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"Conservation of Mediterranean Plant Diversity: Complementary Approaches and New Perspectives"

The role of translocations in conservation of wetland-dependent plant species

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Wetlands

Wetlands provide a variety of important ecological services but…

…are affected by multiple threats: vegetation clearing and drainage for agriculture, infrastructure expansion, invasive species, pollution and global climate change.

Aquatic macrophytes fulfil a wide range of complex interconnected functions, providing fundamental contributions to the structure and service of wetlands (i.e.: riparian/sediment stabilization, nutrient recycling, water purification)

Sometimes they act as ‘engineering species’, representing an habitat themselves

Some wetland species are already globally or regionally extinct:

Stellaria elatinoides Hook.f. (last collected in New Zealand in the 1940s)

Nymphaea thermarum Eb.Fisch. (only known in the wild from the type locality in Rwanda, collected in 1987, and now considered EW)

Trapa natans L. (RE in Spain) or *Stratiotes aloides* L. (RE in Italy)

Orsenigo (2018) *Aquatic Conservation: Marine and Freshwater Ecosystems* 28:772-775

Definitions

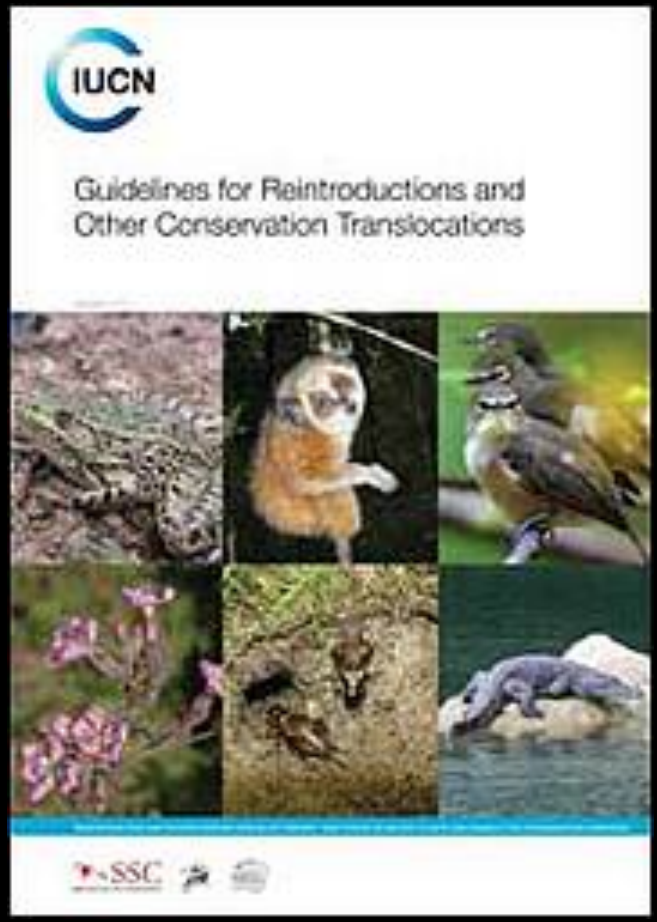
IUCN Guidelines 2013

Translocation: is the human-mediated movement of living organisms from one area, with release in another.

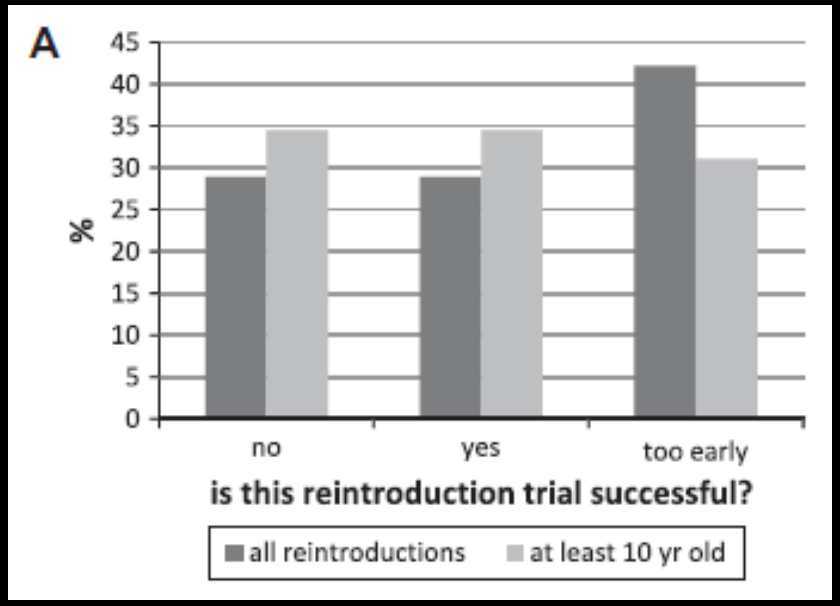
includes:

Reinforcement: is the intentional movement and release of an organism into an existing population.

Reintroduction: intentional movement and release of an organism inside its indigenous range.



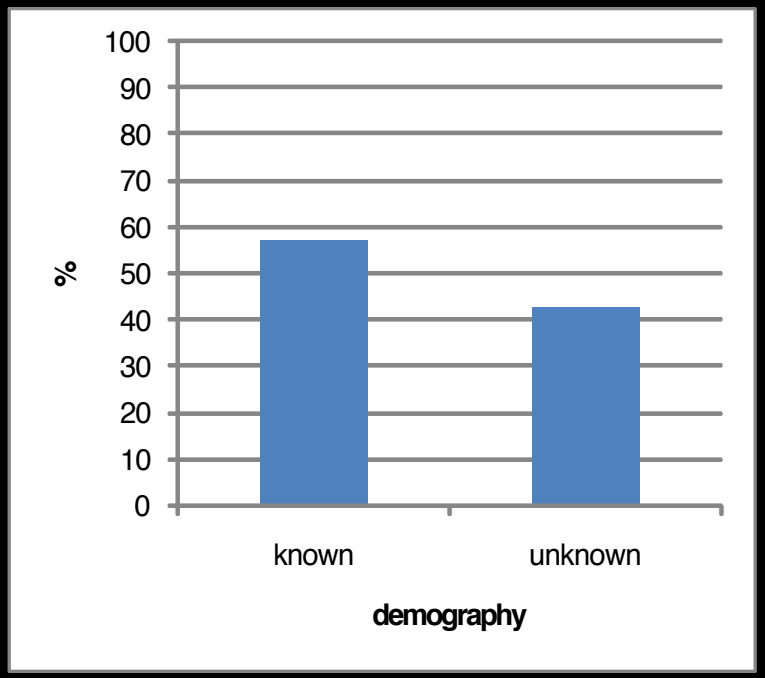
Conservation introduction: is the intentional movement and release of an organism outside its indigenous range.

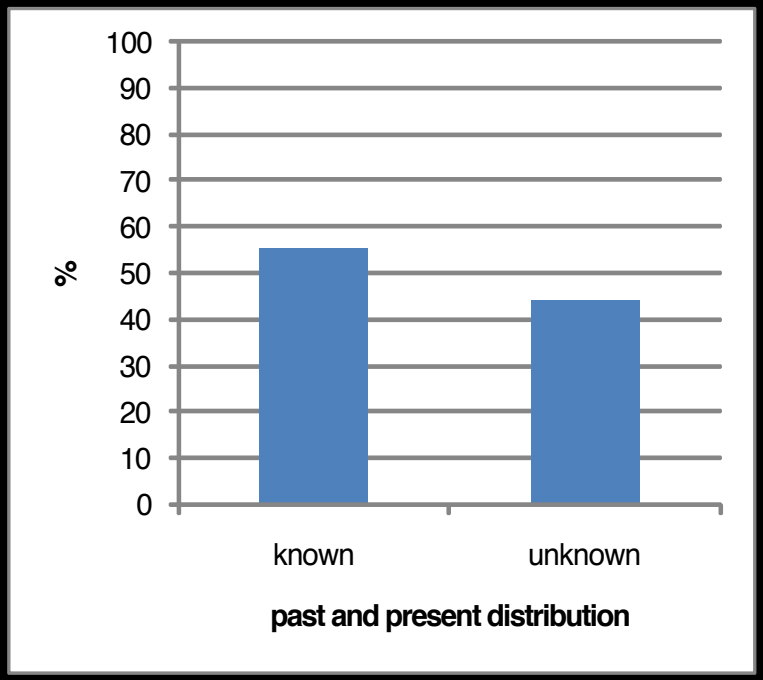


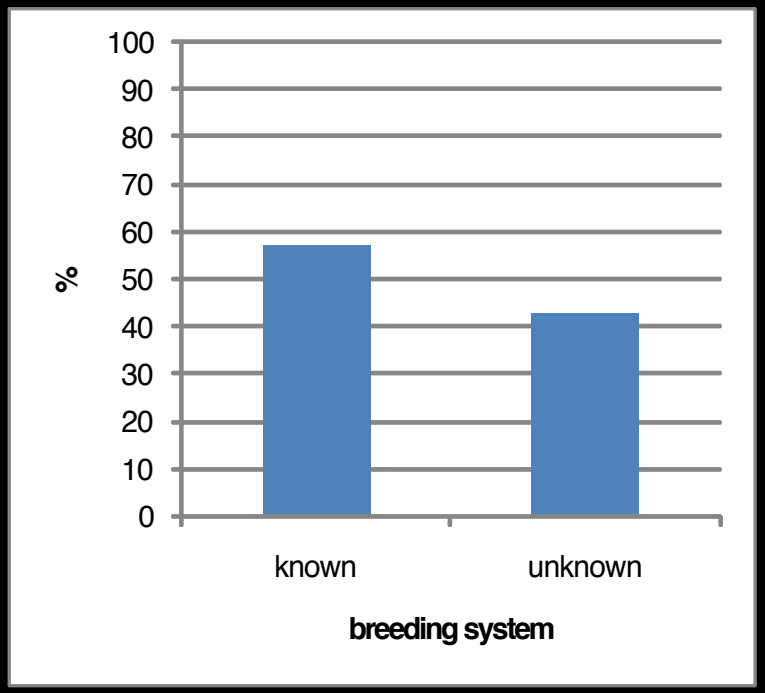
Translocations are risky conservation options with high rate of failure, but sometimes the only option.

