

3rd Mediterranean Plant Conservation Week

**“Plant Conservation Strategies:
from Science to Practice”**

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



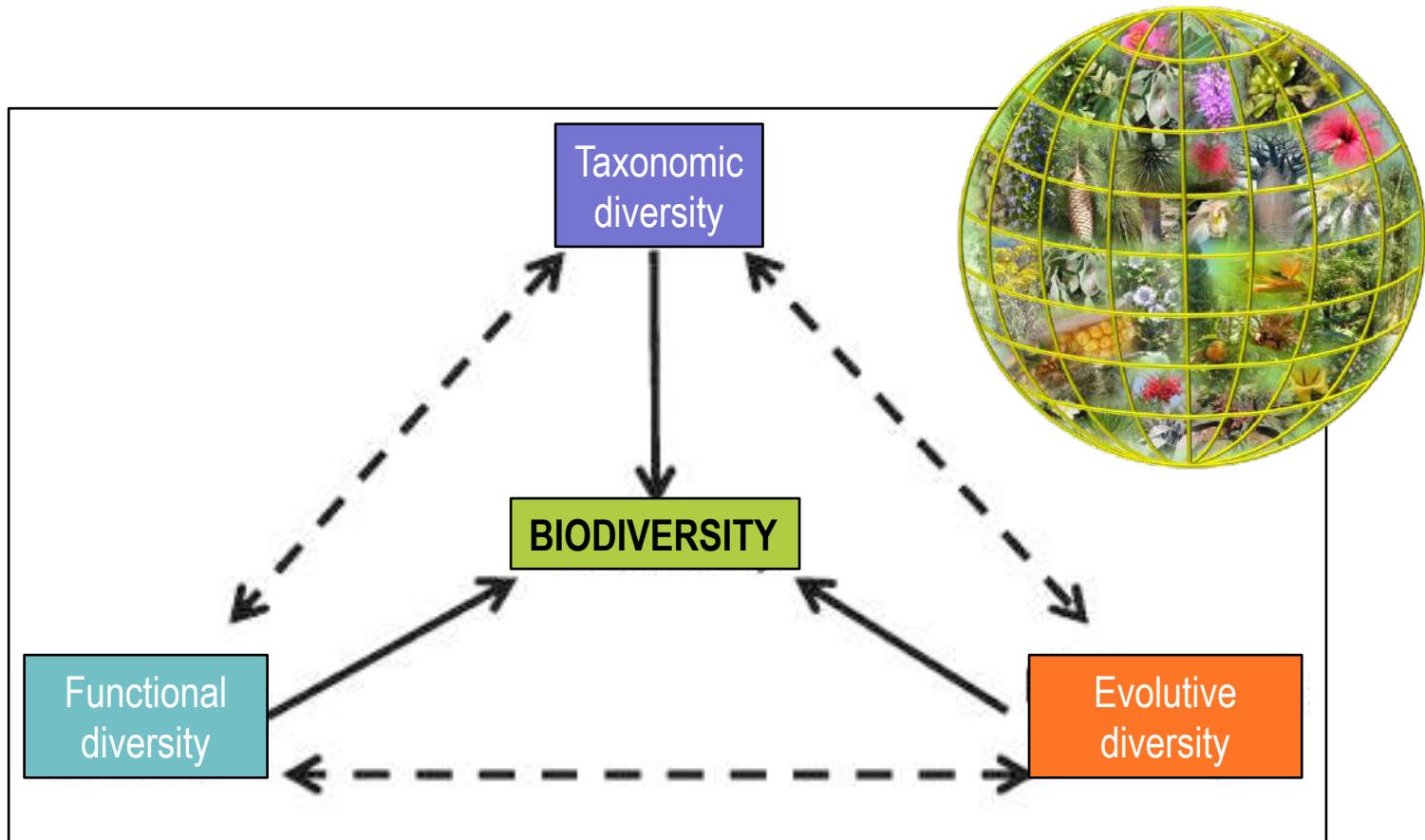
Importance of evolutionary and ecosystem-based approaches to *in situ* conservation practices of the Mediterranean flora

Pr. Frédéric MEDAIL

with the collaboration of Eric Meineri & Marie Finocchiaro



The need to get an *integrative* view of biodiversity

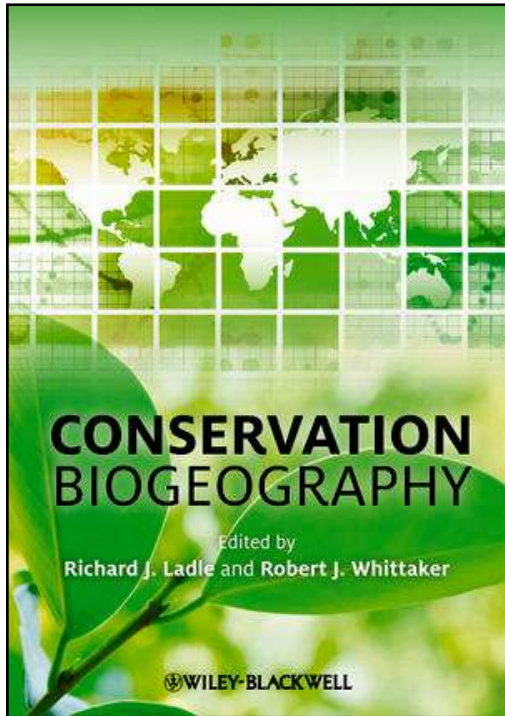


Taxonomic or species diversity

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



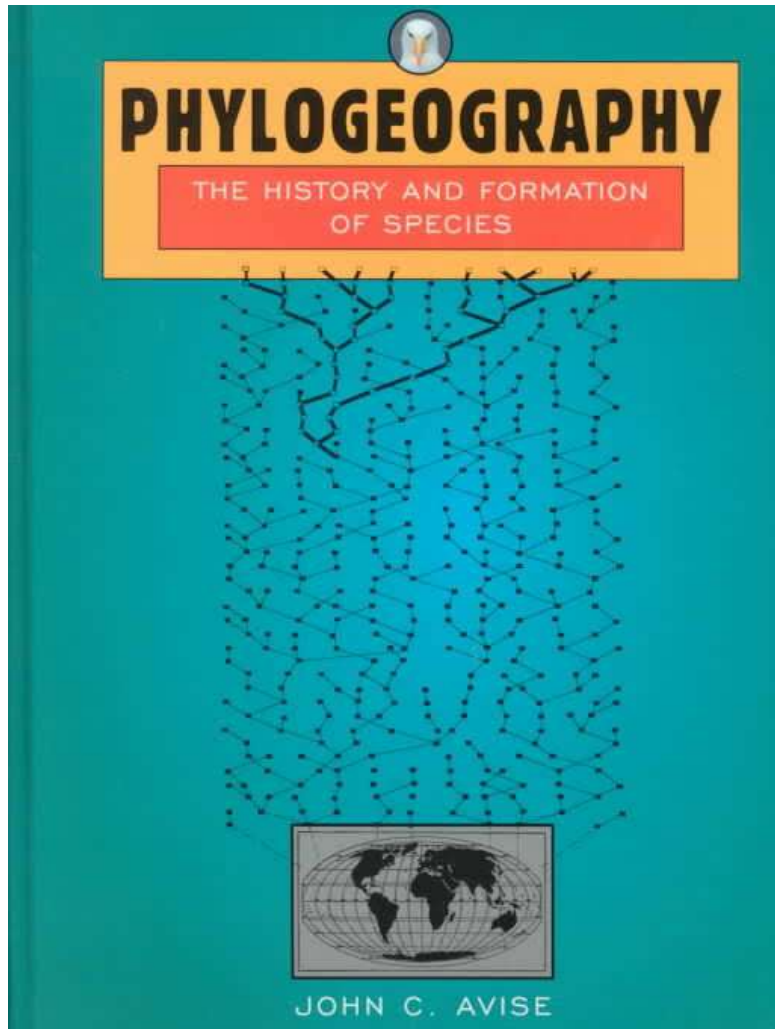
Owing to its uniqueness and fragility, the Mediterranean region urgently need some integrated conservation planning, notably within the biodiversity hotspots, for the long-term preservation of this outstanding biological heritage.



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

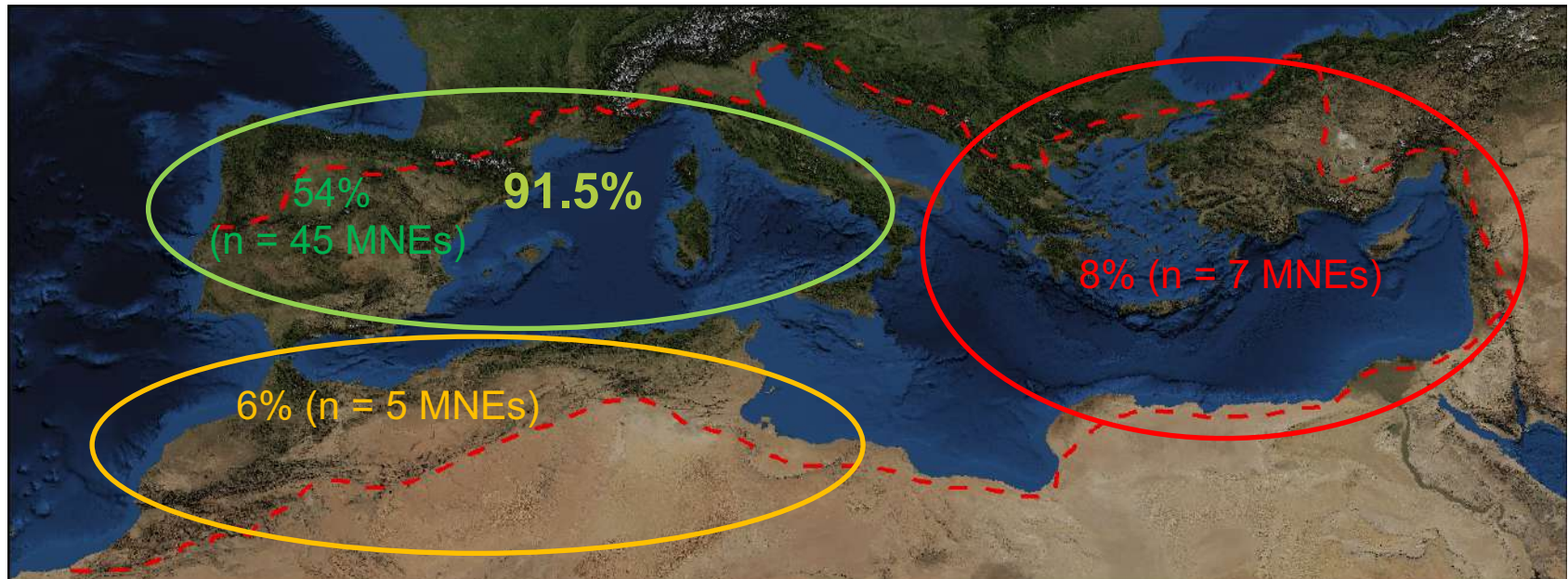
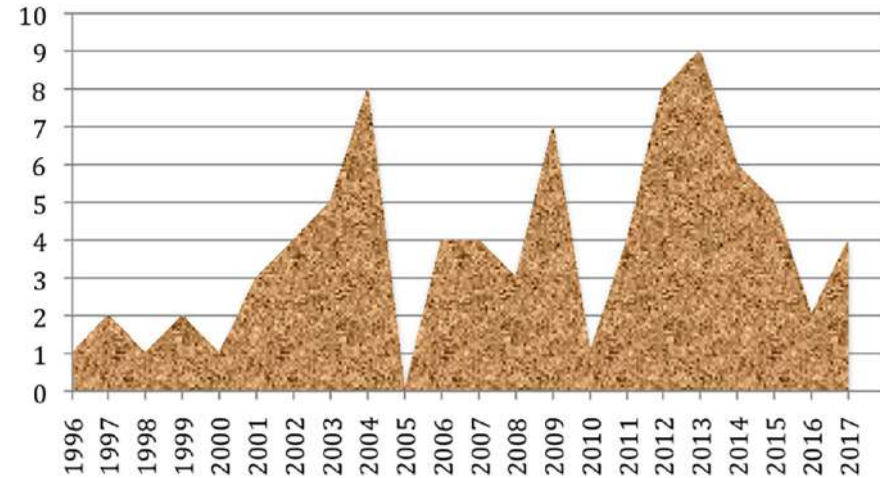
Using phylogeography to define conservation priorities: The case of narrow endemic plants in the Mediterranean Basin hotspot



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.

