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Arcachon 2025

The genetic component of seagrass restoration

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Impact and restoration

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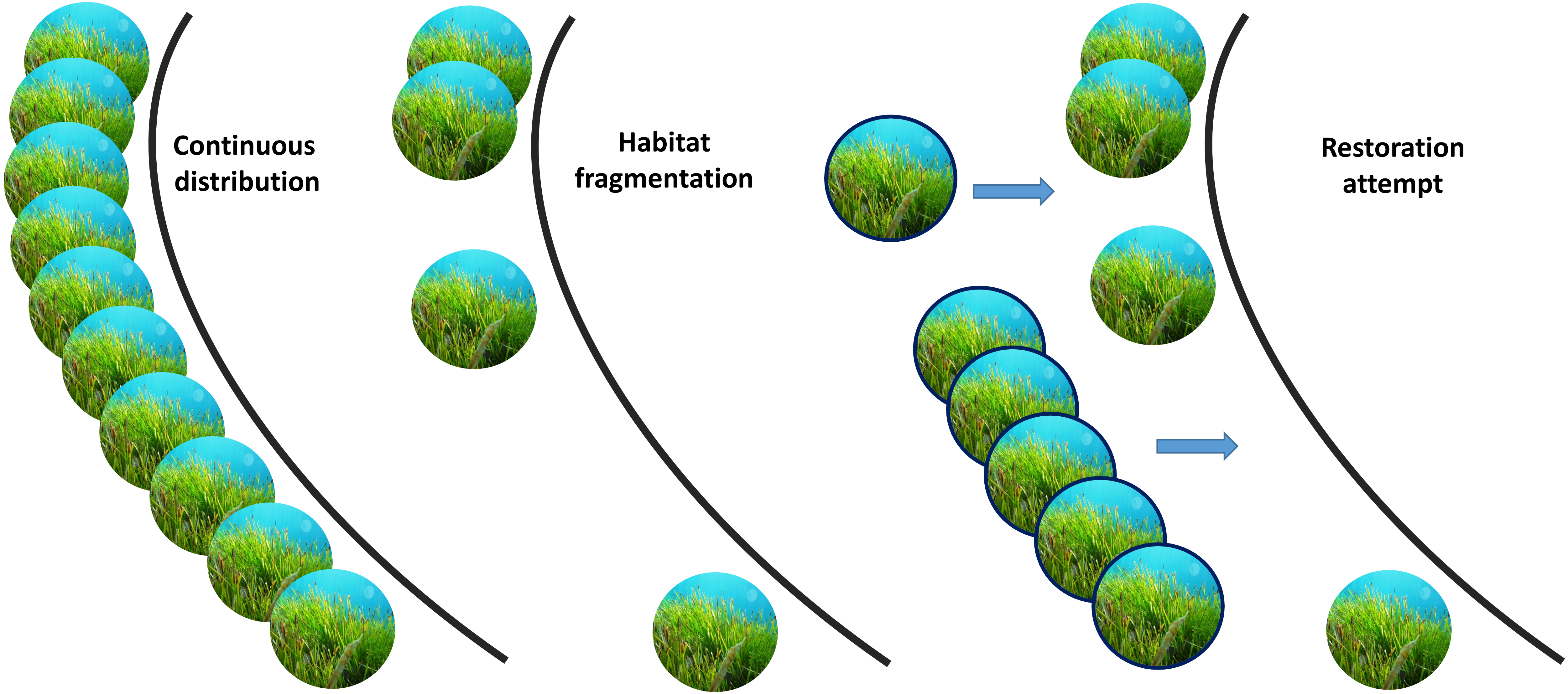
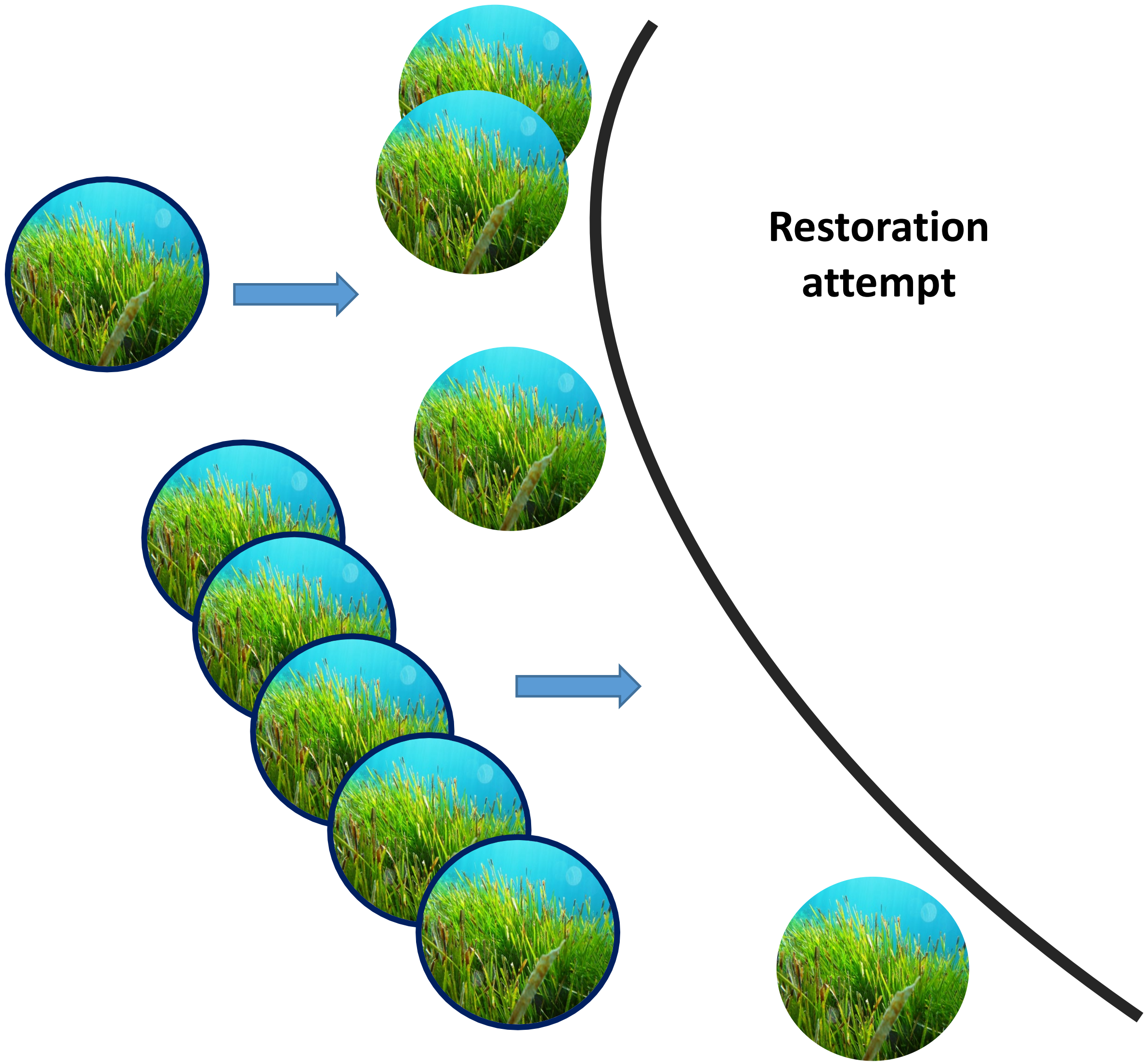


Impact and restoration. General concepts

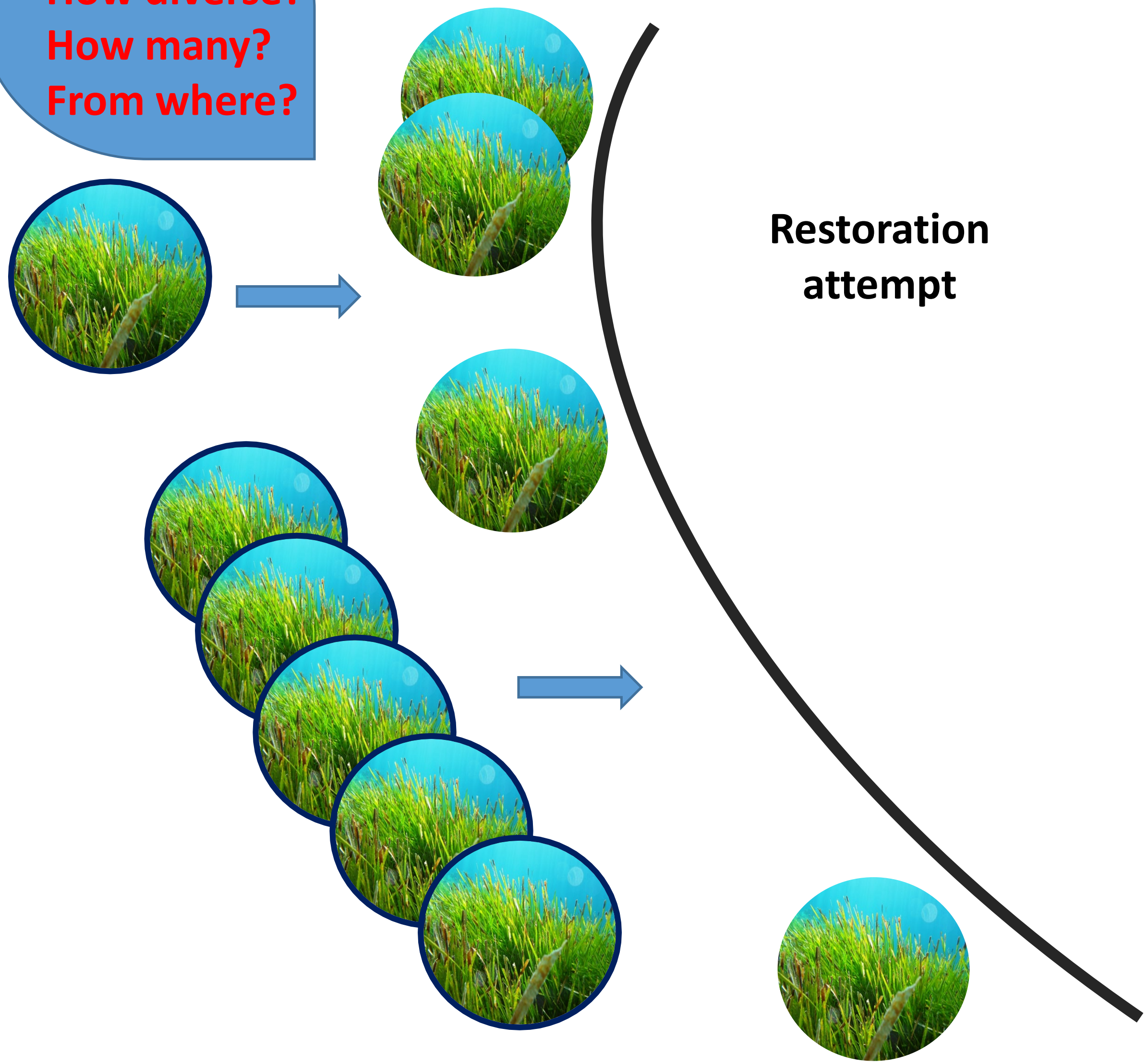
- **Accurancy** (replication of the original gene pool)
- **Functionality** (how well a restored population will work in terms of persistence, resilience, and stability) in selecting donor populations



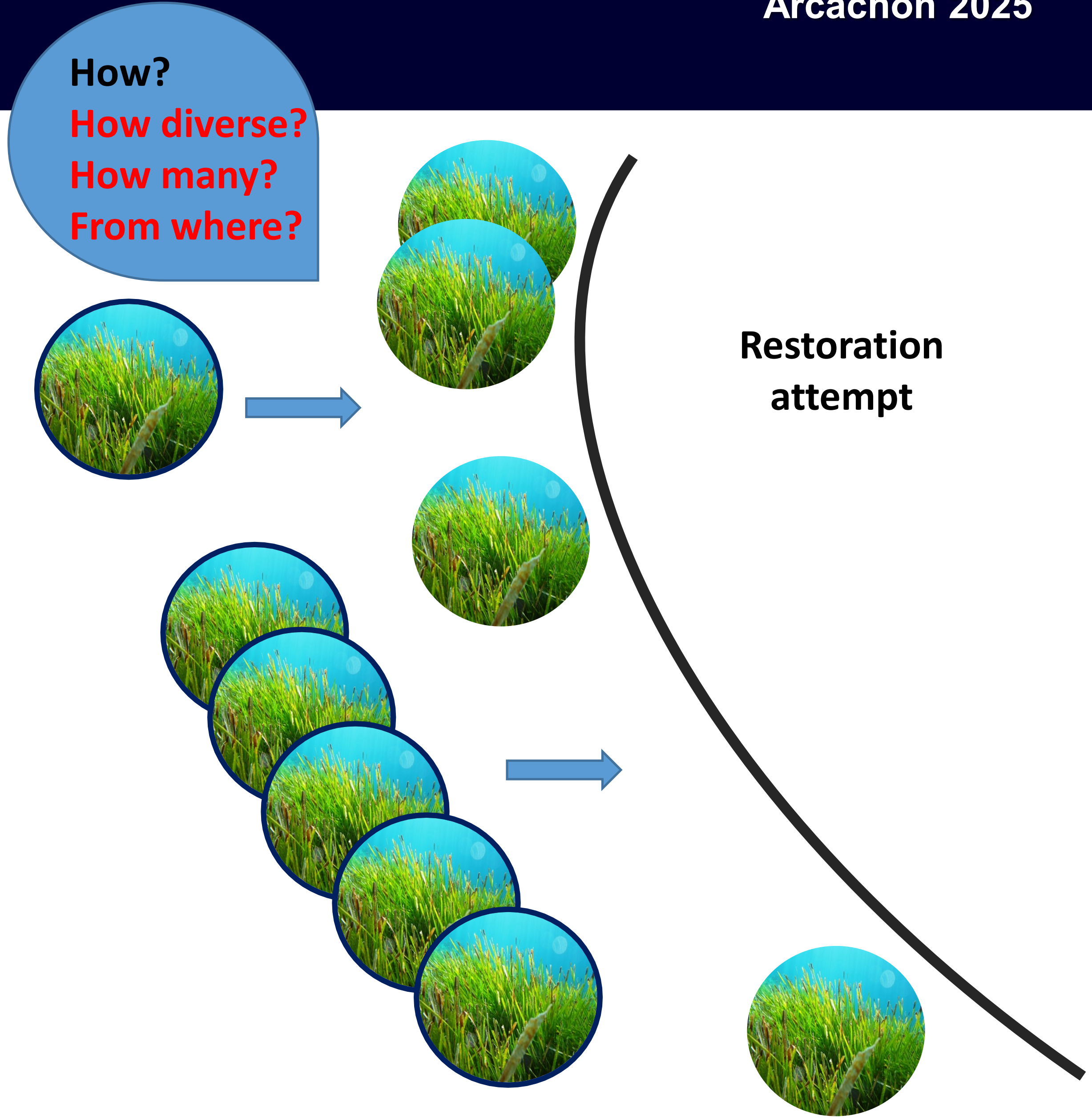
Genetics can contribute to:

- ***Choice of sites for reintroduction***
- ***Choice of individuals, and numbers to release***
- ***Deciding upon the number of released sites***
- ***Genetic management of released populations***