Godefroid *et al.* (2011) *Biological Conservation* 144:672-682

Understanding species traits and requirements is crucial







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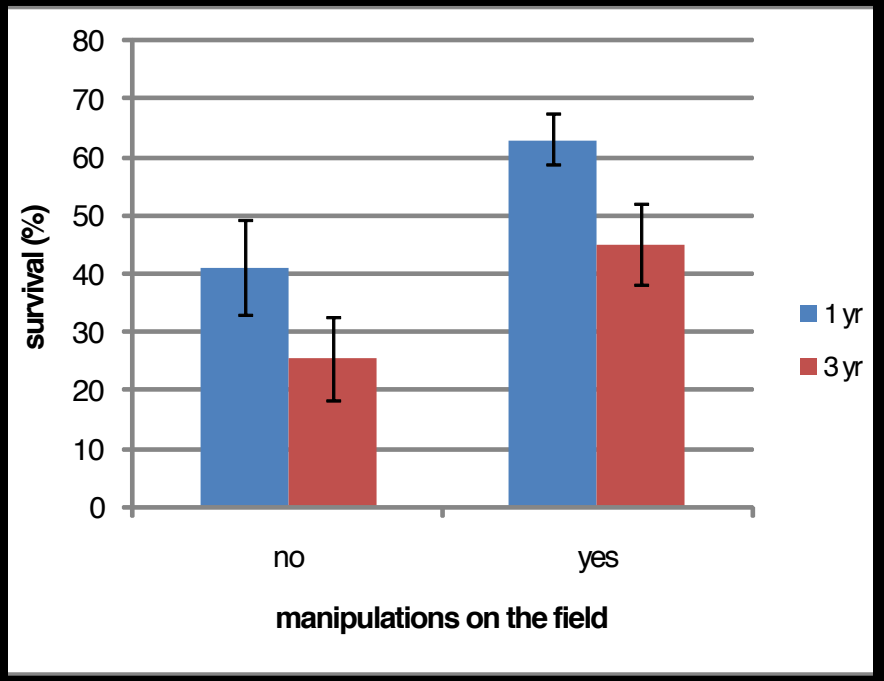
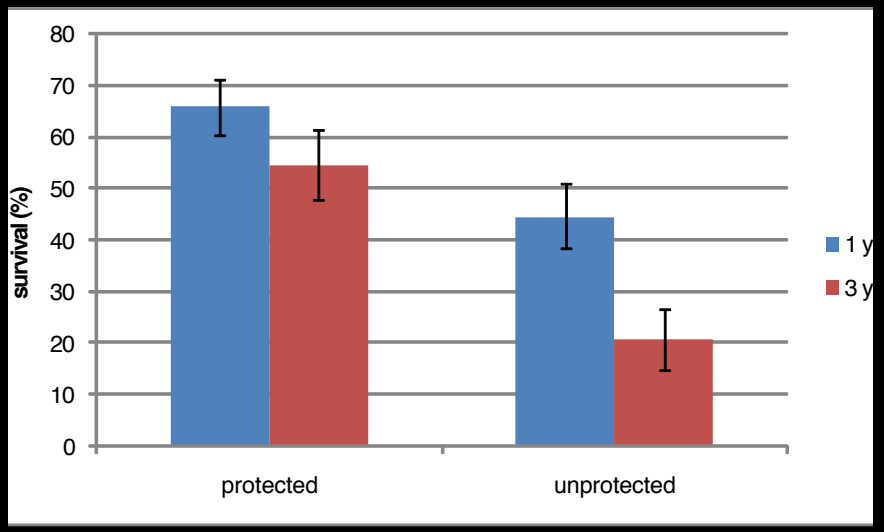
Site care and preparation

Pre-translocation manipulation have positive effects

Post-translocation monitoring tells us if cares are needed, but generally care enhance the success



Perform a translocation in a protected area increases the success (protection, patrolling, constant monitoring, less threats, etc.)



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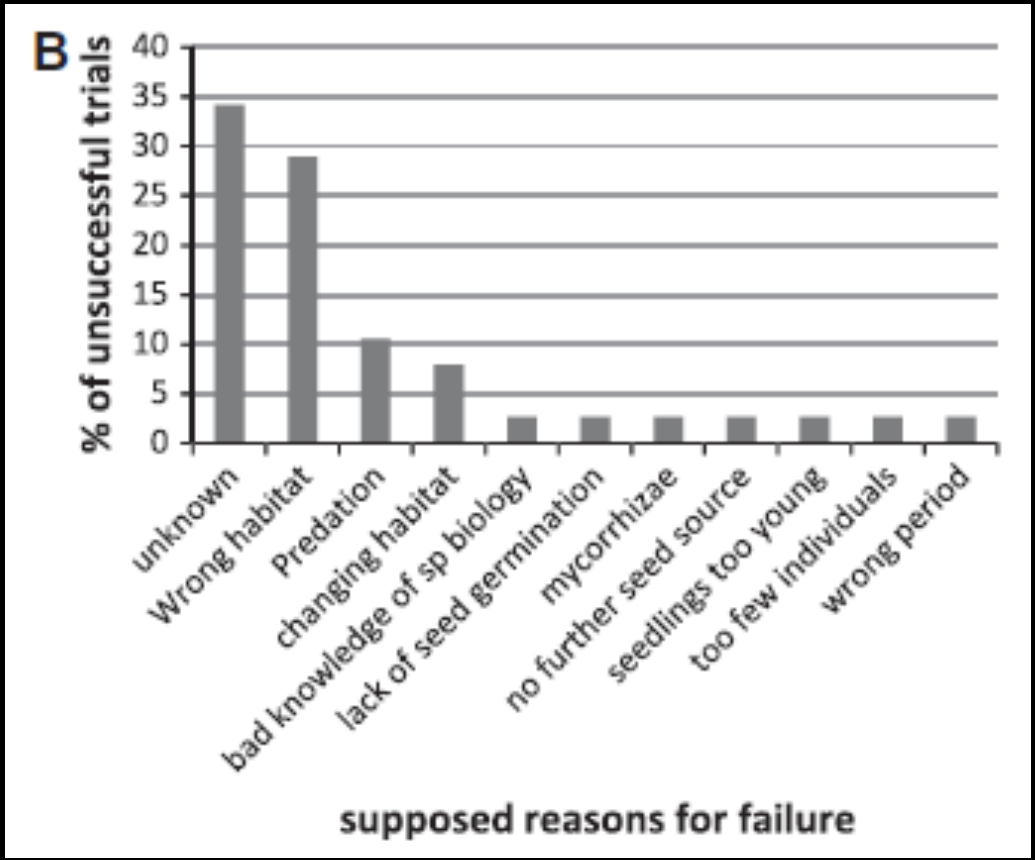


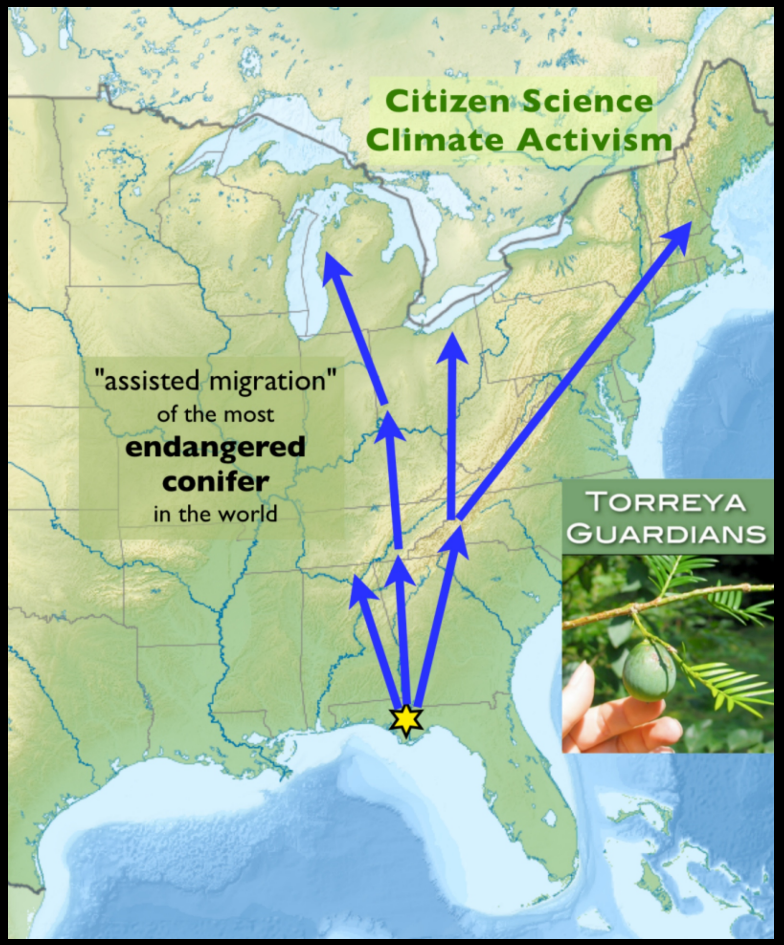
Factors that contribute to success or failure of a translocation are manifold and distinct; the partial lack of knowledge even in one of these factors may prevent the success of the intervention.

