QUANTIFYING STRUCTURAL RESPONSE TO WATER AVAILABILITY USING TERRESTRIAL LASER SCANNING

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Living Planet 2022

CONTEXT

- Forest ecosystem services

- Climate change
  - T, rainfall seasonality ↑

    ↓

  - hotter & drier climates
  - frequency droughts ↑

↕ Link?

- Forest/tree structure

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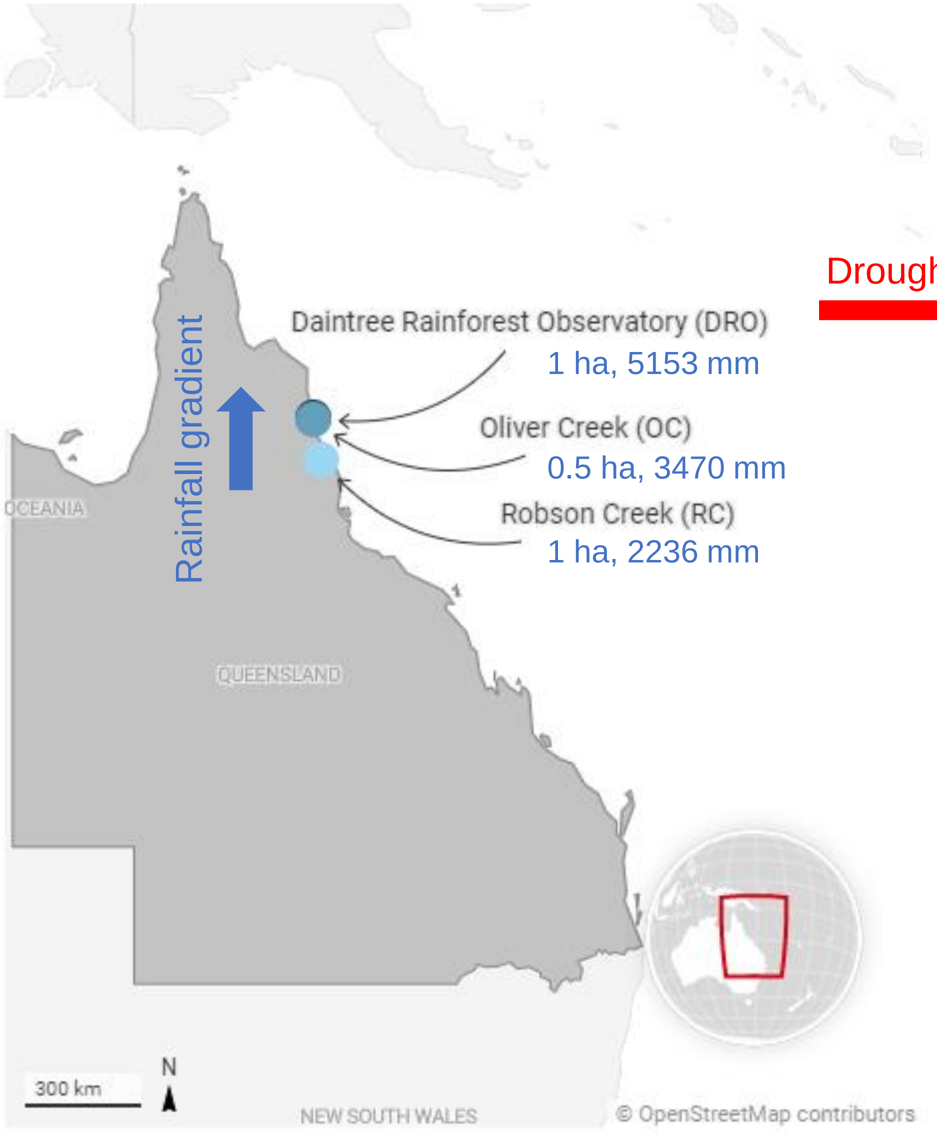
OBJECTIVES

- Differences in tree structures in wet tropical forest sites with ≠ water availabilities?
  - rainfall gradient
  - drought experiment

- How do different species contribute to the overall structural diversity?

