2nd Mediterranean Plant Conservation Week
"Conservation of Mediterranean Plant Diversity: Complementary Approaches and New Perspectives"

Conservation biogeography
a relevant challenge for plant conservation in the Mediterranean Basin hotspot

Frédéric MEDAIL

Aix Marseille université Initiative d'excellence

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Diversity and Distributions, (Diversity Distrib.) (2005) **11**, 3–23

SPECIAL PAPER

Conservation Biogeography: assessment and prospect

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ABSTRACT

There is general agreement among scientists that biodiversity is under assault on a global basis and that species are being lost at a greatly enhanced rate. This article examines the role played by biogeographical science in the emergence of conservation guidance and makes the case for the recognition of Conservation Biogeography as a key subfield of conservation biology delimited as: *the application of biogeographical principles, theories, and analyses, being those concerned with the distributional dynamics of taxa individually and collectively, to problems concerning the conservation of biodiversity.* Conservation biogeography thus encompasses both a substantial body of theory and analysis, and some of the most prominent planning frameworks used in conservation. Considerable advances in conservation guidelines have been made over the last few decades by applying biogeographical methods and principles. Herein we provide a critical review focussed on the sensitivity to assumptions inherent in the applications we examine. In particular, we focus on four inter-related factors: (i) scale dependency (both spatial and temporal); (ii) inadequacies in taxonomic and distributional data (the so-called Linnean and Wallacean shortfalls); (iii) effects of model structure and parameterisation; and (iv) inadequacies of theory. These generic problems are illustrated by reference to studies ranging from the application of historical biogeography, through island biogeography, and complementarity analyses to bioclimatic envelope modelling. There is a great deal of uncertainty inherent in predictive analyses in conservation biogeography and this area in particular presents considerable challenges.

Protected area planning frameworks and their resulting map outputs are amongst the most powerful and influential applications within conservation biogeography, and at the global scale are characterised by the production, by a small number of prominent NGOs, of bespoke schemes, which serve both to mobilise funds and channel efforts in a highly targeted fashion. We provide a simple typology of protected area planning frameworks, with particular reference to the global scale, and provide a brief critique of some of their strengths and weaknesses. Finally, we discuss the importance, especially at regional scales, of developing more responsive analyses and models that integrate pattern (the compositionalist approach) and processes (the functionalist approach) such as range collapse and climate change, again noting the sensitivity of outcomes to starting assumptions. We make the case for the greater engagement of the biogeographical community in a programme of evaluation and refinement of all such schemes to test their robustness and their sensitivity to alternative conservation priorities and goals.

Keywords

Conservation biogeography, models, protected area frameworks, scale, sensitivity analysis, uncertainty.

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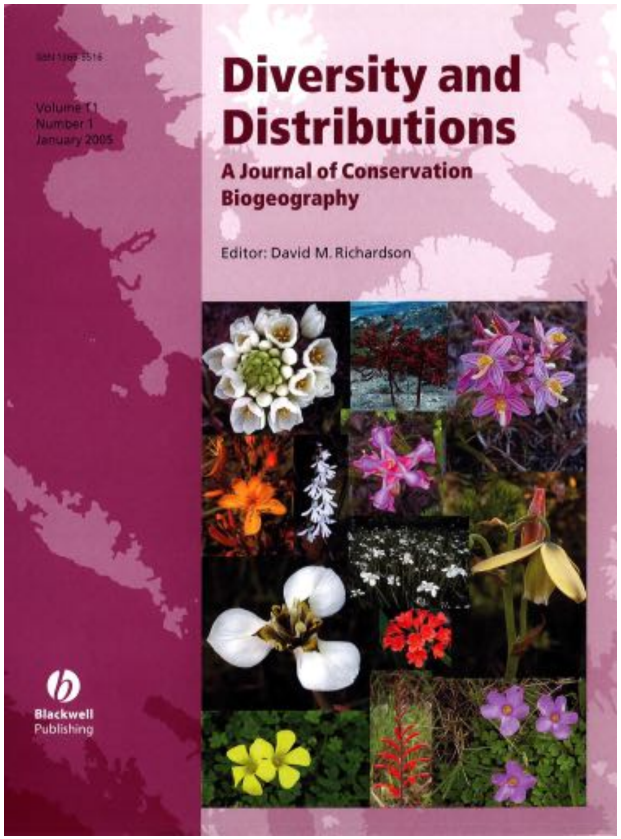
Order of co-authors arranged alphabetically.

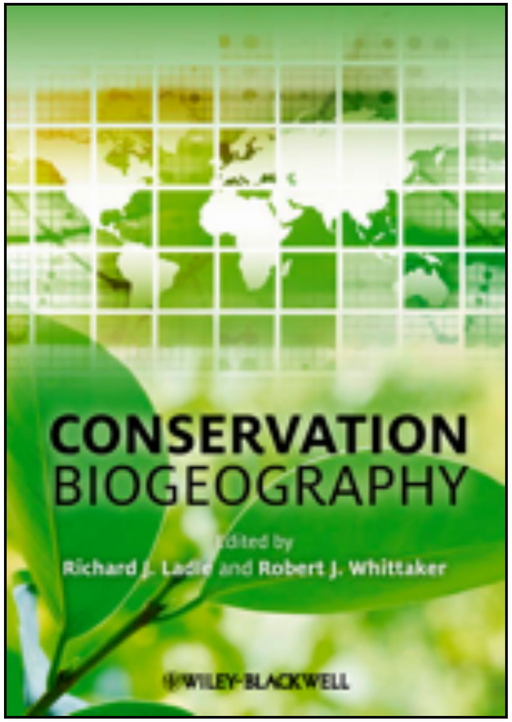
What is Conservation Biogeography?



Conservation Biogeography

Application of biogeographical principles, theories, and analyses, being those concerned with the distributional dynamics of taxa individually and collectively, to problems concerning the conservation of biodiversity

The key role of biogeography for biodiversity conservation



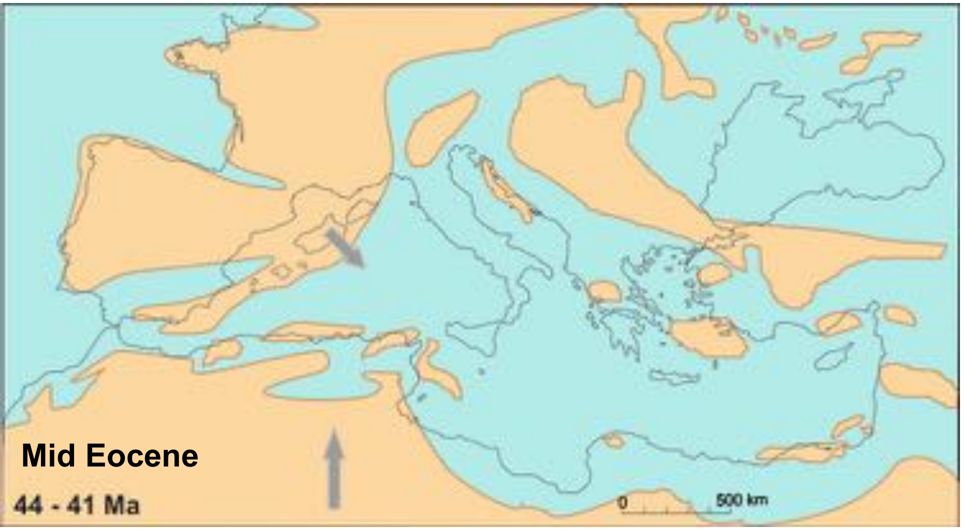
Owing to its uniqueness and fragility, the Mediterranean region urgently need some integrated and biogeographical conservation planning (notably within the biodiversity hotspots) for the long-term preservation of this outstanding biological heritage.

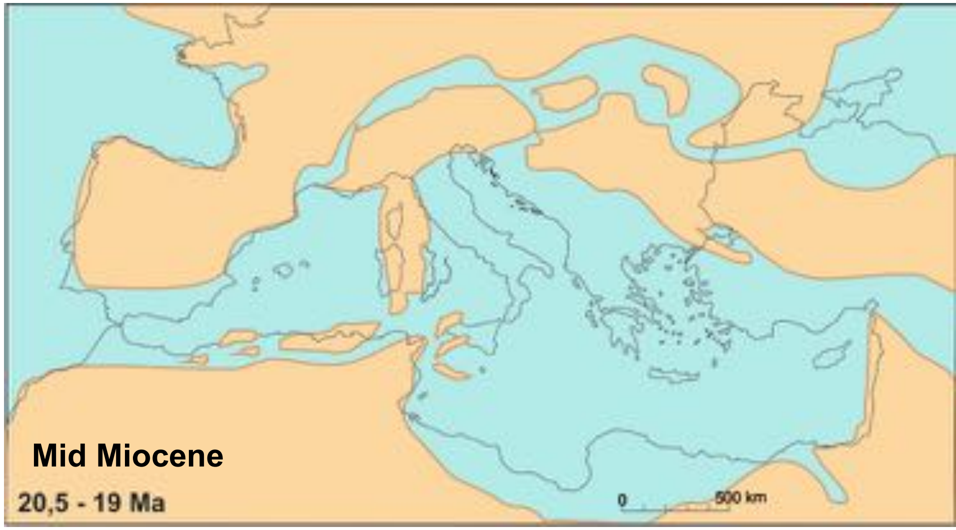

Sicily (Salina island)

