LSV - Montpellier

Biological Invasions

Success factors for plant invasions

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Surpervised by Guillaume Fried

anses

UNIVERSITÉ DE MONTPELLIER

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What is an invasive plant ?

- naturalized taxon
- produces fertile individuals, often in very large numbers
- spreads rapidly over a considerable area
- strong growth in local abundance (populations becoming dominant) and in regional frequency (regional expansion)

In France, 3,029 species of exotic plants have been recorded.

(INPN, 2021)

Richardson et al. (2000) **Diversity and Distributions**
Fried et al. (2024) **Naturae**

IPBES Invasive Alien Species Assessment: Summary for Policymakers

Roy, Helen E.[1]; Pauchard, Aníbal[2]; Stoett, Peter[3]; Renard Truong, Tanara[4]; Bacher, Sven[5]; Galil, Bella S.[6]; Hulme, Philip E.[7]; Ikeda, Tohru[8]; Sankaran, Kavileveettil[9]; McGeoch, Melodie A.[10]; Meyerson, Laura A.[11]; Nuñez, Martin A.[12]; Ordonez, Alejandro[13]; Rahlao, Sebataolo J.[14]; Schwindt, Evangelina[15]; Seebens, Hanno[16]; Sheppard, Andy W.[17]; Vandvik, Vigdis[18]

A. Invasive alien species are a major threat to nature, nature's contributions to people, and good quality of life

→ socio-economic and health threats

→ environmental threats

B. Globally, invasive alien species and their impacts are increasing rapidly and are predicted to continue rising in the future

→ dynamics difficult to predict

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KM-A3 **The economy, food security, water security and human health are profoundly and negatively affected by invasive alien species**

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KM-A3 **The economy, food security, water security and human health are profoundly and negatively affected by invasive alien species**

→ environmental threats

KM-A2 **Invasive alien species cause dramatic and, in some cases, irreversible changes to biodiversity and ecosystems, resulting in adverse and complex outcomes across all regions of Earth, including local and global species extinctions**

B. Globally, invasive alien species and their impacts are increasing rapidly and are predicted to continue rising in the future

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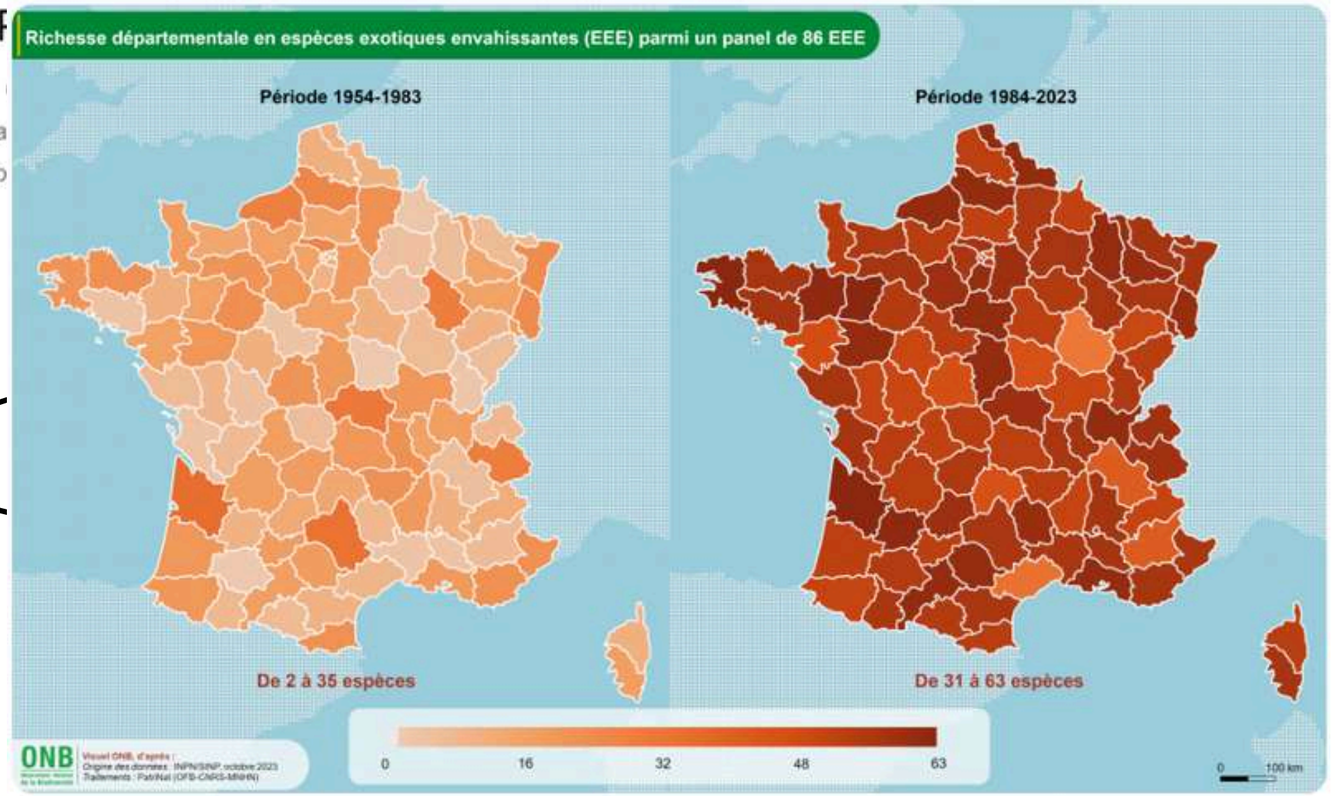


B. Globally, invasive alien species and their impacts are increasing rapidly and are predicted to continue rising in the future

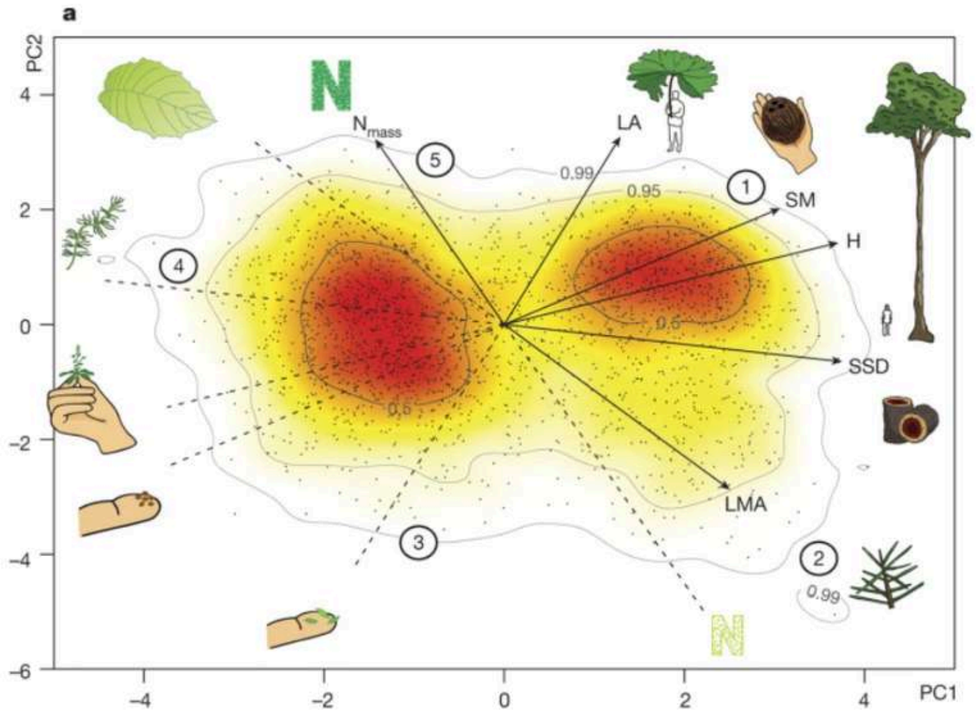
→ dynamics difficult to predict

KM-B4 **The magnitude of the future threat from invasive alien species is difficult to predict because of complex interactions and feedback among direct and indirect drivers of change in nature**

Functional ecology and trait study

> *By identifying plant fonctional types, it may be possible to predict, monitor and manage impacts of environnemental change.*
>
> *Philip Grime, 2003*

Figure 2: The global spectrum of plant form and function.



