BUNDES FORSCHUNGS ZENTRUM FÜR WALD

Biodiversity-friendly reforestation and tree planting: the role of tree species and genetic diversity to improve ecosystem services and resilience

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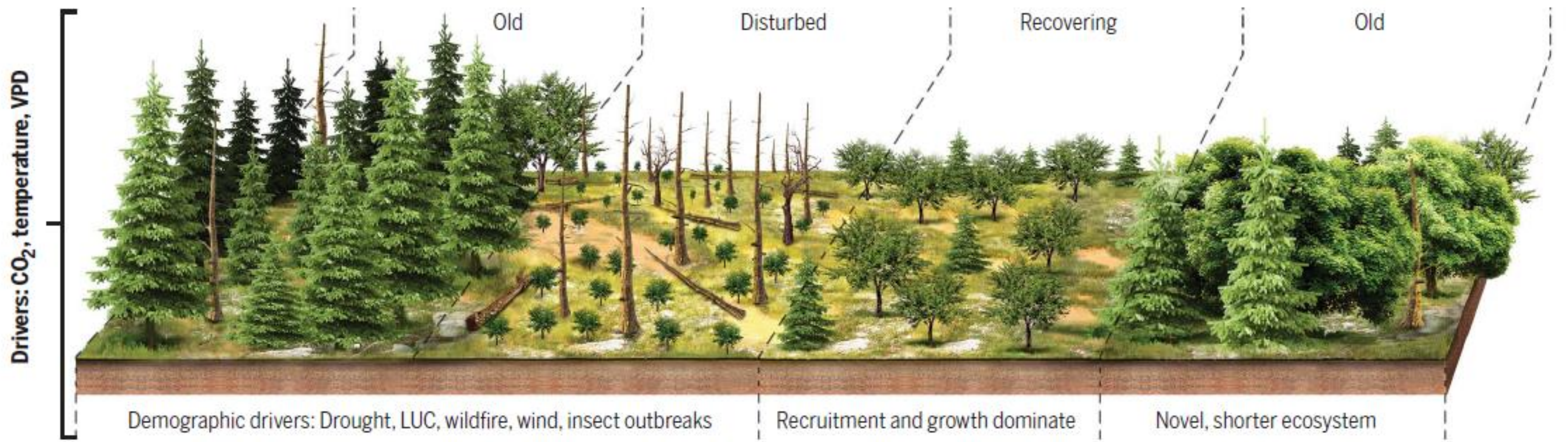
EC Workshop on Forest Guidelines

Helsinki
28. January 2025






Consequences of climate change

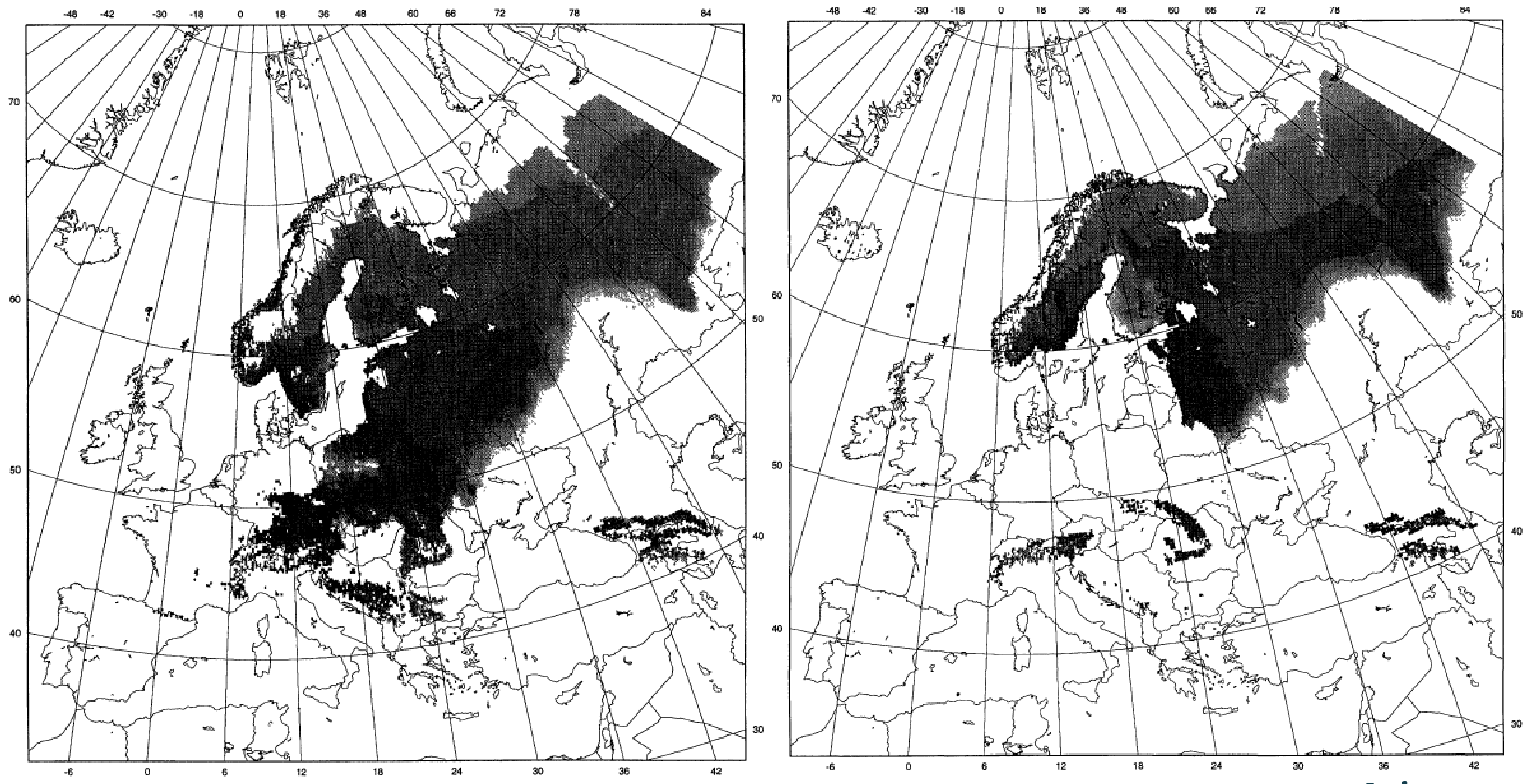


A conceptual diagram of the components of forest dynamics and the disturbances that drive them. In the far-left panel, a mature ecosystem is responsive primarily to localized mortality, and the primary drivers of demography are chronically changing variables such as CO_2, temperature, and vapor pressure deficit (VPD). In the next panel, the system is disturbed by fire, insect outbreak, or another large-scale perturbation that removes most of the overstory trees, and species adapted to rapid postdisturbance recruitment become established. In the third panel, recruitment and growth dominate demographic processes, with mortality increasing over time as competition leads to self-thinning. In the last panel, a mature ecosystem is dominated by species that have replaced the original community in response to chronic environmental changes, leading to a novel ecosystem.

