3rd Mediterranean Plant Conservation Week

"Plant Conservation Strategies: from Science to Practice"

Chania, Crete, Greece
27 September -- 1 October 2021

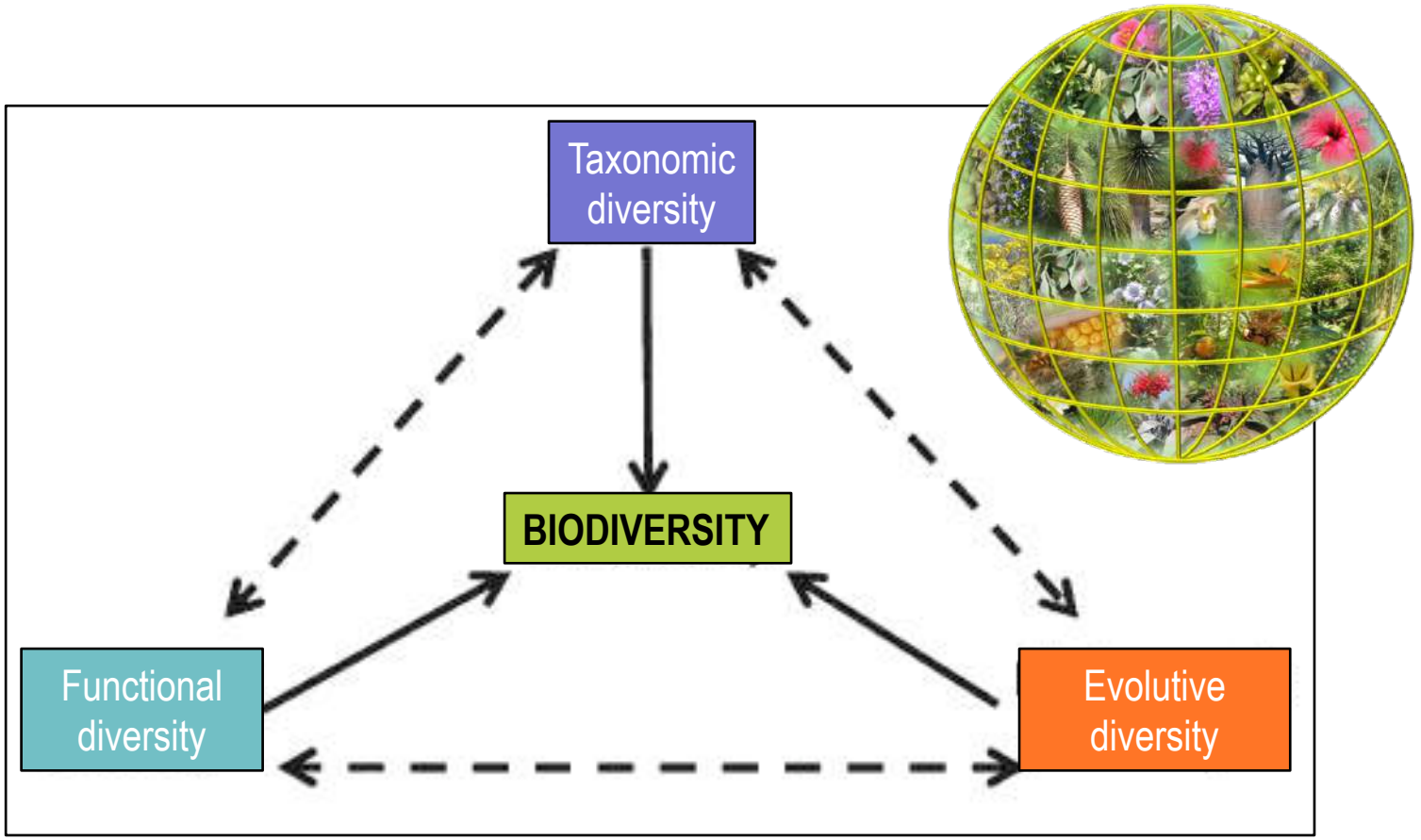
Importance of evolutionary and ecosystem-based approaches to *in situ* conservation practices of the Mediterranean flora

Pr. Frédéric MEDAIL
with the collaboration of Eric Meineri & Marie Finocchiaro

Aix*Marseille université
Initiative d'excellence

imbe
institut méditerranéen de biodiversité et d'écologie
marine et continentale

The need to get an *integrative* view of biodiversity

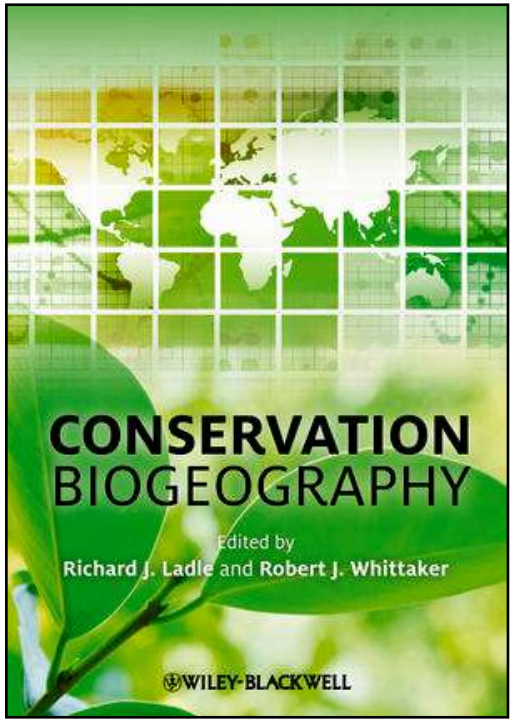


Taxonomic *or* species diversity

Not sufficient to develop a more proactive approach of conservation biogeography

Uninformative about functional and evolutive differences among species or populations

The key role of biogeography for biodiversity conservation



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


Sicily (Salina island)

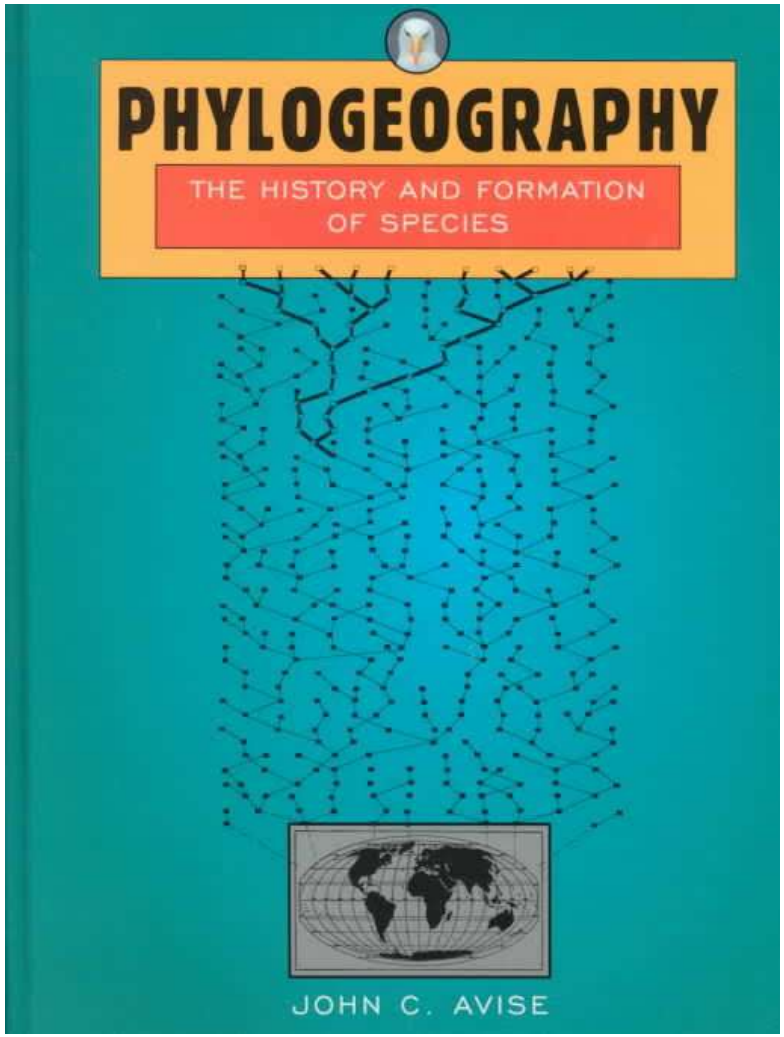

Cyprus


Corsica

Importance of integrative species-based approaches

Importance of evolutionary approach

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

The clues needed to define areas having a pivotal role for persistence (refugia), diversification (evolutionary cradles) or dispersal (large scale barriers or corridors) for several species / various taxonomic groups

Importance of evolutionary approach

Biological Conservation 224 (2018) 258–266

Contents lists available at ScienceDirect

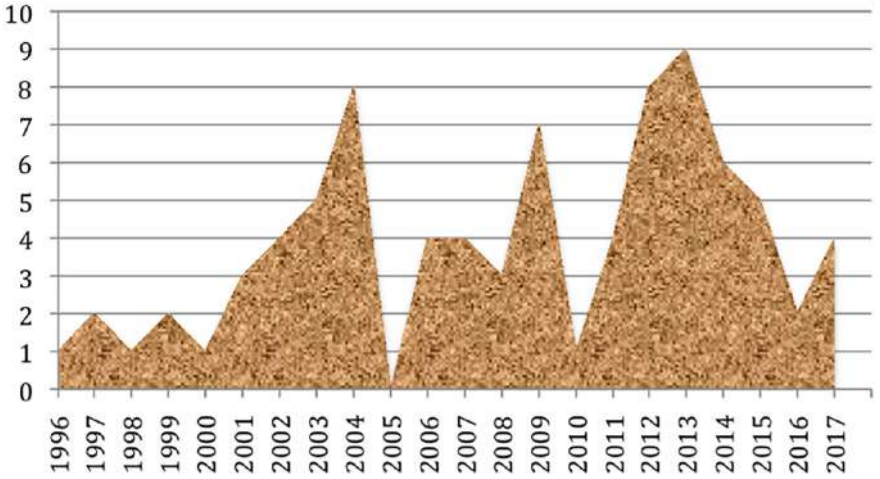
Biological Conservation

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

Review

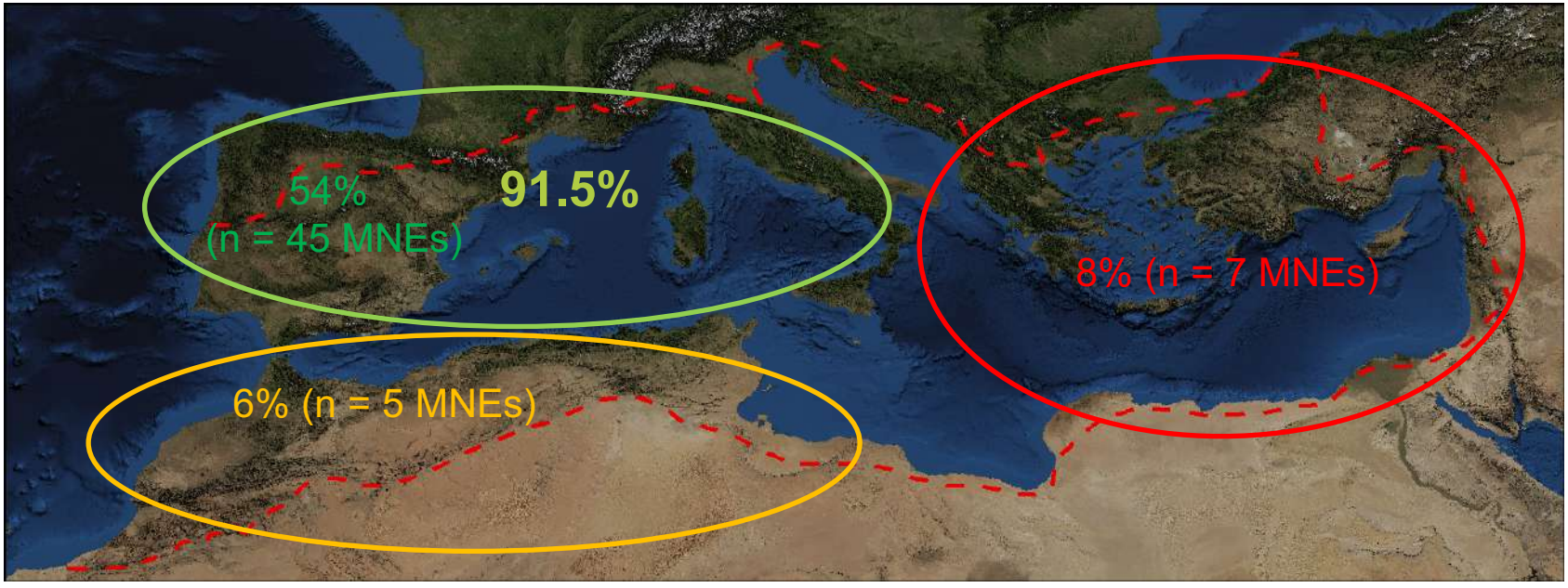
Using phylogeography to define conservation priorities: The case of narrow endemic plants in the Mediterranean Basin hotspot

Frédéric Médail*, Alex Baumel



Annual records of publications using genetic data for Mediterranean narrow endemic plants (MNEs)

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



Importance of evolutionary approach

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

The conservation biogeography framework is relevant:
- 65% of MNEs included in one of the 10 regional biodiversity hotspots
- 75% of the MNEs included in one (or more) of the 52 main glacial refugia *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 of 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.