Dìaz et al. (2016) **Nature** 529: 167

Functional trait

- morphological, biochemical, physiological, structural or phenological characteristics of organisms that influence performance or fitness

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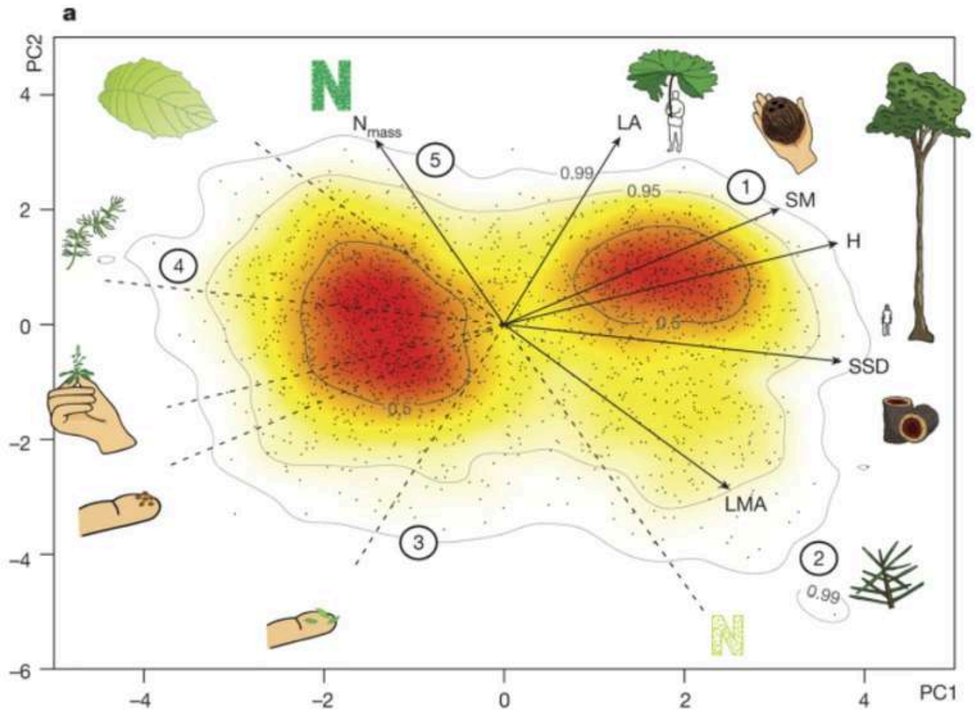

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Functional trait

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Two common applications :

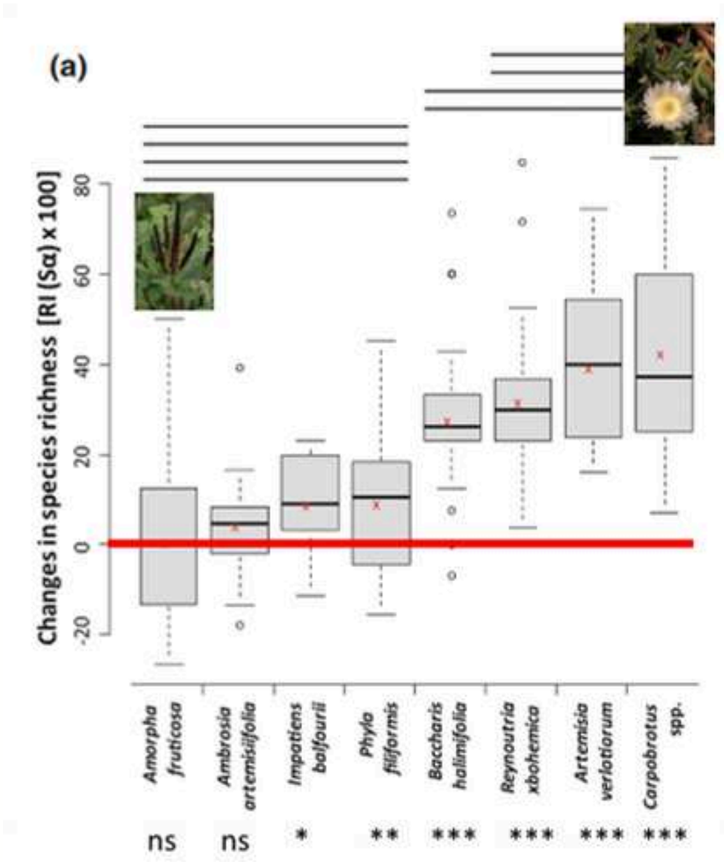
- characterise community responses to changes in the environment
- quantify the influence of community shifts on ecosystem processes.

Biol Invasions (2014) 16:1639–1658
DOI 10.1007/s10530-013-0597-6

ORIGINAL PAPER

Impact of invasive plants in Mediterranean habitats: disentangling the effects of characteristics of invaders and recipient communities

G. Fried · B. Laitung · C. Pierre · N. Chagué · F. D. Panetta



- Baisse moyenne de 34% de la richesse spécifique
  Carpobrotus spp. [Dunes] - 65.8% ***
  Amorpha fruticosa [Dunes] + 2.3% ns

Fried et al. (2014) ***Biological Invasions*** 16 (8) : 1639-1658.

Diversity Indexes according to biological type

Table 3 Hierarchical general linear model used to examine the mean relative impacts (RI) of invasive plants grouped in growth forms

	S (α-species richness)	H′ (Shannon's diversity)	D_j (Jaccard dissimilarity index)
Anova table			
Species (life forms)	$F_{4,202} = 23.95$; $P < 0.001$	$F_{4,202} = 6.69$; $P < 0.001$	$F_{4,202} = 8.94$; $P < 0.001$
Life forms	$F_{3,202} = 25.44$; $P < 0.001$	$F_{3,202} = 2.87$; $P = 0.037$	$F_{3,202} = 14.11$; $P < 0.001$
Mean RI per life form			
Rhizomatous perennials	0.36 ± 0.17^{a}	0.12 ± 0.21^{a}	0.76 ± 0.13^{a}
Creeping perennials	0.26 ± 0.25^{a}	0.07 ± 0.24^{ab}	0.66 ± 0.17^{b}
Shrubs	0.14 ± 0.22^{b}	0.04 ± 0.25^{ab}	0.56 ± 0.21^{c}
Annuals	0.07 ± 0.01^{b}	-0.01 ± 0.01^{b}	0.66 ± 0.15^{bc}

Similar single letter (a, b, c) indicates groups that are not significantly different ($P < 0.05$, Tukey–Kramer post hoc tests)

Fried et al (2014) **Biological Invasions**

Diversity Indexes according to biological type

underground competition

↳ resulting in stands with a very high cover

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Similar single … ps t… erent … ost…

Artemisia verlotiorum

Reynoutria x bohemica

Phyla filiformis

Carpobrotus

Fried et al (2014) **Biological Invasions**

A two-step study

1

Study of functional diversity

Study of flora response traits (biotic filter response traits) and consequences for the ecosystem (pollination-related effect traits).

