Tree diversity patterns in New Caledonian forests
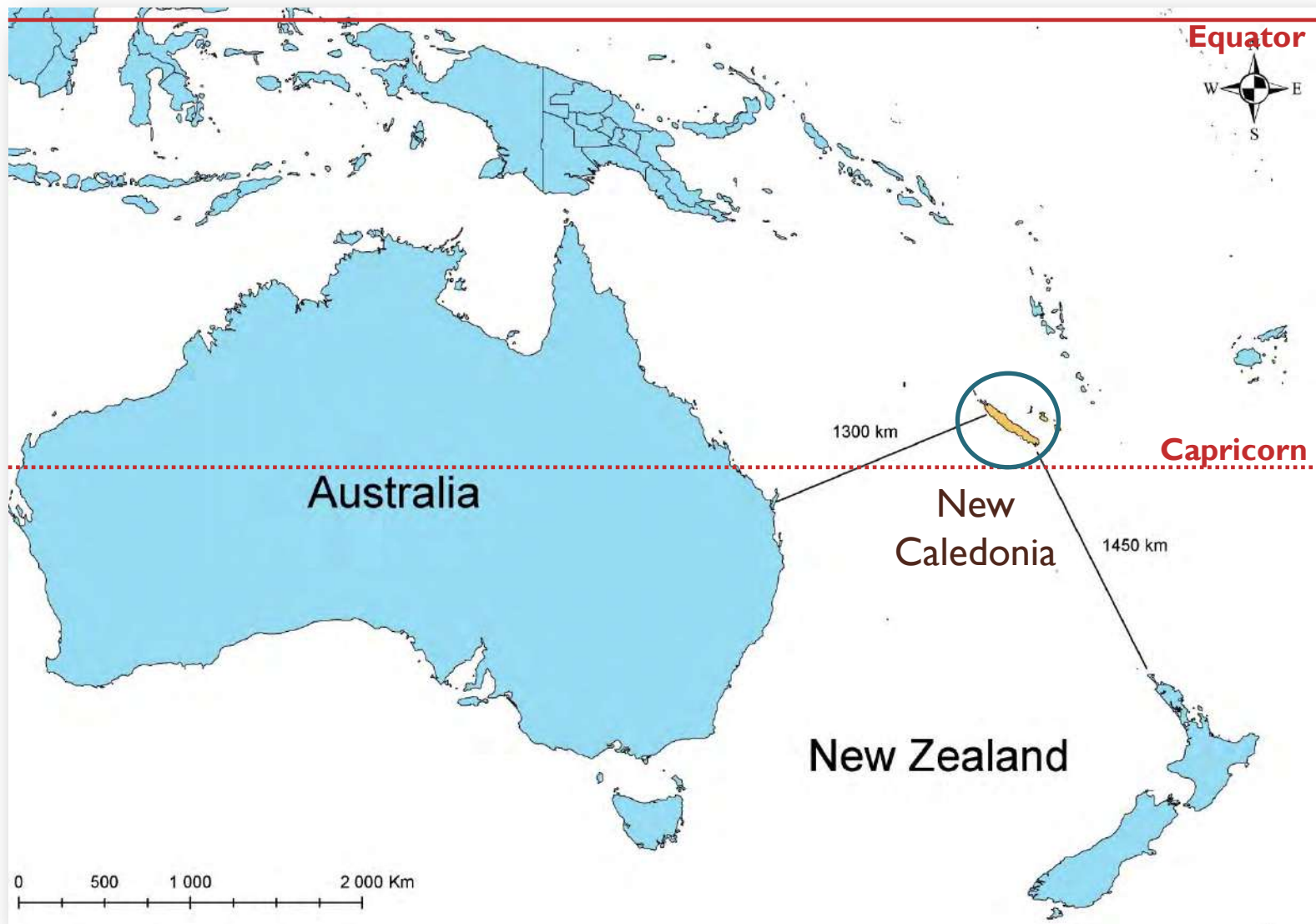
Birnbaum Ph, Ibanez T., Pouteau, R., Bayle E., Blanchard, E. Vandrot, H. & Hequet, V.
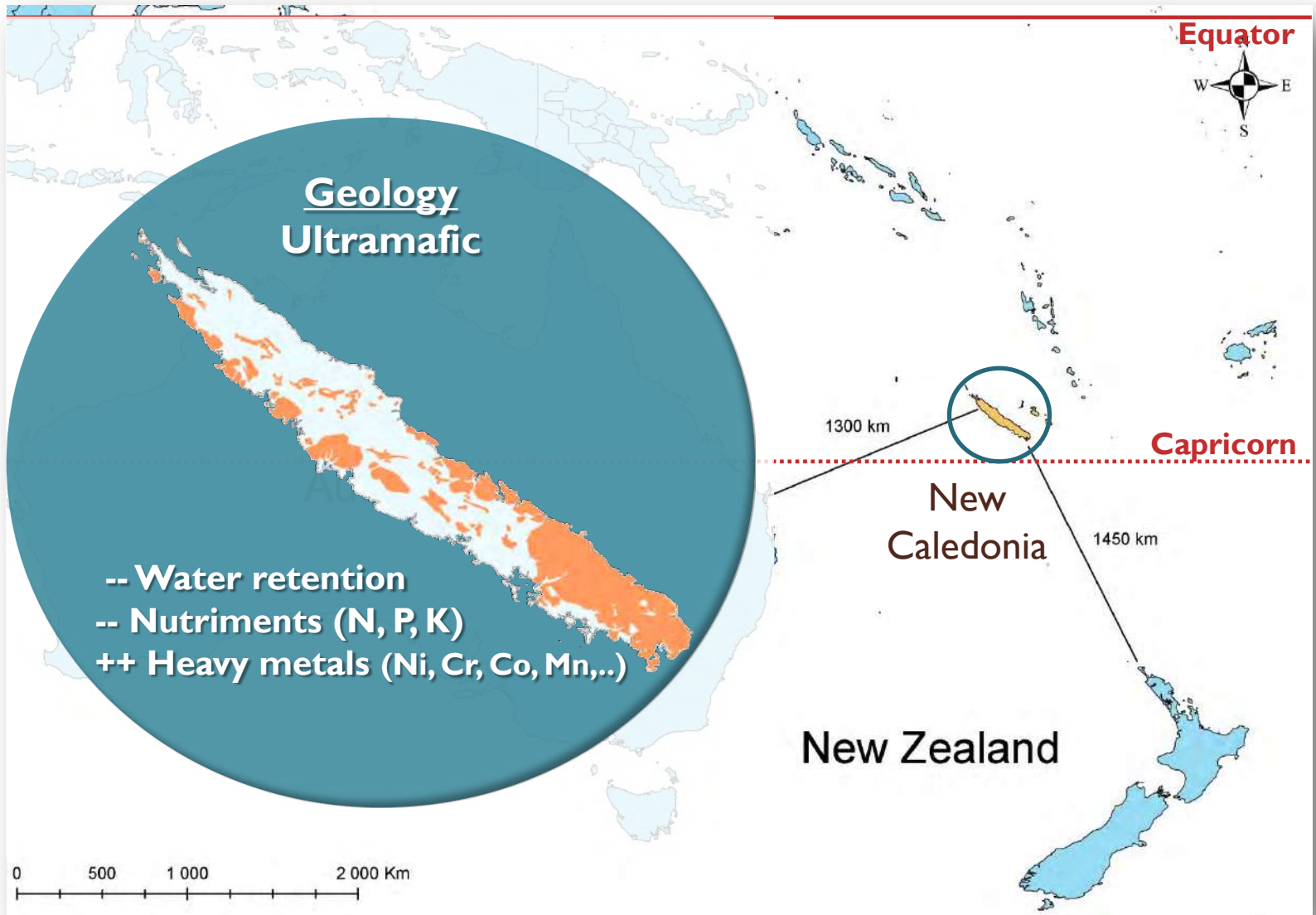
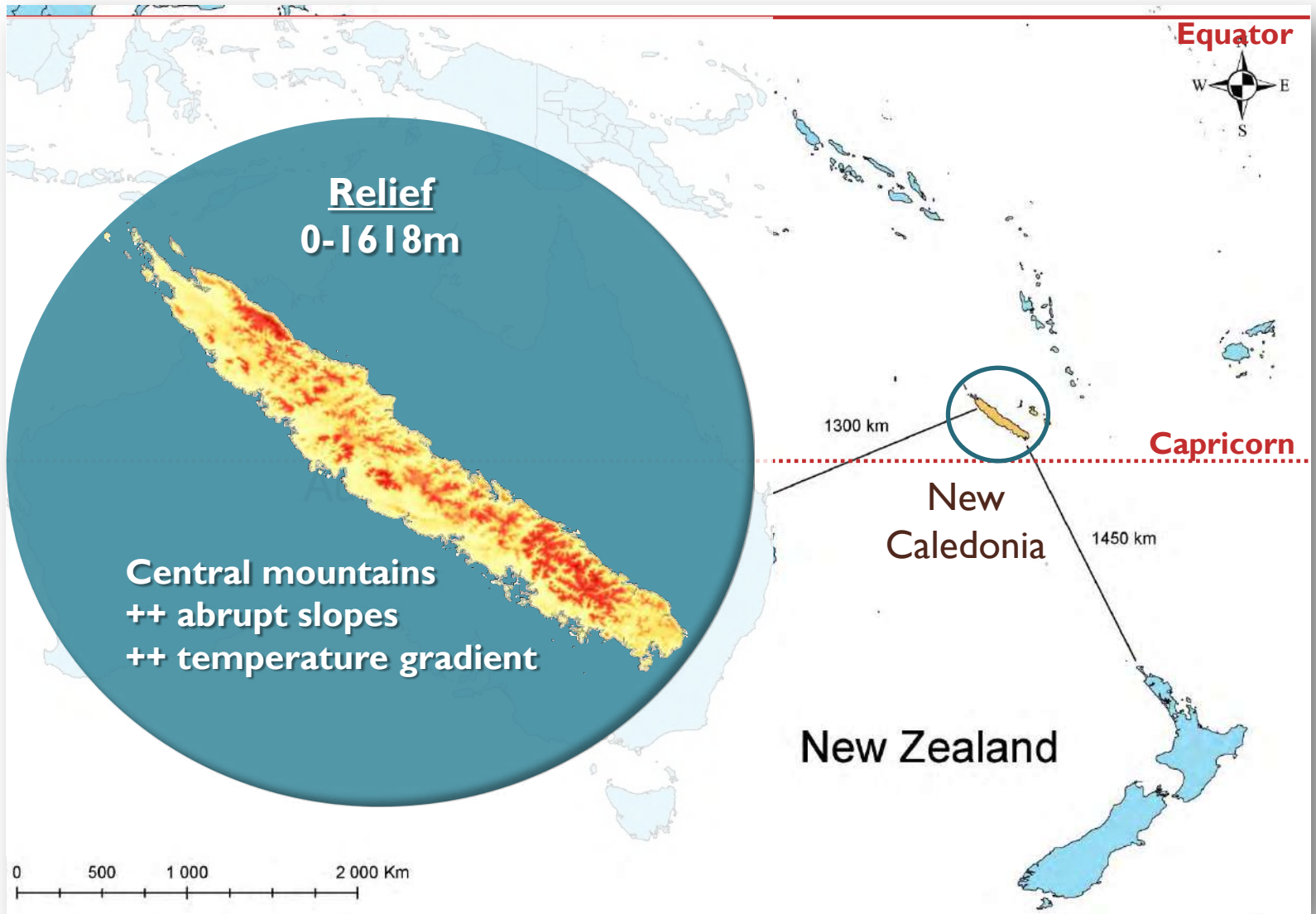Island biology, Honolulu 7-11 July 2014

