

PALM TURMOIL

*Spatial guidelines for a future
(re)generation of palm oil
plantations on Kalimantan*



Douwe Douma 4451708

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MSc Urbanism TUDelft

P5 31-08-2022

Smallholders

2 P5 UM+C
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Industrial scale

3

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Areas (in Ha)	Indonesia	Sumatra	Kalimantan
Oil palm expansion 2001–2019	8,477,253	3,457,500	4,598,415
Oil palm area 2019 (This study)	16.237,047	9.486,516	6.044,517
Industrial	10,316,986 (64%)	4,684,385 (49%)	5,105,427 (84%)
Smallholder	5,920,061 (36%)	4,802,130 (51%)	939,091 (16%)

Gaveau (2021)

1km

ESA Copernicus II above Eastern Kalimantan palm oil expansion (2019)

Establishment



$t < 0$ yr Pre-establishment



$t = 0$ yr Leveling/draining



$t = 2$ yr Vegetative



$t = 10$ yr Production/expansion



$t = 30$ yr End of harvest (clearance)



Primary forest



Mature oil palm



Oil palm seedling

(economic) Benefits

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- Most profitable oil crop (Sung, 2016)
- 58% of global production (USDA Foreign Agricultural Service, 2021)
- 7.5 million employees (Sung, 2016)
- 85% for export, worth 20 billion USD (Shigetomi, Ishimura, & Yamamoto, 2020)
- Infrastructure

Problem statement

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Main driver (~50%) of **deforestation**.

- Devastates local environment (soil, water & air conditions)
- Biodiversity loss
- Vulnerability to flood and fire
- Carbon emissions



© H Dragon

Research Goal

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‘Regenerative’ spatial guidelines
for oil palm plantations in Kalimantan

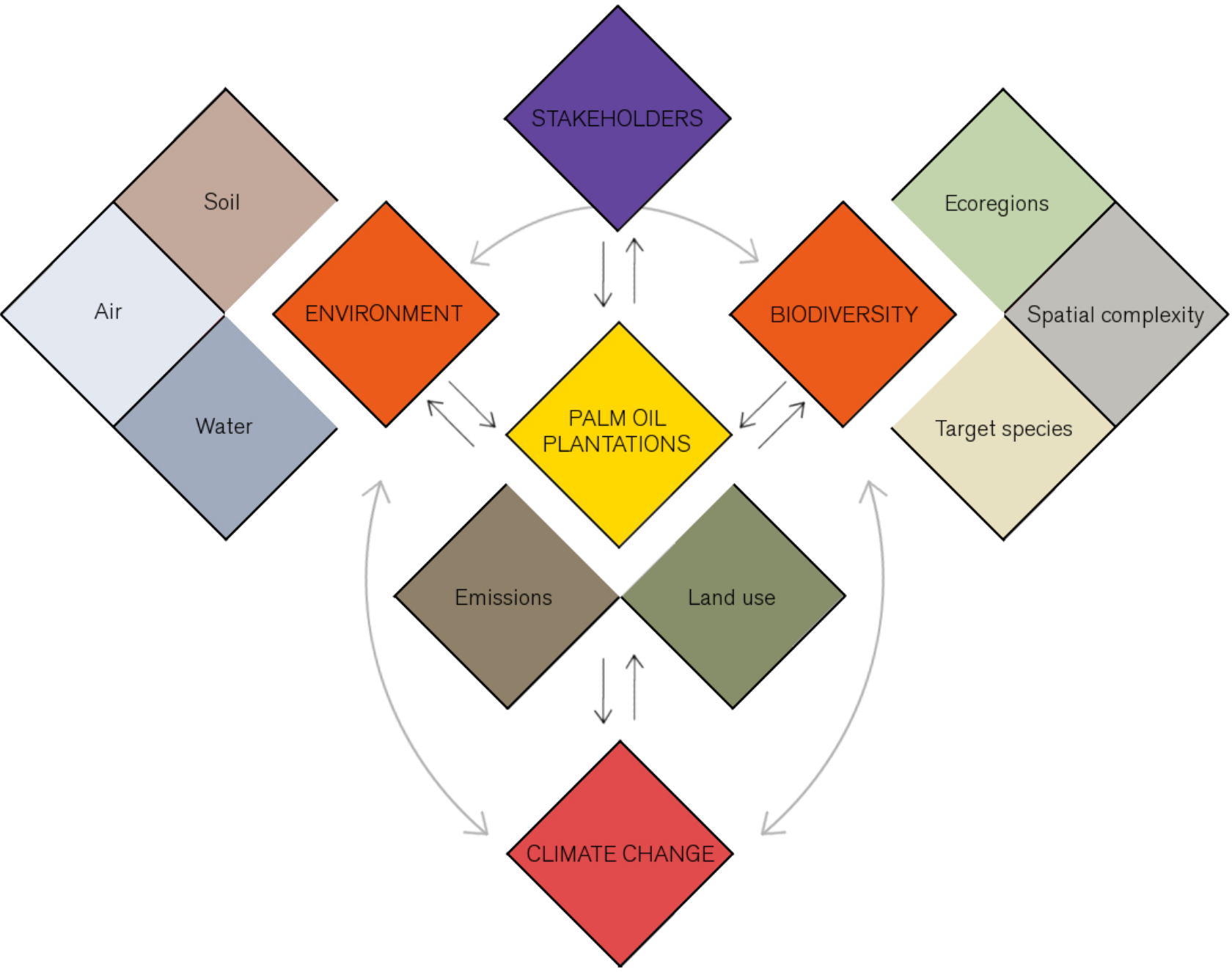
(1) lower environmental impact

(2) while stabilizing biodiversity

(3) within a changing climate.

Conceptual FW

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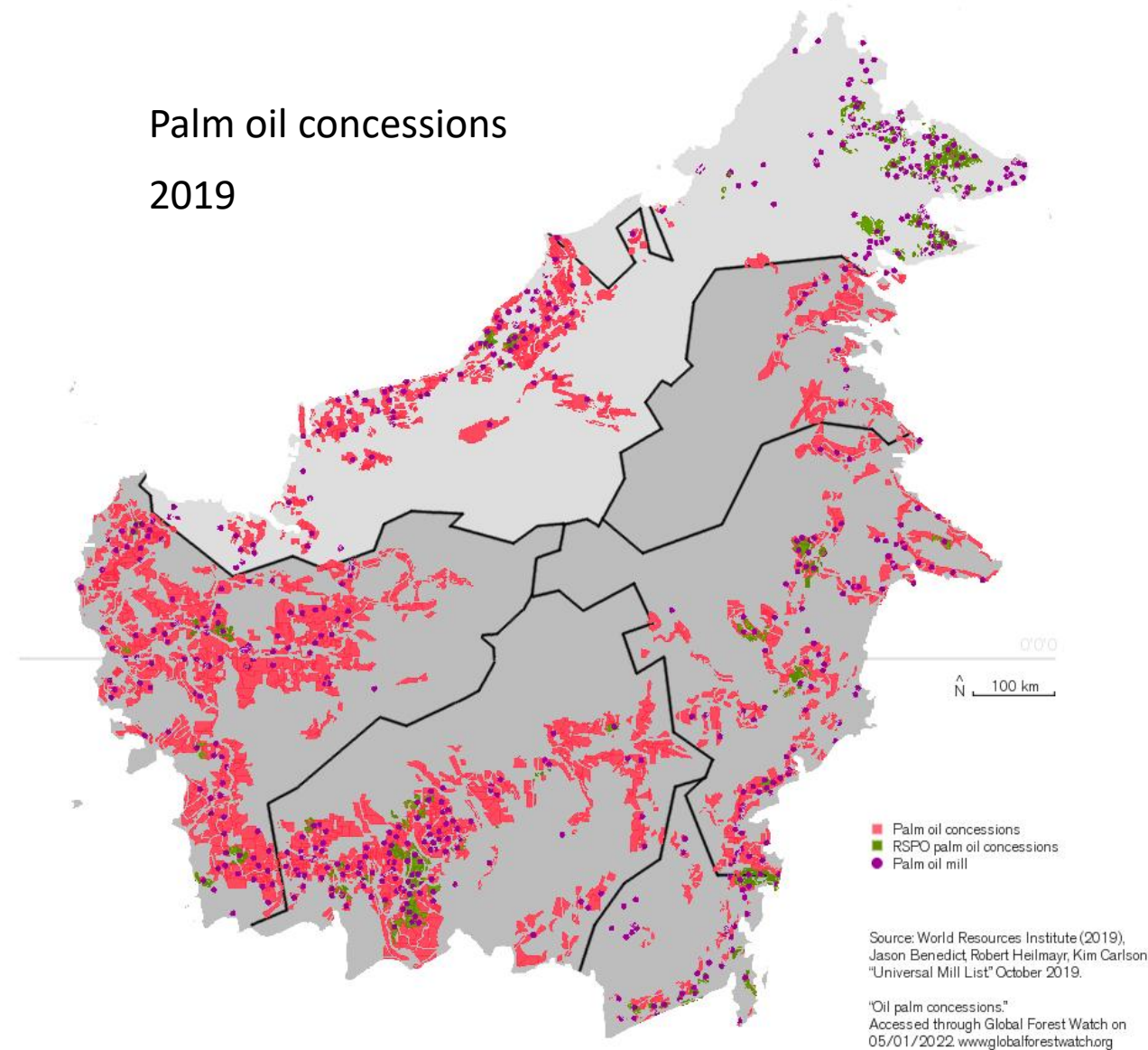
Analysis

Kalimantan



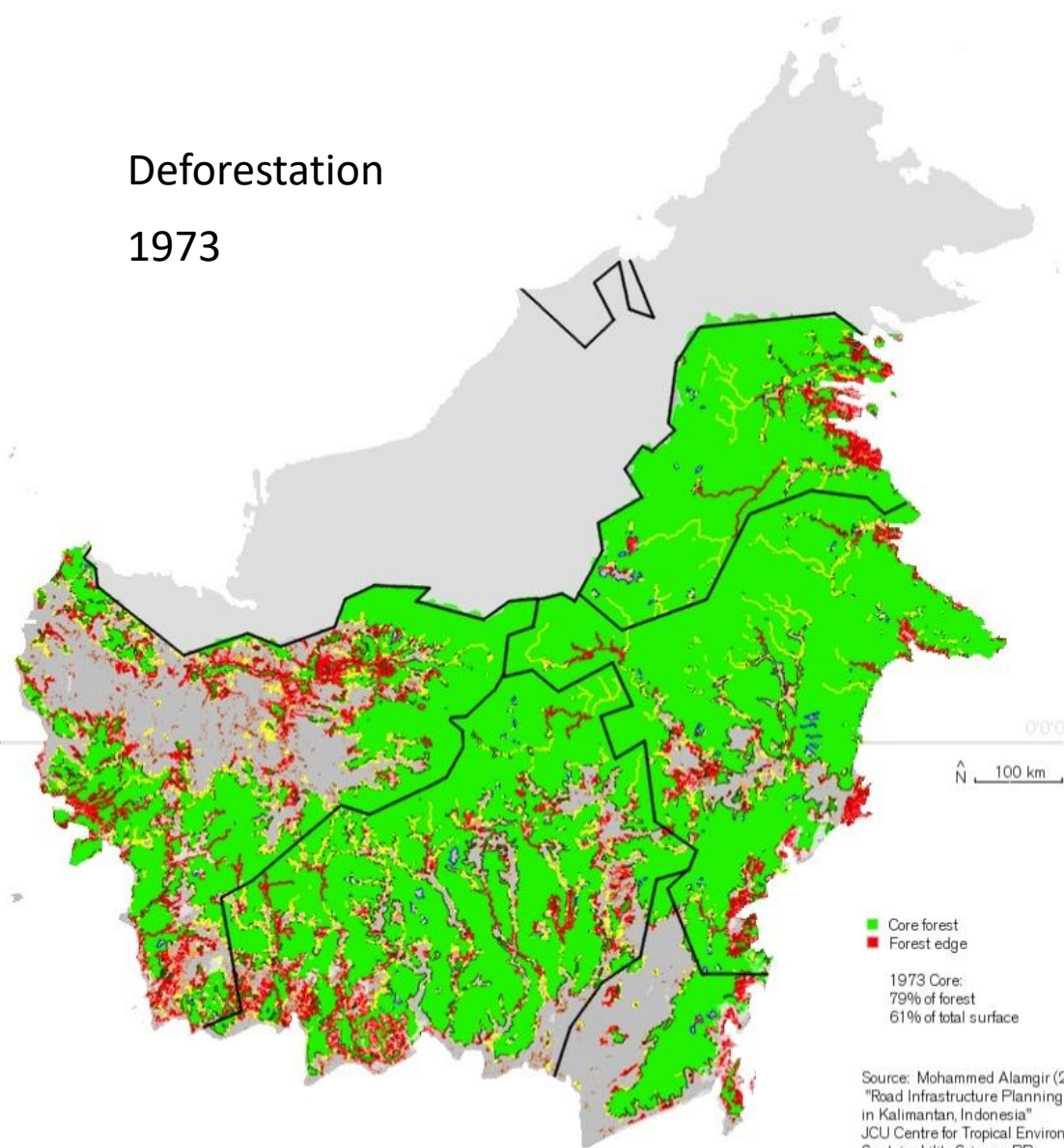
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Palm oil concessions 2019

