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Special Session
Alien species ecological impacts: from genomics to macroecology

NON-NATIVE SPECIES IN ITALIAN FRESHWATER HABITATS: A MACROECOLOGICAL ASSESSMENT OF INVASION DRIVERS

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LifeWatch ITALIA

A macroecological approach to invasion biology

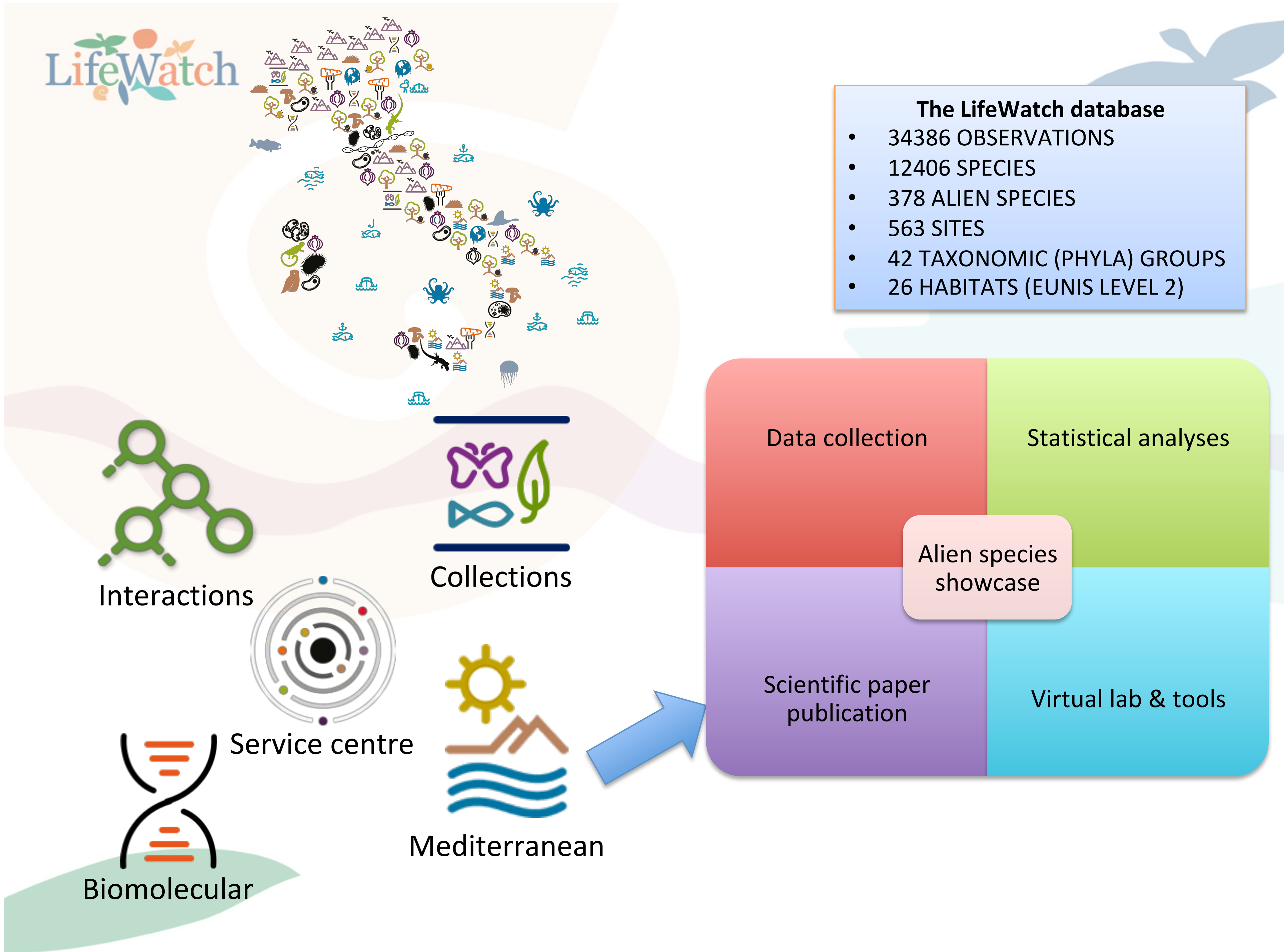
- Invasion biology research often focus on single alien taxon or groups of closely related species
- Few studies have attempted to identify general drivers of invasion which can be applied to a range of different species across both animals and plants

Different questions, different answers

- Single taxon approach:
  - **What are the biological features that makes a species a successful invader?**
- Multiple-taxon (macroecological) approach:
  - **What makes a community (site) more susceptible to invasion?**

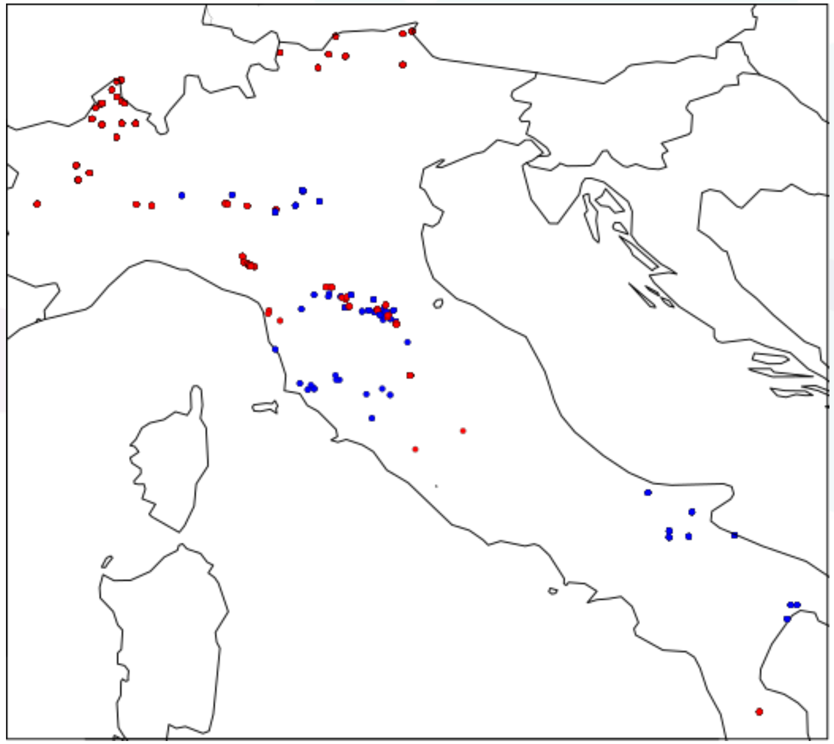
The availability of large database allow to test generalized invasion patters in a macroecological framework:

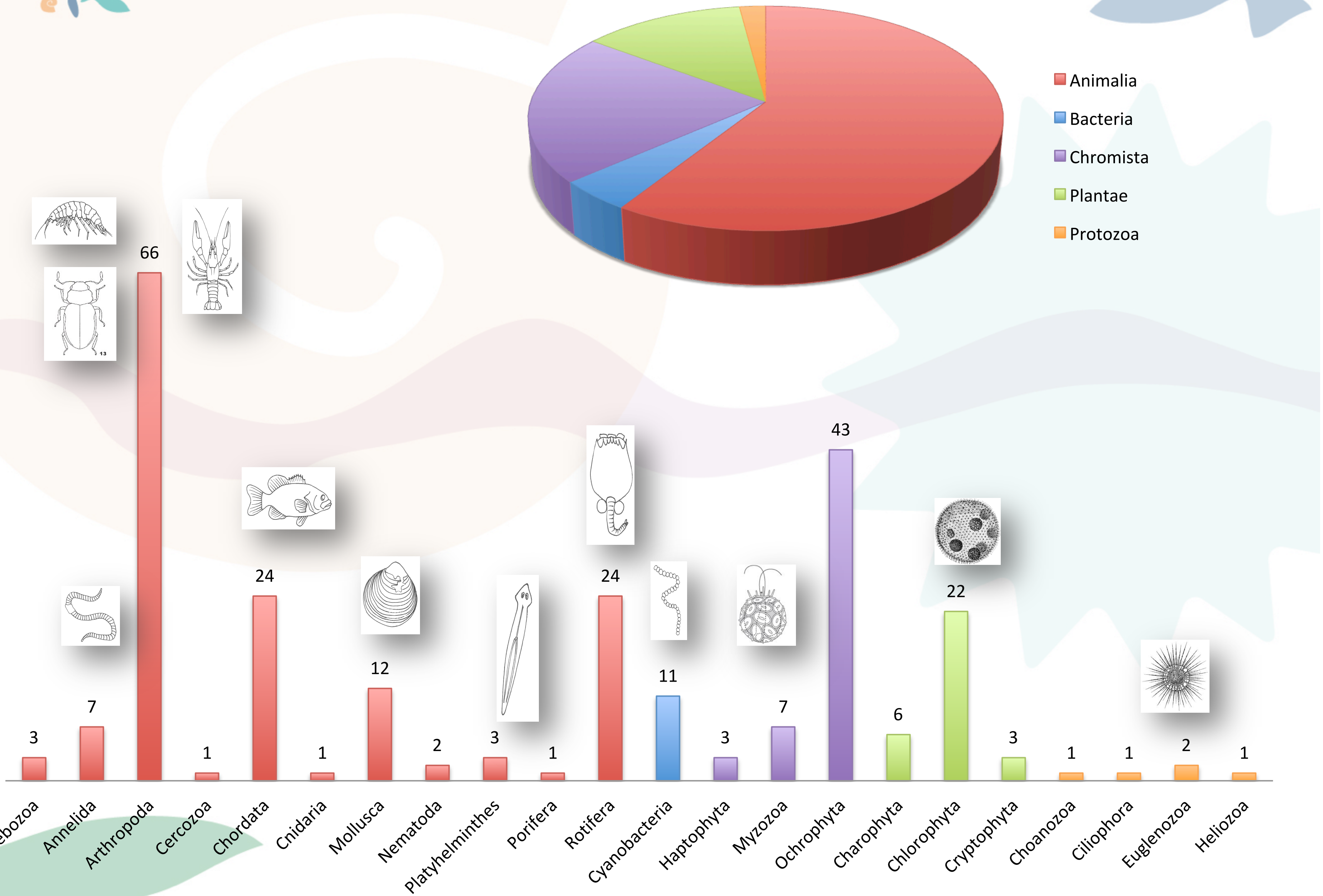
- Multiple taxa
- Multiple habitat
- Multiple sites


LifeWatch
The LifeWatch database
• 34386 OBSERVATIONS
• 12406 SPECIES
• 378 ALIEN SPECIES
• 563 SITES
• 42 TAXONOMIC (PHYLA) GROUPS
• 26 HABITATS (EUNIS LEVEL 2)
Interactions
Collections
Service centre
Biomolecular
Mediterranean
Data collection
Statistical analyses
Alien species showcase
Scientific paper publication
Virtual lab & tools

Focus on ecosystems and sites

- 5299 occurrence data
- 139 sites
  - 85 lentic, 54 lotic
- 1630 species
  - 244 families, 22 phyla
- 51 non-native species
  - (~ 3% of the total species diversity)




Animalia
Bacteria
Chromista
Plantae
Protozoa
3
7
66
1
24
1
12
2
3
1
24
11
3
7
43
6
22
3
1
1
2
1
Amoebozoa
Annelida
Arthropoda
Cercozoa
Chordata
Cnidaria
Mollusca
Nematoda
Platyhelminthes
Porifera
Rotifera
Cyanobacteria
Haptophyta
Myzozoa
Ochrophyta
Charophyta
Chlorophyta
Cryptophyta
Choanozoa
Ciliophora
Euglenozoa
Heliozoa

