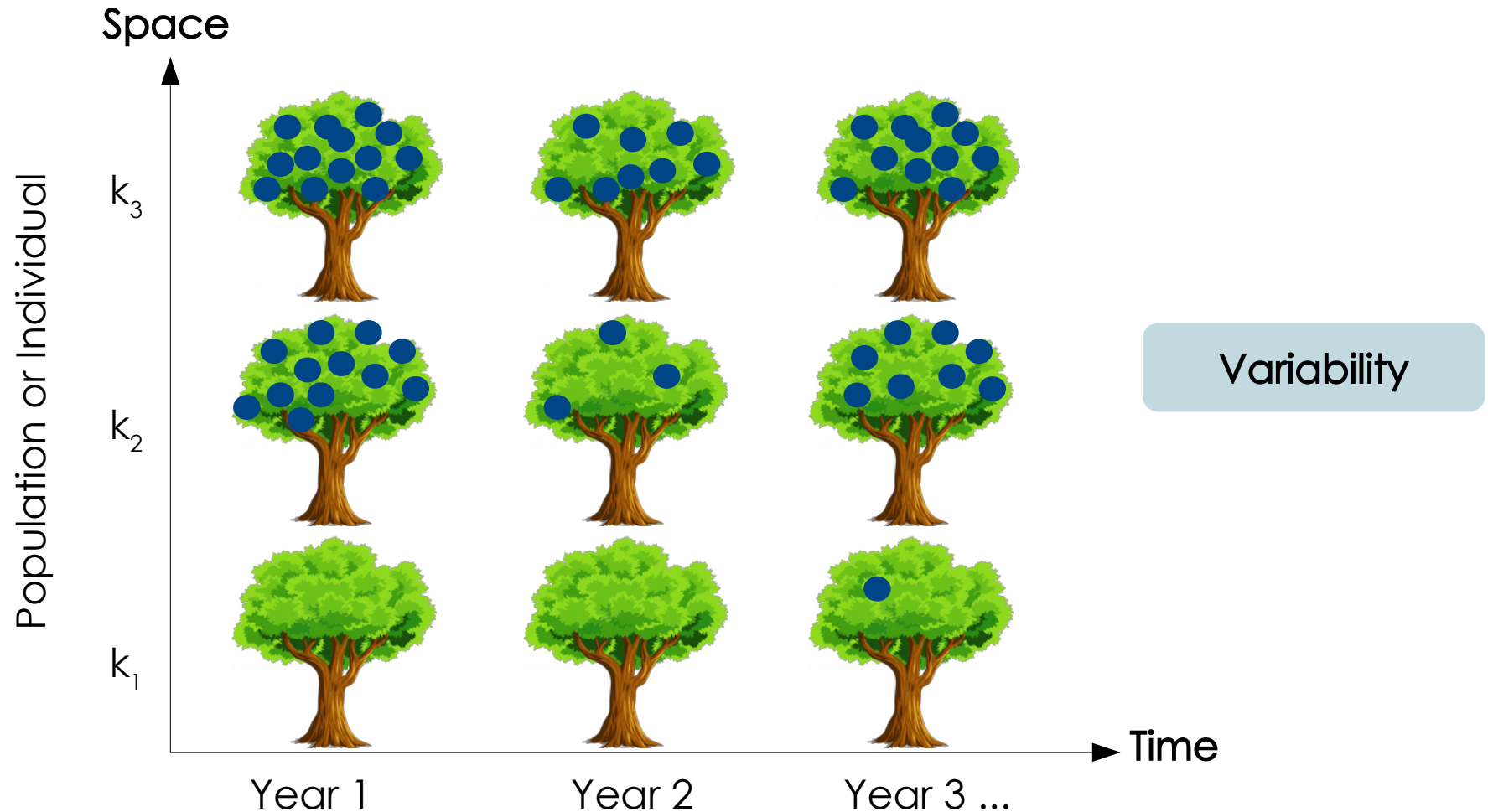


# Risk of fruit production failure

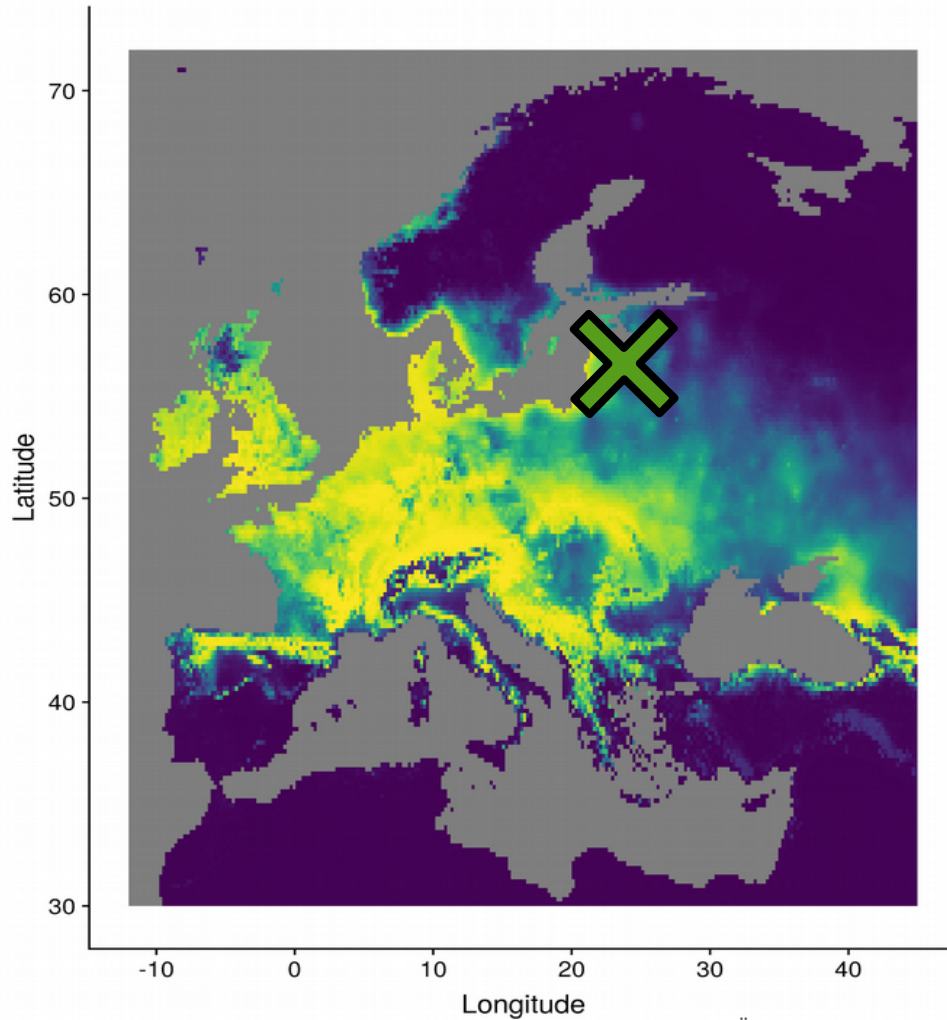
How extreme events can limit fruit production of forest trees at the rangewide scale?

