Modeling forest dynamics using tree functional traits

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The need for models in a changing world

- It's difficult to **construct experiments to test the effects of climate change** on forest dynamics and species distributions
  - Large spatial and temporal scales
  - Complex and nonlinear dynamics

- Forest communities may not migrate as an entity, but **changes in community composition and species interactions** should be expected

Models of forest dynamics (stand-level)

Models of forest dynamics

Advantages

- Appropriate for mixed stands, each species responds individually
- Better simulation of fine-scale processes (biotic competition and dispersal) → sps. distributions emerge from them

Disadvantages

An approach based on functional traits (FT)?

Plant functional traits are the features (**morphological, physiological, phenological**) that represent ecological strategies and determine how plants respond to environmental factors

(Perez-Harguindeguy *et al*. 2013)

Hypotheses

- Ecological strategies should be related to FT
- A model of forest dynamics could be constructed based on FT
  - Easier to parameterize (implement for new species)
  - More ecologically meaningful than current parameters

SORTIE-ND: spatially-explicit, individually-based model

Lines, 2012

Objective

Assess how well can FT predict SORTIE's parameters

The database: SORTIE in the world

Great Mountain Forest	CN (USA)	Temperate mixed forest	**Waitutu**	New Zealand	Cool temperate rainforest
Date Creek	BC (Canada)	Temperate mixed forest	**Pyrenees**	Spain	Montane-subalpine forest
BC	BC (Canada)	Sub-boreal forest	**Ossenbos**	Netherlands	Temperate mixed forest
Duparquet	QC (Canada)	Boreal forest	**Nakagawa**	Japan	Cool-Temperate forest
Estrie	QC (Canada)	Temperate broadleaf mixedforest	**Cinte Tesino**	Trentino (Italy)	Subalpine forest

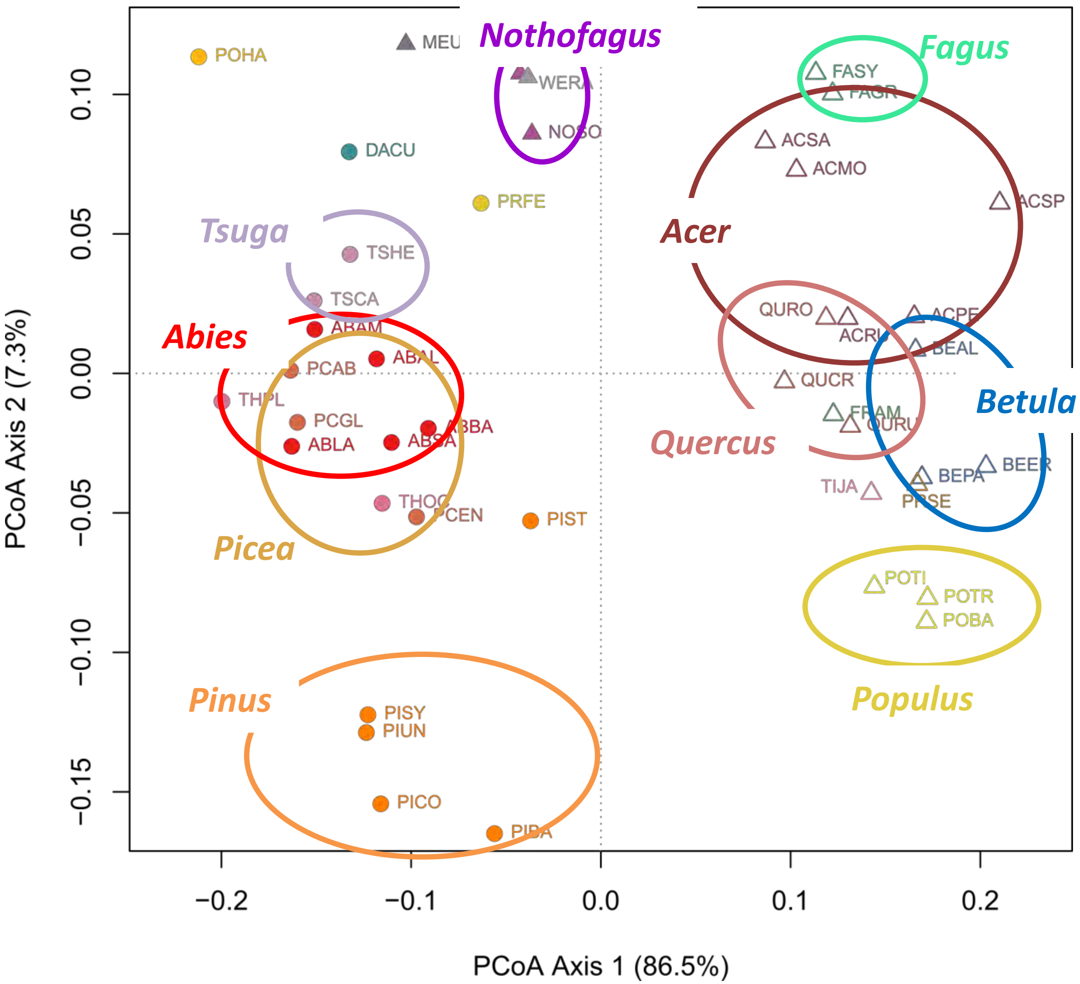
The dataset: 43 sp. Some repeated! (19 genus)

