Drivers of tree species richness in New Caledonia

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A hotspot for biodiversity conservation
A lab for ecological studies

New Caledonia Biodiversity hotspot

> 3000 vascular plant species

≈ 75 % of endemism

1500 km

Tropic of Capricorn

2000 km

Australia

New-Zealand

A hotspot for biodiversity conservation
A lab for ecological studies




New Caledonia Biodiversity hotspot

> 3000 vascular plant species

≈ 75 % of endemism

1500 km

Tropic of Capricorn

Australia

2000 km

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 km² (≈ 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

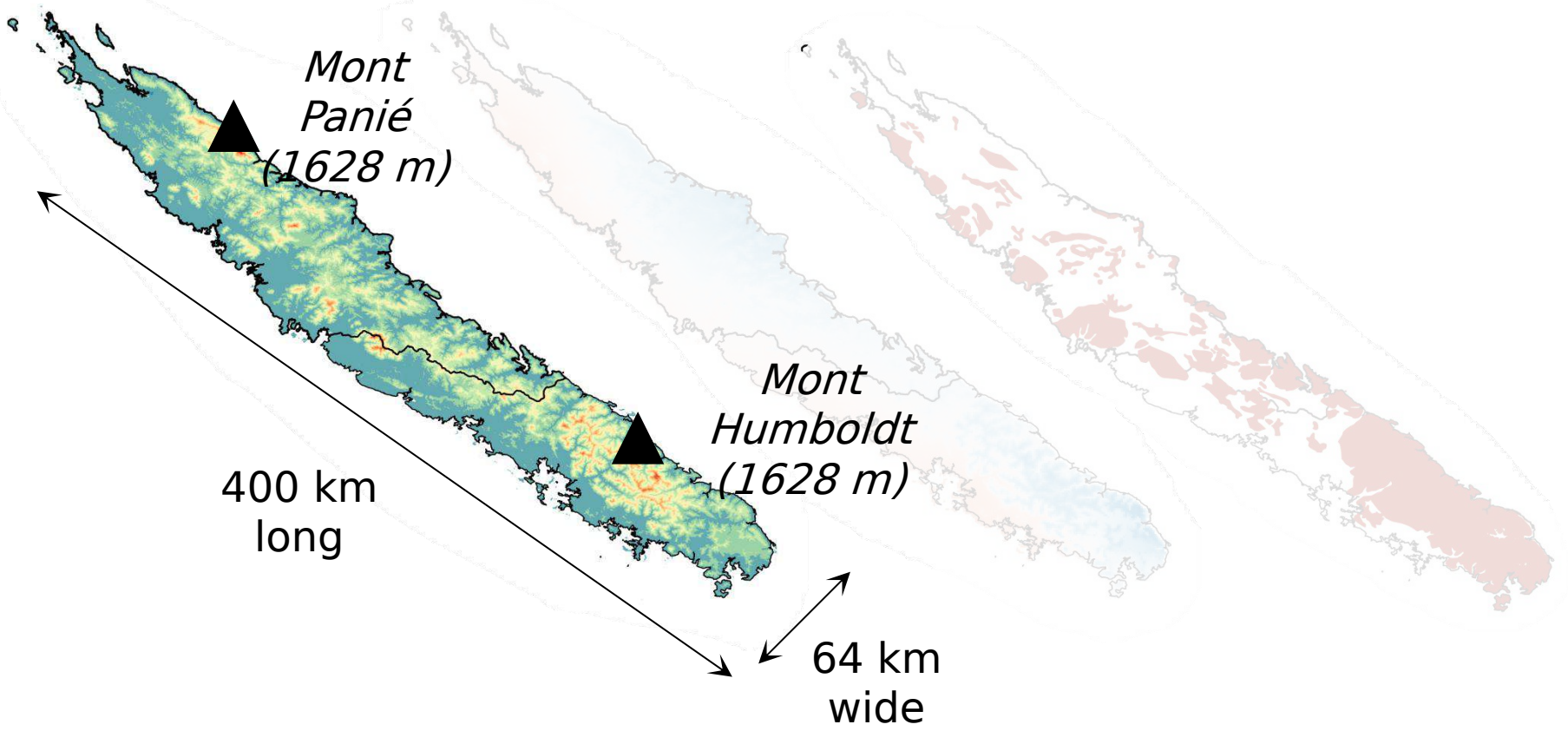
How **species composition** and **species richness** vary across **space** and time ?

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

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

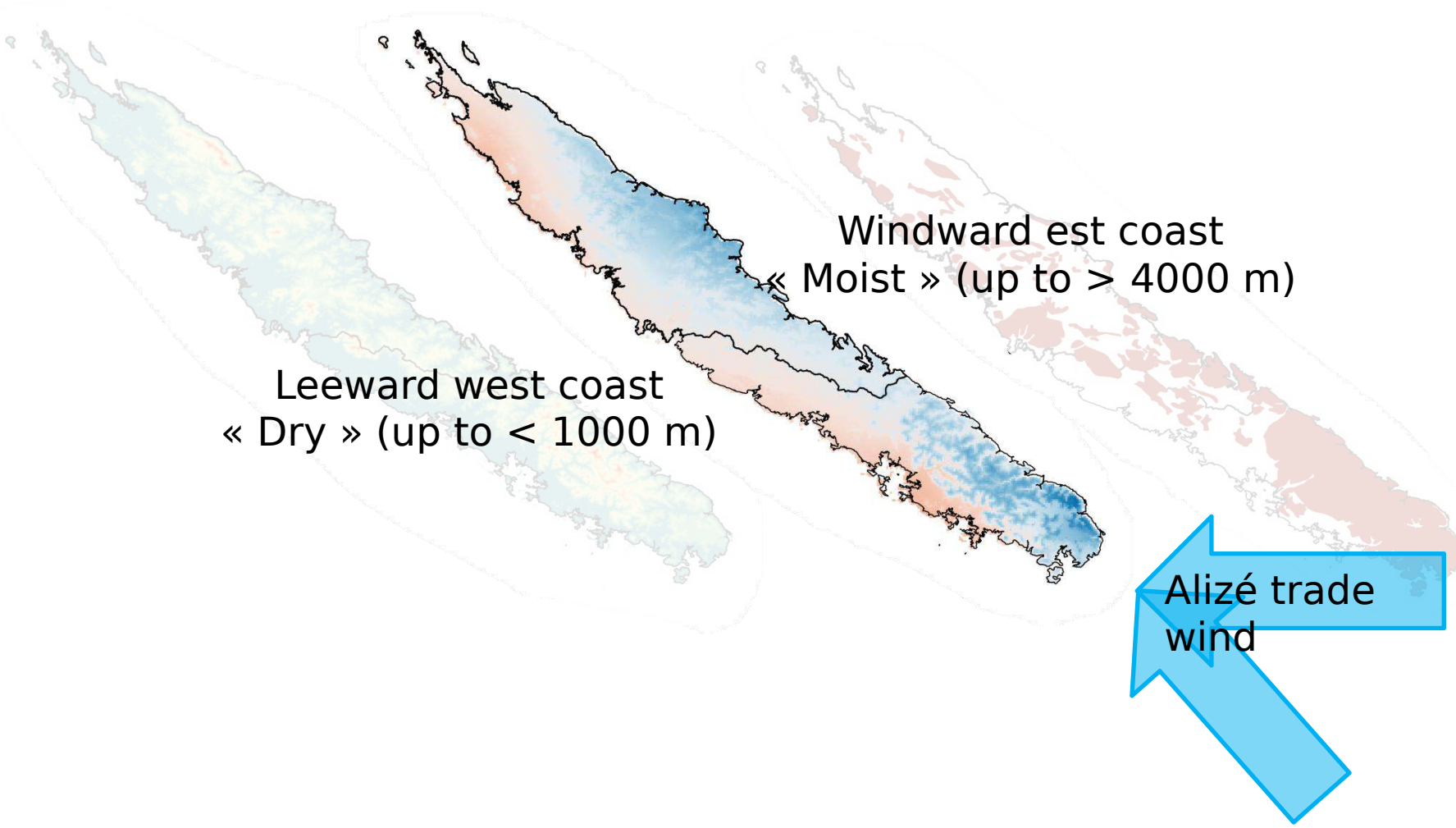
Floristic diversity
Environmental diversity

Elevation Rainfalls Substrates



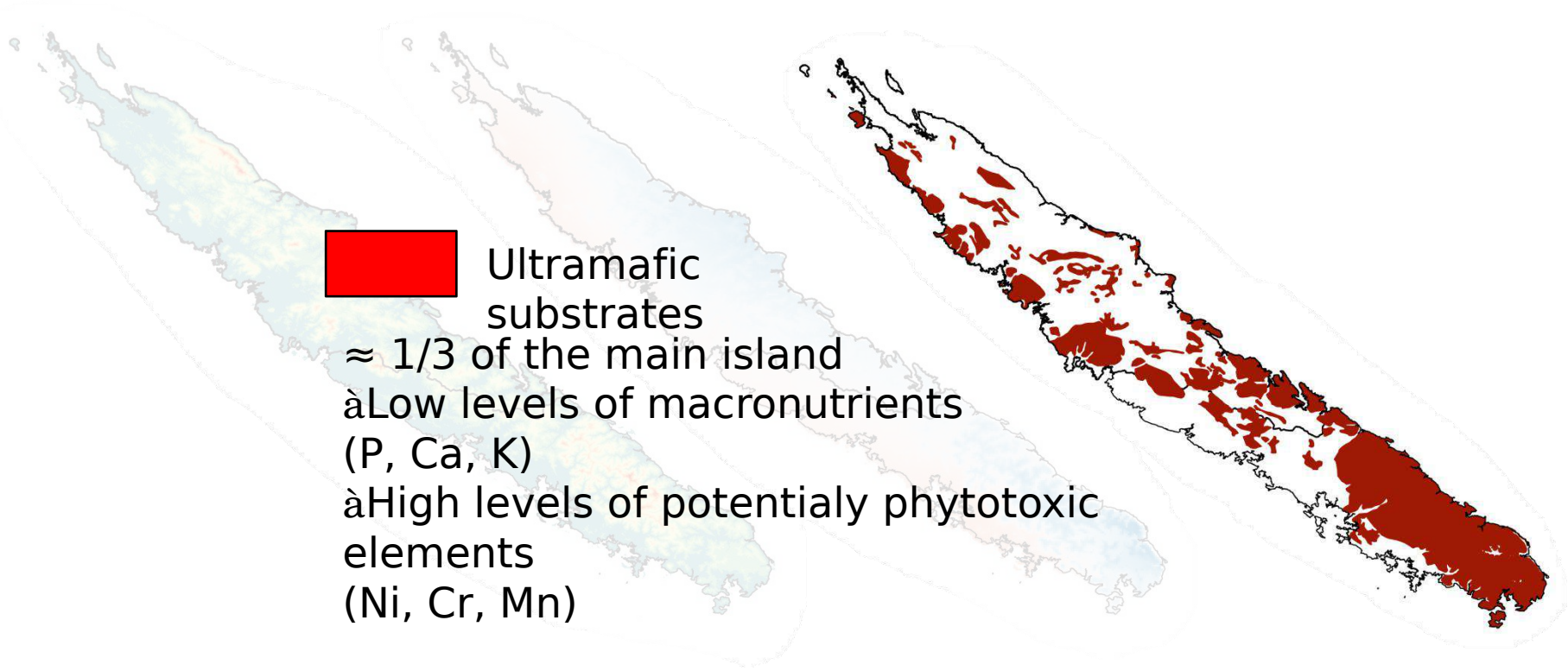
Floristic diversity
Environmental diversity

