TOWARDS A PROCESS-BASED CONSERVATION STRATEGY FOR MEDITERRANEAN PLANT DIVERSITY

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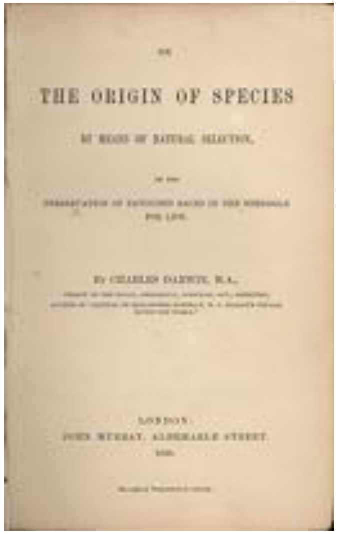
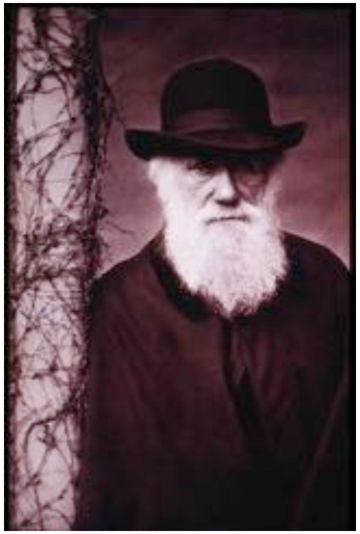
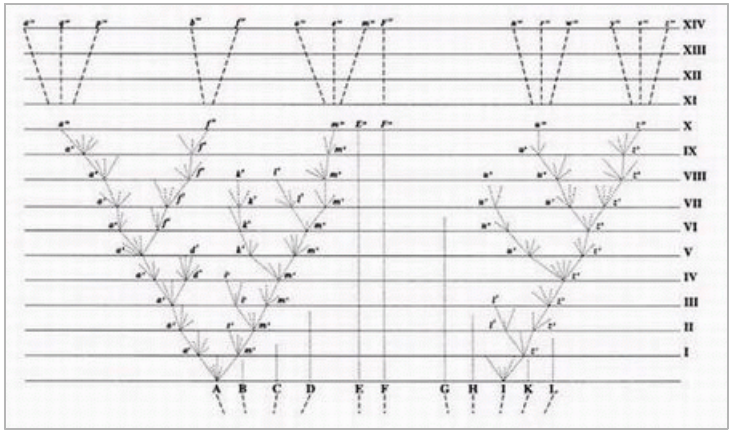
THE CONSERVATION DIALOGUE

WHAT ARE THE MESSAGES ?

The fundamental characteristic of biodiversity : evolutionary change







We cannot save biodiversity with an Ark

The conservation objective : understand the processes to protect persistence & diversification

Conservation of evolutionary potential

Reid & Miller 1989 : Keeping options alive: the scientific basis for conserving biodiversity

Smith *et al*. 2001 : Strategy for conserving the maximum amount of adaptive variation - preserve populations on environmental gradients

Stockwell *et al.* 2003 : "In a world full of contemporary evolution, conservation efforts that ignore its implications will be less efficient"

Stronen & Paquet 2013; Thompson *et al*. 2010, 2018 : Conservation policy and action must recognize populations of wild organisms that hybridize naturally - target populations with hybrid individuals, genetic variation for future evolution

The most urgent conservation issue is the loss of evolutionary potential

1. **History** : persistence and evolution

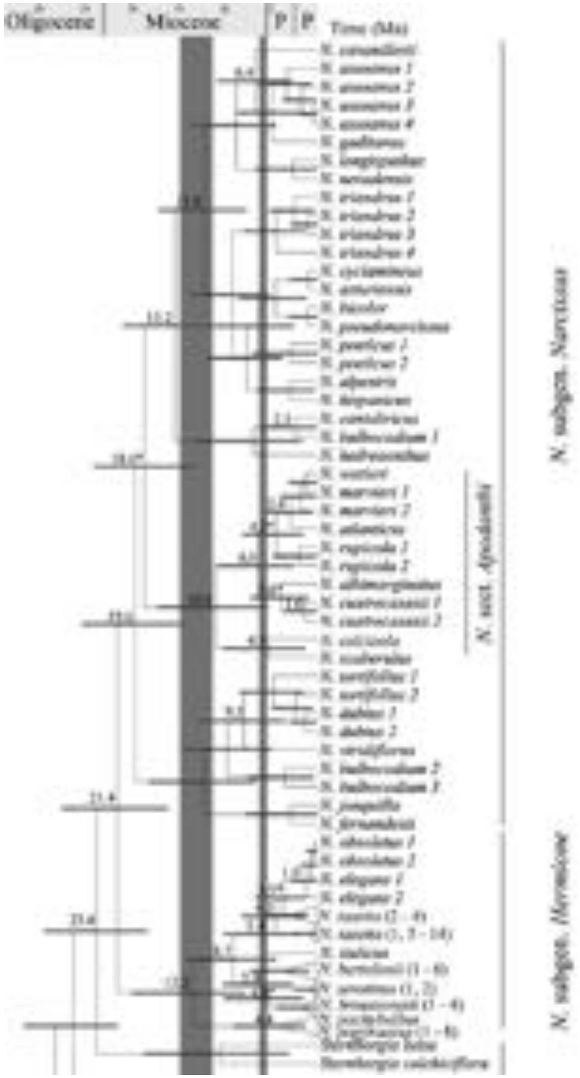
2. **On-going evolution** : genetic and ecological variation, isolation or contact
   1. * geographic (ecological) differentiation
   2. * local adaptation
   3. * hybridisation and evolution of new diversity

3. **Vulnerability** : a correct quantification and the initiation of new dynamics which remediate vulnerability

REAL HISTORY can be written about processes of evolution of Mediterranean plant biodiversity

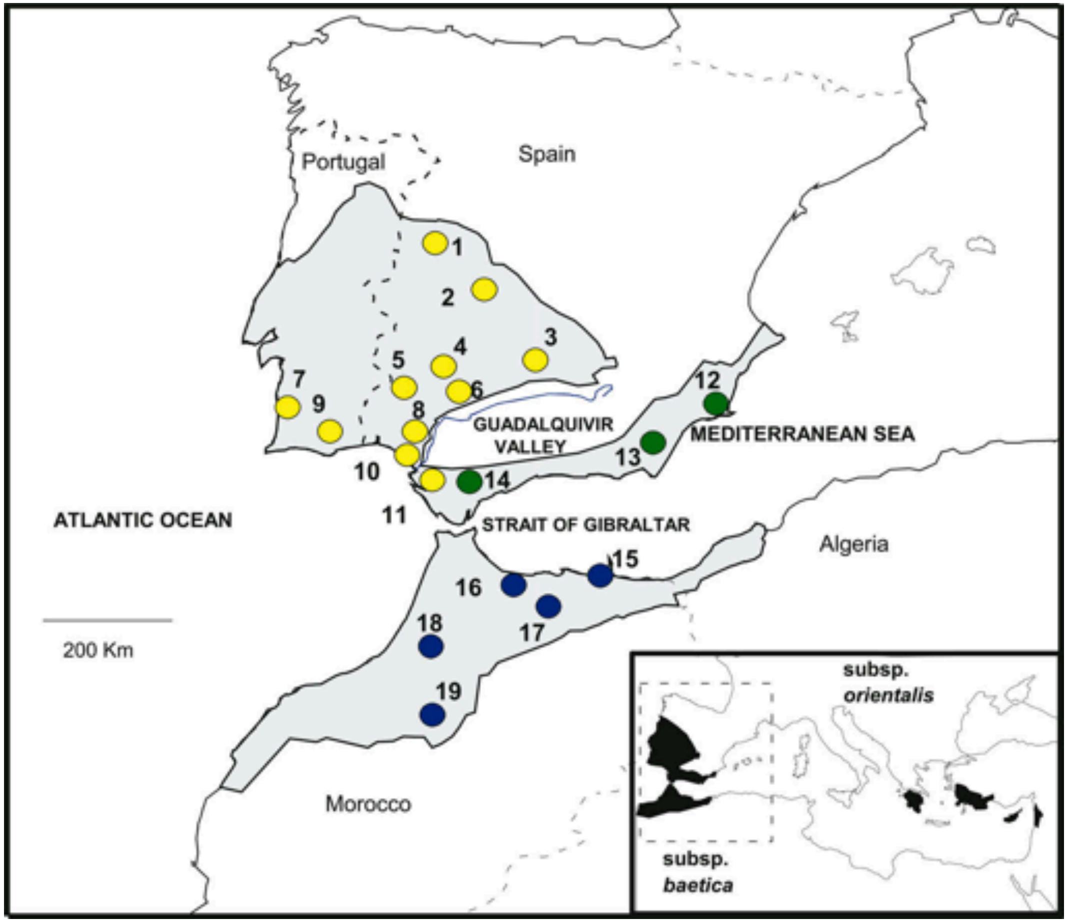
Several major historical events in *Narcissus* diversification :

- tectonic shifts in the western Mediterranean ;
- the Messinian salinity crisis ;
- the onset of the Mediterranean climate ;
- repeated glaciation