Valentin JOURNÉ, Cathleen Petit, Sylvie ODDOU-MURATORIO, Hendrik DAVI

# Introduction – Fruit production variation

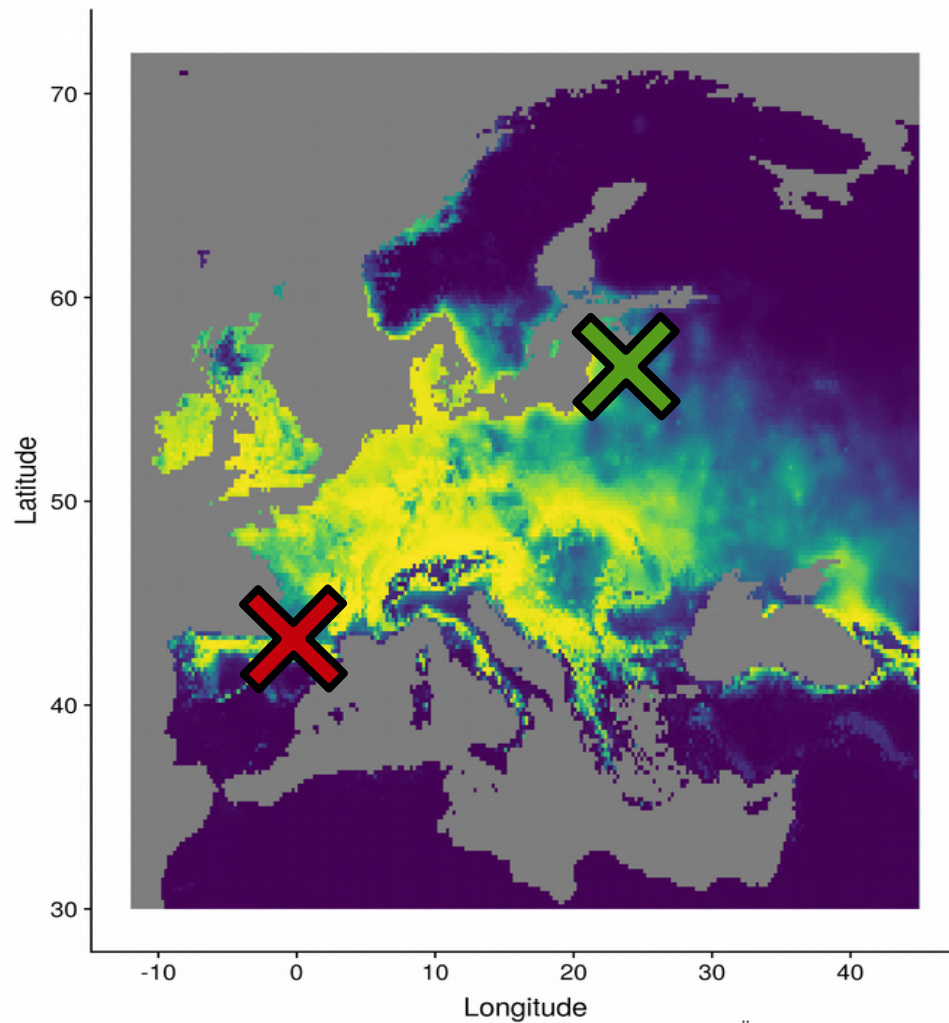


# Introduction – No consensus at large scale



Productivity

# Introduction – No consensus at large scale



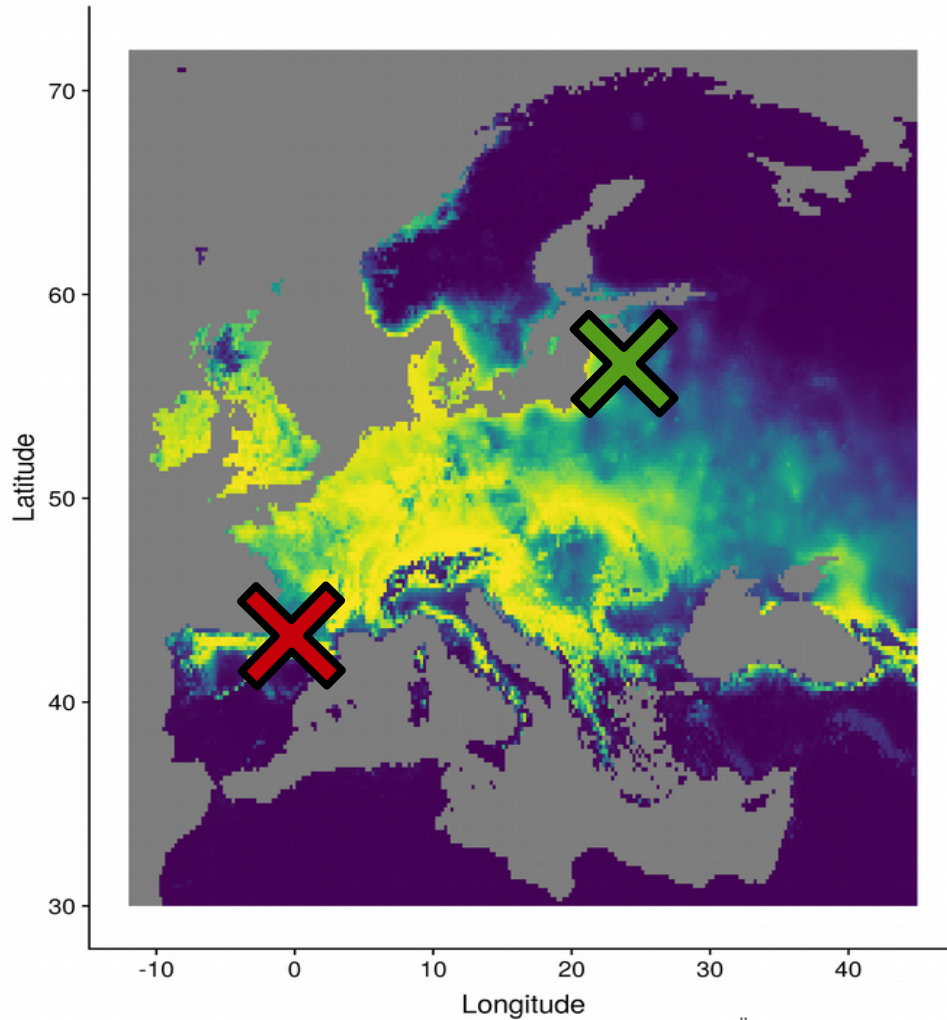
Productivity



Productivity

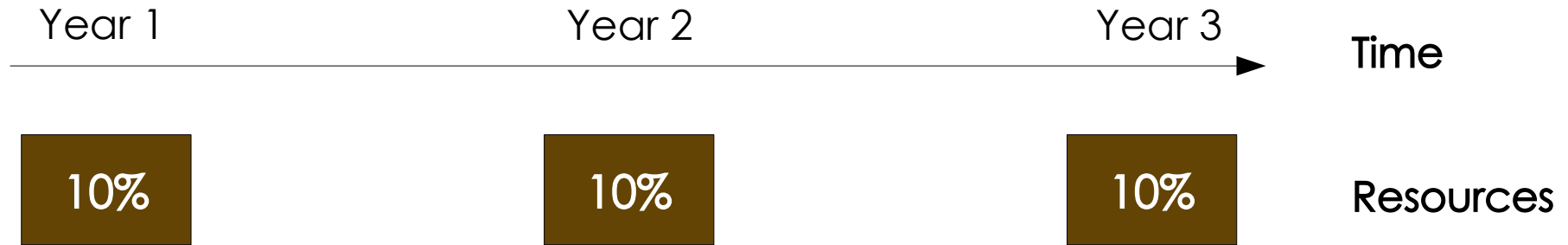


# Introduction – No consensus at large scale



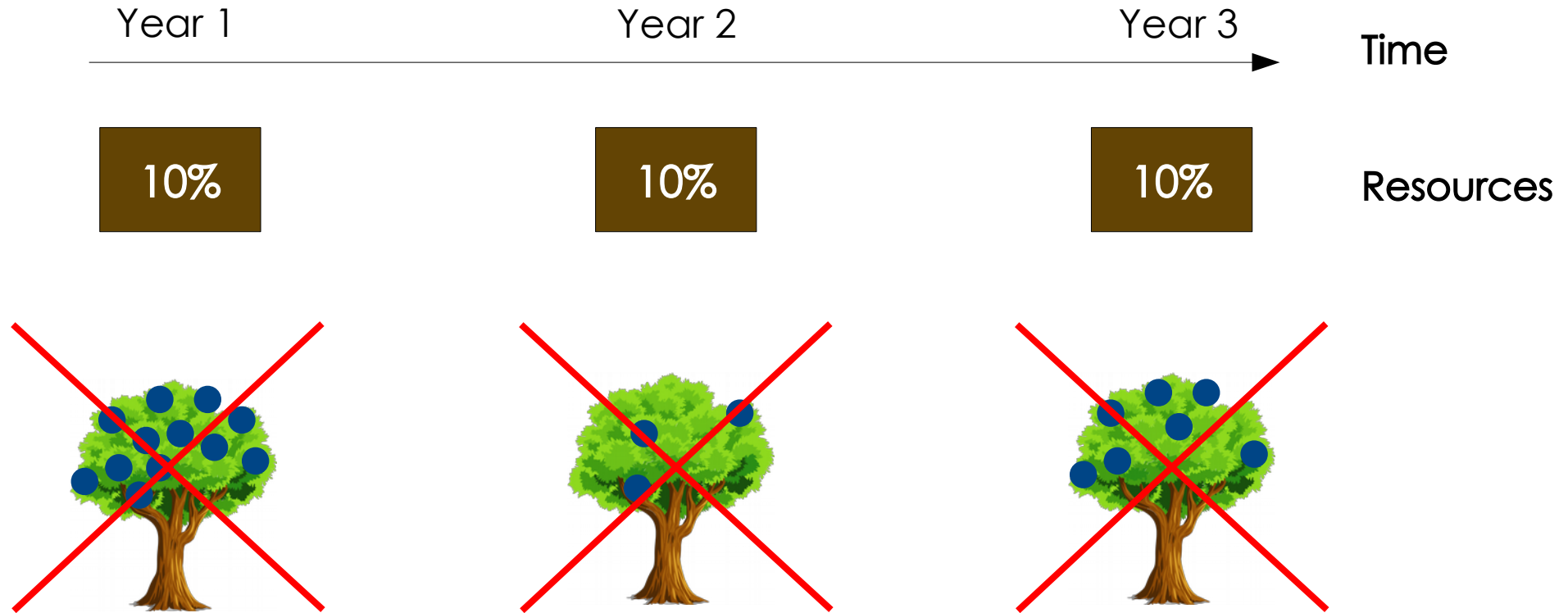
Major consequences :  
forest dynamic and persistence