Elevation **Rainfalls** Substrates



Floristic diversity
Environmental diversity

Elevation **Rainfalls** **Substrates**



Ultramafic substrates

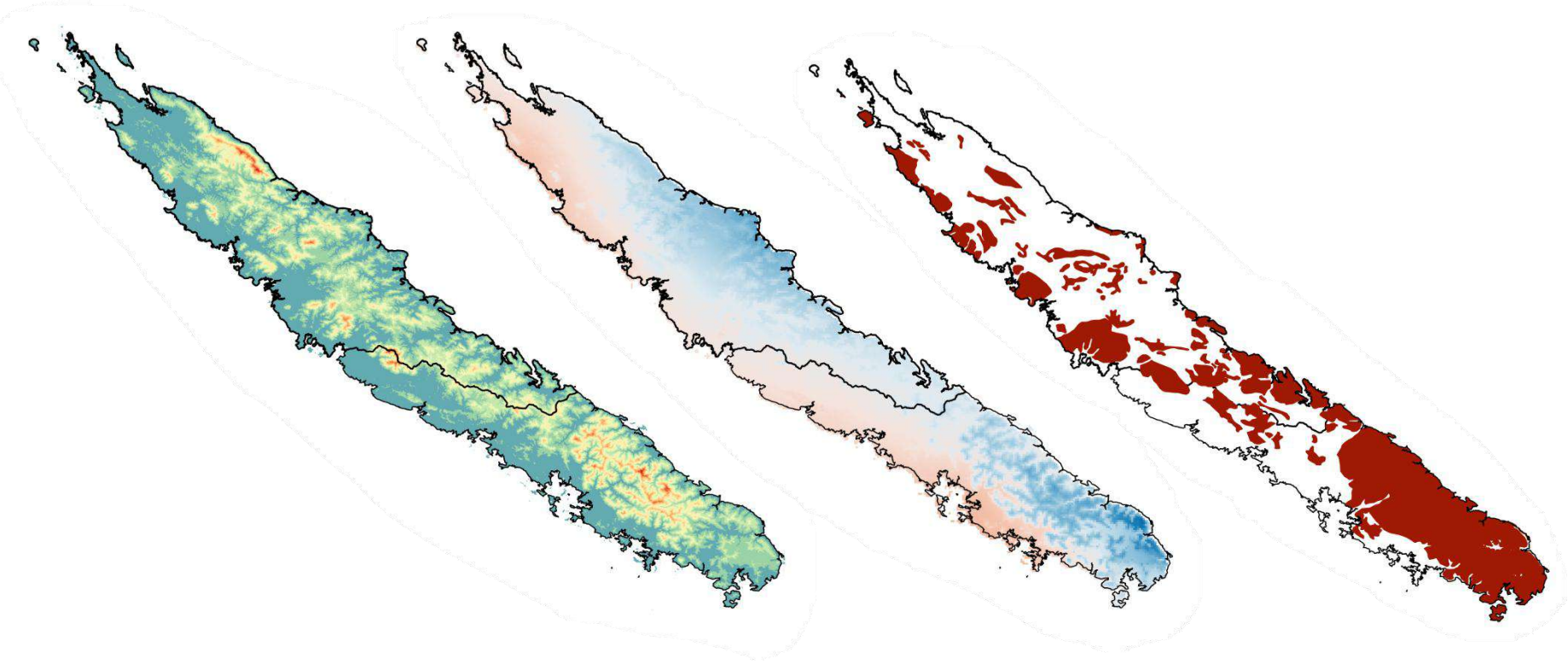
≈ 1/3 of the main island

àLow levels of macronutrients (P, Ca, K)

àHigh levels of potentialy phytotoxic elements (Ni, Cr, Mn)

Floristic diversity
Environmental diversity

Elevation **Rainfalls** **Substrates**

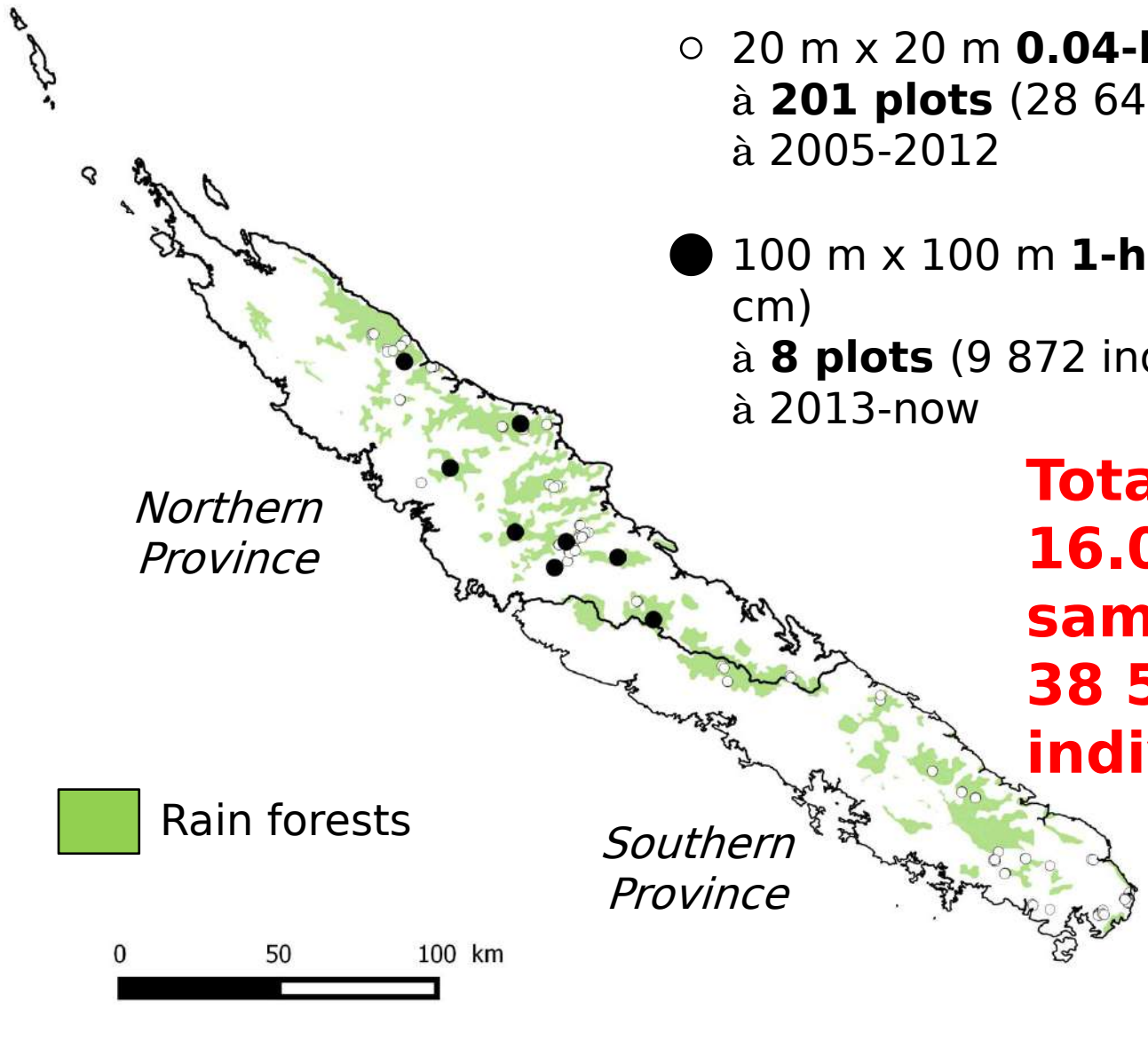


‘Relation between ecological diversity and floristic diversity in New Caledonia’

Need for standardized plant survey to better understand these drivers

New Caledonian Plant Inventorie and Permanent Plot Network (NC-PIPPN) 2005-Now

NC-PIPPN: Forest structure and composition
Exploring large-scale spatial variability

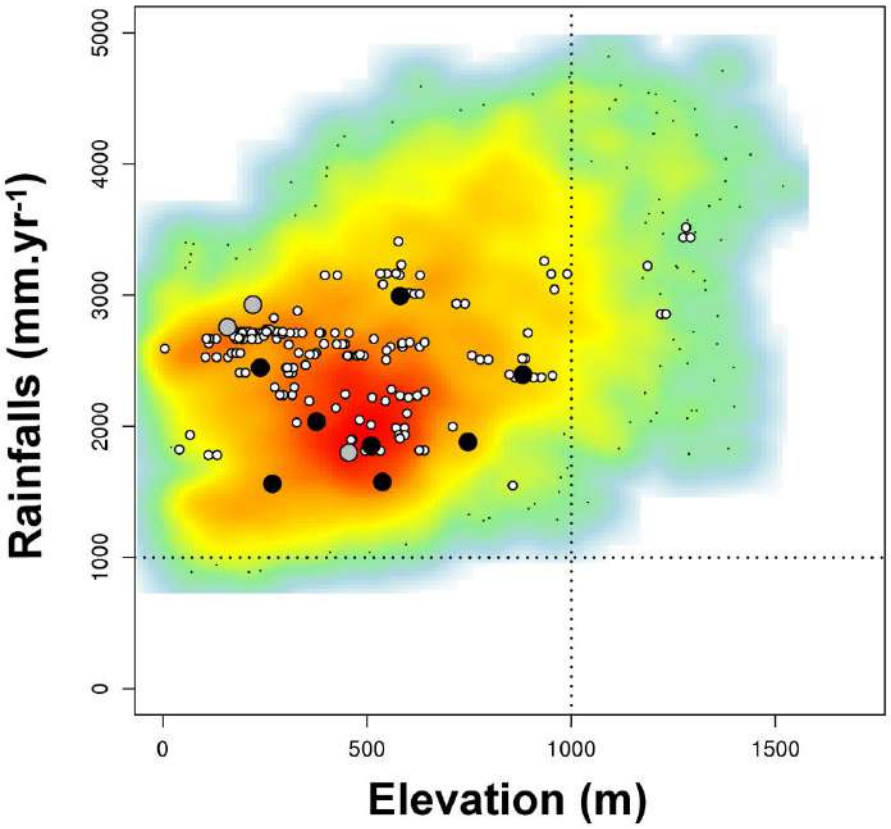


- 20 m x 20 m **0.04-ha plots** (DBH ≥ 5cm)
  - à **201 plots** (28 640 individuals)
  - à 2005-2012
- 100 m x 100 m **1-ha plots** (DBH ≥ 10 cm)
  - à **8 plots** (9 872 individuals)
  - à 2013-now

Total:
16.04 ha sampled
38 512 individuals

IC-PIPPN: Forest structure and composition
Exploring environemental variability

Distribution of forest area along altitudinal and rainfall gradients



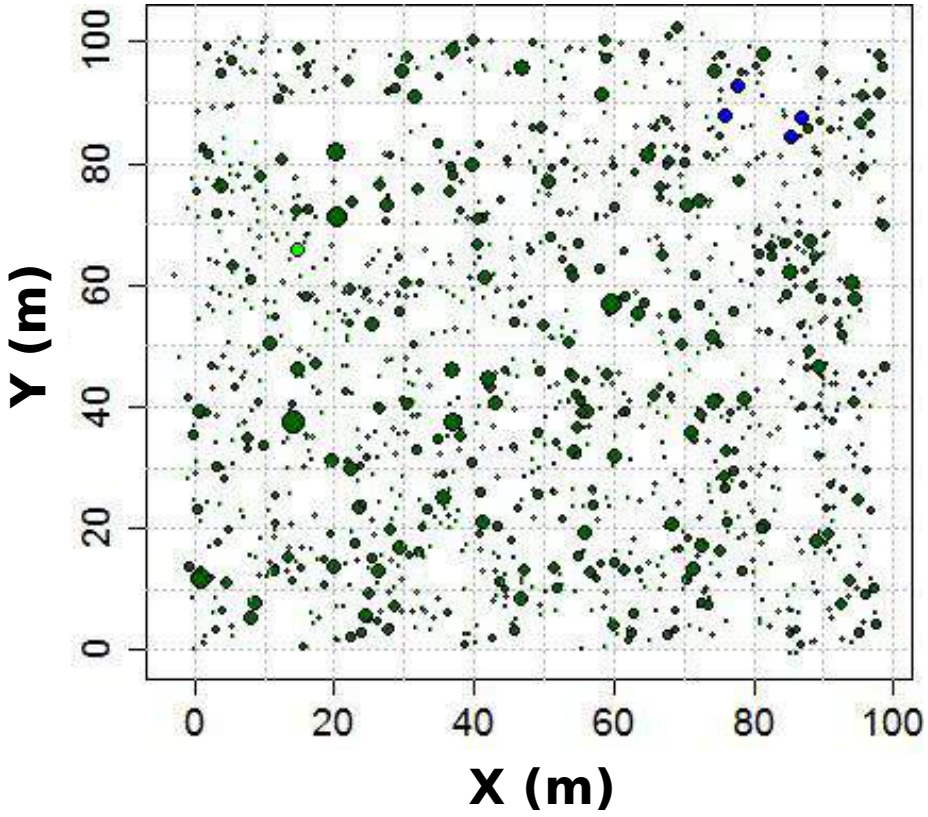
- 0.04-ha plots
- 1-ha plots
- 1-ha plots from Jaffré *et al.* (1991, 1995)