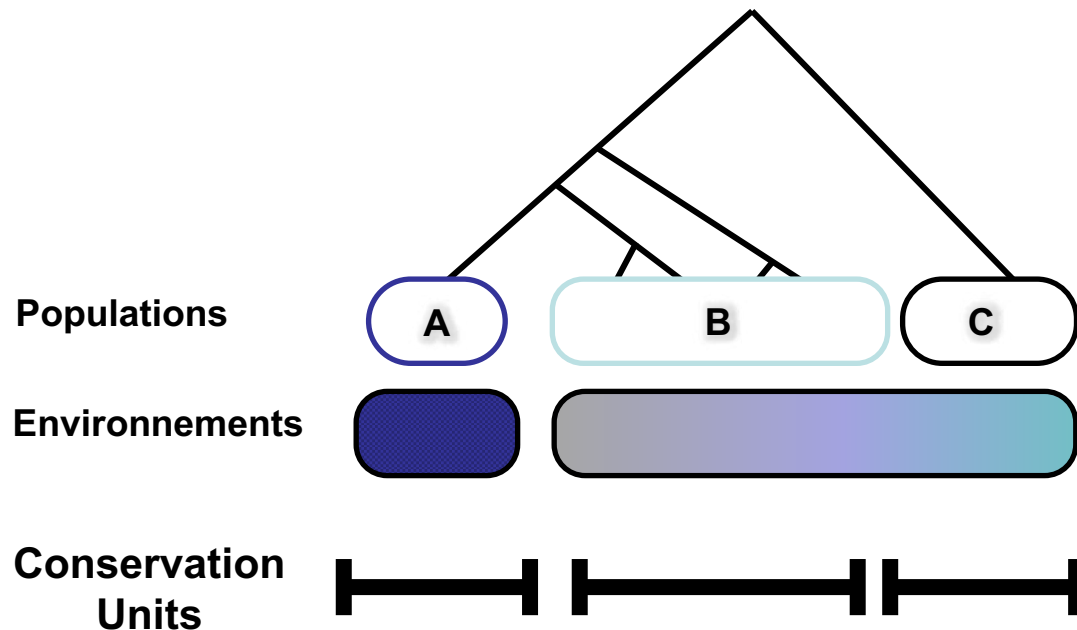
Most of the analyzed studies have focused on the long-lived MNEs occurring on stable ecosystems, notably cliffs and other rocky habitats.

Integrating evolution and ecology to define plant microreserves

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

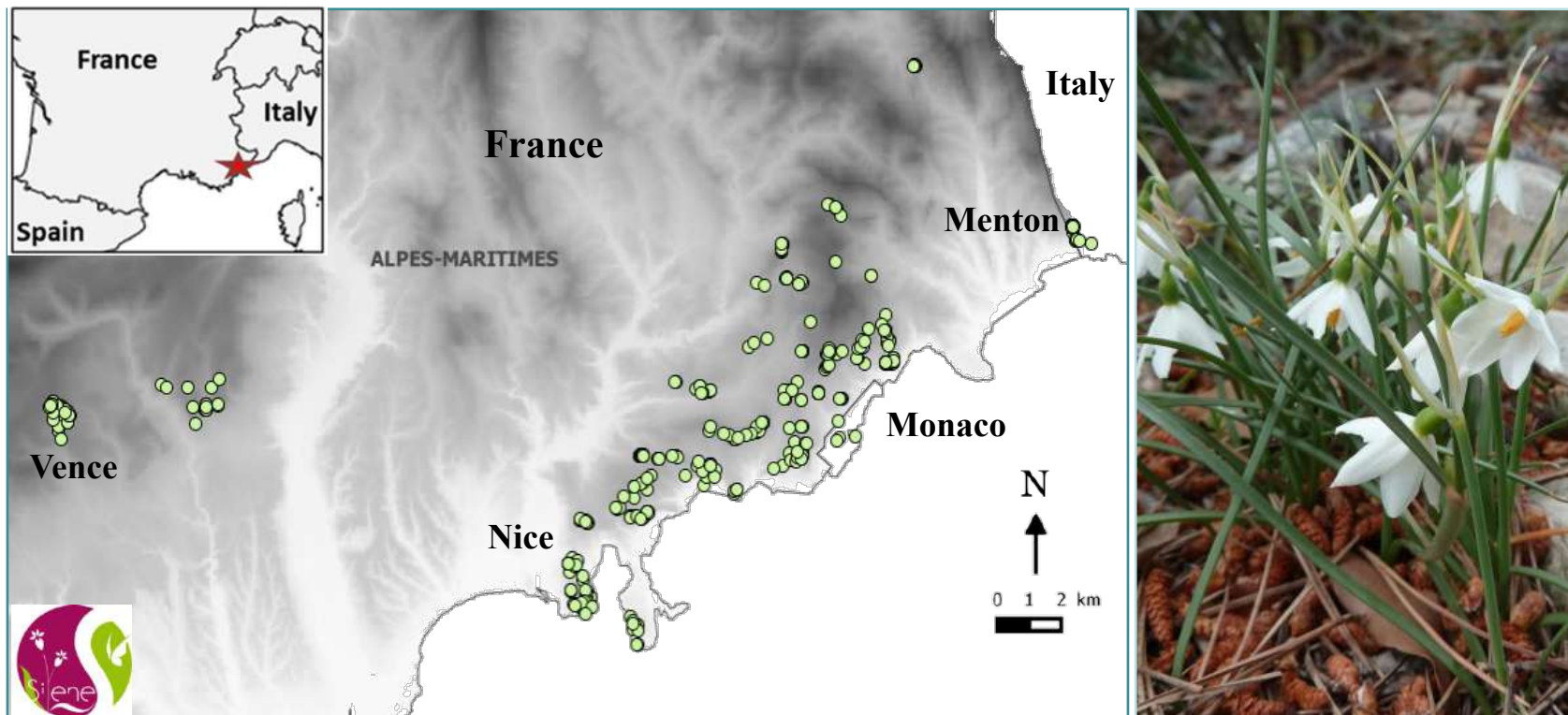
The use of genetic and ecological distinctiveness to delineate **conservation units**

Haplotype + ecological group = Unit



Integrating evolution and ecology to define plant microreserves

Acis nicaeensis, The Riviera snowflake (Amaryllidaceae)



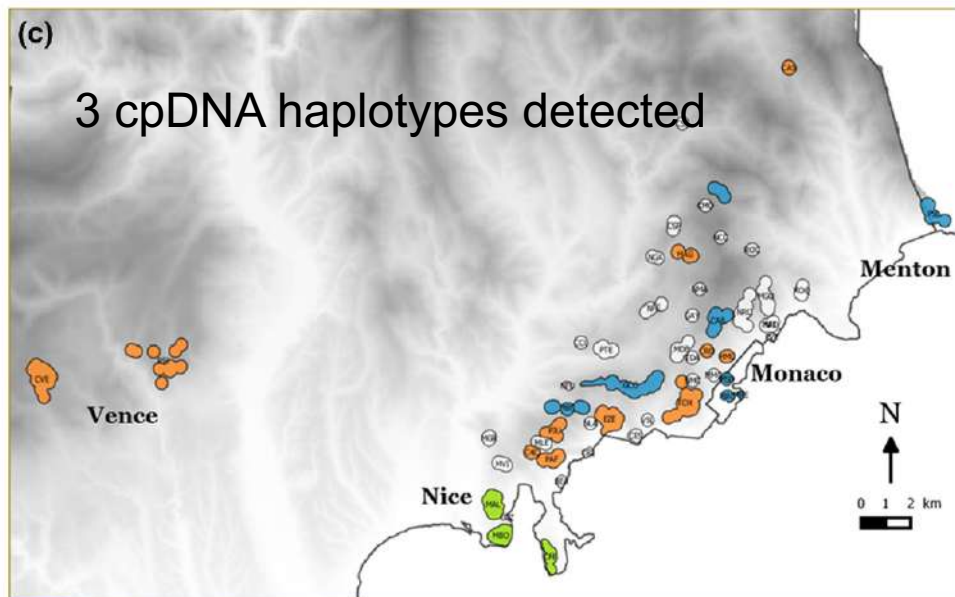
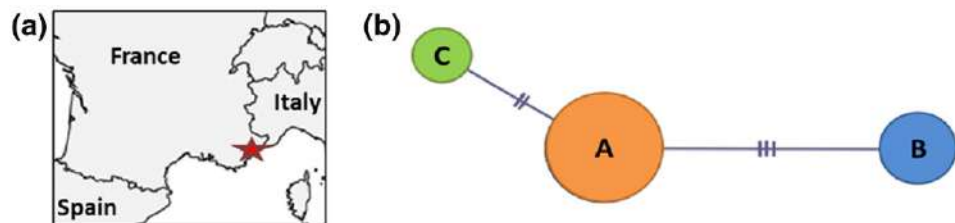
Narrow endemic geophyte from the Maritime Alps (distribution: 12 x 35 km)

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

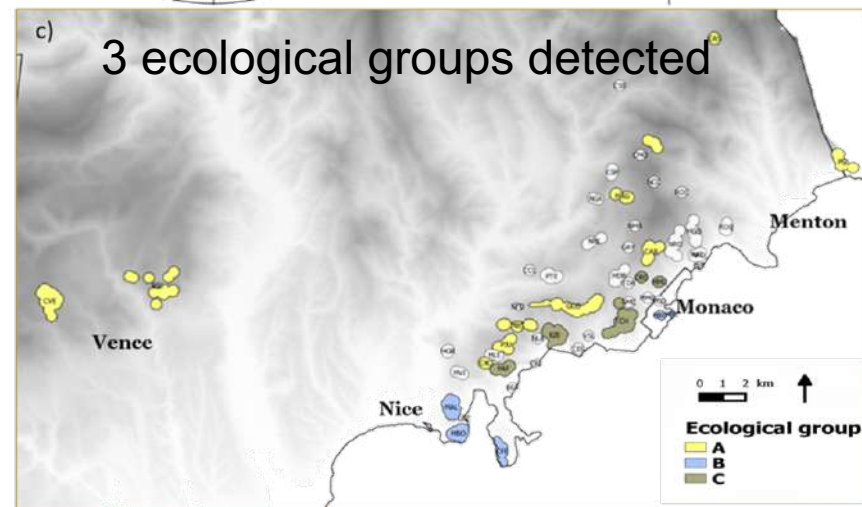
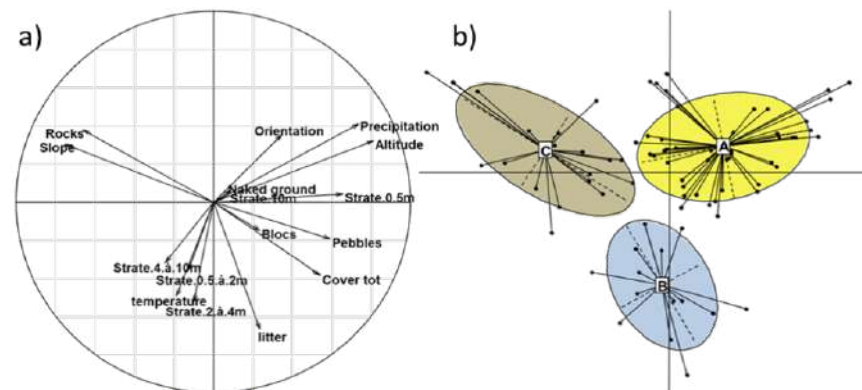
Highly threatened by human activities (EN in the French IUCN Red List)

