Warm temperatures increase biomass production of seedling: Implication for management of *Ludwigia hexapetala* and *Ludwigia peploides* subsp. *montevidensis*

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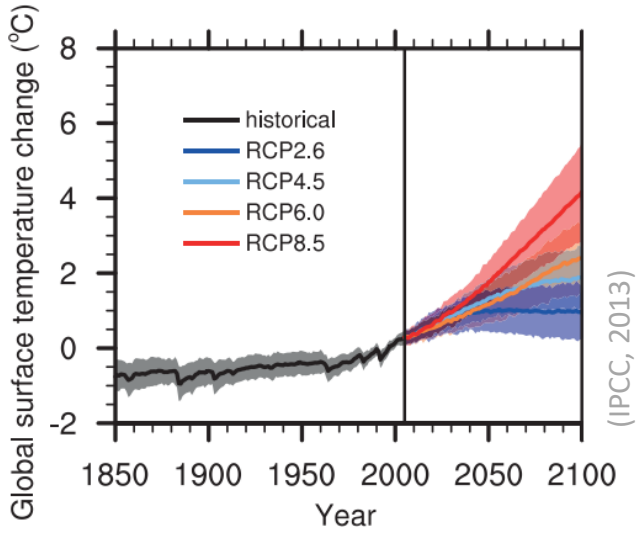
Climate change, an indirect influence of humans on ecosystems



Increase of greenhouse gas emission

+1 to +4°C by 2100

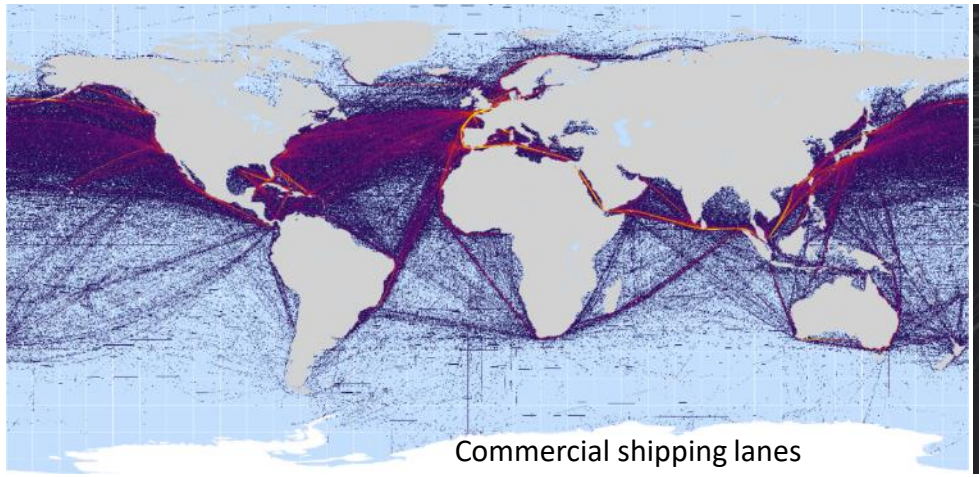
Precipitations

Extreme events

RCP 2.6

RCP 8.5

Biological invasions, a direct influence of humans on ecosystems



Commercial shipping lanes

Air routes

Increase of intercontinental exchanges ➡ displacement of some species (voluntary or involuntary)

Species introduced outside of its native range = exotic species

Some introduced species can become invasive

The case of freshwater ecosystems

Sensitive ecosystems

Biological invasions

favor

Climate change

- Hydrological regimes
- Drying up and flooding
- Temperature

- Multiple sources of introduction of exotic aquatic species (Strayer, 2010)
- Hydrosystems connectivity: dispersion facilitated

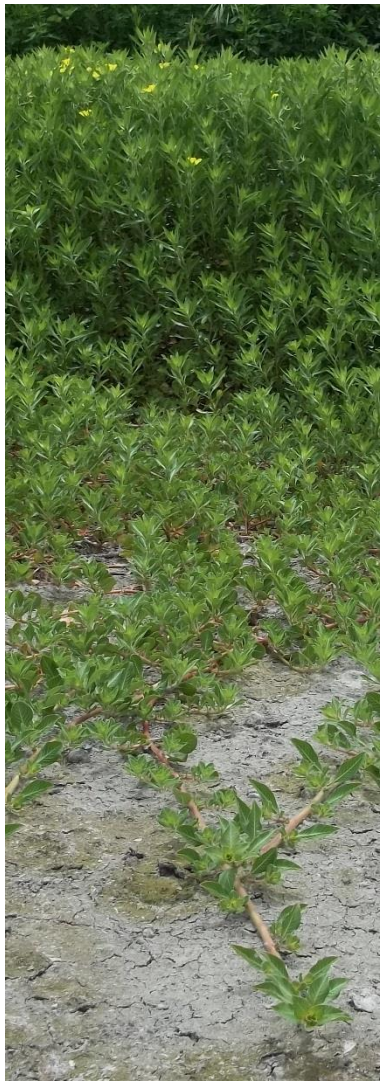
15 freshwater species
in the list of the 100 « worst » invasive species
(Lowe *et al.*, 2004)