# Introduction – H1, fixed fraction of resource



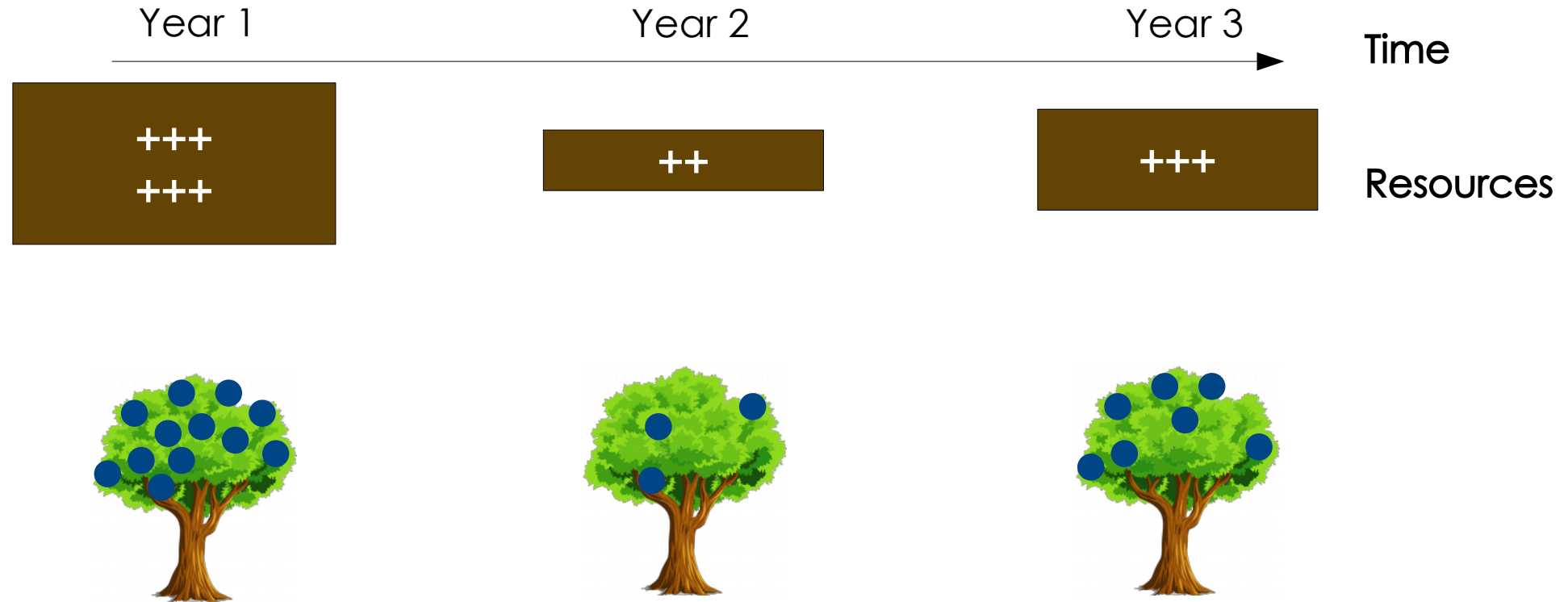
DGVM, LPJ, Ecosystem Demography...

# Introduction – H1, fixed fraction of resource



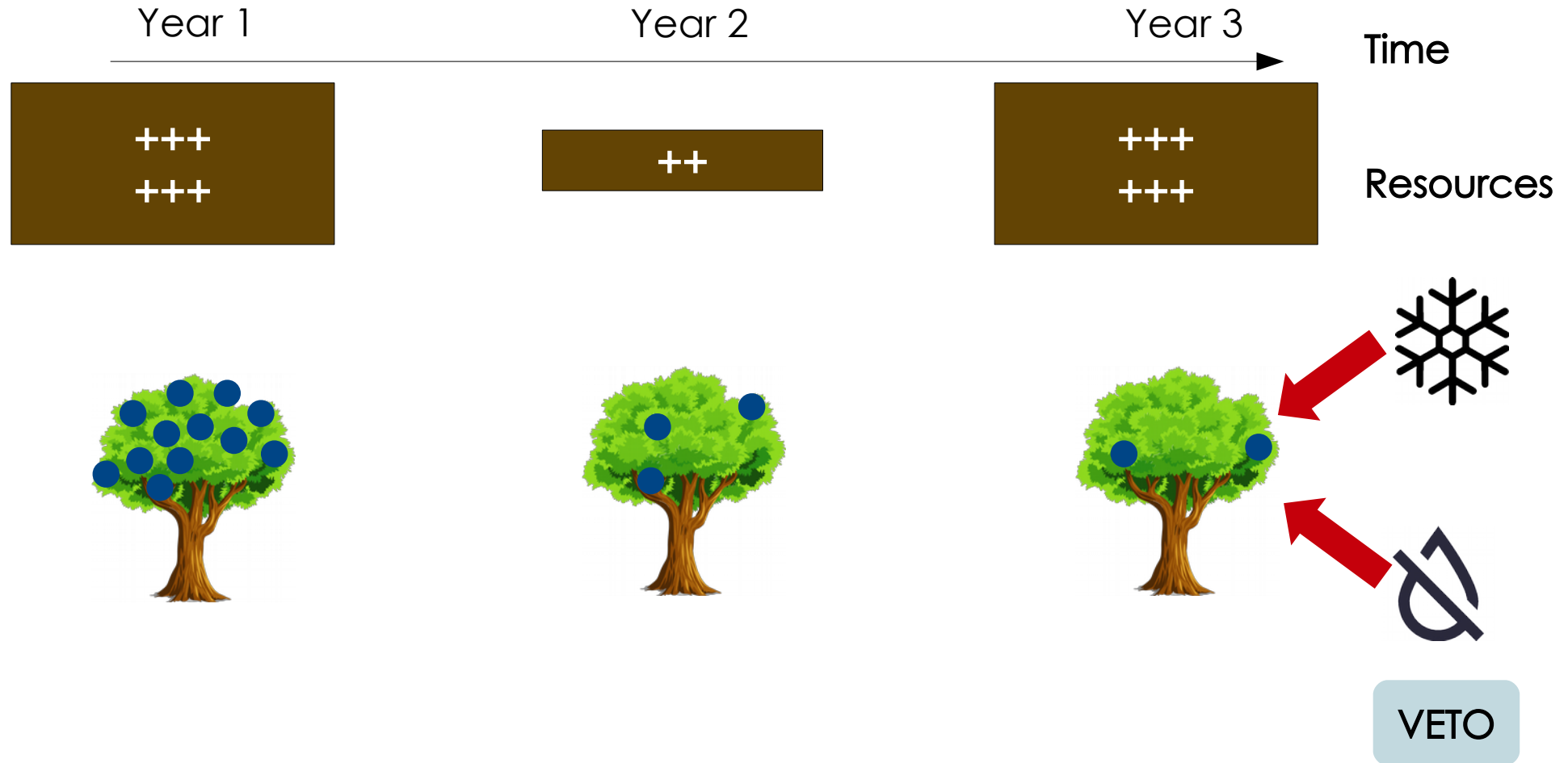
DGVM, LPJ, Ecosystem Demography...