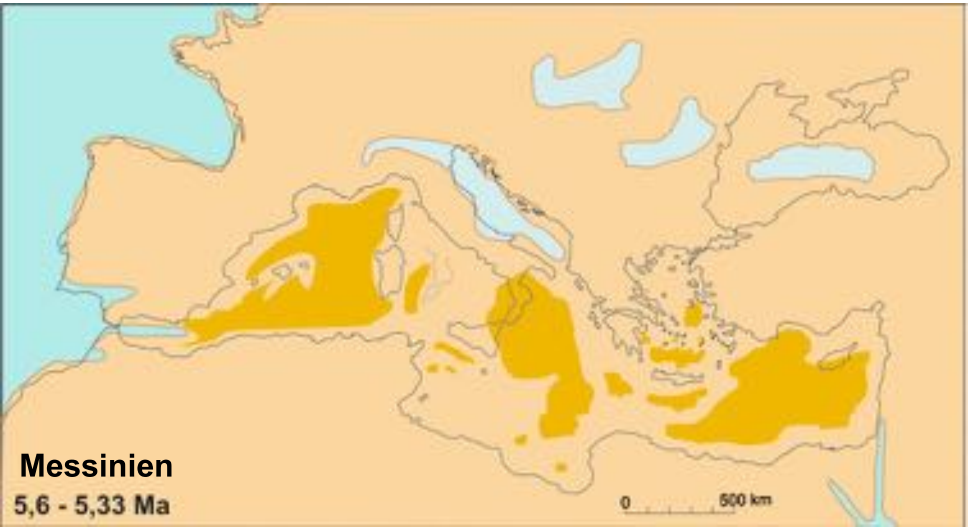

Sardinia

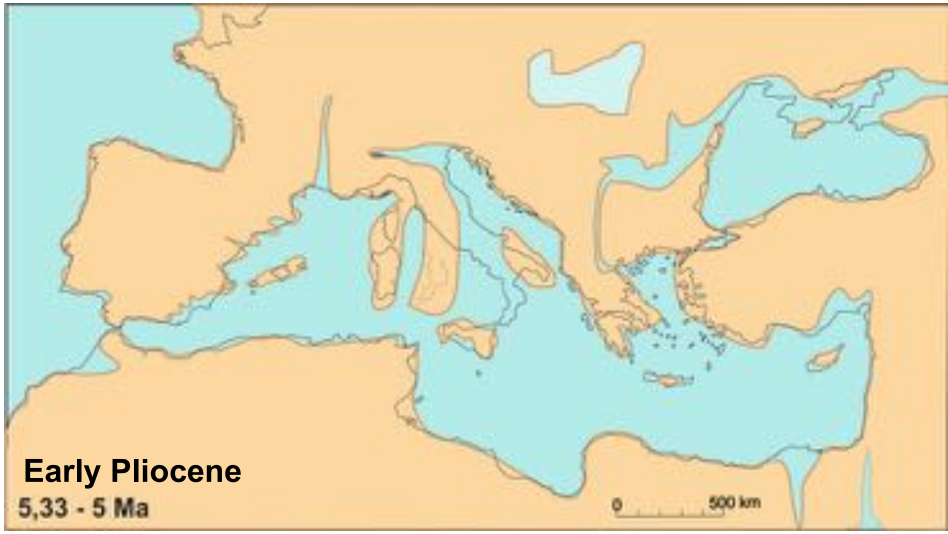

Corsica

Importance of historical biogeography





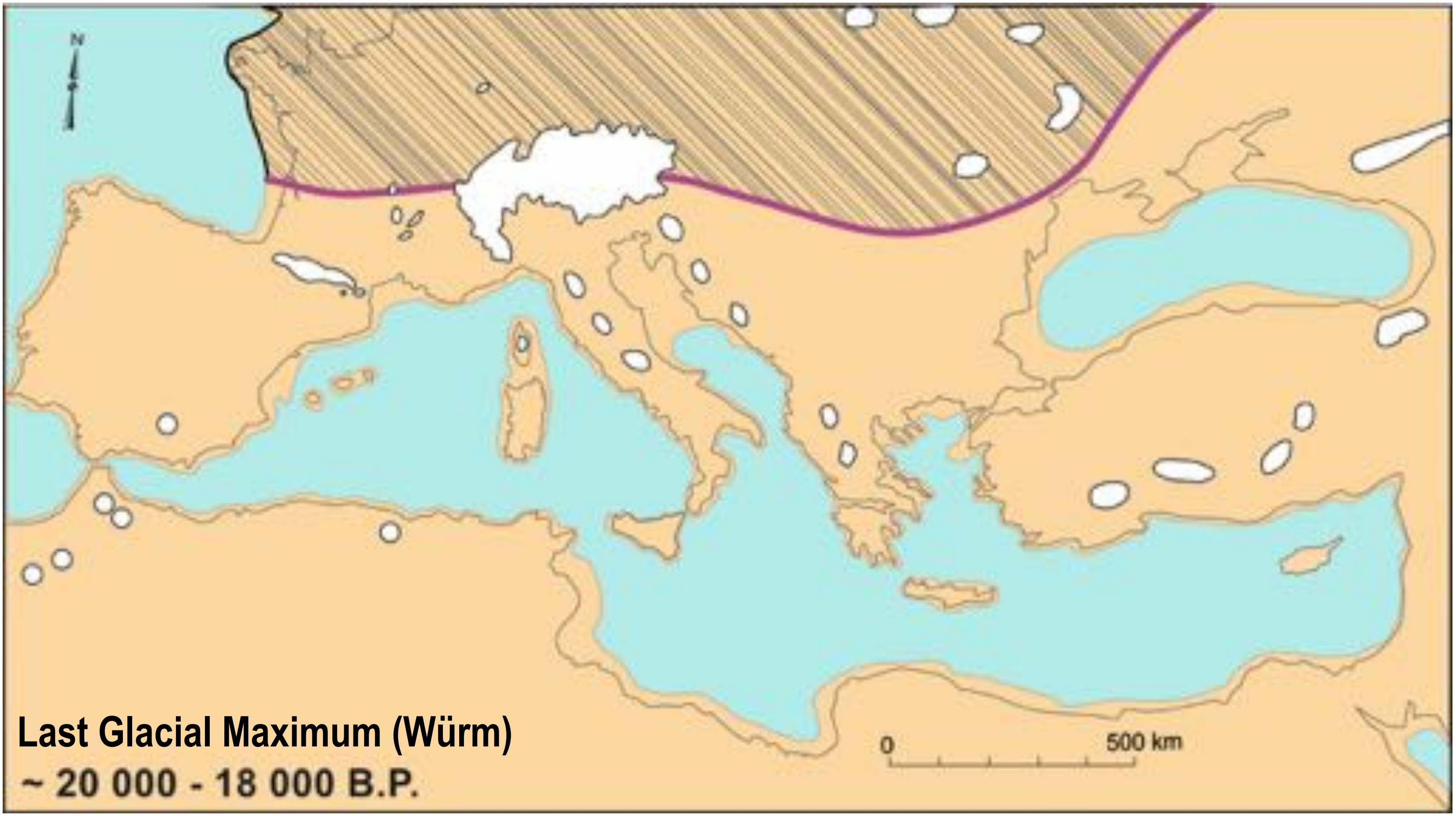




Suc J.-P. *in* Noble V. & Diadema K., 2011. *La flore des Alpes-Maritimes et de la Principauté de Monaco.* Naturalia Publications.

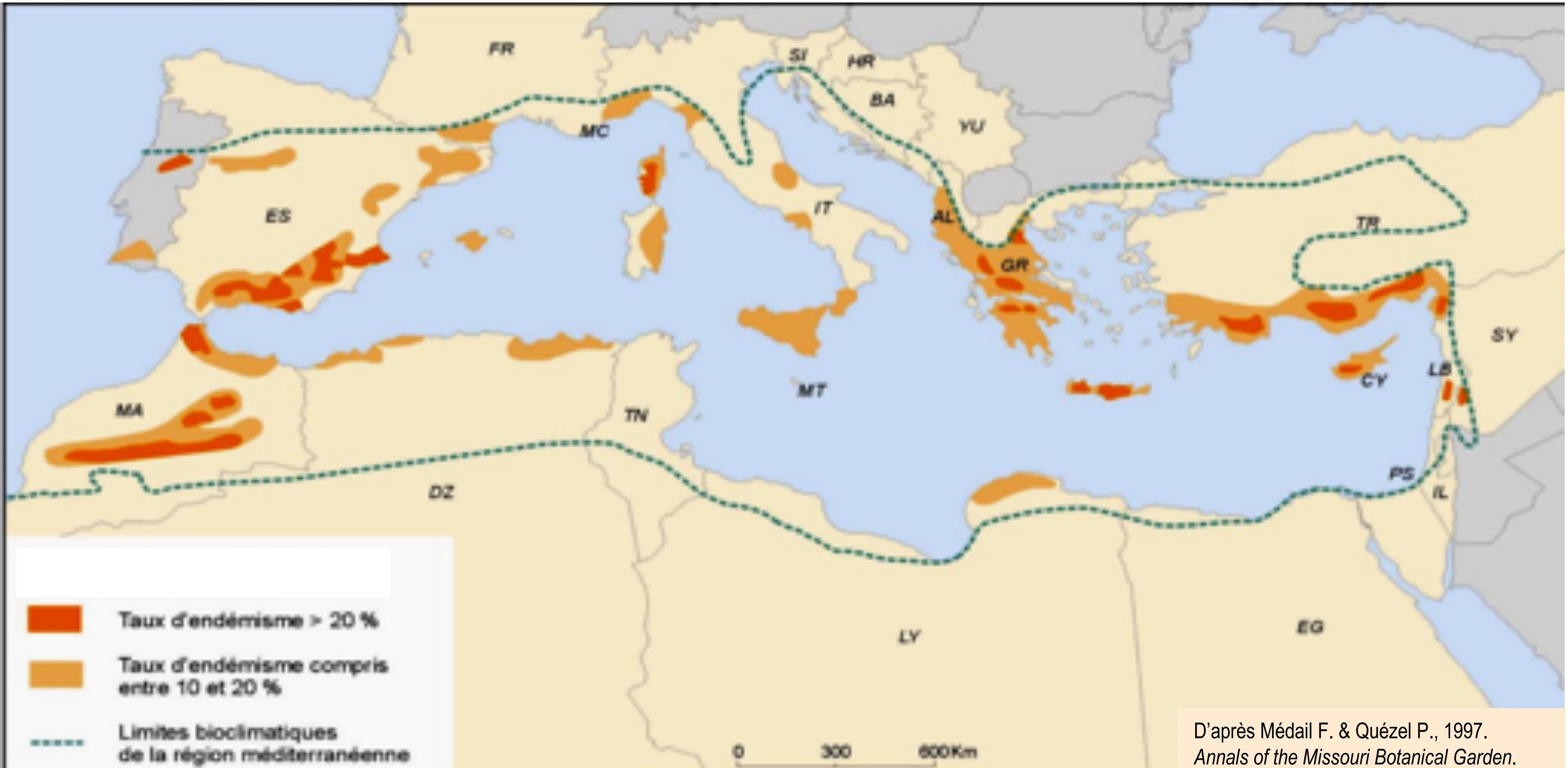
Importance of historical biogeography

The key role of glacial / interglacials episodes



Quézel P. & Médail F., 2003. *Ecologie et biogéographie des forêts du bassin méditerranéen*. Elsevier, Paris.

Major areas of plant endemism in the Mediterranean



D'après Médail F. & Quézel P., 1997. *Annals of the Missouri Botanical Garden*.

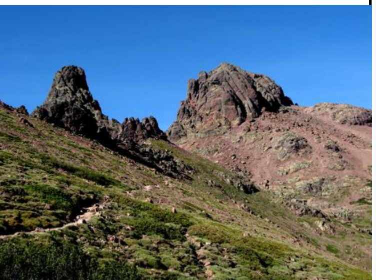

Onosma (Albanie)

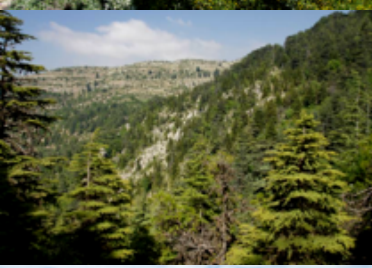
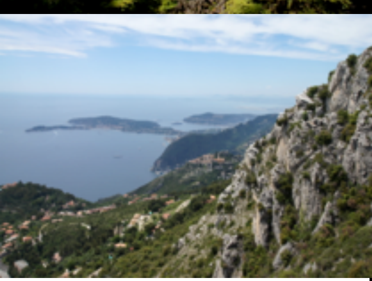

Genista corsica (Corse)


Iris planifolia (Andalousie)


Rosularia libanotica (Liban)

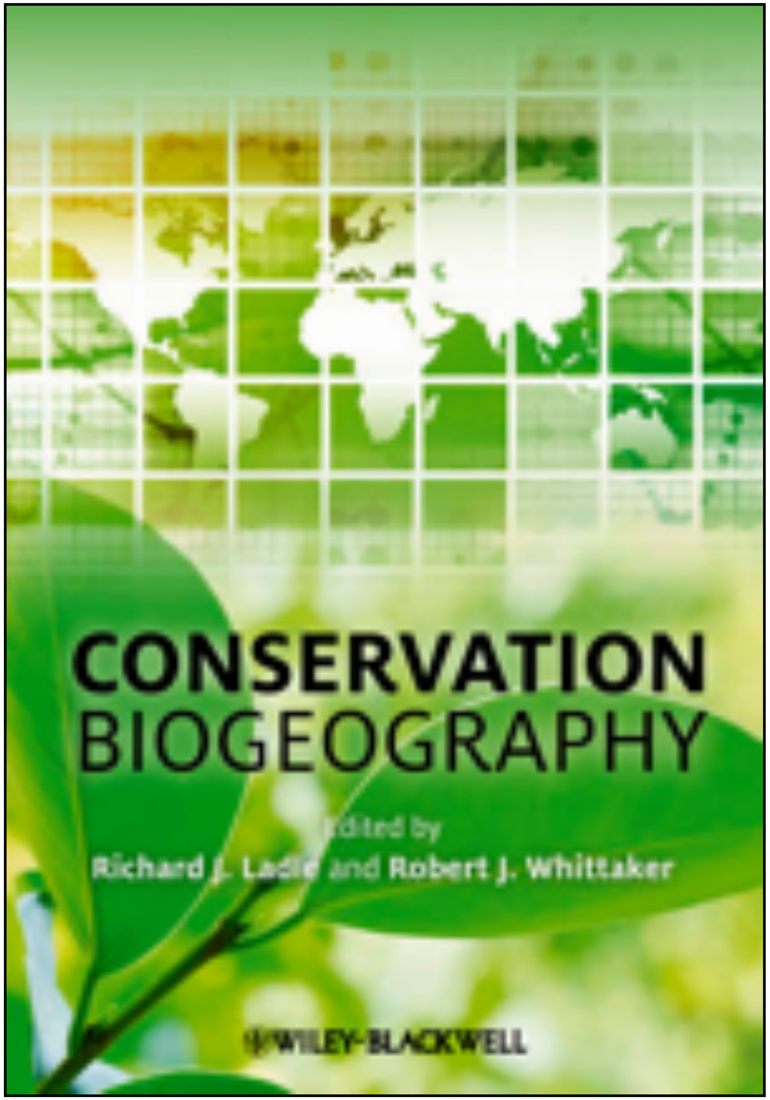
Major phylogeographical refugia of plants in the Mediterranean



Médail F. & Diadema K., 2009.
Journal of Biogeography, 36.