Integrating evolution and ecology to define plant microreserves

Phylogeographical structure



Ecological structure



Integrating evolution and ecology to define plant microreserves



Contents lists available at ScienceDirect

Journal for Nature Conservation

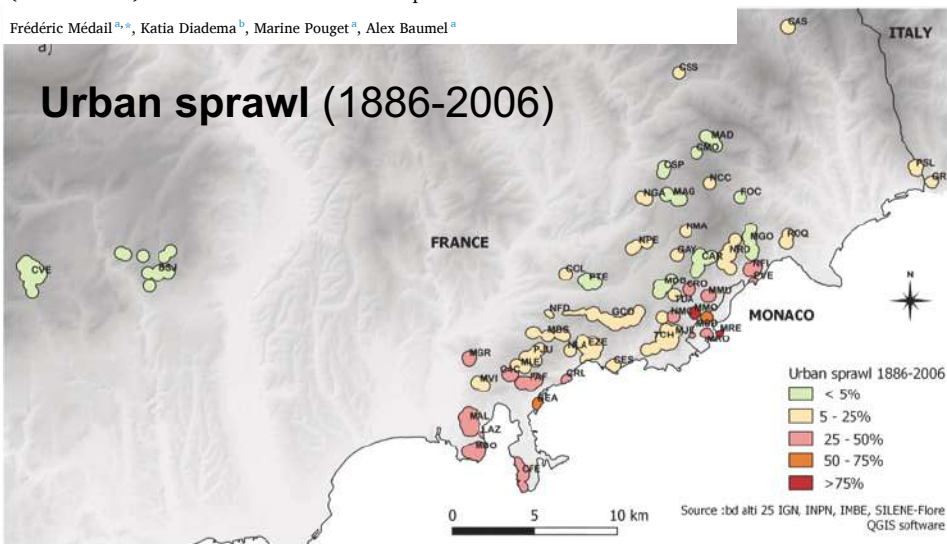
journal homepage: www.elsevier.com/locate/jnc



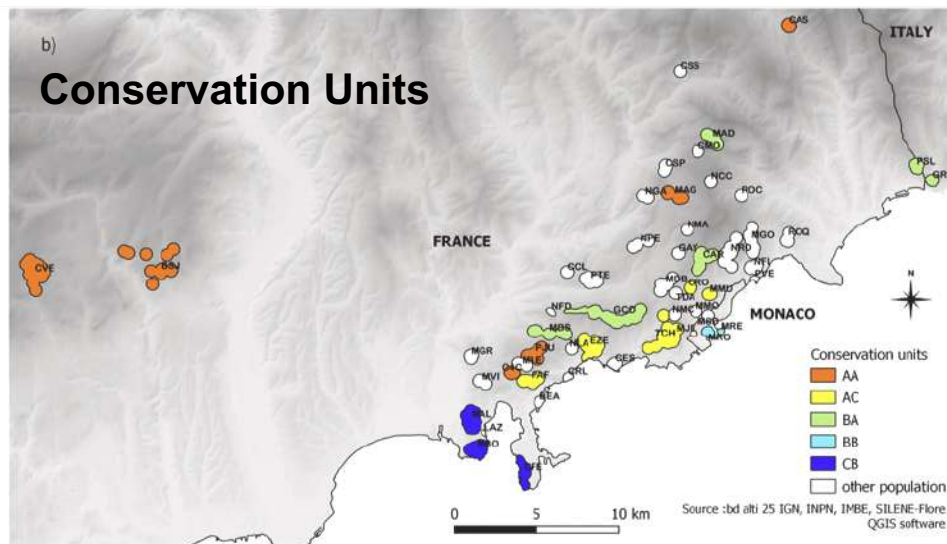
Identification of plant micro-reserves using conservation units and population vulnerability: The case of an endangered endemic Snowflake (*Acis nicaeensis*) in the Mediterranean Basin hotspot

Frédéric Médail^{a,*}, Katia Diadema^b, Marine Pouget^a, Alex Baumel^a

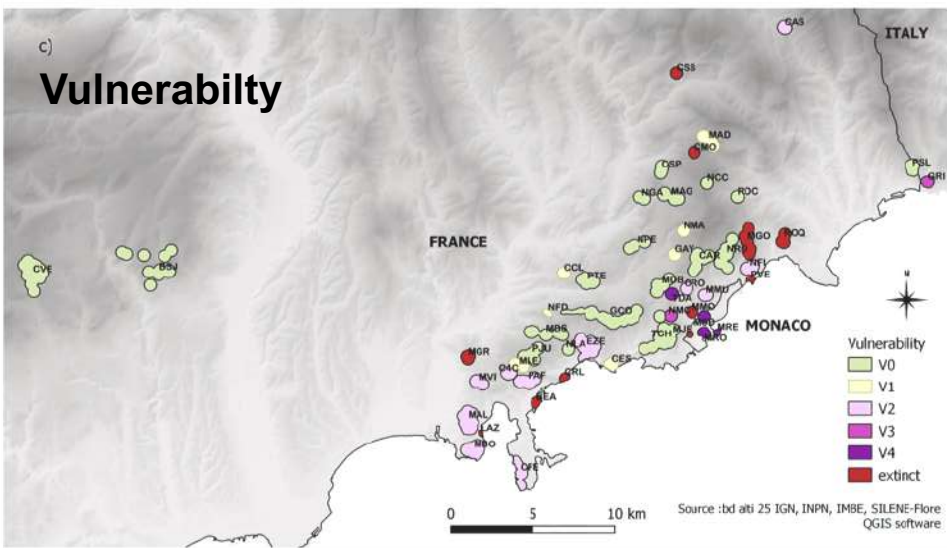
Urban sprawl (1886-2006)