First links in food webs: primary producers

The importance of understanding the reproduction of invasive species

- The establishment of an exotic plant species is determined by the effectiveness of recruitment and reproduction of new ramets or genets, critical to successful colonization and invasive spread

→ Knowledge about reproduction are crucial information for developing risk assessment and management strategies



Two congeneric species invasive in Europe and in North America

Ludwigia hexapetala

(Uruguayan primrose-willow)

decaploid

2 = 80

Ludwigia peploides

subsp. *montevidensis*

(Creeping water primrose/
Floating primrose willow)

diploid

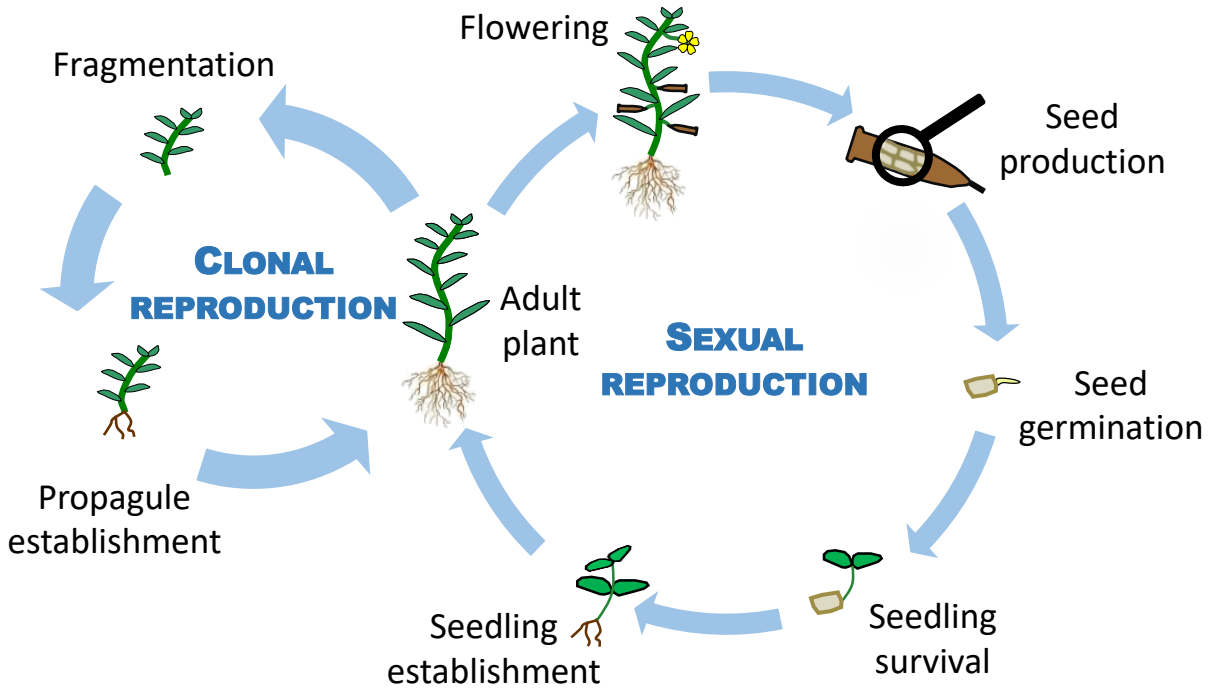
2 = 16

Two types of reproduction for the invasive Ludwigia

- Invasive *Ludwigia* taxa spread mainly clonally (limited genotypic variation) **except** in disturbed areas (Okada et al., 2009)

- Combining clonal and sexual reproduction represents an advantage to face changing conditions

