Estimation of phenology-performances relations using CAPSIS-CASTANEA model

The study of a common beech (*Fagus sylvatica*) population.

Mt Ventoux, France

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Réunion CAQSIS 5/4/16
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European forests and climate changes

- In the northern hemisphere, climate changes will cause :

  ◦ Modifications of the species geographic ranges

  ◦ Changes in tree performances within the geographic niche

  ◦ Modifications of forests ability to provide ecosystems services

  ◦ **→ Necessity to quantify the selection pressures and natural adaptation potential of tree populations.**

Phenology and adaptations

▸ Phenological traits are highly plastic (Temperatures, photoperiod, etc...), and have genetic bases

▸ In northern temperate areas, spring phenology results of a trade-off between :
  ◦ The risk of late frost damages
  ◦ The necessity to maximize the vegetation season length

Davi & al, 2011

→ **Spring phenology : major determinant of the individual fitness**

Objectives

▸ Determine how strong are selection pressures on phenological traits

▸ Test the existence of optimal traits values regarding fitness

▸ Compare the theoretical optimal trait values with observed trait and optimum values

Castanea Model : Determining the selection gradients values

- ▶ CASTANEA : Process-based, individual-based model (Dufrêne et al. 2005)
- ▶ Integrated in Capsis (2010)
  - ◦ Module CASTANEAonly
  - ◦ Library CASTANEA
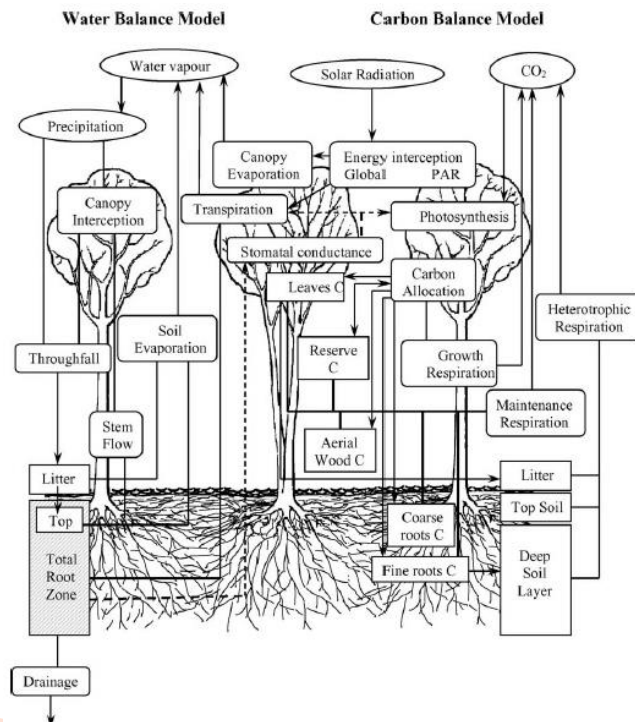
Variables of interest :

Fitness estimators :
- Seed Production
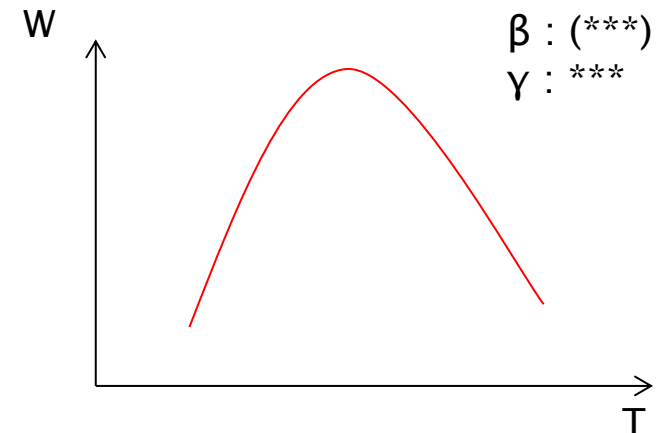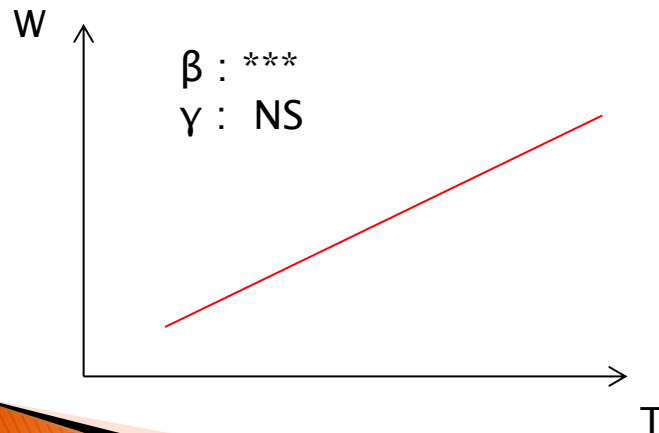- Reserves
- GPP