Santos-Gally et al. 2012

Land-bridges and their disconnections

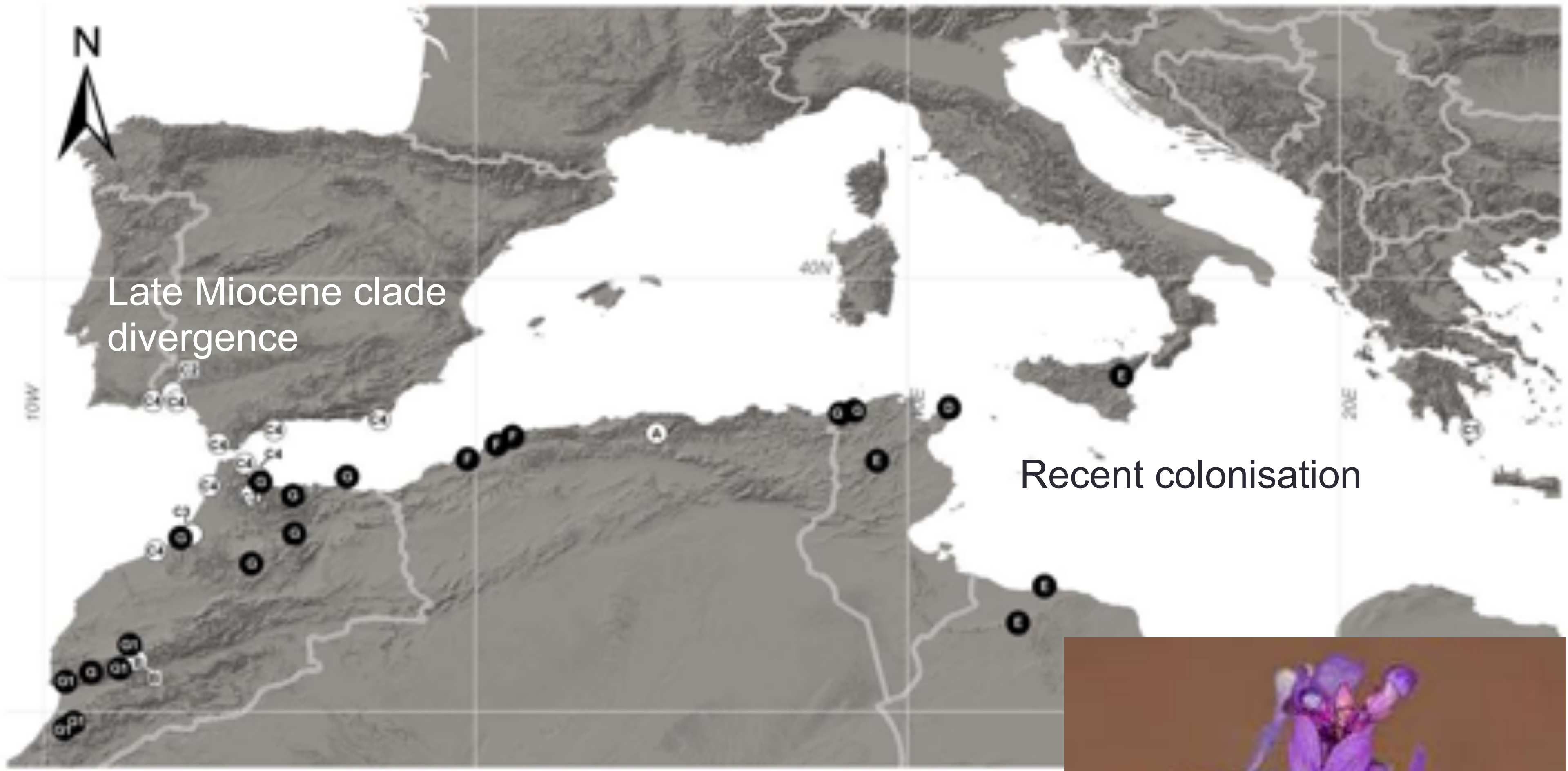


Erophaca baetica

Sub-species break (Tertiary : 12 mya)
Population differentiation (Late-Miocene : 5.3 mya)

(Casmiro –Soriguer et al. 2010)

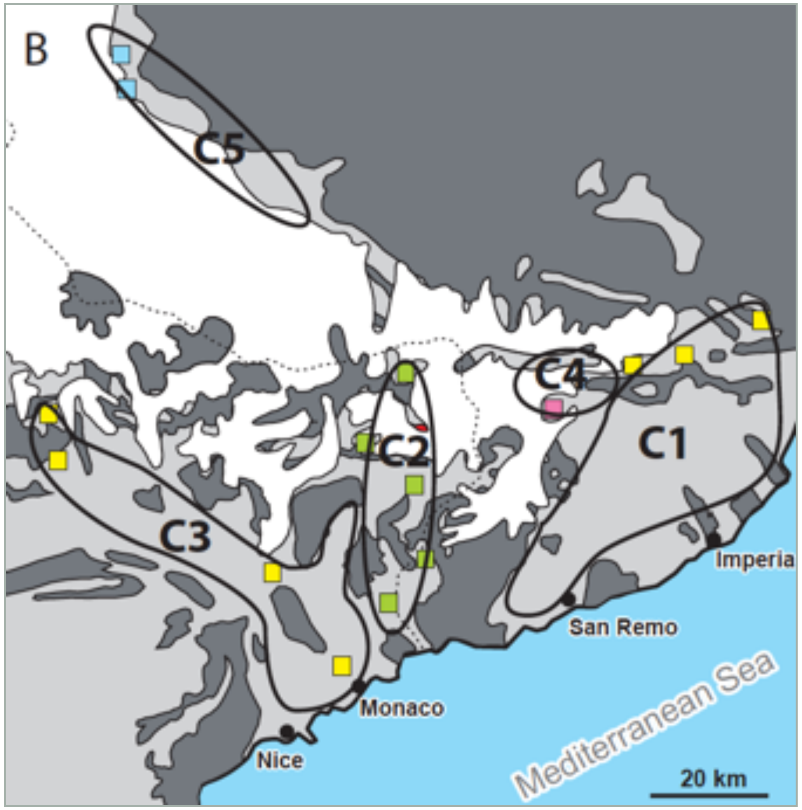
Land-bridges and long distance colonisation



Linaria sect. *Versicolores*

(Fernández-Mazuecos & Vargas 2011)

Spatial conjunction : historical persistence and evolution



Spatial genetic structure of
Gentiana ligustica

(Diadema et al. 2005)




> 100 endemic species in the Mediterranean Alps

(Casazza et al. 2008)

Persistence of ancient endemics, diversification of neo-endemic species and population differentiation

Endemism in the Mediterranean : historical phasing of divergence

The originality lies in the close relation between evolutionary processes and history (geology, climate)

We can write a real history of the evolution of the biodiversity we wish to conserve

An amazing evolutionary potential

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Peripheral populations : a dilemma

- Reduced size, isolation, less genetic variability … more differentiation … genetic originality – conservation ???

  (Eckert, et al 2008 ; Leppig & White 2006)

- Ecological originality ?

  (Pironon / Papuga et al. 2016)

- Conservation “parochialism” : an administrative prism (borders) in which one protects locally rare, but globally common species

  (Hunter & Hutchinson 1994)

Genetic originality

(Petit et al. 1998)

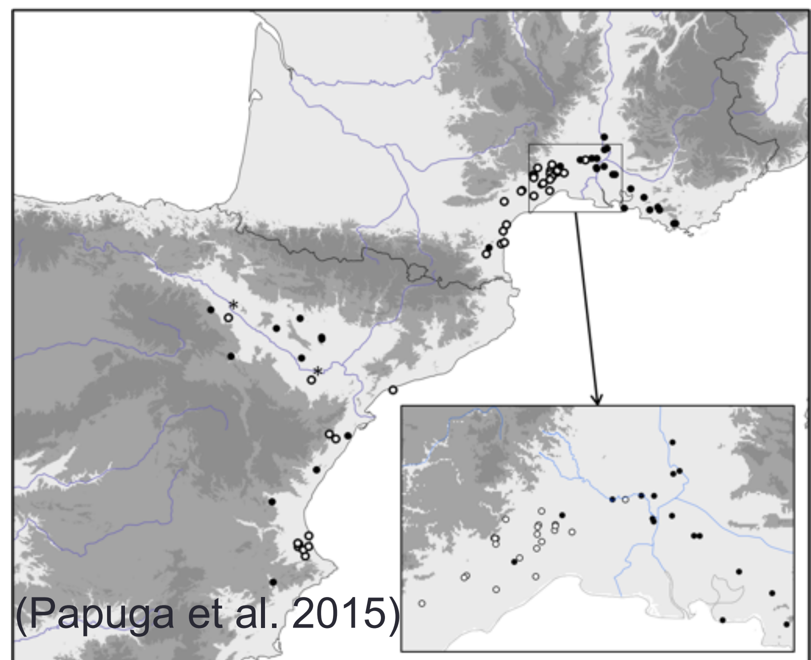
Argania spinosa - argan tree

Peripheral populations :

- Low diversity, presence of unique alleles
- Contribution to total diversity > central populations

Naricissus dubius

Peripheral populations :
Evolution of a floral polymorphism



(Papuga et al. 2015)

The future : incipient species ?

