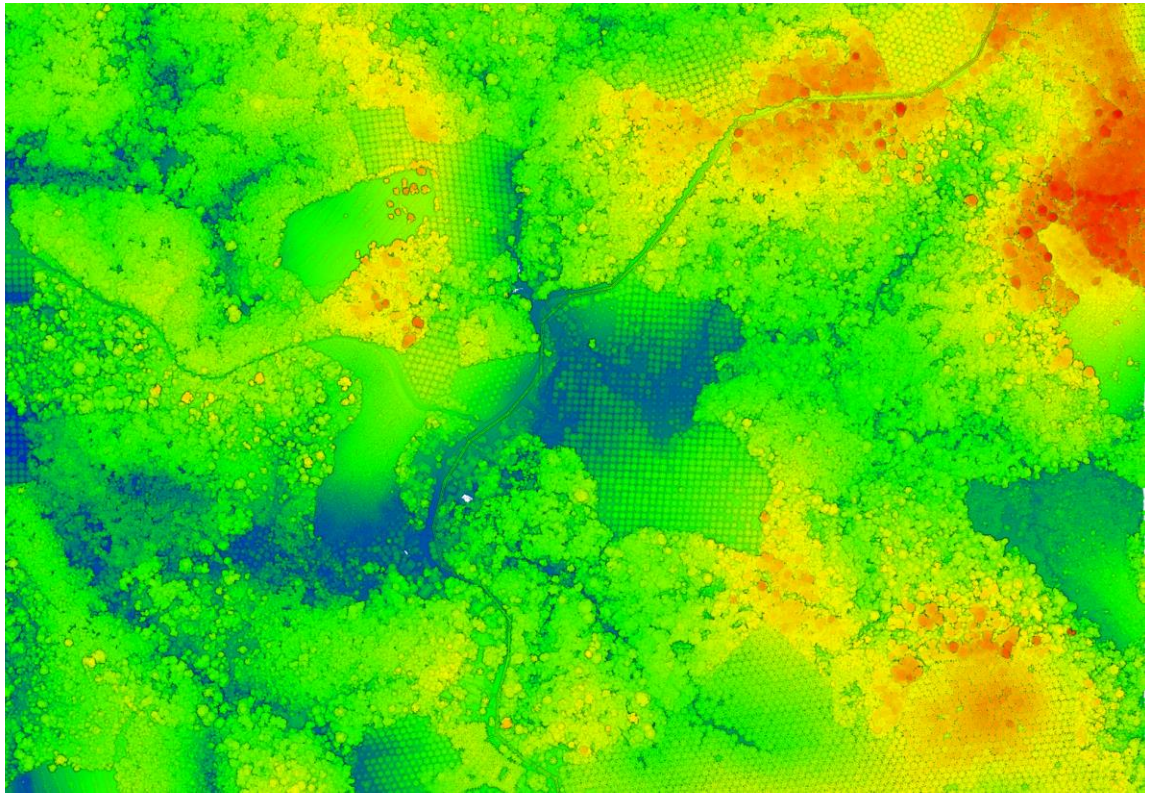
A rapid assessment of microclimate and canopy properties in the tropical lowlands of Jambi province (Sumatra, Indonesia) across 120 plot locations



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Land-use change in Indonesia

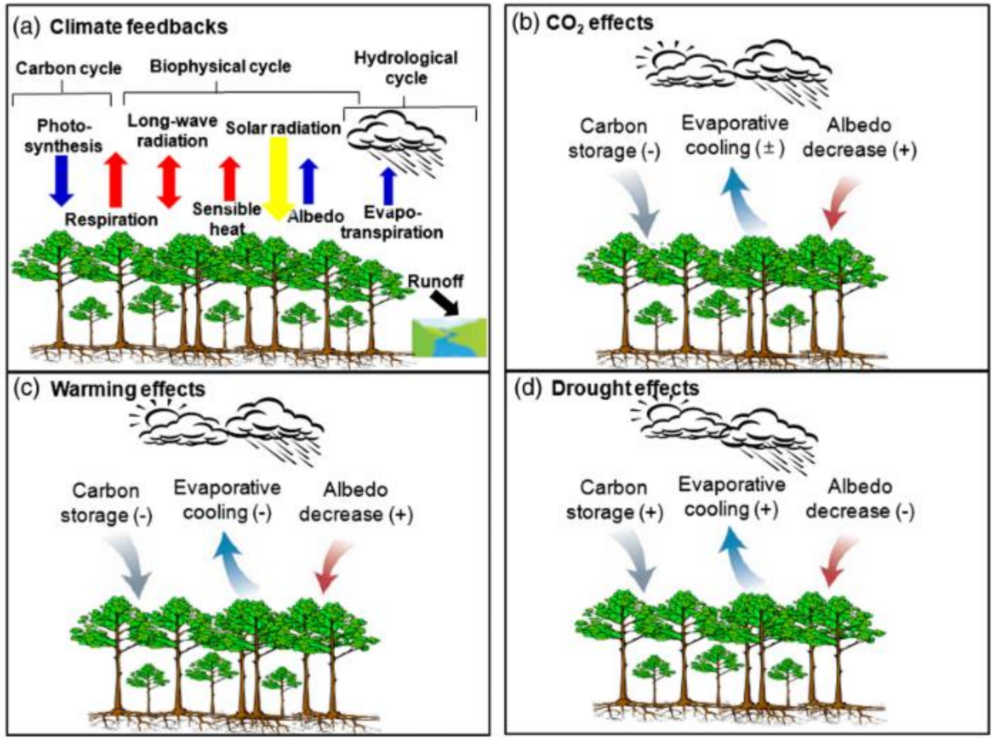
Indonesia is one of the hotspots of land transformation from forest ecosystems toward oil palm and other cash-crop monocultures.

Deforestation arising from cropland expansion in the tropics poses threats to forest ecosystem services, climate regulation and carbon stocks.

Substantial loss of primary forest cover in Indonesia.

- 2001-2016: total loss ~9.2 Mha
  (=size of Portugal, or ~90% of South Korea, or Maine (USA))

Picture credit: Dipa



Zhou et al. (2013)

Rapid Assessment: Study aim & hypothesis

Study aim:

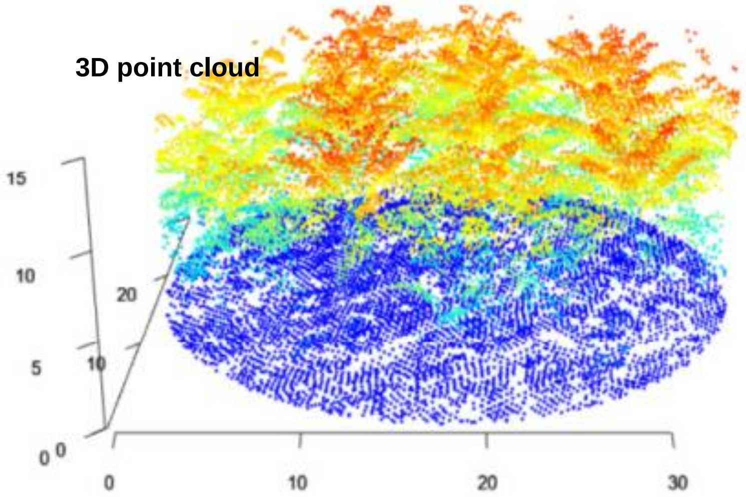
- Asses below-canopy microclimate and its spatial small-scale variability within the most common land-use types in tropical lowland Jambi province (Sumatra, Indonesia) using *a Rapid (Ecological) Assessment* approach.
- Explore functional relationships between microclimate and vegetation characteristics.
- Create microclimatic maps of the study area.

