Sources of phenotypic variation of life history traits in an invasive species, *Senecio inaequidens* DC. (Asteraceae)

Arnaud Monty & Grégory Mahy

Laboratory of Ecology
Gembloux Agricultural University

Science Facing Aliens
2nd Belgian Conference on biological invasions


Introduction

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- Alien species invade contrasted environments

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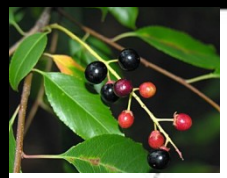

Invasion of contrasted climat

Prunus serotina Ehrh.

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Invasion of contrasted climat

Impatiens glandulifera ROYLE

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Invasion of contrasted climat

Robinia pseudoacacia L.

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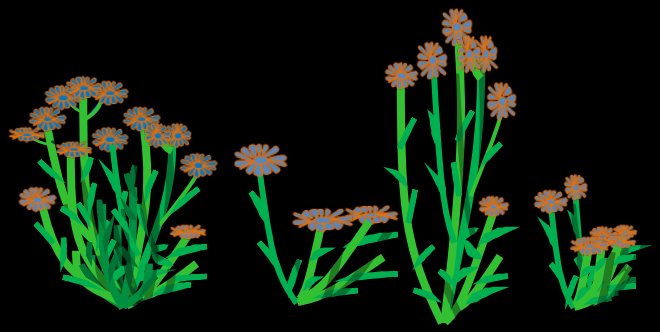
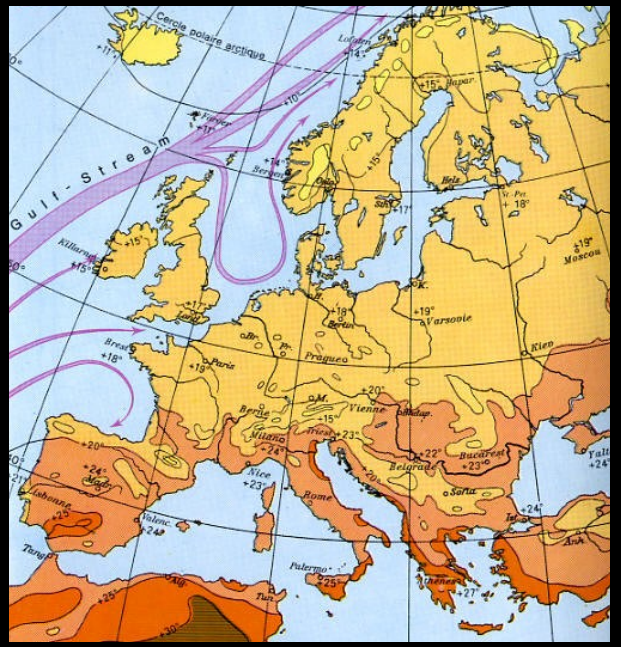
« *phenotypic variability* »

➔ *Germination*
➔*Growth*
➔*Reproduction*
➔ *Etc.*



Variability in invaded area



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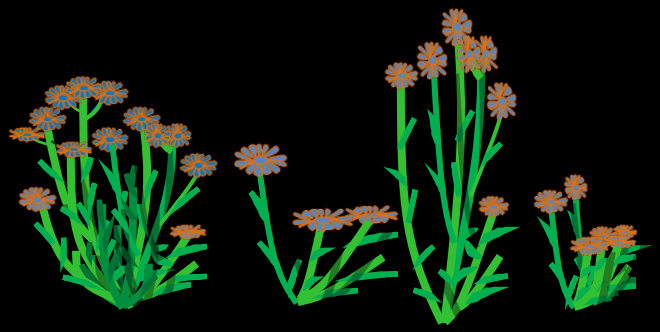

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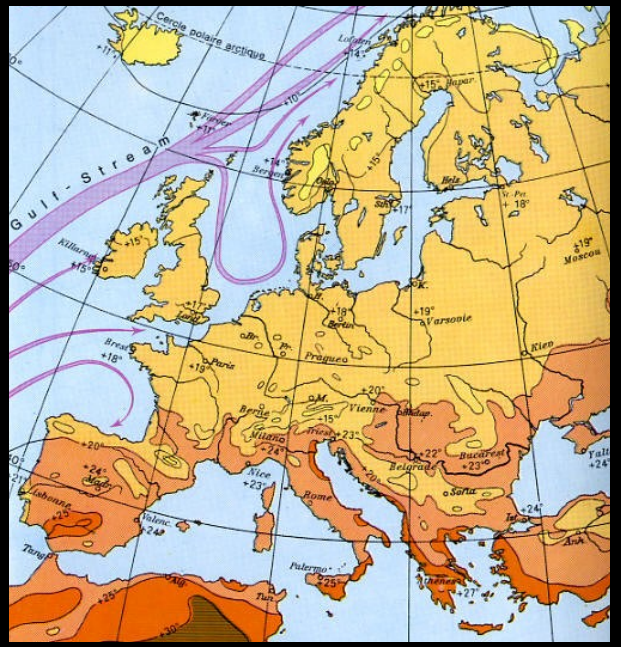

What **mechanisms** allow invasion in contrasted environments ?

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4 evolutionary forces

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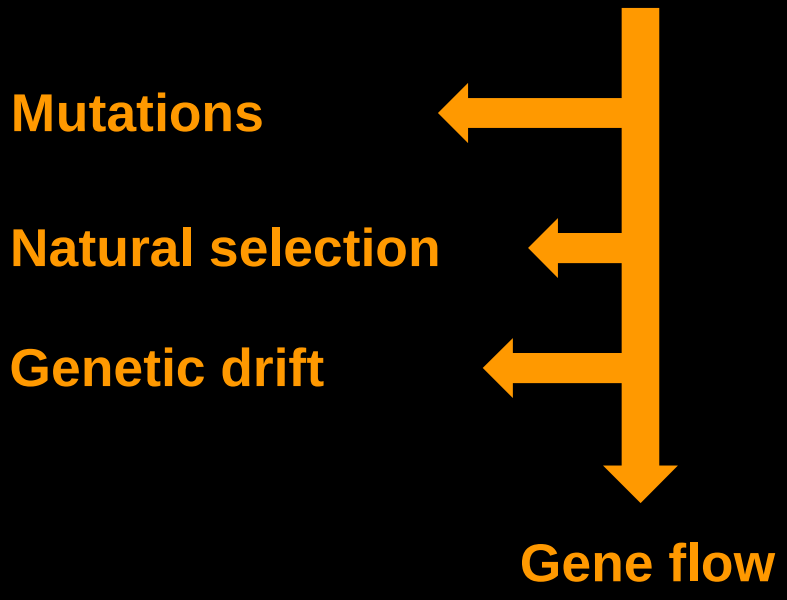

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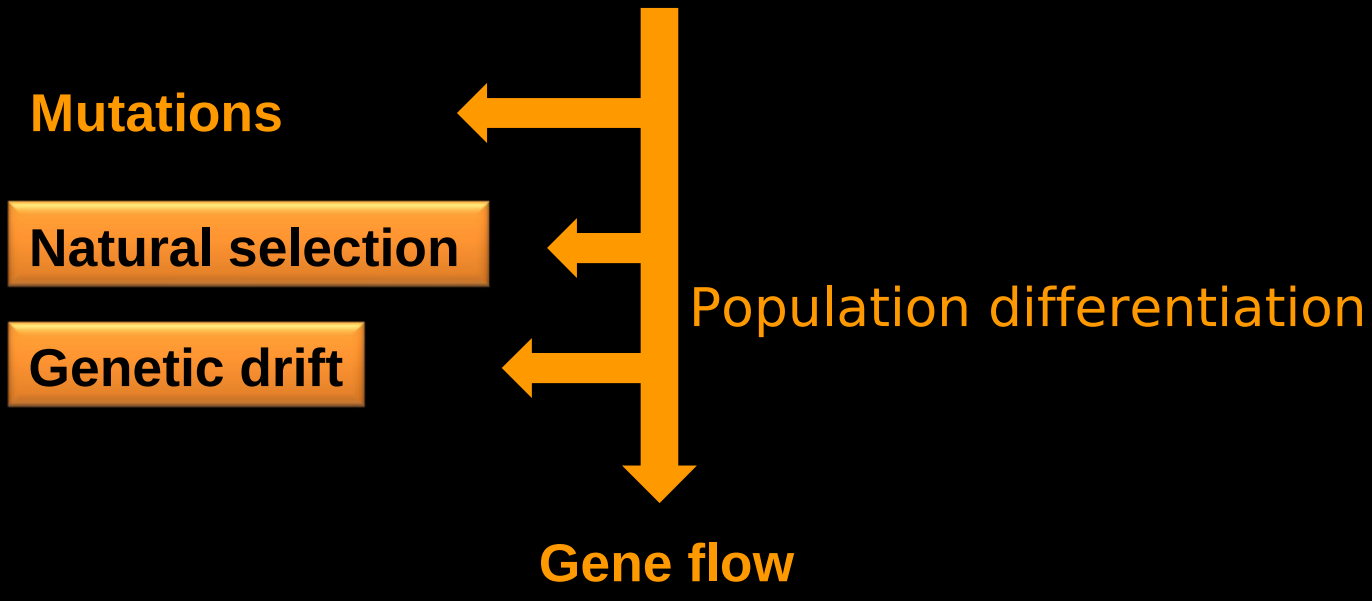

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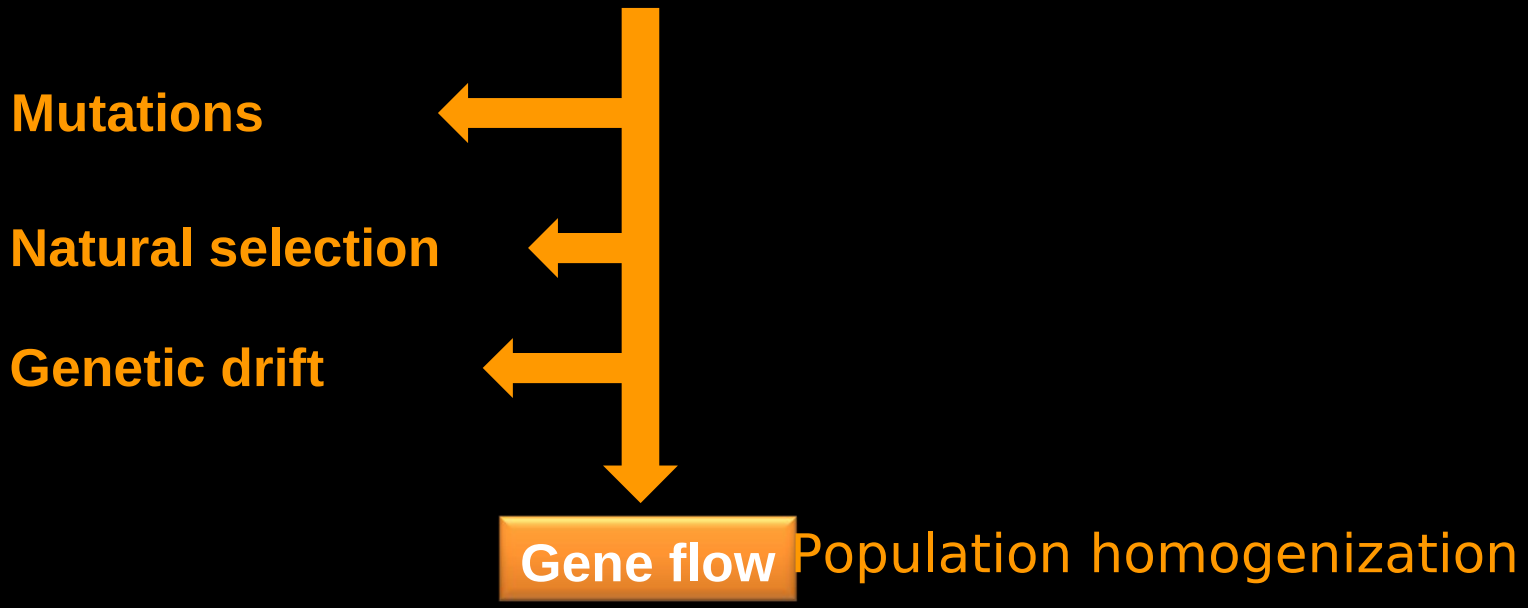

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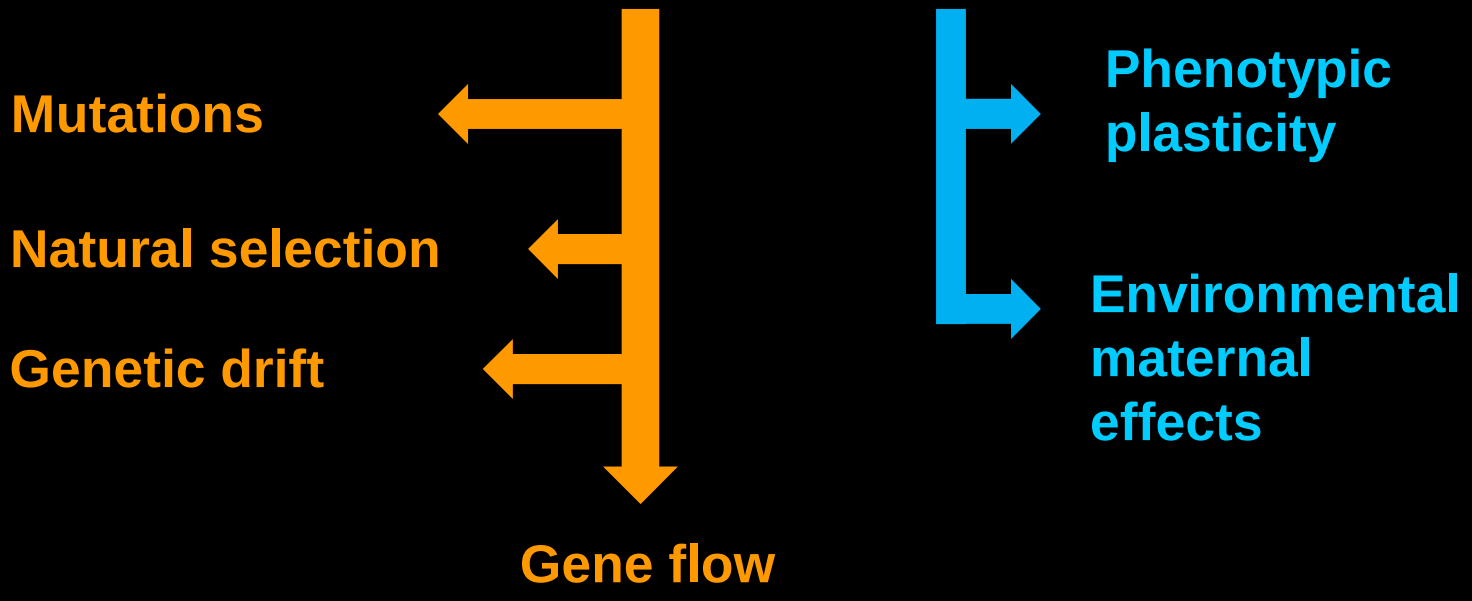

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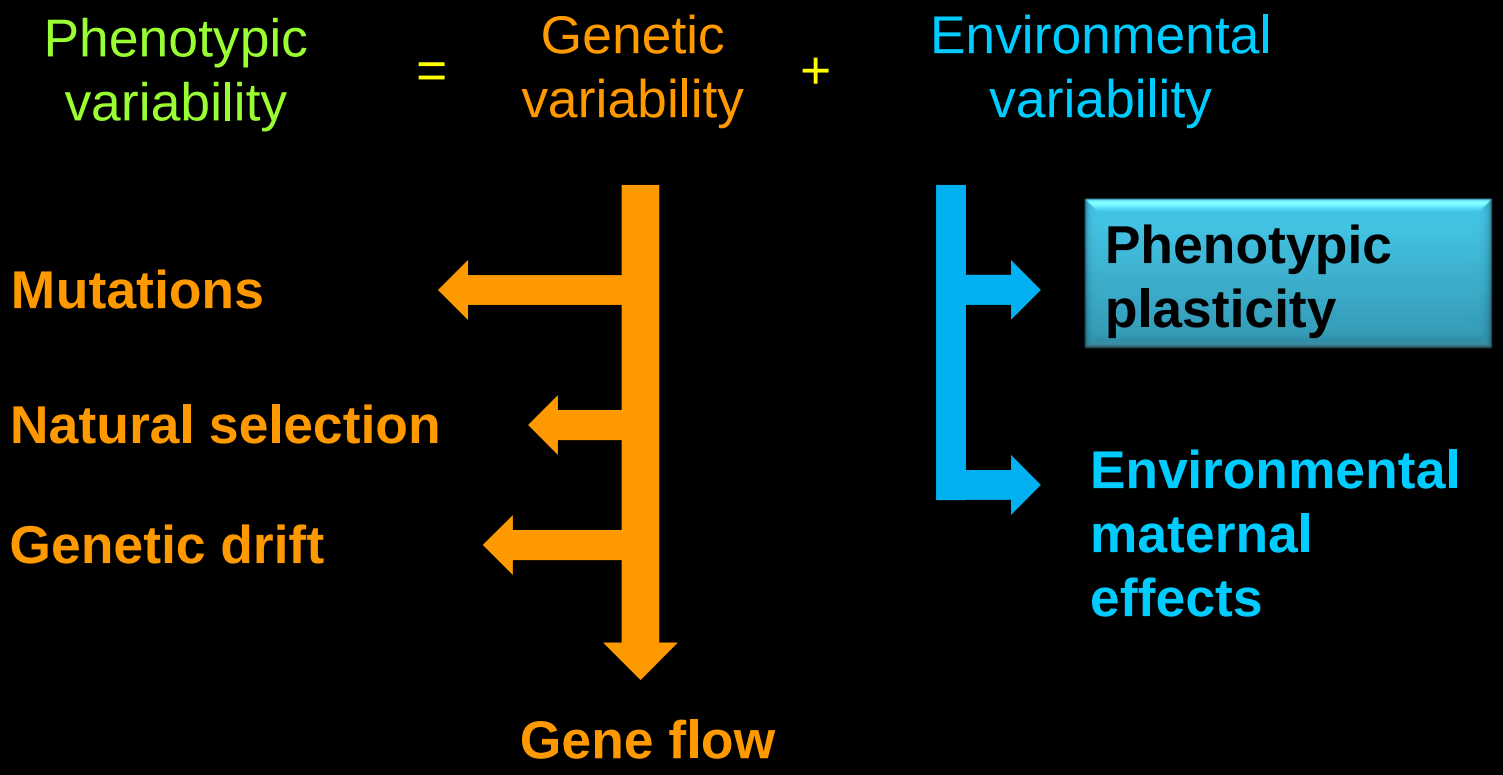

