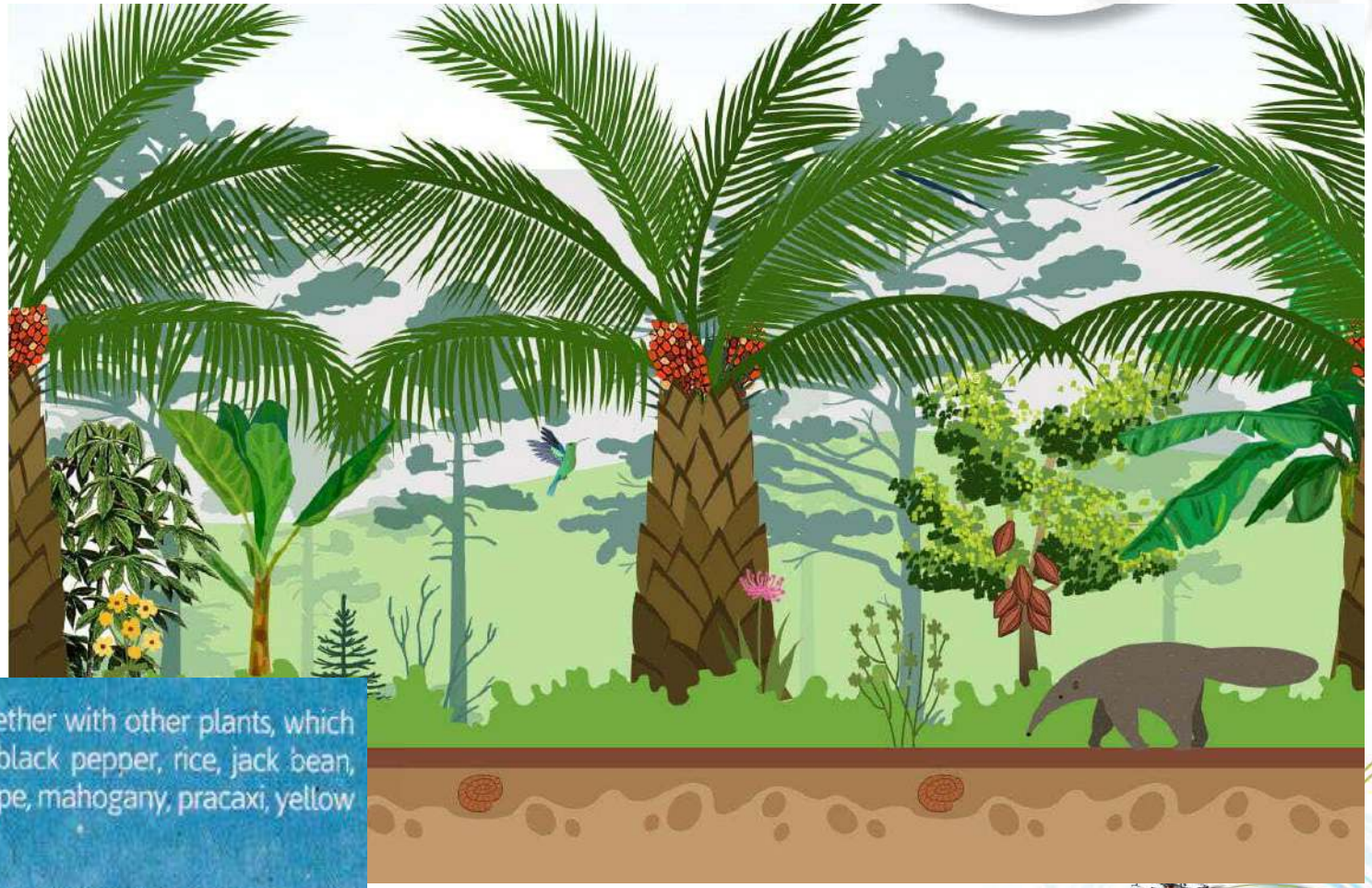
Zemp, D.C., Guerrero-Ramirez, N., Brambach, F., Darras, K., Grass, I., Potapov, A., Röll, A., Arimond, I., Ballauff, J., Behling, H. and Berkelmann, D., 2023. Tree islands enhance biodiversity and functioning in oil palm landscapes. Nature, pp.1-6.

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 multiversity 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.