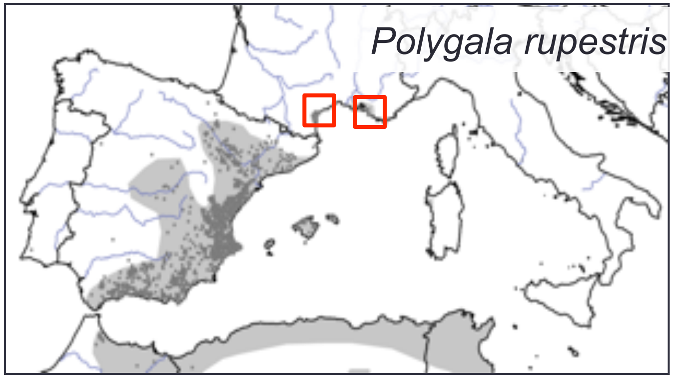
« Budding speciation », a new "endemic" species forms in peripheral populations of widespread species … A unique signature … asymmetric and mostly with ecological differentiation

(Gottlieb 2004; Crawford 2010; Anacker & Strauss 2014)

Narrow endemic species very often have a different ecology

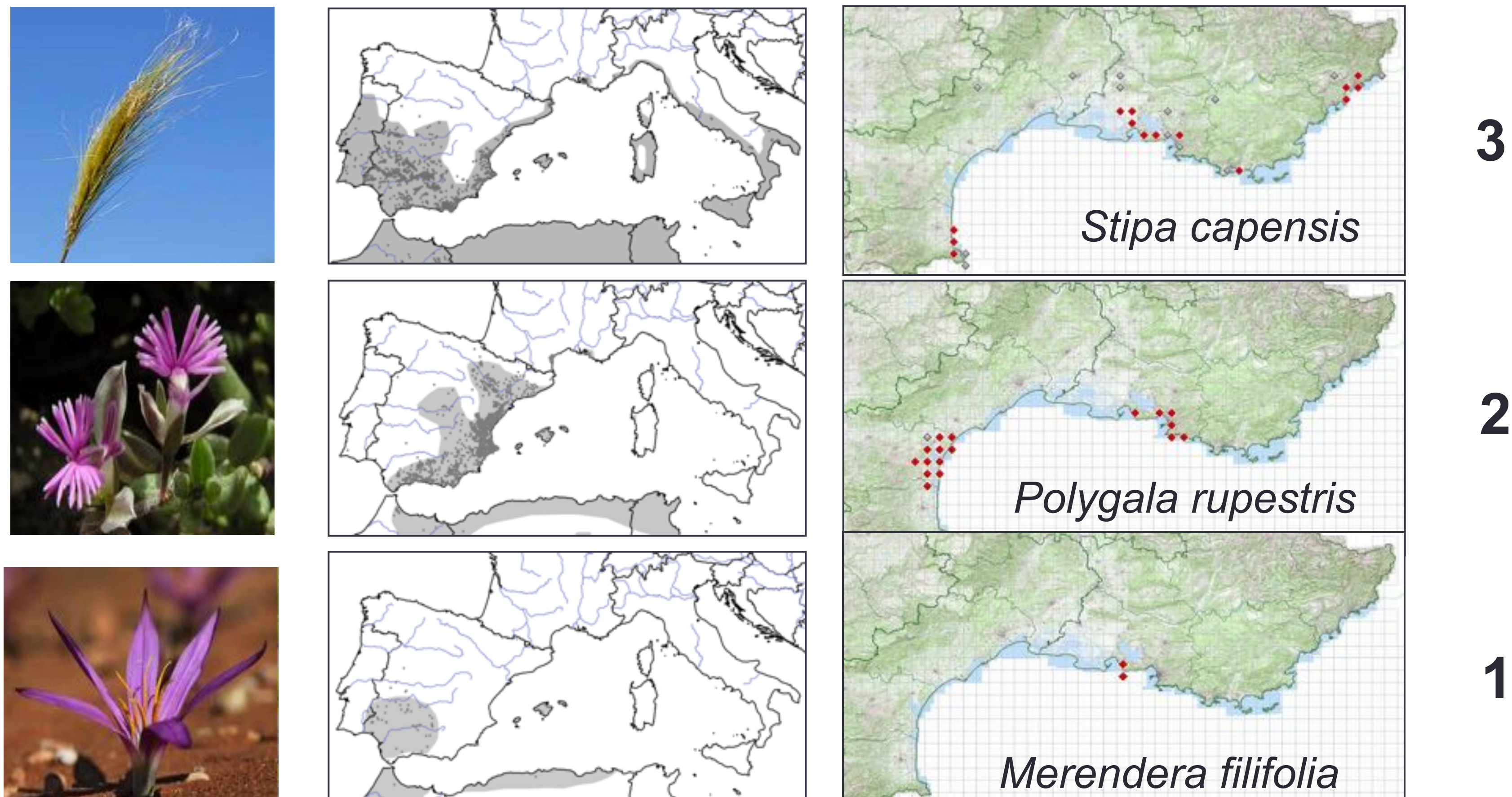
Lavergne et al. 2004

Peripheral populations ?

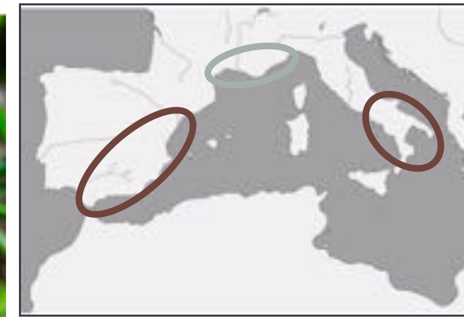


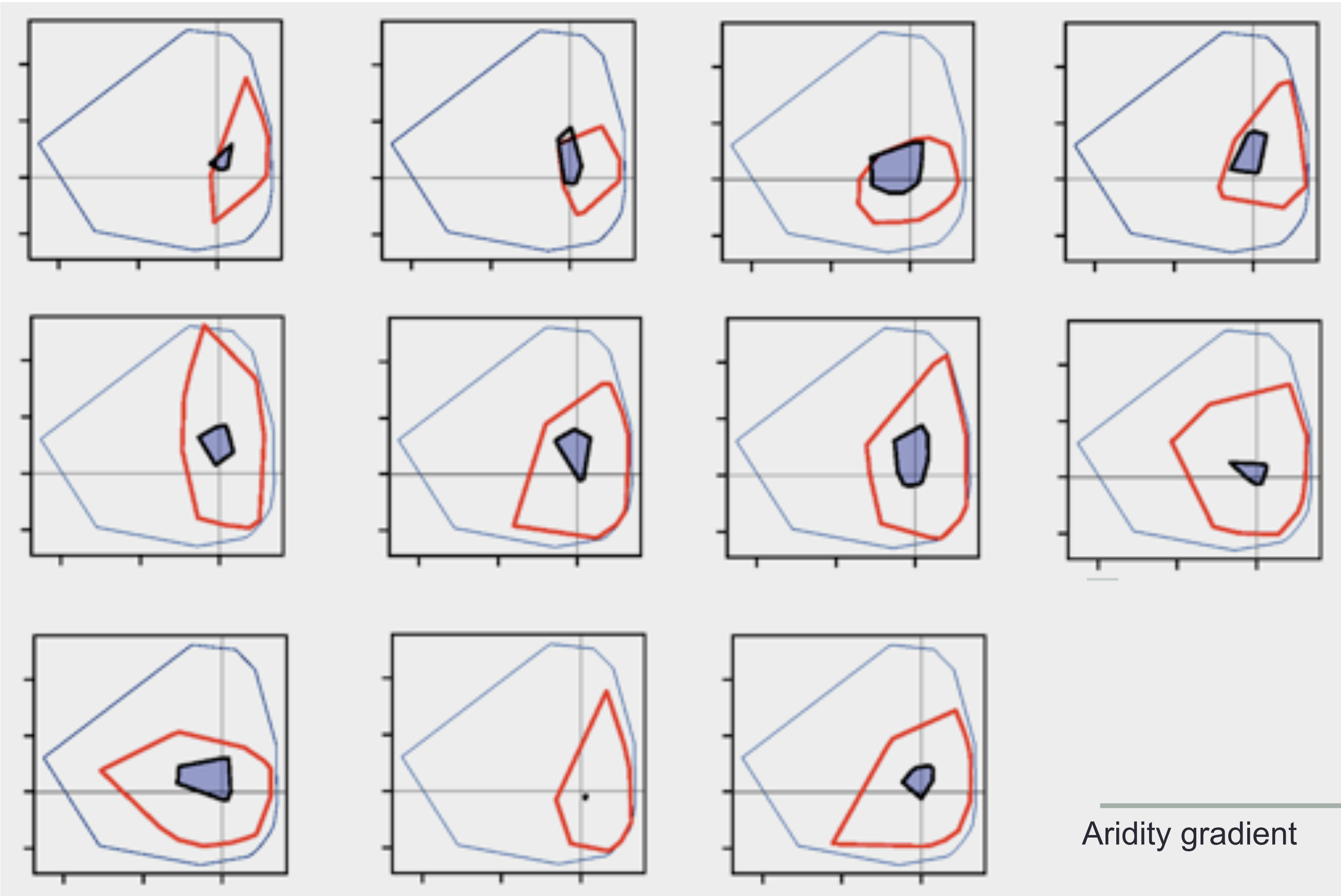
The future : population dynamics in a changing climate