Functional traits

- Available for most species
- When possible, the same data source for all species

Code	Trait	Units
LMA	Leaf mass area	$g\ m^{-2}$
Amass	Photosynthetic capacity per unit leaf mass	$mmol\ CO_2 g^{-1} s^{-1}$
Nmass	Leaf N content per unit mass	%
Pmass	Leaf P content per unit mass	%
LL	Leaf longevity	months
Llength	Leaf length	mm
Lsize	Leaf size	Ordinal (1-4)
SeM	Seed mass	g
WD	Wood density	$g\ cm^{-3}$
MaxH	Maximum height	m
MaxAge	Maximum age	years
TolS	Shade tolerance	Categoric (1-5)
TolD	Drought tolerance	Categoric (1-5)
TolW	Tolerance to waterlogging	Categoric (1-5)

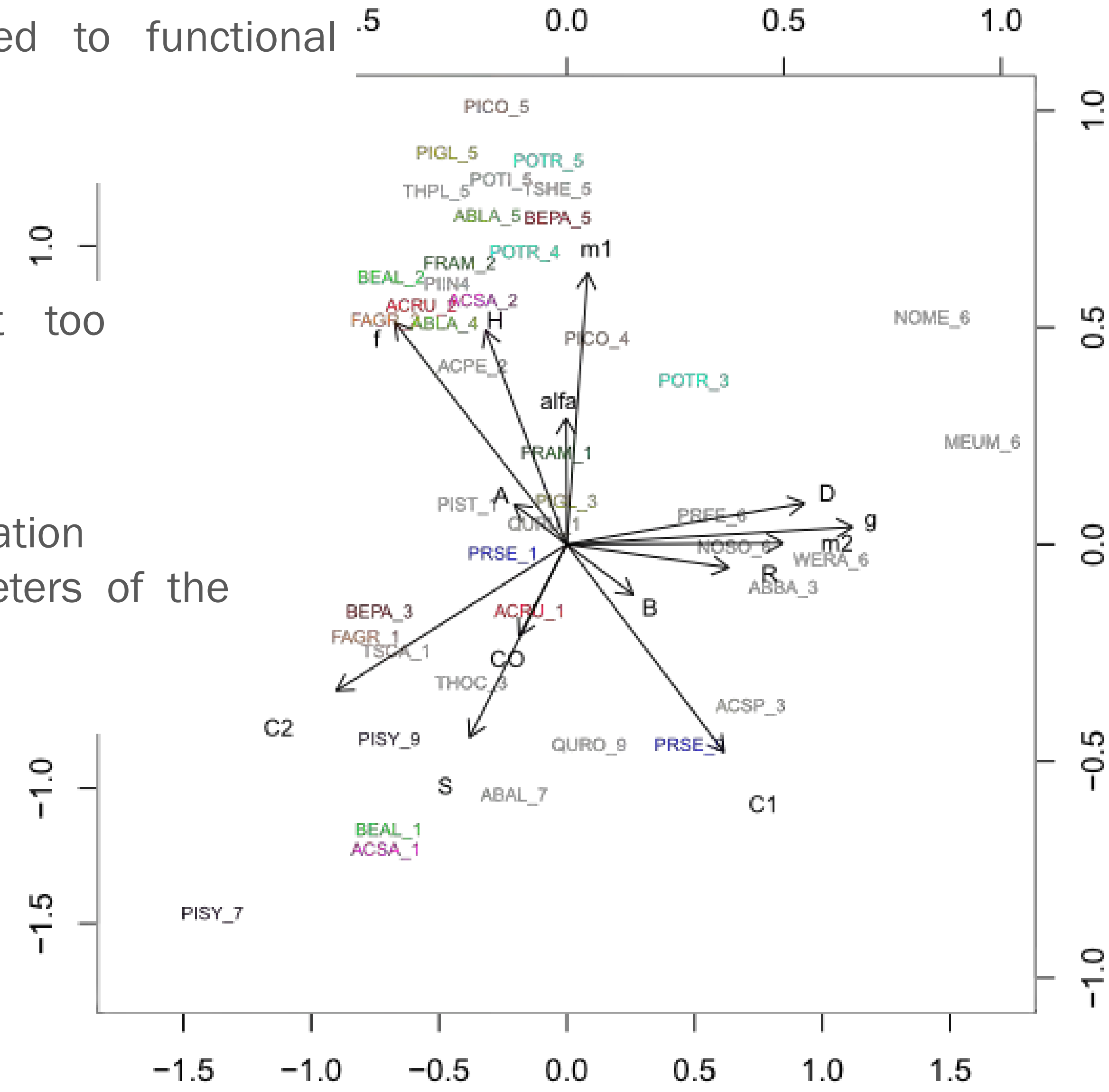
Functional traits



- Distribution along axes consistent with genus
- Variables most related to axes:
  - Leaf economics spectrum (LMA, Amass, LL)
  - Wood density
  - Drought and shade tolerance

Prediction of SORTIE parameters