McDowell et al., Science 2020

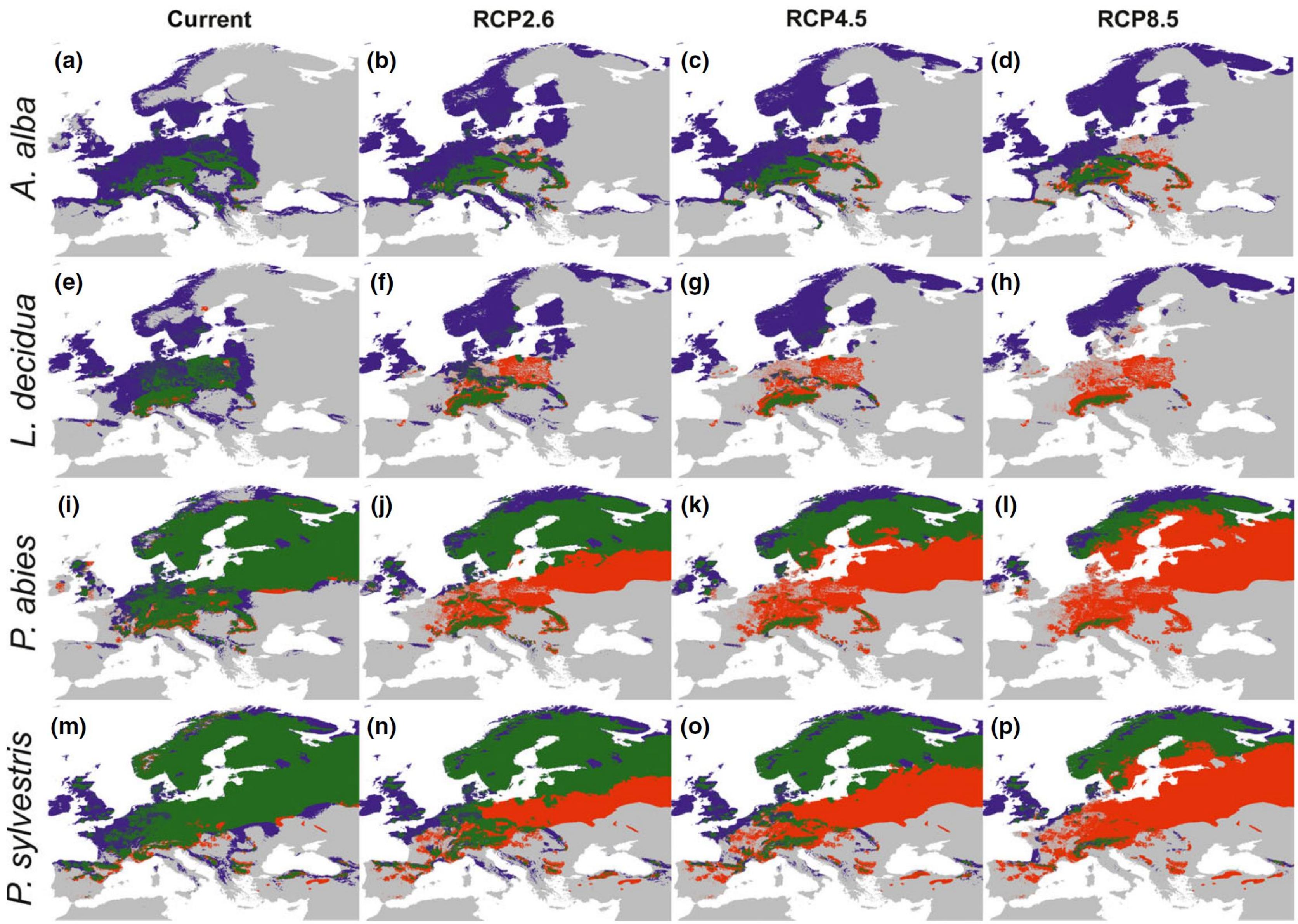
Climate change ➔ Change in species distribution

Evidence since around 30 years!!



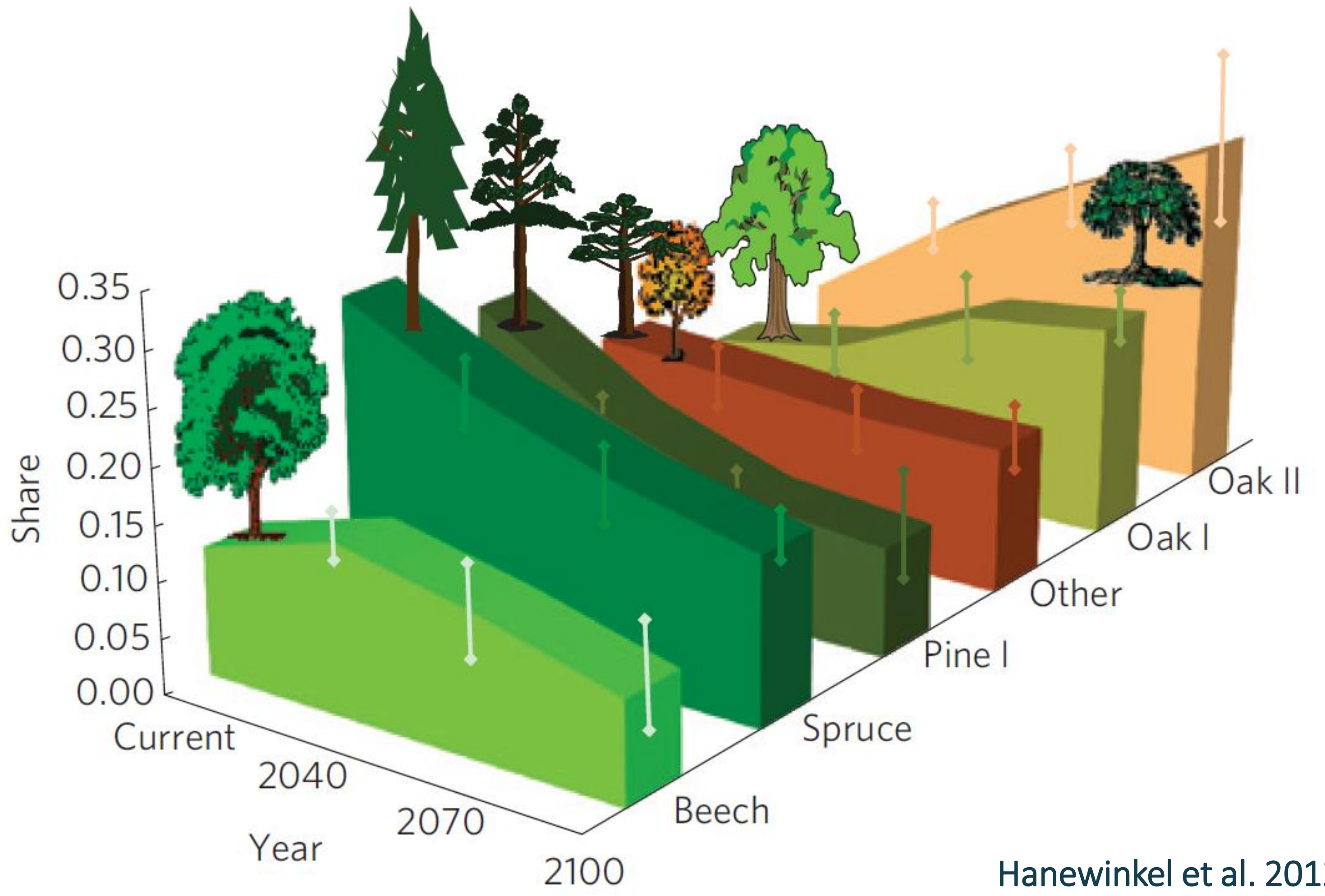
Sykes et al. 1996

Climate change ➔ Change in species distribution



Dyderski et al. 2018

Predicted tree species change



Hanewinkel et al. 2012

Tree species change of major European trees

Europe‘s heritage: tree diversity in northern hemisphere forests

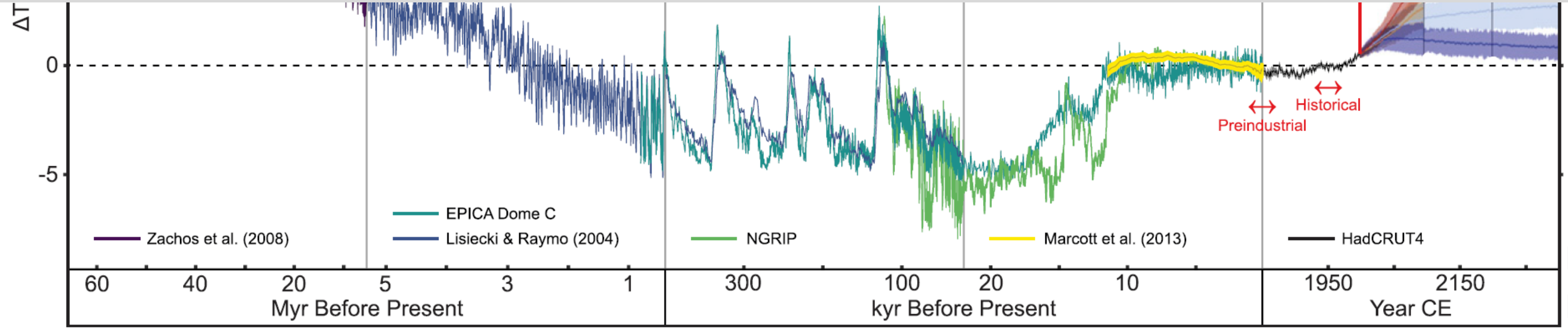
Fossil tree genera		Surviving until Holocen
60	Eastern North America	49 (82%)
75	Western North America	35 (47%)
122	North/East Central Asia	117 (96%)
[illegible]	Europe	[illegible]