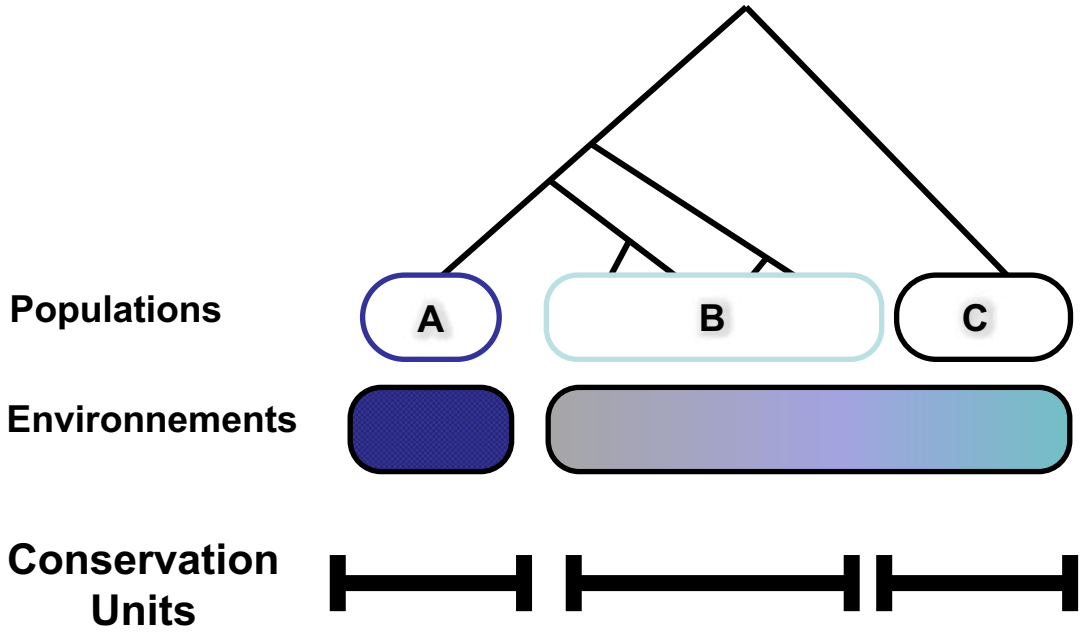
Most of the analyzed studies have focused on the long-lived MNEs occurring on stable ecosystems, notably cliffs and other rocky habitats.

Integrating evolution and ecology to define plant microreserves

How to preserve the evolutionary and ecological legacy of a endangered plant?

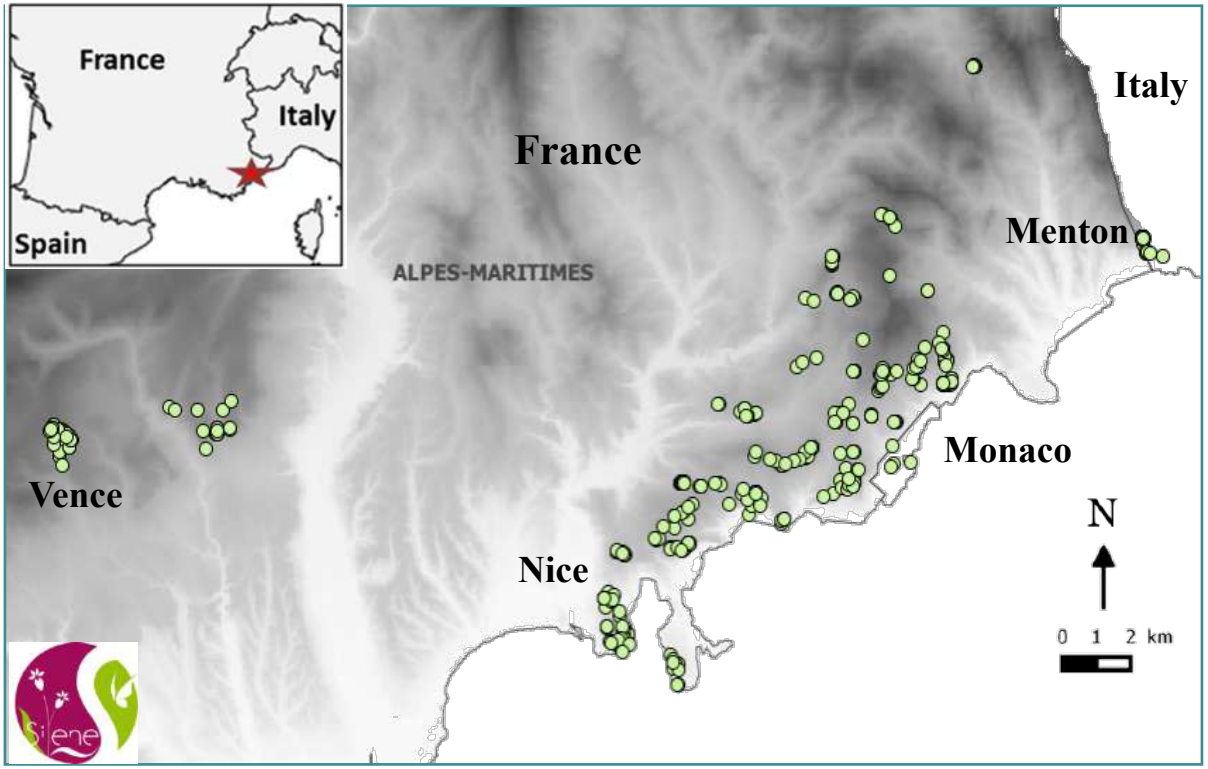
The use of genetic and ecological distinctiveness to delineate **conservation units**

Haplotype + ecological group = Unit



Integrating evolution and ecology to define plant microreserves

***Acis nicaeensis*, The Riviera snowflake** (Amaryllidaceae)



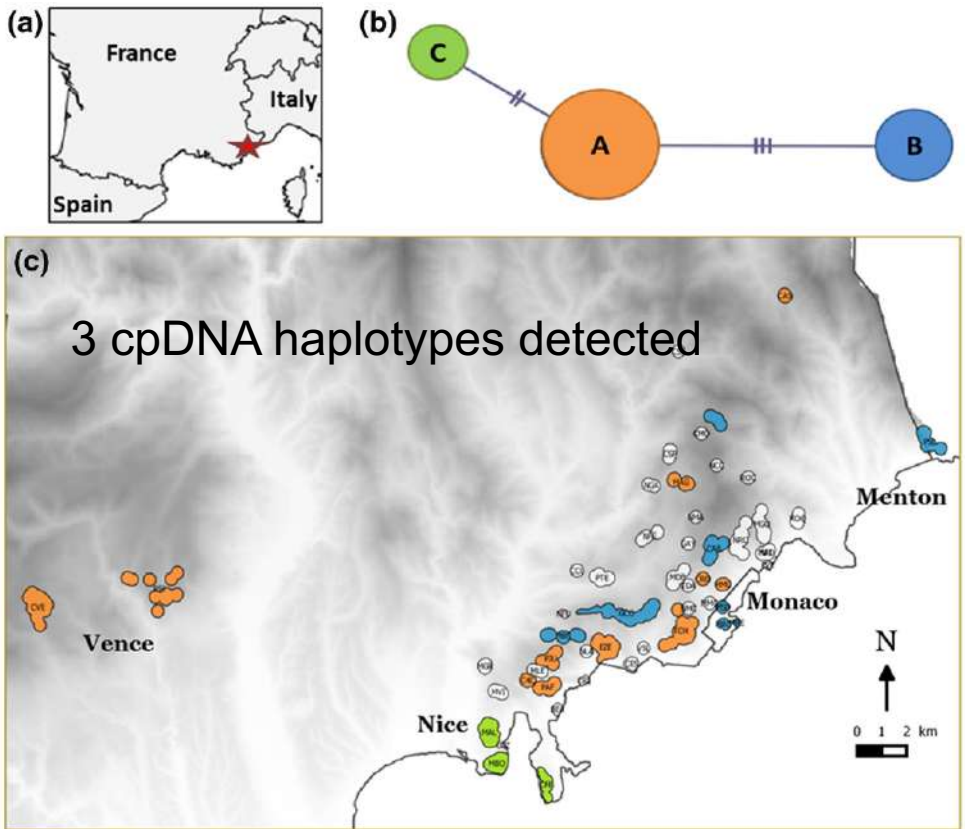
Narrow endemic geophyte from the Maritime Alps (distribution:12 x 35 km)

Calcareous rocky grassland from thermo-mediterranean to upper meso-Mediterranean vegetation levels (from 5 m to 970 m in elevation)

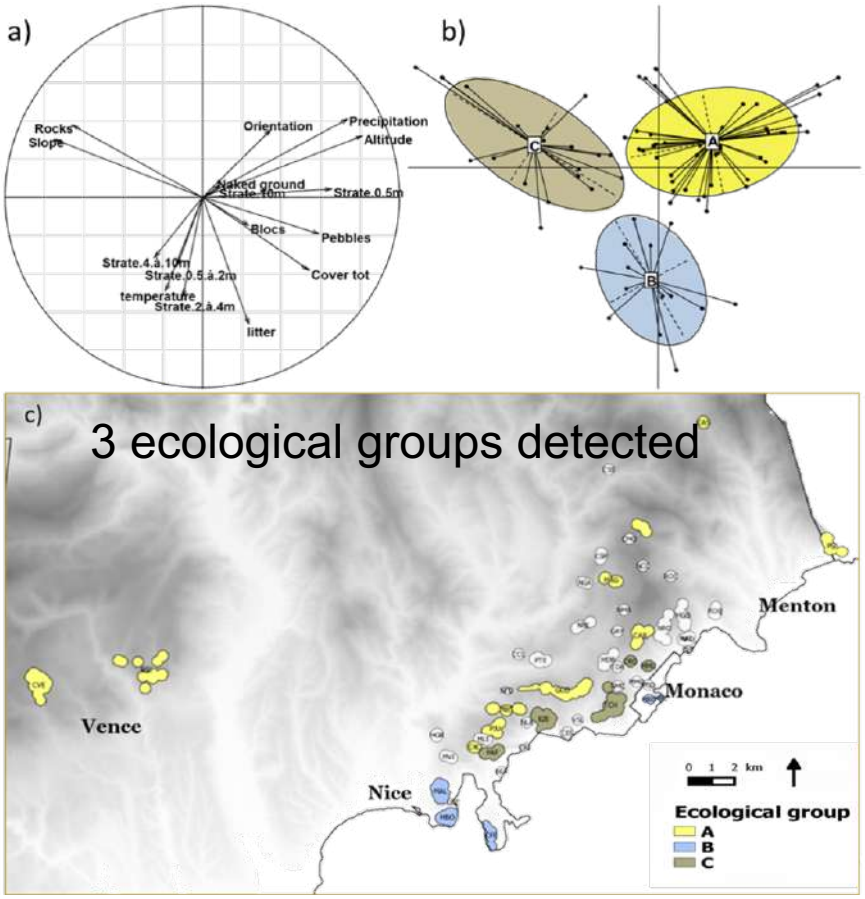
Highly thretatened by human activities (EN in the French IUCN Red List)

Integrating evolution and ecology to define plant microreserves

Phylogeographical structure



Ecological structure



Pouget M. et al., 2017. *Biodiversity and Conservation*, 26.

