

# Drivers of tree species richness in New Caledonia

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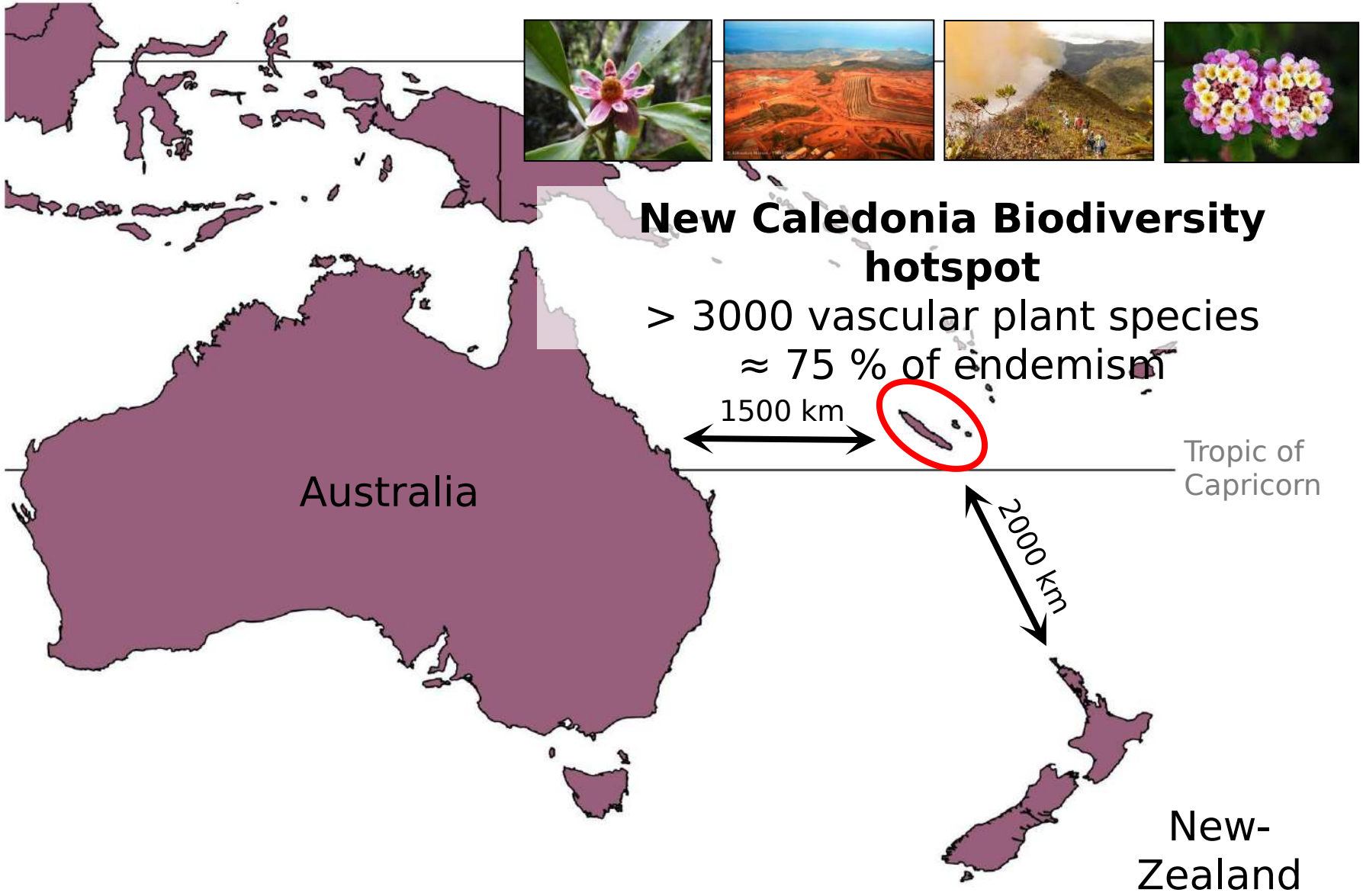




# A hotspot for biodiversity conservation

## A lab for ecological studies

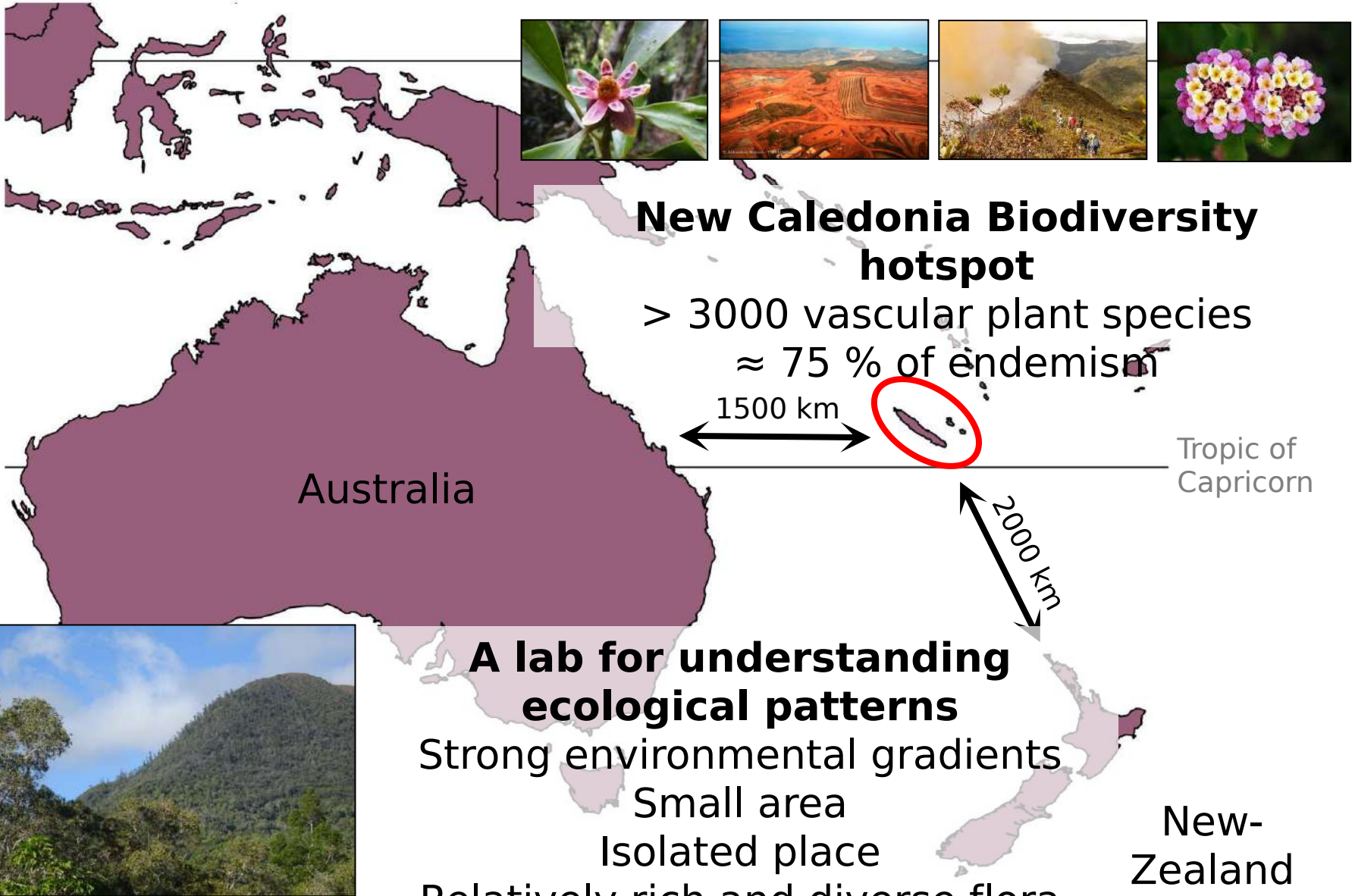
Drivers of tree species richness in New Caledonia



# A hotspot for biodiversity conservation

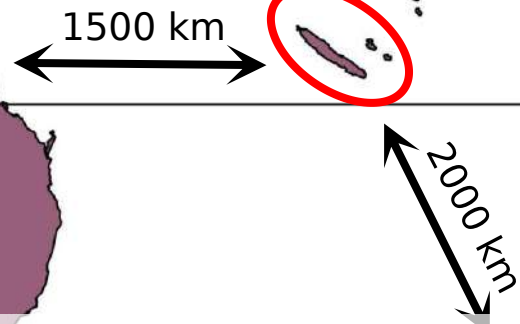
## A lab for ecological studies

Drivers of tree species richness in New Caledonia



### New Caledonia Biodiversity hotspot

> 3000 vascular plant species  
≈ 75 % of endemism



### A lab for understanding ecological patterns

- Strong environmental gradients
- Small area
- Isolated place
- Relatively rich and diverse flora

New Zealand

# New Caledonian rainforest

## A rich but understudied ecosystem



≈ 3800 km<sup>2</sup> (≈ 20 % of the territory area)  
> 2000 vascular plant species  
> 85 % of endemism

Studies focused on the origin, evolution and diversification of the biota  
Studies on ecosystems that support this biota remain scarce

**High levels of threat  
vs.  
Knowledge gaps**

# New Caledonian rainforest

## Knowledge gaps

How species composition and species richness vary across space and time ?

Which parameters, environmental or other, drive this variability?

Which forest communities, habitats, or ecosystems can we delineate ?

# New Caledonian rainforest

## Knowledge gaps

How **species composition** and **species richness** vary across **space** and time ?

Which parameters, **environmental** or other, drive this variability?

Which forest communities, habitats, or ecosystems can we delineate ?