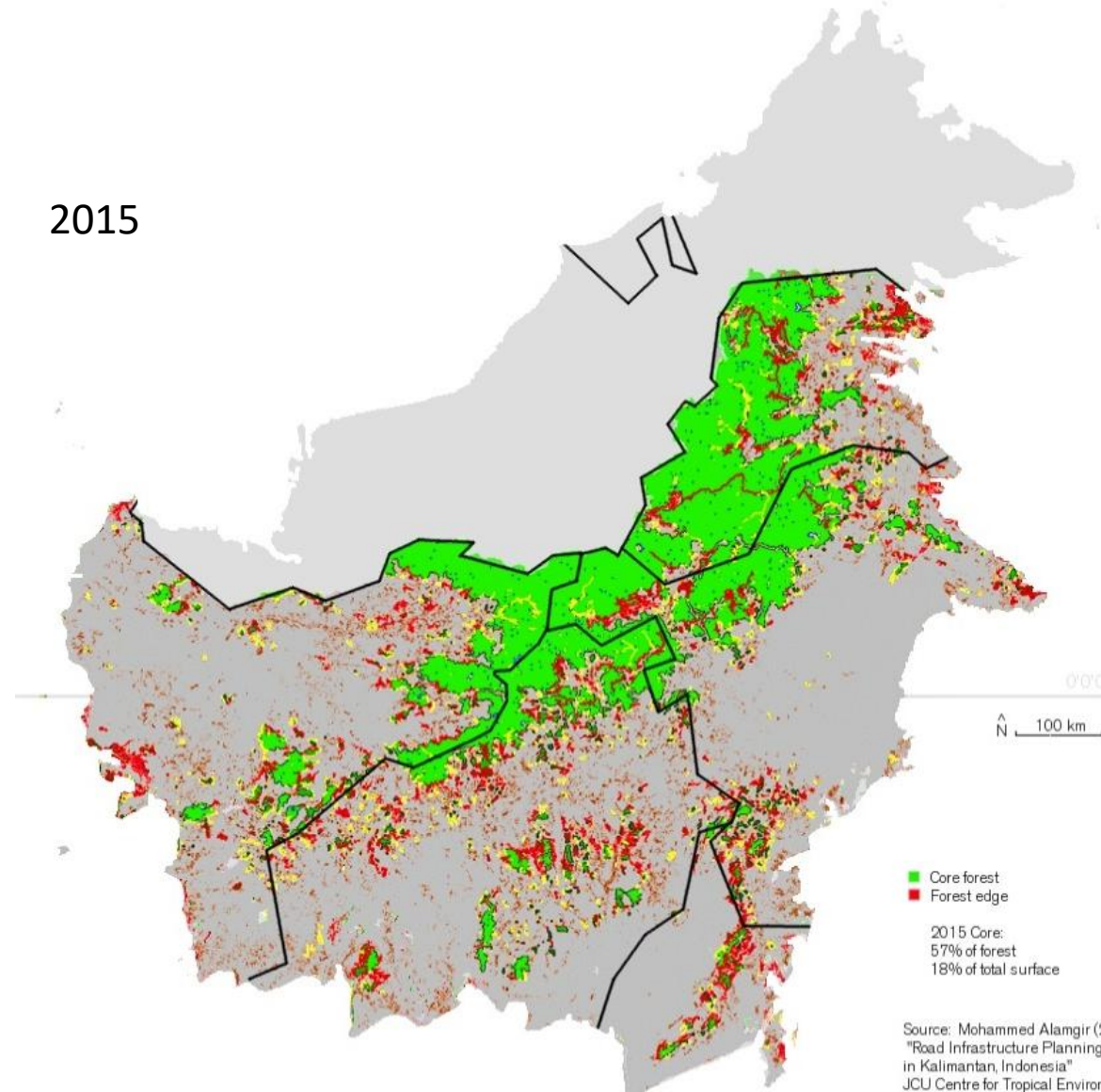


Deforestation

1973

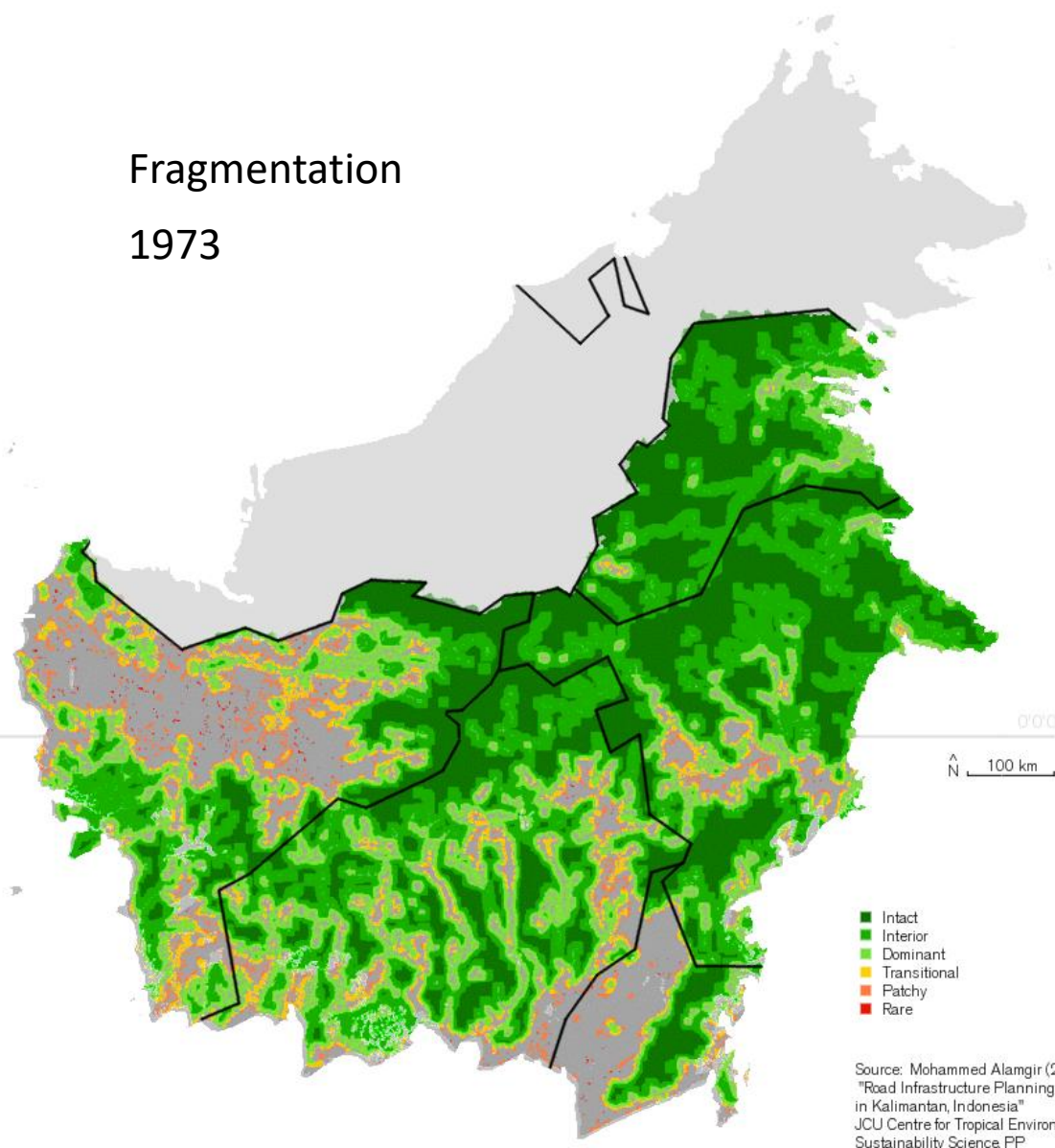


2015

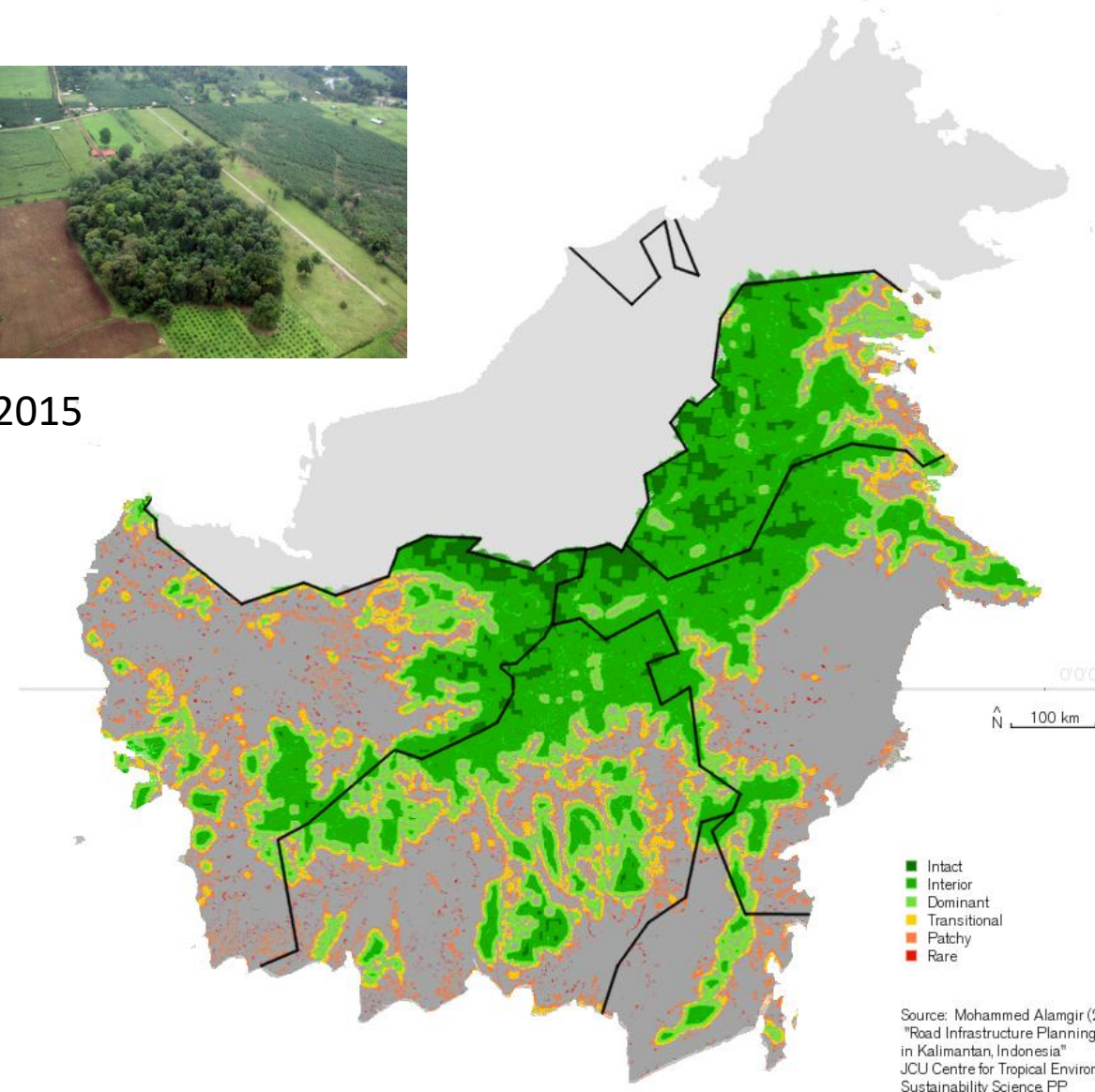


Fragmentation

1973

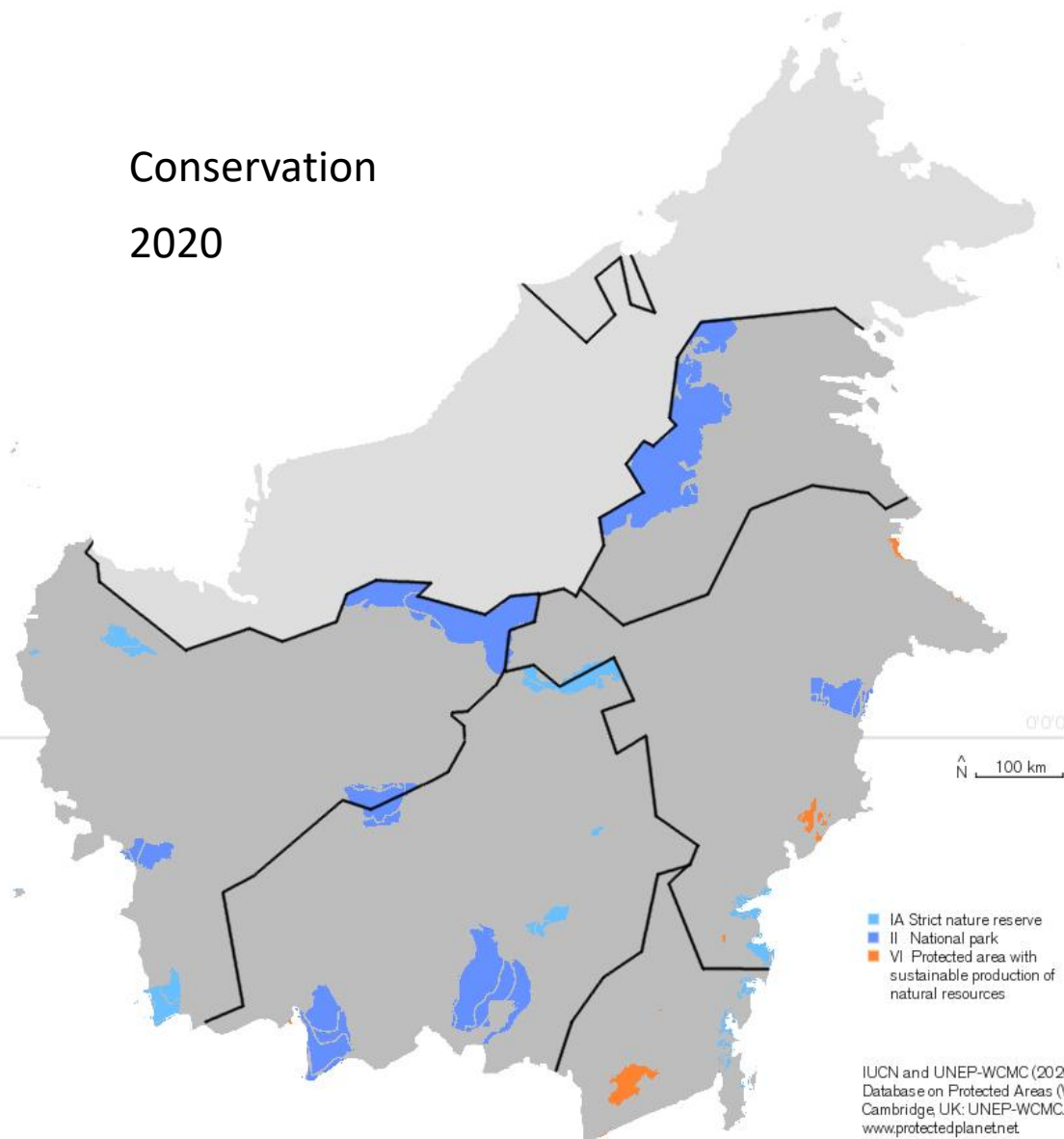


2015



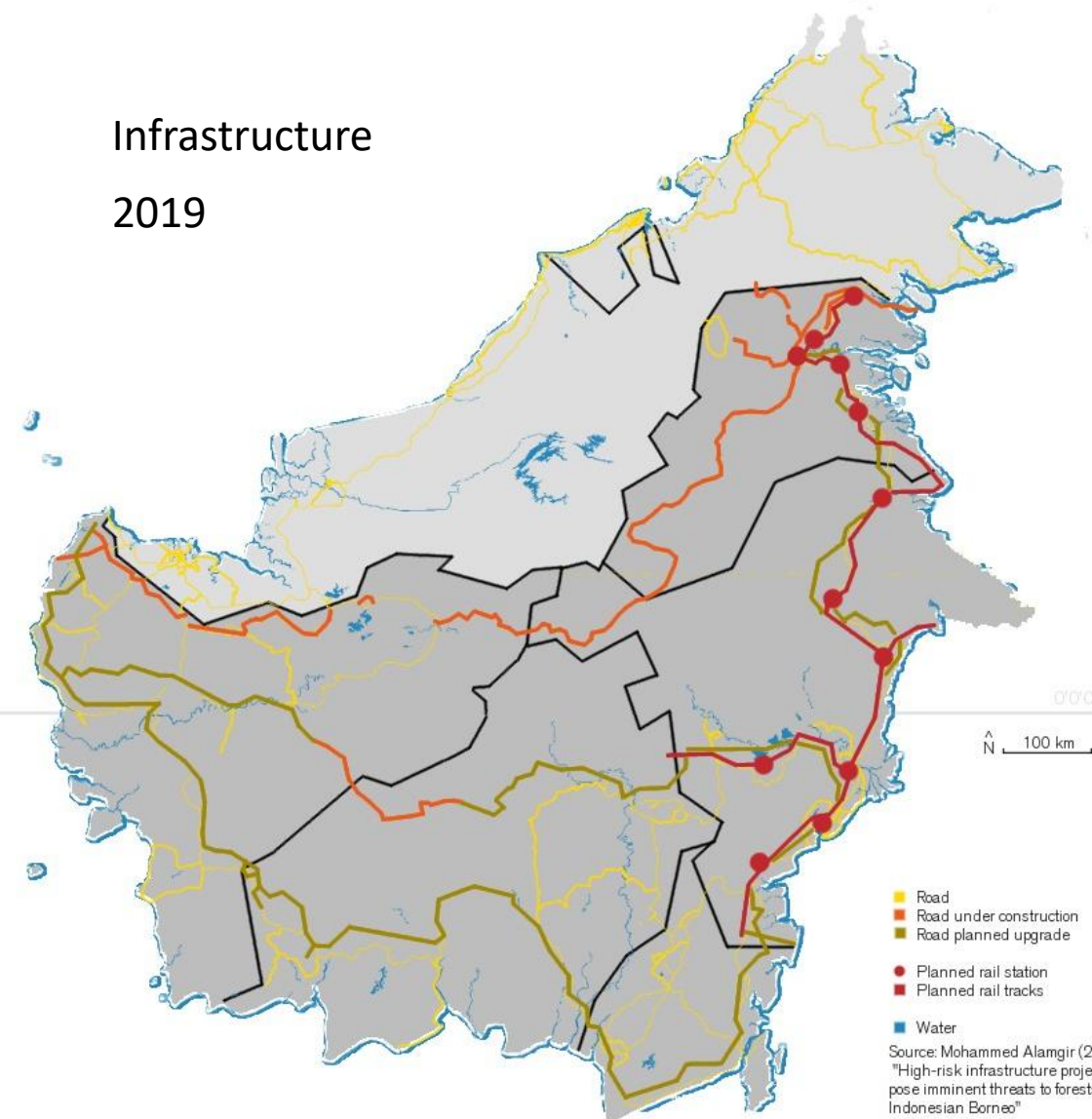
Conservation

2020



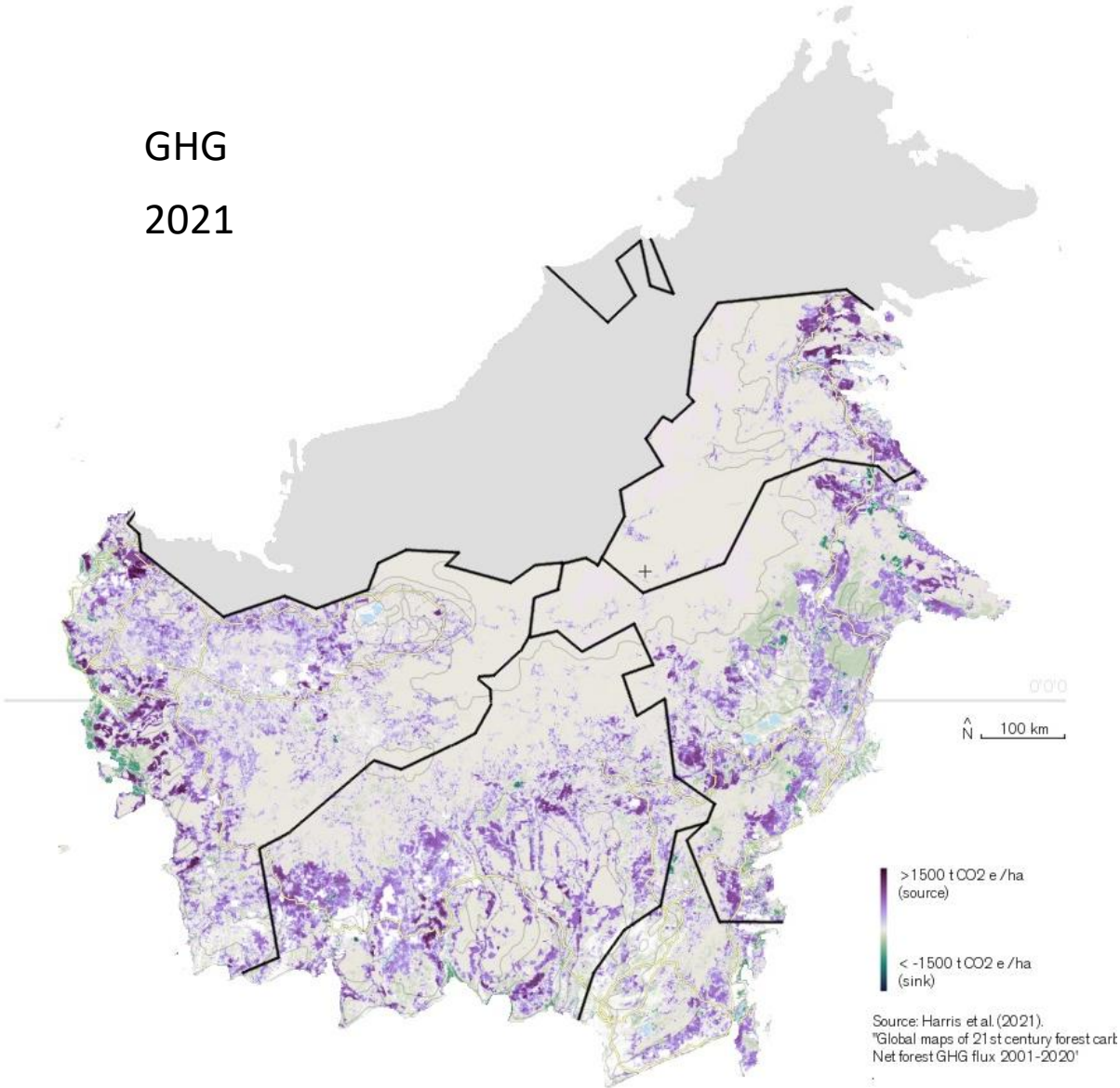
Infrastructure

2019



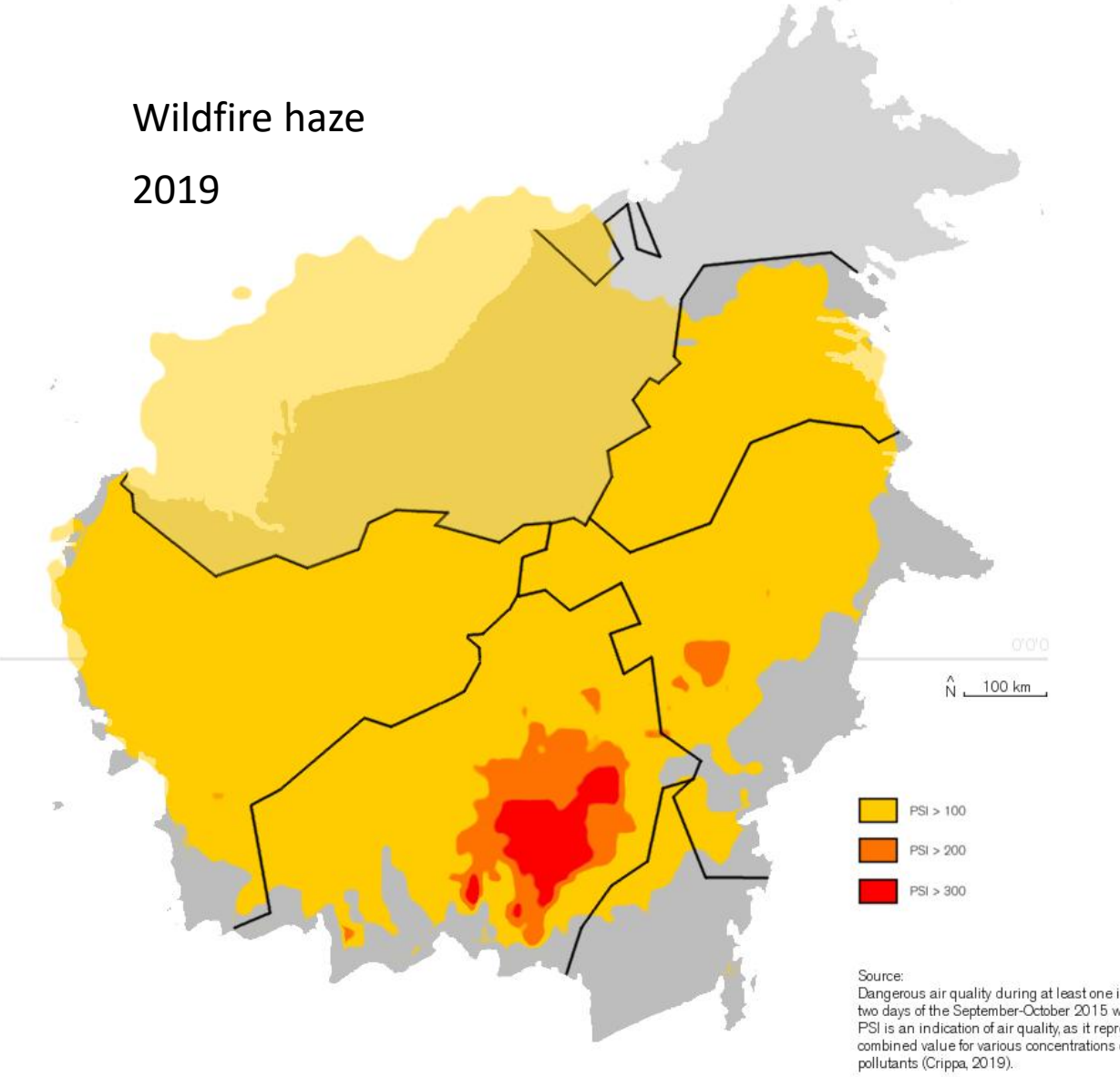
GHG

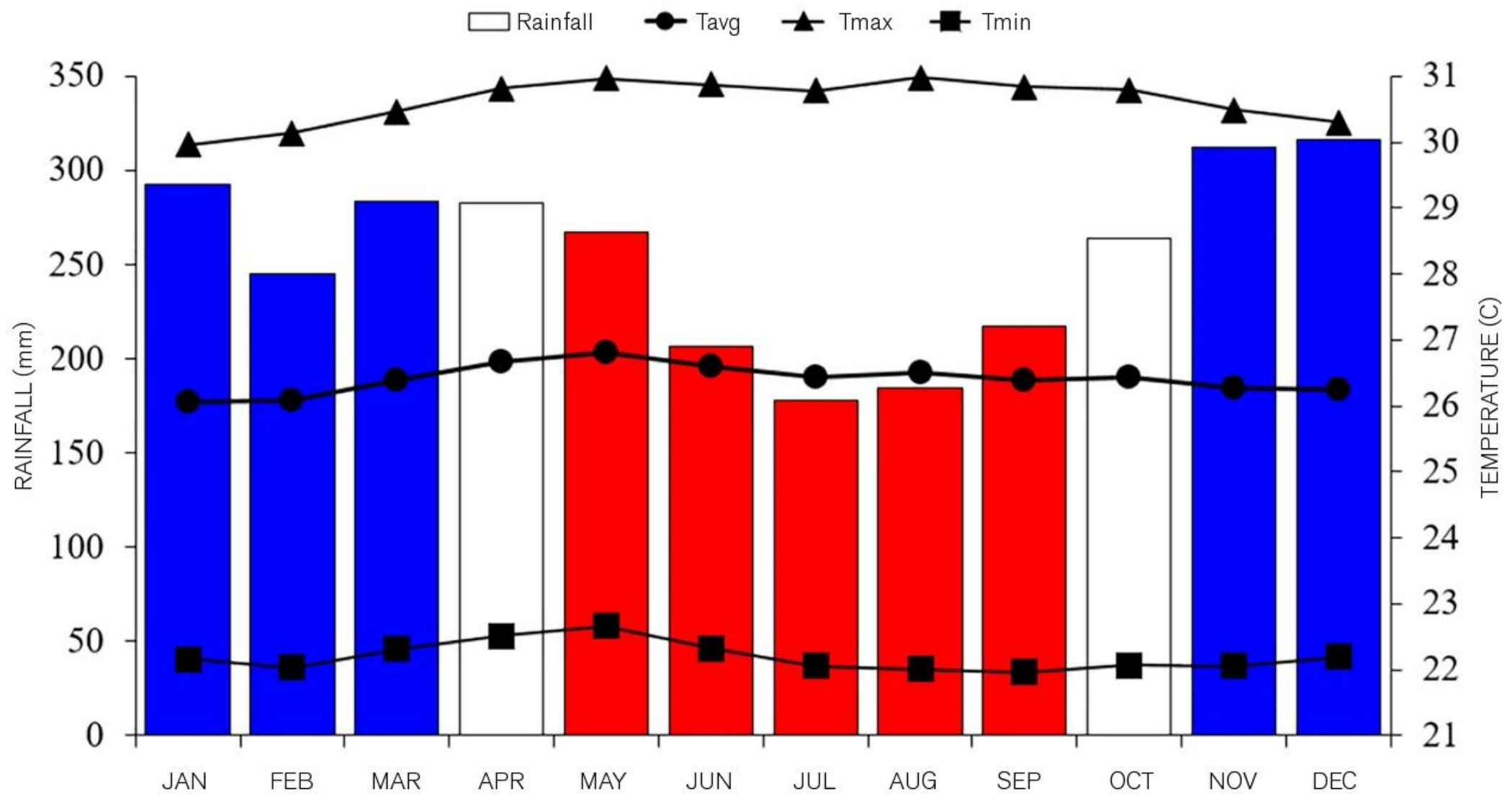
2021



Wildfire haze

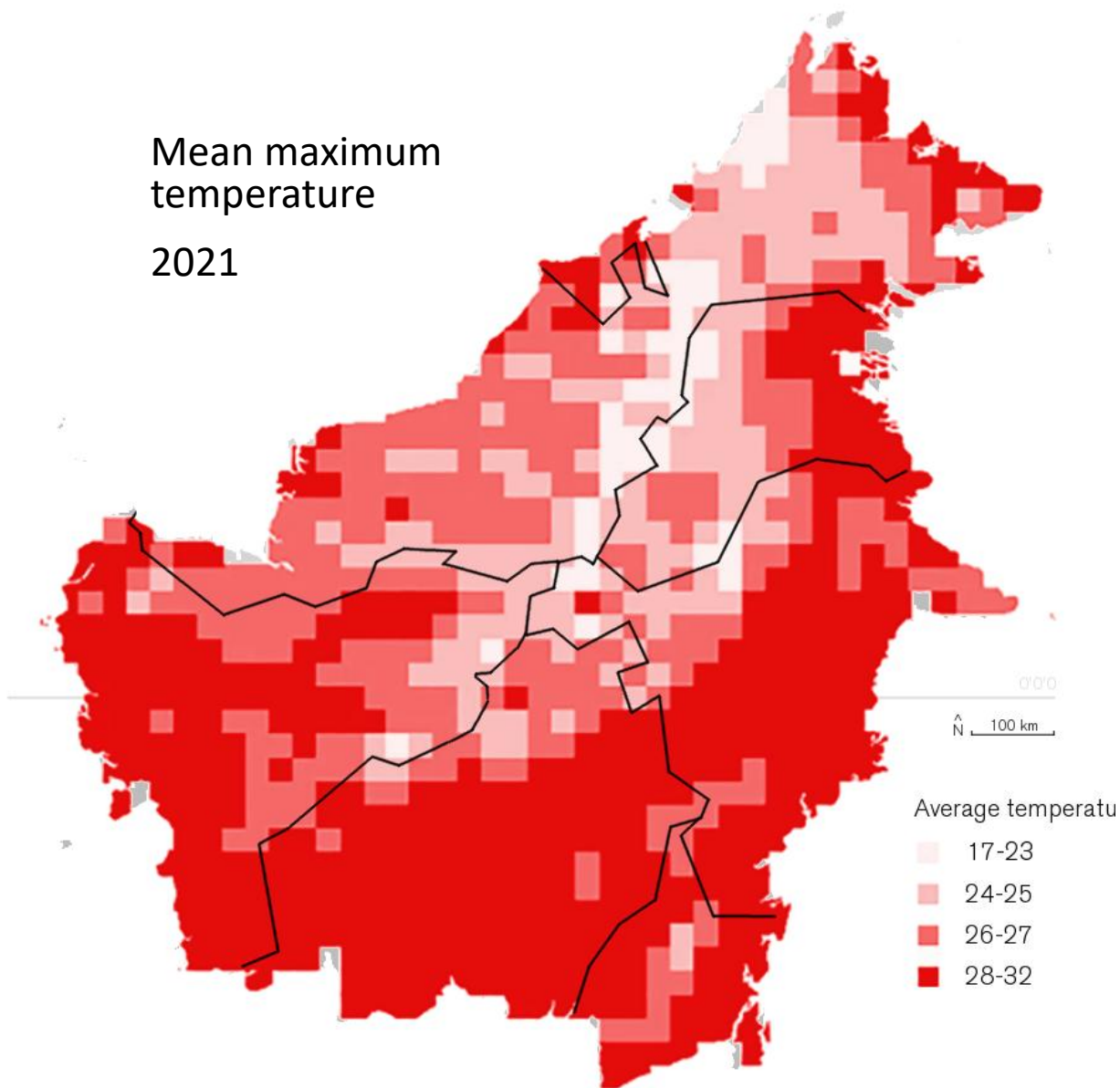
2019





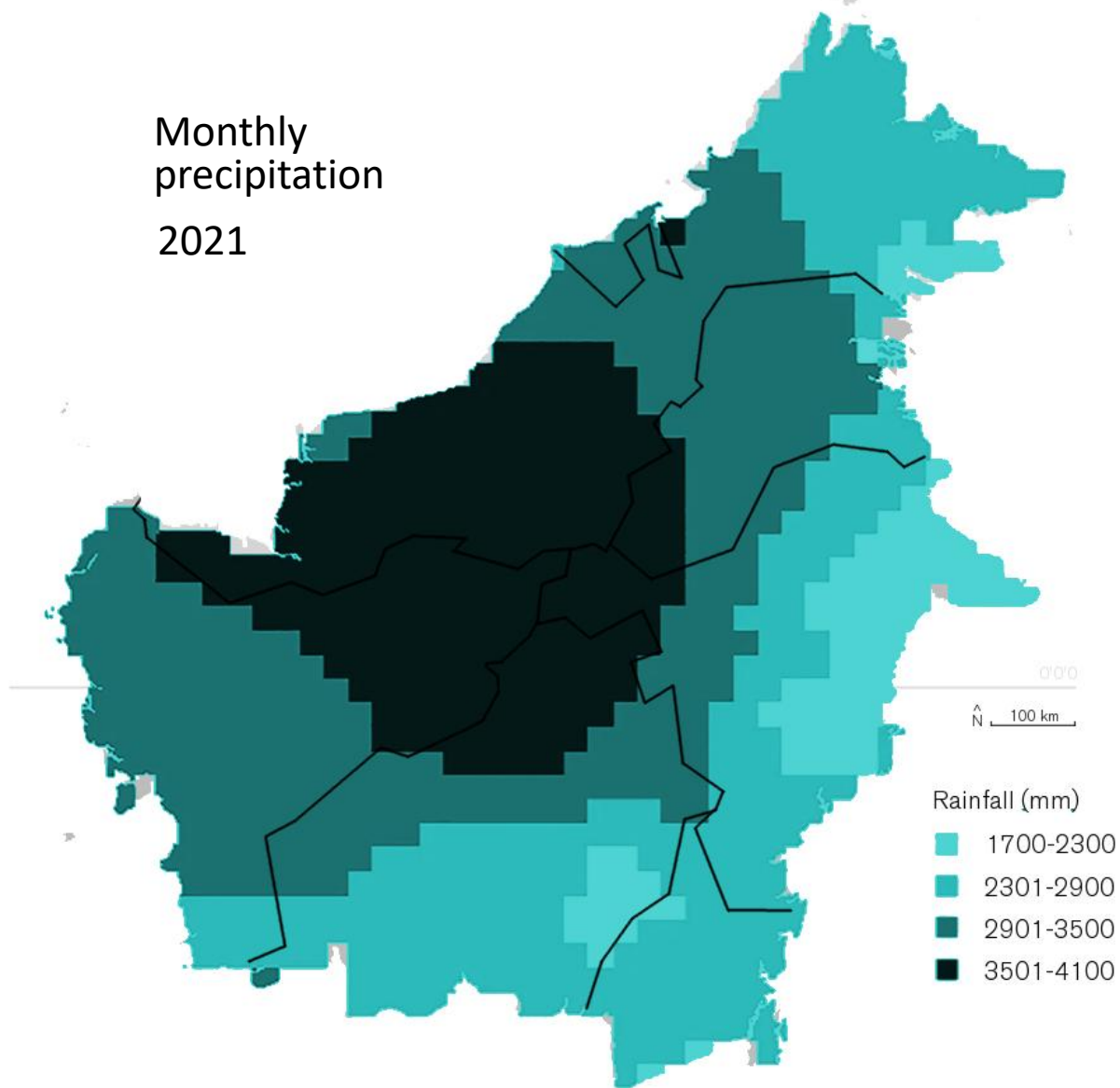
Mean maximum
