

# Water availability shapes the functional structure of lowland tropical forest tree communities at both regional and landscape scales in New Caledonia

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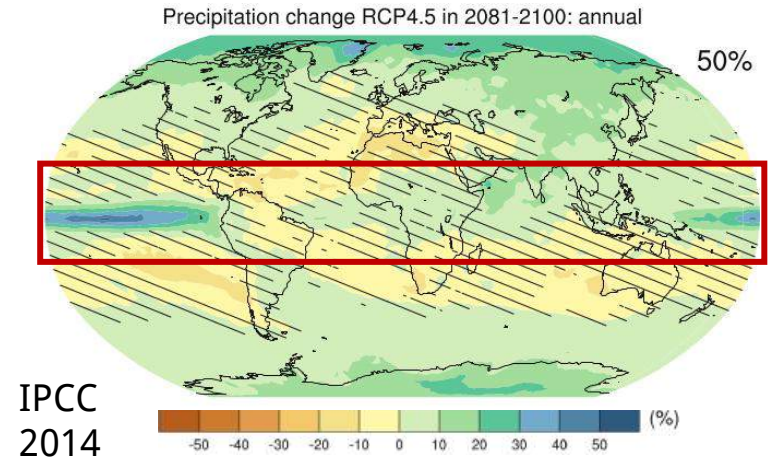
What will be tomorrow's tropical climate?



=> *Increase of temperature*

=> *Precipitation changes*

=> *More extreme drought events*



nature  
climate change

LETTERS

PUBLISHED ONLINE: 19 JANUARY 2014 | DOI:10.1038/NCLIMATE2100

**Increasing frequency of extreme El Niño events  
due to greenhouse warming**

Wenju Cai *et al.* 2014

# Climate change, water availability & tropical forests



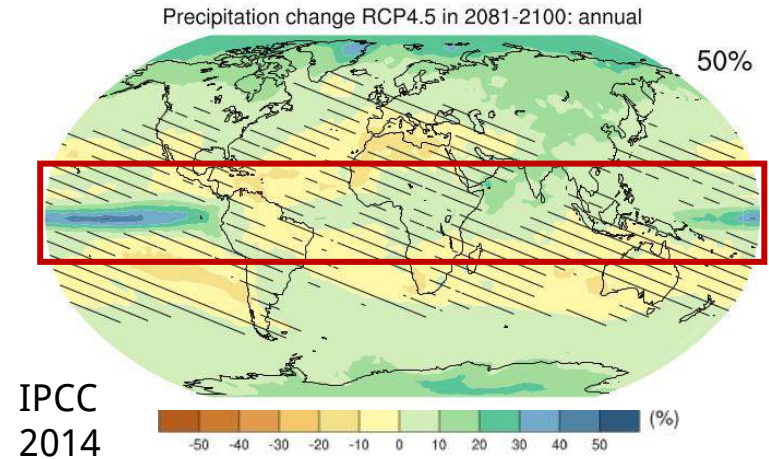
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Water availability is likely to change in the next decades



Key factor for plants



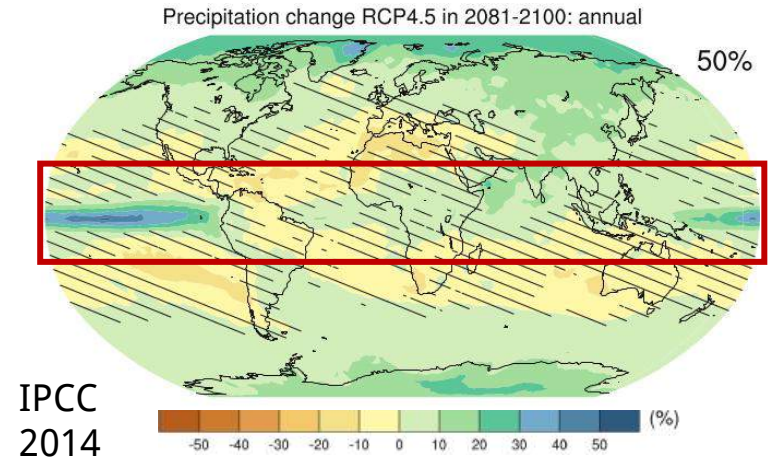
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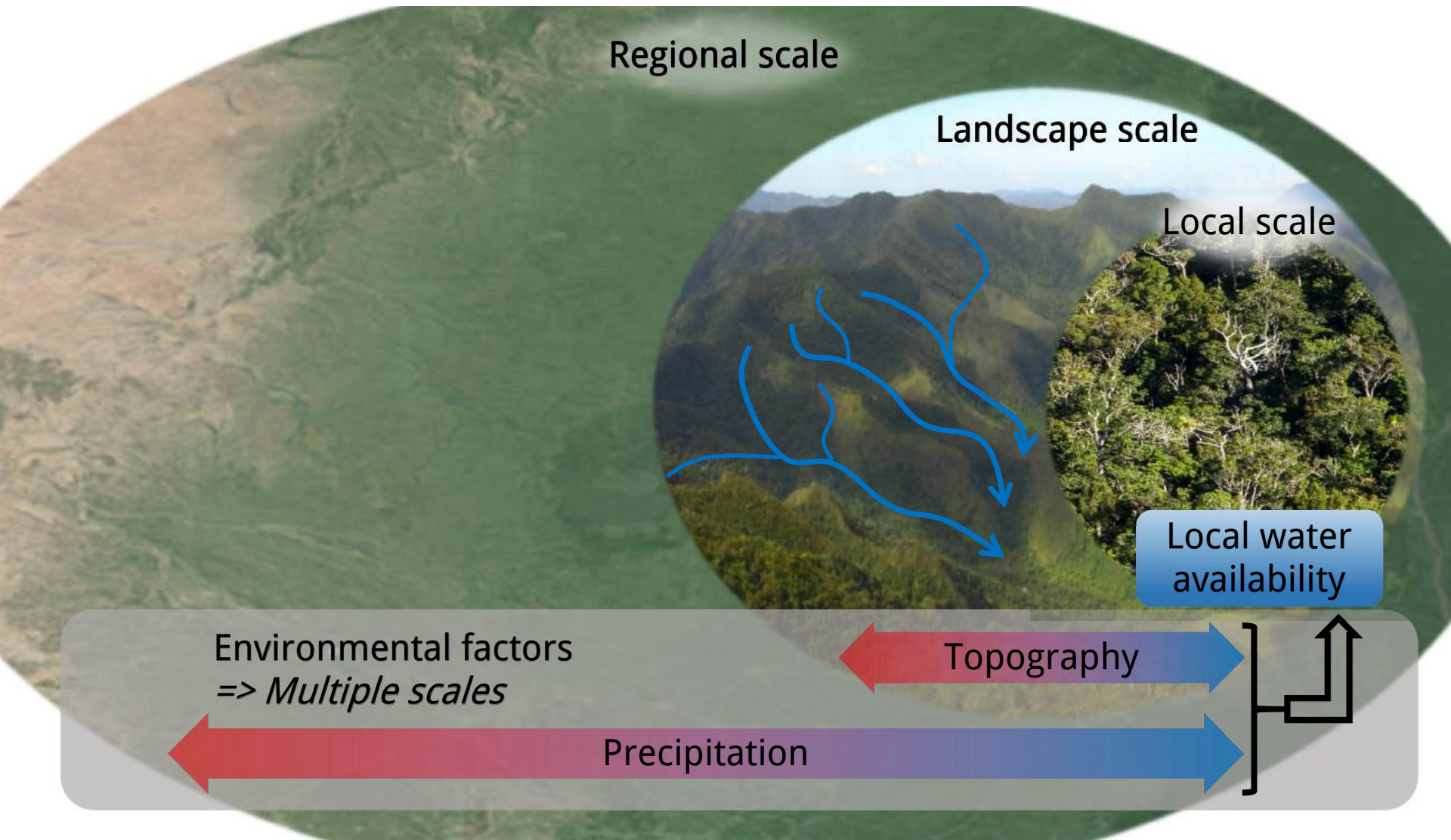


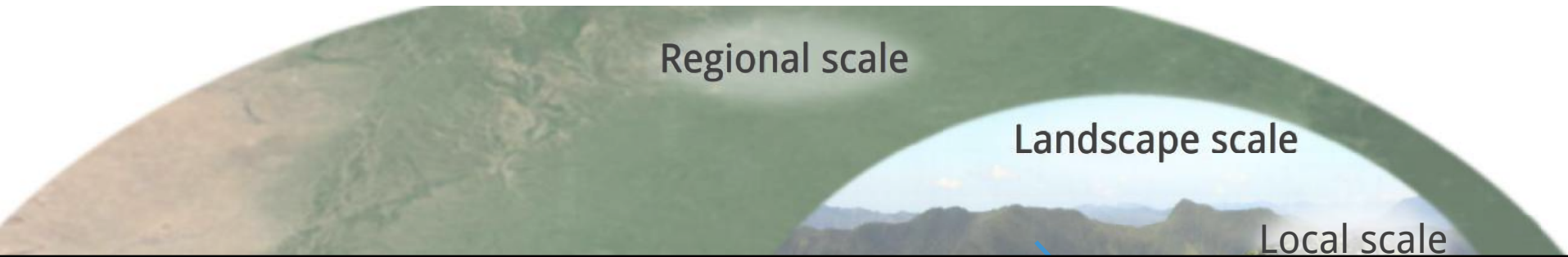
Key factor for plants



=> **Critical need for understanding how variation in water availability influence tree assemblages to improve tropical forest conservation**

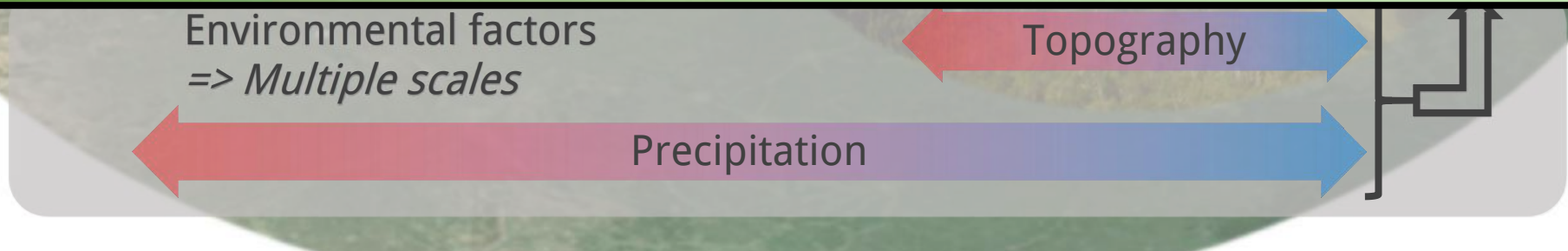
# Water availability across spatial scales