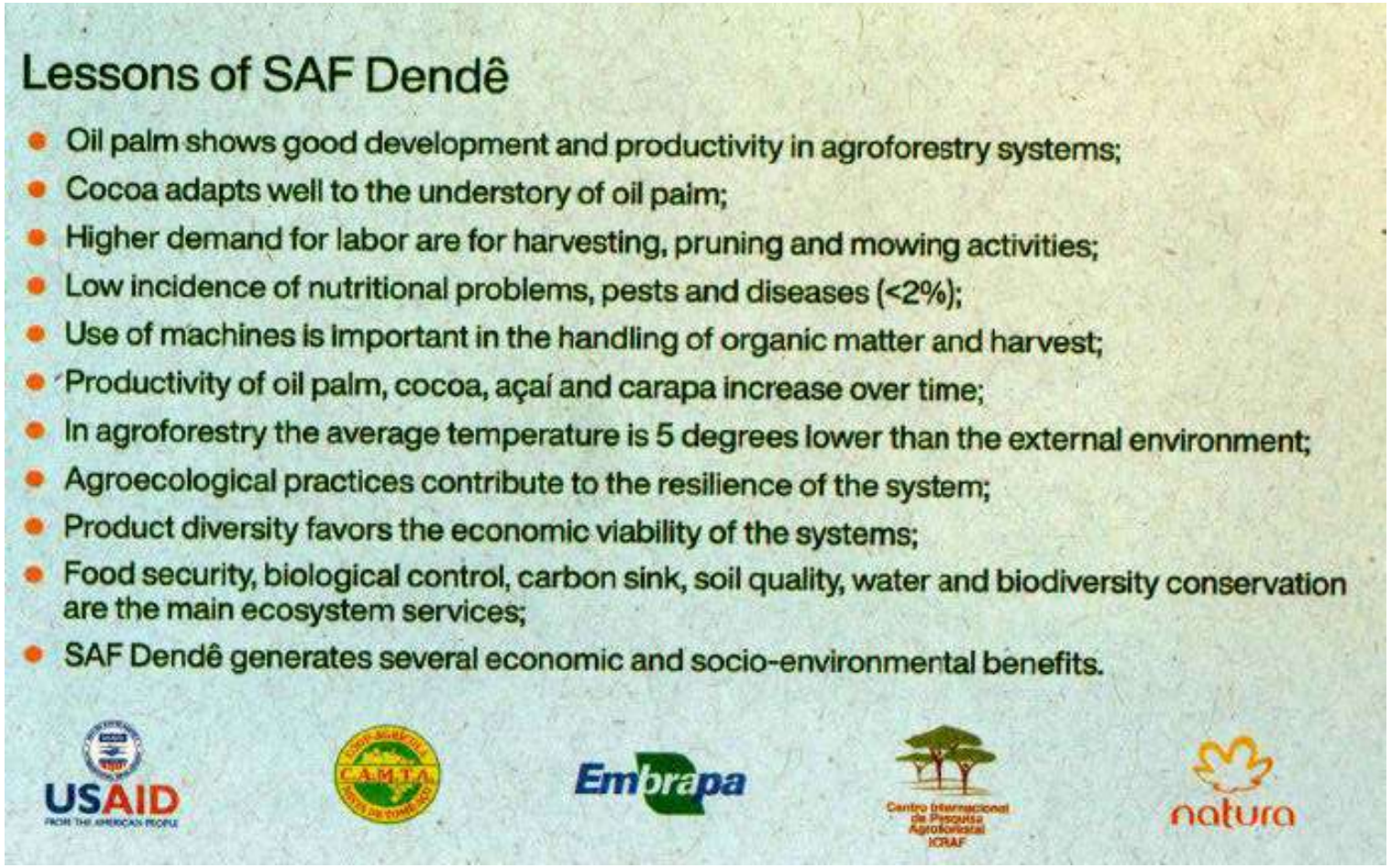
SAF DENDÊ

innovation and sustainability



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.



Lessons learned

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


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).
2008
• 81 to 99 oil palm pl/ha
• harvesting of food crops
2011
• start of oil palm production
product and income diversification
2015
• SAF Dendê generates 3x more environmental services than monoculture
biodiversity
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.
18 DEMONSTRATION UNITS in 61 ha
2019
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.

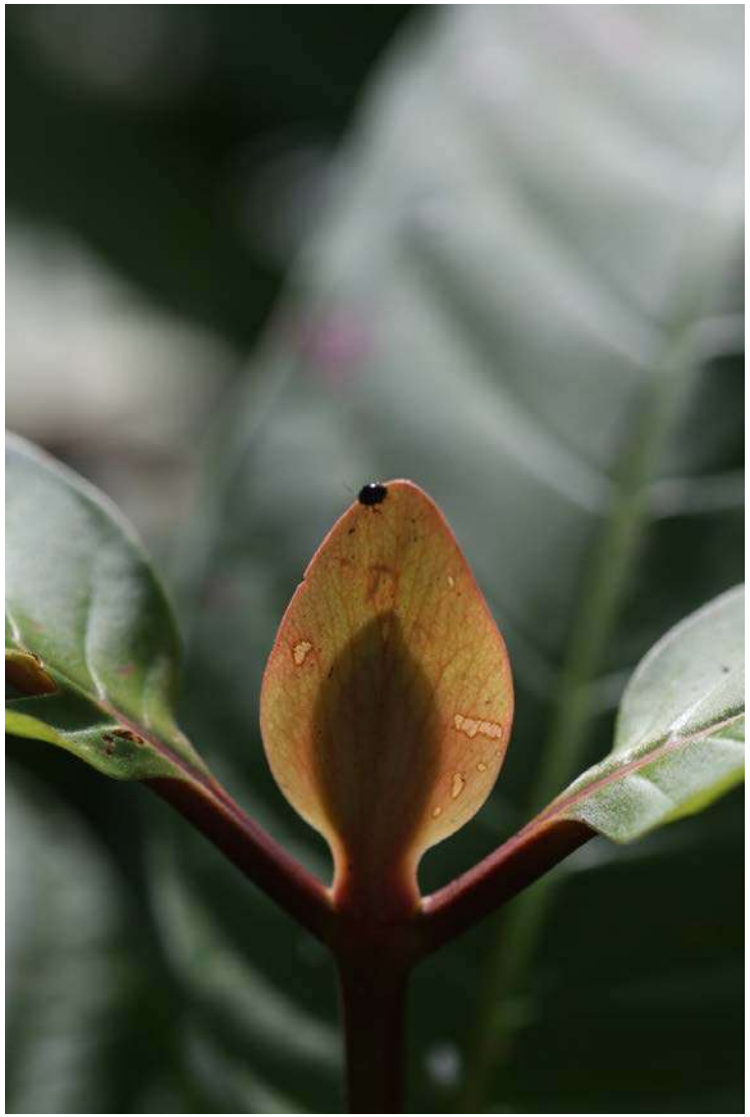
TRAILS links academics, NGO, private and public stakeholders.

TRAILS relies on long term expertise and multidisciplinary approaches from various science fields.

TRAILS deals with agronomy, forestry and conservation sciences.