New Caledonia

New Caledonia
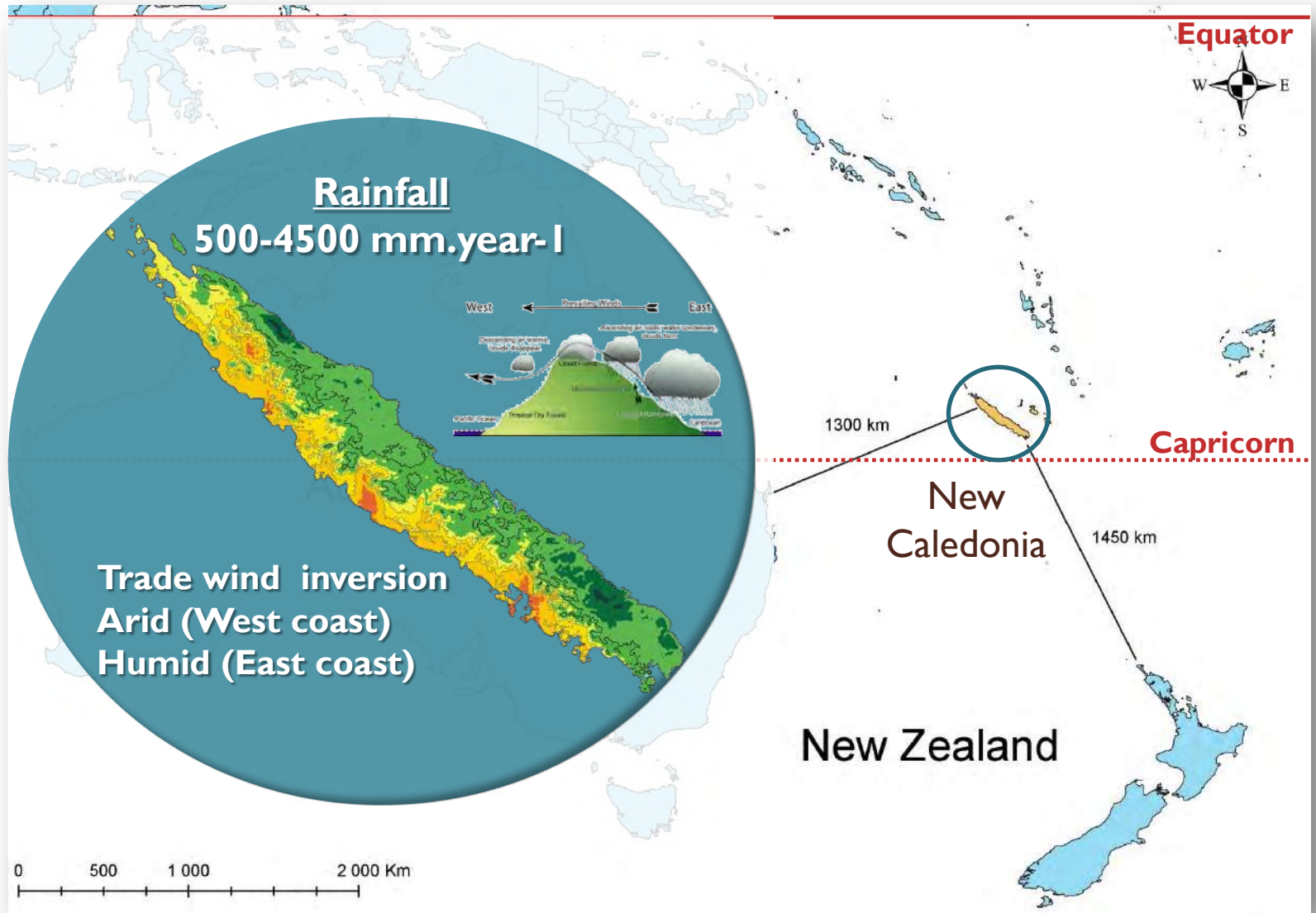
Equator

Capricorn

Geology
Ultramafic

-- Water retention
-- Nutriments (N, P, K)
++ Heavy metals (Ni, Cr, Co, Mn,..)

New Caledonia

1300 km

1450 km

New Zealand

0   500   1 000   2 000 Km

New Caledonia

Equator

Relief
0-1618m

Central mountains
++ abrupt slopes
++ temperature gradient

1300 km

New
Caledonia

Capricorn

1450 km

New Zealand

0   500   1 000   2 000 Km

New Caledonia

Equator

Rainfall
500-4500 mm.year-1

West ← Prevailing Winds → East

1300 km

Capricorn

New
Caledonia

1450 km

Trade wind inversion
Arid (West coast)
Humid (East coast)

New Zealand

0   500   1 000   2 000 Km

…high heterogeneity of environnemental parameters…
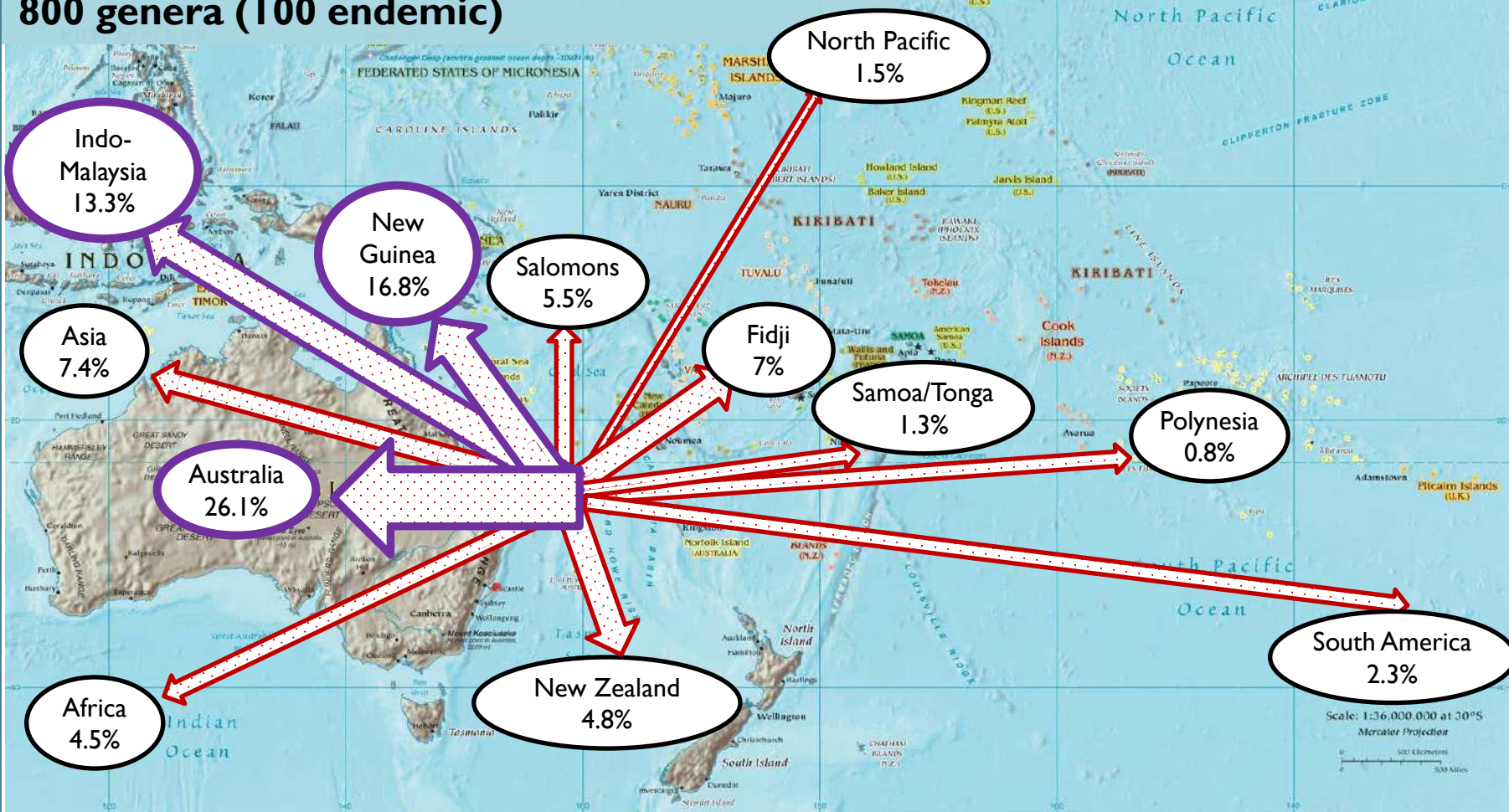
Flora of New Caledonia