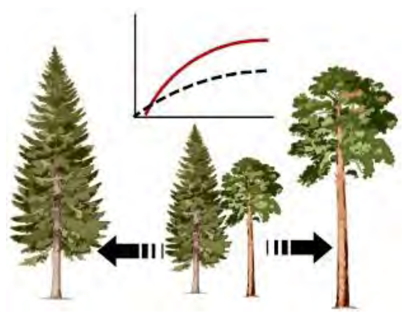
- Poor predictions (non-significant Mantel test)
- Some parameters are related to functional traits, but most are not.
- Distribution along axes not too consistent for same species
  - Intraspecific variability
  - Differences in parameterization
  - Trade-off between parameters of the same equation
  - Ecologically meaningless?



Prediction of life-history parameters (ecological strategies)

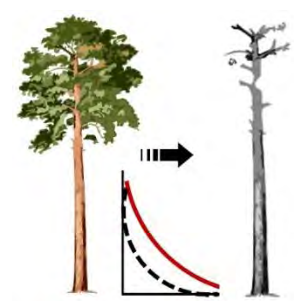
- Parameters that represent the main performance traits of species (allometry and light interception, seed dispersal, growth and mortality) and allow for direct comparison among species parameterized in different ways

Crad	Crown radius for a DBH=30 cm tree
Clength	Crown length for a DBH=30 cm tree
Cratio	Crown length/Tree height
Shade	Shade cast of an adult tree with DBH=30 cm



