

# Assessing tree species vulnerability to climate change in French Guiana using joint species distribution models

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# Plan

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- 1 Introduction
  - JSDMs
  - METRADICA's objectives
- 2 Material and methods
  - Datasets
  - Study scales
- 3 Perspectives
  - Model comparison
  - Applications

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# Joint Species Distribution Models (JSDMs)

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## Species Distribution Model (SDM), for one single species.

- $y_i \sim \text{Bernoulli}(\theta_i)$ ,  $y_i \in \{0, 1\}$
- $i$  : site
- $p(\theta_i) = X_i\beta$
- $X$  : environmental variables
- $\beta$  : species effects

## JSDM = SDM for community of species.

- $p(\theta_{ij}) = \alpha_i + X_i\beta_j + \Sigma_{ij}$
- $i$  : site,  $j$  : species
- Site effect  $\alpha_i$  : mean site suitability
- Variance-covariance matrix  $\Sigma_{ij}$  : species co-occurrences

# Joint Species Distribution Models

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JSDMs provide a convenient statistical framework to test **trait-environment** interactions.

$\beta_j$  can be expressed as a function of functional traits

- $p(\theta_{ij}) = \alpha_i + X_i\beta_j + \Sigma_{ij}$
- $p(\beta_j) = N(T_j\gamma, V_\beta)$

JSDMs can help narrow the gap between **correlative** and **mechanistic** species distribution models.

jSDM R package (first chapter of Jeanne's PhD thesis),  
<https://ecology.ghislainv.fr/jSDM/>

## Objectives of METRADICA (Task 3)

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Using JSDBMs :

- Test **trait-environment** interactions for determining tree species distribution in French Guiana.
- Assess species vulnerability to climate change (through contraction of species range).
- Interpret species vulnerability to climate change in terms of functional traits.
- Derive maps of  $\alpha$  and  $\beta$  diversity for French Guiana.
- Identify refuge area for biodiversity under climate change (stable tree communities).

# Plan

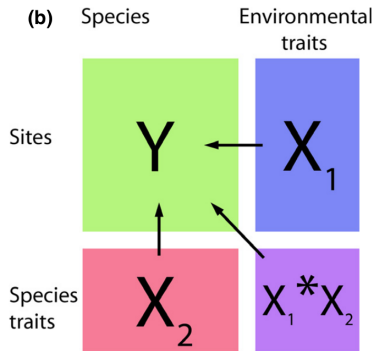
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# Datasets

Three types of data-sets :

- Species occurrences on sites
- Species trait database
- Environmental database

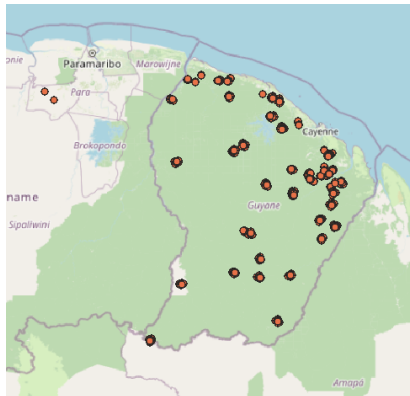




# Occurrences

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- Forest plot inventories coming from several networks combined together
- Networks : Guyafor, Gentry, Habitat, Guyadiv
- Presence-absence data and abundances
- 285 forest plots
- About 1700 tree species, most of which are rare



# Traits

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- Large “soft” trait (WD, LSA, tree max height, etc.) databases from previous CEBA projects.
- Five additional mechanistic traits from Metradica project :
  - leaf water potential at which cells lose turgor (Ptlp), minimum leaf conductance (gmin), leaf saturated water content (LSWC), vein density (VLA), stomatal density (SD).
  - 24 species, 672 trees, three sites with both hills and valleys spread on a precipitation gradient.

# Environment

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- Topographic data (SRTM and LiDAR)
- Soil data
- Distance to human infrastructures (roads, villages)
- Climatic data (Chelsa) in the present and the future
- <https://guyaclim.cirad.fr>

# Scales : biogeography and micro-environment

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## Local scale : microtopography × traits

- Scale = ~10km, resolution = ~5m
- Explicative model :  $E \times T$
- Using MNT at 5m : hills ("*terra firme*") and valleys

## Country scale (French Guiana)

- Scale = FG, resolution = ~1km
- Explicative and predictive model
- Two models
  - Without traits
    - Predictive model
    - Present : distribution and co-occurrences of species
    - Future : range contraction in the future : (i) species vulnerability to climate change, (ii) change in species composition
  - With traits
    - Explicative model :  $E \times T$
    - Explaining species location (biogeography)

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# Model comparison with forest dynamics models

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## TROLL model

- Tropical forest dynamics model
- Growth, mortality, recruitment through carbon allocation
- Species parameters are derived from traits
- Calibrated on some forests of French Guiana

## Model comparison

- Species excluded from the community with TROLL under climate change.
- Do the same species experience a severe range contraction with JSDMs?

# Applications

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- Anticipating climate change effects on tropical forest in French Guiana
  - Massive tree mortality events and forest conversion to savannas?
  - Change in species composition ?
- Identification of refuge areas for conservation  $\Rightarrow$  systematic conservation planning.

... Thank you for attention ...

<https://ecology.ghislainv.fr/presentations>



AMAP<sup>lab</sup>