Phenology variables :
- BudBurst date
- Senescence date

How to estimate the strength and direction of natural selection ?

▸ Selection gradients : Lande & Arnold, 1983

▸ W = f(P)   W = fitness (estimator), P : Phenotype

▸ For one trait T : $W = \alpha + \beta T + 1/2\gamma T^2 + \varepsilon$

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β : ***
γ : NS

T

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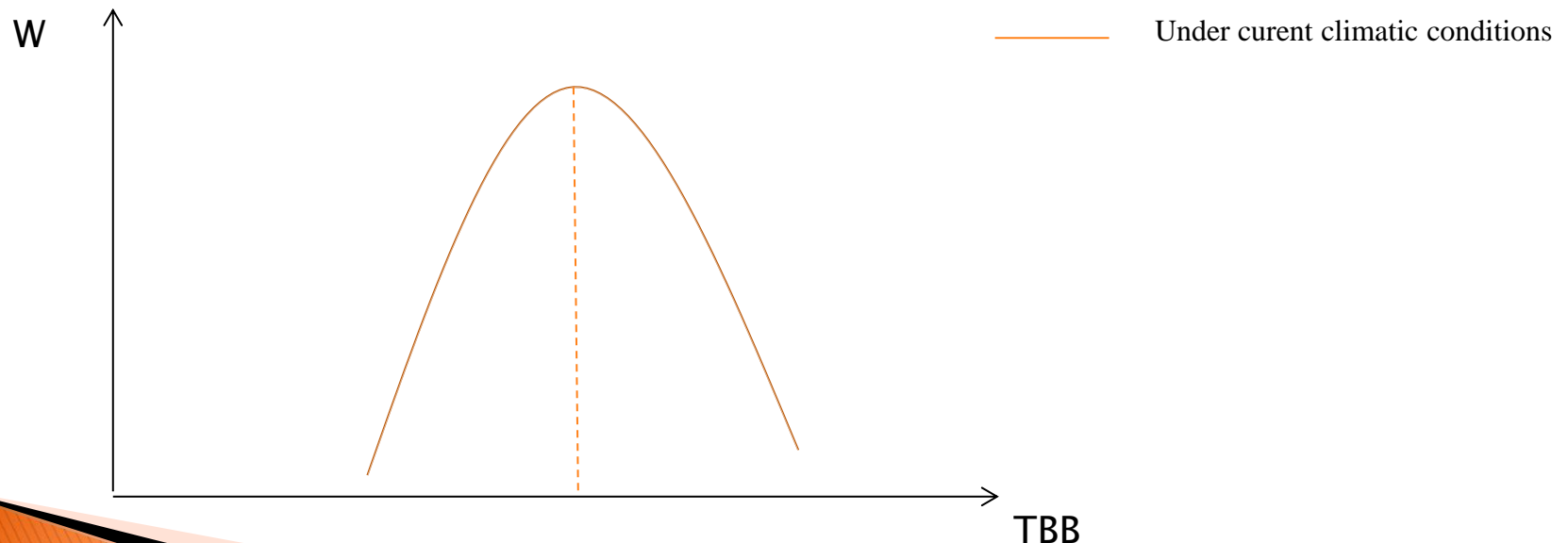
T