Godefroid *et al.* (2011) *Biological Conservation* 144:672-682

Translocation as conservation tool **vs.** **Gardening approach**

↓ ↓

Science-based **vs.** **Amatorial approach**



Behind each translocation there should be a level of pragmatic and focused science to support the actions and to interpret the long-term viability of the action

Abeli & Dixon (2016) *Plant Ecology* 217:123-125

Pre-release considerations are crucial for translocation success

Stratiotes aloides L. (Hydrocharitaceae)

Water-soldier is a vascular aquatic dioecious macrophyte, it grows in ponds, ditches, canals and lakes, where it often forms very dense stands

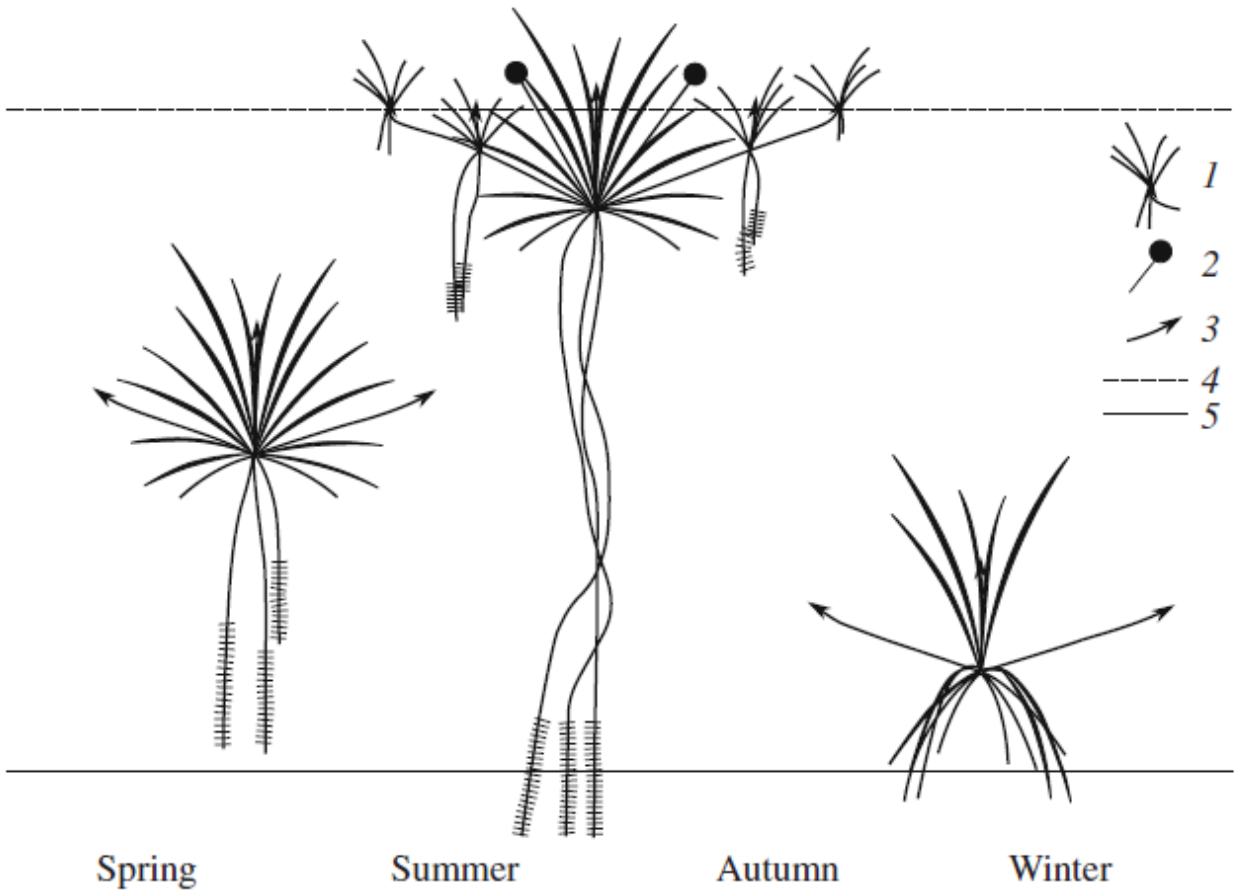


Fig. 1. Seasonal state of individuals of *Stratiotes aloides* in water bodies of the southwest of western Siberia and in the north of Kazakhstan: (*1*) rosette shoot with roots; (*2*) turion at the end of stolon; (*3*) inflorescence; (*4*) water level; (*5*) ground level.

Figure reproduced from Efremov & Sviridenko Inland Water Biology 1(3):225–230 (2008)

S. aloides is floating in summer and submerged in winter

It is an Euro-Siberian species that is declining in south-western Europe, where it has recently become extinct at the southern edge of its range (Italy).

Before the extinction, some individuals were collected from the wild

The discovery of surviving plants of *S. aloides* provides the opportunity to evaluate the reintroduction of the native Italian population in historical sites of occurrence or other sites in the historical distribution area.

Ecology and genetic diversity poorly known

Which are the ecological requirements of *S. aloides*?

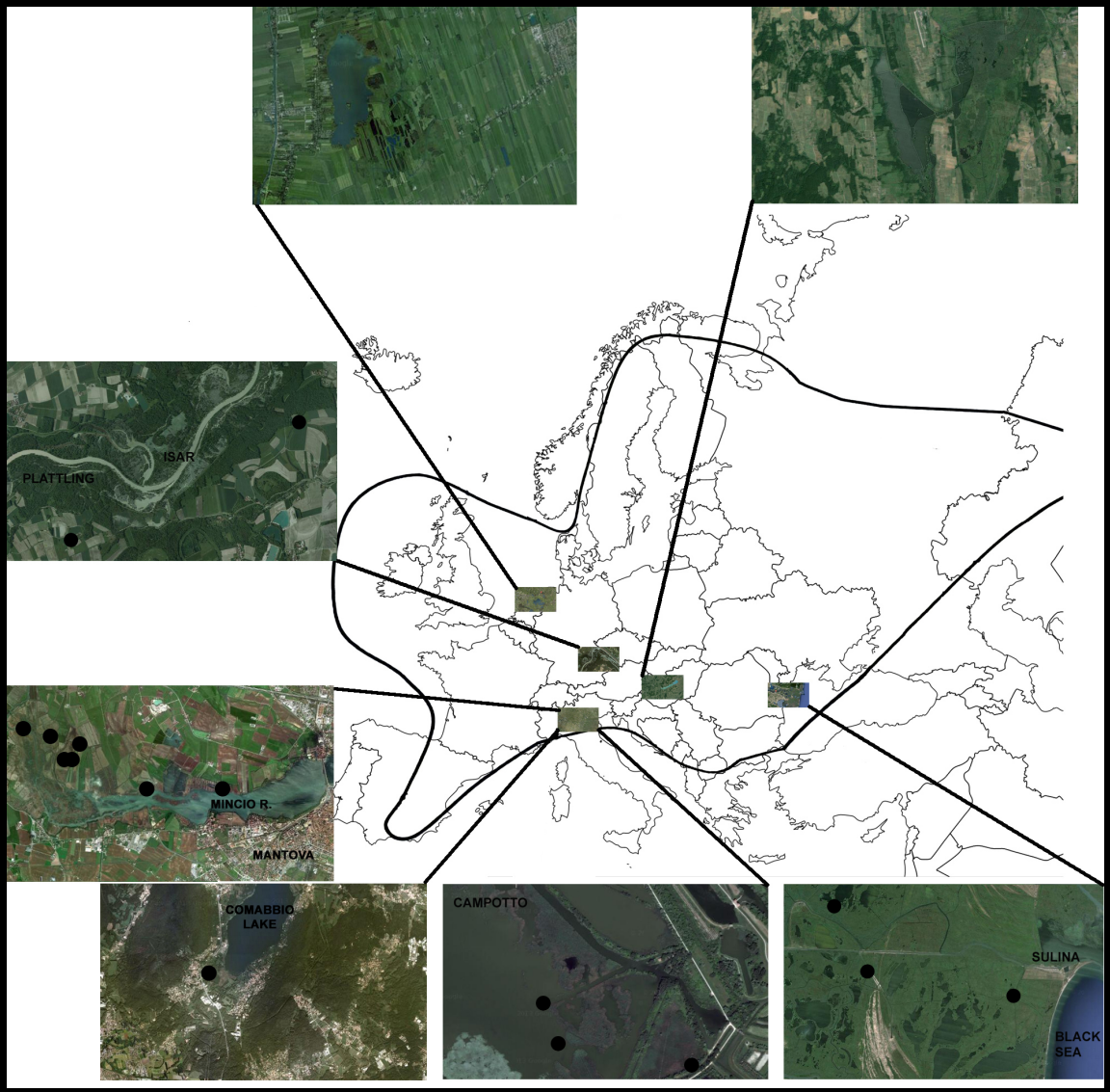
Does the Italian female population have a good genetic variability or it requires a reinforcement to increase its genetic variation?

Which is the best source for male individuals to re-establish a viable population?

We decided to address these problems considering both ecology and genetic variation of *S. aloides*

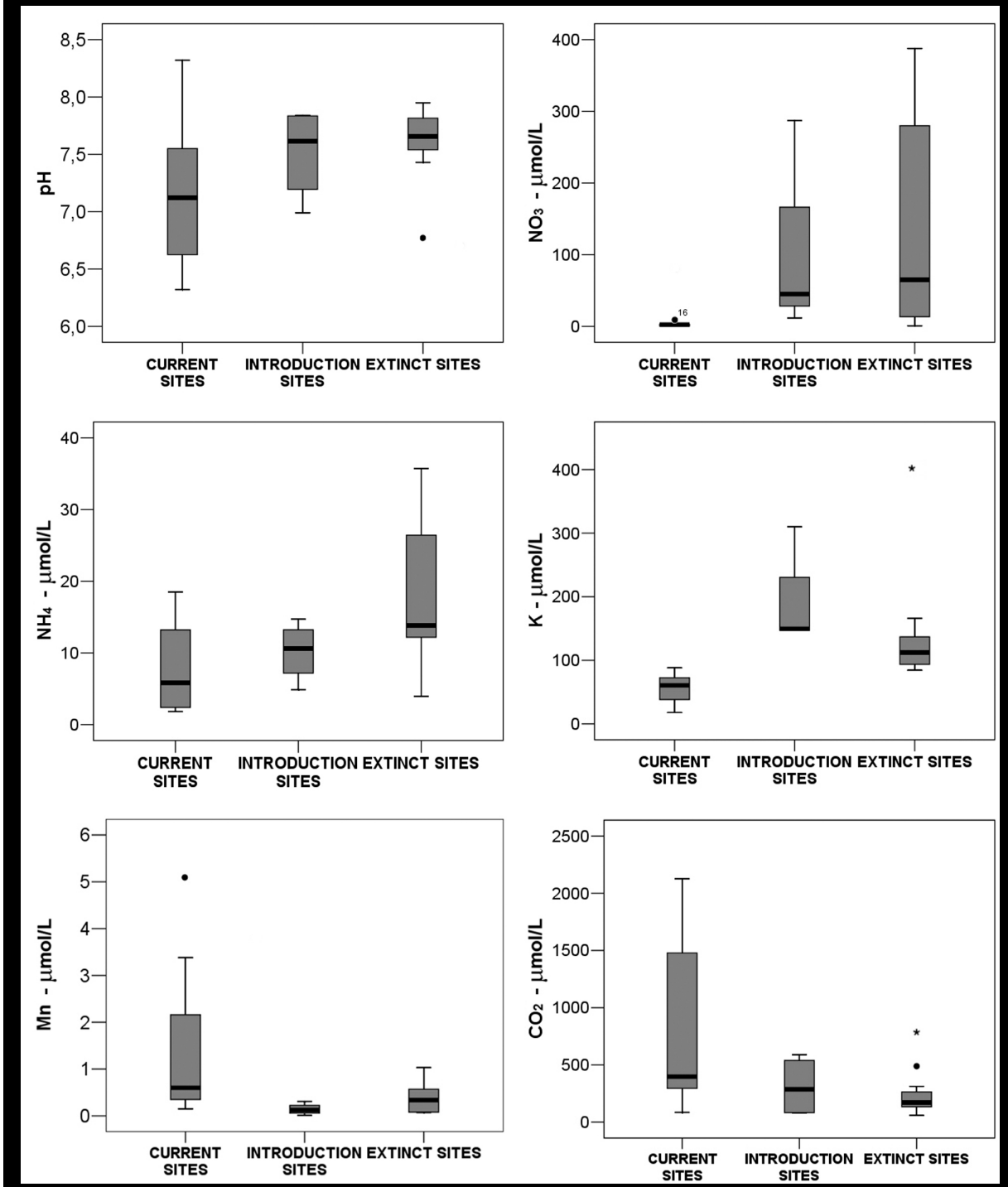
Current/historical growing site comparison