According to Florical (Morat & al., 1994, 2012)
3371 species (75% of endemic)
194 families (3 endemic)
800 genera (100 endemic)

North Pacific 1.5%

Indo-Malaysia 13.3%

New Guinea 16.8%

Salomons 5.5%

Asia 7.4%

Fidji 7%

Samoa/Tonga 1.3%

Polynesia 0.8%

Australia 26.1%

South America 2.3%

Africa 4.5%

New Zealand 4.8%

New Caledonian Flora

- **Gymnosperms**
  - 7% of all world species
  - 5 families (15 genera, 13/19 of known Araucaria species)
- **Monocotyledons**
  - Arecaceae (11 genera, 39 species, 9 endemic)
  - Pandanaceae (45 species, 38 endemic)
- **Dicotyledons**
  - 128 families
  - ++ Rubiaceae, Pittosporaceae, Cunoniaceae, Euphorbiaceae
  - --   Fabaceae, Lamiaceae, Malvaceae, Ericaceae
- **Basal angiosperms group**
  - Lauraceae, Proteaceae, Winteraceae, Piperaceae, Annonaceae, Monimiaceae…
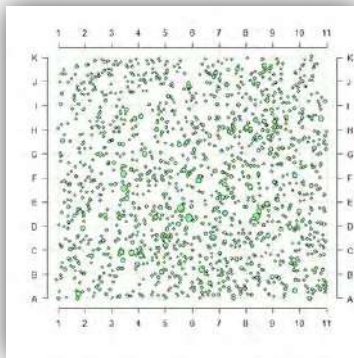 - & the famous Amborella…

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Lauraceae, Proteaceae, Winteraceae, Piperaceae, Annonaceae, Monimiaceae…

& the famous Amborella…

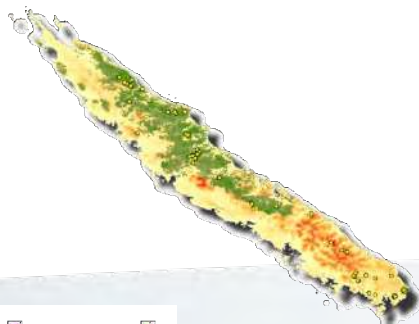## How such a diverse flora is distributed in such diverse habitats ?

Available Datasets

Herbarium (NOU)

- Specimens collected from 1855
- ≈ 403 types (mainly isotypes)
- ≈ 80 000 specimens
- ≈ 4000 taxa (194 families)

Permanent Plots (NC-PIPPN)

- Established in humid forest since 2005
- 200 plots (0.04ha, DBH>=5cm)
- 6 plots (1ha, DBH>=10 cm, X,Y)
- ≈ 38000 trees
- ≈ 1000 taxa (90 families)

Cartography (GIS) and modelling
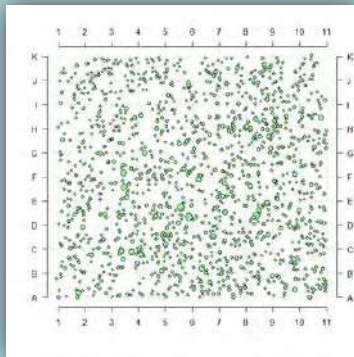
- Substrat, topography, orography
- Vegetation

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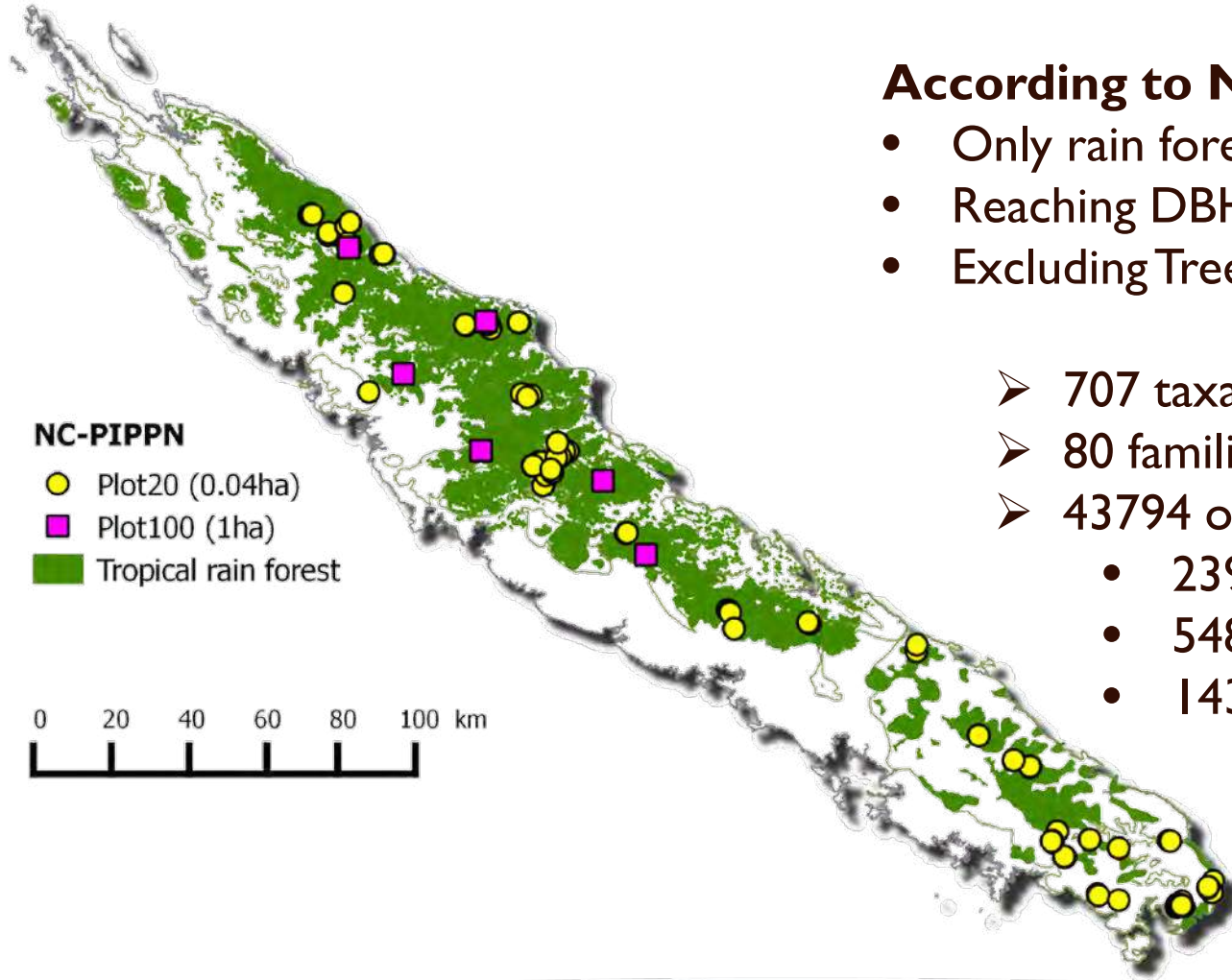- Substrat, topography, orography
- Vegetation