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 regeneration of biodiversity in specific areas: agroforestry plantings, riparian corridors, and oil palm plantations in comparison with native forest.
- To comparatively study oil palm performance in different systems: growth and development, phenology, fruit yields and bunch characteristics.

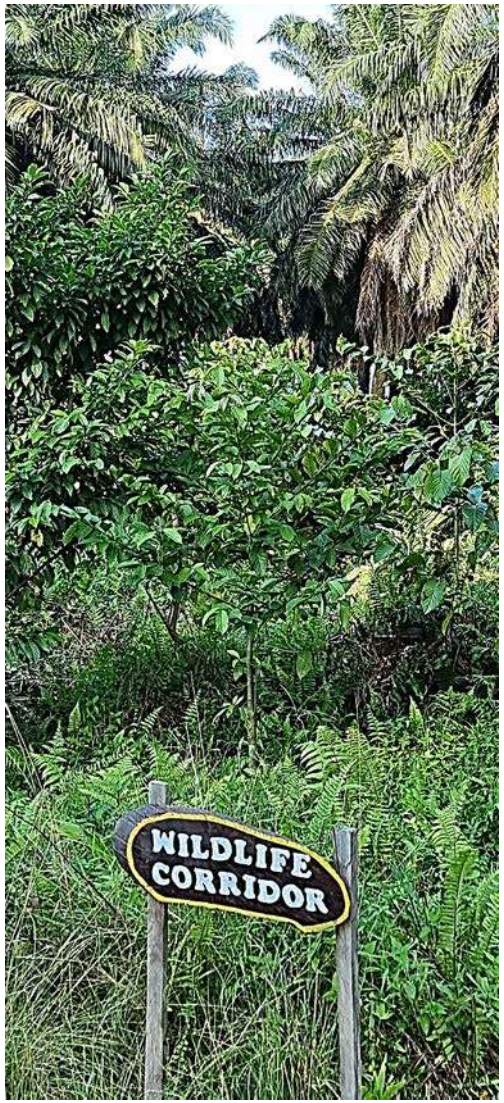


Specific objectives

- To understand the key characters of climatic resilience and the bioclimatic condition of the agroforestry parcels

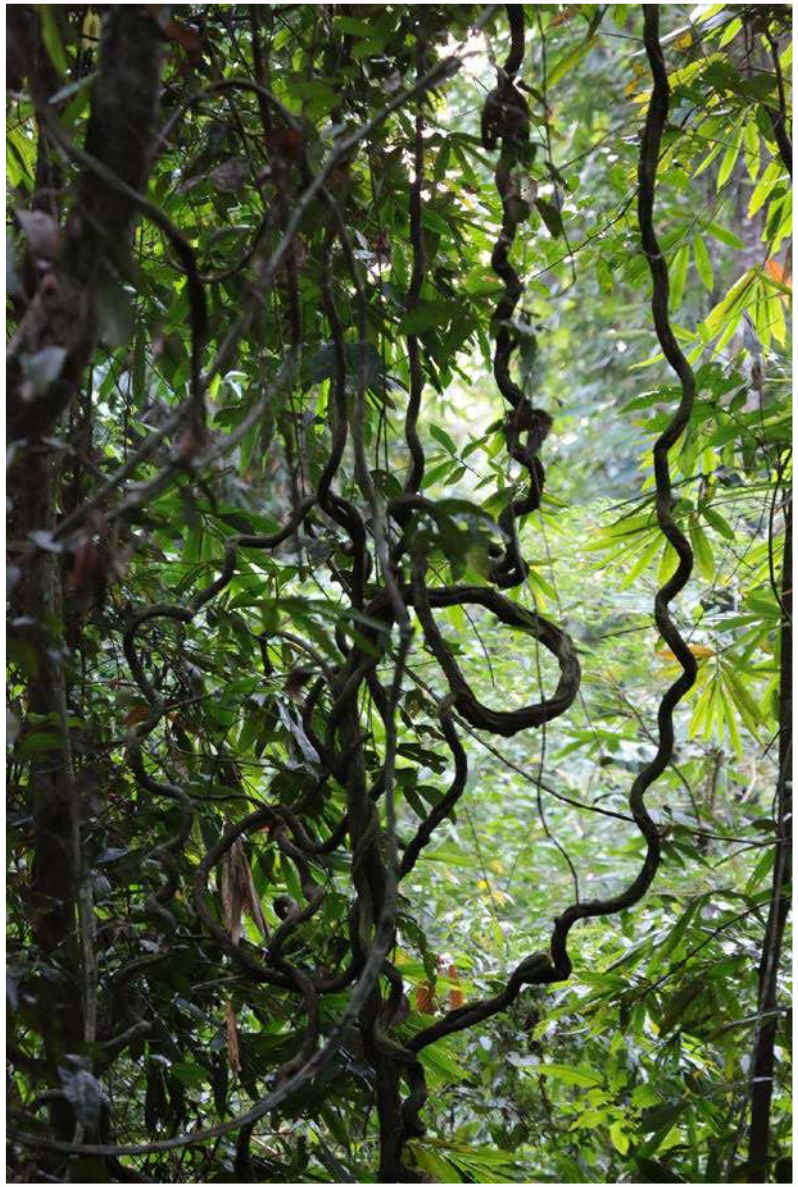
- To assess the ability of mixed planting at improving environmental services, such as:
  - increased biomass and photosynthetic capacity,
  - soil health,
  - water quality
  - abundance of pollinators…

- To analyse the socioeconomic impact of the transition from oil palm monospecific plantation to diversified agroforestry systems.