(Papuga et al. 2017)



11 species in 9 families





Seasonality gradient

HIGH

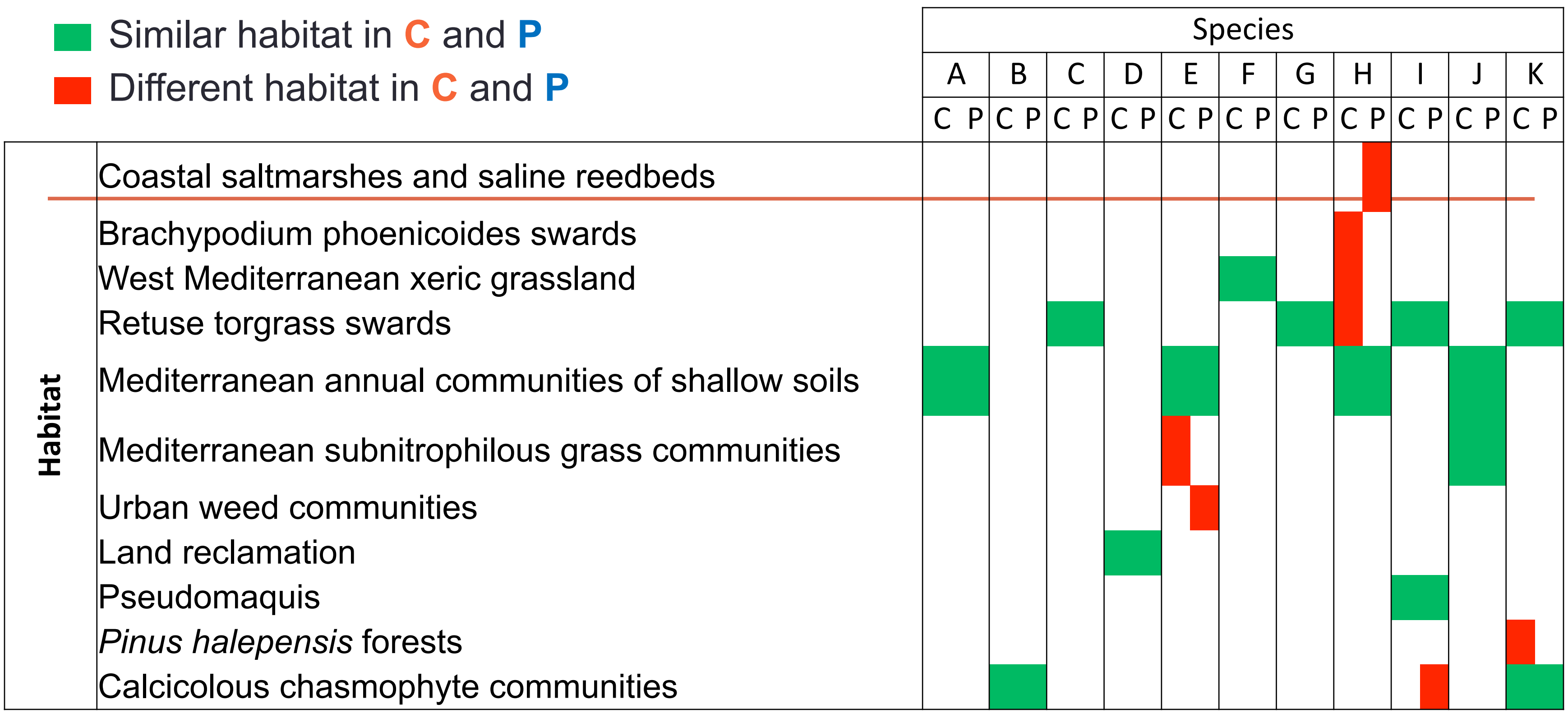
Aridity gradient

HIGH

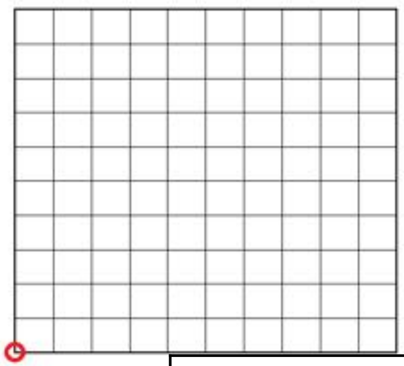
Central populations   Peripheral populations   Western Mediterranean

less arid & cooler but not marginal

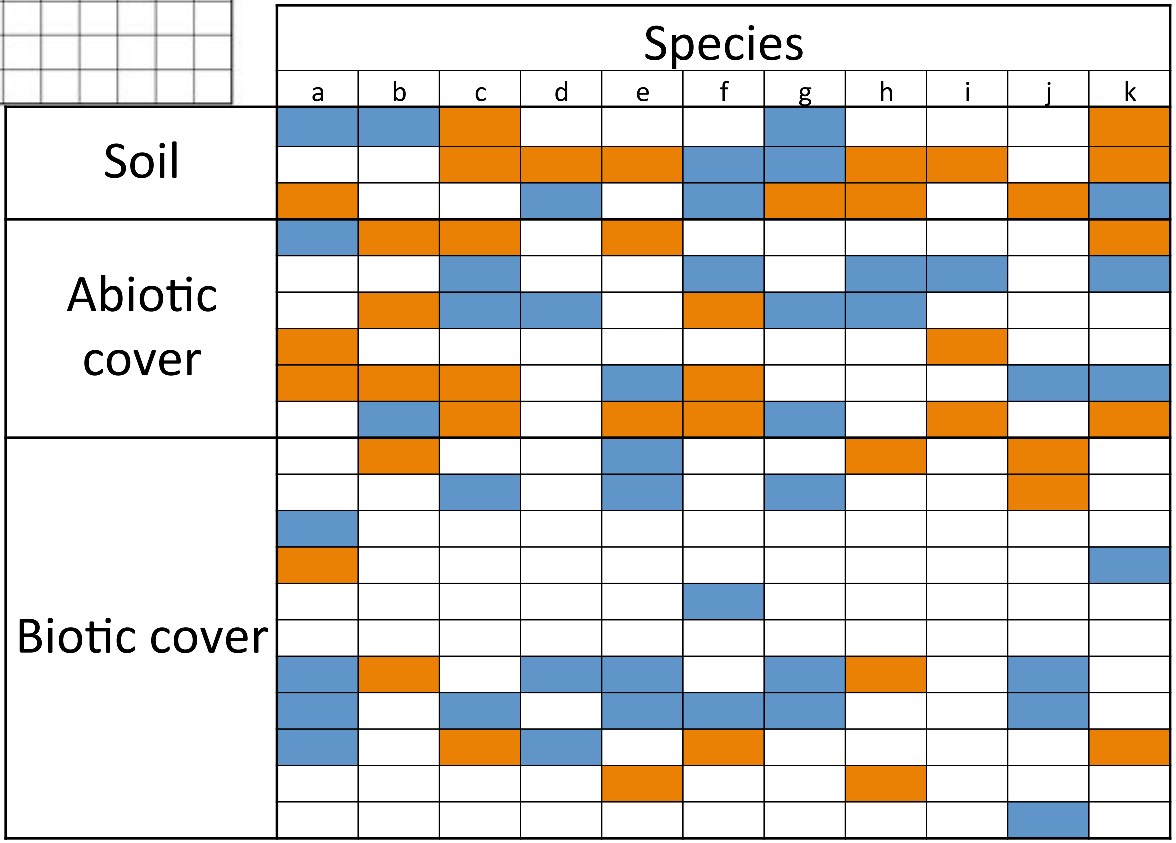
Similarity of broad habitat for central (c) and peripheral (p) populations