temperature

2021



Monthly
precipitation

2021



Literature review conclusions

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Soil

- Soil erosion
- Reduced natural fertility
- Artificial fertilizer overshoot

Literature review conclusions

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Air

- Increase in microclimate air temperature
- Carbon emissions
(forest $702 \pm 183 \text{ MgCO}_2 \text{ ha}^{-1}$, peat $3452 \pm 1294 \text{ MgCO}_2 \text{ ha}^{-1}$)

Literature review conclusions

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Water

- Reduced storage capacity
- Lower overall water quality
- Oil palm will die in waterlogged conditions

Biodiversity

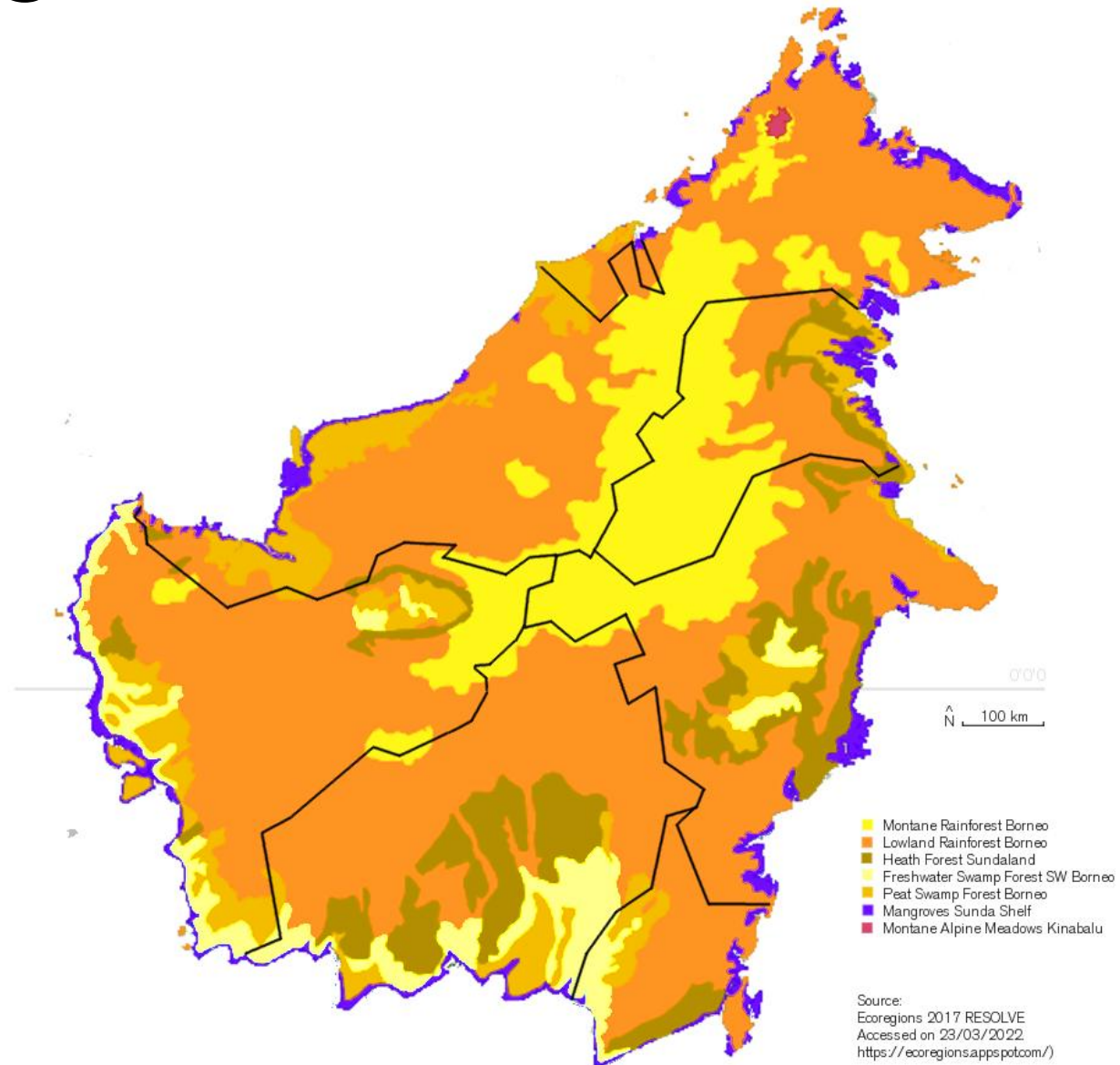
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Ecoregions

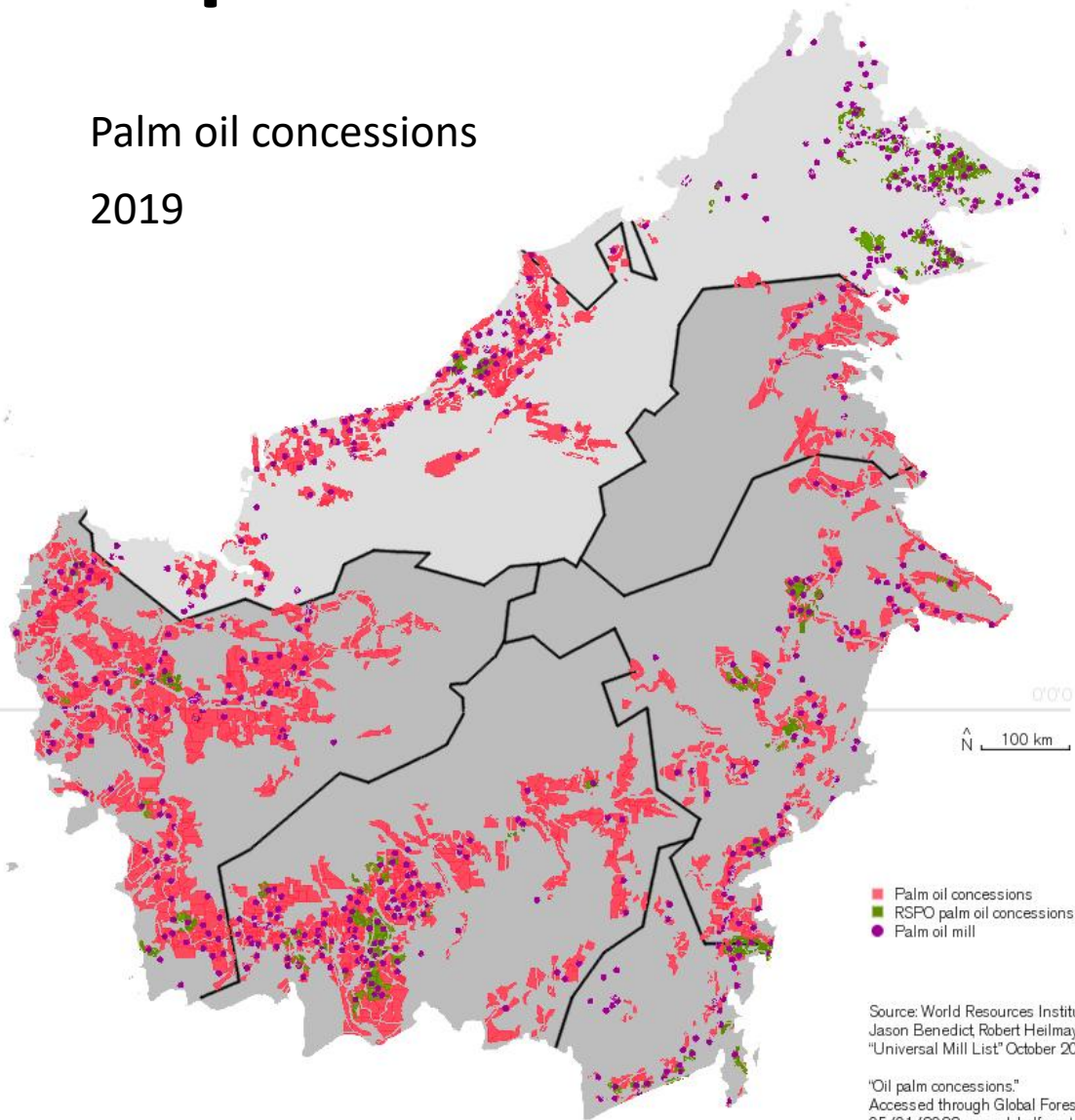
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Oil palm threat

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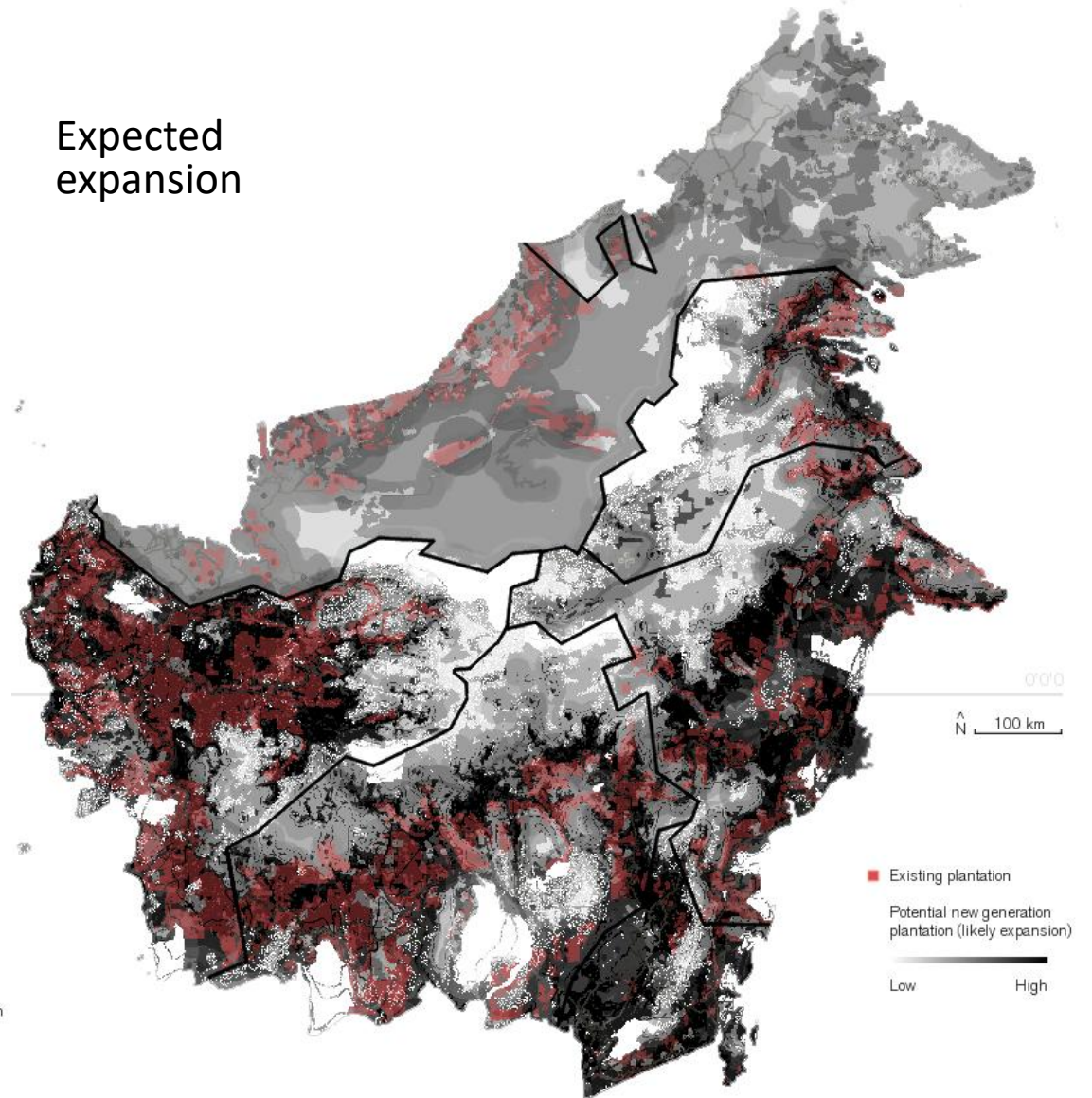
Palm oil concessions
2019



Source: World Resources Institute (2019),
Jason Benedict Robert Heilmayr, Kim Carlson
"Universal Mill List" October 2019.