Integrating evolution and ecology to define plant microreserves

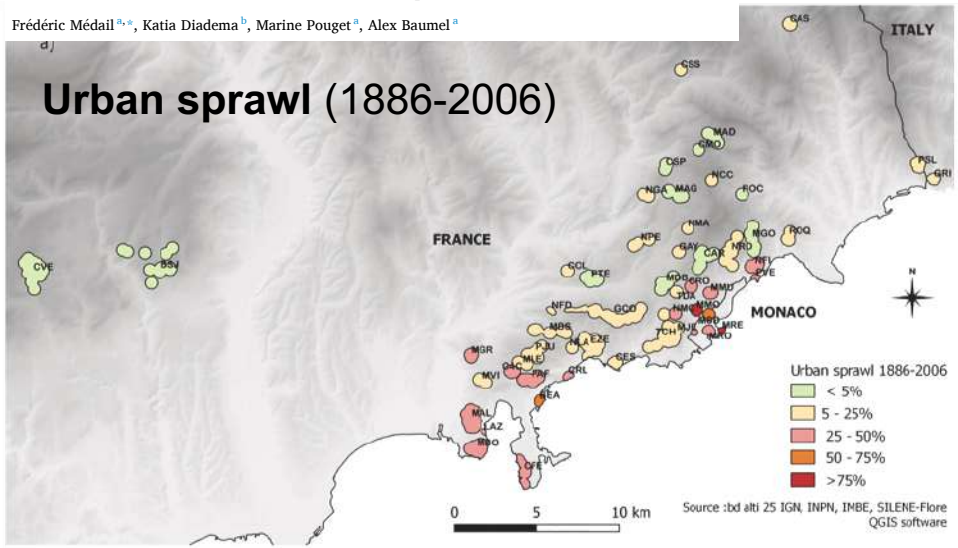
Contents lists available at ScienceDirect

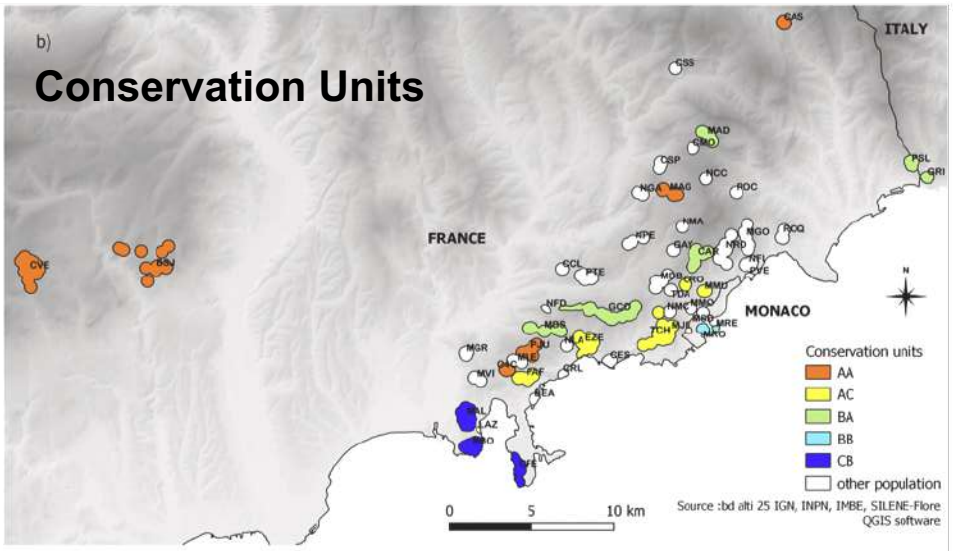
Journal for Nature Conservation

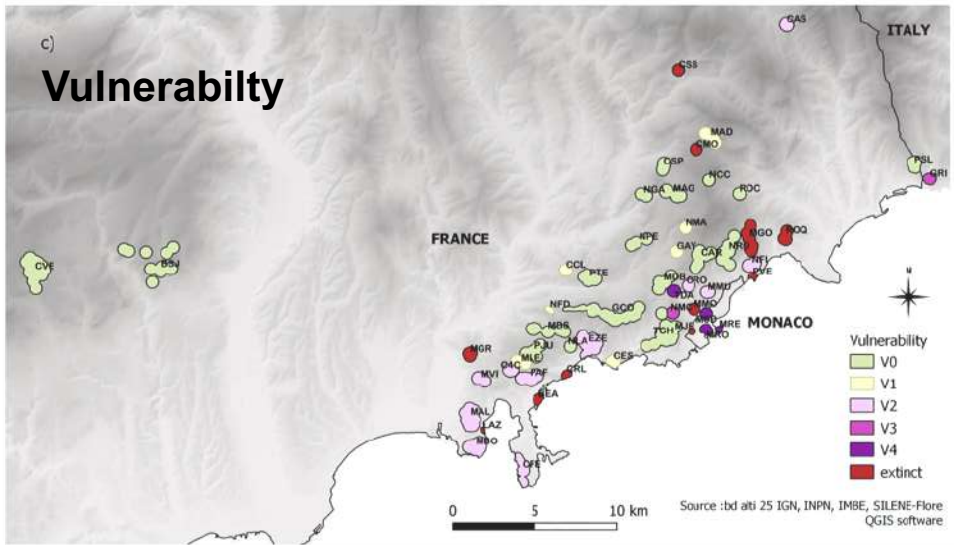
journal homepage: www.elsevier.com/locate/jnc

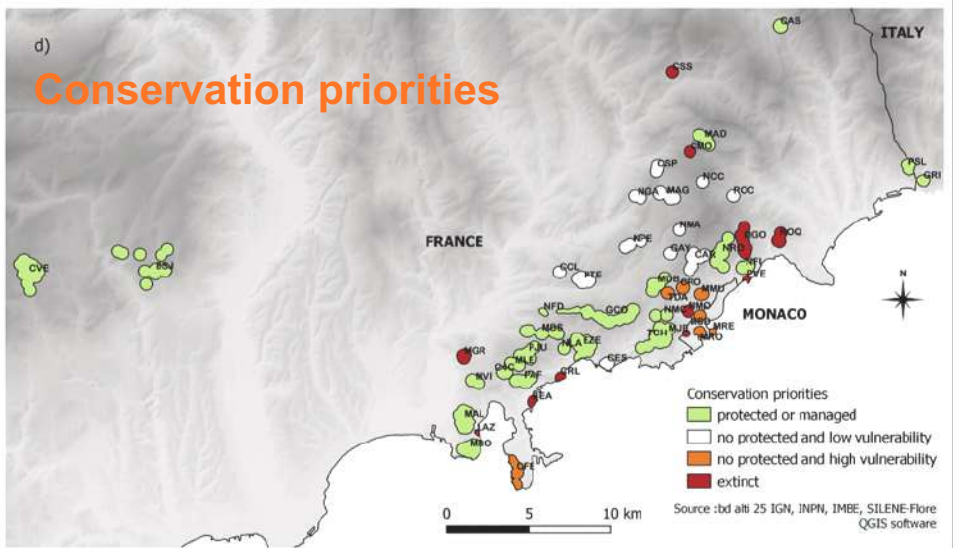
Identification of plant micro-reserves using conservation units and population vulnerability: The case of an endangered endemic Snowflake (*Acis nicaeensis*) in the Mediterranean Basin hotspot

Frédéric Médail [a,*], Katia Diadema [b], Marine Pouget [a], Alex Baumel [a]



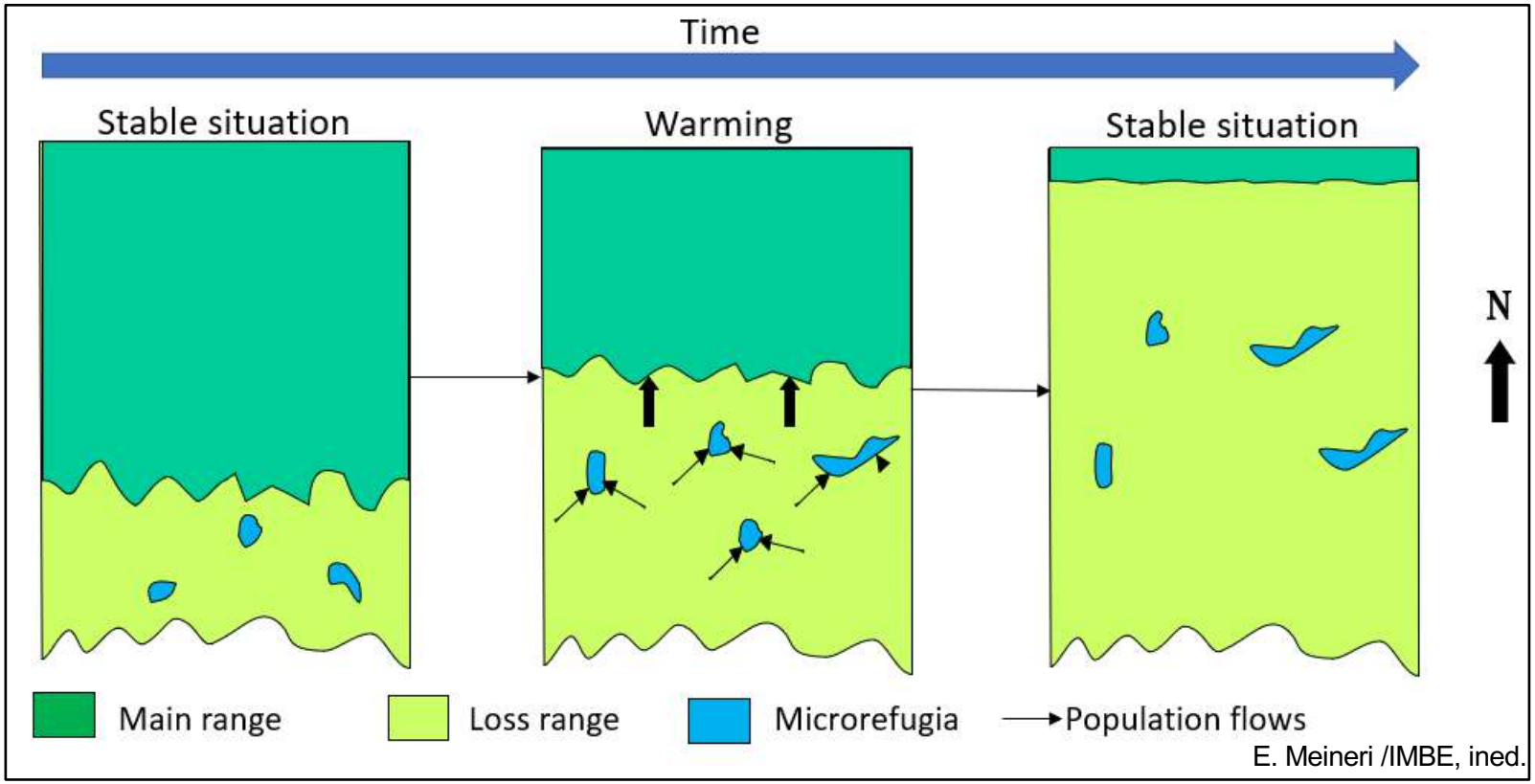






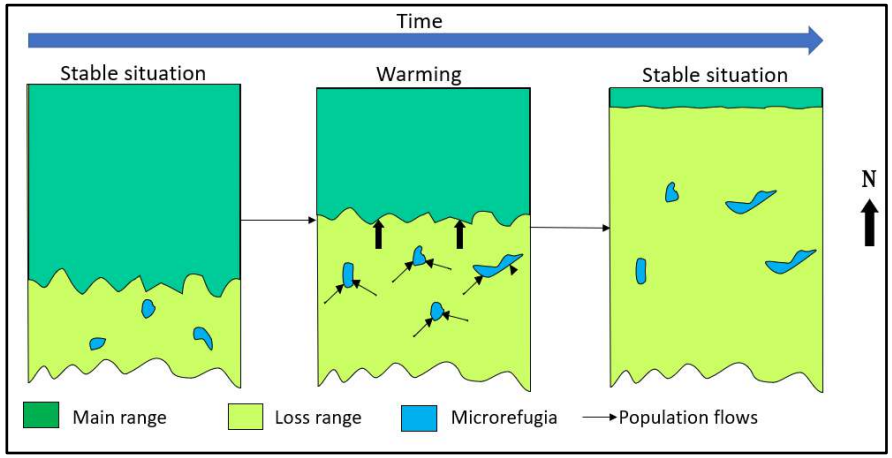
Role of microrefugia for plant conservation faced with climatic change