TRAILS in numbers

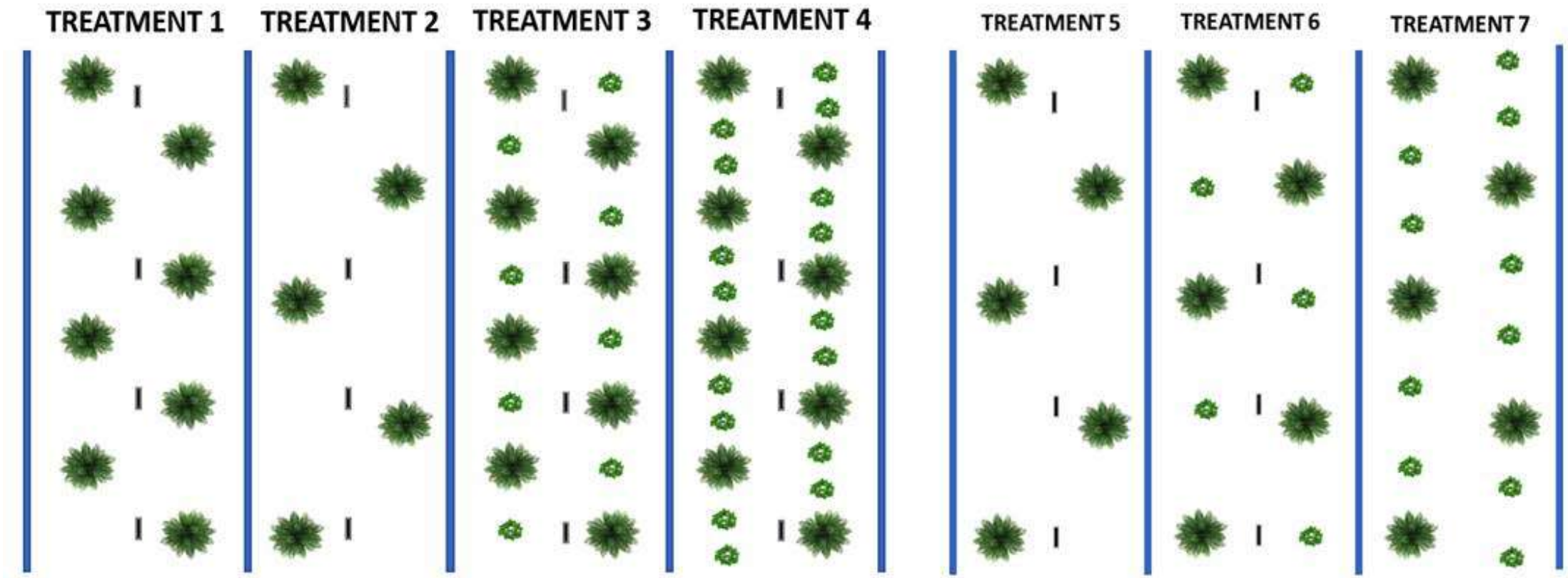
- ✓ Allocated area : 100 ha
- ✓ Present planted area : 37 ha
- ✓ Planted forest species : 15
- ✓ Planted trees : 3,000
- ✓ Specific planting designs : 3