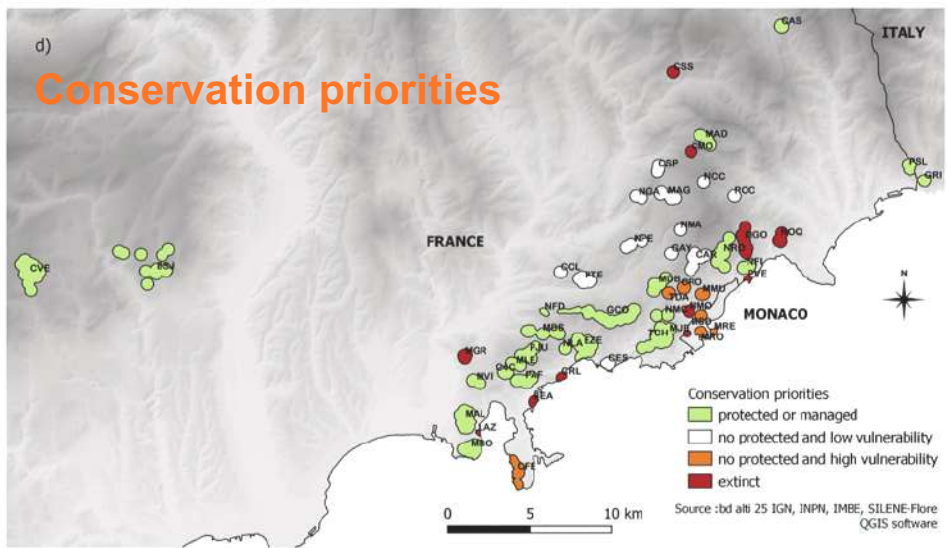
Conservation Units



Vulnerability



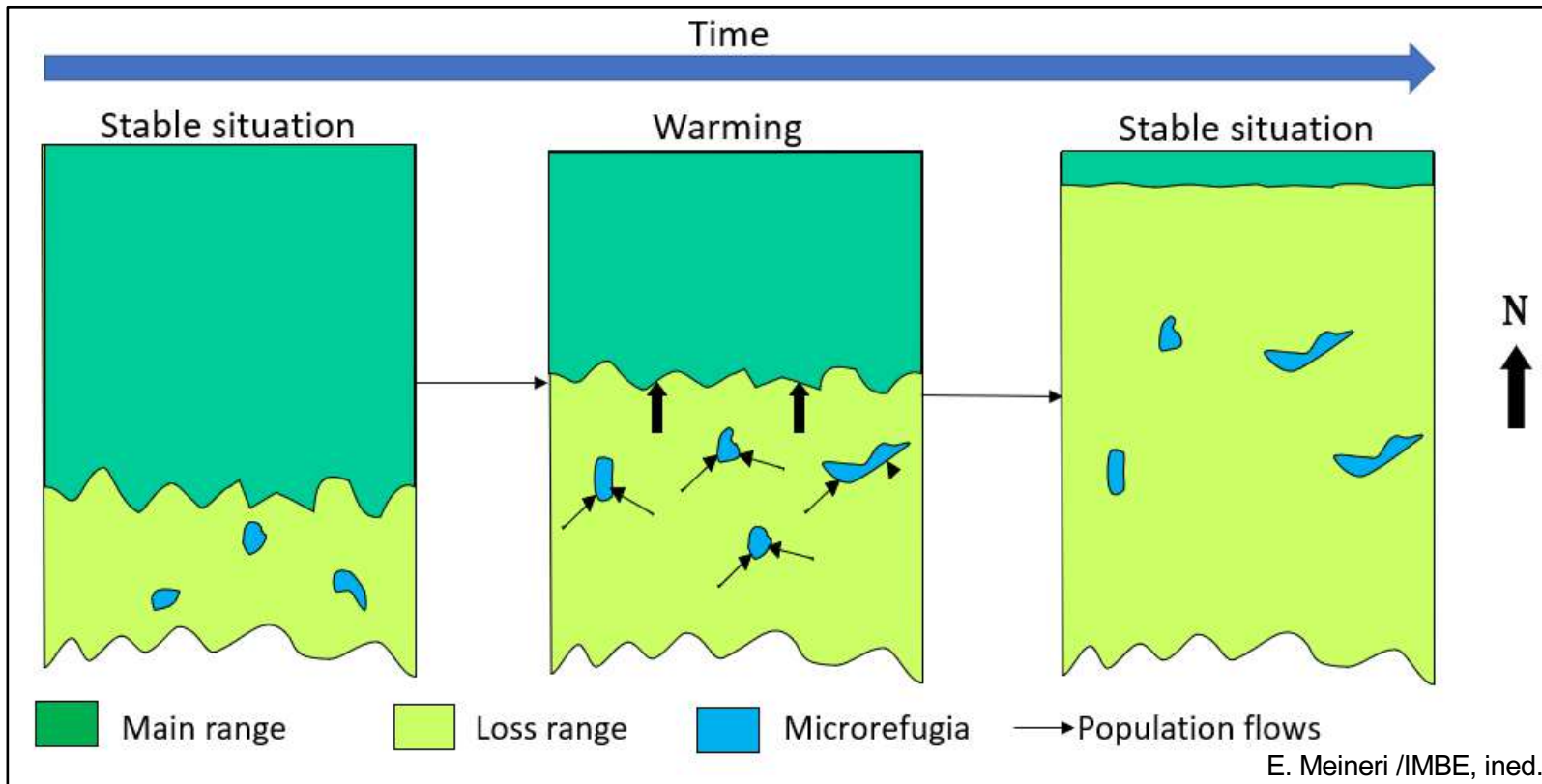
Conservation priorities



Role of microrefugia for plant conservation faced with climatic change



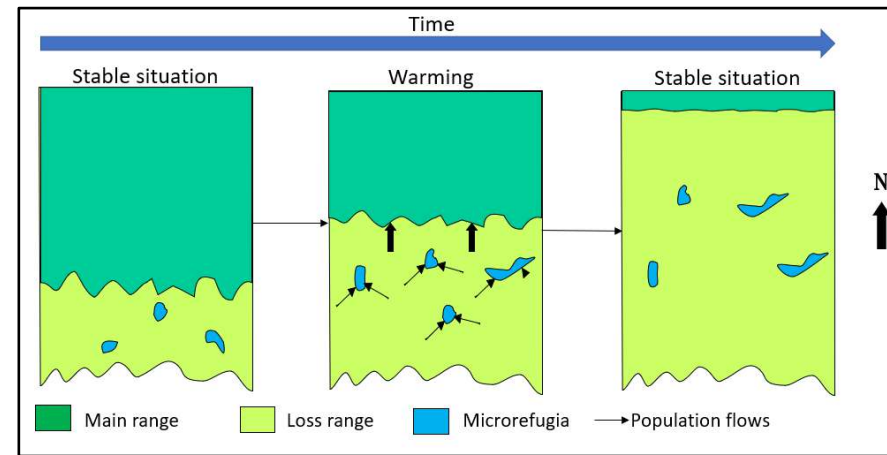
MICROMED - Conservation of flora faced with global warming: characterizing, mapping and assessing the role of microrefugia in the South region of France



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.

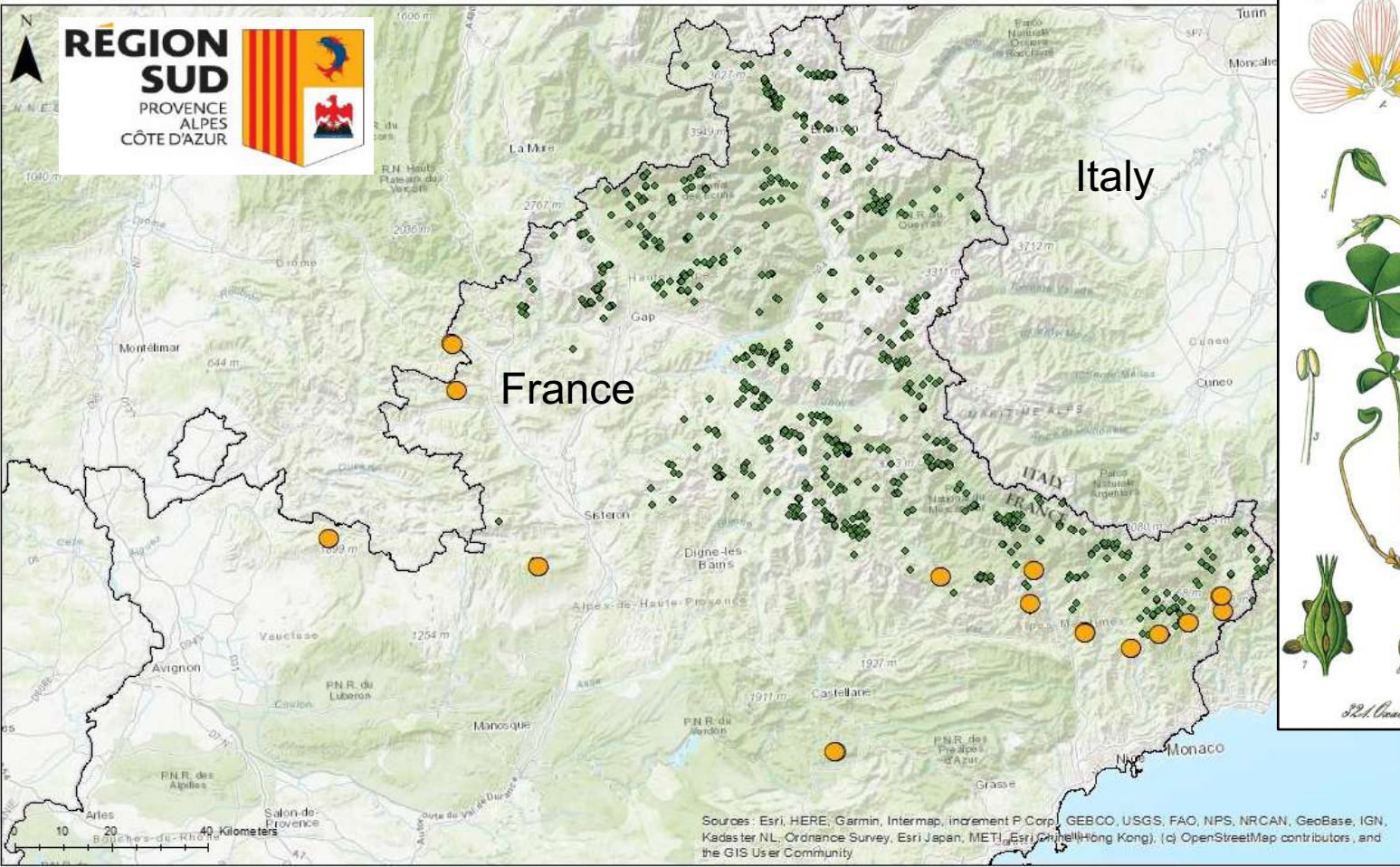
These climatic "havens" represent a solution limiting the migratory needs of species and allowing the flora to recolonize the landscape quicker if environmental conditions become more favourable.



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?



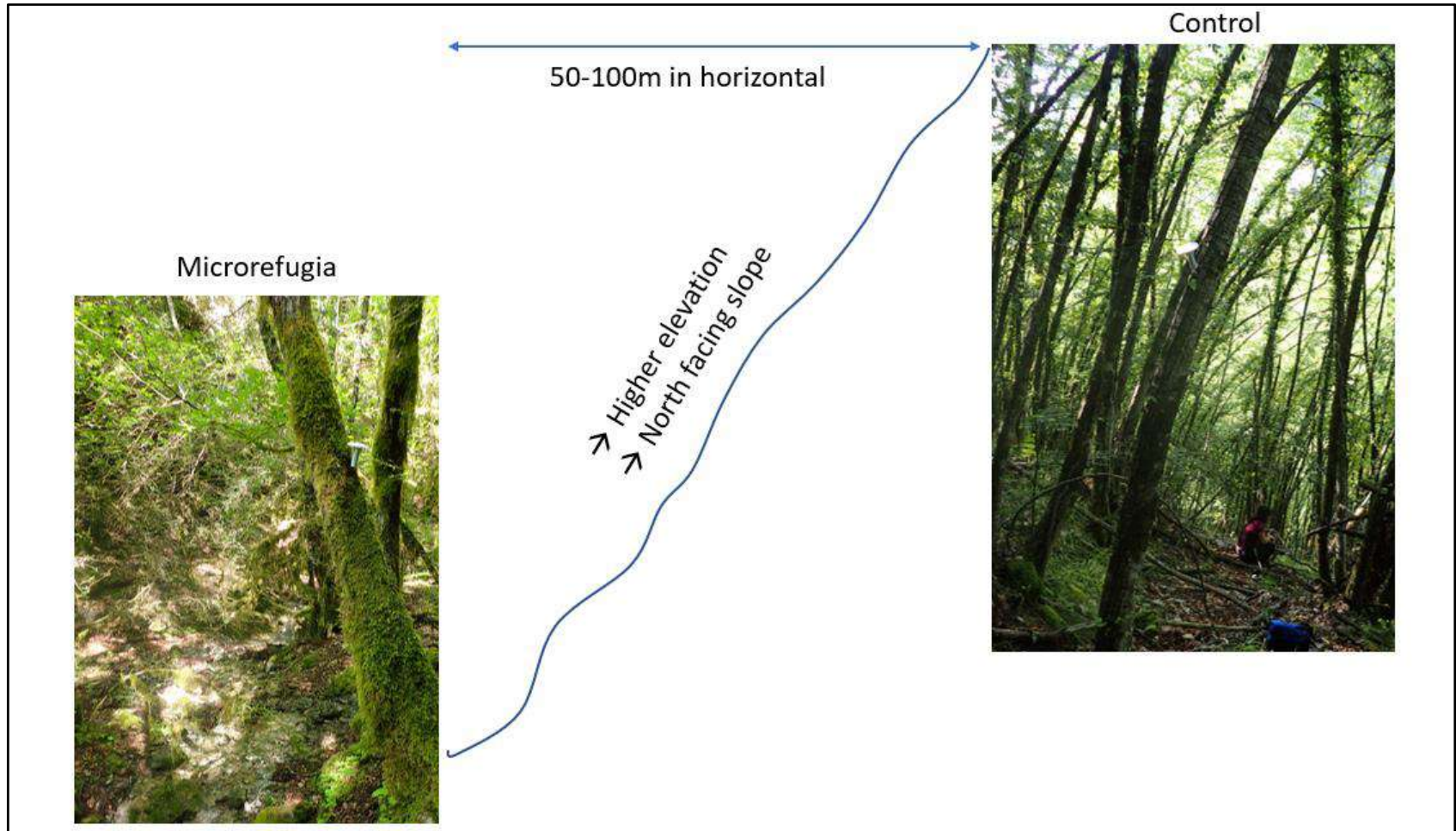
- ◆ Relevés de l'espèce indicatrice *Oxalis acetosella* L. (SILENE)
- Microrefuges équipés en enregistreurs de température

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.