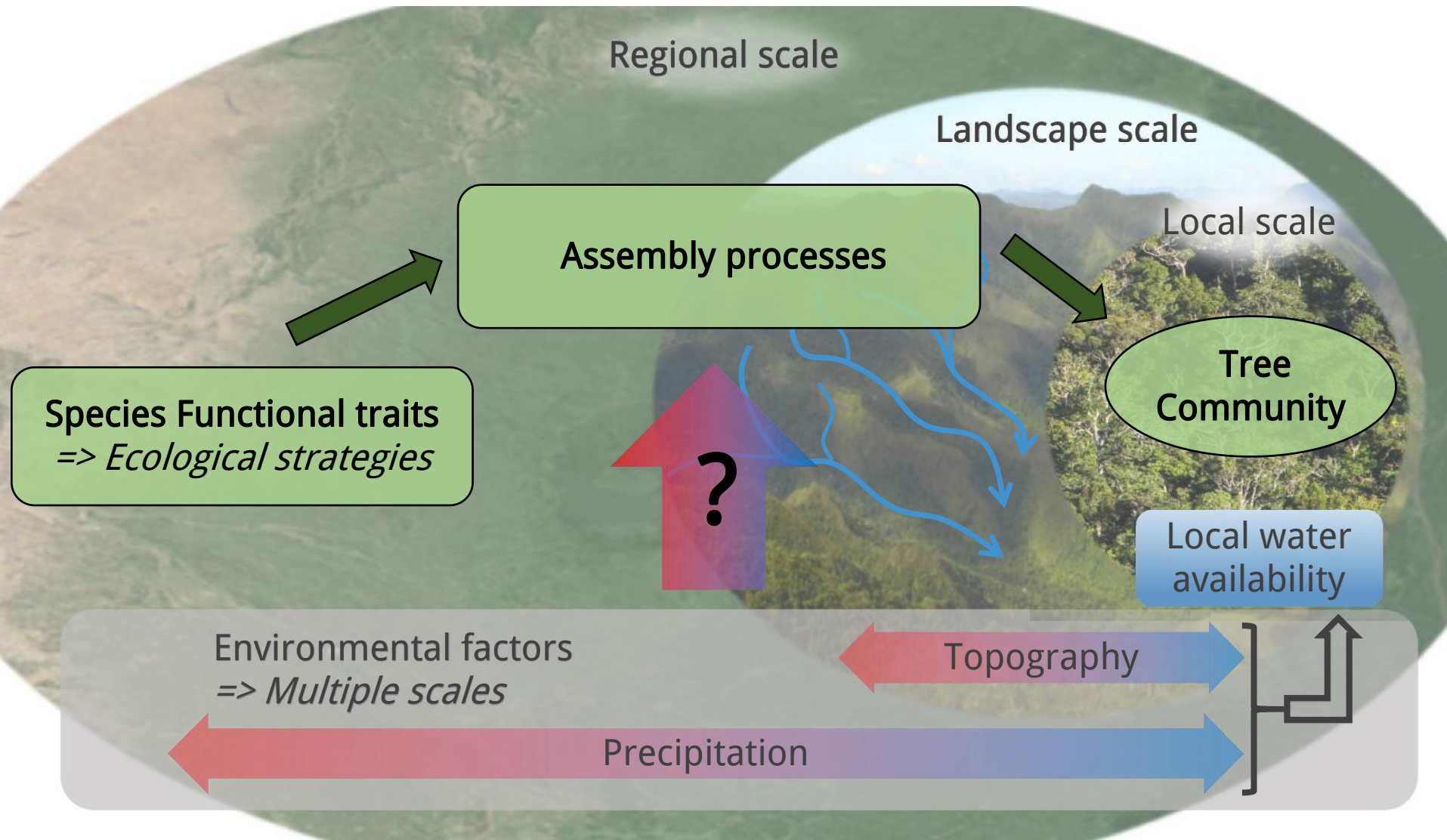


## Questions

1. How regional precipitation gradient and landscape topographic gradient influence tree assemblages ?
2. Does the influence of topography on tree assemblages depend on precipitation context?

