A macroecological approach to assess the drivers of alien species invasion in Italian freshwaters

a case study by the Virtual Research Infrastructure LifeWatch

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Show Cases

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The LifeWatch show cases will facilitate the development of integrative researches on key scientific issues by using already existing evidences, which will be organized and reinforced with additional LifeWatch information and made accessible to the scientific community and the general public.
The case studies thus far identified (and now in the starting phase) are:

- Monitoring Alien Species (coordinated by Italy),
- Migrating Birds (coordinated by Netherlands) and
- Wetlands (coordinated by Spain).

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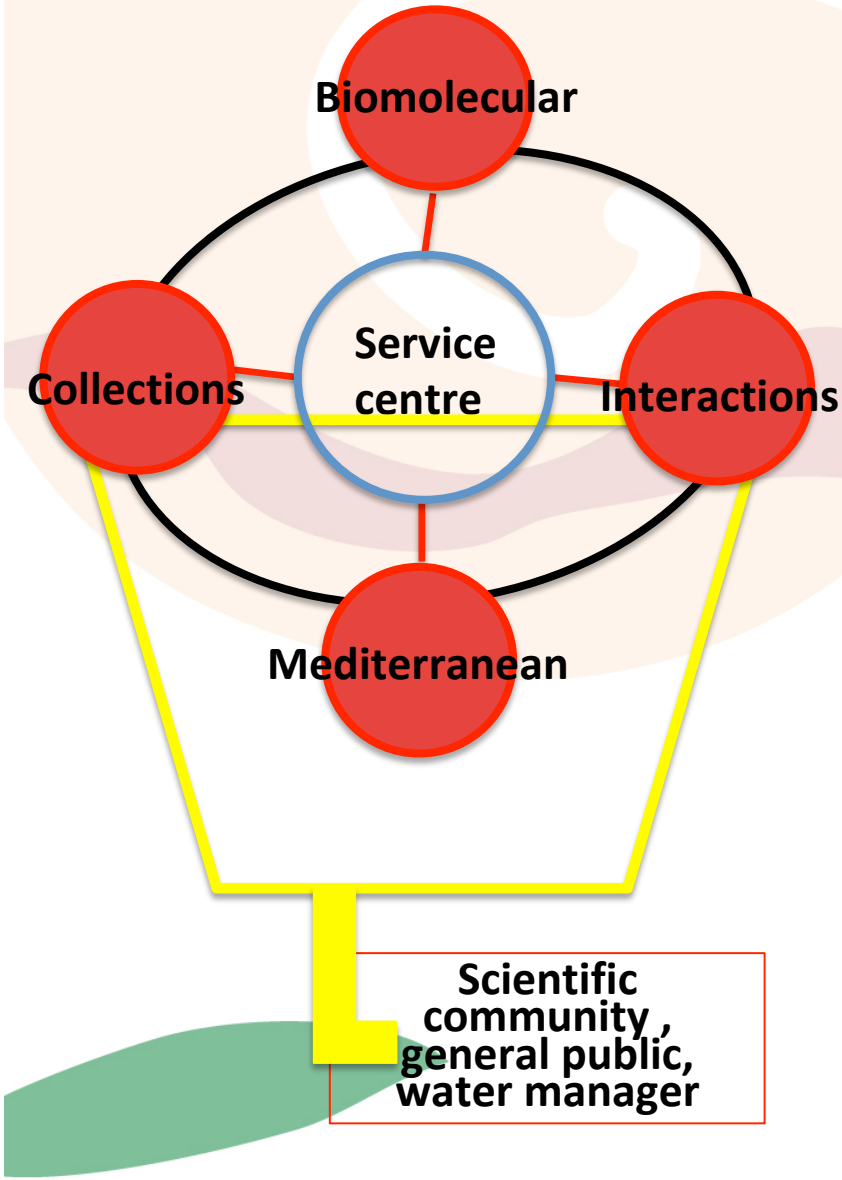
Opportunities for Biodiversity Research



LIFEWATCH through the distributed biodiversity institute and its thematic Centres is:

- capitalising on existing knowledge (i.e., knowledge-based resources);
- integrating inter-disciplinary fields, data sources and data processing tools (to strengthen collaboration through sharing software facilities)

to create the environment to:

- address innovative scientific questions (i.e., virtual research projects, virtual experiments etc);
- deepen current understanding of Biodiversity in its broadest sense;
- decrease the uncertainty of environmental management, governance and policy

