



La gestione forestale per l'adattamento ai cambiamenti climatici



UNIVERSITÀ
DEGLI STUDI
DI MILANO

LA STATALE



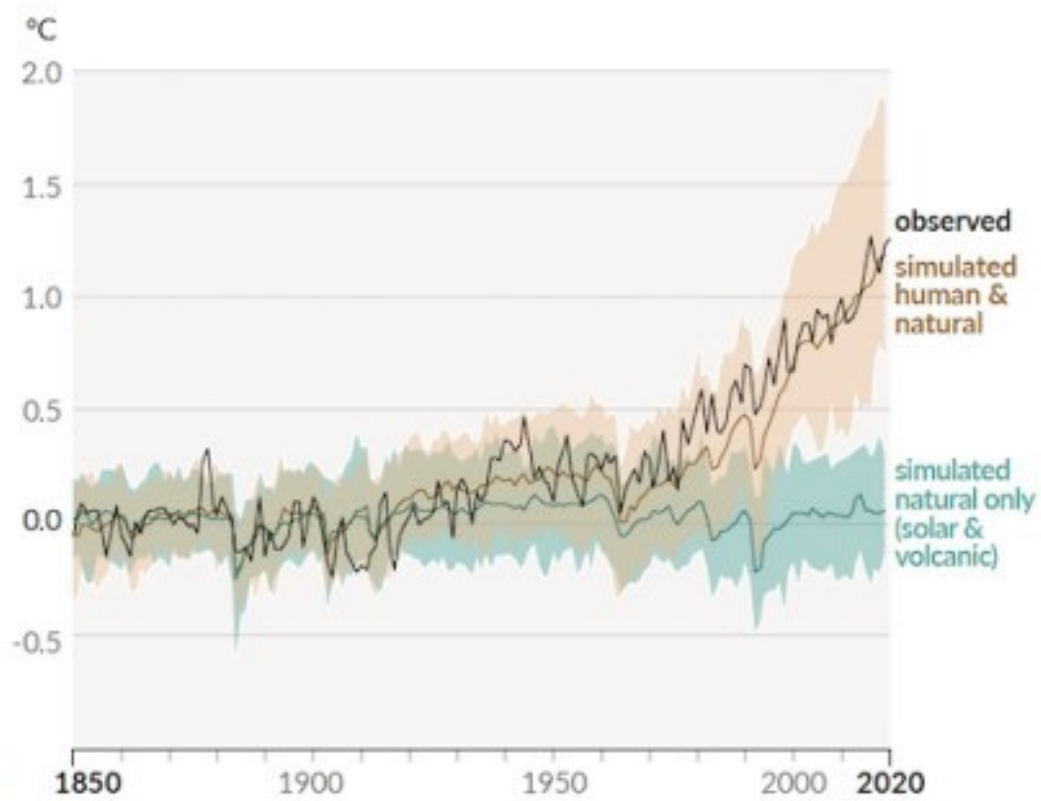
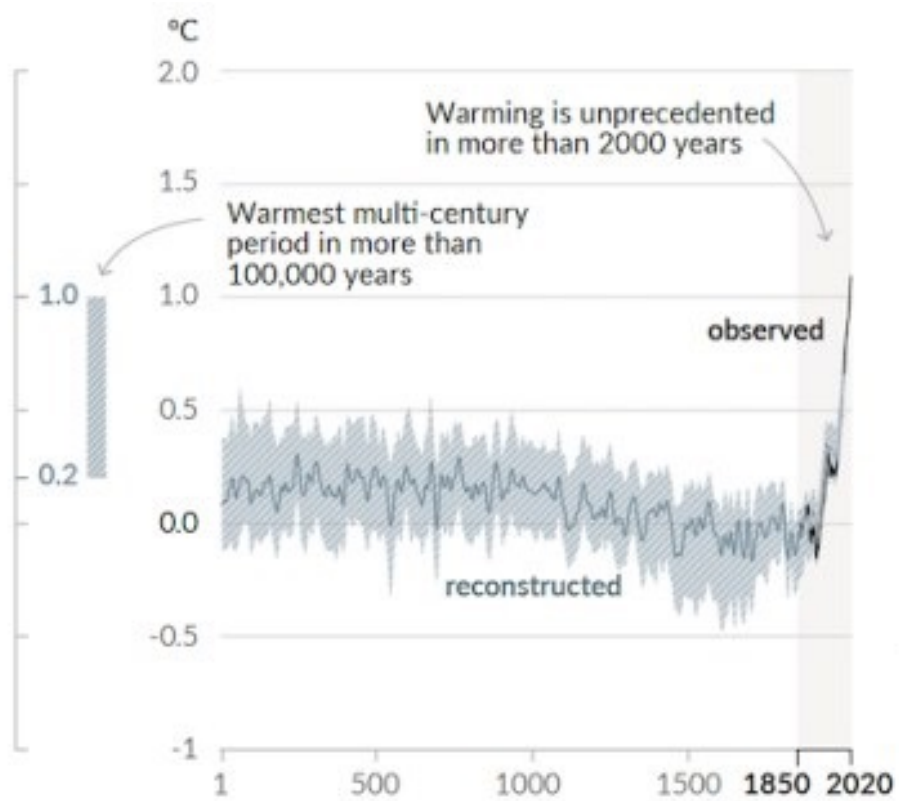
DiSAA

DIPARTIMENTO
di SCIENZE
AGRARIE e
AMBIENTALI

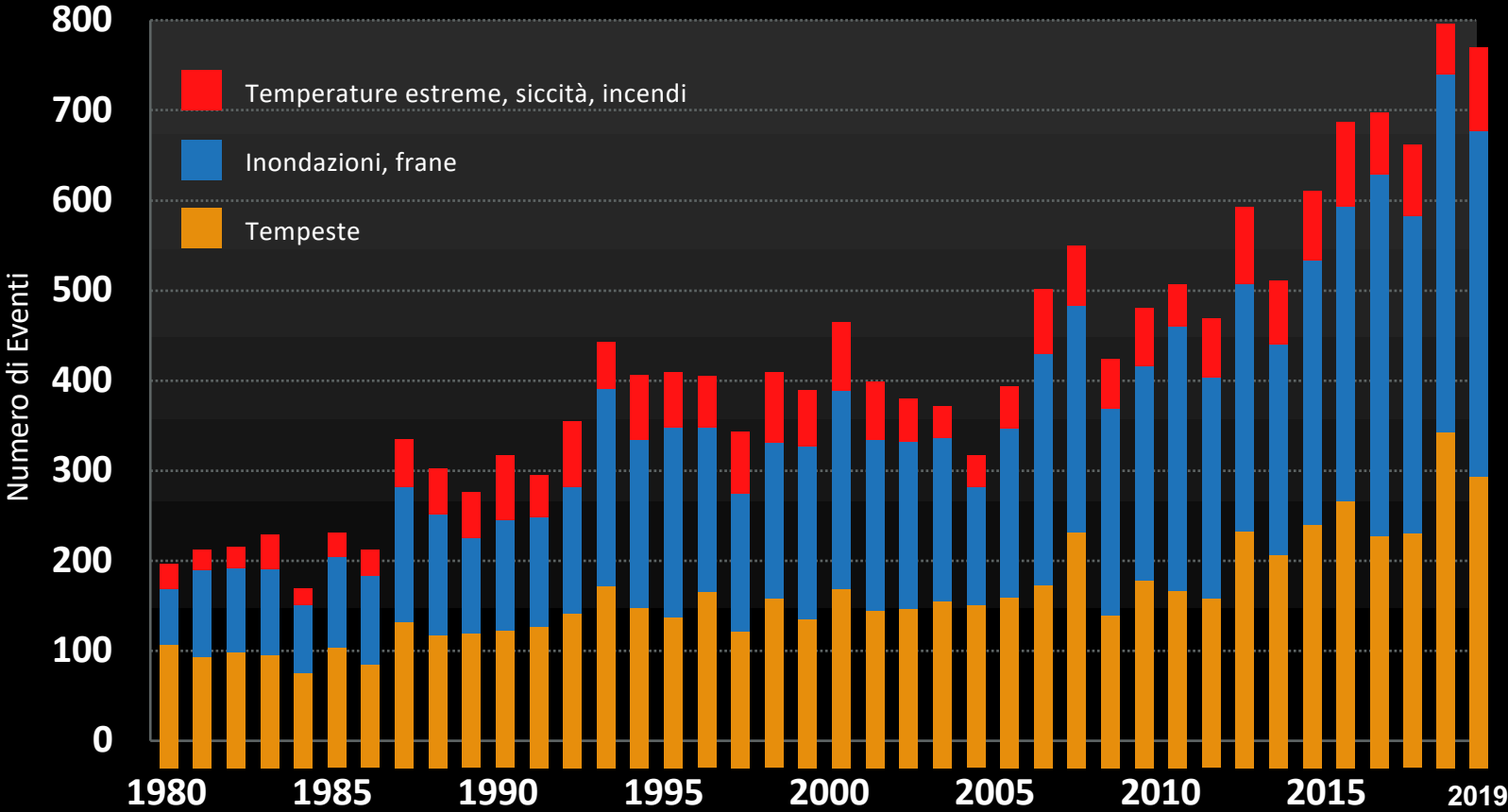
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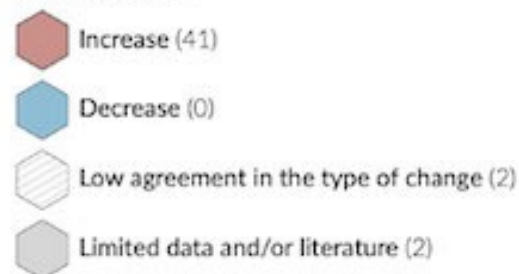
Eventi meteorologici estremi a scala globale



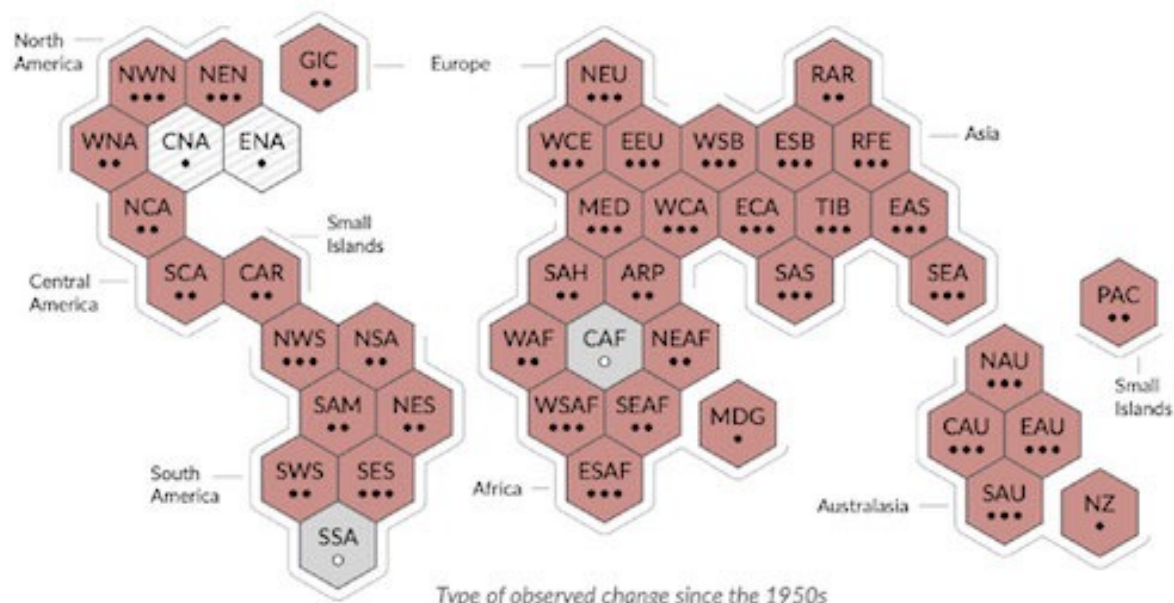
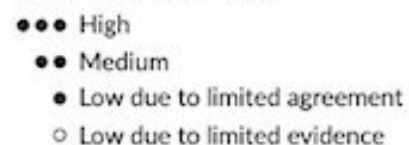
Data: Munich Re, Geo Risks Research, NatCatSERVICE

a) Synthesis of assessment of observed change in hot extremes and confidence in human contribution to the observed changes in the world's regions