SITES



Map: Louise Terryn • Created with Datawrapper

Drought experiment

Soil water availability -30%

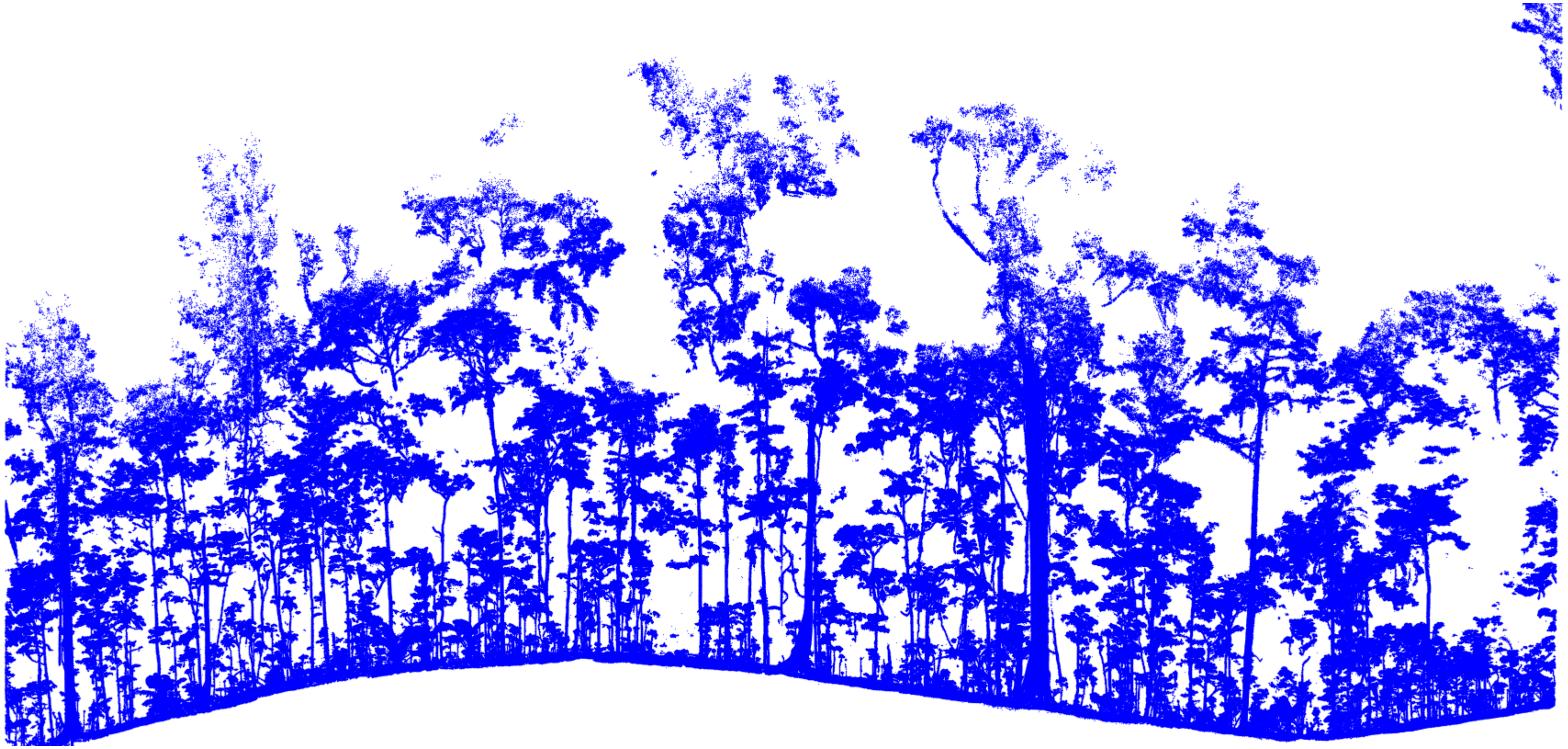
(Vogado et al., 2020)

Modifying hydraulic architecture

(Tng et al., 2018)

LASER SCANNING

- TLS (2018)
  - RIEGL VZ-400
  - 10 m x 10 m regular grid
  - Reflective targets



TREE SEGMENTATION

DRO	OC	RC
33 (control) + 26 (experiment)	32	57

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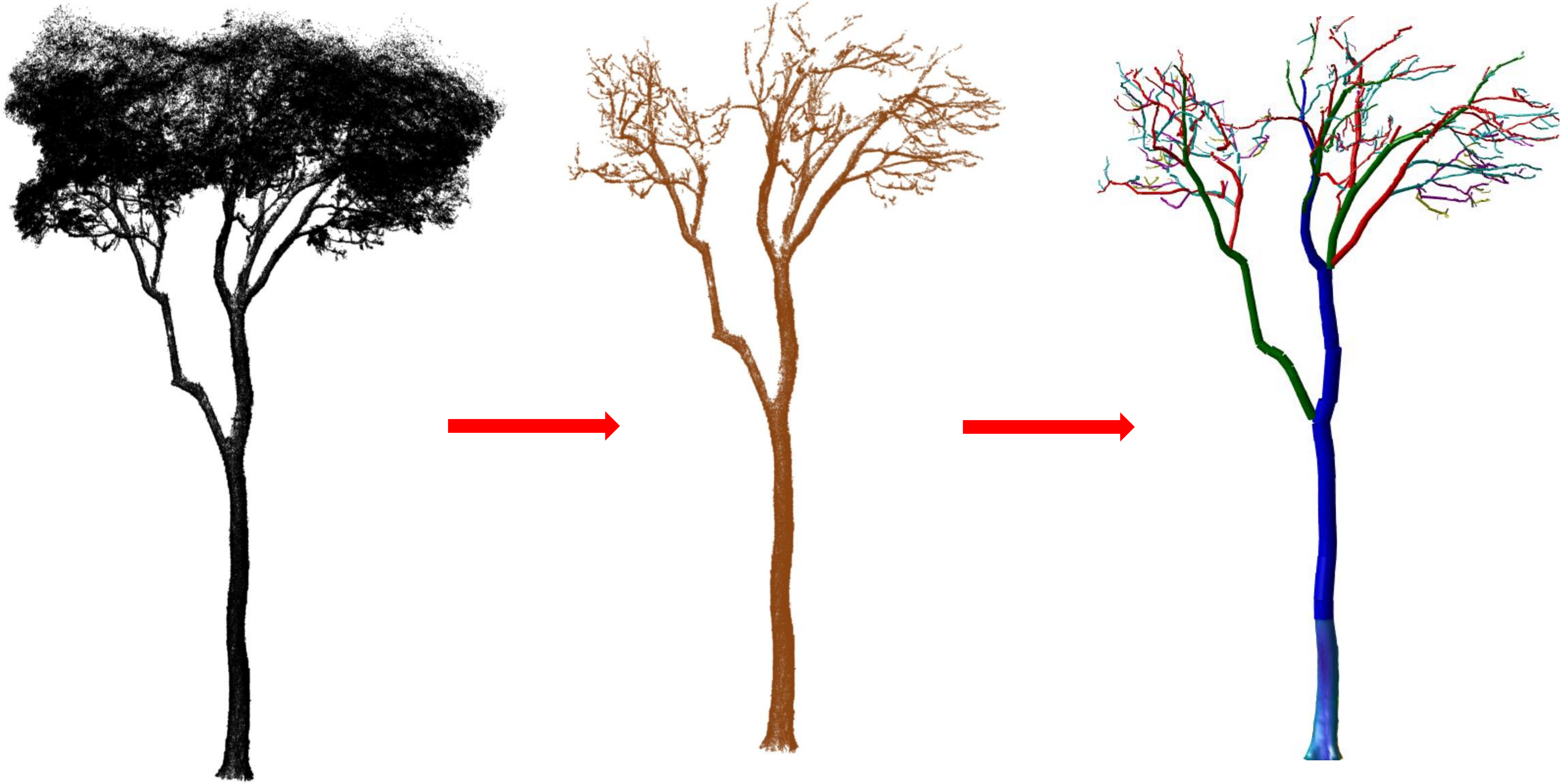
QUANTITATIVE STRUCTURE MODELING