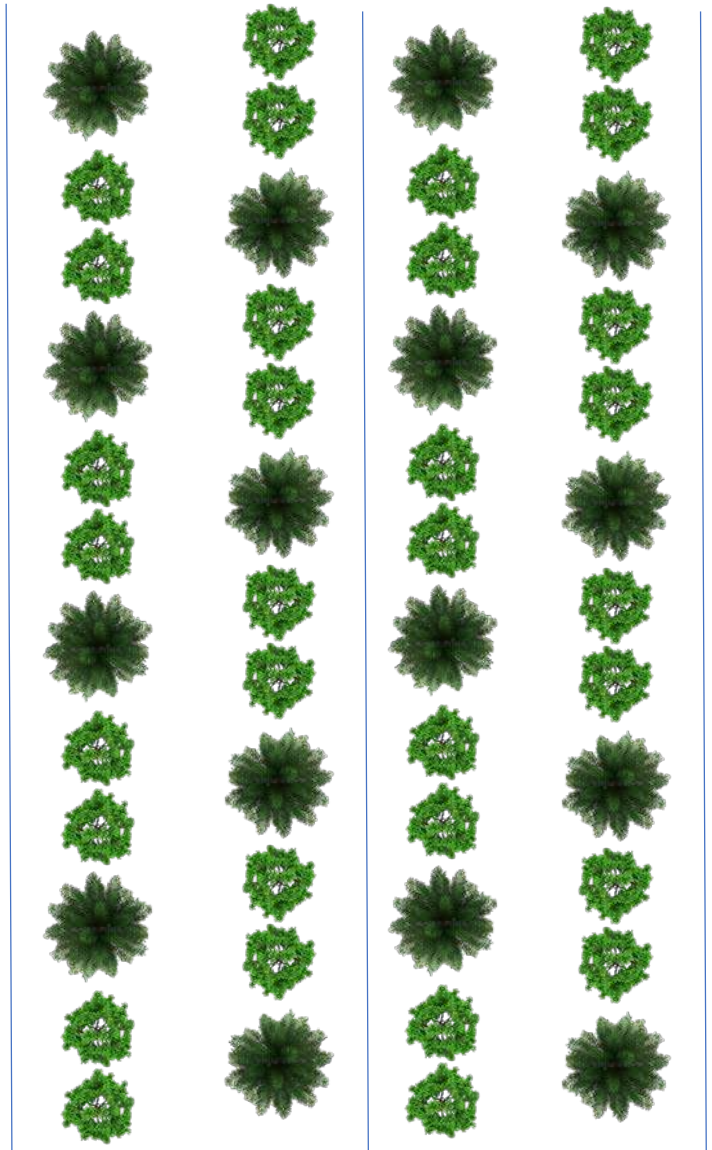


TRAILS in numbers - 27 native species

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



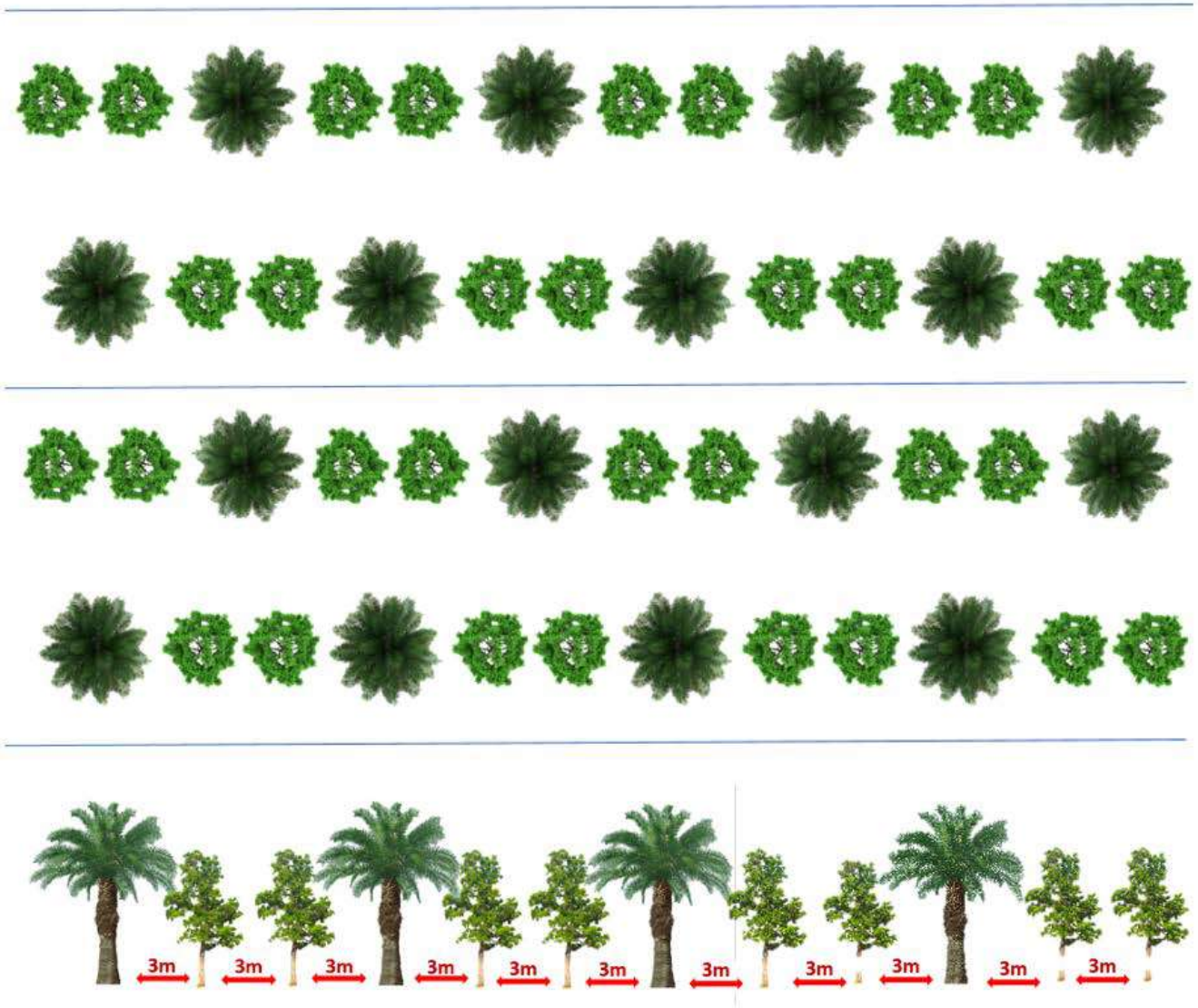


Expected results

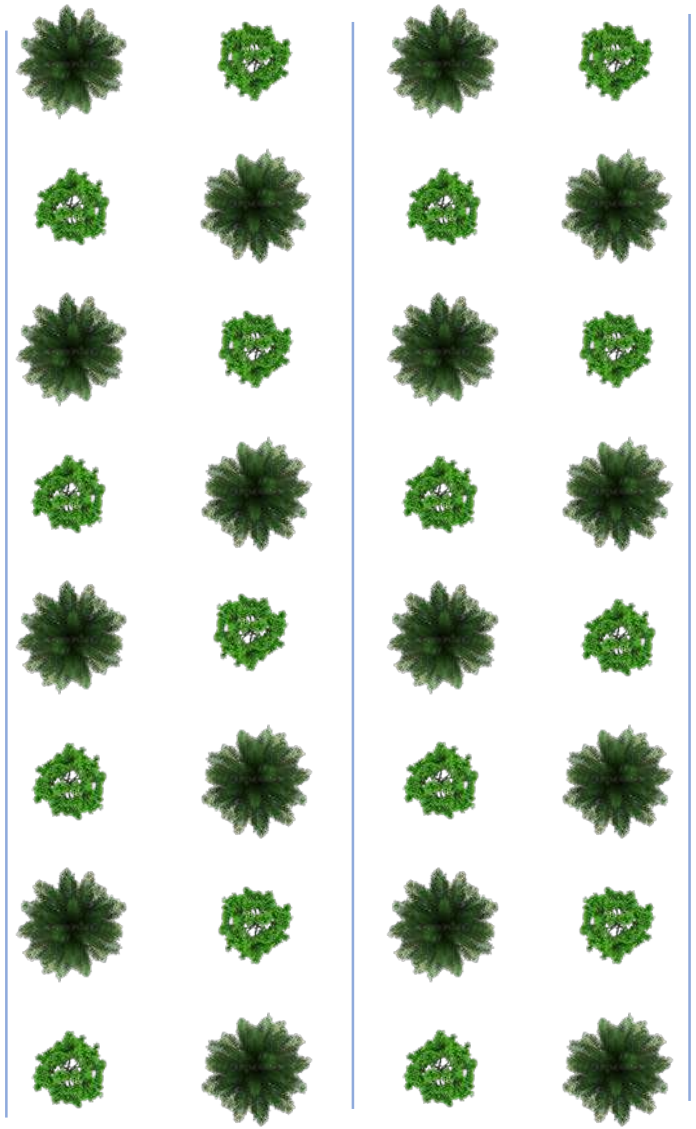
- Impact of the reduction of oil palm density (143 to 93 palms/ha)
- Effect of forest trees co-planting on oil palm productivity
- Changes in biodiversity parameters
- Changes in biophysics parameters (soil, water, plant)