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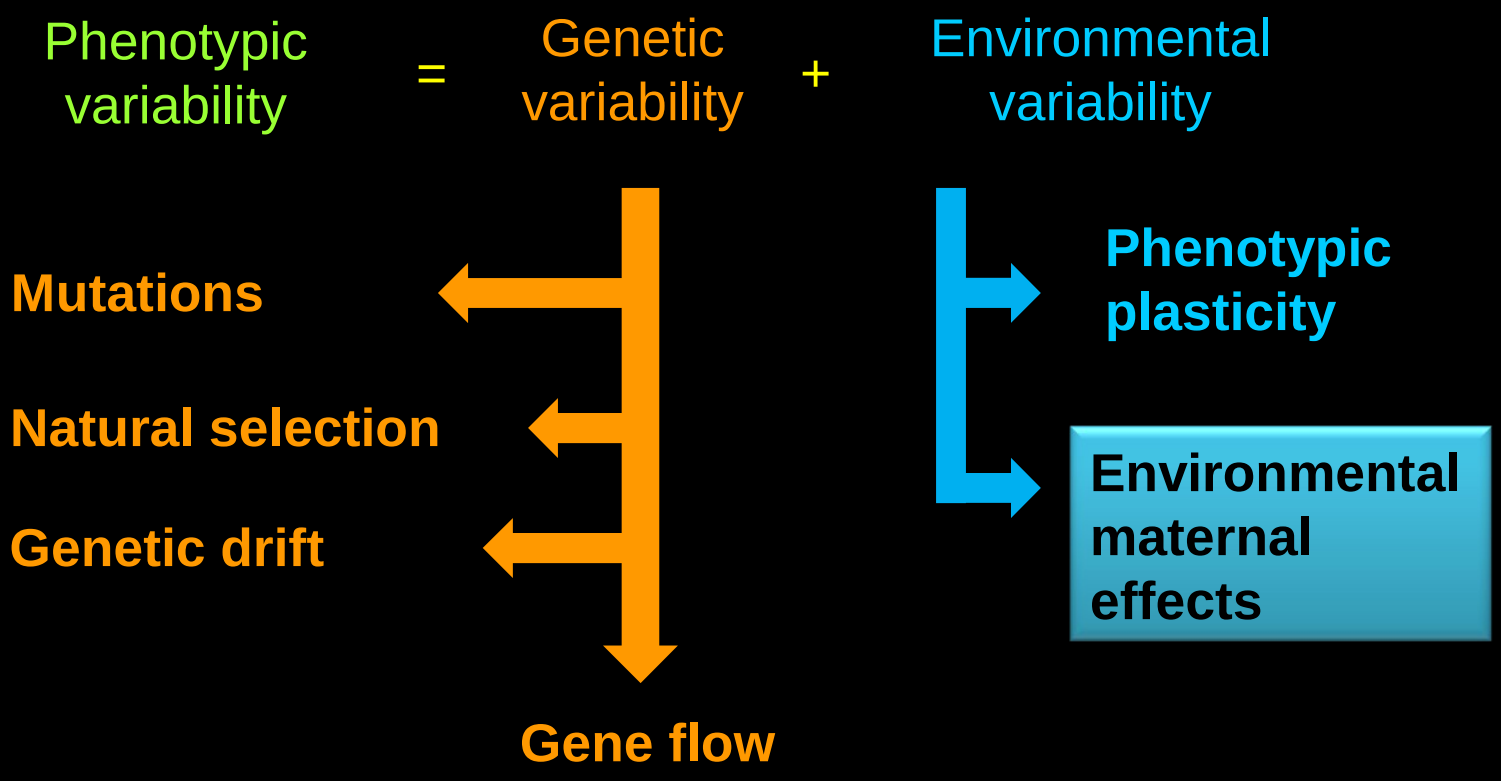

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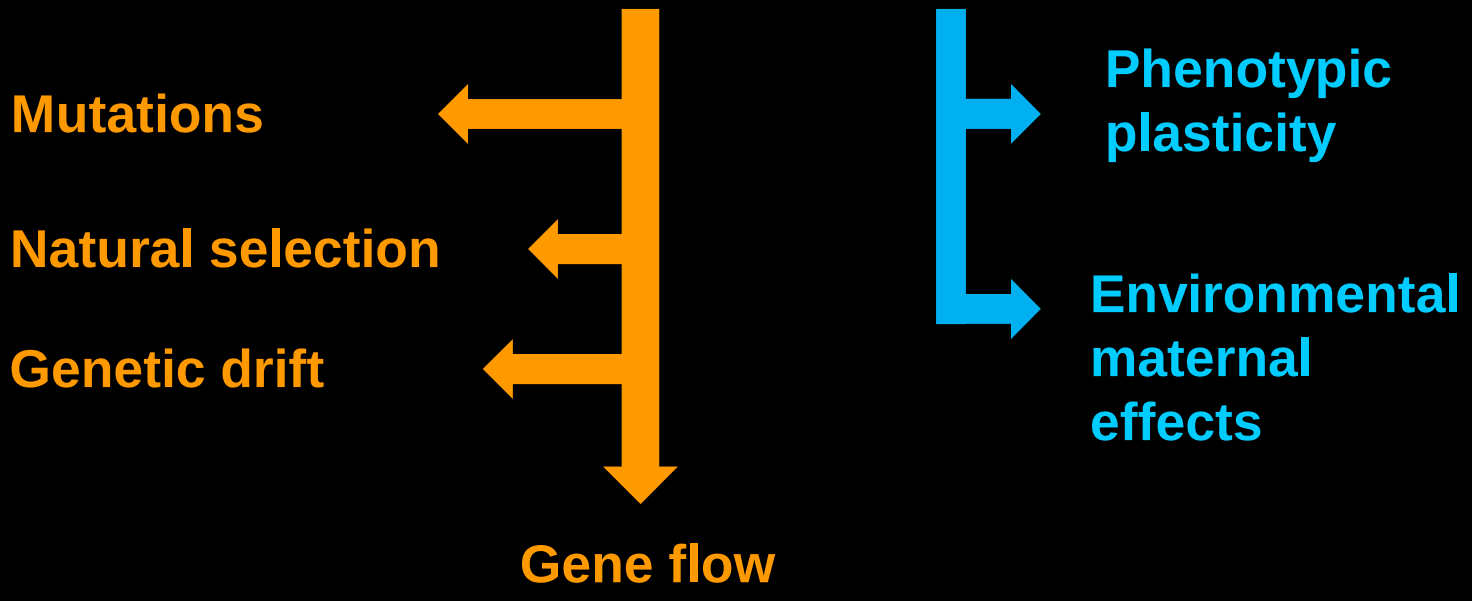


Objectives

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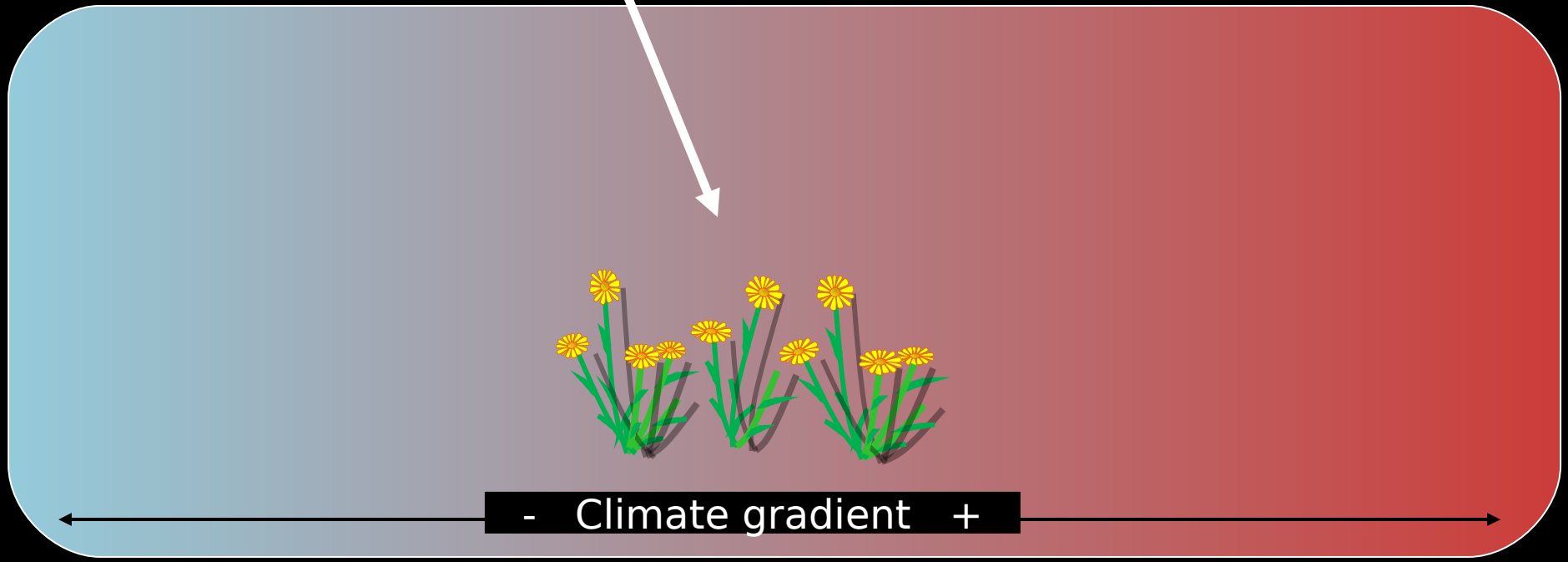
Native range

In the **invasion range**, what are the **sources of phenotypic variability** that allow the colonization of **contrasted climatic zones** ?

Invasion range



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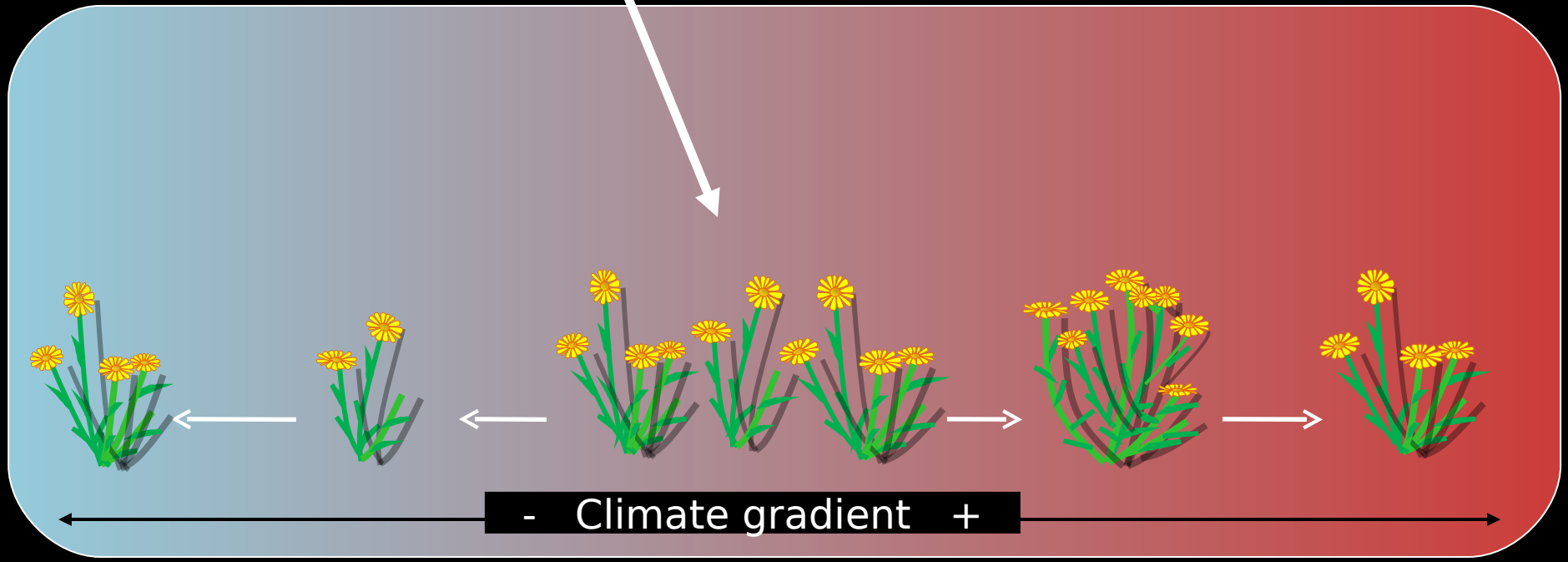

Objectives

Native range

In the **invasion range**, what are the **sources of phenotypic variability** that allow the colonization of **contrasted climatic zones** ?

Invasion range

election and adaptation ?
enetic drift ?
henotypic plasticity ?
nvironmental maternal effects ?

Objectives

Using *Senecio inaequidens* as a study model, within the invaded range, we ask:

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What is the importance of **environmental maternal effects** in relation to **climate** ?

If there is a genetic differentiation, is it **adaptation to climate**?

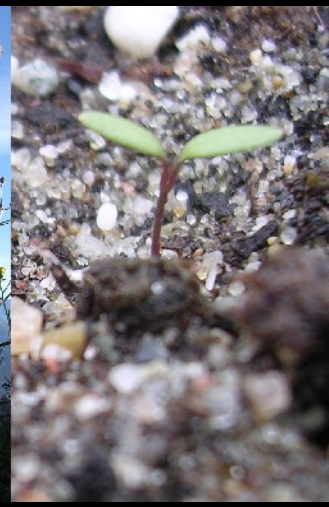

Study model

Study model: *Senecio inaequidens* DC.

- Perrenial herbaceous shrub
- Native to South Africa and Lesotho
- Pioneer species

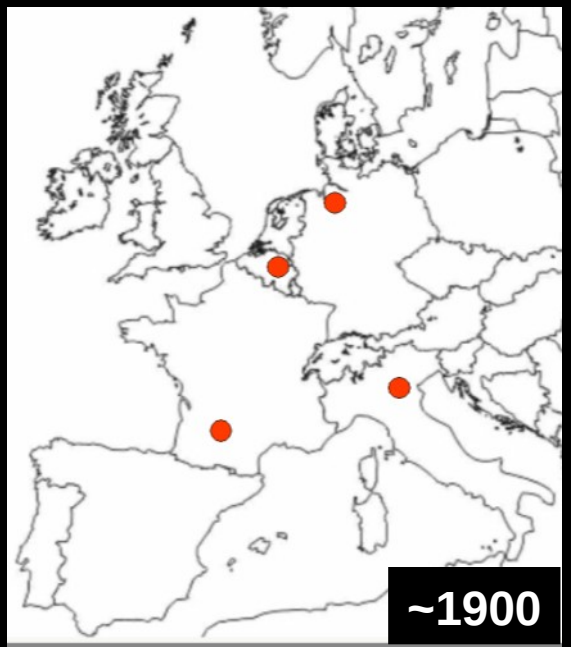




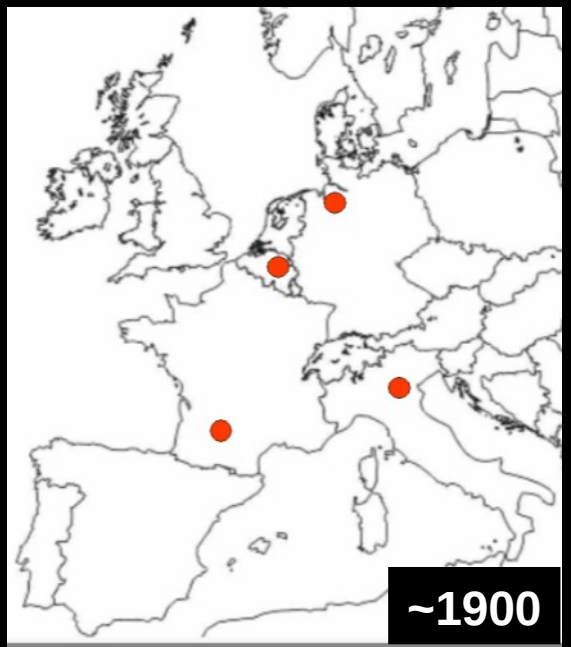
Study model: *Senecio inaequidens* DC.