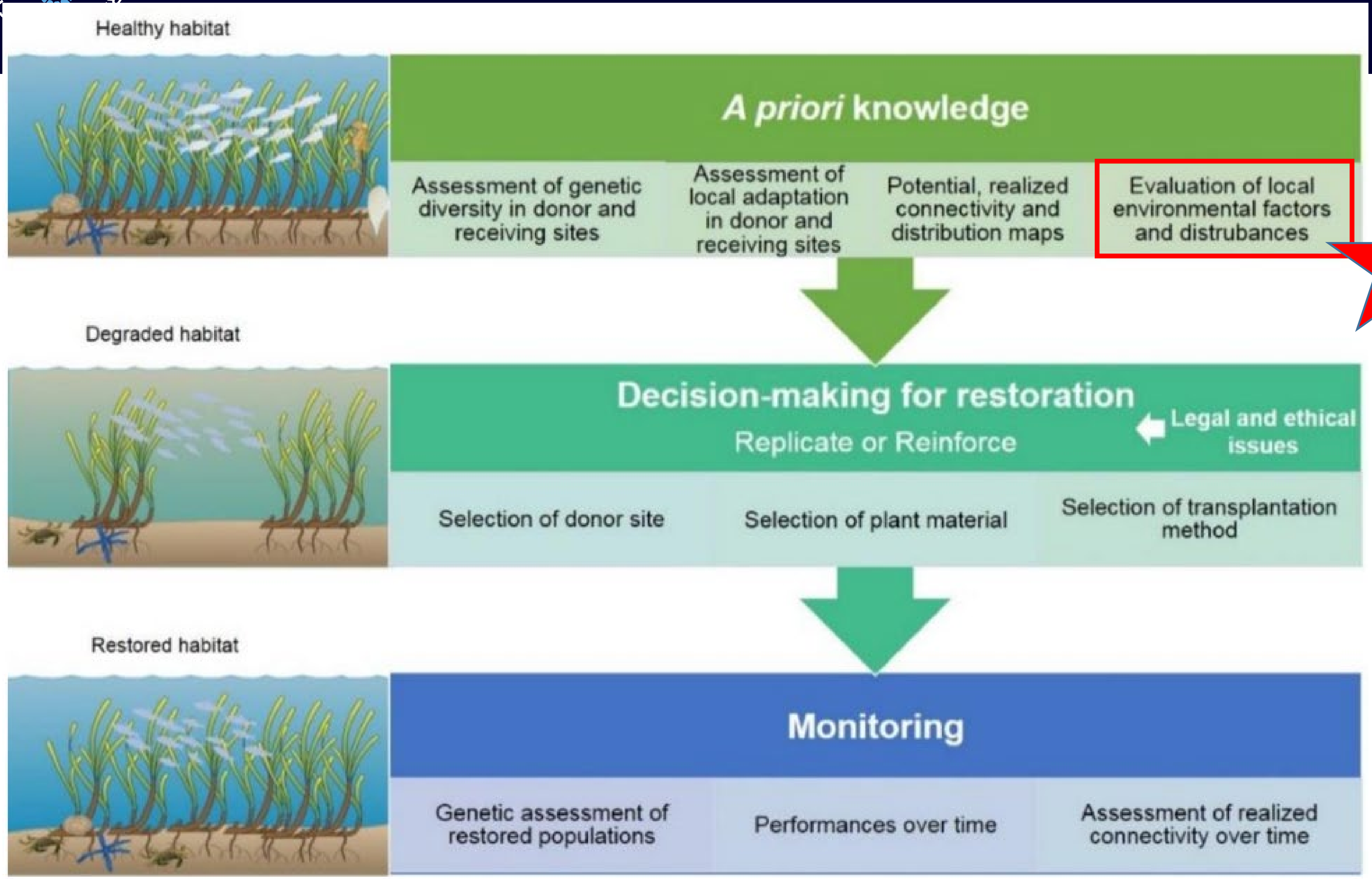
How?
How diverse?
How many?
From where?



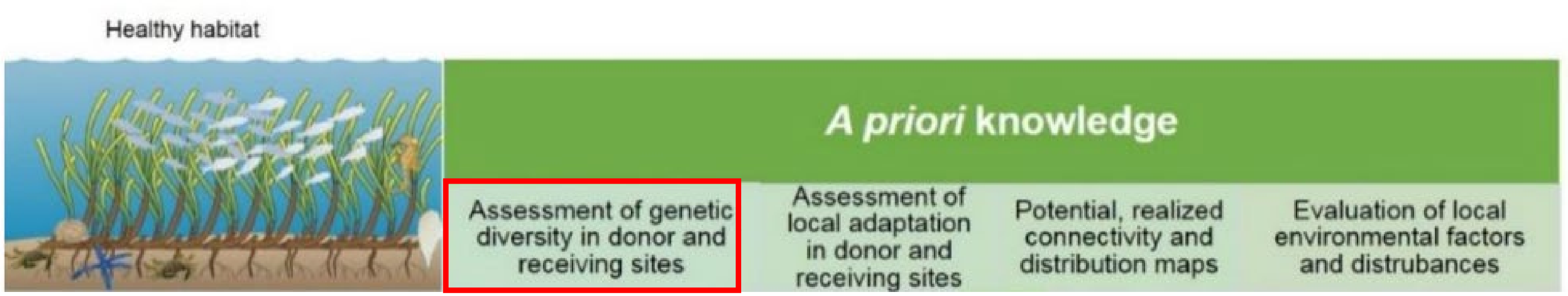
Genetic approaches can contribute to address the basic questions of restoration ecology



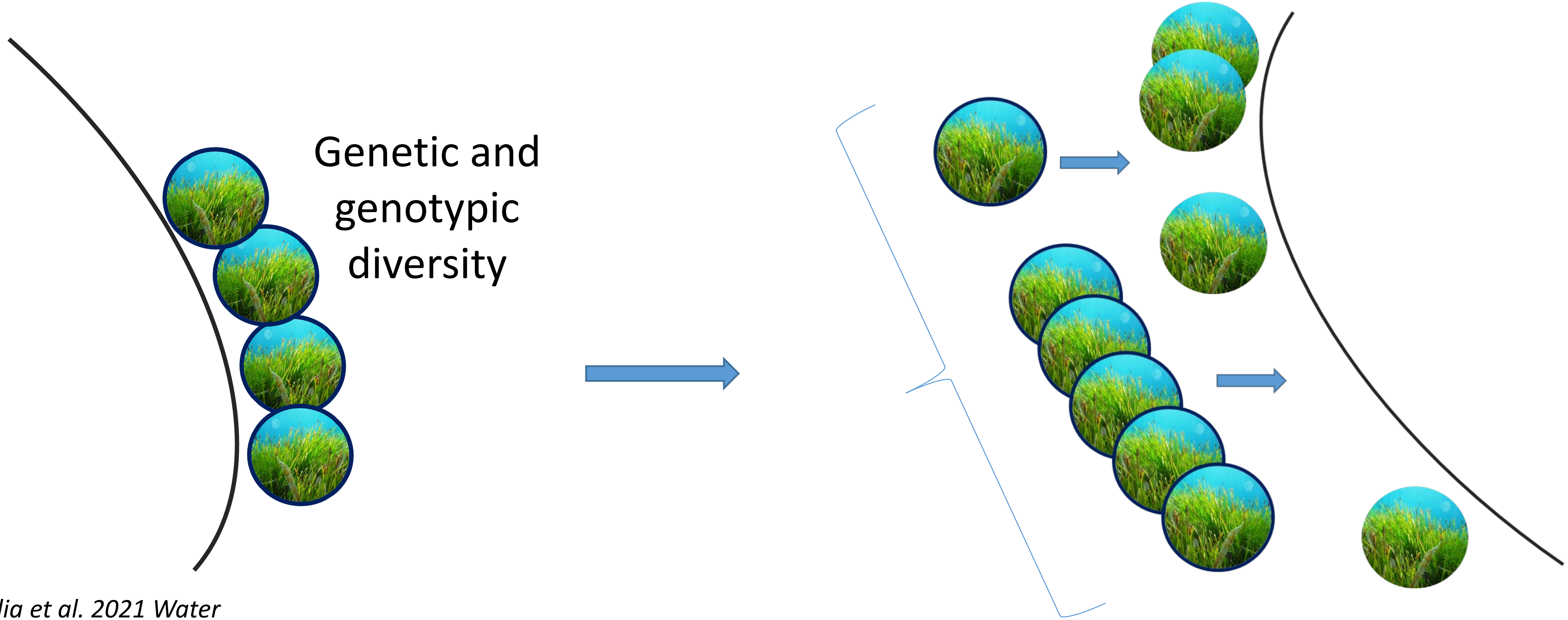
Genetic diversity
Connectivity
Local adaptation



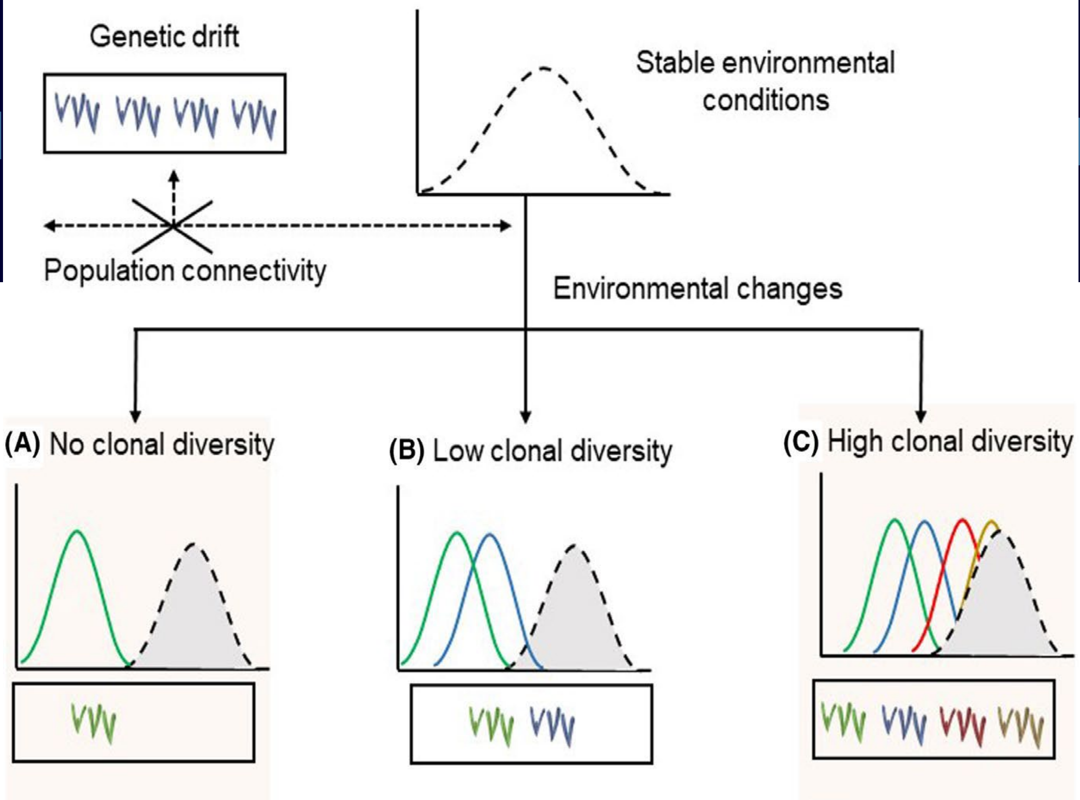
Pazzaglia et al. 2021 Water



Genetic diversity and distribution



Pazzaglia et al. 2021 Water

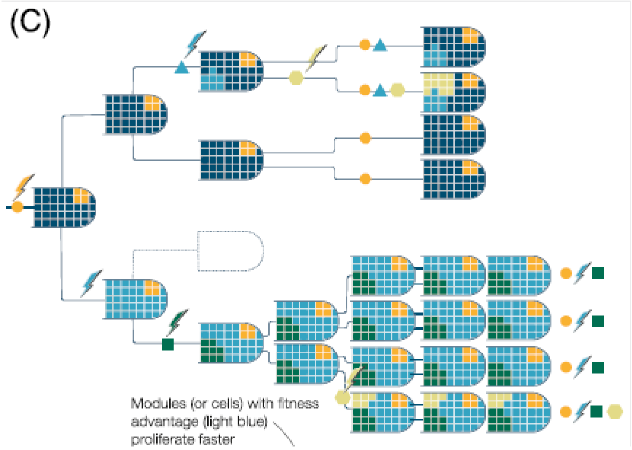


Spatial genetic structure

gene flow

Genotypic diversity

number of genotypes within a population



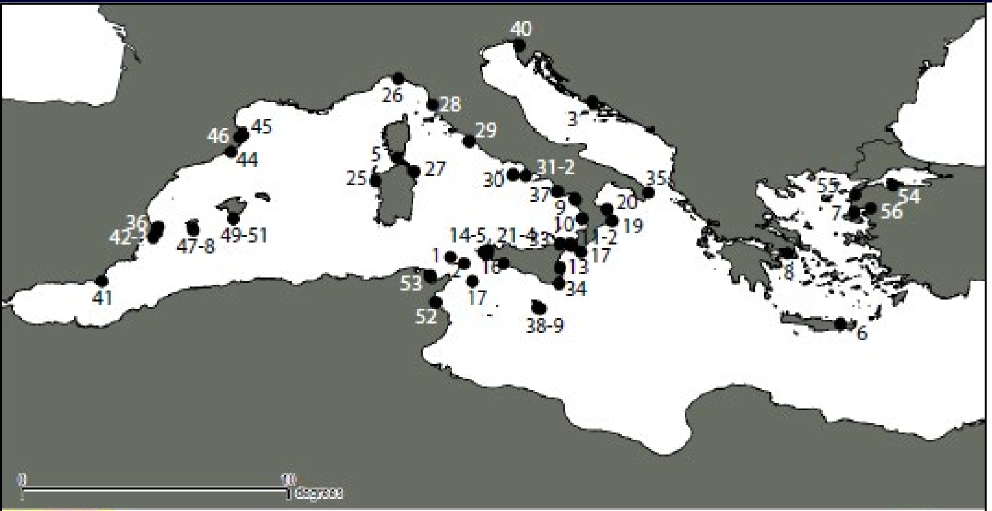
Genetic diversity

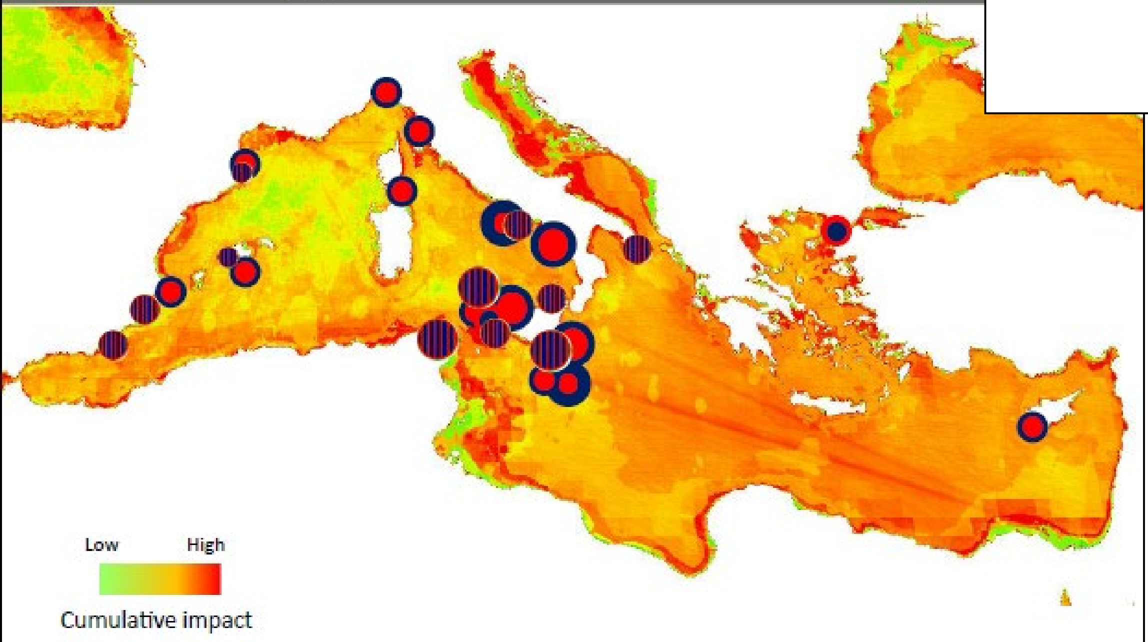
allelic richness, heterozygosity, epigenetic diversity