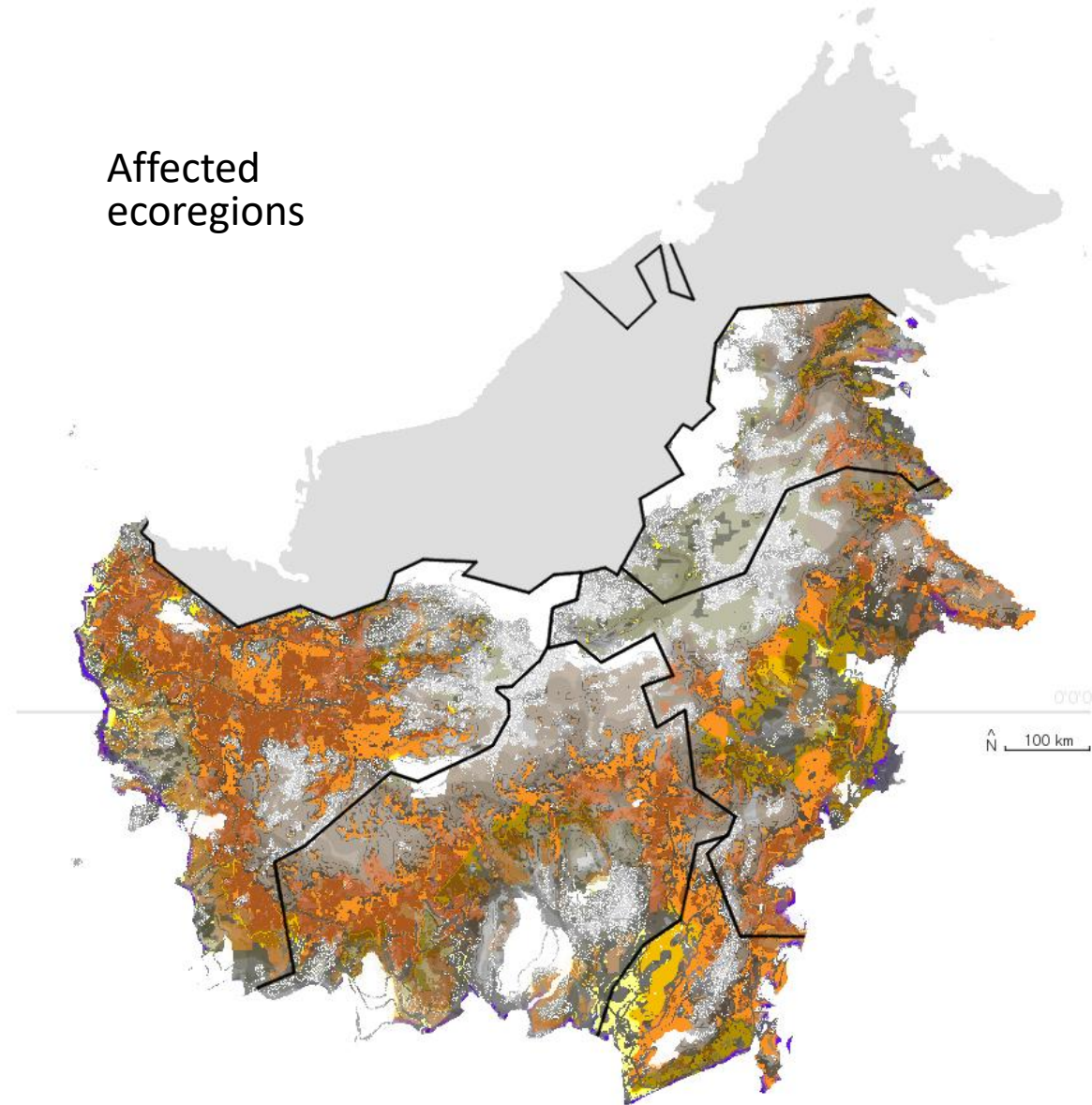
"Oil palm concessions."
Accessed through Global Forest Watch on
05/01/2022. www.globalforestwatch.org

Expected
expansion



Synthesis

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Target species

1. NAME
2. SCIENTIFIC NAME
3. CLASS
4. ORDER
5. POPULATION
6. IUCN VULNERABILITY STATUS

7. IDENTIFICATION

8. GEOGRAPHIC RANGE

9. HABITAT PREFERENCE

10. DIET

11. THREATS

1. **Helmeted Hornbill**
2. *Rhinoplax vigil*
3. Aves
4. Bucerotiformes
5. Not quantified (decreasing)
6. **Critically endangered** (2020)



Brown and white feathers, red casque and yellow beak. Can grow up to 120 cm. High-pitched "Pooh" and "Poohoh" calls ending in harsh, cackling laugh (Kemp et al. 2014).



9. **Primary** (semi-)evergreen **lowland forest**, up to **1500m**. Prefers rugged terrain and **closed (high) canopy** forests, exceeding **10.000 hectares** (IUCN, 2022). Does occur in 'smaller' conservation areas. Unknown to accept artificial nestboxes (Jain et al. 2018).

10. Feeds on fruiting trees, especially fig. Fledged chicks within the nest demand 900-1900g of fig fruits a day (Kitamura et al. 2011). Seed disperser. Also feeds on small animals, such as (stick) insects, squirrels, snakes and other birds.

11. Hunting pressure, lowland deforestation, climate change. Suitable habitat expected to decrease by **32%** in 2050 (Singh, 2021).

1. **Blue-headed Pitta**
2. *Hydornis baudii*
3. Aves
4. Passeriformes
5. 10-20k (decreasing)
6. **Vulnerable** (2016)



Distinctive combination of blue crown and reddish mantle. Can grow up to 20cm. Soft, descending whistle "ppor-wi-ill" (IUCN, 2022).



9. Locally common (but fragmented) in **primary evergreen lowland forest** up to **600m**. Also occurs in secondary and regenerating selectively logged forest. Sticks to dense cover (IUCN, 2022). Nests in trees, shrubs and on the ground.

10. Feasts on caterpillars, earthworms, beetles, ants, grasshoppers, crickets and snails.

11. Lowland deforestation, climate change. Suitable habitat expected to decrease by **30%** in 2050 (Singh, 2021).

1. **Bornean Wren-babbler**
2. *Ptilocichla leucogrammica*
3. Aves
4. Passeriformes
5. 10-20k (decreasing)
6. **Vulnerable** (2016)



Brown upperparts, white throat. Short tail and long pinkish legs. Can grow up to 15cm. Sings two pure notes "fii-fii" (IUCN, 2022).



9. **Moist lowland and evergreen forest**, occasionally peat swamp. Ascends terrain up to 900m. Inhabits dark and shady understory vegetation in pairs (IUCN, 2022).

10. Small insects and berries. Hops around the understory, turning over fallen leaves and searching fruit bearing bushes.

11. Lowland deforestation, climate change. Suitable habitat expected to decrease by **66%** in 2050 (Singh, 2021).

1. **Bornean Orangutan**
2. *Pongo pygmaeus*
3. Mammalia
4. Primates
5. 100k, mean 0.7/ km2 (decreasing rapidly)
6. **Critically endangered** (2016)



Brown/reddish hair. Short legs and long arms as they are arboreal. Although the Bornean orangutan spends more time on the ground than its Sumatran counterpart.



9. Historically most abundant in **inundated** and semi-inundated **lowland Dipterocarp mosaic forests**, where movement between different habitat types could buffer them against shortages in food availability (IUCN, 2022).

10. Primarily gathers wild fruits like lychees, mangosteens, or figs. Slurps water from holes in trees (WWF, 2022). Leaves, bark, flowers and insects are also included in the diet. Fruit bearing trees are widely scattered and only yield enough to feed an individual.

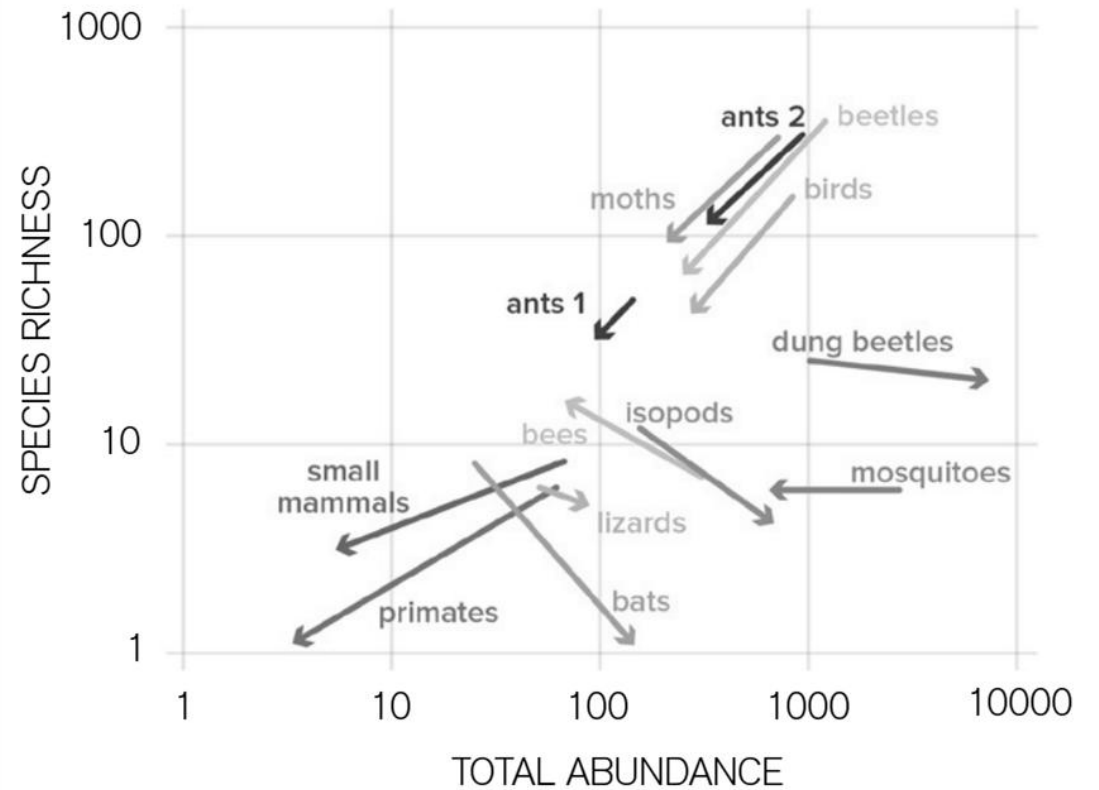
11. Hunting, habitat loss, climate change. Models from Struwig et al. (2015) point to a **69-81%** reduction in habitat by 2080 (from 2010) when factoring in both climate change and deforestation projections.

Literature review conclusions

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Biodiversity

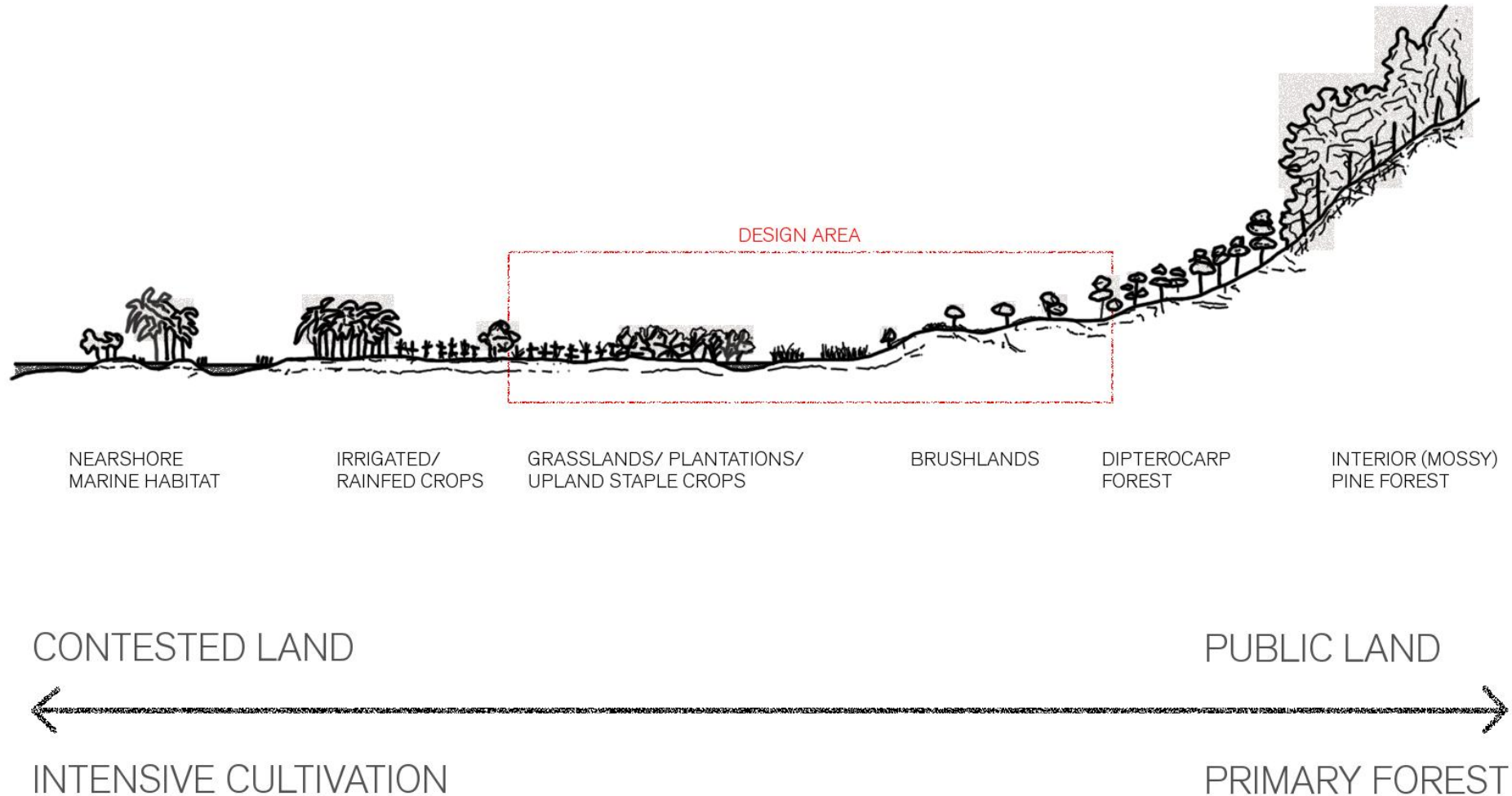
- Heterogeneity or 'spatial complexity'
- Species richness declines