• Design

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



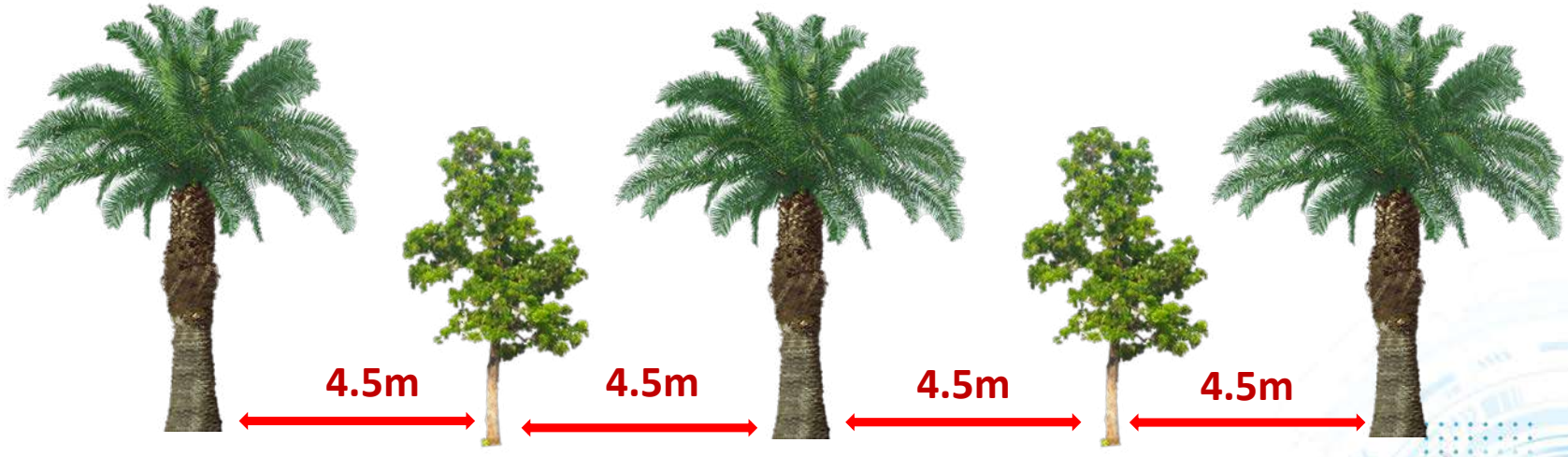
Schematic representation of an example of agroforestry planting (Treatment 4) involving the “Interplanted rows” design

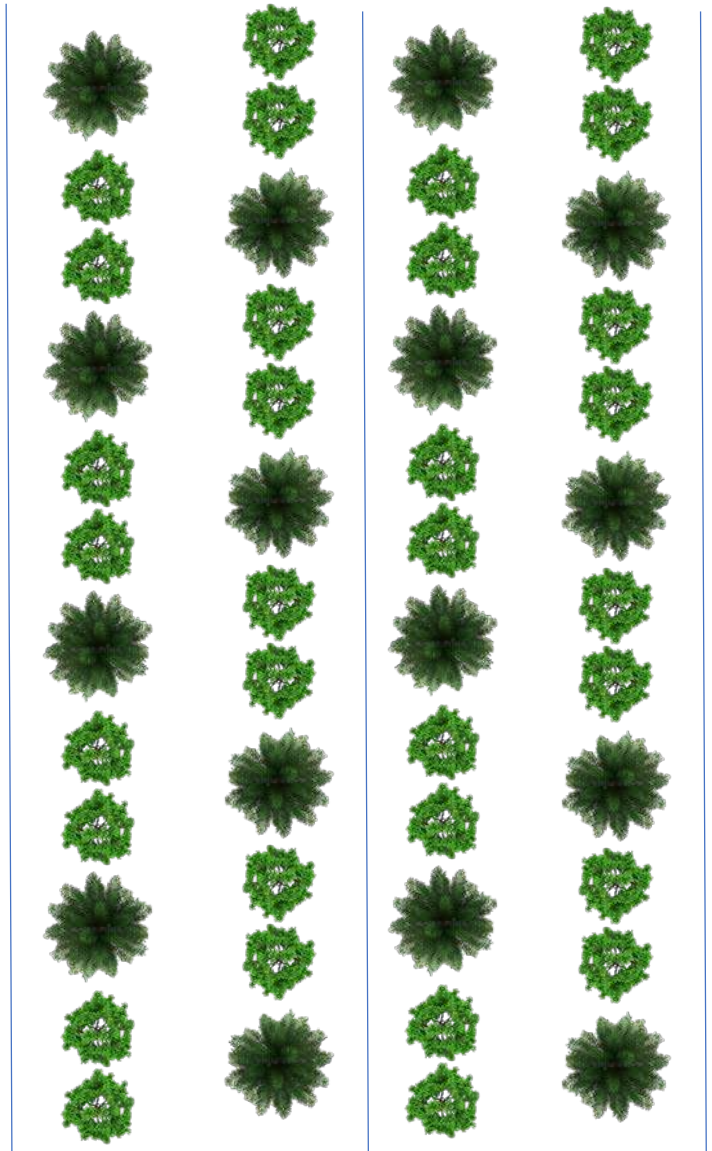


TRIAL 1 : Interplanted Rows

TREATMENT 3

1 forest tree is planted
between 2 palms on the line (64 trees)
trees & palms Spacing is 4.5m