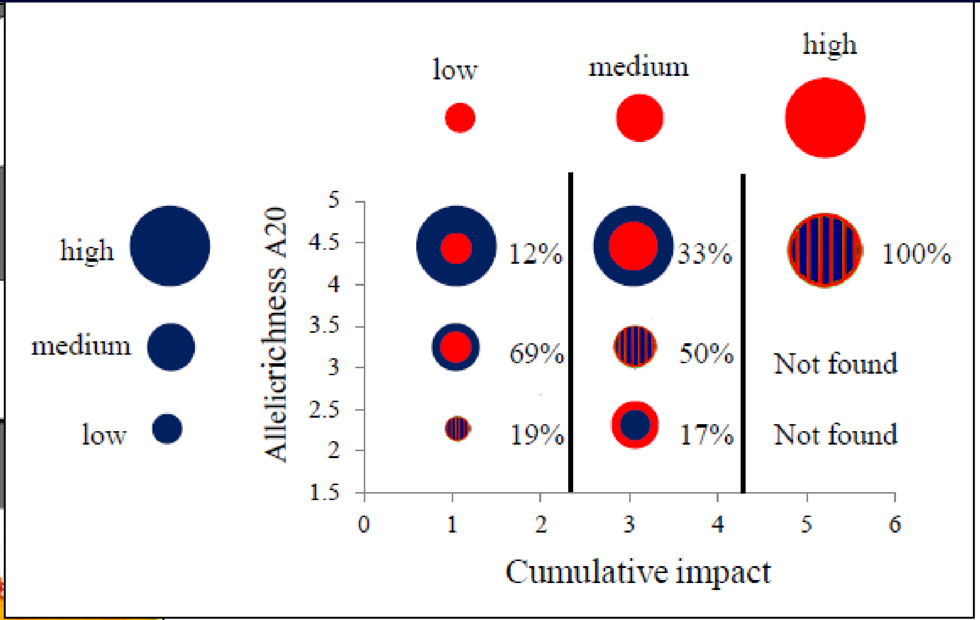
Resuch et al., 2021 – TREE

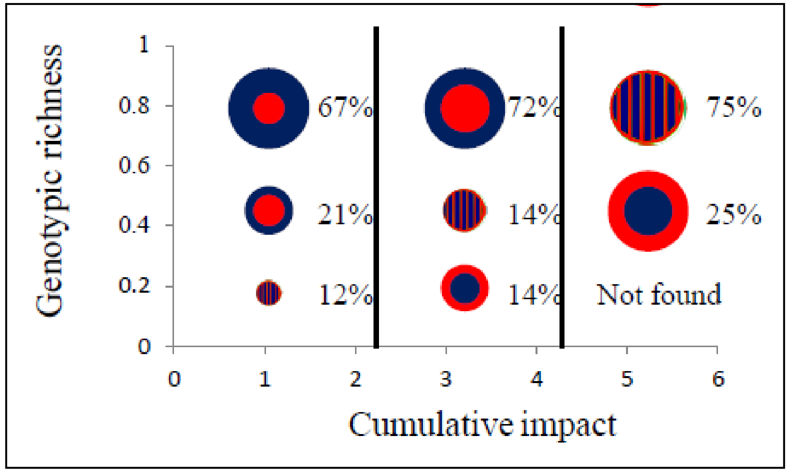
Pazzaglia et al., 2021 – Evol Appl

Genetic diversity matters - Disturbance and genetic diversity





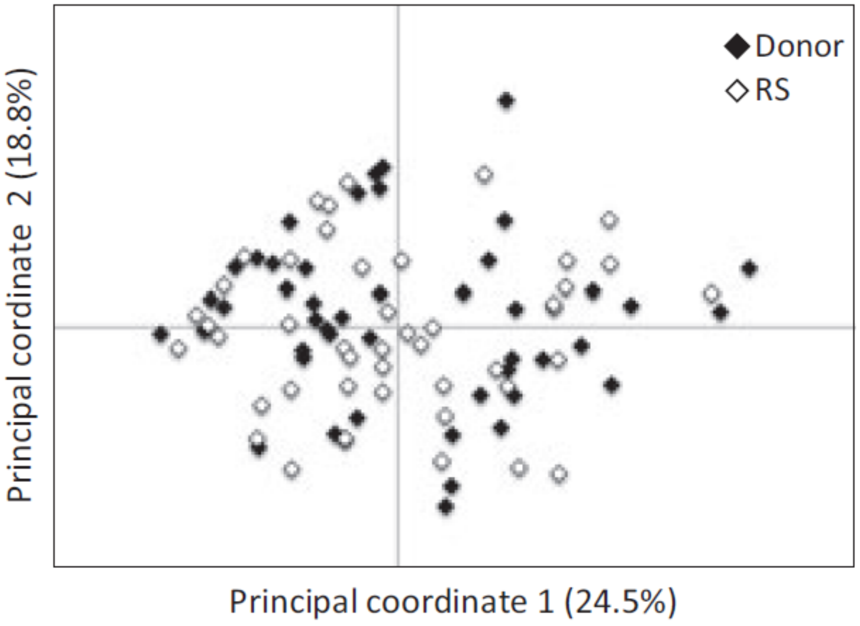




Blue: Allelic/Genotypic richness
Red: cumulative impact

Jahnke et al., 2015 – Mol Ecol

Genetic diversity matters – A successful example of restoration



Restoration of *Posidonia australis* in 3.2 hectares of bare sand at 2.2–4.0 m depth on Southern Flats, Cockburn Sound, WA

Donor material sourced on Parmelia Bank, at the northern end of Cockburn Sound, approximately 16 km away from the recipient site

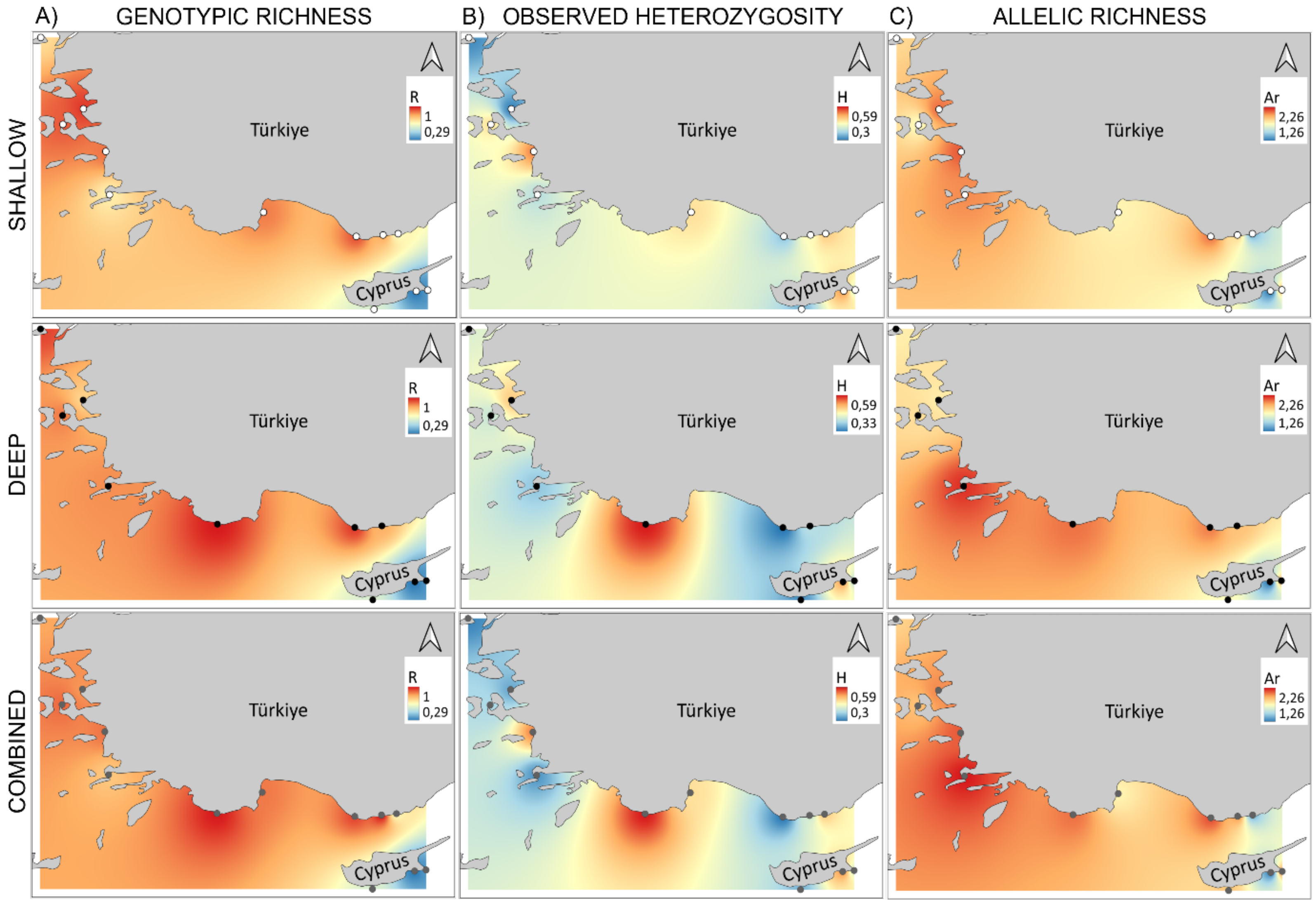
The restored meadow was healthy and expanding 5 years after transplantation

Sample site	N	Area (m^2)
Donor site	47	900
Restoration site	47	1963

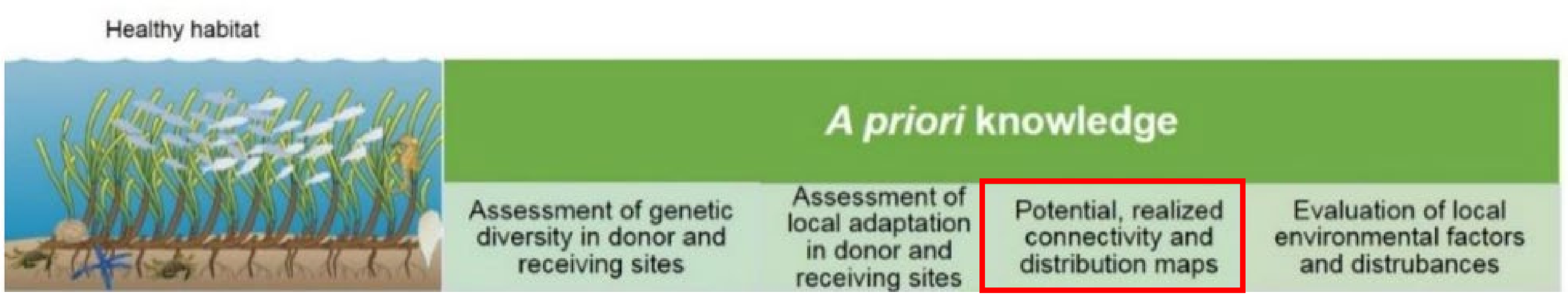
MLG	R	Na	p[I]	H_o	H_e
46	0.98	40	7	51.3	53.1
45	0.96	44	11	47.8	50.0

Sinclair et al 2013 Ecol Man Rest

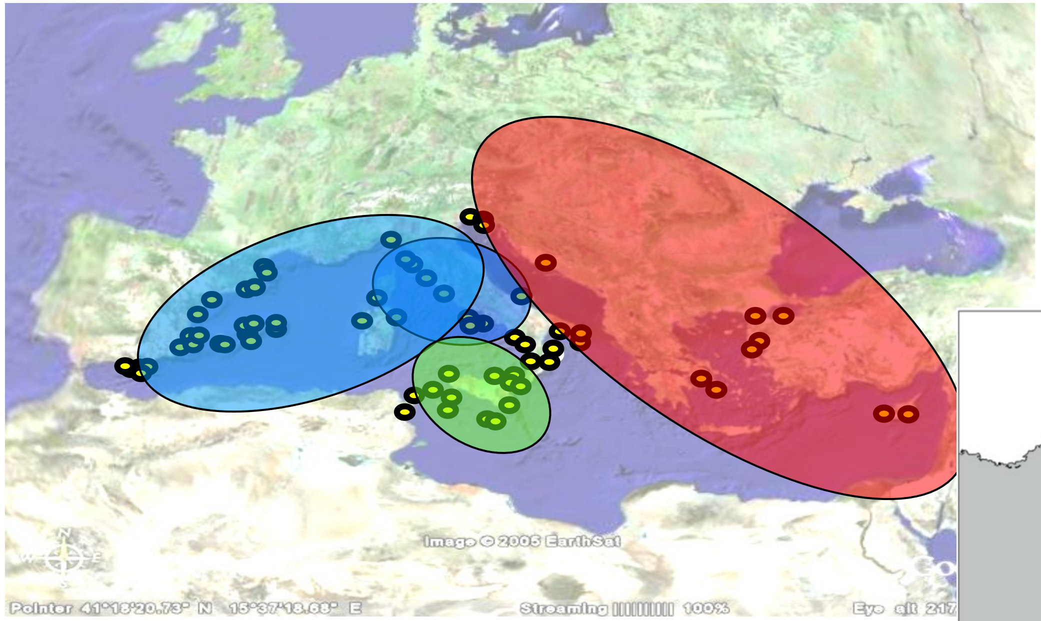
GIS mapping of genetic diversity



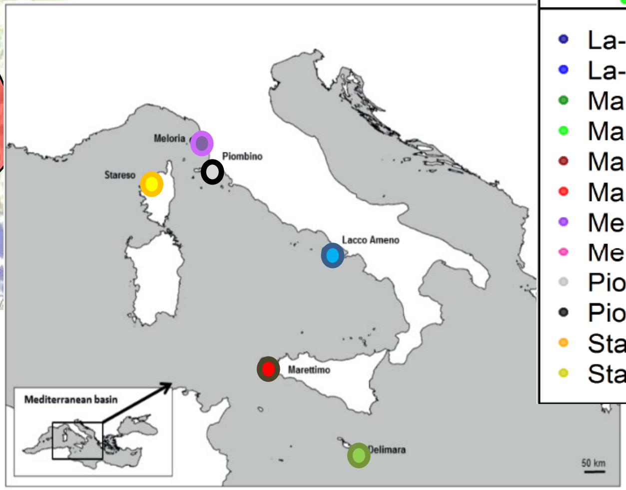
Haverbeck et al, in prep.