Type of observed change in hot extremes



Confidence in human contribution to the observed change



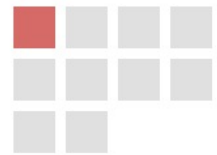
Extreme heat becomes more frequent

Projected increase in frequency and intensity of high temperatures which only occurred once in every 10 years on average in a climate without human influence

Frequency every 10 years

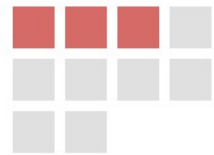
Future global warming levels

1850
to 1900



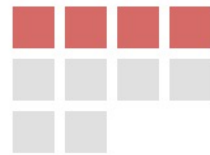
Once every
10 years

Present
1C warmer



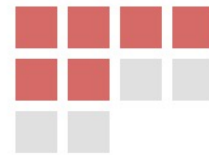
Now likely
to occur
2.8 times

1.5C
warming



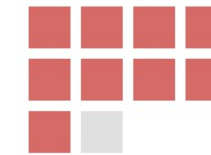
Likely
to occur
4.1 times

2C
warming



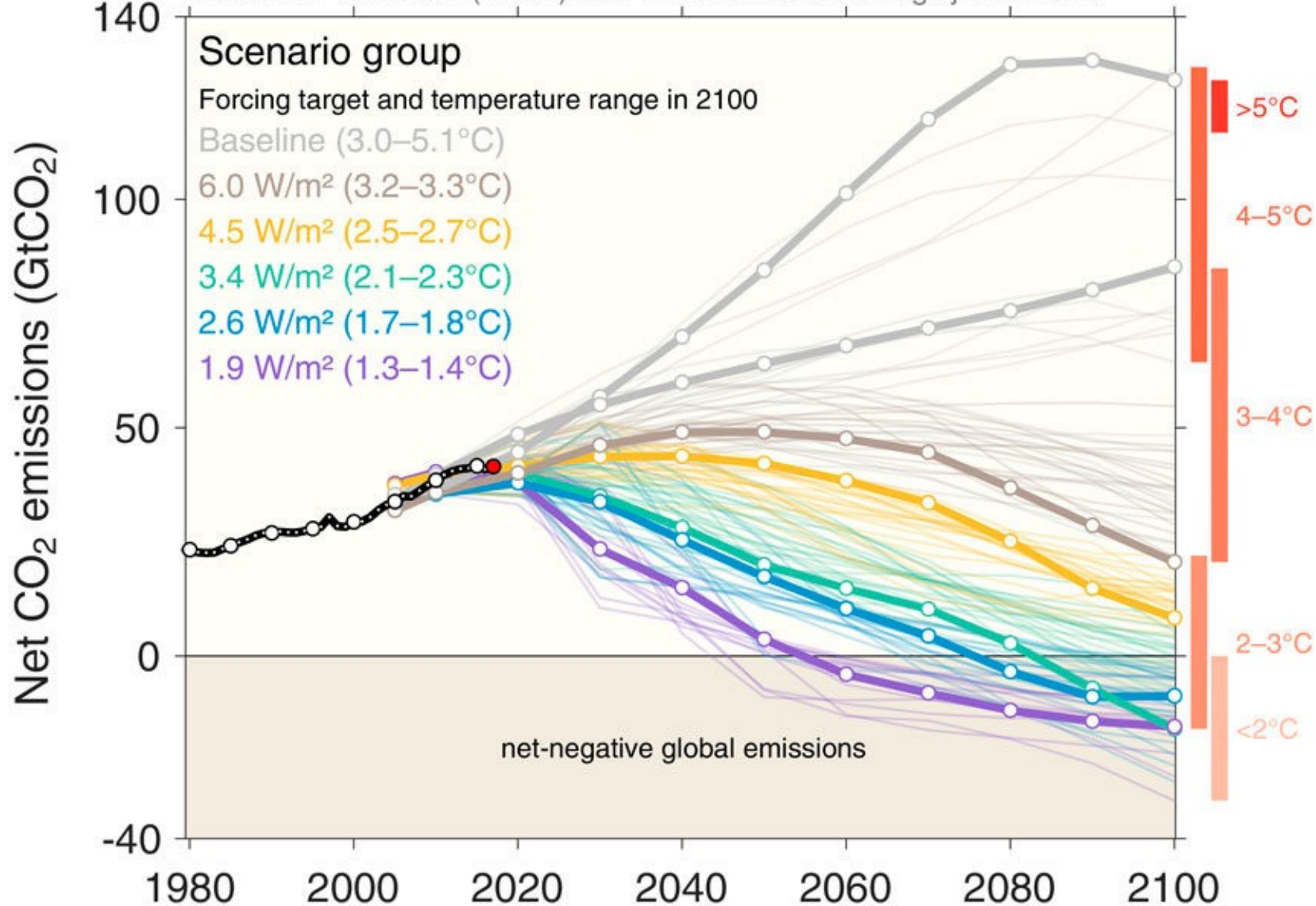
Likely
to occur
5.6 times

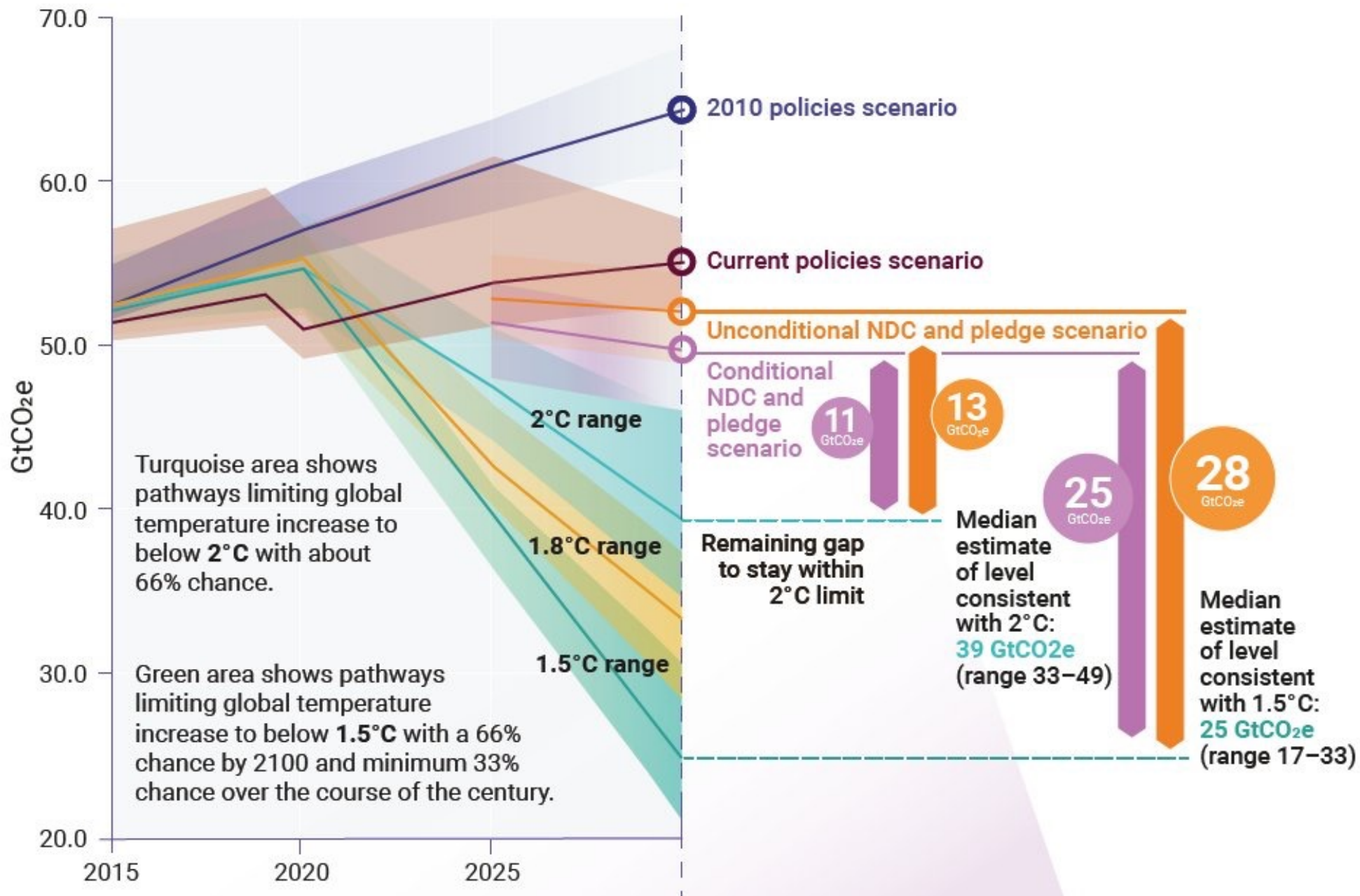
4C
warming



Likely
to occur
9.4 times

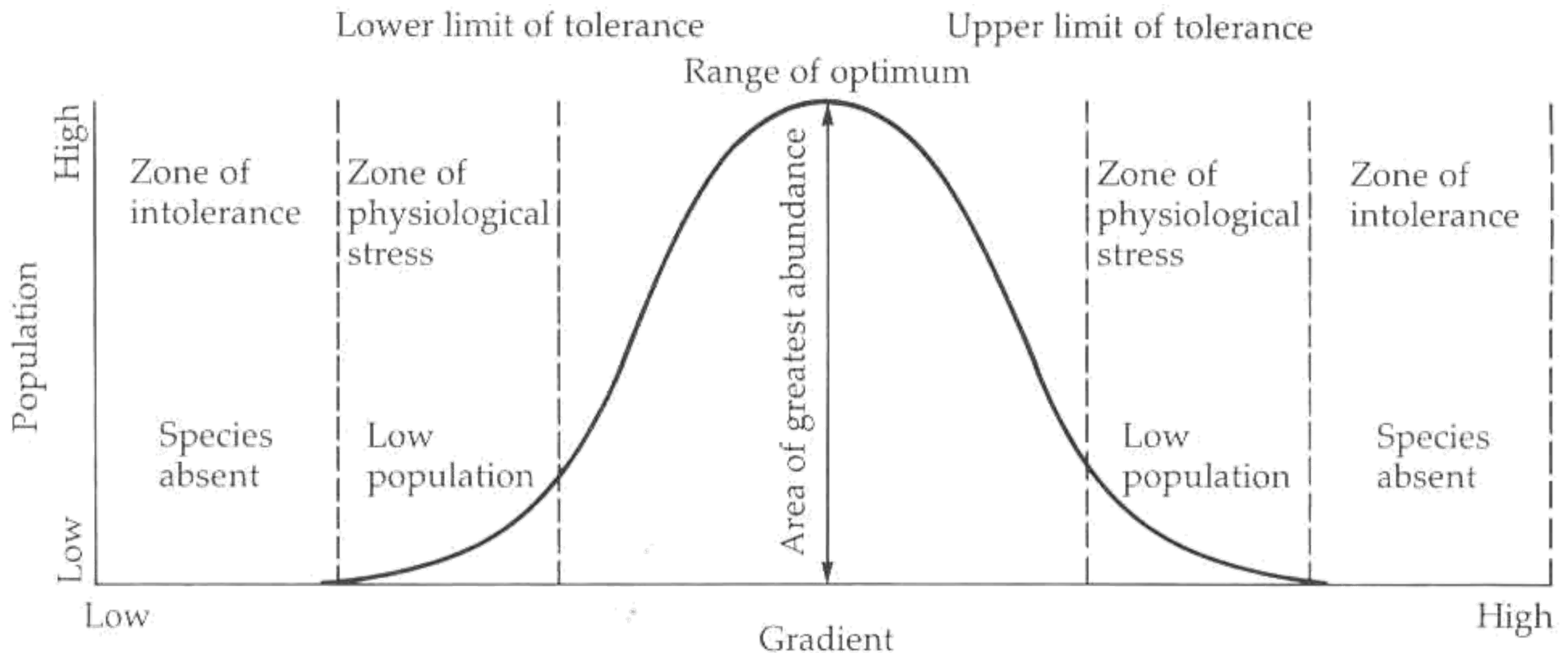
