Testing drivers of alien species occurrence in Italian freshwater habitats

a case study by the Virtual Research Infrastructure LifeWatch

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Water Resources and Wetlands International Conference
Tulcea, 08-10 September 2016

http://www.lifewatch.eu

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E-Science European Infrastructure for Biodiversity and Ecosystem Research

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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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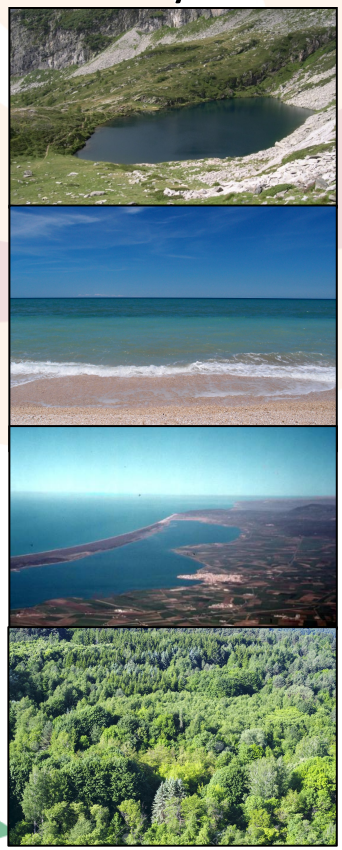
Biodiversity Research: different scales

National

Ecosystem



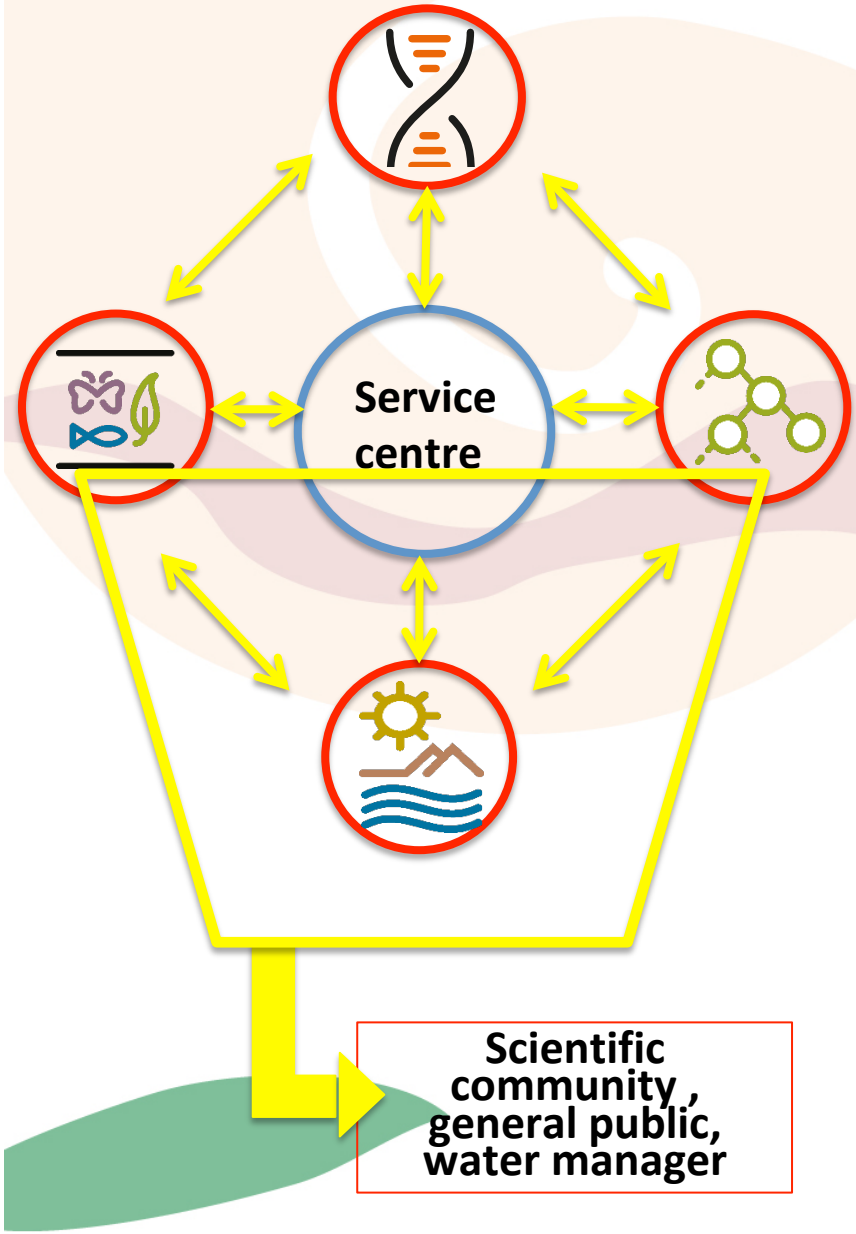
Habitat

EUNIS level 2

Species

Molecular

Opportunities for biodiversity research



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

- capitalising on existing knowledge;
- integrating inter-disciplinary fields, data sources and data processing tools

to create the environment to:

- address innovative scientific questions;
- deepen current understanding of Biodiversity;
- 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)

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 (Boggero et al. 2014), 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

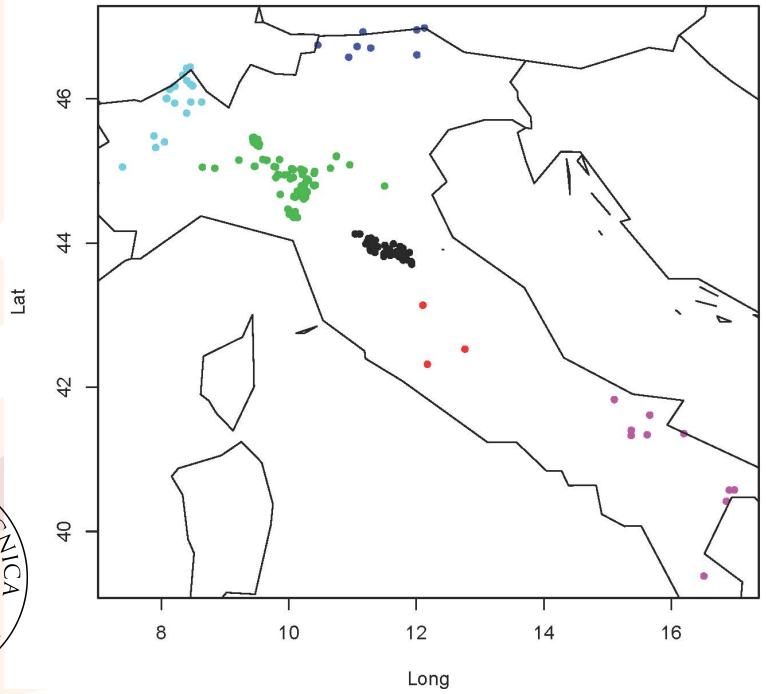
The definition is available in the Alien Species Thesaurus produced by LifeWatch Italy (http://thesauri.lifewatchitaly.eu/alienspecies/index.php)

Boggero A., A. Basset, M. Austoni, et al. 2014. Aquatic Conservation: Marine and Freshwater Ecosystems, 24.

Pyšek P., V. Jarošík, P.E. Hulme, et al. 2010. Proceedings of the National Academy of Sciences USA, 107.