- *Understand the dynamics of establishment and expansion of invasive species*
- *Assess impacts on other plants and pollinators, and associated risks*

A two-step study

2

Study of temporal dynamics

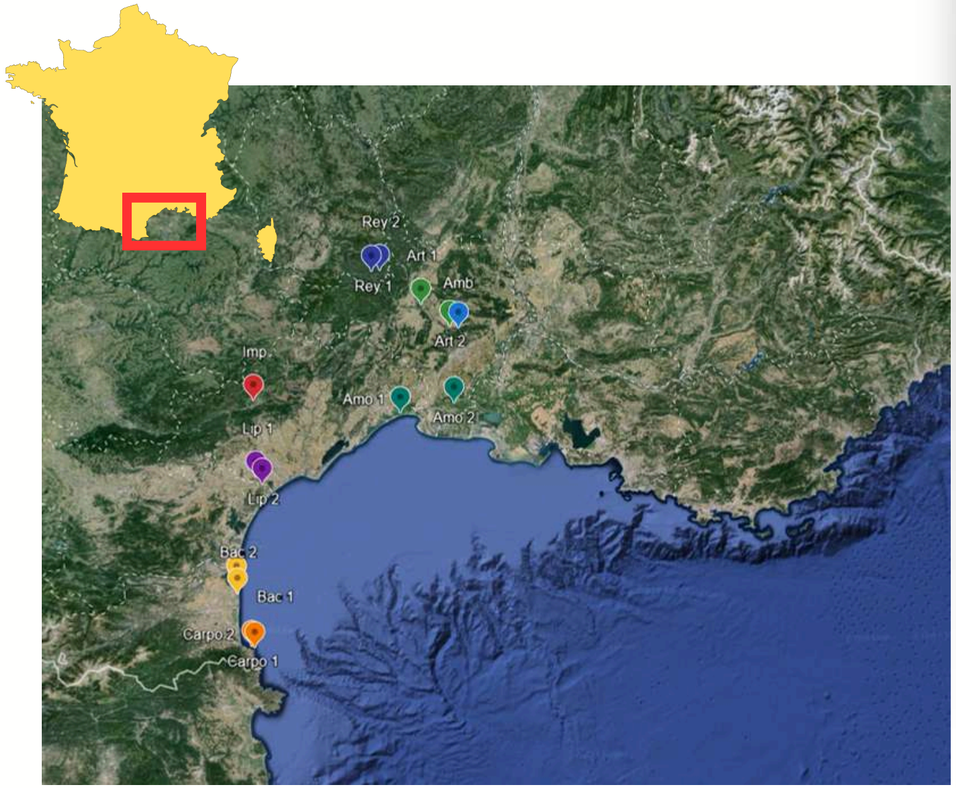
Study of the temporal evolution of the impact of invasive plants
Revisit plots sampled 10 years ago

A significant decline in taxonomic richness averaging 34% was observed on these plots, what about 10 years later ?

- *Assess the probability of temporal persistence of invasive plants and the associated risks*
- *Discuss the need to implement means of managing invasive plants based on the persistence of risks*

Biological materials

- 8 invasive species from the Mediterranean basin



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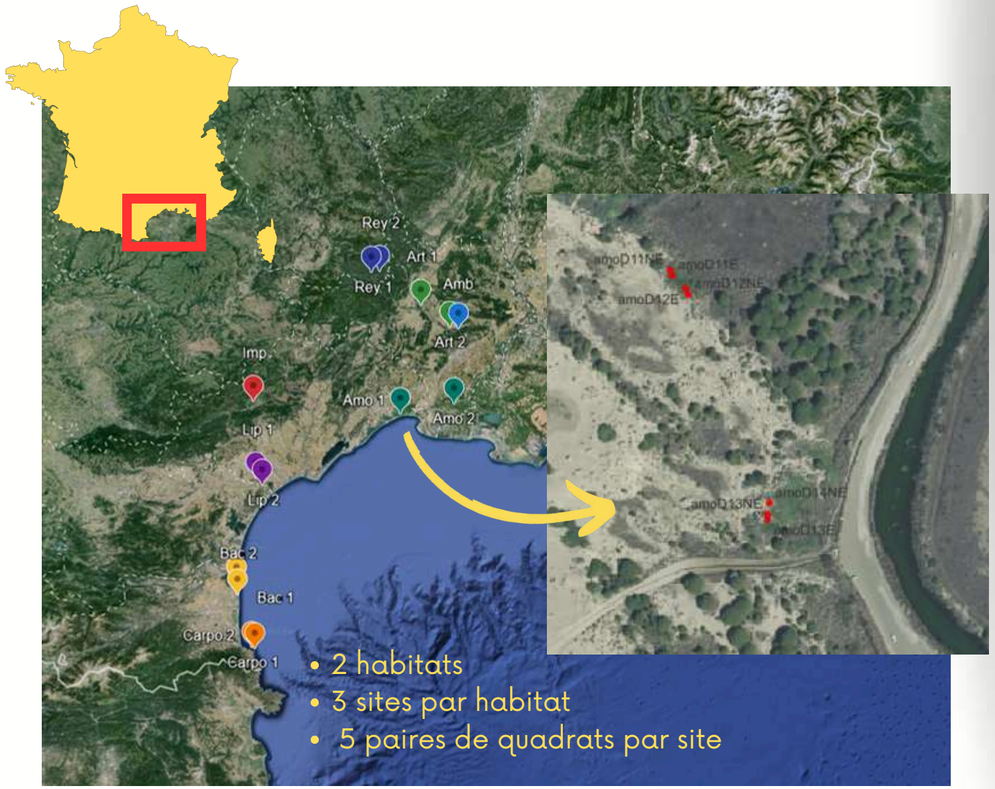
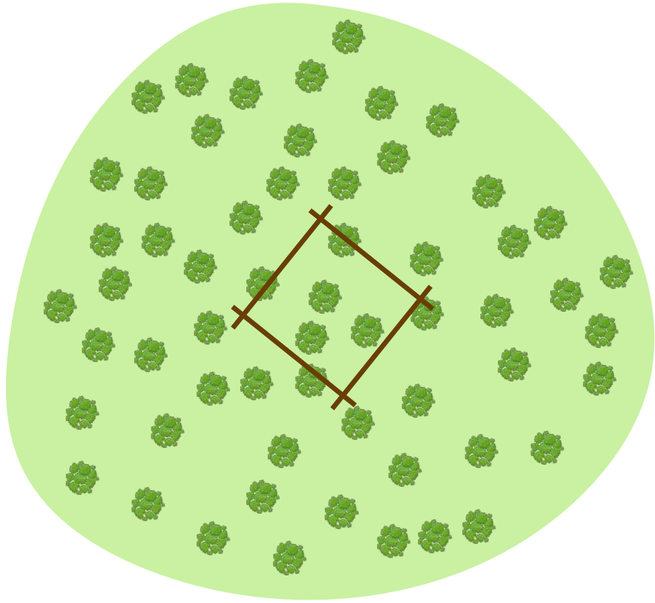


Mesuring the impact in the field

Data collection : 420 quadrats (4m²)

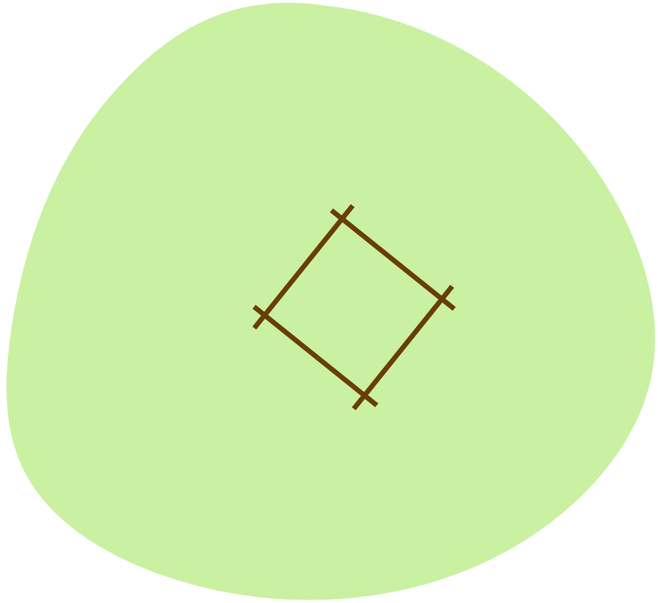
- **Type of habitat**
- **Abundancy of each species**
- **Height of the dominant species**
- **Height of the invasive species**