Marked differences in the micro-niche : where plants grow



40% vary significantly

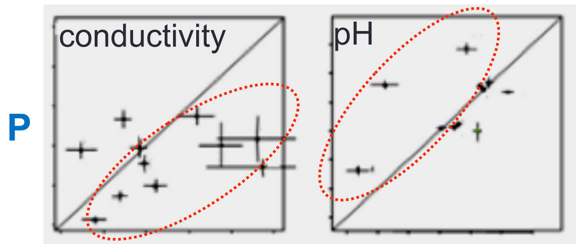


pH, conductivity, water retention

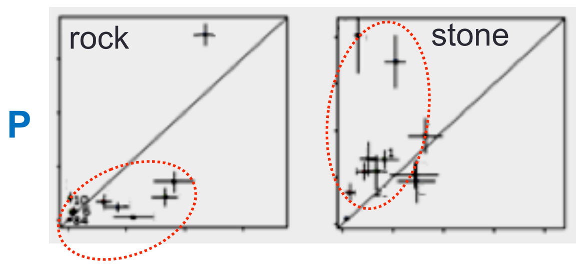
bare soil, rocks, stone

Litter, species, …

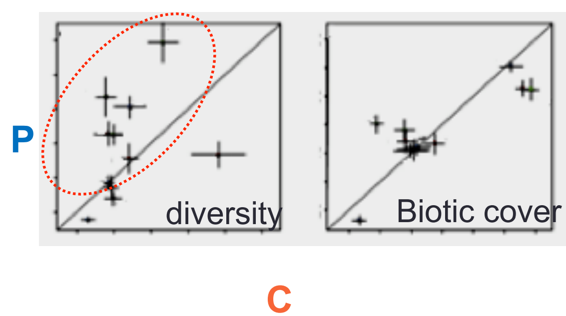
Soil



Abiotic



Biotic



Lower conductivity & greater pH

Lower rock cover & greater stone cover

Similar vegetation structure but higher diversity

rocky outcrops

↓

stony species-rich grasslands

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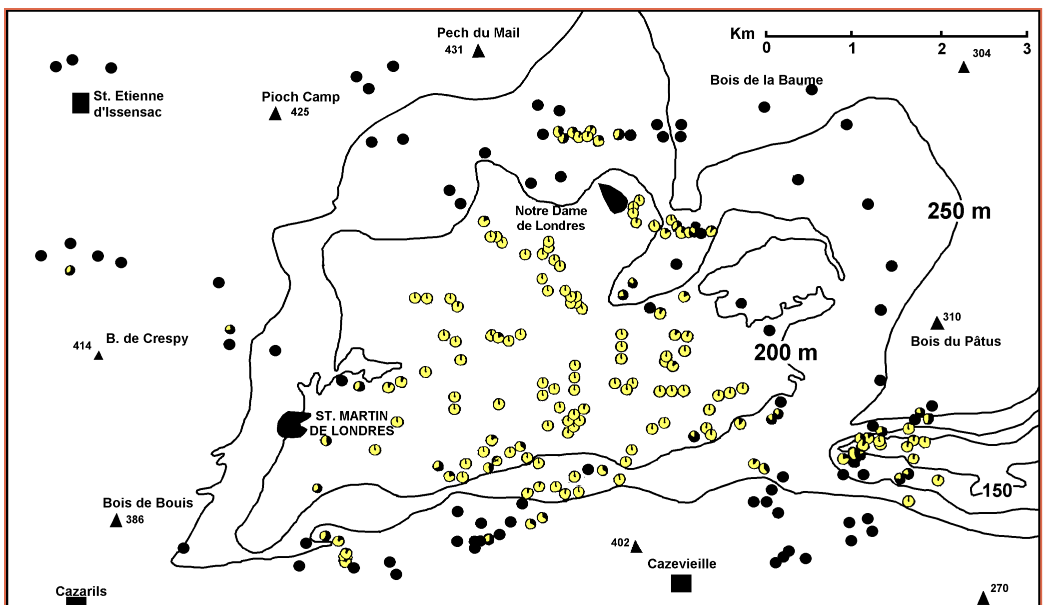
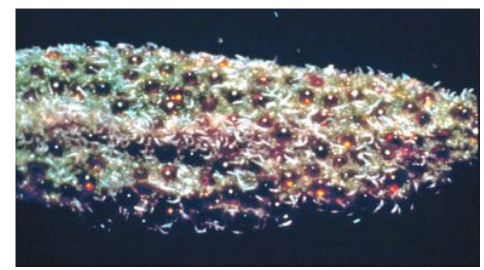
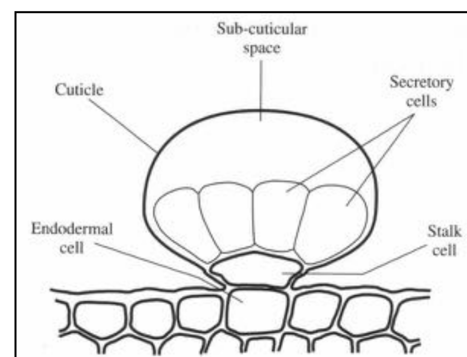
Climate change and on-going local adaptation

Chemical polymorphism : *Thymus vulgaris*







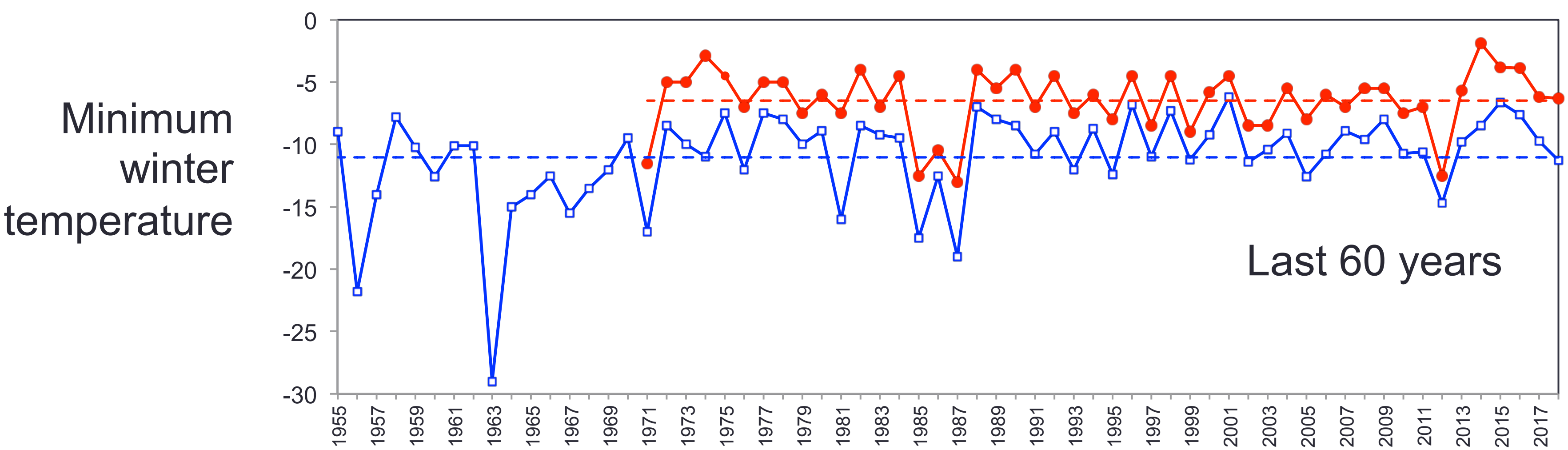
Adaptation to climatic variation

Phenolic chemotypes : high drought resistance - low tolerance of early winter freezing

Non-phenolic chemotypes : low drought resistance - high tolerance of early winter freezing

(Amiot et al. 2005, Thompson et al. 2007)

The climate is changing

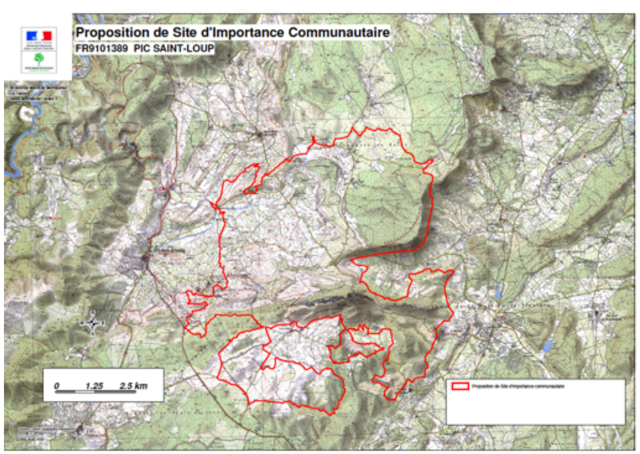


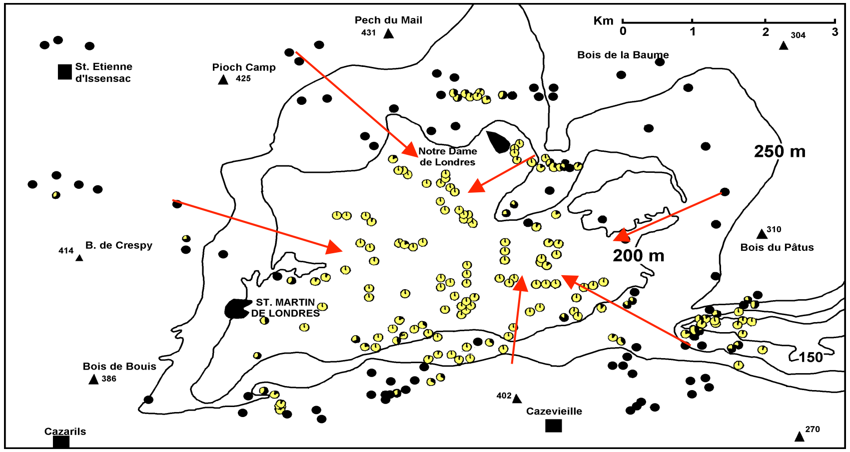
An ecological and evolutionary transition