MICROMED - Conservation of flora faced with global warming: characterizing, mapping and assessing the role of microrefugia in the South region of France



Predictions of the impact of ongoing climate change on the distribution of a species

Role of microrefugia for plant conservation faced with climatic change



Hypotheses

Microrefugia are small areas characterized by favorable environmental conditions for the survival of populations outside their main distribution.

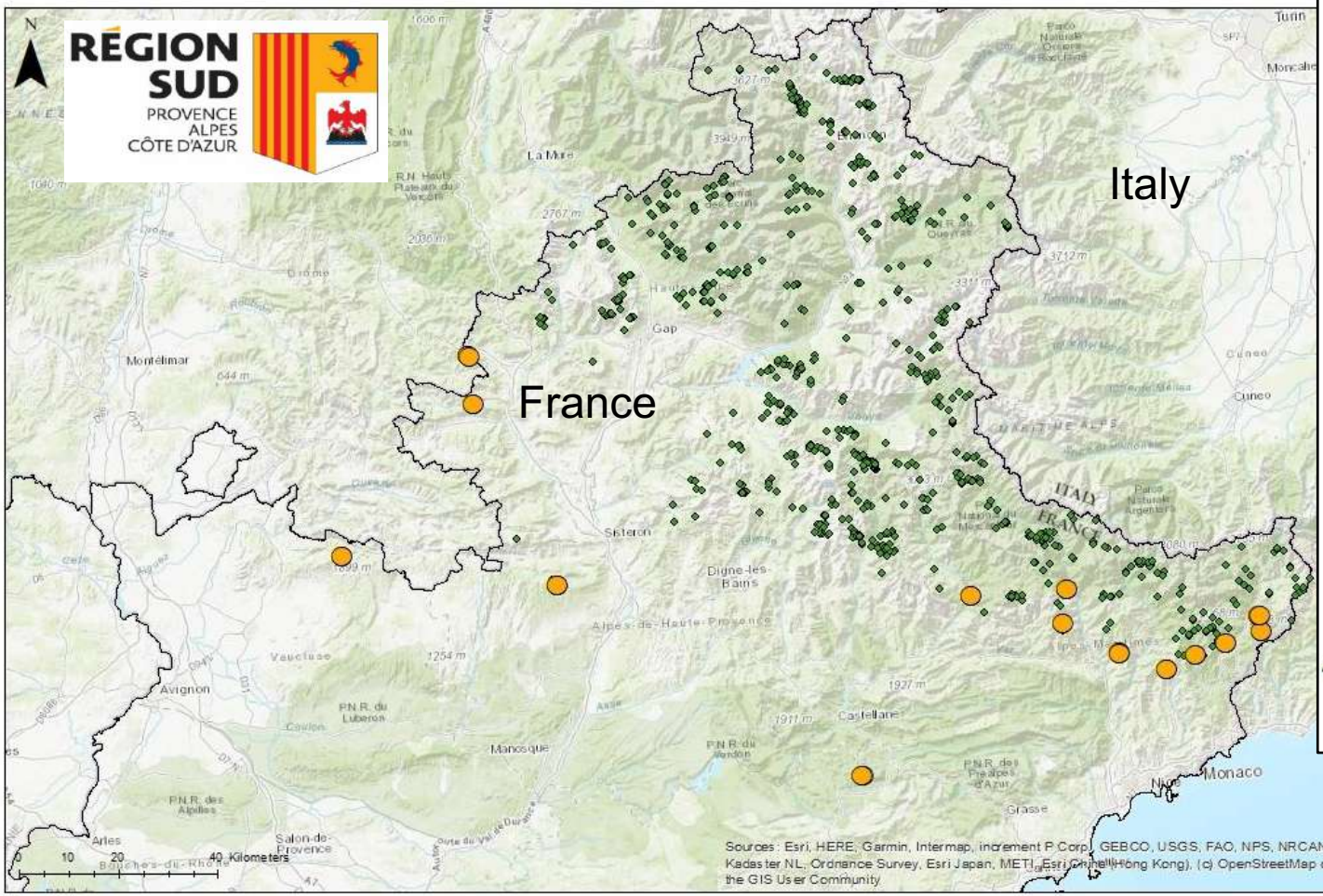
These microsites are less subject to climate change because they would benefit from microclimatic conditions disconnected from the regional climate.

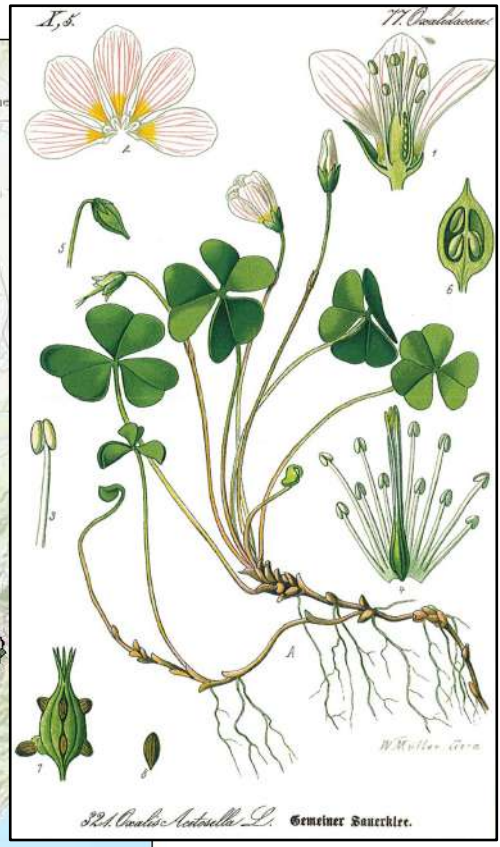
These climatic "havens" represent a solution limiting the migratory needs of species and allowing the flora to recolonize the landscape quicker if environmental conditions become more favourable.

MICROMED project aims to identify species threatened by climate change and model their potential microrefuges in the Sud-PACA region, in order to better understand and quantify the links between landscape heterogeneity, forest characteristics and microclimate.

Role of microrefugia for plant conservation faced with climatic change

How can persist a cold-adapted plant into constrained limited surfaces and under the regional Mediterranean climate?

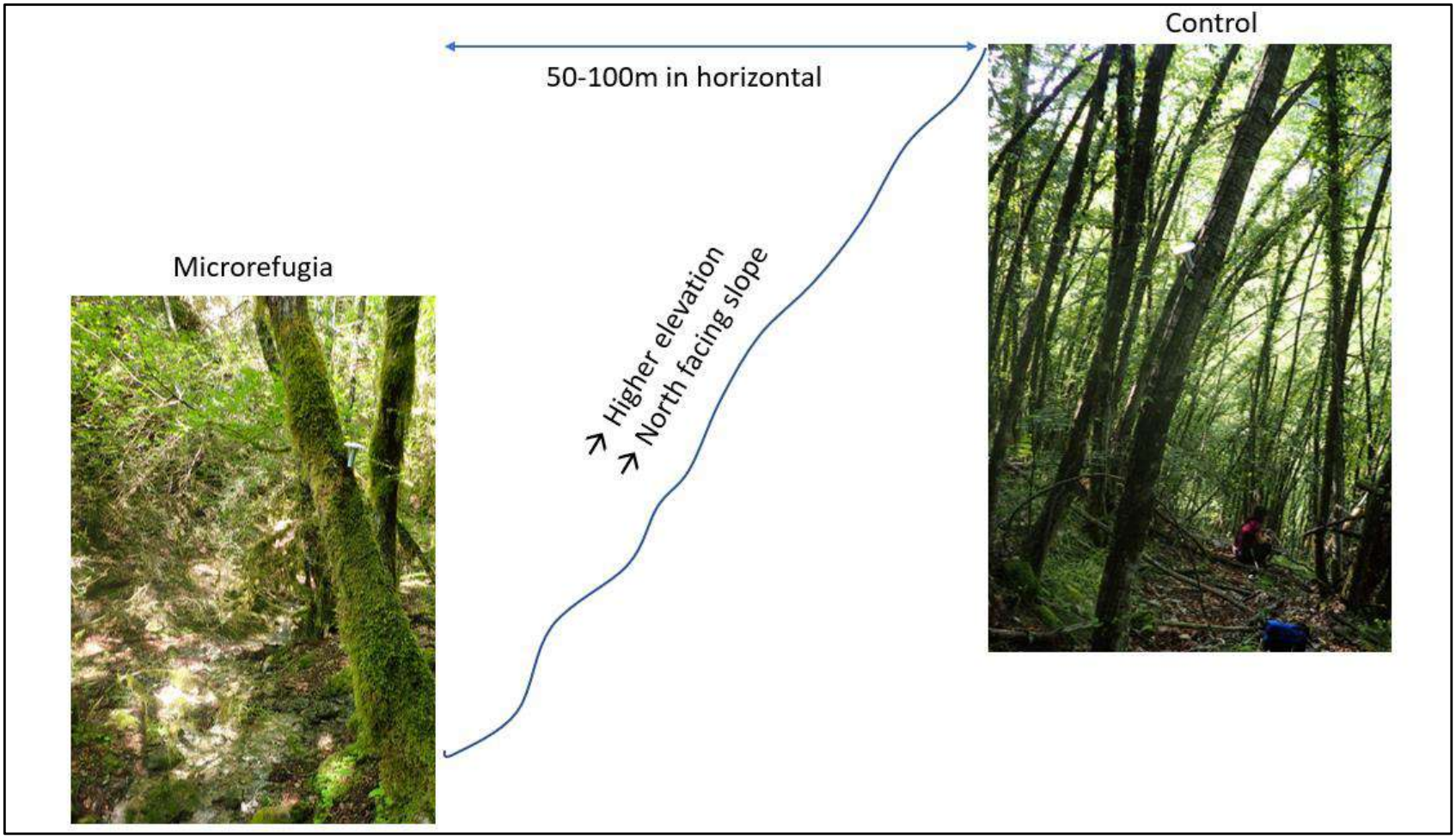




Analysis of ***Oxalis acetosella*** populations located in southern **microrefugia** of S.E. France