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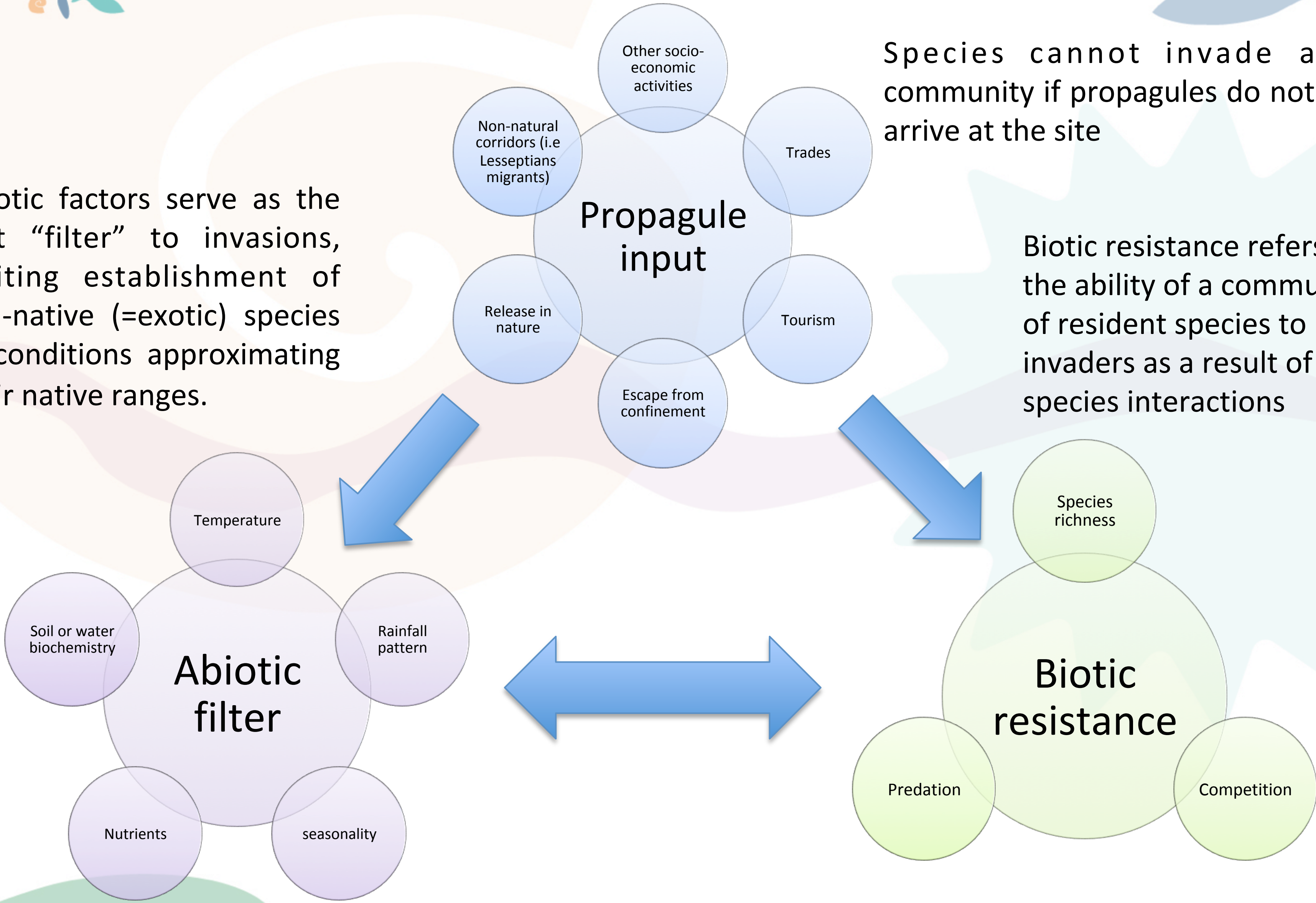
The Propagule, Abiotic, Biotic framework

Abiotic factors serve as the first “filter” to invasions, limiting establishment of non-native (=exotic) species to conditions approximating their native ranges.

Species cannot invade a community if propagules do not arrive at the site

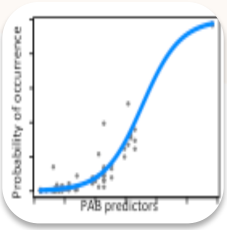
Biotic resistance refers to the ability of a community of resident species to repel invaders as a result of species interactions



Identify emergent patterns regarding the potential drivers of alien species occurrence in freshwater sites within a PAB framework

Habitat vulnerability

Are different freshwater systems (lotic vs lentic) more susceptible to invasion?



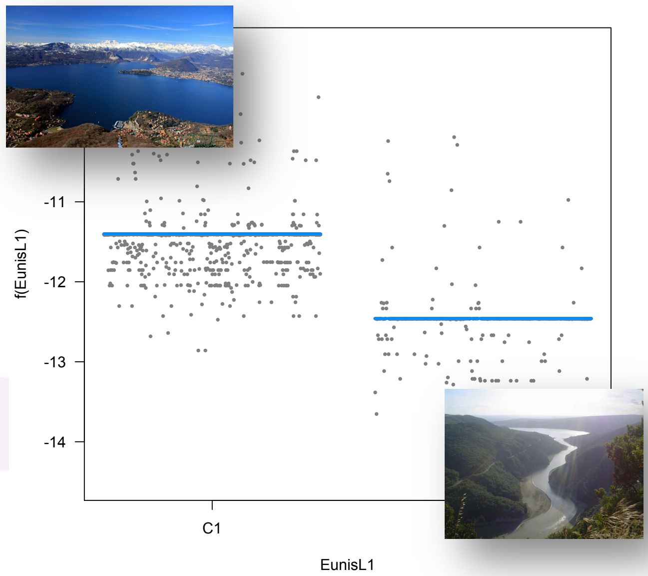
Invasion drivers

Which abiotic, biotic and pressure attributes of the recipient site affect invasion probabilities (presence/absence)?