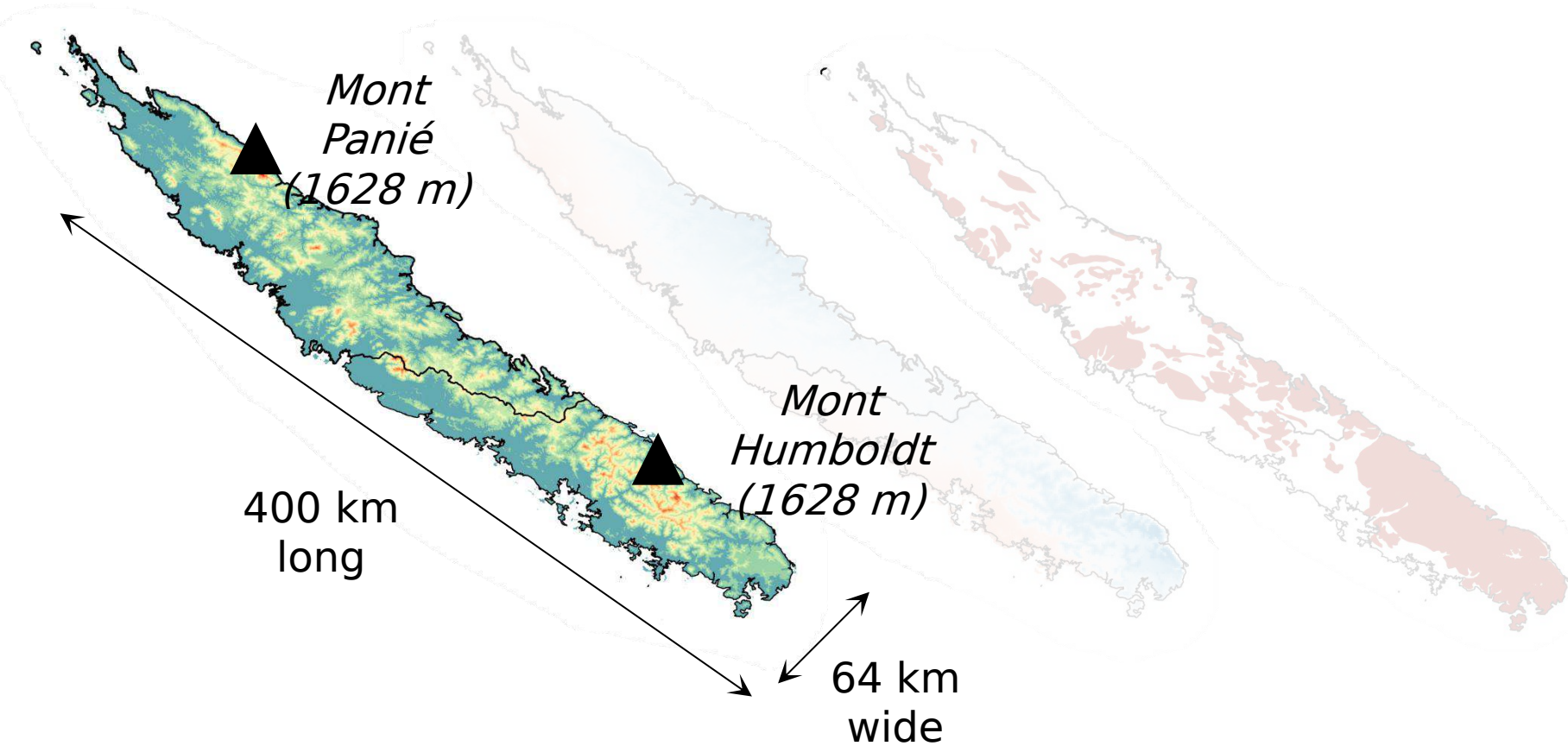


# Floristic diversity Environmental diversity

Elevation

Rainfalls

Substrates

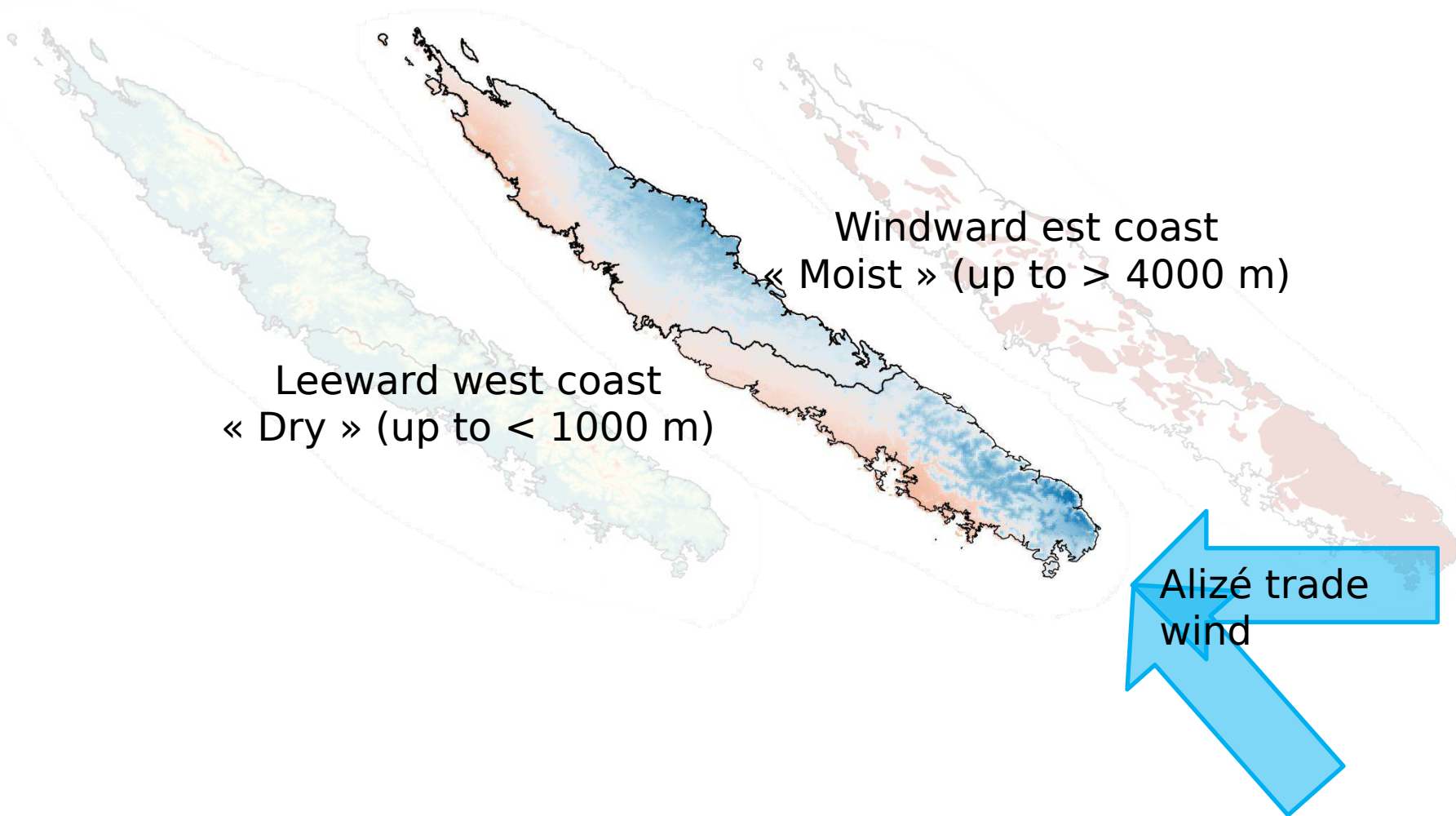


# Floristic diversity Environmental diversity

Elevation

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Substrates



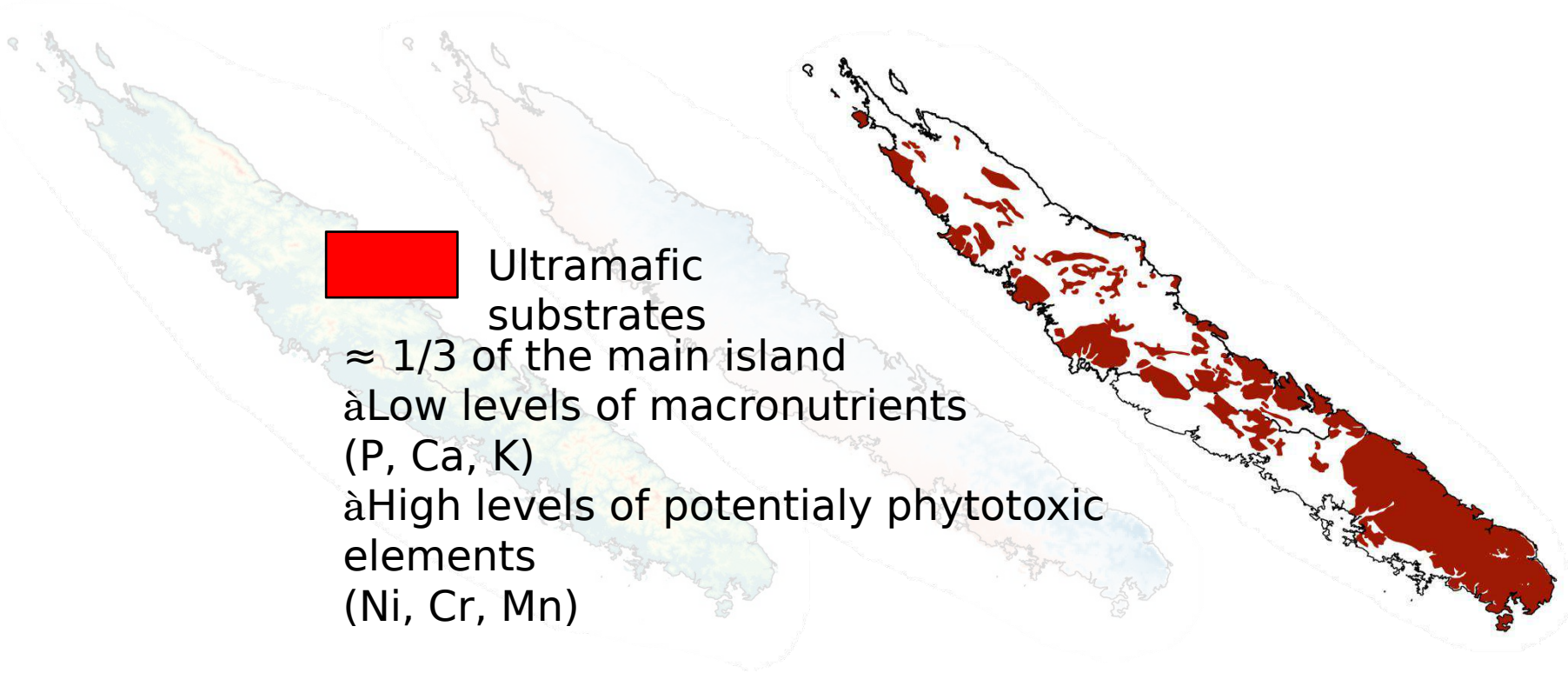


# Floristic diversity Environmental diversity

Elevation

Rainfalls

Substrates

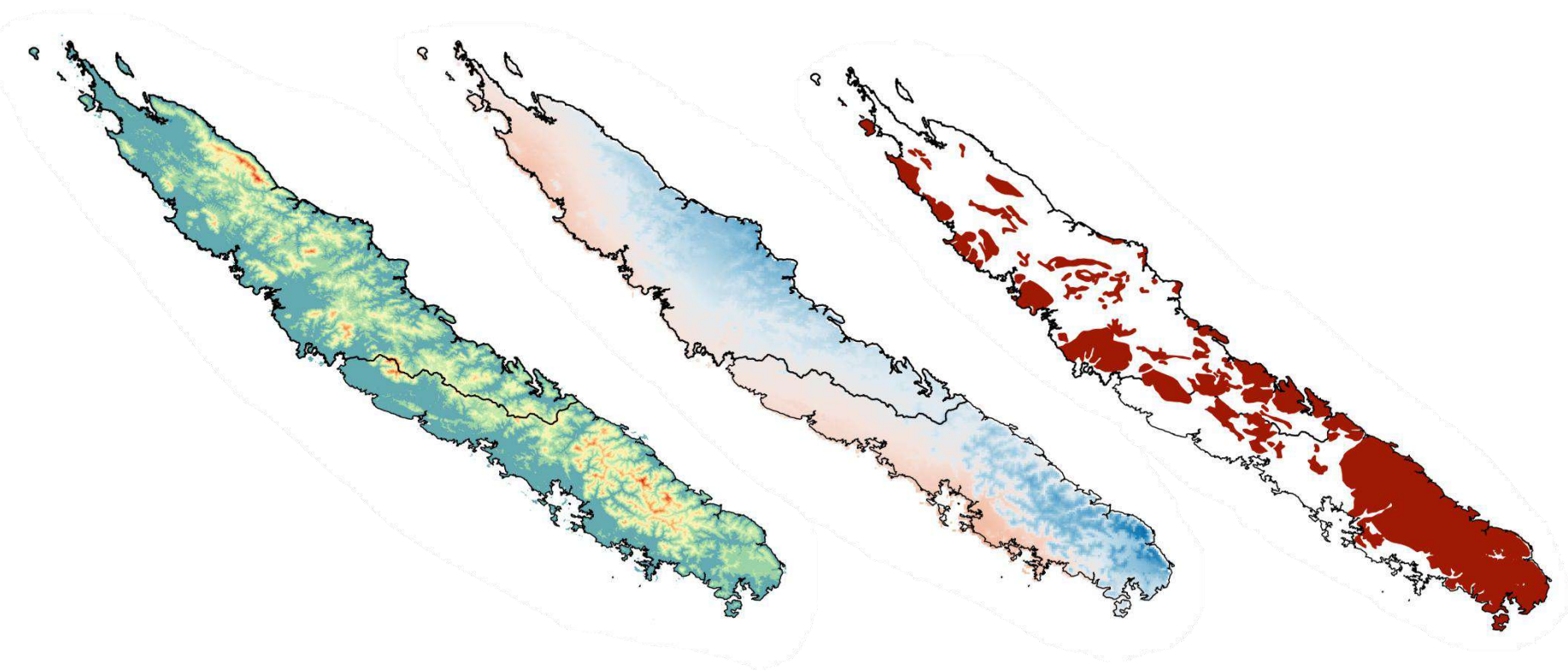


# Floristic diversity Environmental diversity

Elevation

Rainfalls

Substrates



‘Relation between ecological diversity and floristic diversity in New Caledonia’

**Need for standardized plant survey to better understand these drivers**

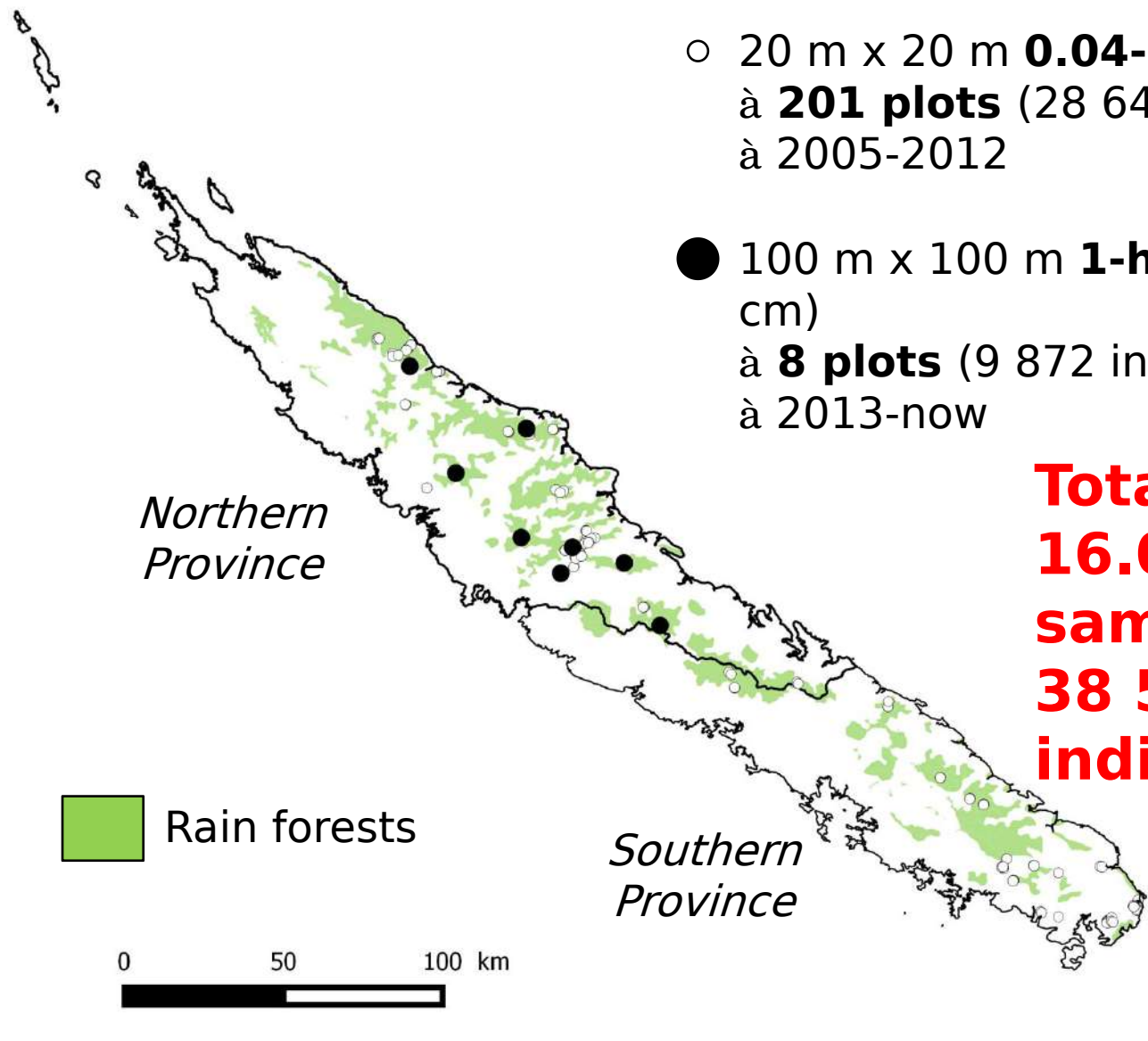


# **New Caledonian Plant Inventories and Permanent Plot Network (NC- PIPPN) 2005-Now**



# IC-PIPPN: Forest structure and composition

## Exploring large-scale spatial variability



- 20 m x 20 m **0.04-ha plots** (DBH  $\geq$  5 cm)  
à **201 plots** (28 640 individuals)  
à 2005-2012
- 100 m x 100 m **1-ha plots** (DBH  $\geq$  10 cm)  
à **8 plots** (9 872 individuals)  
à 2013-now