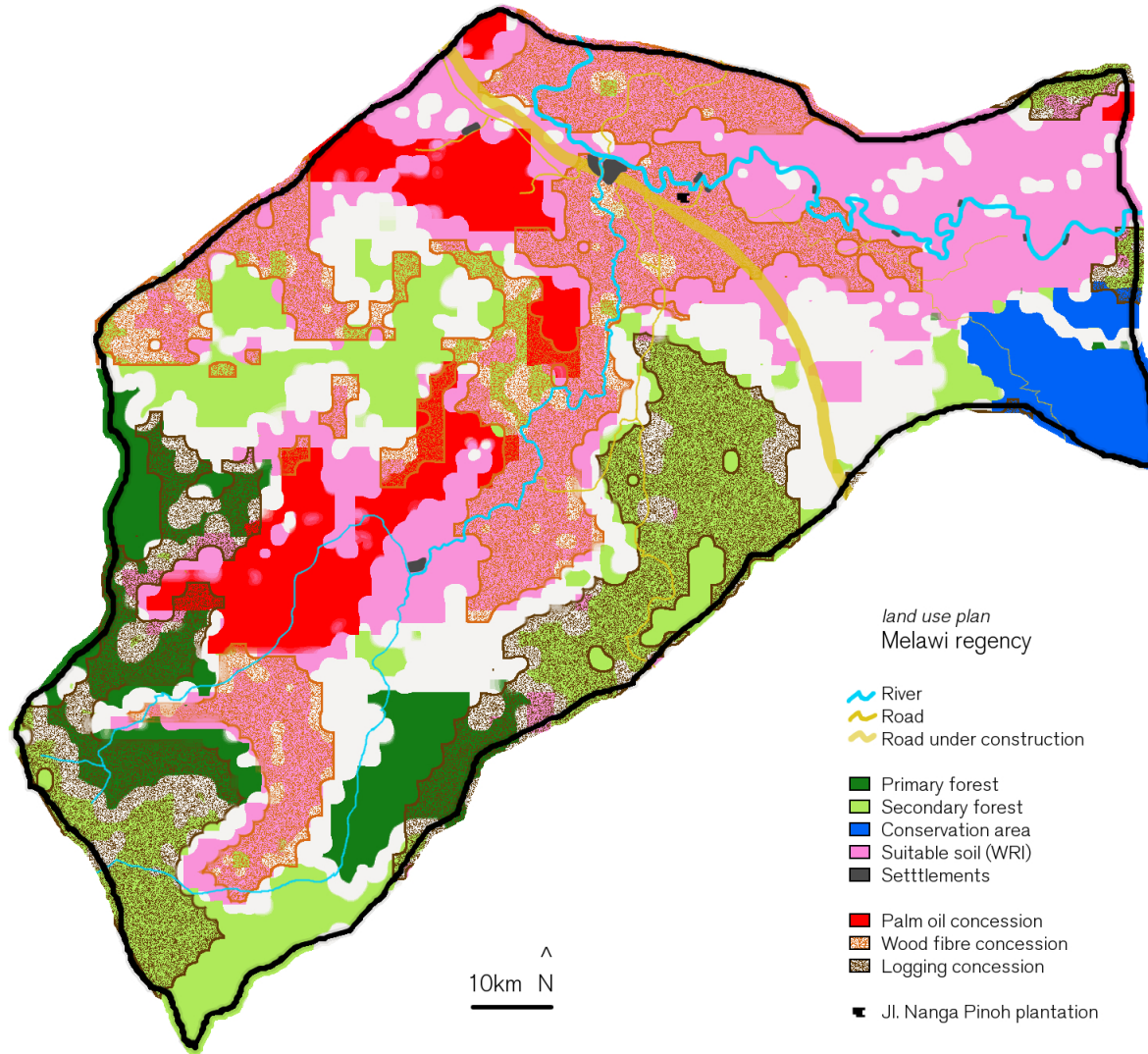
Design

Site selection

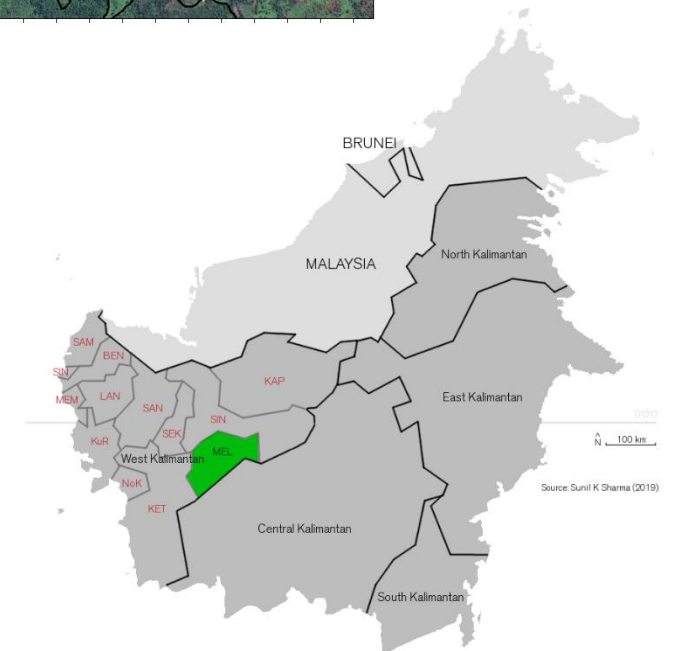
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Site selection

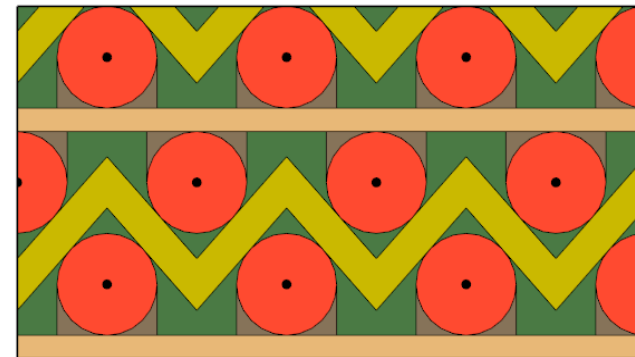
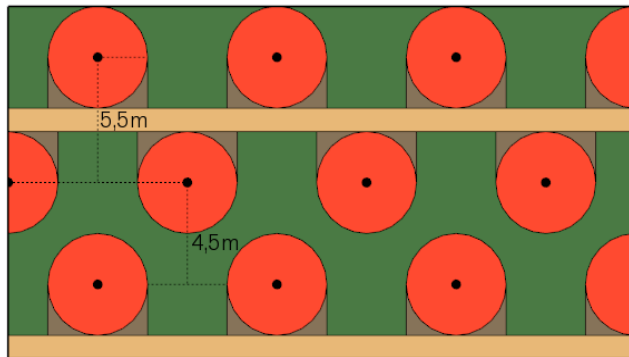
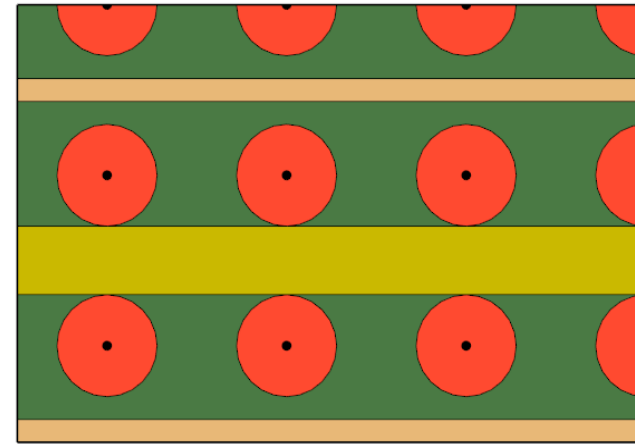
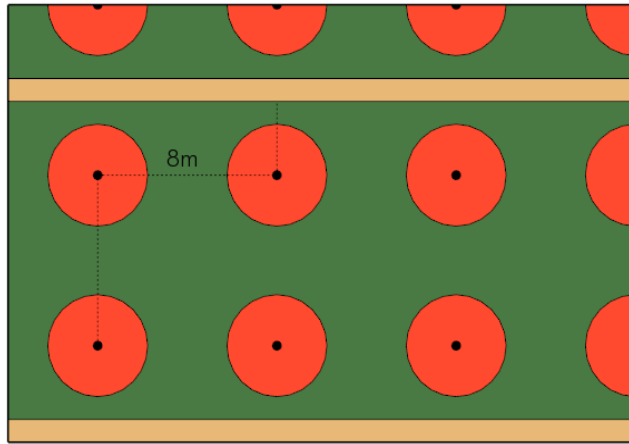


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Current grid

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- Harvest circle
- Understory
- Pathways
- Waterways
- Intercropping

Intercropping

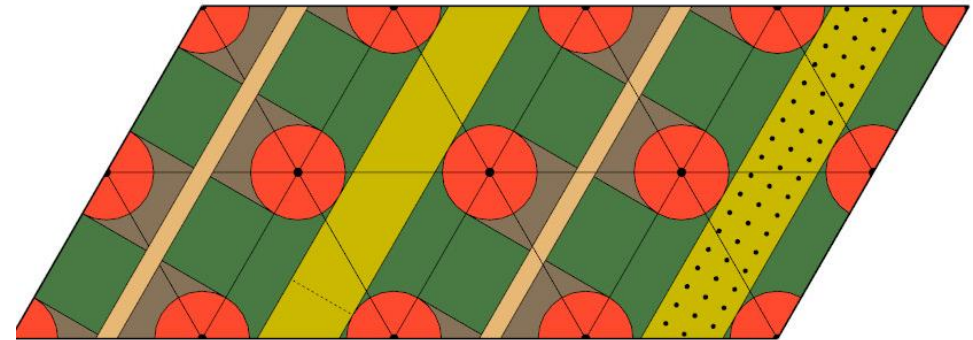
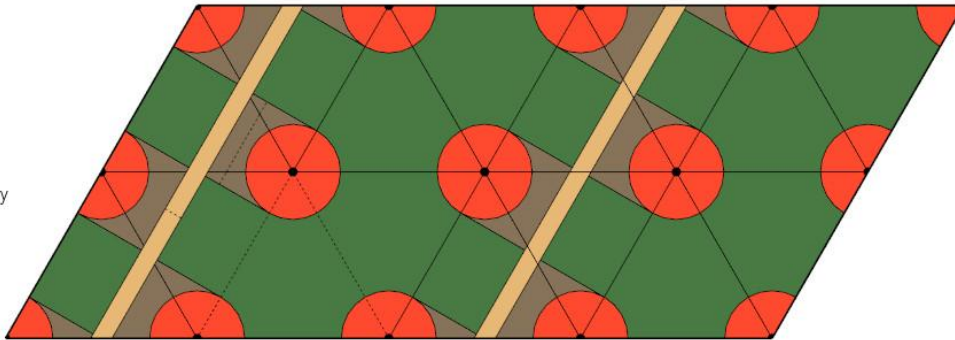
30 P5 UM+C
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Proposed grid

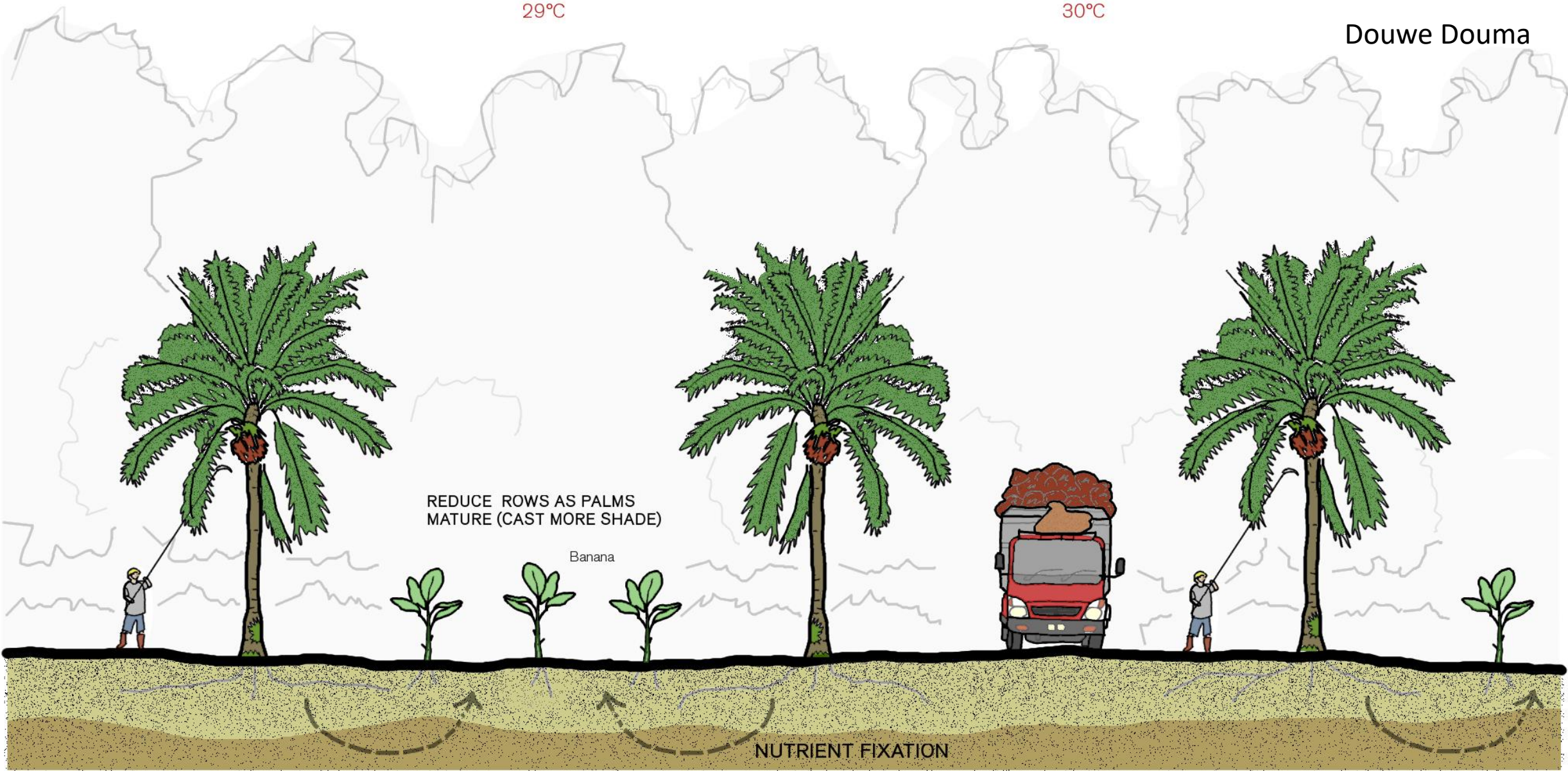
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- Harvest circle
- Understory
- Pathways
- Waterways
- Intercropping
- Cover cropping
- Ramp
- Wetland
- Plantation boundary
- Organic boundary



Typical section intercropping

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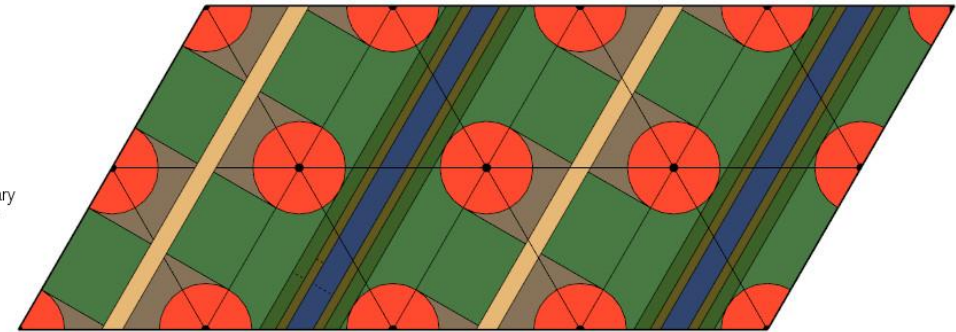
HARVEST PATH ———|——— INTERCROPPING ———|——— HARVEST PATH ———|——— INTER

Drainage ditches

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- Harvest circle
- Understory
- Pathways
- Waterways
- Intercropping
- Cover cropping
- Ramp
- Wetland
- Plantation boundary
- Organic boundary