The challenges of Conservation Biogeography



The knowledge shortfalls

– The Linnean shortfall

– The evolutionary shortfall*

– The Wallacean shortfall

– The Flahautian shortfall*

– The climate change shortfall*

– The functional shortfall*

– The extinction estimate shortfall

From Ladle & Whittaker 2011, completed (*F. Médail, this communication)

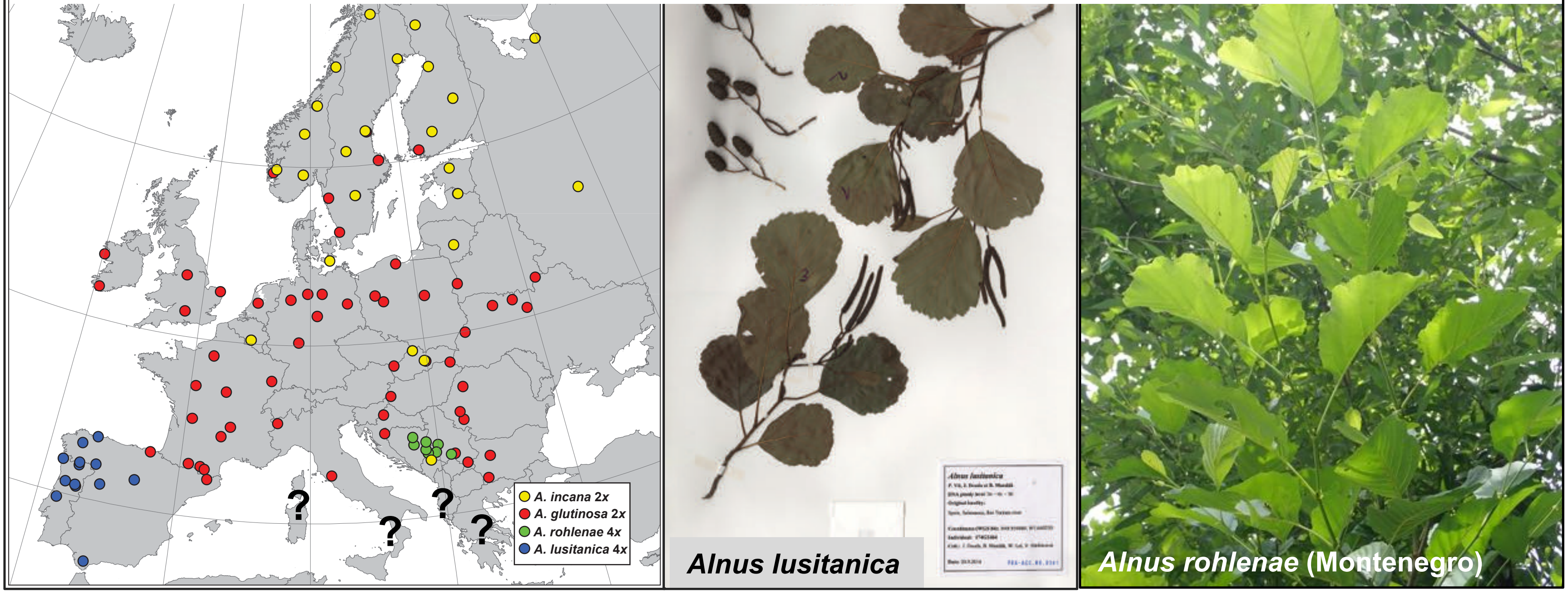
The Linnean shortfall

Strong discrepancy between the number of species that have been formally described by taxonomists and the total number of species that are thought to exist

Brown & Lomolino (1998)

In well-studied groups like vascular plants: often morphologically cryptic species

Two new polyploid species related to *Alnus glutinosa* (Vit *et al.*, 2017. *Taxon*)



How many plants in the Mediterranean <u>Biogeographic</u> Region ?

The Linnean shortfall

PLANT BIOSYSTEMS – AN INTERNATIONAL JOURNAL DEALING WITH ALL ASPECTS OF PLANT BIOLOGY, 2018
VOL. 152, NO. 2, 179–303
https://doi.org/10.1080/11263504.2017.1419996

An updated checklist of the vascular flora native to Italy

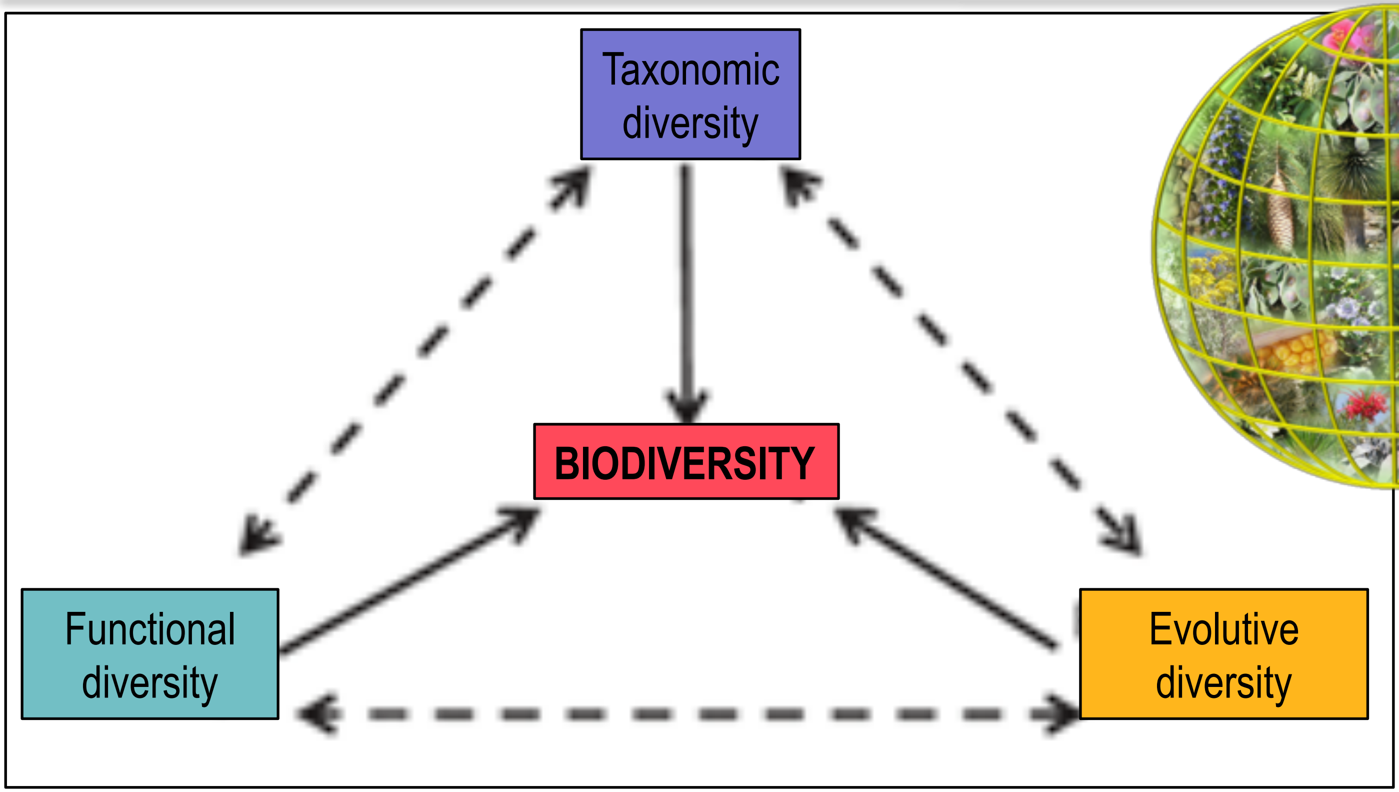
Genera	P
Hieracium	686
Taraxacum	135
Carex	122
Centaurea	115
Limonium	108
Ranunculus	103
Ophrys	101

« An updated checklist is a fundamental tool in floristic, taxonomic and particularly in conservation research »

« The native flora of Italy include 8195 species and subspecies taxa. It is the highest number in Europe and, at the Mediterranean region level, only Turkey hosts a higher number of native plant taxa »

A strong discrepancy / other European & Mediterranean floras or checklists…

The need to get an *integrative* view of biodiversity



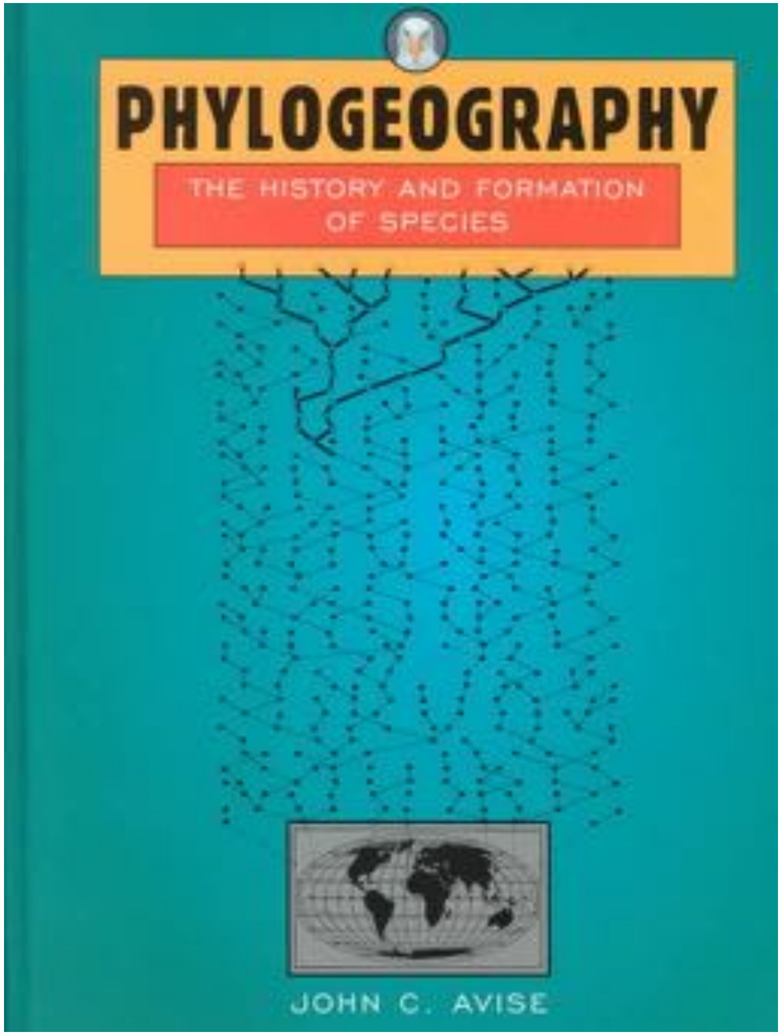
Taxonomic *or* species diversity

Not sufficient to develop a more proactive approach of conservation biogeography

Uninformative about functional and evolutive differences among species or populations

The evolutionary shortfall

Phylogeography, a determinant tool for conservation biogeography

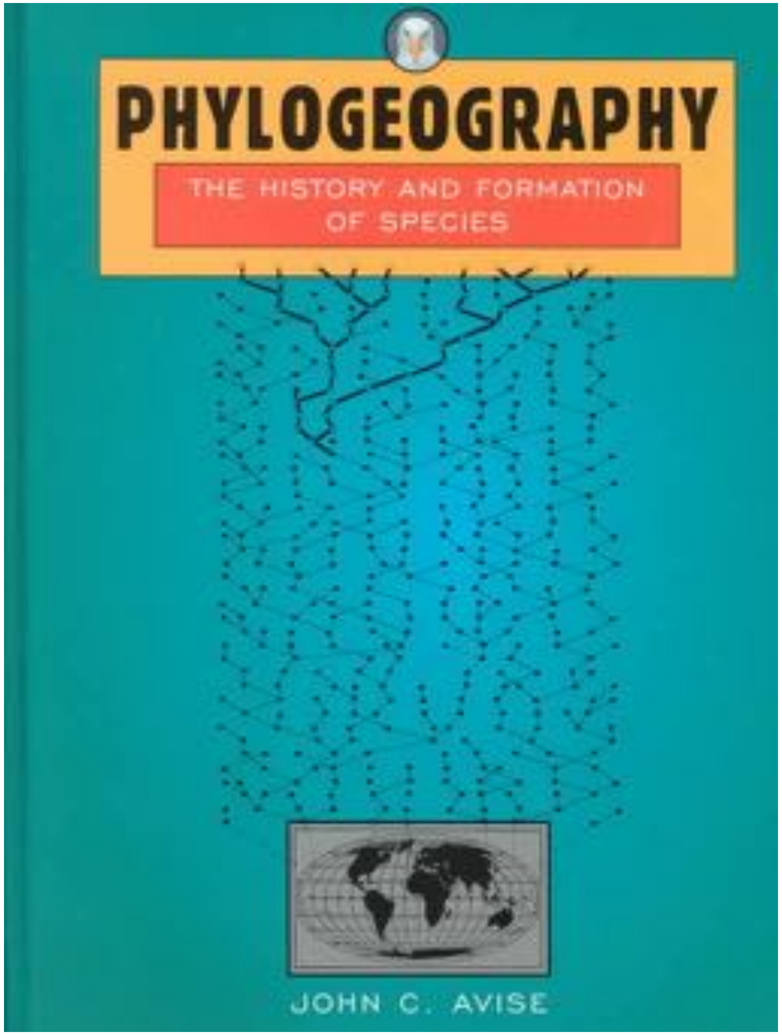


"**Phylogeography** is a field of study concerned with the **principles and processes** governing the **geographic distributions of genealogical lineages**, especially those within and among **closely related species**"