Habitat vulnerability

We can reject the null hypothesis (LRT: $p<0.001$) of no differences of aliens species occurrence between lentic (level-1 EUNIS: C1) and lotic habitats (level-1 EUNIS: C2).

Lakes (Eunis C1) are more susceptible to AS invasions



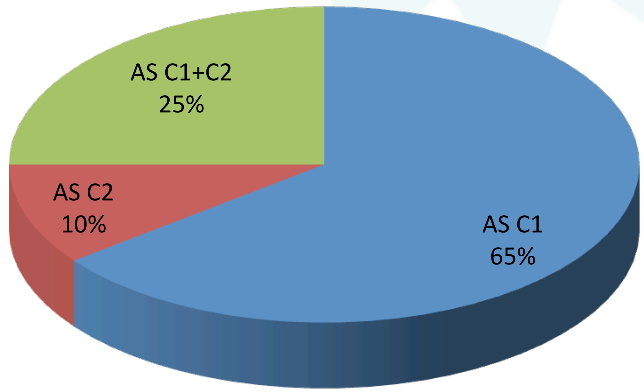
Random effects:

Groups Nam	Variance	Std.Dev.
family (Intercept)	168.8	12.99

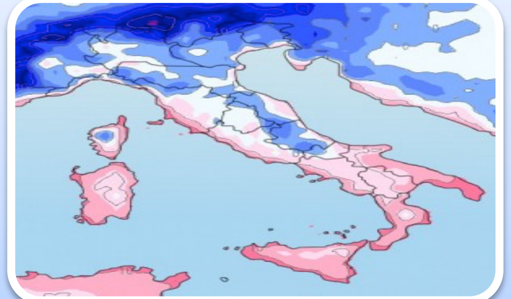
Number of obs: 2262, groups: family, 244

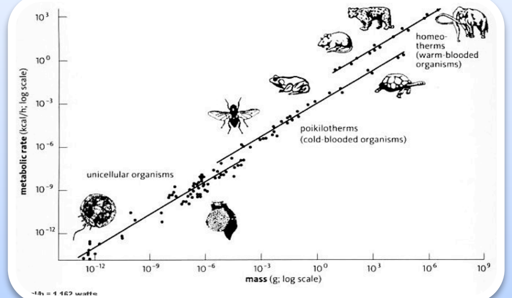
Fixed effects

	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	-11.4007	1.0073	-11.318	< 2e-16
EunisL1C2	-1.0576	0.3055	-3.462	0.000535



Invasion drivers





Pressure

- **Accessibility**

  (time in minutes to reach the closest town with at least 50000 inhabitants)

Abiotic

- **Climate:**
  - Mean annual temperature & diurnal range
  - Annual precipitation
  - Precipitation &temperature stagionality
- **Geographic location:**
  - Latitude
  - longitude

Biotic

- **Species richness**
- **Body Size**

  (maximum body size was estimated for each species and then averaged by family)

Principal Component Analysis

Generalized linear mixed model

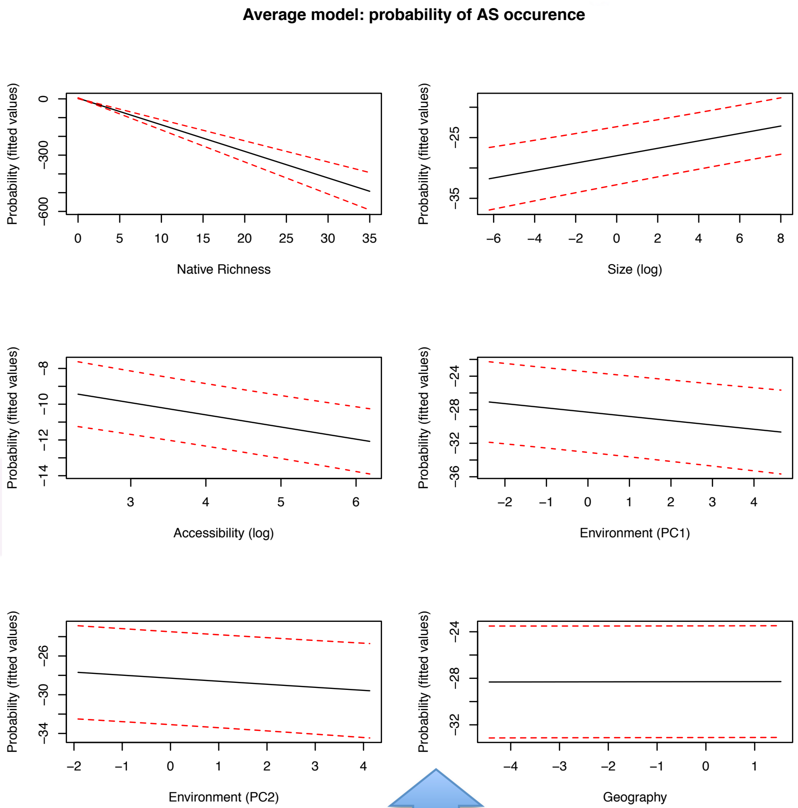
Random effects

Groups	Name	Variance	Std.Dev.	Corr
family	(Intercept)	43.7263	6.6126	
	nat_rich	116.3256	10.7854	-0.95
EunisL1	(Intercept)	0.3908	0.6251	

Number of obs: 2262, groups: family, 244; EunisL1, 2

Fixed effects:

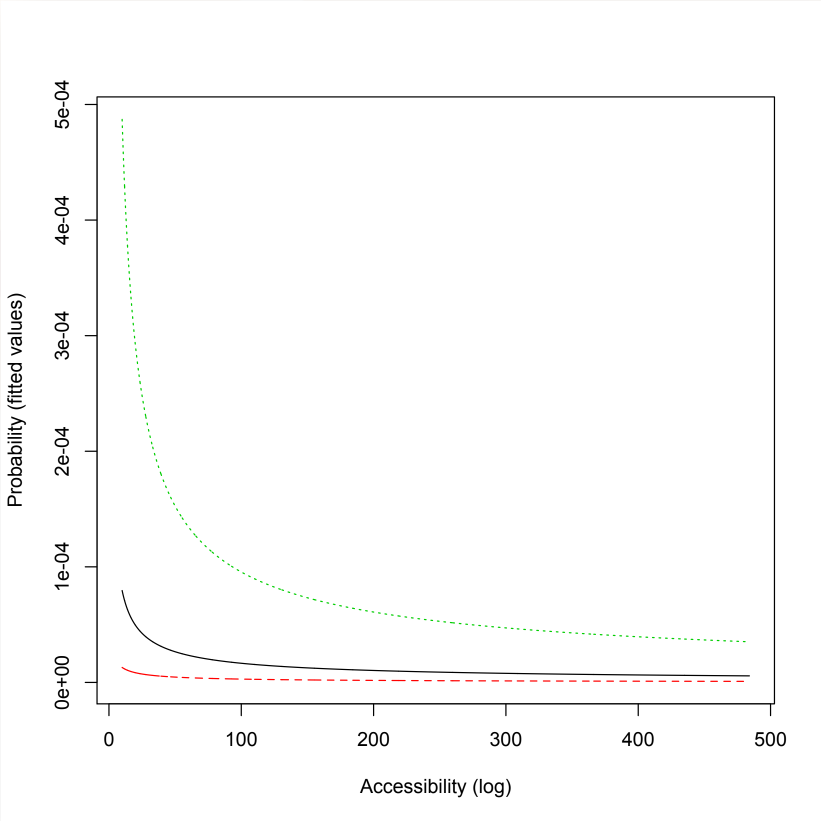
	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	6.55874	2.54936	2.573	0.010091	*
nat_rich	-14.14233	2.89113	-4.892	1e-06	***
logSIZE	0.61296	0.17519	3.499	0.000467	***
PC1.env	-0.52441	0.22672	-2.313	0.020720	*
PC2.env	-0.38721	0.19472	-1.989	0.046753	*
logAccessibility	-0.64238	0.24635	-2.608	0.009120	**
PC1.geo	-0.02107	0.16394	-0.128	0.897757	

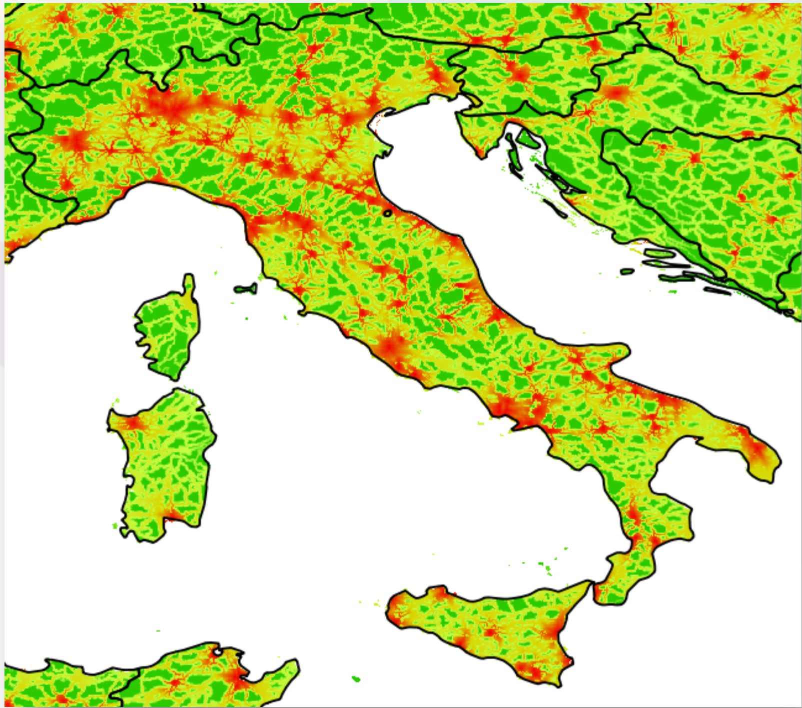


Model-averaged coefficients:					
	Estimate	Std.Error	Adjusted SE	z value	Pr(>|z|)
(Intercept)	6.791272	2.602285	2.603624	2.608	0.009097
Log Accessibility	-0.679659	0.258201	0.258323	2.631	0.008512
Log Size	0.610709	0.175495	0.175589	3.478	0.000505
Native richness	-14.172474	2.904901	2.906462	4.876	1.10E-06
PC1 environment 1	-0.509716	0.250974	0.251077	2.03	0.042344
PC2 environment 2	-0.314222	0.213014	0.213077	1.475	0.140297
Geog. Location	0.005871	0.092418	0.092458	0.063	0.949369

	Relative variable importance:	N containing models
Log Accessibility	1	5
Log Size	1	5
Native richness	1	5
Environment PC1	0.95	4
Environment PC2	0.83	3
Geographic location	0.28	2