Latham & Ricklefts 1993

A drastic decline of tree diversity in prehuman times due to

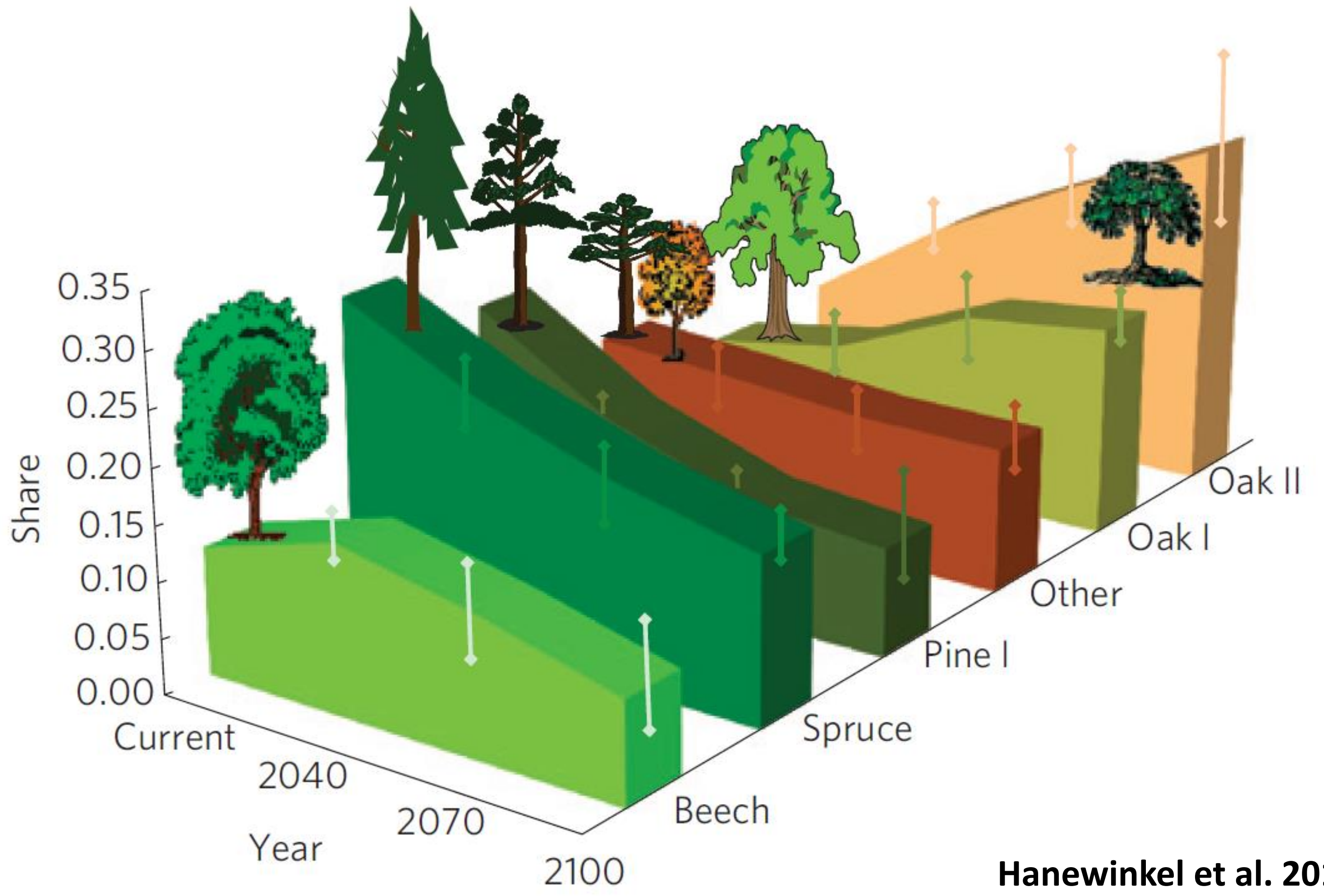
➔ mismatch of species niches and changing environments

➔ lags in adaptation and migration



Burke et al. PNAS (2018)