Hypothesis:

- Agricultural land-use systems (e.g. oil palm & rubber monocultures) with their lower vegetation structural complexity, have warmer and drier microclimates and reduced microclimatic buffering capacities compared to forest systems.

Picture credit: Basri

3D point cloud



Study area

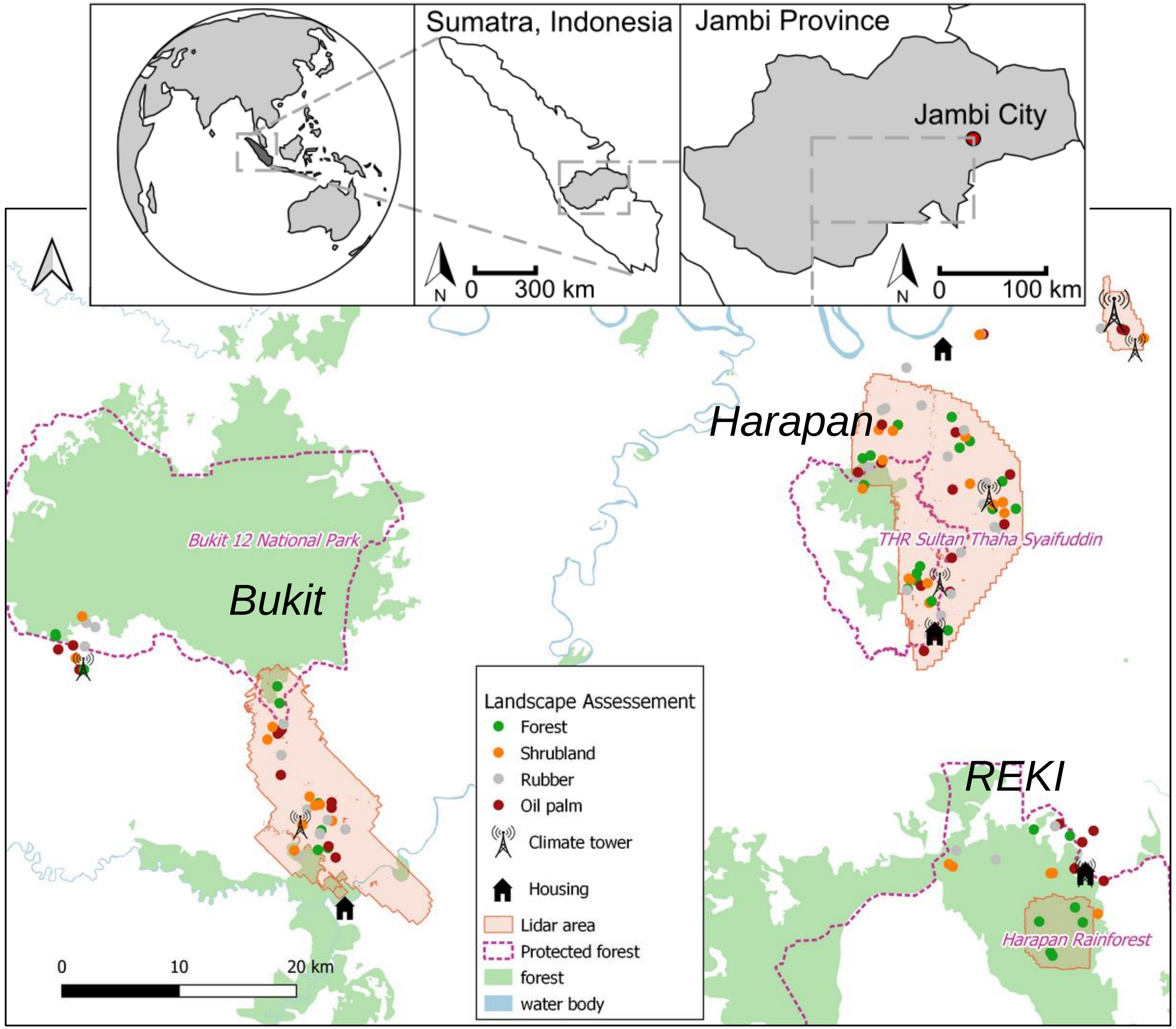
Study area:
Tropical lowland Jambi Province, Sumatra, Indonesia

3 landscapes:
"*Bukit*", "*Harapan*" & "*REKI*"

4 main land-use types:
Forest, oil palm & rubber plantations, shrub (fallow) land

132 locations → "plots"

Duration:
May – November 2021



Source: Stiegler et al., 2019, EFForTS-sharepoint

Instrumentation

Micrometeorological measurements:

- "Mini meteo stations" *ClimaVUE 50 Compact Digital Weather Sensor*, Campbell Scientific; *TRIME-PICO32* soil moisture & temperature)

- Measured parameters:
  - Air temperature
  - Air relative humidity
  - Air pressure
  - Air vapor pressure
  - Wind speed
  - Wind direction
  - Solar radiation
  - Precipitation
  - Lightning (lightning strike count, lightning average distance)
  - Soil moisture
  - Soil temperature

Picture credit: Basri

Airborne laser scanning (*ALS*) & hyperspectral parameters:

- Collected on seven separate days between 24 January and 5 February 2020, covering a total surface of 434,14 km^2.

- BN2T fixed-wing aircraft, *Riegl LMS-Q780* full waveform scanner.

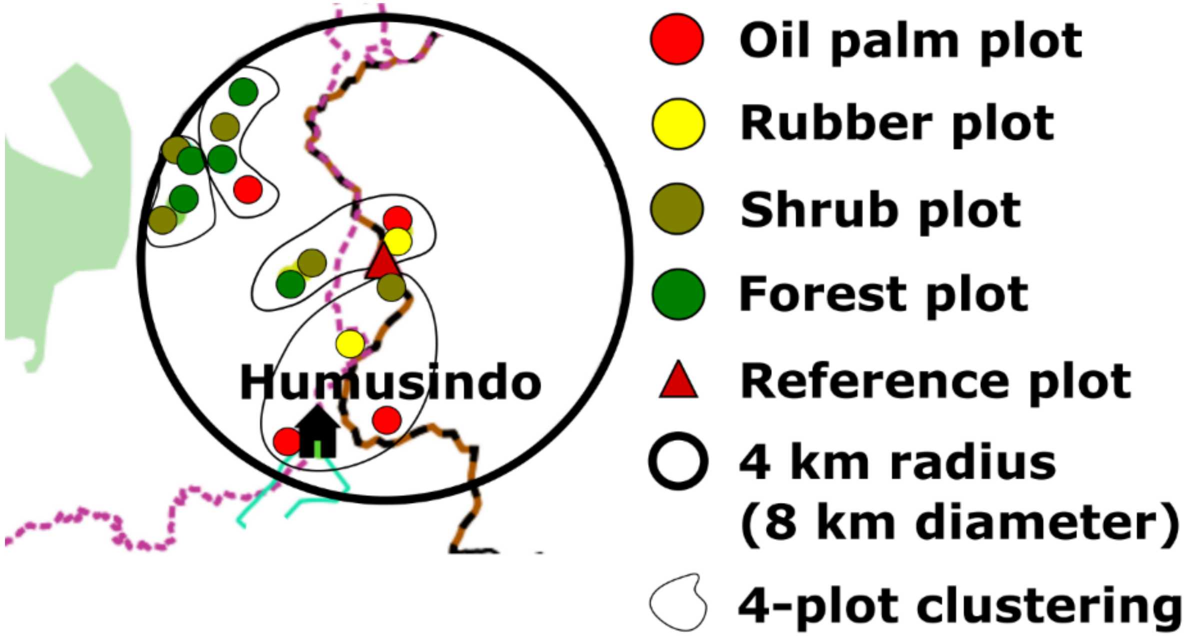
Picture credit: Riegl.com

- For each individual site, a suite of ALS-derived metrics was computed, e.g.:
  - Vegetation height
  - LAI, NDVI
  - Complexity/heterogeneity measures (rumple index, etc.)
  - Measures of vertical (e.g. foliage height diversity) and horizontal structure (e.g. canopy gaps)

Measurement design

- The entire study region is divided into 16 micro-regions.
- Each micro-region has a radius of 4 kilometers.
- Within each micro-region, a reference meteorological station is installed in an open area.
- During one set of measurements (4-plot clustering), one station is installed at each of the 4 plots. After 2 days of measurements, the meteo stations are moved to 4 new plots.