Biodiversity Research: different data providers

Nodes



istituto per il rilevamento elettromagnetico dell'ambiente

IBBE
Istituto di Biomembrane e Bioenergetica

ISMAR

APPA BOLZANO

ARPA PUGLIA

Università di Roma
Tor Vergata

IBAF

OGS

UNIVERSITA' DEGLI STUDI DI MILANO BICOCCA

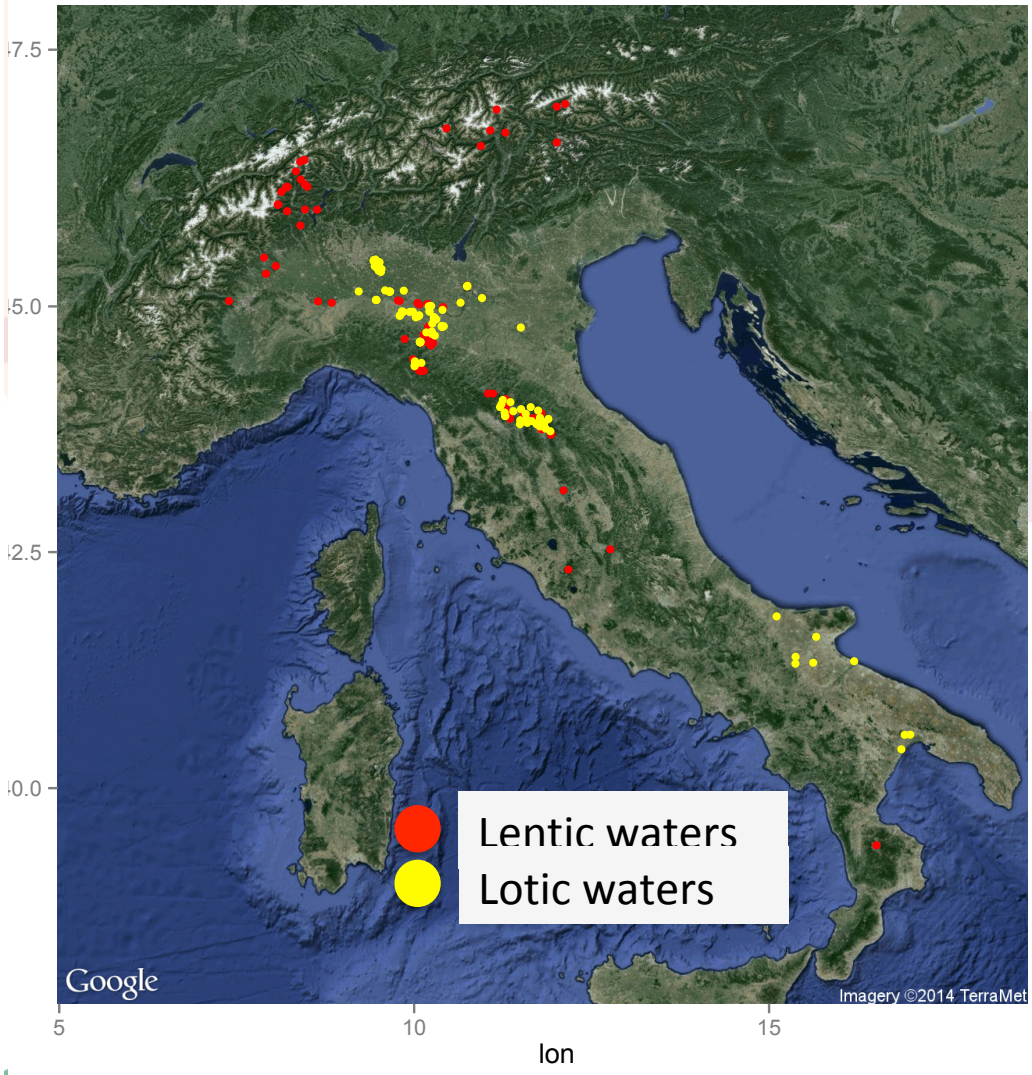
ROMA TRE
Università degli studi

I.S.E.

STAZIONE ZOOLOGICA ANTON DOHRN
Napoli

Database description

Eunis Habitats level 2



Site code EUNIS:

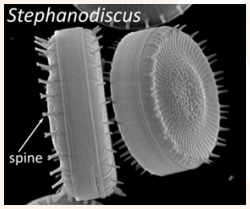
C1.1 permanent oligotrophic waters
C1.2 permanent mesotrophic waters
C1.3 permanent eutrophic waters
C1.6 temporary waters

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

The dataset

cianobacteria

fishes



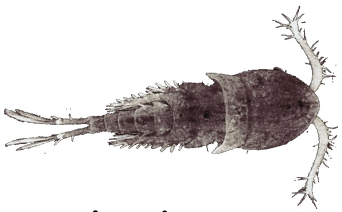
diatoms

- Several taxonomic groups were involved
- Only presence/absence data
- The data cover the last 50-years (1962-2014)

macroinvertebrates

phytoplankton

rotifers



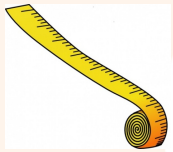
zooplankton

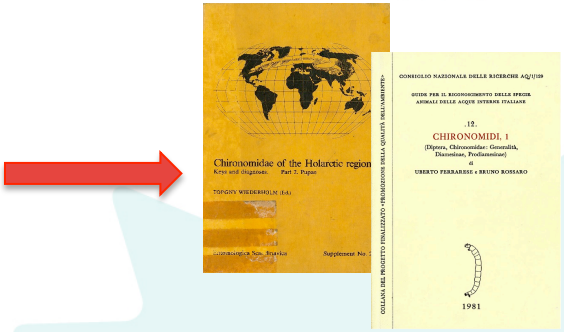
macrophytes

Numbers in the database

- **6463** observations
- **1738** species
- **390** freshwaters sites
- **11** EUNIS taxonomic groups
- **46** AS (<3% total diversity)
- Most of the taxonomic groups do not have AS (76%), some 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)

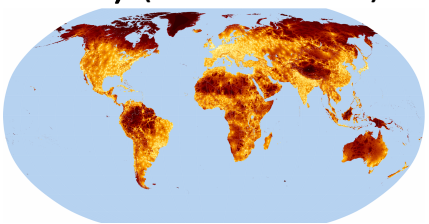
WorldClim - Global Climate Data
Free climate data for ecological modeling and GIS

-  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), *the average annual temperature and the average annual precipitations as* proxies for abiotic characteristics,
3. *the site accessibility* as a proxy for propagule pressure