Data: SSP database (IIASA)/GCP/Riahi et al 2017/Rogelj et al 2018







La risposta delle specie a qualsiasi fattore ambientale segue la “legge dell’ottimo”. Dove il livello del fattore ambientale supera il **limite di tolleranza**, la specie o il processo sono assenti.



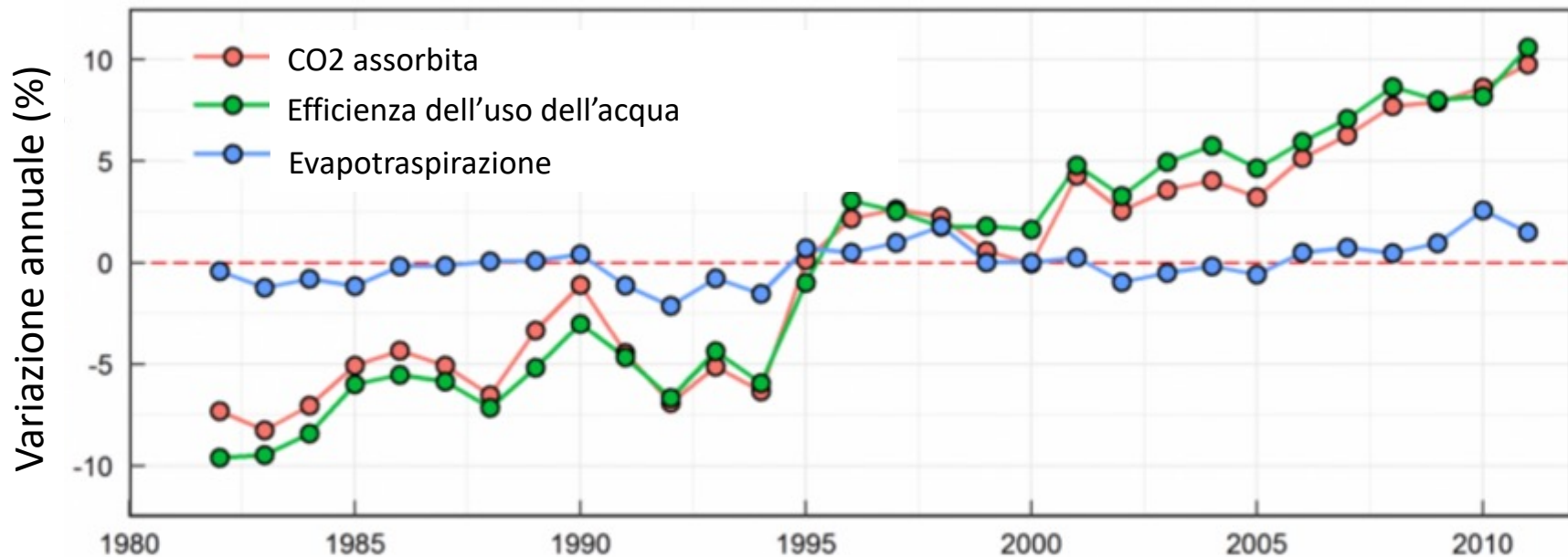
Aumento di CO₂

- Aumento della velocità della fotosintesi (“fertilizzazione”)
- Aumento dell’efficacia di uso dell’acqua
- Risposta variabile nelle diverse specie
- Effetto molto rilevante nelle aree più aride (es. Mediterraneo)

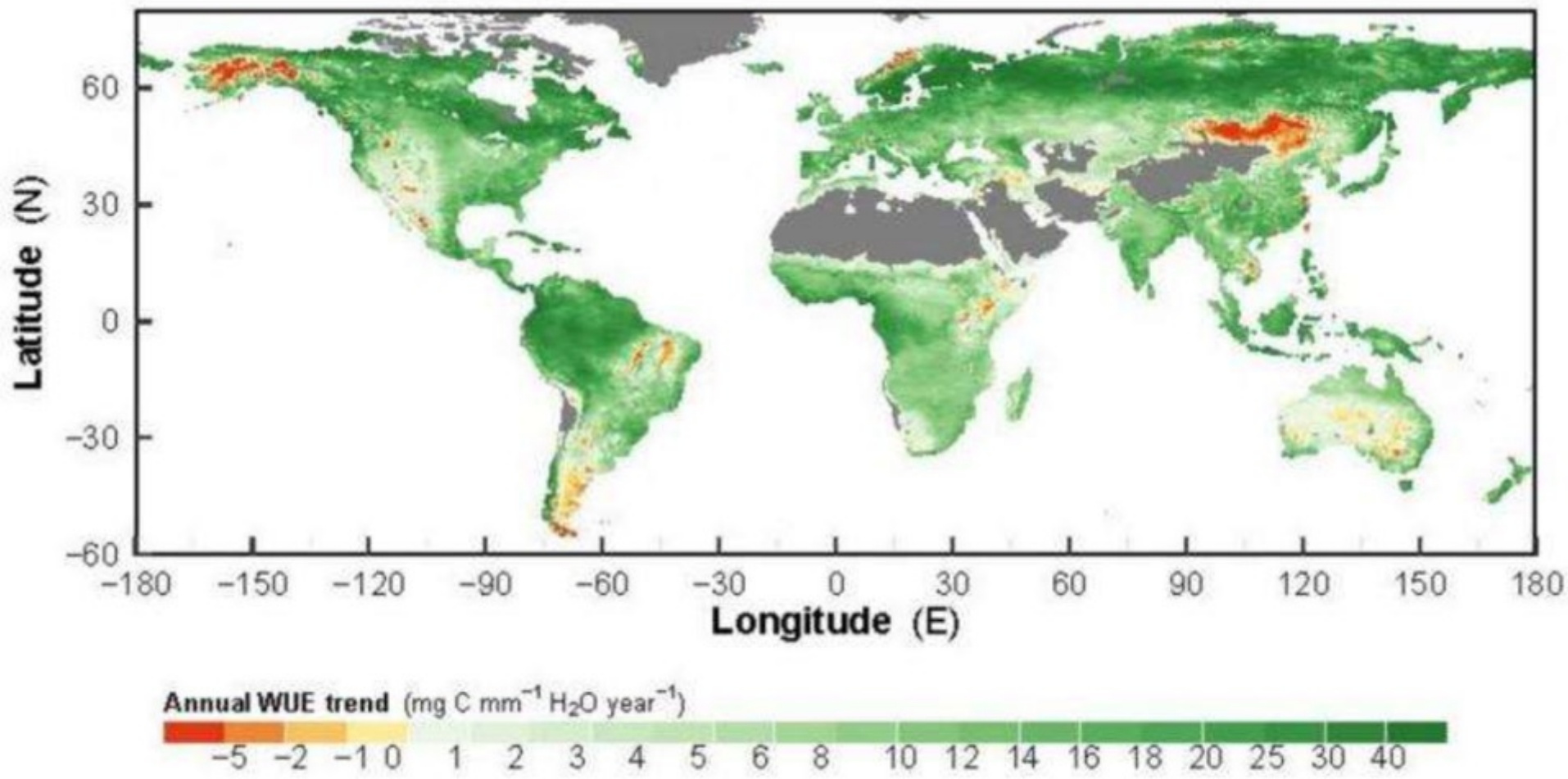


Esperimento FACE (Free-Air Carbon Enrichment)

Se aumenta solo la CO₂ (e non la temperatura) l'evapotraspirazione rimane stabile, mentre l'efficienza dell'uso dell'acqua aumenta.



Changes in global terrestrial uptake of carbon dioxide, water use efficiency and ecosystem evapotranspiration during 1982-2011.