# Introduction – H2, resource-dependent investment

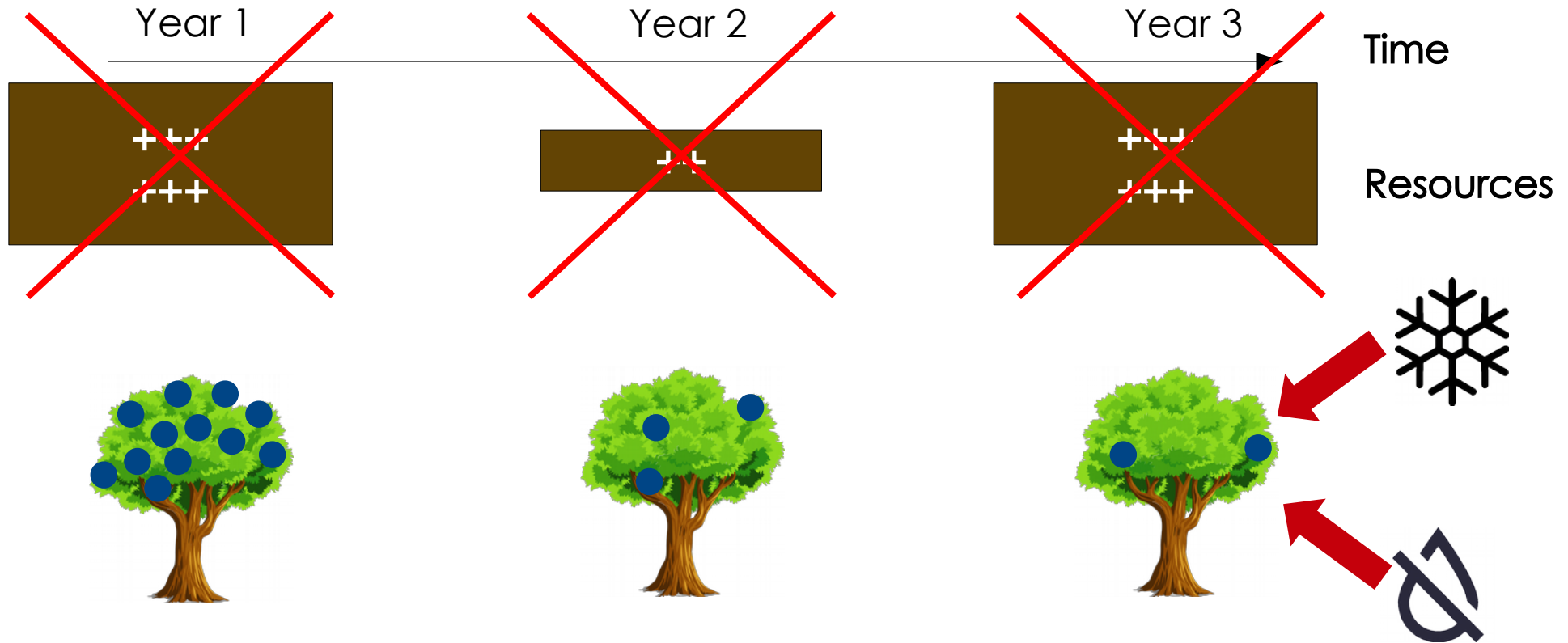


CASTANEA

# Introduction – H3, external agents



# Introduction – H3, external agents



# Question

## Step 1

Create an appropriate model of reproduction

## Step 2

Validate the model and select appropriate mode

## Step 3

Projection across Europe

## Step 1

Create an appropriate model of reproduction

## Step 2

Validate the model and select appropriate mode

## Step 3

Projection across Europe

**How extremes events alter fruit production in forest trees?**

Test 1 : Inclusion of a combination of frost and drought veto

Test 2 : No inclusion of veto



# Material and Method

Deciduous temperate tree: *Fagus sylvatica*



N

Initiation



N+1

Anthesis

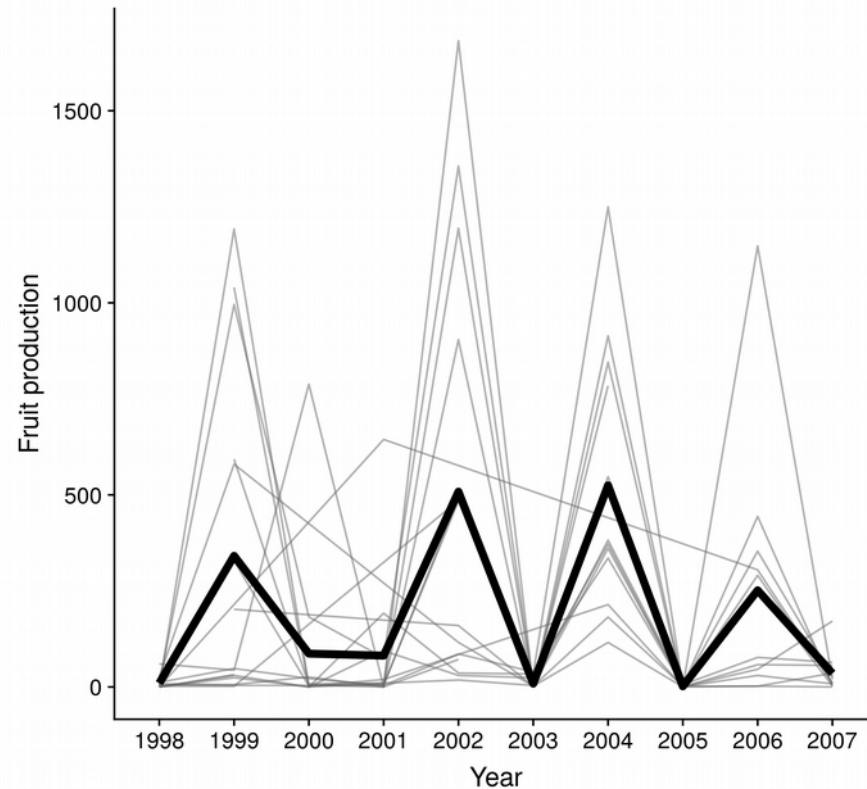


Maturation

# Material and Method

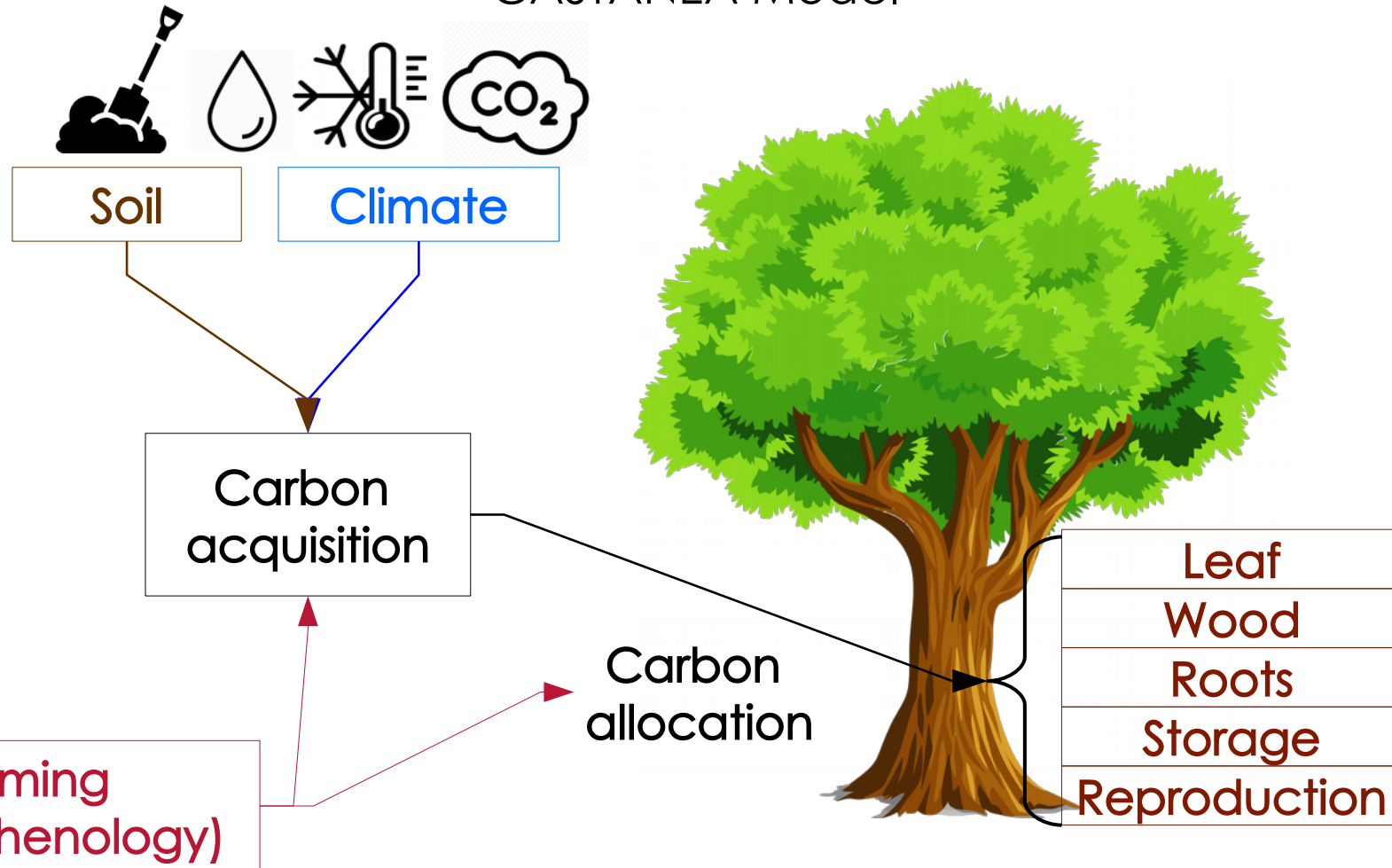
Deciduous temperate tree: *Fagus sylvatica*

Present variation of fruit production (called masting species)





# Material and Method

## CASTANEA Model



# Material and Method

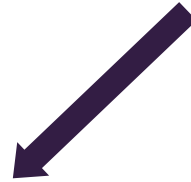
CASTANEA Model    
**Climate**



Real population



"mean" population



Simulation with  
characteristics of the  
mean population

# Material and Method



Initiation rules

Storage

Alternate

Fixed

**Step 1**

Carbon allocation from  
buds to fruits



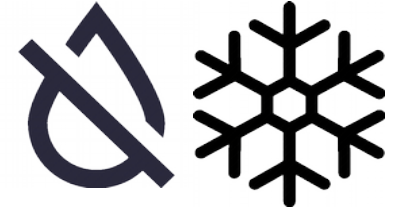
Survival rules

Constant

Matching

Switching

Storage



# Material and Method



Initiation rules

Storage

Alternate

Fixed



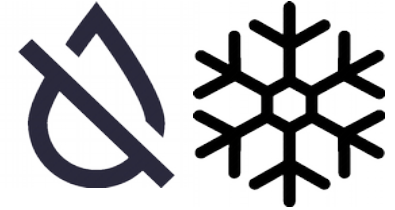
Survival rules

Constant

Matching

Switching

Storage



OFF

ON



How to defined a number of buds?

- **Storage** : quantity of reserves determine number of buds