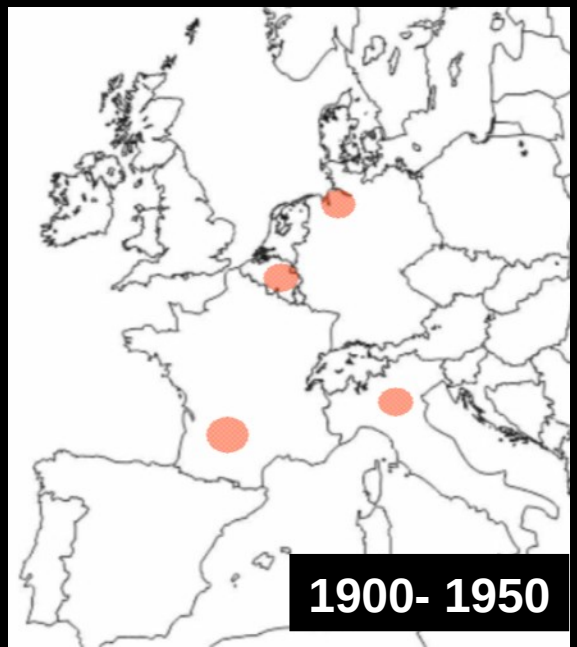
- Introduced to Europe as a wool alien in several locations linked to wool industries:
  - Verviers (Belgium) : 1892
  - Bremen (Germany) : 1896
  - Mazamet (France) : 1936
  - Verona (Italy) : >1940



Study model: *Senecio inaequidens* DC.

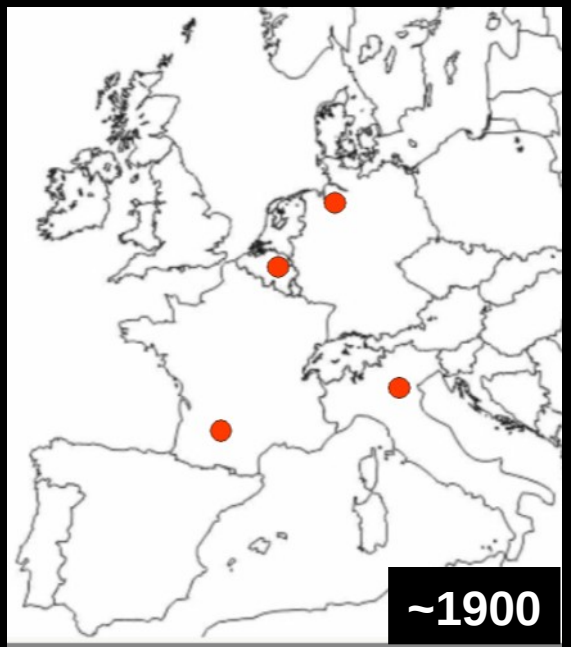
- During several decades, it was only found in the vicinity of wool-processing areas

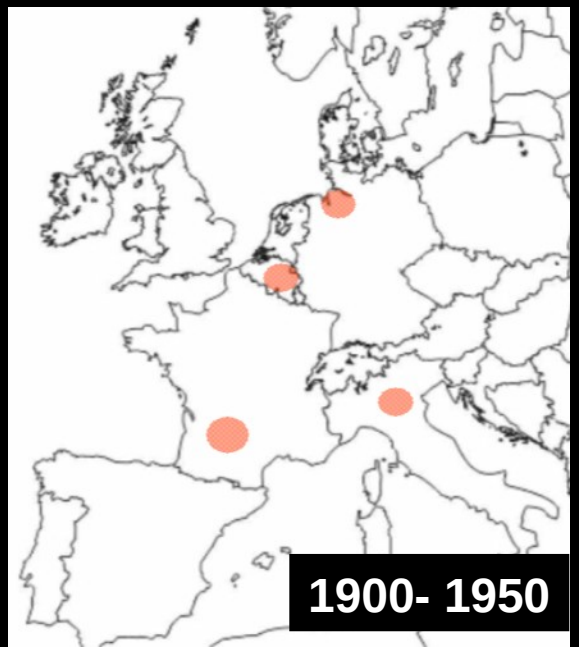


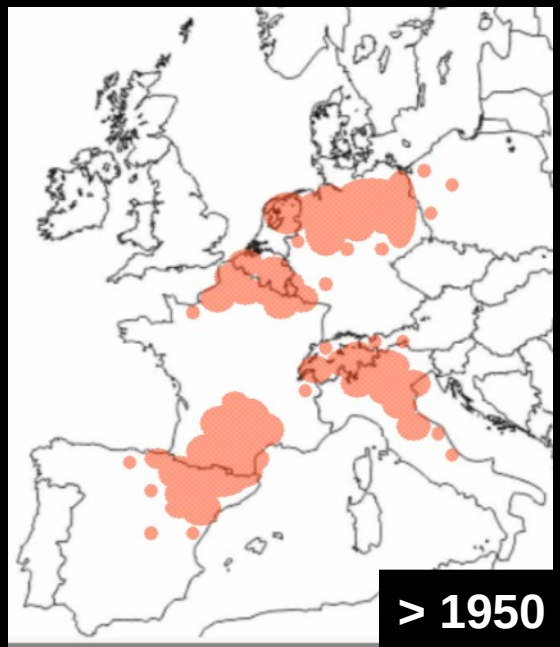


Study model: *Senecio inaequidens* DC.

- From 1950-1970, it started to spread throughout Europe



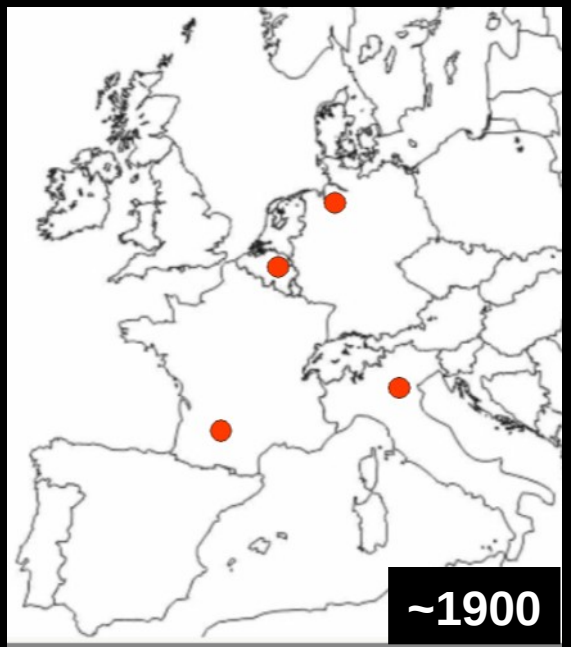


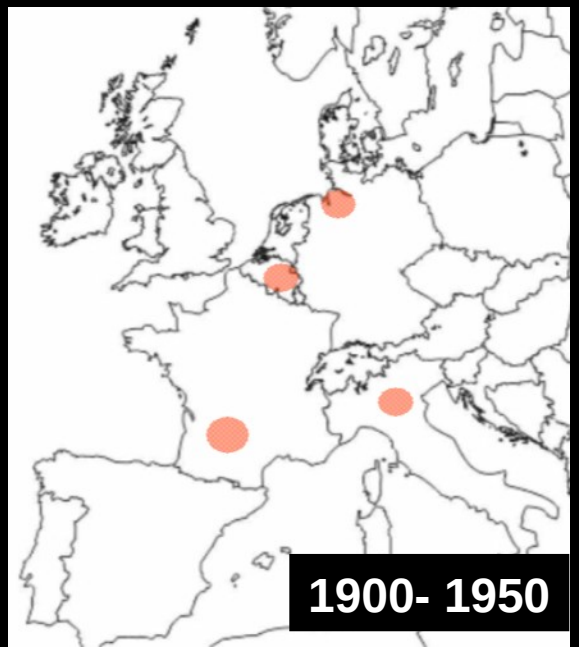


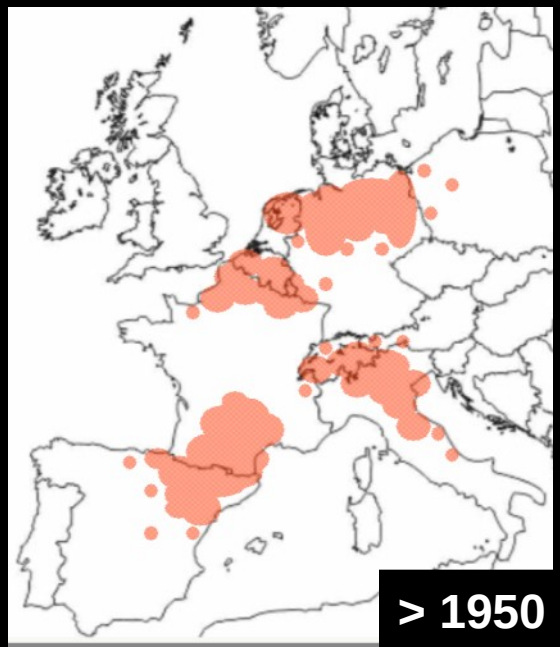
Study model: *Senecio inaequidens* DC.

- From 1950-1970, it started to spread throughout Europe

➔ **During ~ 50 years of invasion, *Senecio inaequidens* gradually encountered contrasted climatic zones**





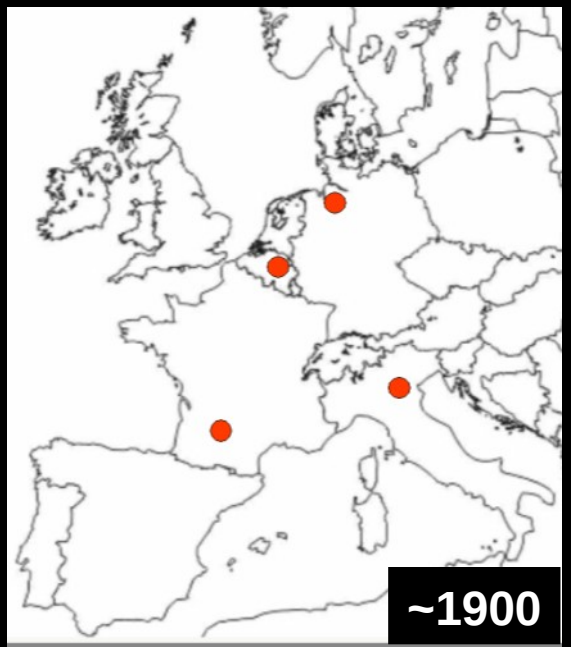


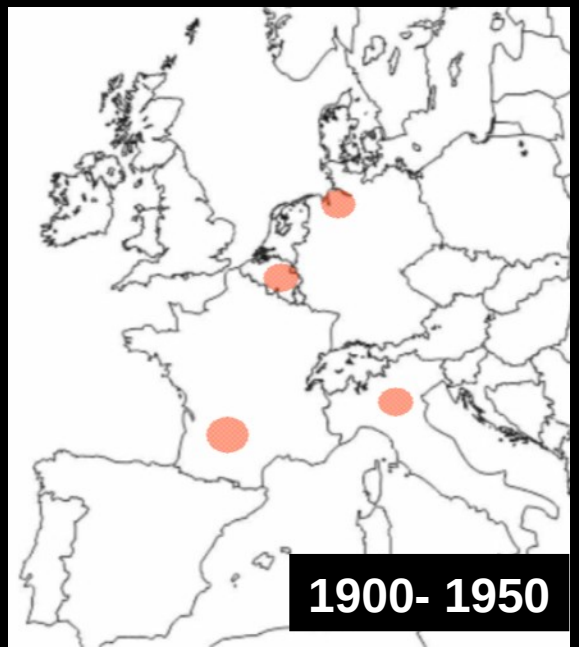
Study model: *Senecio inaequidens* DC.

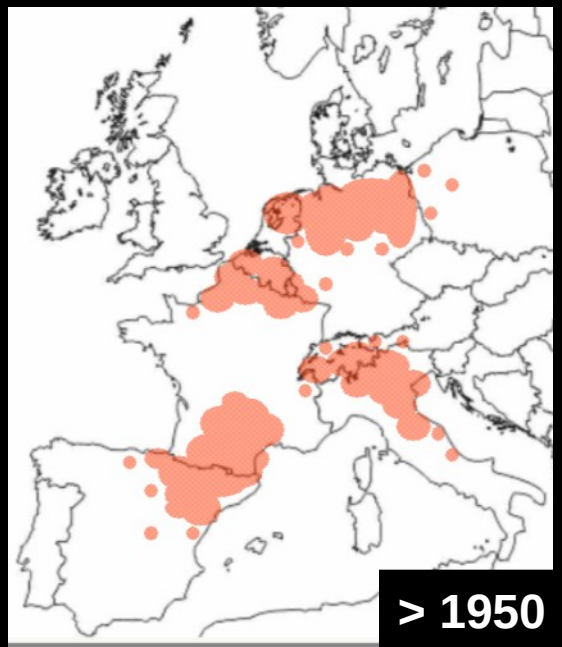
- From 1950-1970, it started to spread throughout Europe

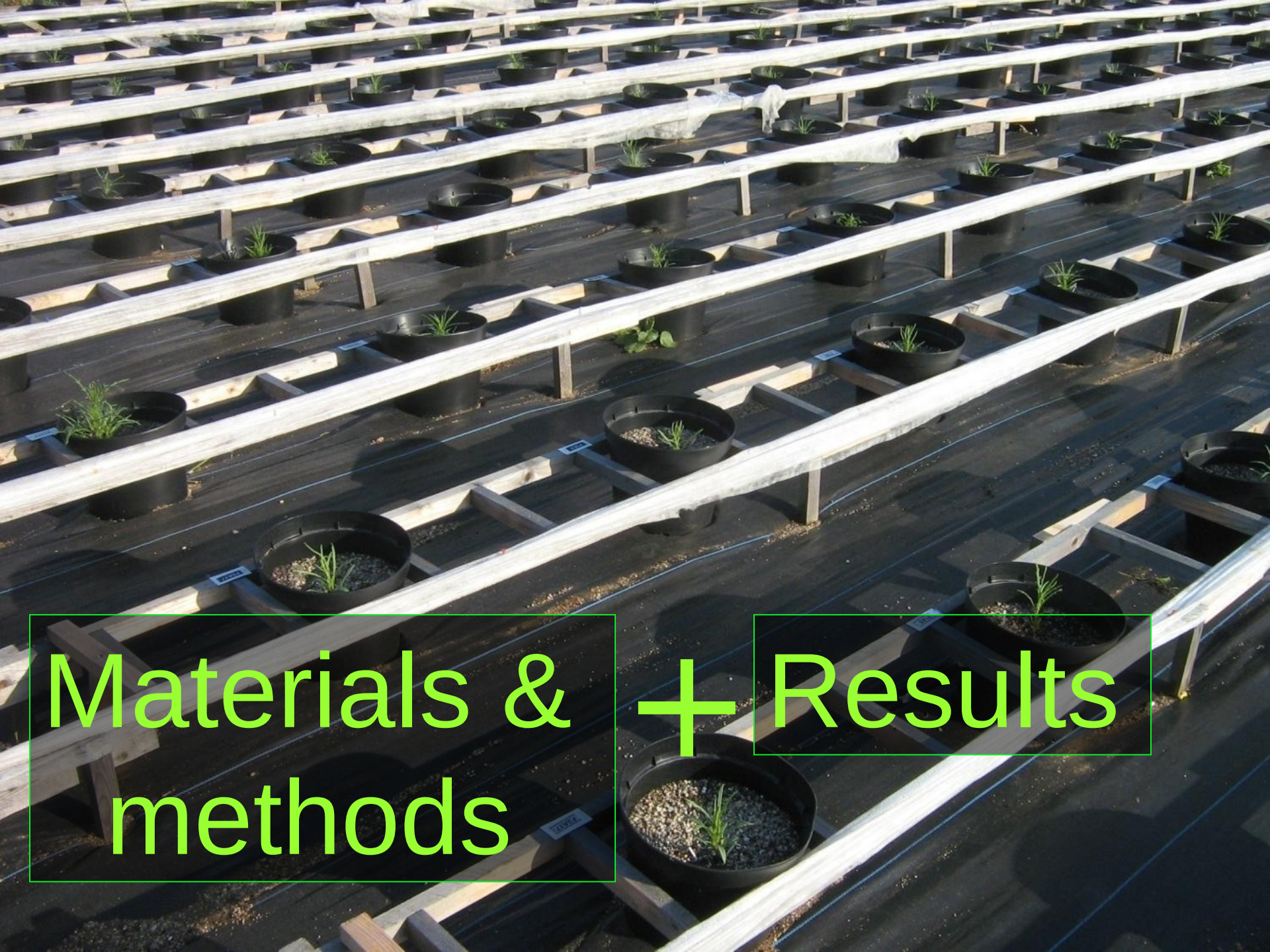
→ **During ~ 50 years of invasion, *Senecio inaequidens* gradually encountered contrasted climatic zones**

→ **Several independent colonizations in Europe**








Materials & methods
+
Results

Materials & methods + results

1) Is phenotypic variation related to climate ?

2) Does this variation reflect a genetic differentiation ?