Variazioni nell'efficacia dell'uso dell'acqua 1982-2011

Effetto congiunto dell'aumento di temperature e di CO₂ sulla produttività forestale in Europa

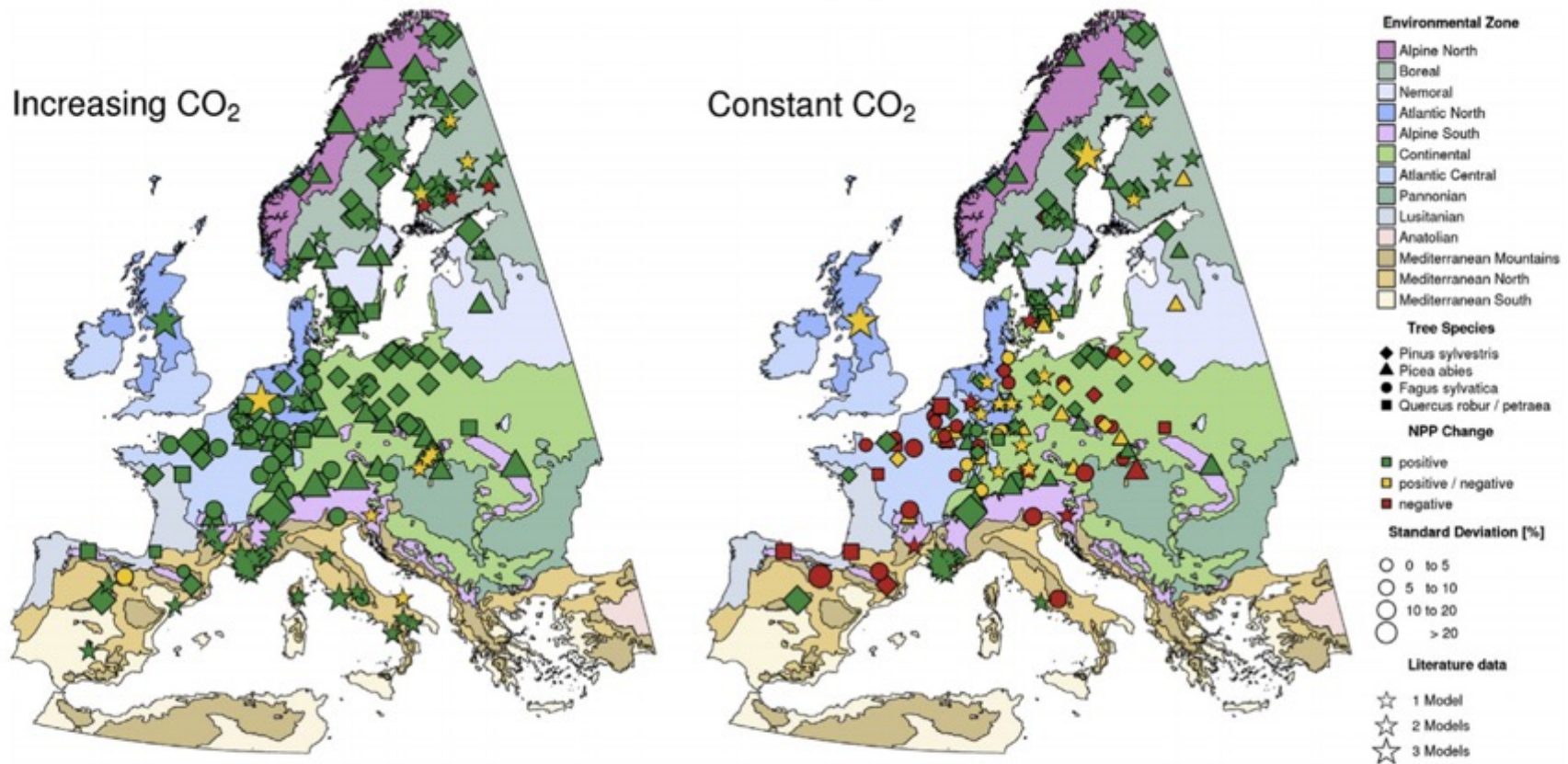
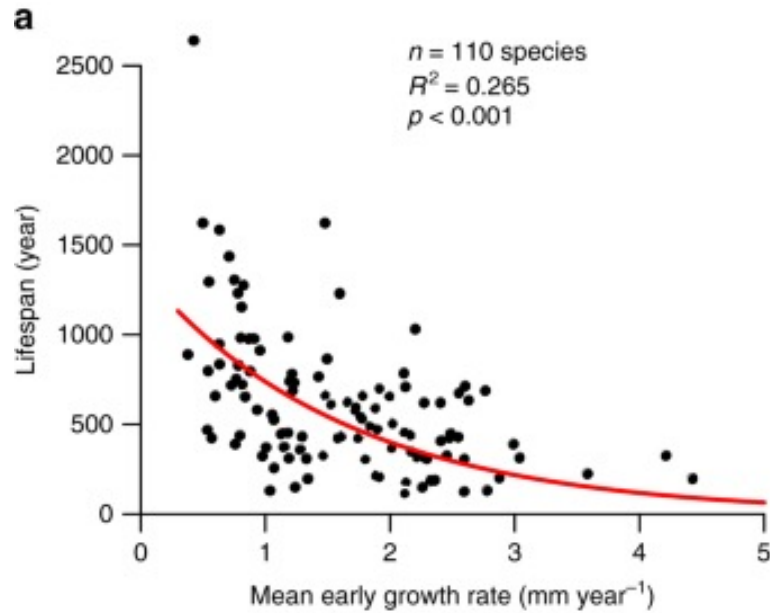


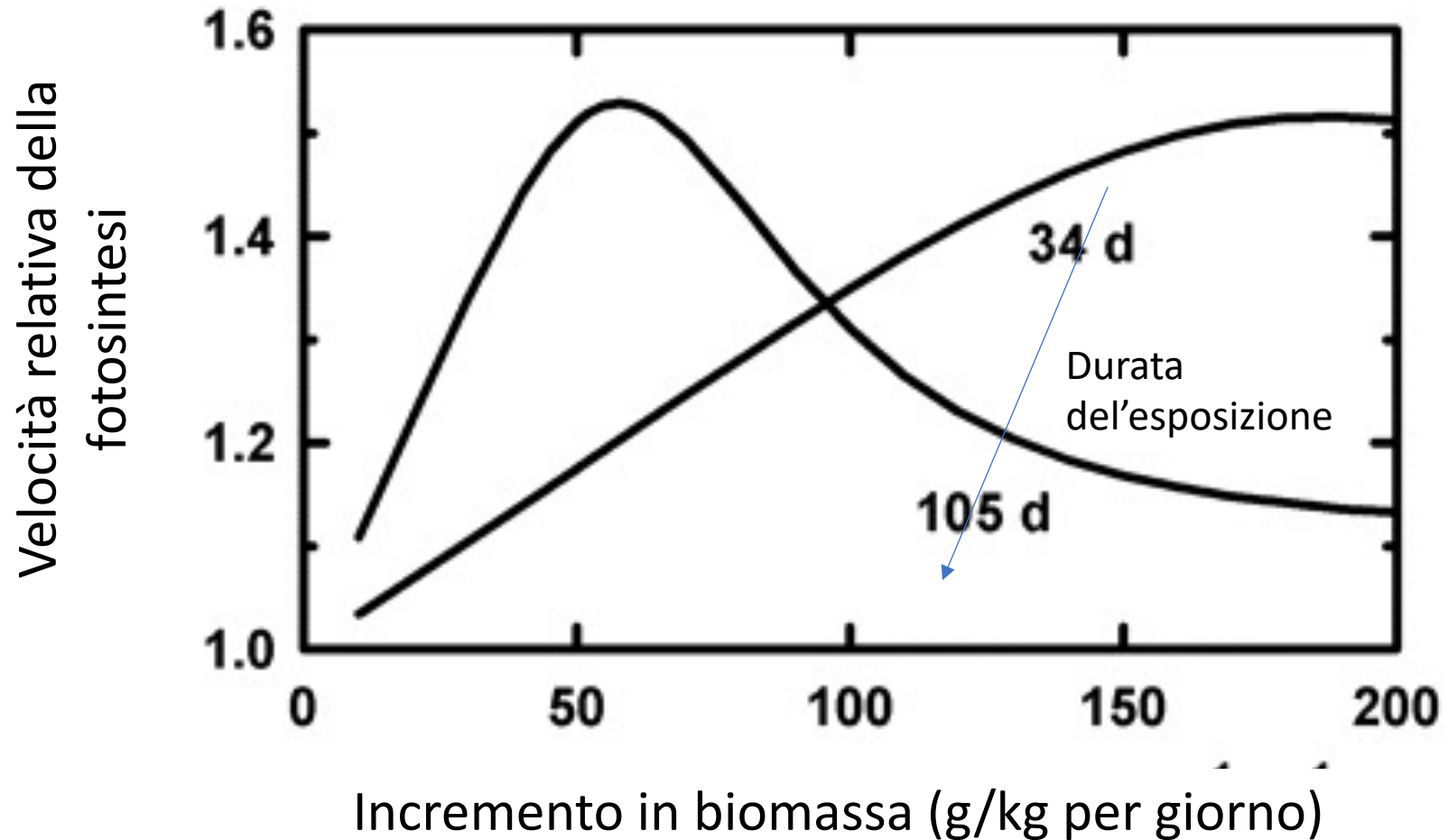
Fig. 3. Projections of changing NPP in Europe from a European-wide application of the 4C model (Reyer et al., 2013a) and a literature review of similar modelling studies (Reyer, 2013) with increasing CO₂ (left) and with constant CO₂ (right) for different Environmental Zones after Metzger et al. (2005). For the 4C simulations, the standard deviation indicates the variability over several climate change scenarios and time periods, while for the literature data, the number of models indicates how many different models were applied at each site.