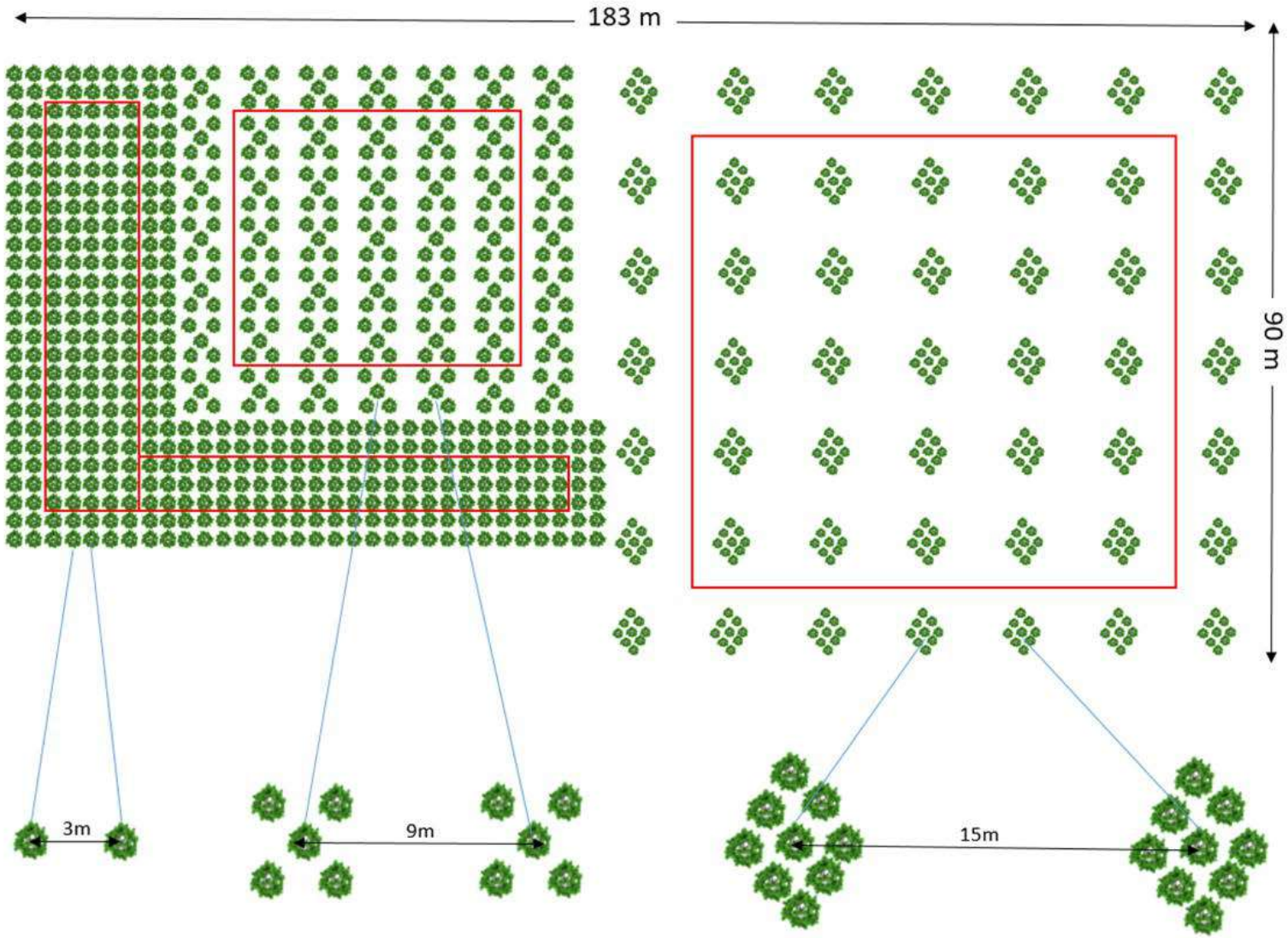




TRIAL 1 : Interplanted Rows

TREATMENT 4

2 forest tree are planted
between 2 palms on the line (128 Trees)
trees & palms spacing is 3m



TRIAL 2 Mixed Forests

Experimental design

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

TRIAL 2 Mixed Forests

1	2	3	4	5	6	7	8	9
3	27	19	22	7	22	11	3	14
4	27	26	11	12	4	11	3	26
22	19	7	27	26	12	3	4	11
11	4	3	14	26	12	7	26	19
26	14	27	12	7	4	14	11	22
4	11	22	26	27	14	12	19	7
3	7	19	12	14	11	22	19	27
26	22	14	7	11	19	27	3	4
4	3	12	22	26	26	11	7	14
14	12	3	11	4	22	3	26	27
3	26	4	27	7	19	11	22	14
14	26	22	11	12	4	12	3	19
26	12	3	4	27	22	7	19	27
22	19	7	27	26	12	3	4	11
11	4	3	27	14	14	7	26	4
26	19	11	26	12	4	3	11	22
4	11	22	14	27	19	19	26	7
3	7	19	22	14	4	14	3	7
22	11	14	12	27	12	26	4	22
12	7	4	14	4	11	3	12	27
3	4	4	27	7	22	19	11	14
12	7	22	11	12	4	14	3	26
27	19	3	4	14	27	7	27	27
22	19	7	27	14	12	3	11	11