**Total:**  
**16.04 ha**  
**sampled**  
**38 512**  
**individuals**

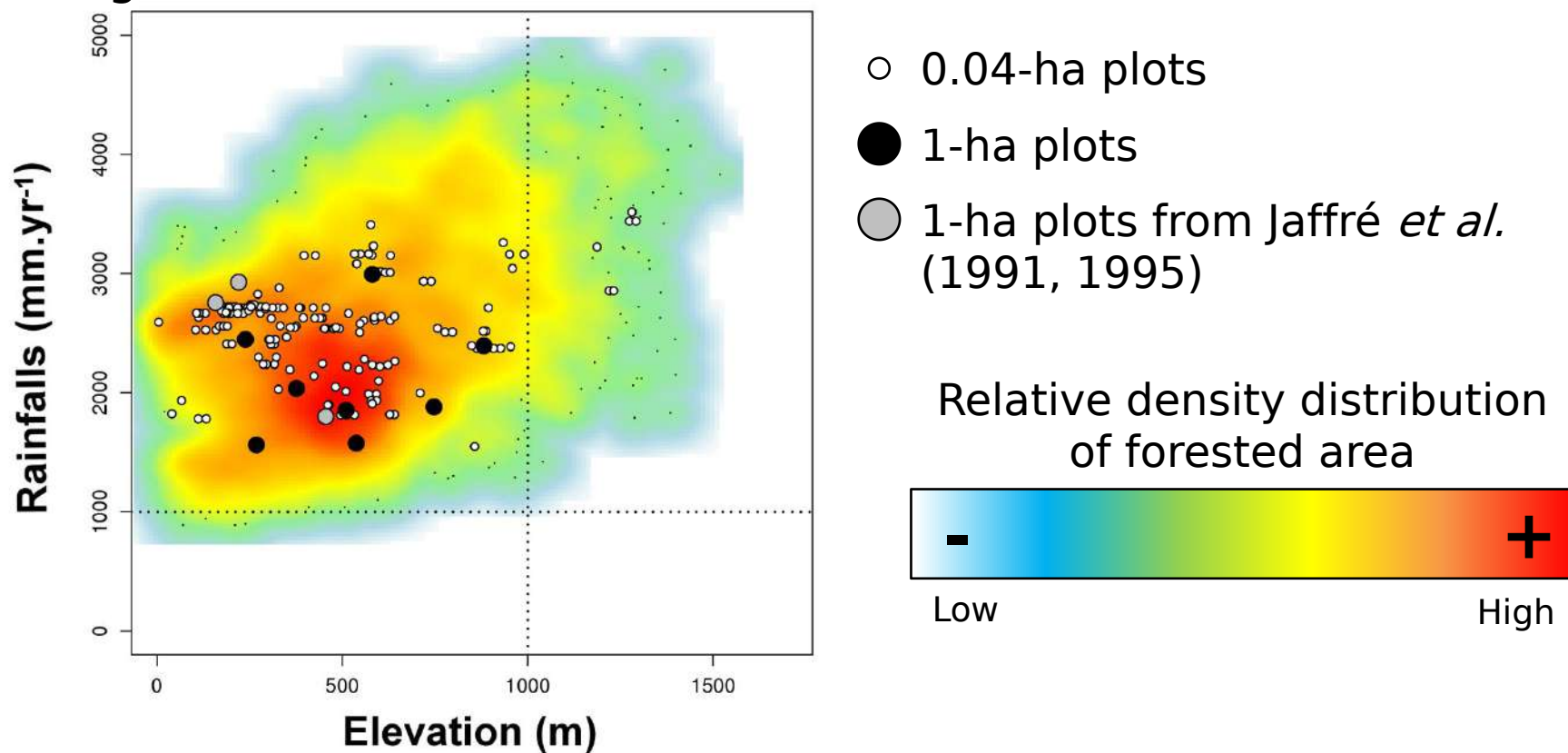
■ Rain forests

0 50 100 km

# IC-PIPPN: Forest structure and composition

## Exploring environmental variability

Distribution of forest area along altitudinal and rainfall gradients

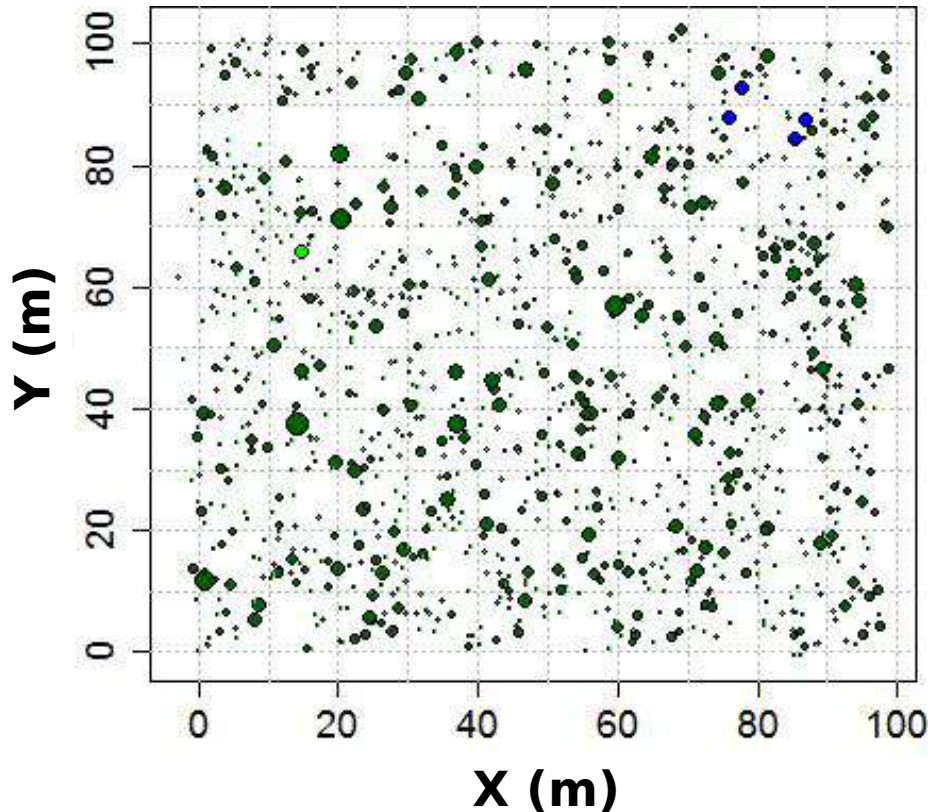


High elevation forest (i.e.  $> 1000$  m)  $\approx 100$  km<sup>2</sup> (2.5 % of total forest areas)

# IC-PIPPN: Forest structure and composition

## Exploring fine-scale spatial variability

6 fully-mapped 1-ha plots



*e.g.* Boirou  
1197 stems (672 trees)  
85 species (80 tree species)

Subsampling  
Gap dynamics



# NC-PIPPN: Forest structure and composition

## PI@ntNote database

PI@ntNote - NC-PIPPN - [Requête < Parcelles 1Ha >]

Fichier Edition Affichage Données Fenêtre ?

Mode Sauvegarder Propriétés Supprimer

Afficher les: Individus Figer les champs

ID Individus	Identifiant	Localité	Taxon	Statut de Dernière Lecture	Strate	Circonférence de Dernière Lecture	Hauteur	Densité Bois	Nom	Non
36733	45582	Parcelle 1ha - Laguen	Basselinia glabrata	Mort	Indeterminee	38			Areca Bas:	
36734	45583	Parcelle 1ha - Laguen	Cyphophoenix alba	Vivant	sous-bois	33			Areca Cysl	
36735	45584	Parcelle 1ha - Laguen		Mort	Indeterminee	44				
36736	45585	Parcelle 1ha - Laguen	Cyphophoenix alba	Vivant	sous-bois	36			Areca Cysl	
36737	45586	Parcelle 1ha - Laguen	Cupaniopsis petiolulata	Vivant	canopée	59	12.88	0.75	Sapini Cup	
36738	45587	Parcelle 1ha - Laguen	Calophyllum caledonicum	Vivant	émergent	222		0.73	Calopl Calc	
36739	45588	Parcelle 1ha - Laguen	Basselinia glabrata	Vivant	sous-bois	31			Areca Bas:	
36740	45589	Parcelle 1ha - Laguen		Mort	Indeterminee	49				
36741	45590	Parcelle 1ha - Laguen	Cyphophoenix alba	Vivant	sous-bois	35			Areca Cysl	
36742	45591	Parcelle 1ha - Laguen	Basselinia glabrata	Mort	Indeterminee	37			Areca Bas:	
36743	45592	Parcelle 1ha - Laguen	Basselinia glabrata	Vivant	canopée	42			Areca Bas:	
36744	45593	Parcelle 1ha - Laguen	Basselinia glabrata	Mort	Indeterminee	42			Areca Bas:	
36745	45594	Parcelle 1ha - Laguen	Guioa ovalis	Vivant	sous-bois	36			Sapini Guic	
36746	45595	Parcelle 1ha - Laguen	Cupaniopsis petiolulata	Vivant	canopée	44			Sapini Cup	
36747	45596	Parcelle 1ha - Laguen	Basselinia glabrata	Mort	Indeterminee	37			Areca Bas:	
36748	45597	Parcelle 1ha - Laguen	Gossia vieillardii	Vivant	sous-bois	41			Myrtac Gos	
36749	45598	Parcelle 1ha - Laguen	Dicksonia thyrsopteroides	Vivant	sous-bois	55			Dicks Dick	
36750	45599	Parcelle 1ha - Laguen	Poljosma leratii	Vivant	sous-bois	31			Escall Poly	
36751	45600	Parcelle 1ha - Laguen	Cyphophoenix alba	Vivant	canopée	38			Areca Cysl	
36752	45601	Parcelle 1ha - Laguen	Acropogon grandiflorus	Vivant	sous-bois	41	8.76		Malva Acr	
36753	45602	Parcelle 1ha - Laguen	Cupaniopsis macrocarpa	Vivant	canopée	57			Sapini Cup	
36754	45603	Parcelle 1ha - Laguen	Acropogon grandiflorus	Vivant	sous-bois	41	8.19	0.53	Malva Acr	
36755	45604	Parcelle 1ha - Laguen	Cupaniopsis petiolulata	Vivant	émergent	103		0.78	Sapini Cup	
36756	45605	Parcelle 1ha - Laguen	Cryptocarya elliptica	Vivant	émergent	102			Laura Cry	

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Données Images Carte

NC-PIPPN

- Botanistes < 62 >
- Localités < 225 >
- Taxons < 9325 >
- Individus < 40093 >
- Déterminations < 39754 >
- Herbiers < 101 >
- Images < 1598 >
- Inventaires < 40101 >
- Observations < 41949 >
- Requêtes
  - Parcelles 1Ha
  - Parcelles 20 m
  - Pour les Botanistes
- Sélections flottantes
- Modèles d'ajout

# NC-PIPPN: Forest structure and composition

## Pl@ntNote database


PI@ntNote - NC-PIPPN - [Requête < Parcelles 1Ha >]

Fichier Edition Affichage Données Fenêtre ?

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36741	45590	Parcelle 1ha - Laguen	Cyphophoenix alba	Vivant	sous-bois					



Propriétés < Obs. - ID50646 >

Précédent Suivant Nouveau Sauver Assistant Recharger Vertical Unique Cor

61 Obs.: Vivant - 14 octobre 2013

- Individu: ID38424
- Det: Garcinia densiflora (det: Vandrot et al.)
- Obs.: Vivant - 14 octobre 2013
- Plot: 51778, Parcelle 1ha - Tiwae

Hauteur < Valeur Nulle >

Nombre De Tiges 1

Circonférence 51.0000

Phénologie < Valeur Nulle >

Couleur Inflorescence < Valeur Nulle >

Végétatif < Valeur Nulle >

Domaties Faux

Contreforts Faux

Lenticelles Faux

Type Ecorce Liegeuse

Couleur Ecorce < Valeur Nulle >

Slash Dureté Tendre fibreux

Slash Couleur Claire

Slash Odeur < Valeur Nulle >

Latex Jaune

Commentaire < Valeur Nulle >

Date modification 2014/02/04 18:18:00


Editer les propriétés Afficher les Images

Observateurs

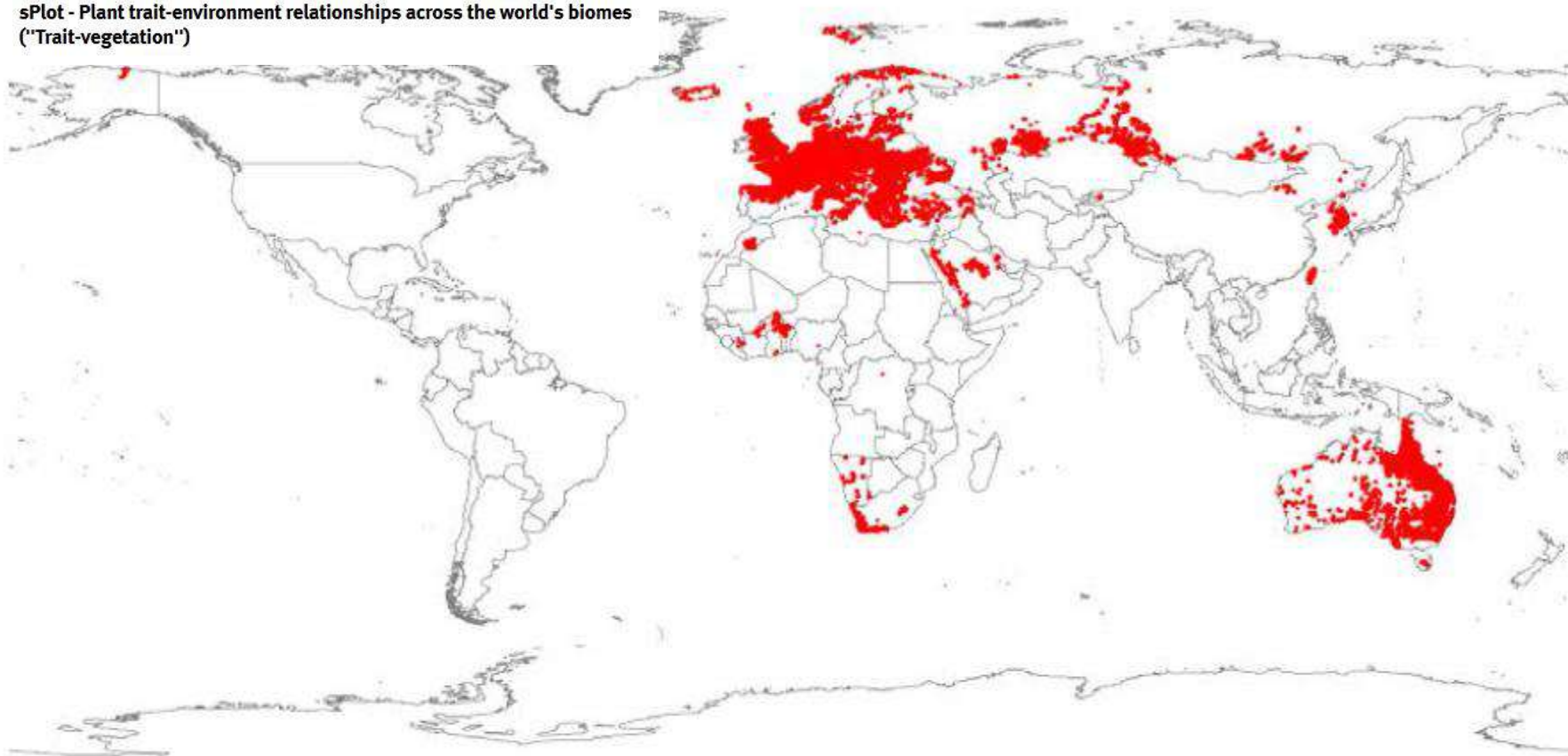
# IC-PIPPN: Forest structure and composition