Crescita più rapida = vita più breve

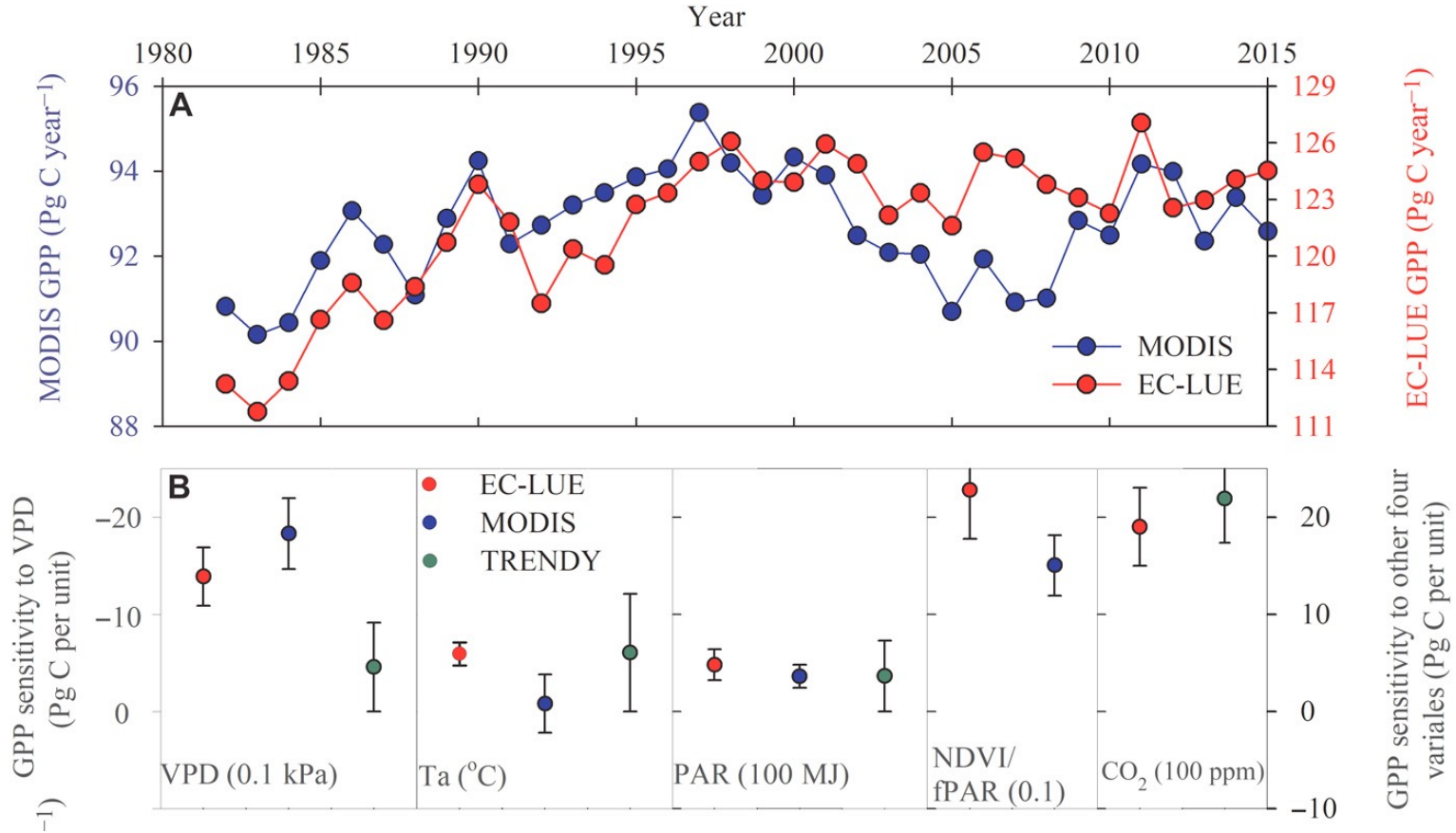


<https://www.nature.com/articles/s41467-020-17966-z>

Se l'esposizione alla CO_2 si prolunga, la velocità della fotosintesi e l'incremento di biomassa si riducono a causa dell'**acclimatemento**.

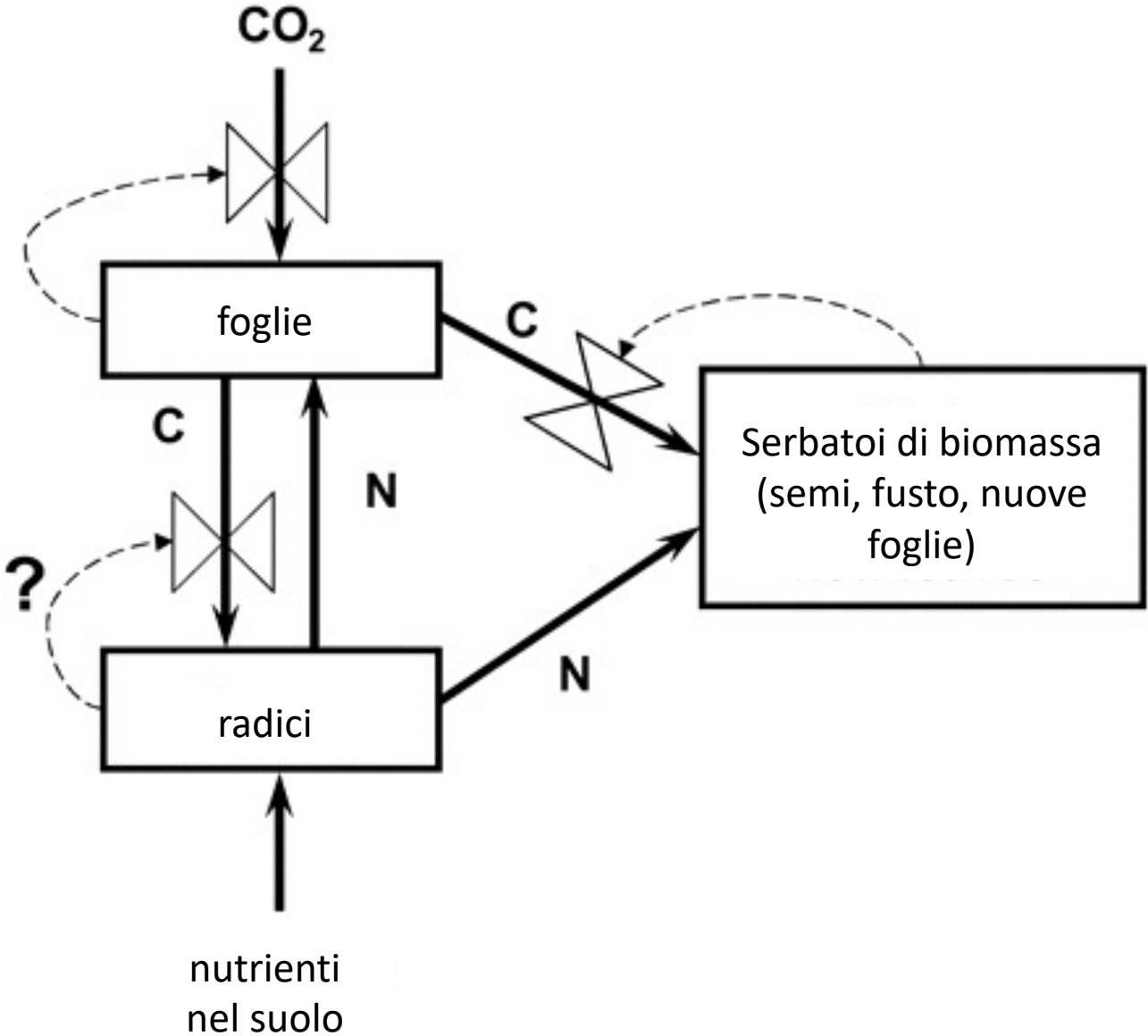


Global carbon sink



Yuan et al. 2018, Science Advances

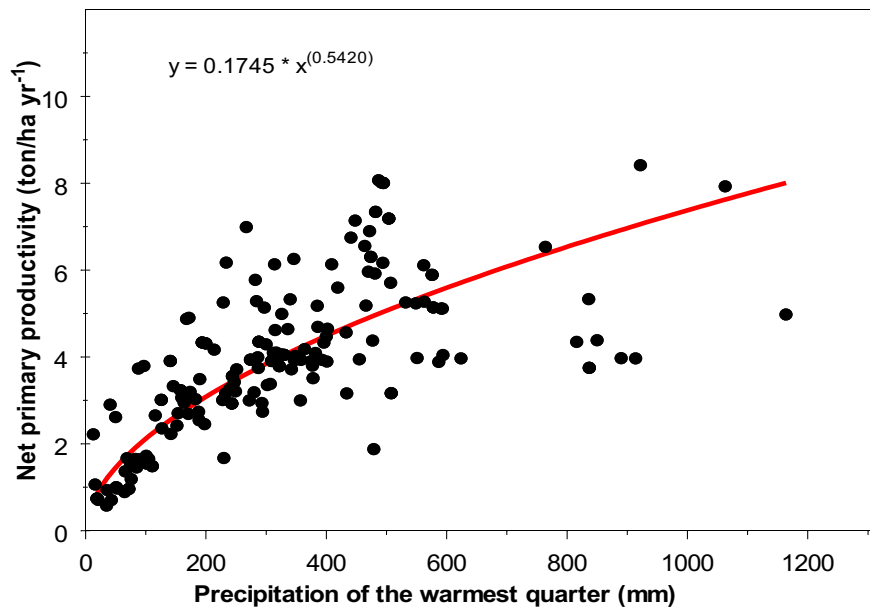
L'incremento in biomassa può non aumentare in modo proporzionale alla velocità della fotosintesi a causa della presenza di altri **fattori limitanti** (es. temperatura, acqua, azoto).



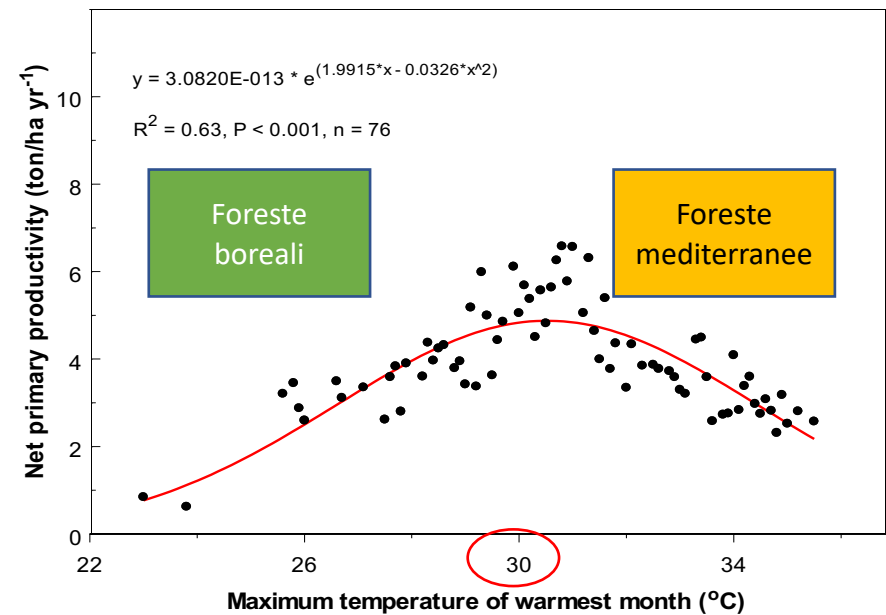
Temperatura e precipitazioni

La produttività primaria aumenta sempre con l'aumento delle precipitazioni (A), ma diminuisce oltre una certa soglia di temperatura (B).