LifeWatch Show cases at European level

- *Wetlands* - SP (to study biodiversity in marine wetlands with examples from Waddenzee, Adriatic lagoons, Doñana marsh, Danube delta)
- *Migratory birds* - NL (to study migration, navigation, foraging strategies on land and at sea)
- *Alien species* - IT (to study the vulnerability of fresh-, marine and brackish waters and terrestrial habitats to AS invasion. The results will allow the mapping of the vulnerability of different ecosystem types)

These case studies were developed to demonstrate the functionality of the e-infrastructure and its potential

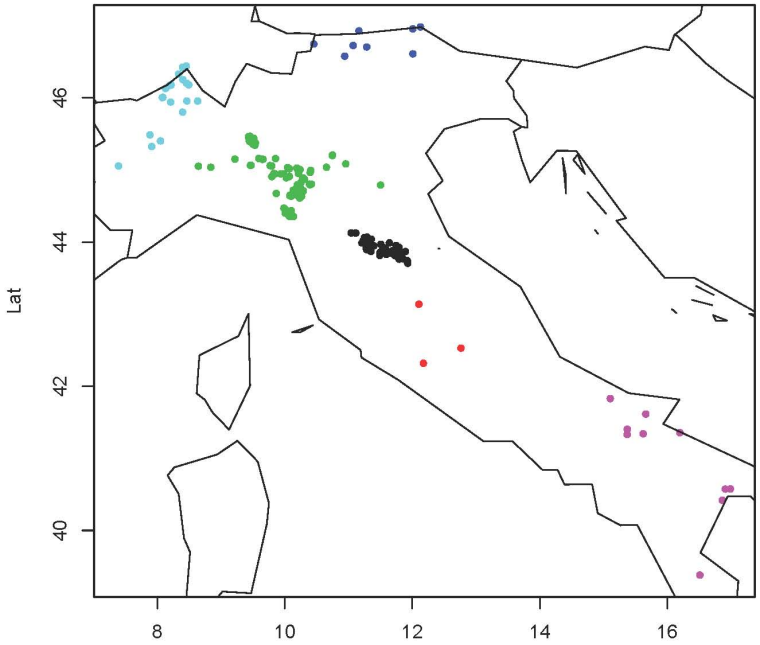
Alien Species definition

Alien Species (AS) = any species deliberately or inadvertently introduced to Italy by human activities after the discovery of the New World by Columbus in 1492, similar to what plant invasion biologists call 'neophytes' (Pyšek, 1998)

In the present work the term alien is used in its broadest meaning , without considering the naturalization stage of species