- Few information about the sexual reproduction of these taxa



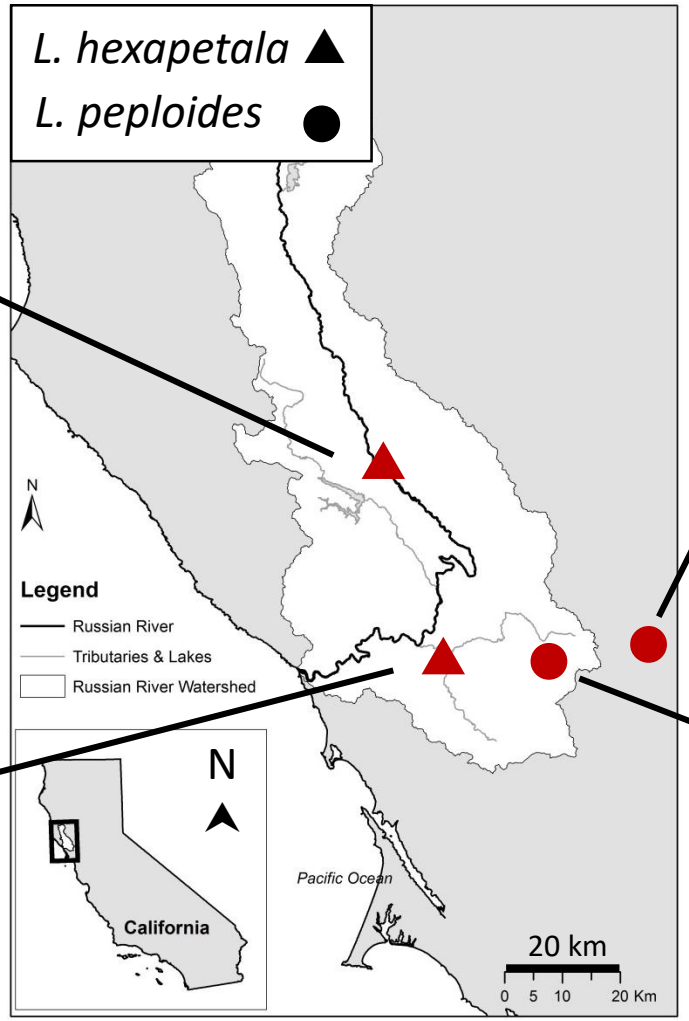
What is the impact of warmer temperatures on the germination, early seedling survival and growth of *L. hexapetala* and *L. peploides*?