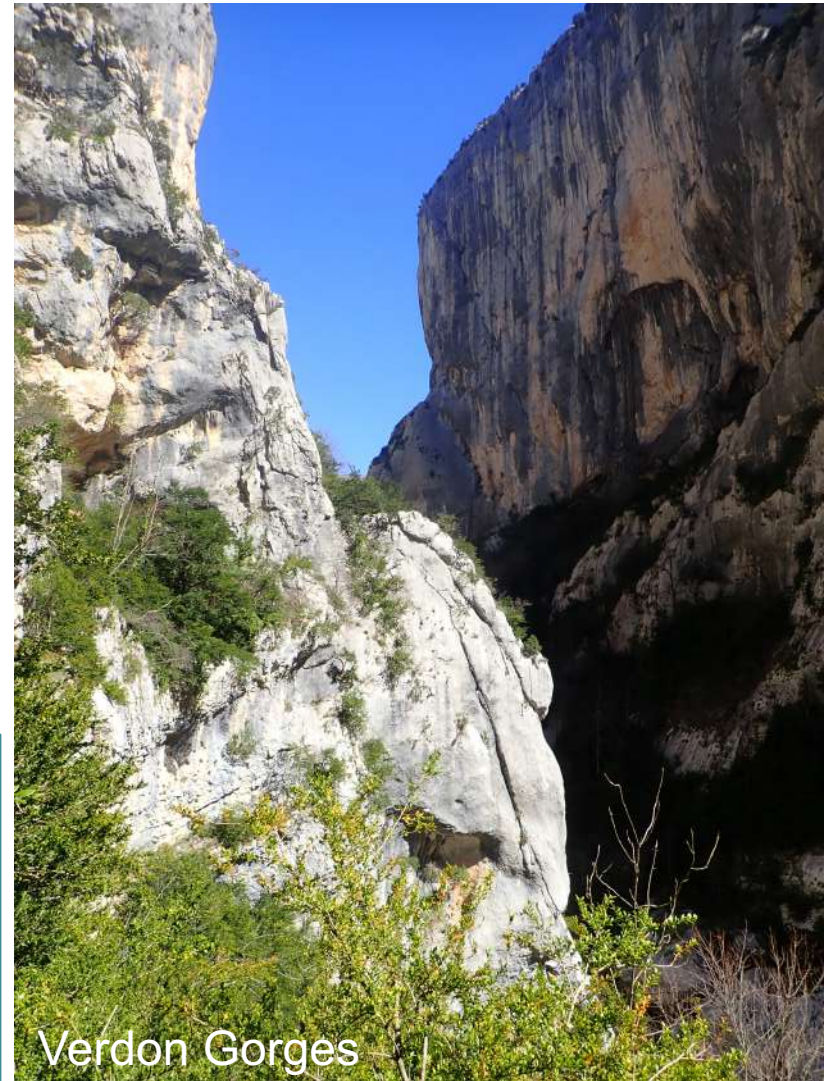
Plant communities present in micro-refugia have cooler temperature and wetter humidity optima than communities present in the control sites

(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?



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.

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

The ecosystem-centred approach has several strong points:

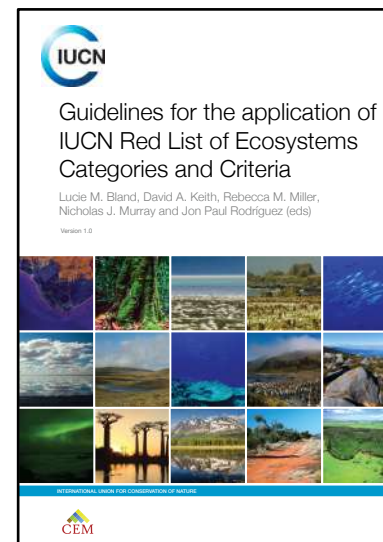
(iv) The conceptual model can be a stepping stone towards analytical or numerical **modelling**, where flows (e.g. C, N, P) between compartments are quantified.

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

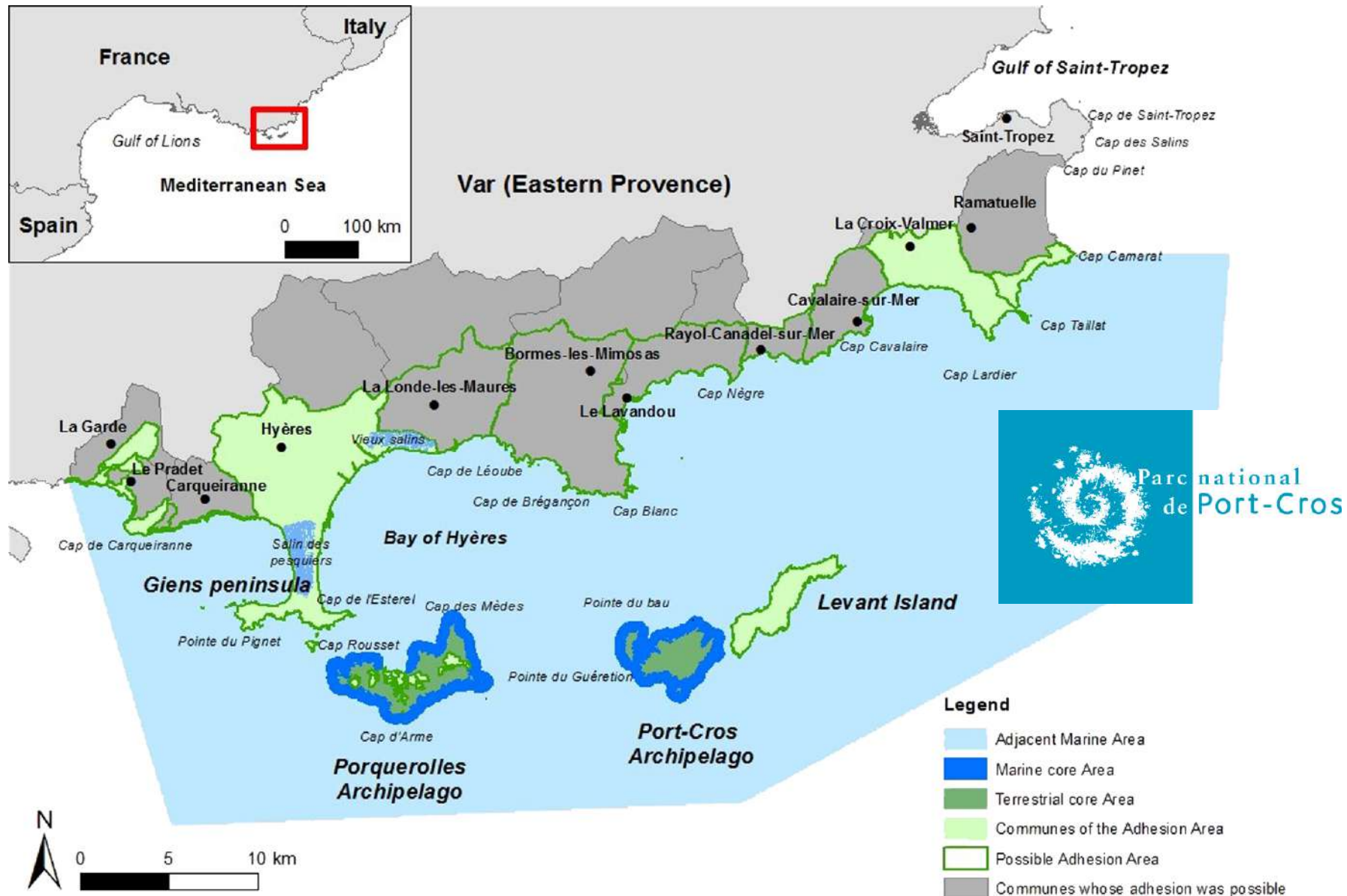
(vi) This approach enables the development of **environmental quality indices** (e.g. Ecosystem-Based Quality Index, EBQI) that are much more significant and reliable than indices based on one or a few species.

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

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



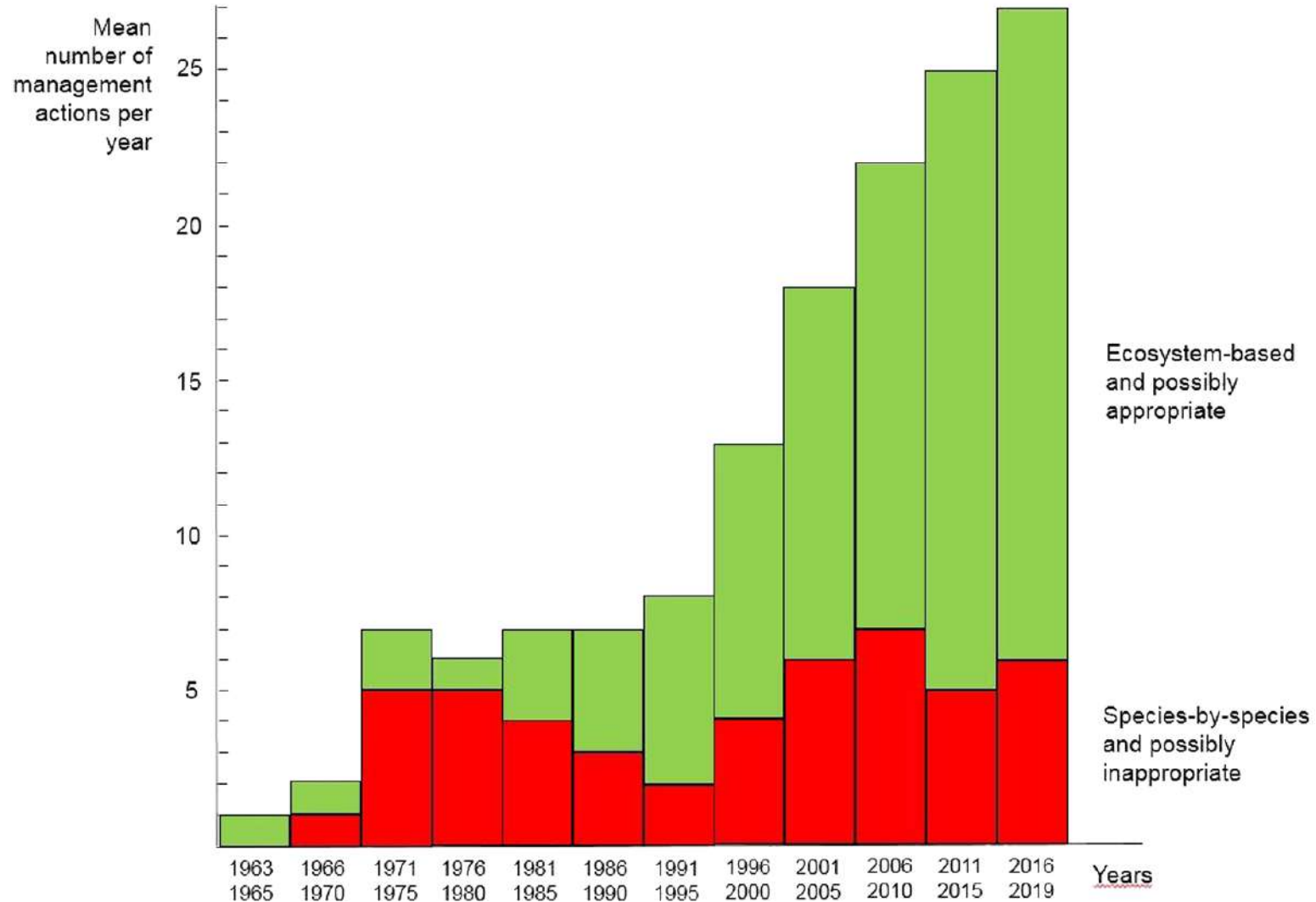
Ecosystem-based approaches on a threatened protected area