Relative density distribution of forested area

High elevation forest (i.e. > 1000 m) ≈ 100 km² (2.5 % of total forest areas)

NC-PIPPN: Forest structure and composition
Exploring fine-scale spatial variability

6 fully-mapped 1-ha plots

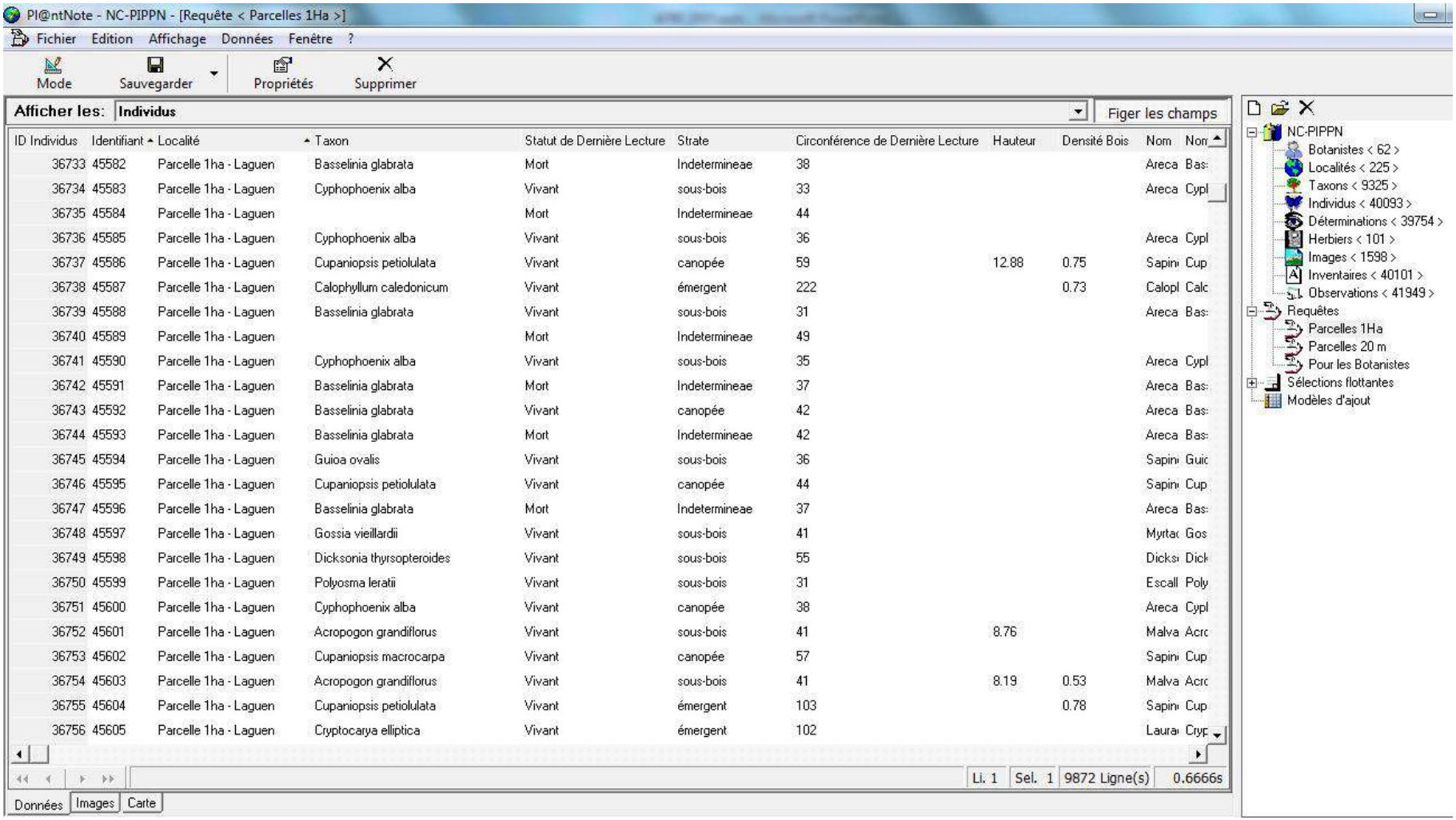


e.g. Boirou
1197 stems (672 trees)
85 species (80 tree species)

Subsampling
Gap dynamics

NC-PIPPN: Forest structure and composition

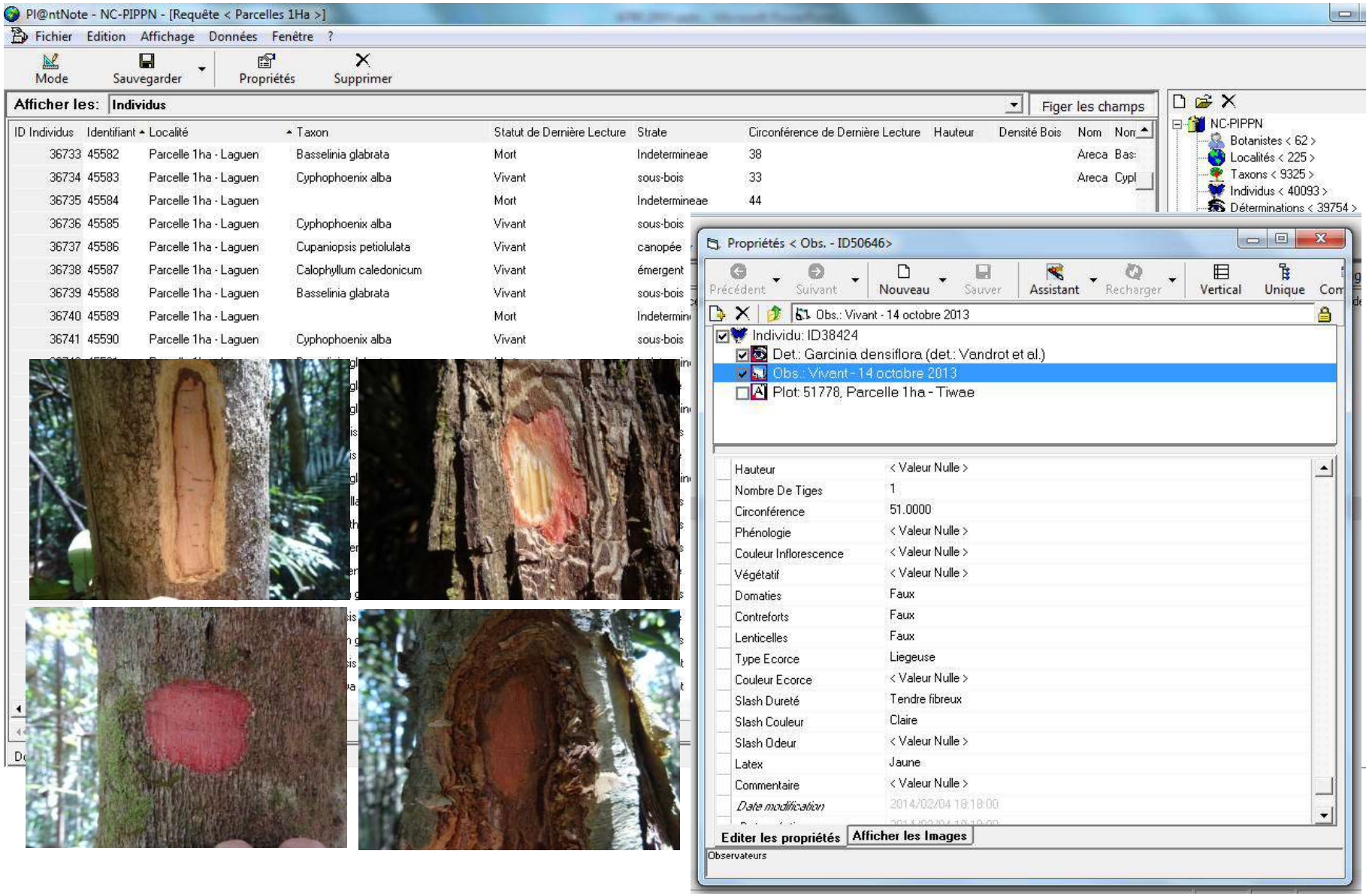
Pl@ntNote database



Drivers of tree species richness in New Caledonia

NC-PIPPN: Forest structure and composition

Pl@ntNote database



UC-PIPPN: Forest structure and composition

Sharing data for global analysis

sPlot

a project of iDiv

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

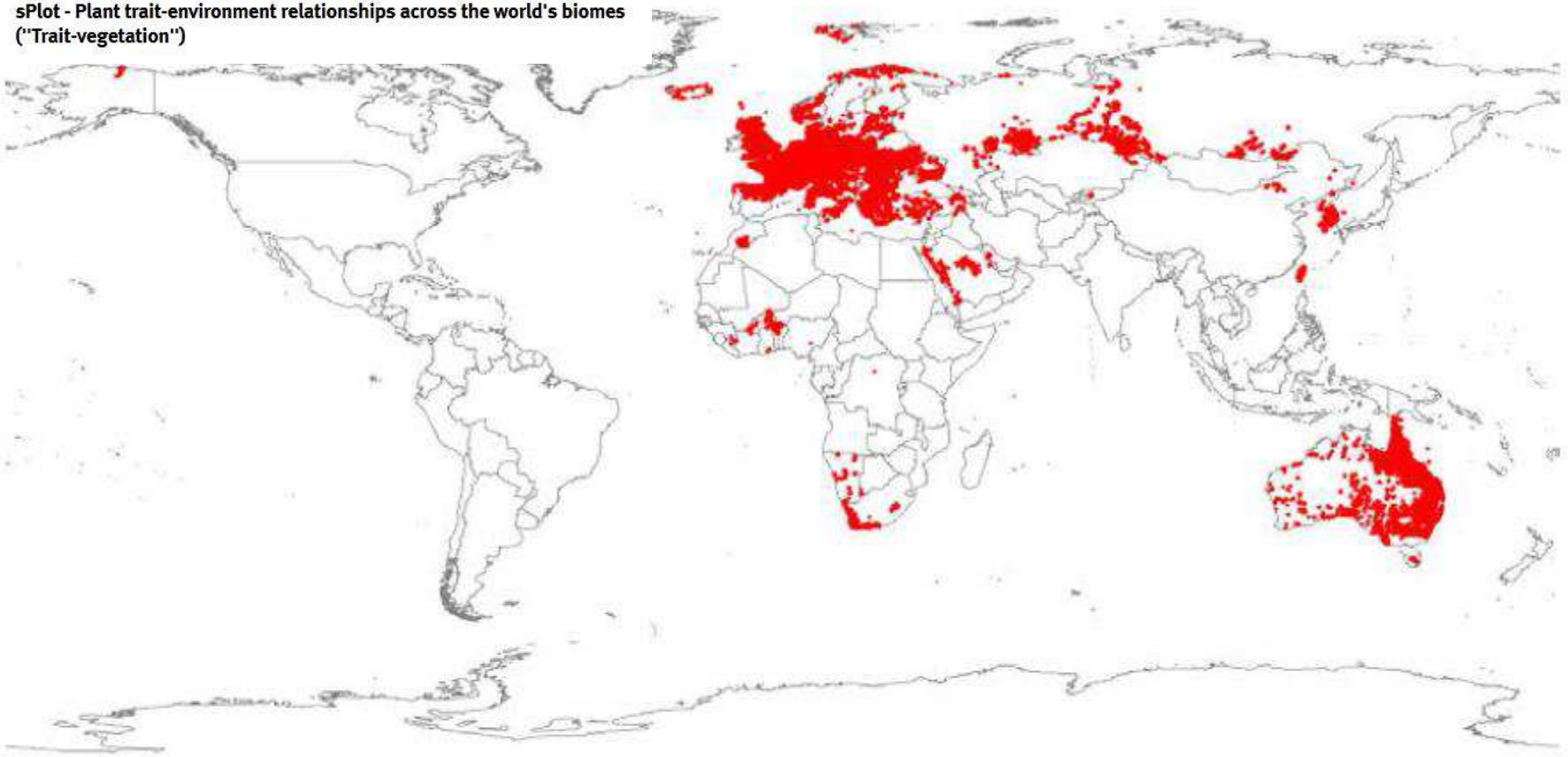
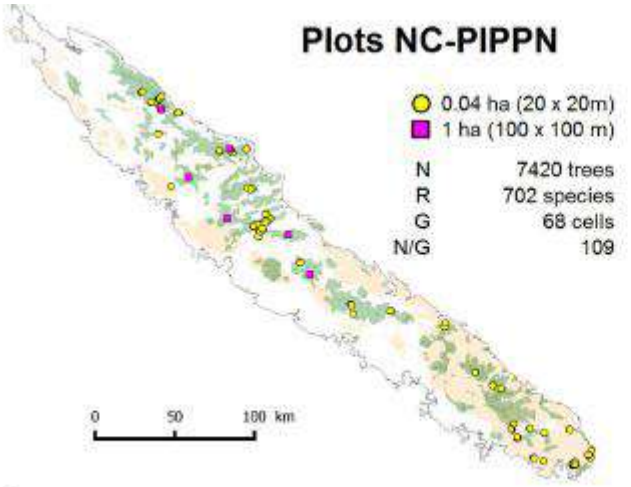


Fig. 2: Geographic distribution of vegetation plots in sPlot 1.0.