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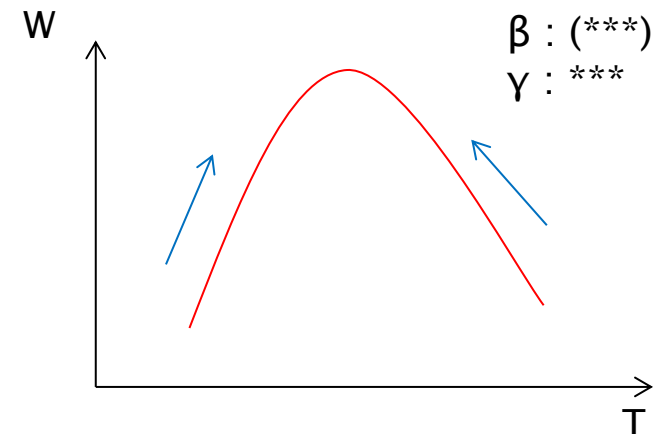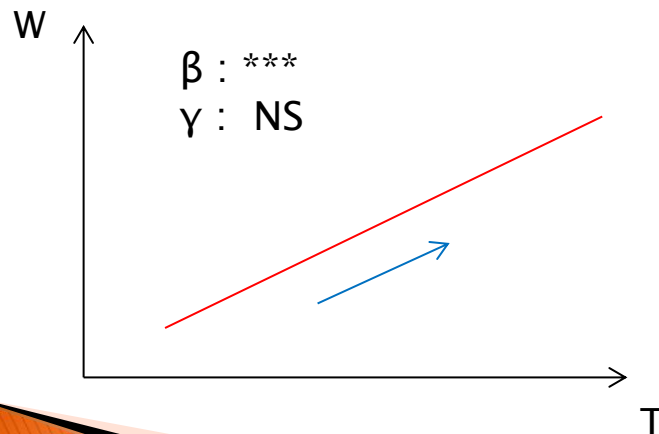
Selection pressures

Spring phenology and performances

- Spring phenology determines :
  - Period during which photosynthesis occurs
 - The risk of late frost damages to young leaves.

- Does a Timing of BudBurst (TBB) optimum exists, maximizing tree performances ? (under specific climatic conditions)

W

——— Under curent climatic conditions

TBB

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—— Under curent climatic conditions