Invaded site

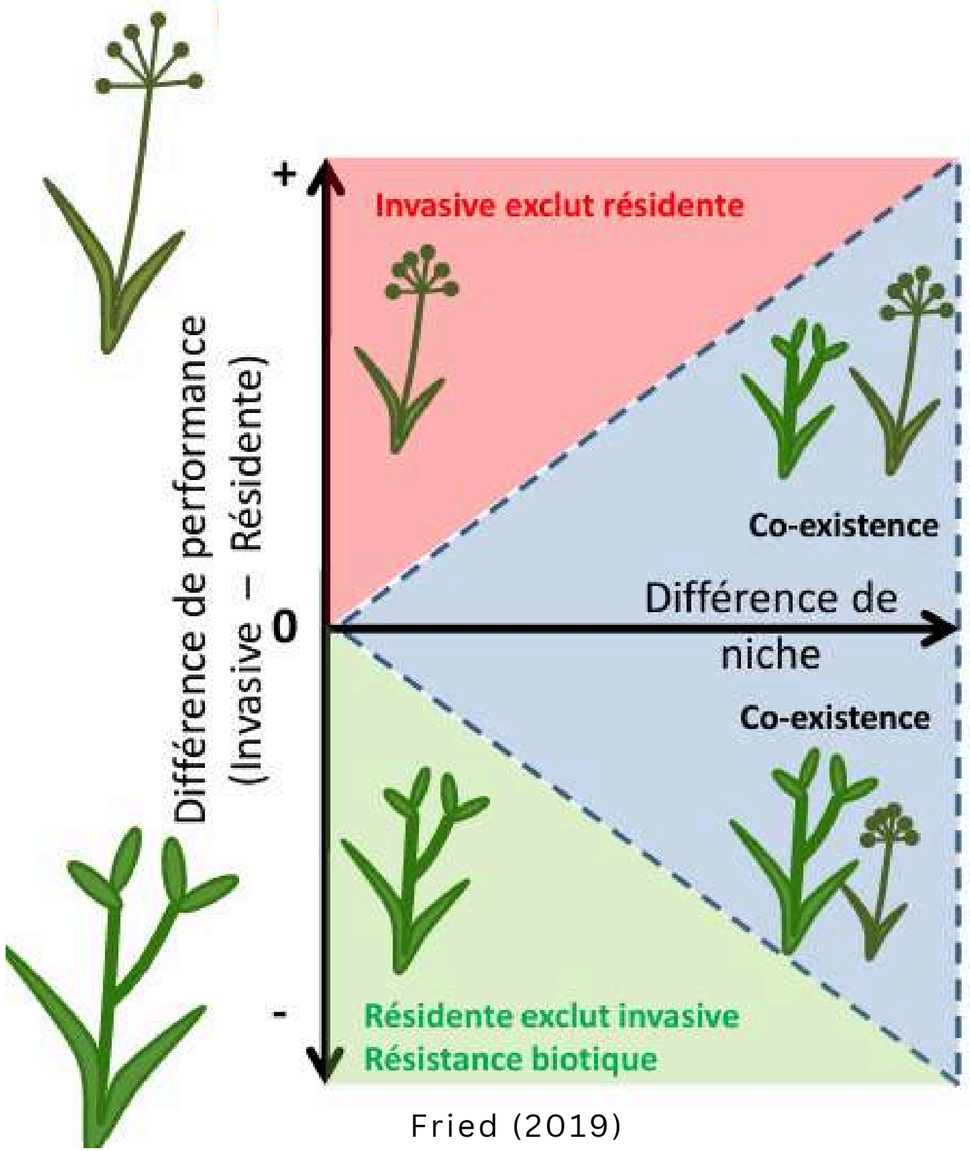


vs

Non Invaded site



Coexistence hypothesis



Fried (2019)

Chesson (2000) **Annual review of Ecology, Evolution and Systematics**
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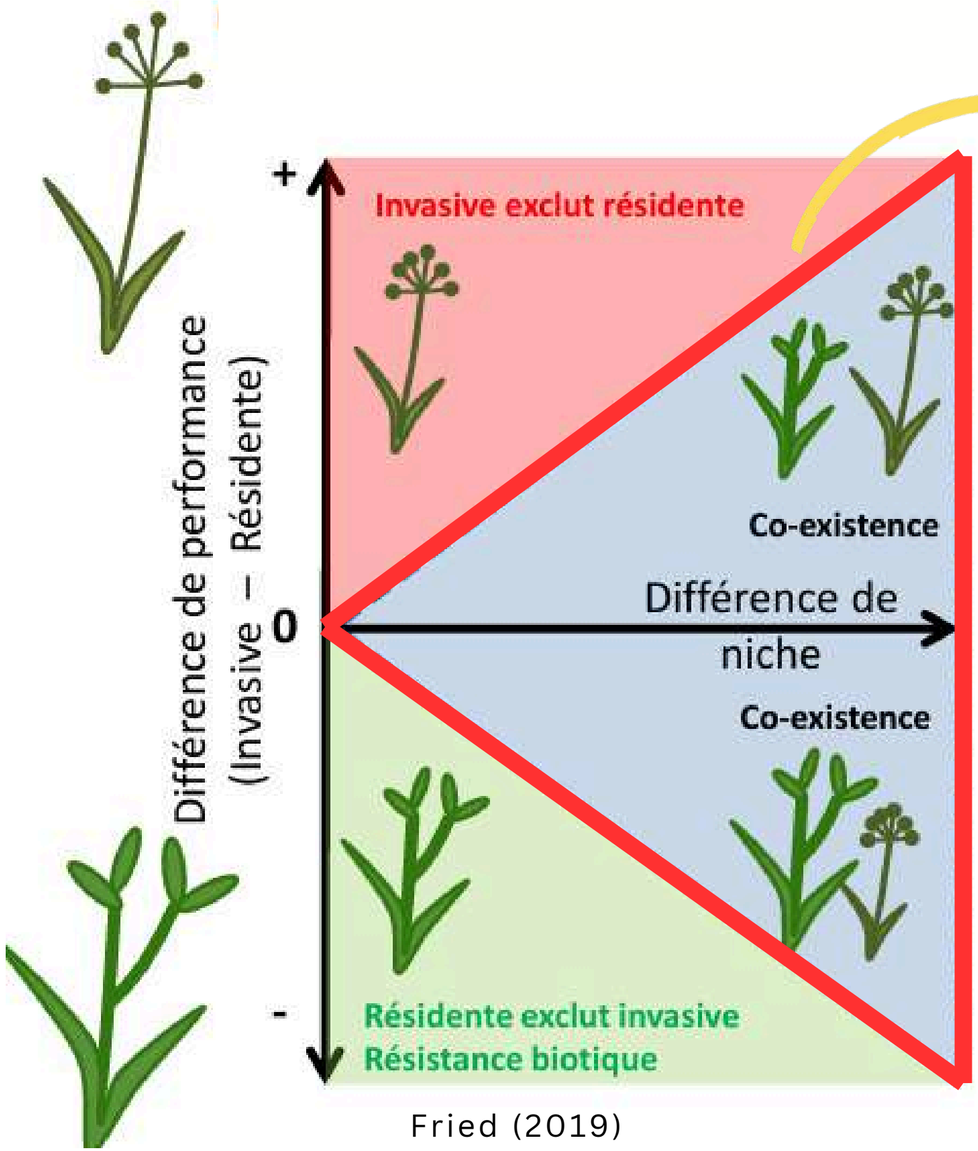
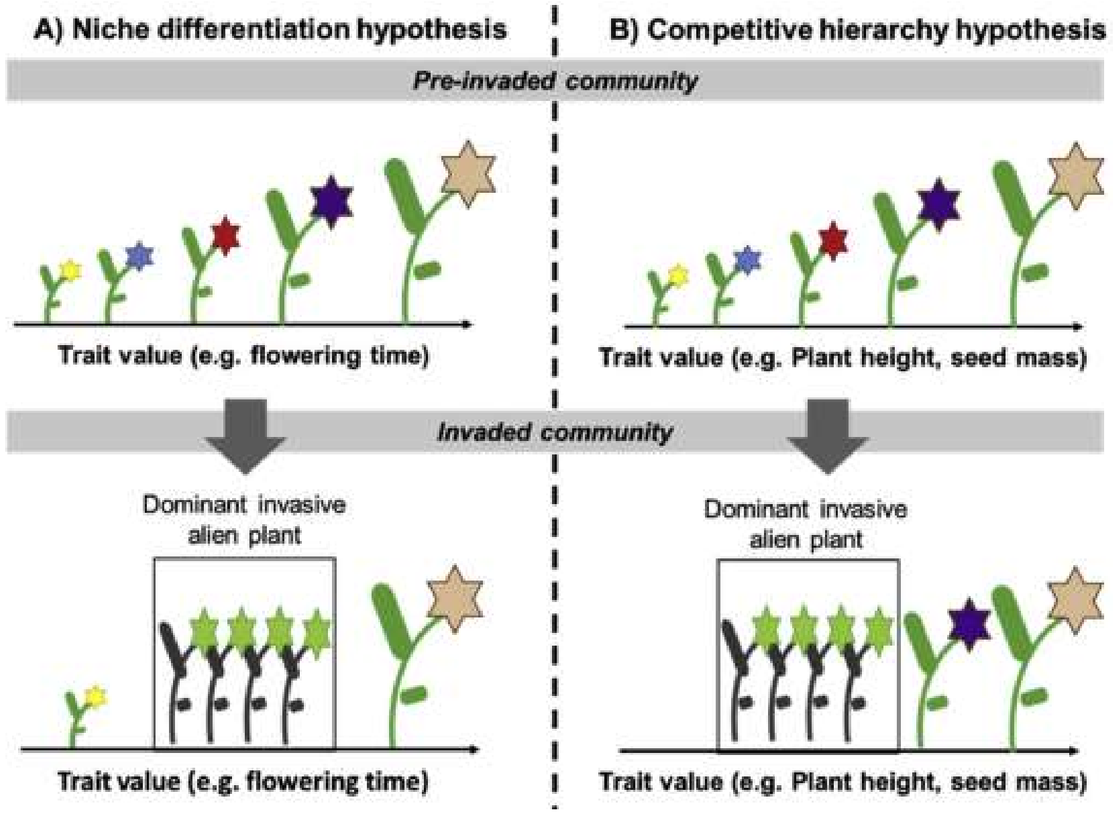