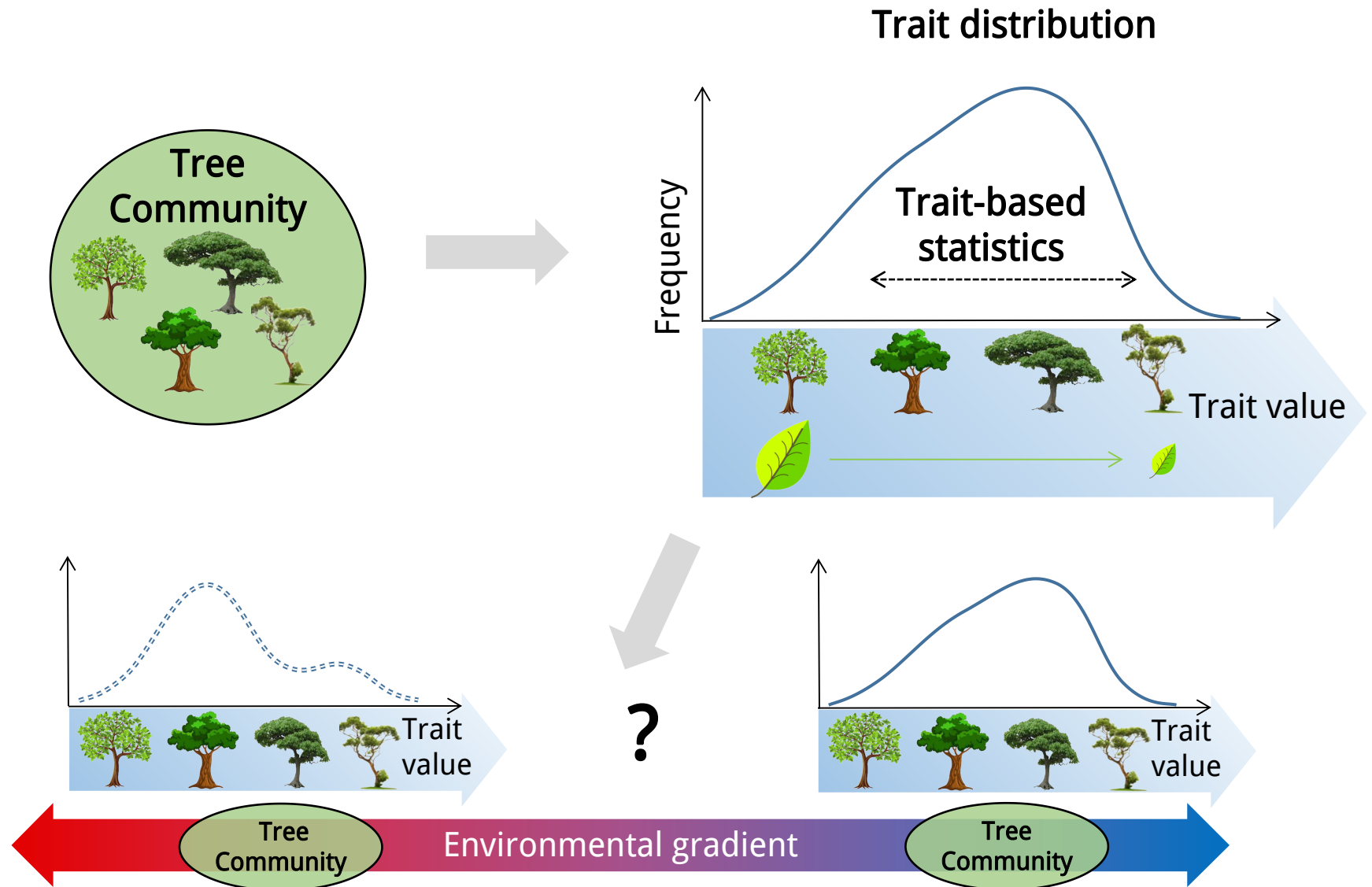


# Water availability across spatial scales



=> Functional approach

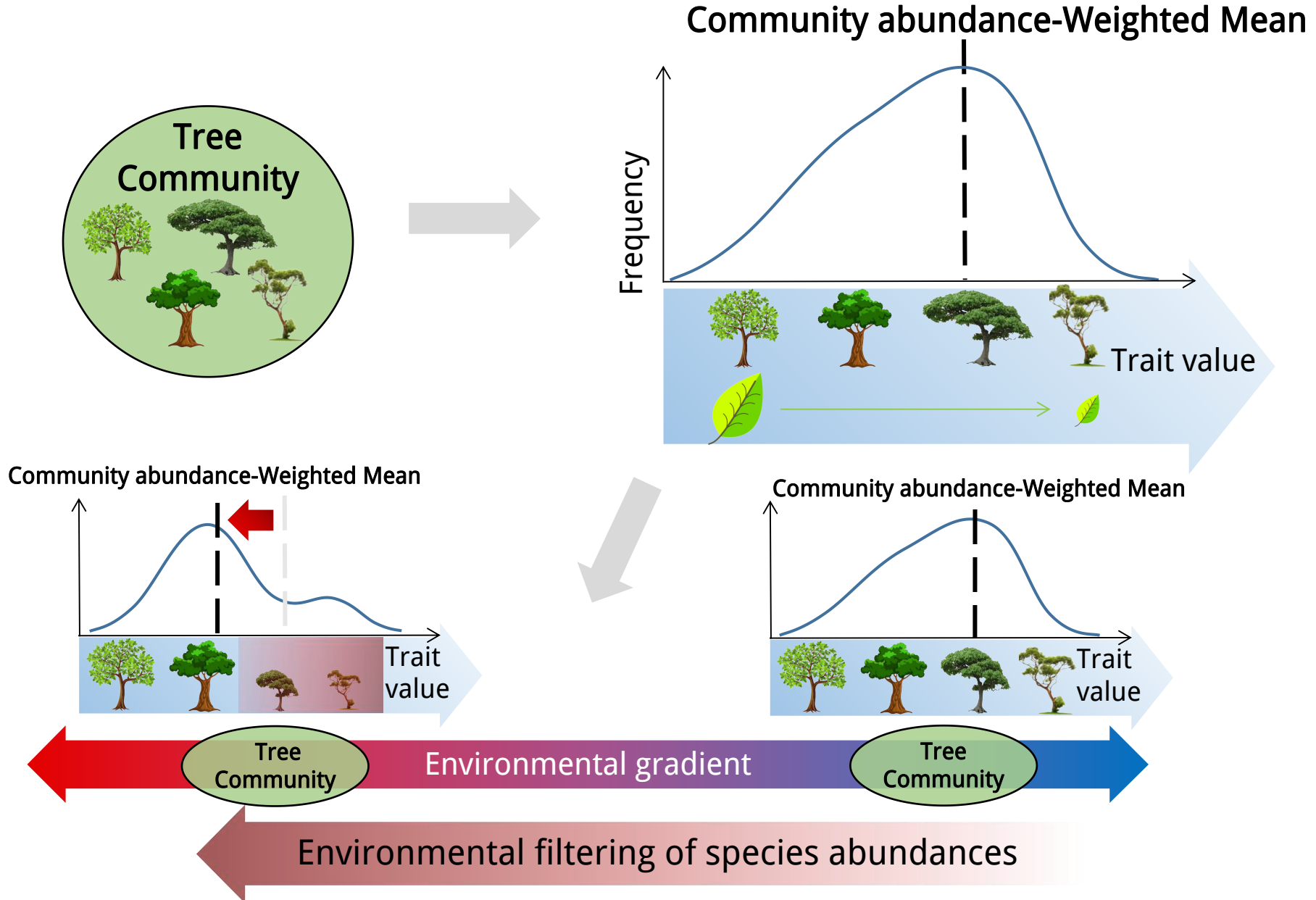
# Functional approach



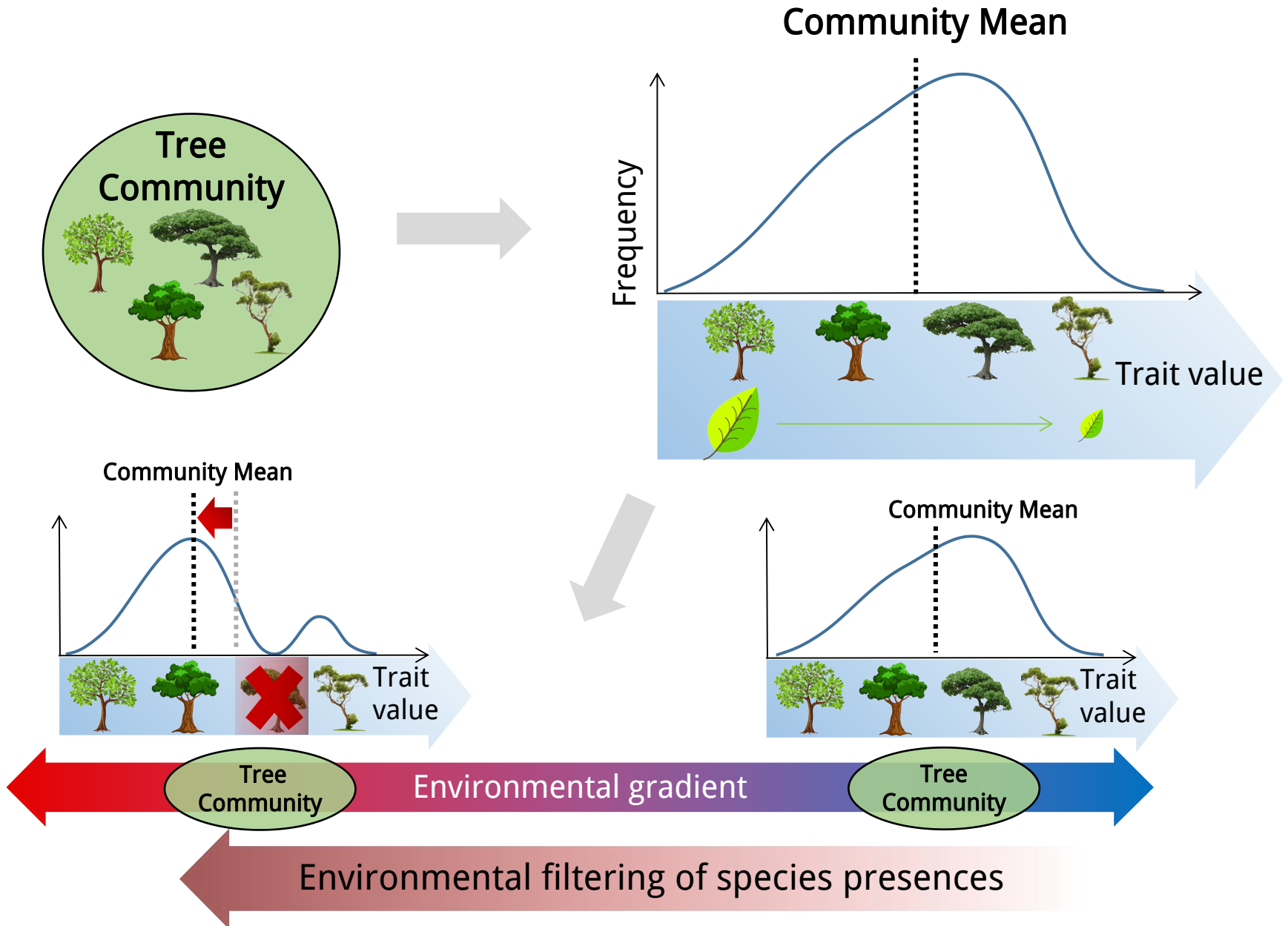
*=> Infer assembly processes*



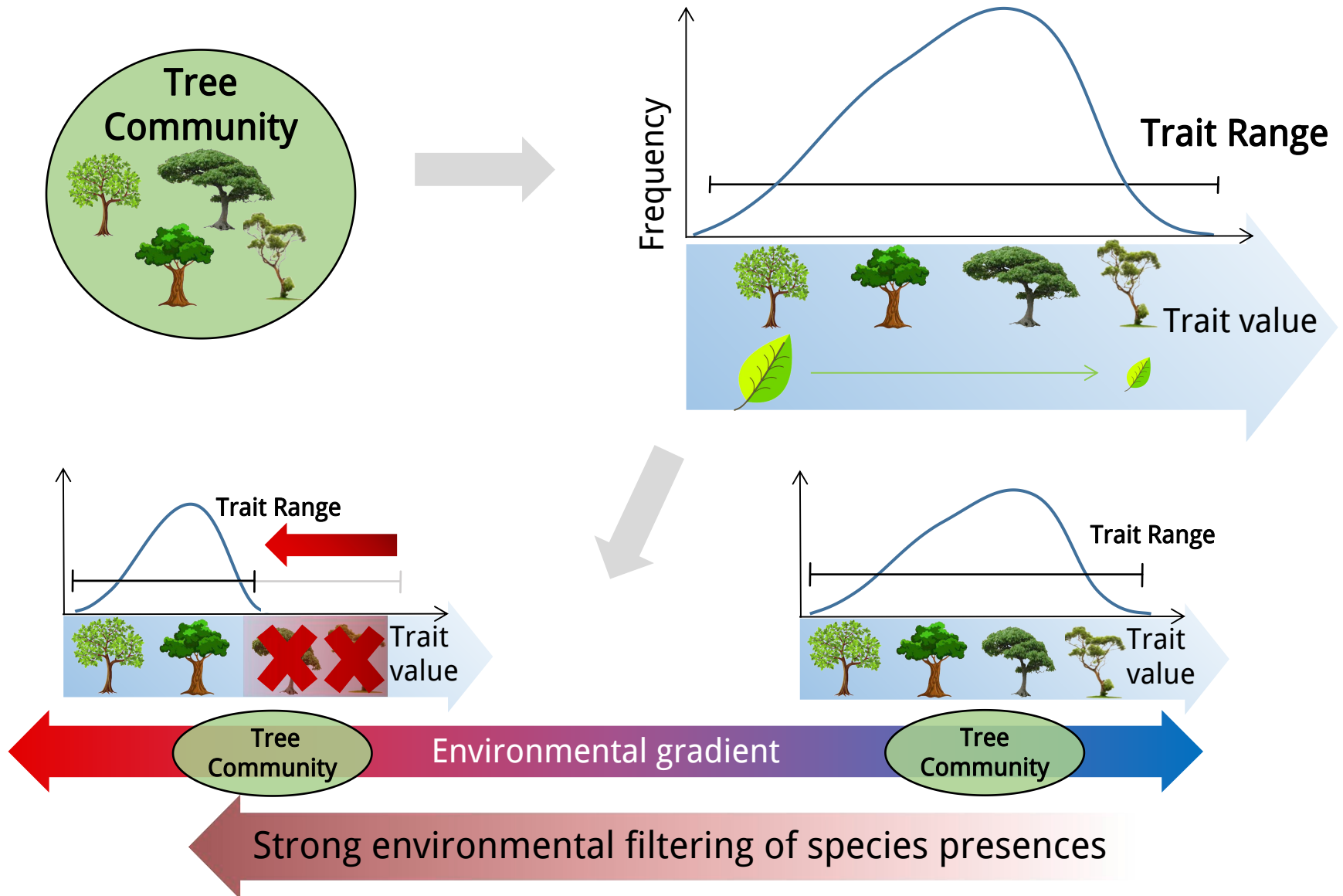
# Functional approach

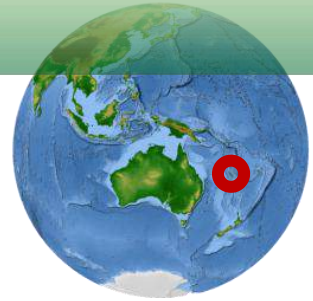


# Functional approach



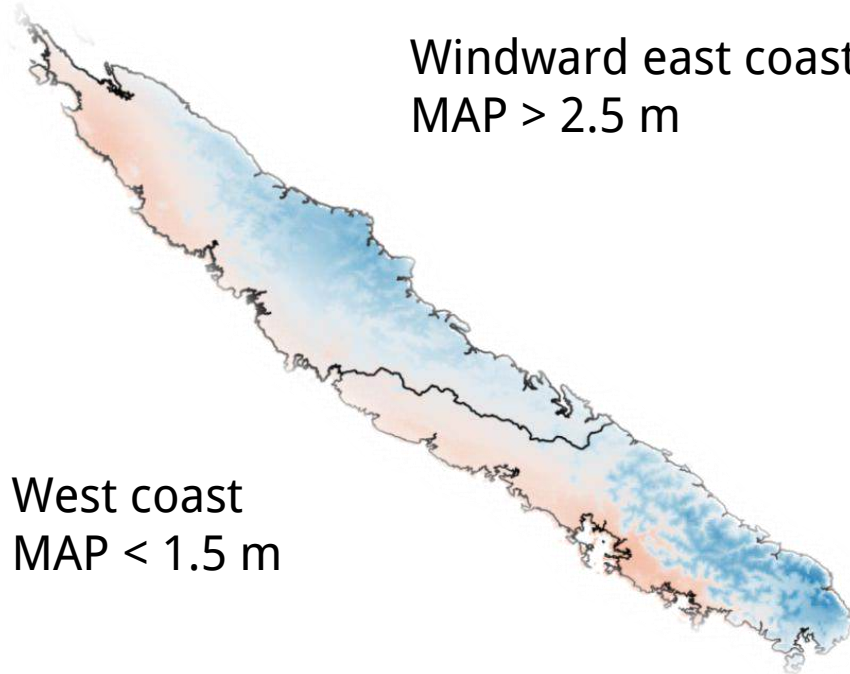
# Functional approach



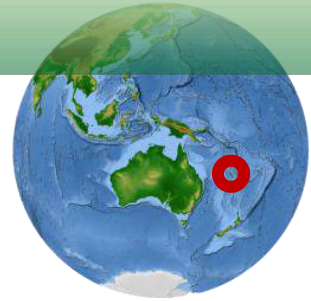


## Precipitation gradient

Windward east coast  
MAP > 2.5 m

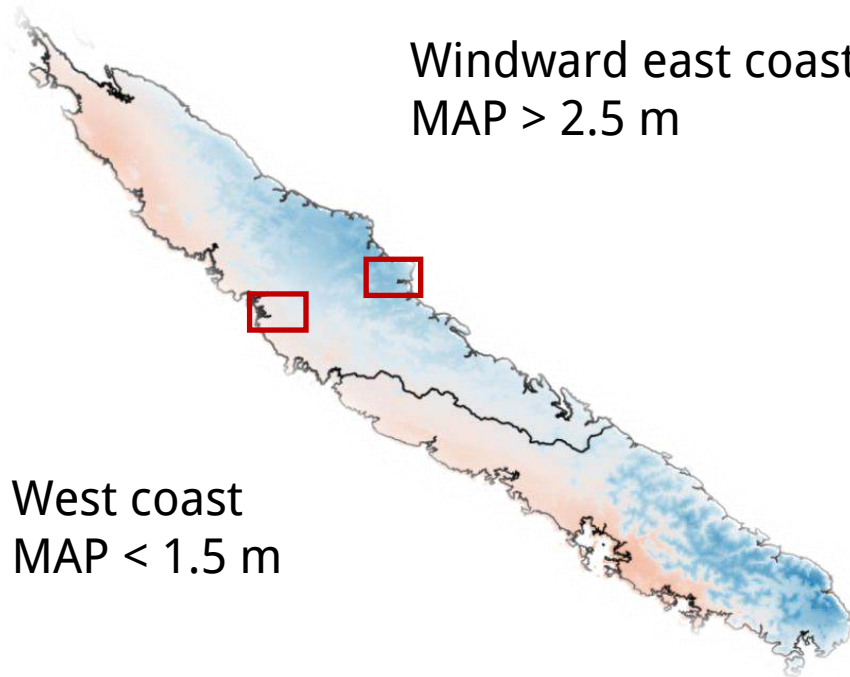


West coast  
MAP < 1.5 m



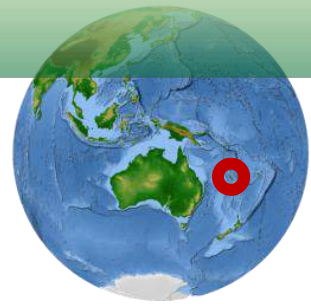
## Precipitation gradient

Windward east coast  
MAP > 2.5 m



West coast  
MAP < 1.5 m

2 Landscapes : Dry vs Wet

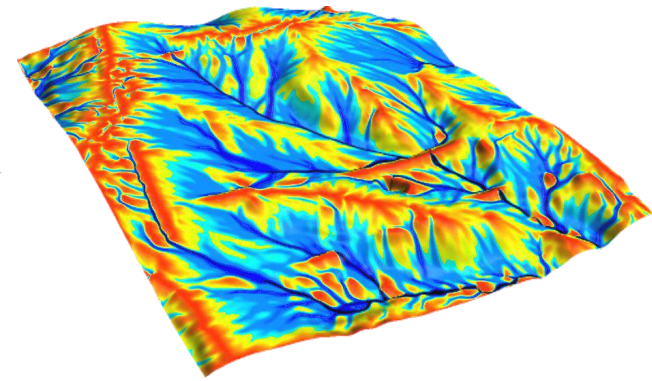


Precipitation gradient

Topographic gradient

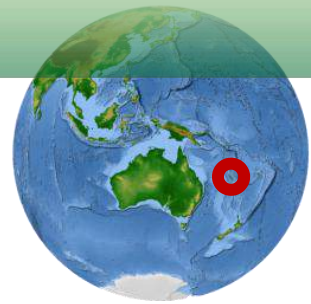
Windward east coast  
MAP > 2.5 m

West coast  
MAP < 1.5 m



Topographic Wetness Index (TWI)