Example of a micro-region



Reference (open-land)

Oil palm plot

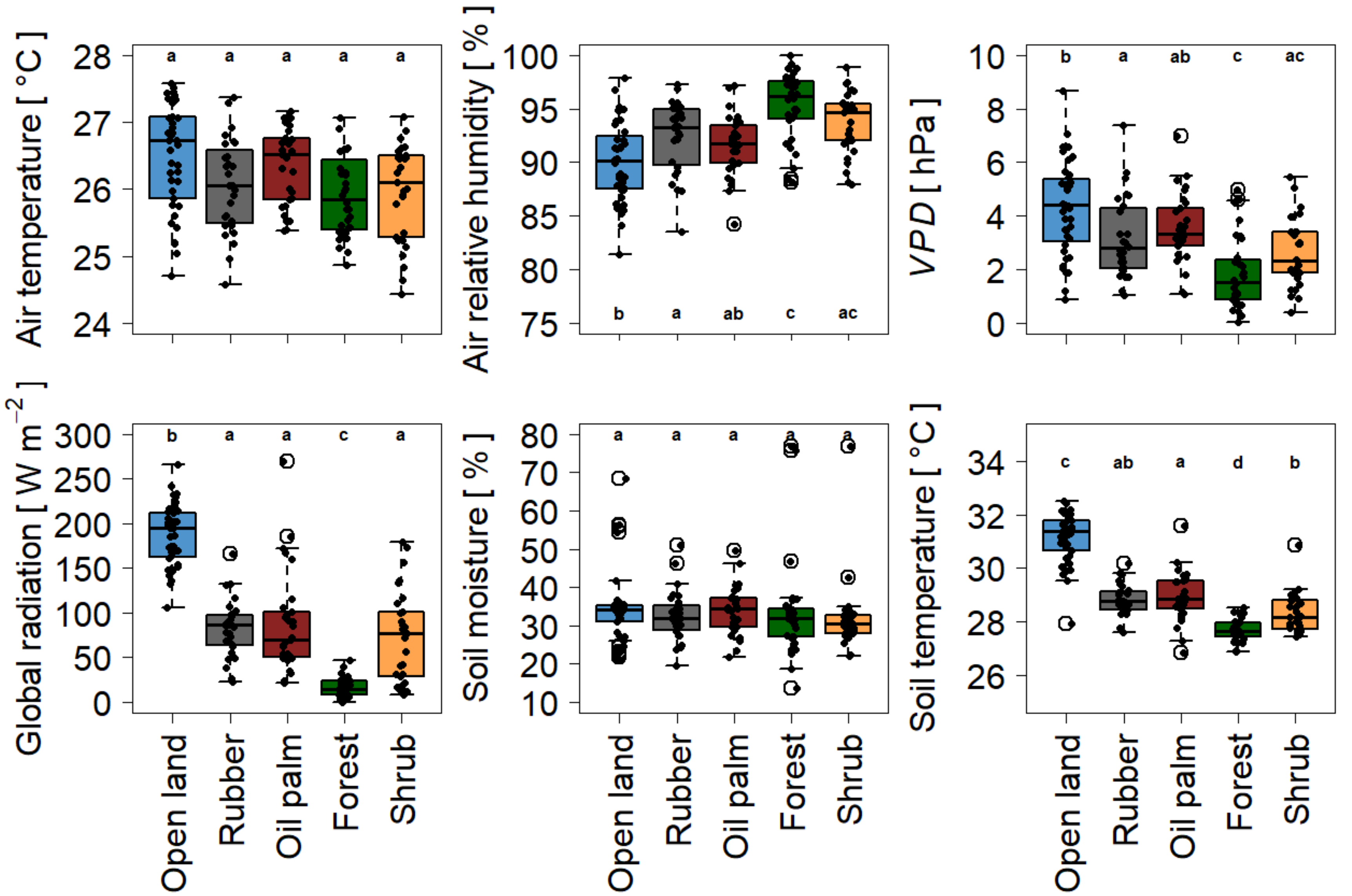
Shrub plot

Forest plot

Rubber plot

Picture credits: Basri, Bayu, Tika, Alifian

Average microclimatic conditions



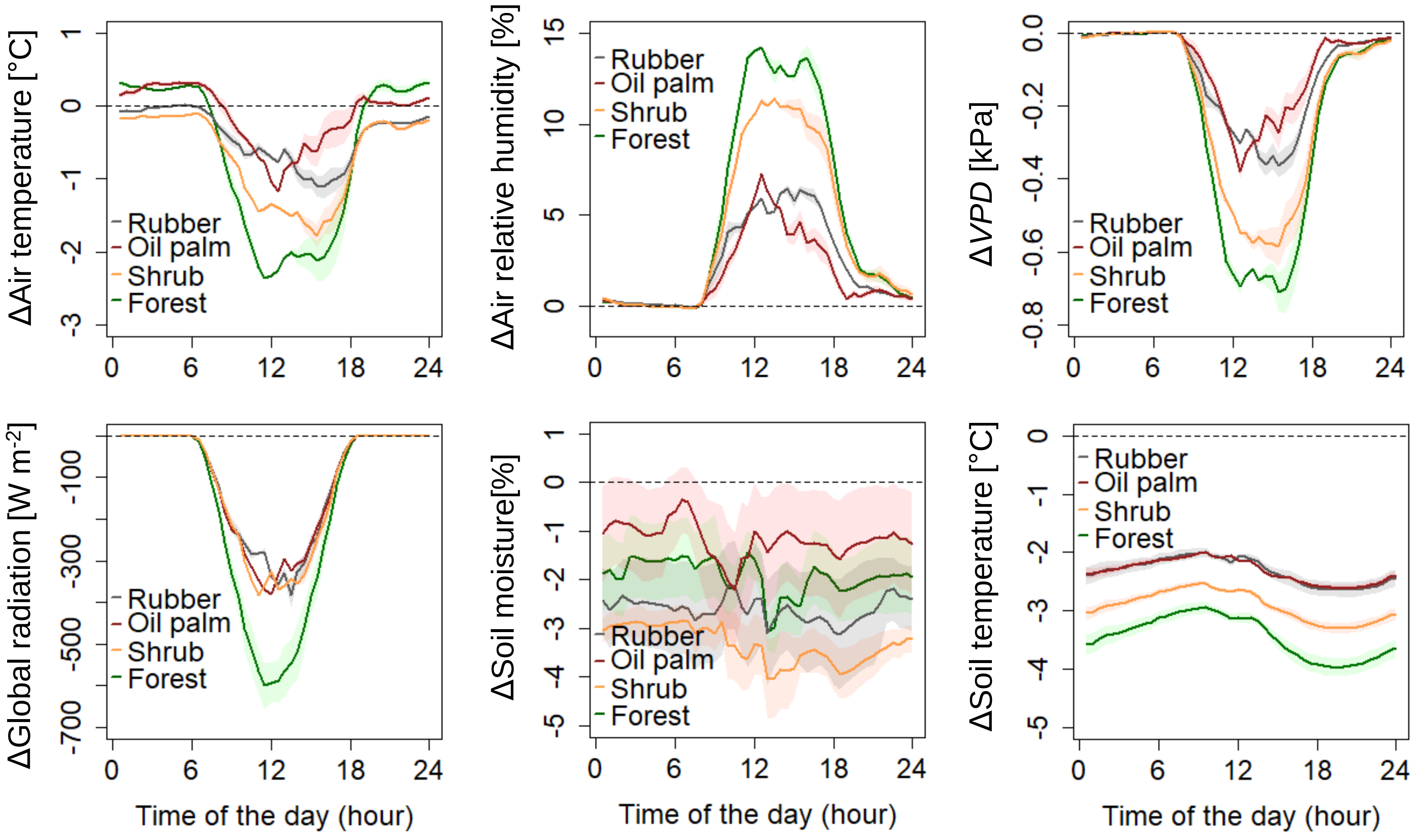
Forests and shrub (fallow) land sites are generally cooler, wetter, and receive lower radiation compared to agricultural systems and open land.