Materials & methods + results: study transects

French transect:

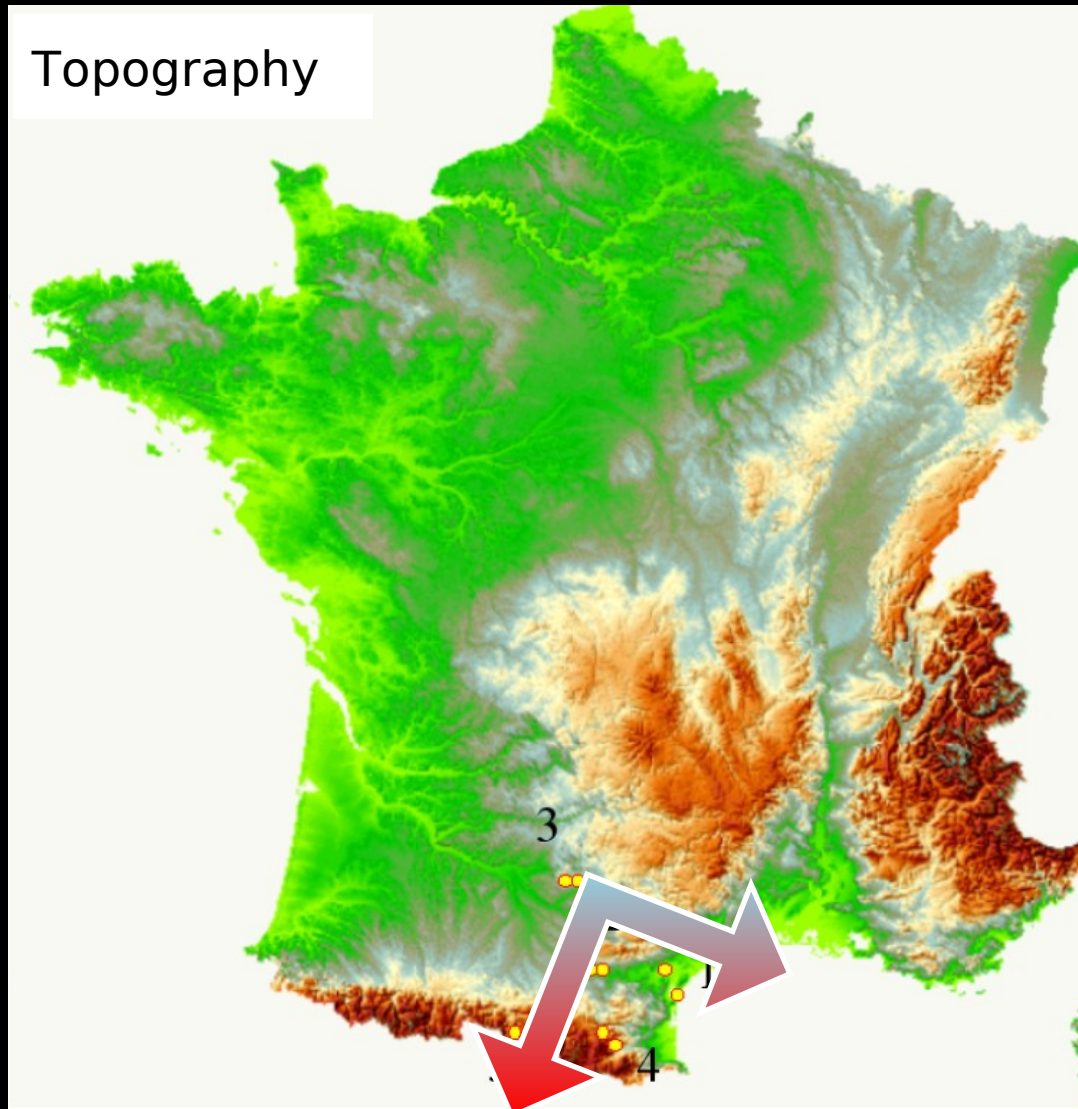
➔5 altitudinal zones:

Altitudinal range: 0 – 1600 m

➔ 2 populations per zone

Meteorological analysis:

Temperature and summer-drought gradient



Materials & methods + results: study transects

Belgian transect :

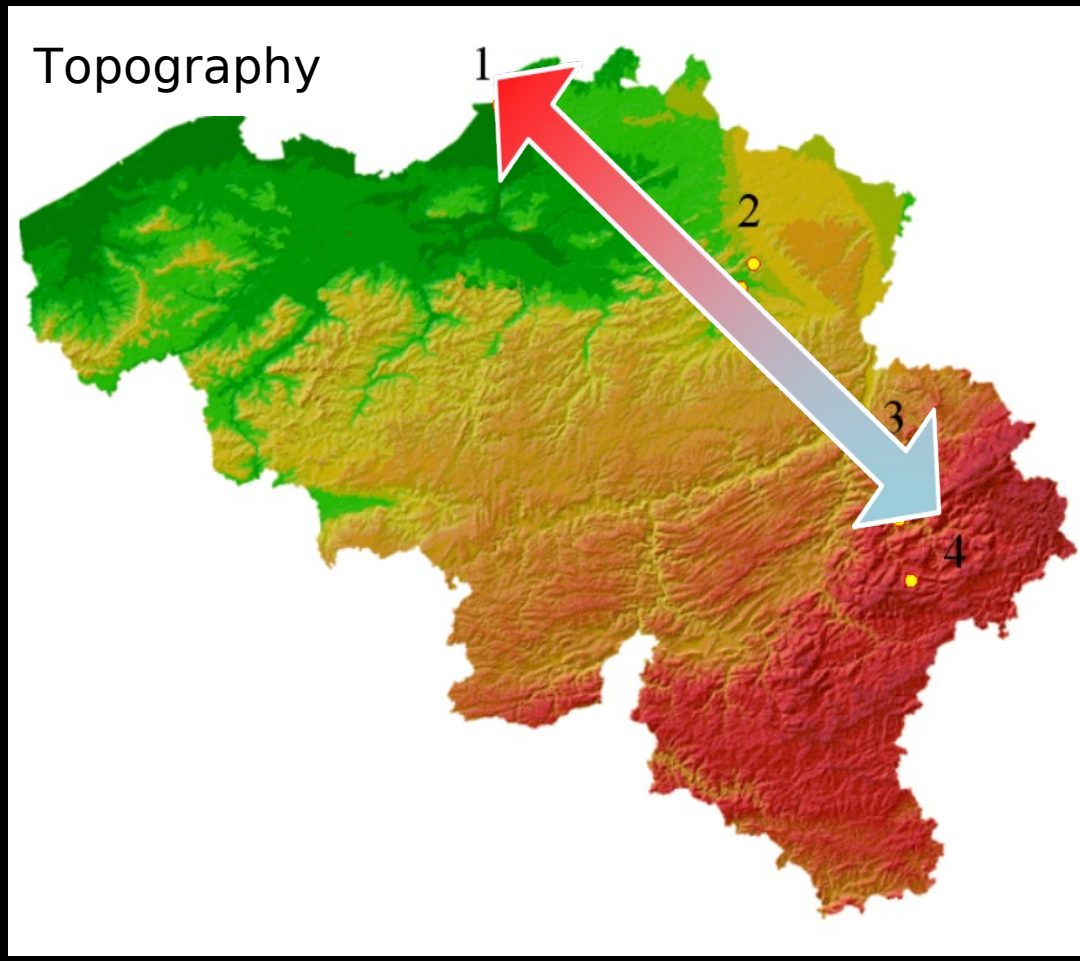
➔ 4 altitudinal zones:

Altitudinal range: 0 – 480 m

➔ 2 populations per zones

Meteorological analysis:

Temperature and rainfall gradient



Materials & methods + results

10 individuals
per population

Growth trait measurements in natural populations

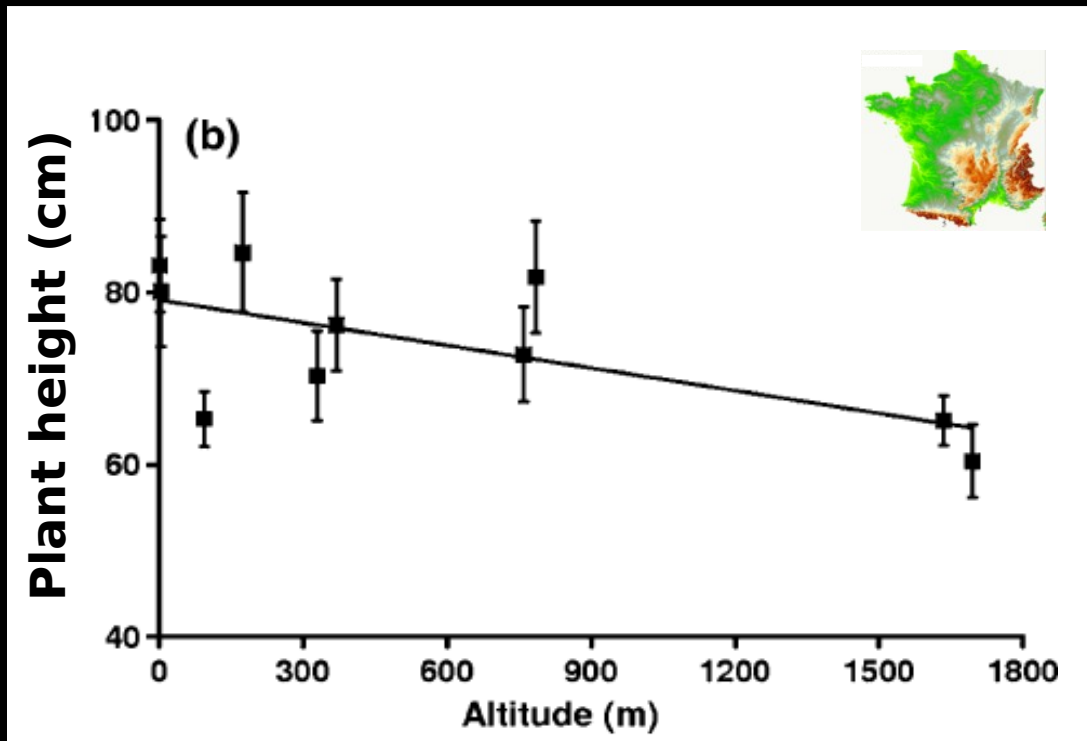
Materials & methods + results

10 individuals per population

Growth trait measurements in natural populations

Results:

Gradual decrease of plant traits with altitude



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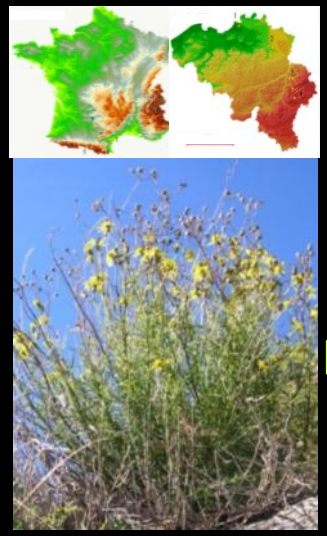
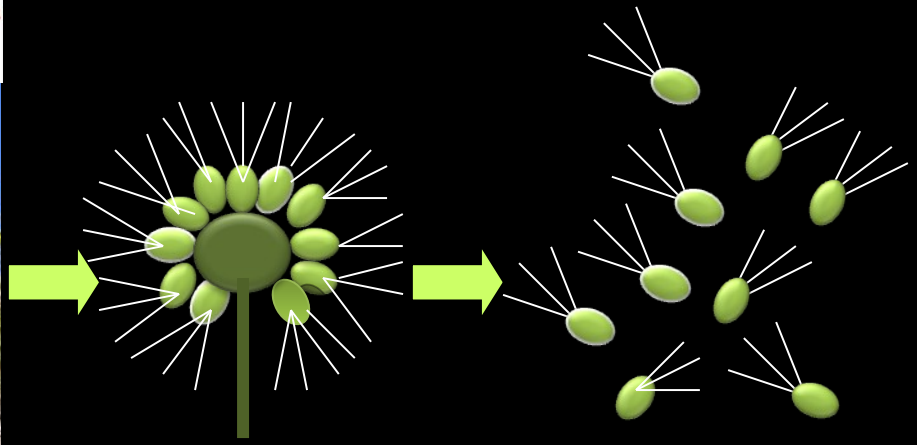
Materials & methods + results

2006

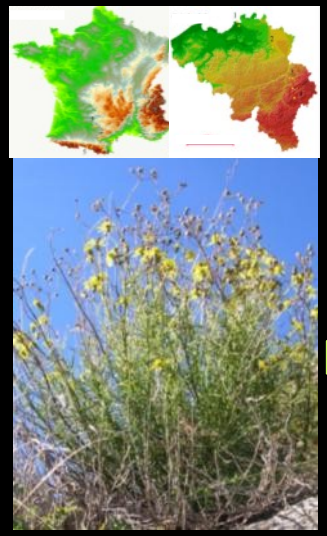


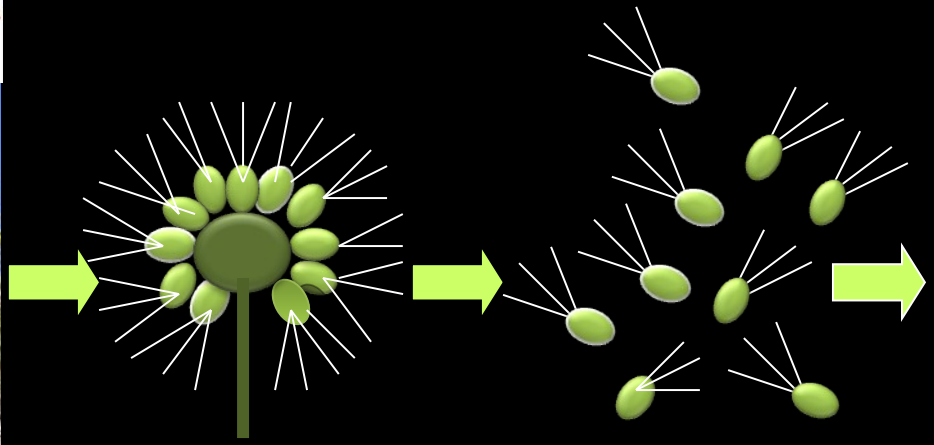


10 parent individuals
per population

10 achenes per
parent individual

Materials & methods + results





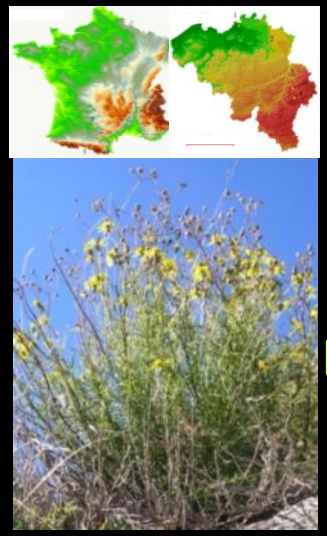
2006

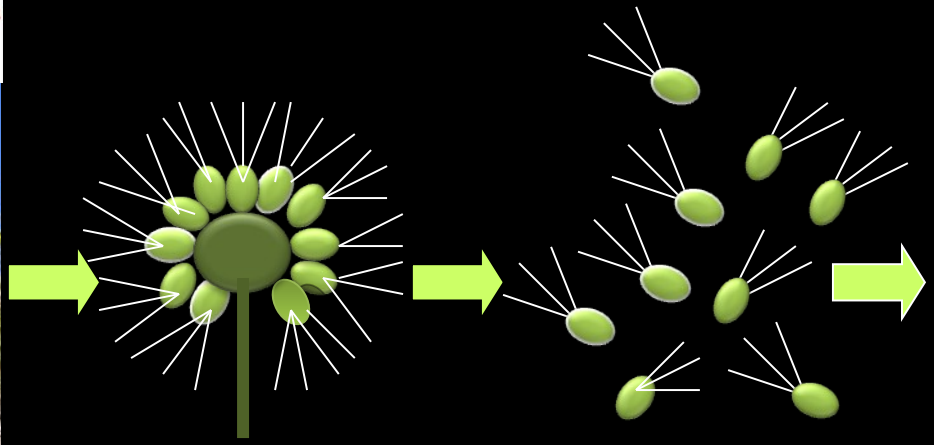
10 parent individuals per population

10 achenes per parent individual

1 descendant per parent individual

Materials & methods + results





2006

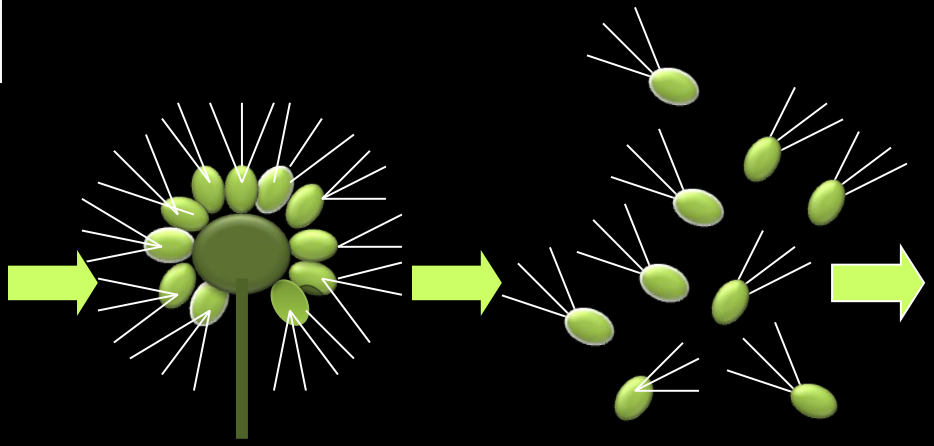
Life history traits:

- *Germination delay*
- *Flowering delay*
- *Height at maturity*
- *Final plant height*
- *Aboveground biomass*

Materials & methods + results

Replication of the whole experiment

2007



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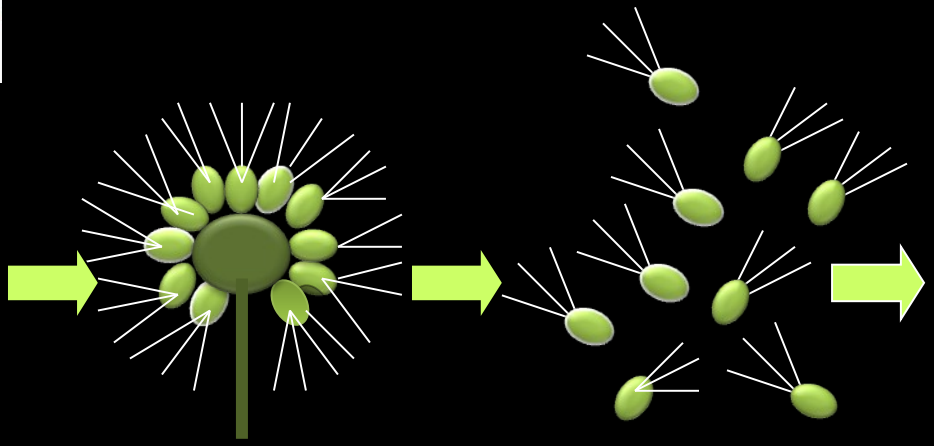