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

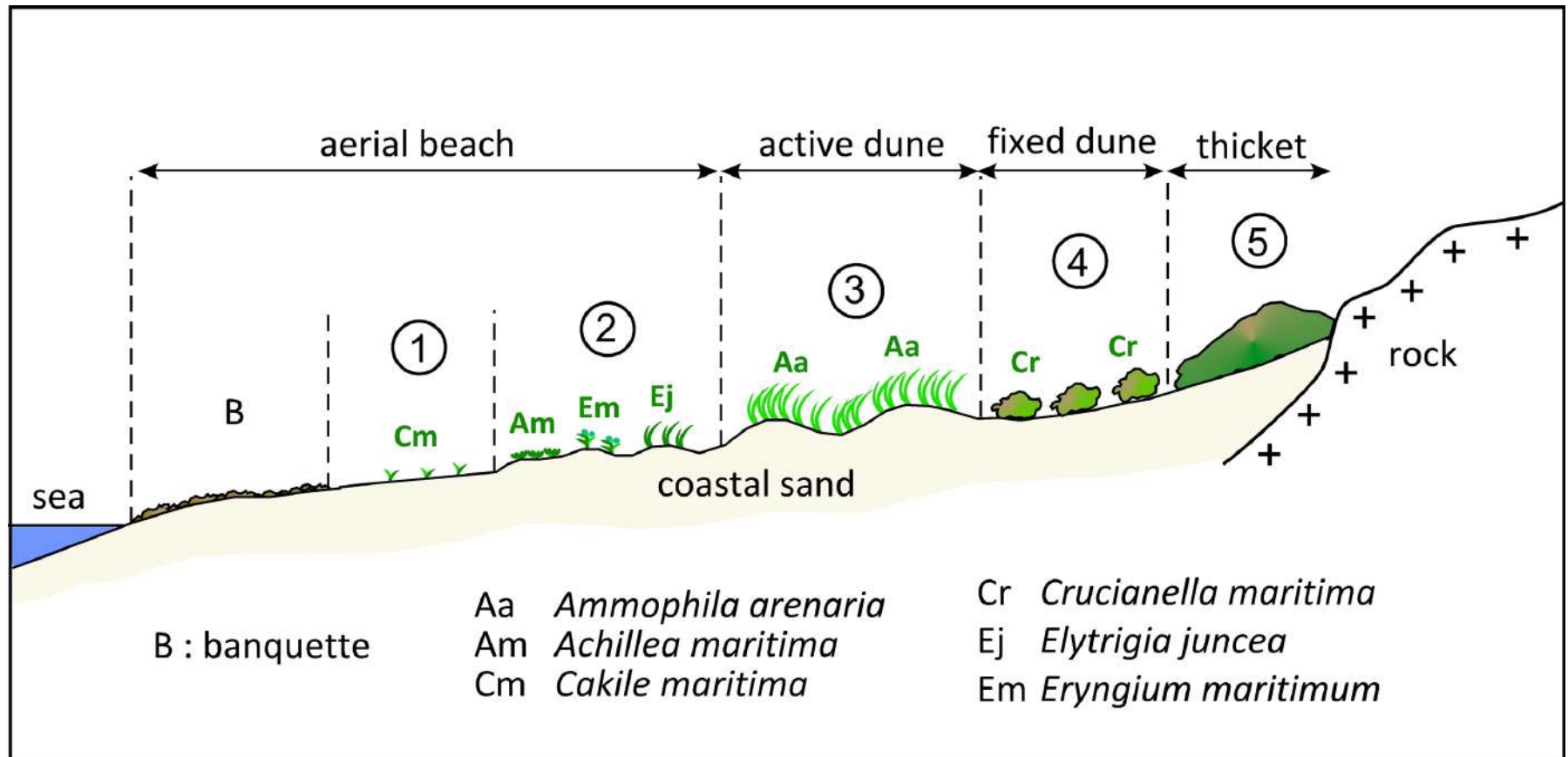
Mean number of management actions, species-by-species and possibly inappropriate and ecosystem-based and possibly appropriate, over time in the Port-Cros NP



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

Original drawing © Guilhan Paradis and Carole Piazza in Boudouresque *et al.*, submitted

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



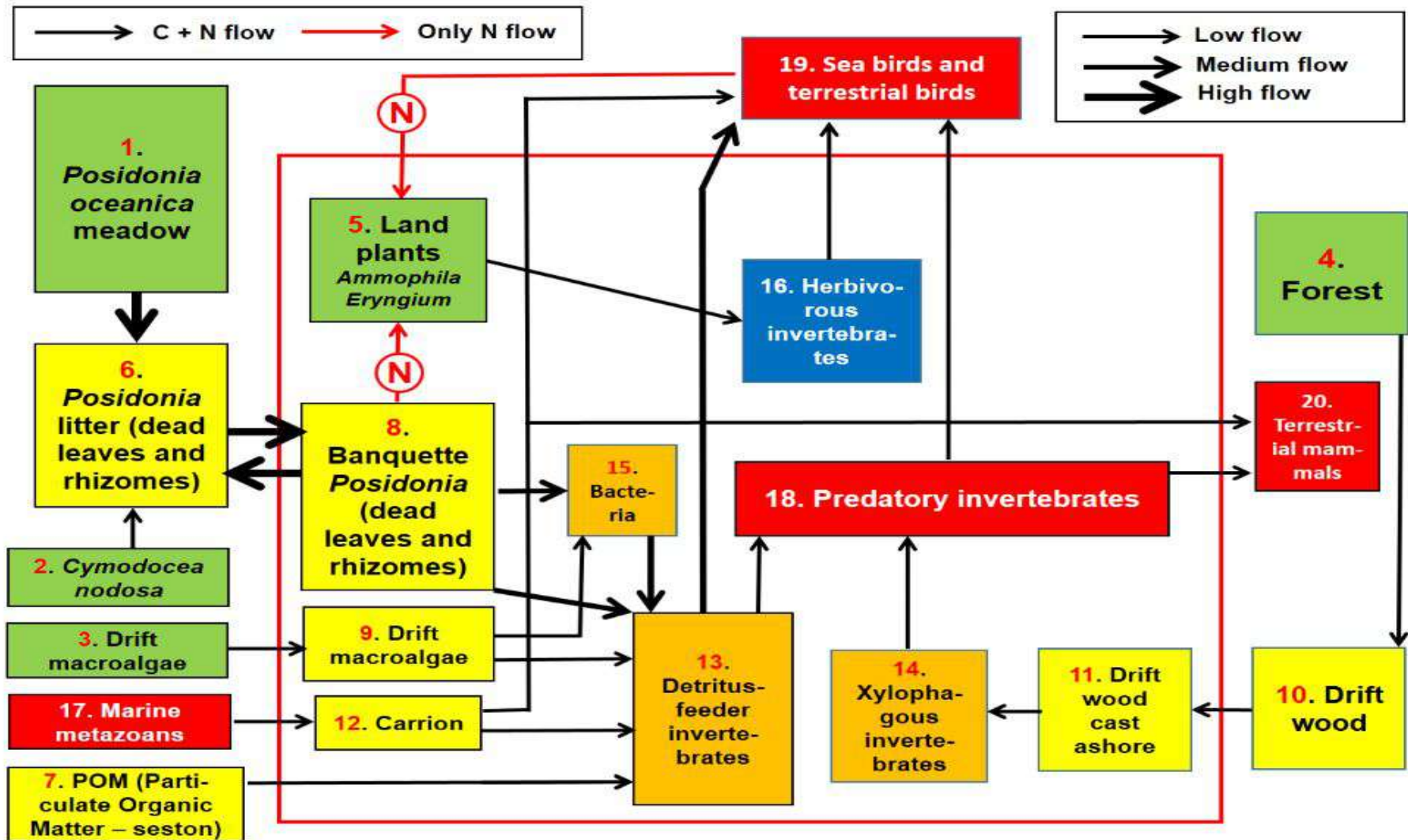
Several small species of psammophilous Coleoptera spend their whole life cycle deeply buried in the substratum

Trachyscelis aphodioides, *Ammobius rufus*, *Brindalus porcicollis* and *Xenonychus tridens*.

Bar scale = 1 mm. Photos © Philippe Ponei

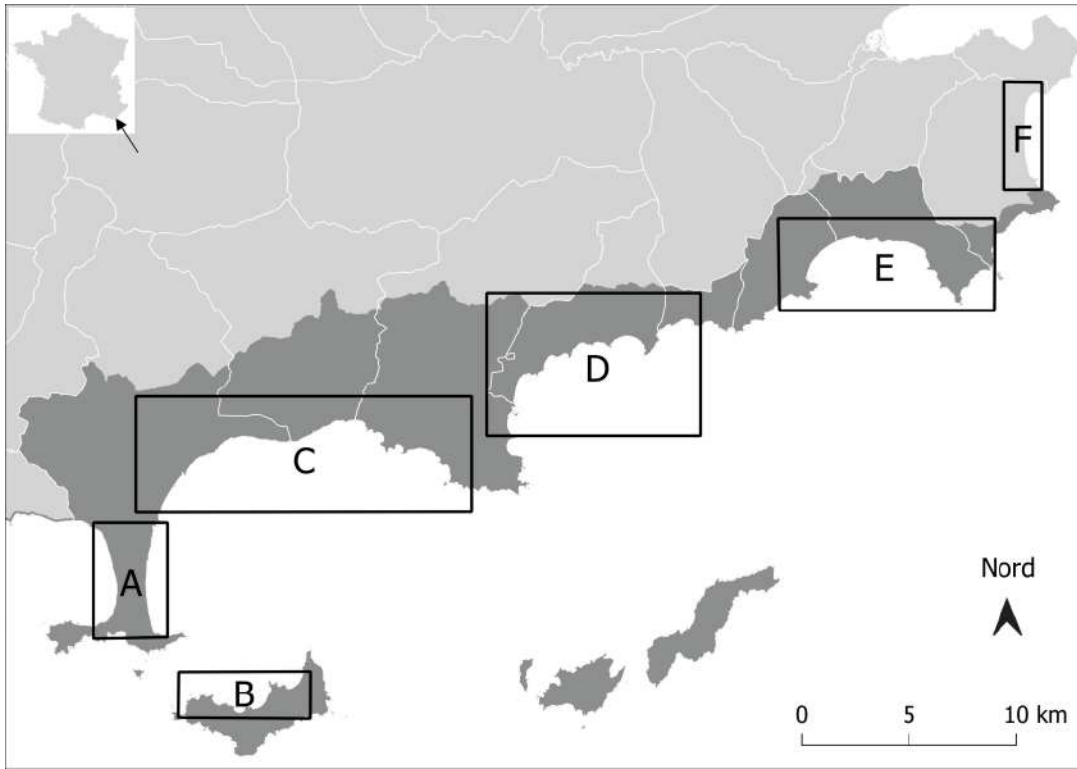
Ecosystem-based approaches on a threatened habitat