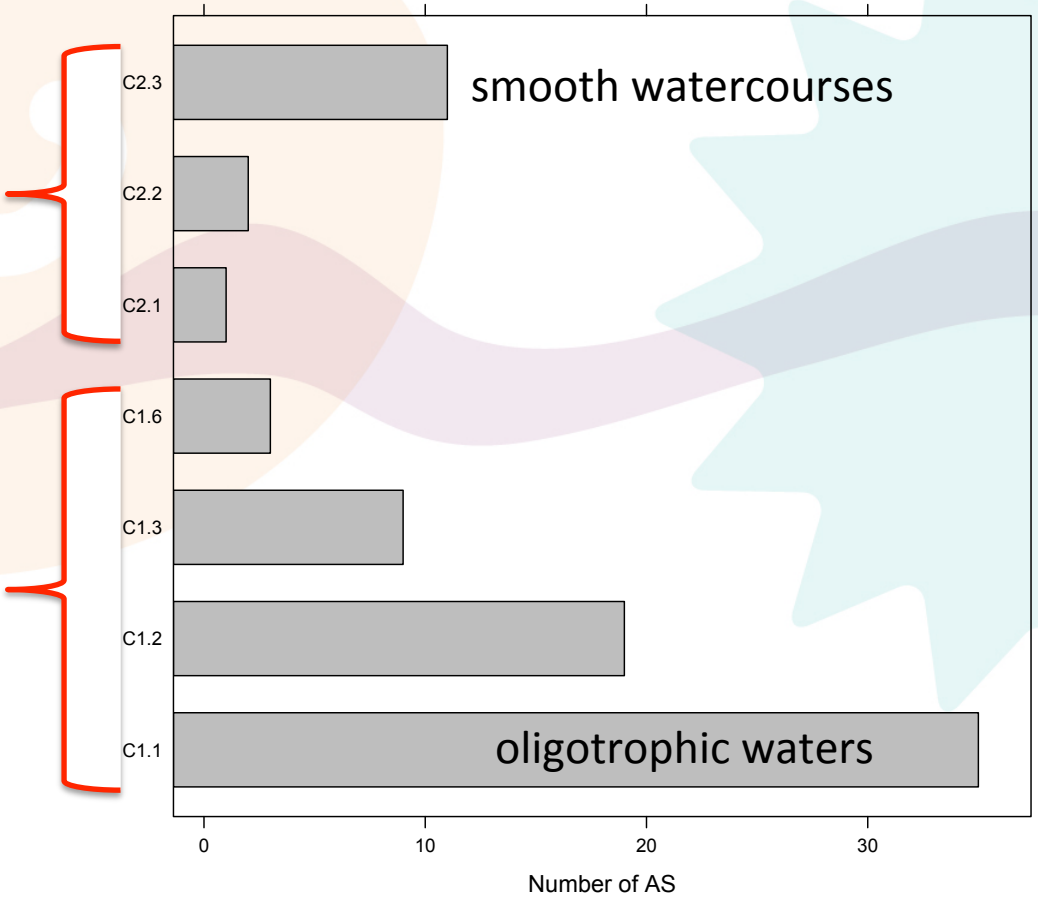
Models construction

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

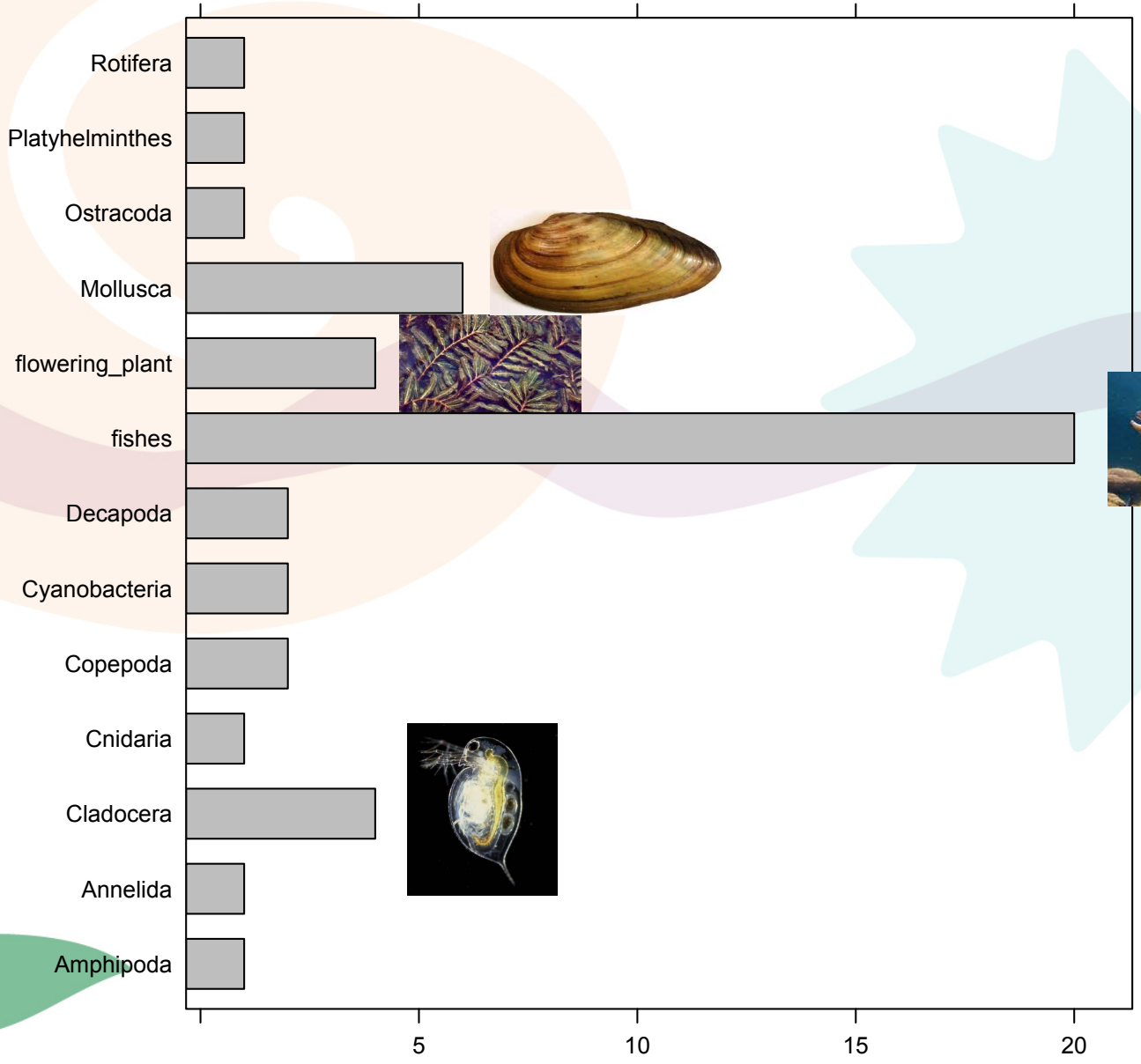
- The six geographical areas may create three possible errors:
  - spatial autocorrelation due to cluster of similar values
  - taxonomy based on different expertise
  - sampling performed with different methodologies