Sample size:

- Forest: 32
- Oil palm: 29
- Shrub: 29
- Rubber: 28
- Open-land locations: 41

Diel microclimatic patterns

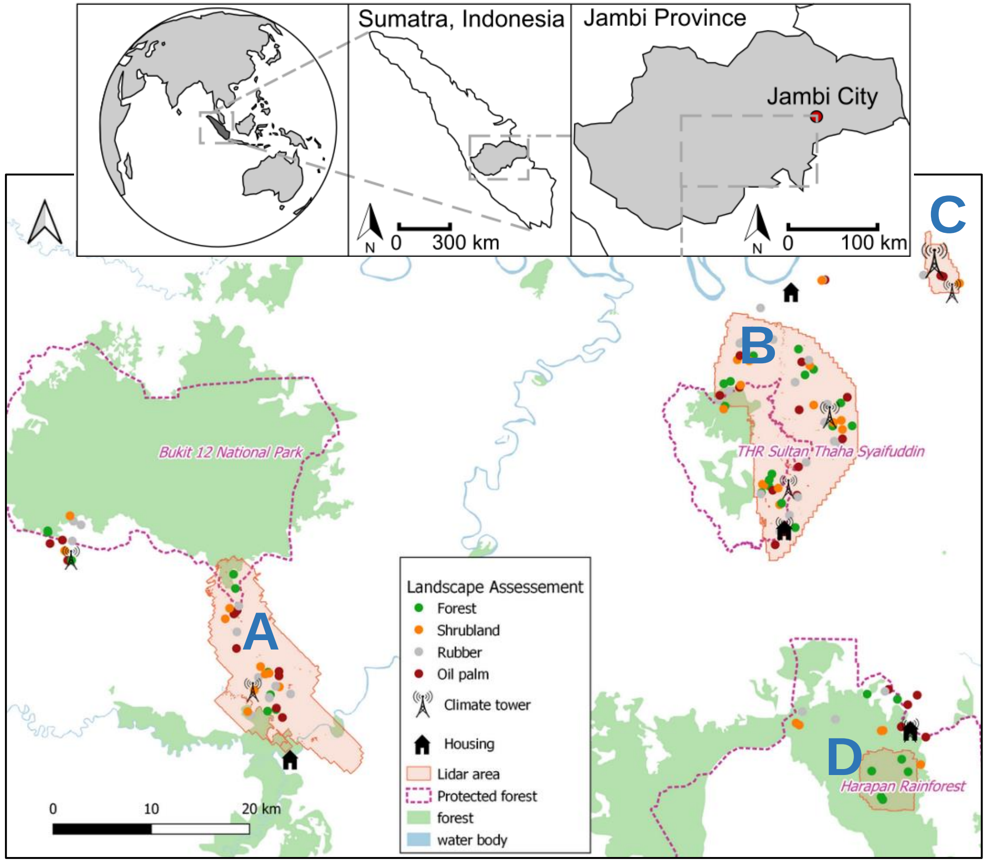
Diel microclimatic differences (*Δ*) compared to open land

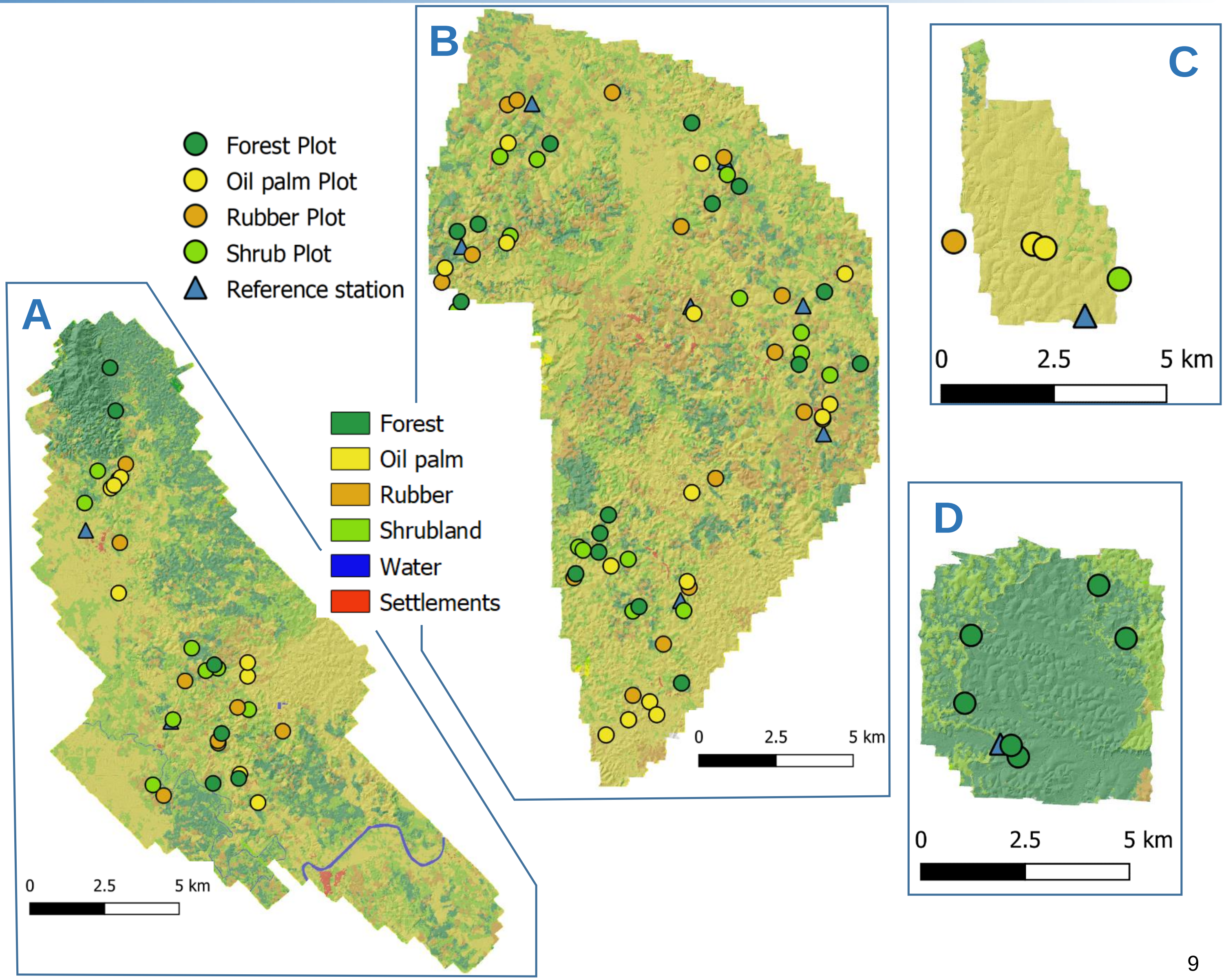


On a diel scale, differences in meteorological conditions are most pronounced around noon and in the afternoon hours.