tree point cloud

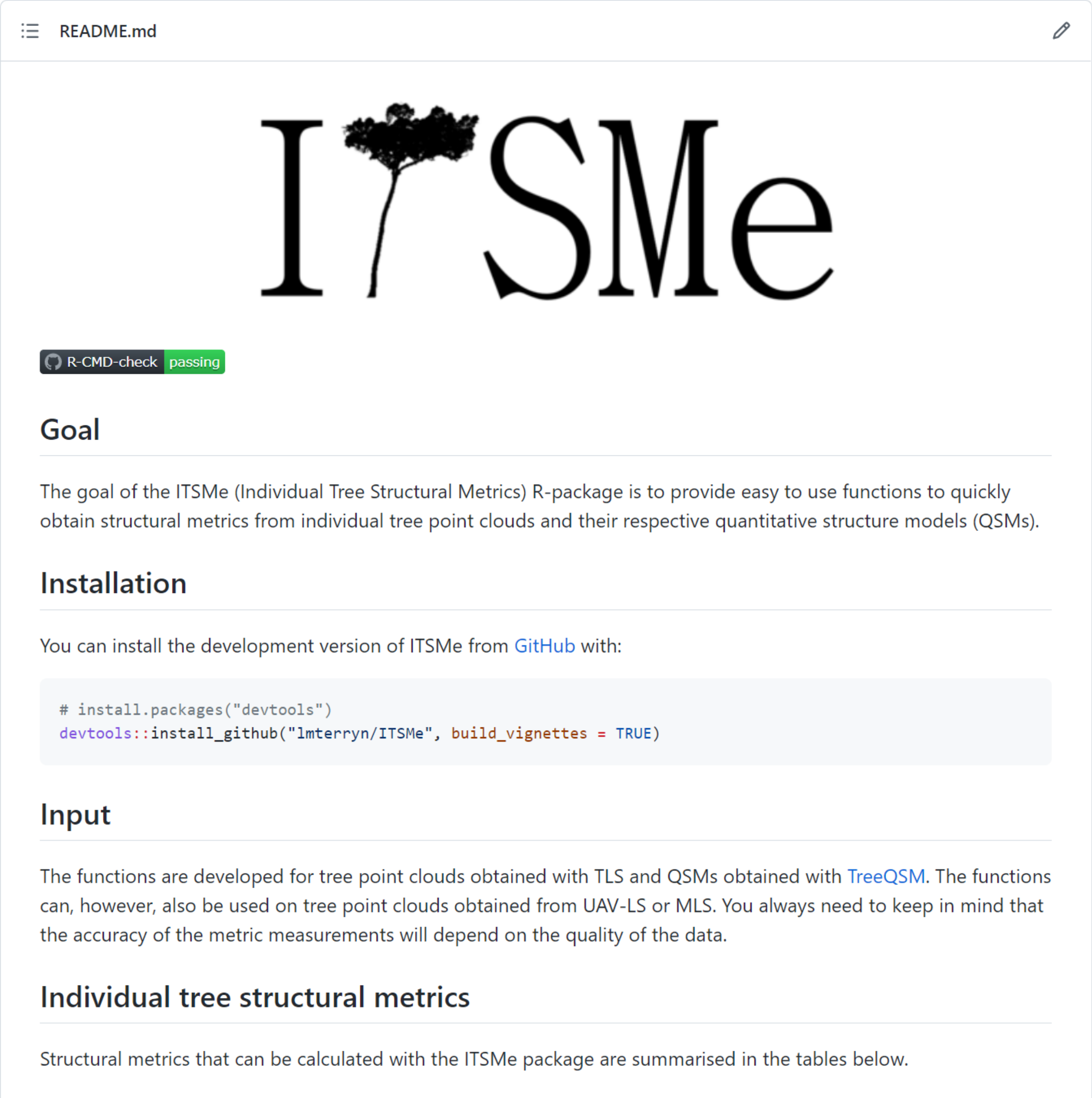
wood point cloud

quantitative structure model

https://github.com/InverseTampere/TreeQSM

STRUCTURAL METRICS

- R package ITSMe
- Publicly available on GitHub: https://github.com/lmterryn/ITSMe
- Point cloud metrics & QSM based metrics
- Workflow: https://lmterryn.github.io/ITSMe/index.html



README.md

ITSMe

R-CMD-check passing

Goal

The goal of the ITSMe (Individual Tree Structural Metrics) R-package is to provide easy to use functions to quickly obtain structural metrics from individual tree point clouds and their respective quantitative structure models (QSMs).