A



B





Variazioni di produttività forestale previste per il periodo 2013-2070

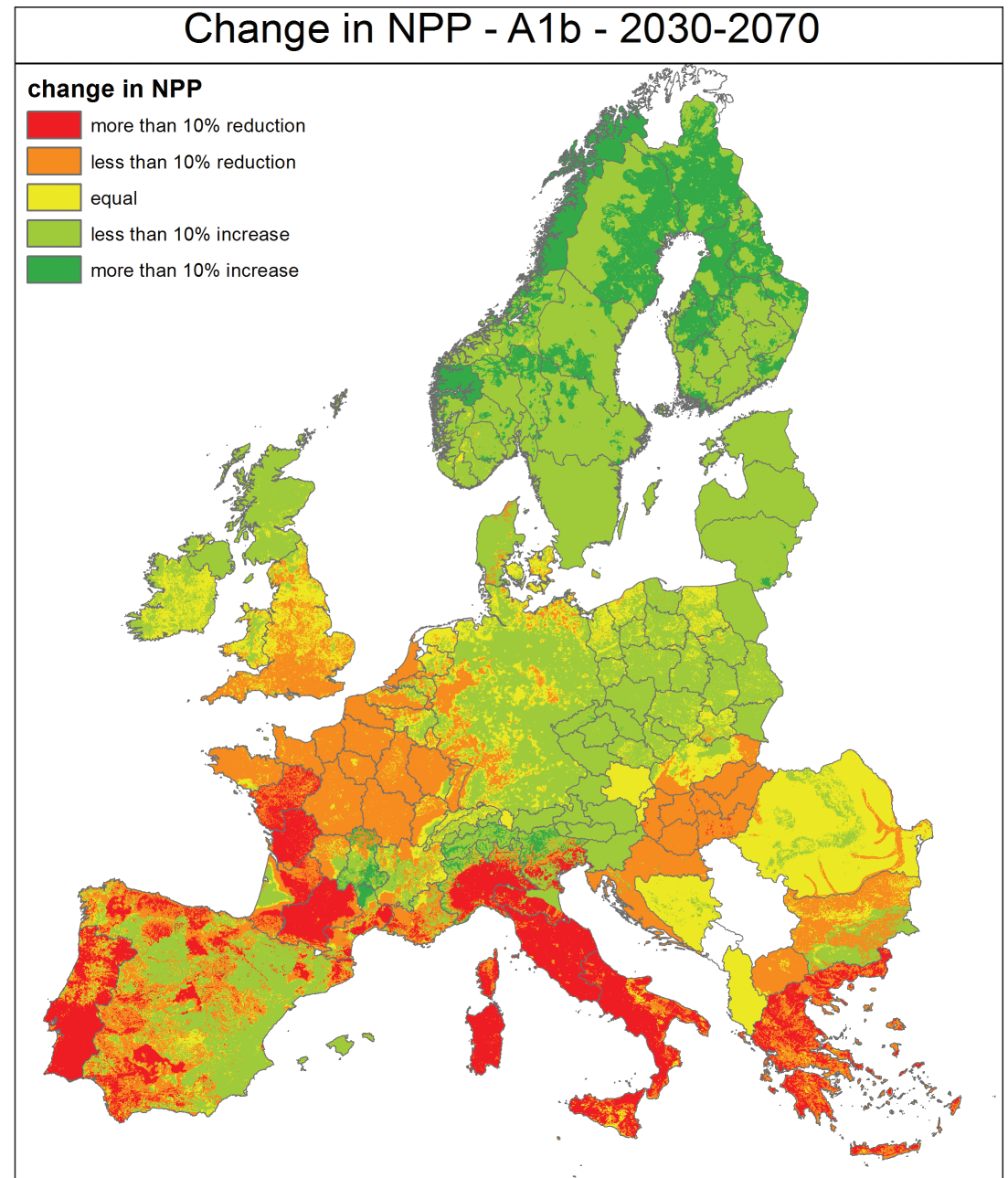
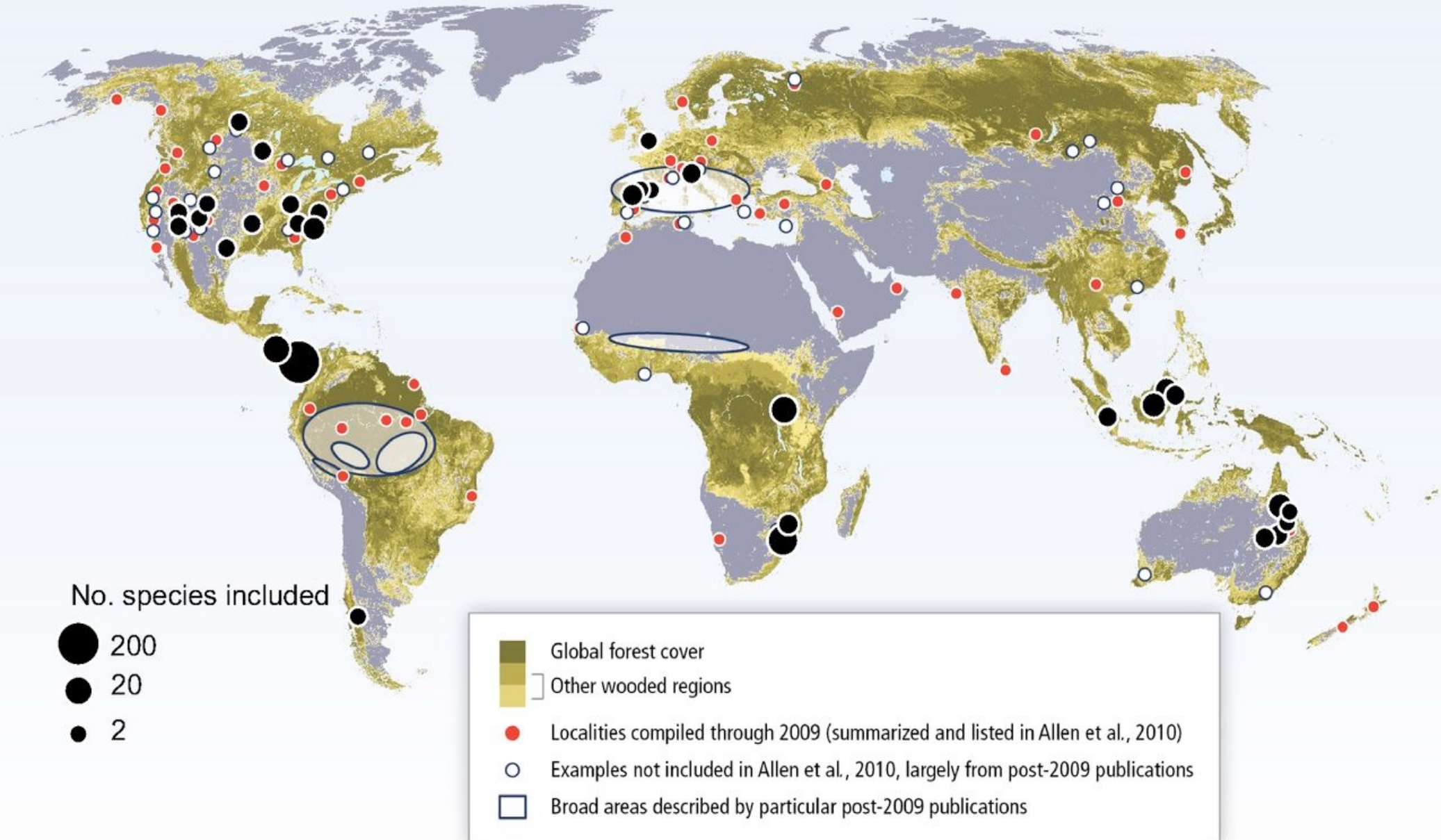
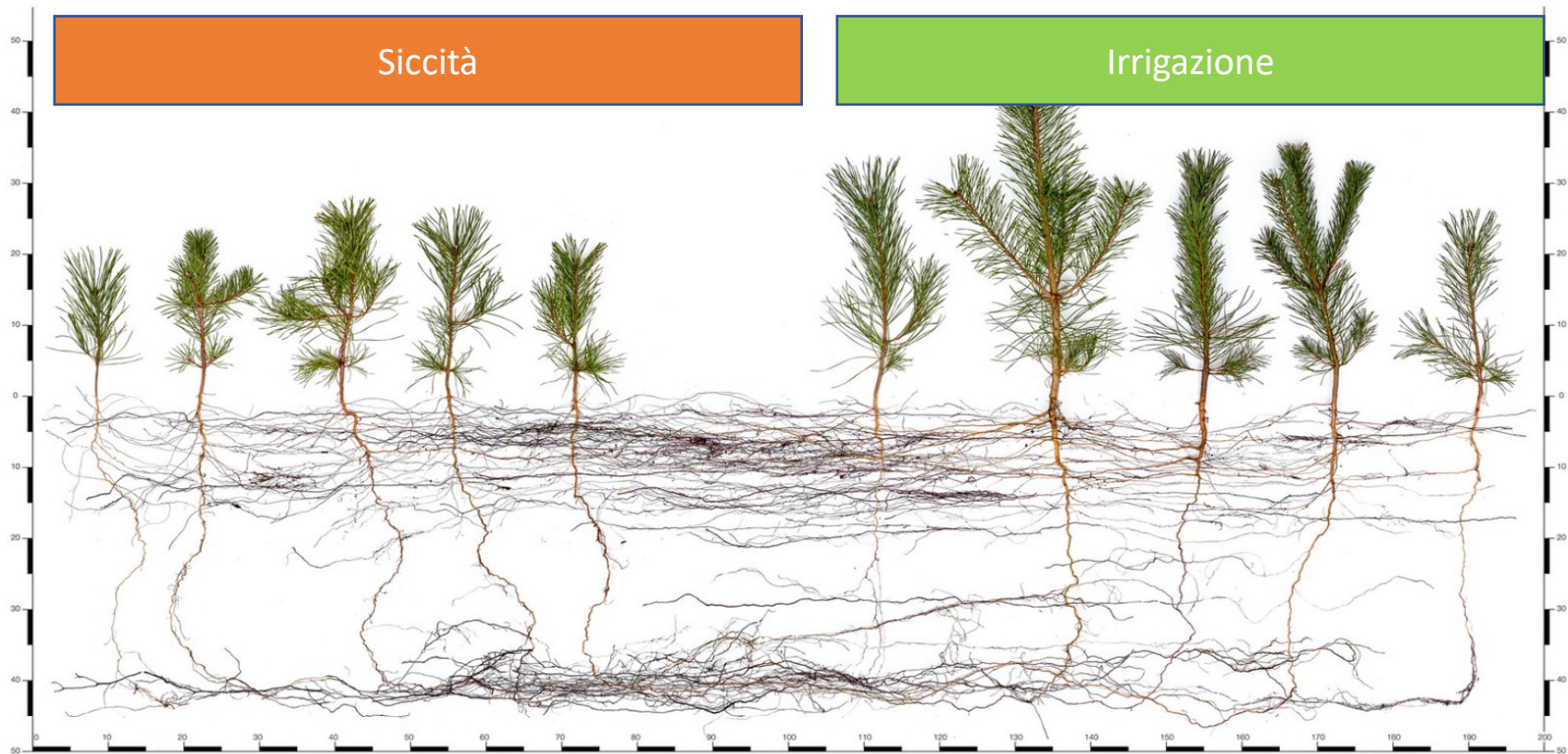


Figure 2. Expected average change in NPP in the period 2030–2070 per km², derived from Reyer et al. (2012).