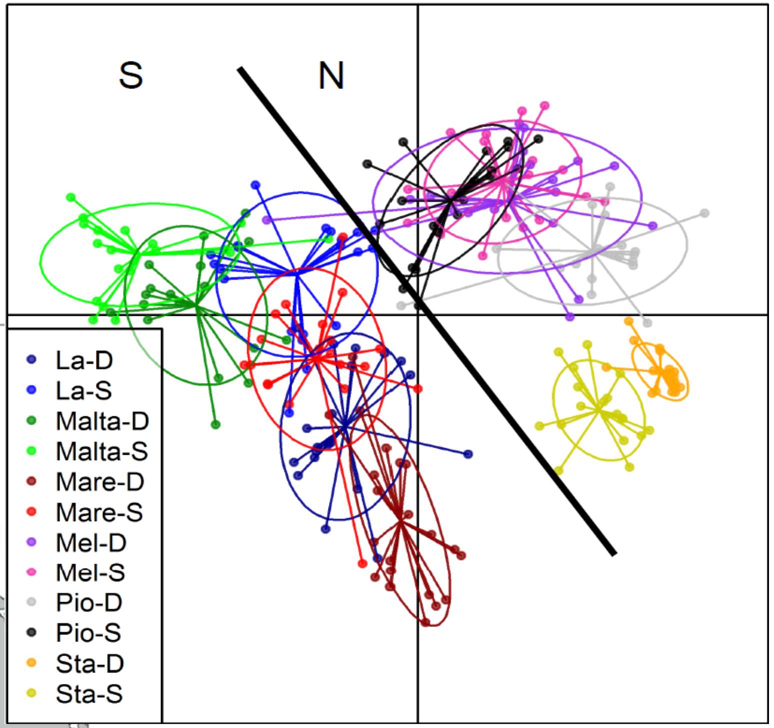
Population connectivity



Serra et al 2010 Mol Ecol



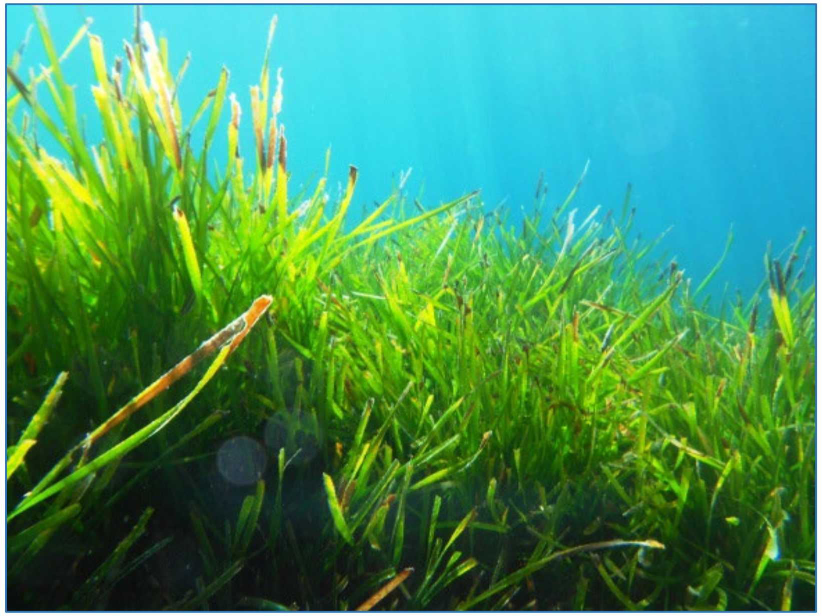
Pazzaglia et al. 2021 Water

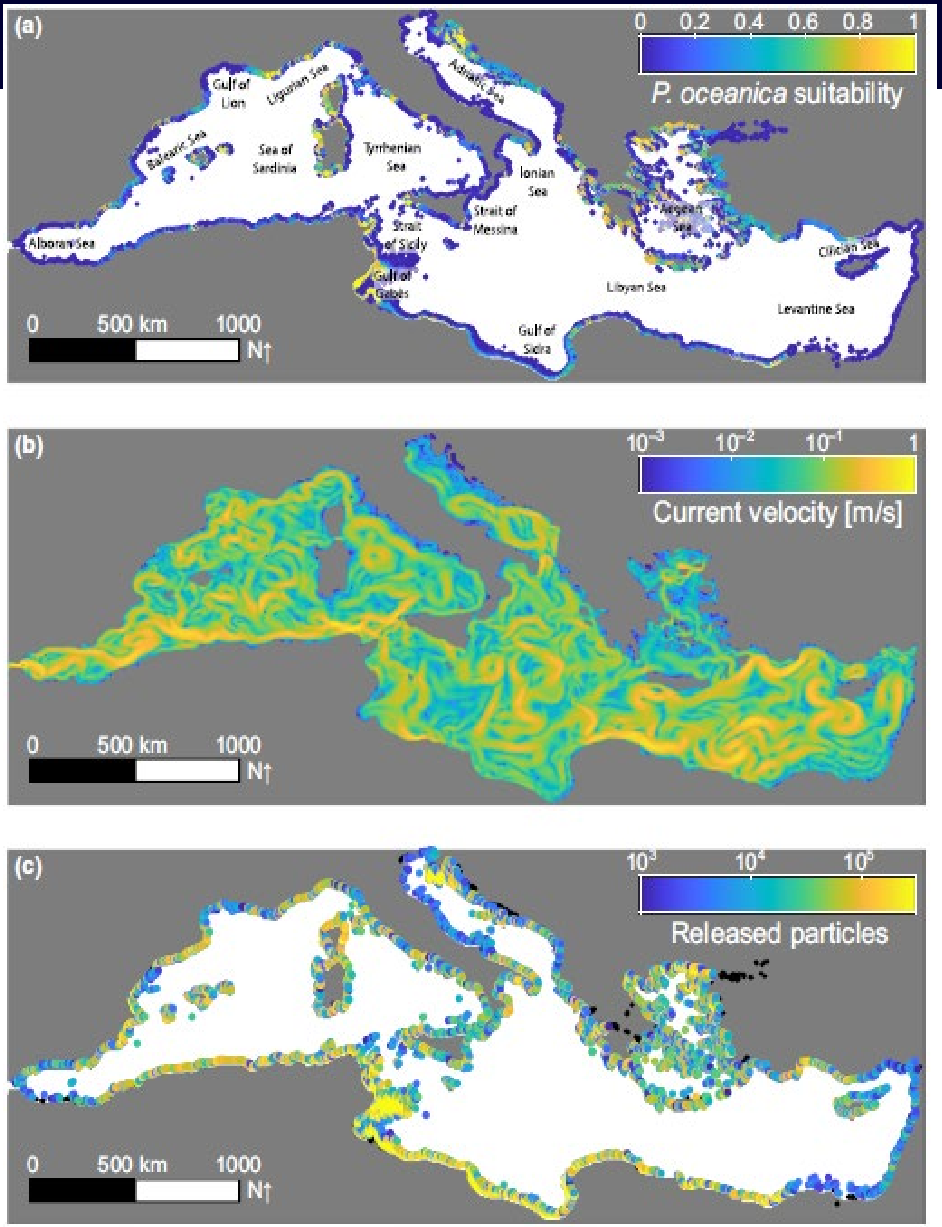


Jahnke et al 2019 Heredity

Potential and realized connectivity

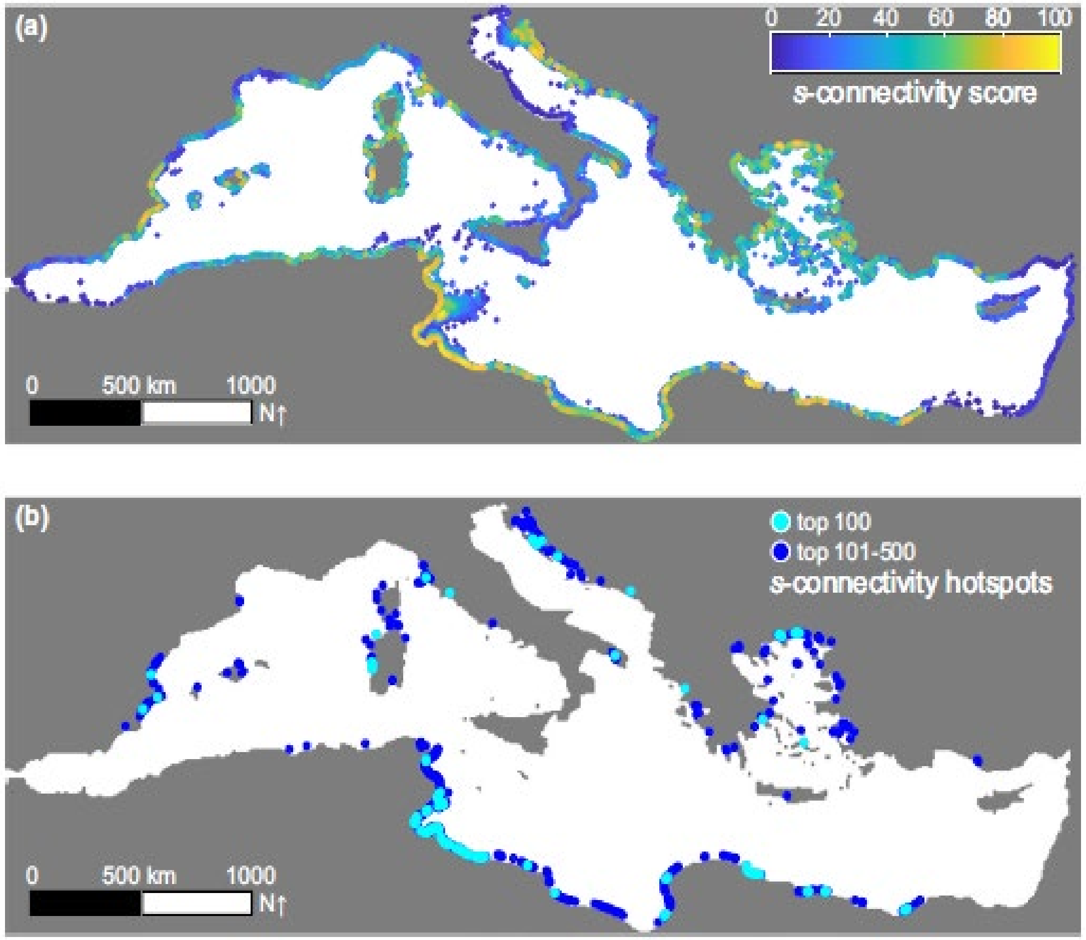
Posidonia oceanica in the whole Mediterranean basin