Hypothesis : Warmer temperature favor the performances of the two taxa

Collection sites in California

Russian River @ Asti

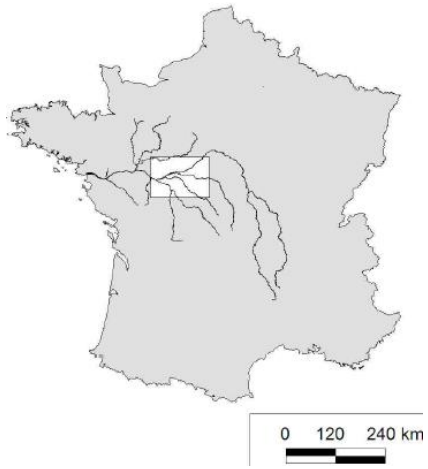
Laguna de Santa Rosa



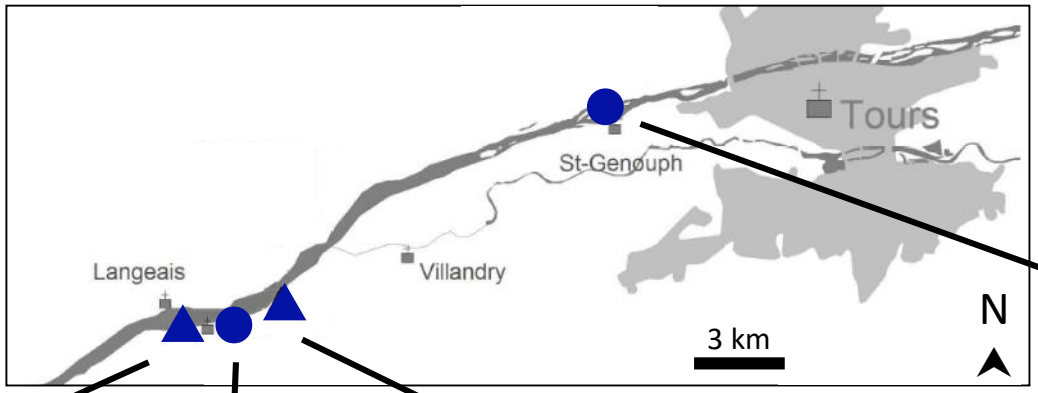
Sage Creek – Napa River Watershed

Spring lake

Collection sites in France



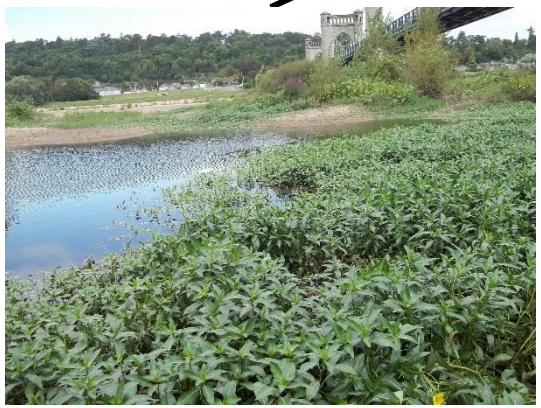
@ the Loire River



L. hexapetala ▲

L. peploides ●

Port de Vallières

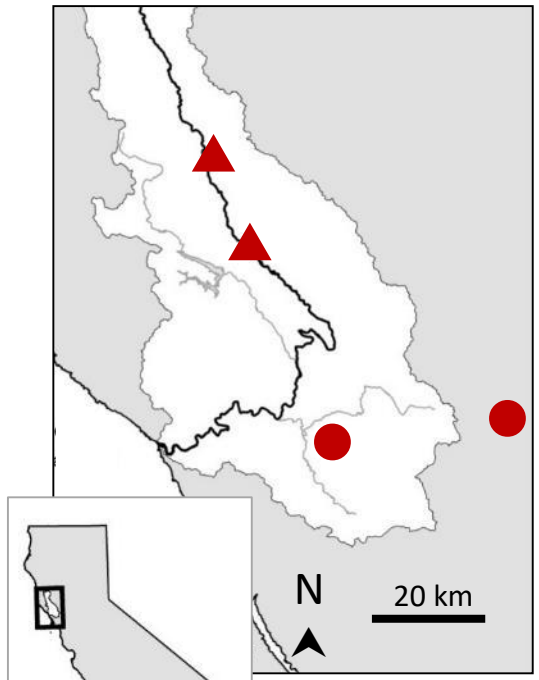


Ile du château

Ile Joli Cœur

Les Raguins

Reciprocal transplant experiment



12 capsules per population

sowing

2304 seeds

Experimental gardens May-June 2016

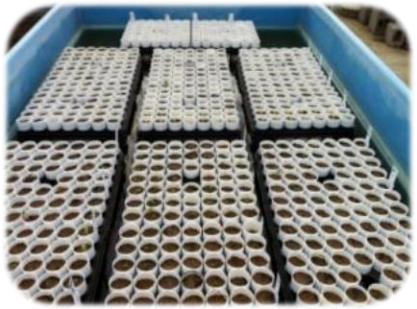
CA

Davis (CA, USA)

+5.6°C

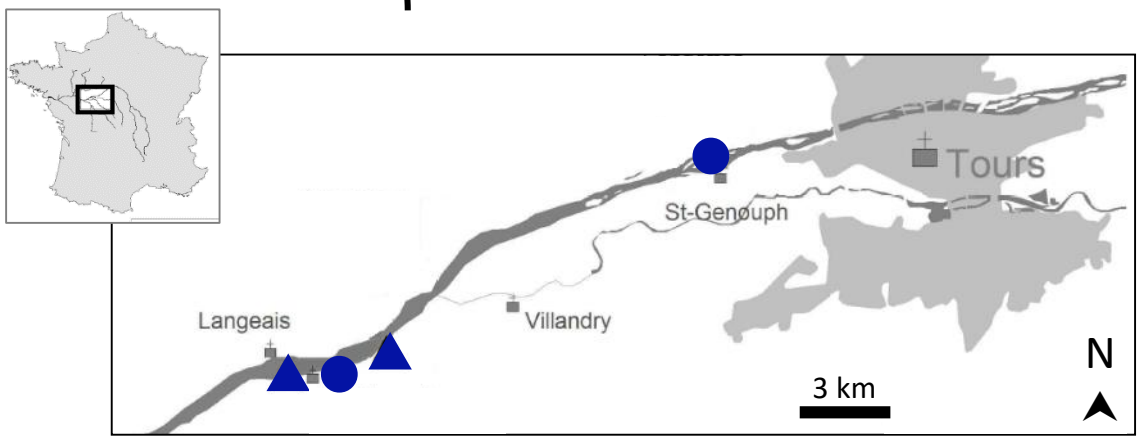
FR

Rennes (France)