Fried (2019)

Hypothesis 1: Niche differentiation



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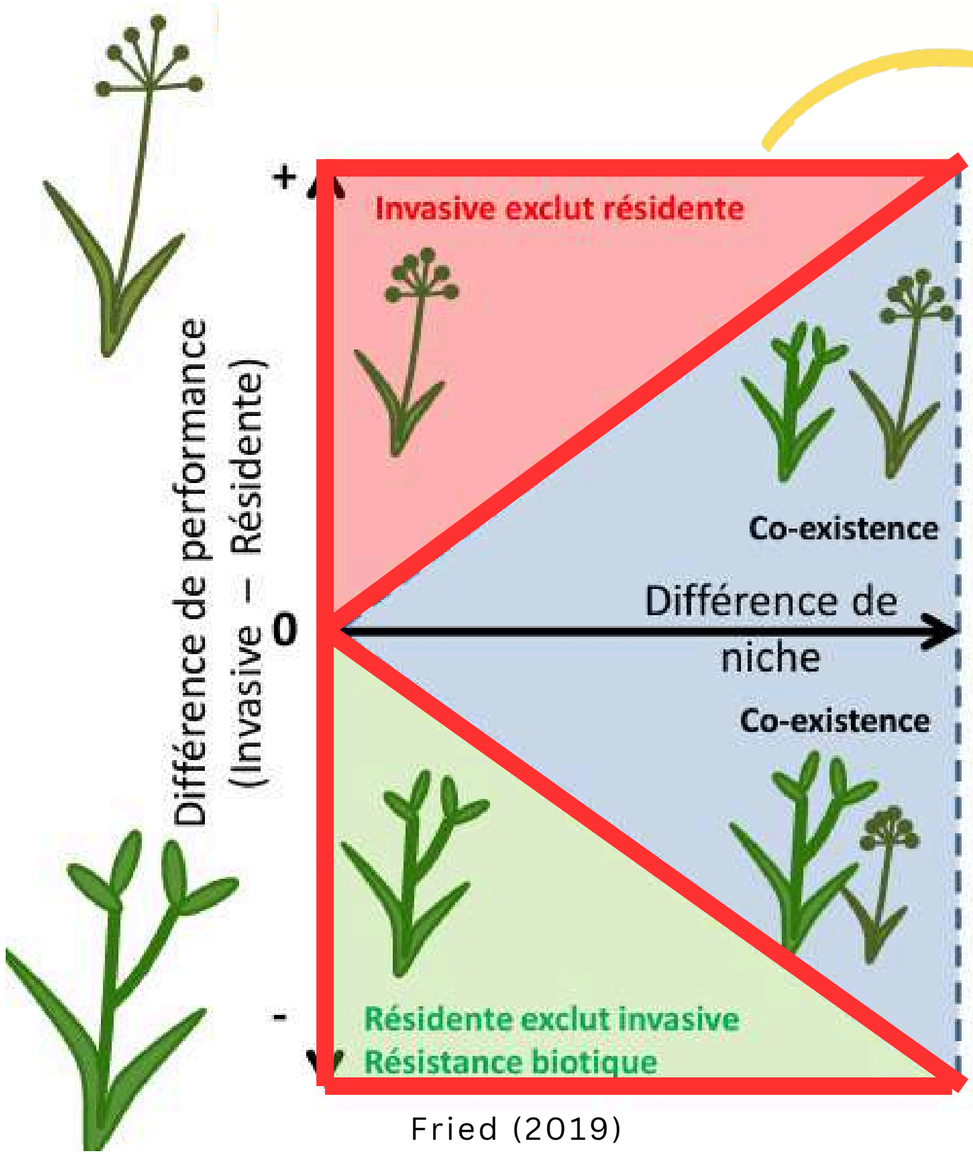
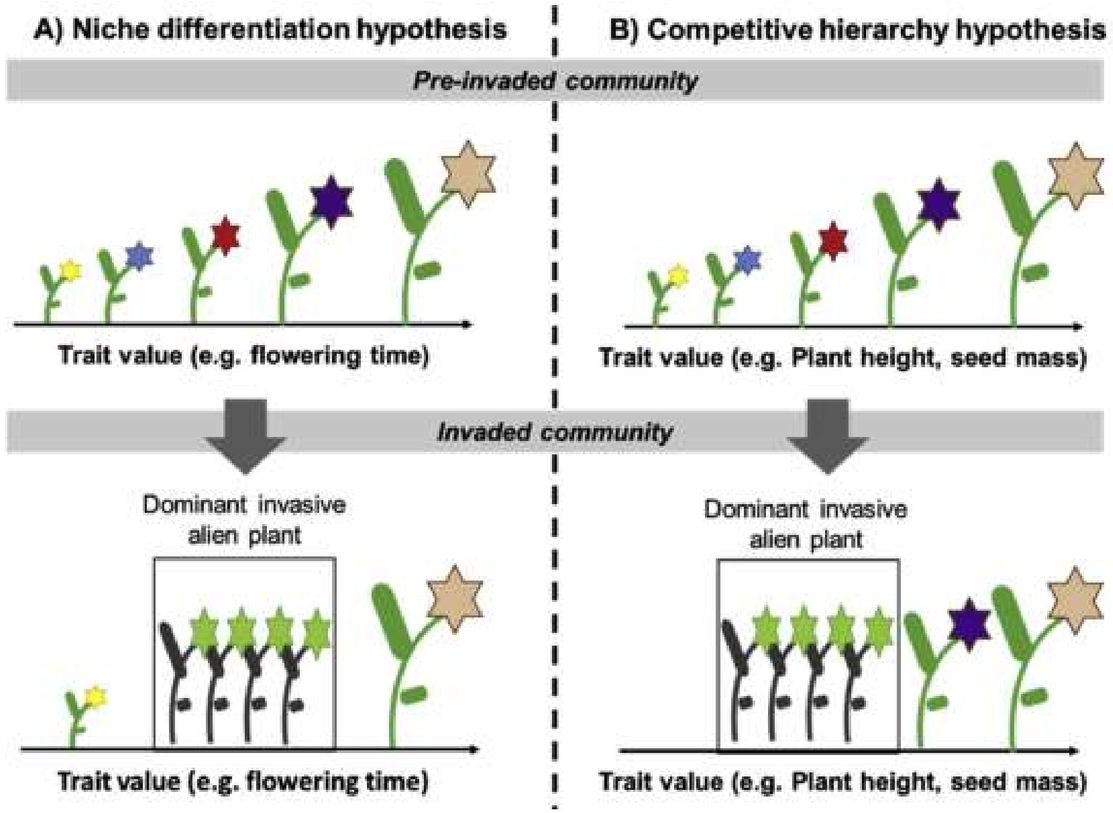