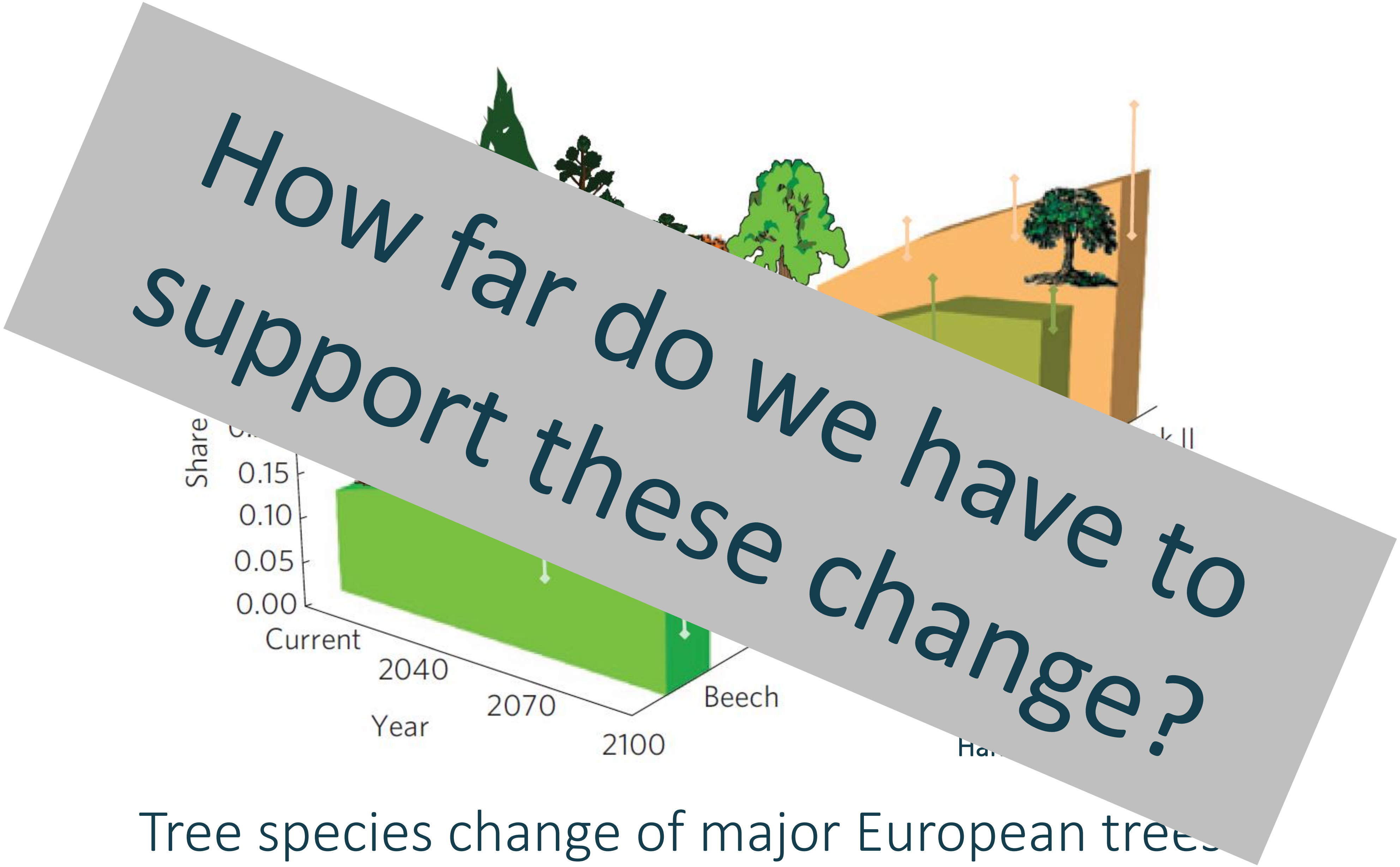
Predicted tree species change



Hanewinkel et al. 2012

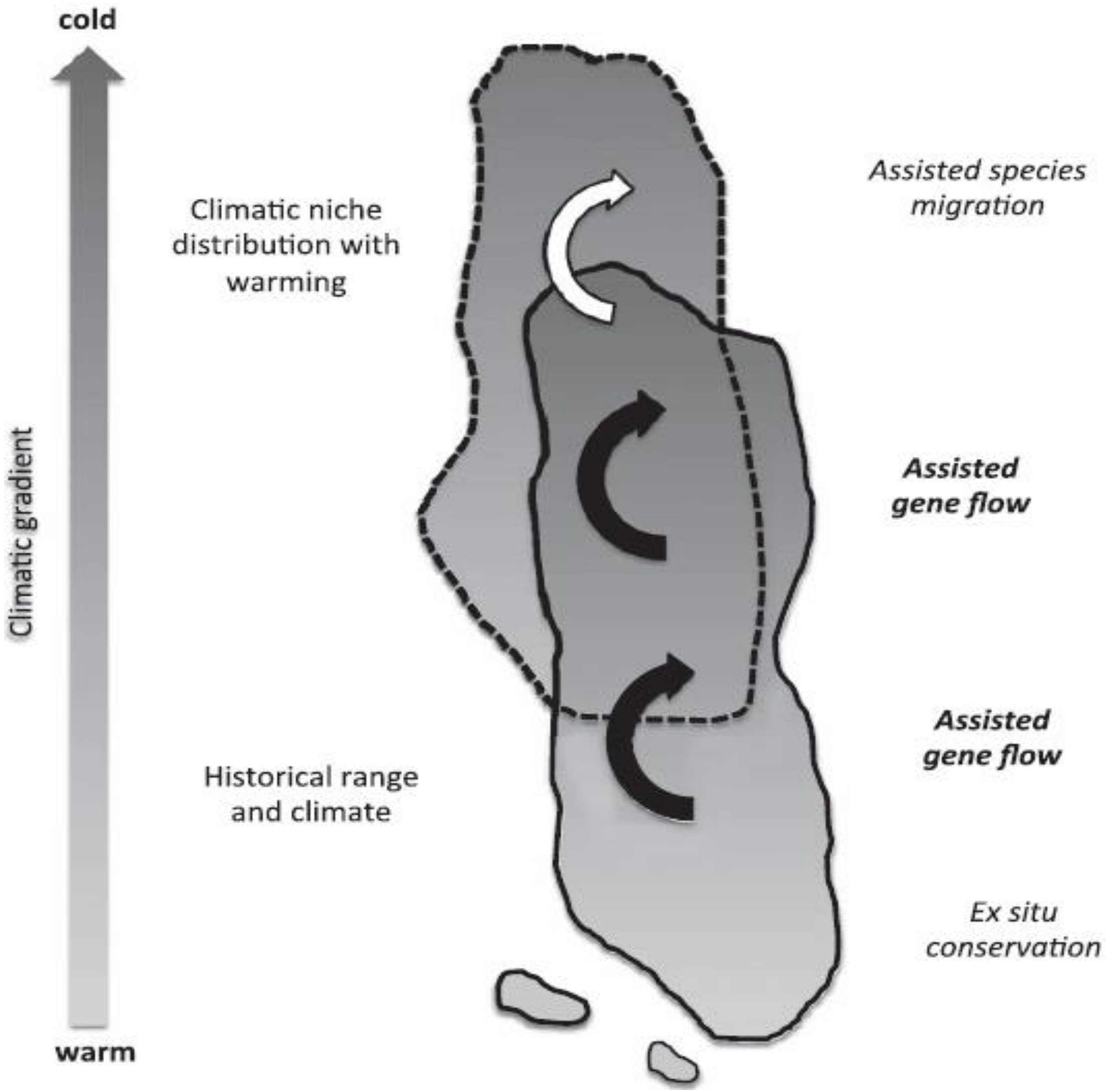
Tree species change of major European trees

Predicted tree species change



Tree species change of major European trees

Assisted migration



Aitken & Bemmels (2016)

Assisted migration

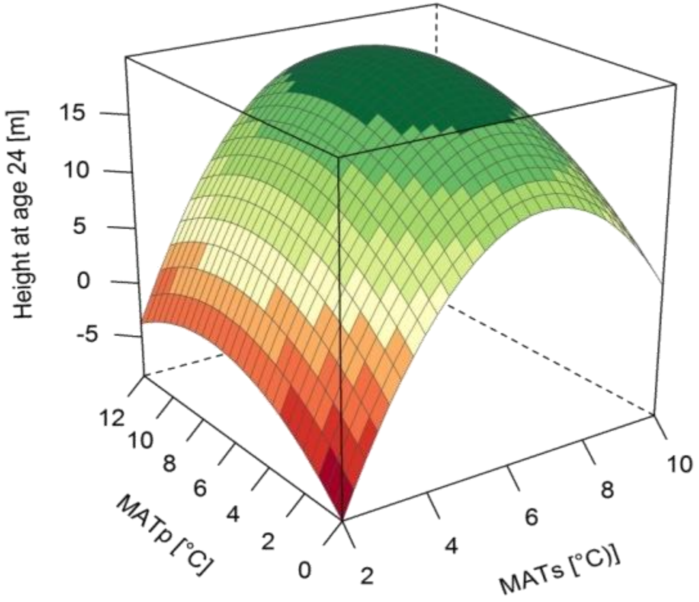
SUSTREE achievement:

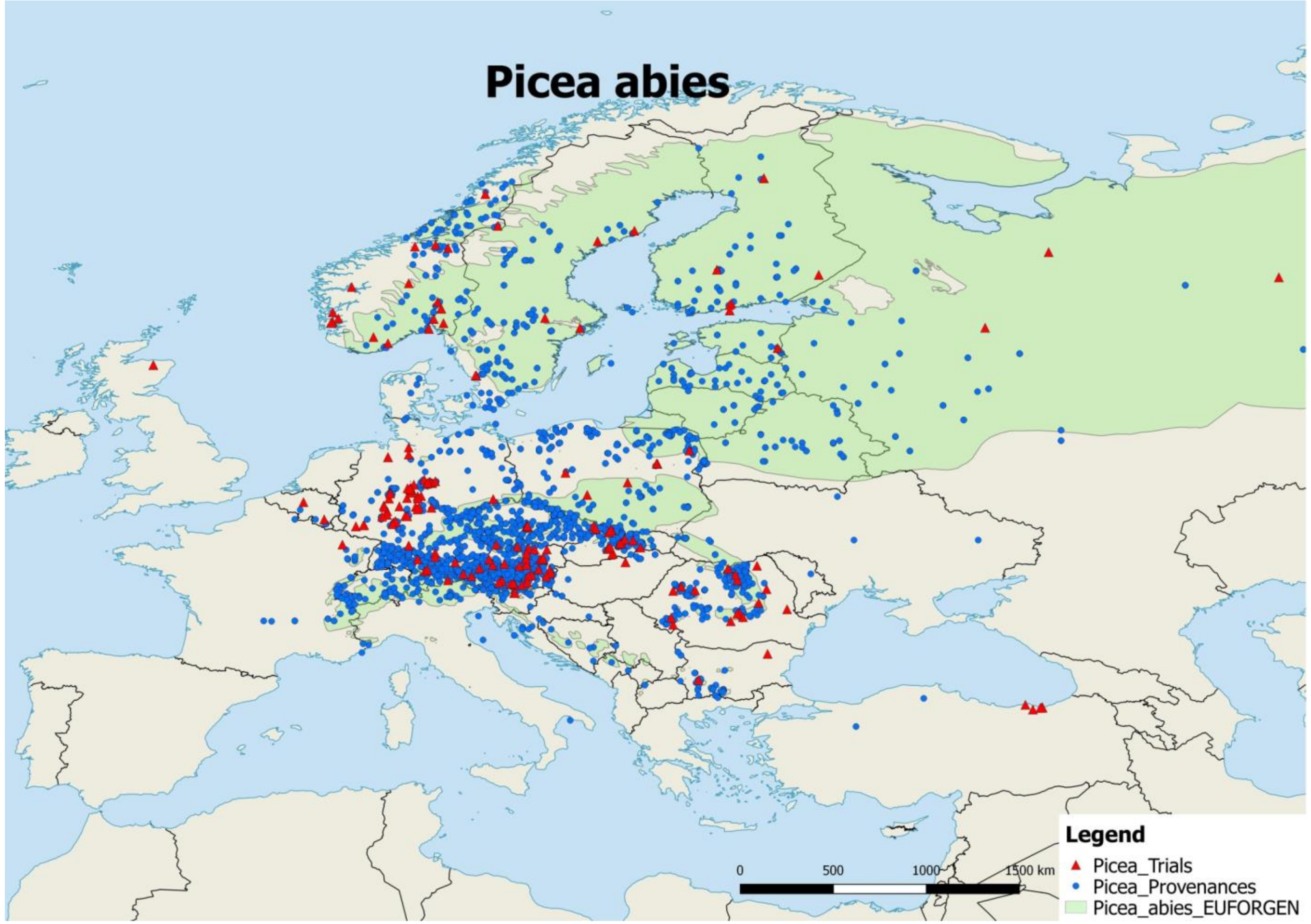
- harmonized database of provenance trials across Europe

Species	Nr. of Trials
Abies alba	45
Fagus sylvatica	31
Larix decidua	52
Picea abies	247
Pinus sylvestris	136
Quercus petraea	31
Quercus robur	45
Sum	**587**

Assisted migration

- Harmonized database of provenance trials
- Universal Climate-Response Models (Random Forest)





247 trials and more than 1000 tested seed sources

Impact of assisted migration on forest carbon sequestration

How much carbon could be added to European forest if proper seed provenances are being planted?