Propagule pressure





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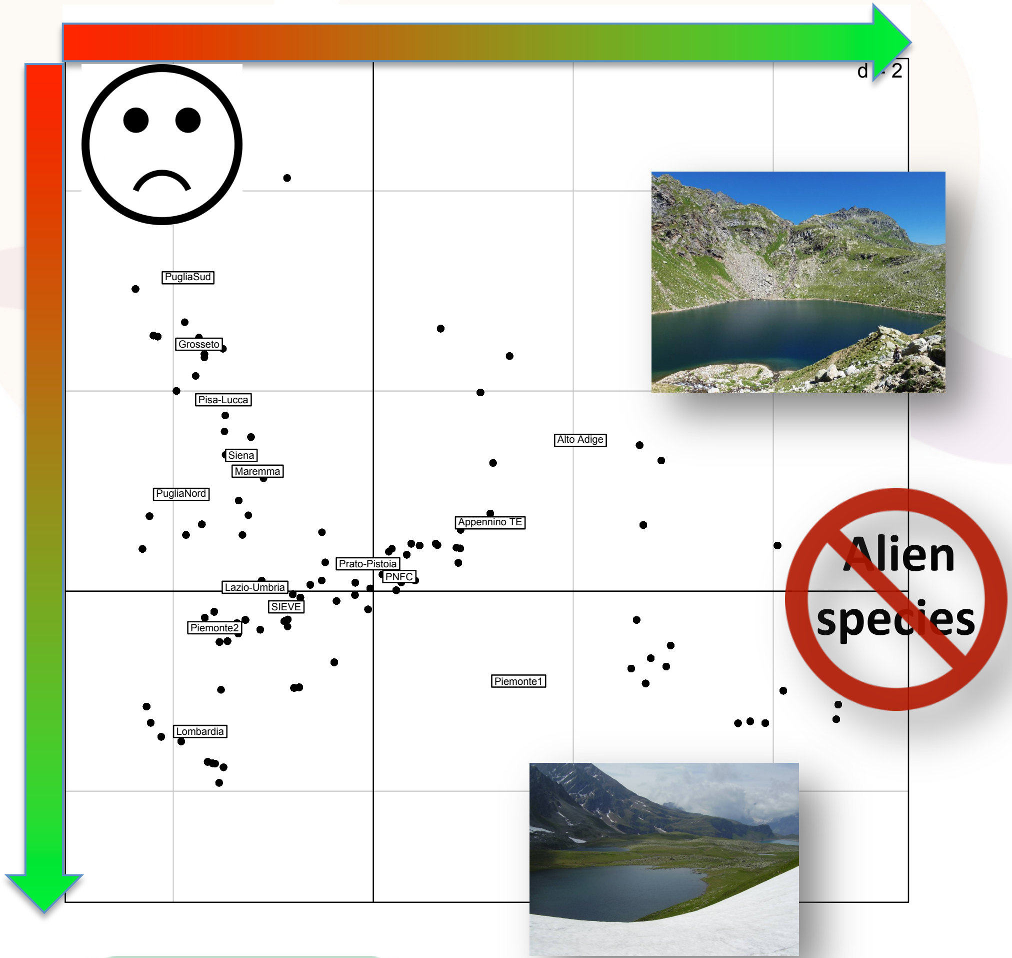
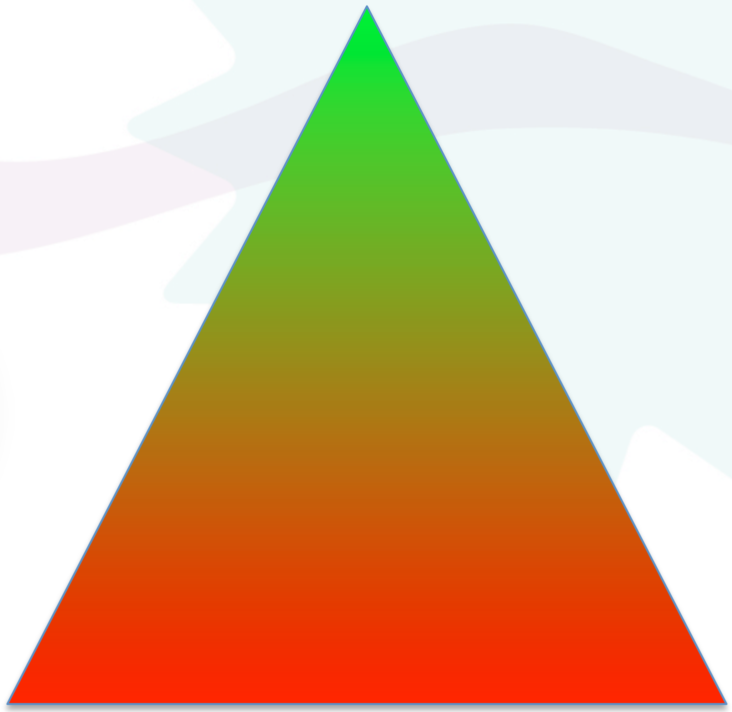
Abiotic filter