Installation

You can install the development version of ITSMe from GitHub with:

```
# install.packages("devtools")
devtools::install_github("lmterryn/ITSMe", build_vignettes = TRUE)
```

Input

The functions are developed for tree point clouds obtained with TLS and QSMs obtained with TreeQSM. The functions can, however, also be used on tree point clouds obtained from UAV-LS or MLS. You always need to keep in mind that the accuracy of the metric measurements will depend on the quality of the data.

Individual tree structural metrics

Structural metrics that can be calculated with the ITSMe package are summarised in the tables below.

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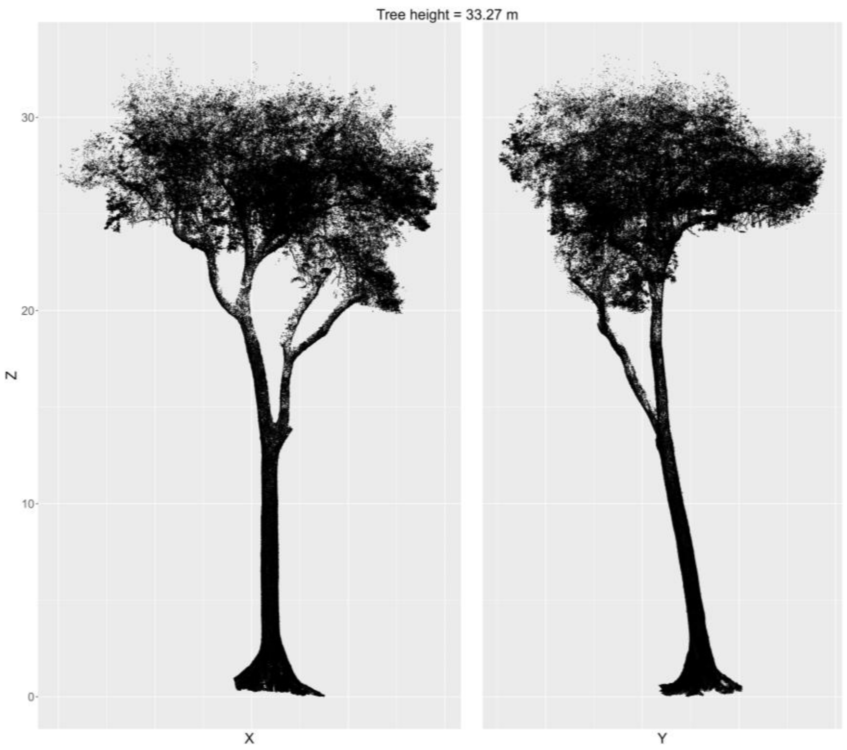
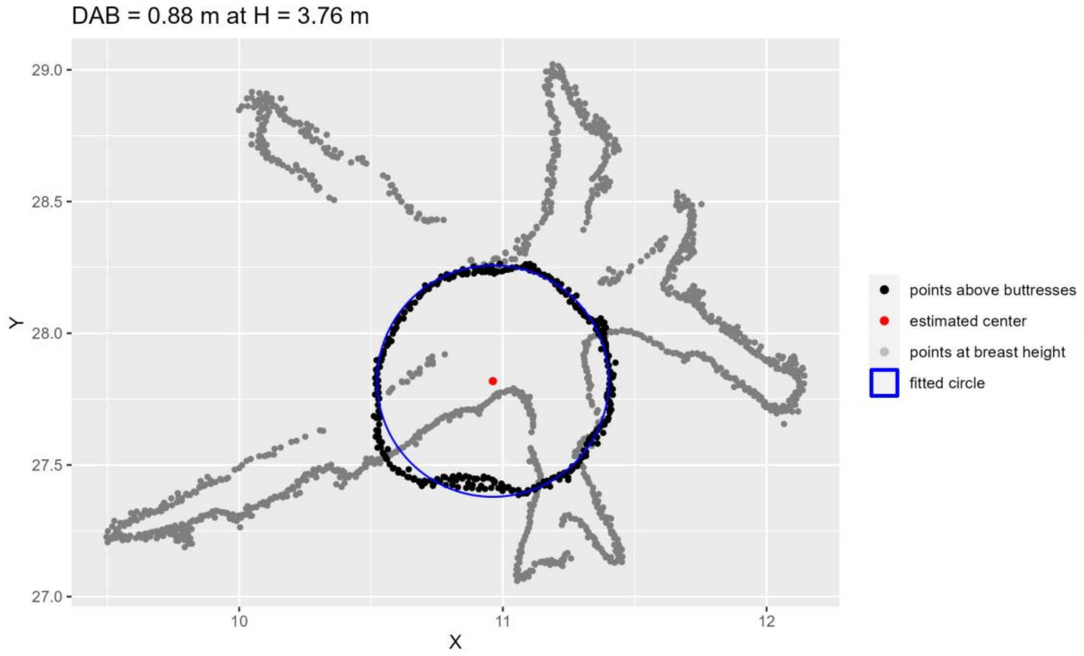
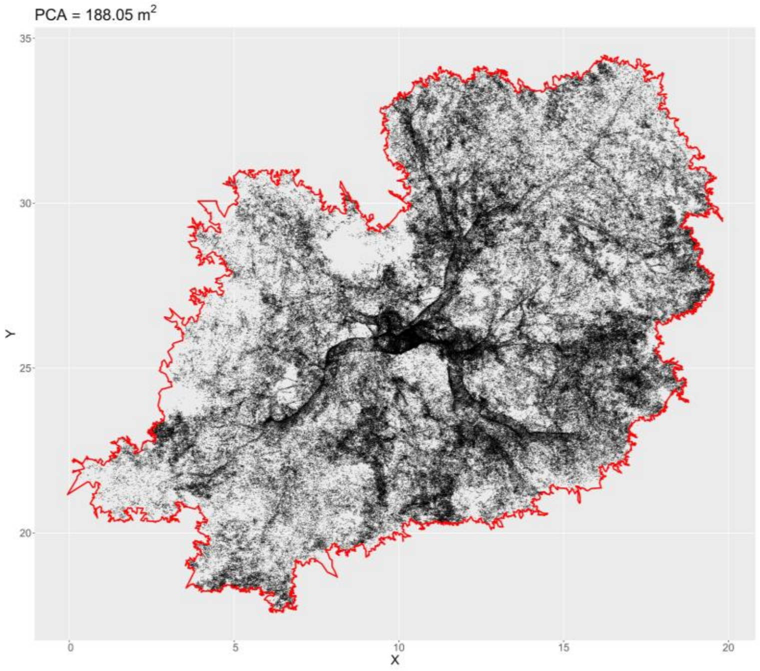
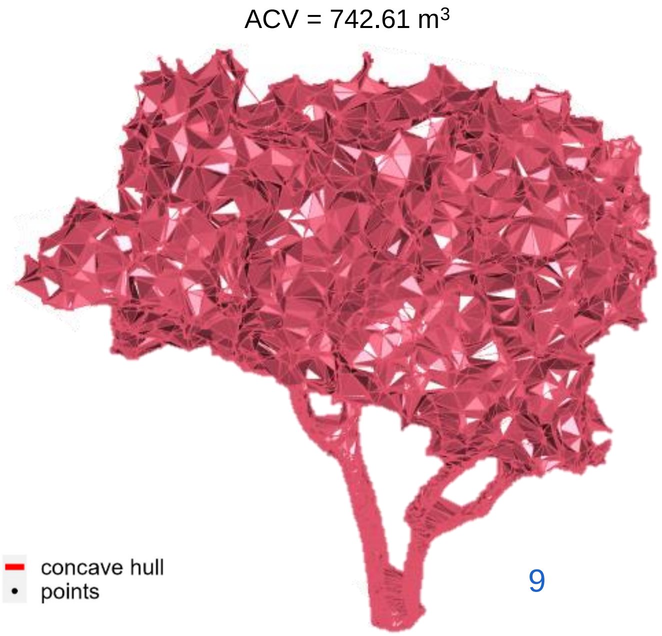
POINT CLOUD METRICS