Forests showed strongest buffering capacities.

Land cover

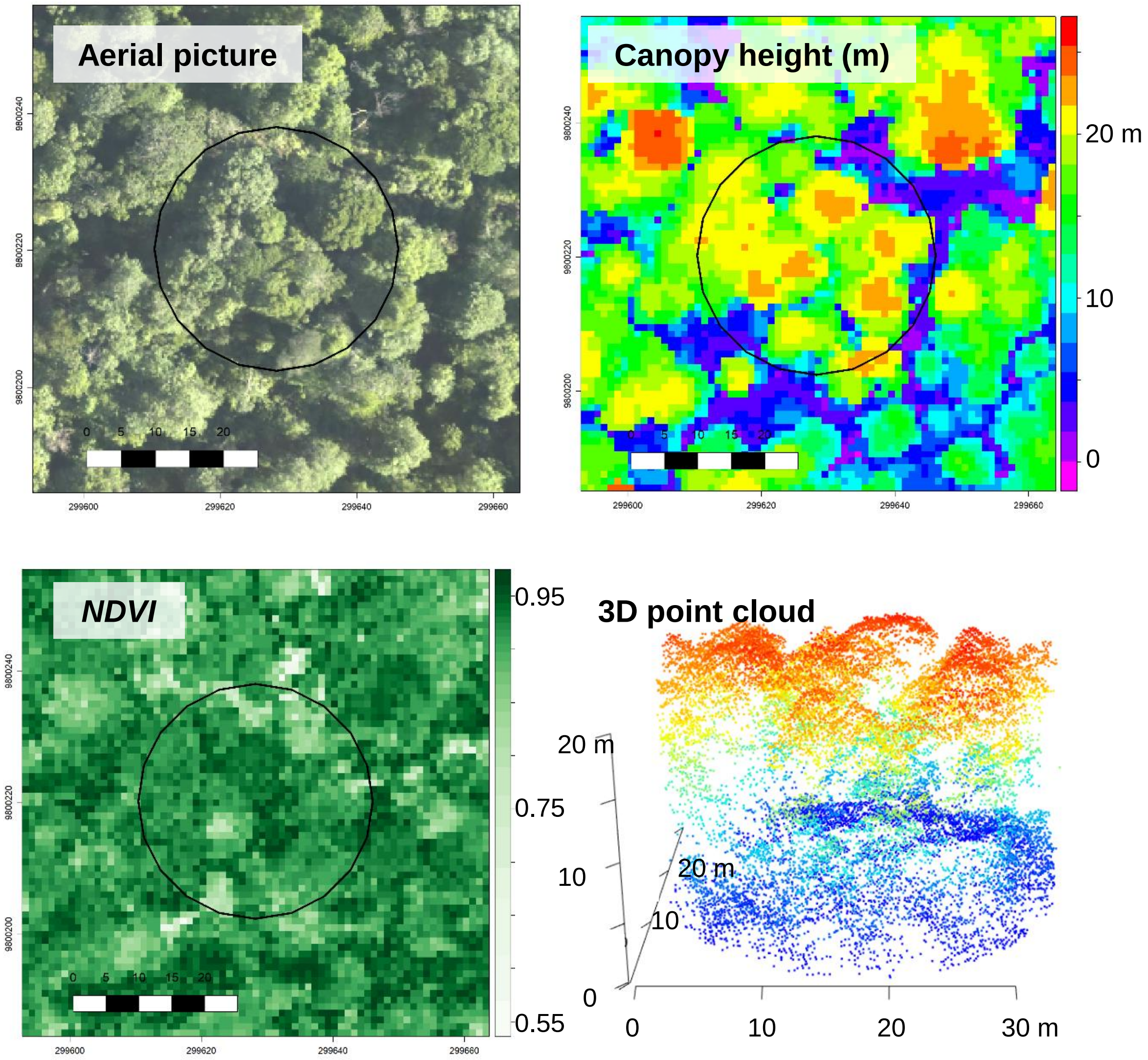




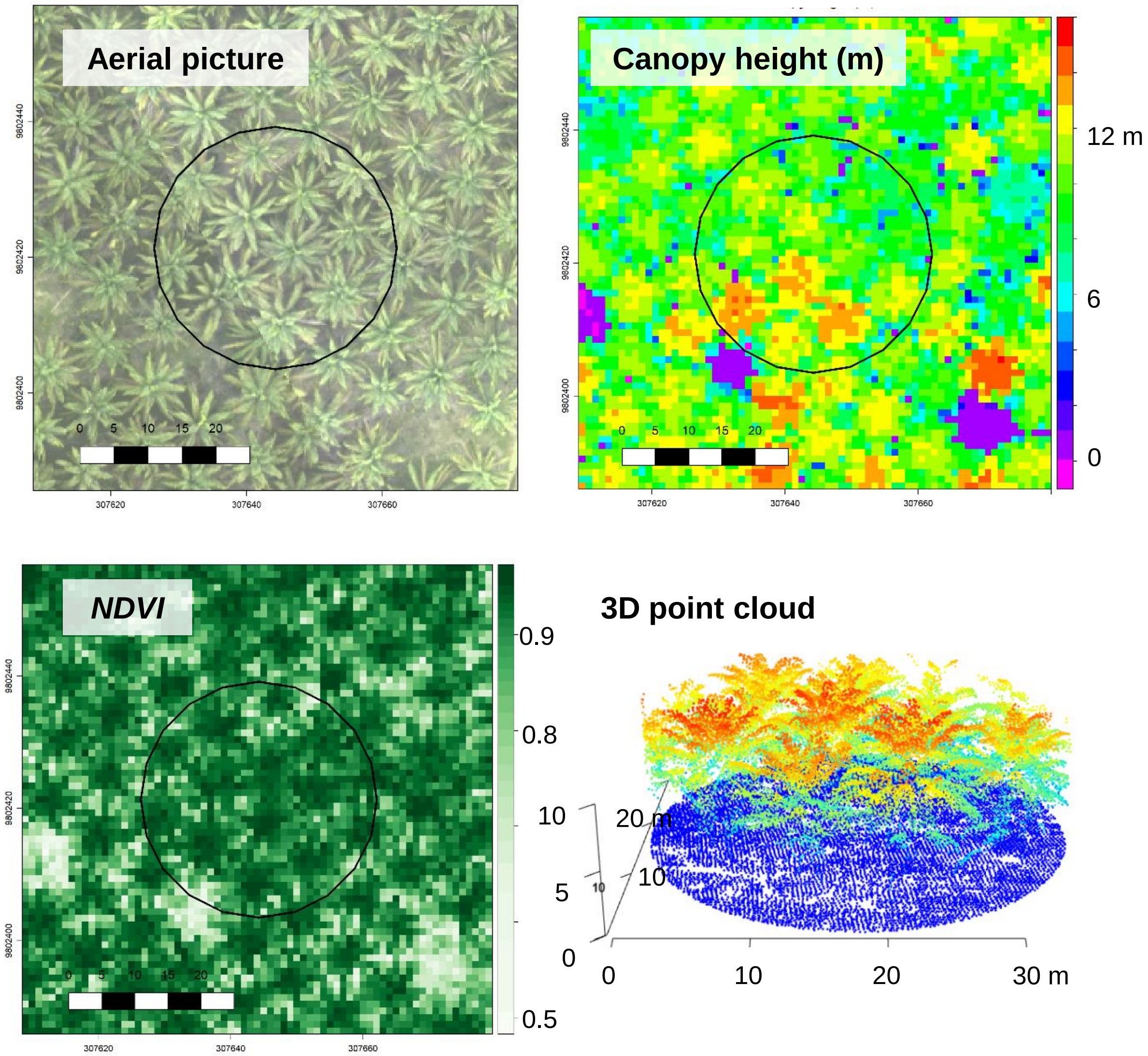
The study region is characterized by high land cover heterogeneity, with monoculture plantations dominating.