Surface water and sediment pore-water samples were collected in the Netherlands, Germany, Italy, Hungary and Romania.

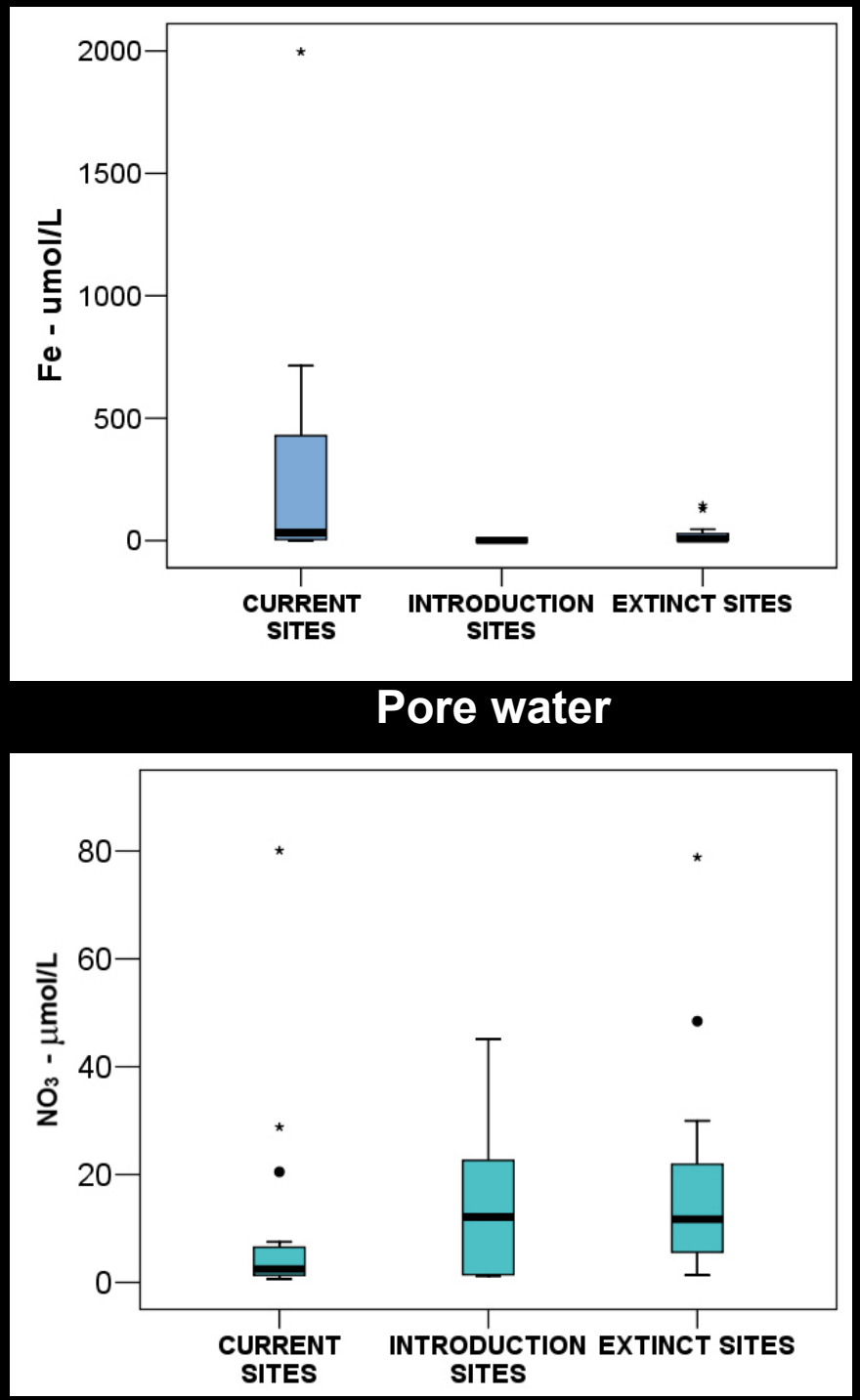


The sampled localities were chosen among current *S. aloides* stands (n=7), sites where the species has disappeared in the last 10 years (n=8), and proposed recipient sites for reintroduction in Italy (n=3).

Abeli *et al.* (2014) *Aquatic Conservation: Marine and Freshwater Ecosystems* 24: 724-729



Surface water



Pore water

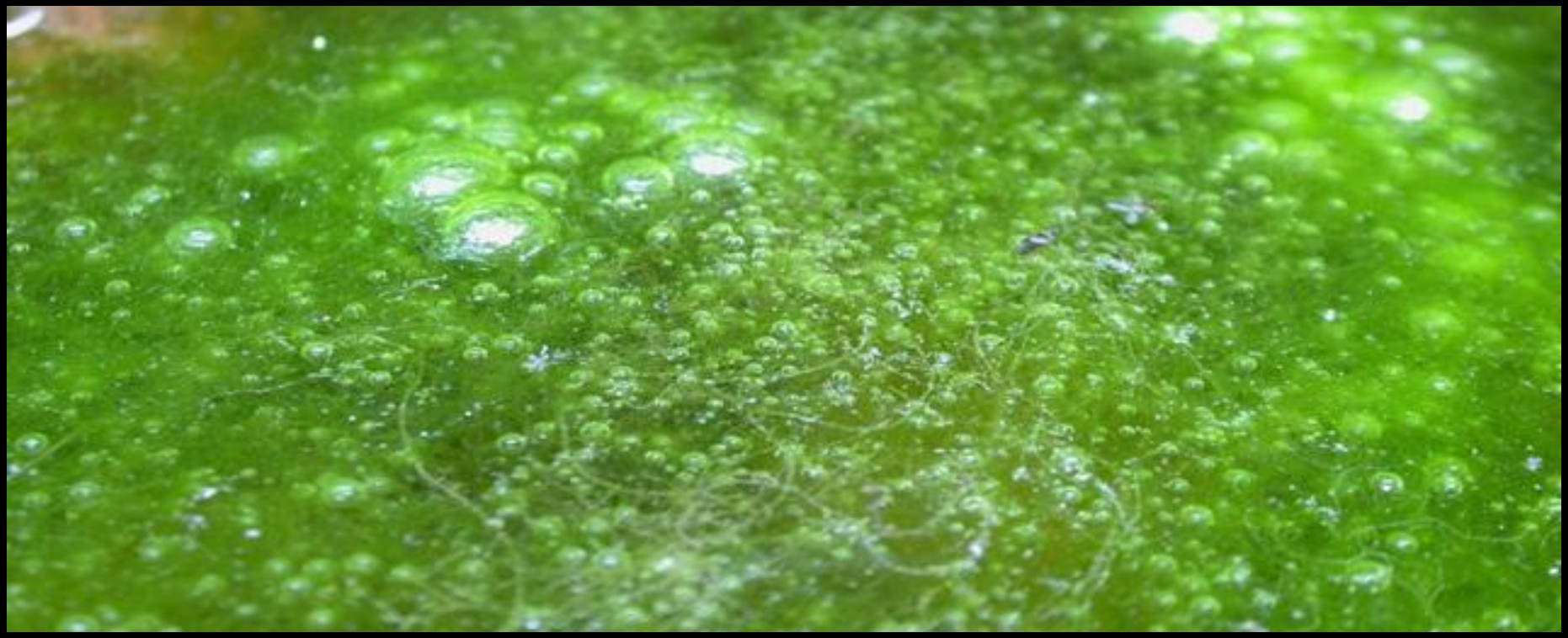
Abeli *et al.* (2014) *Aquatic Conservation: Marine and Freshwater Ecosystems* 24: 724-729