- Tree height,
- diameter at breast height (DBH) / above buttresses (DAB),
- projected crown area (PCA),
- alpha crown volume (ACV)





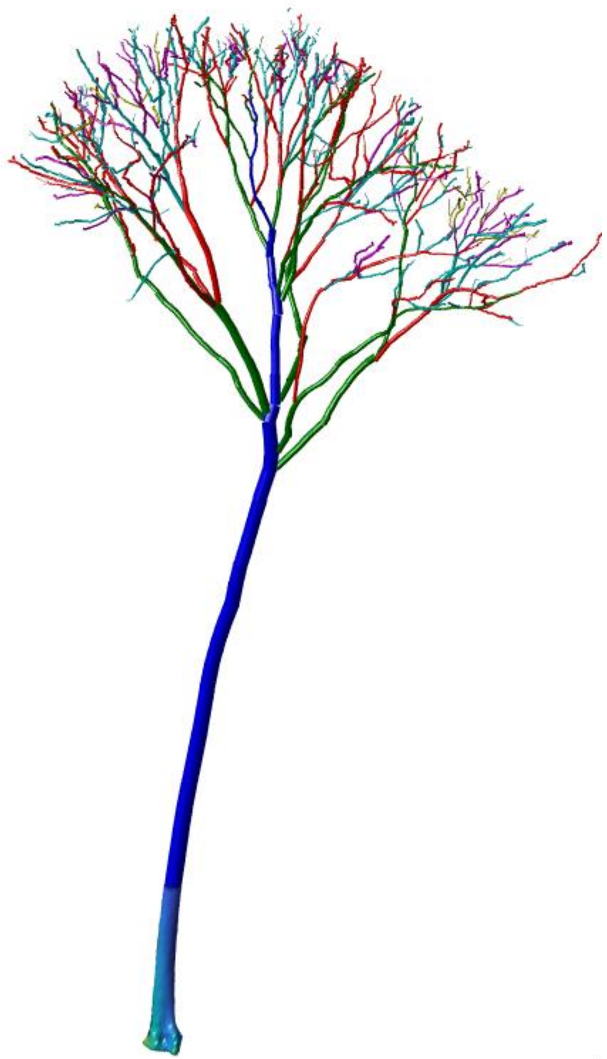




QSM METRICS

– 17 structural metrics

(Akerblom et al., 2017 & Terryn et al., 2020)