John C. Avise, 2000

The evolutionary shortfall

Phylogeography, a determinant tool for conservation biogeography



Importance of phylogeography

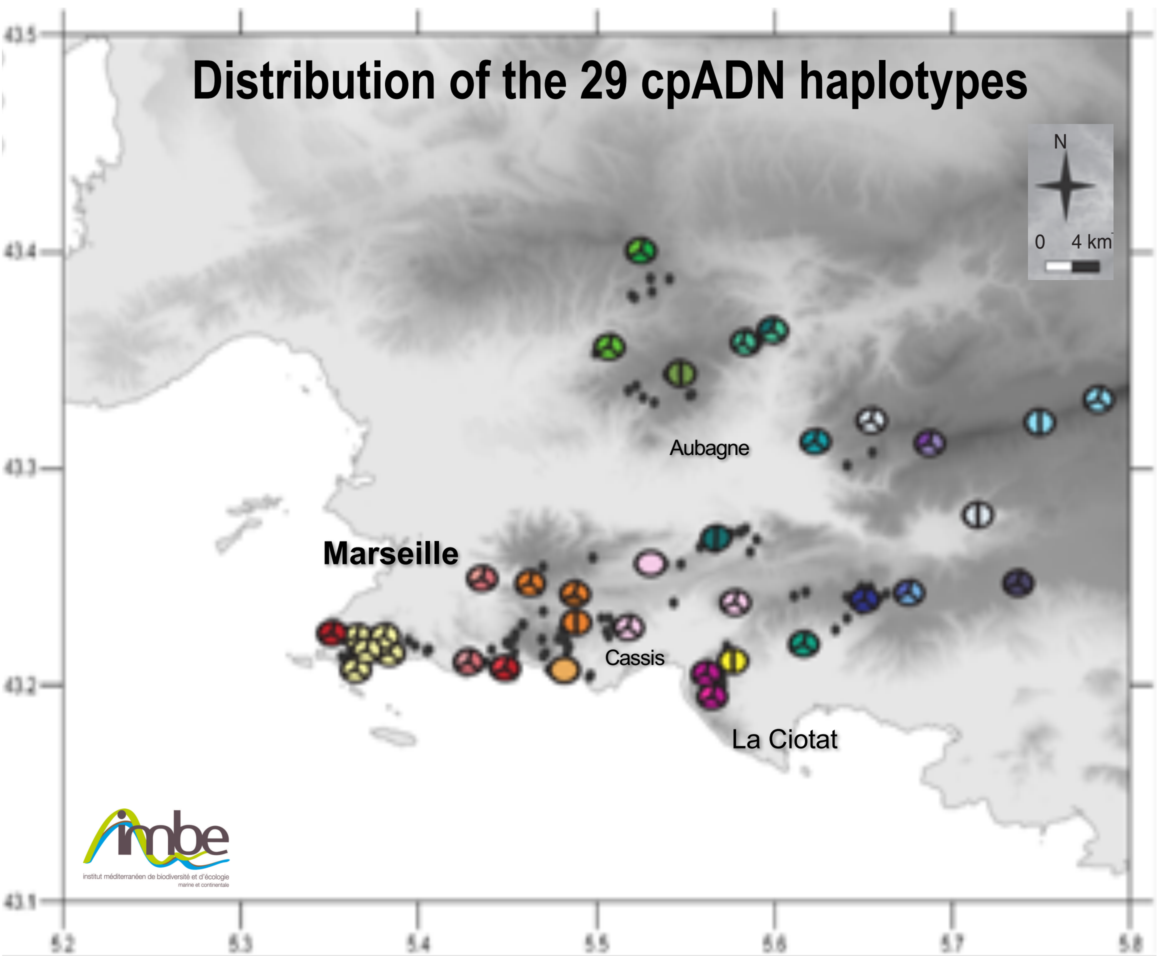
- To predict refugia / hotspots of endemism
- To distinguish cryptic diversity
- To search of independently evolving lineages
- To define ESUs (Evolutionary Significant Units)

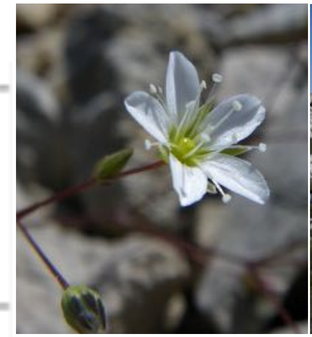
Comparative phylogeography is the clues needed to define areas having a pivotal role for persistence (refugia), diversification (evolutionary cradles) or dispersal (large scale barriers or corridors)

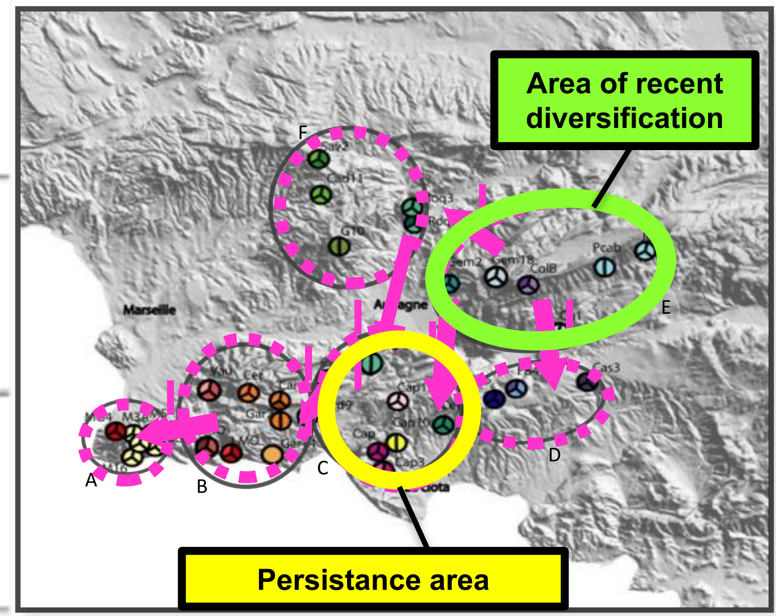
The evolutionary shortfall

The case of a narrow endemic plant with a strong population distinctiveness and a high level of nucleotide variation of cpDNA

Arenaria provincialis
(Caryophyllaceae)







Pouget M., Youssef S., Migliore J., Juin M., Médail F. & Baumel A., 2013. *Annals of Botany*, 112.

The evolutionary shortfall

Biological Conservation 224 (2018) 258–266

Contents lists available at ScienceDirect

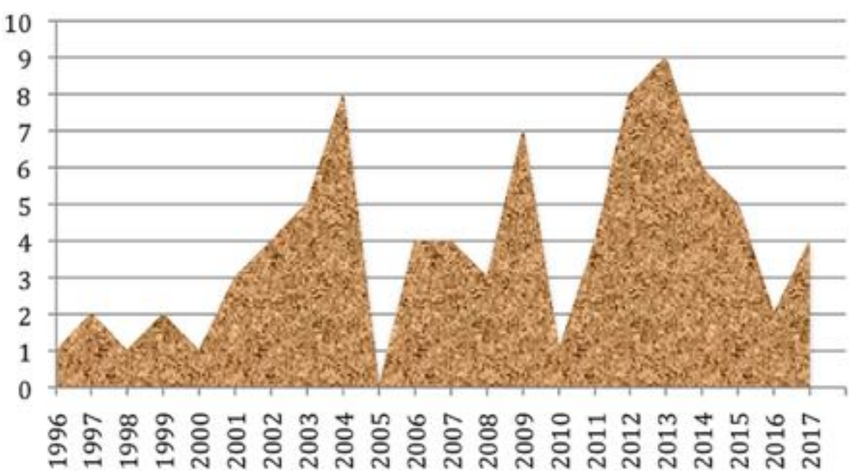
Biological Conservation

journal homepage: www.elsevier.com/locate/biocon

Review

Using phylogeography to define conservation priorities: The case of narrow endemic plants in the Mediterranean Basin hotspot

Frédéric Médail*, Alex Baumel



Annual records of publications reporting the use of genetic data for Mediterranean narrow endemic plants (MNEs):

- **Total number of studies = 84**
- **Total number of studied taxa = 83**

Conceptual position of phylogeography *sensu lato* and implications for conservation genetics

Complementary approaches	Phylogeography *sensu lato*	Applications to conservation genetics
	Single taxon (single species or closely related species)	
Systematics Biogeography	Resolution of unpredictable patterns of genetic structure •Taxonomic uncertainities •Evolutionary significant units (ESUs)	ESUs as outcomes of past and ongoing diversification
Paleoecology Population biology	Better understanding of diversification •Spatial level: barriers, isolation by distance or by environment, admixture •Population level: refugia, expansion, demographic bottleneck	Incorporation of evolutionary processes in conservation
	Multiple taxa (several species across several phyla)	
Historical biogeography Macroecology	Comparative phylogeography	Conservation biogeography

The evolutionary shortfall

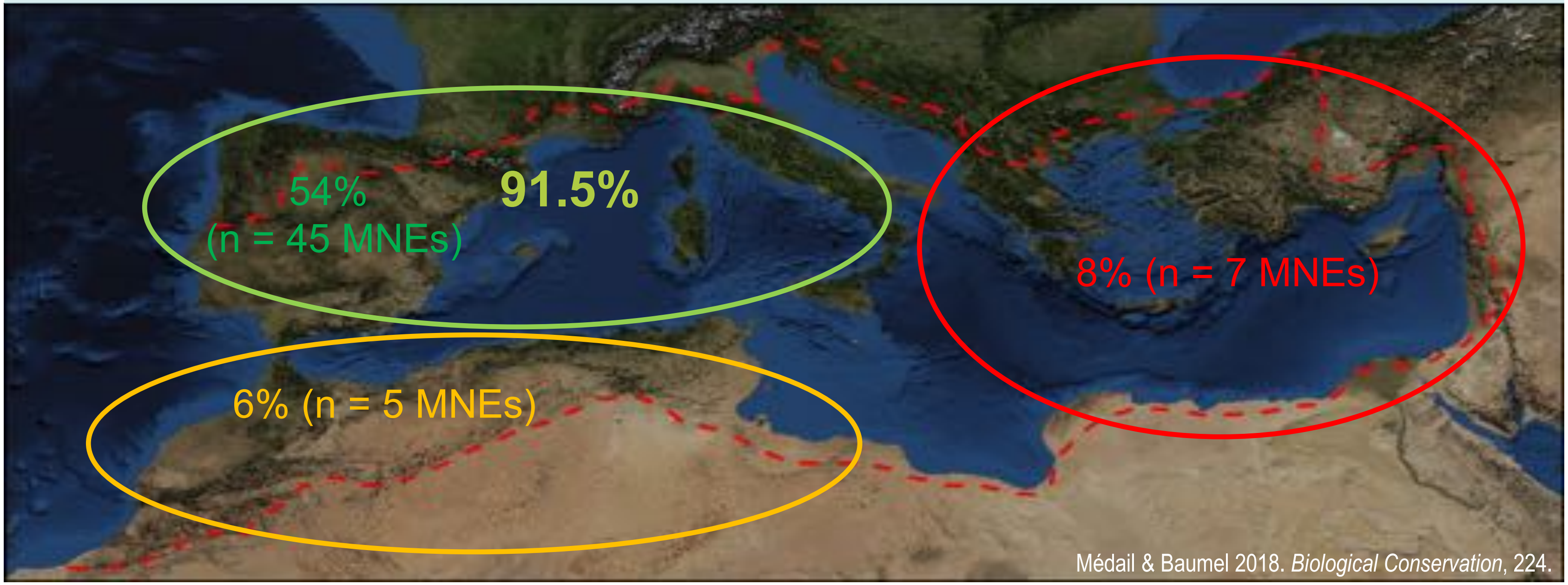
These 83 MNEs represent only 0.75% of the 11,000 MNEs of the Mediterranean region

60% occur on the continent and 40% on some large Mediterranean islands
(The Balearic Islands: n = 15; Sardinia: n = 7; Sicily: n = 6)

91.5% of the analyzed MNEs are located in the NW part of the Mediterranean region

Recent (55% of neoendemics) and ancient lineages (40% of palaeoendemics) are in balance

MNEs are not "evolutionary dead-ends": 50% of the studied species have moderate to high genetic diversity, and genetic differentiation is geographically structured in 56% of the case studies



Médail & Baumel 2018. *Biological Conservation*, 224.

The evolutionary shortfall

2/3 of these 83 MNEs represent threatened taxa *sensu* IUCN
(CR: n = 16; EN: n = 20; VU = 19)

The conservation biogeography framework is quite relevant:
- 65% of these MNEs occur in one of the 10 regional biodiversity hotspots for plants
- 75% of the MNEs are included in one (or more) of the 52 identified glacial refuge areas *sensu* Médail & Diadema (2009)

Daphne rodriguezii (Menorca)

BUT

- 24 of these refugias (i.e. 46%) do not include any of the studied MNEs
- Only 27% of the studies showing a genetic structure of populations explicitly used this information to set conservation priorities
- Only 18% of the studies (i.e. 16 MNEs) inferred genetic units for conservation (ESUs, CUs, MUs)

Cytisus aeolicus (Stromboli, Eolie)

The design of conservation units is generally overlooked and was not a priority issue, rather a way to enhance the scope of genetic diversity analyses.

Most of the analyzed studies have focused on the long-lived MNEs occurring on stable ecosystems, notably cliffs and other rocky habitats.