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)

Herbarium (NOU)

Occurrences
N 1
R 658 species
G 1073 cells
N/G 11

Observations

Occurrences
N 18390 trees
R 626 species
G 340 cells
N/G 54

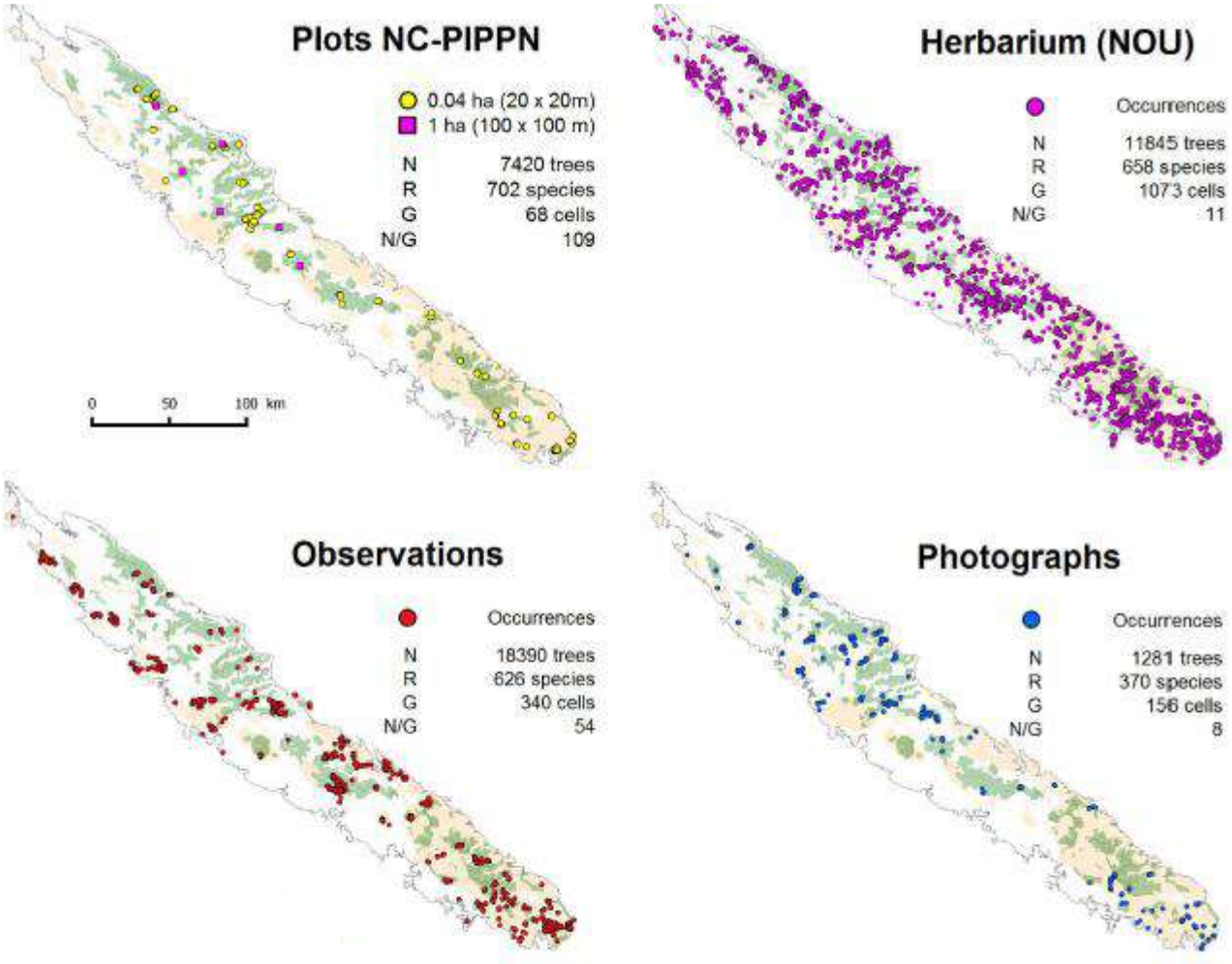
Photographs

Occurrences
N 1281 trees
R 370 species
G 156 cells
N/G 8

Birnbaum *et al (in press) AoB plants*

NC-PIPPN: Forest structure and composition

Plant inventory: Tree species distribution



> 100 000 reliable tree occurences

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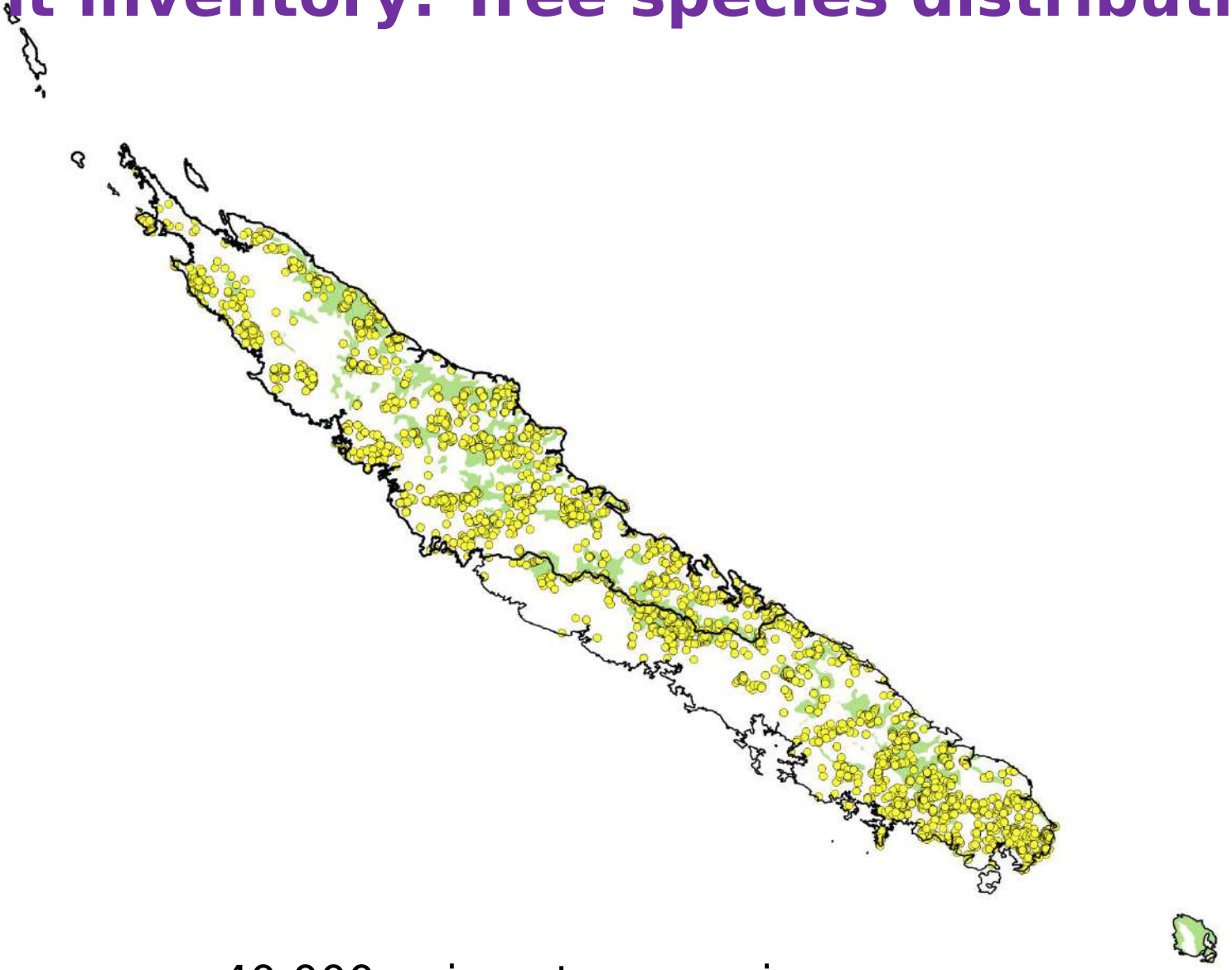
UC-PIPPN: Forest structure and composition

Plant inventory: Tree species distribution



≈ 40 000 unique tree species occurences

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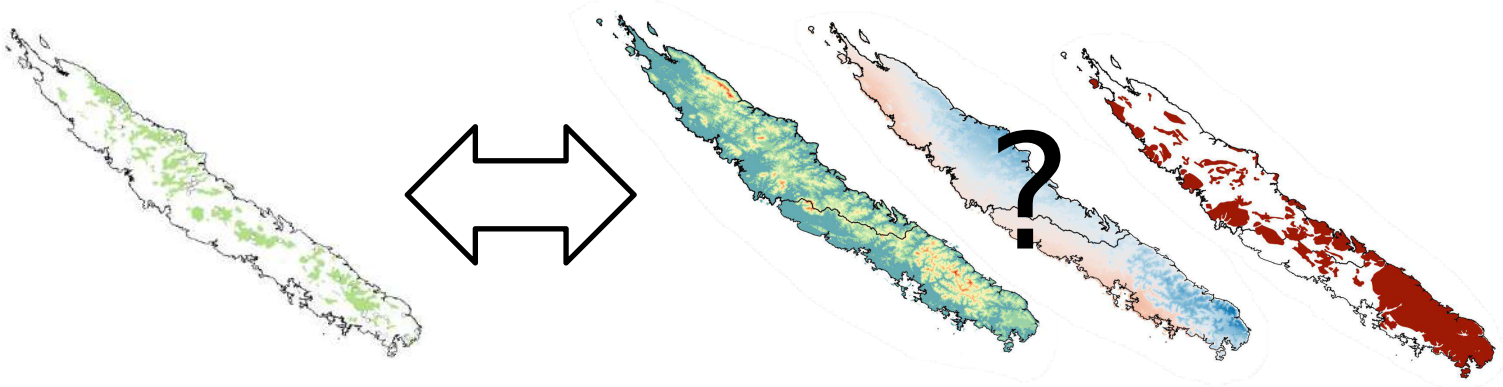
New statement of knowledge
Forest structure & composition (0.04 ha-plots)
Tree species distribution (occurrences)

Structural & floristic diversity
A first large-scale synthesis

201 plots (0.04-ha, DBH ≥ 5 cm)

Describe the structural and floristic diversity
àComposition, richness, diversity, density, basal area

Investigate environemental determinants
Elevation, rainfalls, substrates, slopes, geographical position