## Sharing data for global analysis



a project of  iDiv

sPlot - Plant trait-environment relationships across the world's biomes  
("Trait-vegetation")

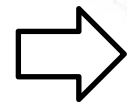
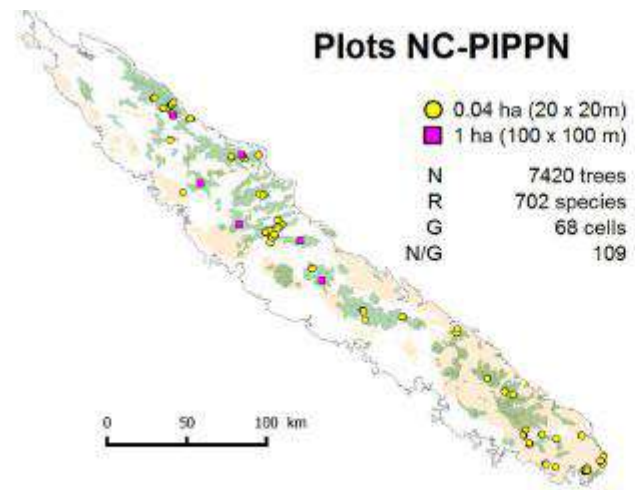


**Fig. 2:** Geographic distribution of vegetation plots in sPlot 1.0.



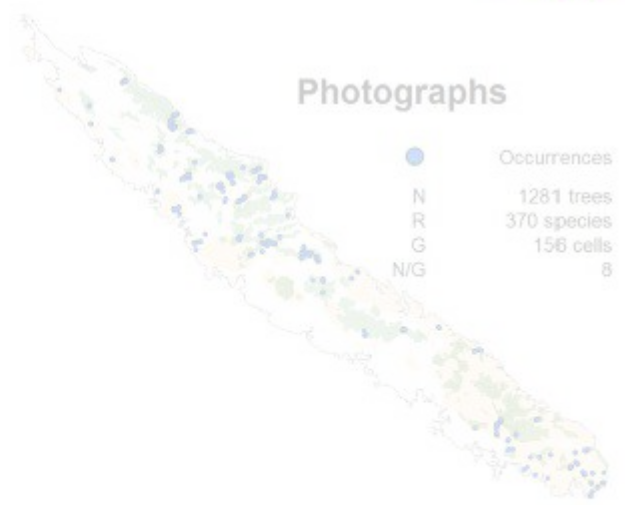
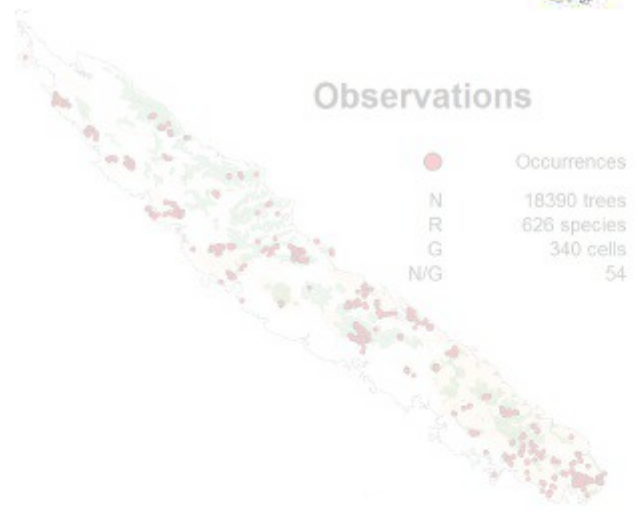
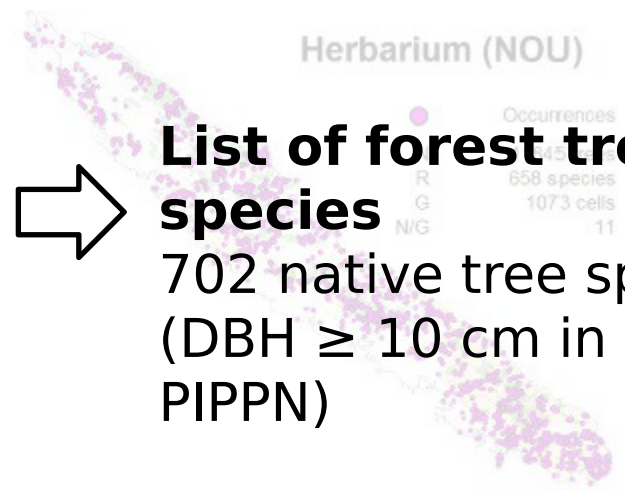
# NC-PIPPN: Forest structure and composition

## Plant inventory: Tree species distribution



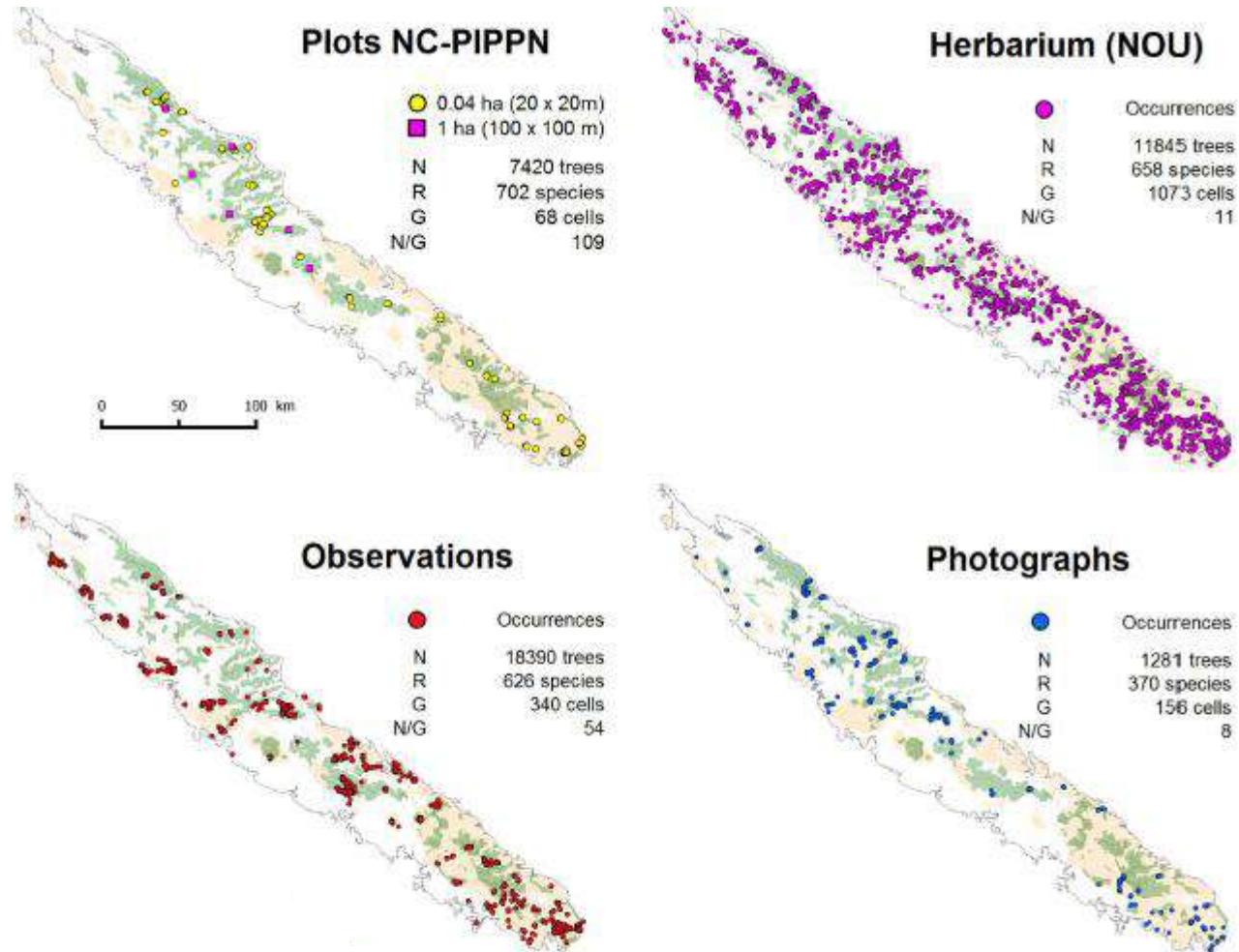
**List of forest trees species**

702 native tree species (DBH ≥ 10 cm in NC-PIPPN)



# NC-PIPPN: Forest structure and composition

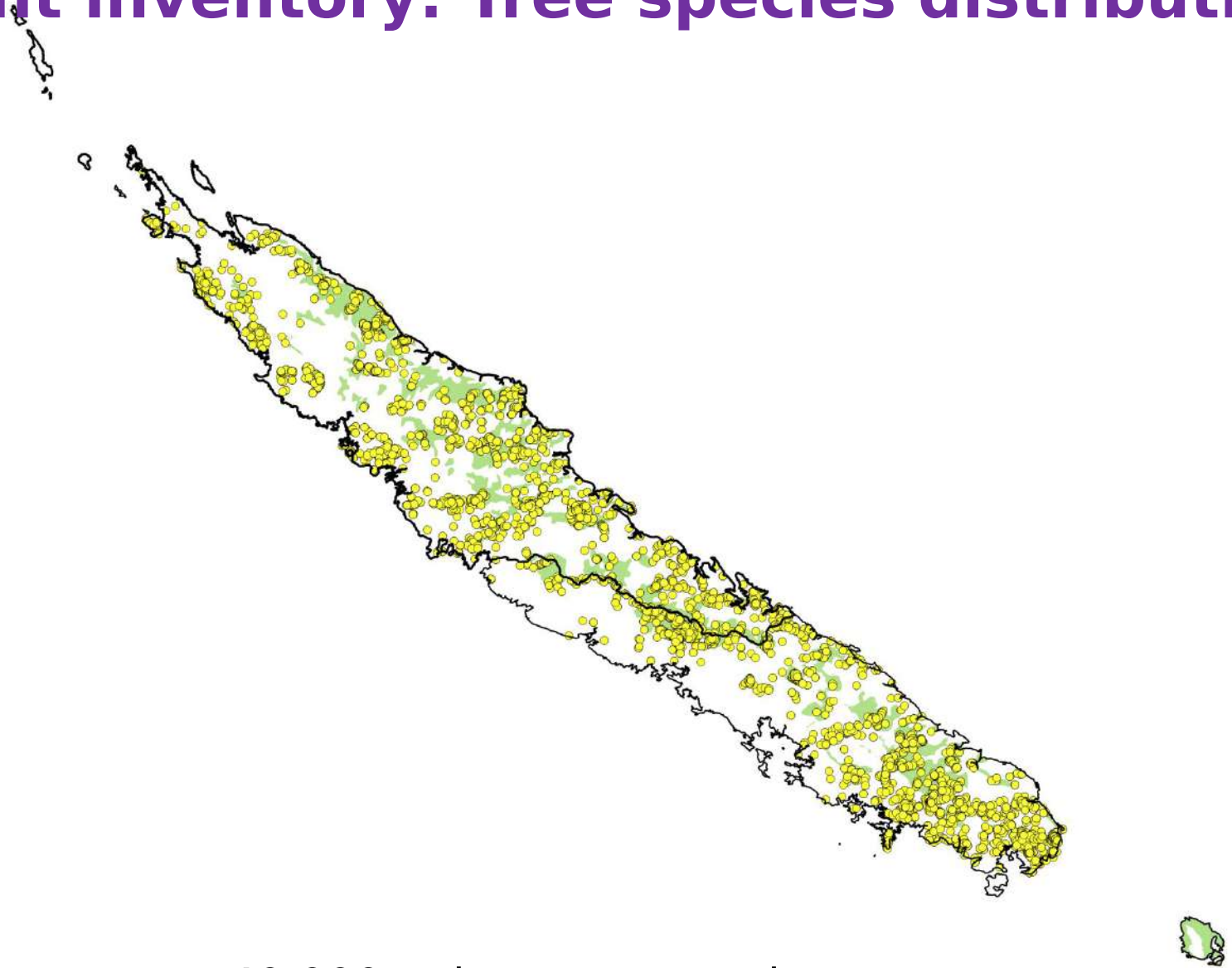
## Plant inventory: Tree species distribution



> 100 000 reliable tree occurrences

# IC-PIPPN: Forest structure and composition

## Plant inventory: Tree species distribution



≈ 40 000 unique tree species occurrences

Birnbaum *et al* (*in press*) *AoB plants*





**New statement of knowledge  
Forest structure & composition (0.04  
ha-plots)  
Tree species distribution (occurrences)**