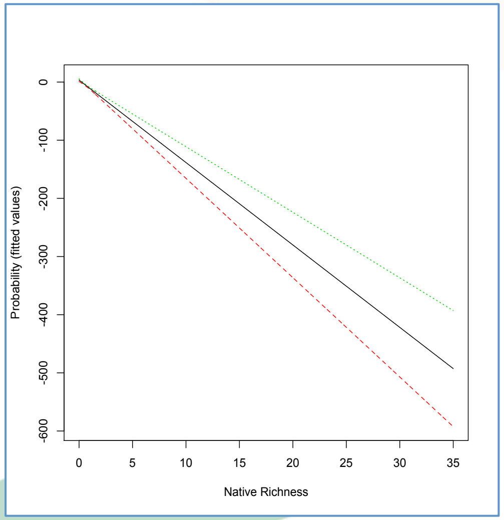


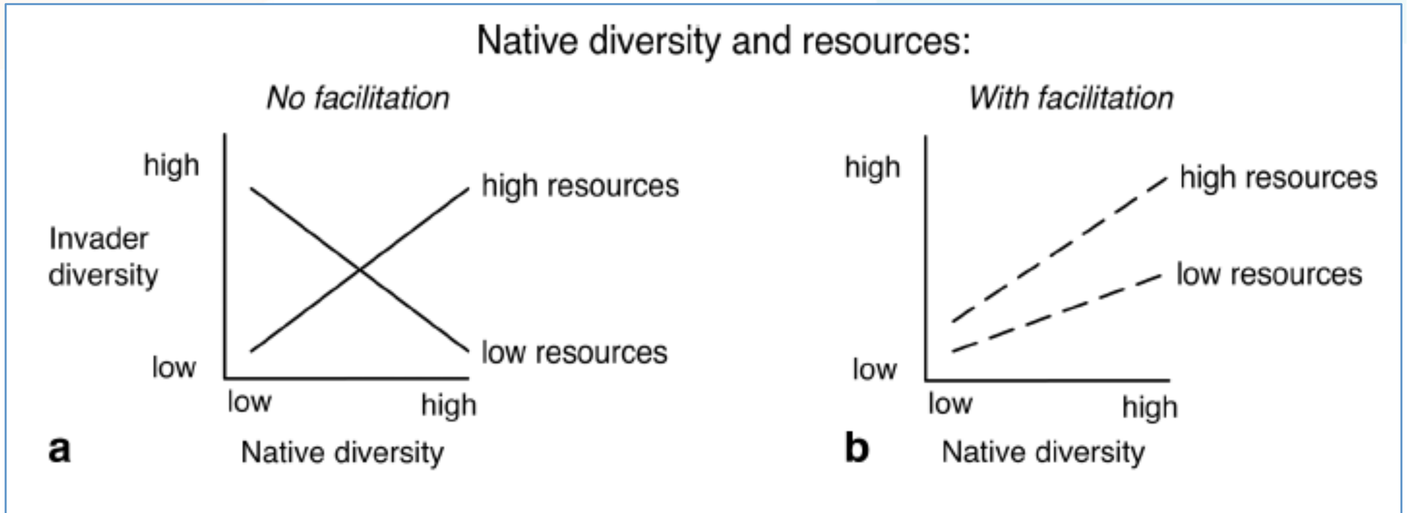


Biotic resistance

Native species diversity is an important determinant of invasion success?

- The relationship between native and alien richness is debated. The scale of the experiment and/or observation appear to be relevant in determining a positive or negative relationship.
- In our case the relationship is negative supporting a scenario where sites with low native richness are more susceptible to non-native species invasions



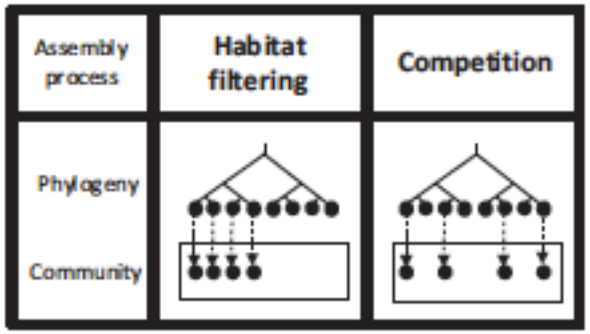


from Olyarnik et al., 2009

What is “richness” and how much it is useful in inviasion biology and community ecology?

- α and β diversity are sufficient to explore AS/NS relationship?
- Other metrics such as phylogenetic diversity might represent a good proxy of species diversity and community composition?

Phylogenetic-patterns-as-proxy approach:

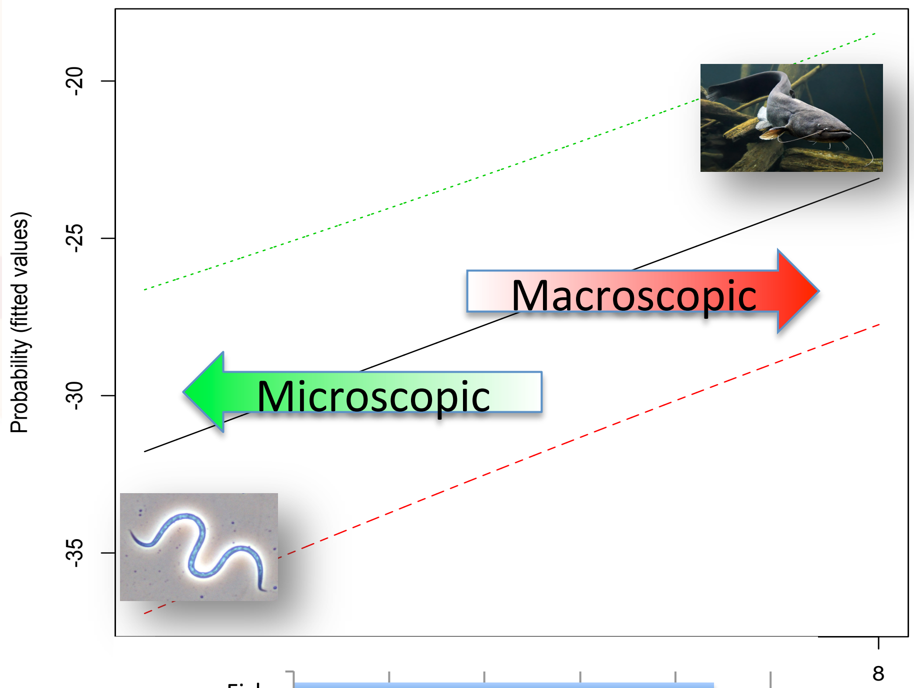


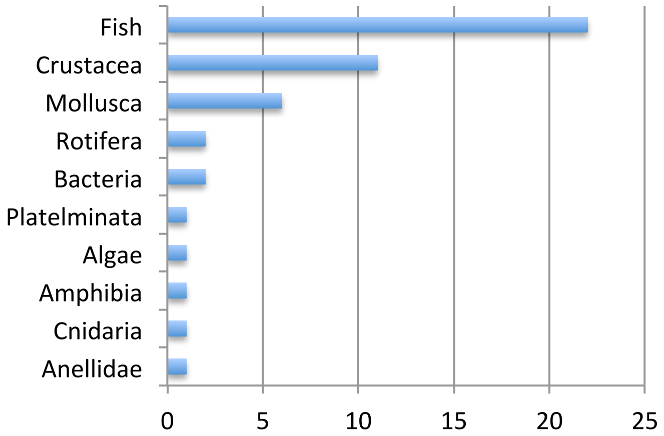
Gerhold et al., Functional Ecology 2015, 29,