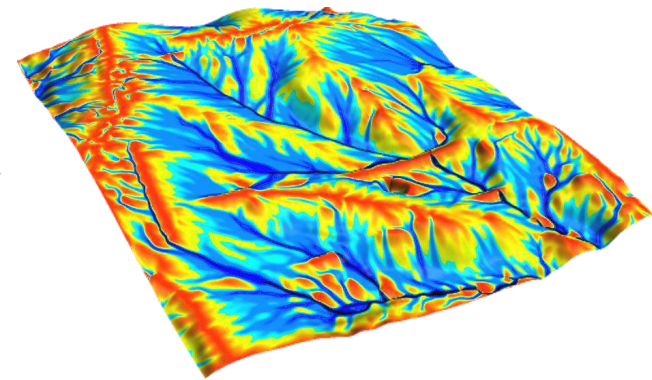
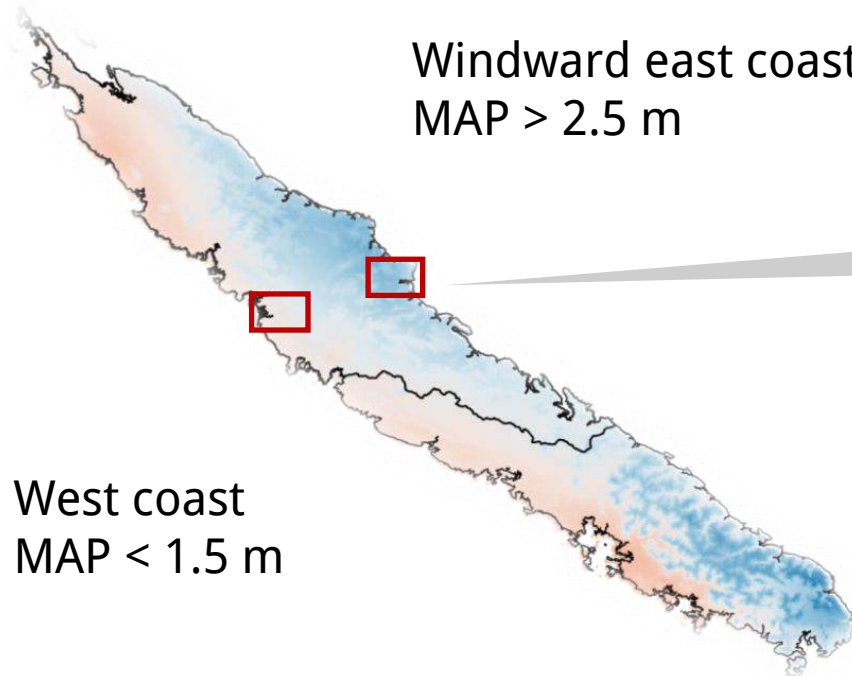
2 Landscapes : Dry vs Wet



Precipitation gradient

Topographic gradient

Windward east coast  
MAP > 2.5 m



Topographic Wetness Index (TWI)

2 Landscapes : Dry vs Wet

In each landscape => Sampling across topographic gradient

20 tree communities (400m<sup>2</sup> plots, DBH > 10 cm)



Precipitation gradient

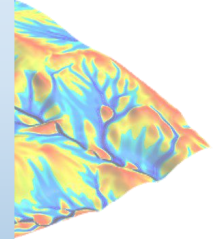
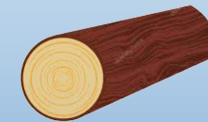
Topographic gradient

## Data set

2 landscapes, 2 sets of 20 communities, 127 species

5 Functional traits (species level) :

- Wood Density (WD)
- Leaf Area (LA)
- Leaf Specific Area (SLA)
- Leaf Dry Matter Content (LDMC)
- Leaf Thickness (LT)



+  
ex (TWI)

West coast  
MAP < 1.5 m

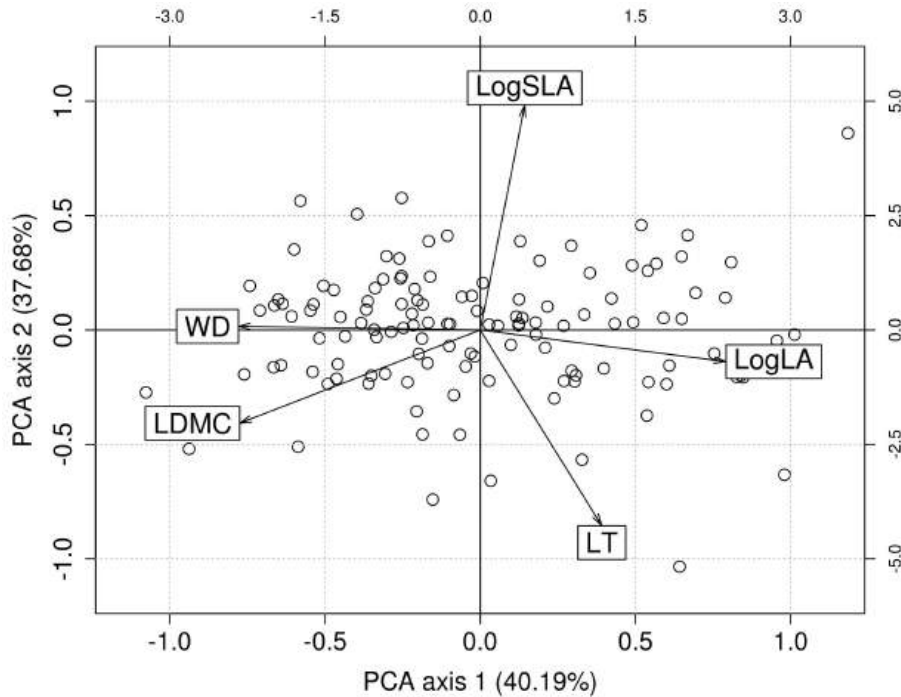
2 Landscapes

In each landscape => Sampling across topographic gradient

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## Principal Component Analysis of species traits