- **Alternate** : high year of fruit production followed by a null production of fruits (i.e. trade-off between current and future reproduction)
- **Fixed** : constant fraction of buds



# Material and Method



Initiation rules

Storage

Alternate

Fixed



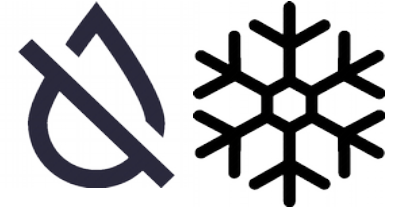
Survival rules

Constant

Matching

Switching

Storage







How to defined a number of final fruits?

- **Constant** : only a constant fruit mortality (species specific)
- **Matching** : if wood allocation is high, fruit mortality is low
- **Switching** : if wood allocation is high, fruit mortality is high
- **Storage** : if storage allocation is high, fruit mortality is low

# Material and Method



Initiation rules

Storage

Alternate

Fixed



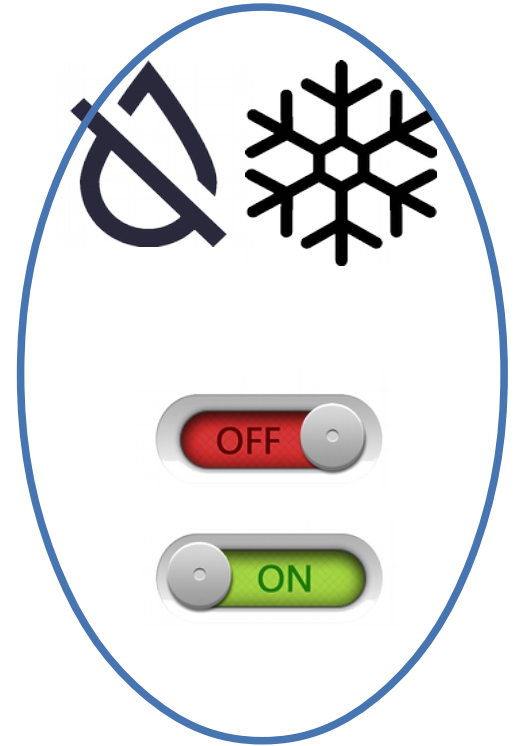
Survival rules

Constant

Matching

Switching

Storage





$$PLC = \frac{1}{1 + e^{cte(\Psi_{min} - \Psi_{P50})}}$$

Percent loss of hydraulic conductivity (PLC)

- $\Psi_{min}$  : simulated water potential (MPa)
- $\Psi_{50}$  : species-specific potential below which 50% of the vessels are embolized (MPa)
- Cte : constant (%.MPa<sup>-1</sup>)



$$FD = \frac{1}{1 + e^{BF(R - T_{min})}}$$

$$BF = \alpha + \beta e^{\gamma * R}$$

## Frost Damage (FD)

- $T_{min}$  : minimal temperature (°C)
- BF : slope parameter
- R : level of frost hardness (depends of night length and temperature, see *Leinonen, 1996*)

# Material and Method



$$PLC = \frac{1}{1 + e^{cte(\Psi_{min} - \Psi_{P50})}}$$



$$FD = \frac{1}{1 + e^{BF(R - T_{min})}}$$

$$BF = \alpha + \beta e^{\gamma * R}$$



# Material and Method



$$PLC = \frac{1}{1 + e^{cte(\Psi_{min} - \Psi_{P50})}}$$



$$FD = \frac{1}{1 + e^{BF(R - T_{min})}}$$

$$BF = \alpha + \beta e^{\gamma * R}$$



Both effects active or  
no effects !