—— Under future climatic conditions

TBB
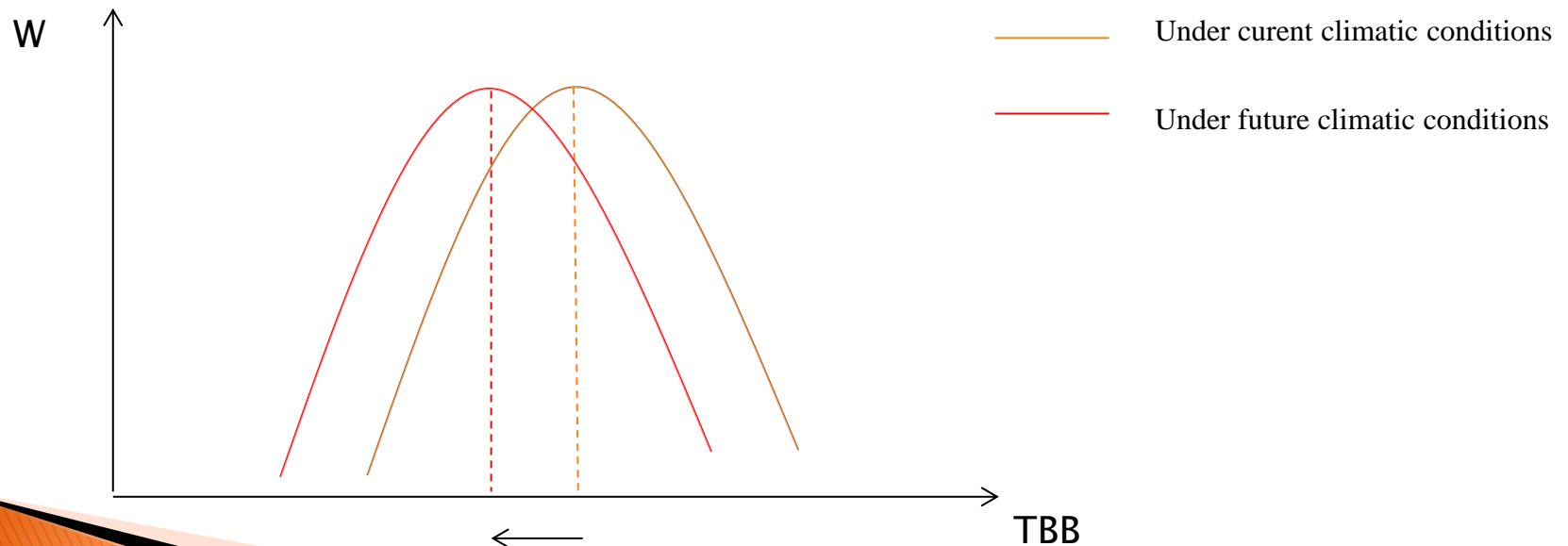
Estimation of Phenology-Performance relations with CASTANEA :

▸ Simulation details :

- **Input variables** : climatic data (1959-2012).
- **Input parameters** : relative to species caracteristics (beech), environmental components (North Mt Ventoux).

- Each tree is caracterised by a Temperature Sum (TSUMBB, input parameter), determining BudBurst

- The carbon and water-fluxes at tree level are simulated for 53 years.

CASTANEA : improvement of the phenology module.

- ▸ The model as designed in 2005
  - ◦ Does not take into account Chilling
 - ◦ Does not simulate the post-frost reflushing

- ▸ Modelling the biological effects of late frost on Leaf Area Index, *Fagus sylvatica*

Evolution of LAI in 1991. Alt = 1125 m
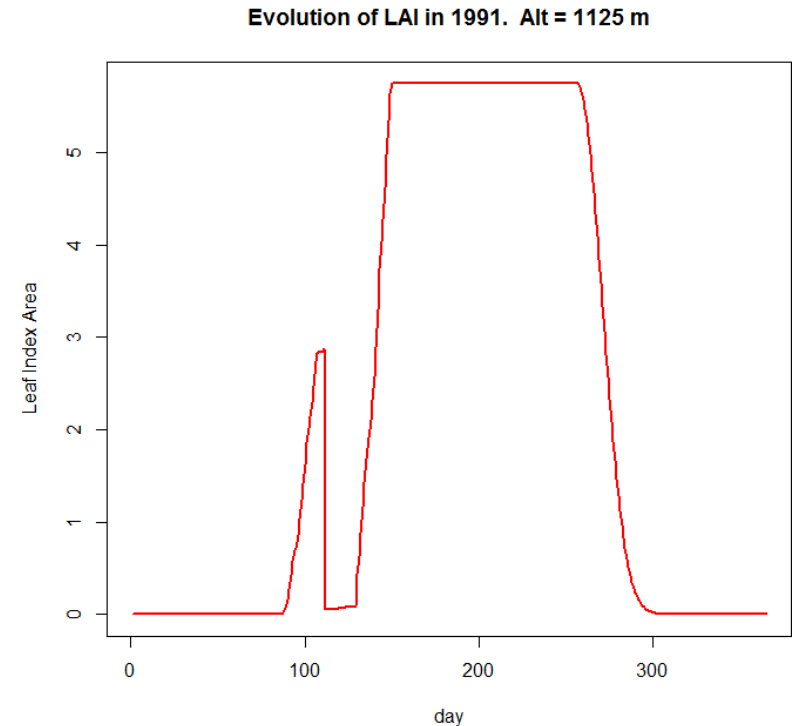
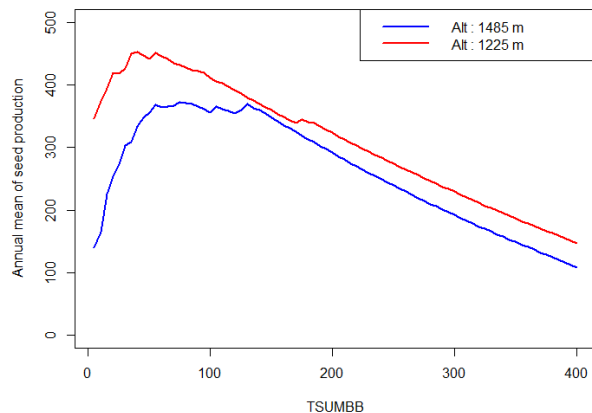Effects of a late frost in LAI of a *Fagus sylvatica* (Day of BudBurst = 88).