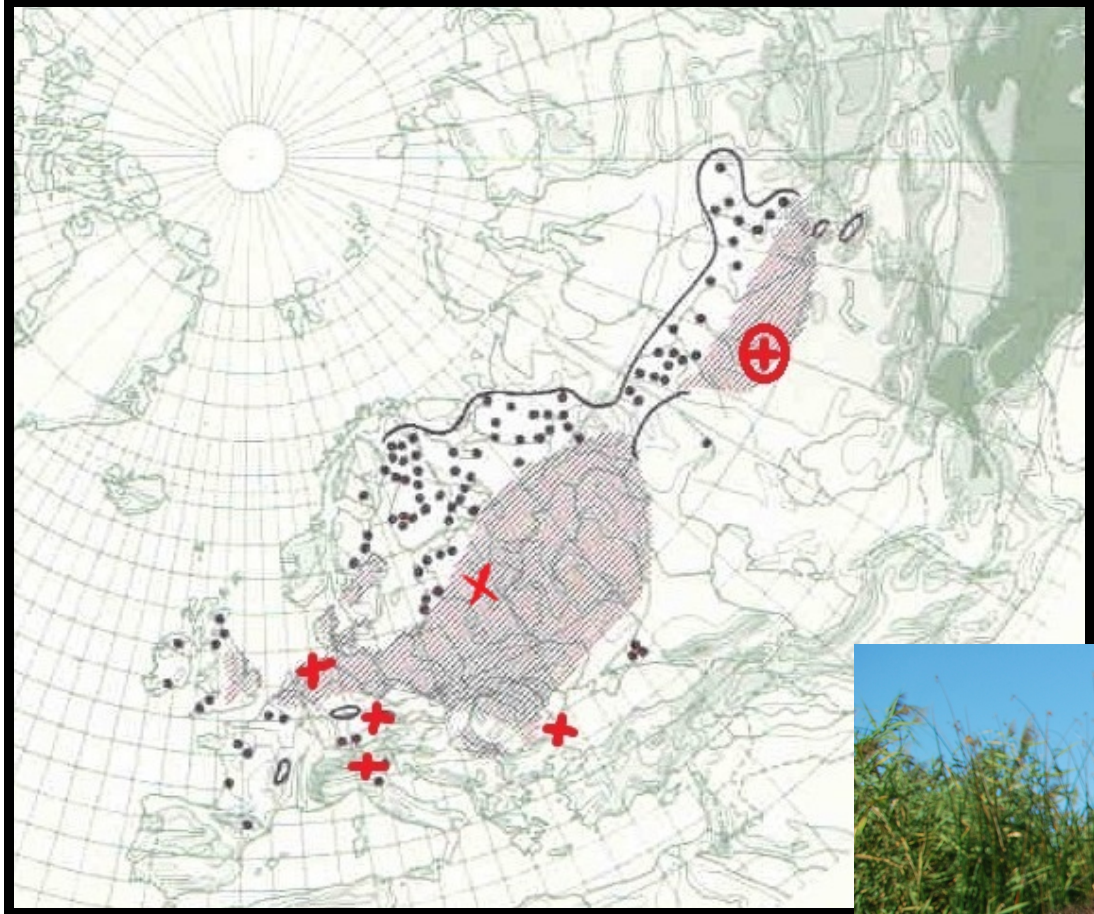
None of proposed Recipient Site differed from Extinct site for any of the surface water parameters

Abeli *et al.* (2014) *Aquatic Conservation: Marine and Freshwater Ecosystems* 24: 724-729

Surface waters from sites where *S. aloides* has recently disappeared are characterized by high inorganic nitrogen concentrations.

- direct physiological effect
- strong stimulation of the growth of filamentous algae, that prevent the possibility of *S. aloides* to become buoyant in spring

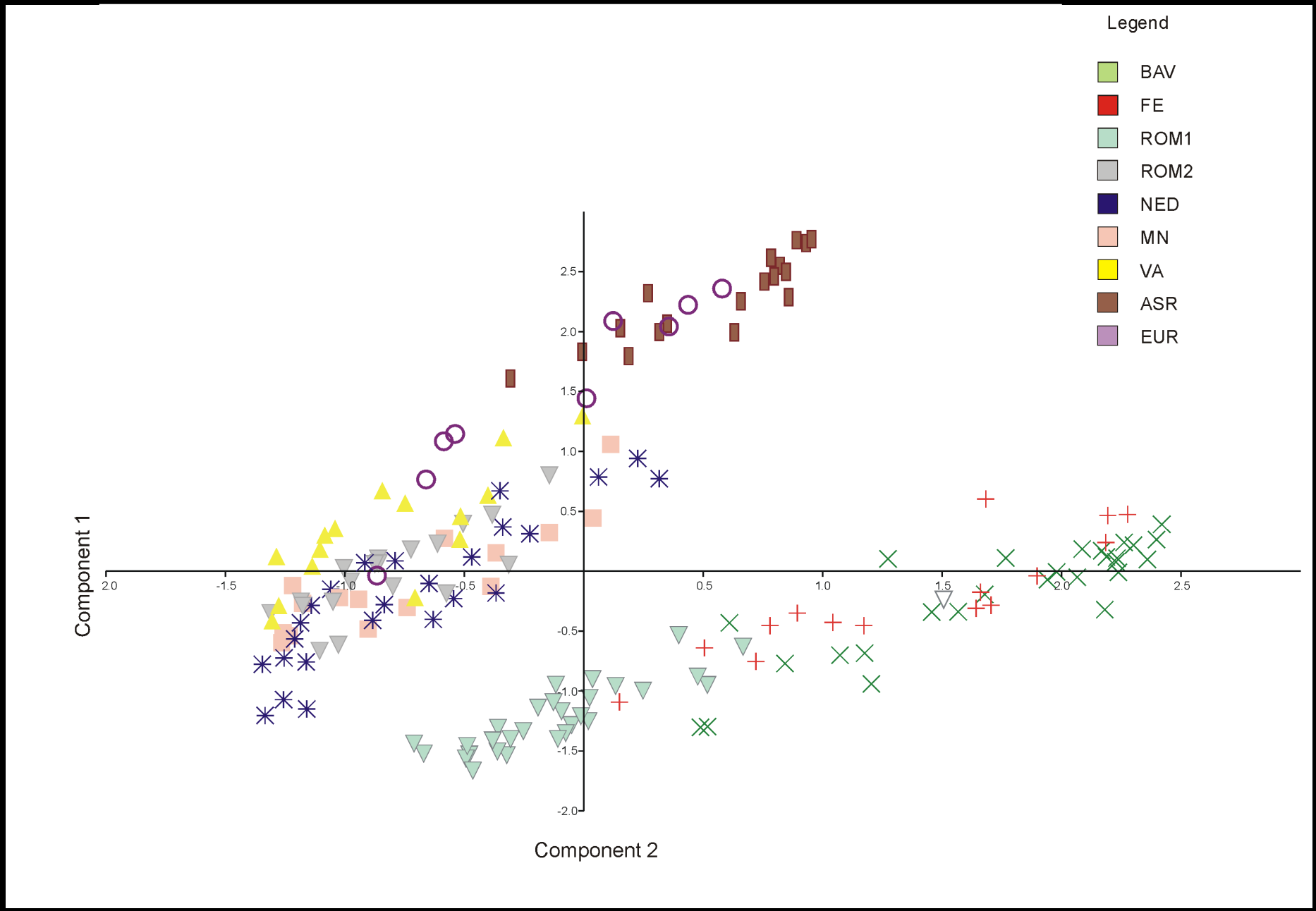




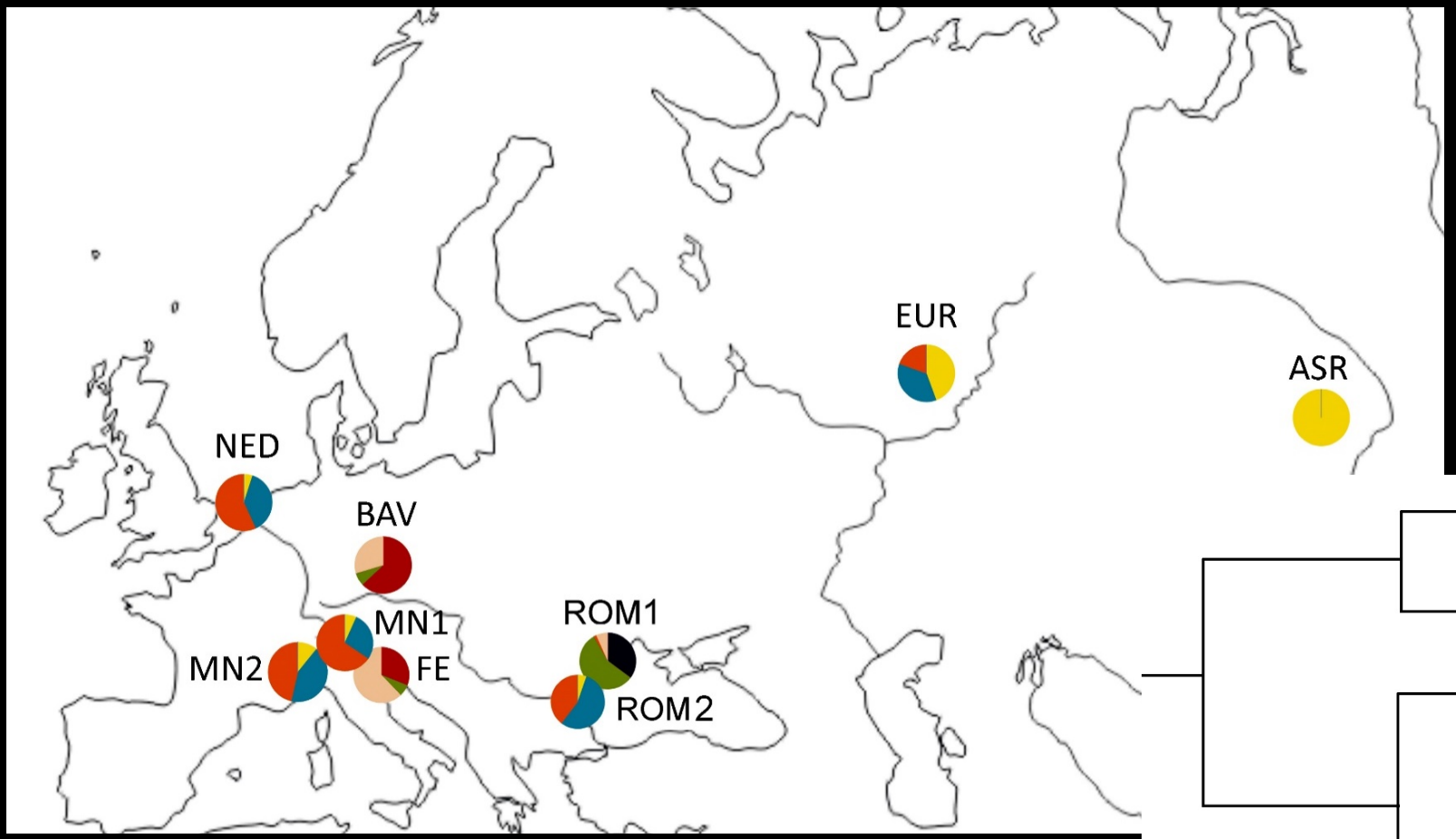
9 accessions from 6 natural populations of *S. aloides* from the Netherlands (NED), Germany (BAV), Romania (ROM1; ROM2), Western (EUR) and Central Russia (ASR), 2 ex situ populations (MN1; MN2), and 1 population cultivated at the Ferrara Botanical Garden (FE)