L. hexapetala ▲

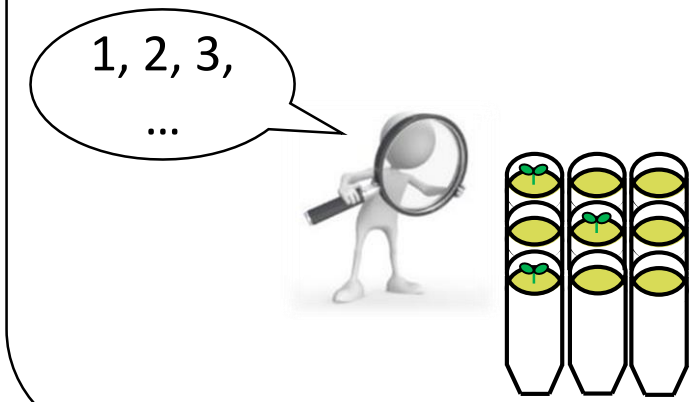
L. peploides ●



(Ruaux, 2008)

Trait response measurements

Monitoring 3 times a week for 47 days

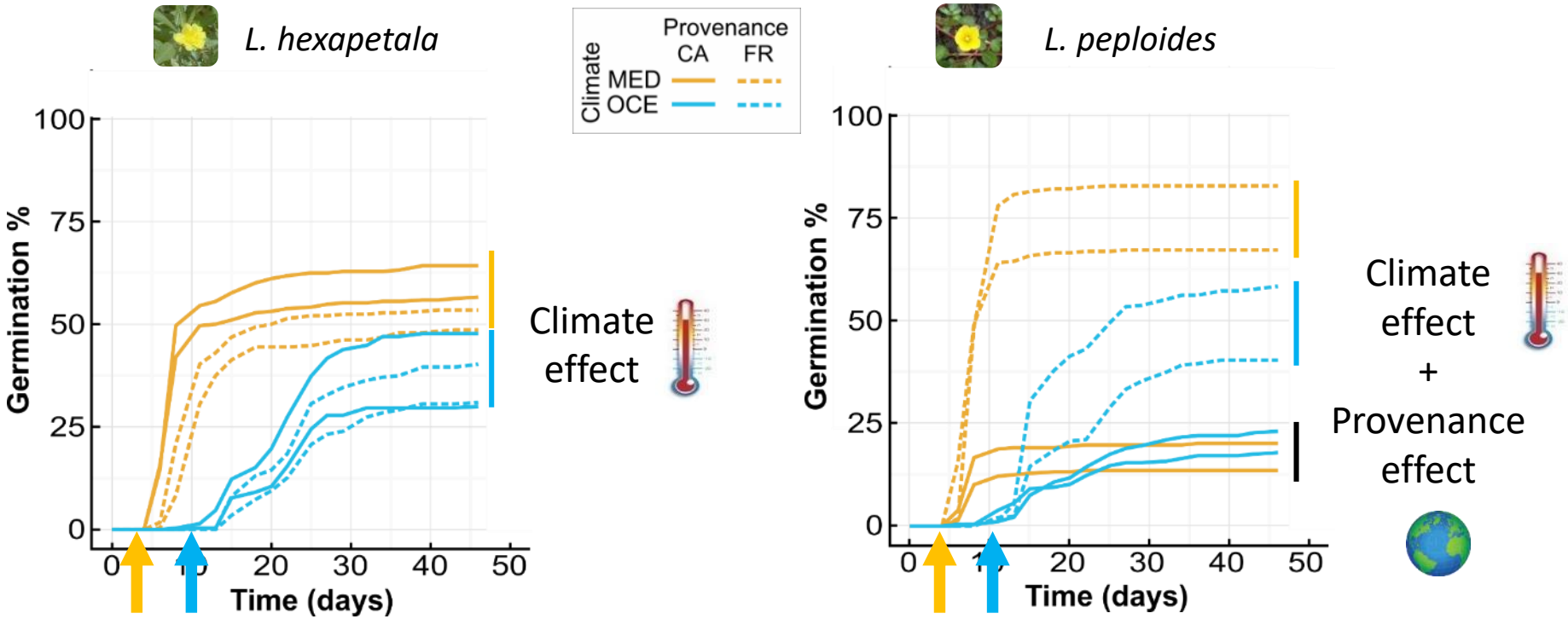


After 47 days:

- Ungerminated seeds: Test of embryo viability
- Seedlings :

Shoots and roots { length  dry biomass 

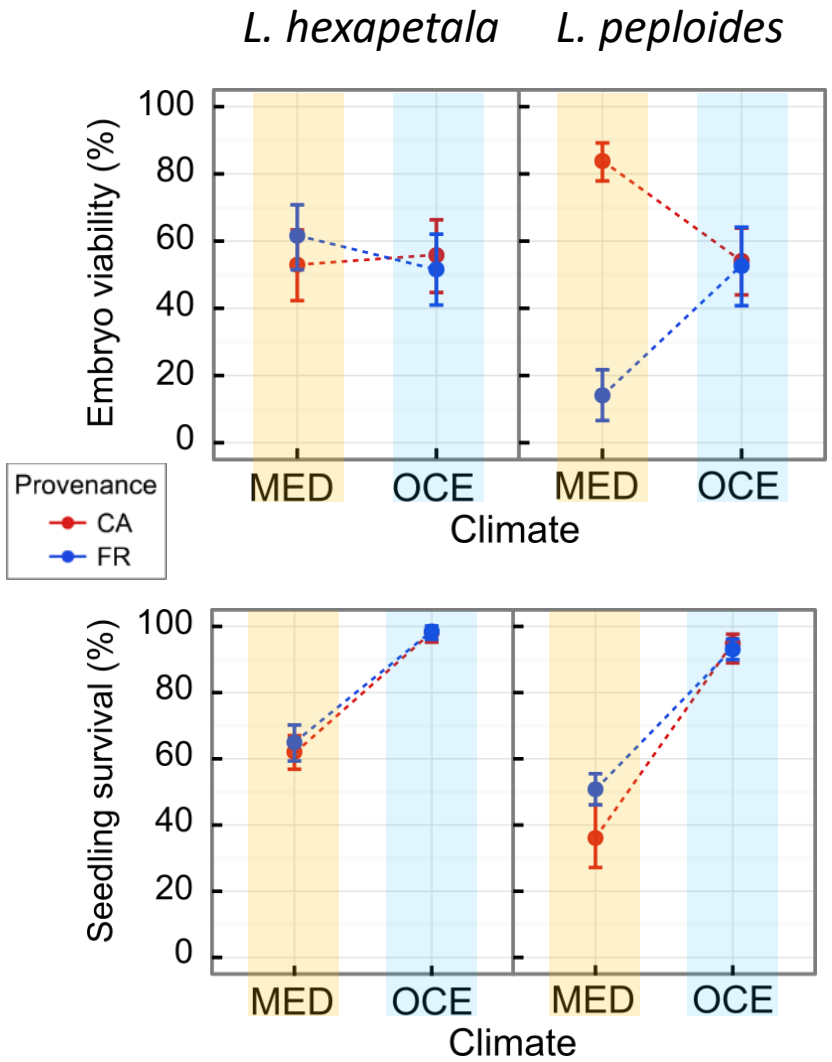
Germination characteristics



Temperature increase
- Germination velocity ↗
- Germination percentage ↗ or =

Gillard *et al.* (2017) *Frontiers in Plant Science*

Embryo viability and seedling survival



- **Embryo viability of ungerminated seeds**

L. hexapetala

No effects

L. peploides

Climate effect positive or negative, depending on seeds provenance

- **Seedlings survival**

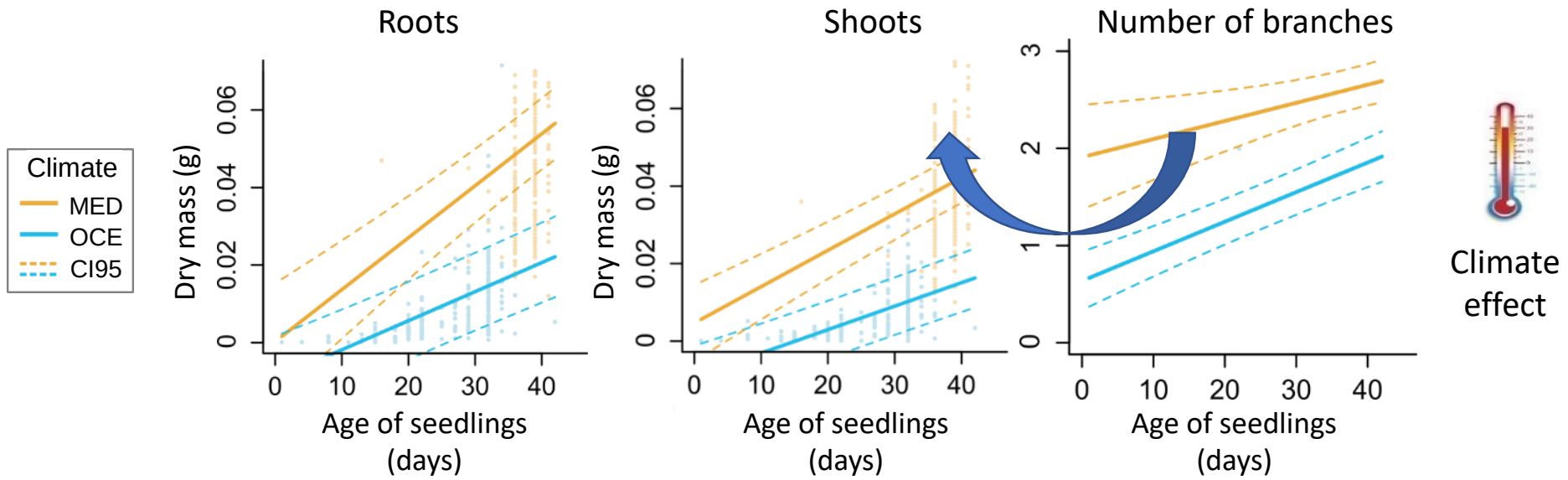
L. hexapetala

L. peploides

negative climate effect

Gillard *et al.* (2017) *Frontiers in Plant Science*

Seedling characteristics



No climate effect on the length of shoots and roots

Roots more ramified and/or thicker

Gillard *et al.* (2017) *Frontiers in Plant Science*

In the end, does warmer climate favour invasive *Ludwigia* taxa?

Warmer temperatures:

- Germination velocity ↗
- Germination % ↗ or =
- Seedling biomass ↗
- Seedling survival ↘

In average, total biomass produced = **6.7-fold greater** under warmer climate

→ **Warmer climate = favorable**

Gillard *et al.* (2017) *Frontiers in Plant Science*

Implications for management

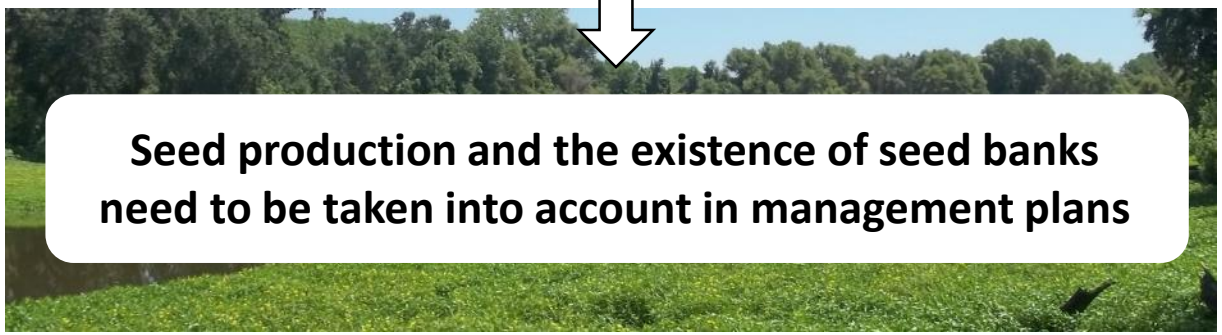
Under Oceanic-type climate

- In the future:
  Establishment from sexual propagules, with higher biomass production as temperature increase

Under Mediterranean-type climate

- Currently :
  Invasive *Ludwigia* taxa grow easily and fast from the seeds they produce
- In the future:
  Increase of habitat disturbance
  → Recruitment from seed bank facilitated?

Climate warming may increase
the invasiveness of *L. hexapetala* and of *L. peploides*



Seed production and the existence of seed banks need to be taken into account in management plans

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Thank you for your attention