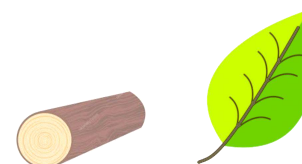
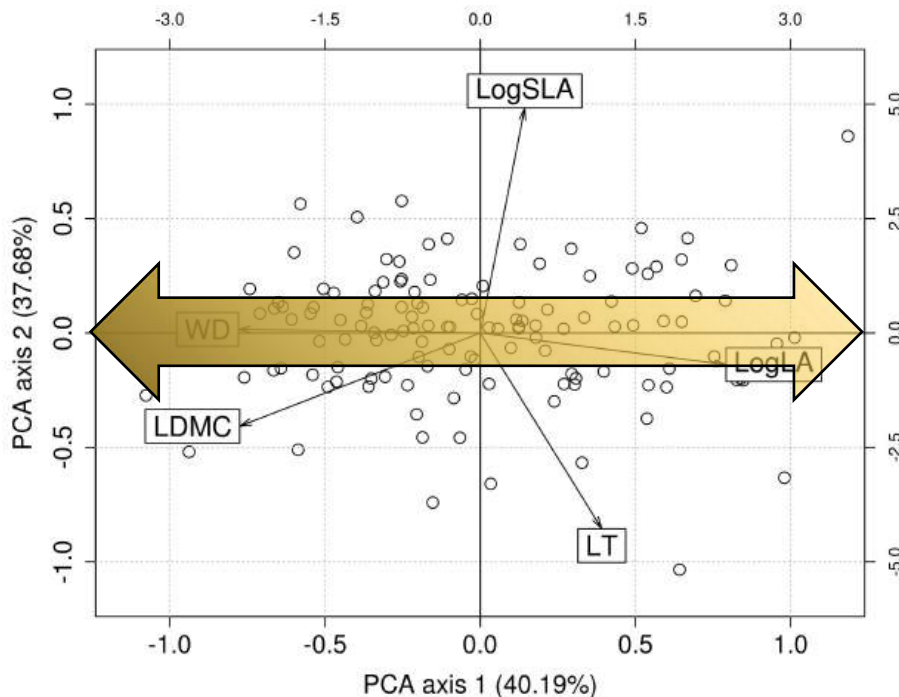
# From functional trade-offs to ecological strategies



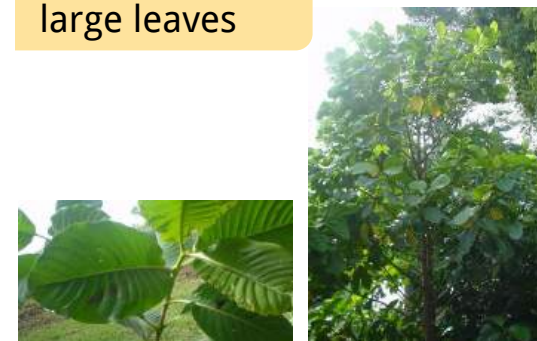
dense wood  
small leaves



e.g. *Diospyros pustulata*



light wood  
large leaves



e.g. *Neuburgia novocaledonica*

# From functional trade-offs to ecological strategies



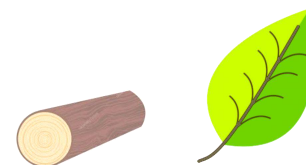
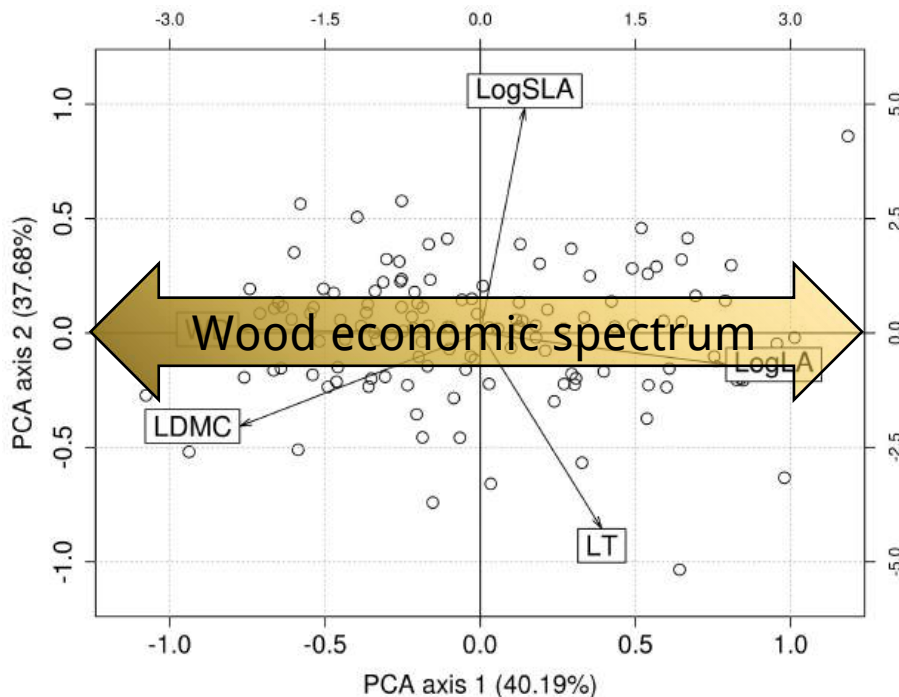
dense wood  
small leaves

Drought  
resistance

⊖ embolism  
⊖ transpiration



e.g. *Diospyros pustulata*



light wood  
large leaves

Hydraulic  
efficiency

High growth rate  
⚠ embolism

e.g. *Neuburgia novocaledonica*

*Ecology Letters*, (2009) 12: 351–366

doi: 10.1111/j.1461-0248.2009.01285.x

## REVIEW AND SYNTHESIS

## Towards a worldwide wood economics spectrum

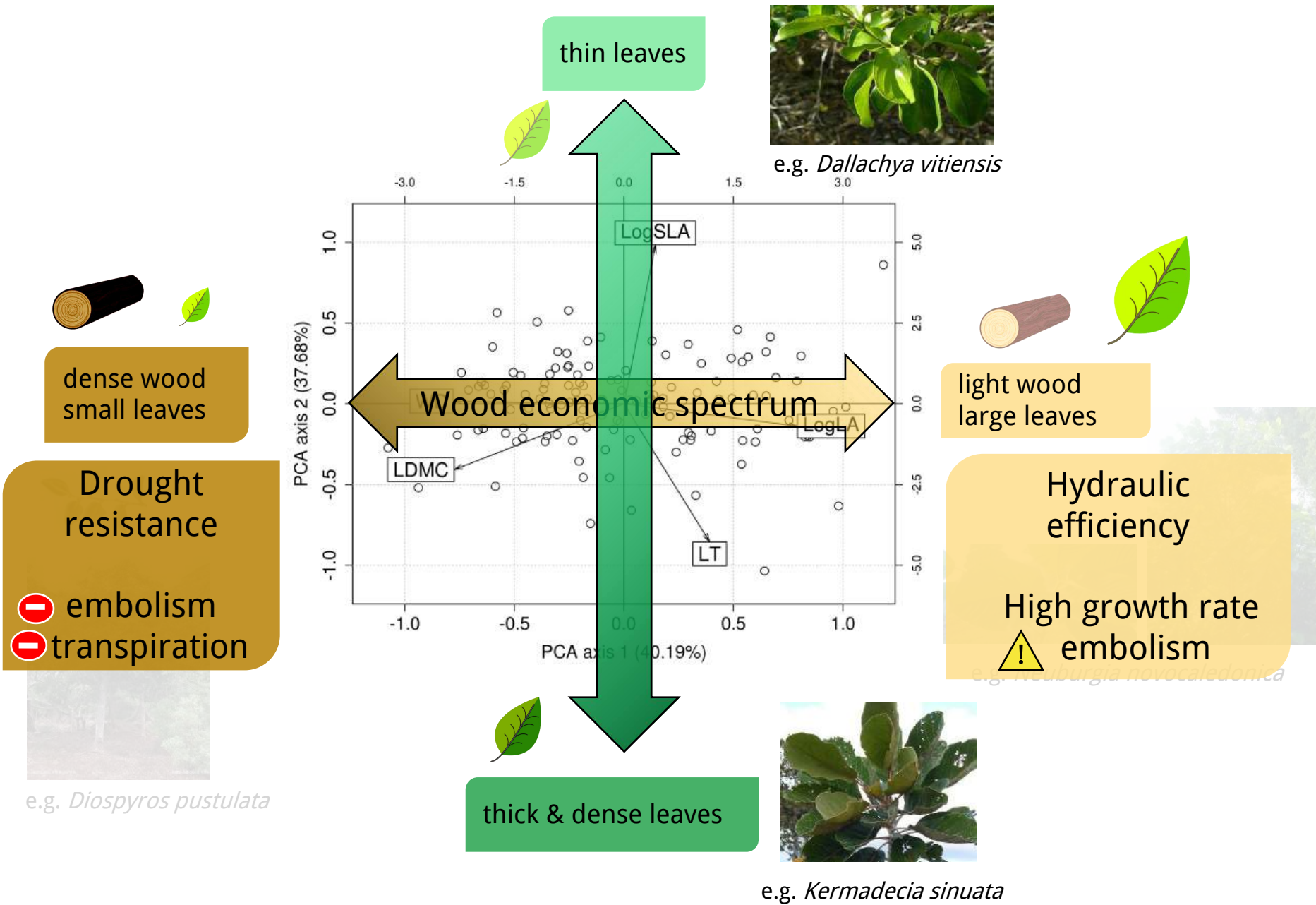
### Abstract

Wood performs several essential functions in plants, including mechanically supporting aboveground tissue, storing water and other resources, and transporting sap. Woody tissues are likely to face physiological, structural and defensive trade-offs. How a plant optimizes among these competing functions can have major ecological implications.