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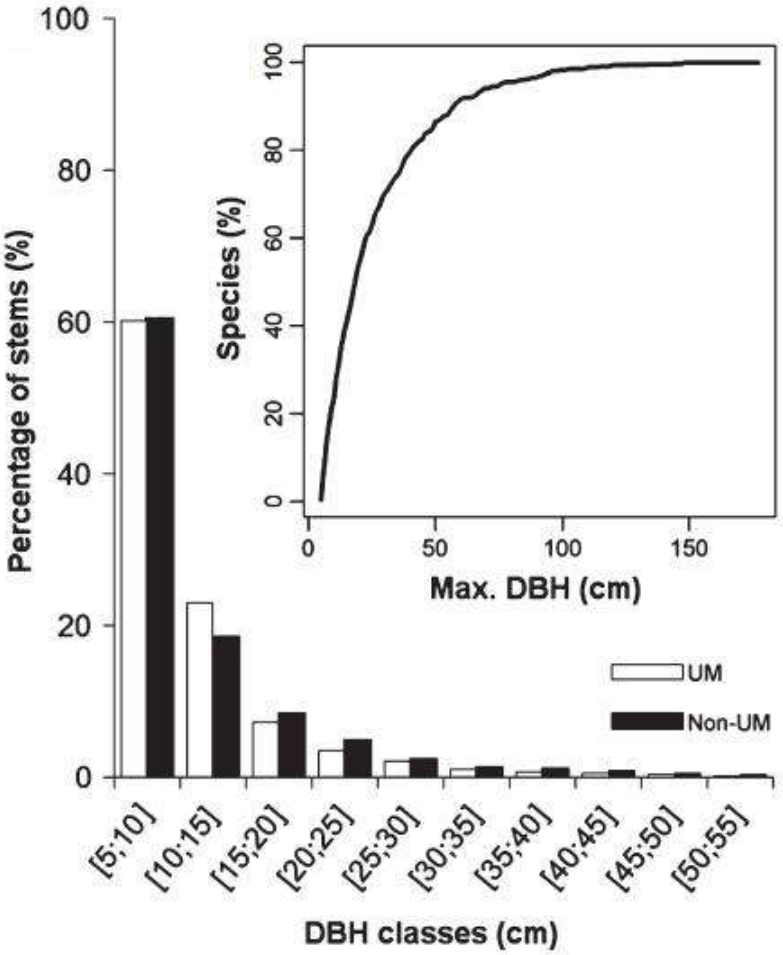
Structural & floristic diversity
The [5-10] cm DBH class



60 % of the individuals in [5-10]

≈ 25 % of species never ≥ 10 cm

≈ 75 % of species never ≥ 35 cm

A great part of the total species richness

Species richness [5-10] cm highly correlated to species richness [≥ 10] cm

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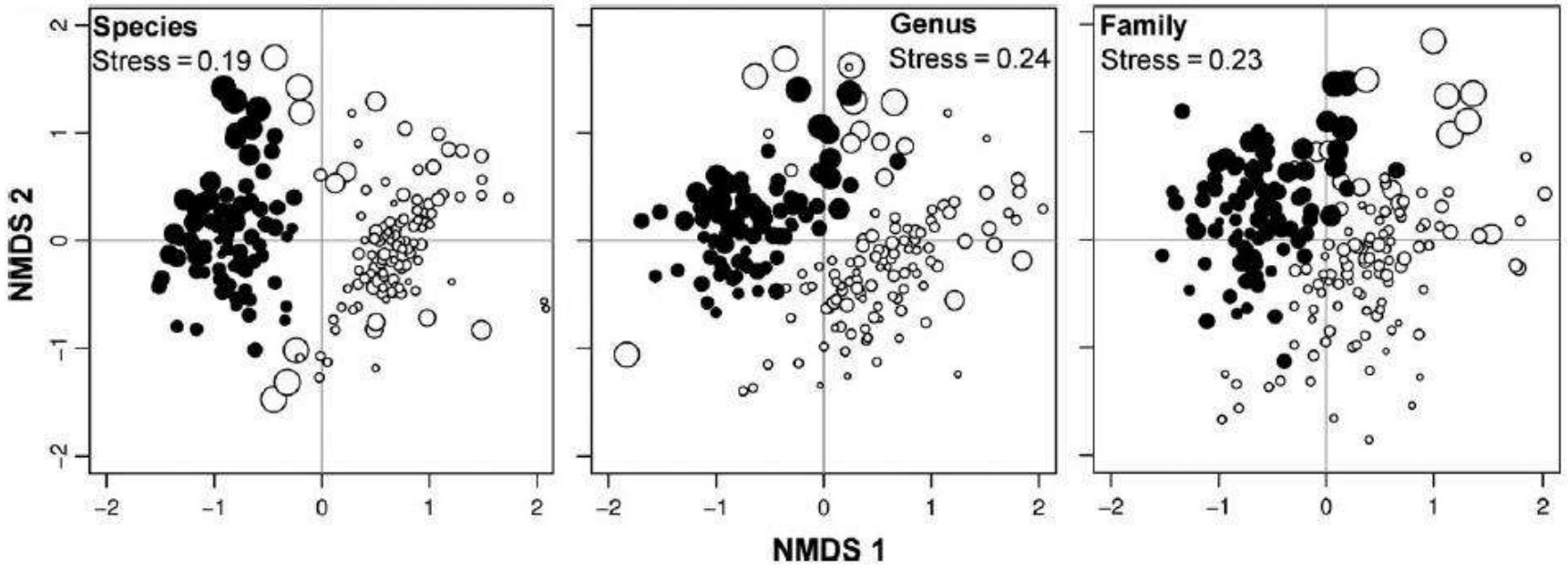
Structural & floristic diversity
Ultramafic vs. non-ultramafic substrates

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

Differences in forest composition

à> 75 % of species occured only on one substrate

à decrease of floristic dissimilarity with elevation



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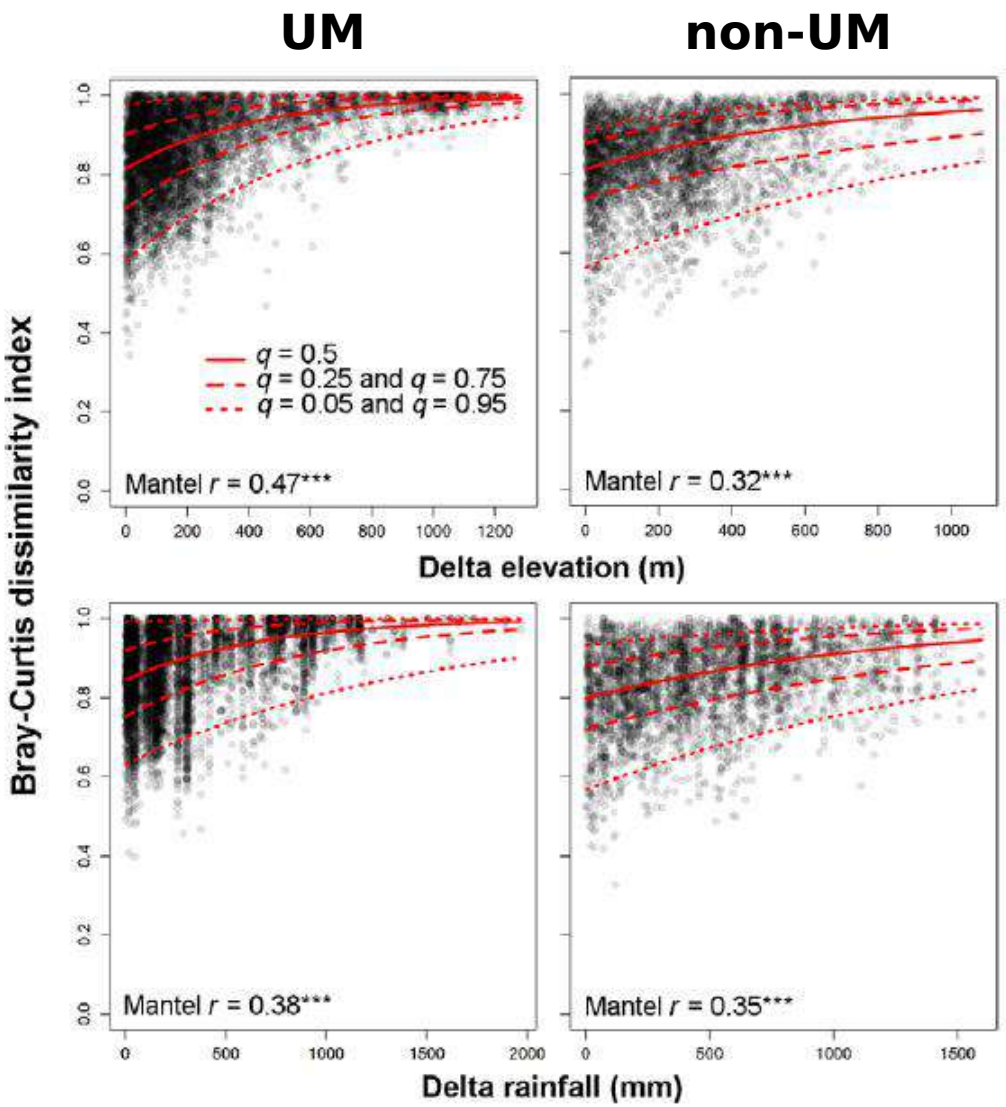
Structural & floristic diversity
High β diversity, weak environmental drivers



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

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Structural & floristic diversity
Conclusions

NC-PIPPN (0.04-ha plots) very efficient to explore the richness of the flora (ϒ diversity)

High species richness (ϒ ≈ 750 species inventoried, α ≈ 40 species/plot)

Substrates types on of the main drivers of species richness (through β)

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

BUT low reliability of structural parameters, species richness (α) and floristic dissimilarities (β) due to the small size of the plots

à **Need complementary larger plots**
(international standard 1-ha, 10 cm DBH)

Ibanez *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

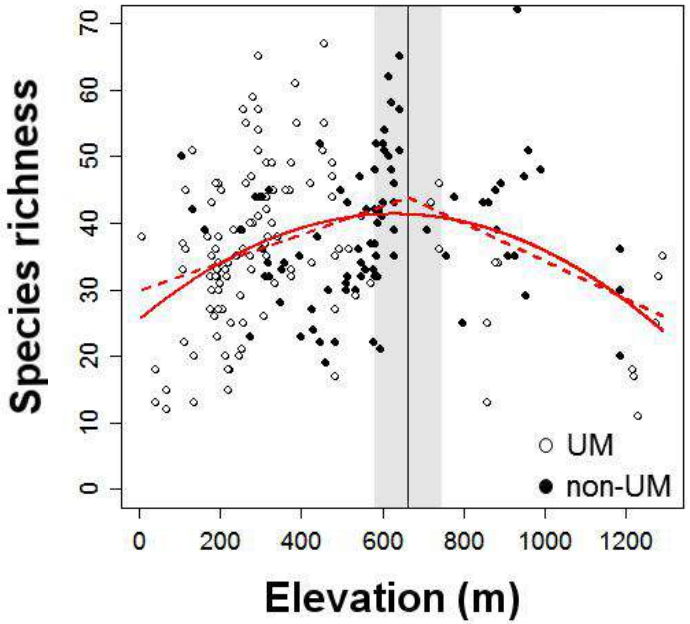
COMMENTARY

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.

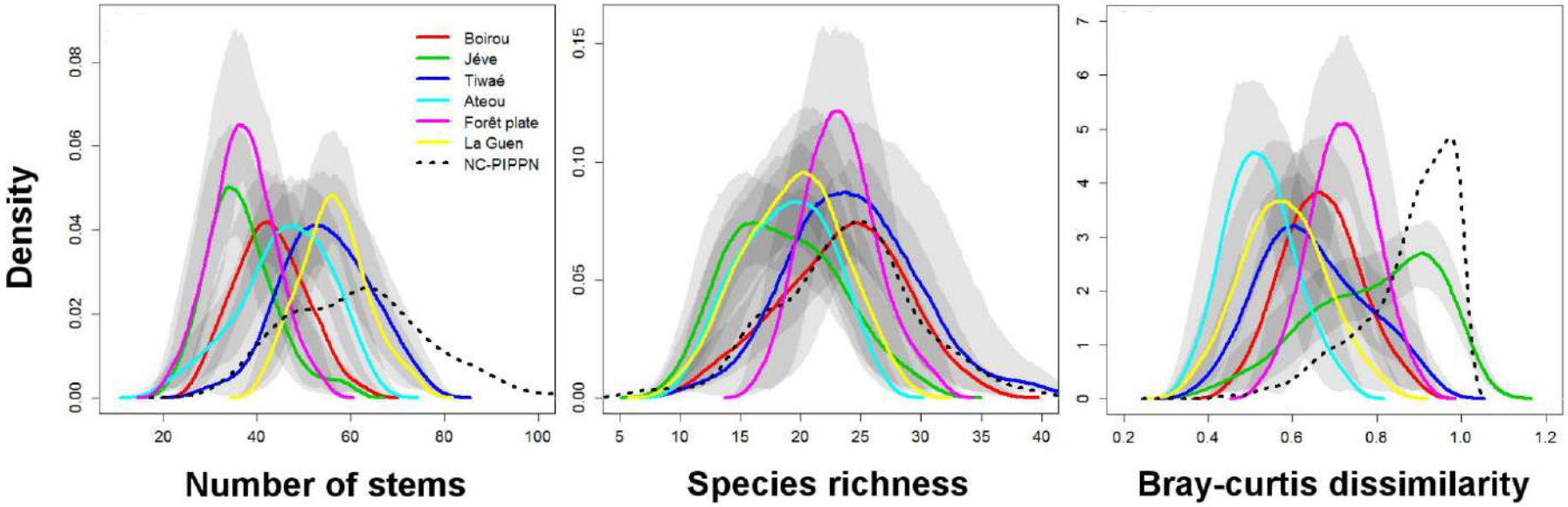


Weak mid-peak pattern

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)