Vegetation structural characteristics

Forest

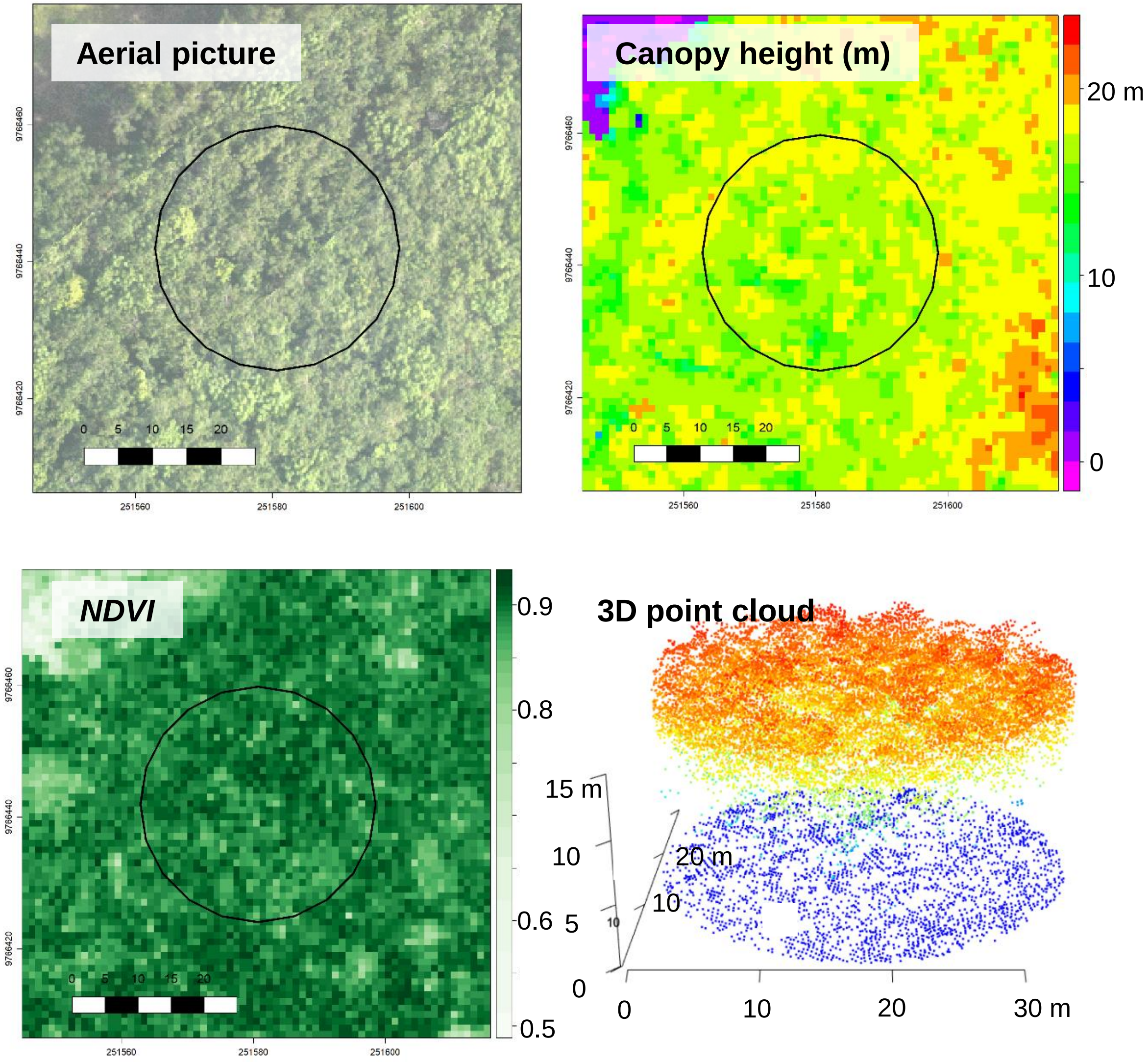


Oil palm

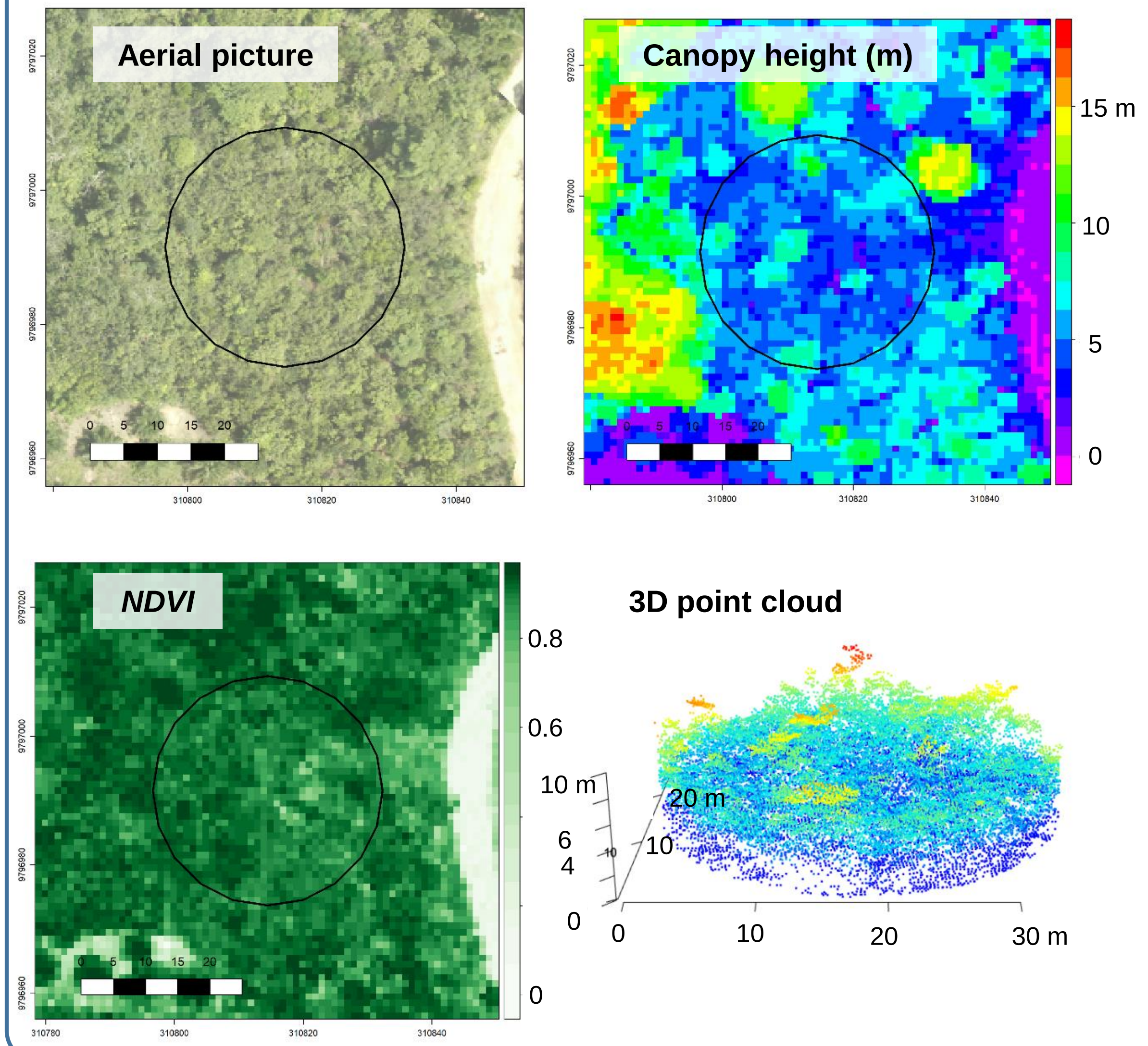


Vegetation structural characteristics

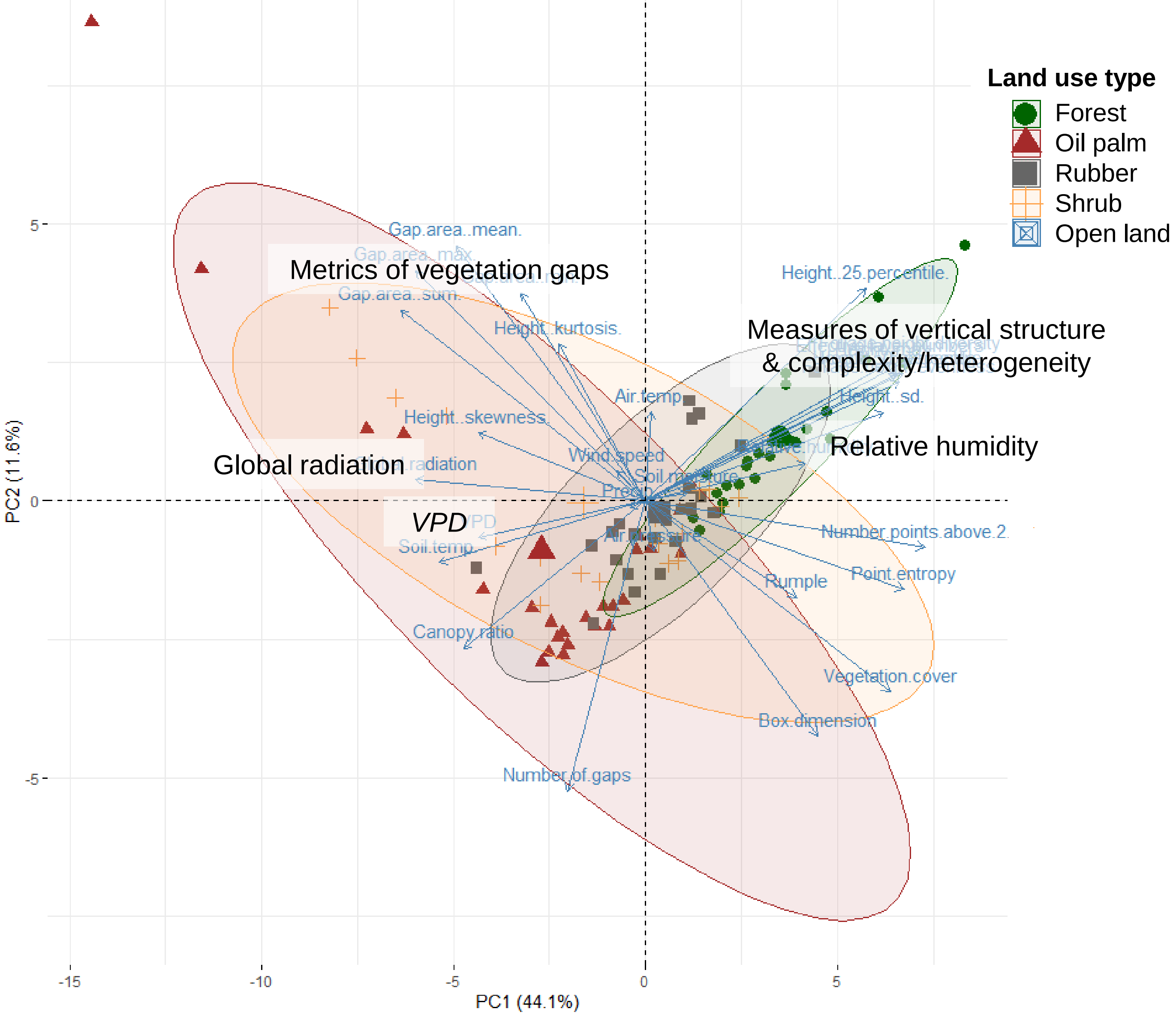
Rubber



Shrub



PCA of ALS metrics and microclimatic conditions

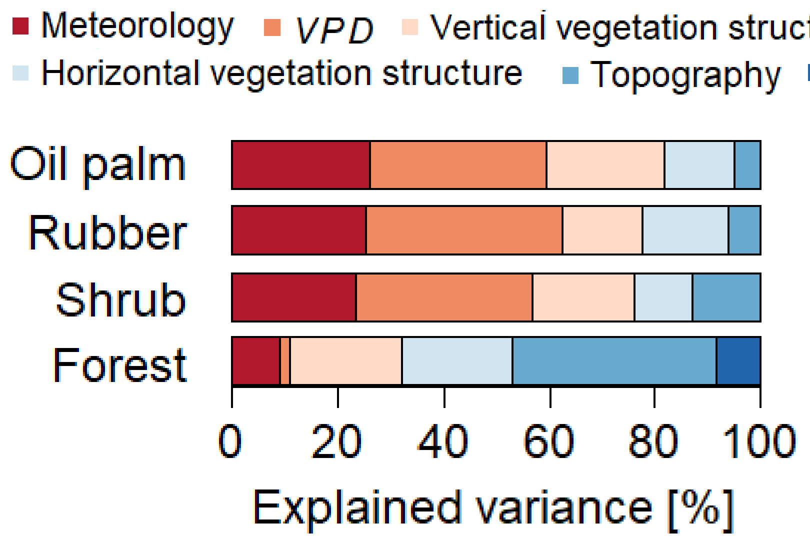


Stand summary statistics (e.g. *LAI*), measures of vertical structure (e.g. height, foliage height diversity), measures of complexity & heterogeneity (e.g. rumple) and air humidity seemed to be mostly related to forest and partly to rubber locations.

Below-canopy global radiation, vapor pressure deficit and metrics of vegetation gaps, were mainly related to oil palm plantations and shrub (fallow) lands.