Life history traits:

- *Germination delay*
- *Flowering delay*
- *Height at maturity*
- *Final plant height*
- *Aboveground biomass*

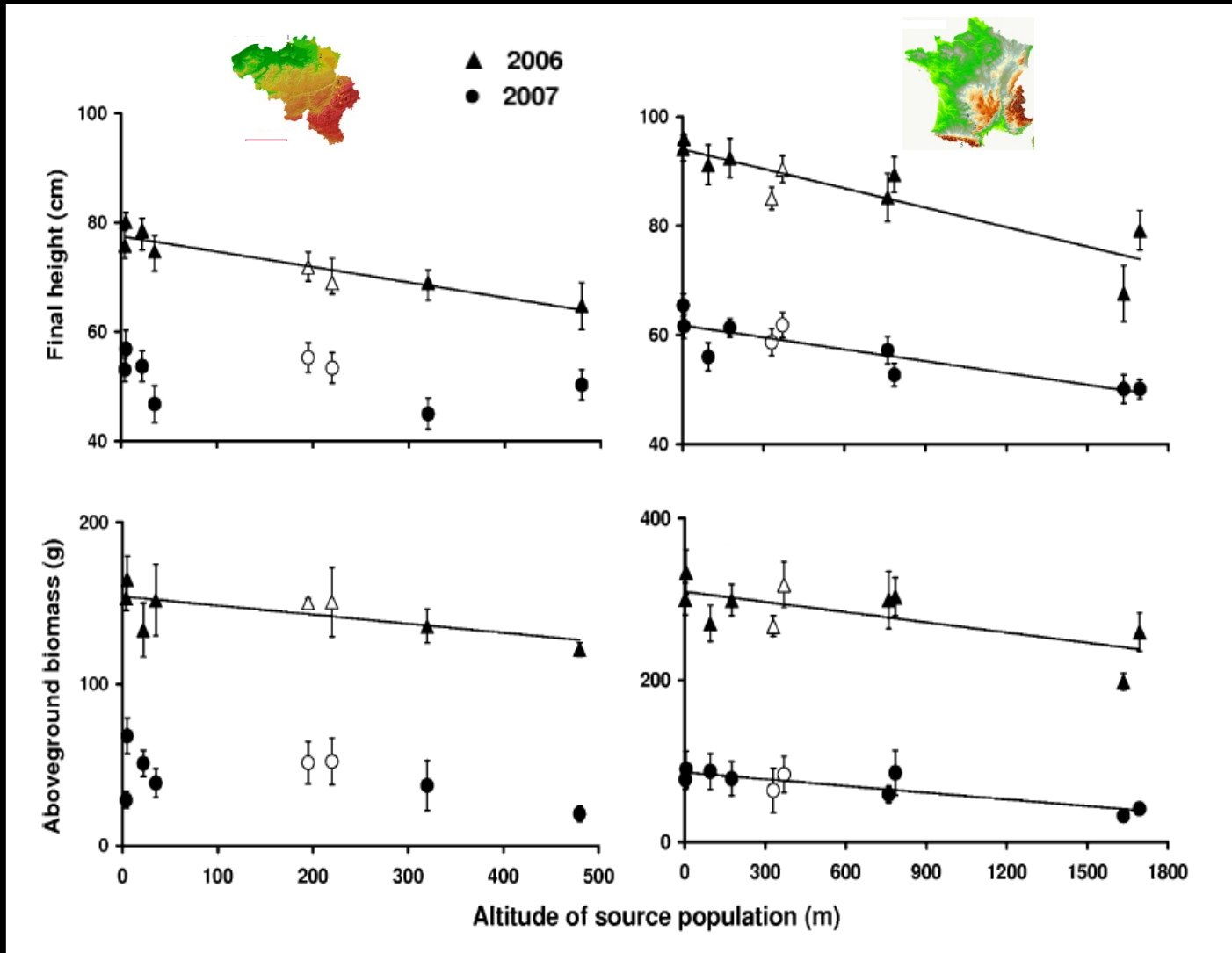
Spatial replication: 2 study transects

Temporal replication: 2 years of experiment

Materials & methods + results

Results:

- Clinal reduction of growth traits with altitude of source populations !
- Clearer in France



Materials & methods + results

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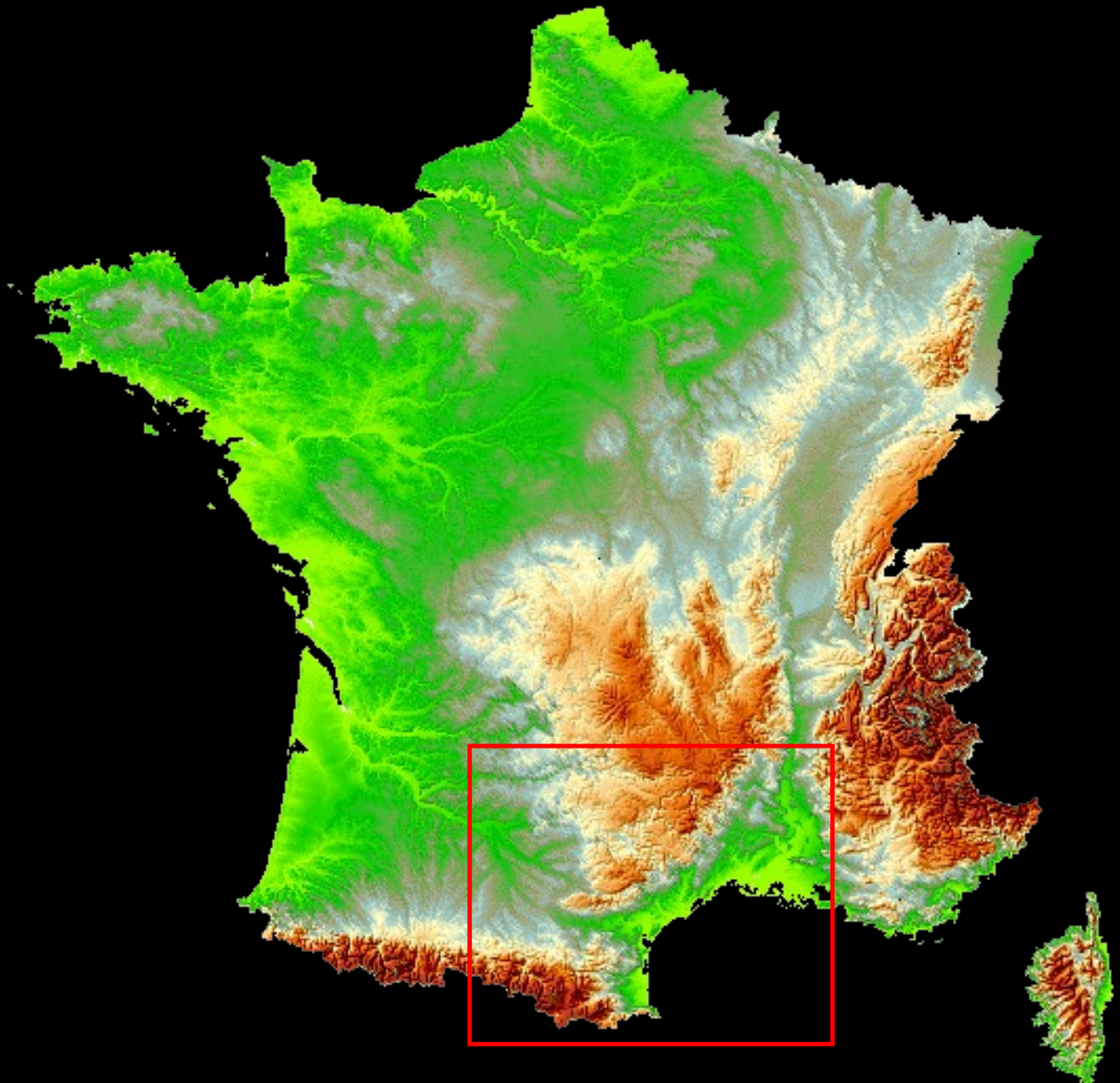
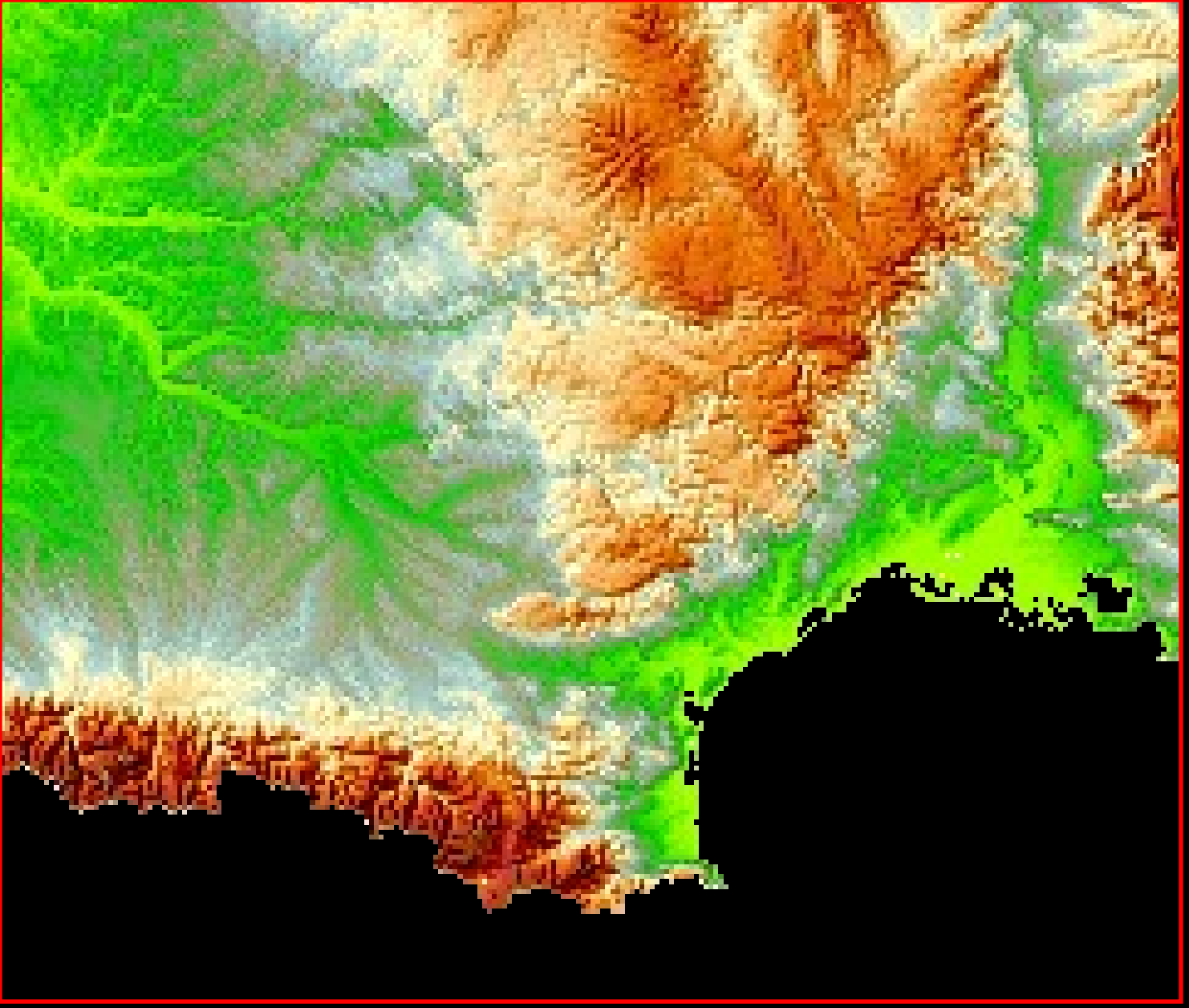
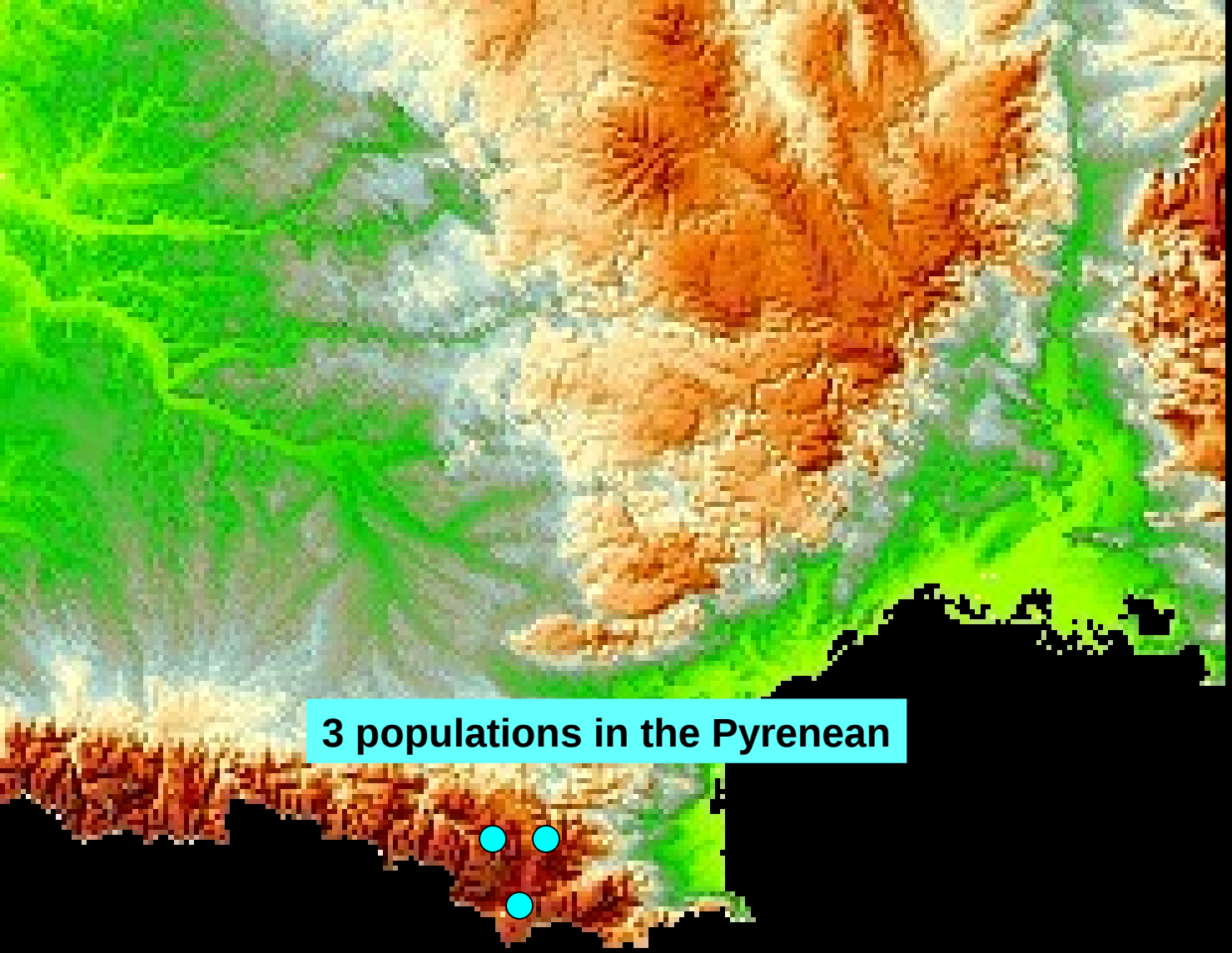
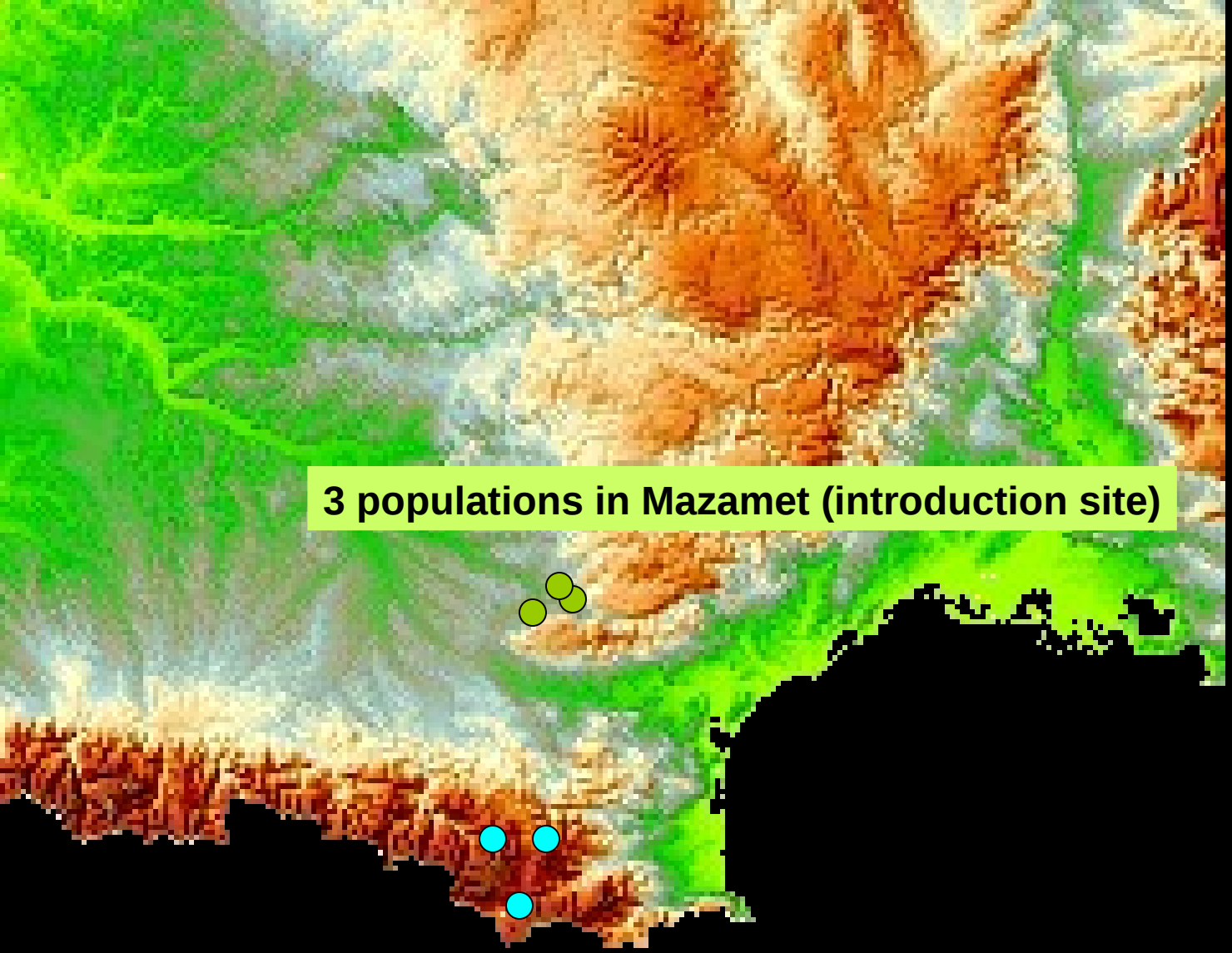
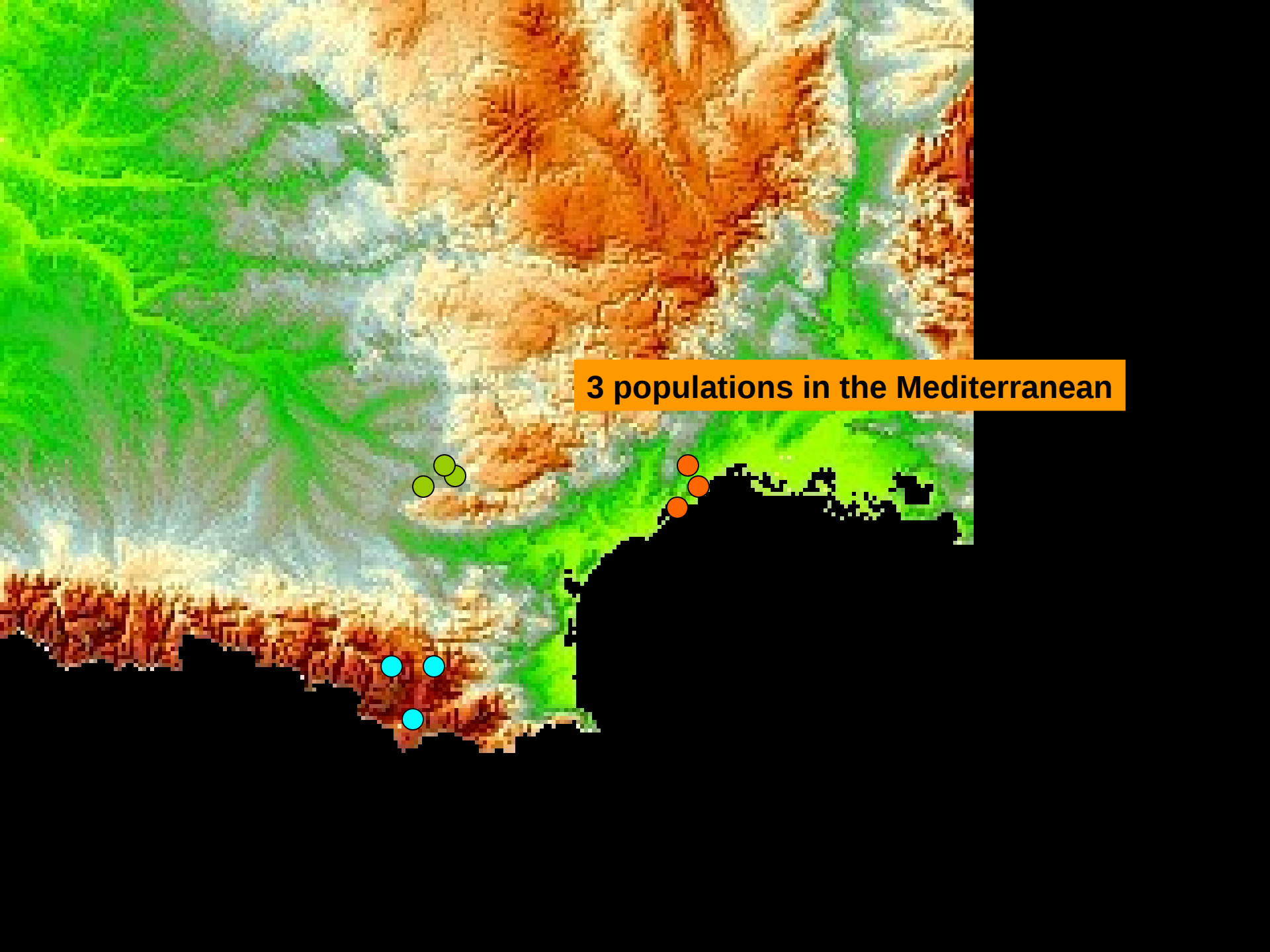
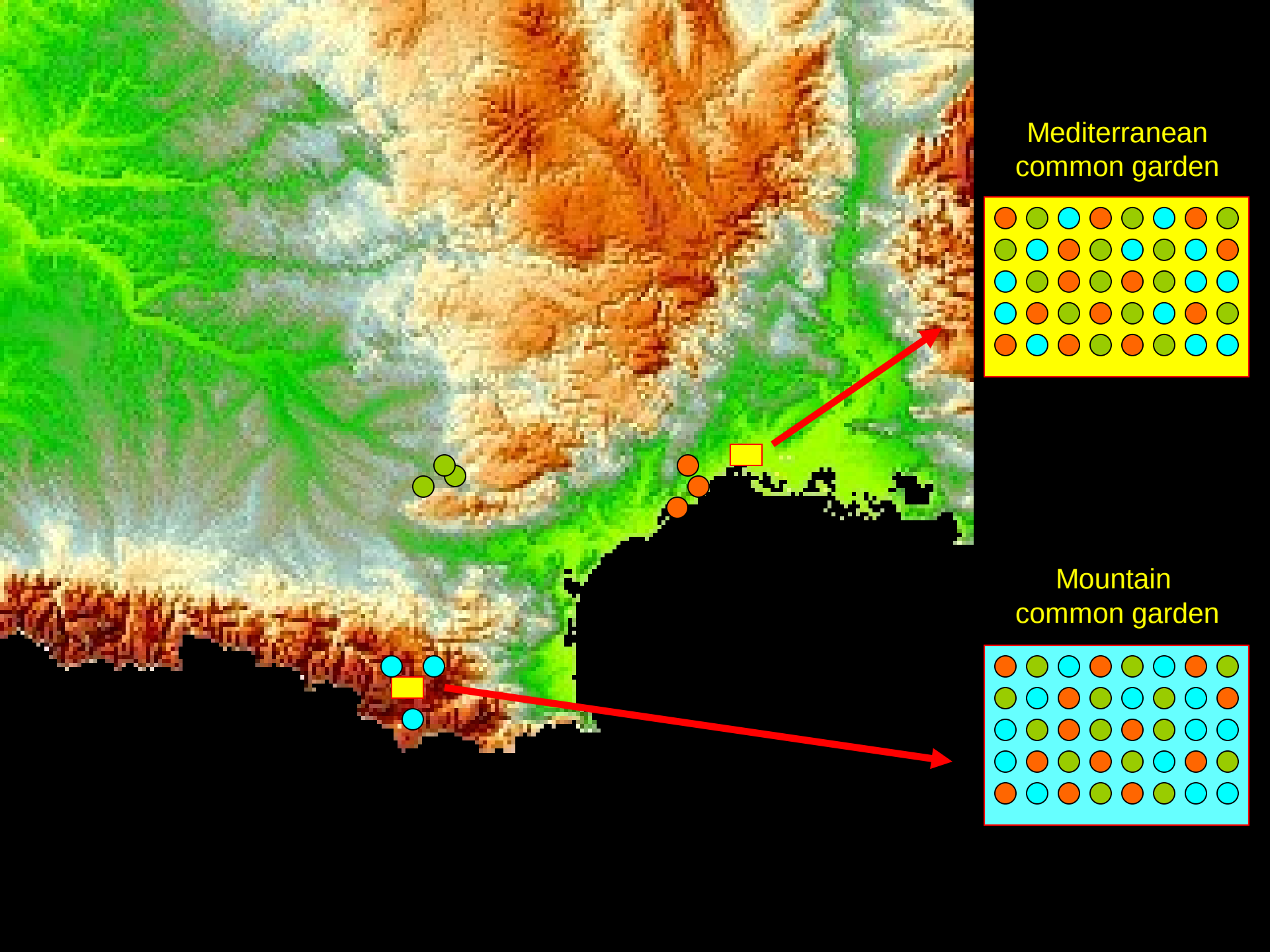