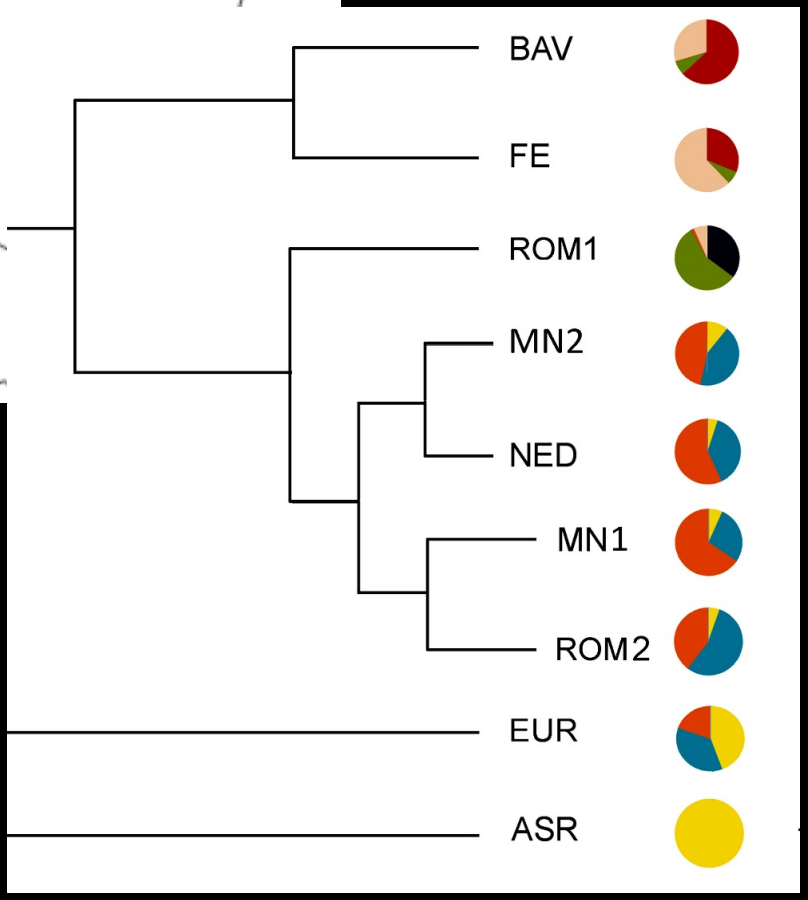
5 different river basins: Po, Rhine, Danube Volga and Ob

Geographically closest populations may represent the best source populations for male reintroduction.



Orsenigo *et al.* (2016) *Aquatic Conservation: Marine and Freshwater Ecosystems* 27:10-23





Ancestry was estimated to model population structure using Bayesian methods in STRUCTURE

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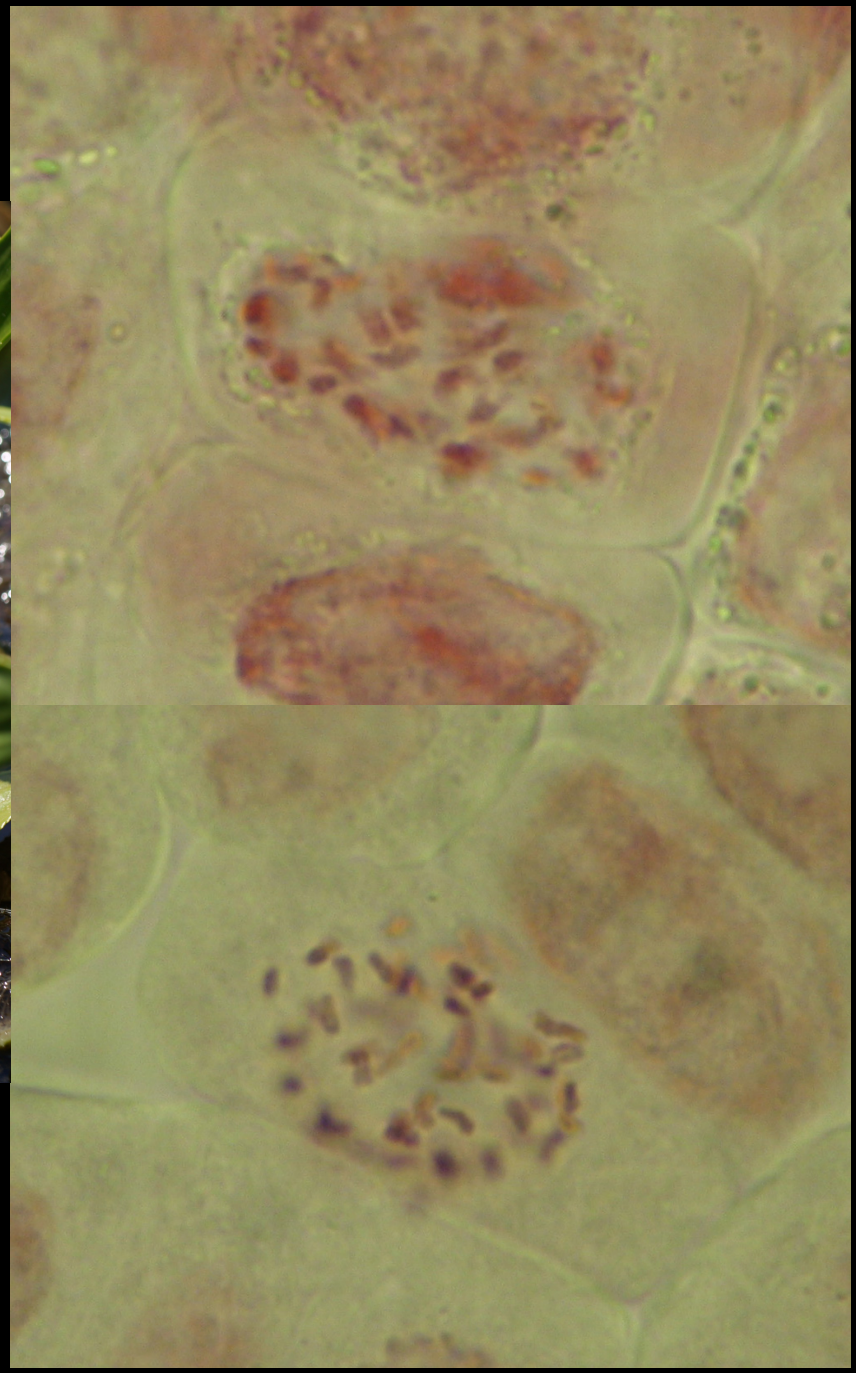
BAV are diploid, 2n=2x=24



MN and NED are tetraploid, 2n=4x=48

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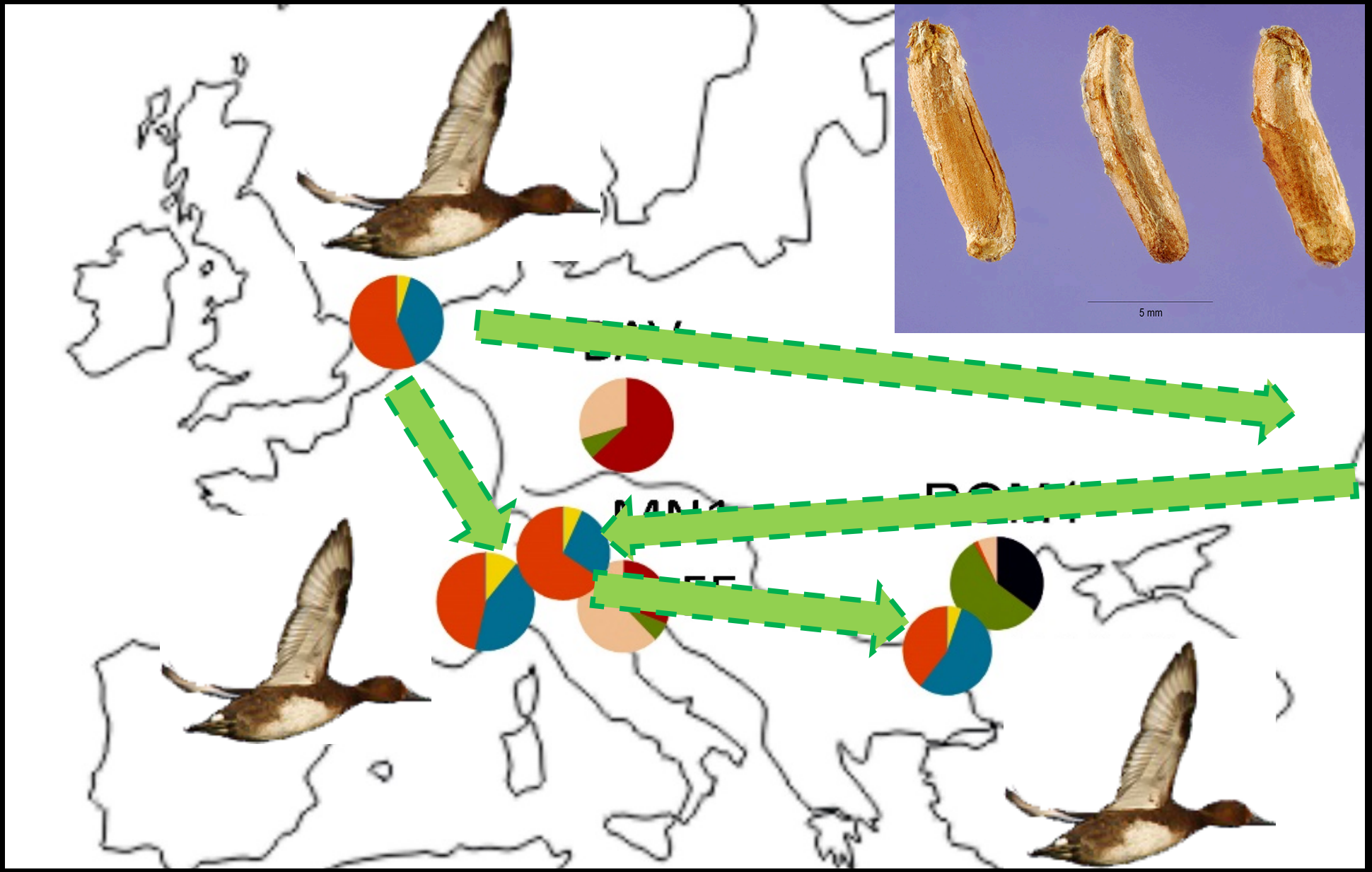
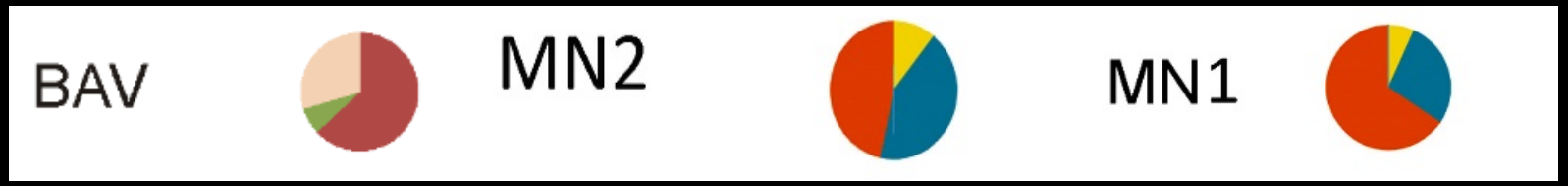
Long-distance bird-mediated dispersal events