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

Ecosystem-based approaches on a threatened protected area

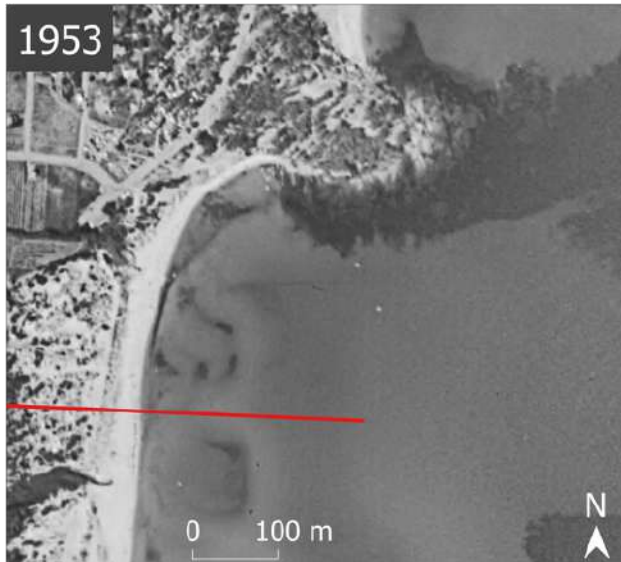


Conservatoire Botanique National
Méditerranéen



Morando & Noble, 2019

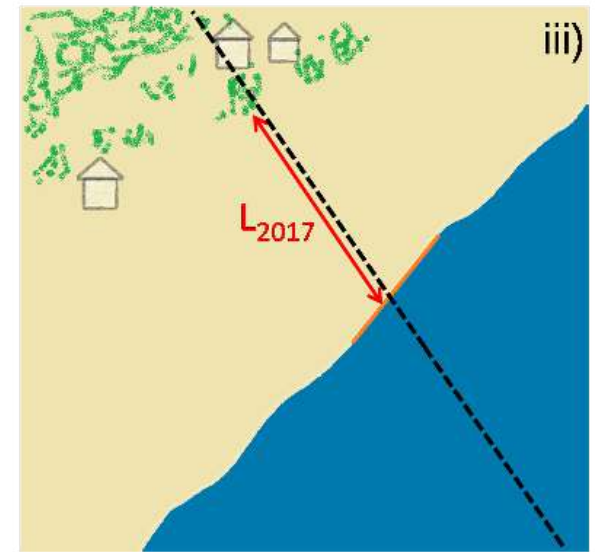
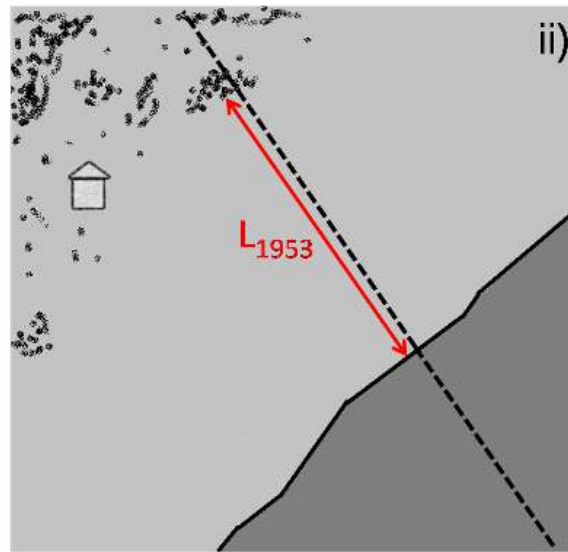
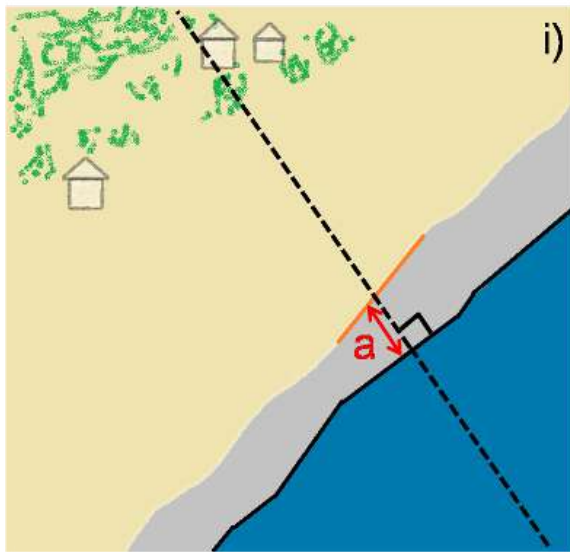
PORQUEROLLES



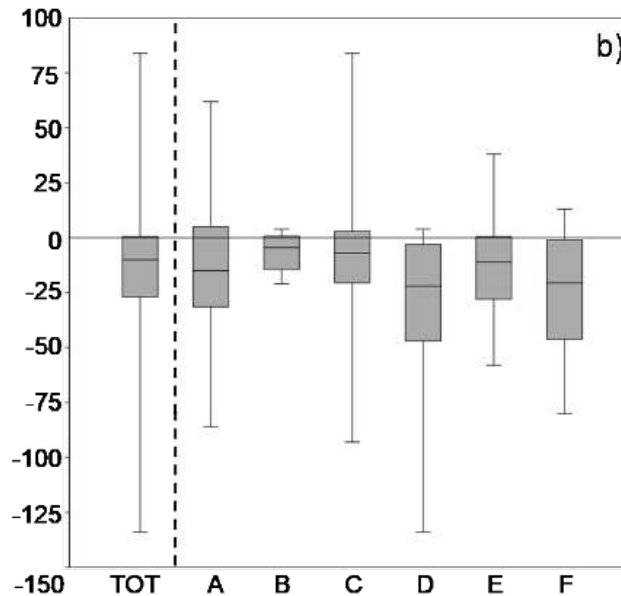
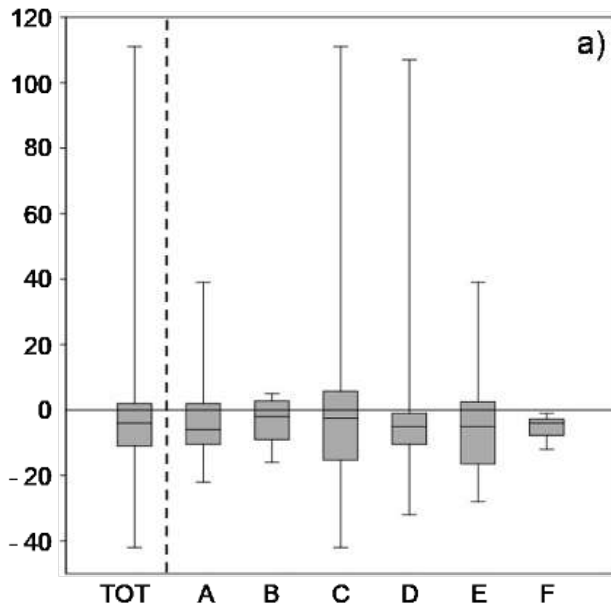
Example of an extreme change of a coastal landscape between 1953 and 2017

(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)



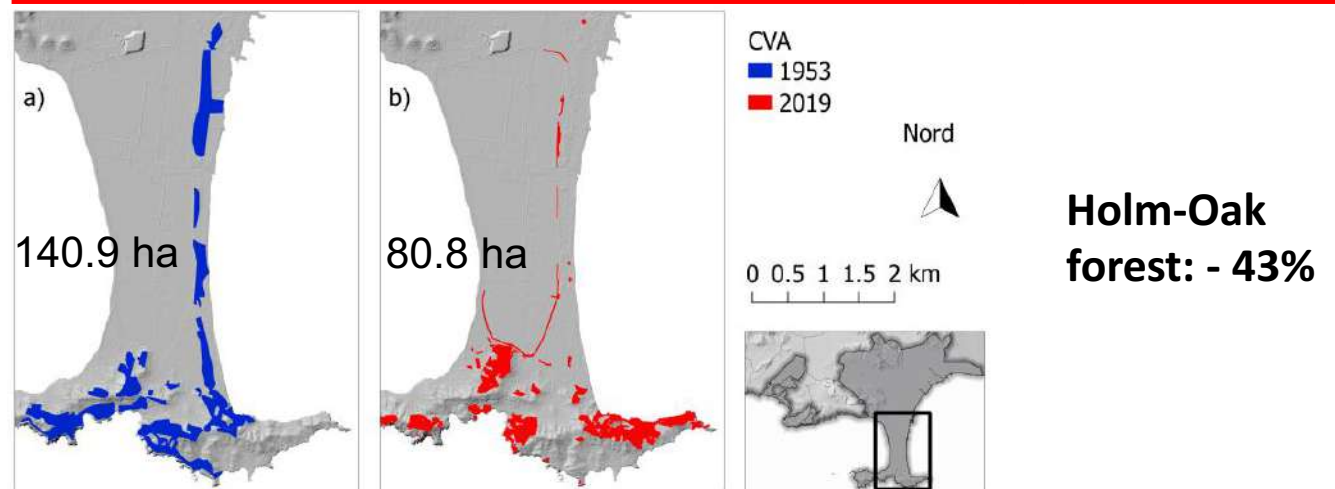
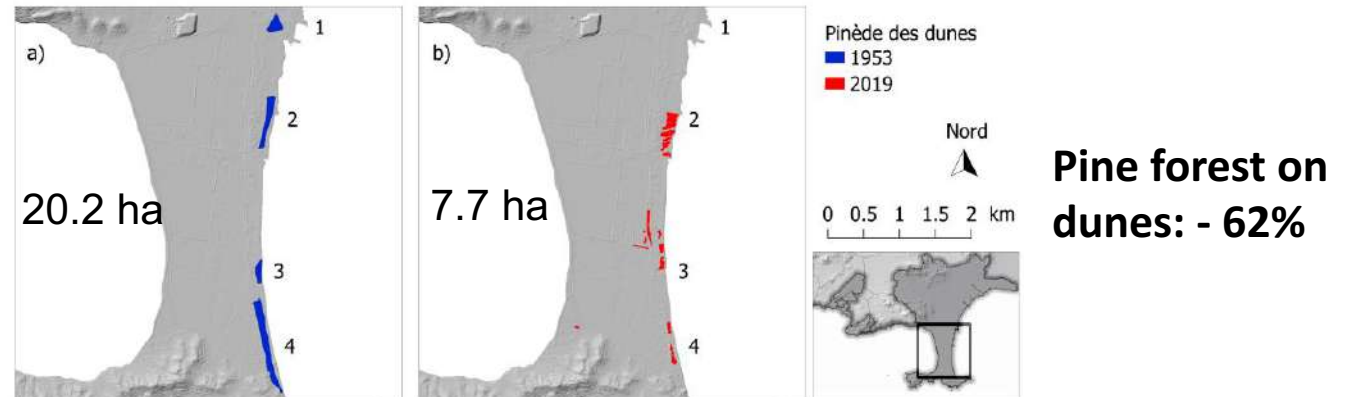
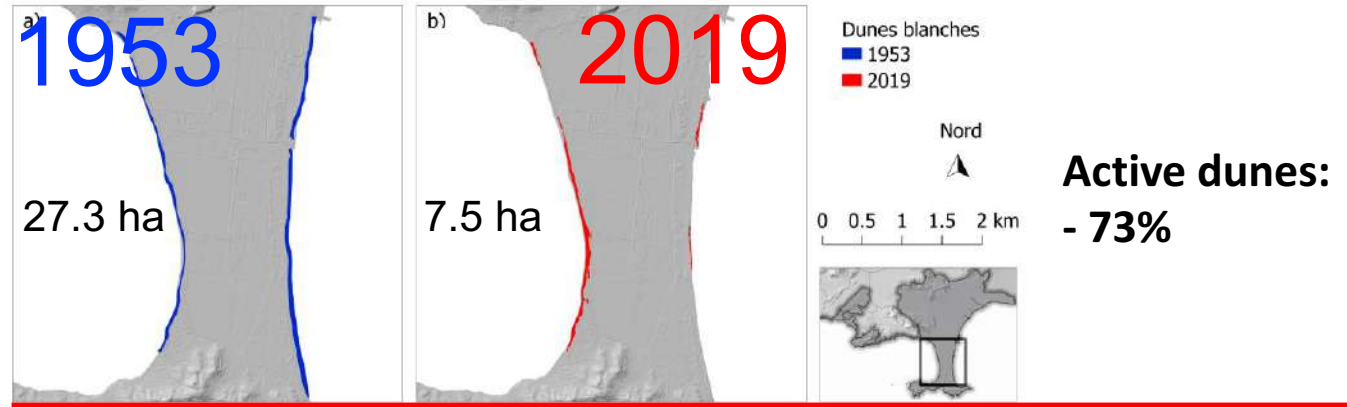
c)