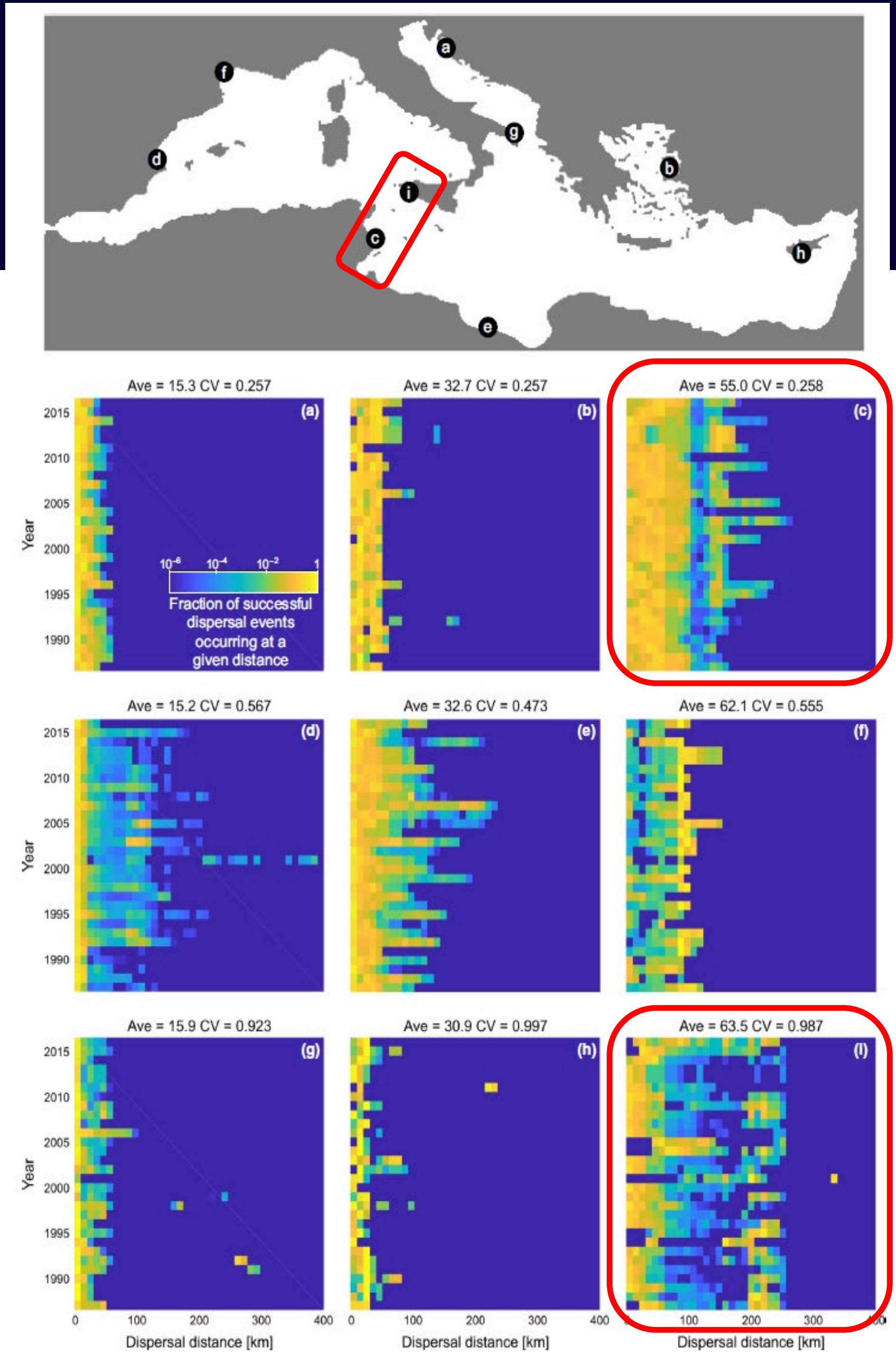




Mari et al 2020 Div Distr

Potential and realized





Mari et al 2020 Div Distr

Potential and realized connectivity

A focus on Western Sicily

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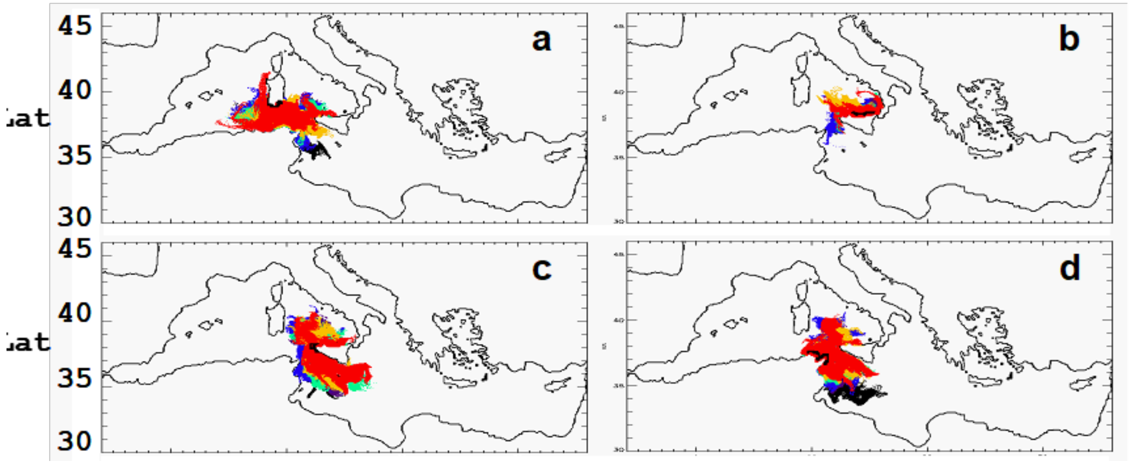
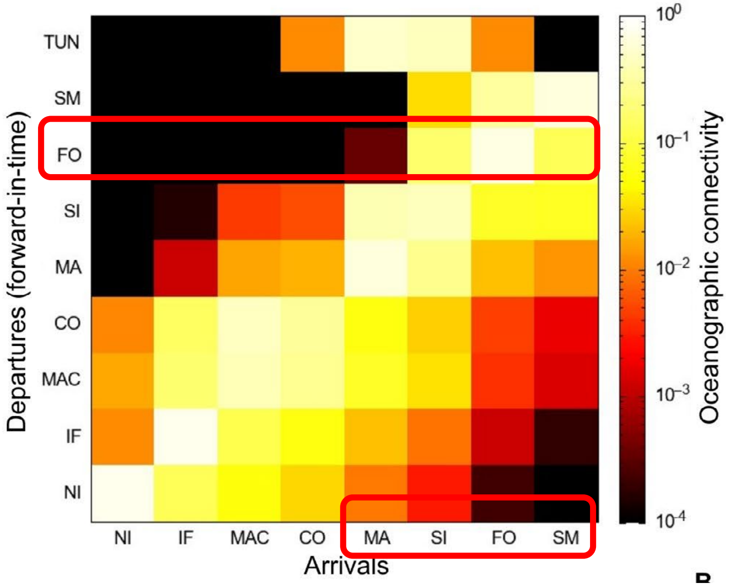
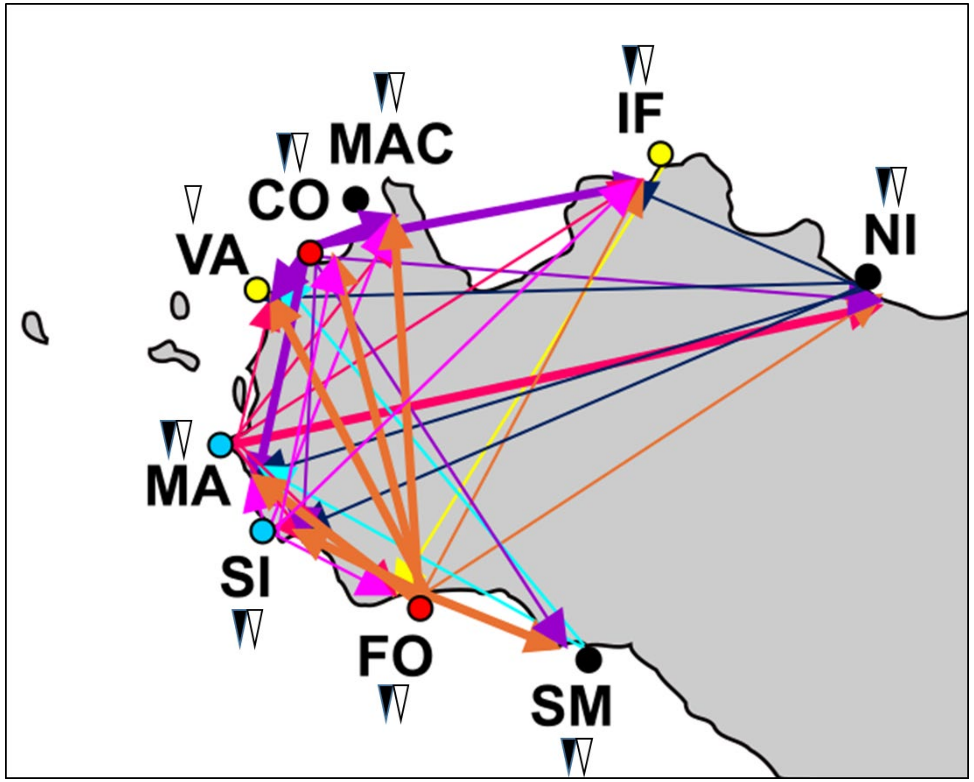


Serra et al 2010 Mol Ecol



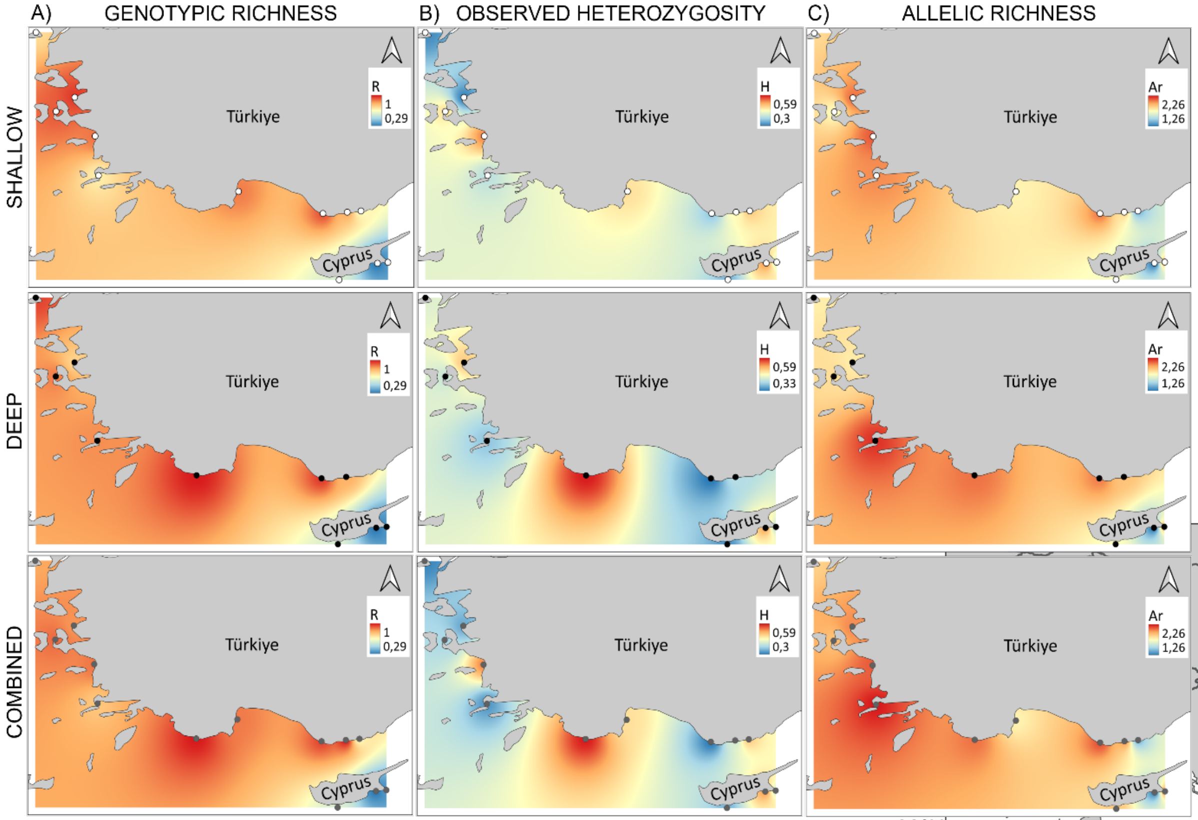
Population connectivity

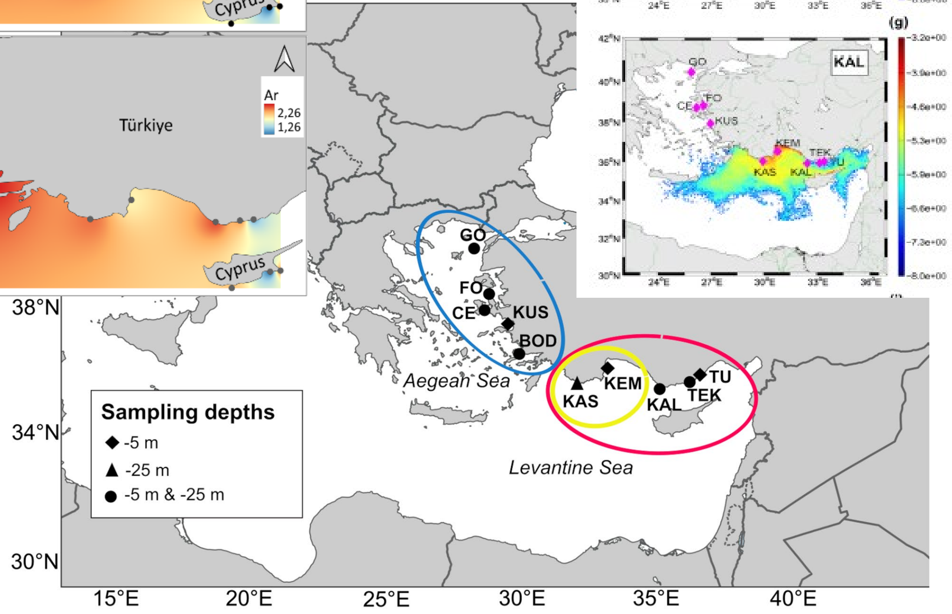


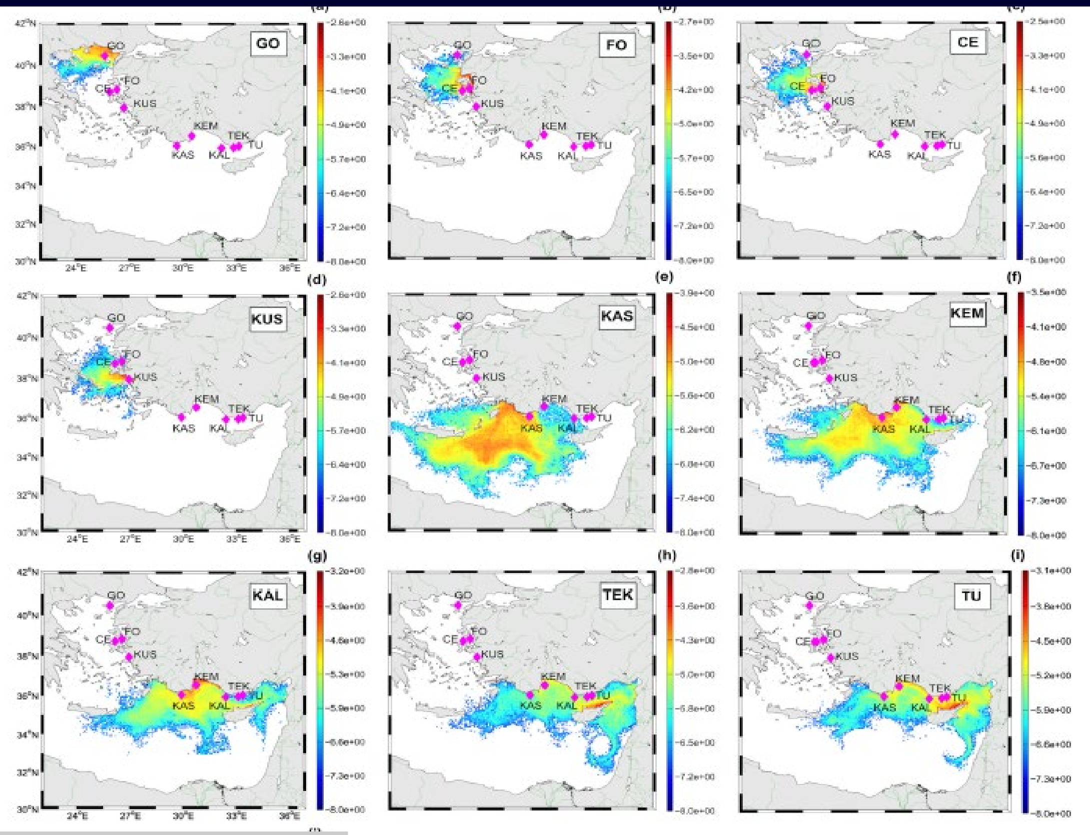
Ruocco et al 2024 Div Distr

GIS mapping, potential and realized connectivity

2° ESRW
Arcachon 2025

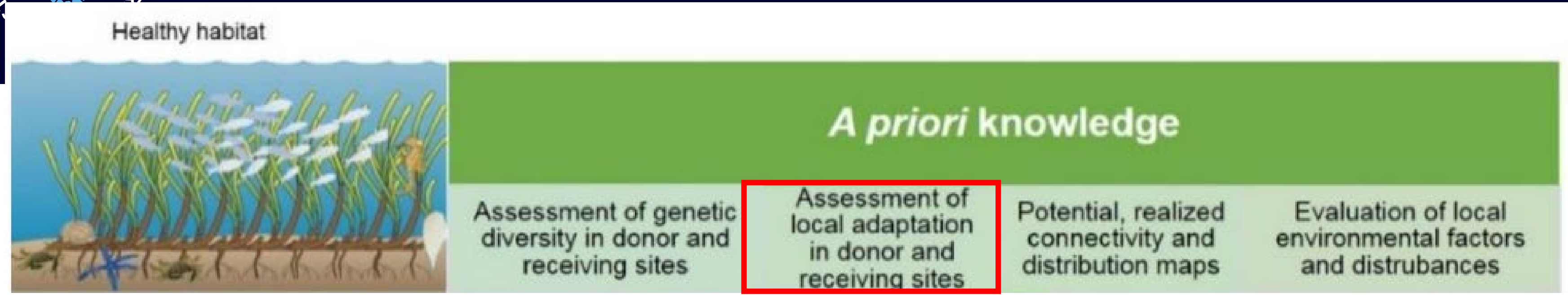






Tutar et al. 2022 ICES JMS

Local adaptation



Local adaptation

Accurancy and **Functionality** in selecting donor populations

“space-for-genotype” substitution: we expect that populations near one another, and growing in similar conditions, will be more similar genetically due both to ecotypic variation and the effects of gene flow.