Daily data recorded
at 1.5 m in height
and 5 cm below ground

Role of microrefugia for plant conservation faced with climatic change



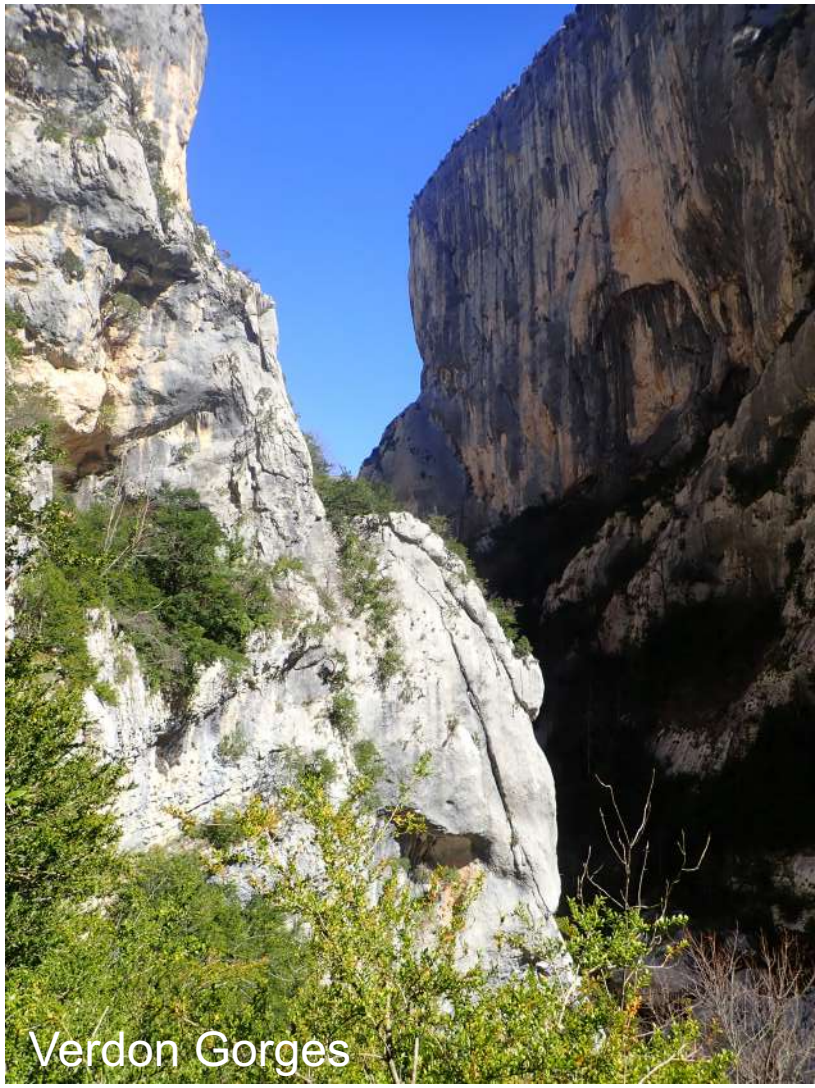
Temperature records are made every 15 minutes in microrefugia and their controls (50-100m) to quantify and model the degree of **climate decoupling based on landscape characteristics** (relative elevation to the rest of the landscape, density of canopy cover, proximity to streams or water bodies)

Role of microrefugia for plant conservation faced with climatic change

Systematic fine scale variations in **temperature** with **cooler and more stable conditions within microrefugia** compared to its immediate surroundings landscape.
These contrasts were larger during the growing season.

Plant communities present in micro-refugia have cooler temperature and wetter humidity optima than communities present in the control sites
(mixed effects models taking into account the site effect, $p < 0.05$).

Next steps
Detection of microrefugia with the aim of their preservation at the very fine scale (ca. 25 m): confrontation / regional network of protected areas
Integrative approach including soil functioning and phylogeography?


Verdon Gorges

Importance of ecosystem-based approaches

From a species–centred approach to an ecosystem–based approach

The ecology and conservation biology of the 20th century was based on concepts that are now considered a bit naïve:

(i) Ecosystems were considered to be in **equilibrium**, while their functioning is today considered to be partly and naturally chaotic.

(ii) After a disturbance, ecosystems returned to a stage of equilibrium, the **climax**, *via* a well-defined ecological succession.

(iii) **Disturbances** were thought to only negative (decrease of species richness, but cf. Intermediate Disturbance Hypothesis, IDH; importance for the regeneration niche).

(iv) Biodiversity was reduced to **species diversity**, while the number of species is only one descriptor of biodiversity.

(v) The species-by-species approach was the rule, with a strong (unique) focus on **'remarkable' / 'iconic' species.**

From a species–centred approach to an ecosystem–based approach

The ecosystem-centred approach has several strong points:

(i) It allows the **inclusion of humans** in the functioning of the ecosystem, in a natural way, thus evolving from the notion of ecosystem to that of socio-ecological system.

(ii) It requires the construction of a framework corresponding to a **conceptual model** of the ecosystem, including even the unremarkable species that often play an important role in the functioning of ecosystems.

(iii) Building a conceptual model makes it possible to link the species together, following a **network of interactions** and to better interpret the possible fluctuations in their abundance.

Boudouresque *et al.,* 2020. *Life Environment*, 70 & *Diversity,* submitted.

From a species–centred approach to an ecosystem–based approach

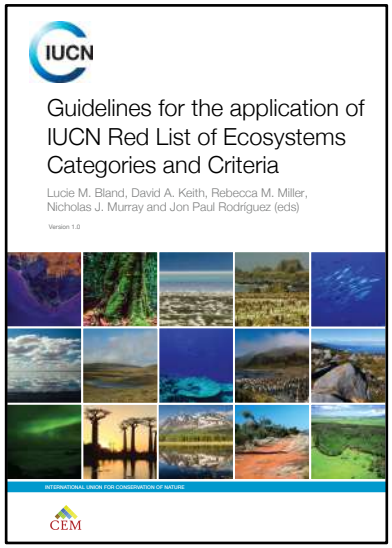
The ecosystem-centred approach has several strong points:

(iv) The conceptual model can be a stepping stone towards analytical or numerical **modelling**, where flows (e.g. C, N, P) between compartments are quantified.

(v) It also highlights the importance of tackling the **coupling** between adjacent ecosystems (e.g. including terrestrial and marine ecosystems).

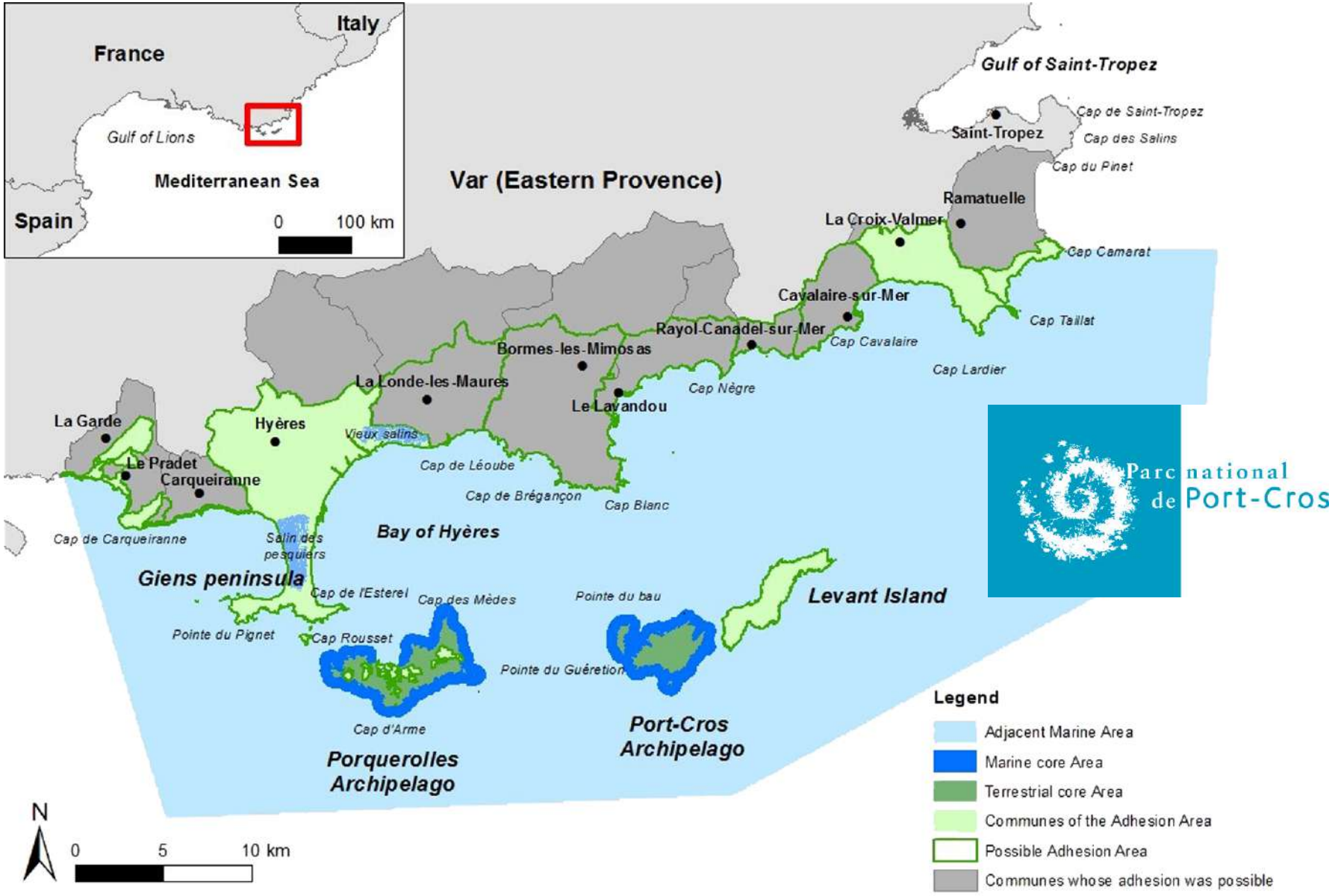
(vi) This approach enables the development of **environmental quality indices** (e.g. Ecosystem-Based Quality Index, EBQI) that are much more significant and reliable than indices based on one or a few species.

Importance to develop some integrative approaches of IUCN Red Lists of ecosystems / various taxonomic groups



Boudouresque *et al.,* 2020. *Life Environment*, 70 & *Diversity,* submitted.