Preliminary results : phenology and performances

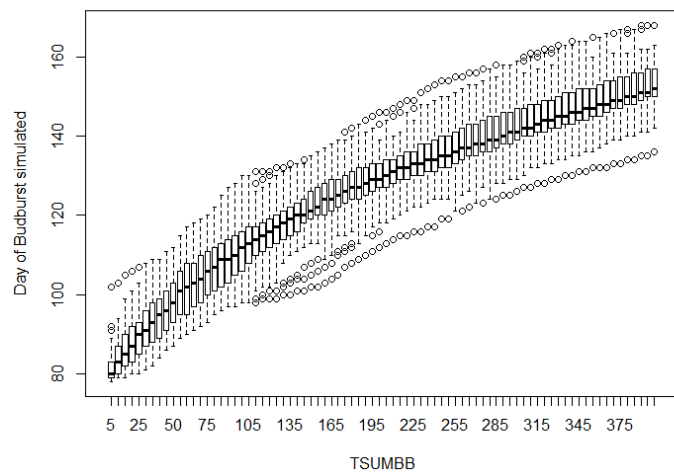Selection gradient curve on Temperature sum requirements

Preliminary results : phenology and performances
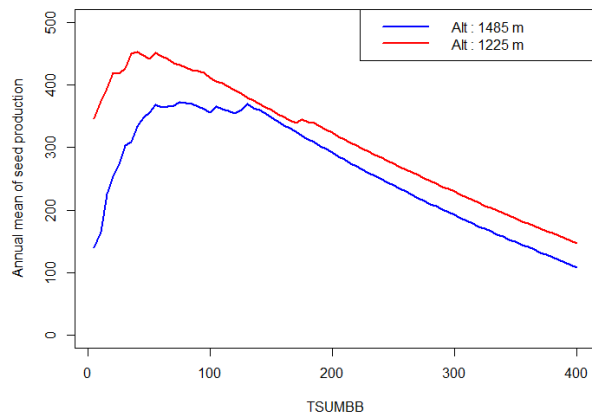