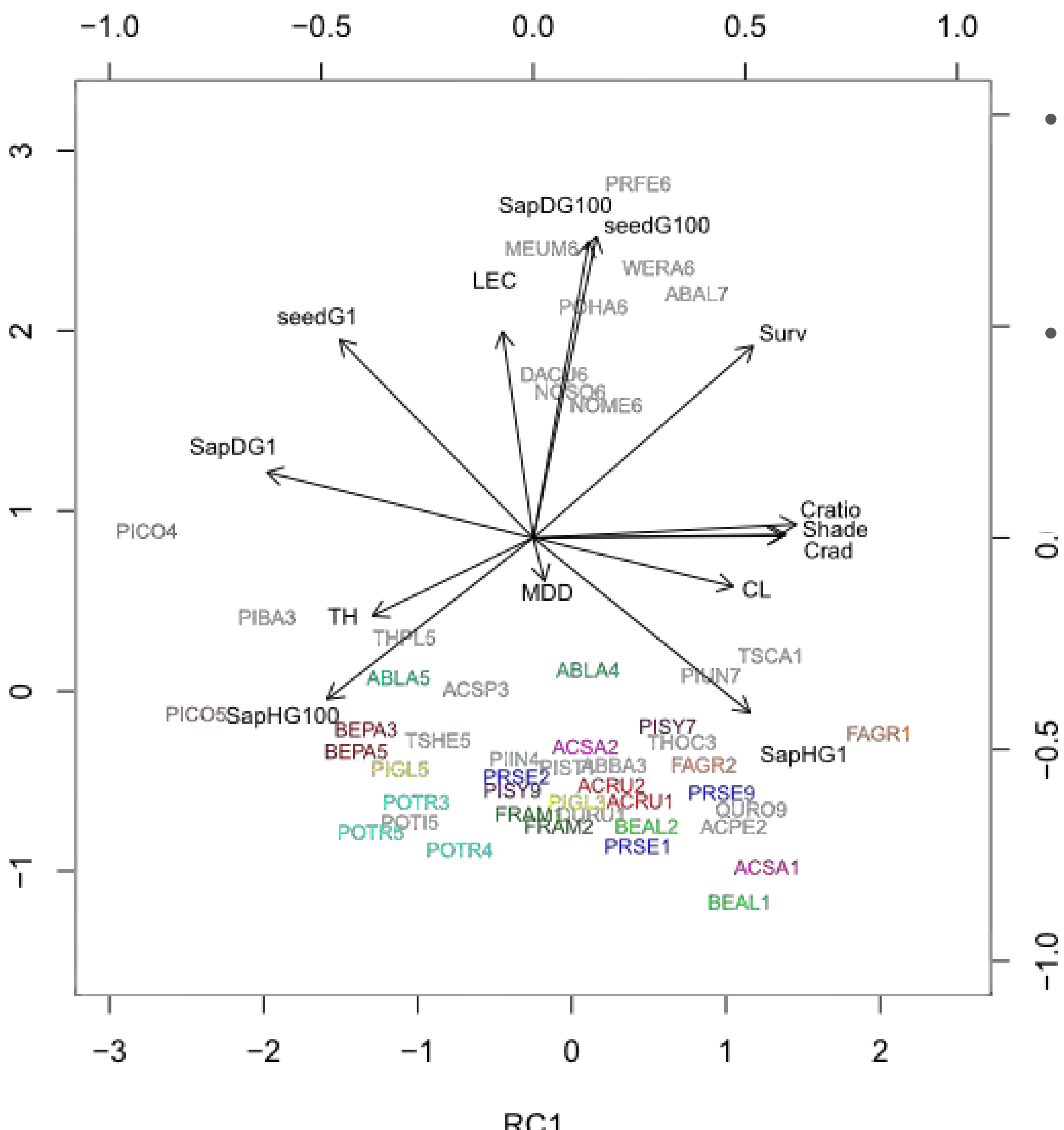
MDD	Mean Seed Dispersal Distance of an adult tree with DBH=30 cm

SeedG100	Time needed for a seedling with d_{10}=2mm to reach 3 m in height when light = 100%
SapHG100	Annual height growth of a sapling with DBH= 1cm and light=100%
SeedG1	Time needed for a seedling with d_{10}=2mm to reach 3 m in height when light = 1%
SapHG1	Annual height growth of a sapling with DBH= 1cm and light=100%



Surv	5-year survivorship of a sapling with DBH= 1cm when light = 1%

Prediction of life-history parameters



- More consistent distribution among axes: no strong intraspecific variability
- Most parameters are well related to functional traits ($R2$~0.5 to 0.8)

Conclusions

- Species-specific FT captured a great part of the variability observed in the model outputs (life-history parameters)

- However, FT were in general poor predictors of the actual SORTIE parameters
  - Trade-off between the different parameters of a given equation
  - Differences in the used equations
  - ~~Intraspecific variability~~
  - ~~Ecologically meaningless~~

- Develop equations that directly relate the demographic processes with species-specific functional traits (less cost, more informative parameters)

MERCI!

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