Fried (2019)

Hypothesis 2: Performance difference



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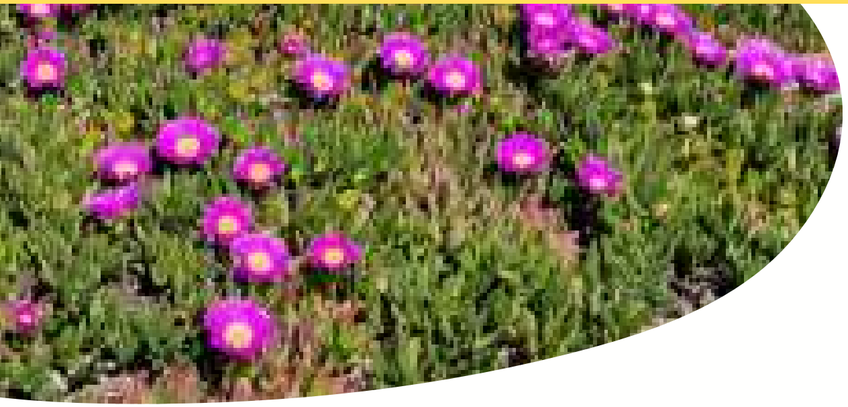
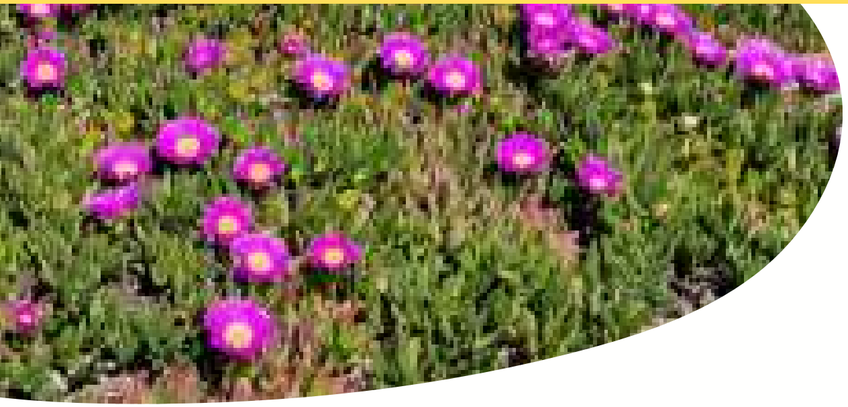


Quantifying the impact with Community weighted mean

Between invaded and non-invaded sites :

compare the weight of each functional trait between resident communities on invaded and non-invaded sites

©G Fried



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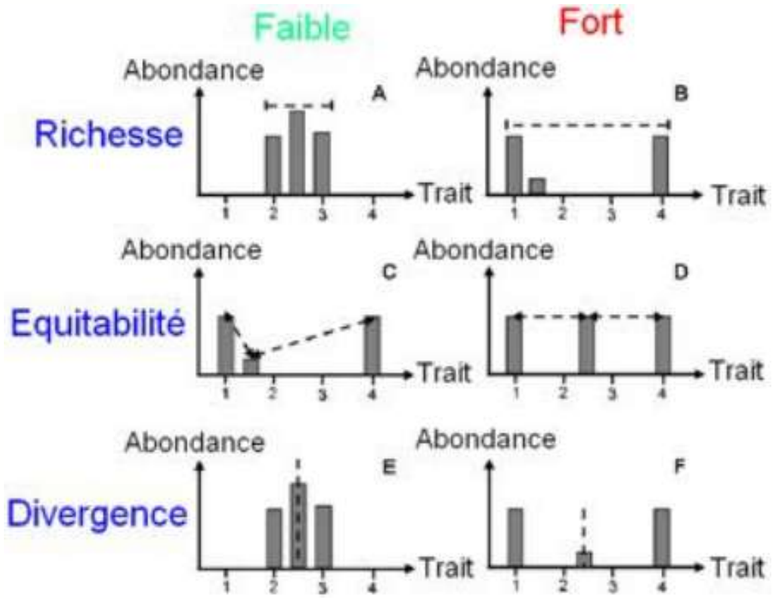
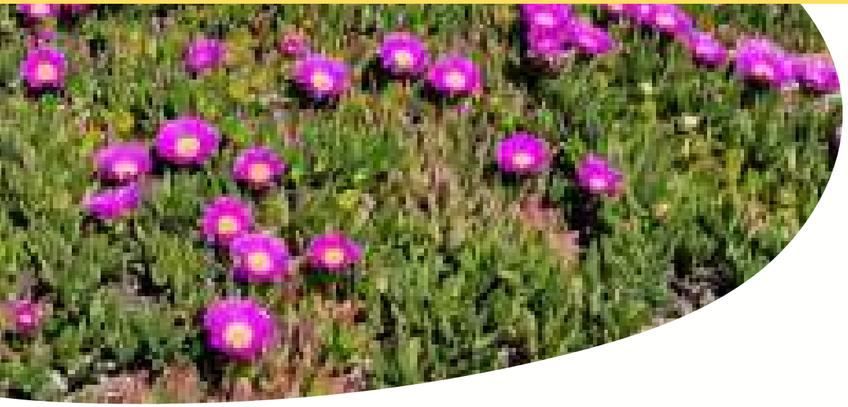