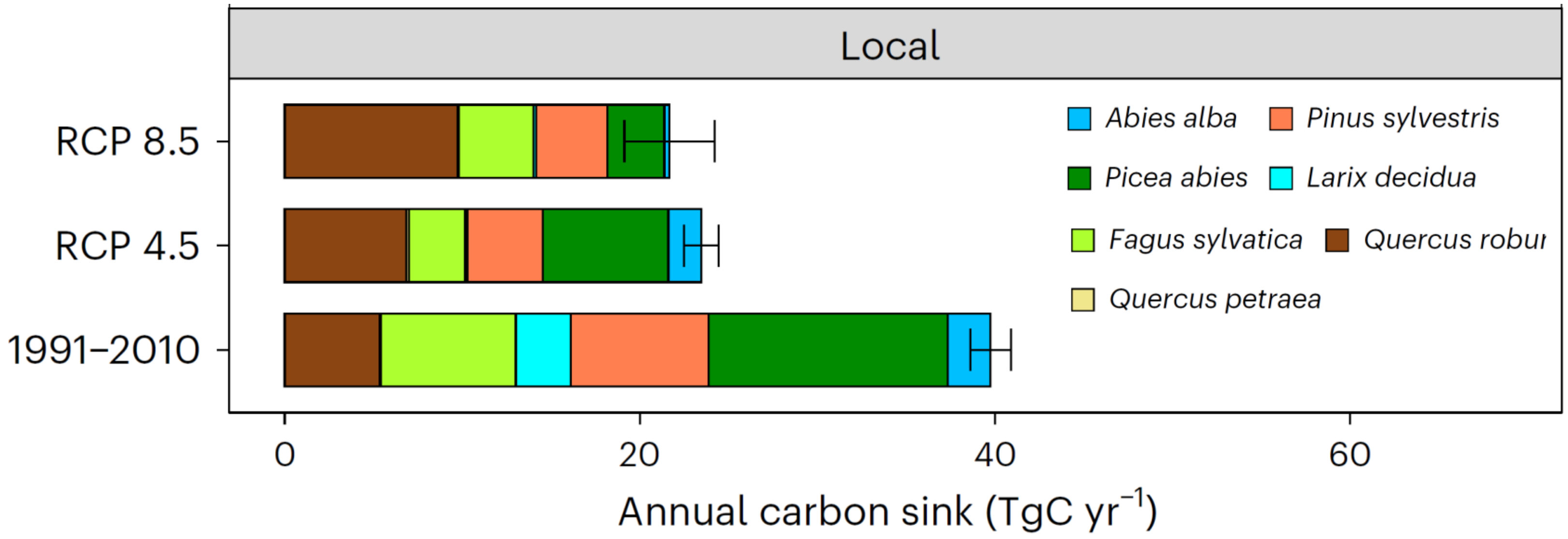
Assumptions:

- Resilient forests with tree species suitable for future climate
- Effect of new reforestation/forest regrowth until the age of 40
- Only actual forest area, no new aforestation

Chakraborty et al. 2024 Nature Climate Change

Impact of assisted migration on forest carbon sequestration

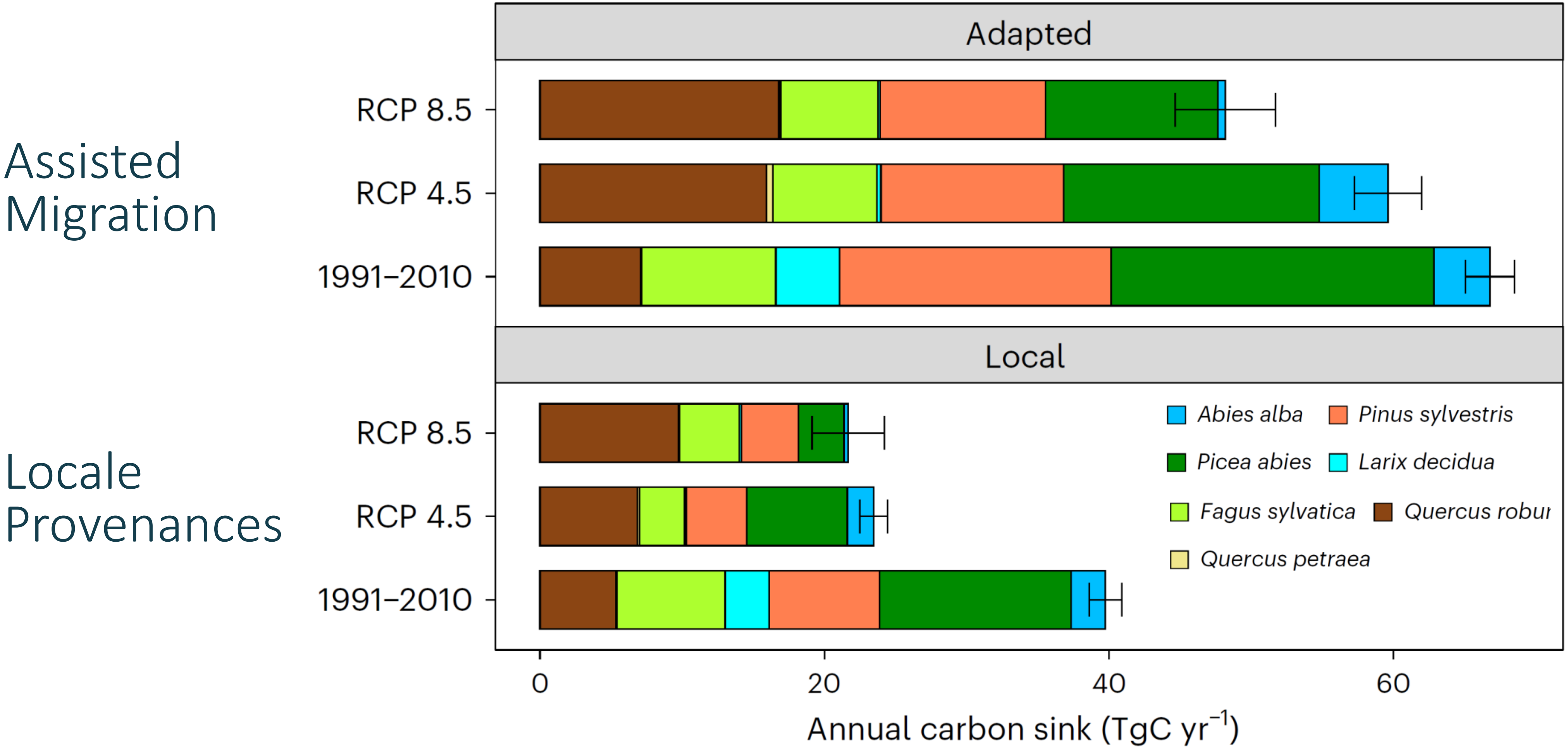
Locale Provenances



Annual Carbon Sequestration in Million Tonnes or Terragram in above ground living biomass of Age Classes I+II (until 40 years)