3 populations in the Pyrenean


3 populations in Mazamet (introduction site)


3 populations in the Mediterranean


Mediterranean
common garden
Mountain
common garden

Materials & methods + results

Life history traits

- *Seed mass*
- *Time to germination*
- *Plant volume*
- *Cumulated flower heads*

Materials & methods + results

Life history traits

- *Seed mass*
- *Time to germination*
- *Plant volume*
- *Cumulated flower heads*

] fitness traits ➔ adaptation to climate ?

Materials & methods + results

Life history traits

- *Seed mass*
- *Time to germination*
- *Plant volume*
- *Cumulated flower heads*

Environmental maternal effects ?

Fitness traits ➔ adaptation to climate ?

Materials & methods + results

Results:

Materials & methods + results

Results:

Environmental maternal effects depend on climate

Materials & methods + results

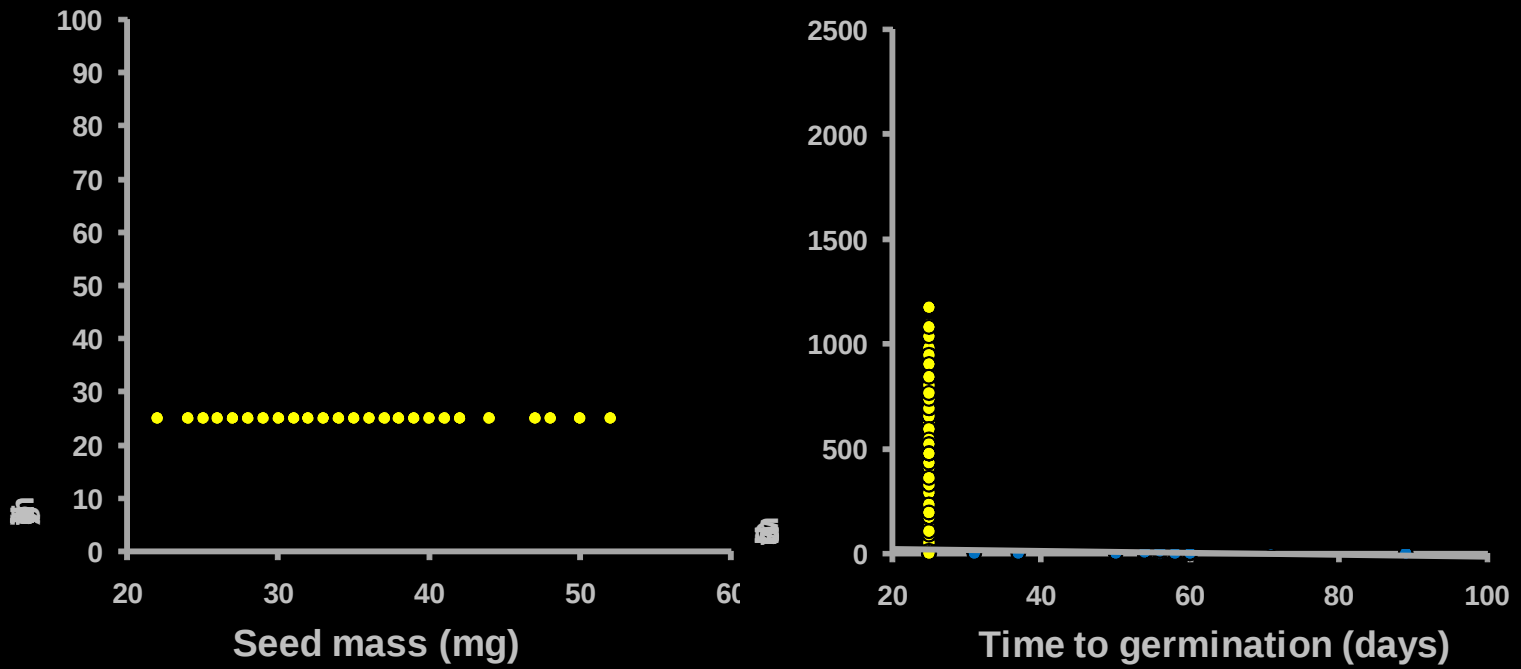
Results:

Environmental maternal effects depend on climate

Mediterranean (Favourable climate)

*Germination **independent** of seed mass*

No influence on fitness



Materials & methods + results

Results:

Environmental maternal effects depend on climate

Mediterranean (Favourable climate)

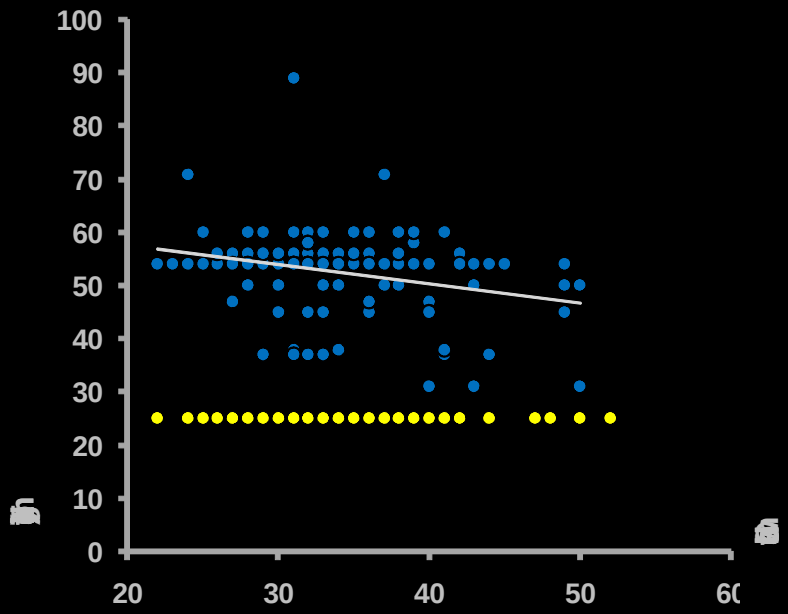
*Germination **independent** of seed mass*

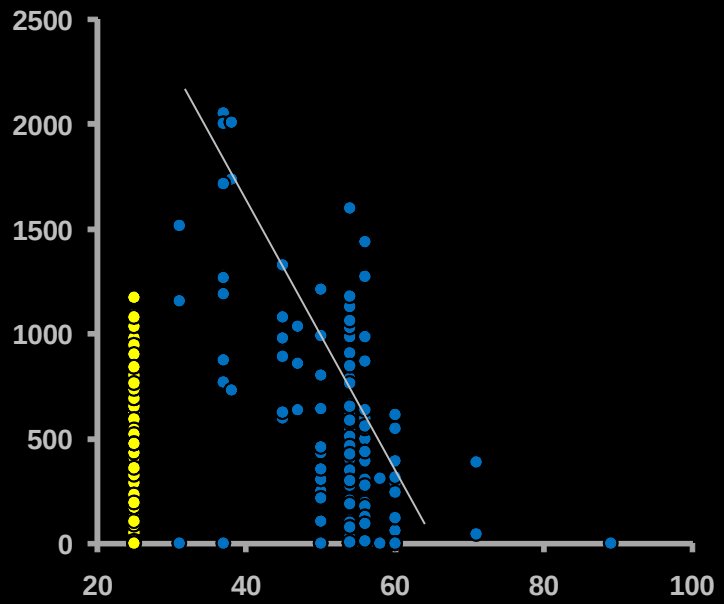
No influence on fitness

Mountain (Harsh climate)

*Germination **dependent** on seed mass*

Strong influence on fitness !