Phylogenetic diversity in macro-ecology and invasion biology:

- Community types composed of species from phylogenetically distinct lineages (i.e., phylogenetically rich or overdispersed communities) are less receptive to alien establishment.
- Community types consisting of closely related species (i.e., phylogenetically poor or underdispersed) are more receptive to aliens.

The role of size in the invasion process





Body size is important in many ways in both macroecology and eco-evolutionary dynamics, and may be a relevant trait in invasion biology

Why bigger taxa are more invasive?

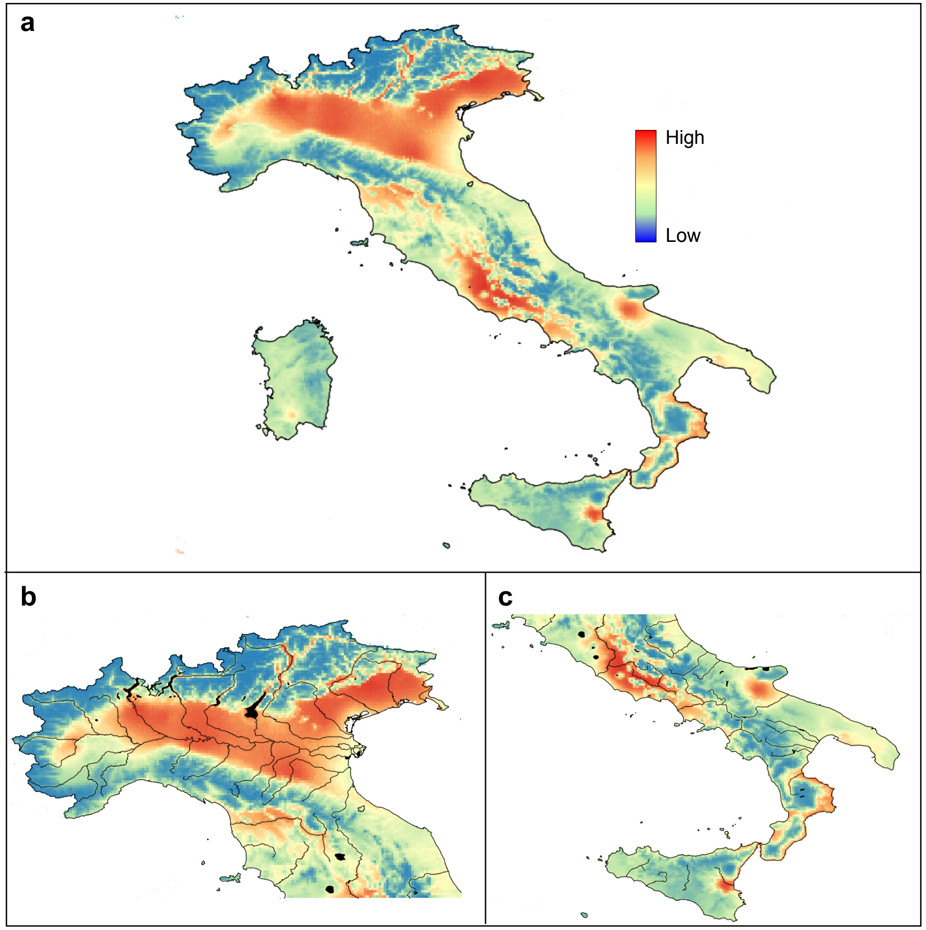
- Larger taxa are likely to occupy higher trophic level and to be less subject to competition and predation.
- Yet, direct human activities are the main driver of the (non accidental) introduction of alien fishes.

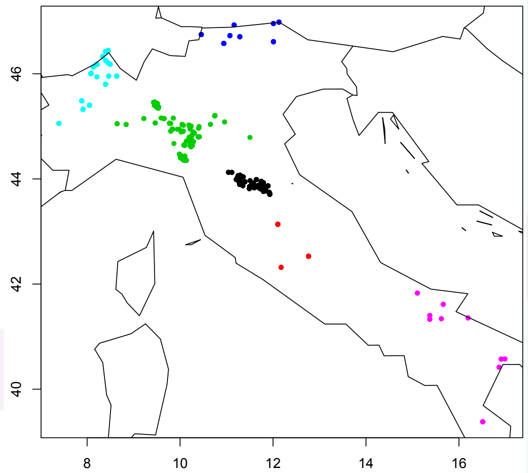
Why small taxa are less invasive?

- Very small size is a disadvantage in colonization process (i.e only passive transport and mostly accidental introduction)
- Complexity to observe alien species in taxonomic groups with smaller size associated with taxonomic uncertainties, and by the larger biogeographical ranges in very small species , i.e. microbial species seems to be less prone to be (or to be considered) aliens

Final remarks

It is possible to predict high risk areas for AS invasion?





An important feature of our models is that it considers simultaneously different taxa and habitats, giving a picture of invasion dynamics not related to a single species.
In principle we can use this model to create an invasion risk map for the entire Italy.

This work is in collaboration with many researchers and institutions