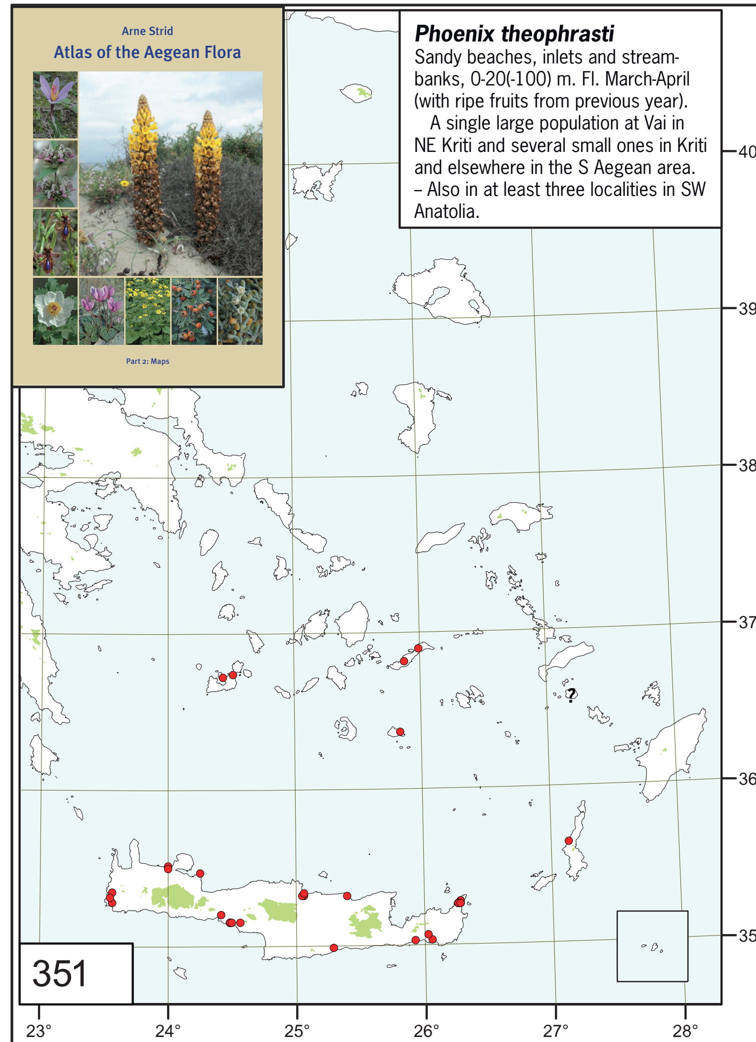
The Wallacean shortfall

Inadequate knowledge of the geographical (global, regional, and even local) distribution of species Lomolino (2004)

Atlas Flora Europaea (1965-)

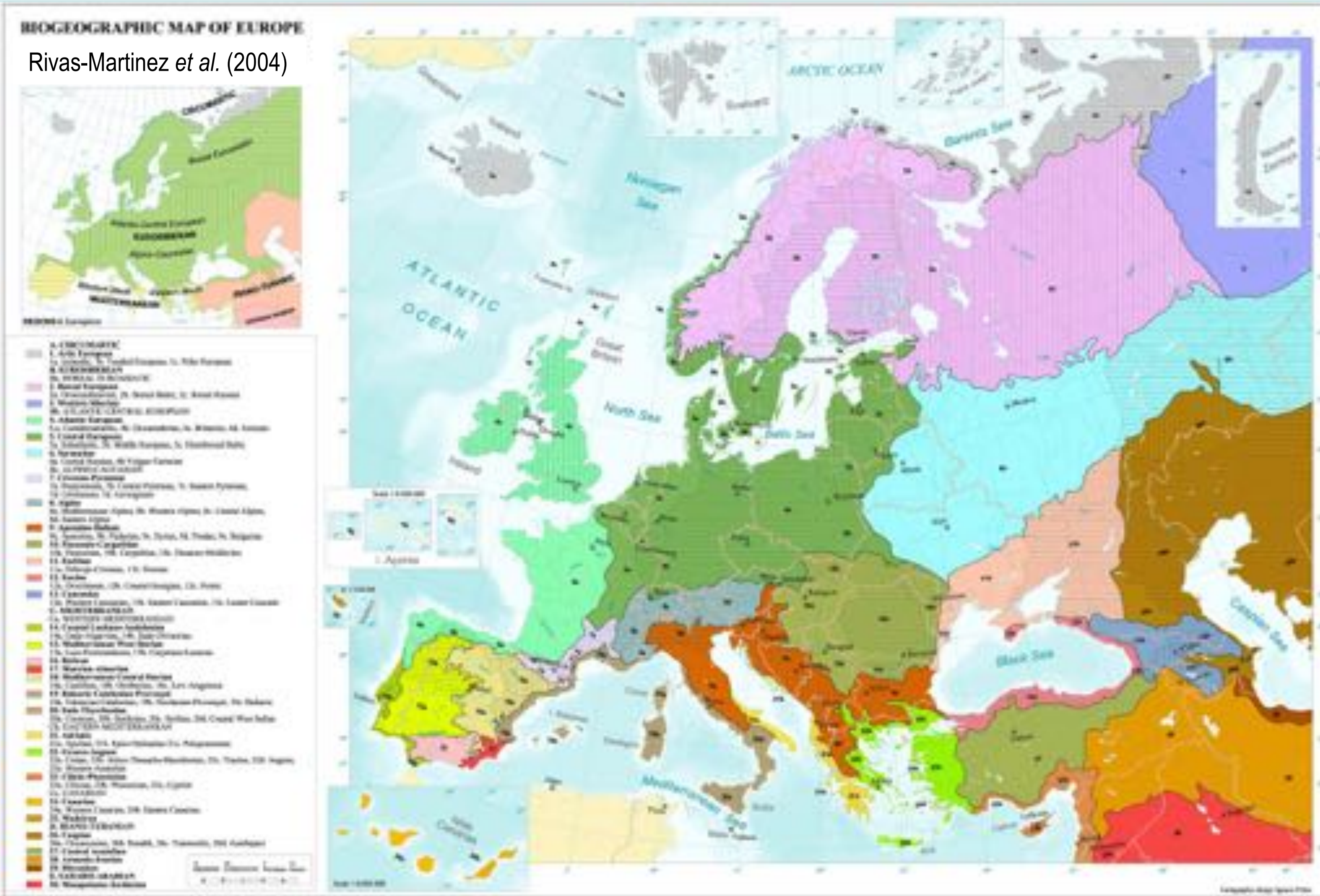
17 volumes, 5054 maps for 4664 species and subspecies

Only 25% of the vascular plants of Europe



The Wallacean shortfall

No yet comprehensive biogeographical analysis and maps allowing the precise sectorization of the whole Mediterranean region



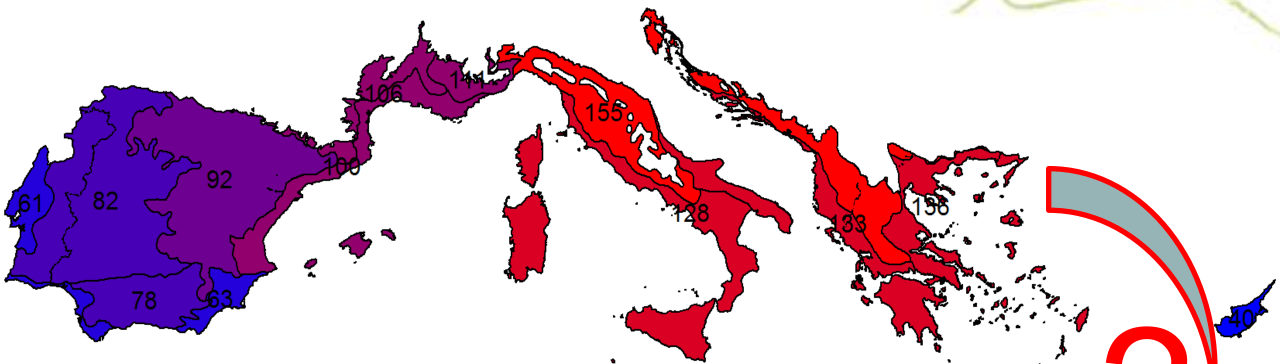
Rivas-Martinez *et al.* (2004)

The Wallacean shortfall

Mediterranean-European tree taxa

How has tree biodiversity been shaped?

How do different facets of biodiversity complement each other?



Distribution by biogeographical provinces *sensu* Rivas-Martinez *et al.* (2004)

Distribution of occurrences by grid cells (50x50 km)

245 tree taxa (210 species and 35 subspecies)

46 endemic tree taxa

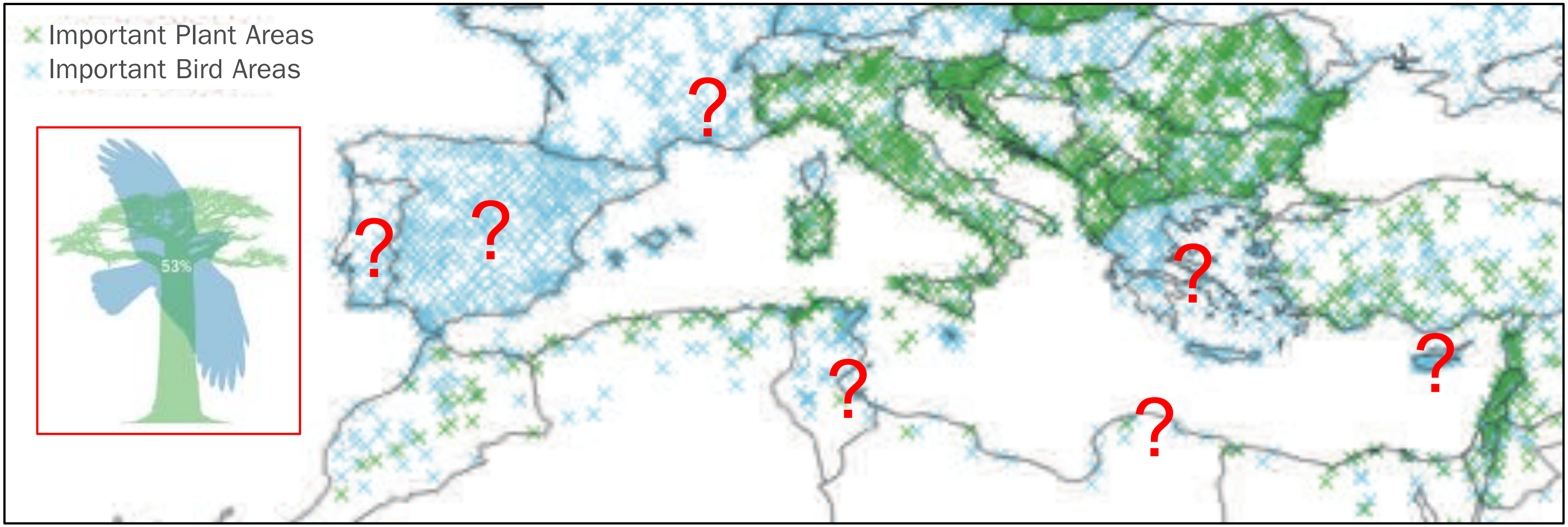
44 "cryptic trees", i.e. 21% of the total

19 threatened tree taxa (15 CR + EN + VU)

Médail F. *et al.* What is a tree in the Mediterranean Basin hotspot? A critical analysis. In prep.

The Wallacean shortfall

Overlap and gaps between Important Plant Areas (IPAS) and Important Bird Areas (IBAs) in the Mediterranean Basin



Very strong spatial heterogeneity in the delineation of IPAs in the Mediterranean Region

Darbyshire I. *et al.* 2017. Important Plant areas., https://stateoftheworldsplants.org/2017/areas-important-for-plants.html

The Flahautian shortfall

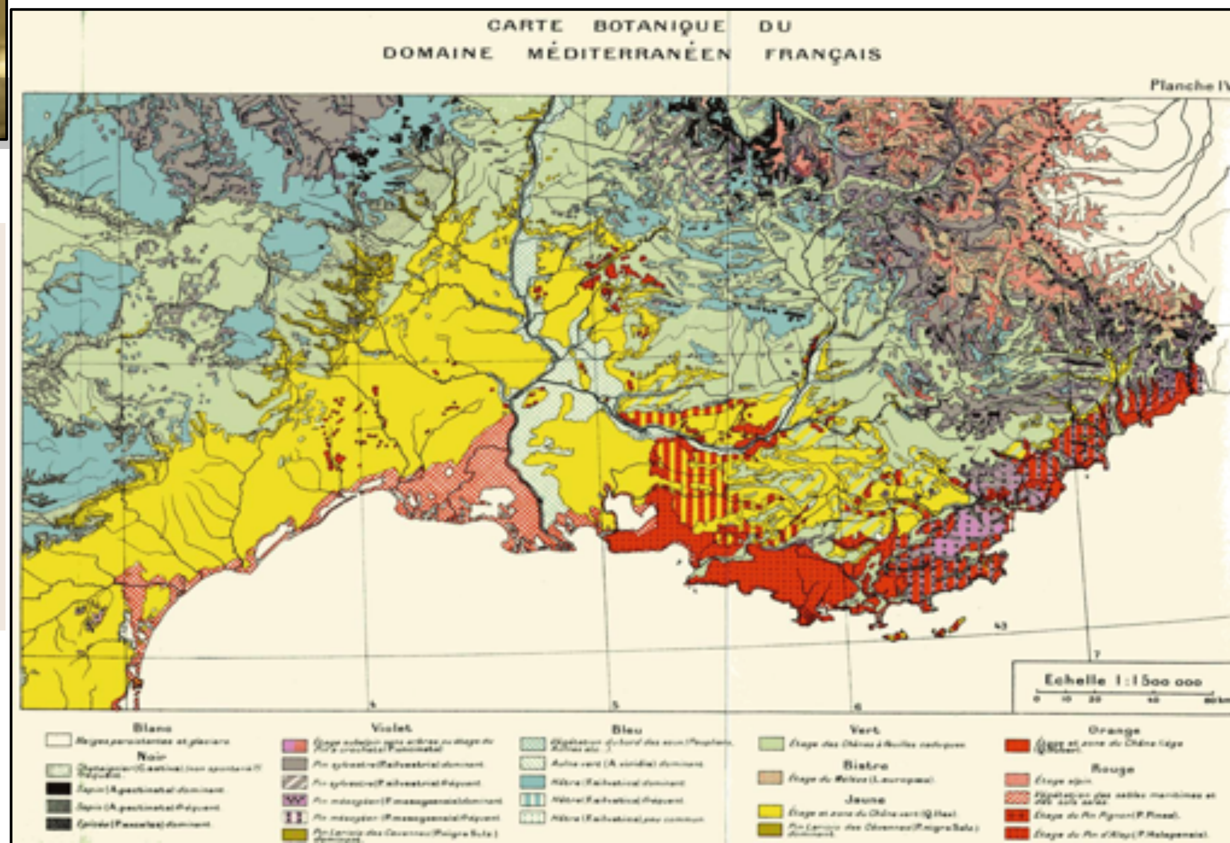
Charles Flahault (1852-1935)

Much of distributional data and many of compilations pertain to political geographical units (states) lacking biological meaning, which have gone their own ways historically in gathering botanical and zoological data, and which vary hugely in area: factors liable to produce serious artefacts when data are combined for analysis

Administrative geographical limits

"Arbitrary, irrational, determined by external considerations to science".