P : 12 phenolic populations…. No change

P+NP : 12 mixed populations ….
Significant increase in frequency of P

NP : 12 non-phenolic populations …
7 with P now present





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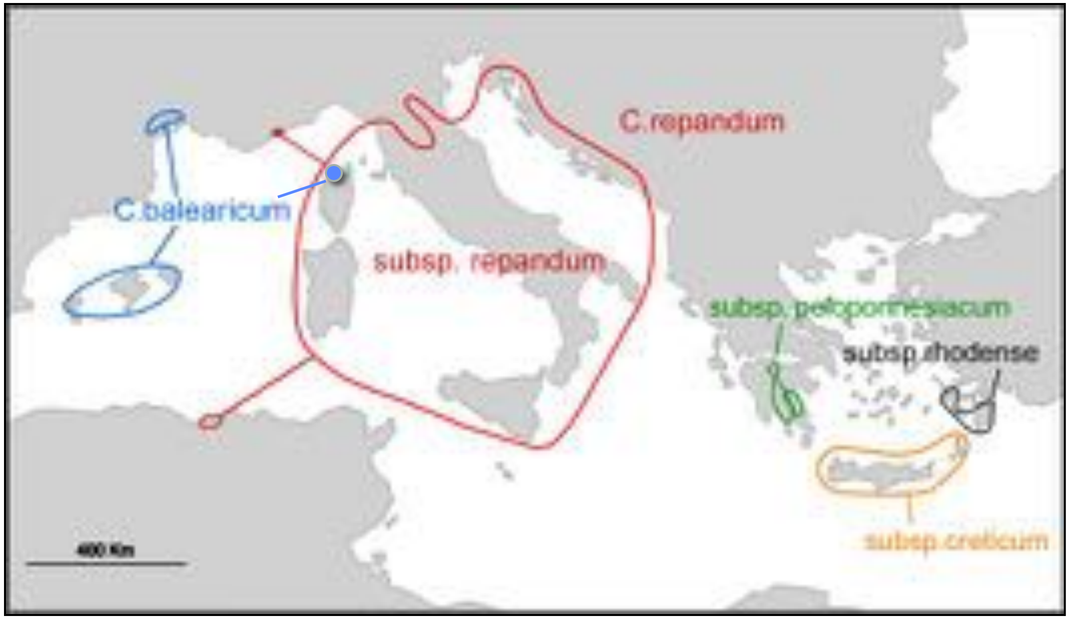
Hybridisation : 51 cases

- 26 fully established new species and 25 on-going
- Recurrent hybridisation between different congeners in *Anthemis*, *Antirrhinum*, *Narcissus*, *Rhododendron*, *Saxifraga, Senecio*, *Serapia*
- Several cases - same species in disjunct parts of their range
- Hybridisation where ranges have contracted and expanded to bring congeners into secondary contact

Peripheral populations where species meet

Spring-flowering *Cyclamen*



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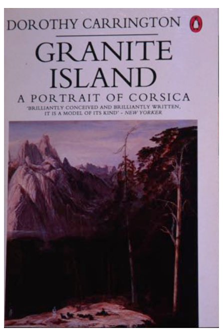
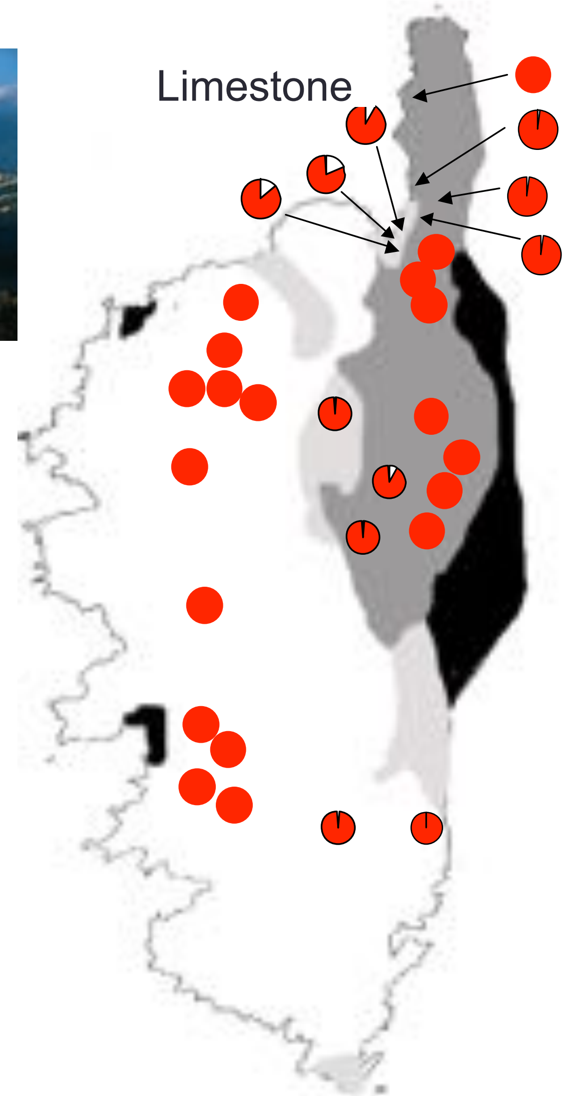
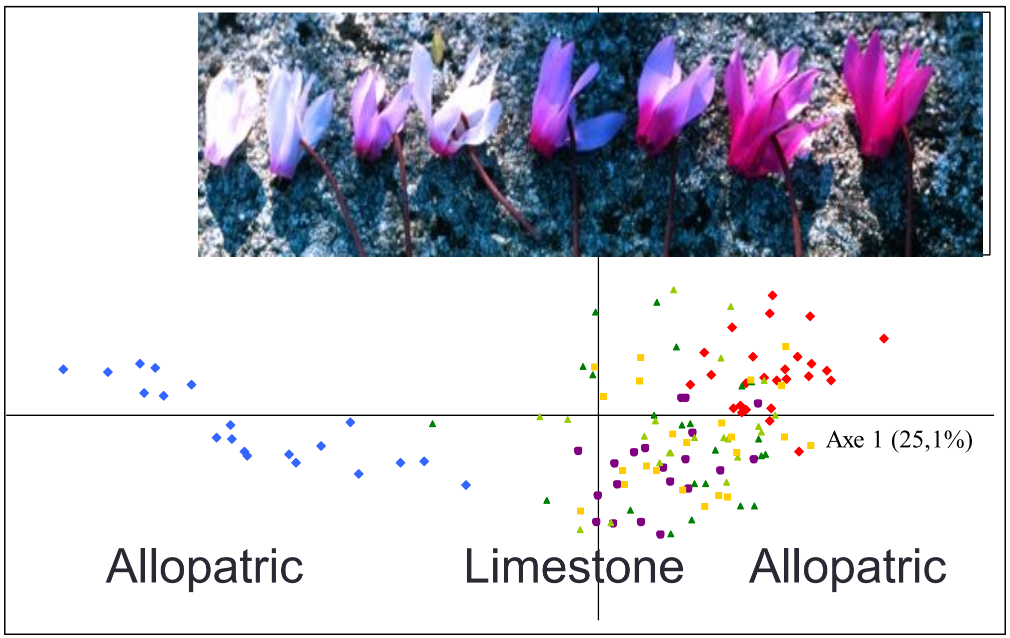
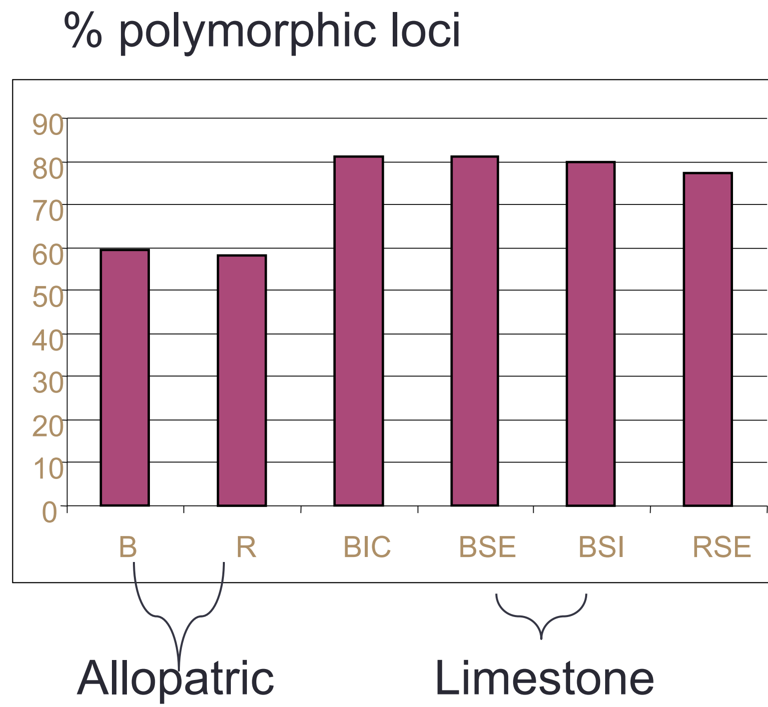