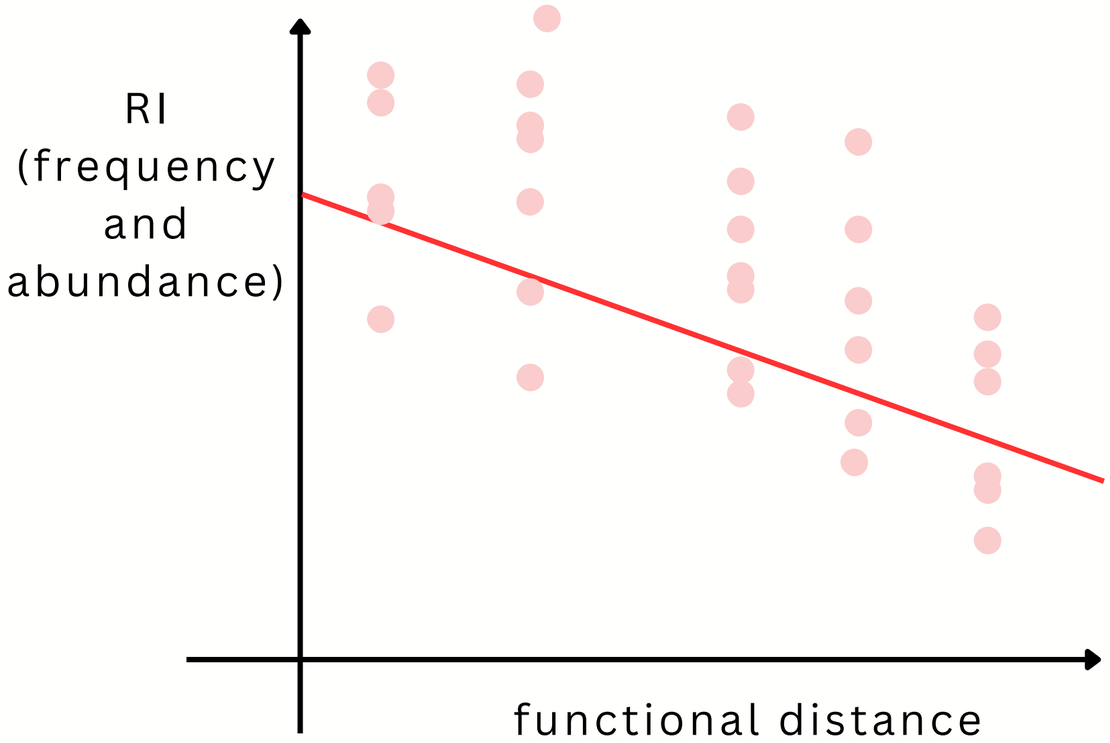
Villégeret al (2008), **Ecological Society of America**

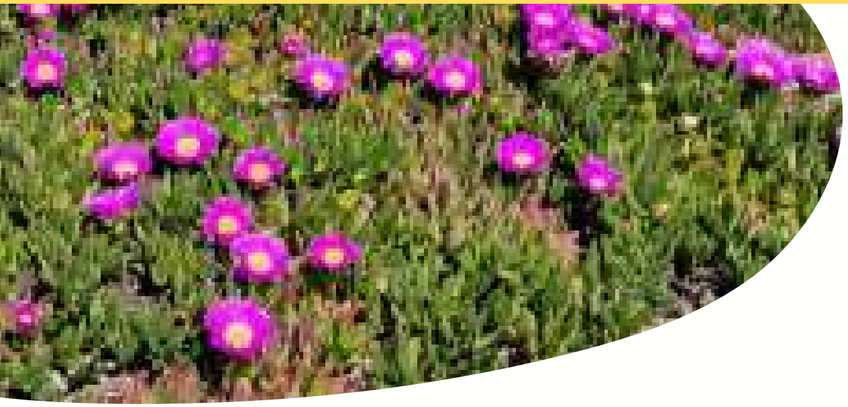


Quantifying the impact with Functional distances

Relative Impact (RI) $RI(a) = \frac{a_{NI} - a_I}{a_{NI} + a_I}$

Vila et al (2006) **Ecology Letters**





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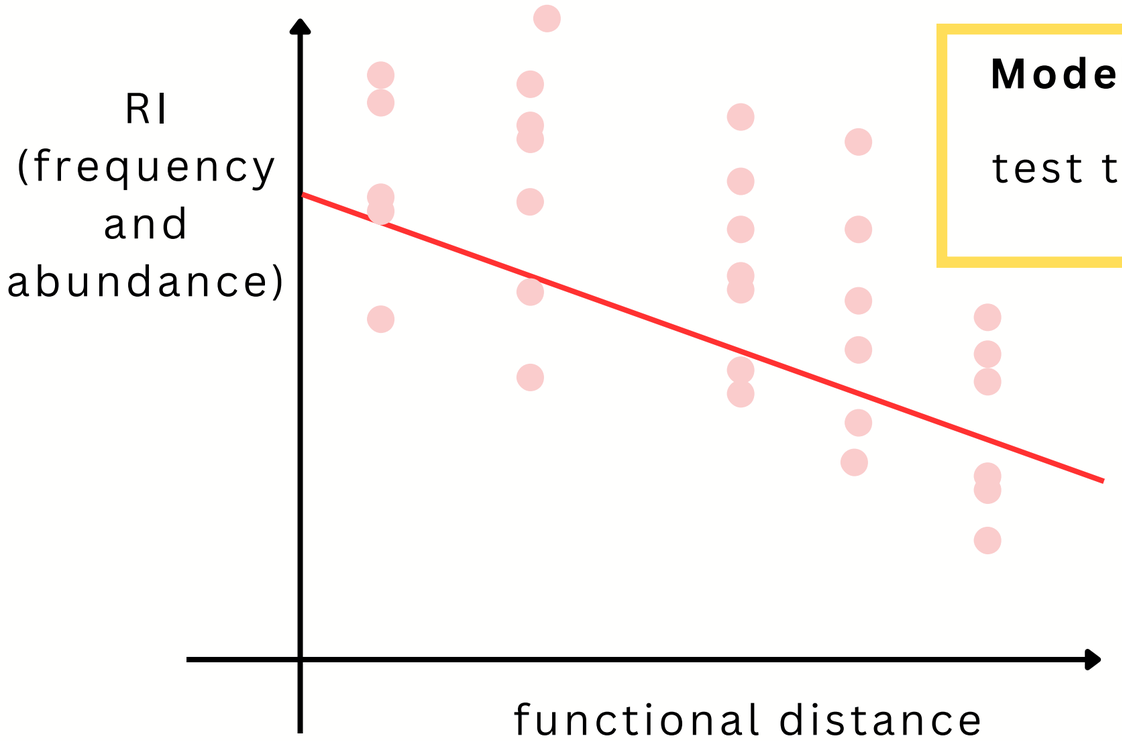
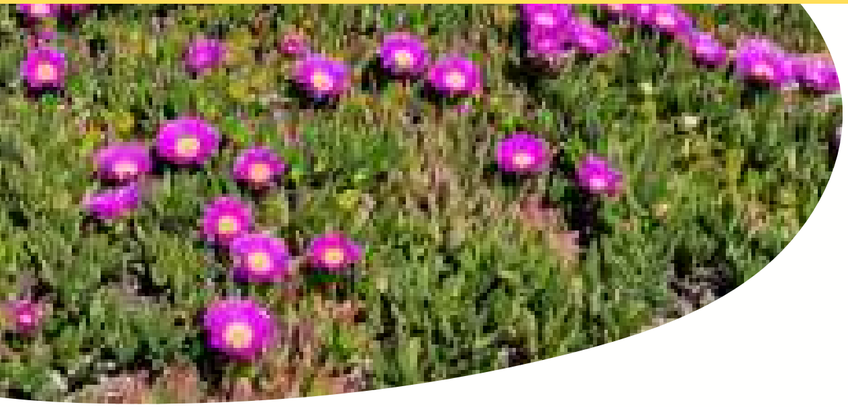