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

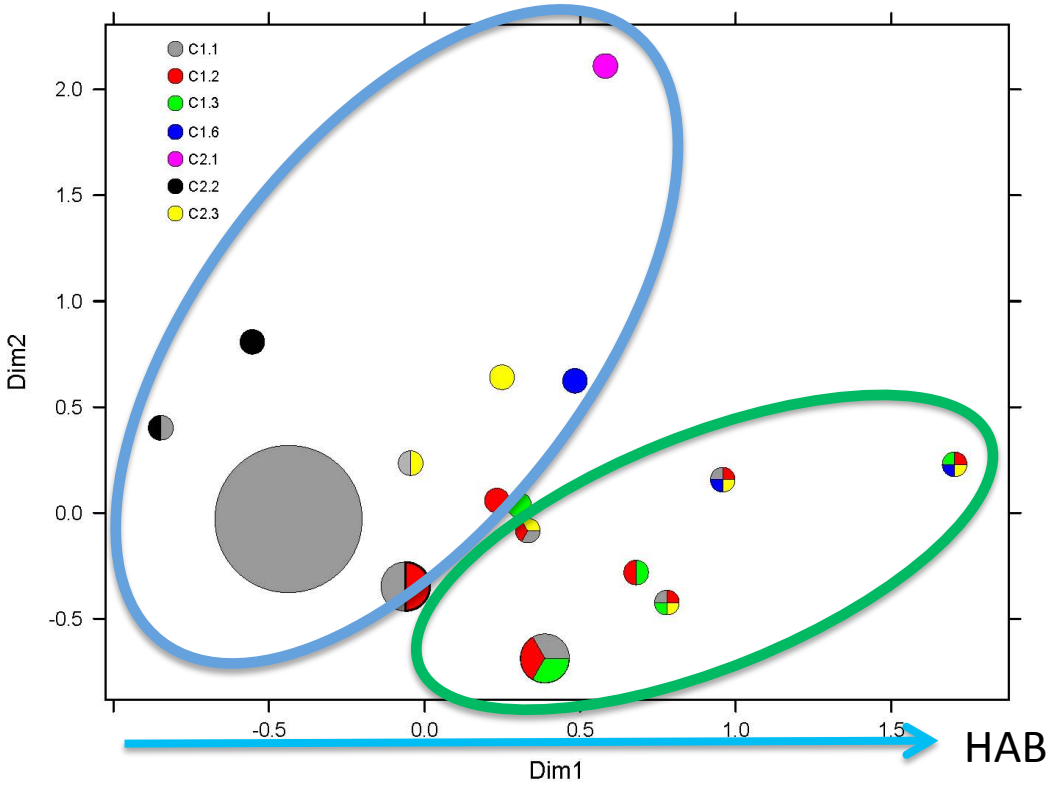
AS Abundance per habitat



AS abundance per taxon



1. Effect of habitat type

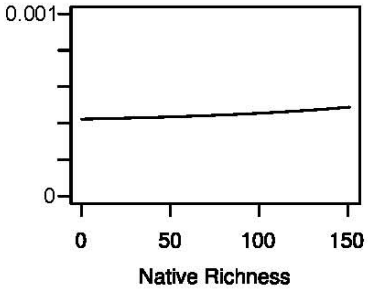


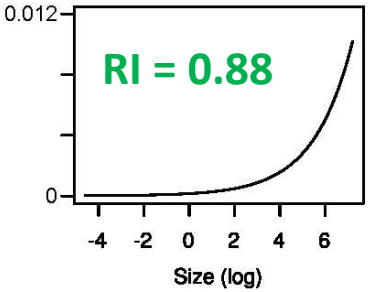
Multiple Correspondence Analysis describes how AS are assembled according to level 2 EUNIS code.