Our hypothesis: the ge[illegible] populations of S. aloides may represent the best s[illegible]ons fo[illegible]duction



Suppositions on the genetic structure of plant populations based on geographical proximity may be wrong.

Mixing material from different source populations usually allow to increase the genetic variation of the translocated population.

In this case, mixing different source populations may result in outbreeding depression.

Caution must be adopted in mixing different genotypes!

Patterns of genetic variation and diversity may be complex resulting further complication in translocation practices

Aquatic plants may show unidirectional gene flow according to water flow and dispersal strategy

Wrong genetic “choices” may lead to a failure

Kosteletzkya pentacarpos (L.) Ledeb. (Malvaceae)

Seashore mallow is a vascular plant species distributed in Europe and N America threatened in southern Europe, considered CR in Italy. It grows in brackish coastal marshes and river deltas.

It is studied by NASA as source of alternative aviation fuel

Reinforcement of wild population of *Kosteletzkya pentacarpos*

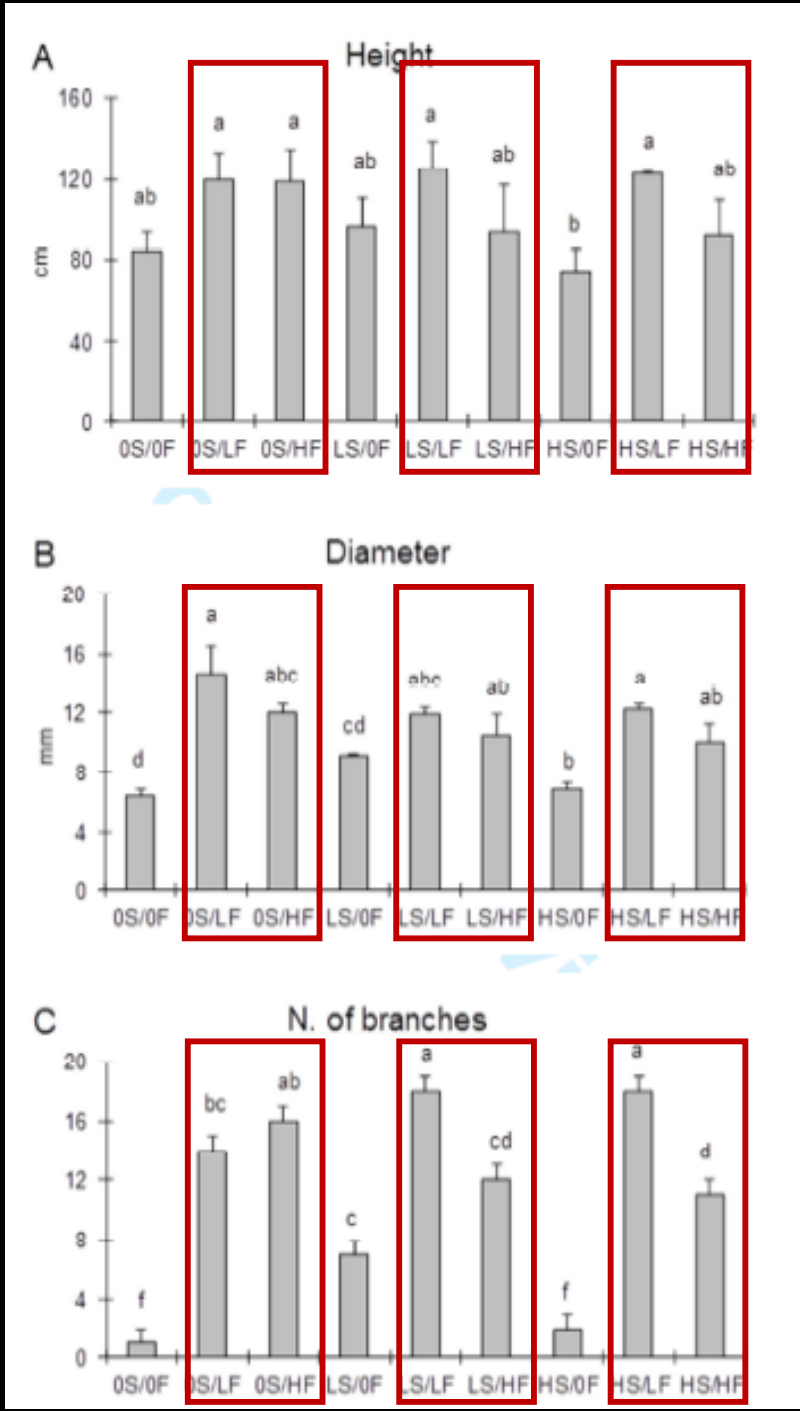
Experimental protocol for *ex situ* cultivation

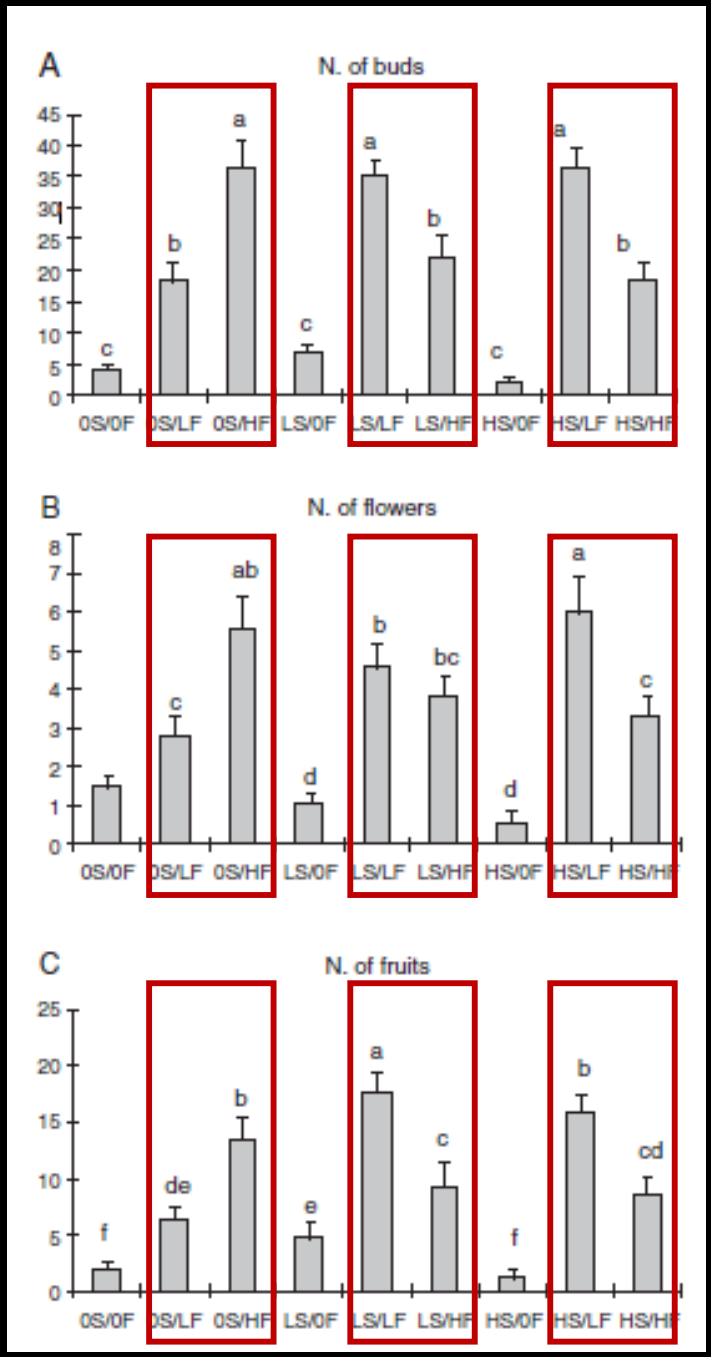
Response of seashore mallow to varying levels of **salinization** (soil salt content) and **fertilization** (nutrient availability)

Treatment	NaCl	NPK
0S/0F	0 g	0 g
0S/LF	0 g	5 g
0S/HF	0 g	10 g
LS/0F	7g	0 g
LS/LF	7g	5 g
LS/HF	7 g	10 g
HS/0F	20 g	0 g
HS/LF	20 g	5 g
HS/HF	20 g	10 g

- Height
- Stem diameter
- N° branches
- Duration of senescence
- Photosinthetic activity
- N° flowers
- N° fruits