Ch. Flahault, 1897



The climate change shortfall

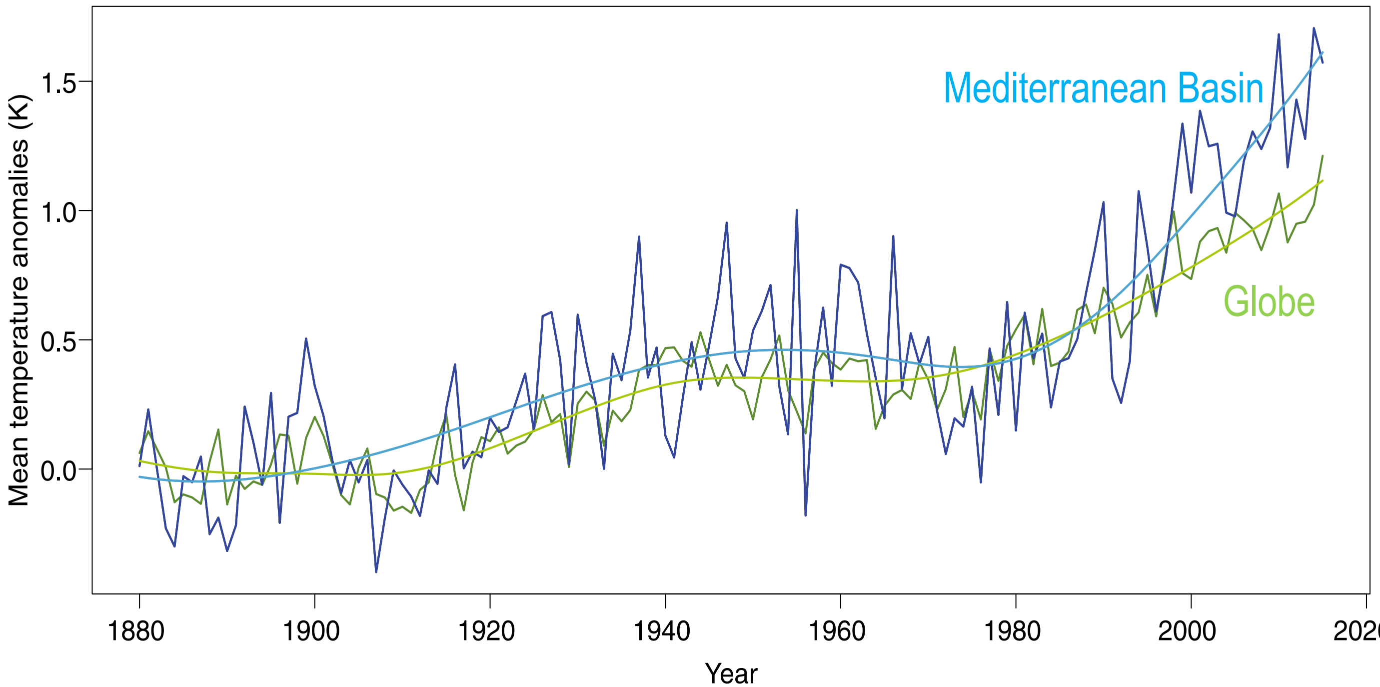
nature climate change
REVIEW ARTICLE
https://doi.org/10.1038/s41558-018-0299-2

Climate change and interconnected risks to sustainable development in the Mediterranean

Wolfgang Cramer[1]*, Joël Guiot[2], Marianela Fader[3], Joaquim Garrabou[4,5], Jean-Pierre Gattuso[6,7], Ana Iglesias[8], Manfred A. Lange[9], Piero Lionello[10,11], Maria Carmen Llasat[12], Shlomit Paz[13], Josep Peñuelas[14,15], Maria Snoussi[16], Andrea Toreti[17], Michael N. Tsimplis[18] and Elena Xoplaki[19]

Observed rates of climate change in the Mediterranean Basin exceed global trends for most variables. Annual mean temperatures are now 1.4 °C above late 19th century levels particularly during the summer months.

Future warming in the Mediterranean region is expected to exceed global rates by 25%, notably with summer warming at a pace 40% larger than the global mean.



Historic warming of the atmosphere globally and in the Mediterranean Basin

Annual mean air temperature anomalies are shown with respect to the period 1880–1899, with (light curves) and without (dark curves) smoothing. Data from http://berkeleyearth.org/

The climate change shortfall

Existence of numerous simplifying assumptions that may bias the projections of future biodiversity patterns in response to climate change

GLOBAL SCALE	LOCAL SCALE
Equilibrium postulate / environment	No individualistic (evolutive) response of individuals or populations
No influence of past climate and biogeographical history	Simplifying patterns of plant dispersal
Spatial homogeneity of climate change	No consideration of demographic processes
Geographic homogeneity in plant - environment relationships	No inclusion of persistance patterns
No (or reduced) influence of other drivers of global-change	No influence of biological interactions

The climate change shortfall

Mediterranean plants are generally able to overcome very severe climatic variations (both intra and inter–annuals)

But what will be the changes as a result of modifications in the species composition and new biotic interactions at the community and ecosystem levels?

Local or total extinction?

Persistance with or without local adaptation?

Migration and modification of species range?

Deep inter-annual fluctuation in the life cycle of a geophyte: *Colchicum filifolium* in S. France

Photos D. Pavon / IMBE

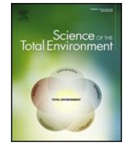
The climate change shortfall

Science of the Total Environment 599–600 (2017) 797–805

Contents lists available at ScienceDirect

Science of the Total Environment

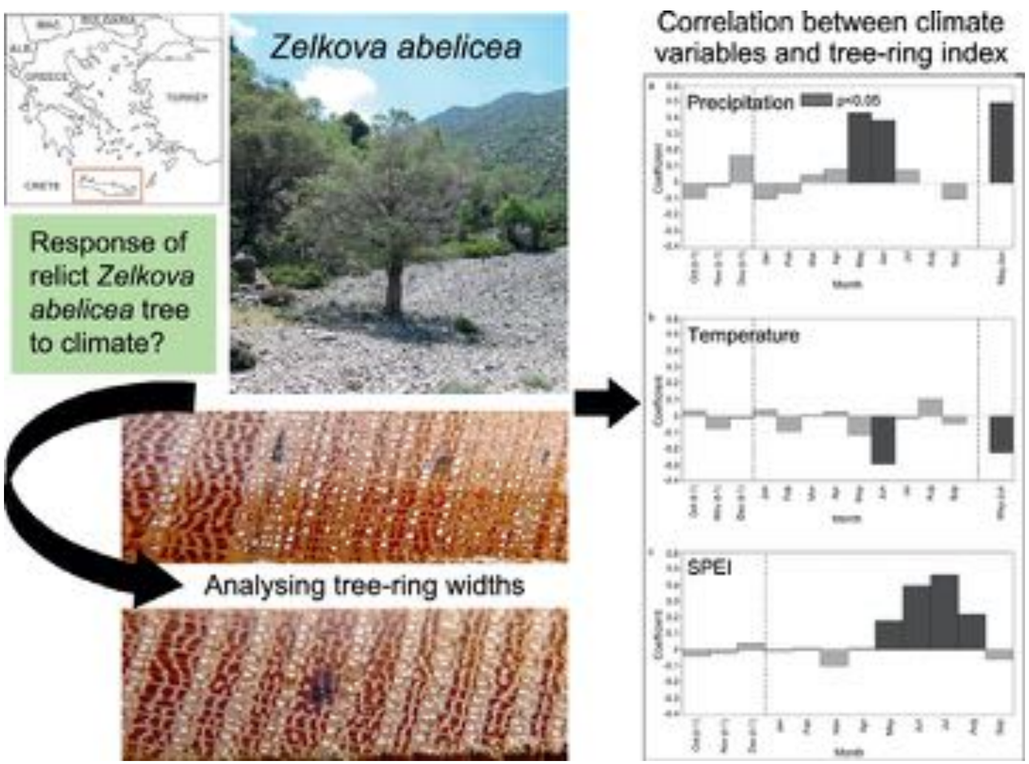
journal homepage: www.elsevier.com/locate/scitotenv



Imprisoned in the Cretan mountains: How relict *Zelkova abelicea* (Ulmaceae) trees cope with Mediterranean climate

Laurence Fazan [a,b,*], Sébastien Guillet [a,c], Christophe Corona [d], Gregor Kozlowski [b,e], Markus Stoffel [a,c]

The case of *Zelkova abelicea*, a narrow endemic of the Cretan mountains



Zelkova abelicea is most sensitive to pre–cipitation and drought in May–June

The climatic sensitivity of the species is stable throughout the 20th century for most of the climatic parameters

No growth change can be related to the increase in dry conditions of the past decades

Zelkova abelicea has a high capacity to withstand changing environmental conditions

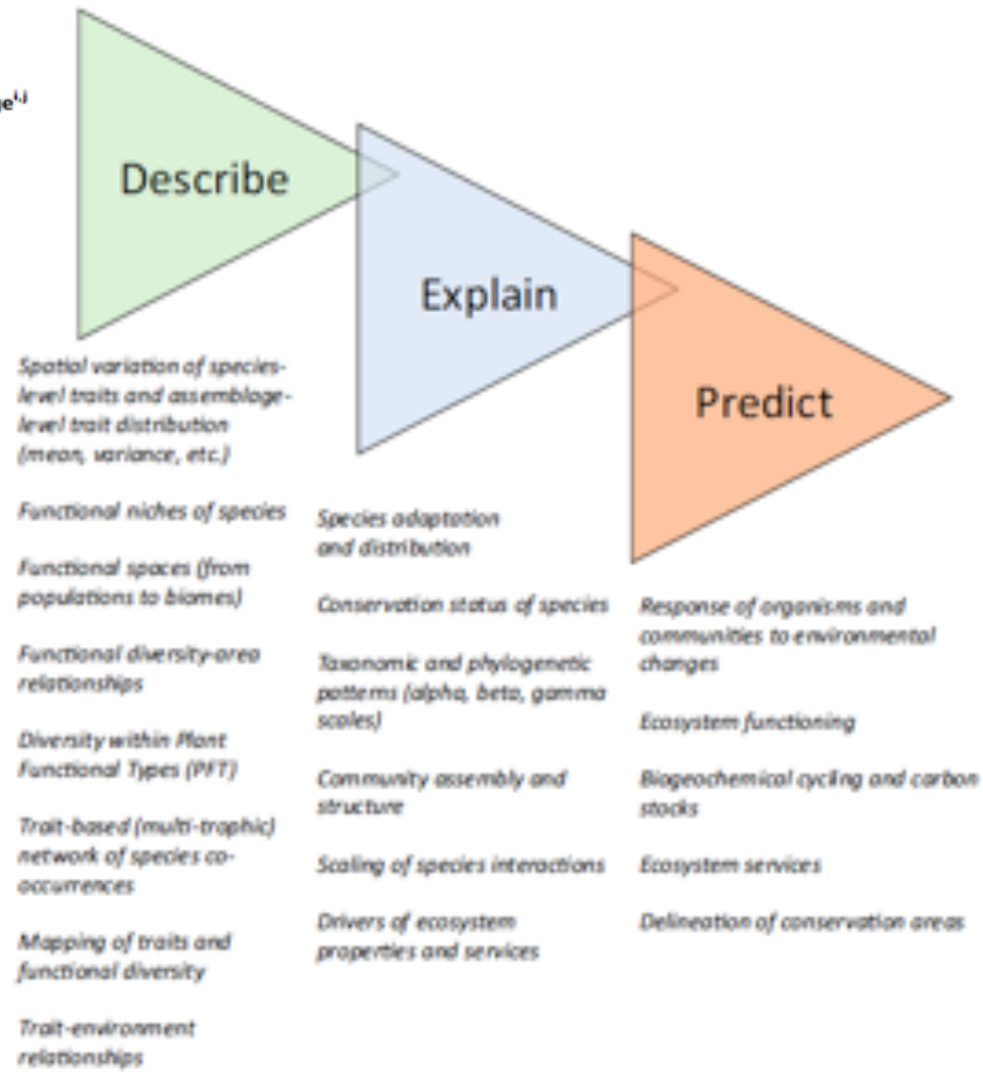
The functional biogeography shortfall

SPECIAL FEATURE: INTRODUCTION

PNAS, 2014

The emergence and promise of functional biogeography

Cyrille Violle[a,b,1], Peter B. Reich[c,d], Stephen W. Pacala[e], Brian J. Enquist[f,g,h], and Jens Kattge[i,j]