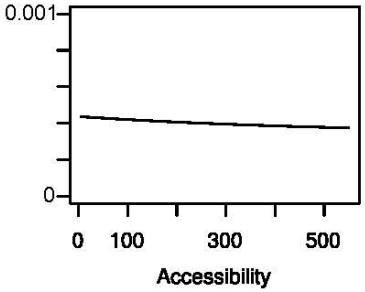
HABITAT COMPLEXITY

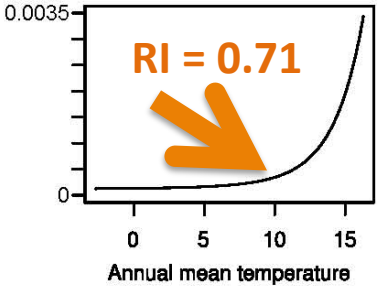
- Species assemblages ordered following an increase in habitat complexity
- Species found in only 1-2 habitat types related with negative values (blu circle)
- Species found in 3-4 habitat types related with positive values (green circle)

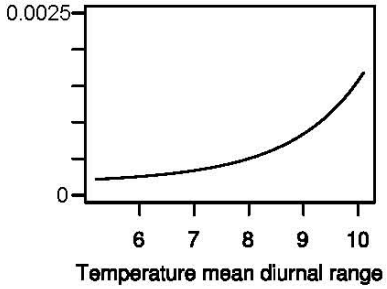
2a. Drivers of AS presence

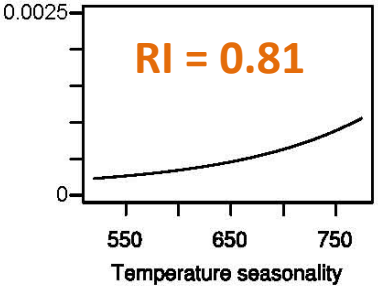


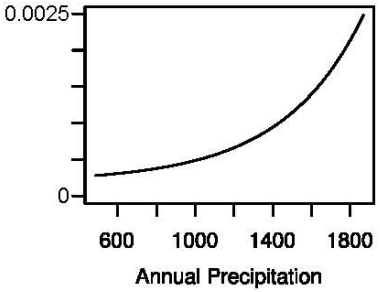


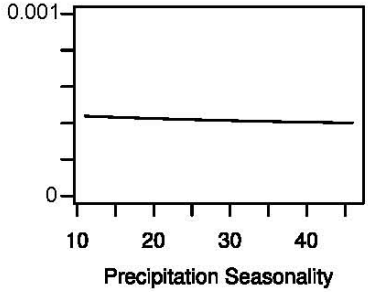












Generalized Linear Mixed Models:

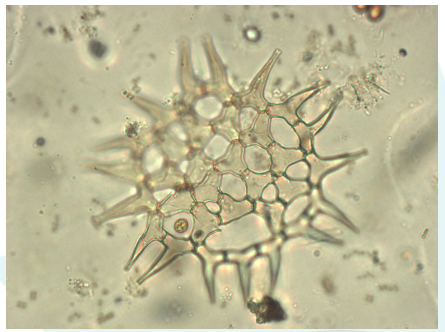
- Body size → AS occurrence

(larger AS has higher probability to be found)

- Climatic vars → AS occurrence
- For an average annual T = 10°C the increase becomes exponential

The role of body size

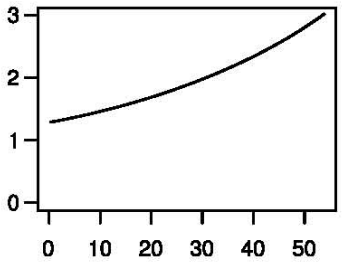


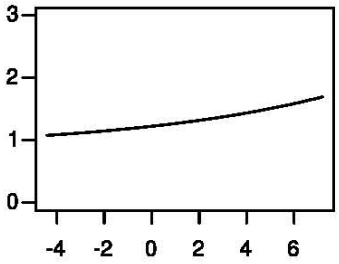


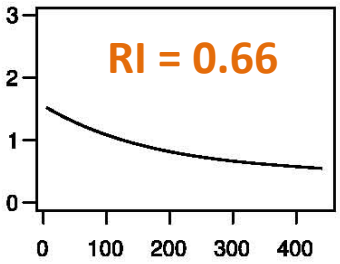
Body size may be a relevant trait in invasion biology

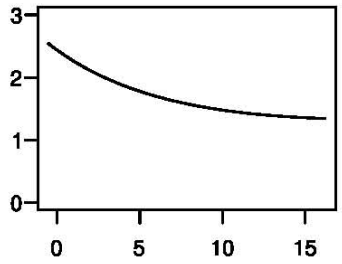
- Most AS were fishes, shared among lentic and lotic sites, and this can be explained through their vagility;
- The occurrence probability increase when size reach 2 cm! This can suggest that very small sizes are a disadvantage in colonization processes because are more prone to passive transport and accidental introduction;
- Body size could be important because of the complexity to observe AS in smaller taxonomic groups where taxonomic uncertainties are present, and because of their larger biogeographical ranges, i.e. microbial species seems to be less prone to be aliens