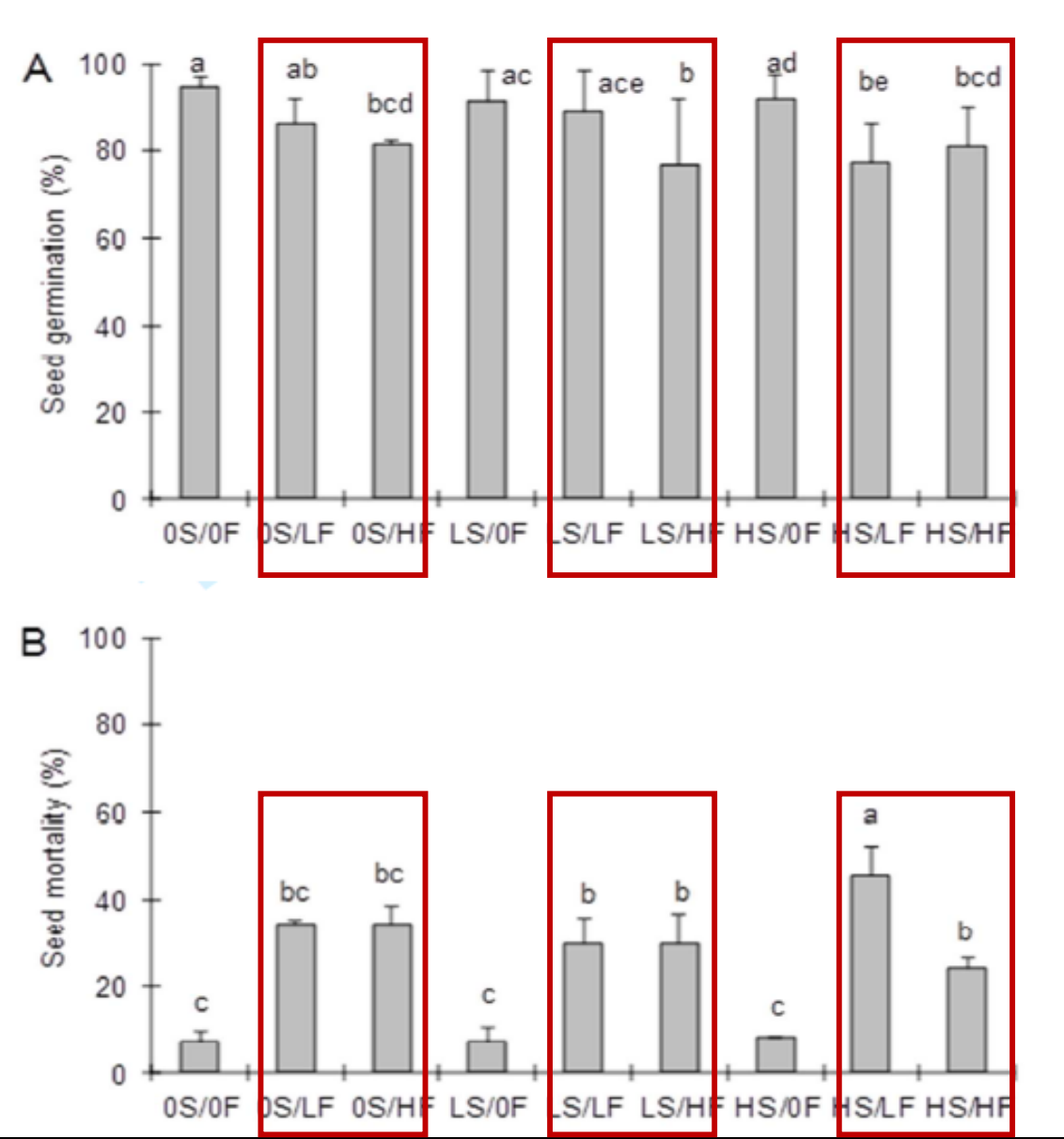
Fertilization enhance biomass, but had no effect on photosinthetic activity





Abeli *et al.* (2017) *Annals of Applied Biology* 170: 263-272

Fertilization decrease % of seed germination and increase seed mortality



Abeli *et al.* (2017) *Annals of Applied Biology* 170: 263-272

Seashore mallow were planted in two recipient sites characterized by nutrient−rich freshwater and nutrient−poor brackish water, respectively.

Two outstanding questions were addressed:

(i) to what extent does the pre−treatment applied during ex situ cultivation enhance the performance of the plants released in the recipient sites?

(ii) to what extent does the pre−treatment applied to maternal plants affect the performance of non−treated offspring via maternal effects?

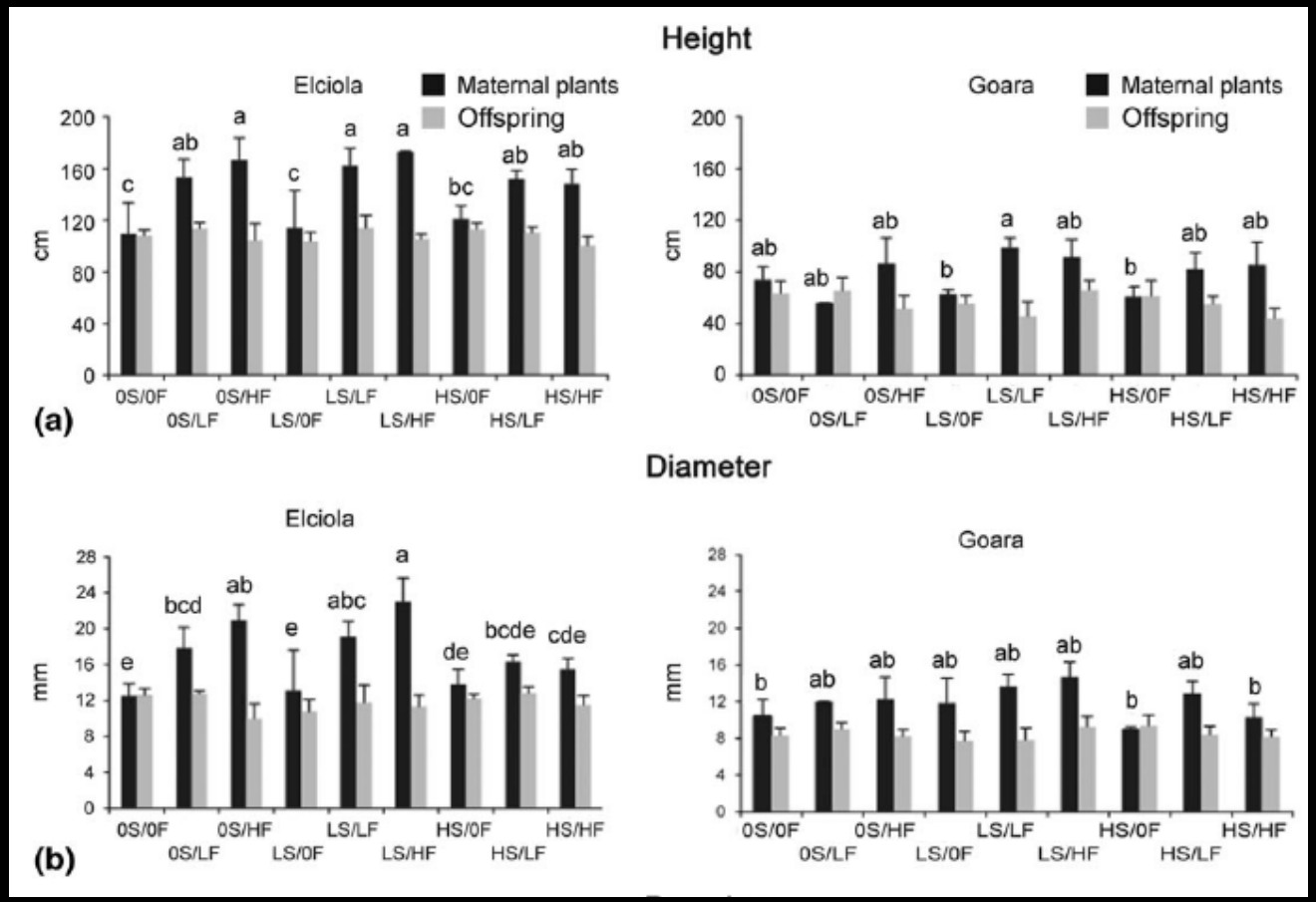
Brancaleoni *et al.* (2018) *Aquatic Conservation: Marine and Freshwater Ecosystems* 28: 641-650

2 generations were translocated (treated maternal plants - non-treated offspring)

Fertilized maternal plants showed higher growth, net CO2 exchange rates and reproduction, compared with non−fertilized plants only in nutrient rich-site.

Fertilized maternal plants showed higher performance than the offspring.

Salinization had no effects



Brancaleoni *et al.* (2018) *Aquatic Conservation: Marine and Freshwater Ecosystems* 28: 641-650

Pre-treatment and ‘memory’ in plants

Plants that experienced high nutrient levels during pre-treatment may have acquired the ability to use nutrients better and faster than untreated plants.

This in part positively answers to our first question: pre-treatments applied during cultivation enhanced the performance of the plants released in the recipient sites...

…but decrease quality of seeds!

Maternal effects were not observed

Further studies on transgenerational plasticity applied to translocation are needed, especially to evaluate whether maternal effects can explain the low success rate of translocations.

Some take home messages

- ✓ Understanding and remove causes of extinction is essential
- ✓ Careful evaluation of optimal ecological parameters is strongly suggested
- ✓ Wrong choices in source populations may lead to a failure
- ✓ Hardening treatments can increase / decrease establishment success

A more active dialogue between researchers and practitioners is needed

General considerations

- ✓ Translocations of wetland–dependent plants performed in the context of **broader wetland habitat restoration projects**
- ✓ Translocation in **artificial / semi-natural environment** and **agro-ecosystems**

Food for thoughts for future research

- ✓ **Transgenerational plasticity** applied to translocation
- ✓ Understanding the role of **competition/facilitation** aspect in translocation
- ✓ Role of **ex situ collection** in translocation projects

Acknowledgements

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THANK YOU!

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Chaperoned managed relocation of only female individuals in isolated water bodies basin (like gravel pits) could be the best solution