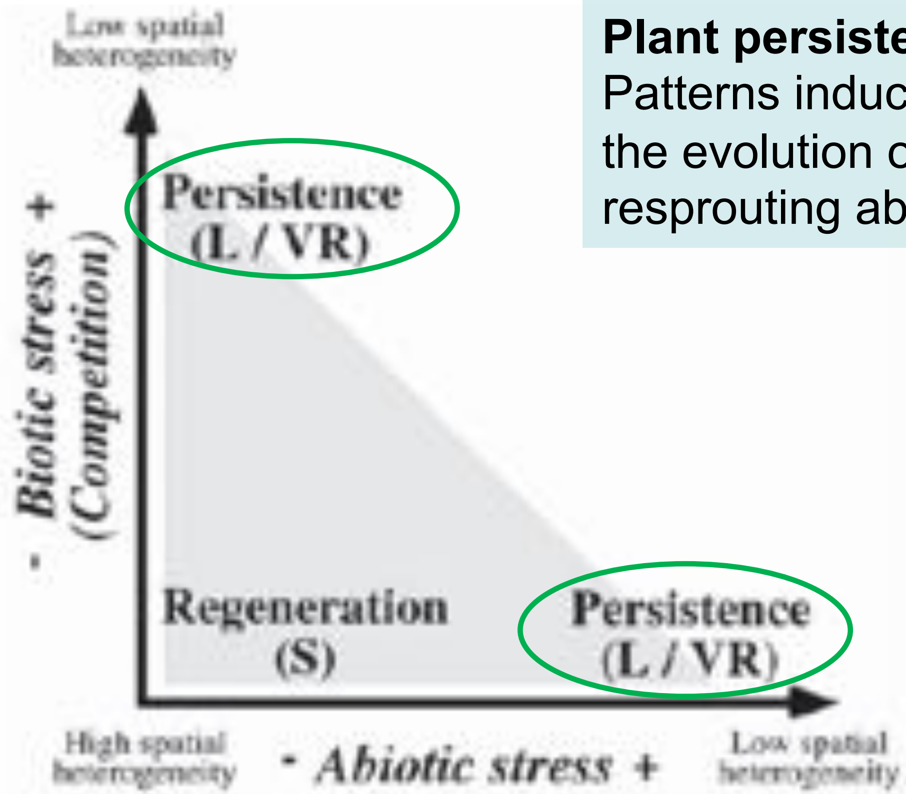


To understand, model, and predict the impact of global change on ecosystem functioning across biogeographical gradients

Study of the geographic distribution of trait diversity across organizational levels

The functional biogeography shortfall

Plant persistence along biogeographical gradients?
Patterns induced by several selective force that shape the evolution of plant reproductive traits such as resprouting ability and propagule persistence in soil



Representation of multiple demographic strategies of persistence and regeneration of a long-lived species, and the biological traits promoting them

L = Longevity

VR = Vegetative Reproduction

S = Seeding

Garcia & Zamora, 2003. *Journal of Vegetation Science*, 14.

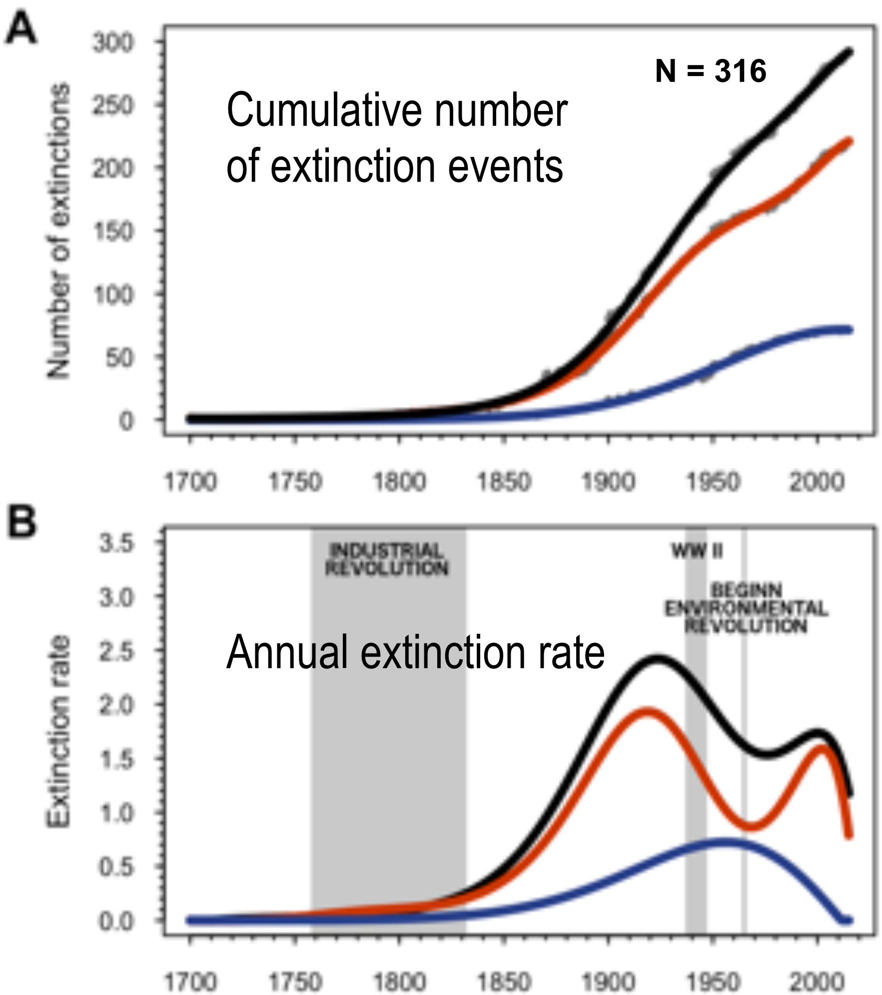
The ca. 1500 geophytes of the Mediterranean Basin are mostly rare and narrow endemic species; their persistence by longevity through seeds and storage organs often reduces their local extinction.

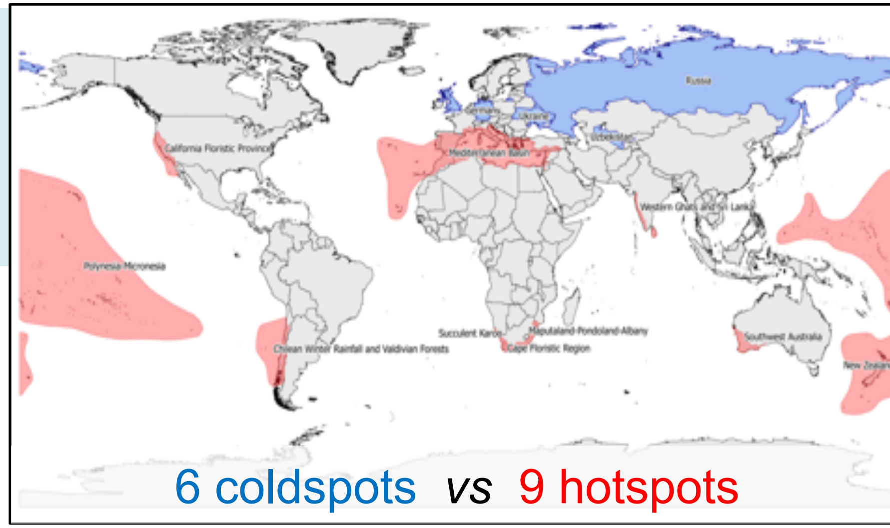
Acis nicaeensis (Maritime Alps)

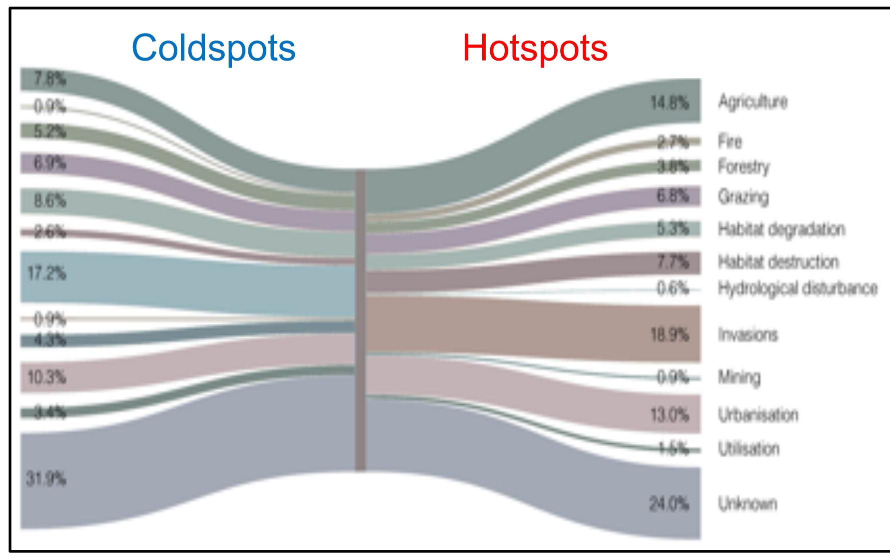
The extinction estimate shortfall

Plant extinctions for biodiversity hotspots (red lines), coldspots (blue lines), hot- and coldspots combined (black lines) since 1700

J.J. Le Roux *et al.*, in prep.







Contribution of the different drivers inducing plant extinctions in coldspots *vs.* hotspots

The extinction estimate shortfall

Extinctions in Mediterranean areas

WERNER GREUTER

Botanischer Garten und Botanisches Museum Berlin-Dahlem, Königin-Luise-Strasse 6–8, D-14191 Berlin, Germany

Phil. Trans. R. Soc. Lond. B (1994) **344**, 41–46

37 Mediterranean plants presumed totally extinct, i.e. an extinction rate of 0.13% of the native flora

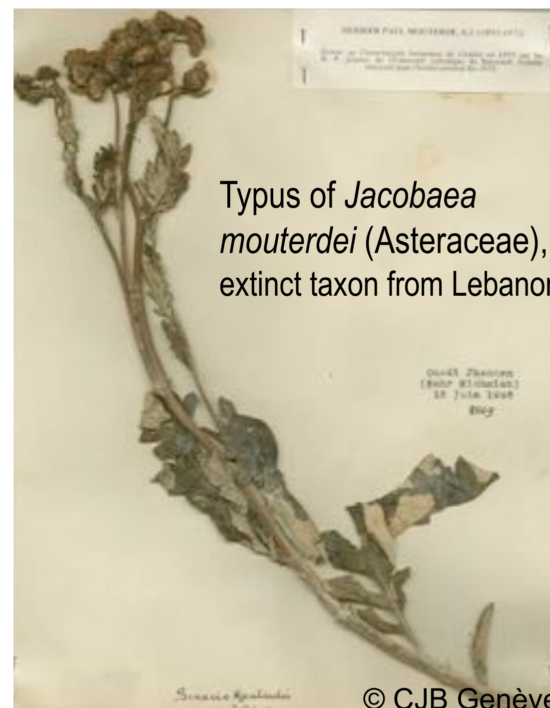
Patterns and processes underlying Anthropocene plant extinctions in biodiversity hot- and coldspots

J. J. Le Roux[1], M. L. Castillo[1], C. Hui[1,2], J. M. Iriondo[3], J-H. Keet[4], A. A. Khapugin[5], F. Médail[6], M. Rejmanek[7], G. L. Theron[4], F. Yannelli[1], H. Hirsch[1]

26 Mediterranean plants probably extinct within the Mediterranean biogeographic region, i.e. an extinction rate of 0.10% (F. Médail & J.M. Iriondo, inéd.)

- 18 of these 26 extinct taxa were not cited by Greuter (1994), i.e. only 30% of the taxa are common between the two surveys.