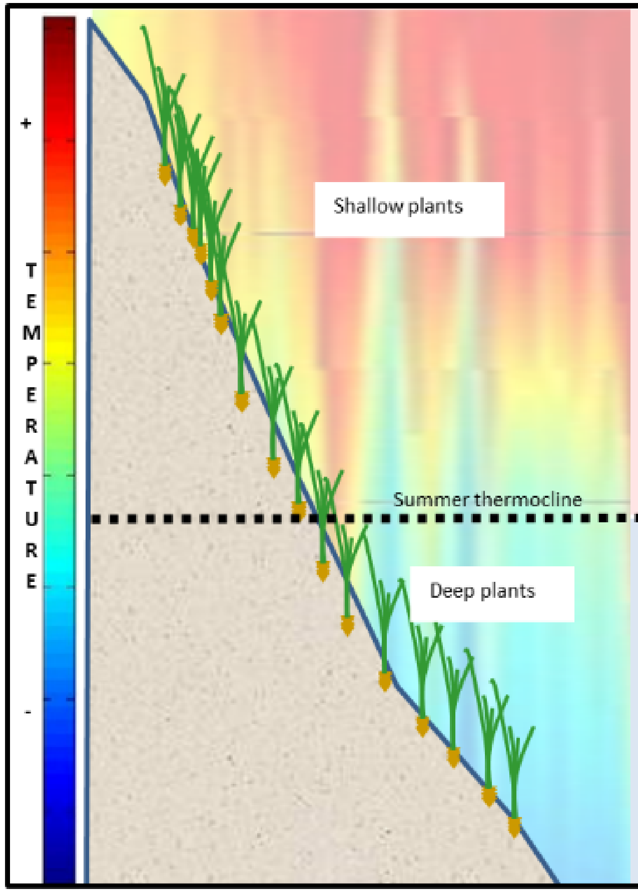
Assisted migration Vs genetic pollution

Introduced populations **may hybridize with the existing native population**, introducing new genes (**genetic pollution**) and potentially negatively affecting genetic integrity

Pazzaglia et al. 2021 Water

Difference in gene expression along depth

Shallow and deep plants are **locally adapted** to the existing environmental conditions and show limited plasticity.



Shallow plants

PHOTOSYNTHESIS

psbB (5.2), psbC (13.6), psbD (13.2), psbE (7.7), psaA (7.6), psaB (7.9), petA (9.5), petB (7.4), ndhB (17.8), ndhF (7.0), ccsA (18.5), atpF (6.8), atpA (5.5), atpB (5.1), rbcL (2.8), psbR (58.7), psbK (65.3)

HSPS & CHAPERONES

CPN60II (3.5), HSP1 (3.2), FES1 (3.3), HSP90-6 (2.4), CPN10 (2.3), AHSA1 (3.9), HSP70 (2.4), HSP90 (2.2), HSC70-1 (39.2), HSP70 (3.9), HSP90-7 (6.4), ATJ6-like (2.8), FKBP62-like (3.0), BAG6 (26.5), Chaperone-domain superfamily (4.6), DnaJ protein (12.6), HSP83 (34.6), Class I HSP (32.0), Class I HSP (34.6), sHSP (26.5), Class I HSP (44.8)

RESPIRATION

COA6 (2.3), Protein midA-like (2.1), Ubiquinol-Cytochrome C reductase (2.2), H⁺-translocating NAHD-quinone oxidoreductase (34.8)

OXIDATIVE STRESS

APX1 (2.2), APX2 (2.0), CCS (3.3), FER3 (4.5)

HSFs

HSFA6b (2.7), HSFB2b (2.2)

METHYLATION

RECQL5 (2.4), MSH1 (2.4), MSH7 (3.2), BRCA1 (3.6), B3GALT5 (4.0), Ash2l (91.3), RPL7D (6.5), rsmB (7.1), TOP3 (4.6)

Deep plants

PHOTOSYNTHESIS

psbR (23.6), psbK (12.5)

HSPS & CHAPERONES

BAG6 (13.9), Chaperone-domain superfamily (6.8), DNAJA1 (5.2), HSP82 (9.1), HSP83 (10.1), Class I HSP (12.0), sHSP (9.2)

RESPIRATION

--

OXIDATIVE STRESS

HRPA2 (101.0)

HSFs

--

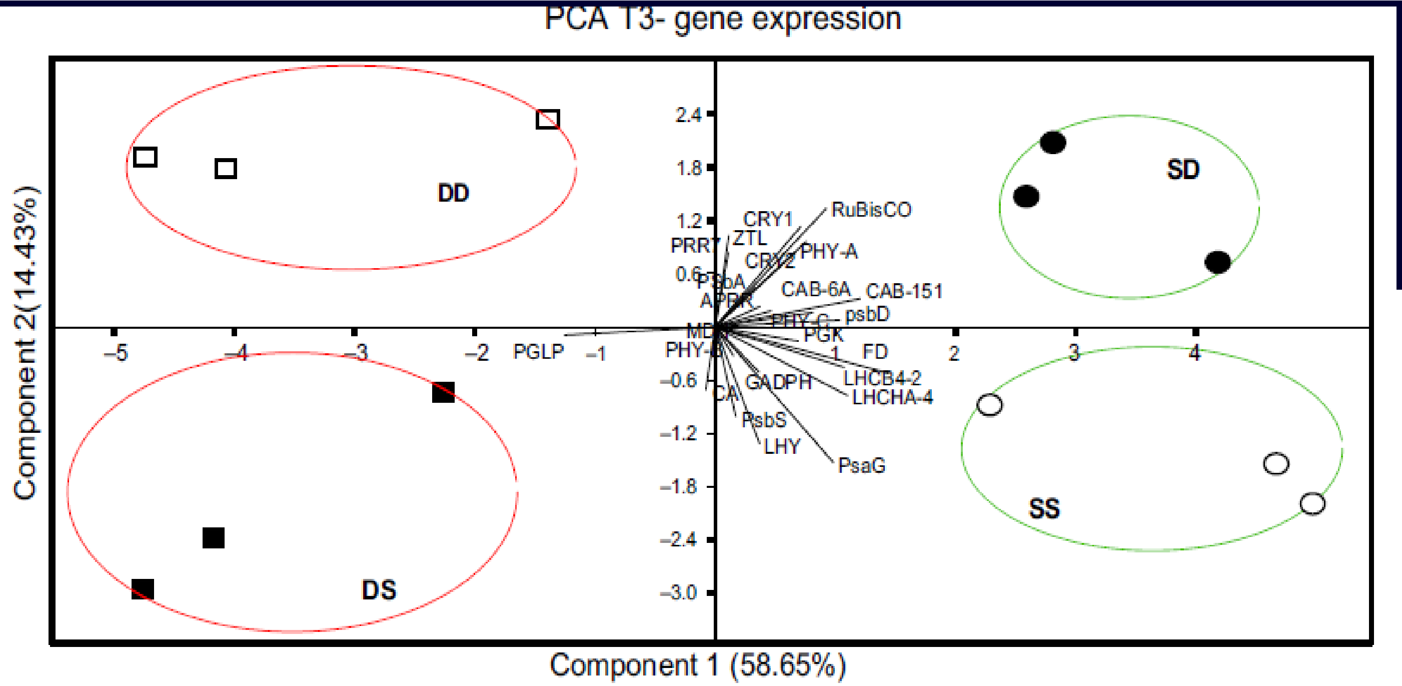
METHYLATION

TOP3 (4.3)

Marin Guirao et al., 2017 Fr Plant Sci

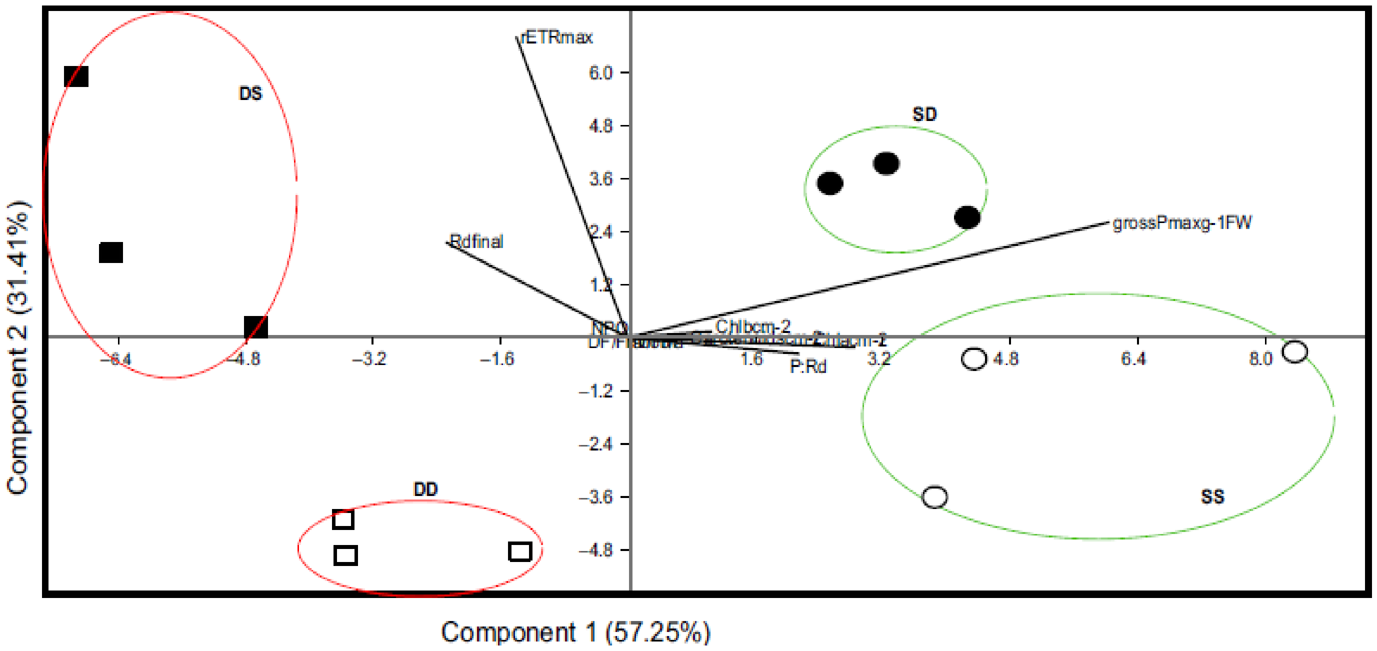
STAZIONE ZOOLOGICA ANTON DOHRN
SZN

Plant exposed to reciprocal light conditions predominantly express their native phenotype



DEEP PLANTS **SHALLOW PLANTS**

PCA T3- photophysiology



Dattolo et al., 2017 Ecol Evol

Pre-adaptation to different thermal environments

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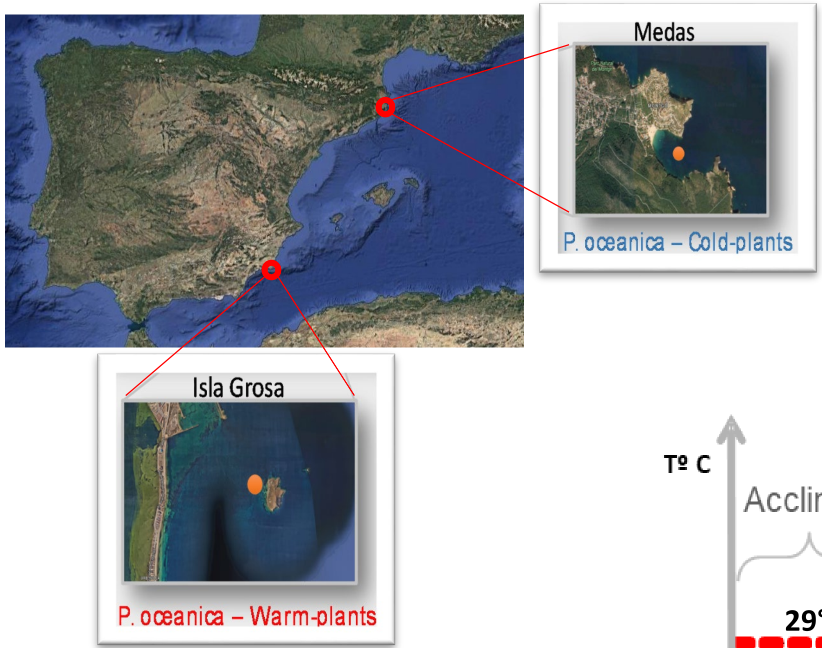
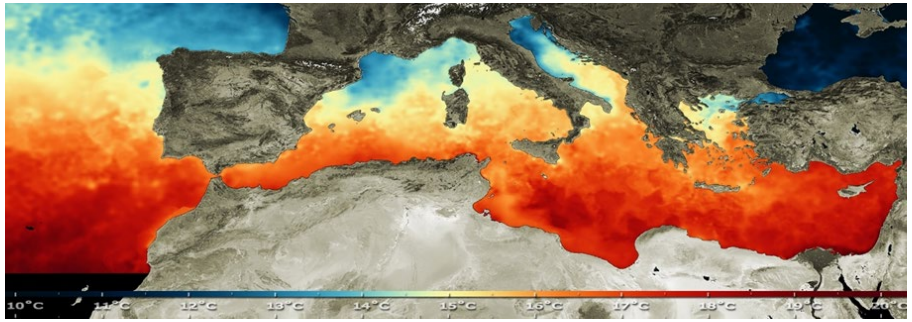
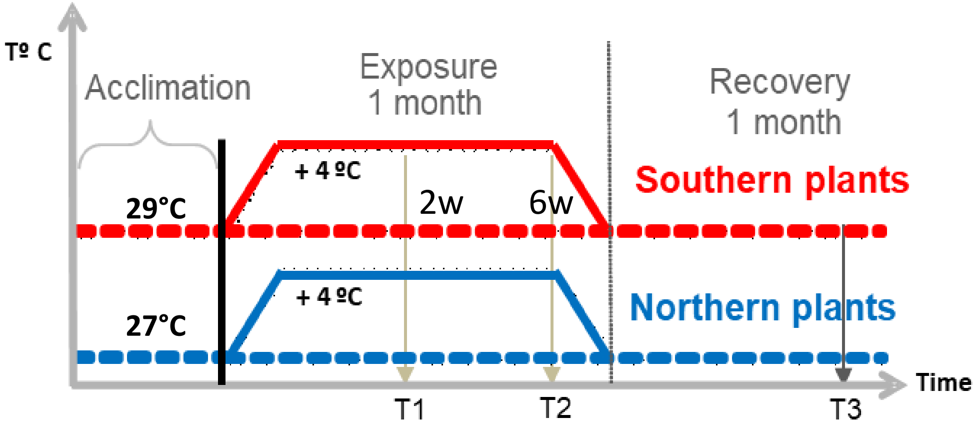
Long term exposure to heat stress of plants from a latitudinal gradient - *P. oceanica*





https://www.esa.int/spaceinimages/Images/2008/10/Mediterranean_sea_surface_temperature