Data providers

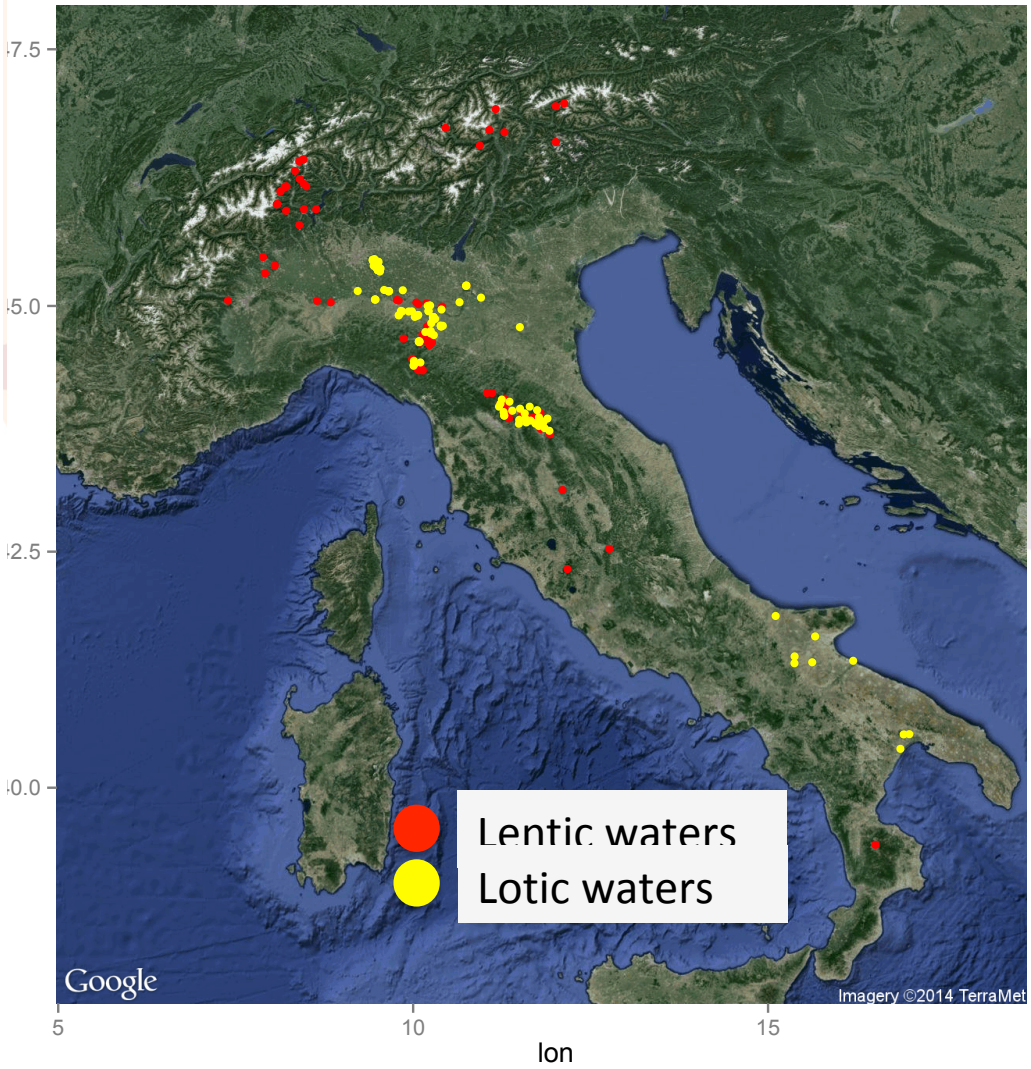
Nodes



1	CNR - Istituto per lo Studio degli Ecosistemi (ISE)
2	Dipartimento di Scienze e di Tecnologie Biologiche ed Ambientali - Università del Salento
3	Agenzia Regionale per la Prevenzione e Protezione dell'Ambiente (APPA) - Puglia
4	Dipartimento Entomologico, Museo di Storia Naturale - Università di Firenze
5	Dipartimento di Scienze della Vita - Università di Parma
6	Dipartimento di Scienze Biologiche - Università di Montréal
7	Dipartimento di Biologia - Università di Bari "Aldo Moro"
8	Dipartimento di Biologia Cellulare e Ambientale - Università di Perugia
9	Dipartimento di Scienze dell'Ambiente e del Territorio e di Scienze della Terra - Università di Milano Bicocca
10	CNR - Istituto per il Rilevamento Elettromagnetico dell'Ambiente (IREA)
11	Centro Nazionale per lo studio e la conservazione della biodiversità forestale "Bosco della Fontana", SFN
12	Environment Agency, Autonomous Province of Bolzano

Database description

Eunis Habitats



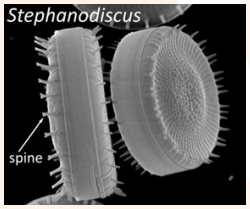
Site code EUNIS:

C1.1 permanent oligotrophic waters
C1.2 permanent mesotrophic waters
C1.3 permanent eutrophic waters
C1.6 temporary waters

C2.1 springs
C2.2 permanent fast watercourses
C2.3 permanent smooth watercourses

The dataset

cianobacteria



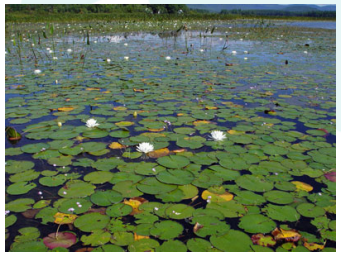
diatoms

phytoplankton

Several taxonomic groups were involved
Only presence/absence data
The data used refer to a 30-year time span

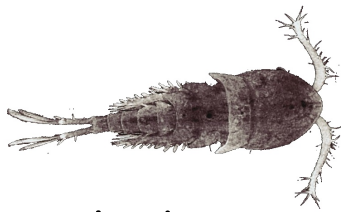
fishes

macroinvertebrates



macrophytes

rotifers

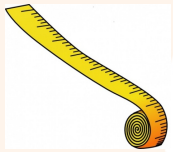


zooplankton

The database in numbers

- **5778** observations
- **1729** species
- **236** freshwaters sites (**99** lotic & **83** lentic)
- **56** taxonomic groups (from cyanobacteria to fish and macrophytes)
- **46** AS (<3% total diversity)
- Most of the taxonomic groups do not have AS (76%), although 13 groups show 1-20 AS.
- The proportion of AS varied from 0.45% (Rotifera) to 100% (Cnidaria)

Integration of data

-  max length of a species (in mm)

-  precipitation amount (average 1950-2000)