Trees of New Caledonian forests

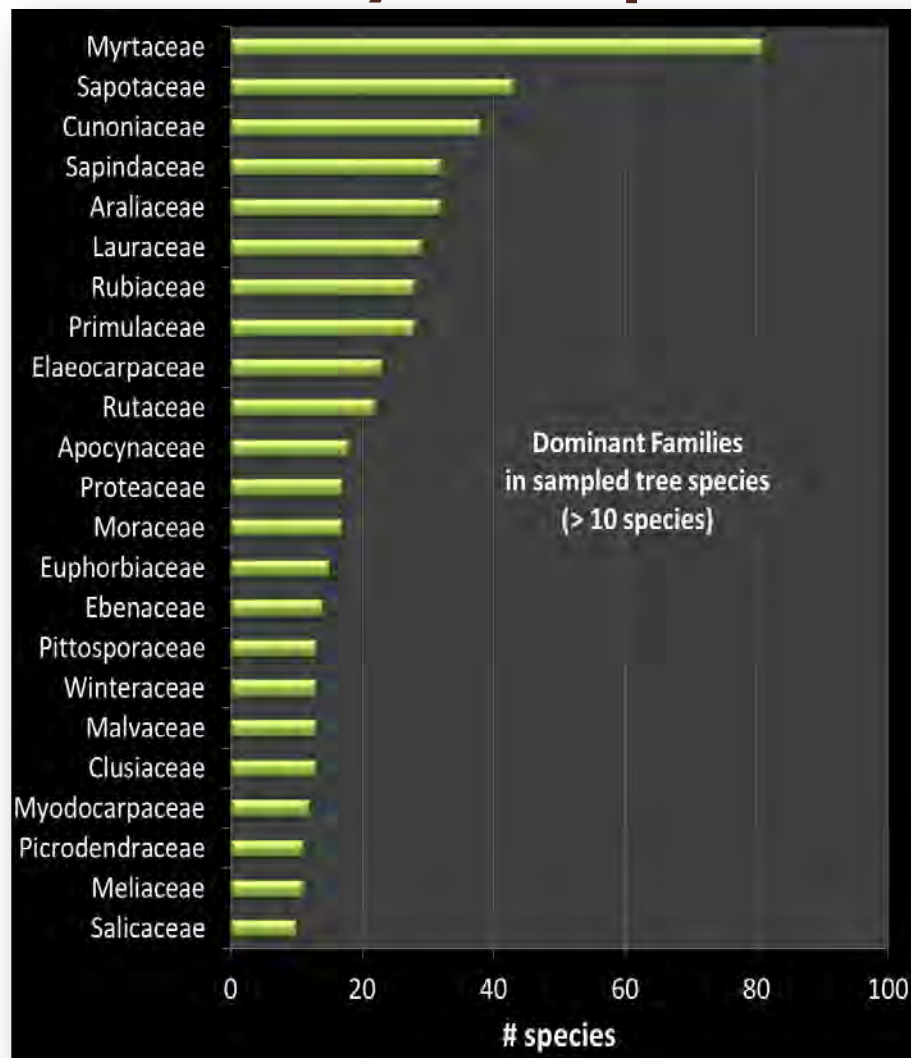## How many tree species in rain forests ?

According to NC-PIPPN

- Only rain forests
- Reaching DBH>=10cm
- Excluding Tree-ferns & palms

➢ 707 taxa at species rank
➢ 80 families, 195 genera
➢ 43794 occurrences
- 23920 in plot20 (0.04ha)
- 5489 in plot100 (1ha)
- 14385 specimen (NOU)

NC-PIPPN

○ Plot20 (0.04ha)
□ Plot100 (1ha)
■ Tropical rain forest

0   20   40   60   80   100 km

How many tree species in rain forests ?

Dominant Families in sampled tree species (> 10 species)

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Island biology, Honolulu 7-11 July 2014

Endemic species : rare or abundant ?

Myrtaceae
Carpolepis laurifolia

- **Rare** in the world (endemic)
- **Widespread** in New Caledonia
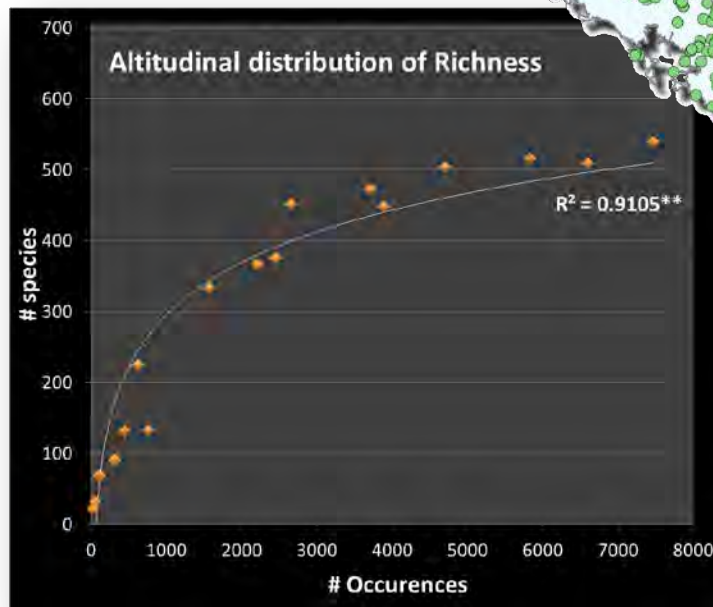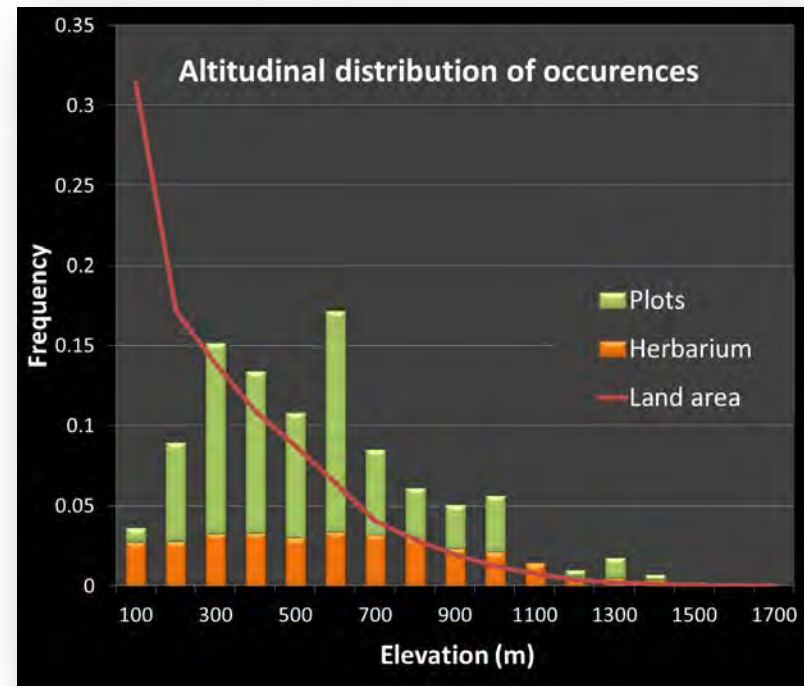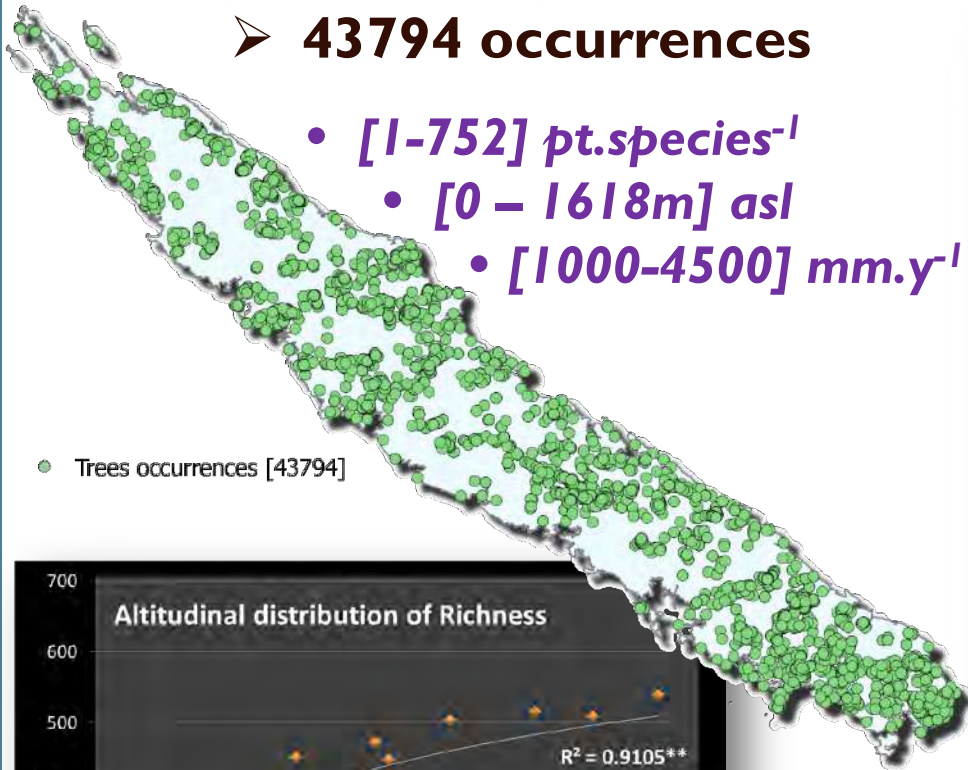 - *Rainfall 1000-4500 mm.year[1]*
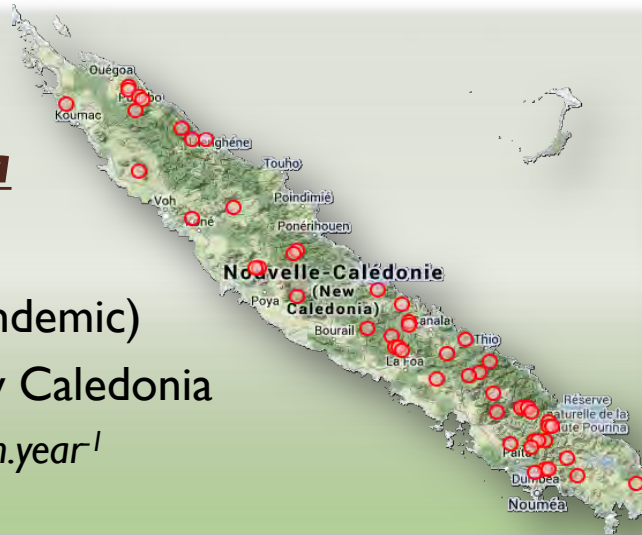
Araucariaceae
Agathis montana