# Structural & floristic diversity

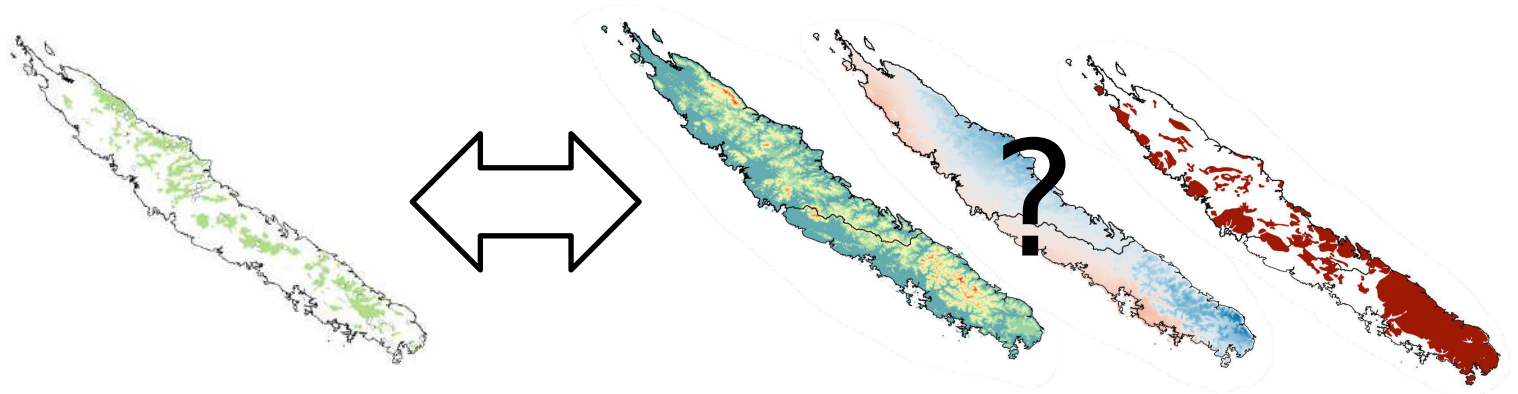
## A first large-scale synthesis

201 plots (0.04-ha, DBH  $\geq$  5 cm)

Describe the structural and floristic diversity  
à Composition, richness, diversity, density, basal area

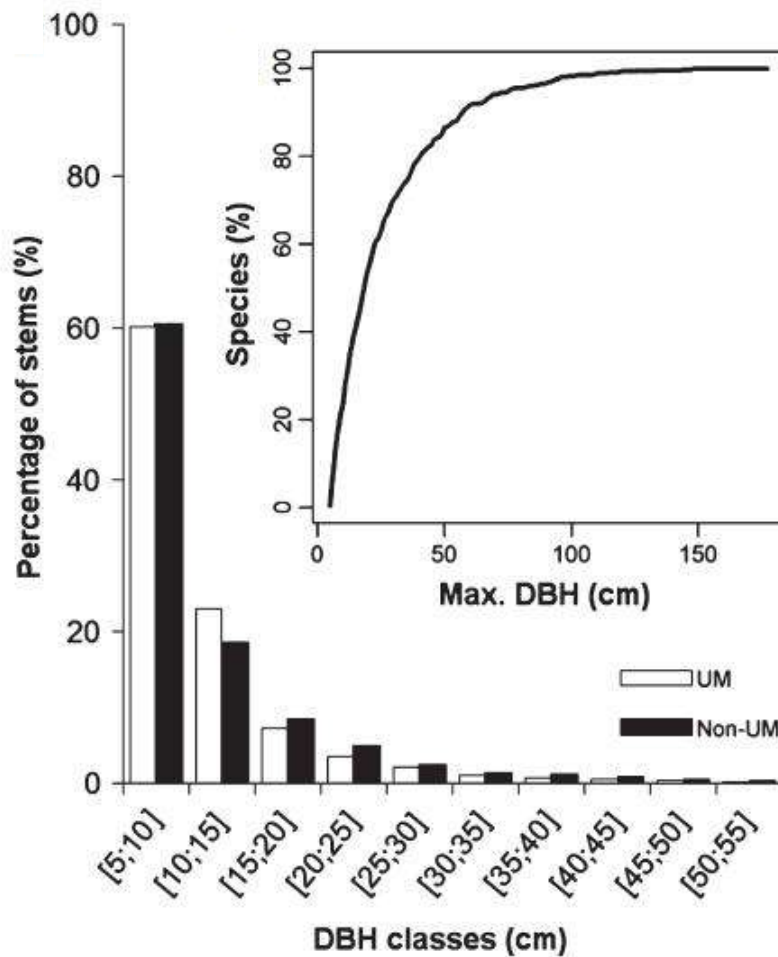
Investigate environmental determinants

Elevation, rainfalls, substrates, slopes, geographical position



# Structural & floristic diversity

## The [5-10] cm DBH class



60 % of the individuals in  
 $\approx$  **25 % of species never**  
 $\approx$  75 % of species never  $\geq$  35 cm

**A great part of the total species richness**

Species richness [5-10] cm highly correlated to species richness  $[\geq 10]$  cm



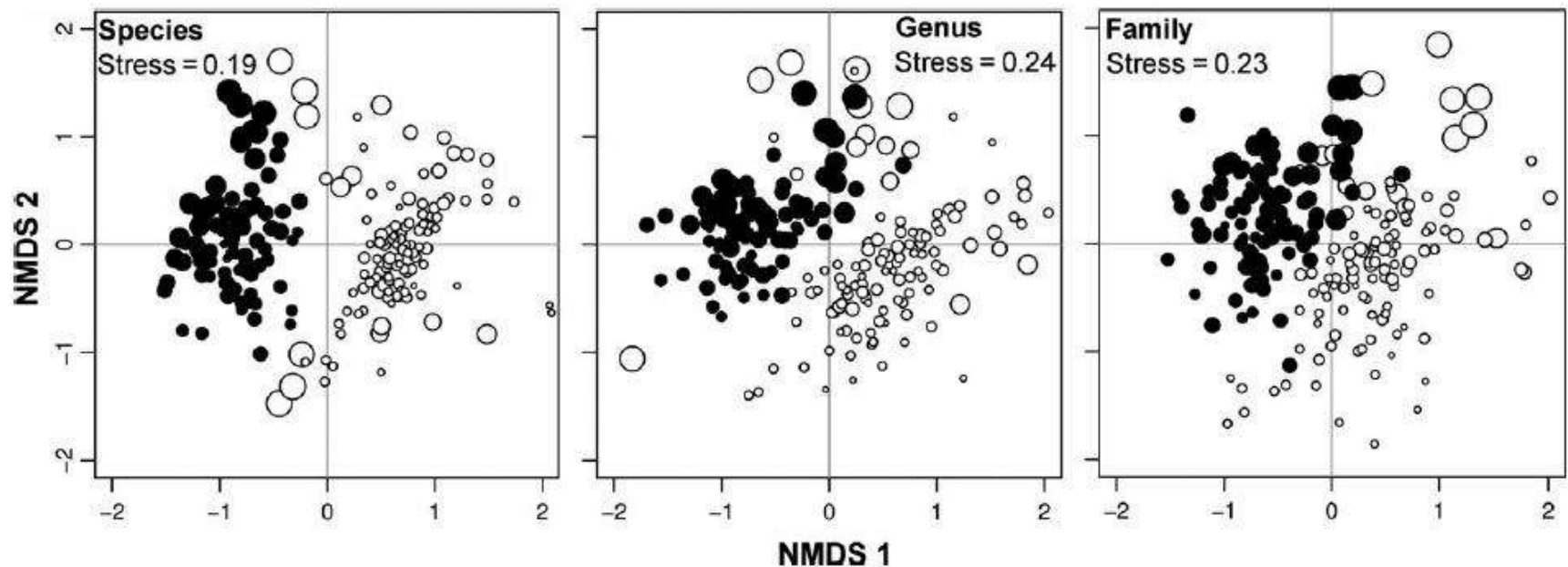
# Structural & floristic diversity

## Ultramafic vs. non-ultramafic substrates

No (or slight) differences in forest structure, richness, diversity

### Differences in forest composition

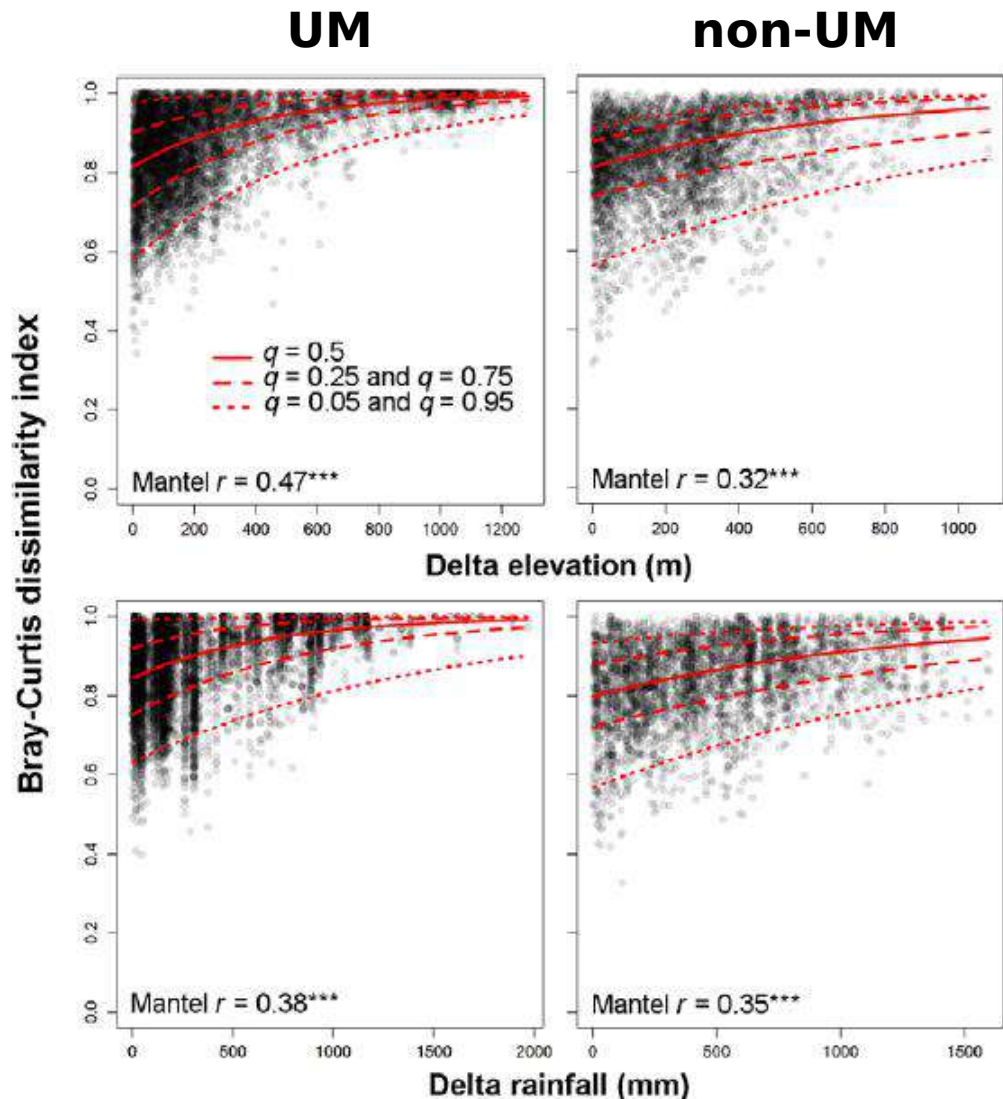
à > 75 % of species occurred only on one substrate  
 à decrease of floristic dissimilarity with elevation



- UM
- non-UM
- High elevation
- Low elevation

# Structural & floristic diversity

## High $\beta$ diversity, weak environmental drivers



**High floristic dissimilarity**  
(Bray-Curtis > 0.70)

**> 1/3 of rare species**  
(singleton or doubleton)

Lack of pattern with geographical distance

Weak patterns with elevation and rainfall gradients

# Structural & floristic diversity

## Conclusions

**NC-PIPPN (0.04-ha plots) very efficient to explore the richness of the flora ( $\Upsilon$  diversity)**

High species richness ( $\Upsilon \approx 750$  species inventoried,  $\alpha \approx 40$  species/plot)

Substrates types on of the main drivers of species richness (through  $\beta$ )

High density ( $> 1000$  stems/ha) of small stems, high basal area ( $> 50$  m<sup>2</sup>/ha)

**BUT low reliability of structural parameters, species richness ( $\alpha$ ) and floristic dissimilarities ( $\beta$ ) due to the small size of the plots**

à **Need complementary larger plots**

(international standard 1-ha, 10 cm DBH) Loanez et al (2014) Applied Vegetation Science



# Structural & floristic diversity

## Selected for Editor's award 2014 (AVS)



*Applied Vegetation Science* 18 (2015) 1–2

### EDITORIAL

## **Plant communities: their conservation assessment and surveys across continents and in the tropics**

Milan Chytrý, Alessandro Chiarucci, Valério D. Pillar & Meelis Pärtel

Ibanez et al. (2014) is a **high-quality vegetation survey study** very different from Jiménez-Alfaro et al. These authors focused on tropical rain forests in New Caledonia, a biodiversity hotspot in which knowledge of vegetation patterns is still largely incomplete. Using a series of new inventory and permanent plots distributed across the island, each with accurate measurements of individual trees, they provided a basic description of the rain forest diversity on the island. **More such studies are needed from tropical regions to better understand the vegetation in the endangered and fascinating ecosystems of tropical rain forests.**

# Structural & floristic diversity

## An insightful comment



*Applied Vegetation Science* 17 (2014) 381–383

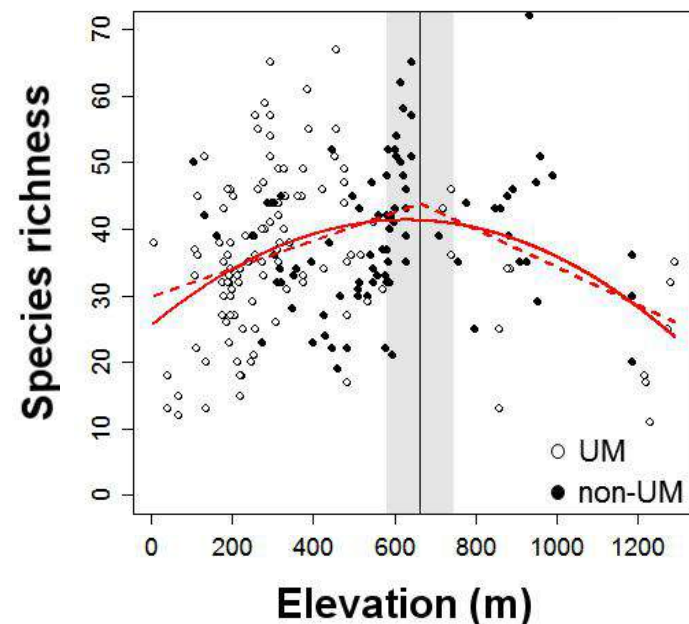
### COMMENTARY

## Diversity patterns in a diversity hotspot

John-Arvid Grytnes & Vivian A. Felde

What might be easier to agree on is that efforts to describe the biodiversity in diverse areas, as done in the **New Caledonian Plant Inventory and Permanent Plant Network**, have an enormous value in our quest to understand and conserve global biological diversity.