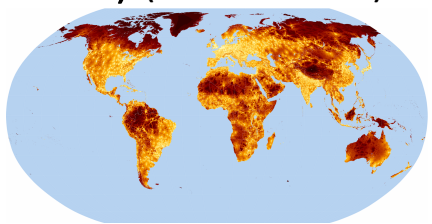
WorldClim - Global Climate Data
Free climate data for ecological modeling and GIS

-  local temperature (average 1950-2000)

UNEP
United Nations Environment Programme

- 

distance (in min) from large cities (inhabitants > 50000) (Nelson 2008)



Spatial maps

Hypothesis

- Identify the responsible variables for AS presence, testing the relative role of propagule pressure, abiotic and biotic factors (PAB framework), and the influence of anthropic activities
- Consider the occurrence of AS (as relative abundance) and their richness (as absolute abundance) as key variables in our models
- Consider as independent variables:

1. *the richness of native species and their size* as a proxy for biological characteristics,
2. *the habitat* (Eunis code – level 1 and 2), *the average annual temperature and the average annual precipitations as* proxy for the abiotic characteristics
3. *the site accessibility* as proxy for the propagule pressure

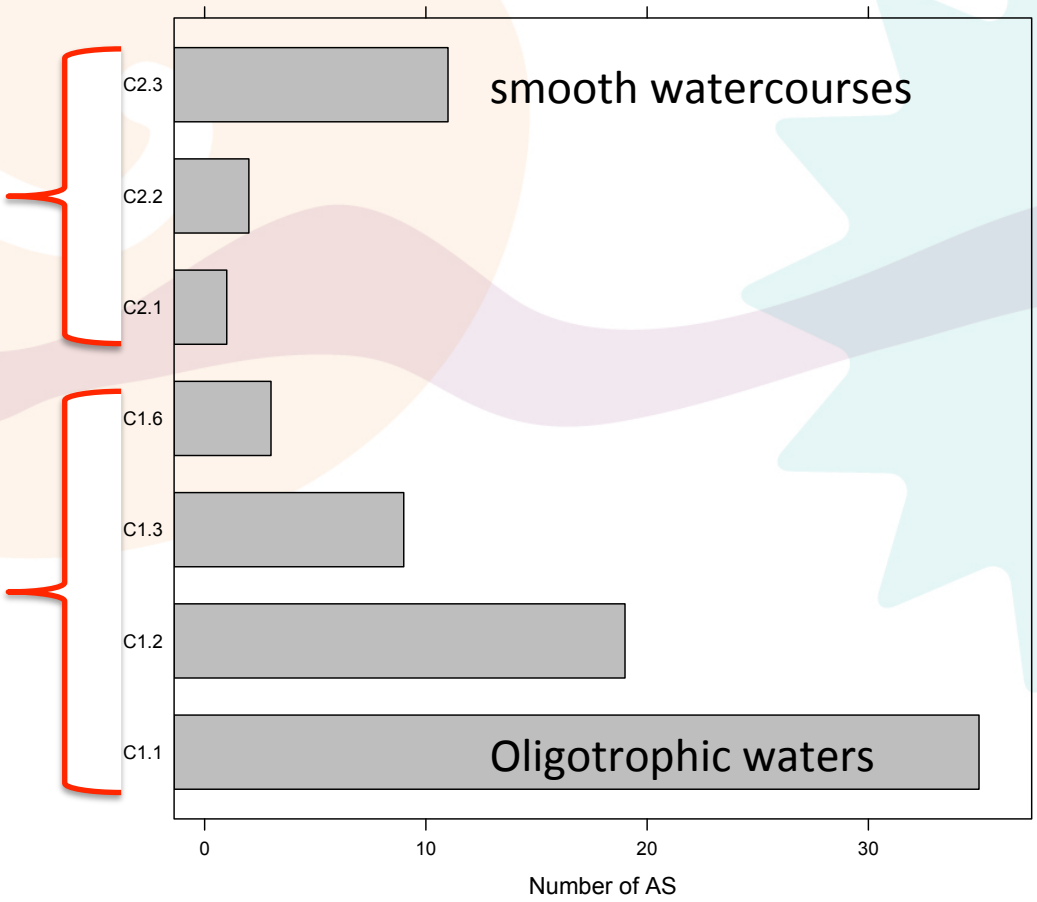
Models construction

- Generalized linear mixed model (GLMM) were used to highlight the possible errors due to the organisation of the dataset.