- Endemic to Caledonia
- **Rare** in New Caledonia
- **Abundant** on Mt Panié
  - *Elevation 1250-1600m*
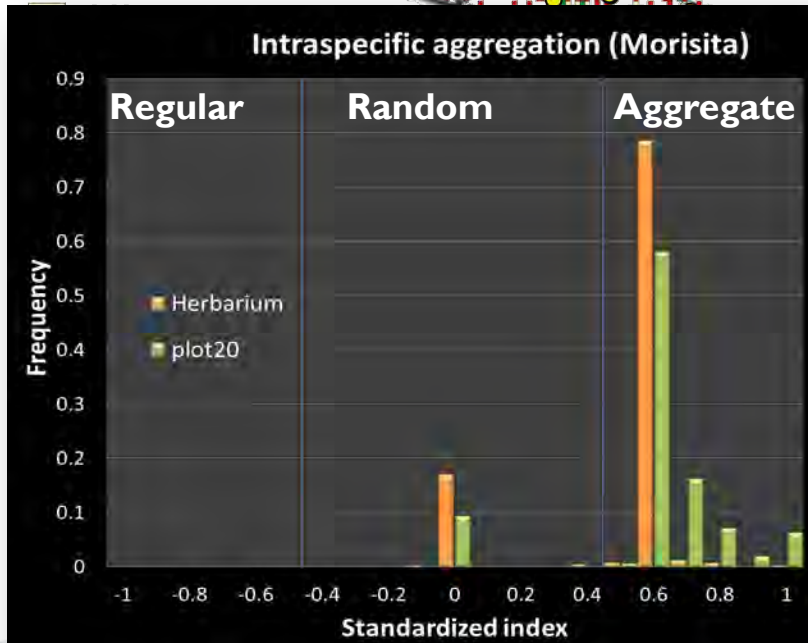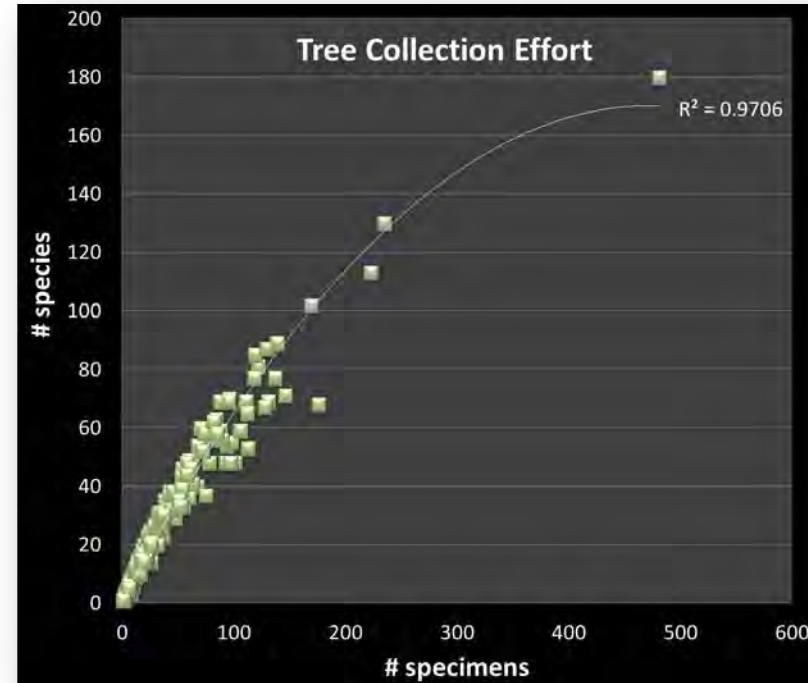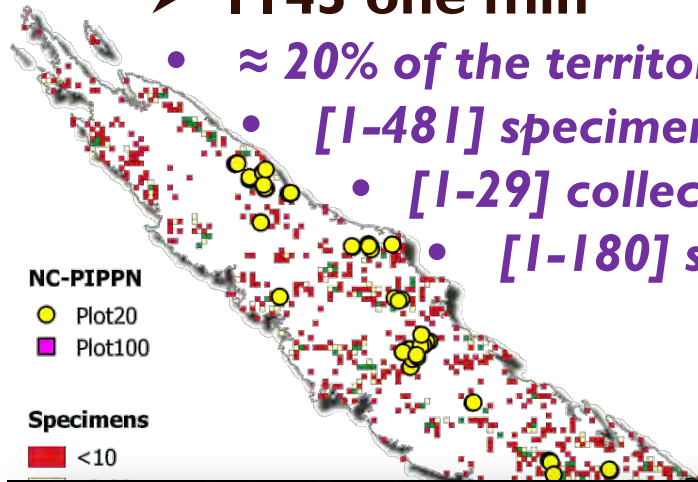
Distribution of Tree Occurrences

➢ **43794 occurrences**

- *[1-752] pt.species⁻¹*
- *[0 – 1618m] asl*
- *[1000-4500] mm.y⁻¹*

Trees occurrences [43794]

Altitudinal distribution of occurences

Altitudinal distribution of Richness

$R^2 = 0.9105**$

➢ *Broad range of rain forest tree species distribution*
➢ *Unbalanced sample in respect to the altitudinal gradient*
➢ *Richness depends on the observation effort*
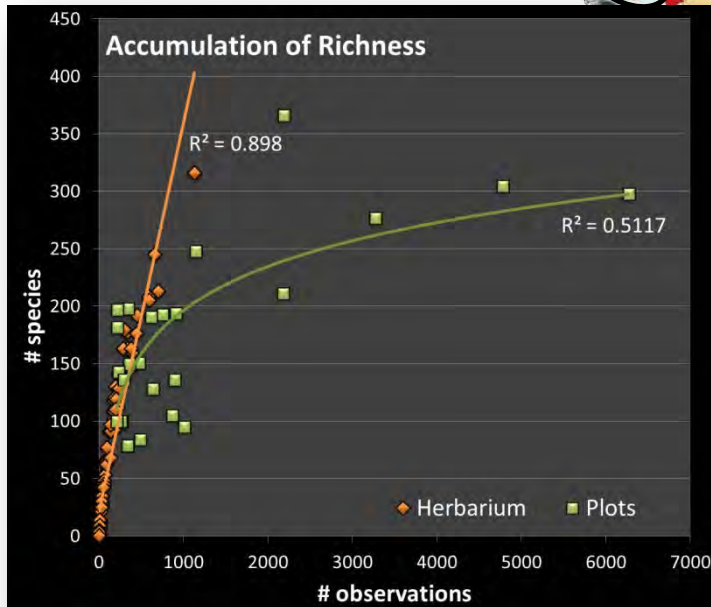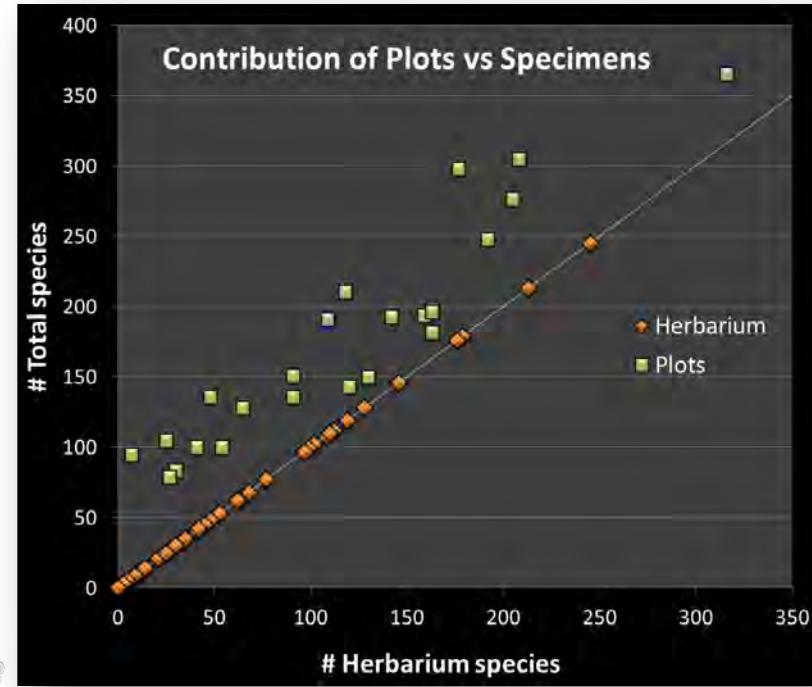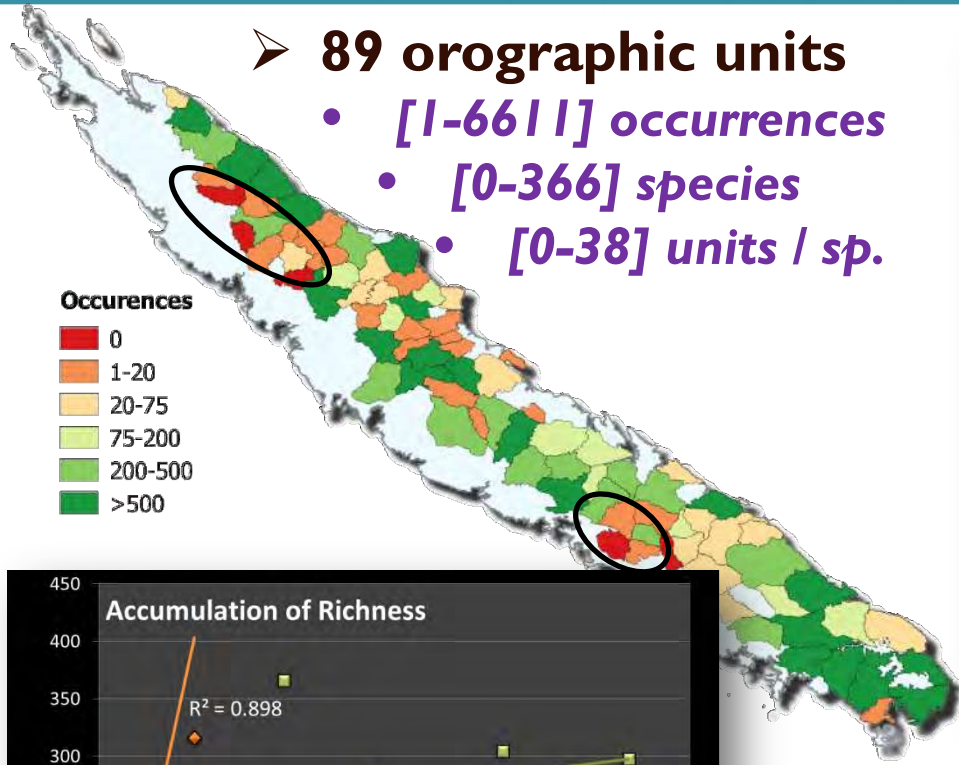
Distribution of Tree Taxa