Variance in mean air temperature and *VPD*

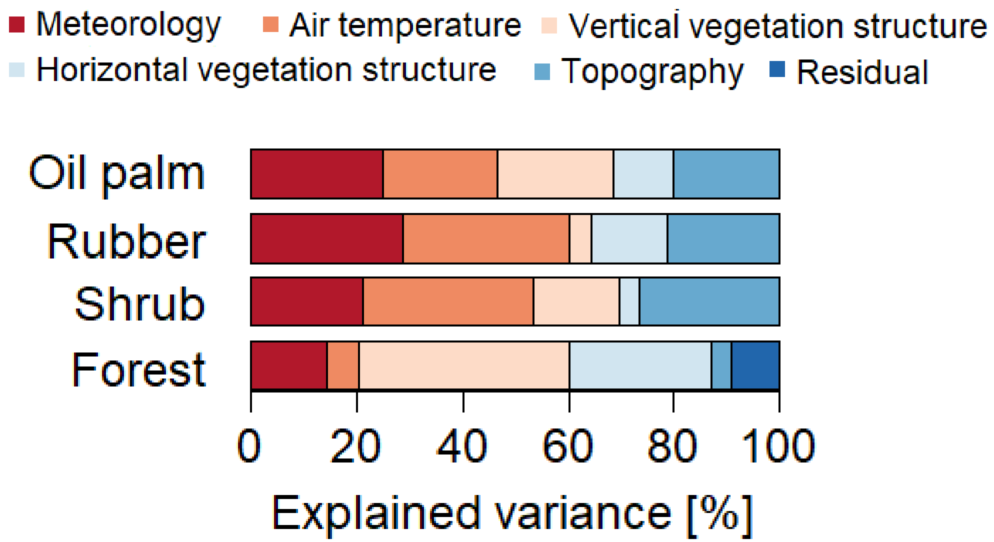
Explained variance (R^2) in mean air temperature



In oil palm, rubber and shrub, regression models explained most of the variance in mean air temperature by meteorological conditions and *VPD*.

In forests, it is horizontal and vertical vegetation structure and topography.

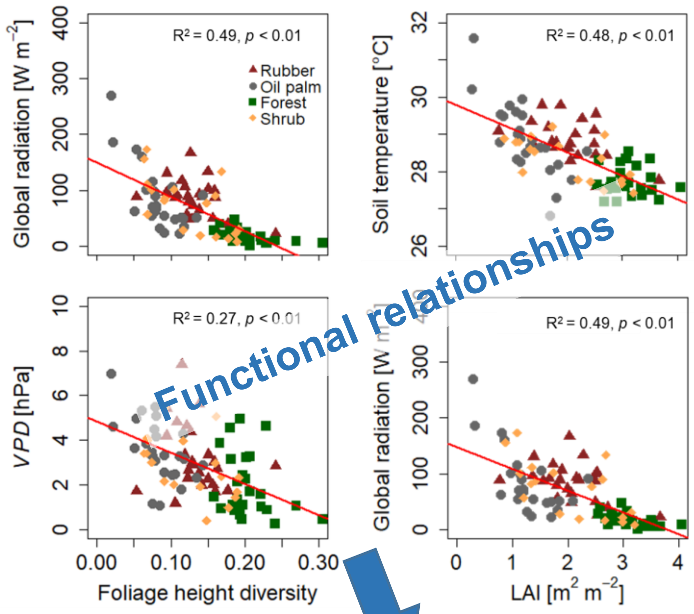
Explained variance (R^2) in mean *VPD*



In oil palm, rubber and shrub, regression models explained most of the variance in mean *VPD* by meteorological conditions, air temperature and topography.

In forests, it is horizontal and vertical vegetation structure.

Outlook: Landscape-scale maps of microclimate



Functional relationships

Multiple linear regression model

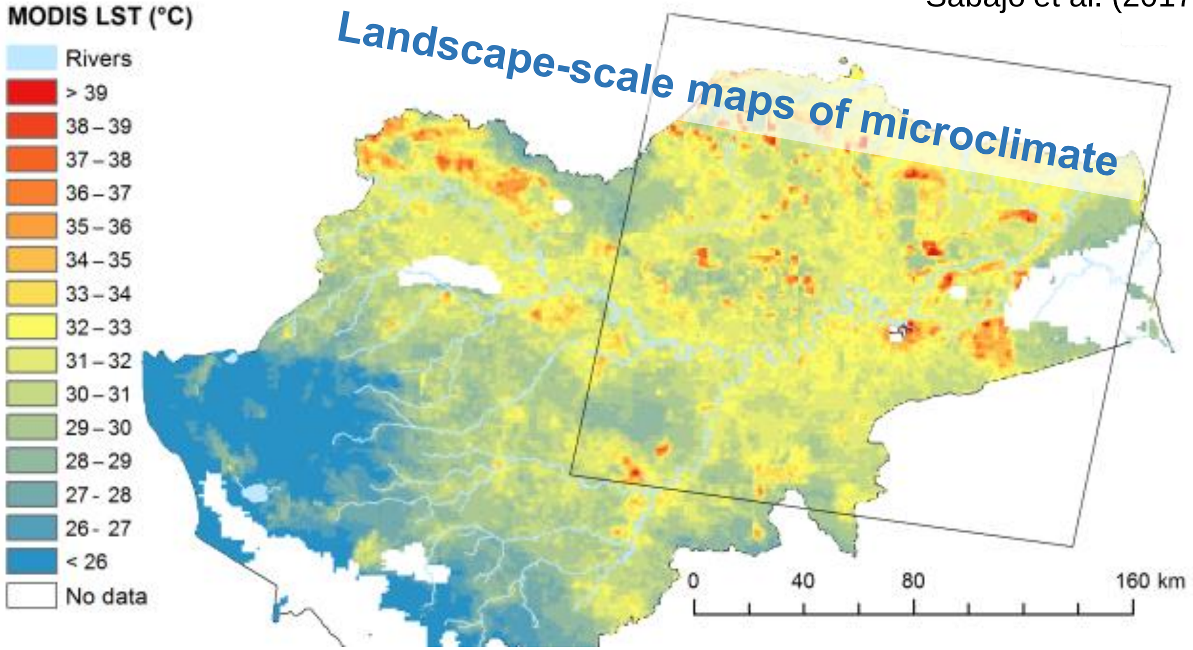

Journal of Applied Ecology

Impacts of forest management on stand and landscape-level microclimate heterogeneity of European beech forests

Journal:	Journal of Applied Ecology
Manuscript ID	JAPPL-2022-00358
Manuscript Type:	Research Article
Date Submitted by the Author:	03-Jun-2022

Menge et al. (in review)

Sabajo et al. (2017)



Landscape-scale maps of microclimate

Based on functional relationships and a multiple linear regression model approach, developed by Menge et al. (in review), we aim to facilitate comparison of microclimate heterogeneity and diversity of microclimates on a landscape-scale.

Summary

- We sampled 118 plots and 15 open-land locations.
- We observed a relatively high variability of meteorological parameters even within the same land-use types and micro-region.
- Forest sites are generally cooler, wetter and possess stronger buffering capacities compared to the other land-use types.
- Forest microclimates can be described mainly by their vegetation structural complexity (e.g. foliage height diversity, leaf area index) while microclimates of oil palm, shrub and rubber are more characterized by (landscape- and small-scale) meteorology and vegetation gaps.
- Next step: Generate landscape-scale maps of microclimate (α-, β-, and γ-diversity).

Source: EFForTS-instagram

A BIG THANKS TO OUR INDONESIAN ASSISTANTS!!!!

Basri

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Alifian

THANK YOU FOR YOUR ATTENTION! Questions?

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