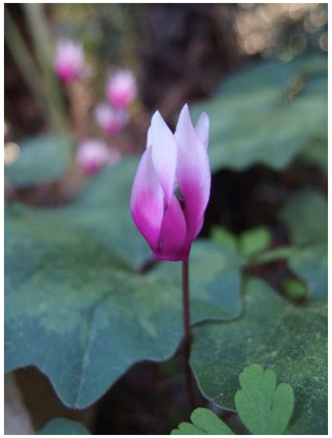
Peripheral populations where species hybridise and create a range of new variation





Thompson et al. (2010)

A replicate on Sardinia



Thompson et al. (2018)

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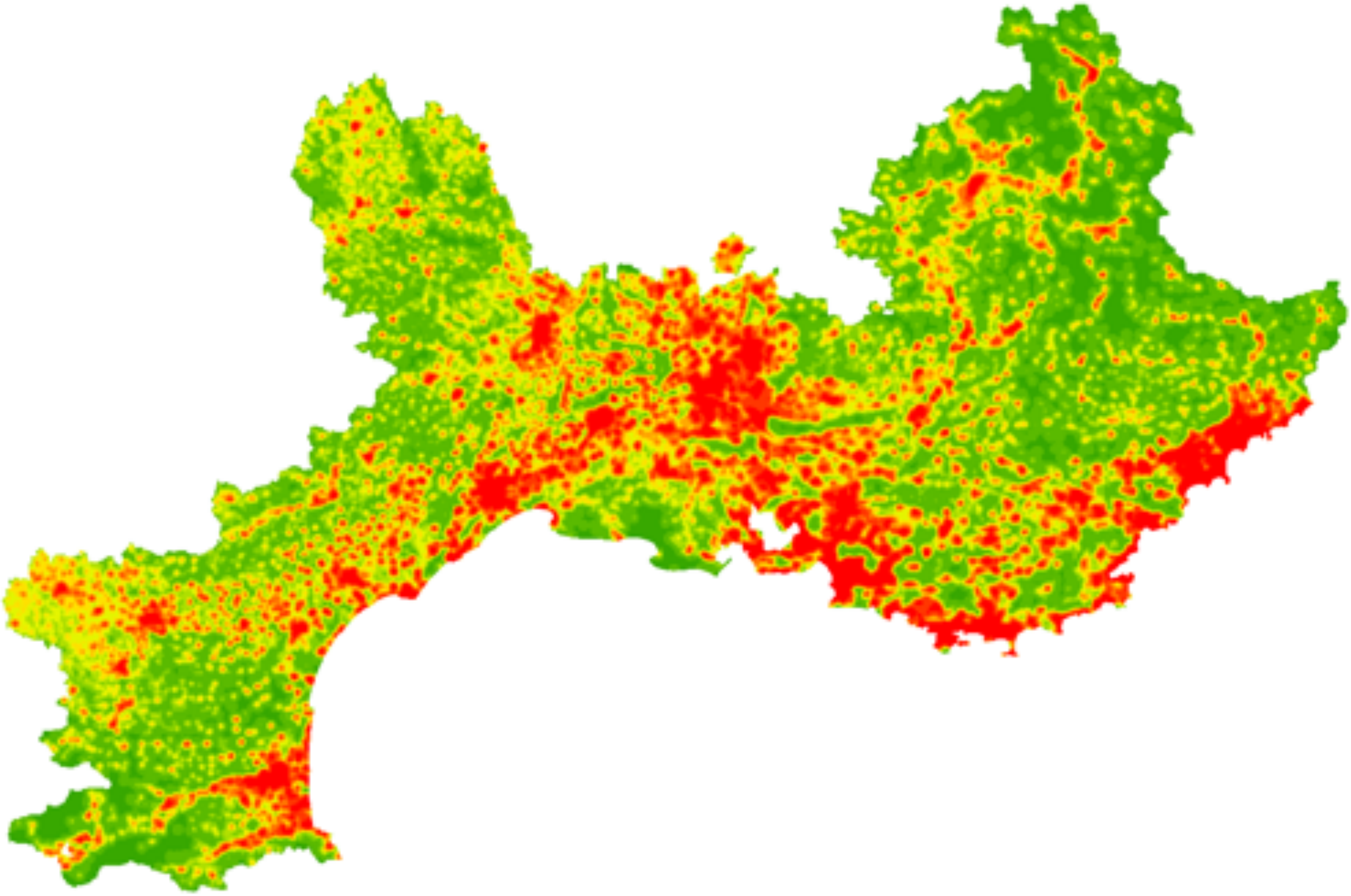
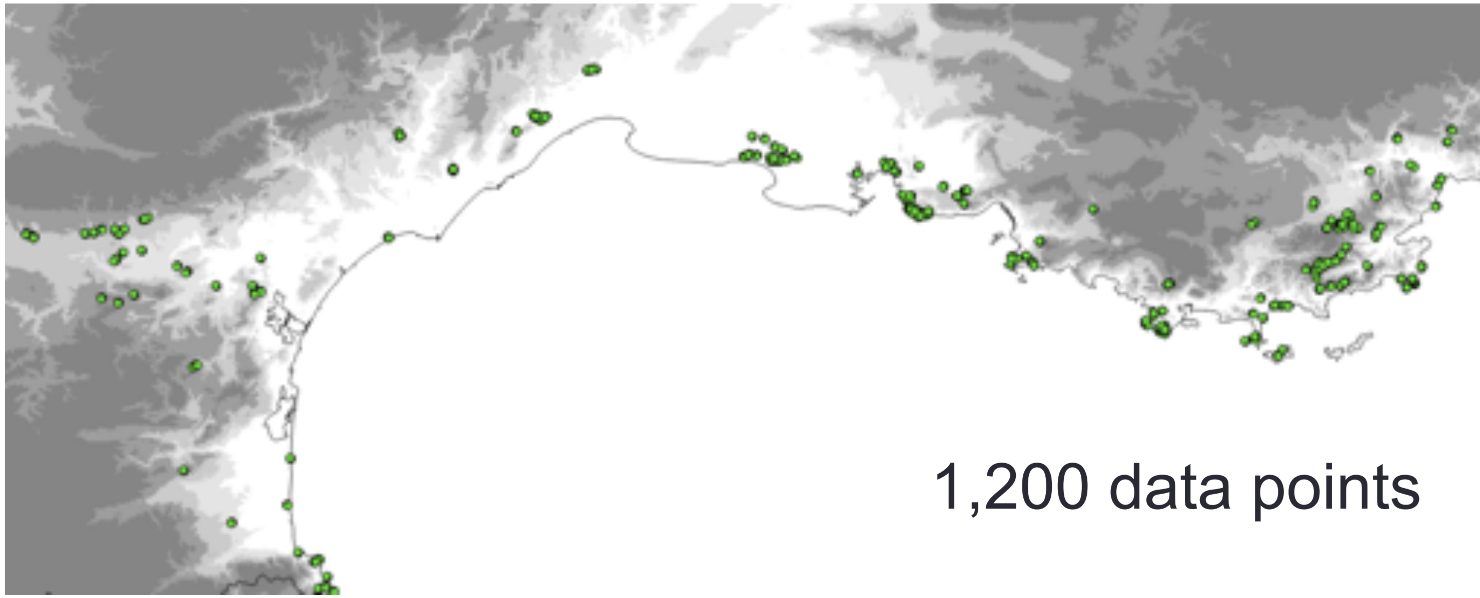
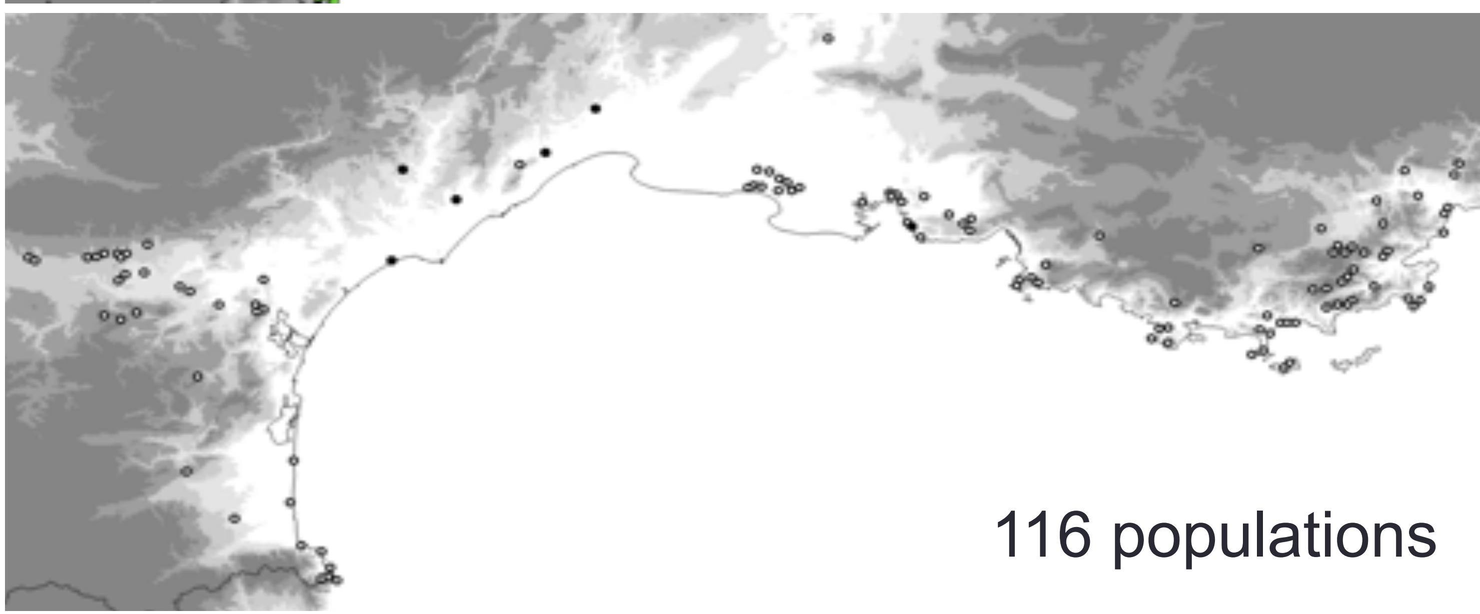
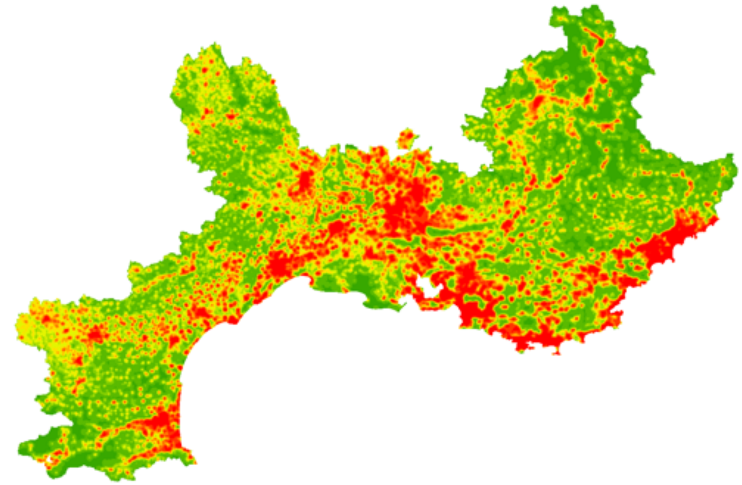
The South of France