Jerome Chave,<sup>1\*</sup> David Coomes,<sup>2</sup> Steven Jansen,<sup>3</sup> Simon L. Lewis,<sup>4</sup> Nathan G. Swenson<sup>5</sup> and Amy E. Zanne<sup>6,7</sup>

Chave *et al.*, 2009

# From functional trade-offs to ecological strategies



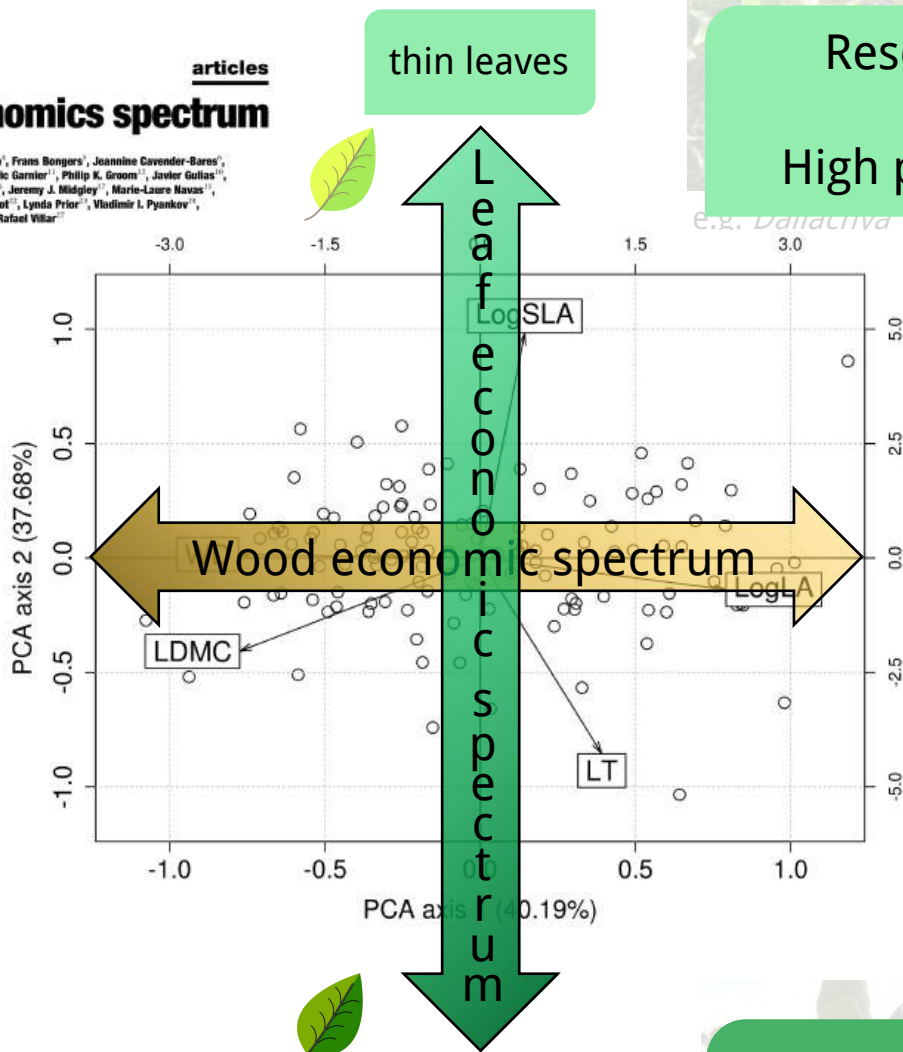
# From functional trade-offs to ecological strategies



## The worldwide leaf economics spectrum

articles  
 Ian J. Wright<sup>1</sup>, Peter B. Reich<sup>2</sup>, Mark Westoby<sup>3</sup>, David D. Ackerly<sup>4</sup>, Zdravko Baruch<sup>5</sup>, Frans Bongers<sup>6</sup>, Jeannine Cavender-Bares<sup>7</sup>, Terry Chapin<sup>8</sup>, Johannes H. C. Cornelissen<sup>9</sup>, Matthias Diemer<sup>10</sup>, Jaime Flexas<sup>11</sup>, Eric Garnier<sup>12</sup>, Philip K. Groom<sup>13</sup>, Javier Gullas<sup>14</sup>, Kouki Hikosaka<sup>15</sup>, Byron B. Lamont<sup>16</sup>, Tali Lee<sup>17</sup>, William Lee<sup>18</sup>, Christopher Lusk<sup>19</sup>, Jeremy J. Midgley<sup>20</sup>, Marie-Laure Navas<sup>21</sup>, Ülo Niinemets<sup>22</sup>, Jacek Oleksyn<sup>23</sup>, Noriyuki Osada<sup>24</sup>, Hendrik Poorter<sup>25</sup>, Pieter Poort<sup>26</sup>, Lynda Prior<sup>27</sup>, Vladimir I. Pyankov<sup>28</sup>, Catherine Roumet<sup>29</sup>, Sean C. Thomas<sup>30</sup>, Mark G. Tjoelker<sup>31</sup>, Erik J. Veneklaas<sup>32</sup> & Rafael Villar<sup>33</sup>

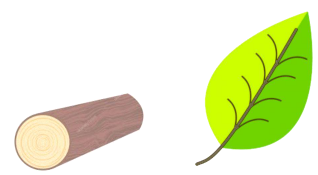
Wright *et al.*, 2004



thin leaves



Resource acquisition  
 High photosynthetic rate  
 e.g. *Dalmanella vitensis*



light wood  
 large leaves

Hydraulic efficiency  
 High growth rate  
 ⚠️ embolism  
 e.g. *Neuburgia novocaledonia*

Resource conservation  
 Long-lived leaves  
 e.g.