Chakraborty et al. 2024 Nature Climate Change

Impact of assisted migration on forest carbon sequestration



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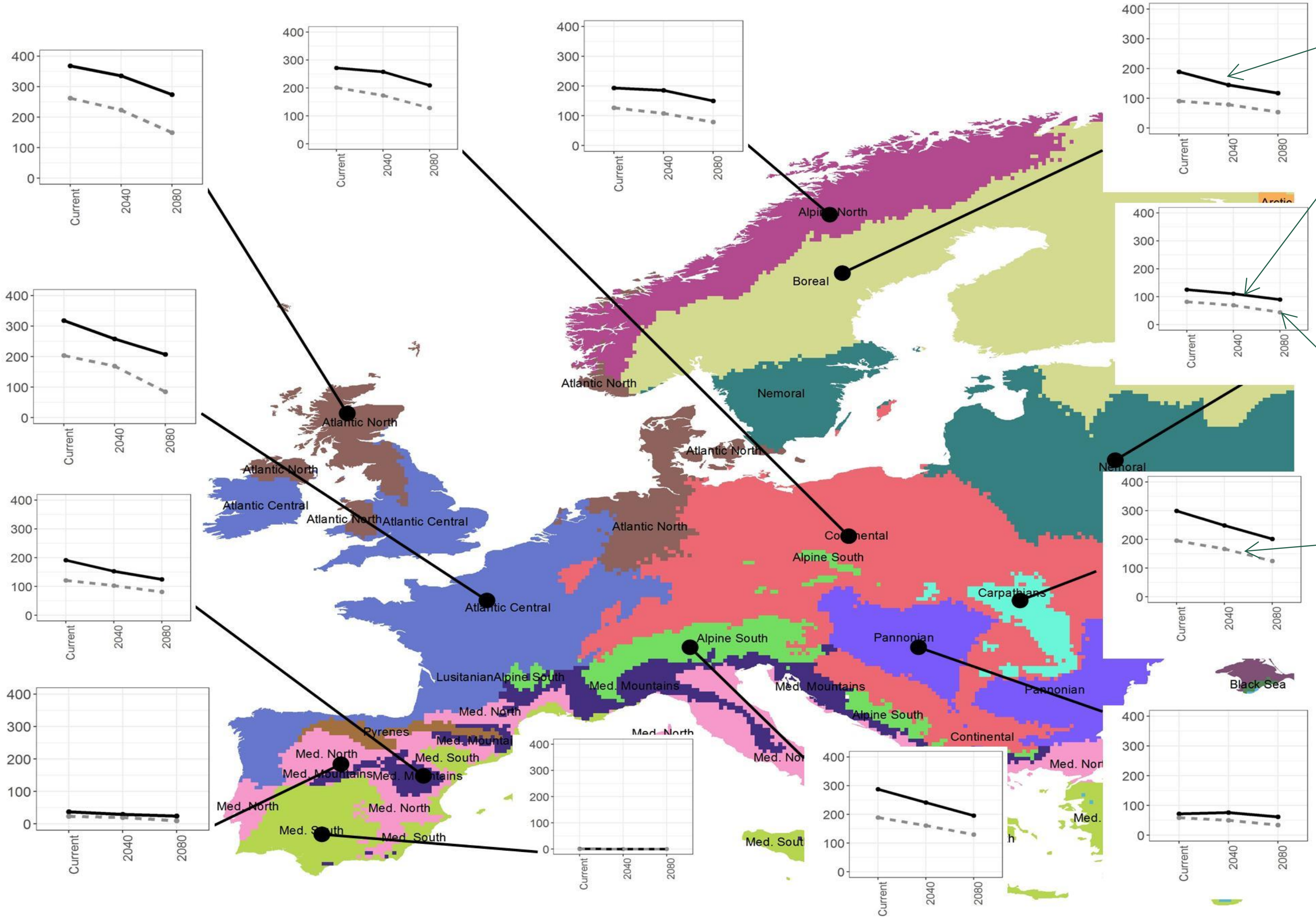
Annual Carbon Sequestration in Million Tonnes or Terragram in above ground living biomass of Age Classes I+II (until 40 years)