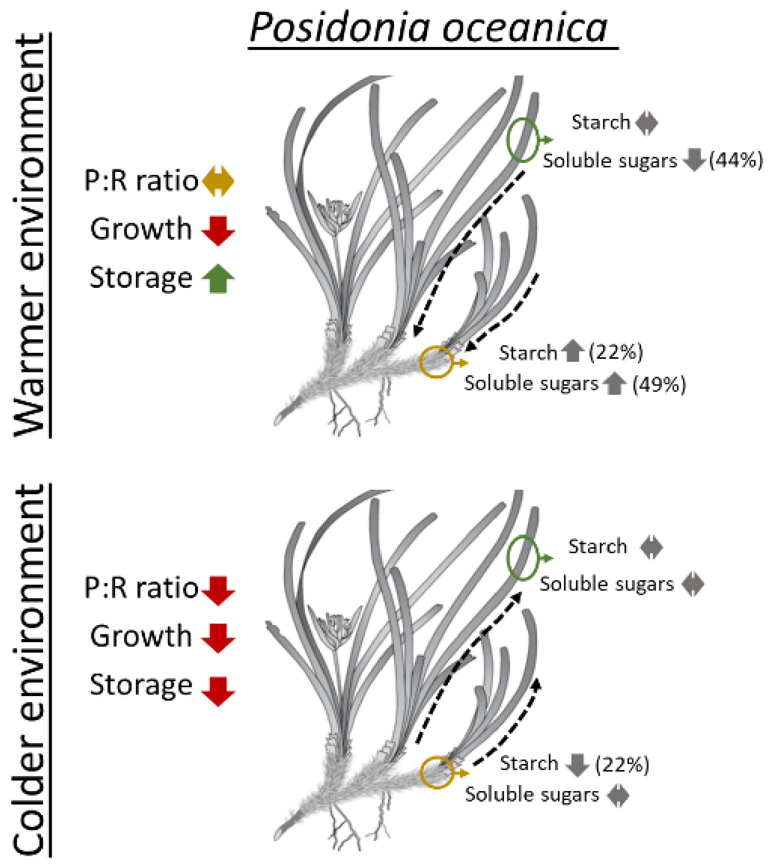


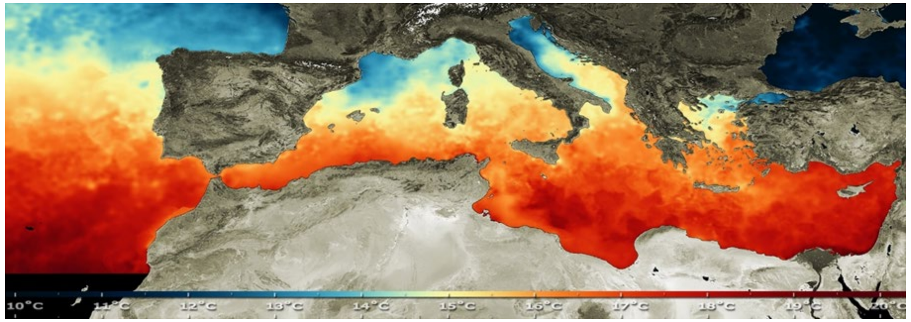
SAMPLING:

- PAM: weekly
- Mortality: weekly
- Antioxidant activity: T2 & T3
- Carbohydrates: T2 & T3
- Photosynthesis & Respiration: T2 & T3
- Pigments: T2 & T3
- Growth: T2 & T3
- Morphology: T2 & T3

Marin Guirao et al., 2018 Mar Poll Bull

Pre-adaptation to different thermal environments





Plants from colder environments are more affected by warming

Marin Guirao et al., 2018 Mar Poll Bull

Pre-adaptation to different thermal environments

2° ESRW
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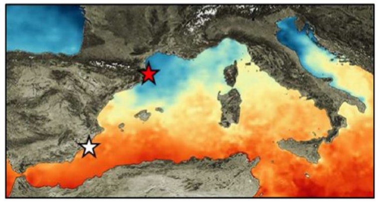
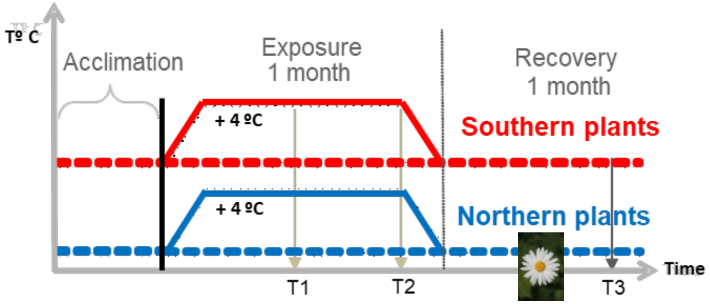
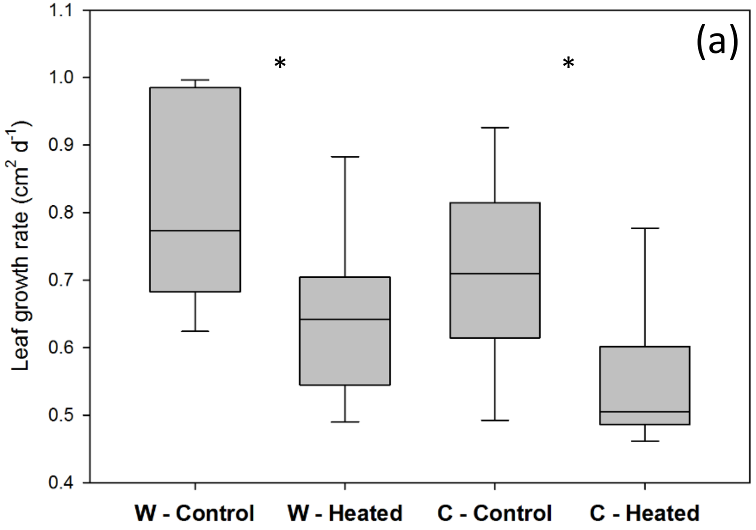
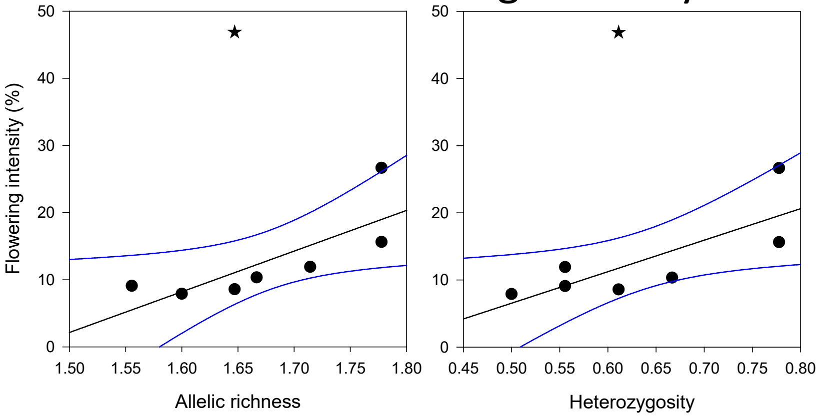
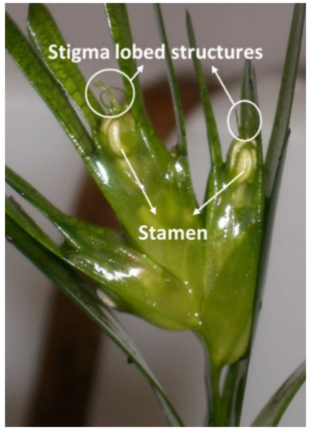






Genetic diversity of flowering plants correlate with flowering intensity





Ruiz et al 2017 Mar Poll Bull; Marin Guirao et al., 2018 Mar Poll Bull

Stress response to warming

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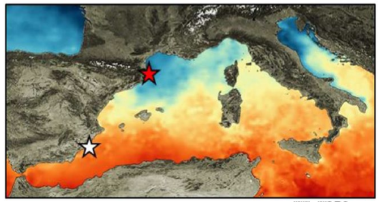

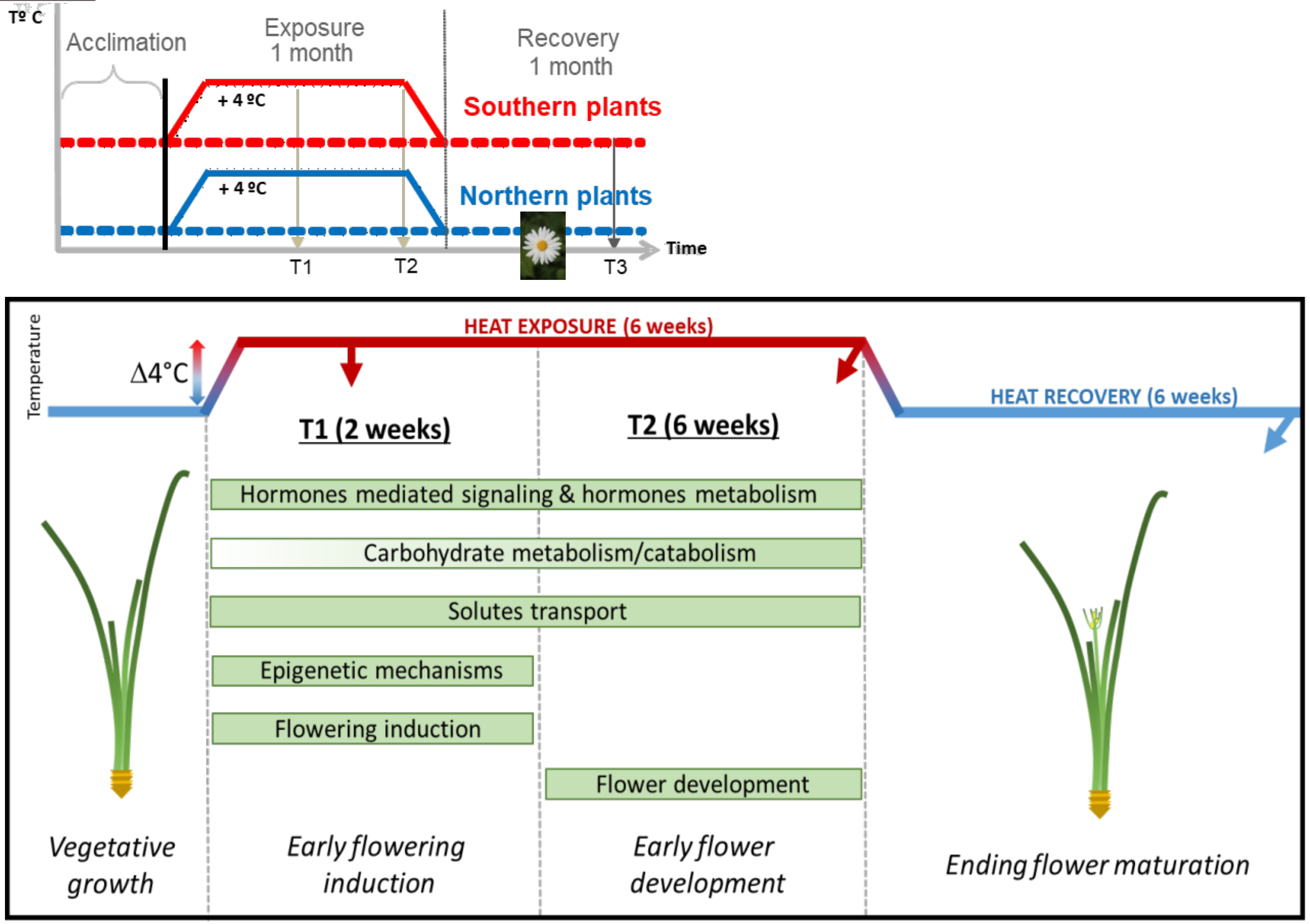

Flowering induction starts already after two weeks of warming

Flower development genes are expressed when flowers are still not visible

Marin Guirao et al., 2019 Mol Ecol

A synthesis

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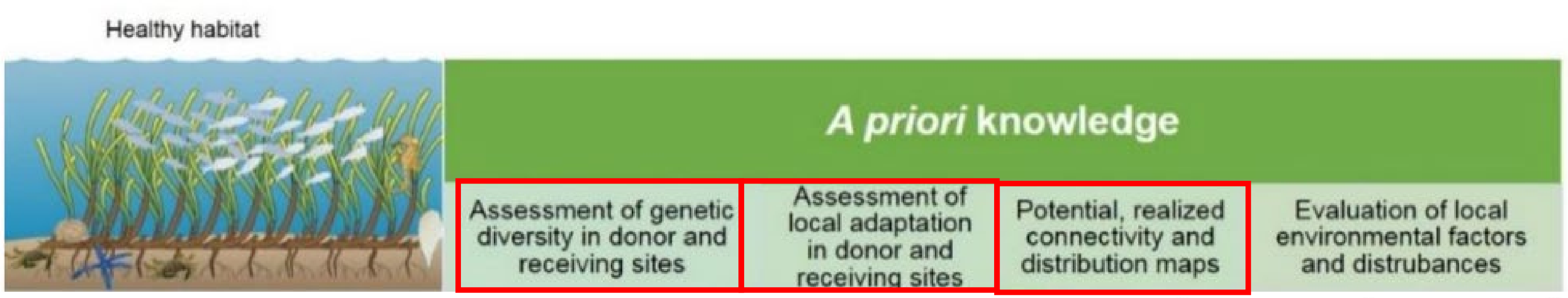
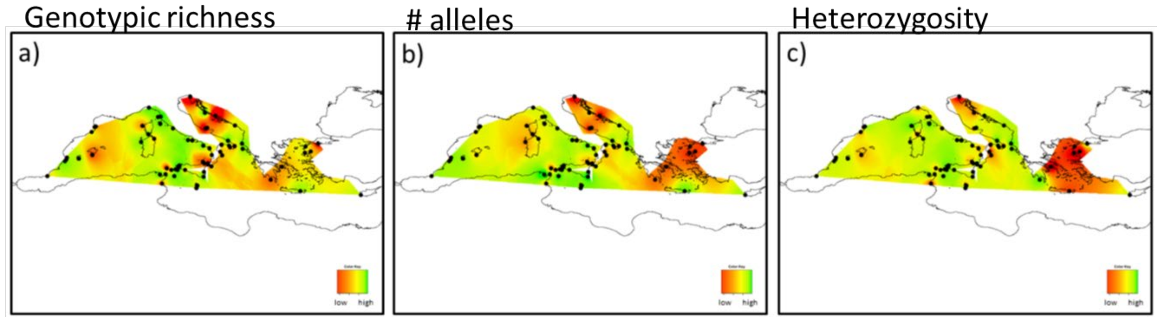
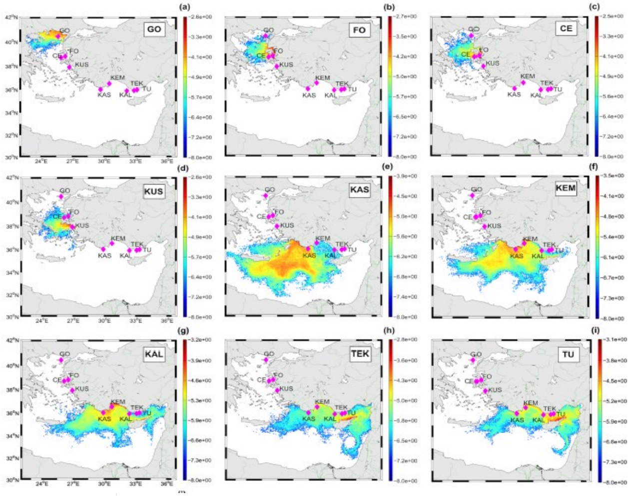
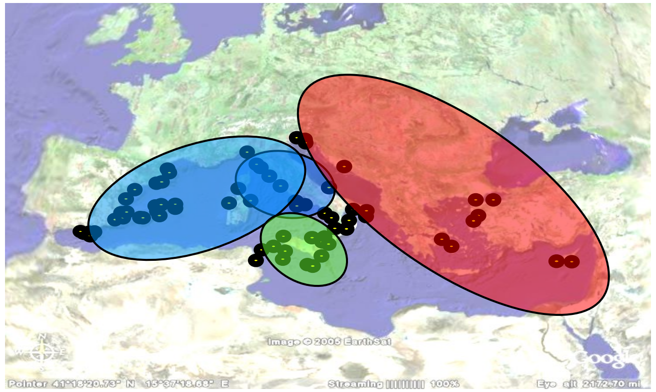
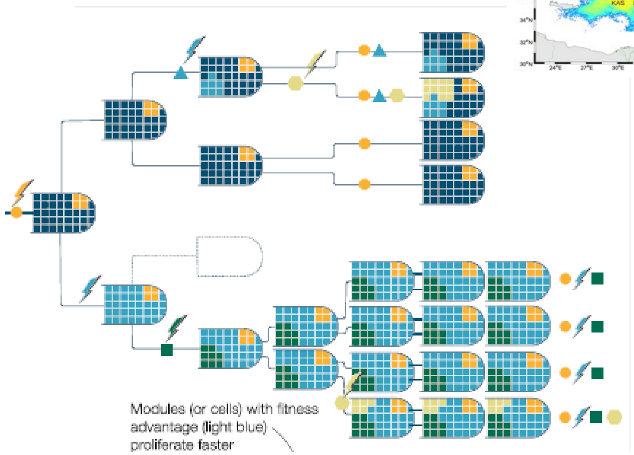
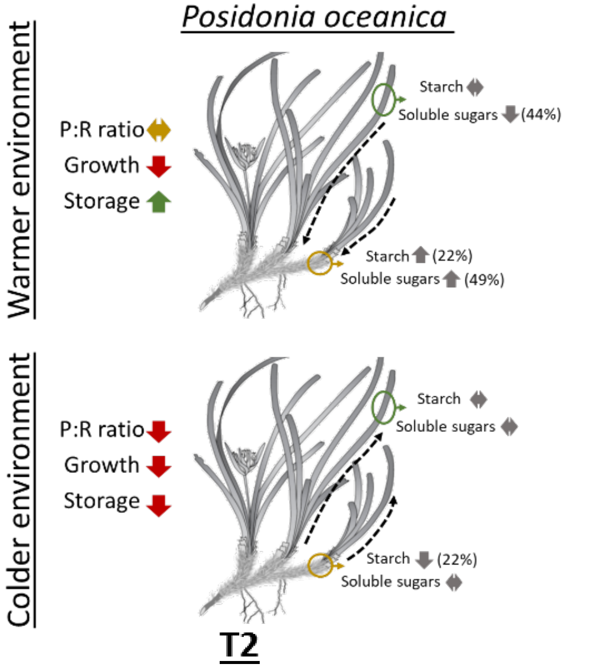