thick & dense leaves



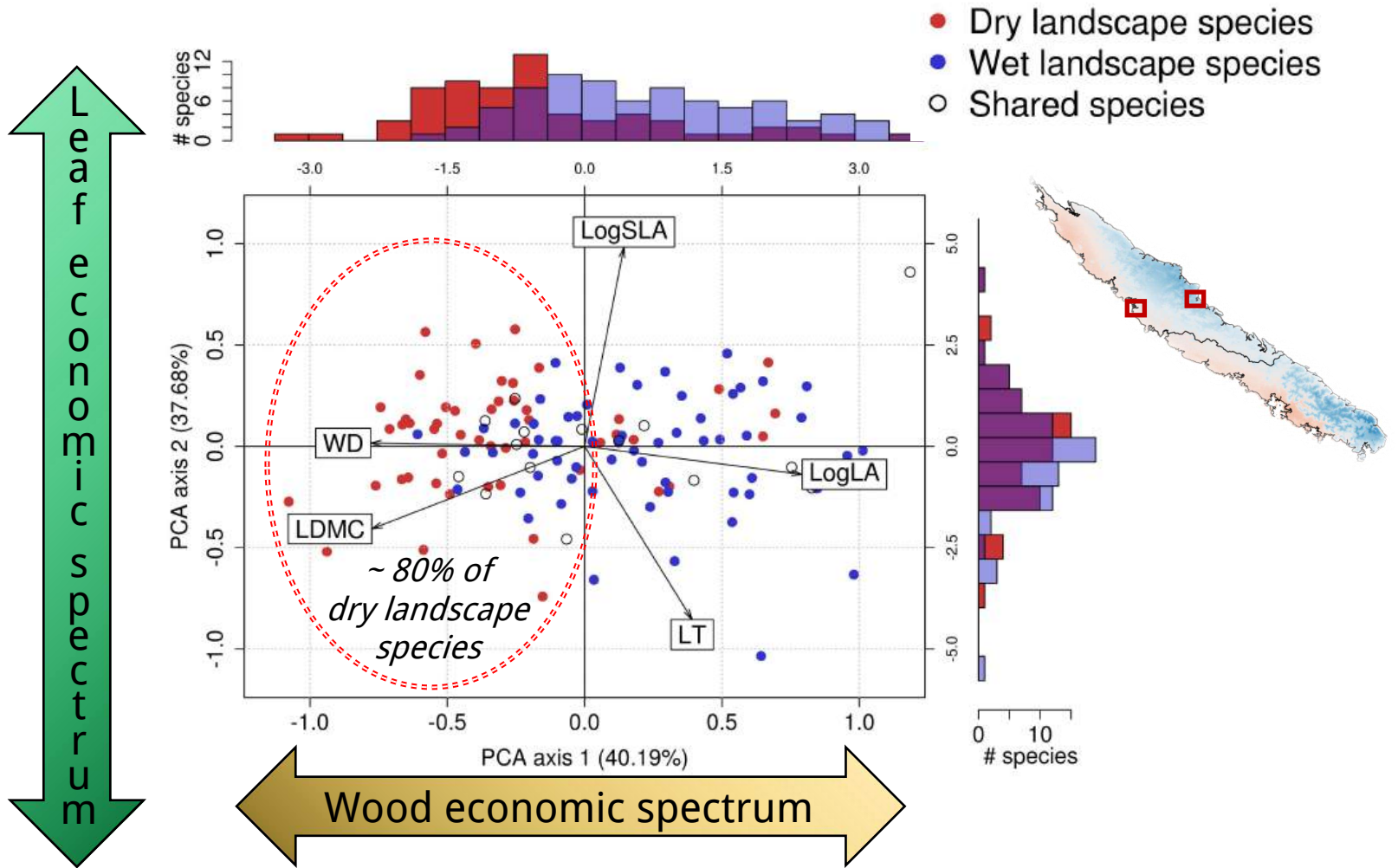
dense wood  
 small leaves

Drought resistance  
 embolism  
 transpiration

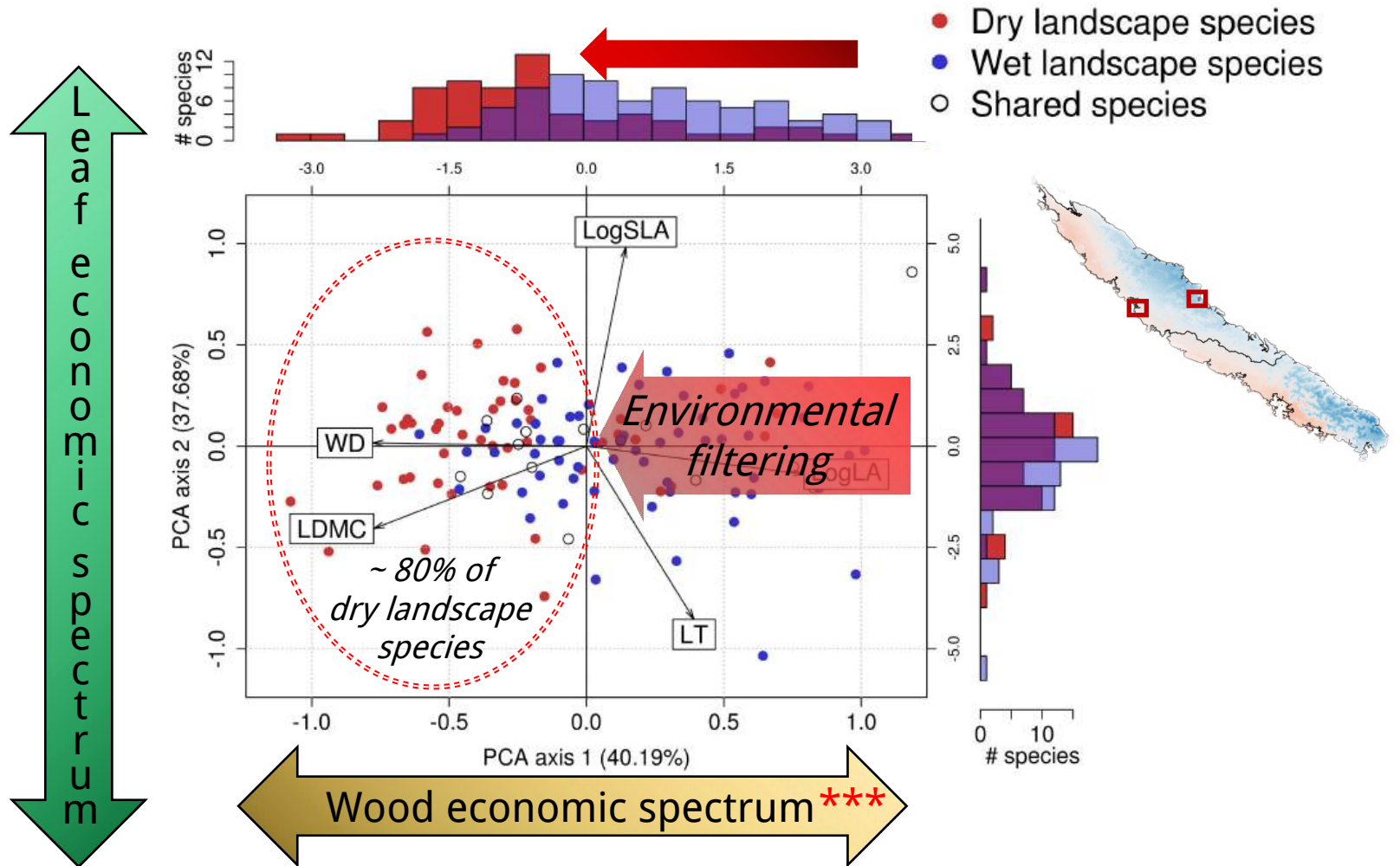


e.g. *Diospyros pustulata*

# Regional scale : influence of precipitation on tree assemblages



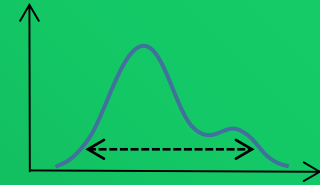
# Regional scale : influence of precipitation on tree assemblages



*Precipitation drives environmental filtering along the Wood Economic Spectrum at the regional scale*

# Landscape scale : null model approach

Community trait-based statistics  
on Wood Economic Spectrum  
and Leaf Economic Spectrum



Landscape-scale null models  
*=> Randomization of species traits*



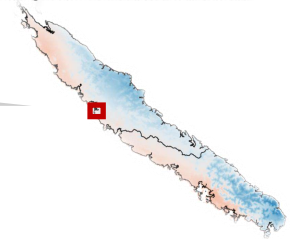
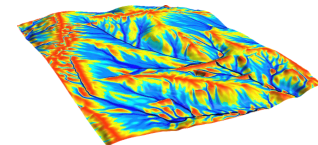
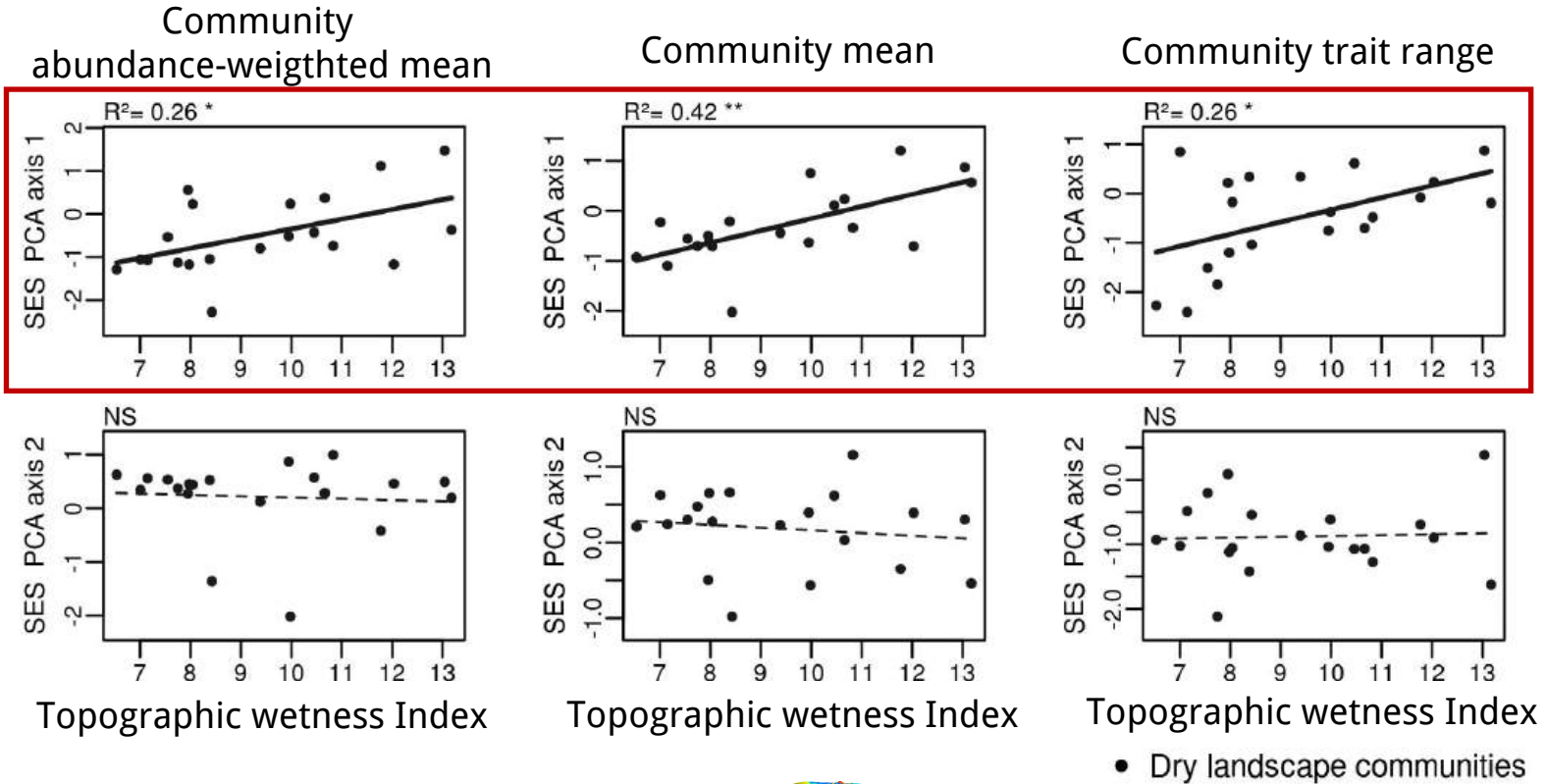
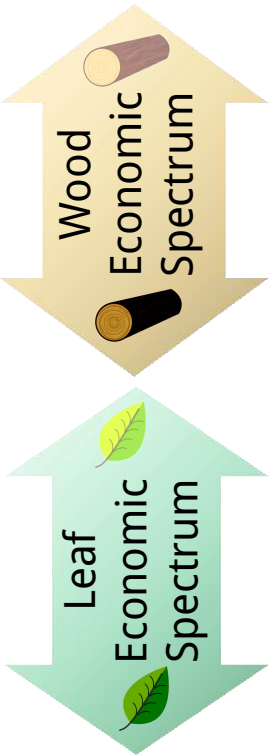
Observed vs. Null expectation  
*=> Standardized effect sizes*

$$SES = (I_{obs} - I_{null}) / I_{sdnull}$$





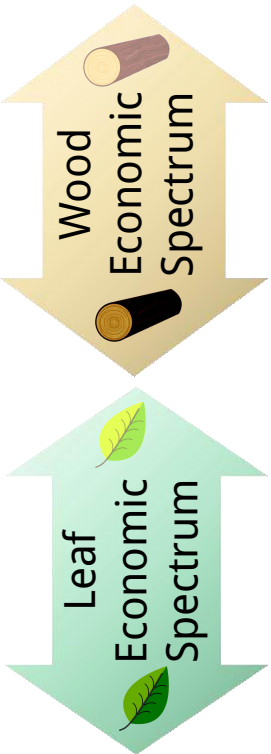
# Strong filtering on Wood E.S. in the dry landscape



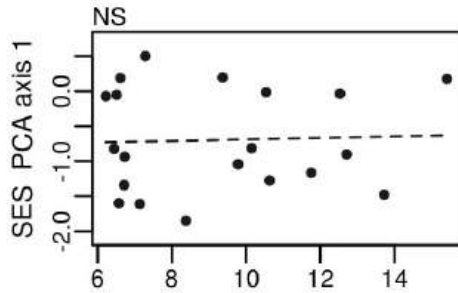
Wood economic spectrum : Environmental filtering on both species abundances & presences + range reduction

=> *Strong environmental filtering of drought-resistance strategies*

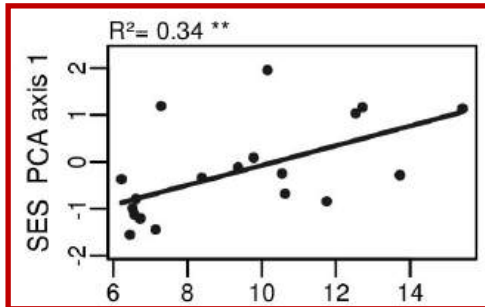
# Filtering on Leaf E.S. in the wet landscape