Structural metric	Definition
Stem branch angle	Median of the branching angles of the 1st order branches in degrees. 0 is upwards and 180 downwards (parallel with the trunk). [°]
Stem branch cluster size	Average number of 1st order branches inside a 40cm height interval for 1st order branches. Each branch can only belong to one interval.
Stem branch radius	Mean ratio between the 10 largest 1st order branches measured at the base and the tree height.
Stem branch length	Average length of 1st order branches normalised by the tree height.
Stem branch distance	Average distance between 1st order branches computed using a moving average with a window width 1 m. If window is empty average distance in window is set as half of window width. [m]
Crown start height	Height of first stem branch in tree crown relative to tree height.
Crown height	Vertical distance between the highest and lowest crown cylinder relative to tree height.
Crown evenness	Crown cylinders divided into 8 angular bins. Ratio between minimum heights of the highest and lowest bin. When one of the bins is empty, the value is set to zero.
Crown diameter/height	Ratio between crown diameter and crown height.
DBH/height	Ratio between DBH and total tree height.
DBH/tree volume	Ratio between DBH and total tree volume. [m^{-2}]
DBH/minimum tree radius	Ratio between DBH and the minimum of the vertical bin diameter estimates.
Volume below 55% of the tree	Relative branch volume below 55% of tree height.
Cylinder length/tree volume	Ratio between total length of all branches and total branch volume. [m^{-2}]
Shedding ratio	The number of stem branches without children divided by the number of all stem branches in the bottom third (lower third when the tree is divided in three parts based on the tree height).
Branch angle ratio	Ratio of the medians of the branching angles of the 1st order branches and 2nd order branches.
Relative volume ratio	Ratio of the percentage volume within 80 to 90% of the tree height and the percentage volume within 0 to 10% of the tree height.

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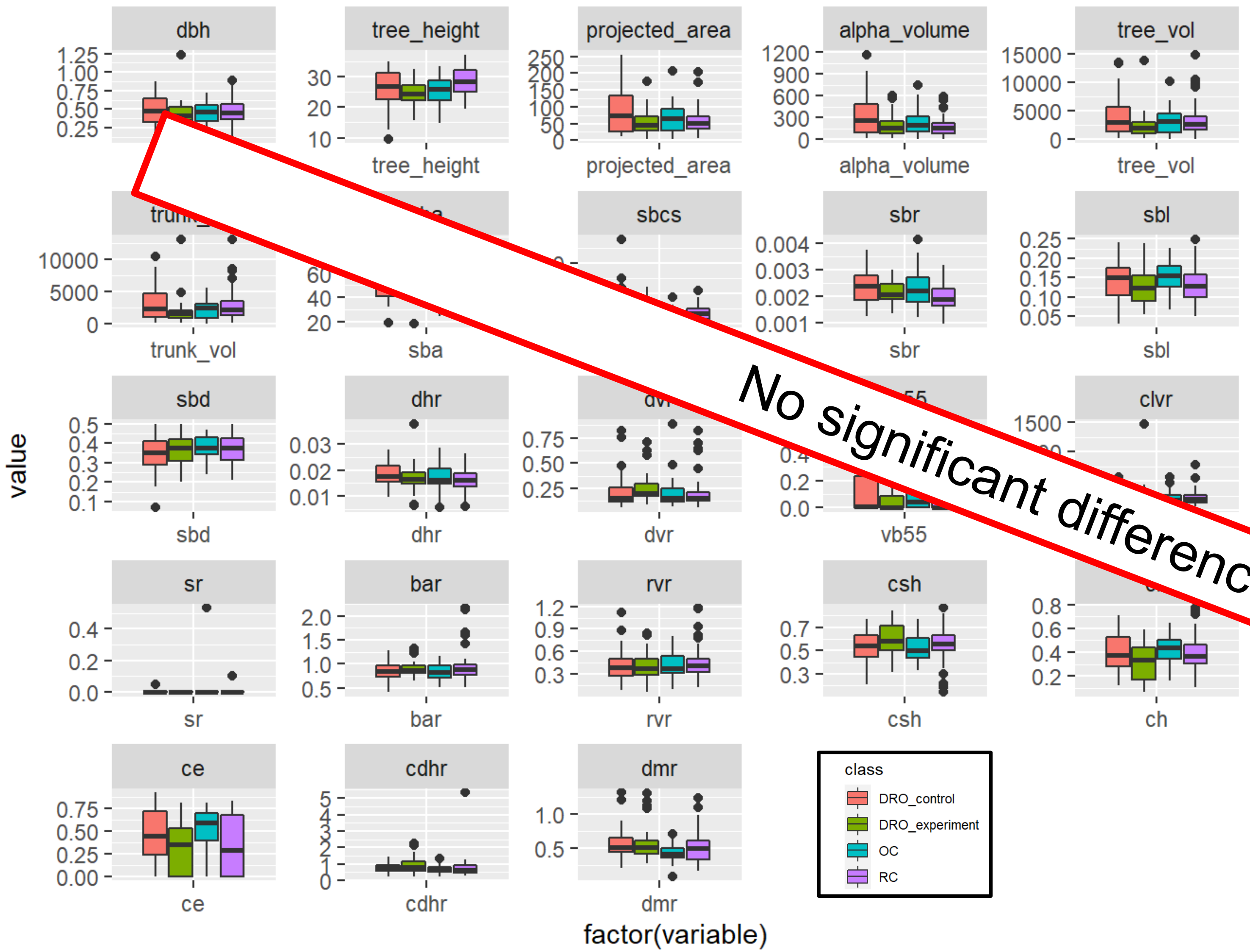
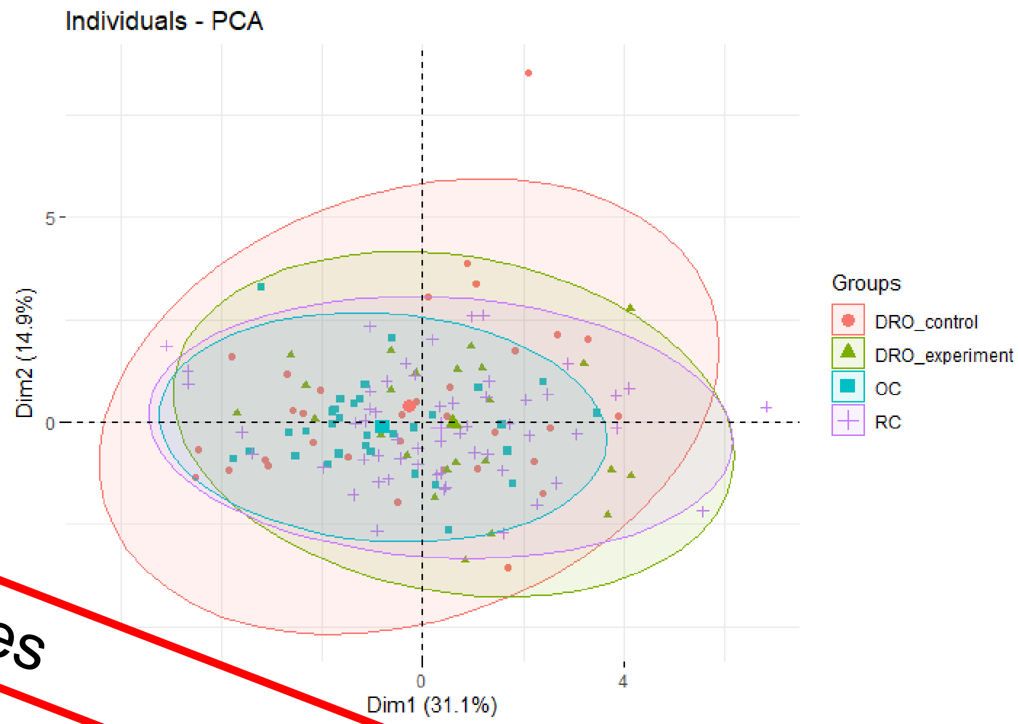
SITE COMPARISON