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

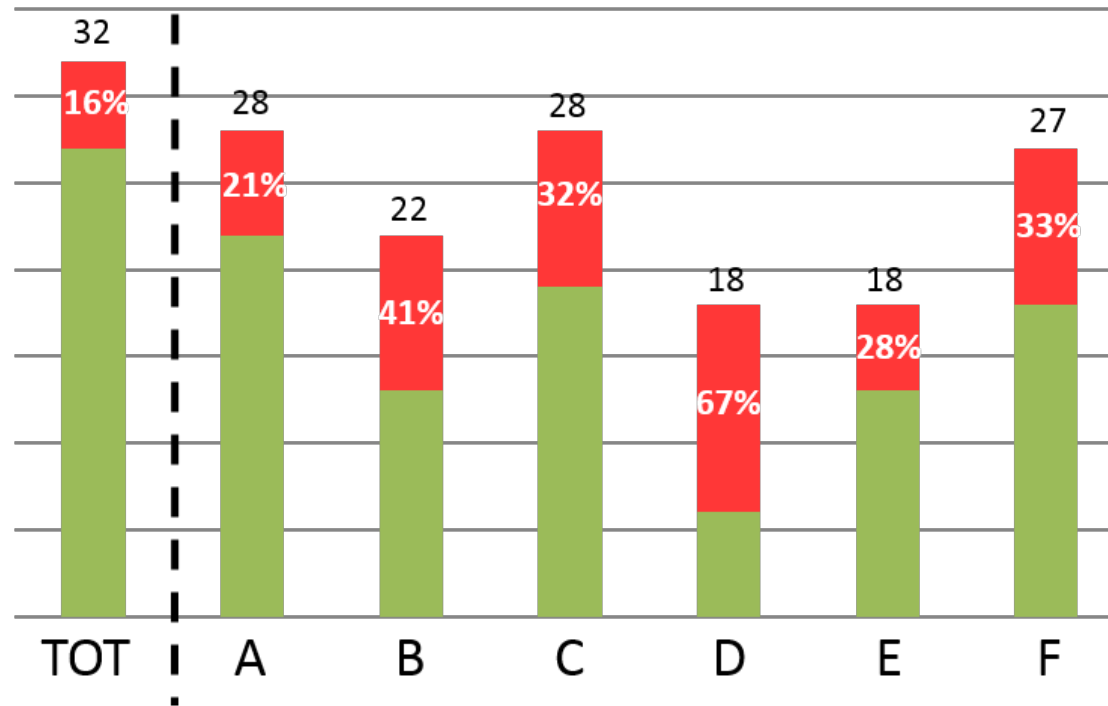
Changes in the position (a) and the width of the dune ecosystem (b) of the coastline in meters between 1953 and 2020; estimates of dune surface losses between 1953 and 2017 (c)

Ecosystem-based approaches on a threatened protected area

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



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



Anthophora mucida
LasioGLOSSUM pygmaeum
Andrena morio
Colletes eous
Apis mellifera
LasioGLOSSUM bimaculatum

Bombus terrestris

Andrena ovata
Bombus pascuorum
Andrena trimmerana
Andrena nigraeana
LasioGLOSSUM leucocome
Nomada succincta
Eucera caspica
LasioGLOSSUM punctatissimum
Anthophora dispar
Osmia aurulenta
LasioGLOSSUM mediterraneum
Eucera nigrescens
Megachile pyrenaica
Osmia caerulea
Osmia bicolor
Xylocopa violacea
Andrena pusilla
Megachile giraudi
Anthophora plumipes
Rhodanthidium septemcostatum
Osmia nasocrotchia
Osmia submicans
LasioGLOSSUM verticillipes

Andrena fulva
Colletes similis
Panurgus dentipes
LasioGLOSSUM fransfordi
Stelis punctatissima
Habropoda tarsata
Anthophora atriceps
Andrena haemorrhoa
Andrena combinata
Andrena senecionis
Andrena rhenana
Andrena laevis

LasioGLOSSUM albocinctum
Anthidium strigosum
Andrena vulpecula
Halictus smaragdula
Hierades rubicola
Anthophora affinis
Andrena hesperia
Andrena aglissima
Anthidium florentinum
LasioGLOSSUM villosulum
Osmia nivescens
Amegilla fasciata
Megachile melanopyga
Hylaeus pictus
Chelostoma florissimae
Andrena cinerea
LasioGLOSSUM leucozonium

Amegilla albigena
Pseudapis bispinosa
Ceratina cucurbitina
Anthophora bimaculata
Stelis agnata
LasioGLOSSUM nidulum
Ceratina parvula
Anthophora crassipes
Megachile pilidens
Halictus quadrifidus
Halictus frivipes
Amegilla garrula
Megachile conicina
Anthidium manicatum
Xylocopa iris
Halictus gemmeus
Halictus scabiosae

Horides crenulata
Colletes nigricans
Ceratina cyanea
Colletes collaris
Hylaeus pictus
Halictus quadricinctus brunnescens
Anthidium loti
Colletes hederae
Colletes abellii

Hylaeus chrypearis
Hylaeus punctatus
Hoplitis benoitii
Hoplitis adoniae
Anthophora femorata
Colletes brevigera
Halictus (Amegilla)
Andrena leucolippa
Andrena pandellei
Chelostoma distinctum
Andrena similis
Megachile parviora
Hoplitis anthocephala
Osmia scutellata

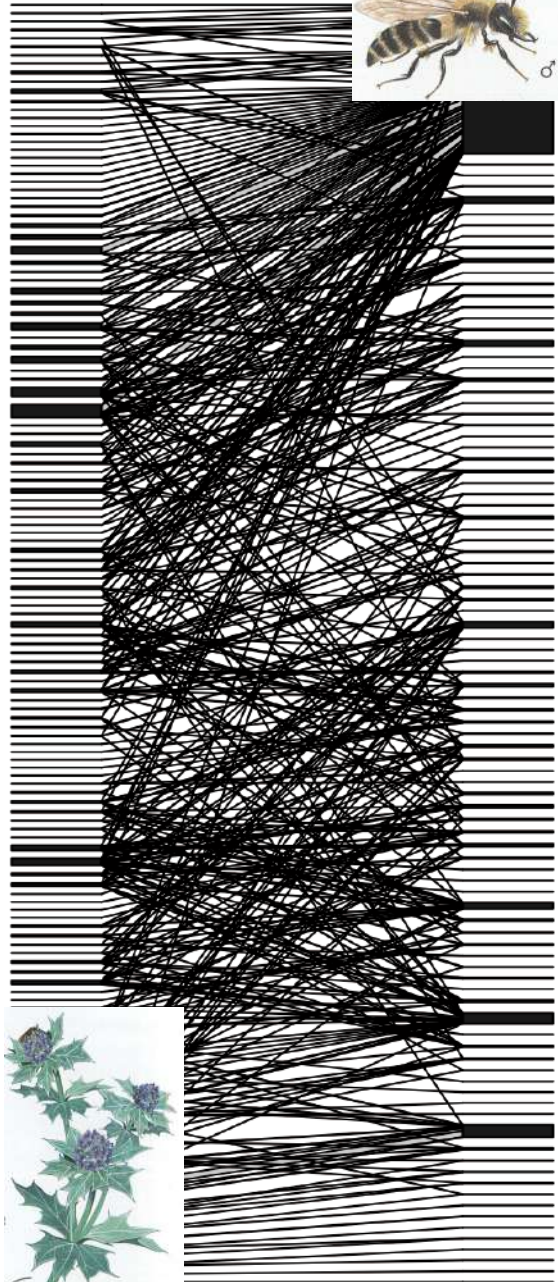
Une abeille rare

Localisation: calanque des Salins et du Bregançonnet. *LasioGLOSSUM bimaculatum* est solitaire et considérée comme rare dans tout l'ouest méditerranéen. Présente à Porquerolles, elle a le statut d'espèce patrimoniale. Elle est particulièrement active en mai où, hyper-spécialisée, elle concentre ses récoltes sur les Cistacées.



LE CISTE CRÉPU
Ce petit arbrisseau est une plante protégée à l'échelon régional. Sa protection favorise *LasioGLOSSUM bimaculatum* qui le butine.

- Muscicaea compactum*
- Vespa velutina*
- Conocera inplexa*
- Myrica coromunda*
- Myosotis ramosissima*
- Cystus monspeliensis*
- Doritis carvotrius*
- Scoparius truncatus*
- Aglyptus turcicus*
- Phagnalon saxatile*
- Coronilla valentina subsp. glauca***
- Dorycnium hirsutum*
- Alkum roseum*
- Erythronium*
- Hibiscus*
- Himantoloba*
- Medicago lupulina*
- Medicago lupulina*
- Oxalis articulata*
- Cistus salvifolius*
- Scorpioides*
- Cypripedium*
- Phacelia*
- Rhamnus alaternus***
- Erica arborea***
- Malva arborea*
- Salpiglossa oronitiformis*
- Rubus*
- Senecio leucanthemifolius subsp. crassifolius***
- Asphodelus xanthocephalus*
- Dorcheanthus*
- Medicago arborea***
- Cerastium pumilum*
- Sonchus asper subsp. glaucescens***
- Rosmarinus officinalis***
- Erodium malacoides*
- Nardus stricta*
- Lavandula stoechas***
- Lotus cytisioides***
- Gladiolus dubius*
- Fumaria capitata*
- Oxalis corniculata*
- Pelargonium xanthoneuron*
- Dorycnium hirsutum*
- Salvia officinalis*
- Bituminaria bituminosa***
- Stachys recta*
- Infundibulum*
- Fumaria bicolor*
- Leucanthemum vulgare*
- Galactites tormentosa*
- Oxalis pes-caprae*
- Euphorbia characias*
- Allium triquetrum*
- Argyranthemum pinnatifidum*
- Leontodon tuberosus*
- Quercus ilex*
- Ruscus aculeatus*
- Aptenia cordifolia***
- Cerastium ruber*
- Urospermum*
- Euphorbia*
- Calceolaria*
- Raphanus raphanistrum*
- Crepis sancta*
- Sonchus oleraceus*
- Euphorbia*
- Cacabea*
- Eragrostis*
- Tropaeolum majus*
- Lotus unguis-cati*
- Onopordium*
- Artemisia*
- Prunella*
- Hedysarum*
- Crepis vesicaria*
- Pancratium maritimum***
- Gezania*
- Limonium pseudomile*
- Jasione montana*
- Echium*
- Heliotropium*
- Teucrium marum***
- Clinopodium nepeta***
- Daphne*
- Cakile maritima***
- Sonchus*
- Hypericum*
- Sepium*
- Amaryllis*
- Rubus*
- Lotus*
- Kali*
- Carline*
- Scabiosa*
- Epicobium*
- Solanum*
- Adiantum*
- Trifolium*
- Cerastium*
- Liparda*
- Ruta*
- Hypericum*
- Thymus*
- Lotus*
- Reseda*
- Symphoricarpos*
- Diploteris*
- Symphoricarpos*
- Engelmannia*
- Chamaecrista*
- Echinum*
- Apium*
- Deucus*
- Foeniculum vulgare***
- Acacia*
- Lotus*
- Dactylis*
- Odonites*
- Helichrysum*
- Campanula*
- Melissa*
- Lotus*
- Echinum*
- Topais*



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



1. Perform a « state of the art » of the current knowledge on taxonomic groups
2. Define a scientific 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 developed, by integrating ecosystem dynamics and species interactions.



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