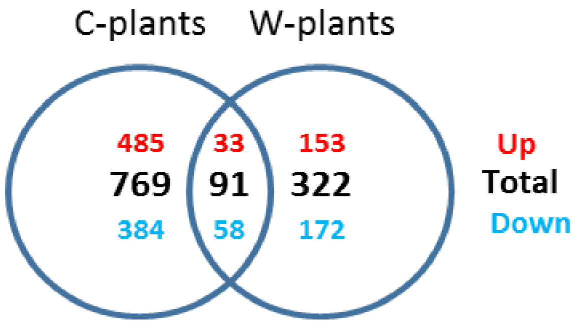


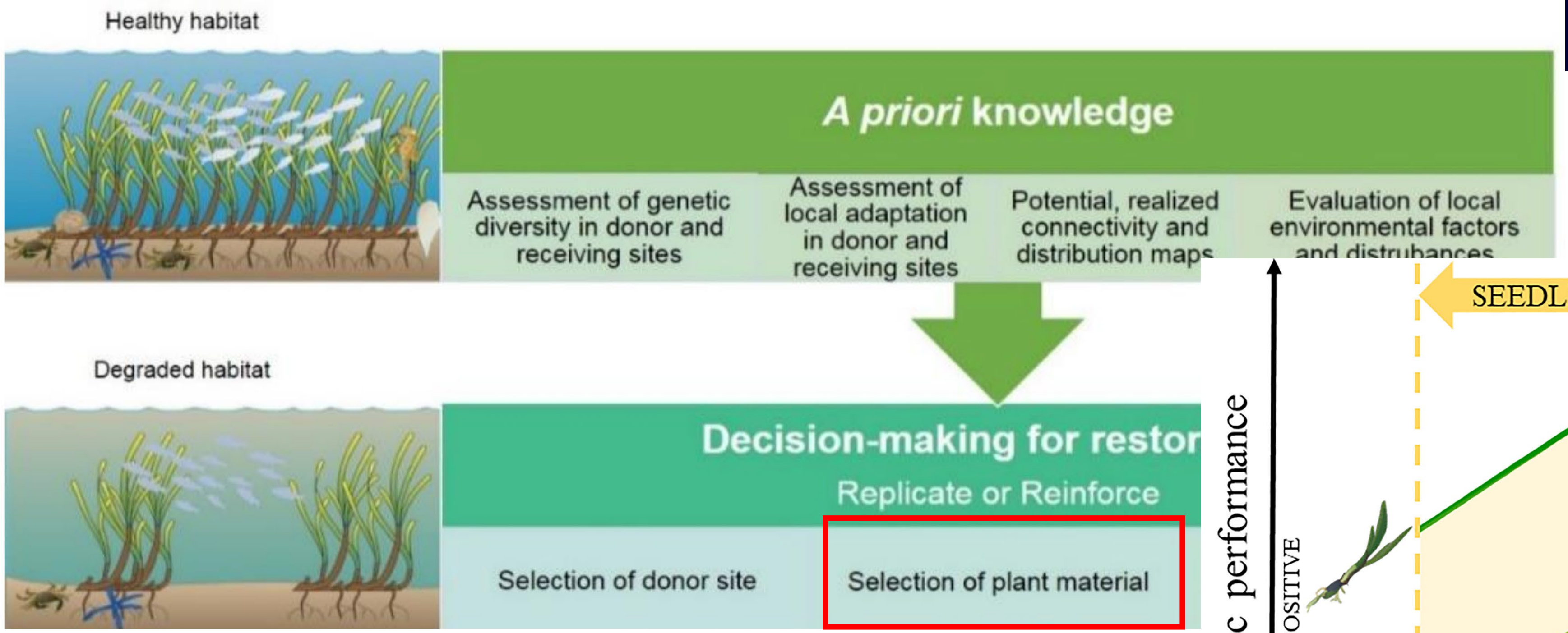






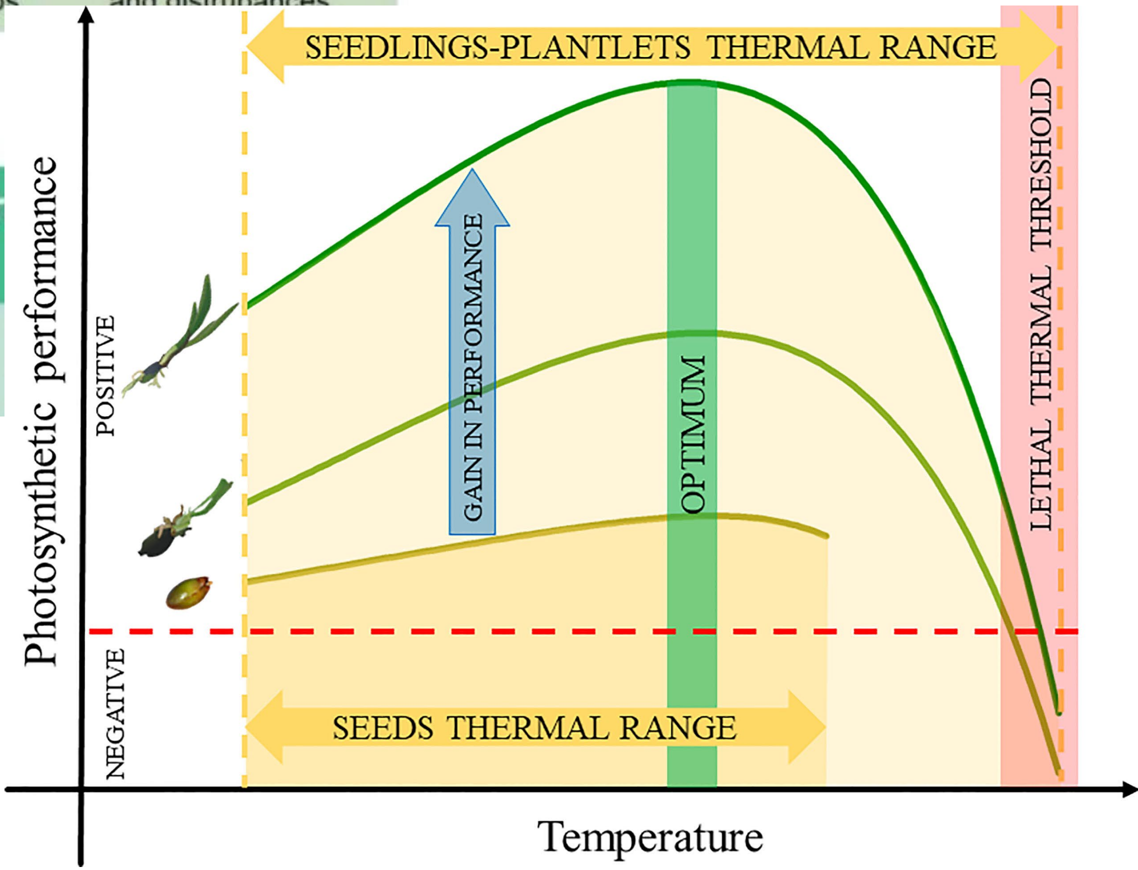






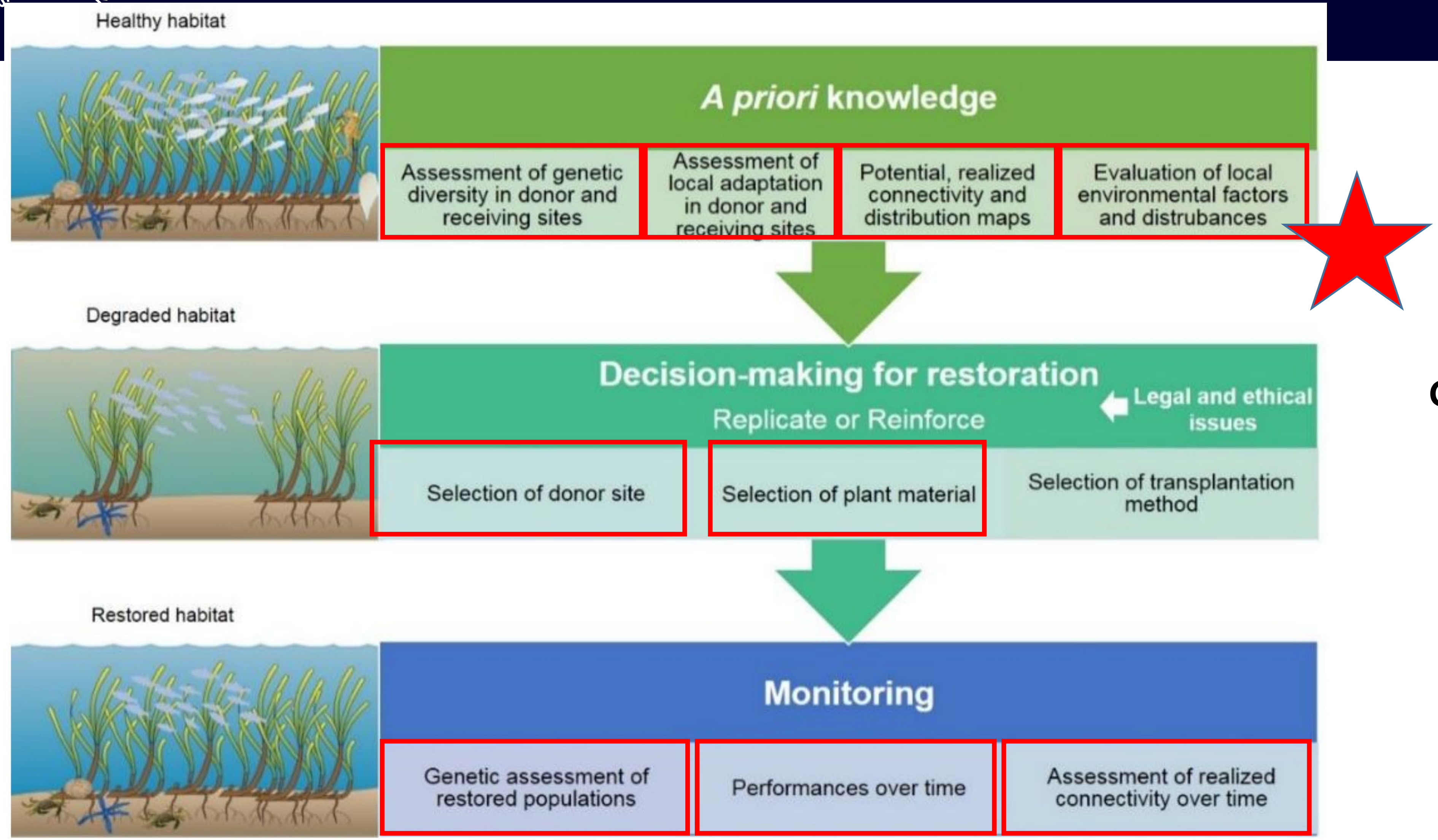
Seedlings
Seeds
Plant fragments

Higher genetic diversity



Pazzaglia et al. 2021 Water

Rinaldi et al 2023 Fr Mar Sci



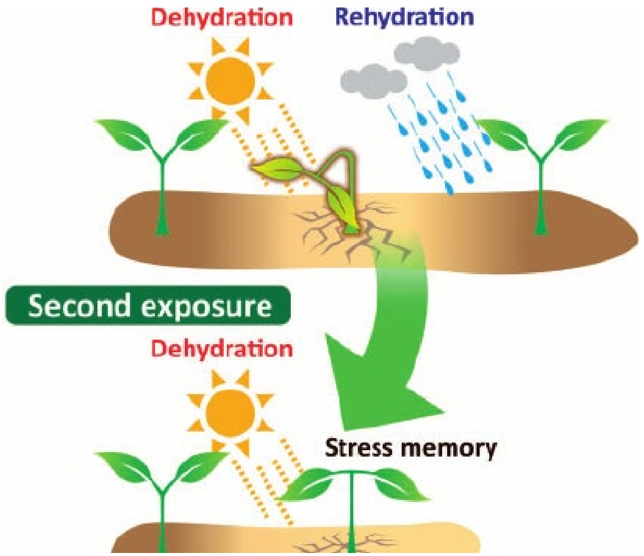
Genetic diversity and distribution

Local adaptation

Monitoring

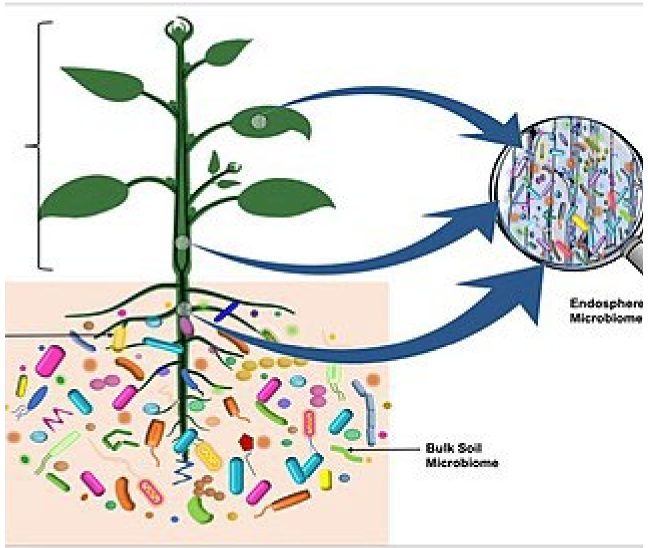
Pazzaglia et al. 2021 Water

Assisted evolution and assisted migration



Priming genotypes

Selection of resistant genotypes



Microbiome

See Posters 17, 31 and 32

Thank you for your attention

Hans von Marées, 1873 (particular) - Fresco Room SZN

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GPRO_group

Past group members:

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