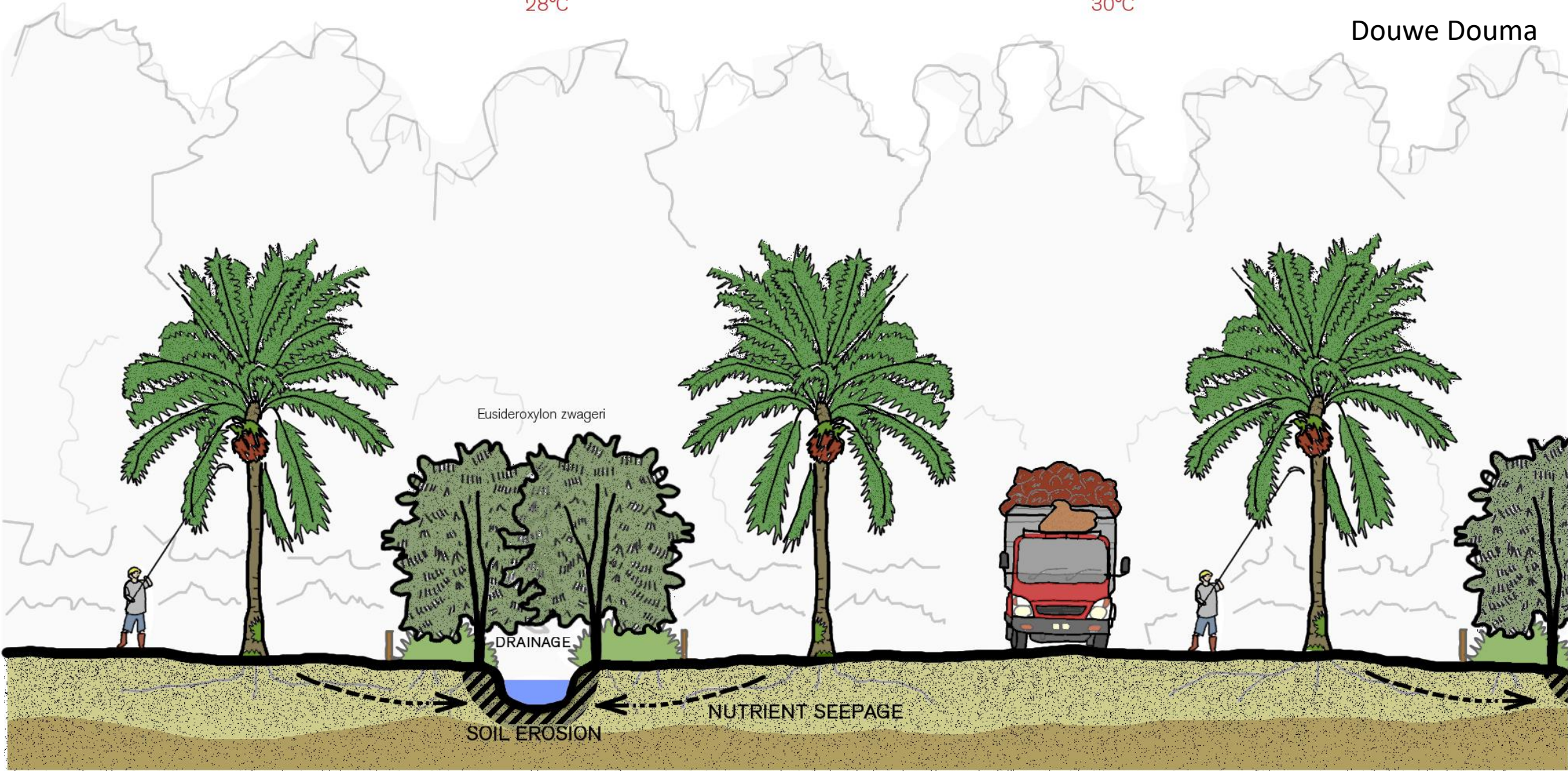
Typical section ditch planting

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28°C

30°C



Eusideroxylon zwageri

DRAINAGE

NUTRIENT SEEPAGE

SOIL EROSION

HARVEST PATH

DITCH PLANTING

HARVEST PATH

DITCH

Boundary planting

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LAYERS

CANOPY
>20m

TREE
~13m

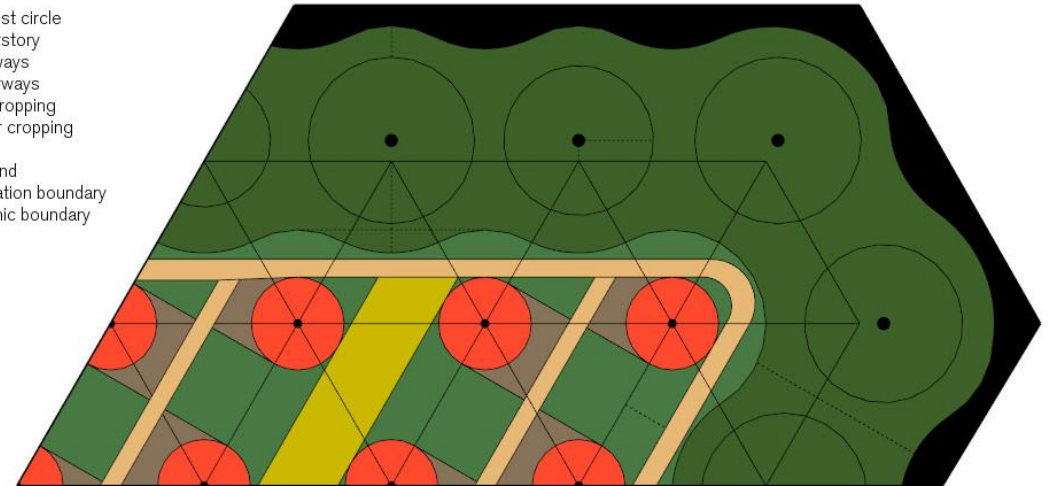
SUB-TREE
~8m

SHRUB
~3m

UNDERGROWTH
ground level



- Harvest circle
- Understory
- Pathways
- Waterways
- Intercropping
- Cover cropping
- Ramp
- Wetland
- Plantation boundary
- Organic boundary

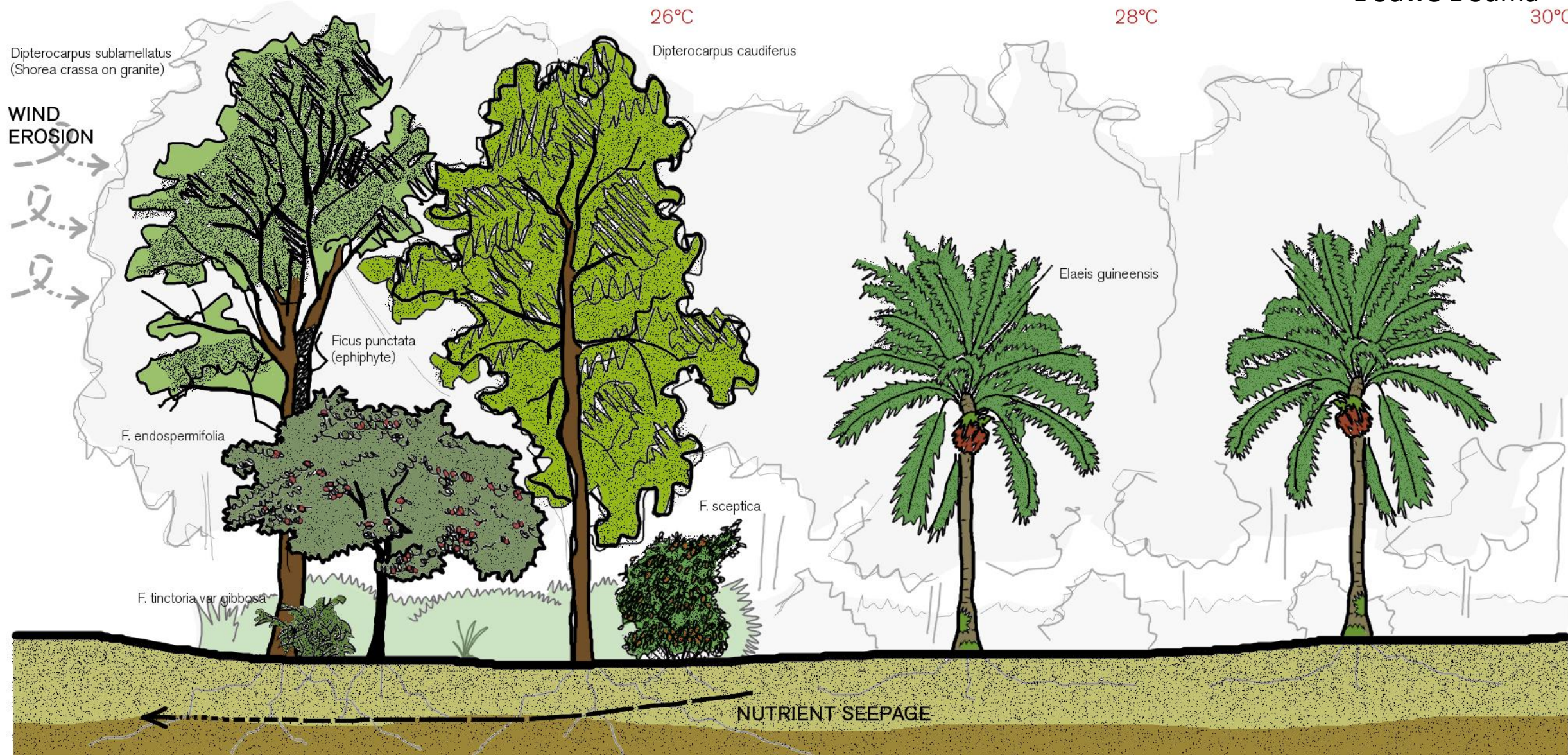


Typical section boundary planting

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30°C



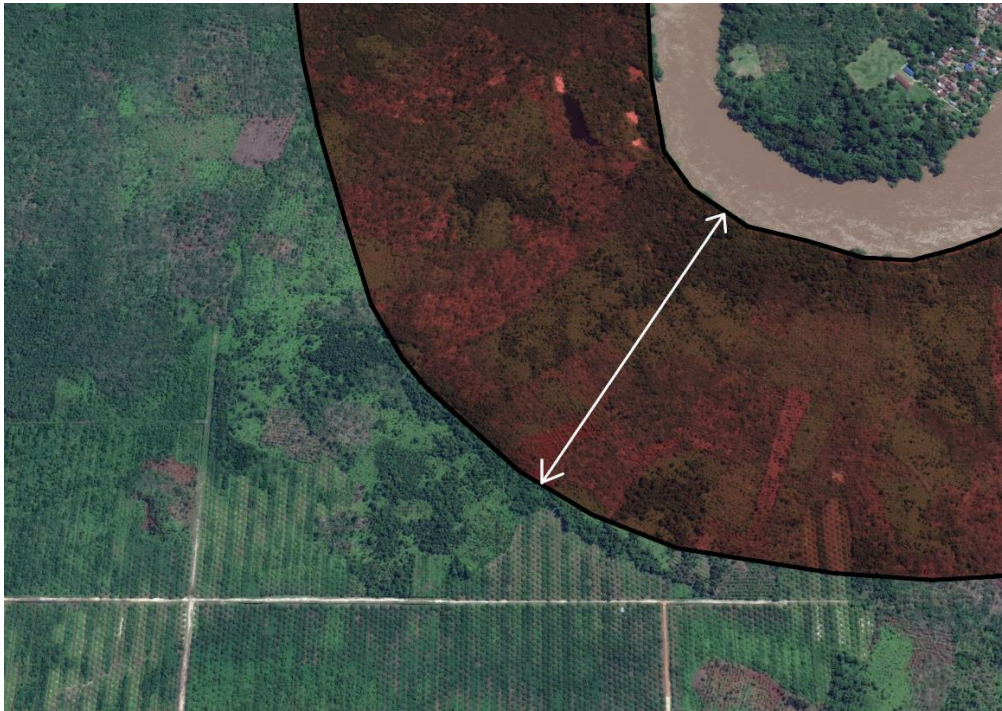
EXTERIOR

BOUNDARY PLANTING

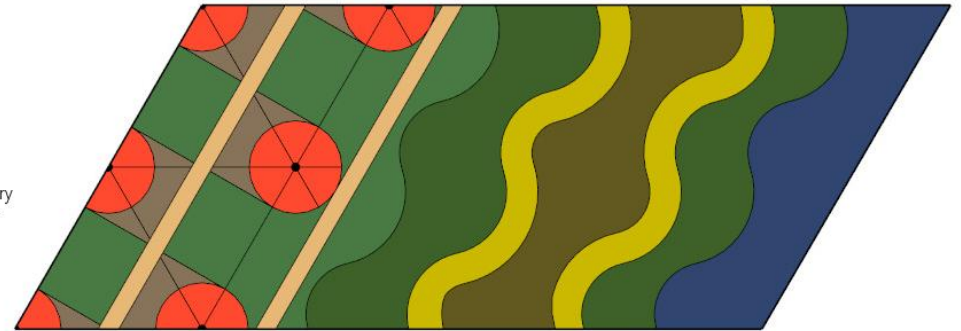
PALM OIL PLANTATION

Restoring riparian buffers

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- Harvest circle
- Understory
- Pathways
- Waterways
- Intercropping
- Cover cropping
- Ramp
- Wetland
- Plantation boundary
- Organic boundary