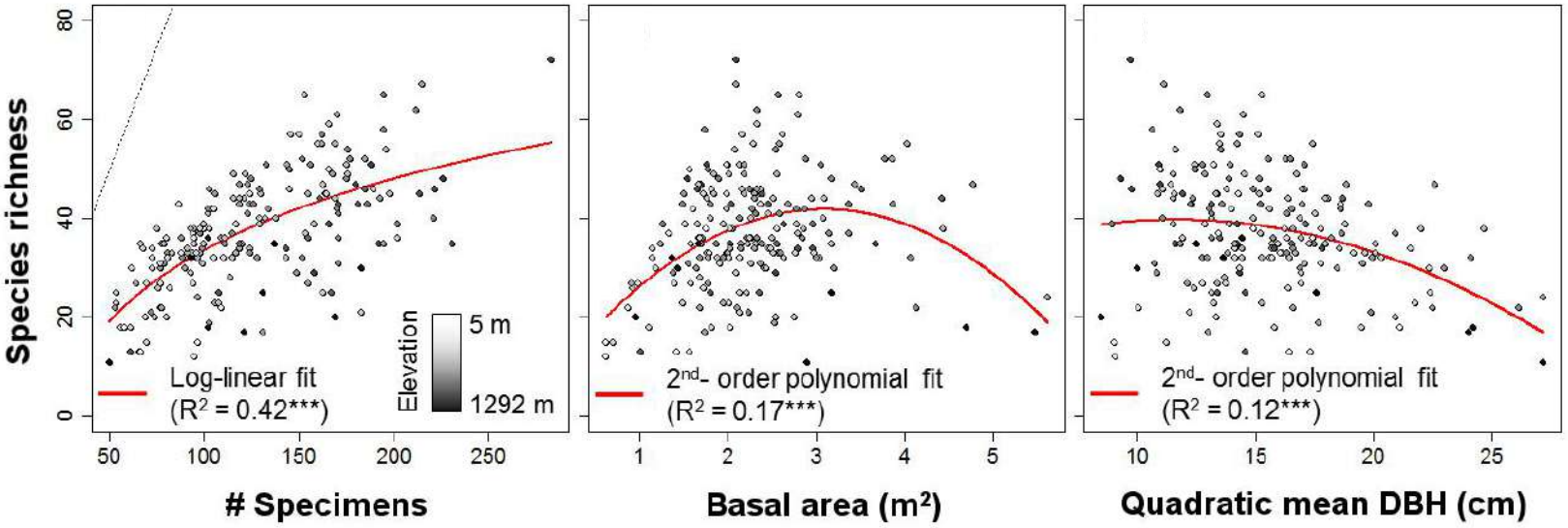


Comparison of the variability within the 0.04-ha plots network and within 1-ha plots (random sub-sampling of each 1-ha plots with 0.04-ha plots)

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 reaveal richness patterns?

Species richness is biased by the number of specimens



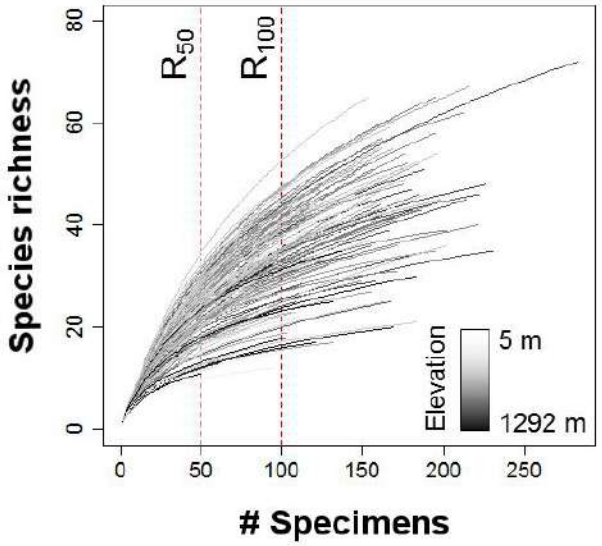
Large plots : “more-individuals hypothesis”
à More productivity, more trees, more species

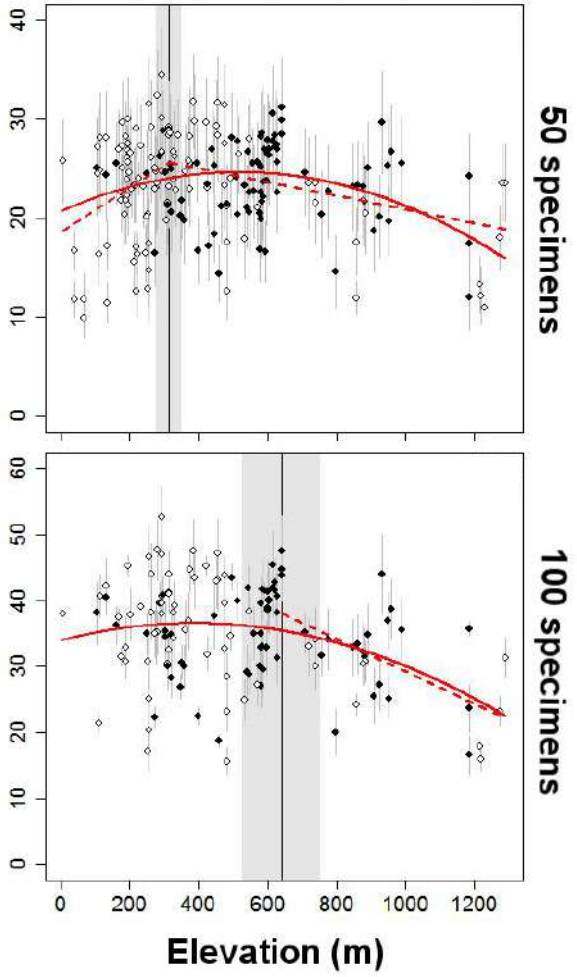
Small plots : “self-thinning hypothesis”
More productivity, bigger trees, less trees, less species

Ibanez *et al (in review) Journal of Vegetation Science*

Lake of diversity patterns with elevation
Does rarefaction reaveal richness patterns?

Standardisation by the number of specimens (rarefaction)





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

Decrease after 600-800

Ibanez *et al (in review) Journal of Vegetation Science*

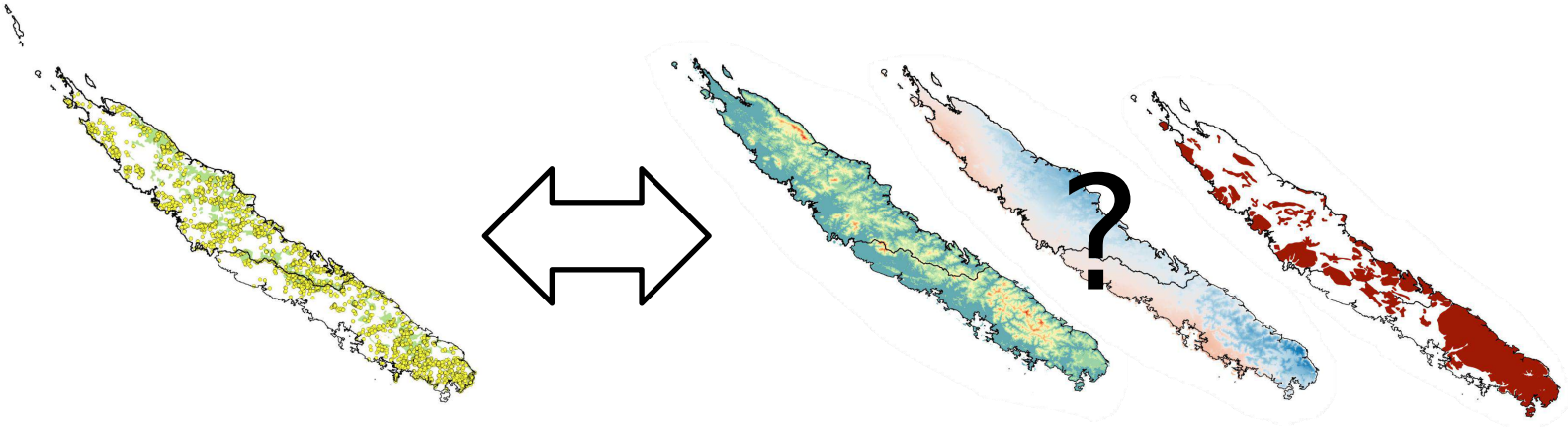

New statement of knowledge
Forest structure & composition (0.04 ha-plots)
Tree species distribution (occurrences)

Tree species distribution
What do we know?

702 native tree species ≈ 40 000 unique tree species occurrences

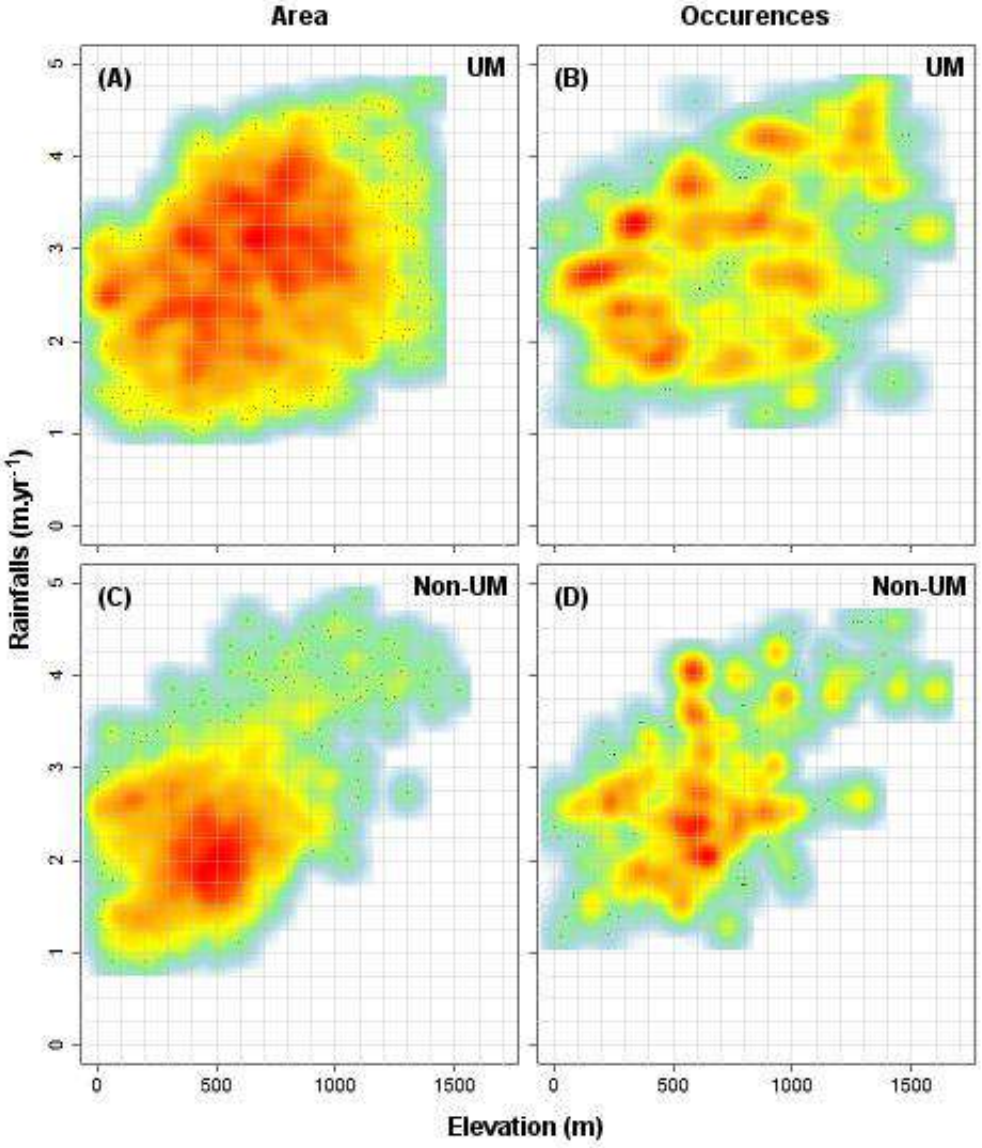
Distribution of tree species
Distribution of tree diversity (α and ϒ diversity)