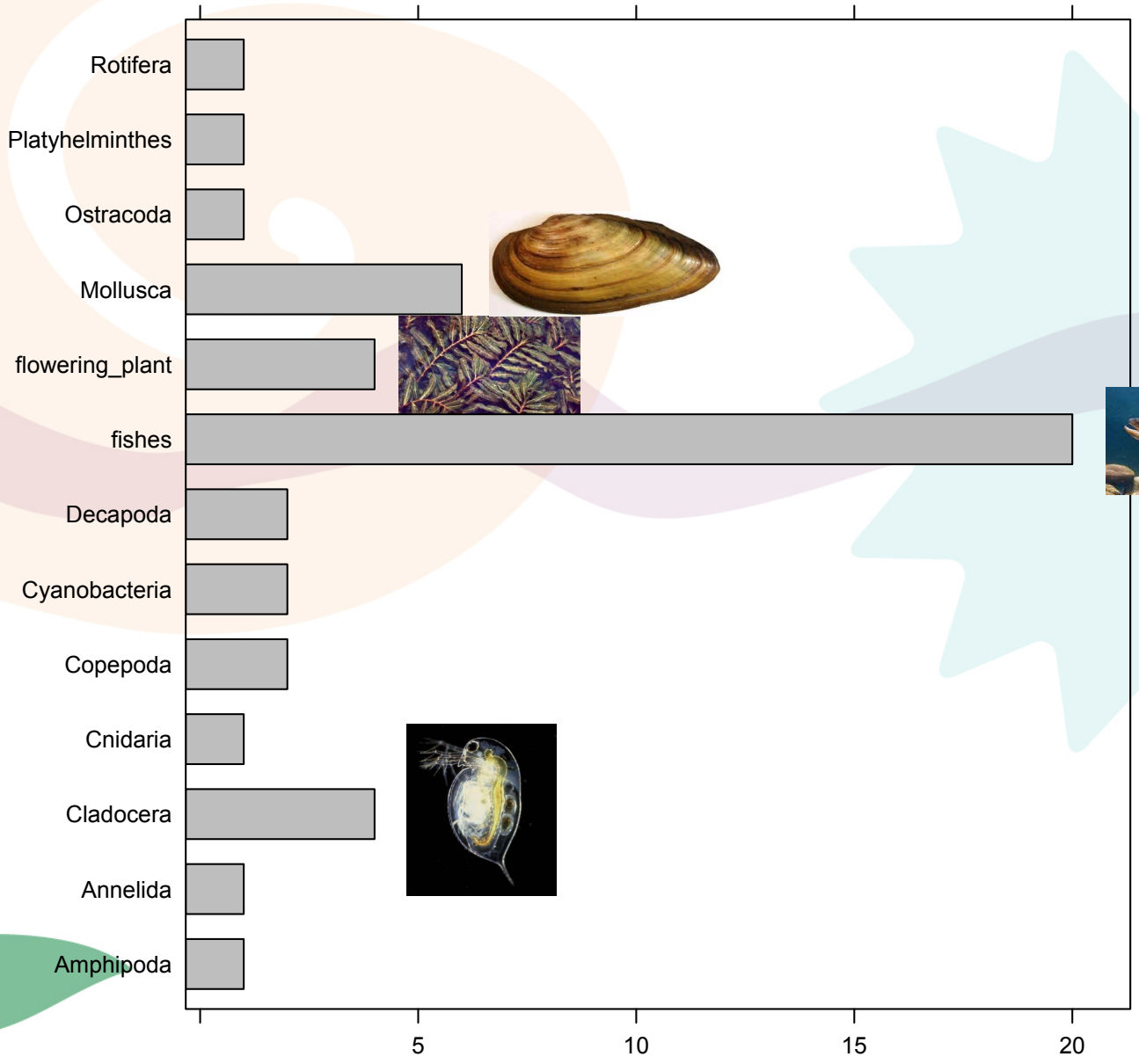
- The six geographical areas may create three possible errors:
  - spatial autocorrelation due to cluster of similar values
  - taxonomic knowledge based on different expertise
  - sampling activities performed with different methodologies

- The Relative Importance (RI) of the considered variables was used to highlight the higher/lower contribution of each variable in explaining the model.