Materials & methods + results

Results:

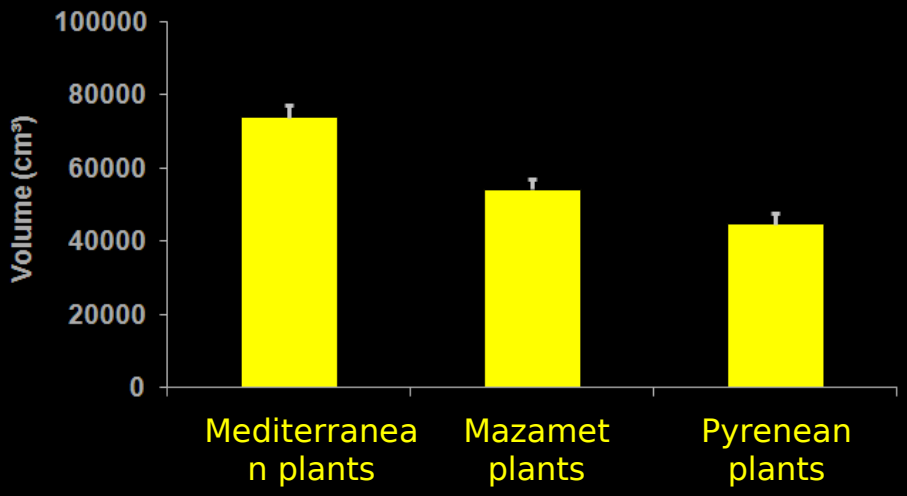
Environmental maternal effects depend on climate

Materials & methods + results

Results:

Environmental maternal effects depend on climate

Mediterranean garden



Pyrenean garden

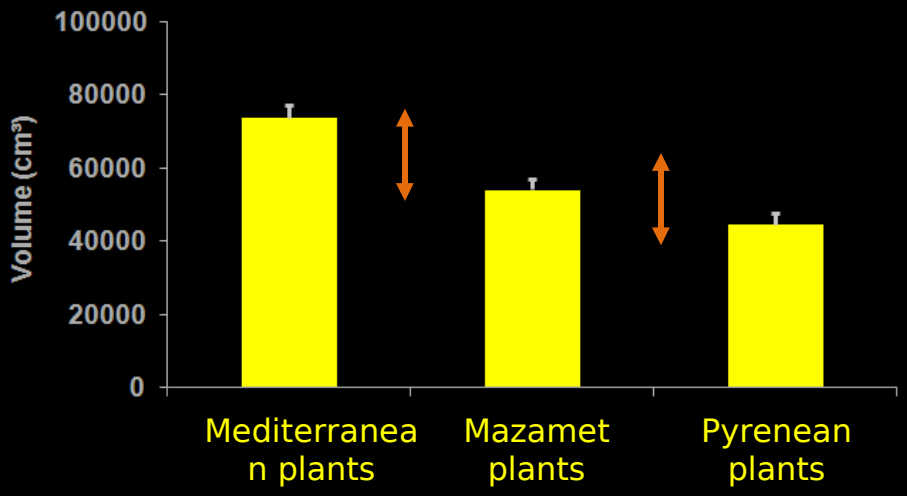
Materials & methods + results

Results:

Environmental maternal effects depend on climate

Genetic differentiation: verified

Mediterranean garden



Pyrenean garden

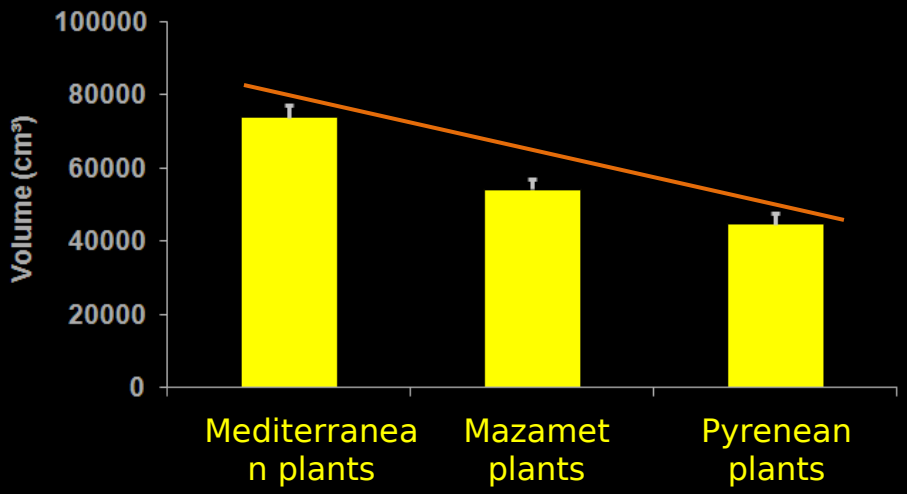
Materials & methods + results

Results:

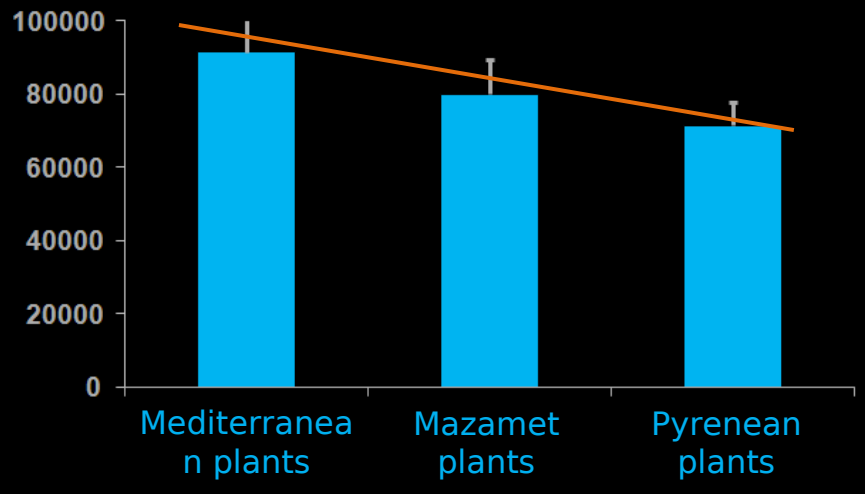
Environmental maternal effects depend on climate

Genetic differentiation: verified

Mediterranean garden



Pyrenean garden



Materials & methods + results

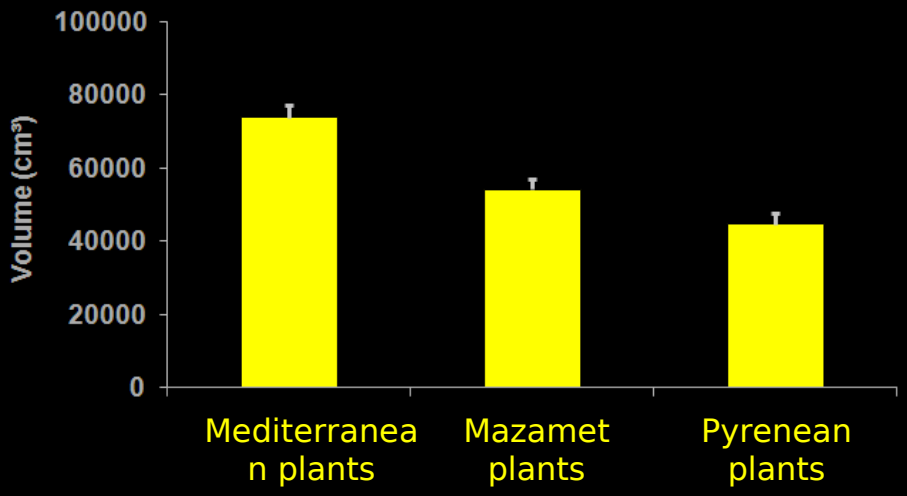
Results:

Environmental maternal effects depend on climate

Genetic differentiation: verified

Plasticity in relation to climate

Mediterranean garden



Pyrenean garden

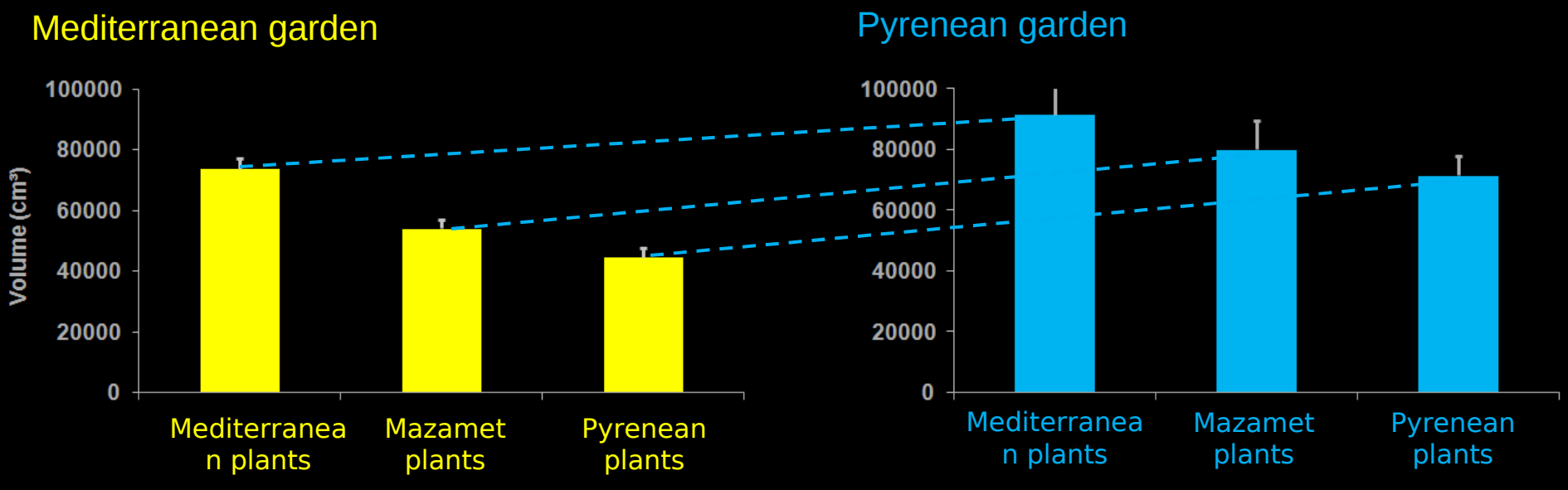
Materials & methods + results

Results:

Environmental maternal effects depend on climate

Genetic differentiation: verified

Plasticity in relation to climate



Materials & methods + results

Results:

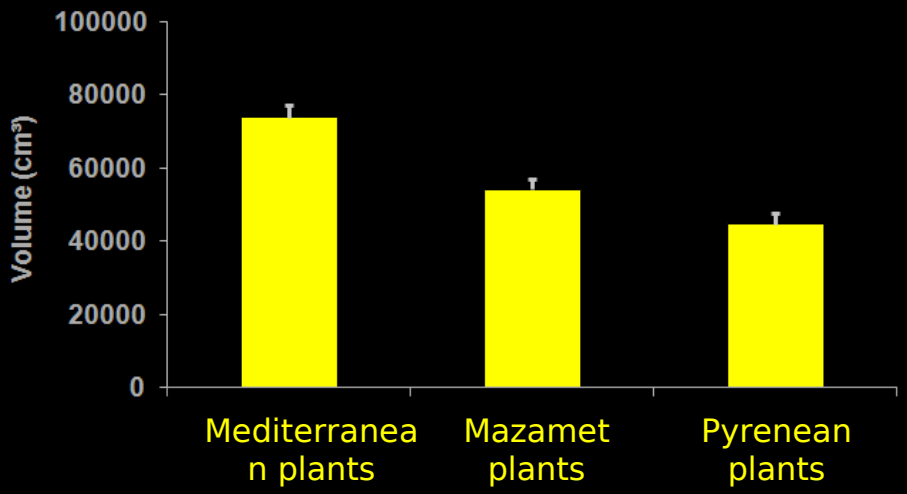
Environmental maternal effects depend on climate

Genetic differentiation: verified

Plasticity in relation to climate

Local adaptation to climate ?

Mediterranean garden



Pyrenean garden

Materials & methods + results

Results:

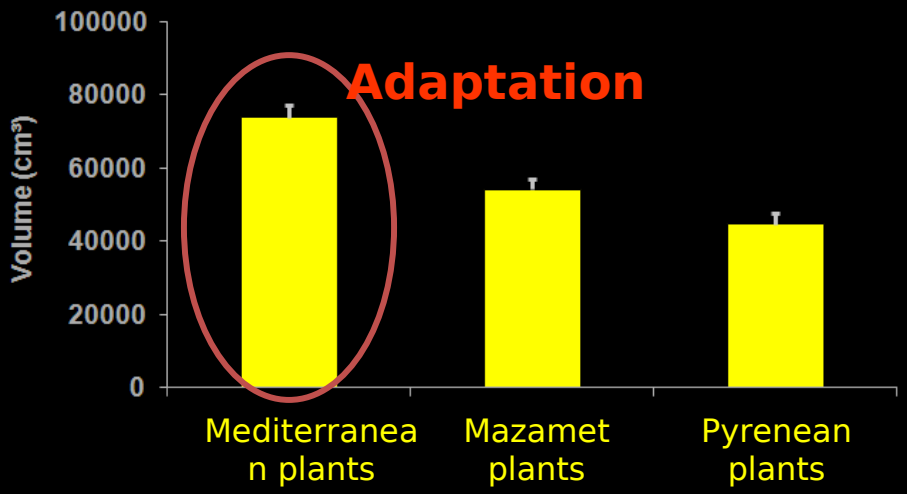
Environmental maternal effects depend on climate

Genetic differentiation: verified

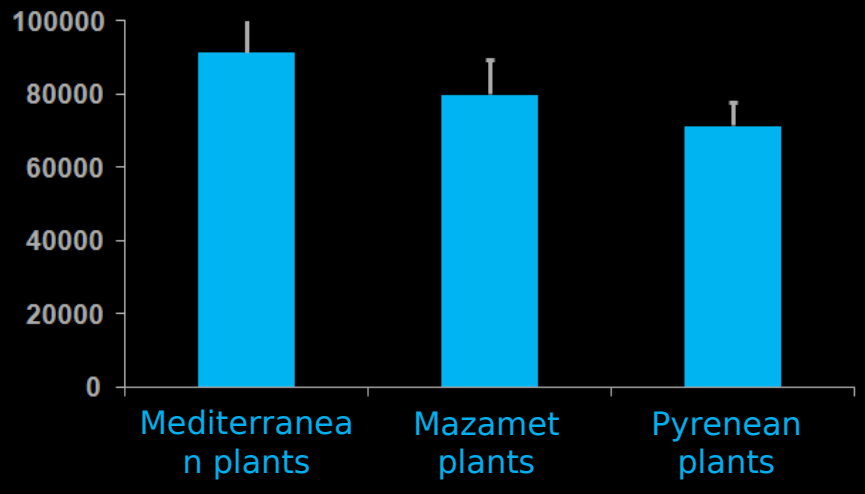
Plasticity in relation to climate

Local adaptation to climate ? Mediterranean: yes!

Mediterranean garden



Pyrenean garden



Materials & methods + results

Results:

Environmental maternal effects depend on climate

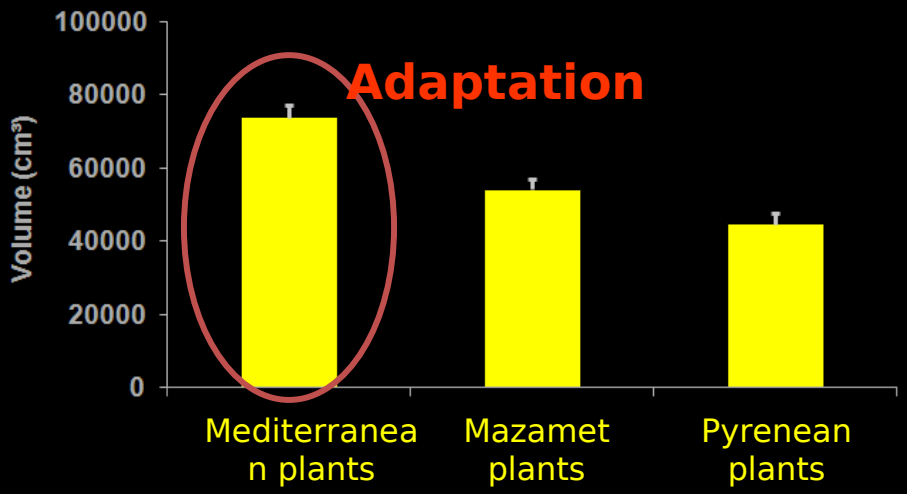
Genetic differentiation: verified

Plasticity in relation to climate

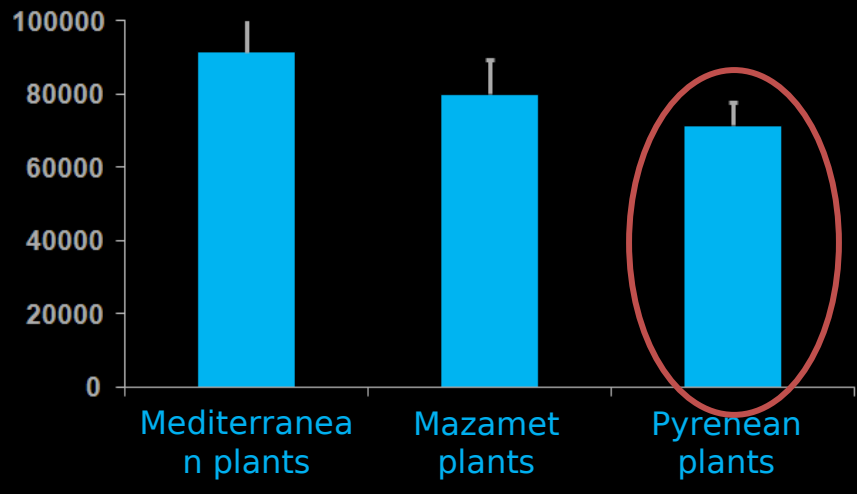
Local adaptation to climate ?