3	FICUS SEPTICA	35
4	PTEROSPERMUM JAVANICUM	42
7	EUGENIA CERASSIFORMIS	40
11	EUGENIA SP	35
12	KOODERSIODENDRON PINNATUM	35
14	MICROCOS CRASSIFOLIA	43
19	TOONA SURENI	35
22	MALLOTUS MUTICUS	41
26	EXCOECARIA INDICA	35
27	EUGENIA CERASIFORMIS	47

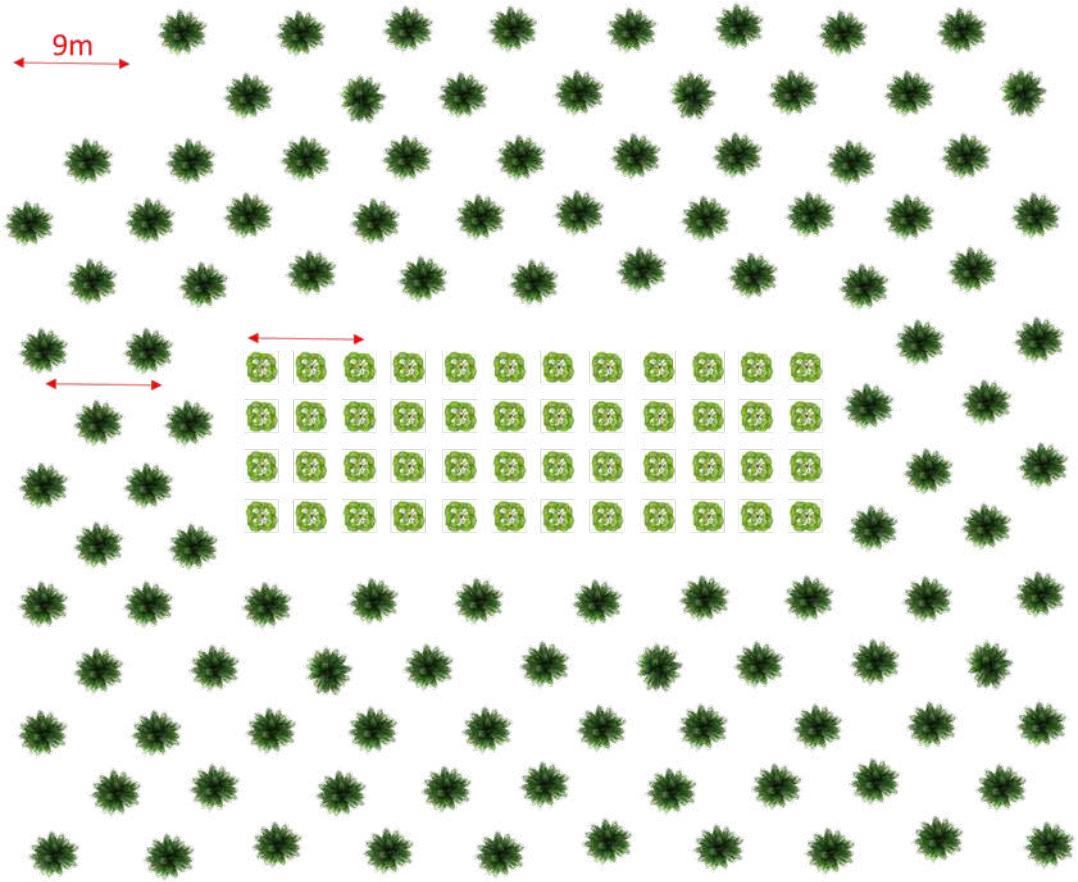
27	4	14	19	22	14	7	26	12	26	27	7	22	11	19	14	22	19	7	4	3	11
26	12	14	27	19	27	3	26	22	7	14	4	27	22	12	26	3	14	19	19	12	12
4	22	26	14	11	12	12	3	7	26	3	14	22	27	19	7	11	19	22	26	11	3
3	7	14	12	14	27	22	26	27	22	19	26	12	3	4	14	4	7	27	22	7	27
27	22	14	11	7	11	12	27	4	11	4	22	14	7	26	14	11	3	4	27	22	12
7	12	12	19	27	27	7	14	14	27	19	19	4	27	22	14	14	12	7	22	26	22
14	7	27	4	4	19	19	27	4	27	7	7	12	19	7	27	27	22	27	4	4	11

TRIAL 2 Mixed Forests

Expected results

- The present trial was planted with forest trees only, aiming at assessing the ability for agroforestry plantation of ten different selected species of native forest trees.
- Three different planting densities and three types of trees associations (individual trees, group of 5, group of 9) were tested.
- We will improve our knowledge on growth and development characteristics of 10 forest specieds, natives of the Kinabatangan Basin,
- Assessed suitability of native forest species to be successful in agroforestry plantations

TRAIL 3 Forest Islands



Goal

To document the interactions between palms and specific tree species

Experimental design:

- 5 replicates x 48 trees = 240 trees per species
- First set of 4 species: *Nauclea subdita*, *Microcos crassifolia*, *Meiogine* sp, *Mallatus muticus*

Specific objectives

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

A 10-years work plan

PROJECT PHASE	YEARS	ACTIVITIES	BUDGET
TRAILS 1	2020 - 2023	• Construction of partnership • Baseline Assessment • Planting Design • Socioeconomic Studies	• 1,000 k€ • 2 years • Private/Public funding
TRAILS 2	2024 - 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

September 2022

October 2023

The best time to plant an oil palm-based agroforests was 20 years ago.
The second best time is now.

Thank you.
Terima kasih.