A last pattern, or rather a lack of pattern, which we find puzzling in the study of Ibanez et al. (2014), is that there is **no relationship between species richness per plot and elevation**. However, as mentioned above, there is a clear relationship between number of individuals and elevation.



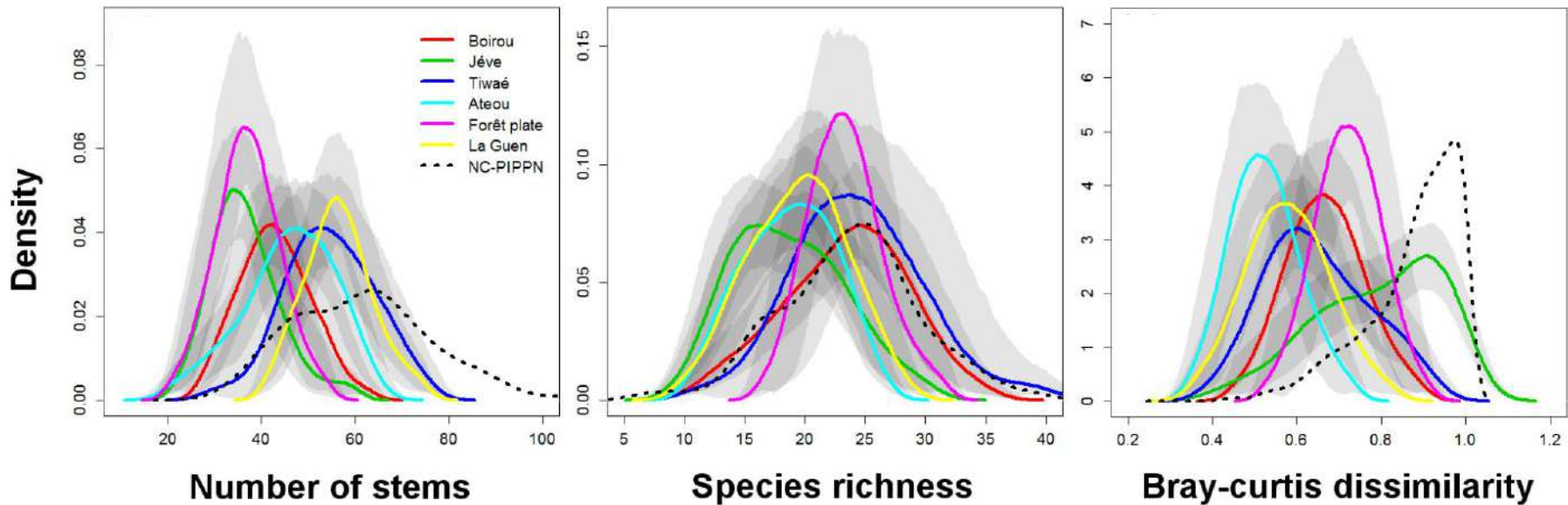
Weak mid-peak pattern

# Lake of patterns with environmental drivers

## One more scale story?

*"To understand the drama, we must view it on the appropriate scale"*

J. A. Wiens (1989)



Comparison of the variability within the 0.04-ha plots network and within 1-ha plots (random sub-sampling of each 1-ha plots with 0.04-ha plots)

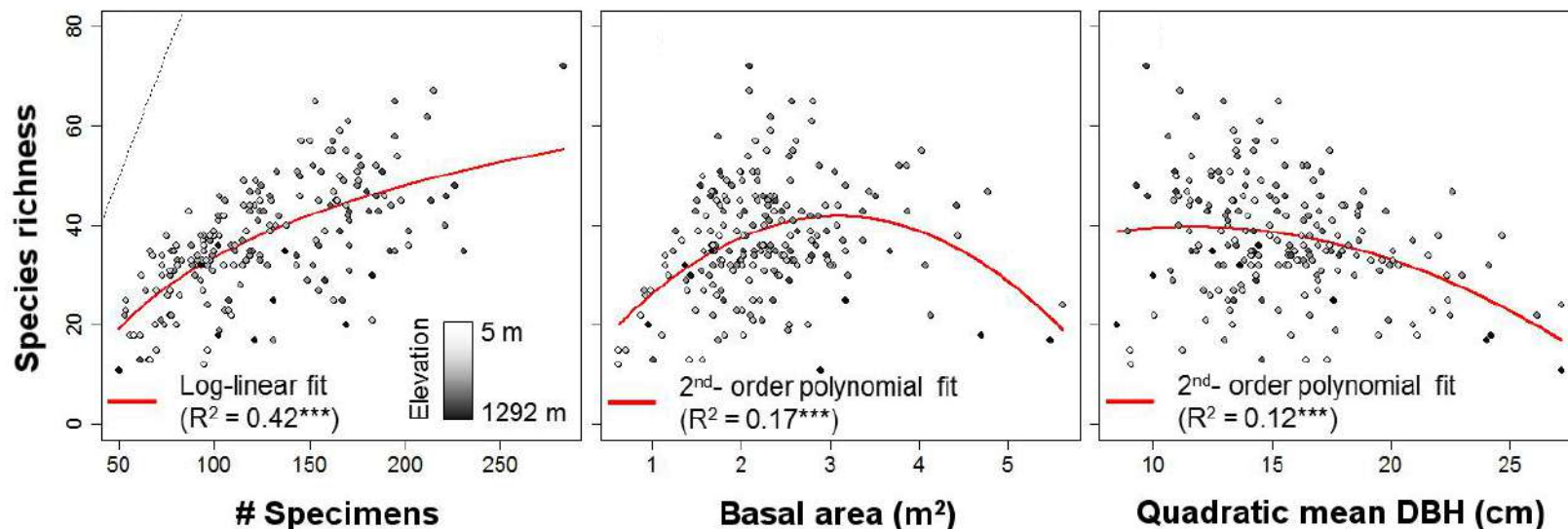
**Most of the variability observed at the scale of New Caledonia (0.04-ha plot network) is observed at**



# Lake of diversity patterns with elevation

## Does rarefaction reveal richness patterns?

Species richness is biased by the number of specimens



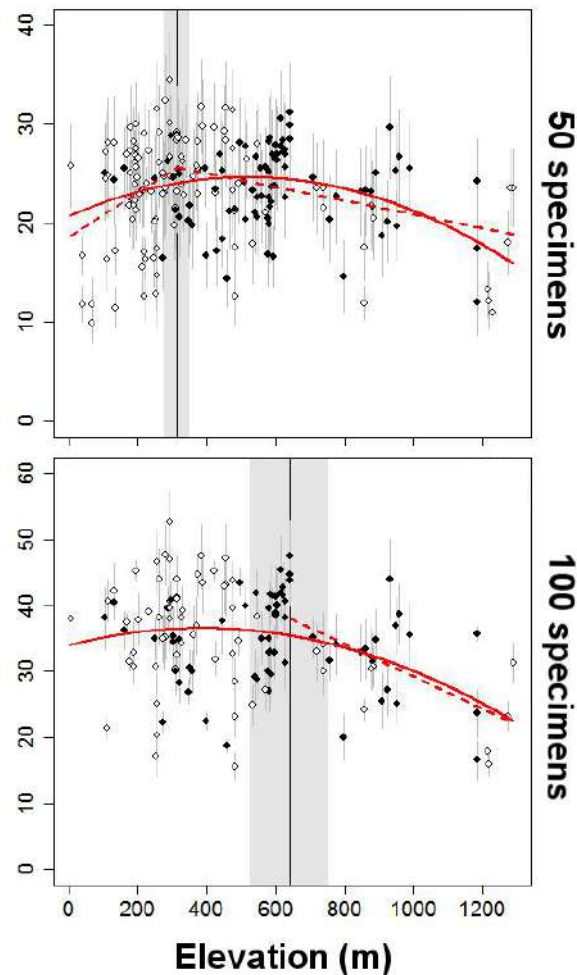
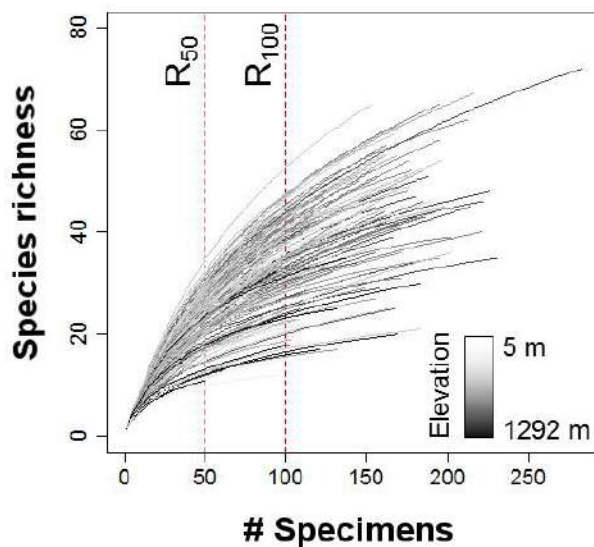
**Large plots** : “more-individuals hypothesis”  
à More productivity, more trees, more species

**Small plots** : “self-thinning hypothesis”  
More productivity, bigger trees, less trees, less species

# Lake of diversity patterns with elevation

## Does rarefaction reveal richness patterns?

Standardisation by the number of specimens (rarefaction)



Change from a « mid-peak » to a « low-plateau » pattern

**Decrease after 600-800** banez et al (in review) Journal of Vegetation Science





**New statement of knowledge  
Forest structure & composition (0.04  
ha-plots)  
Tree species distribution (occurrences)**