Ecosystem–based approaches on a threatened protected area

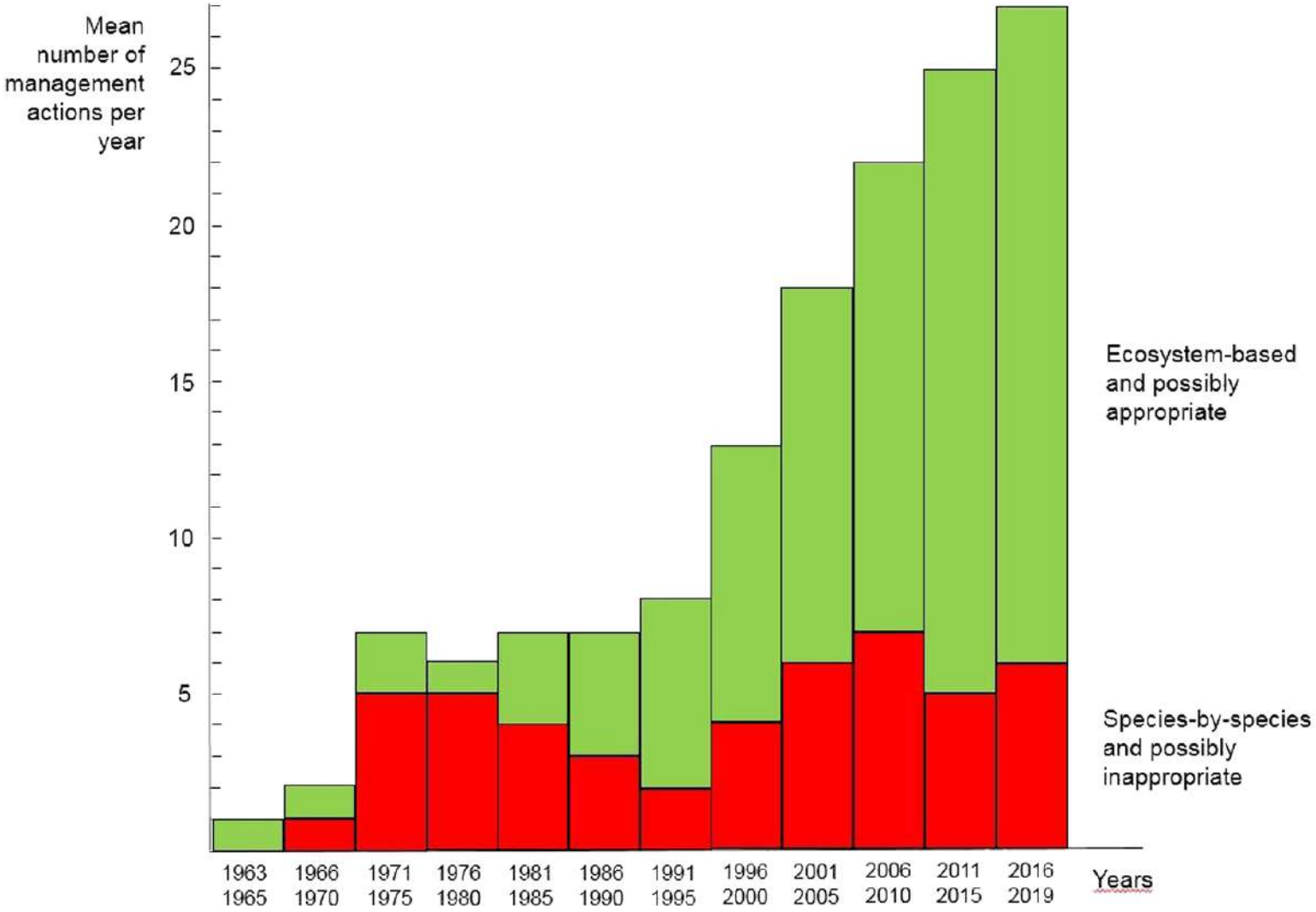


Map of the new Port-Cros National Park (PCNP), established in 2016

The initial PCNP, established in 1963, was restricted to the archipelago of Port-Cros

Ecosystem–based approaches on a threatened protected area

Mean number of management actions, species-by-species and possibly inappropriate and ecosystem-based and possibly appropriate, over time in the Port-Cros NP

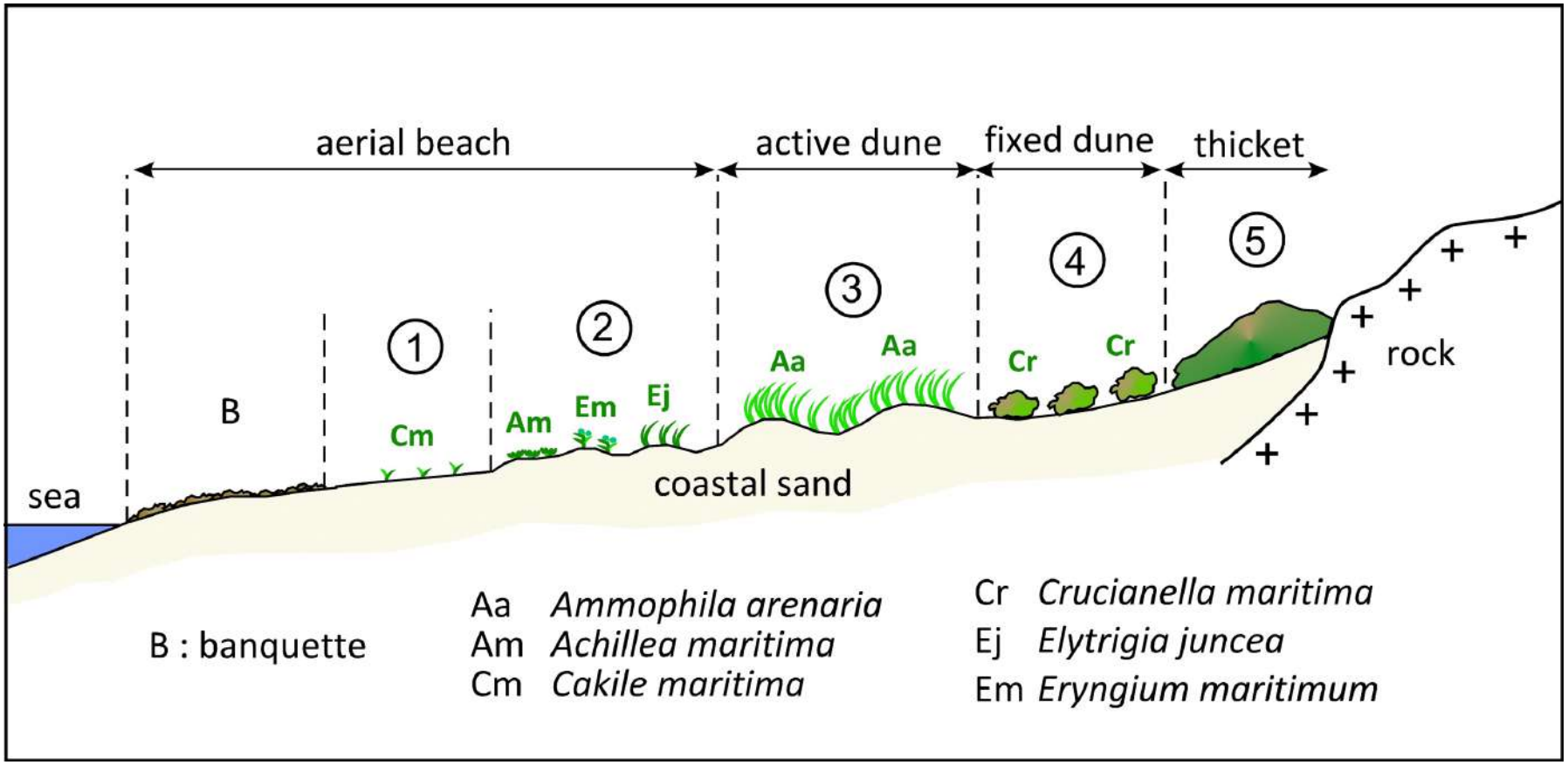


Boudouresque *et al.,* 2020. *Life Environment*, 70.

Ecosystem–based approaches on a threatened habitat

The **Mediterranean beach ecosystem** harbours six 'habitats of community interest', under the European Habitat Directive, with their characteristic flora and fauna

Sandy beaches and dunes provide worldwide a wide range of ecosystem services and values that cannot be supplied by any other ecosystem



Schematic zonation of the vegetation on coastal sand in contact with a rocky hill

Ecosystem–based approaches on a threatened habitat

Banquette / beach /dune
a pivotal role in land-sea coupling and functioning of coastal systems

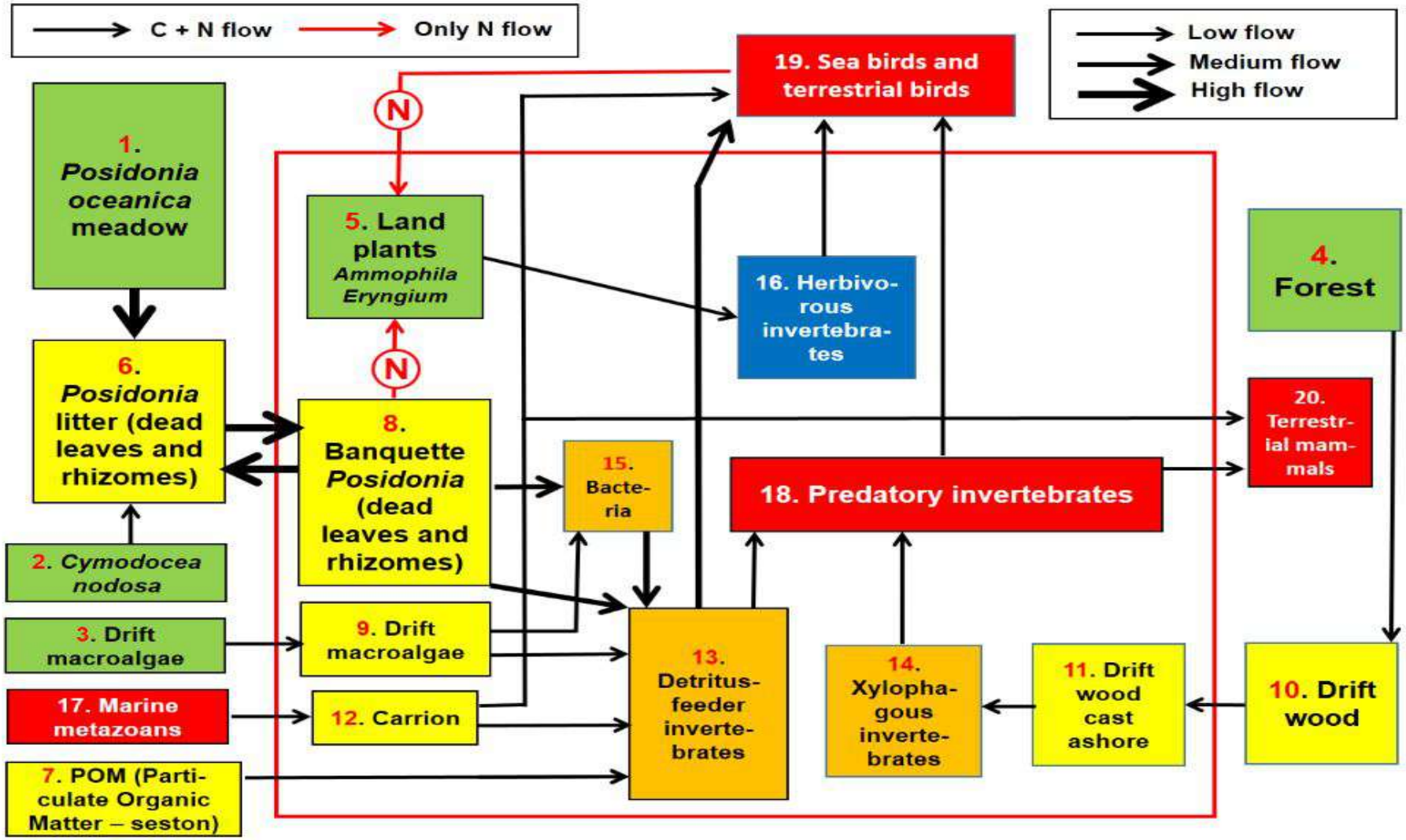
Minaccia Bay, Corsica. Pl: *Pistacia lentiscus* thicket. © G. Paradis

Trachyscelis aphodioides, *Ammobius rufus*, *Brindalus porcicollis* and *Xenonychus tridens*.
Bar scale = 1 mm. Photos © Philippe Ponel

Several small species of psammophilous Coleoptera spend their whole life cycle deeply buried in the substratum