Drought-induced forest dieback

<https://www.pnas.org/content/113/18/5024>





Semenzali di pino silvestre (© Christoph Bachofen, WSL)

<https://esajournals.onlinelibrary.wiley.com/doi/pdf/10.1002/ecs2.2108>

Migrazione della zona climatica ottimale per le specie forestali

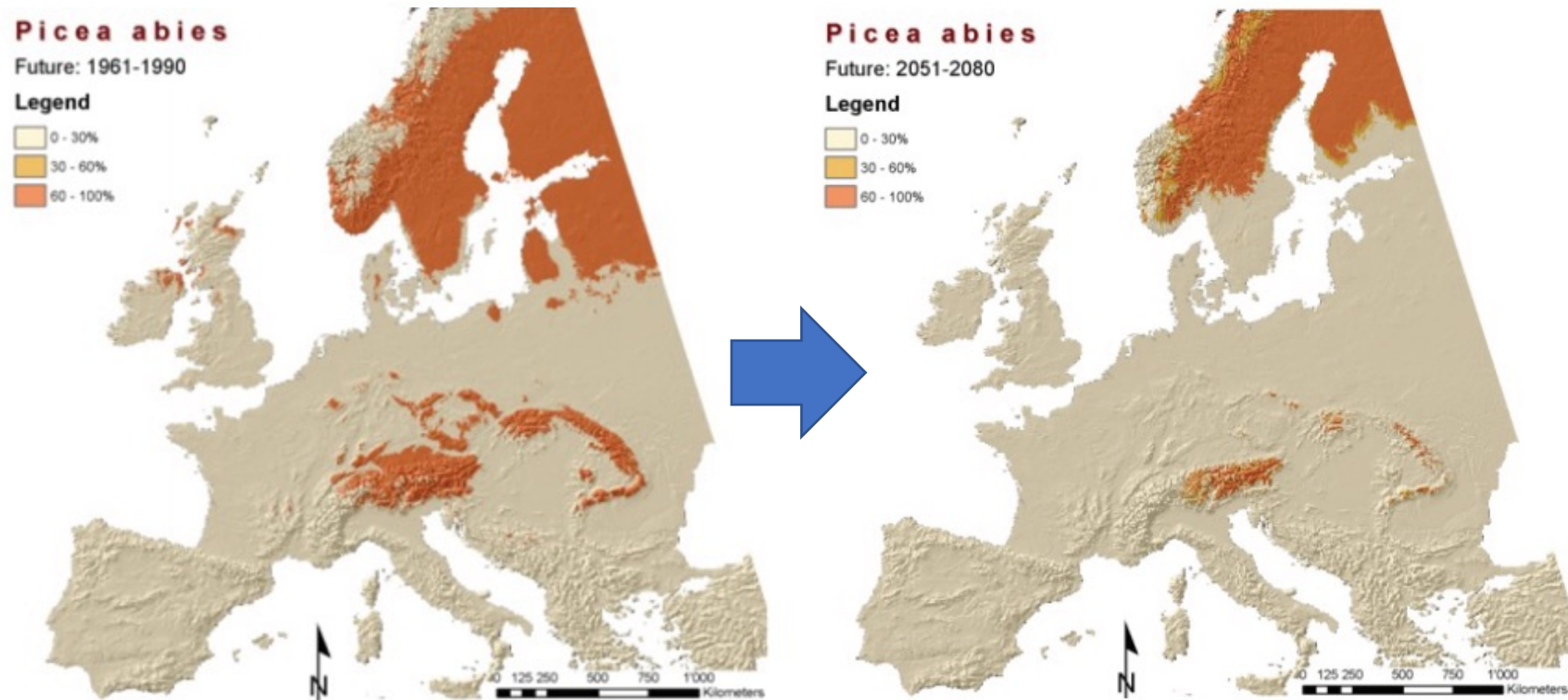
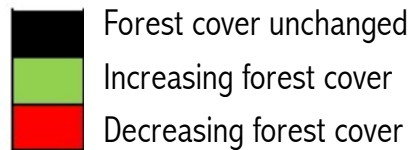


Figure 1. Ensemble projected change in habitat suitability for Norway spruce (*Picea abies*) in Europe following climate change in response to 6 RCM climate models using the A1B scenario and calibrated from 6 statistical models. The legend gives the agreement for simulating suitable habitat among all climate model x statistical model combinations from current (top) to the 2051–2080 period.



Castanea sativa



Mediterranean scrub



Fagus sylvatica

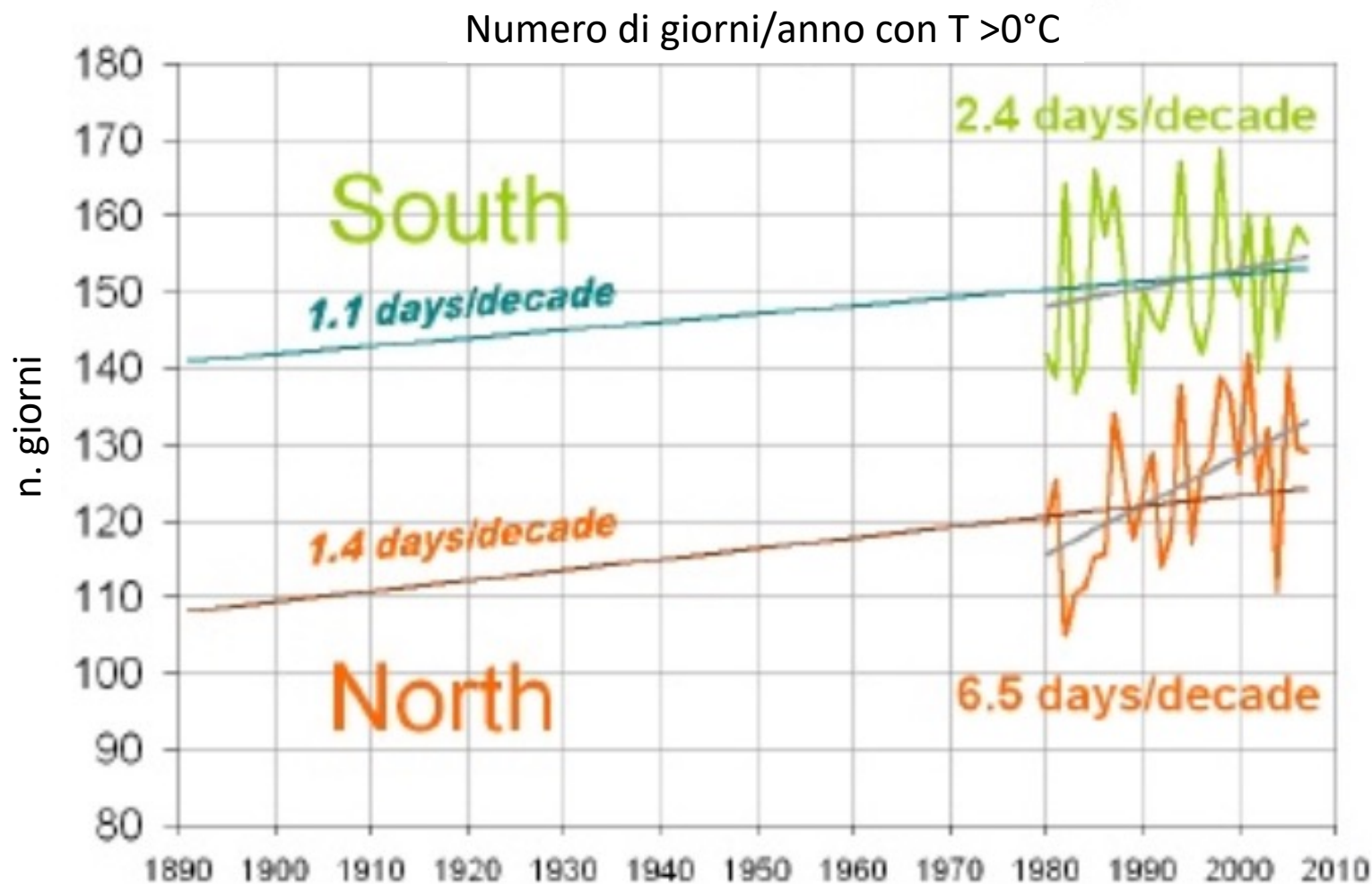


<http://www.minambiente.it/comunicati/ambiente-parte-consultazione-su-piano-nazionale-adattamento-cambiamenti-climatici>

Spostamento del limite degli alberi verso nord e verso l'alto.



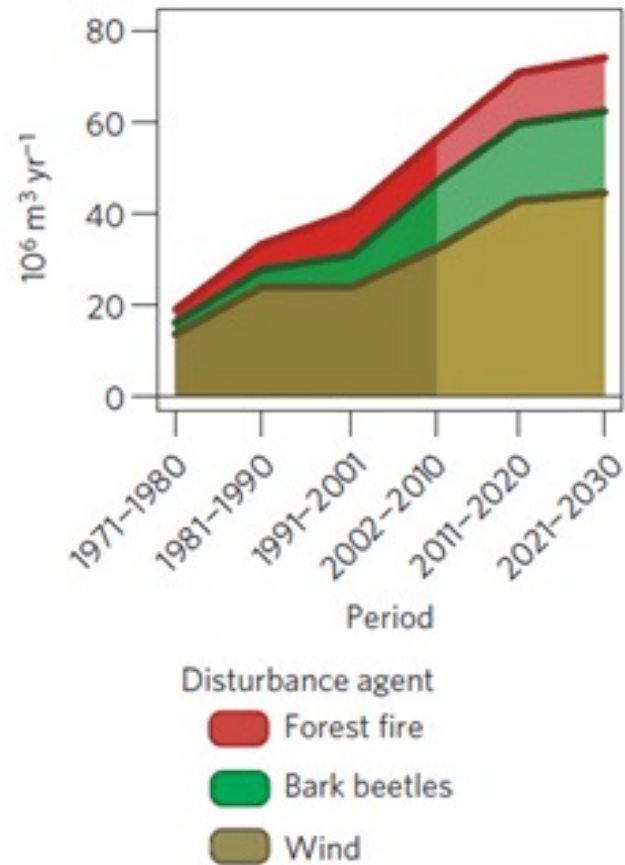
La lunghezza della stagione vegetativa aumenta come risultato dell'innalzamento termico in autunno e primavera. L'aumento sarà più sensibile sui versanti nord.



L'aumento dello stress idrico può influenzare negativamente la disponibilità di azoto e favorire la competizione da parte delle specie aliene e/o della componente erbacea o arbustiva.