# Material and Method



Initiation rules

Storage

Alternate

Fixed



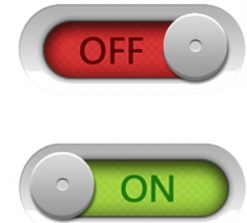
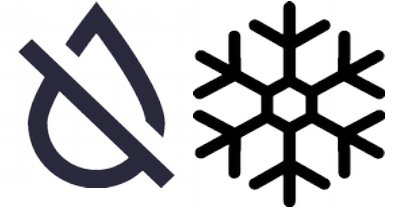
Survival rules

Constant

Matching

Switching

Storage



# Material and Method



Initiation rules

Storage

Alternate

Fixed



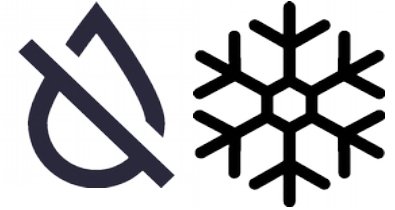
Survival rules

Constant

Matching

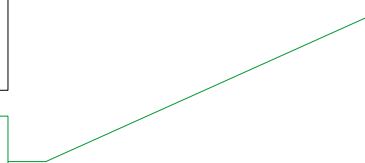
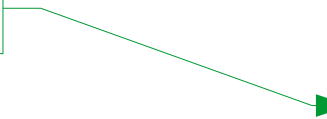
Switching

Storage



OFF

ON





# Material and Method



Initiation rules

Storage

Alternate

Fixed



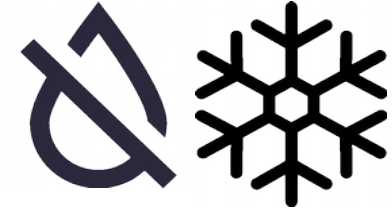
Survival rules

Constant

Matching

Switching

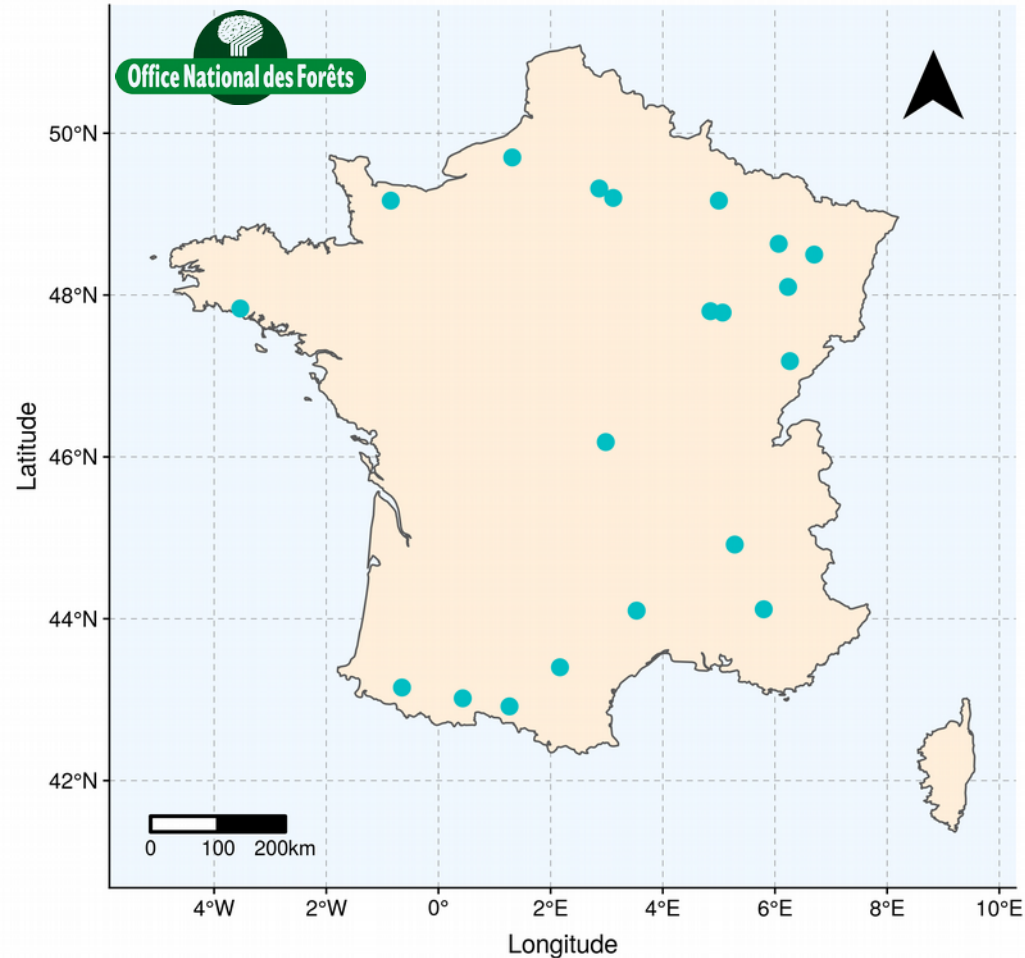
Storage



$$3 * 4 * 2 = 24 \text{ scenarios}$$

## Step 2

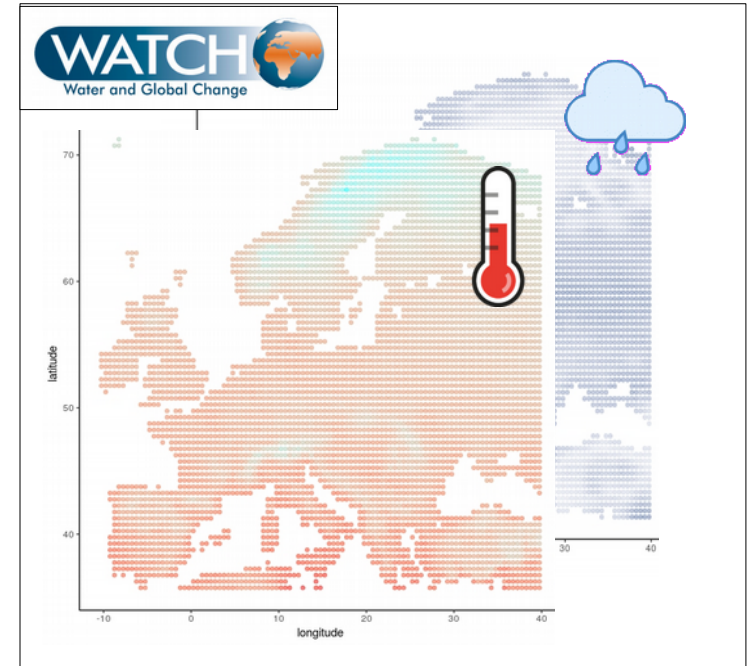
Validate the model and select appropriate mode



## Step 3

### Projection across Europe

South marginal population calibrated and validated with the model

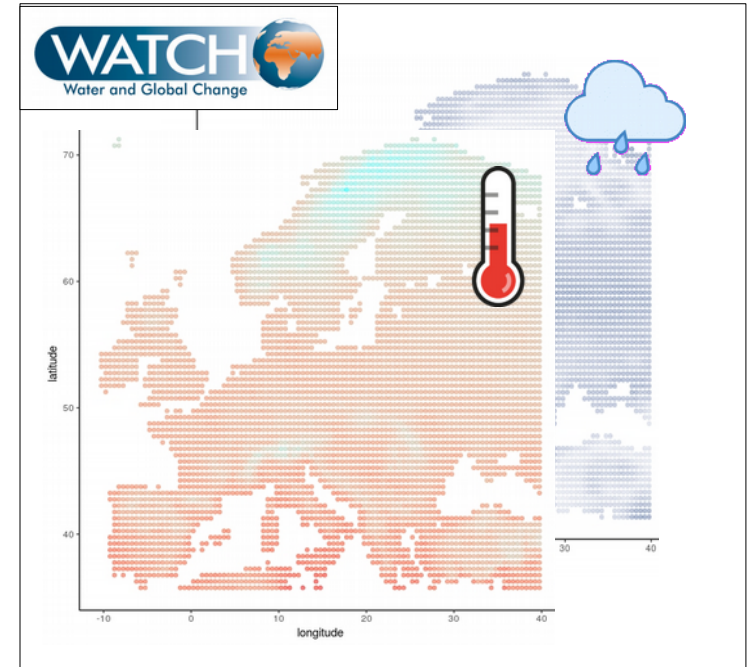
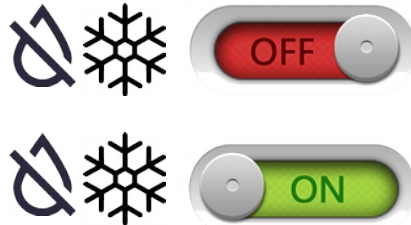