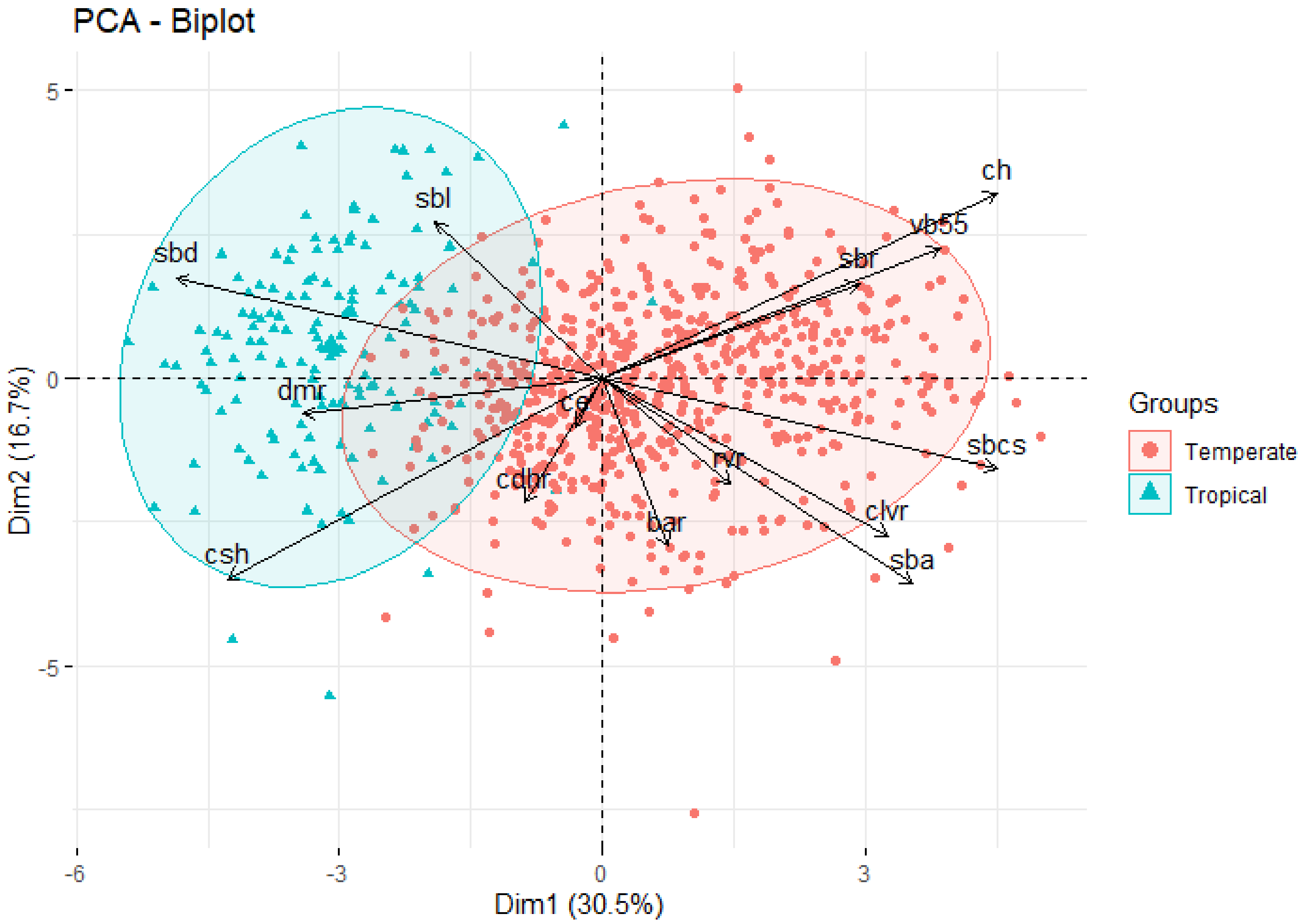
– boxplots



– Principal component analysis



BIOME COMPARISON



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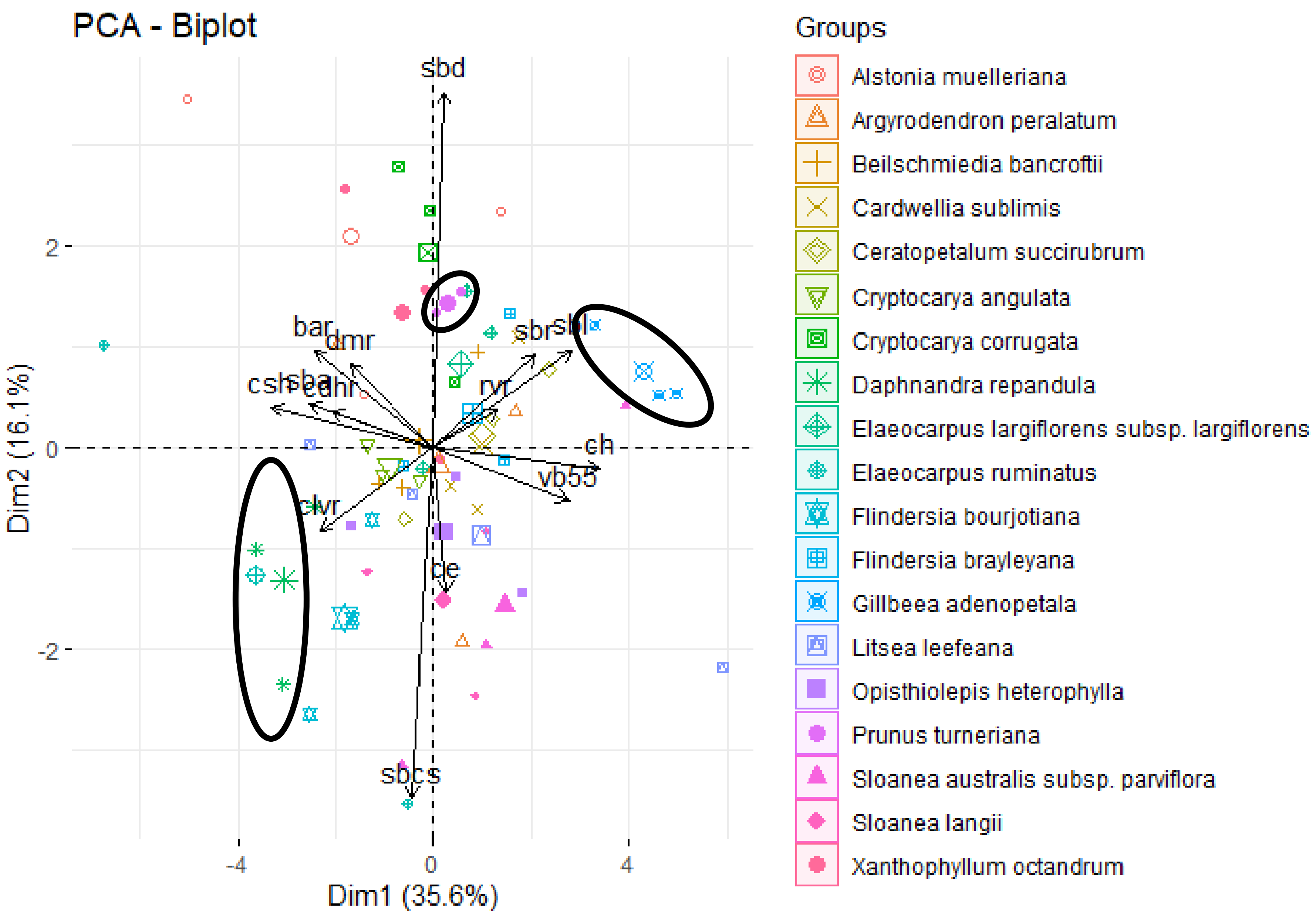
SPECIES COMPARISON



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CONCLUSION & OUTLOOK

- No difference overall tree structure
- Structural metrics reflect different structural strategies

- New structural metrics
- Different structural strategies
- Correlation with functional traits

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Thank you for listening!

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ADDITIONAL SLIDES

	DRO	OC	RC
Annual rainfall (mm)	5143	3470	2236
Mean T (°C)	24.4	25.3	19.4
Site elevation (m)	65	15	700
Soil	Acidic, dystrophic, brown dermosol and colluvial gravels	Oligothropic	Acidic, dystrophic, brown dermosol, developed in alluvium
Stem density (stems ha^{-1})	807	638	967
Tree basal area (m^2 ha^{-1})	33.5	44.4	55.3
Forest classification	Complex Mesophyll Vine Forest	Complex Mesophyll Vine Forest	Simple Notophyll Vine Forest
Disturbances	Cyclones	Cyclones, effect of stream	Historical logging

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