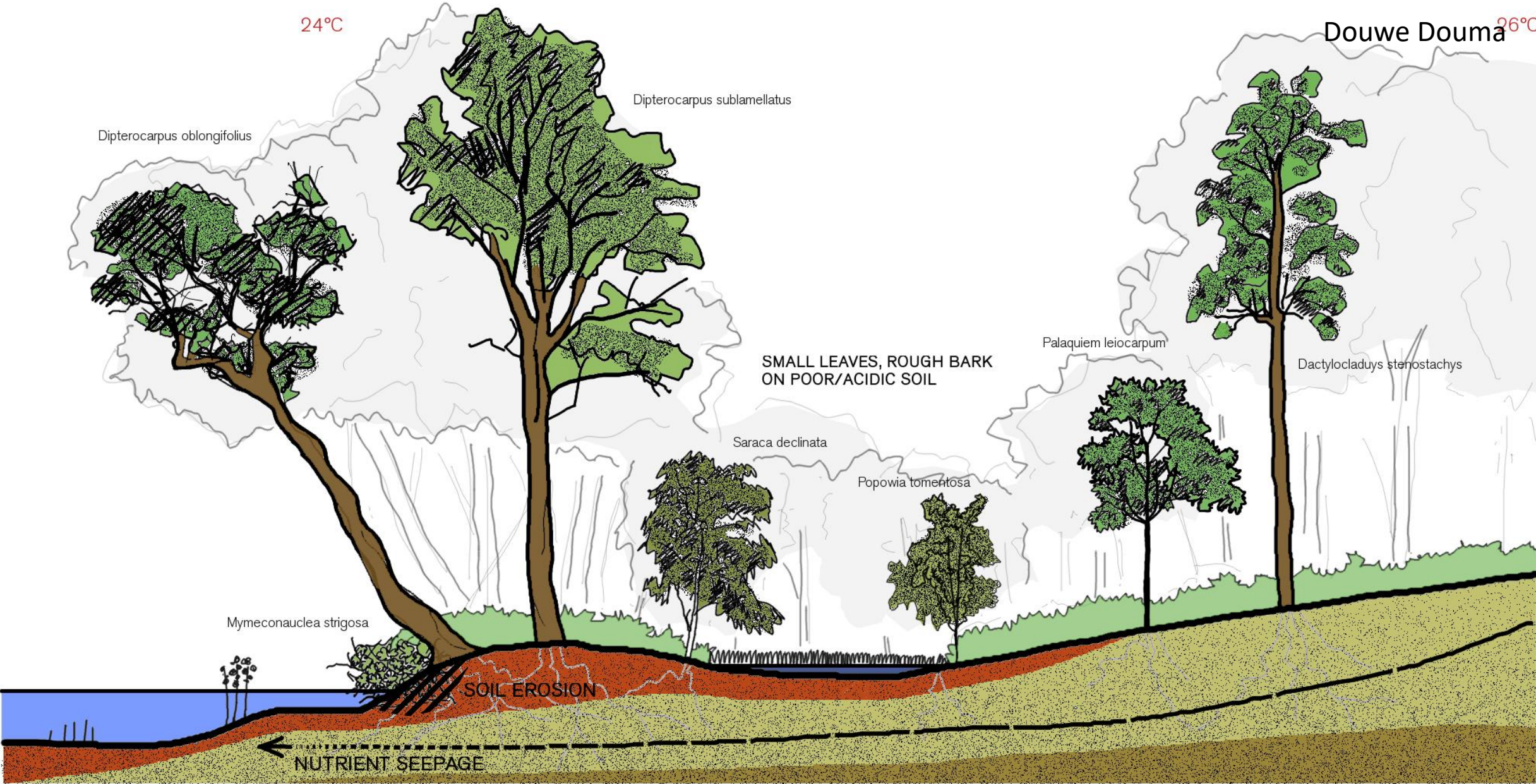


Typical section riparian buffer

38 P5 UM+C

Douwe Douma 26°C

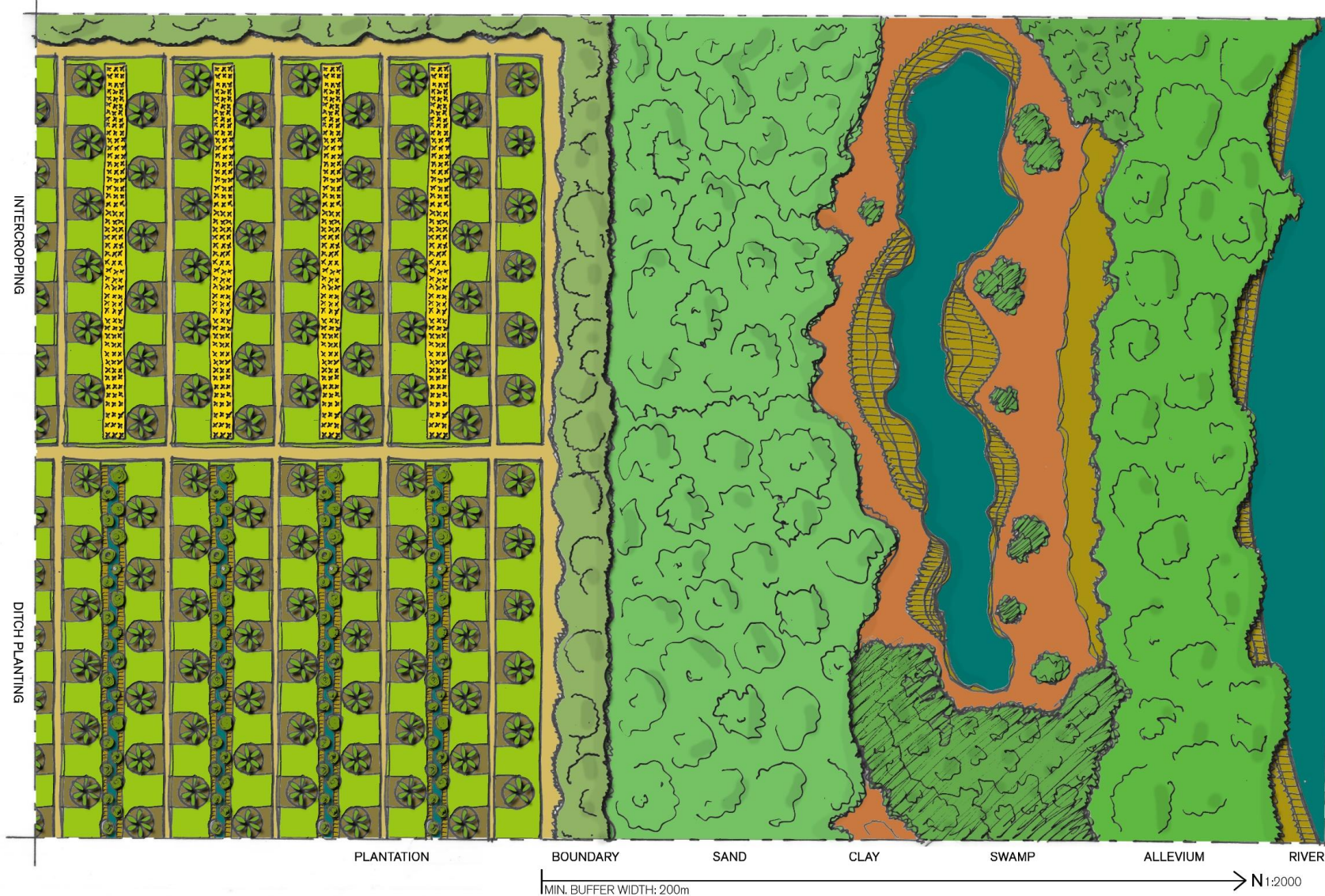
24°C



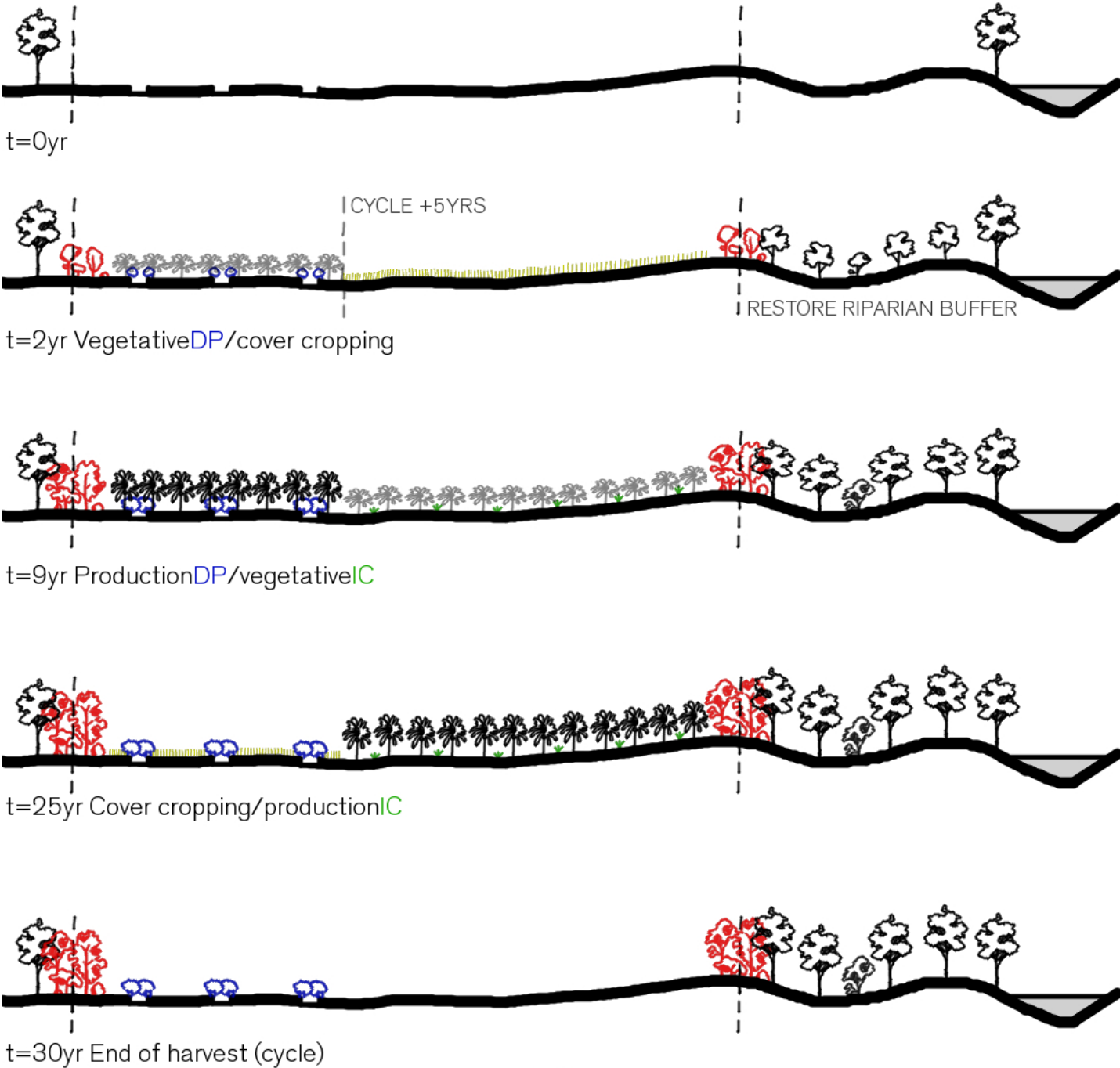
RIVER ——— ALLEVIUM ——— SWAMP ——— CLAY ——— SAND

Pilot plantation overview

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Phasing



- Boundary planting
- Ditch planting
- Inter cropping
- Cover cropping
- Primary forest
- Mature oil palm
- Oil palm seedling

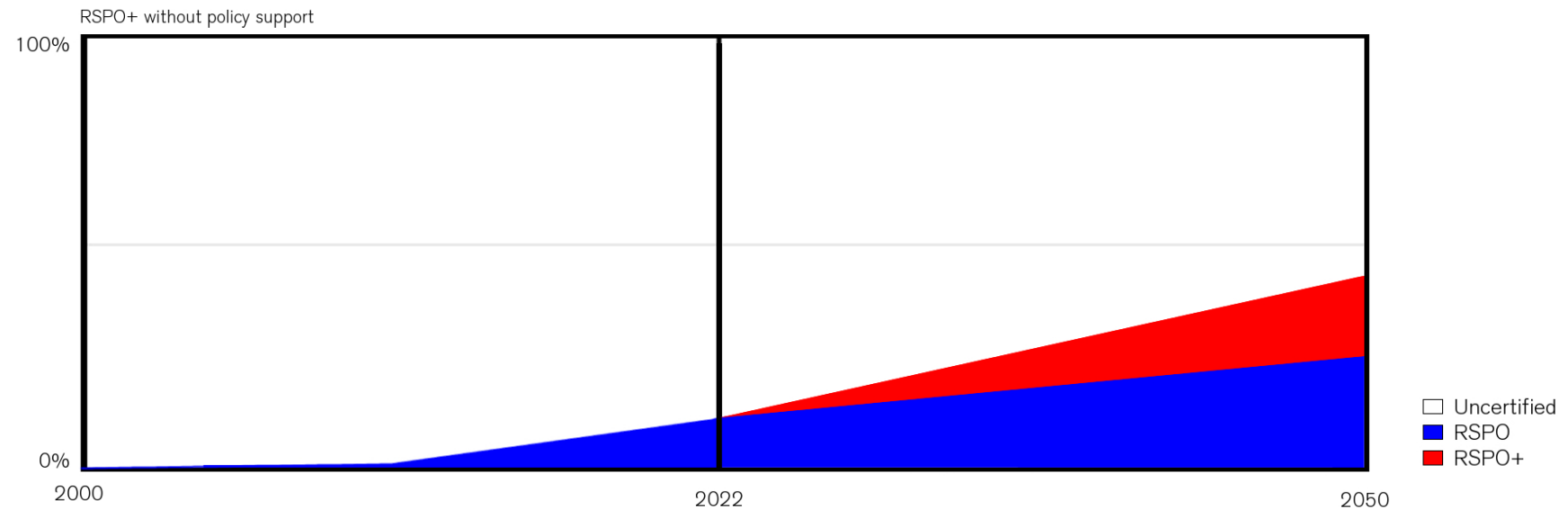
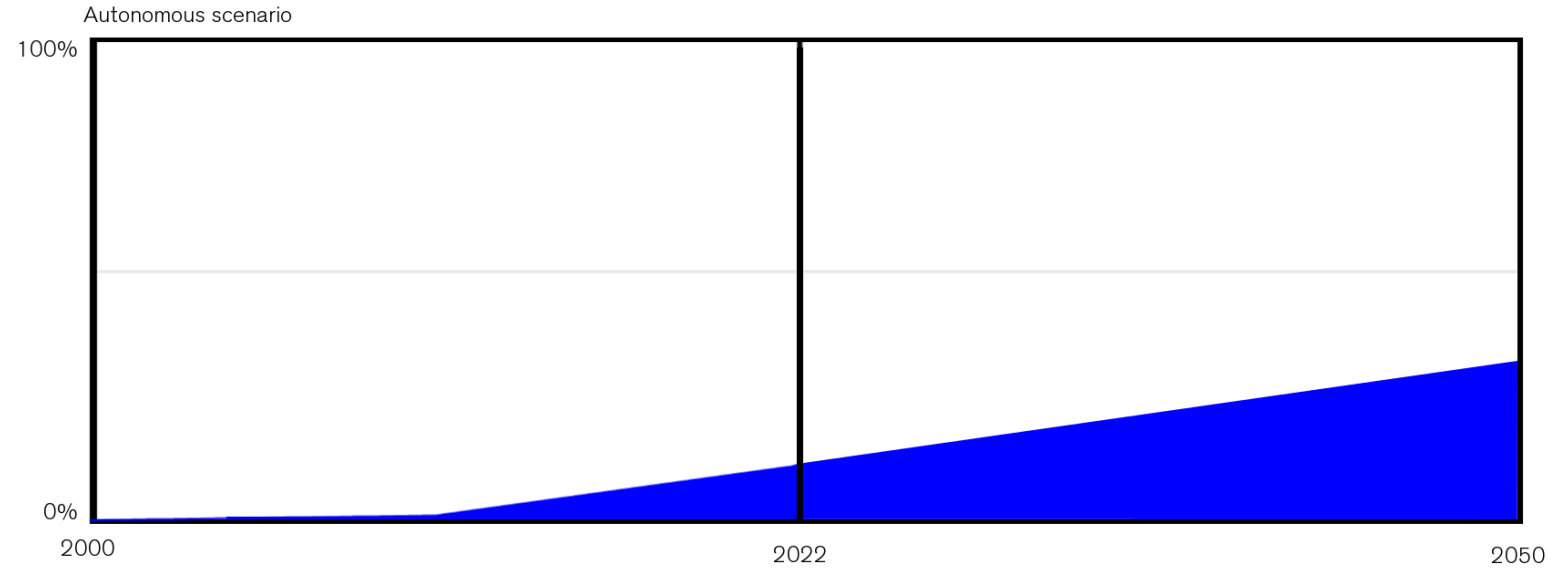
Certification

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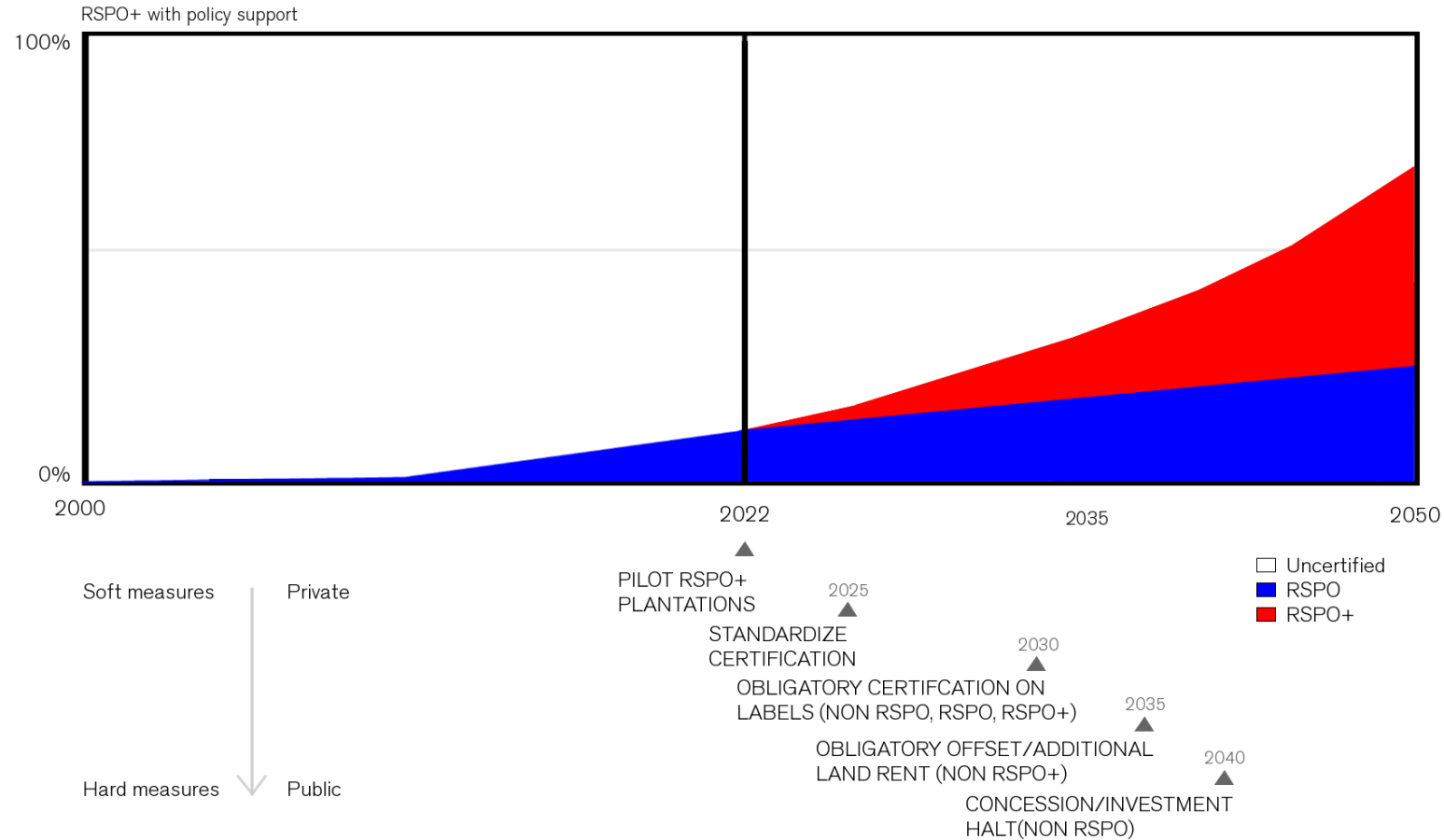
Implementation timeline

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Implementation timeline

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PALM TURMOIL

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