## Step 3

### Projection across Europe

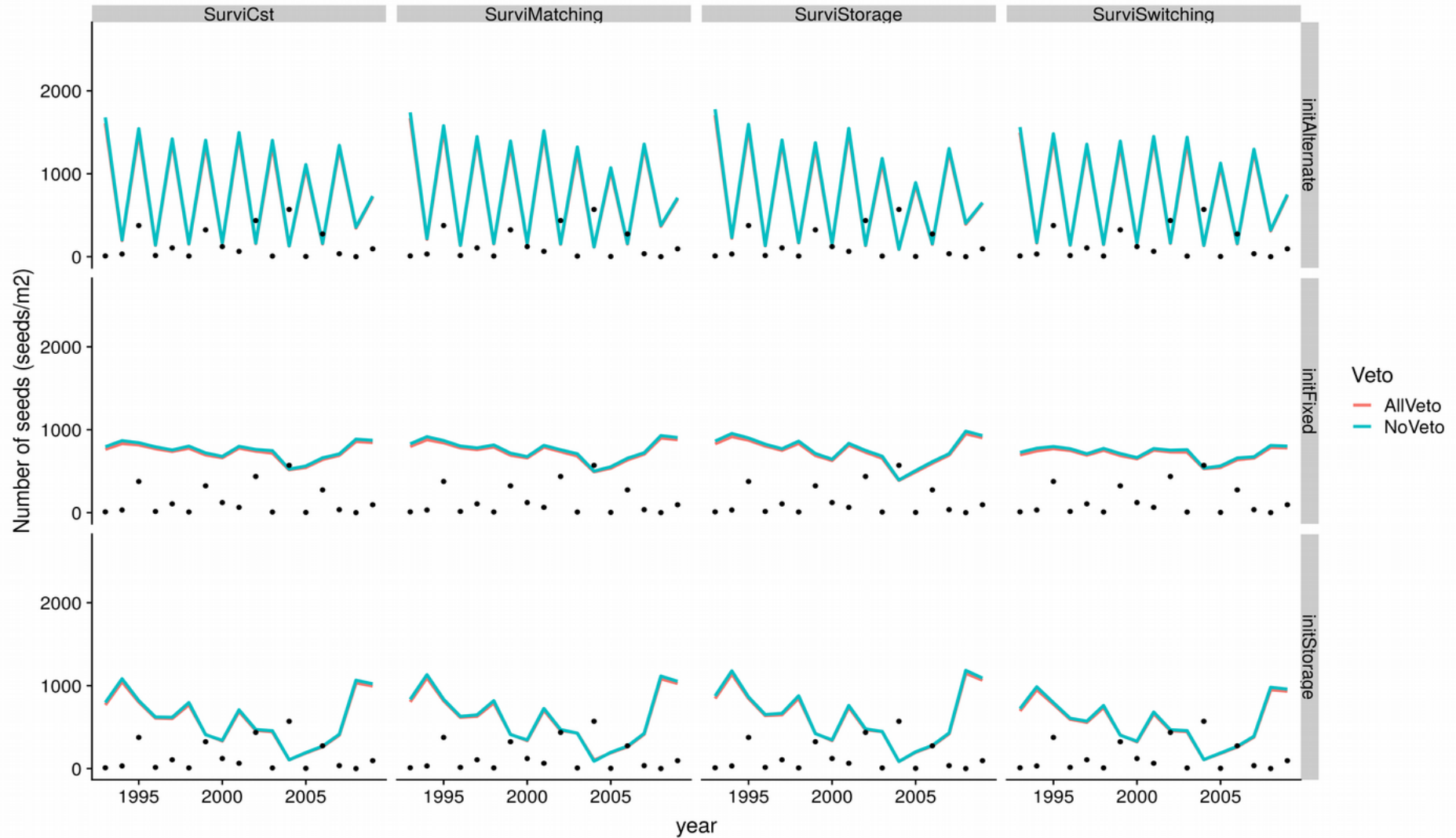
2 tests :

- Scenario without veto
- Scenario with both veto

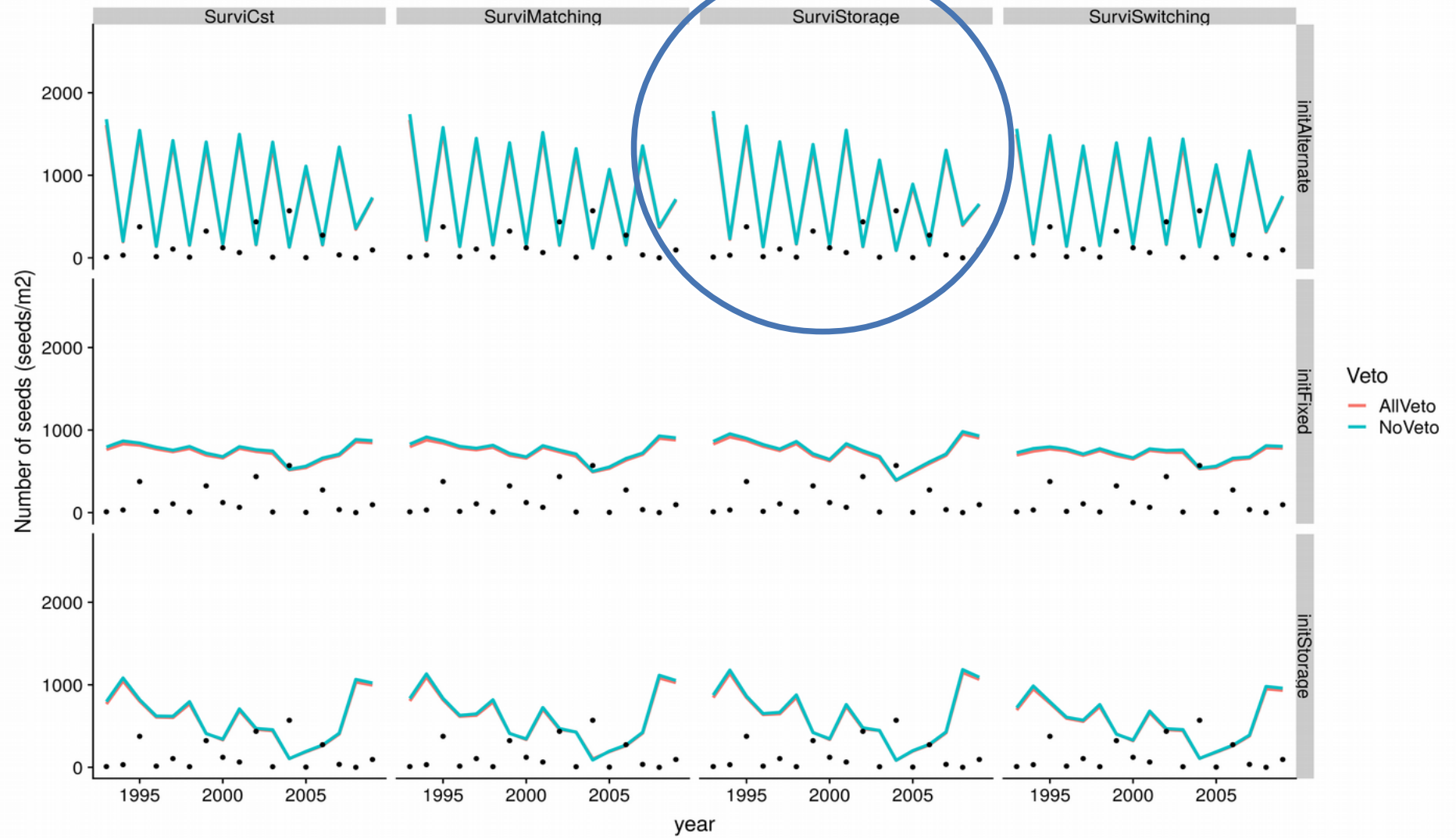


How extremes events alter fruit production in forest trees?