Impact assisted migration on forest carbon sequestration

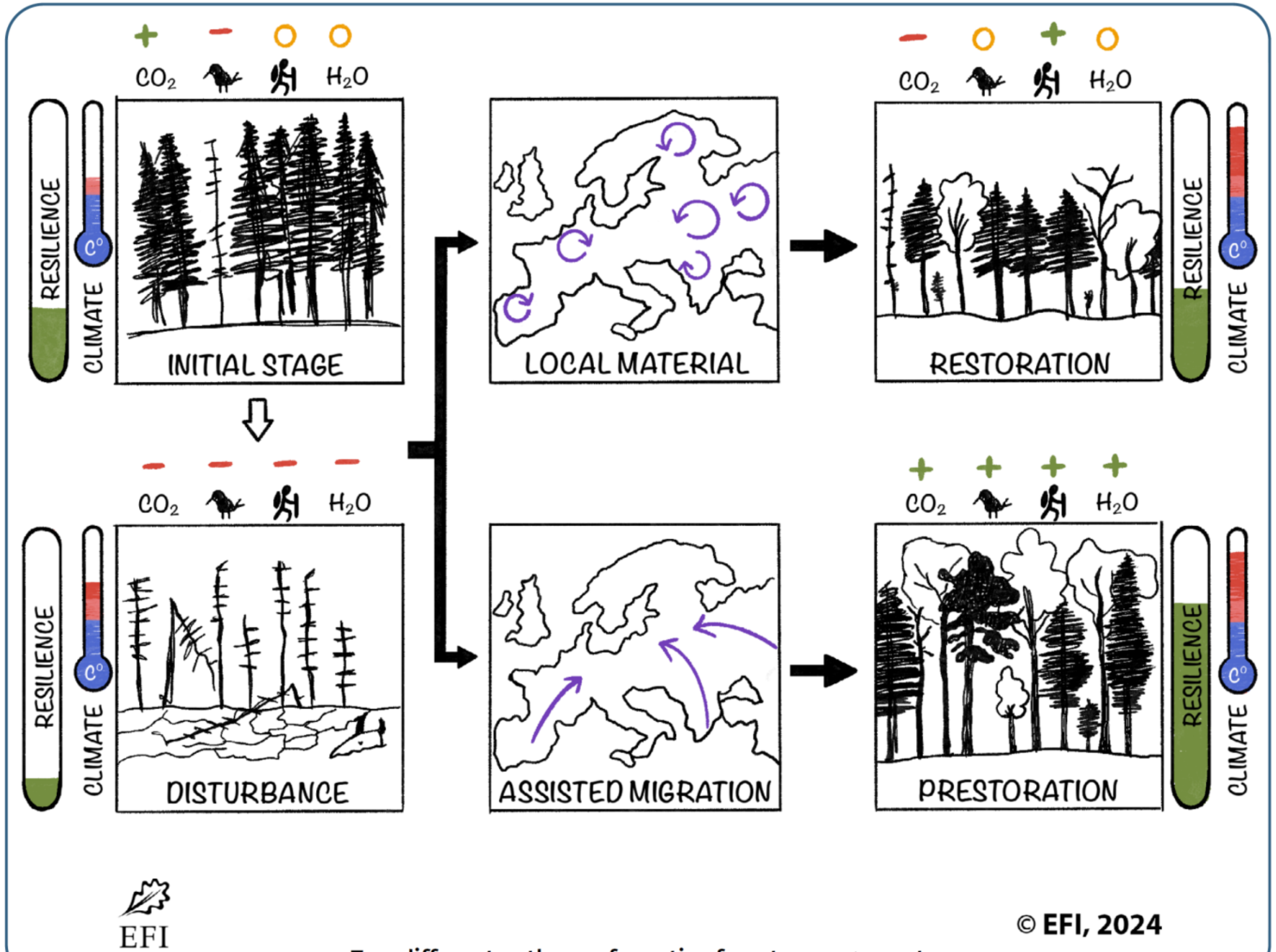


Best seed sources

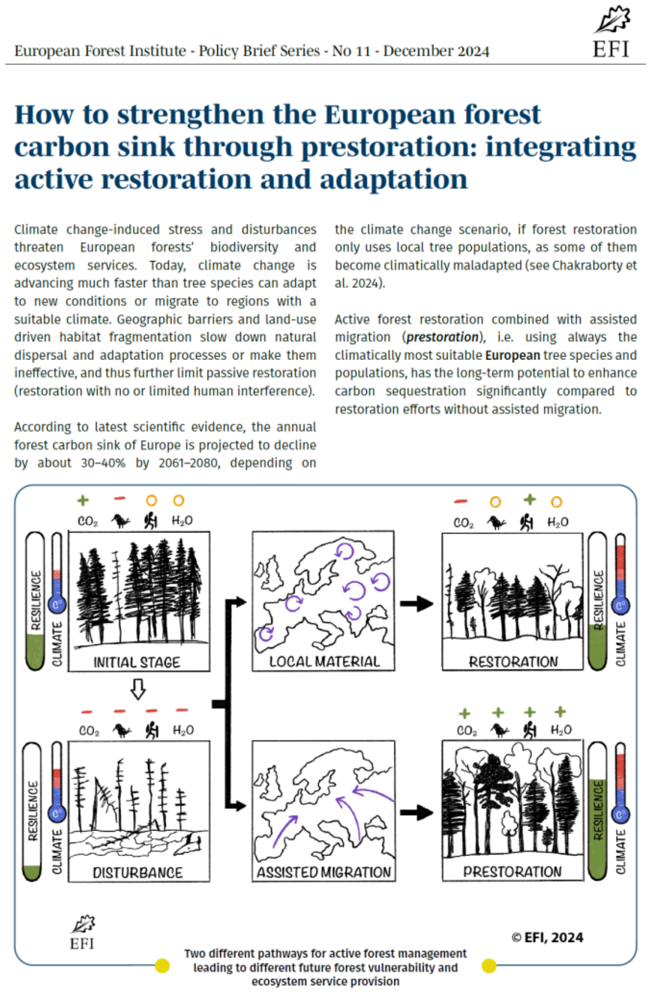
Local seed sources

Chakraborty et al. 2024 Nature Climate Change

Impact of assisted migration on forest carbon sequestration



Two different pathways for active forest management leading to different future forest vulnerability and ecosystem service provision



European Forest Institute - Policy Brief Series - No 11 - December 2024

EFI

How to strengthen the European forest carbon sink through prestoration: integrating active restoration and adaptation

Climate change-induced stress and disturbances threaten European forests' biodiversity and ecosystem services. Today, climate change is advancing much faster than tree species can adapt to new conditions or migrate to regions with a suitable climate. Geographic barriers and land-use driven habitat fragmentation slow down natural dispersal and adaptation processes or make them ineffective, and thus further limit passive restoration (restoration with no or limited human interference).

According to latest scientific evidence, the annual forest carbon sink of Europe is projected to decline by about 30–40% by 2061–2080, depending on the climate change scenario, if forest restoration only uses local tree populations, as some of them become climatically maladapted (see Chakraborty et al. 2024).

Active forest restoration combined with assisted migration (*prestoration*), i.e. using always the climatically most suitable **European** tree species and populations, has the long-term potential to enhance carbon sequestration significantly compared to restoration efforts without assisted migration.

Two different pathways for active forest management leading to different future forest vulnerability and ecosystem service provision

Chakraborty, Schüler et al. 2024. Policy Brief 11. European Forest Institute. https://doi.org/10.36333/pb11

BFW

Seed4Forest

FOREST VULNERABILITY AND SEED TRANSFER TOOL

www.seed4forest.org

Interreg CENTRAL EUROPE
European Union European Regional Development Fund
SUSTREE

Interreg CENTRAL EUROPE
European Union European Regional Development Fund
TEACHER-CE

Interreg
Danube Transnational Programme
REFOCuS

Update Spring 2025 !

BFW. Bundesforschungszentrum für Wald

Seed4Forest 2.0: Tree species mixtures

Selected climate scenario: RCP8.5

Selected timeframe: 2095

Show more +

1. Group 1

Quercus petraea · Robinia pseudoacacia · Malus sylvestris · Acer campestre · Acer platanoides · Carpinus betulus · Pinus nigra · Prunus avium · Quercus cerris

Suitability
in %

66

Show more +

2. Group 2

Quercus petraea · Pinus nigra · Pinus sylvestris

Suitability
in %

65

Show more +

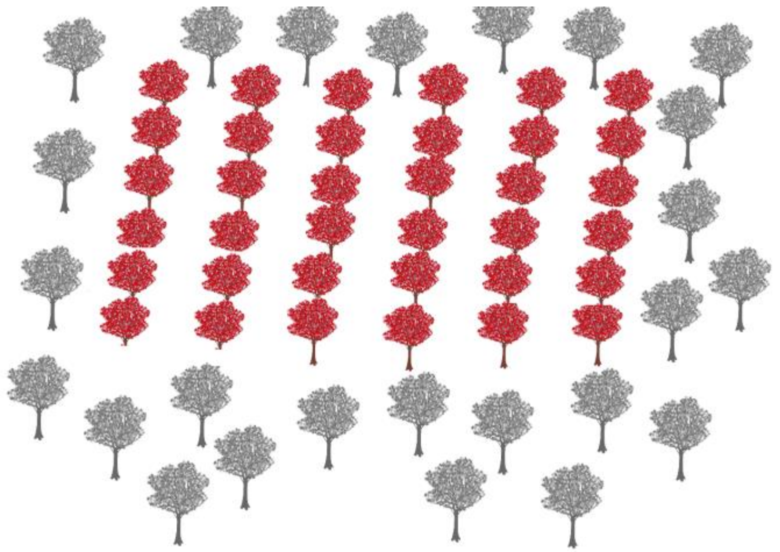
3. Group 3

Quercus petraea · Robinia pseudoacacia · Tilia platyphyllos · Malus sylvestris · Acer campestre · Acer platanoides · Carpinus betulus · Pinus nigra · Prunus avium

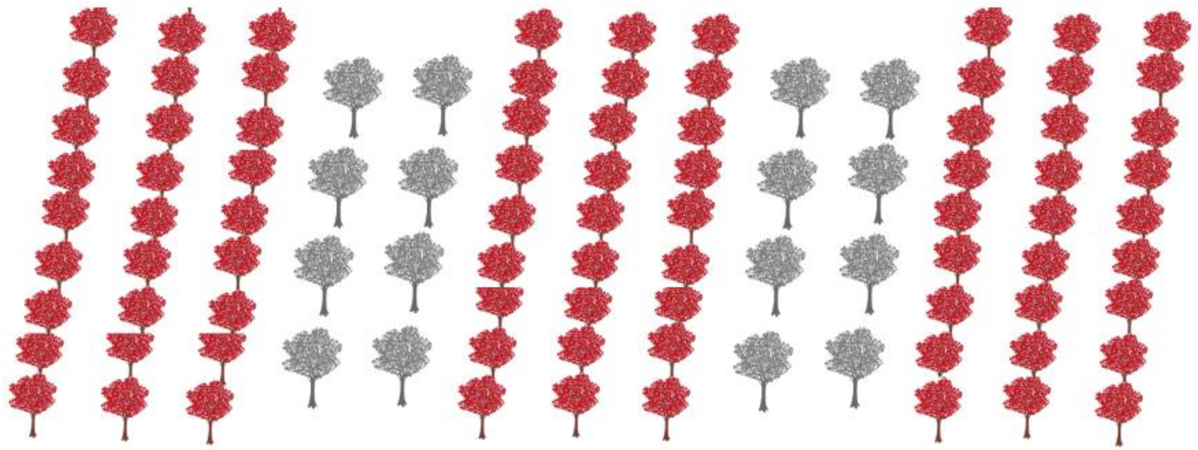
Suitability
in %

63

Establishment of mixtures



Group planting



Row planting

- ➔ Depending on sites, species, etc.
- ➔ 3-5 species for reforestation
- ➔ Combining natural regeneration with planting