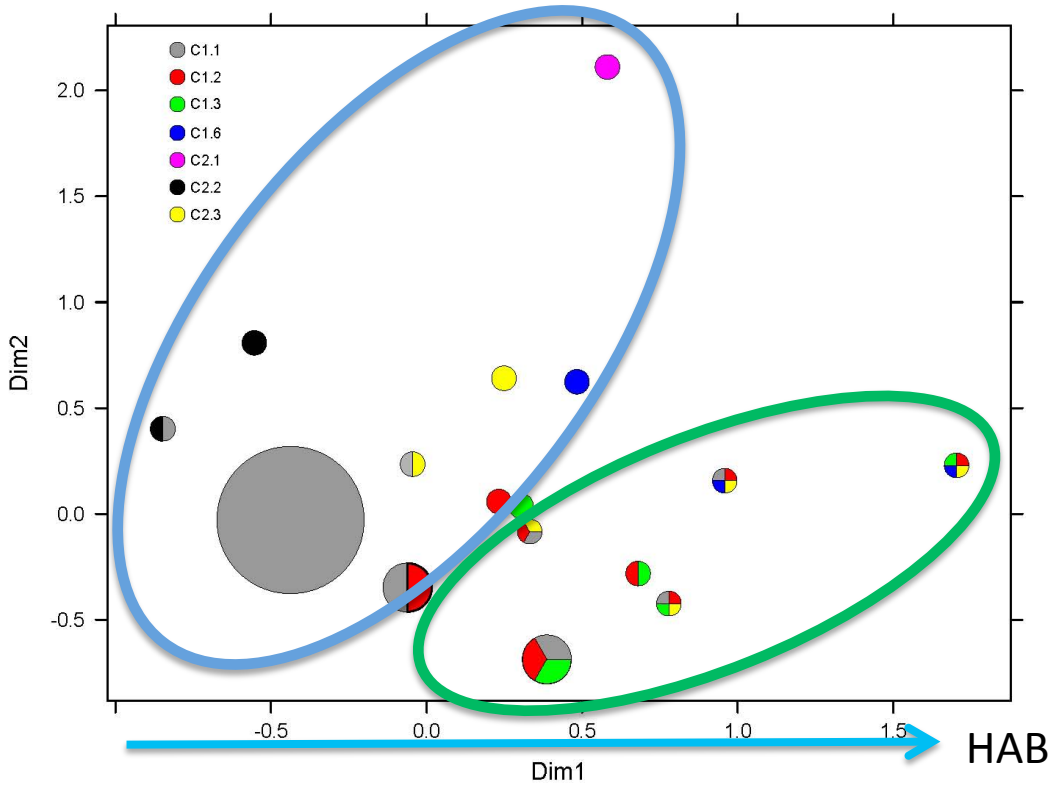
AS Abundance per habitat



LifeWatch AS Abundance per taxonomic gr.



1. Effect of habitat type

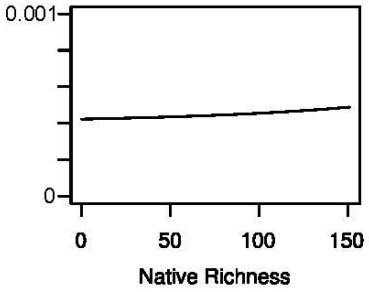


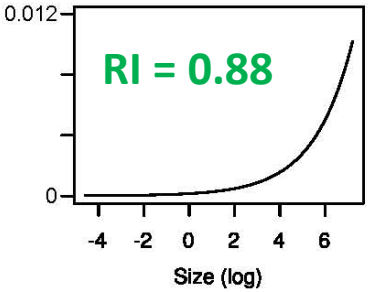
HABITAT COMPLEXITY

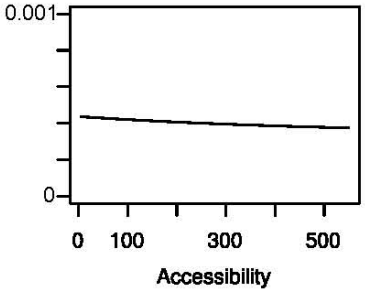
Multiple Correspondence Analysis (MCA) describes how AS are assembled according to level 2 EUNIS habitat.

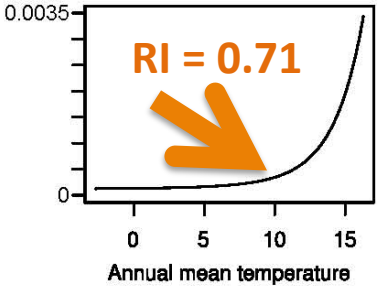
- Species assemblages ordered following an increase in habitat complexity
- Species found in only 1-2 habitat types related with negative values (blu circle)
- Species found in 3-4 habitat types related with positive values (green circle)