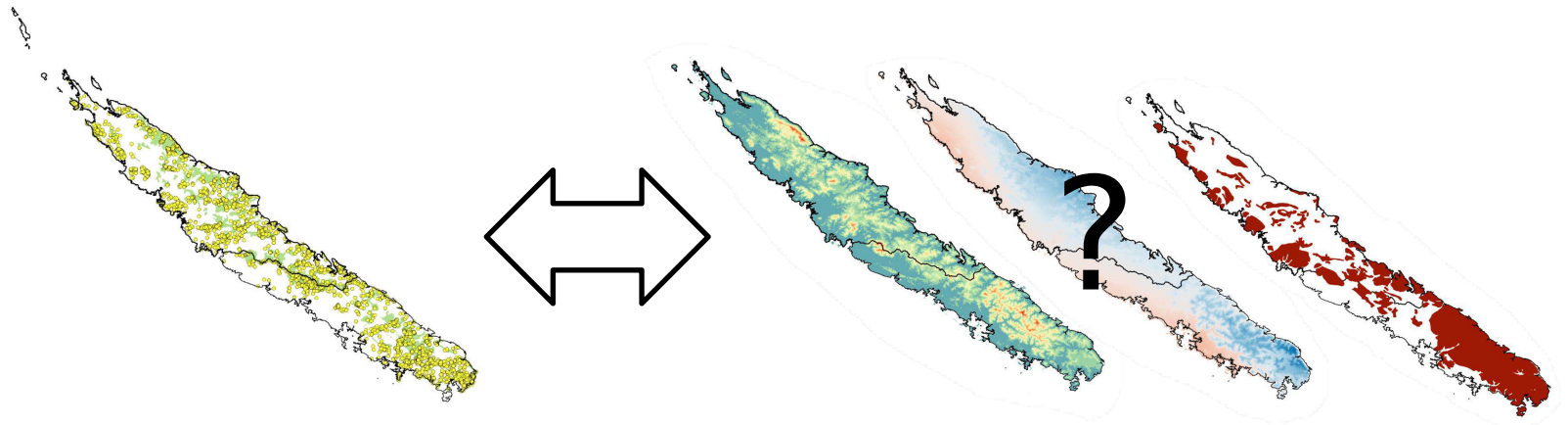
# Tree species distribution

## What do we know?

702 native tree species  $\approx$  40 000 unique tree species occurrences

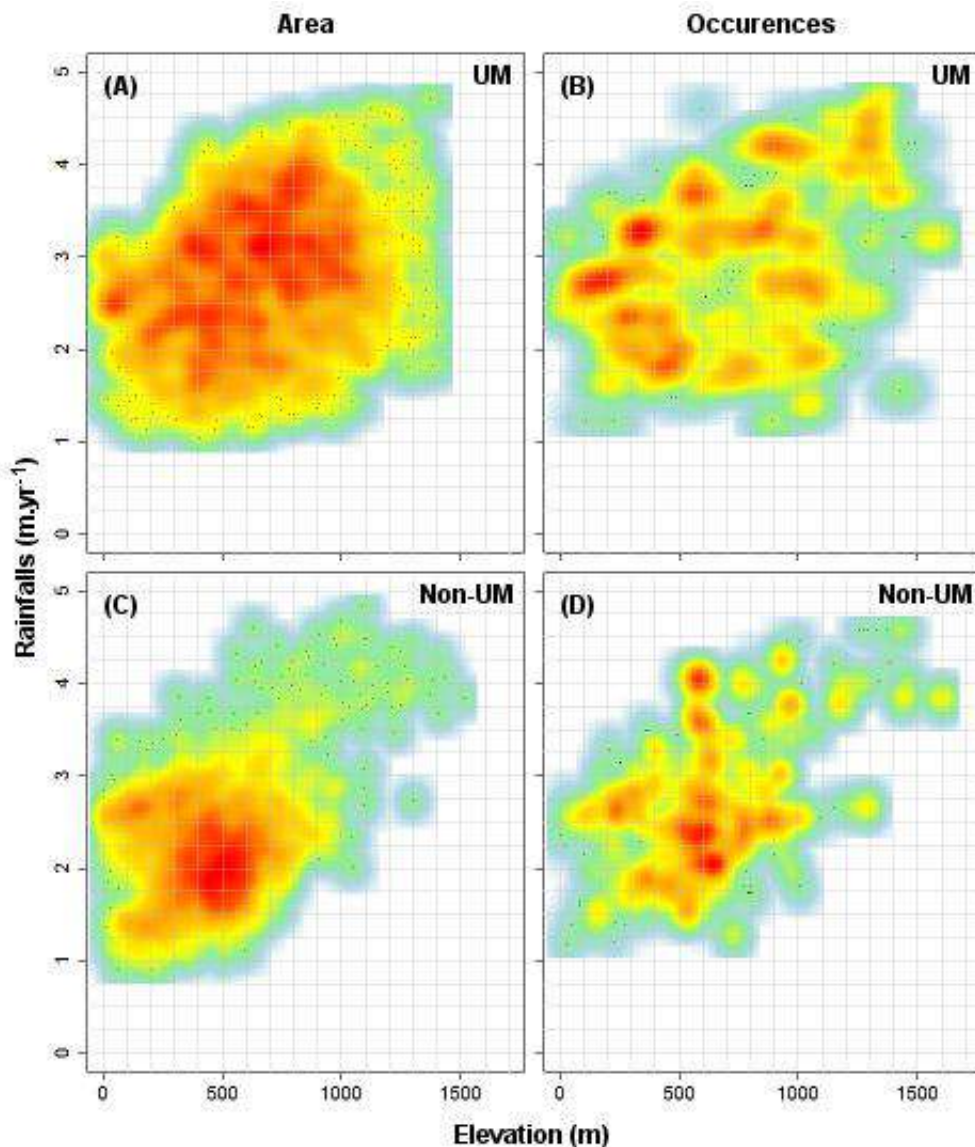
Distribution of tree species  
Distribution of tree diversity ( $\alpha$  and  $\Upsilon$  diversity)

Investigate environmental determinants  
Elevation, rainfalls, substrates, forest area



# Tree species distribution

## Identifying knowledge gaps

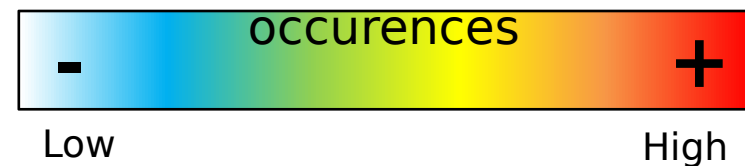


Environmental envelope larger on UM substrates

Relatively good representativeness of occurrences

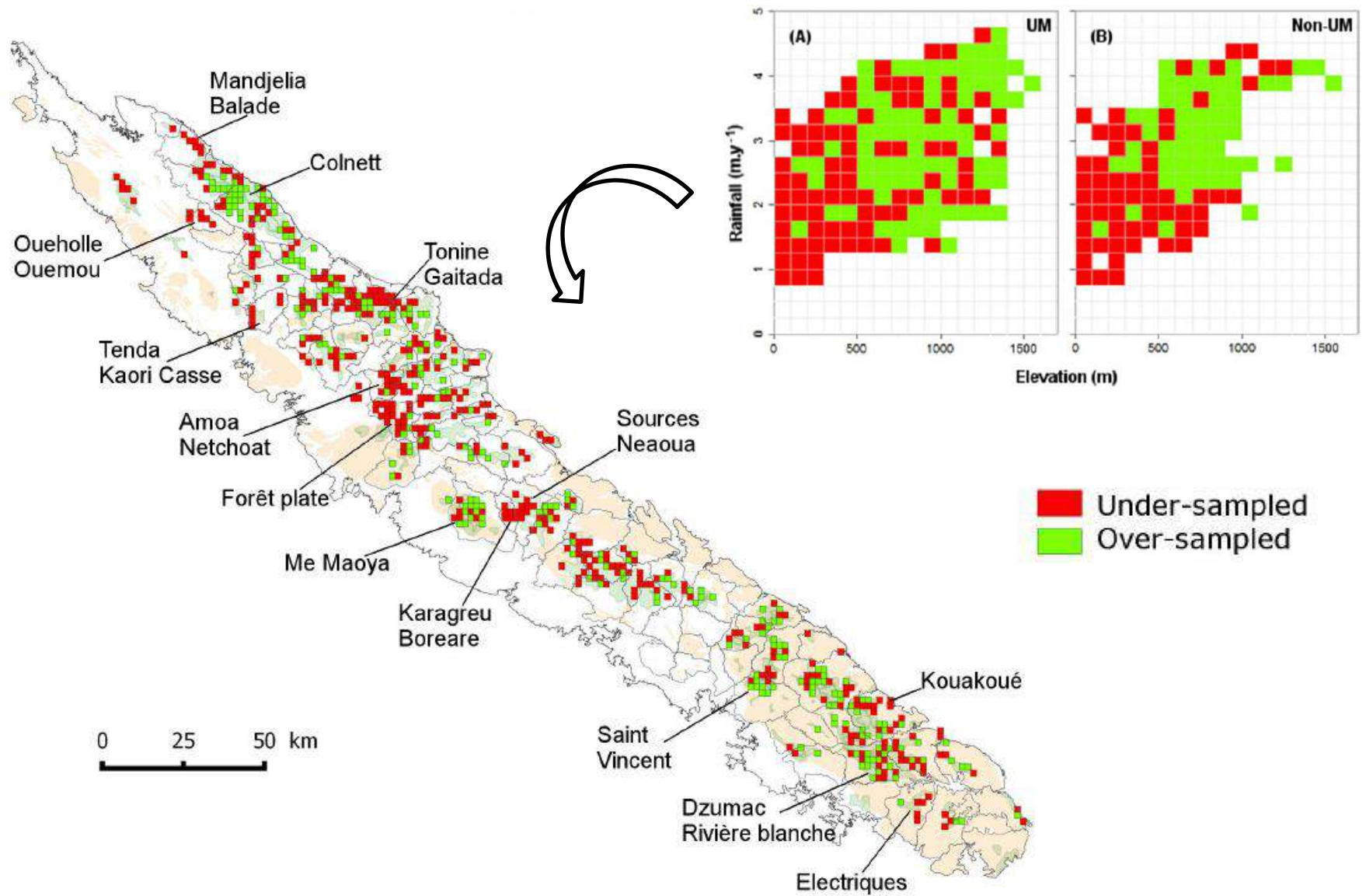
But higher elevation and UM substrates over-sampled

Relative density distribution of forested area /



# Tree species distribution

## Where to go now?

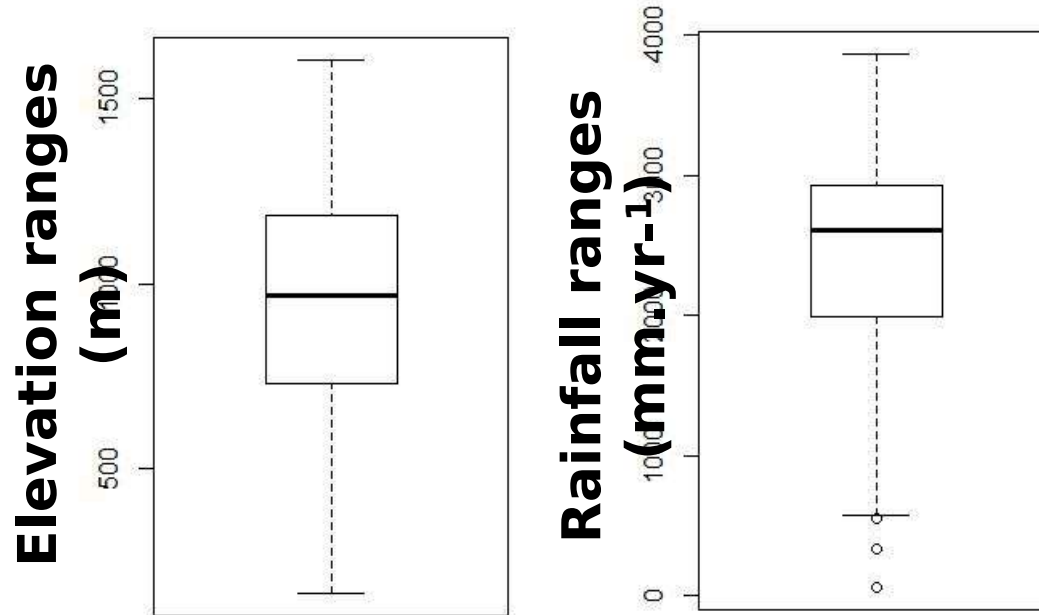




# Tree species distribution

## Spatial aggregation vs. environmental tolerance

**56 % of species** occur on both UM and non-UM substrates



Most species exhibit **wide elevation and rainfall ranges**  
or not enough stressful conditions ?

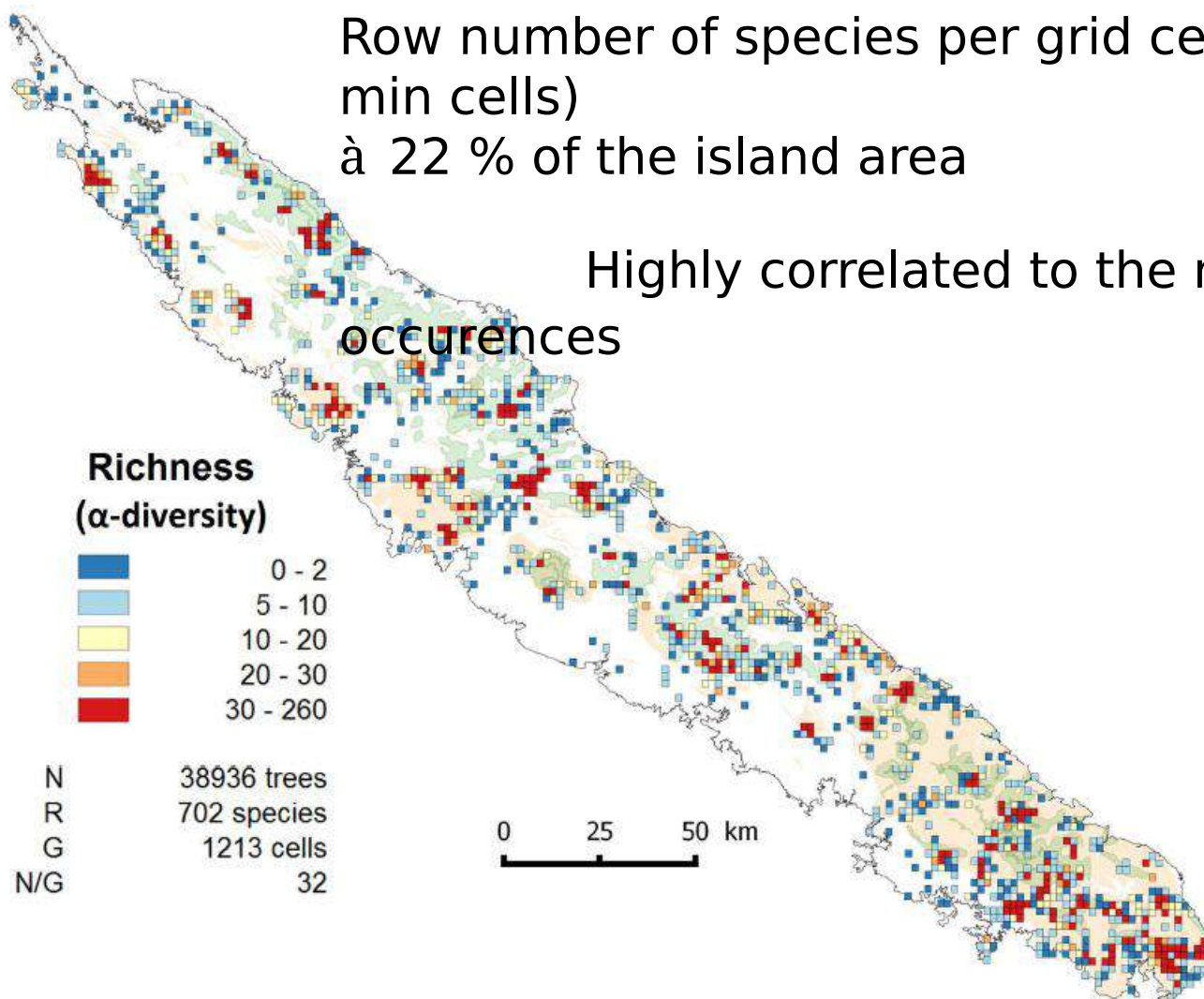
**BUT** most species exhibit **high spatial aggregation**  
Dispersal limitation ?