Mediterranean: yes!
Pyrenean: no clear pattern…

Mediterranean garden



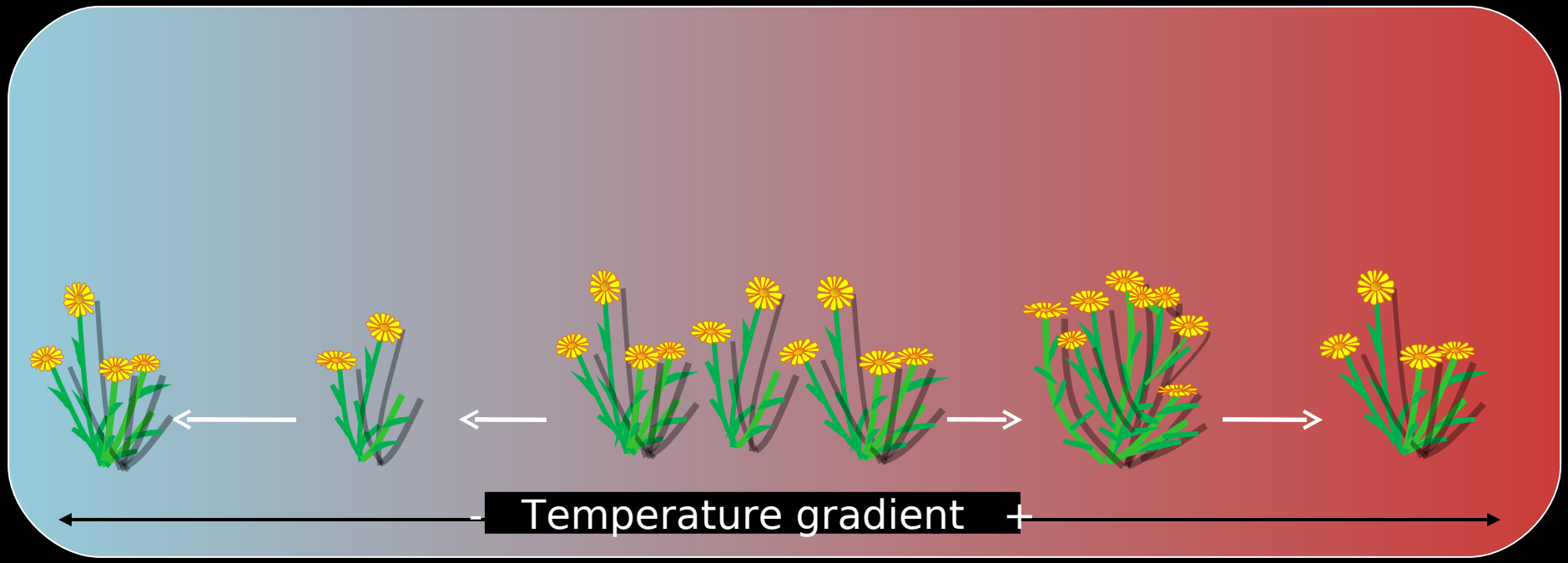
Pyrenean garden




Discussion

Discussion

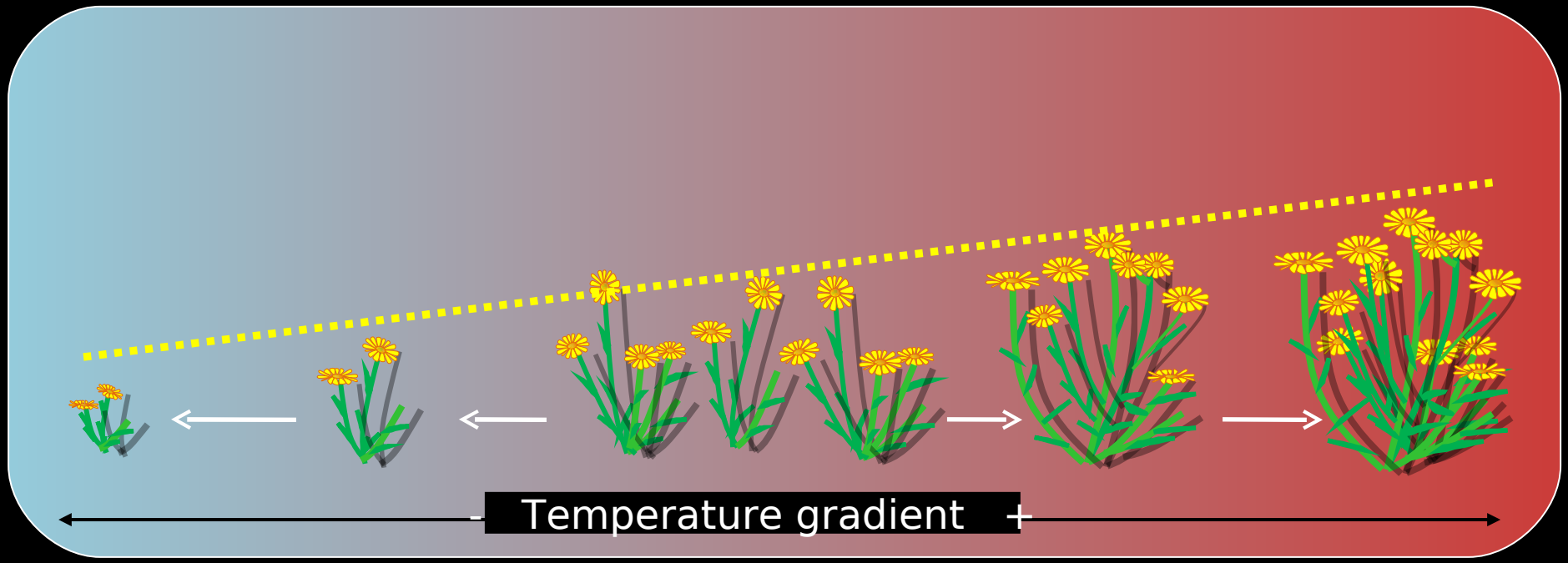
Invasion range



Discussion

➔ Clinal variation in natural populations

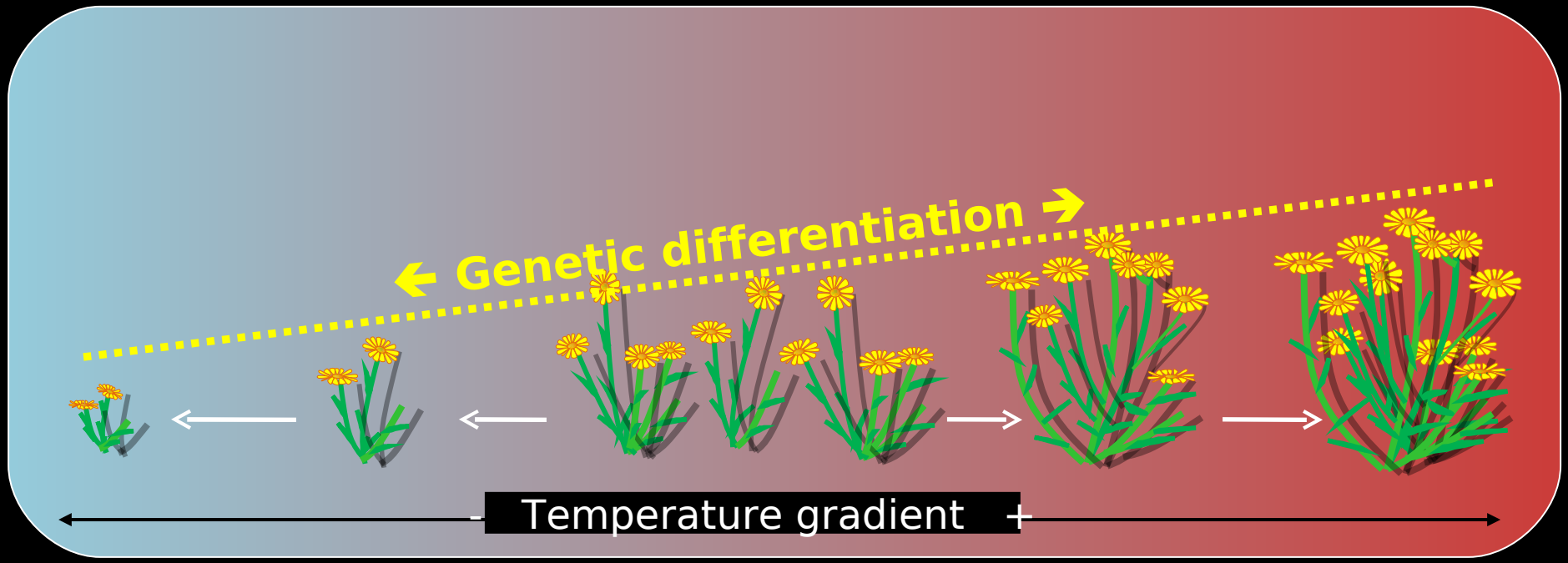
Invasion range



Discussion

- Clinal variation in natural populations
- Marked genetic differentiation:
  - *Adaptation to climate in the Mediterranean, for growth traits*

Invasion range



Discussion

- Clinal variation in natural populations
- Marked genetic differentiation:
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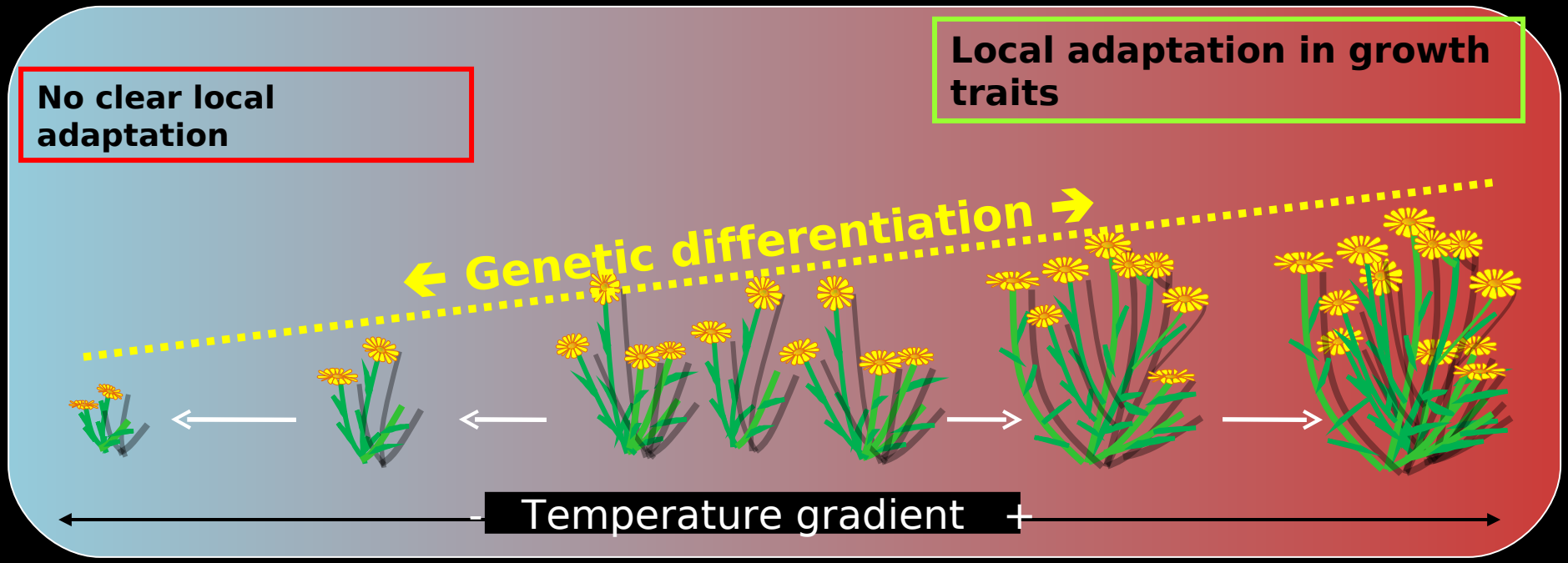
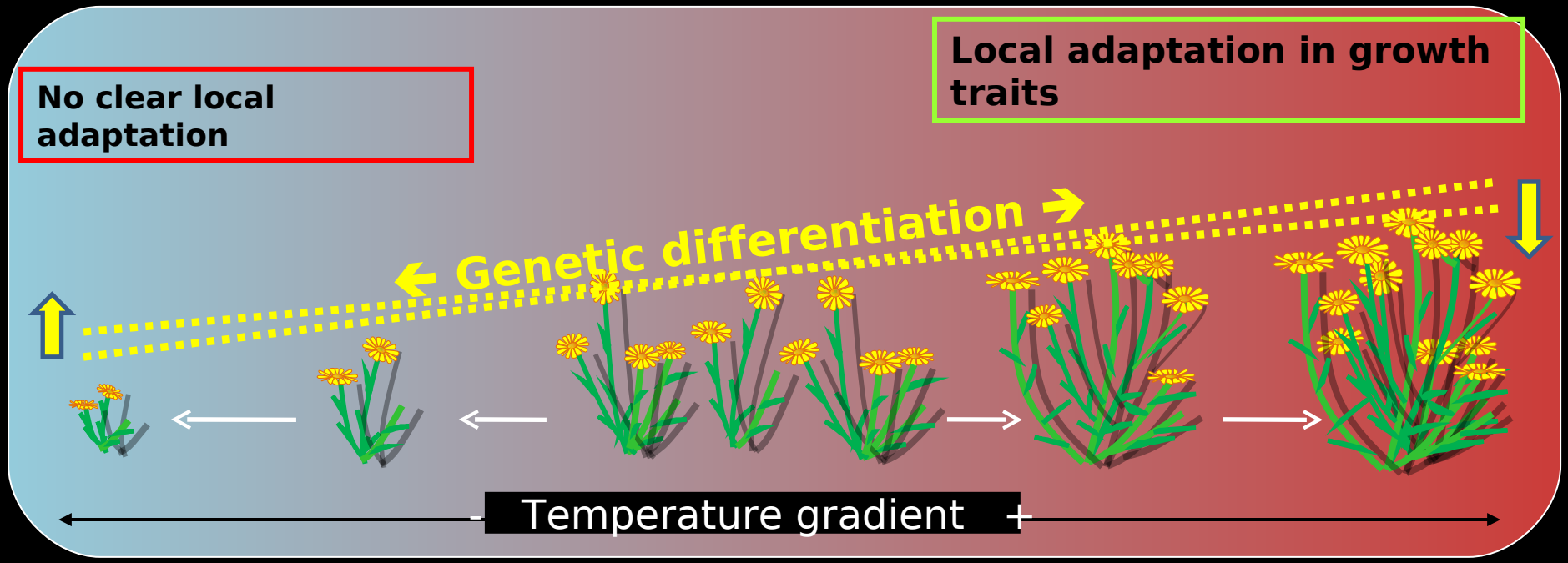
Invasion range



Discussion

- → Clinal variation in natural populations
- → Marked genetic differentiation:
- → Phenotypic plasticity related to climate
  - → *Not responsible for the clinal pattern (>< genetic trend)*

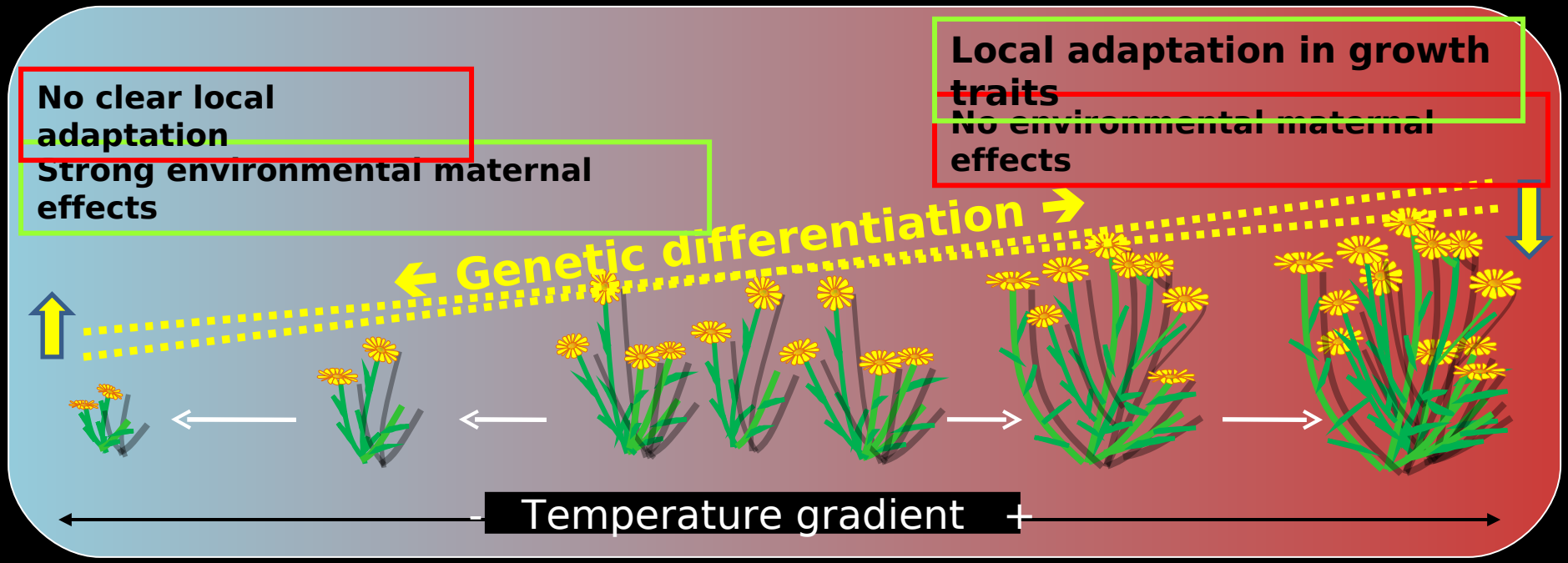
Invasion range



Discussion

- → Clinal variation in natural populations
- → Marked genetic differentiation:
- → Phenotypic plasticity related to climate
- → Environmental maternal effects in harsh climate
  - → *Functional importance of seed mass in mountains*

Invasion range



Conclusions

Conclusions

- **Rapid evolution (time scale < 100 years)** can help plant invasion in contrasted environments

- **Different mechanisms** can explain the success of aliens in **warmer** and **colder** areas

- **All the sources of phenotypic variation should be taken into account to understand the success of invasion in contrasted environments**

Thank you for your attention

This research was supported by the
FONDS NATIONAL DE LA RECHERCHE SCIENTIFIQUE

Laboratory of Ecology
Gembloux Agricultural University, Belgium

gembloux
faculté universitaire
des sciences agronomiques

FNRS