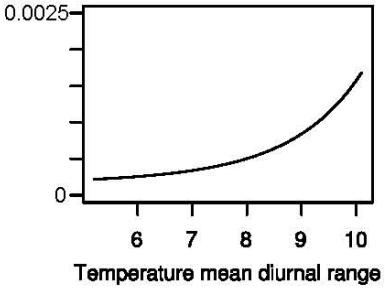
2a. Drivers of AS presence

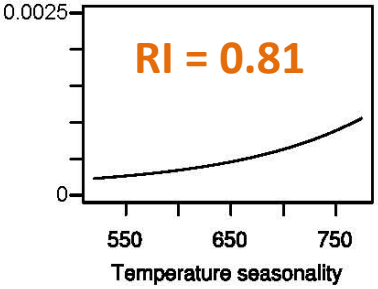


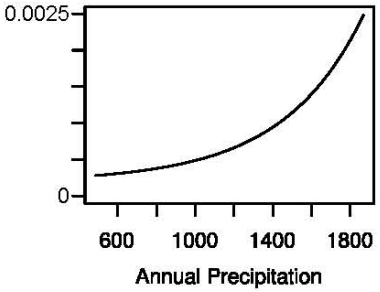


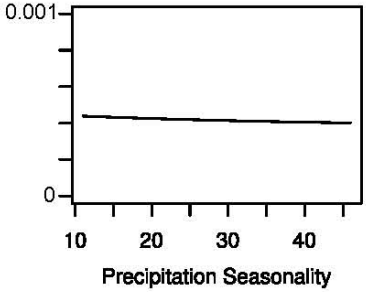








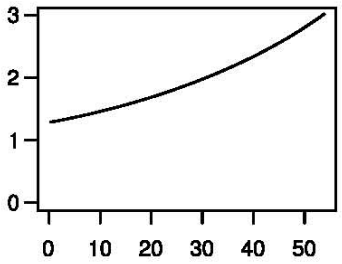


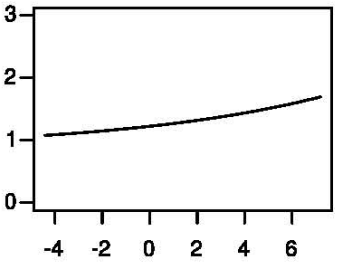


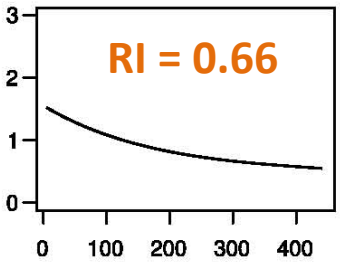
Generalized Linear Mixed Models (GLLM):

- Body size has a a significant correlation with occurrence (larger AS has higher probability to be found)
- Climatic var. are higlhy related to AS presence
- The probability to find AS increases following the increase of climatic var.
- When the average annual T = 10°C the probability increases in an exponential way