Investigate environemental determinants
Elevation, rainfalls, substrates, forest area



Birnbaum *et al (in press) AoB plants*

Tree species distribution
Identifying knowledge gaps



Environmental enveloppe larger on UM substrates

Relatively good representativeness of occurrences

But higher elevation and UM substrates over-sampled

Relative density distribution of forested area / occurences

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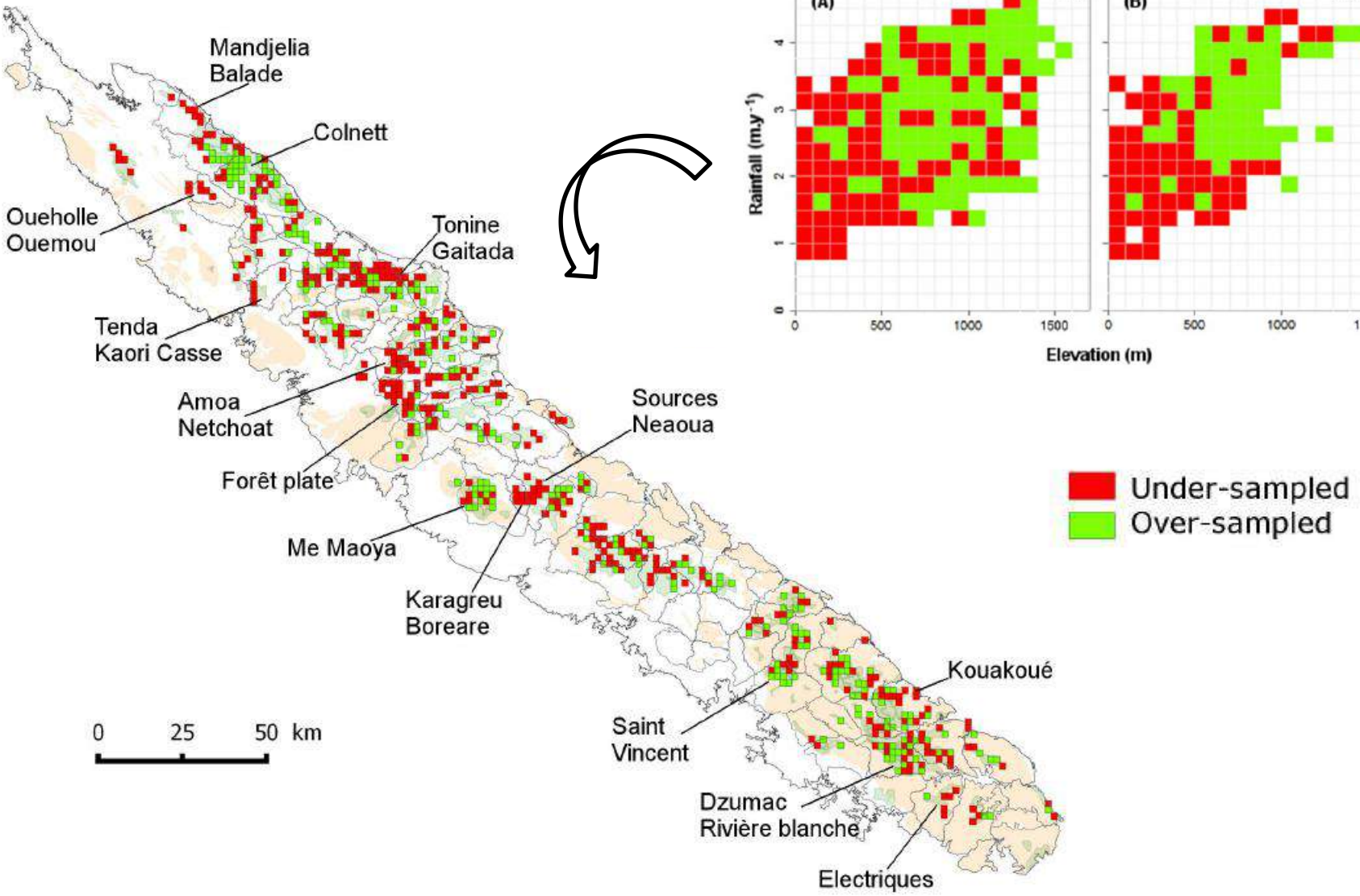
Tree species distribution
Where to go now?



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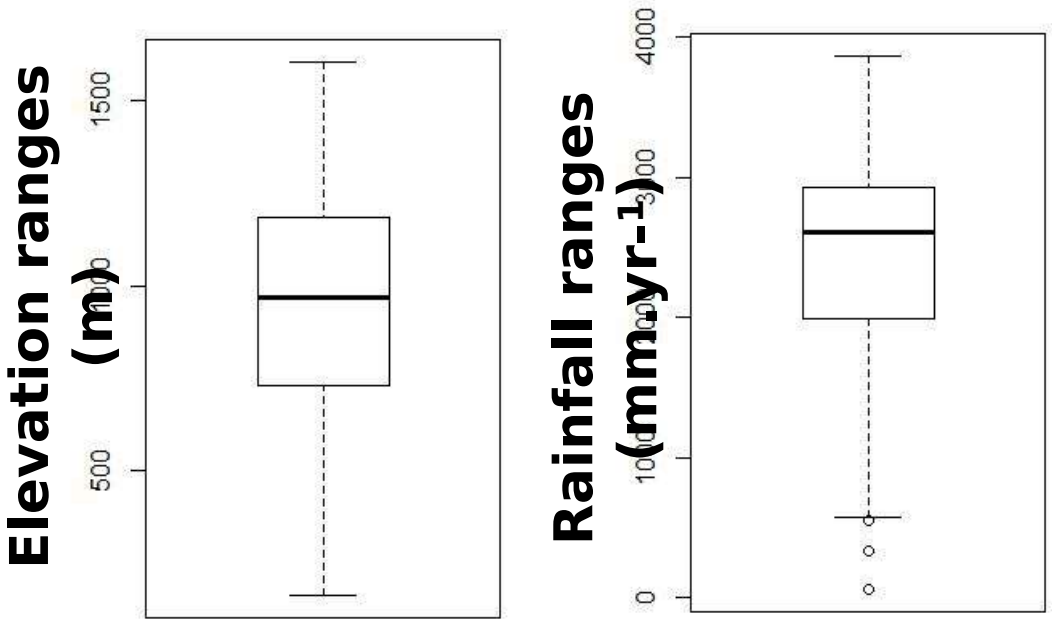
Tree species distribution
Spatial aggregation vs. environemental tolerence

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 ?

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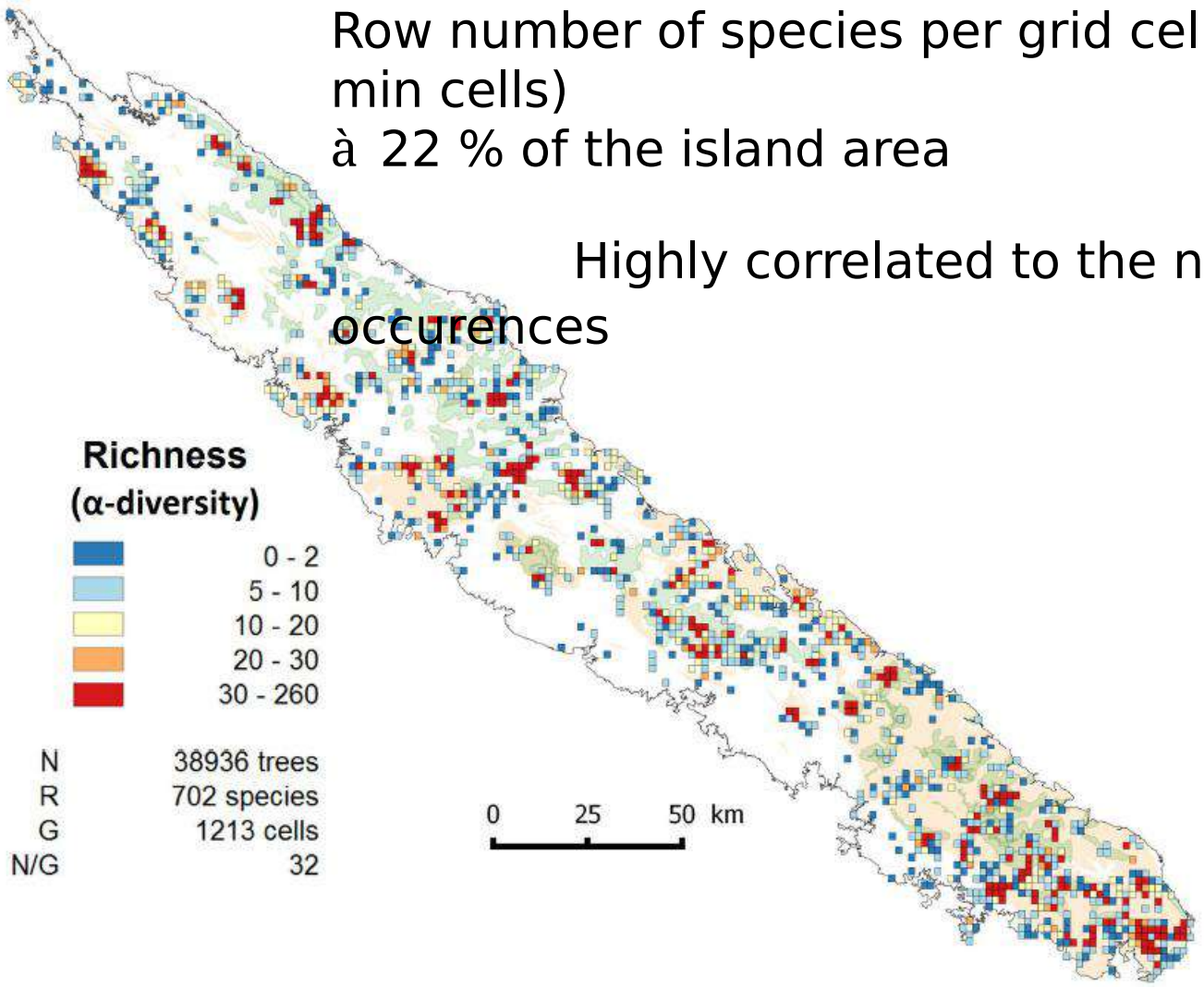
Tree species distribution
Alpha diversity distribution

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 occurences



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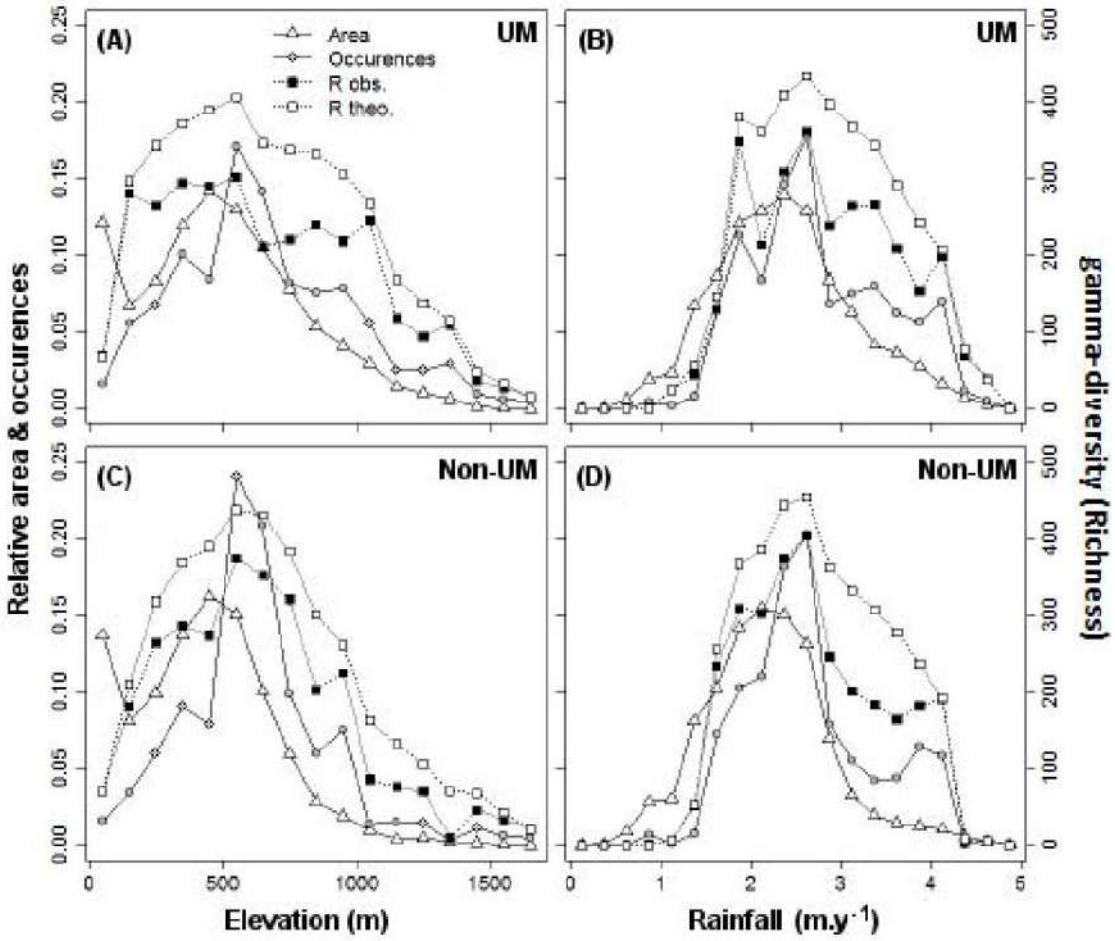
Tree species distribution
Gamma diversity distribution