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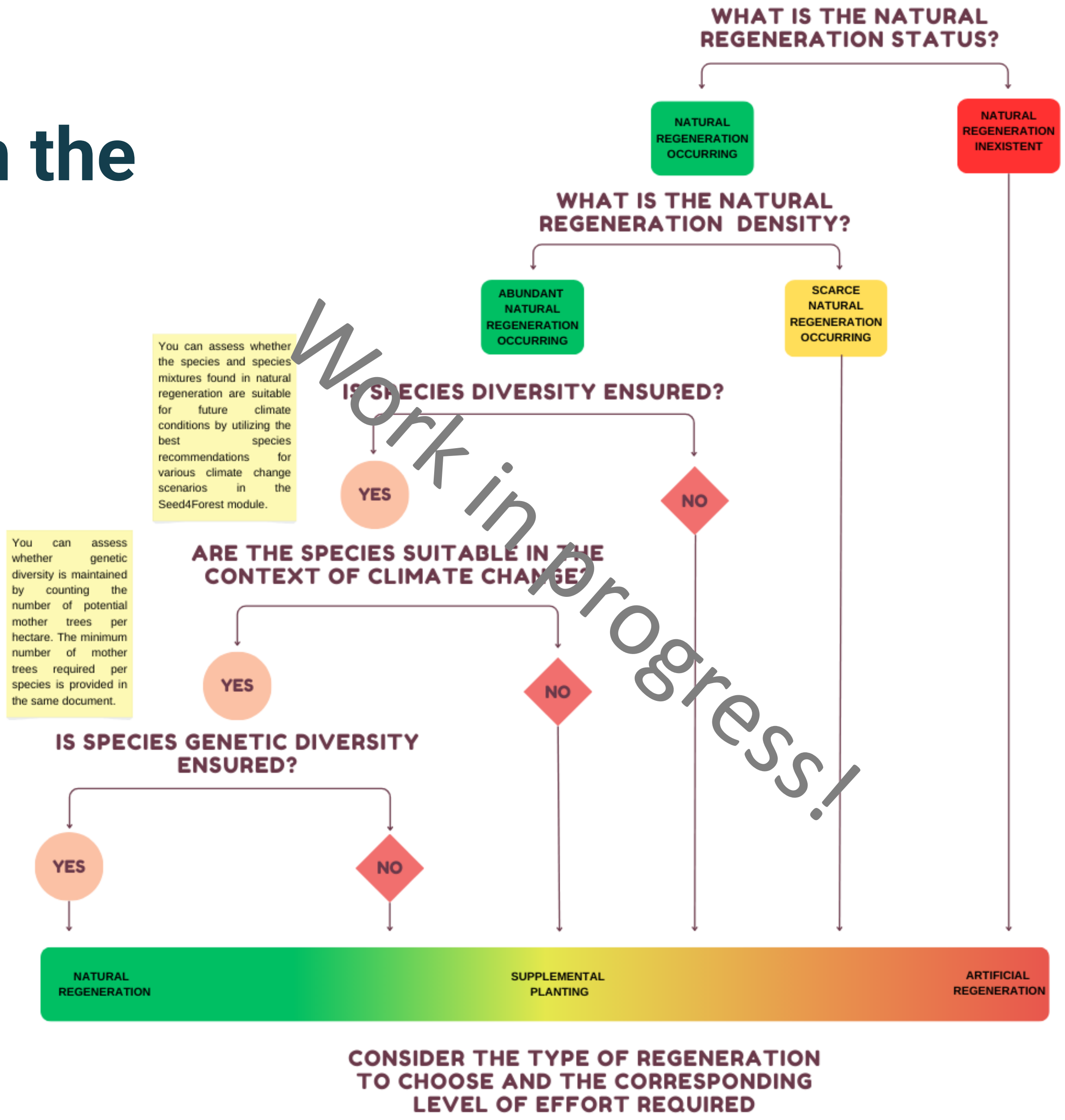
Decision tree

Is natural regeneration the right choice for you?

Considering

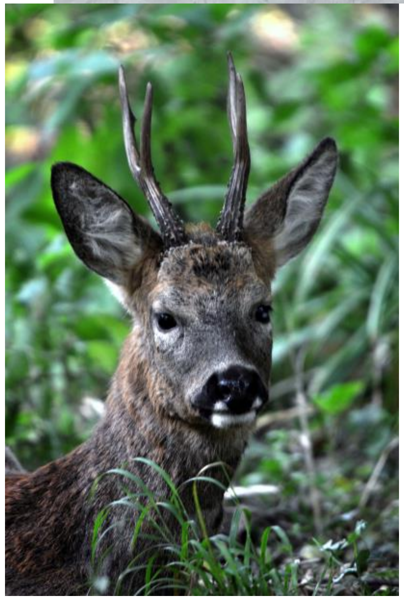
- Species diversity
- Genetic diversity
- Climate change

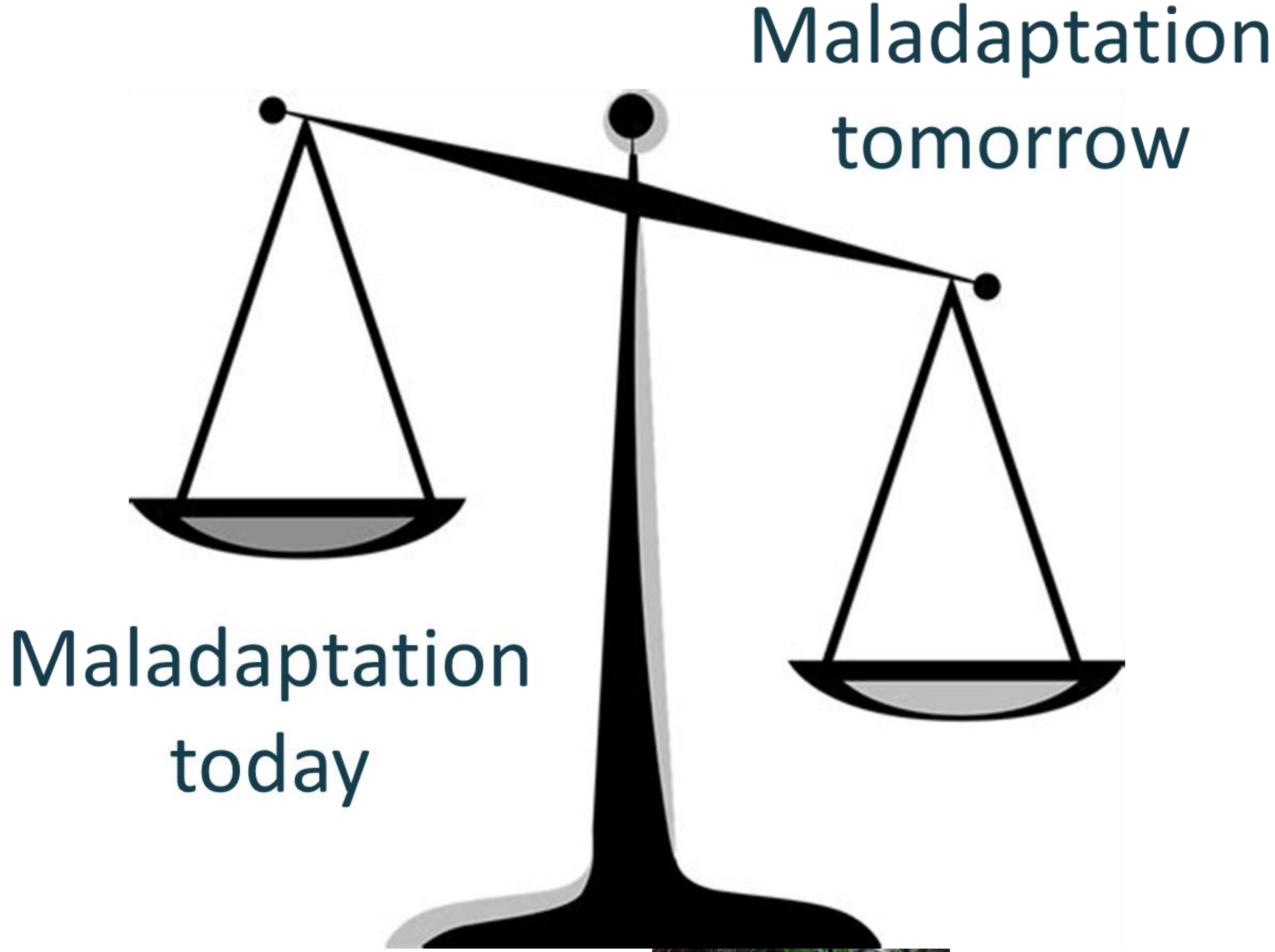


SUPERB
Upscaling Forest Restoration

Problems with „new“ trees in alpine forests

- Snow break
- Late and early frost events
- Inapprobriate game management




Maladaptation
tomorrow
Maladaptation
today

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Conclusions

- Change of dominant forest tree species is required in large parts of Europe to faciliate resilient forests
- Changing only tree species will result in decreasing carbon sink
- **Combining species change with provenance change will result into maintaining the forest carbon sink**
  - ➔ Stronger cooperation among European countries for seed exchange
  - ➔ Revitalisation of seedling production
- Implementation requires regionally adapted species mixtures and planting designs
- Expect failures and foresee iterative testing/learning approaches

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Many thanks for your attention!

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