➤ **1143 one min²**
- *≈ 20% of the territory*
  - *[1-481] specimens*
    - *[1-29] collectors*
      - *[1-180] species*

NC-PIPPN
- ○ Plot20
- ■ Plot100

Specimens
- ■ <10

Tree Collection Effort

$R^2 = 0.9706$

species / # specimens

Intraspecific aggregation (Morisita)

| Regular | Random | Aggregate |

Frequency / Standardized index

- Herbarium
- plot20

➤ *Spatial disparity of tree specimens*
➤ *Linked to the collection effort*
➤ *Species distribution highly clumped (>80%)*

…Taxa aggregation suggests local abundance…

Tree Abundance and Orography

➢ **89 orographic units**
- **[1-6611] occurrences**
- **[0-366] species**
- **[0-38] units / sp.**

Occurences
- 0
- 1-20
- 20-75
- 75-200
- 200-500
- >500

Contribution of Plots vs Specimens

Accumulation of Richness

R² = 0.898

R² = 0.5117

➢ *Two main localities are data deficient*
➢ *Plots highly increase the occurences*
➢ *Herbarium specimens highly increase the diversity*

…Richness highly depends on observation efforts…

Forest Diversity (0.04 ha plots)

> ➤ Low influence of environnemental parameters (Ibanez & al, 2014)
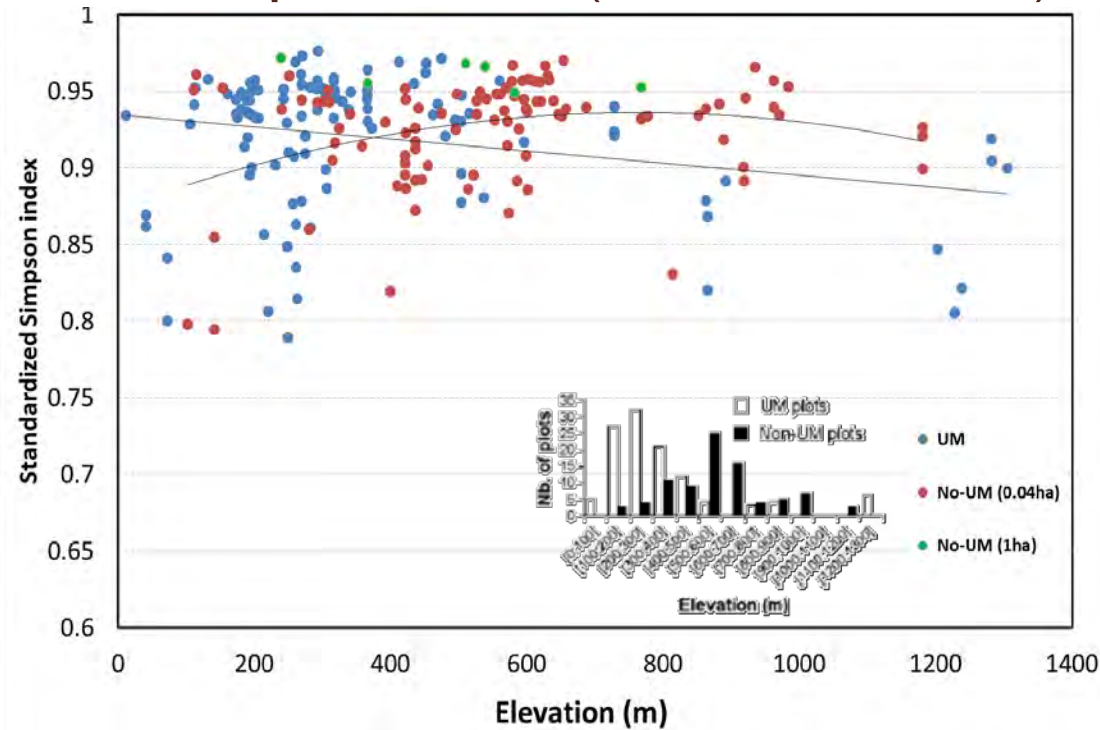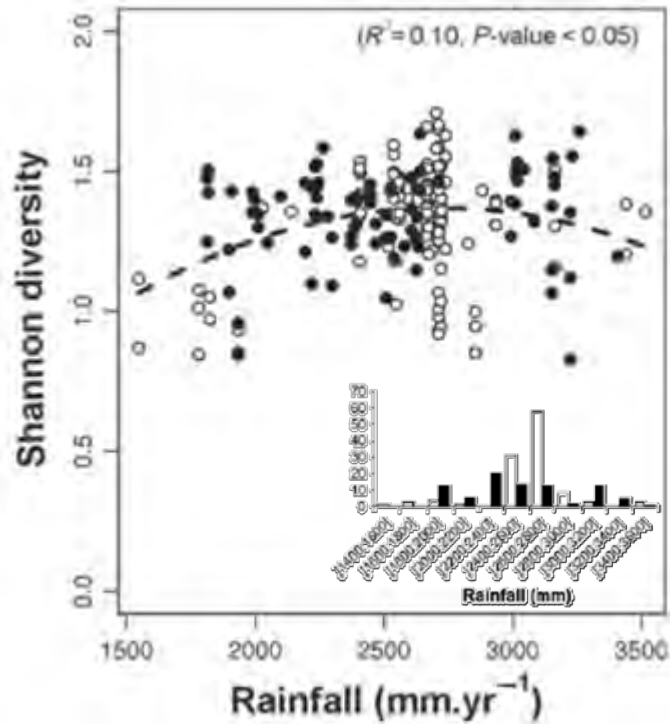
Explained variance (%)	Substrate	Elevation	Rainfall	Slope
Species richness	**2.26***	0.01	**4.88****	0.06
Shannon diversity	0.41	0.8	**5.73*****	0.05
Simpson diversity	0.01	1.18	**4.51****	0.26

> ## **Floristic dissimilarity**

NC-PIPPN – Plot20

❖ Independence of the Euclidean distance

- 201 plots (0.04ha)
- 114 UM
- 87 non-UM
- 23920 trees
- 680 species

Sørensen index

$$Iss = \frac{2C}{(A+B)} \times 100$$

NC-PIPPN

⬤ Plot20 (0.04ha)

Substrats

🟧 Ultramafic (UM)
⬜ No-Ultramafic (No-UM)

0   20   40   60   80   100 km

**Floristic similarity
inter-plots UM & non-UM**

Sørensen index

Euclidean distance (km)
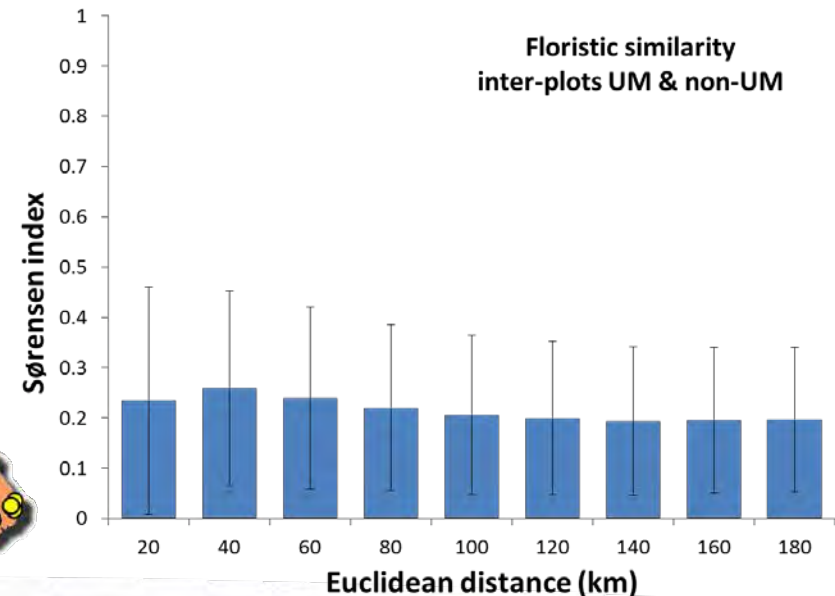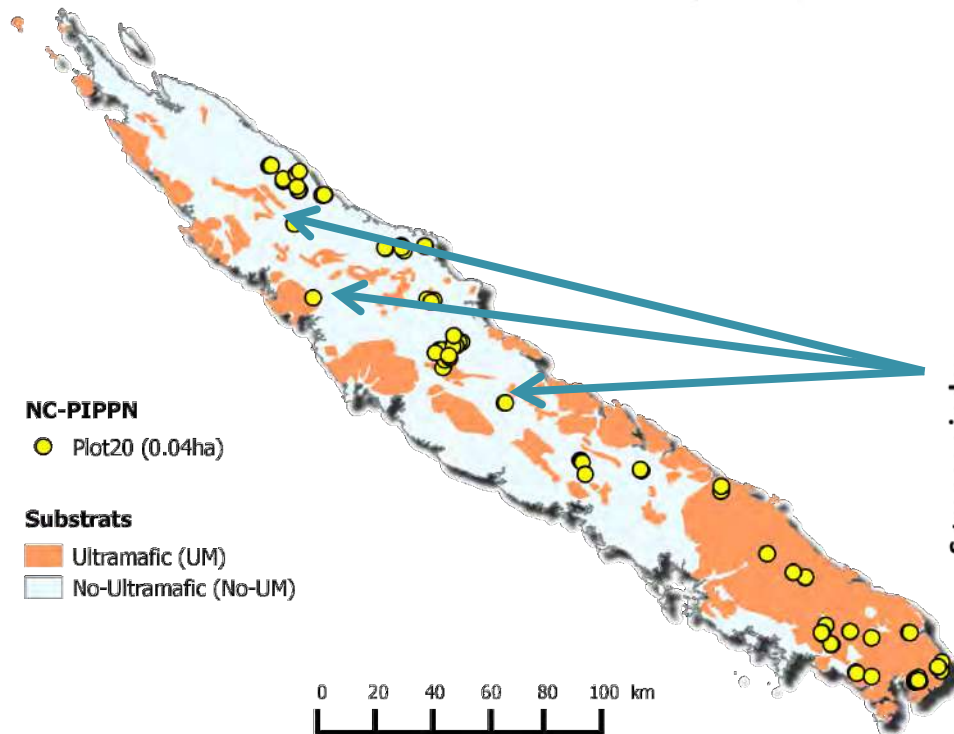
Floristic dissimilarities (0.04 ha plots)