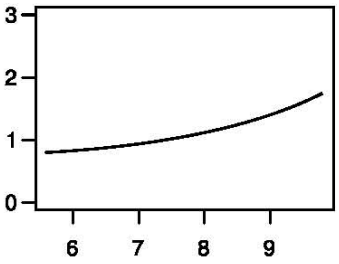
2b. Drivers of AS richness

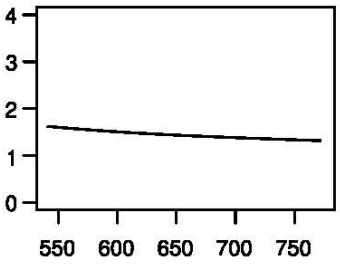


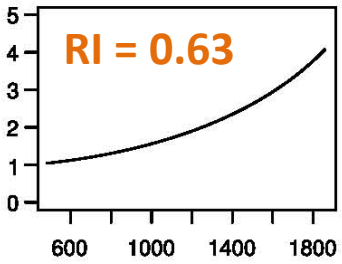


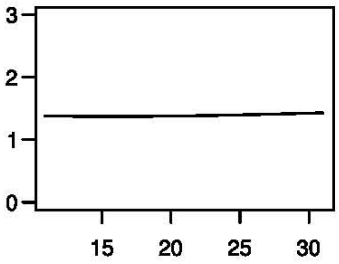








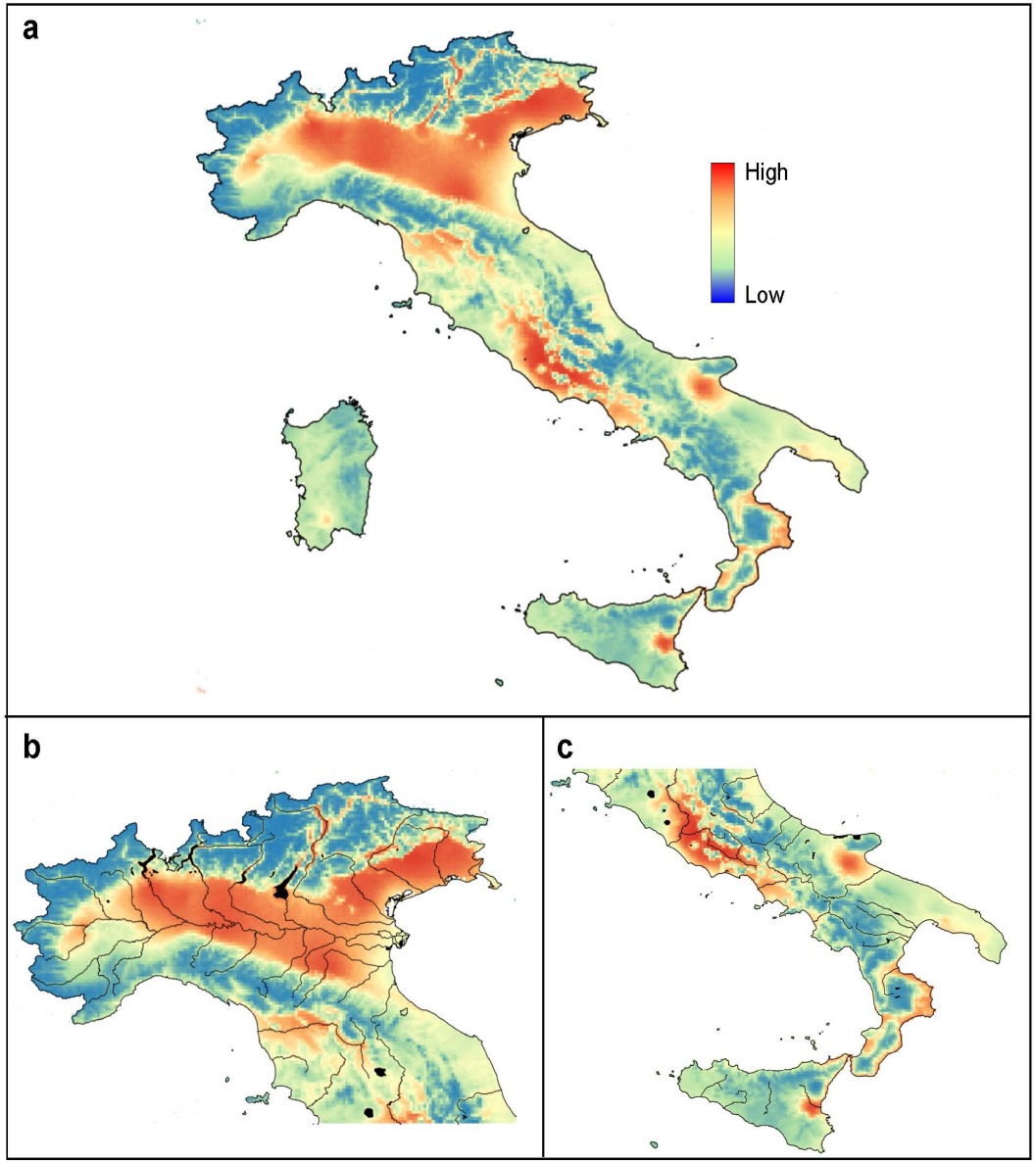




Generalized Linear Mixed Models:

- No variable is predominant → RI < 0.70
- Sites with high number of NS have also an high number of AS
- Sites near to large cities had higher AS richness

3. Predictive model of invasibility



Based on a model explaining AS occurrence through:

- temperature
- precipitations
- site accessibility

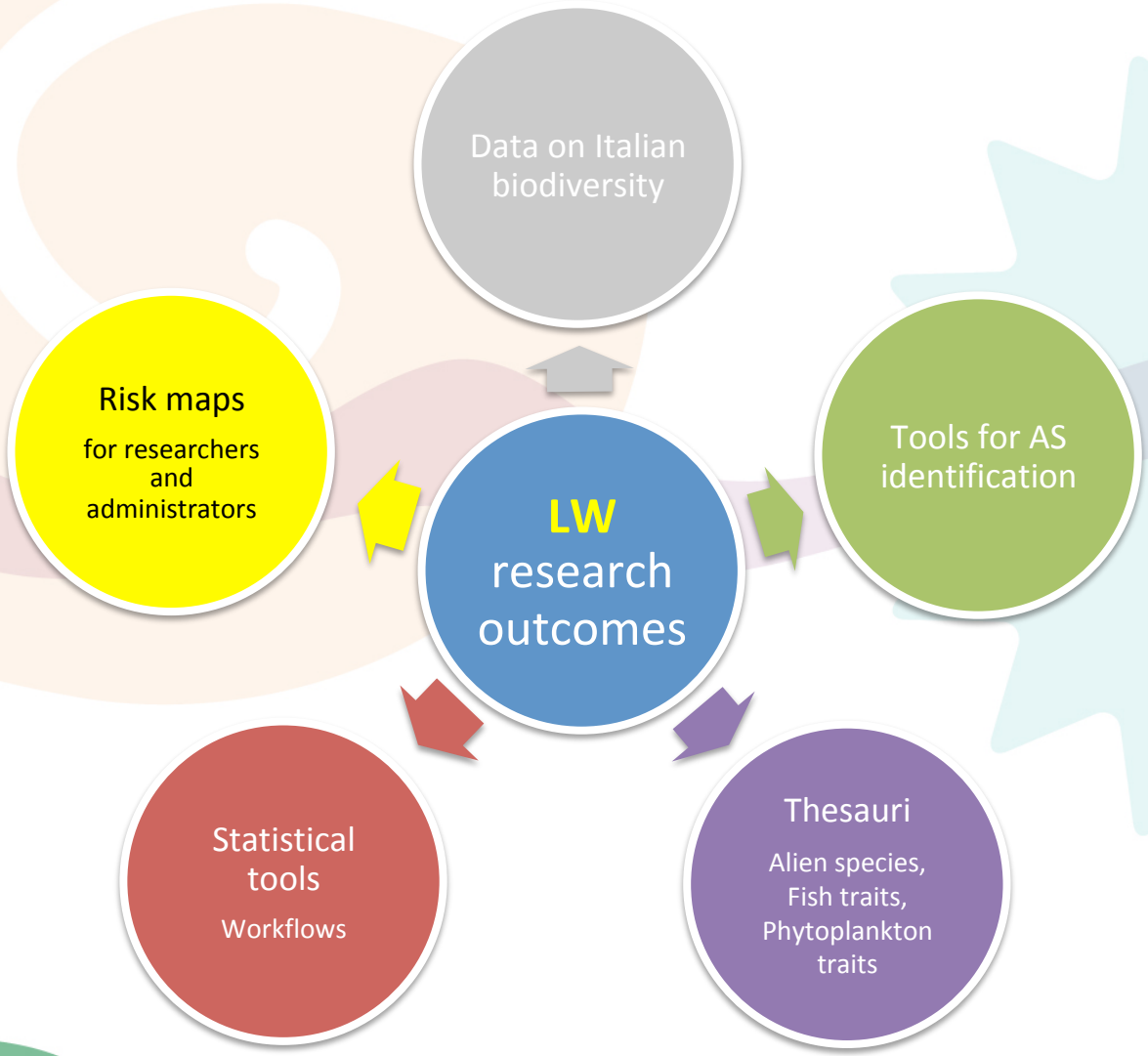
The map highlights areas at high/low risk of invasibility

Resolution ~ 5 km

Conclusions

- ✓ The probability of AS occurrence in freshwaters is strictly related to local climatic conditions, while
- ✓ 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

Outcomes for research activity



Suggestion!

DO NOT WASTE YOUR DATA

LifeWatch RECYCLE THEM!