Ecosystem–based approaches on a threatened habitat

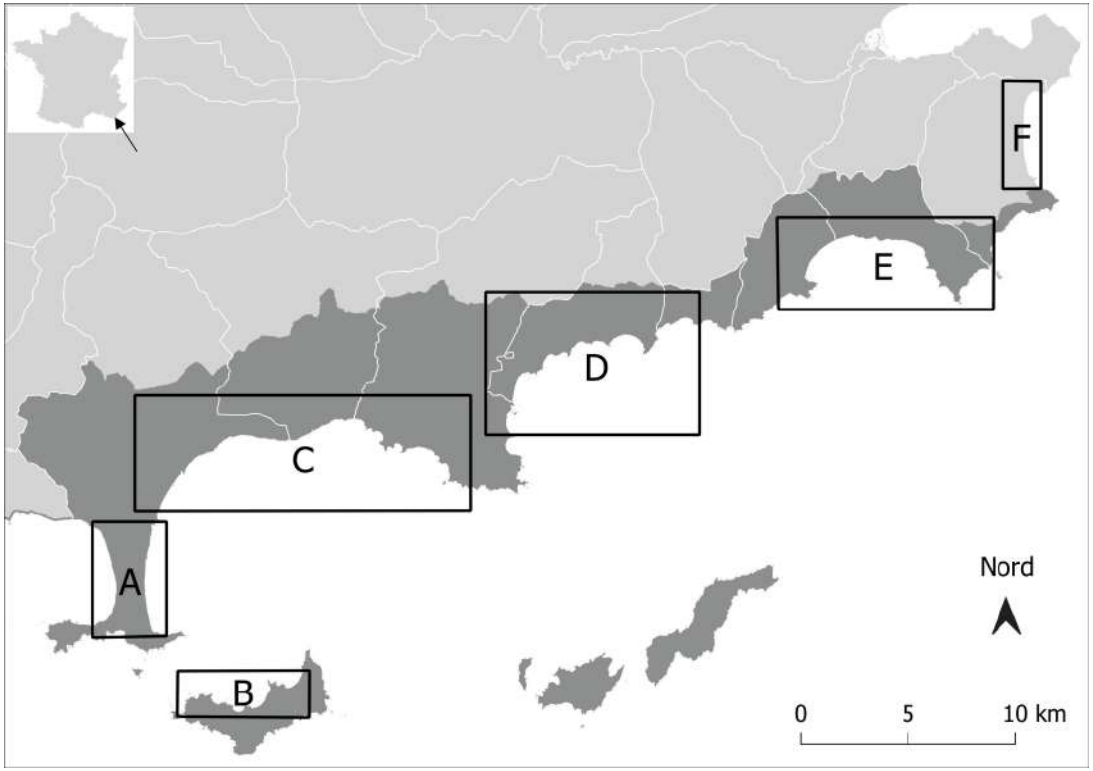
Conceptual model of the functioning of the Dune-Beach-Banquette ecosystem

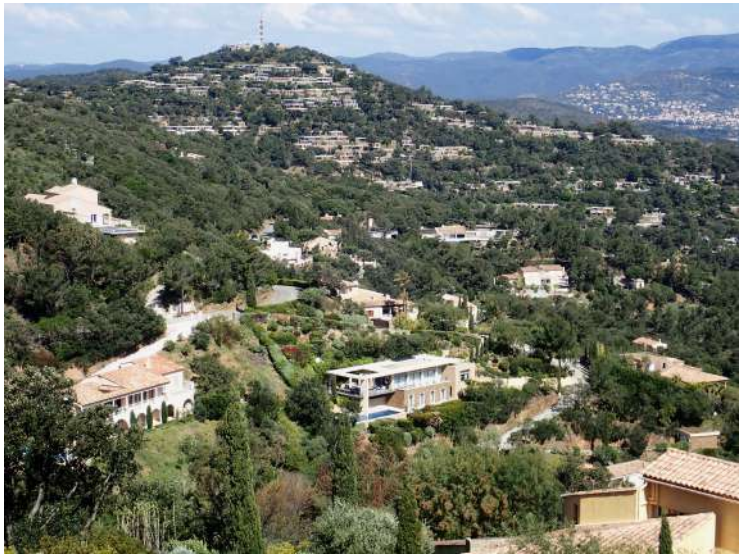


Boxes in green: primary producers. Yellow: detritus. Ochre: detritus-feeders. Blue: herbivores. Red: predators. Red rectangle: Dune-Beach-Banquette ecosystem

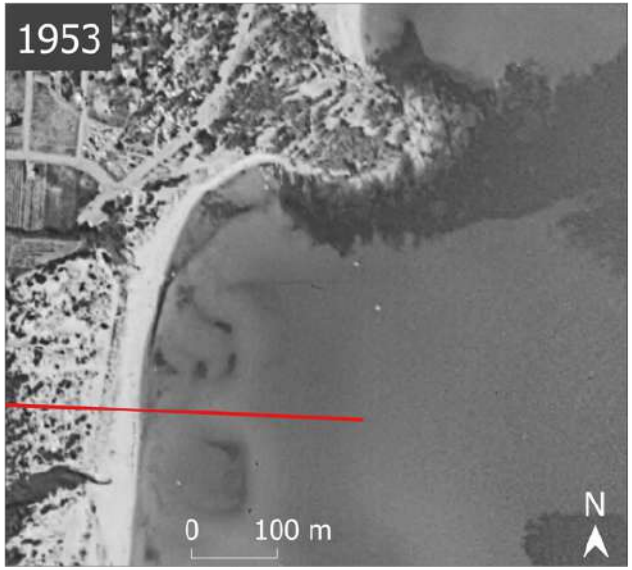
Boudouresque *et al.*, submitted

Ecosystem–based approaches on a threatened protected area



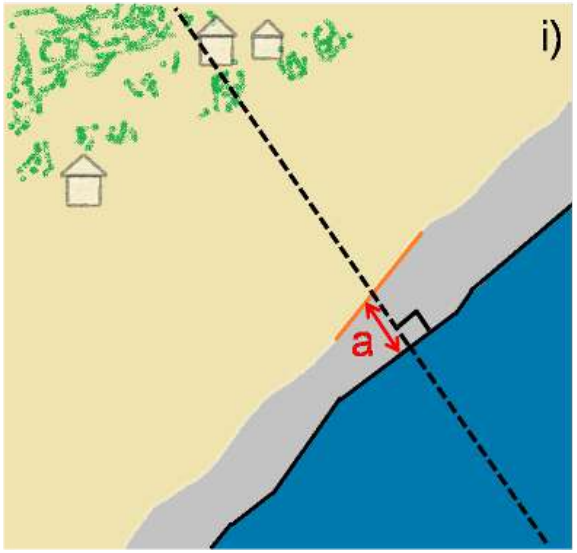


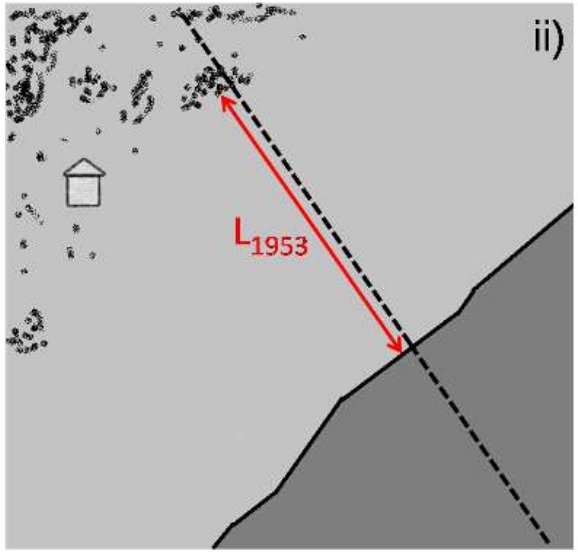
Morando & Noble, 2019

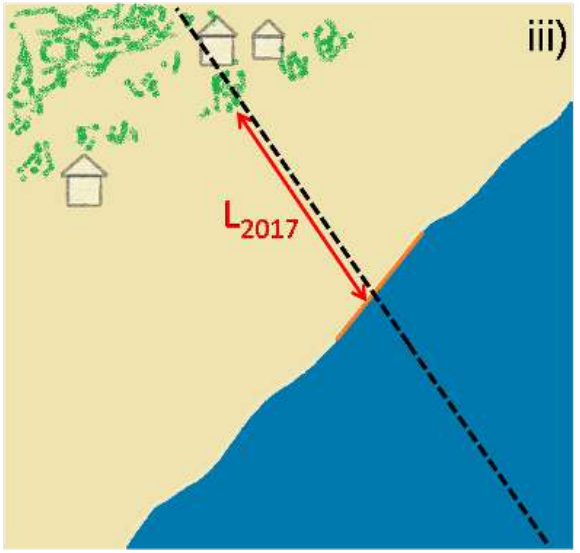


Example of an extreme change of a coastal landscape between 1953 and 2017 (sector D, beach of La Favière and construction of the harbour of Bormes-les-Mimosas)

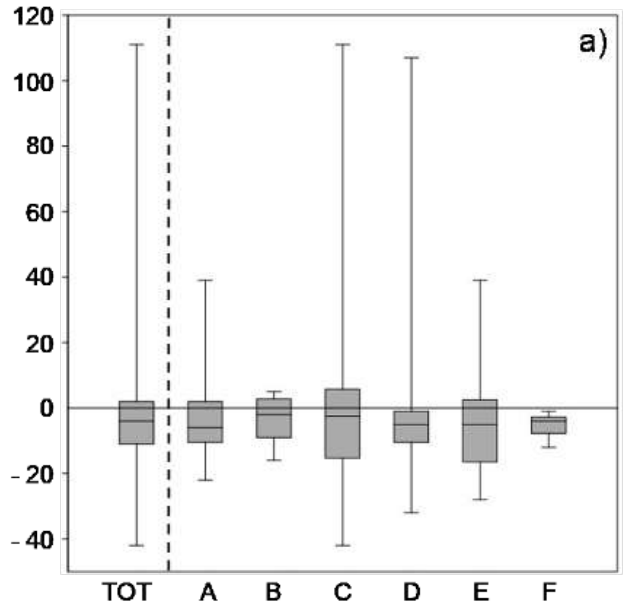
Maps : BD ORTHO® Historique 1953 50 cm DEPT 83 & BD ORTHO® 2017 50 cm en RVB.

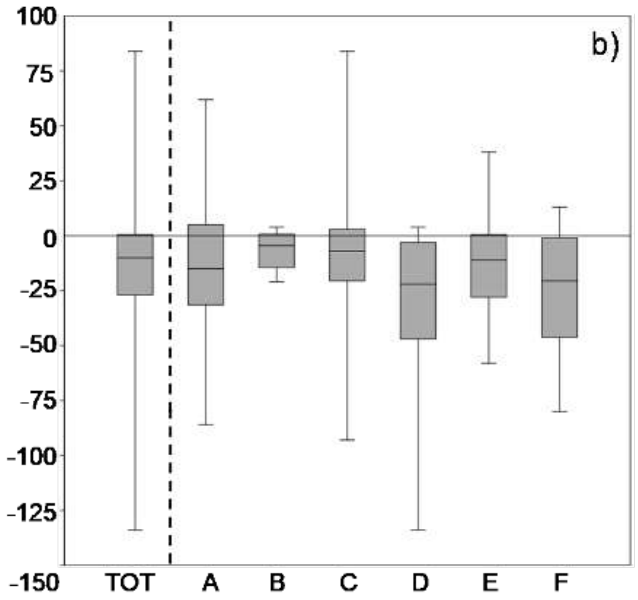






Analysis of the evolution of the coastline (a) and the width of the dune ecosystem between 1953 (L_{1953}) and 2017 (L_{2017}) along a transect (dotted lines)





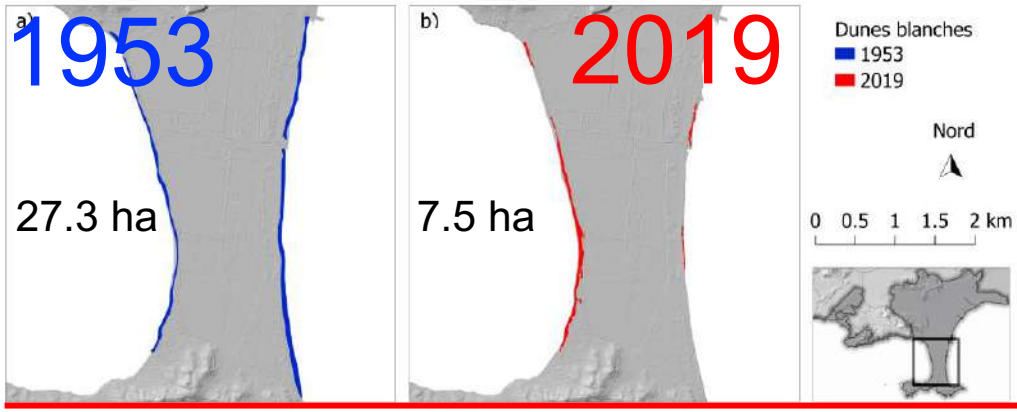
c)