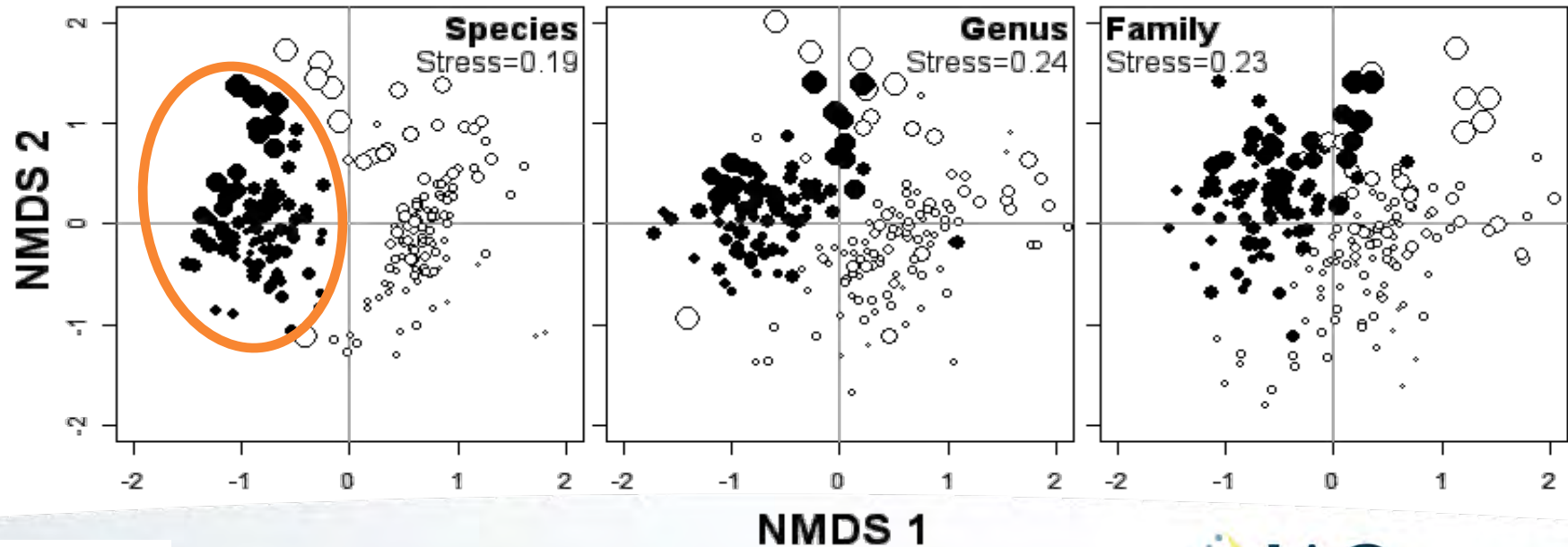➢ **Substrat**

    ❖ ≈ 1/3 species only on UM-substrat

    ❖ ≈ 1/3 species only non-UM-substrat

    ❖ ≈ 1/3 substrat-tolerant
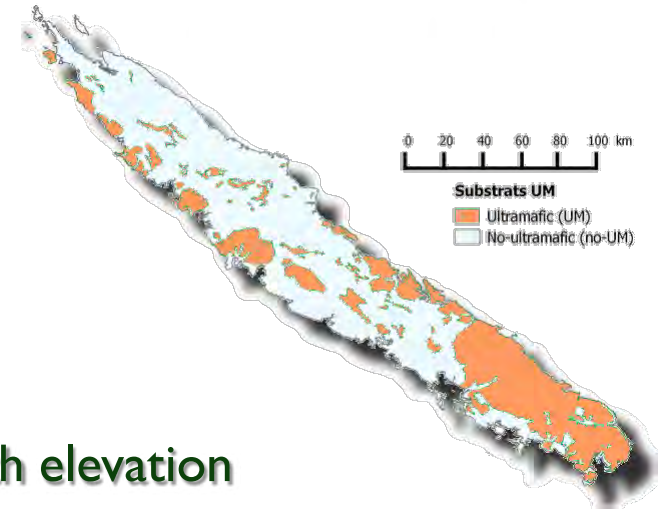
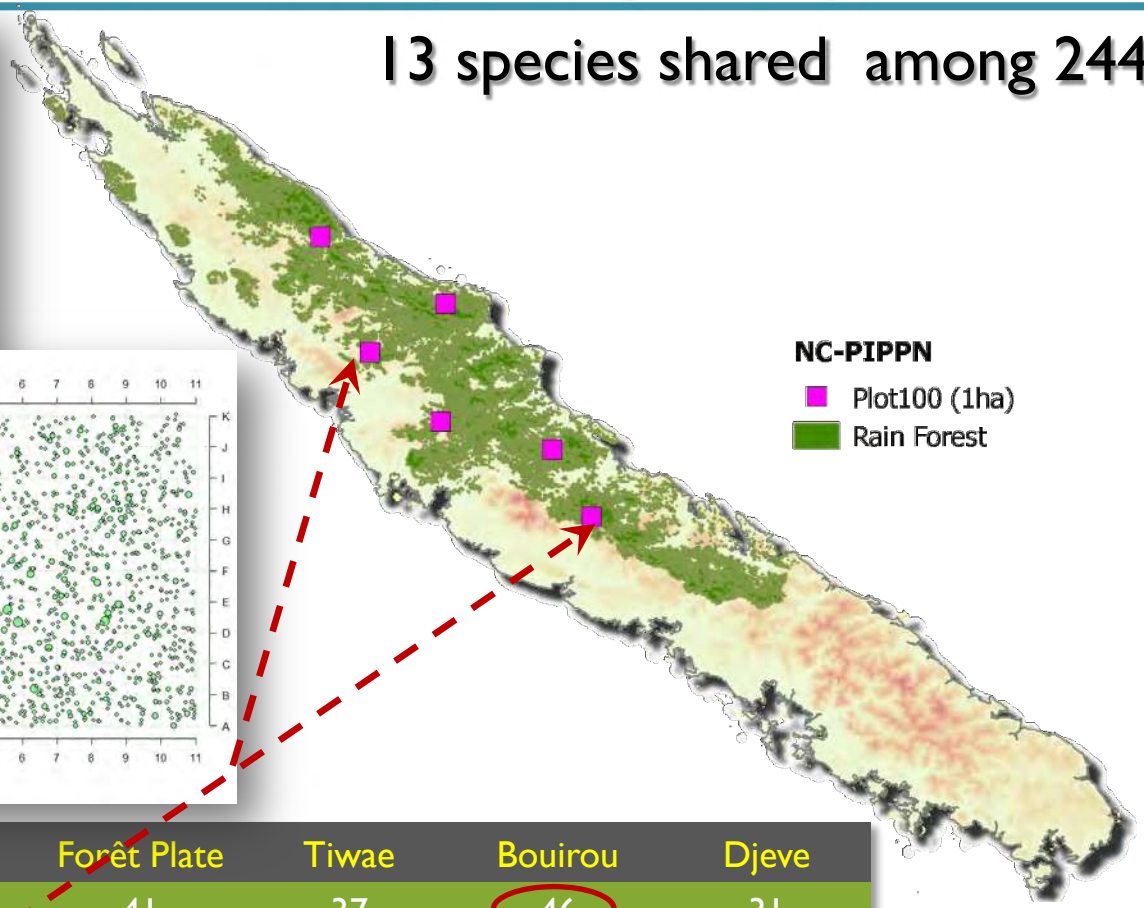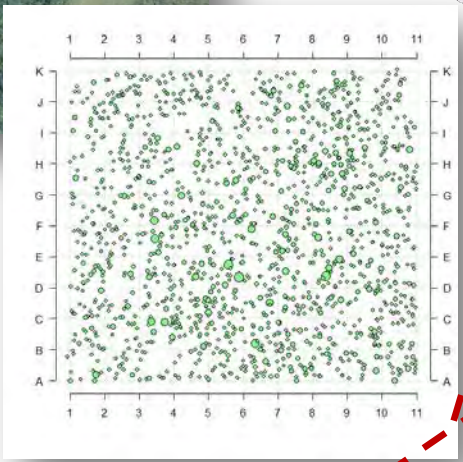➢ **Elevation**