Model 1 : RI in absolute value

test the niche differentiation hypothesis

©G Fried



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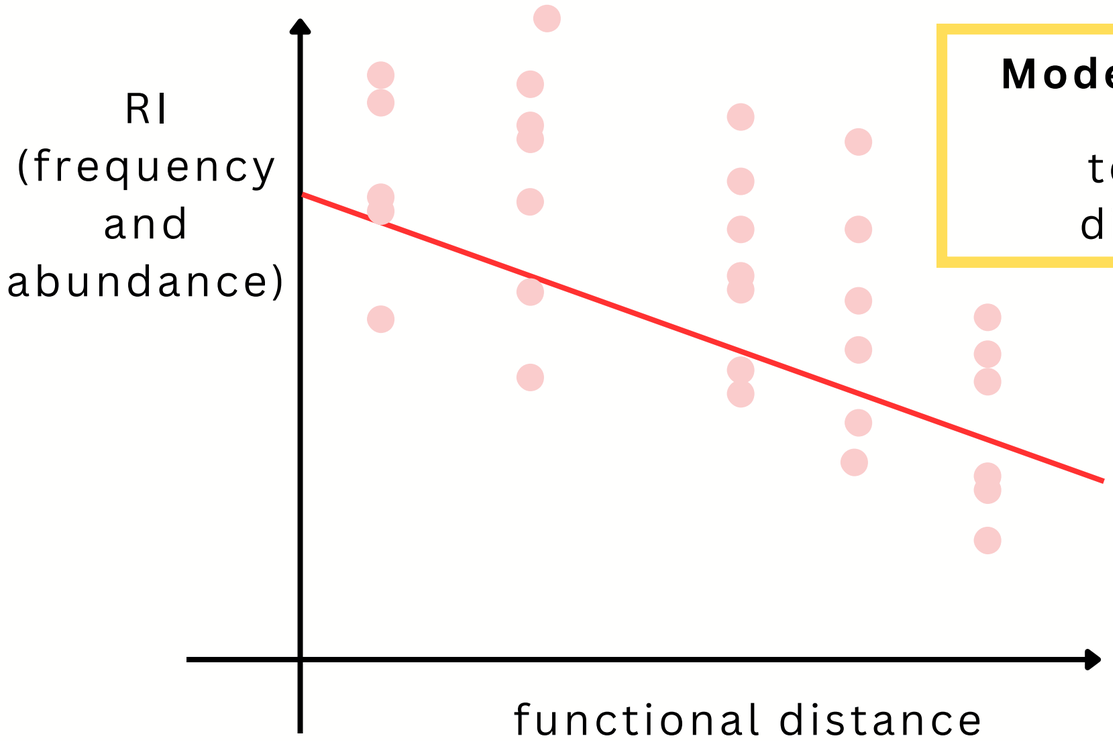

Model 2 : RI in relative value

test the performance difference hypothesis

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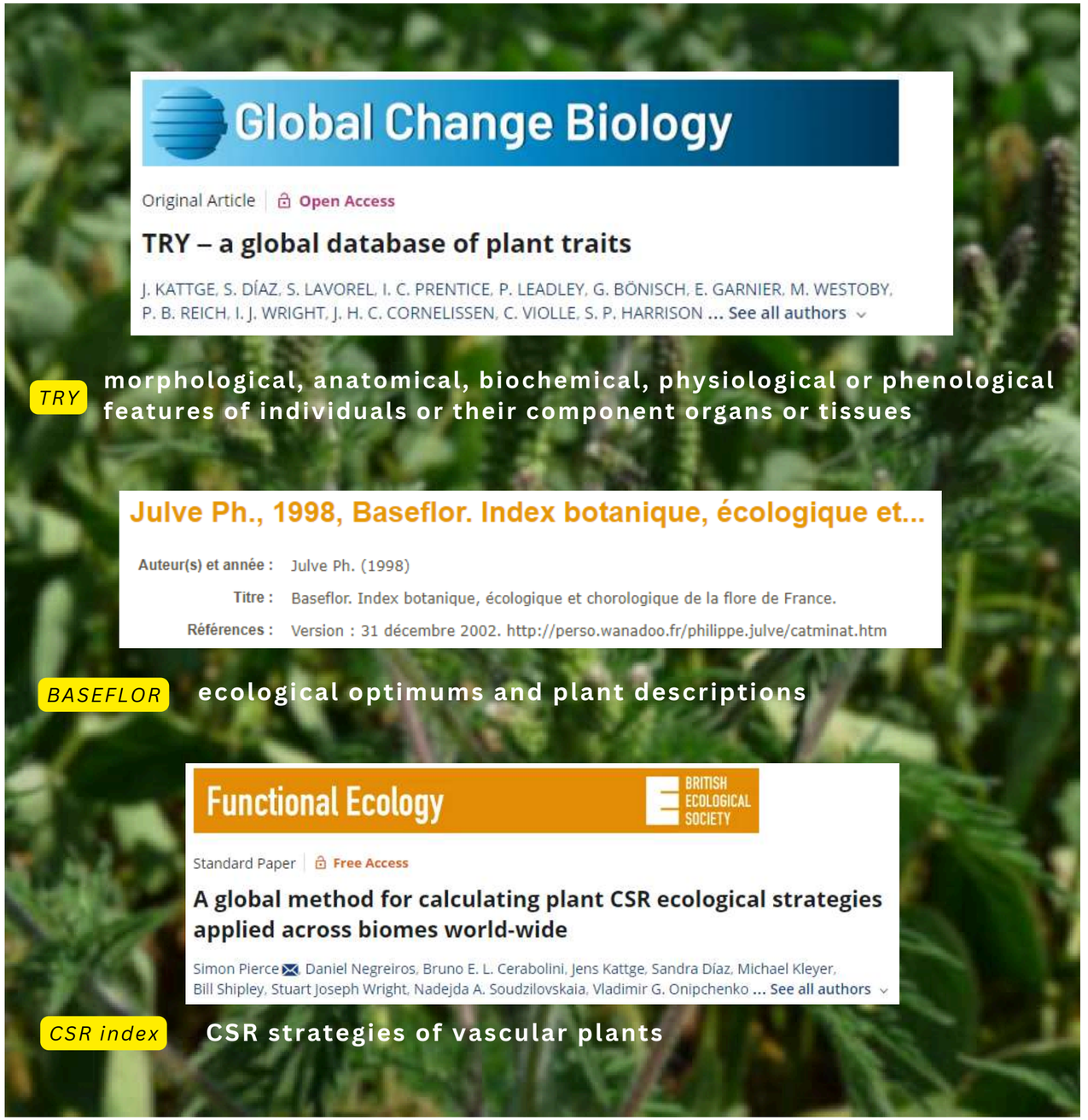
Biological materials

- 3 Plant traits databases



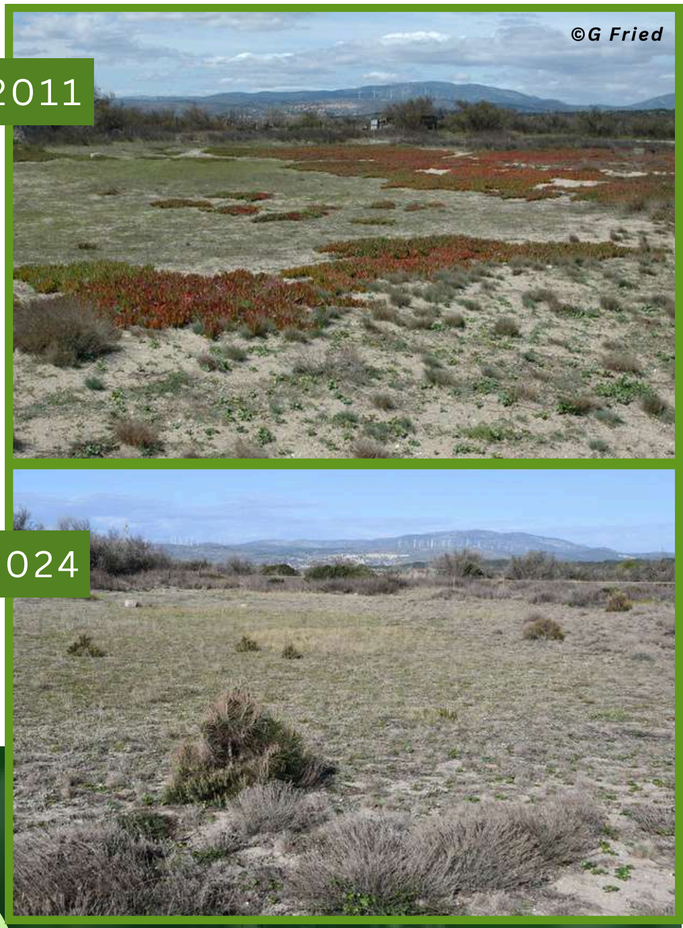
Study of temporal dynamics

- The impact of **annual species** diminishes over time

  Flory et al. (2017) **Journal of Ecology**

- In the presence of **competitive species**, the temporal impact of invasive plants is **reduced**

- An invasive species will have a **greater temporal impact** in an environment **with low plant cover**



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