1,200 data points

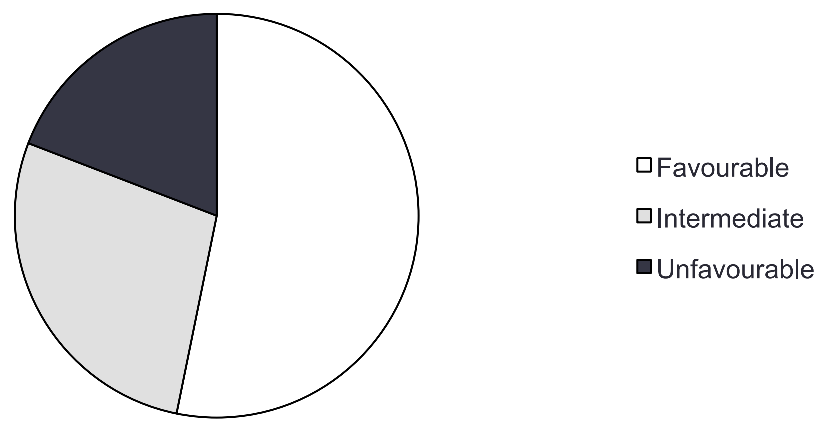

116 populations



Cumulative impacts of development projects

>20 populations impacted or destroyed in ten years

HUMAN FOOTPRINT



Conservation of peripheral populations in a human dominated landscape

Occurrence in anthropic habitats

A convincing dialogue to manage species
.... in degraded habitat ?

Conservation management to make habitats not just habitable but as optimal as possible

Remediating their vulnerability dynamics, reinforcement, reintroduction

Scientific basis

Pertinence and feasability

Include the local population

Iris xiphium

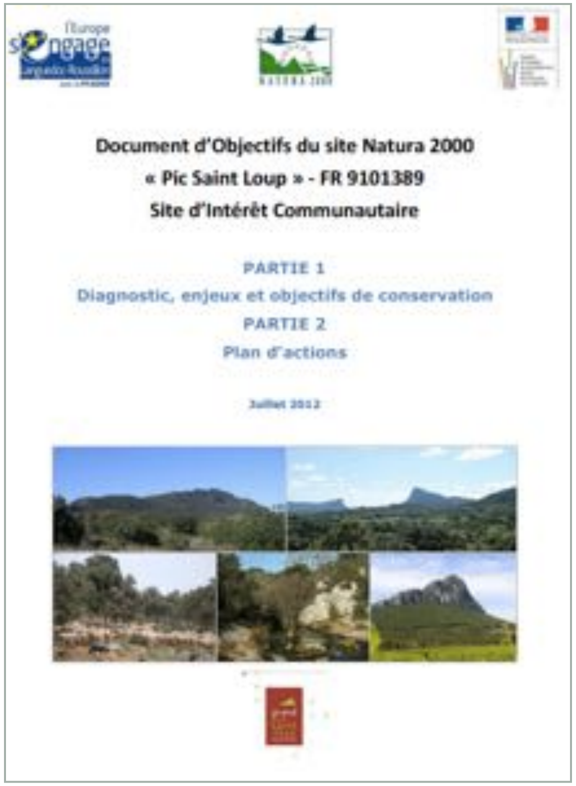
One peripheral isolate in southern France

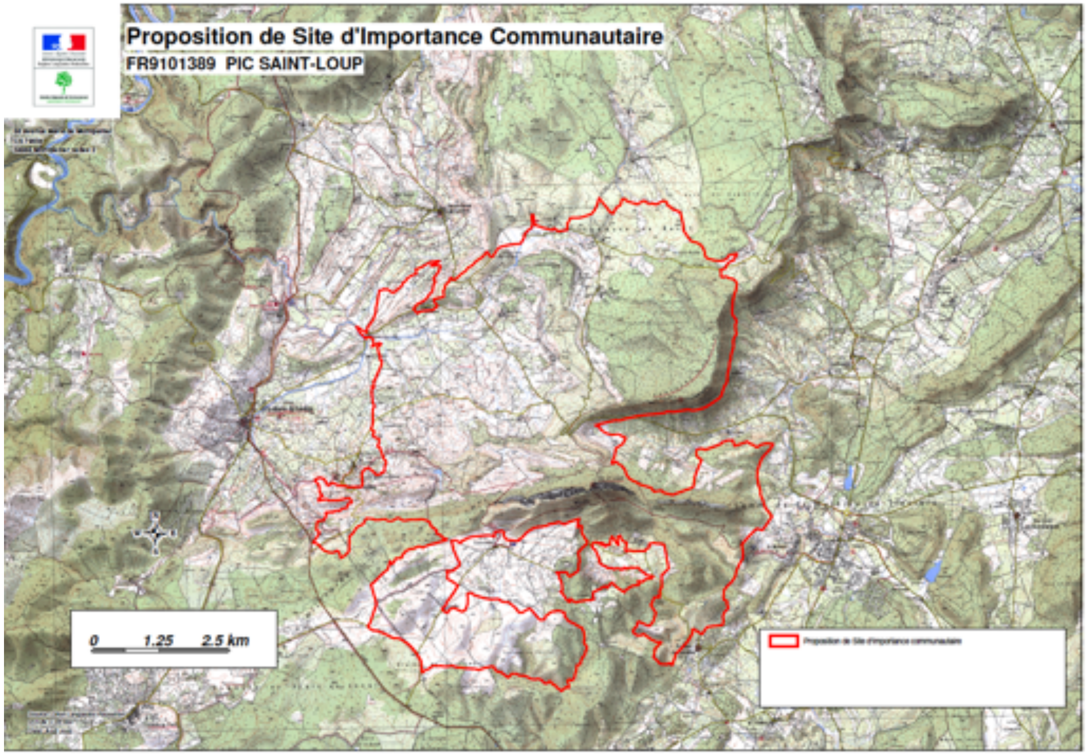
The conservation dialogue

The Mediterranean : a geographic space where evolution has worked wonders

A real history

The conservation dialogue





« The thymes they are-a-changin' !!! » (Bob Dylan)

« We can't change time » (David Bowie)

Comlement conservation policy and action with evolutionary potential ?

The conservation dialogue

Cyclamen : all the wrong features !!!!

- Not annexed species in the Habitats Directive
- No legal protection on Corsica
- Hybrids !!

But they occur in a protected area

Identify, map sites - 25 examples of on-going hybridisation

Conserving Mediterranean biodiversity ··· species to illustrate processes ?

Rare or endemic

Very rare, precious !
High responsibility…
People “listening without hearing”

Processes

Species that people know,
recognise ... that appeal
to them

The conservation dialogue

Representativity
Endemism
Diversity

+

Local adaptation
Peripheral populaitons
Hybrids

The conservation of evolutionary potential