# Results – Step 2

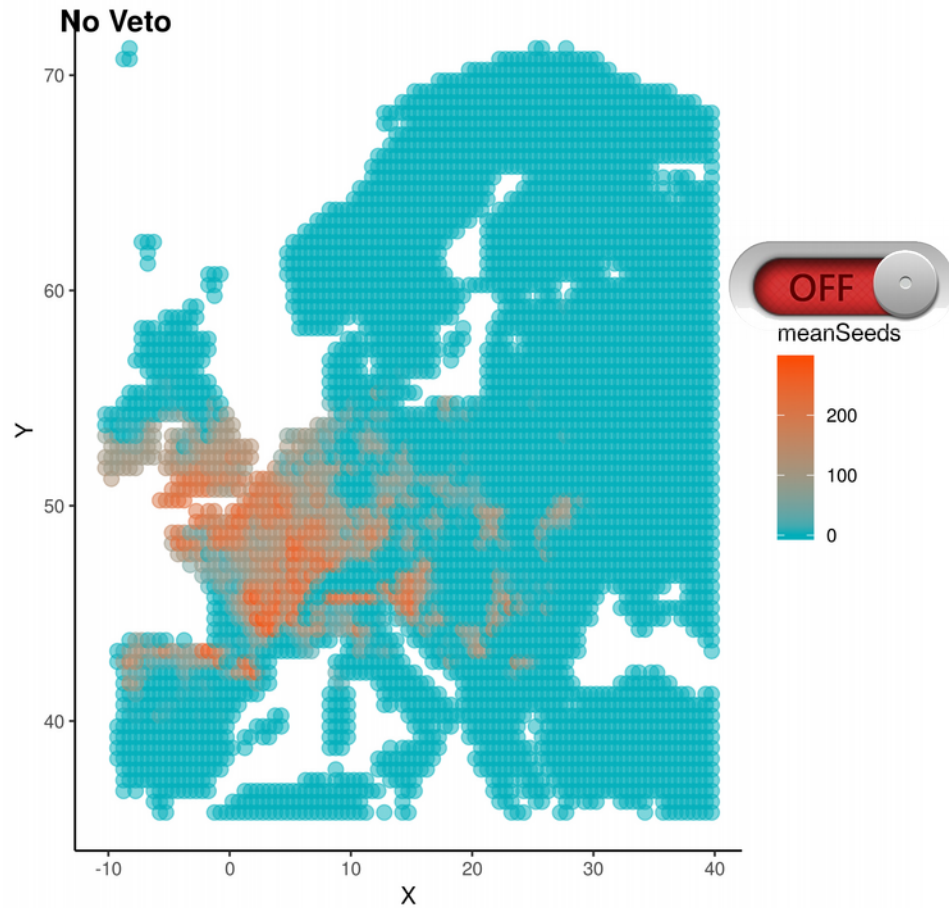


# Results – Step 2

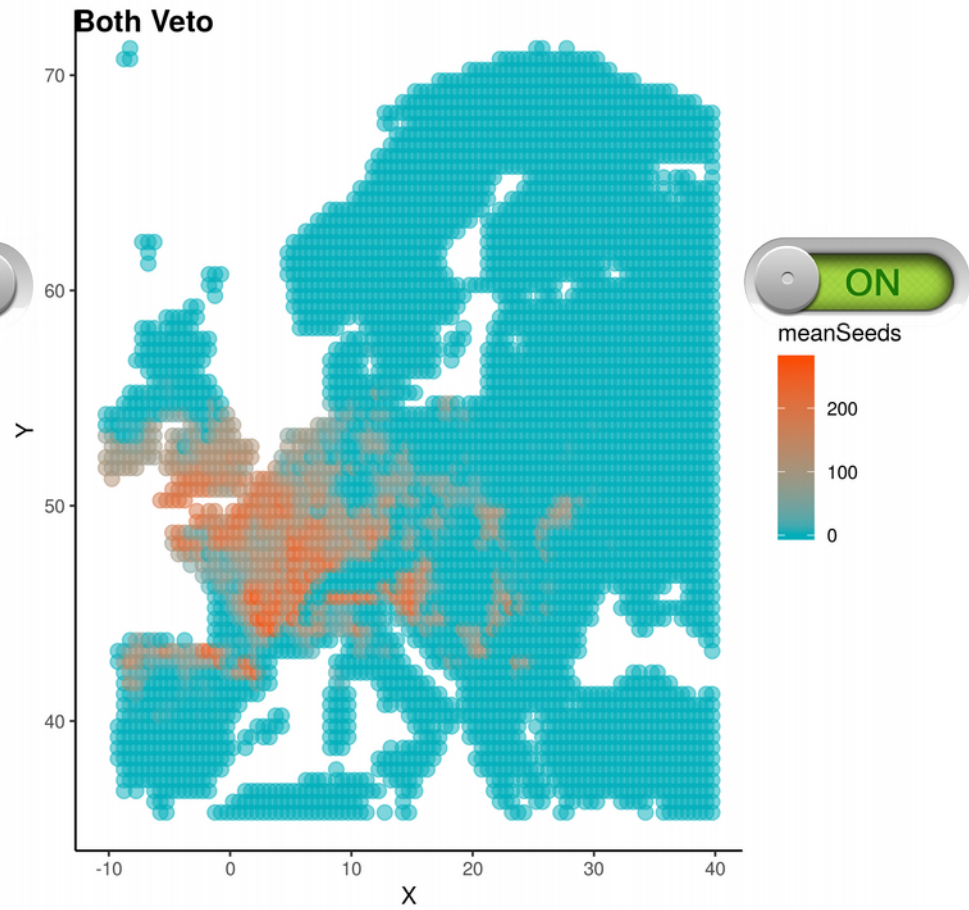
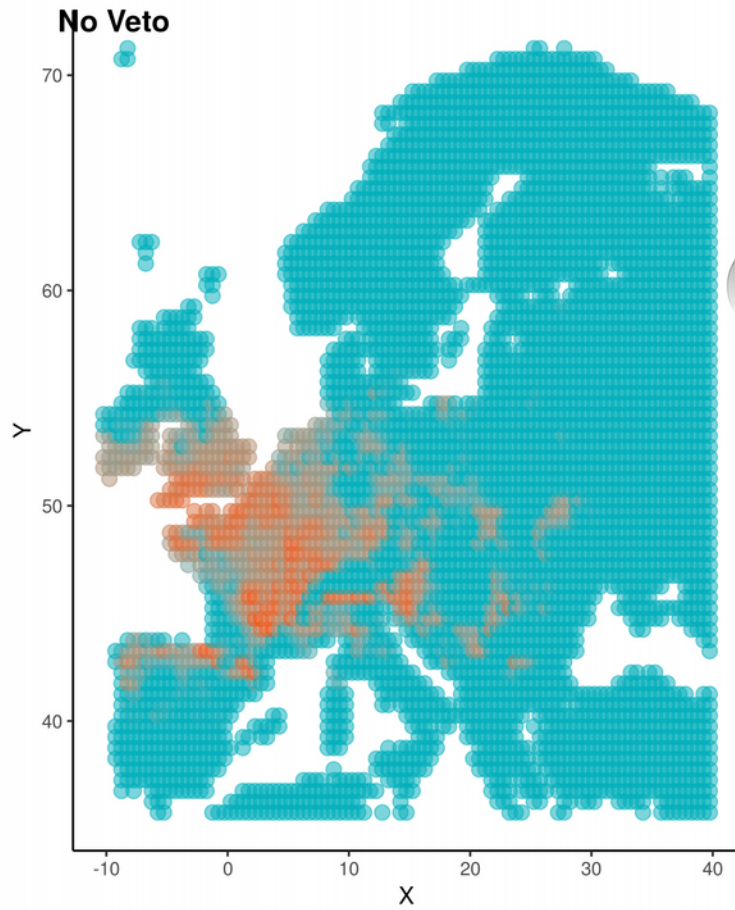




# Results – Step 3 - Maps with a marginal population (rear edge)



# Results – Step 3 - Maps with a marginal population (rear edge)





1/ First process-based model used to investigate variation of fruit production.

2/ Different possibilities to simulate fruit production.

- 1/ First process-based model used to investigate variation of fruit production.
- 2/ Different possibilities to simulate fruit production.
- 3/ Consequences of extremes events on reproductive stage : veto climate can reduce fruit production, but not a major limiting process for *Fagus sp* => Mainly found in other species (i.e. *Quercus* genus).
- 4/ Projection at the distribution scale : did not detected large fruit variation with latitude.

TODO :

- X** Validate the model
- X** Test **veto** on other species (*Quercus sp.*)
- X** Integrate climatic cue to determine number of buds : *Fagus sp* fruit production related to a differential of summer temperature ( $T_2 - T_1$  ; Kelly et al, 2013; Vacchiano et al, 2017; Lebourgeois et al, 2018)
- X** Check on European sites how fruit production can alter carbon stocks and flux and new validation of the model (comparison old and new version)
- X** Check climate change effects on reducing synchrony (Koening et al 2015; Zohner et al 2018)

Take home message : **First** process-based **model** used to investigate variation of  
fruit production



Thanks :)



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Credit photo: O. Gilg, F. Jean