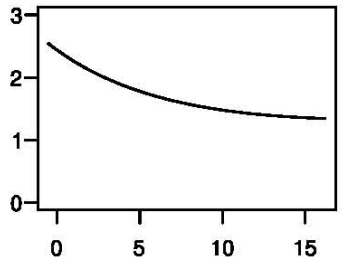
2b. Drivers of AS richness

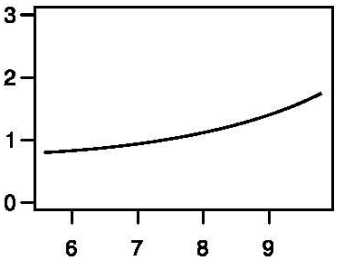


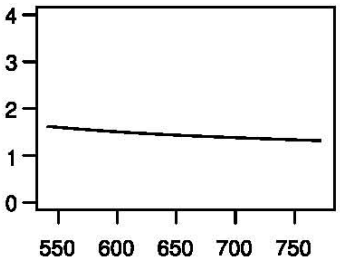


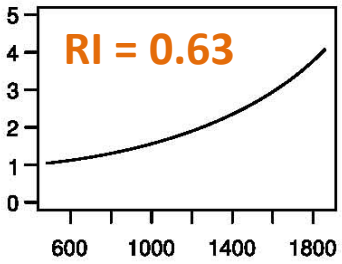


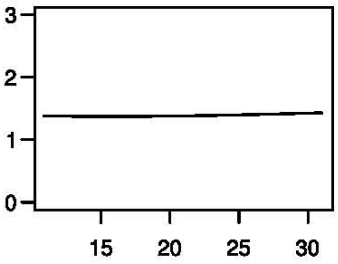
Only on sites with AS







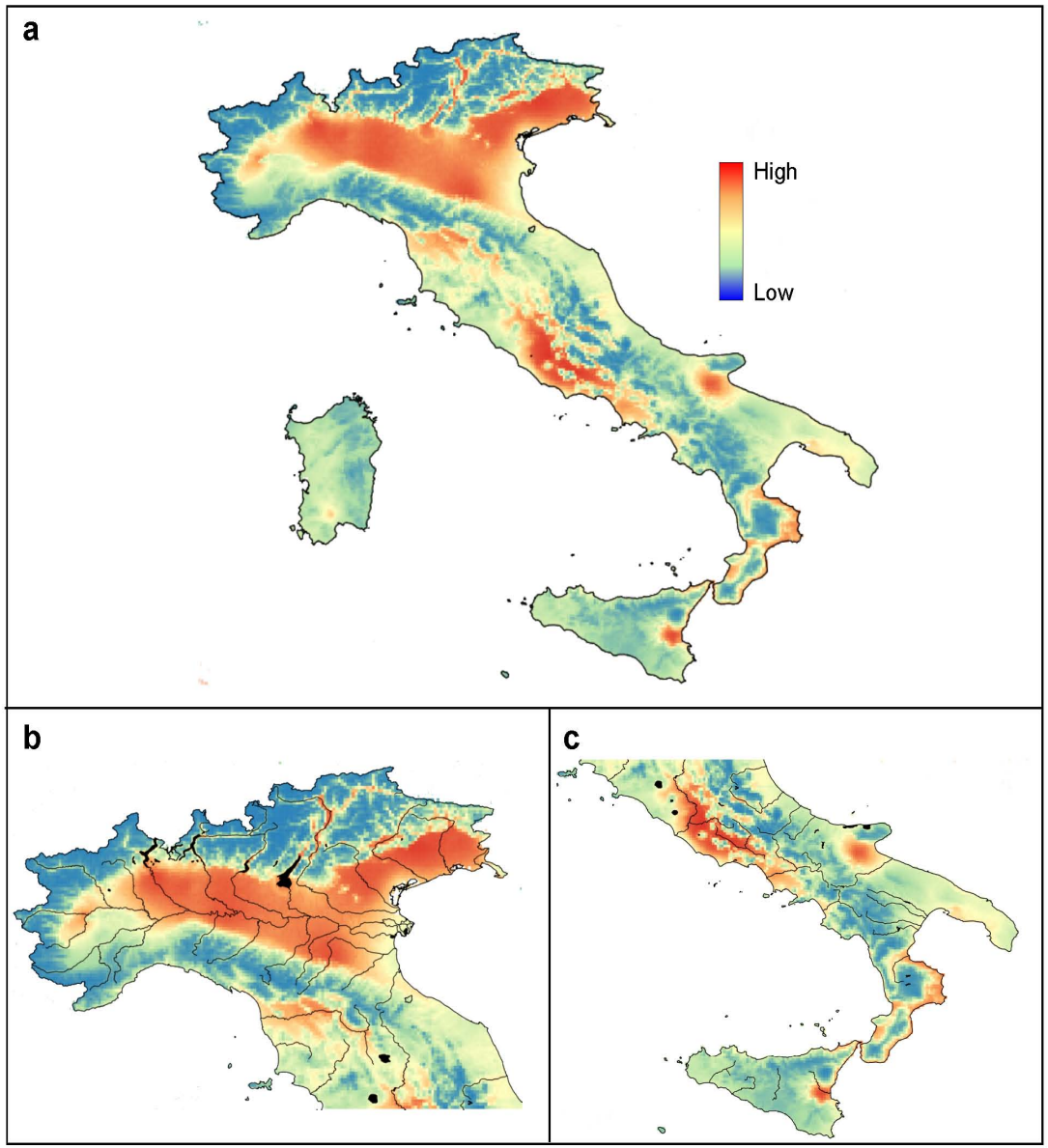




Generalized Linear Mixed Models (GLLM):

- No variable is predominant as RI values are below 0.70
- Sites with high number of native species show also an high number of AS
- Sites far from large cities had lower numbers of AS

3. Predictive model of invasibility



Based on a model explaining AS occurrence through:

- temperature
- precipitations
- site accessibility

The map highlights areas at high/low risk of invasibility

Resolution ~ 5 km

Conclusions

- ✓ The probability of AS occurrence in freshwaters is strictly related to local climatic conditions, while the proximity to large cities showed a lower role
- ✓ On the contrary, proximity to large cities has a significant role in defining AS richness
- ✓ …therefore environmental conditions in a site are essential in explaining the AS establishment, but, at a later stage, the proximity to large cities is essential in explaining the severity of the invasion processes
- ✓ From a management point of view, this approach is highly informative because represent a measure of invasibility risk per each site at national level relative to all faunistic-floristic groups. As a consequence, Parks have to consider the proximity to large urban areas in the development of freshwaters action plans to counteract the AS arrival, mainly in high invasion risk areas
- ✓ All analyses performed using dedicated R packages are one of the services provided by LifeWatch on the web.