Selection gradient curve on Temperature sum requirements

Temperature Sum - Simulated Day of Budburst

Liautaud Kévin
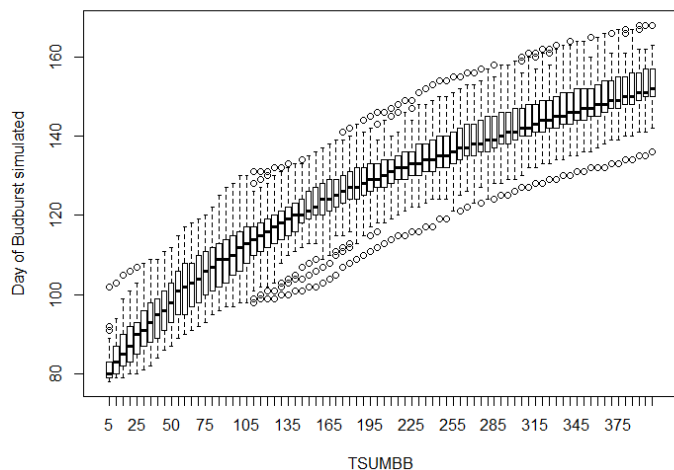05.04.16
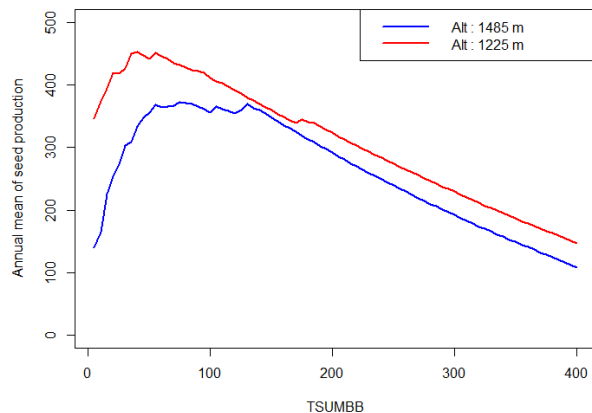
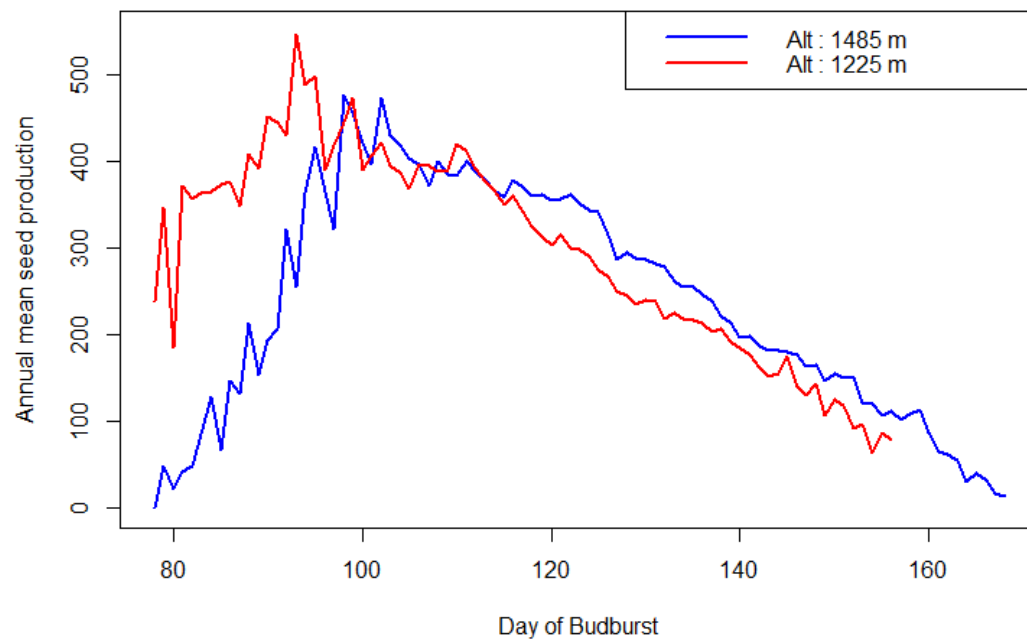# Preliminary results : phenology and performances

Selection gradient curve on Temperature sum requirements

Temperature Sum - Simulated Day of Budburst

Selection gradient curve on a phenological trait

Perspectives

▸ Model improvement : Integration of chilling processes in the phenology module

▸ Key questions :

   ◦ Do other fitness proxy reveal similar optimal trait values?

   ◦ How altitude and curent climate change affect optimal values of phenological traits ?

   ◦ How about a coniferous species : *Abies alba* ?

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Thank you for your attention