# Tree species distribution

## Alpha diversity distribution

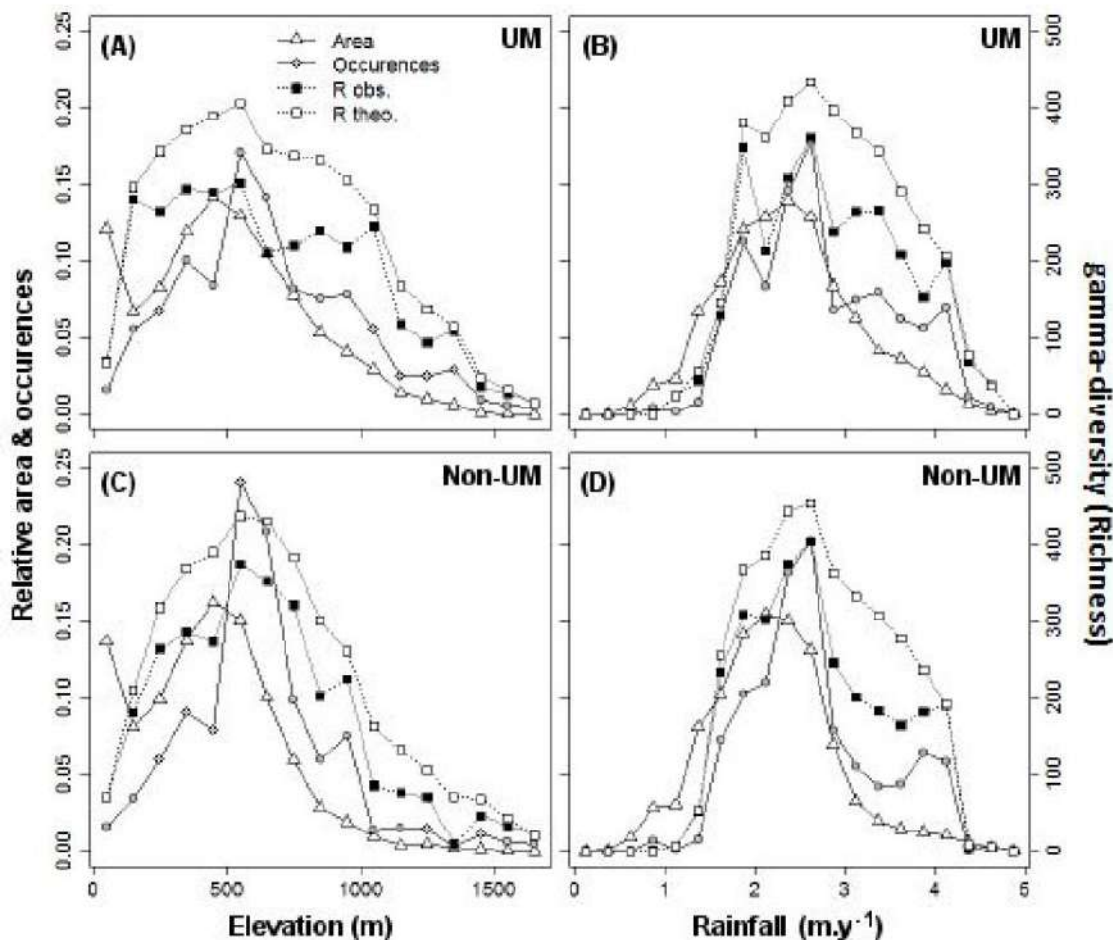
Row number of species per grid cell (1 min x 1 min cells)  
à 22 % of the island area

Highly correlated to the number of occurrences



# Tree species distribution Gamma diversity distribution

Species richness (R obs.), potential richness (R. theo),  
occurrences and available forest area



**High correlations**

Sampling effect

Area effect ?

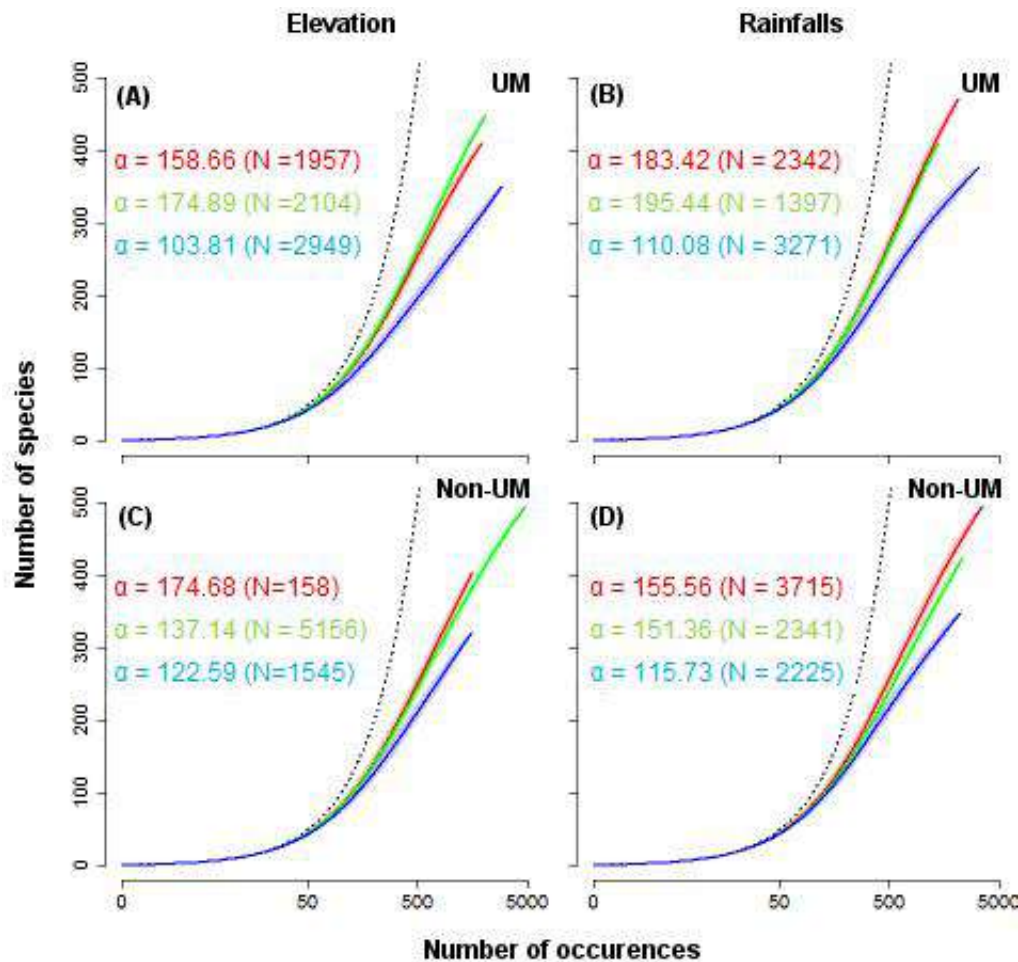
Mid-domain effect ?



# Tree species distribution

## Gamma diversity distribution

Rarefaction curves for different elevation / rainfalls ranges



- Low ( $\leq 400$  m ;  $\leq 2.5$  m/yr)
- Medium ( $> 400$  &  $\leq 800$  m ;  $> 2.5$  &  $\leq 3.0$  m/yr)
- High ( $> 800$  m ;  $> 3.0$  m)

Significant  
**decrease at higher  
elevation / rainfalls**

# Tree species distribution

## Conclusions

Species richness highly correlated with sampling effort  
à Need for standardize richness indices (rarefaction, Hill numbers)  
à Test different spatial scales

Species distributions highlight high environmental tolerances but also high spatial aggregation  
à Dispersal limitation ?  
à At which spatial scale community are structured ?

Species richness likely decrease at higher elevation  
à Which drivers ?  
à Environmental and/or spatial effects (area, isolation) ?



# New insights from 1-ha plots





# New insights from 1-ha plots

## Relative low $\alpha$ diversity vs. high $\beta$ diversity

Site	# Stems	# Trees	R	BA (m <sup>2</sup> )	H (m)
<i>Tiwae</i>	1319	1266	94	32.76	11.90
<i>Djeve</i>	1036	1020	99	56.82	15.35
<i>La Guen</i>	1398	870	80	42.58	10.90
<i>Ateou</i>	1197	672	86	72.18	21.13
<i>Bouirou</i>	1193	919	100	65.08	20.48
<i>Foret Plate</i>	922	885	101	53.19	19.50
<i>Aoupinie</i>	1612	1429	86	53.58	7.88
<i>Gohapin</i>	805	805	38	39.25	
<b>Mean</b>	<b>1240</b>	<b>1009</b>	<b>92</b>	<b>54</b>	<b>15</b>

Relative low  $\alpha$  diversity / # of stems (+ no patterns with elevation)

High  $\beta$  diversity

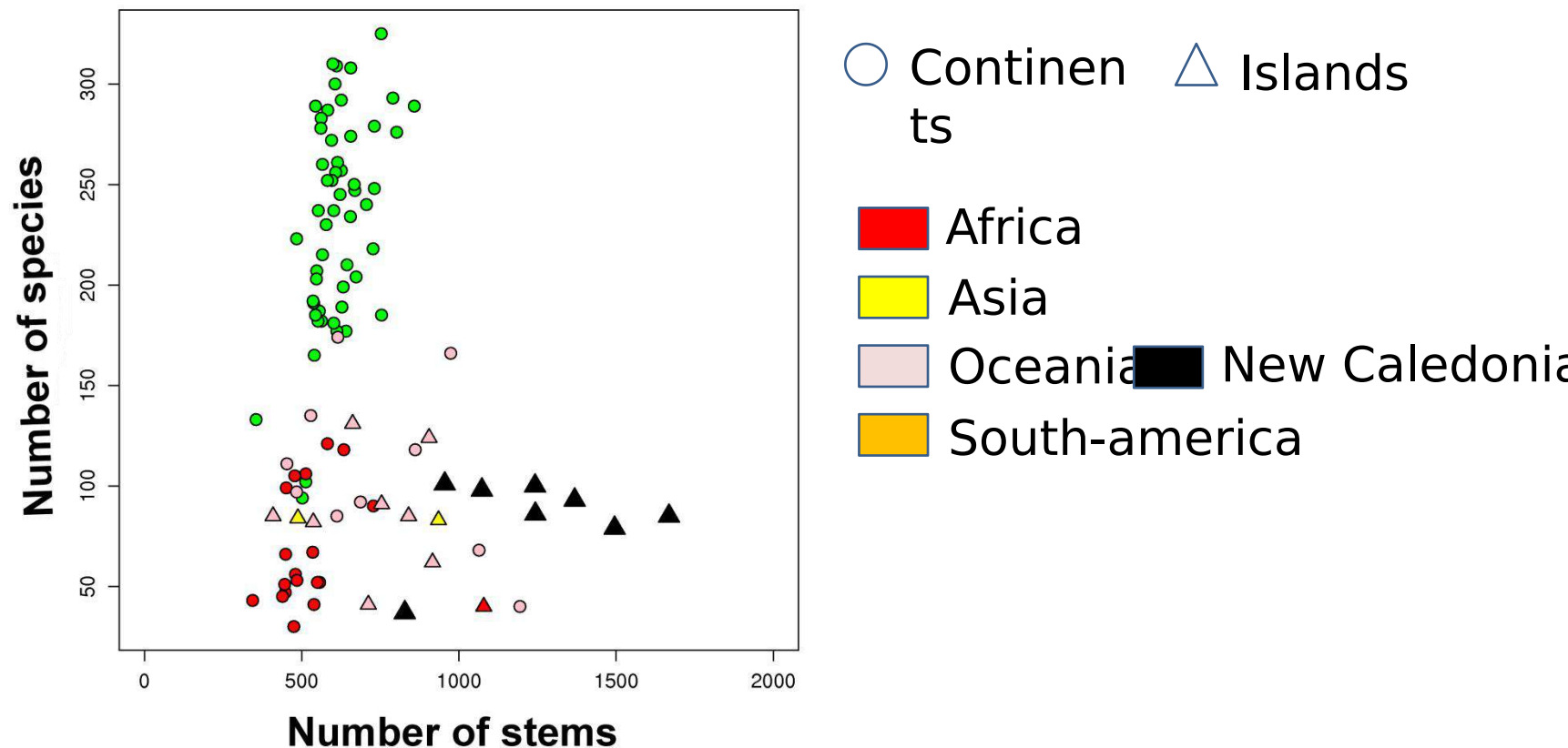
Bray-Curtis dissimilarity: 0.56 - 0.98 (mean = 0.82  $\pm$  0.10)

Jaccard index : 0.72 - 0.99 (mean = 0.90  $\pm$  0.07)

# 1-ha plots insights

## New Caledonia vs. World / Islands vs. Continents

Review of 1-ha plots (DBH  $\geq$  10 cm)



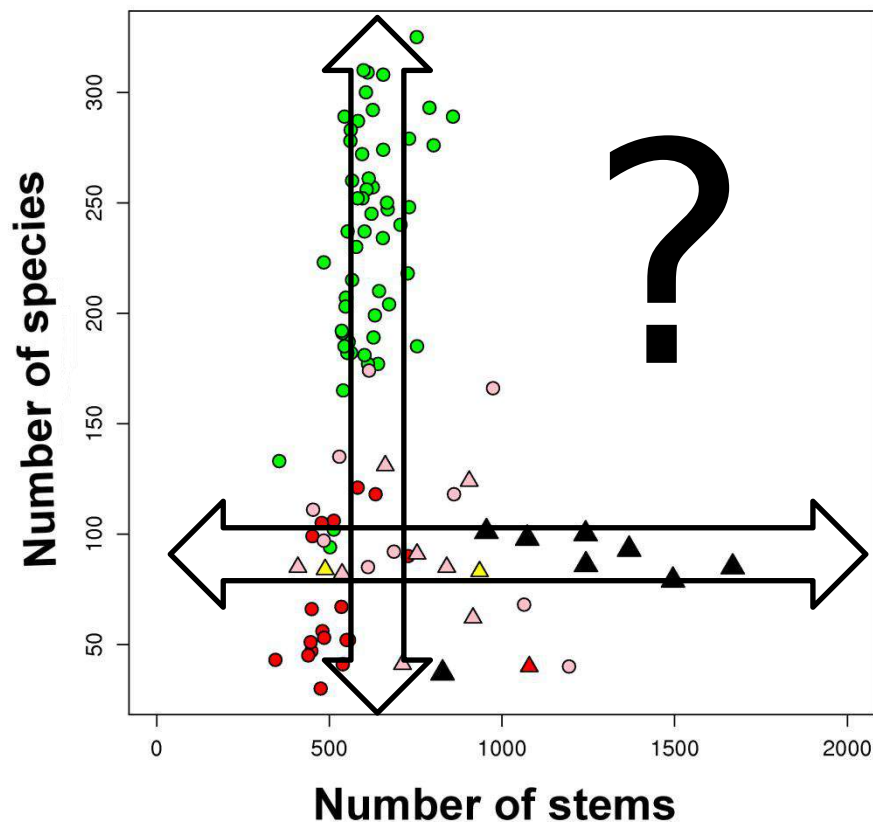
New Caledonia  $\alpha$  diversity relatively small / unusual stem density

Which drive the structure of New caledonian forest ?

# 1-ha plots insights

## New Caledonia vs. World / Islands vs. Continents

Review of 1-ha plots (DBH  $\geq$  10 cm)



○ Continents    △ Islands

■ Africa

■ Asia

■ Oceania    ■ New Caledonia

■ South-america

New Caledonia  $\alpha$  diversity relatively small / unusual stem density

Which drive the structure of New caledonian forest ?



**Oléti (Thank you)**





# 1-ha plots insights