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



High correlations

Sampling effet

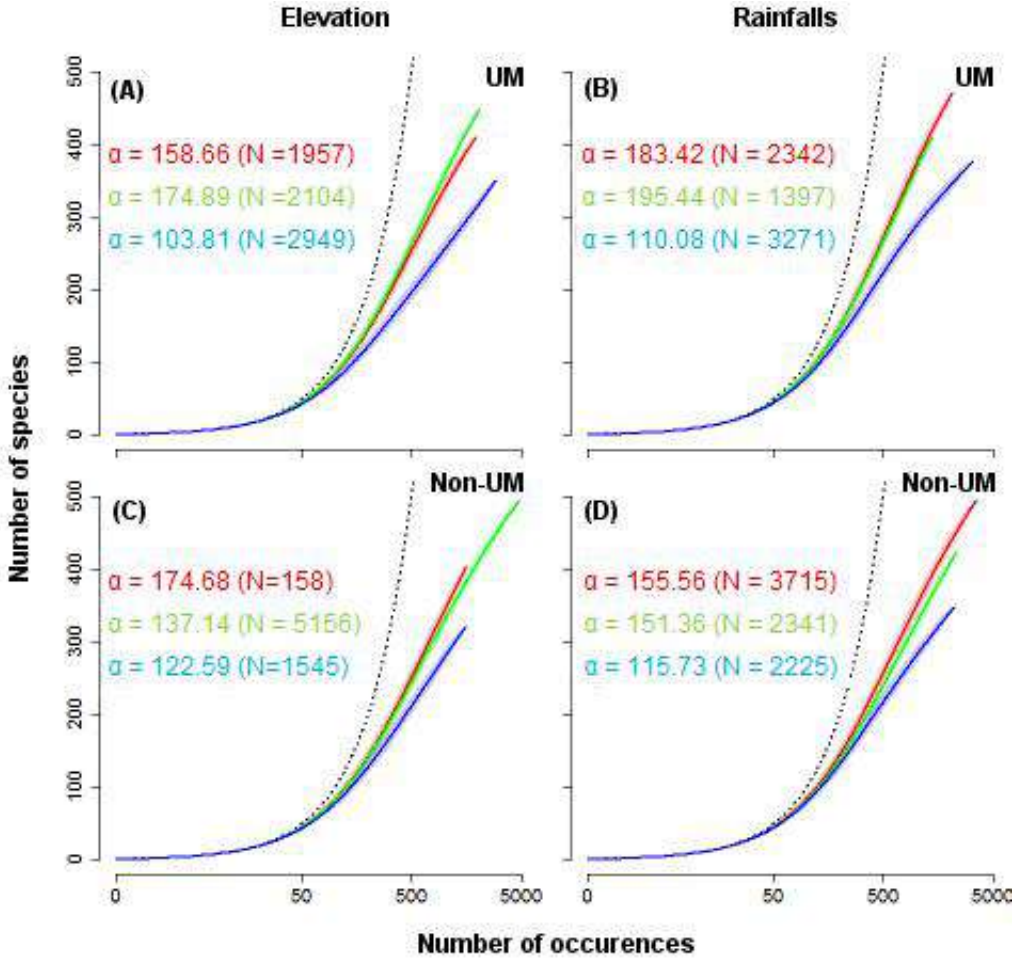
Area effet ?

Mid-domain effet ?

Birnbaum *et al (in press) AoB plants*

Tree species distribution
Gamma diversity distribution

Rarefaction curves for different elevation / rainfalls ranges



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

Significant **decrease at higher elevation / rainfalls**

Birnbaum *et al (in press) AoB plants*

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 tolerences 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) ?

Birnbaum *et al (in press) AoB plants*


Drivers of tree species richness in New Caledonia
New insights from 1-ha plots

New insights from 1-ha plots

Relative low α diversity vs. high β diversity

Site	# Stems	# Trees	R	BA (m²)	H (m)
Tiwae	1319	1266	94	32.76	11.90
Djeve	1036	1020	99	56.82	15.35
La Guen	1398	870	80	42.58	10.90
Ateou	1197	672	86	72.18	21.13
Bouirou	1193	919	100	65.08	20.48
Foret Plate	922	885	101	53.19	19.50
Aoupinie	1612	1429	86	53.58	7.88
Gohapin	805	805	38	39.25	
Mean	**1240**	**1009**	**92**	**54**	**15**

Relative low α diversity / # of stems (+ no patterns with elevation)

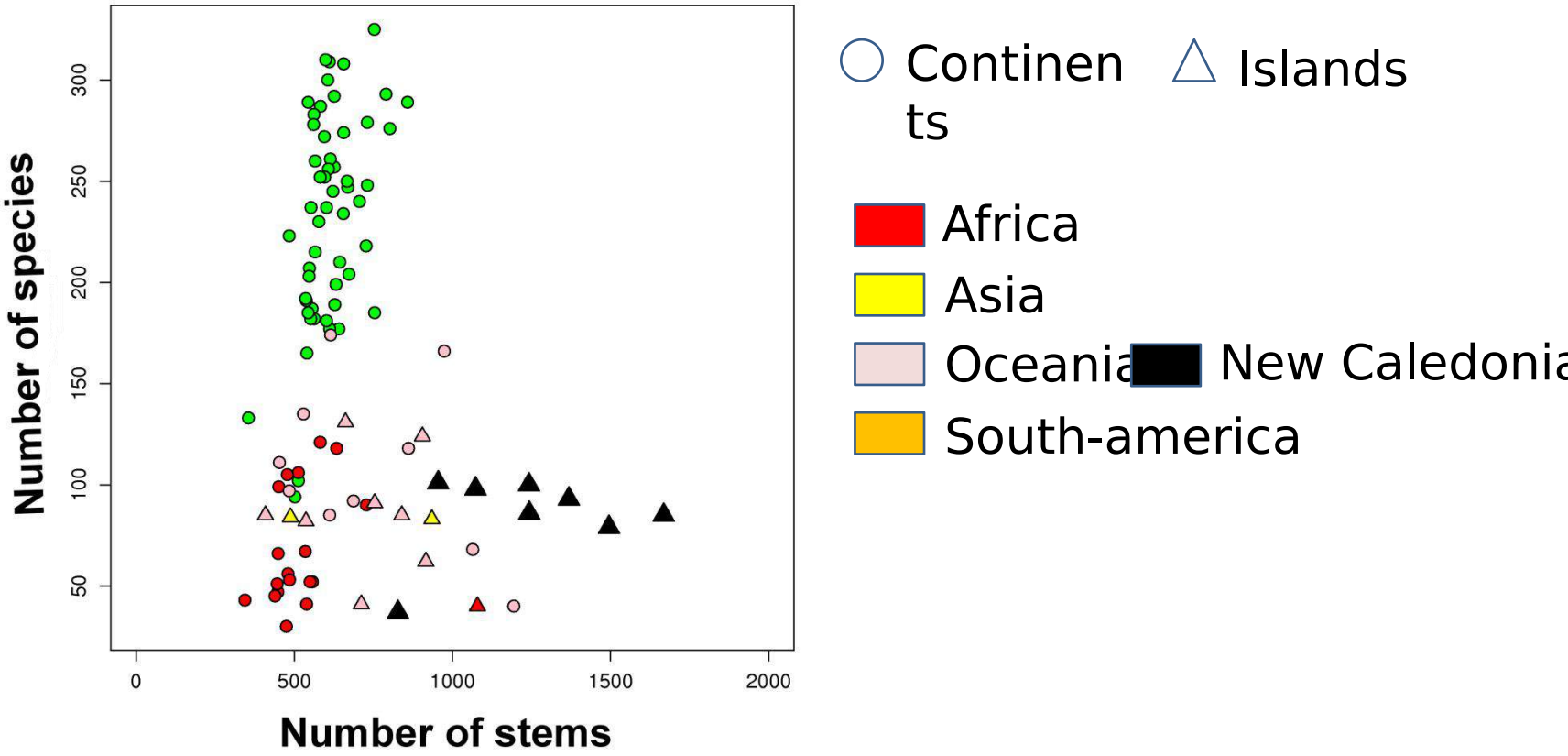
High β diversity

Bray-Curtis dissimilarity: 0.56 - 0.98 (mean = 0.82 ± 0.10)

Jaccard index : 0.72 – 0.99 (mean = 0.90 + 0.07)

1-ha plots insights
New Caledonia vs. World / Islands vs. Continents

Review of 1-ha plots (DBH ≥ 10 cm)

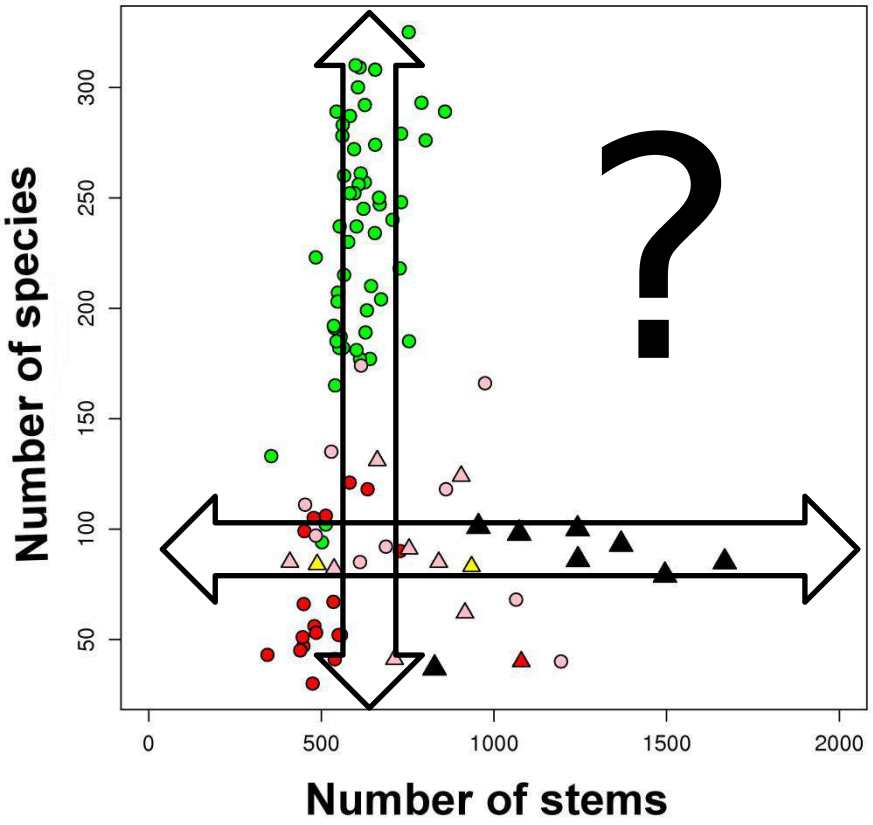


New Caledonia α diversity relatively small / unusual stem density

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 ≥ 10 cm)



New Caledonia α diversity relatively small / unusual stem density

Which drive the structure of New caledonian forest ?


Oléti (Thank you)

1-ha plots insights