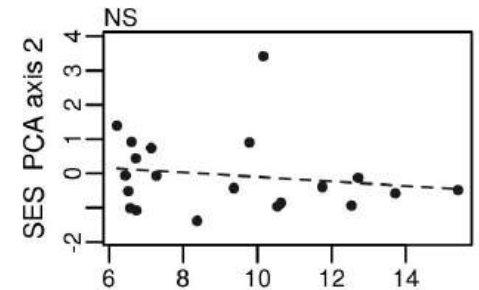
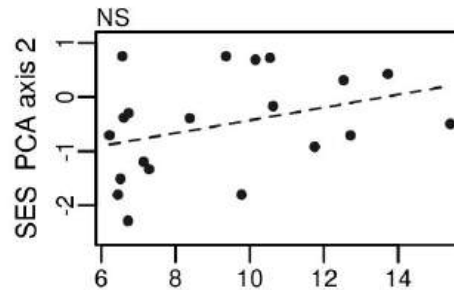
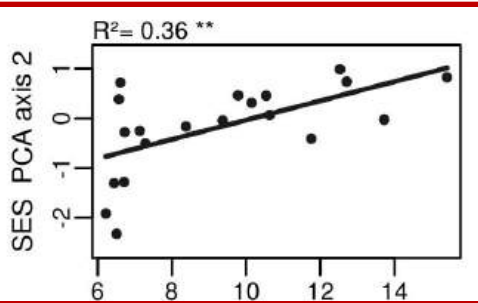
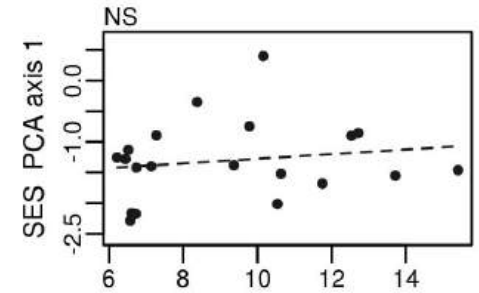
Community abundance-weighted mean



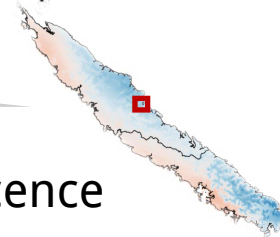
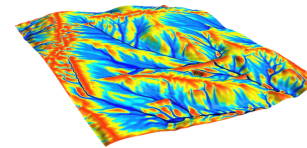
Community mean



Community trait range



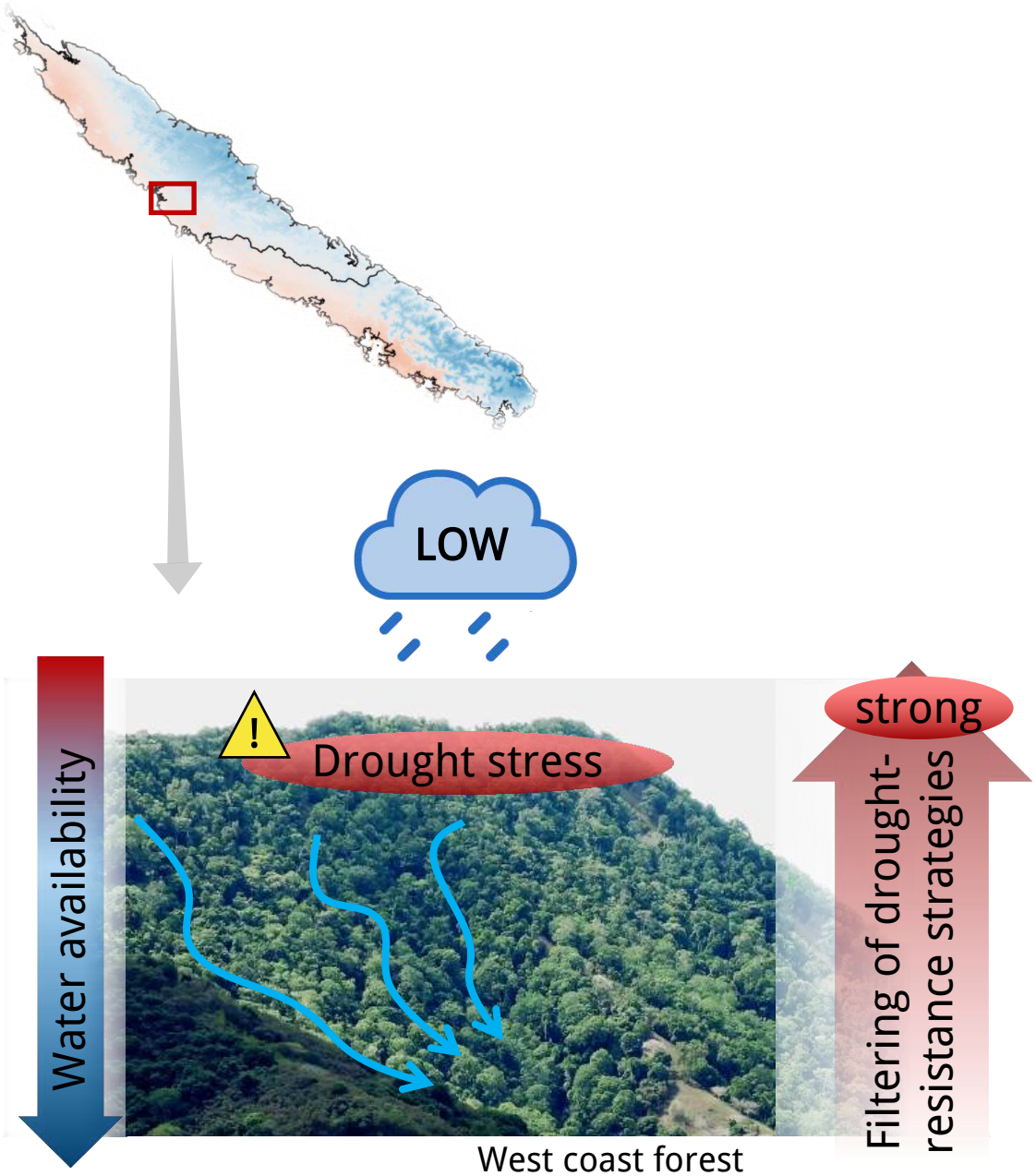
• Wet landscape communities



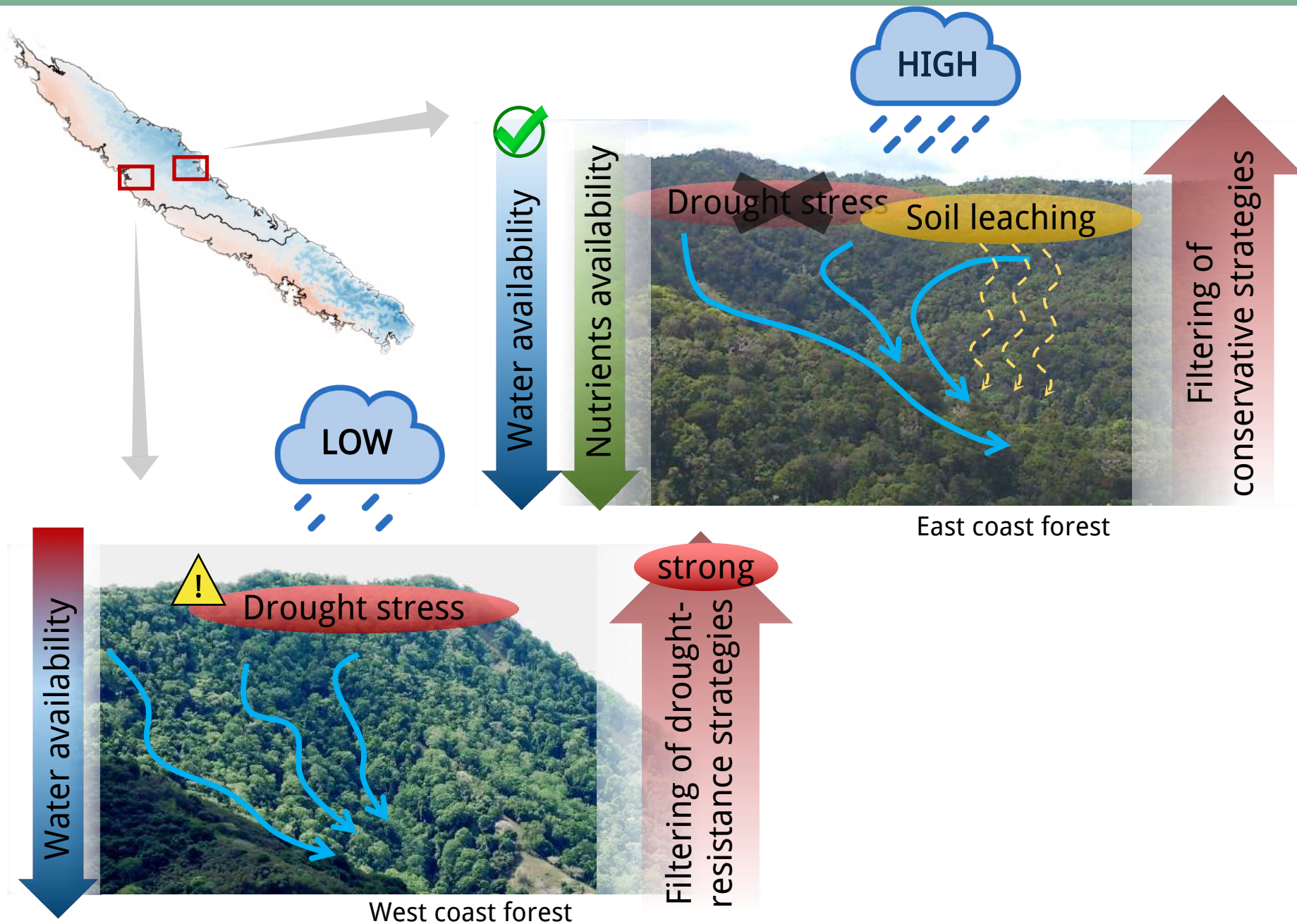
Wood economic spectrum : Environmental filtering only on species presence  
 => *Reduced drought constraints*

Leaf economic spectrum : Environmental filtering on species abundances  
 => *Greater role of resource-use strategies*

# Influence of topography depends on precipitation



# Influence of topography depends on precipitation





Both **regional precipitation gradient** and **landscape topographic gradient** shape the **functional composition** of tree communities

=> *Hierarchical constraints on water availability*

**Influence of topography on assembly processes depends on the climatic context :**

=> *Strong filtering on the Wood Economic Spectrum with low precipitation*

=> *Filtering on the Leaf Economic Spectrum with high precipitation*

If future climate change impact water availability?

=> *Changes in community composition at regional and landscape scales !*

Thank you

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