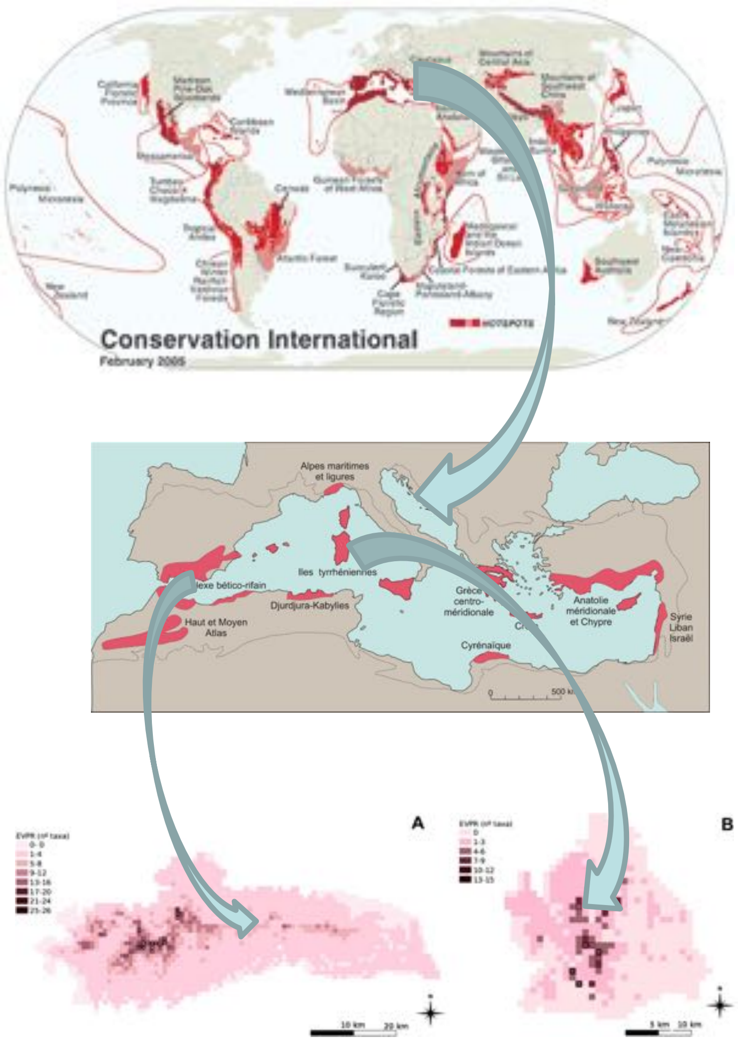
- The most numerous plant extinctions occur in Lebanon (7 taxa), Turkey (5 taxa), Greece and Italy (3 taxa each).



Typus of *Jacobaea mouterdei* (Asteraceae), extinct taxon from Lebanon

The need to fill the conservation shortfalls in the Mediterranean

Hierarchical levels of hotspots



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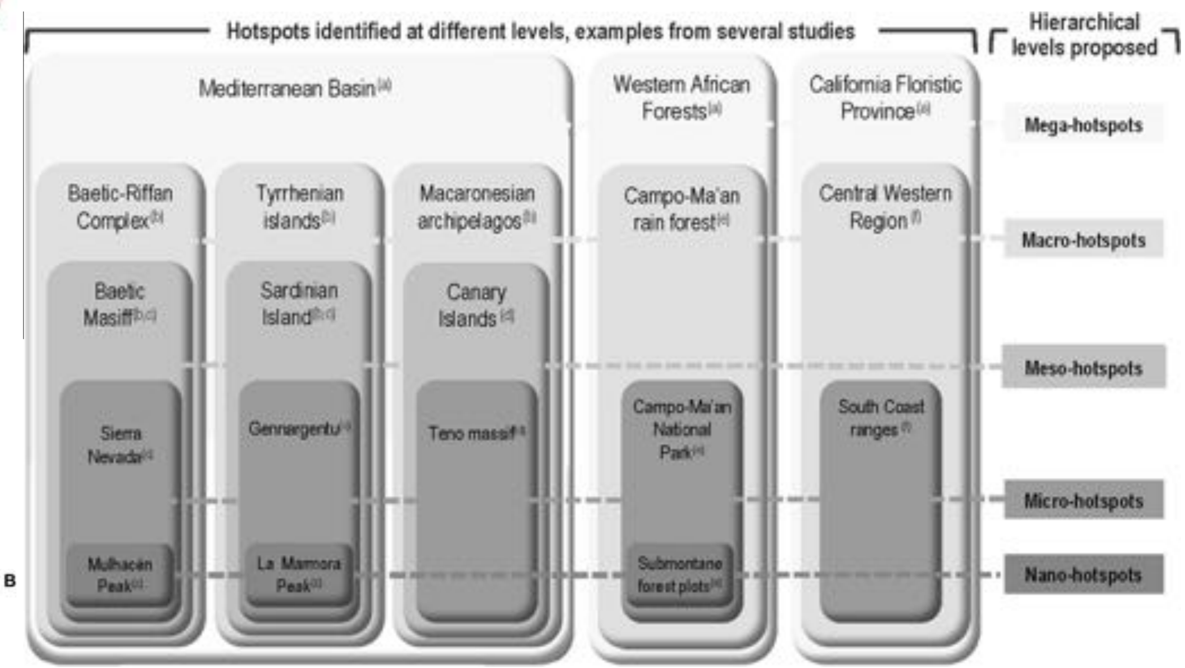
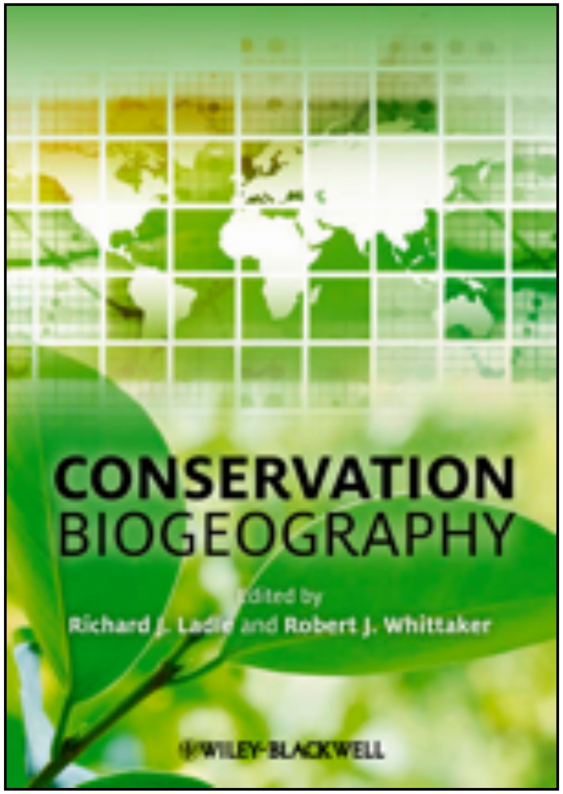
Hotspots within hotspots: Endemic plant richness, environmental drivers, and implications for conservation

Eva M. Cañadas[a,b,*], Giuseppe Fenu[a], Julio Peñas[b], Juan Lorite[b], Efisio Mattana[a,c], Gianluigi Bacchetta[a]



The need to fill the conservation shortfalls in the Mediterranean



– **The Linnean shortfall**

Need of a consensual and modern taxonomic DB across the whole Mediterranean Biogeographic Region (MBR)

– **The evolutionary shortfall**

Need to develop conservation genetics studies on plants of poorly investigated areas (N. Africa, E. Mediterranean) and to strongly develop the ESU approach

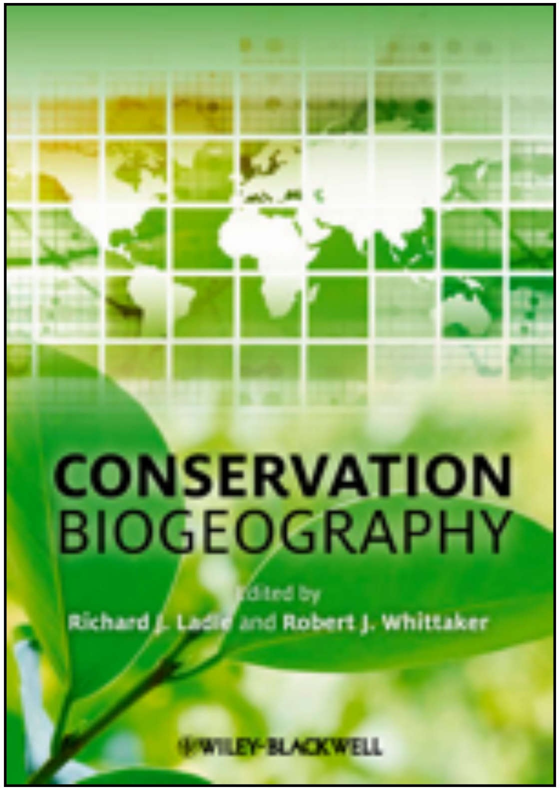
– **The Wallacean shortfall**

Need to develop a commun DB of species occurrences by aggregation of robust and verified data, and to perform a comprehensive biogeographical sectorisation at the MBR scale

– **The Flahautian shortfall**

Need to overcome the administrative limits as much as possible and consider the territories to preserve with a biogeographical perspective

The need to fill the conservation shortfalls in the Mediterranean



– **The climate change shortfall**

Need to develop a network of long–term surveys at local and regional scales to better estimation the projections of future biodiversity patterns (species and habitats)

– **The functional shortfall**

Need to focus on diverse plant functional groups, especially on short–lived plants (annuals and biennials) localized in other habitats (notably coastal areas, grasslands, wetlands) than the rupicolous ones

– **The extinction estimate shortfall**

Need to examine the processes leading to local and regional extinctions of populations and taxa and to confront these patterns with the different drivers of extinction (evolutive/functional, environment/human impacts)

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Daniel Pavon
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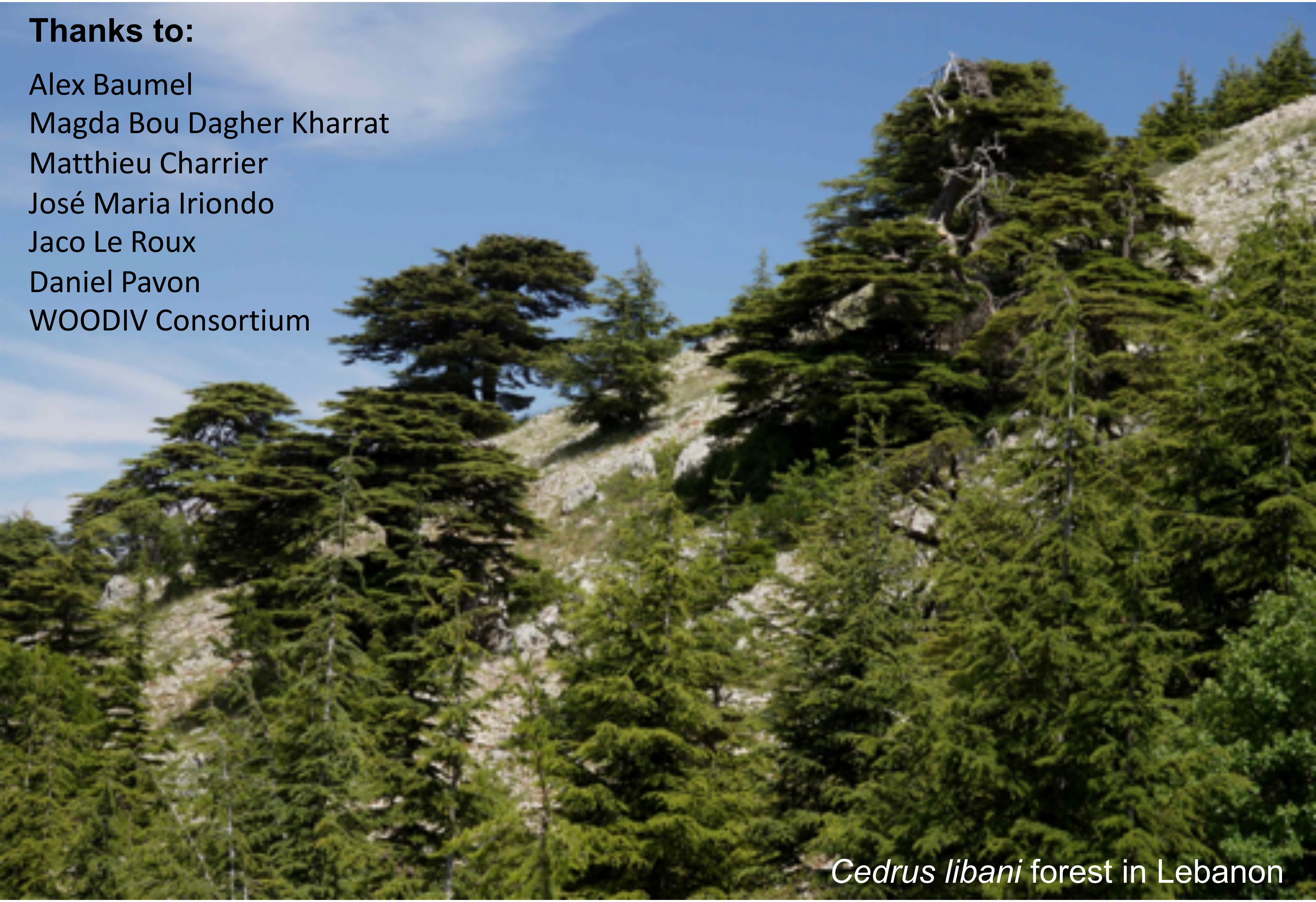

Cedrus libani forest in Lebanon