Secteurs	Estimations pertes de surface (en %)
TOT	31 %
A	32 %
B	39 %
C	8 %
D	55 %
E	39 %
F	34 %

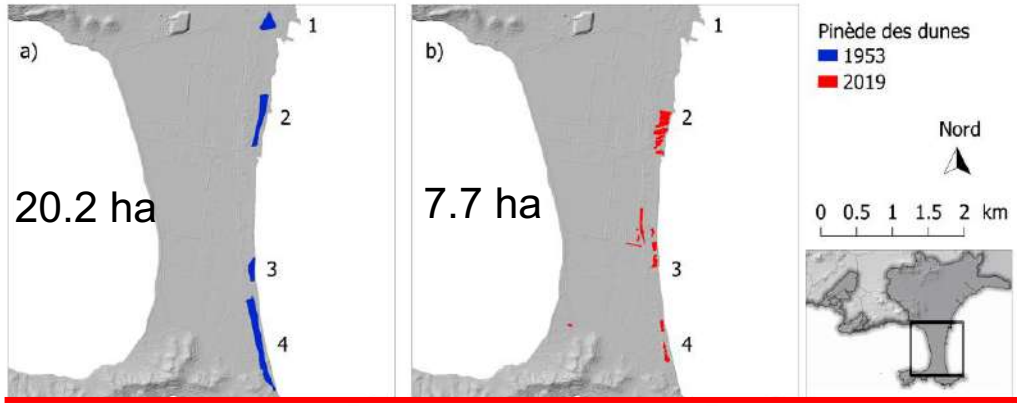
Changes in the position (a) and the width of the dune ecosystem (b) of the coastline in meters between 1953 and 2020; estimates of dune surface losses between 1953 and 2017 (c)

Ecosystem-based approaches on a threatened protected area

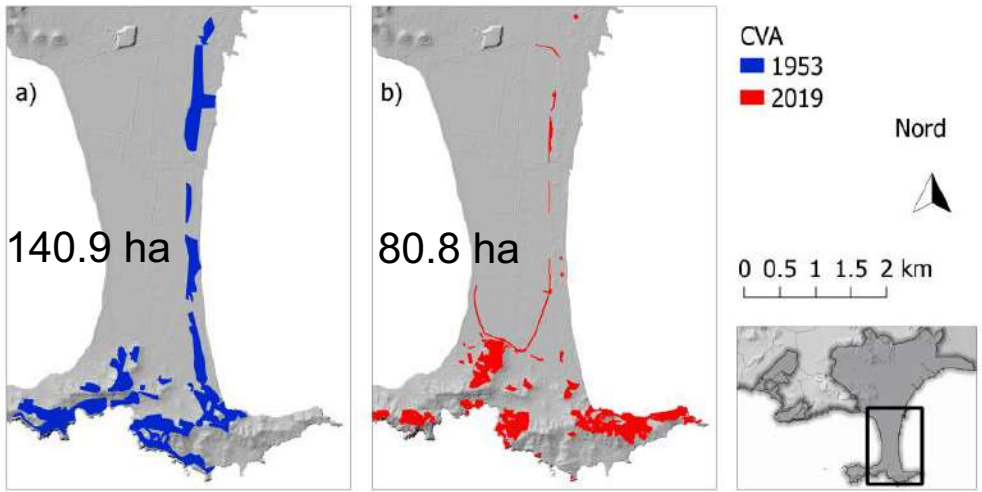
Diachronic evolution of some main vegetation types of the Giens peninsula (Hyères, Var) between 1953 / 2019



Active dunes: - 73%



Pine forest on dunes: - 62%

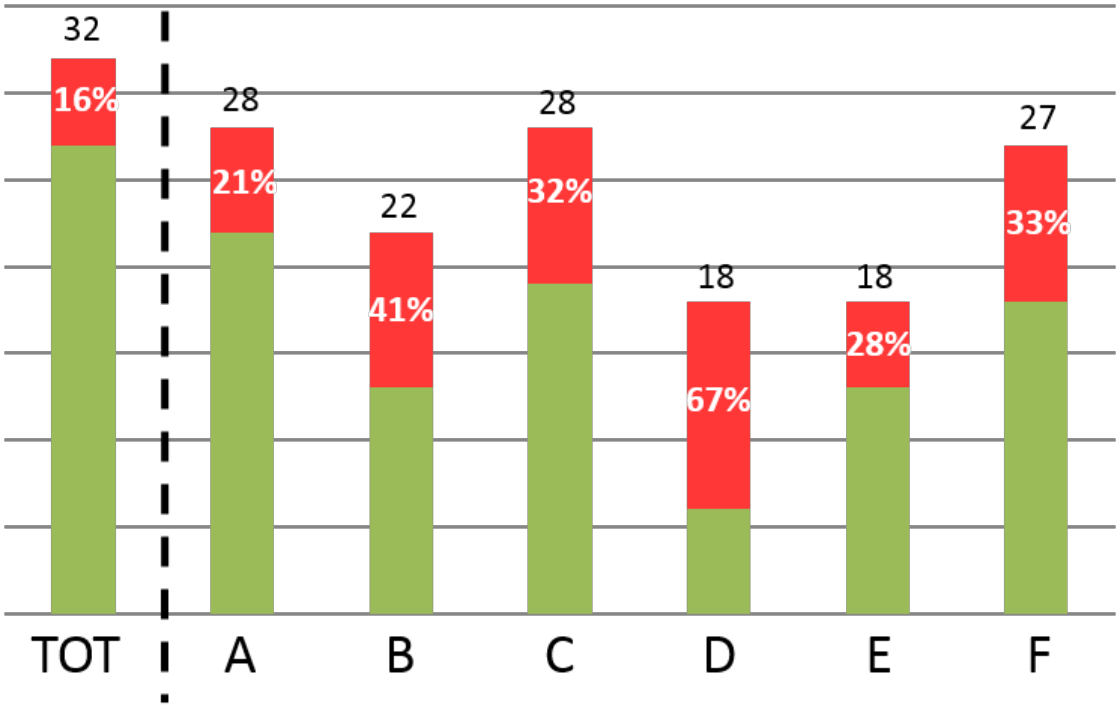


Holm-Oak forest: - 43%

Conservatoire Botanique National Méditerranéen
PORQUEROLLES

Morando & Noble, 2019

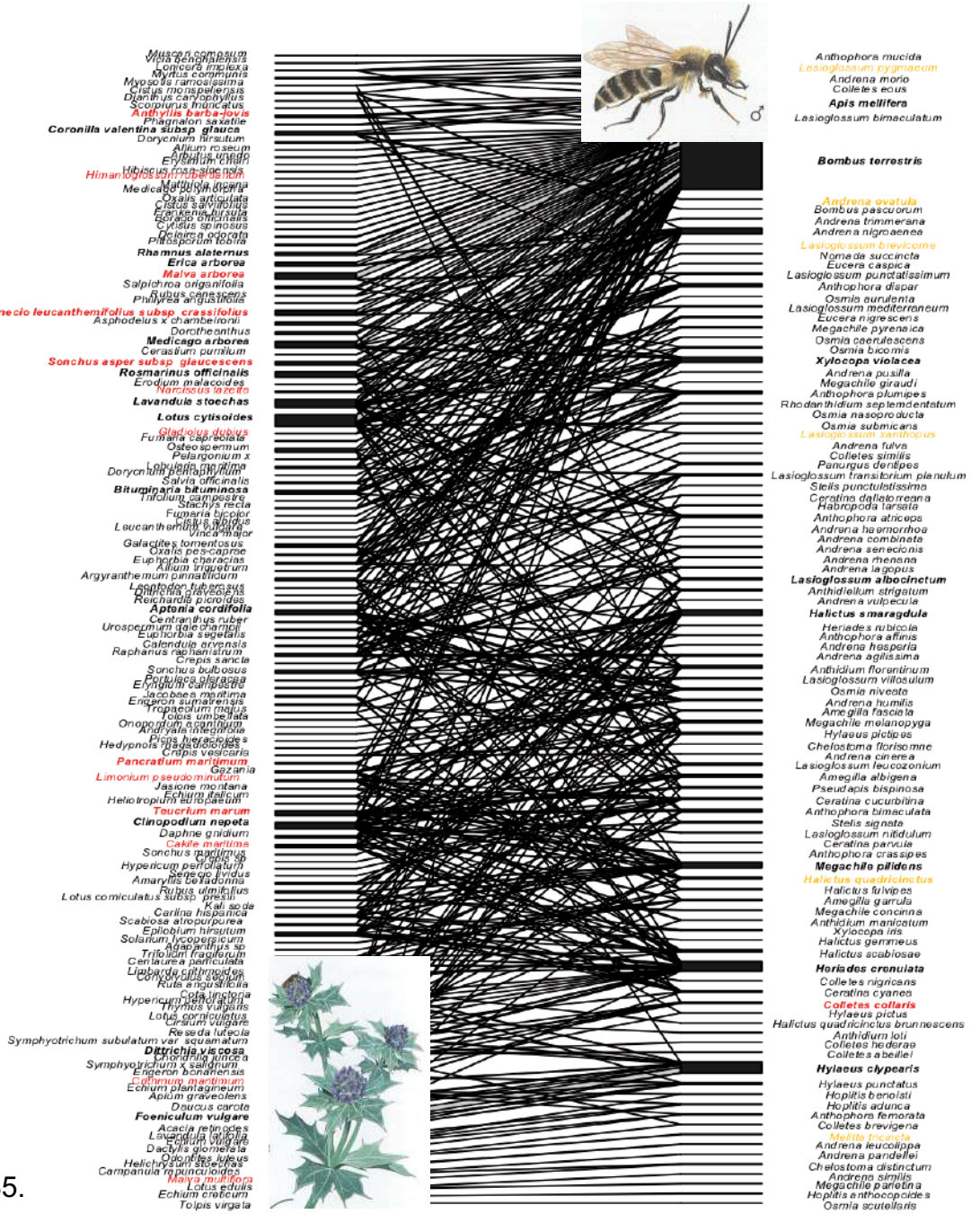
Ecosystem–based approaches on a threatened protected area



Morando & Noble, 2019

Specific richness and percentages of locally extinct plant species over the 2000-2020 period (red), for the entire study area (TOT) and by sectors (A, B, C, D, E, F)

Network of interactions of bee species with plant species in the Port–Cros National Park



The thick nodes represent generalist bees that forage on many species of plants, or plant species that are foraged by many species of bees

Gombaut *et al.*, 2021. *Sci. Rep. Port-Cros Natl. Park*, 35.

Parc national de Port-Cros

STOECHAS

Connaissance et gestion de la biodiversité terrestre du Parc national de Port-Cros

FONDATION PRINCE ALBERT II DE MONACO

Program 2021-2025

1. Perform a « state of the art » of the current knowledge on taxonomic groups

2. Define a scientic strategy dedicated to the definition of ecosystem-based management objectives

3. Inventory of the little-known biodiversity (lichens, bryophytes, fungi, invertebrates)

4. Share the knowledge acquired, and establish fruitful research and expertise partnerships

5. Transform this knowledge into recommendations towards an ecosystem-based management

Importance of evolutionary and ecosystem–based approaches

Evolutionary aspects are still too little considered for the *in situ* conservation of plants, especially in the south and east of the Mediterranean basin.

A protected area is neither a botanical garden nor a zoo, that its role is not to favour certain species at the expense of others.

Nature often does things better than humans and that doing nothing sometimes constitutes the best management action.

The overall ‘non-interventionism’ approach in the management of some protected areas ultimately allows much more effective and less expansive ecosystem conservation than naïve *ad hoc* operations.

Today, the ecosystem-based approach should be developped, by integrating ecosystem dynamics and species interactions.

Thanks to: Alex Baumel, Charles-François Boudouresque, Katia Diadema, Marine Morando, Virgile Noble, Guilhan Paradis, Carole Piazza, Philippe Ponel.

Phoenix theophrasti forest, Vai (E. Crete), January 2011