    ❖ Floristic dissimilarity slightly decreases with elevation

Substrats UM
Ultramafic (UM)
No-ultramafic (no-UM)

Floristic dissimilarities (1ha plots)

13 species shared among 244
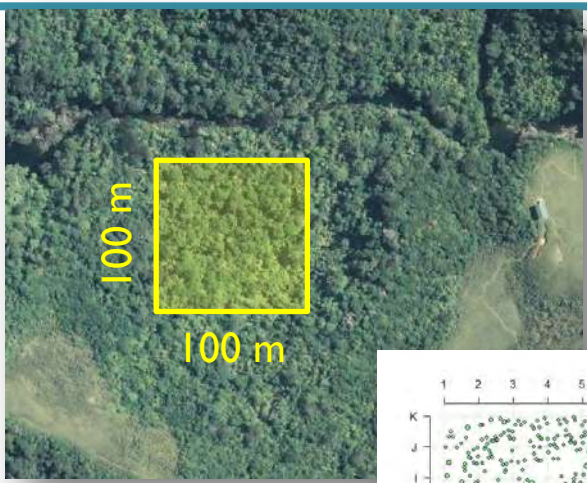
NC-PIPPN
- Plot100 (1ha)
- Rain Forest

	Ateou	Laguen	Forêt Plate	Tiwae	Bouirou	Djeve
Ateou	---	33	41	37	46	31
Laguen	0.72	---	25	31	37	22
Forêt Plate	0.84	0.84	---	39	44	40
Tiwae	0.81	0.71	0.76	---	51	41
Bouirou	0.56	0.62	0.74	0.65	---	45
Djeve	0.89	0.89	0.76	0.76	0.78	---

…high floristic dissimilarities…

Tree Species Richness Modelling

➤ **Sum of tree species niche's models**
- *elevation*
- *rainfall*
- *temperature*
- *slopes*
- *substrat*

NC-PIPPN
- ○ Plot20 (0.04ha)
- ■ Plot100 (1ha)

Predicted Richness
- 27.502200
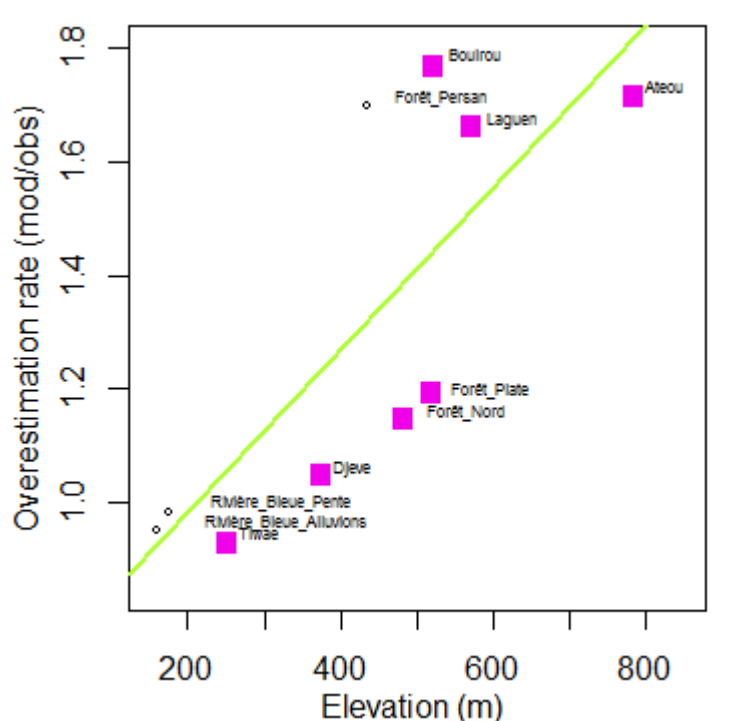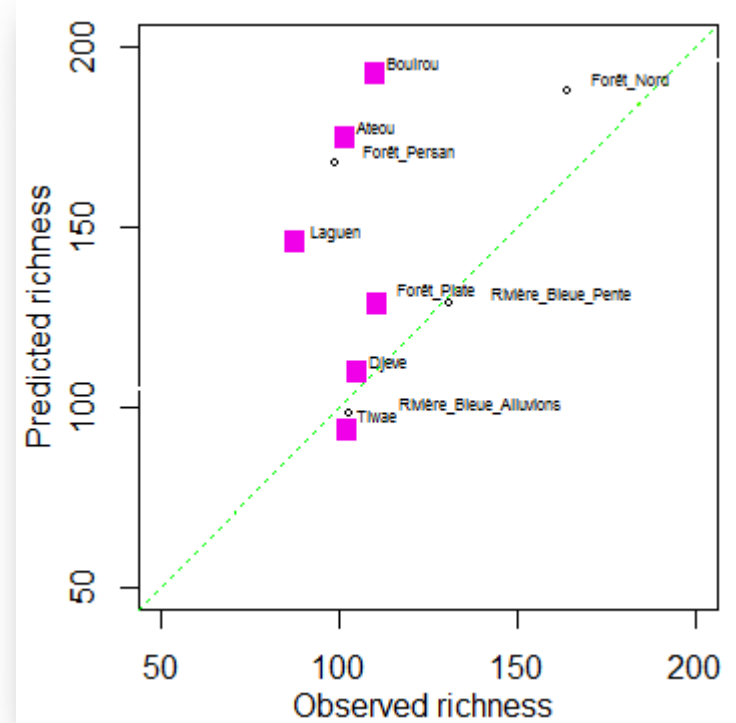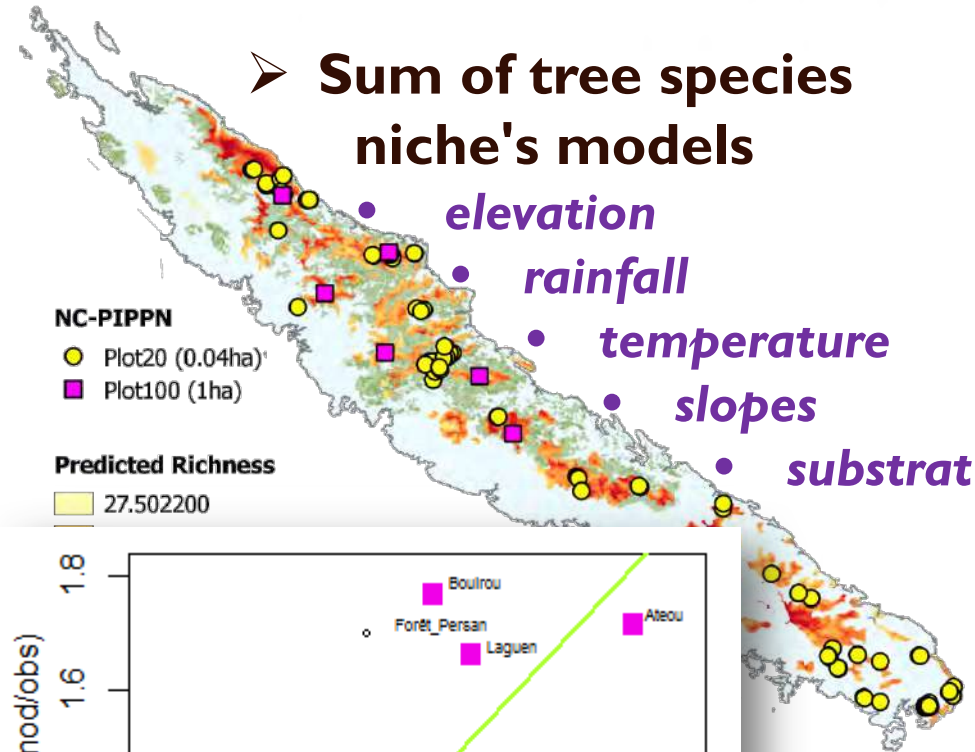
➤ *High variability of the 1ha plot richness [100-200] ?*
➤ *Overestimation rate is mainly explained by the plot elevation*

Forest communities (1ha plot)

1ha Plot	Density	Basal area	Richness
Atéou (NC)	820	70.0	82
La Guen (NC)	1061	41.8	73
Forêt Plate (NC)	973	57.0	94
Tiwae (NC)	1446	37.0	92
Boirou (NC)	1144	69.5	93
Djeve (NC)	1235	70.2	91
Rivière bleue (NC, Jaffré et al., 1991)	1183-1533	47.0 - 49.5	103 - 131
Col d'Amieux (NC, Jaffré et al., 1995)	1256	55.5	95 - 106
New Caledonia (summary)	**820-1533**	**37-70.2**	**73-131**
South Pacific (Keppel, 2009)	**529-916**	**30-46.3**	**35 - 167**
Borneo (Indonesia, Aiba et al., 1999)	464- 510	34 – 38.3	148
Mauritius (Strasberg,, 1996)	1079	81.5	40
French Guiana (Couteron et al., 2005)	397 - 874	20.6 – 34.2	154-220

…Taxa aggregation suggests local abundance…

In Summary…

How are assembled Caledonian rain forests ?

- High taxonomic diversity

- High aggregation of taxa (high local abundance)

- High density of trees (i.e. DBH>10 cm)

- Homogenous diversity

  - Relatively insensitive to environmental conditions

- Medium floristic richness

- High floristic dissimilarities

  - High beta-diversity

…the distributed diversity makes complex conservation actions…

Thank you for your attention…

OLÉTI