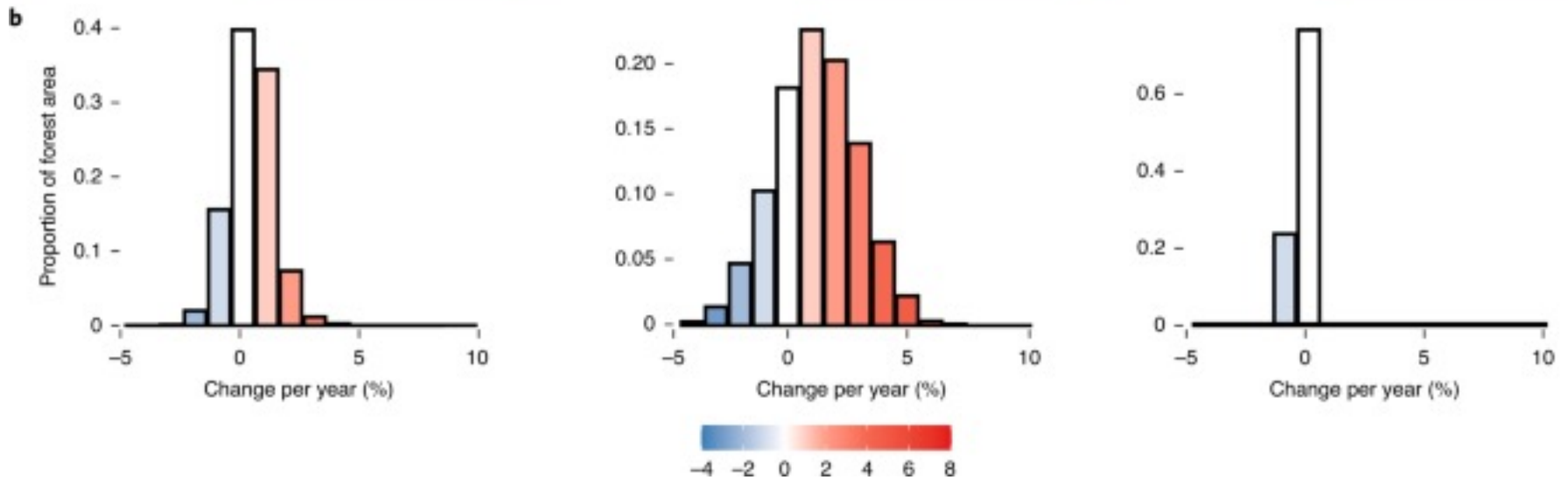
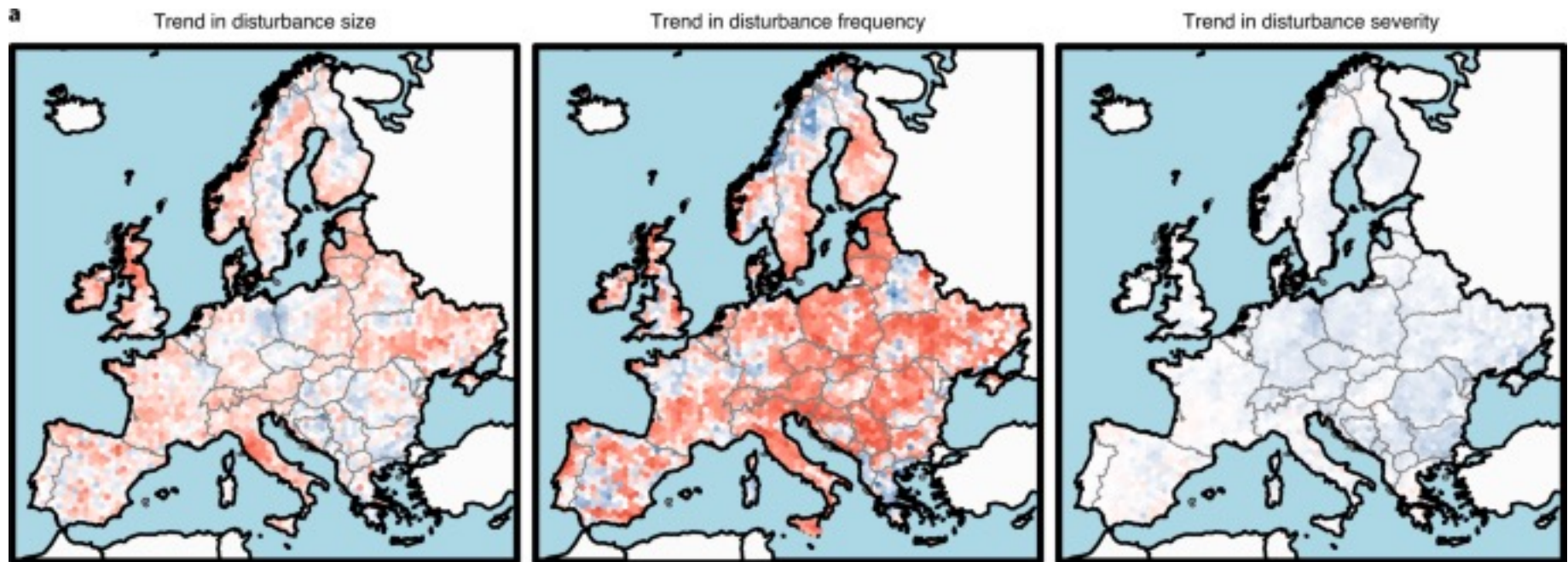


Aumento dei disturbi

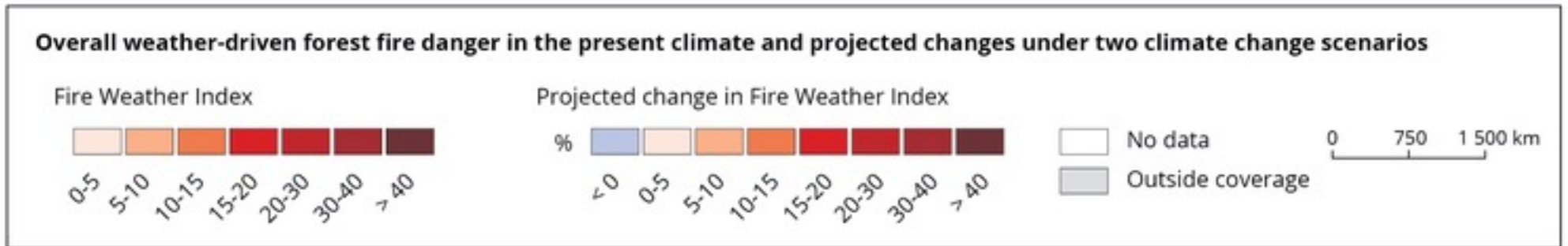
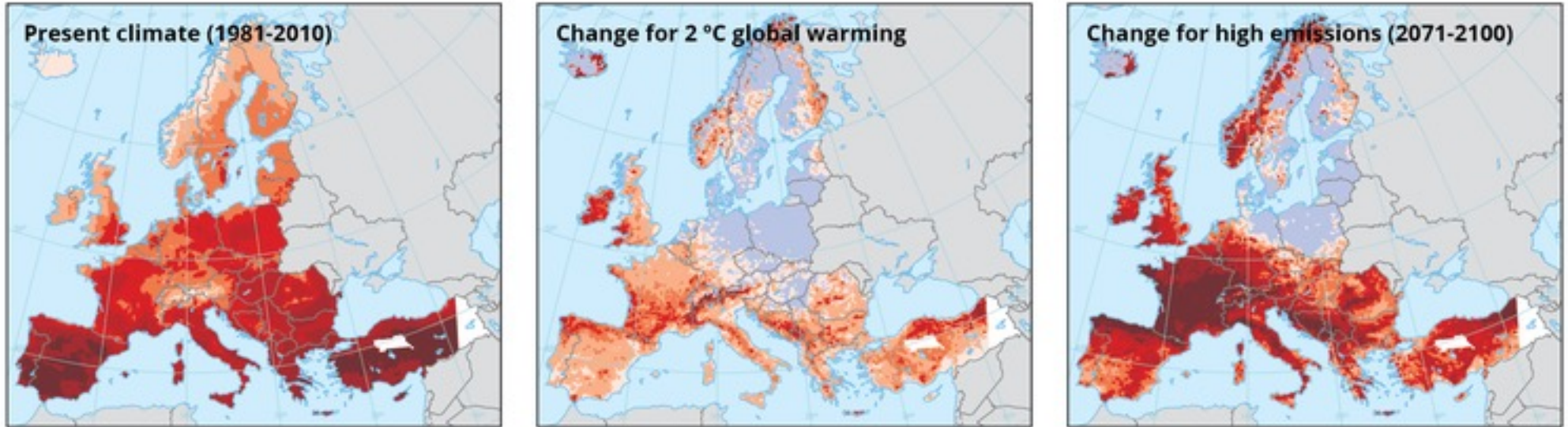


Seldi, et al., Increasing forest disturbances in Europe and their impact on carbon storage, Nature Climate Change August 2014.





Variazioni dell'indice di pericolo incendi in Europa a fine secolo



Variazioni % delle velocità di raffica del vento in Europa (1970-2070)

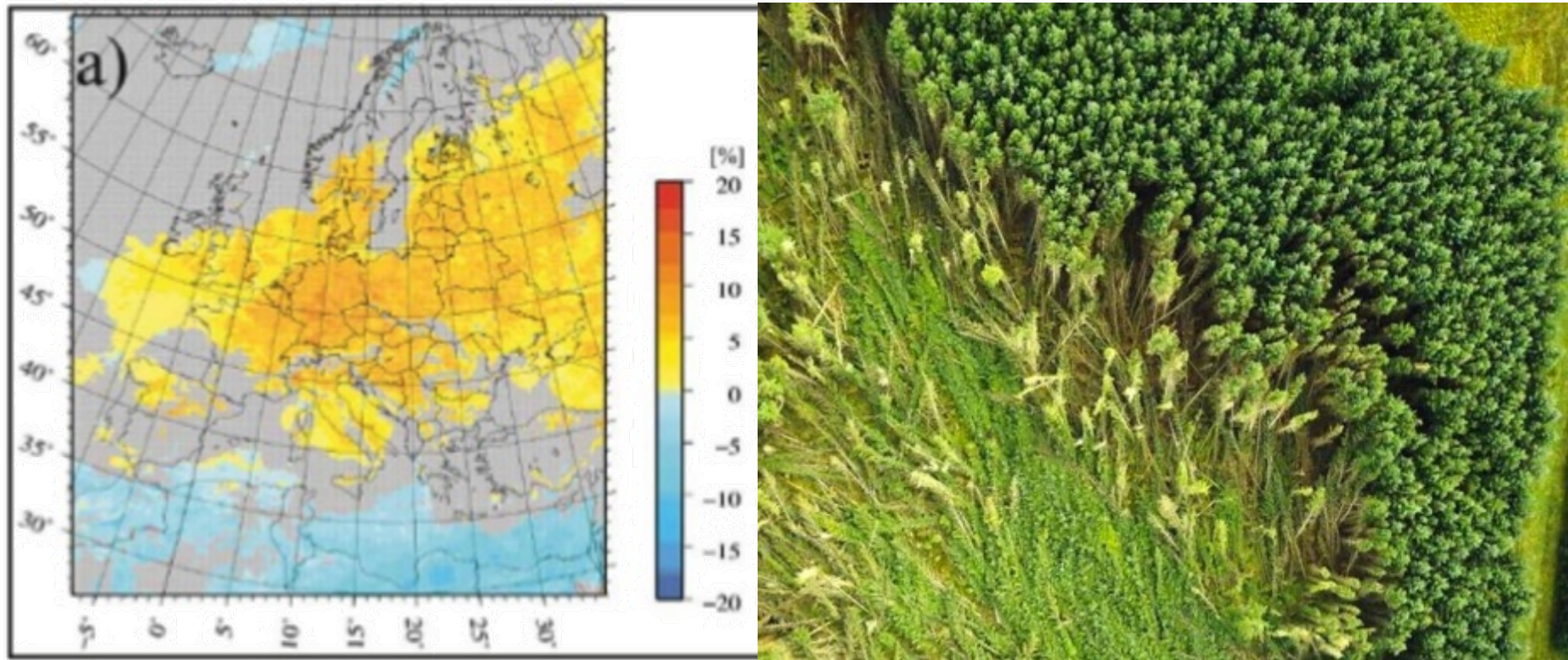


Figure 31. Relative change (in %; 2070–2099 versus 1970–1999) of a measure of extreme wind speed, simulated with two regional climate models nested into the ECHAM5 climate model with mid-range unmitigated emissions: a) all of Europe (based on one of the models) and b) Central Europe (based on the other model). Colours indicate significant changes (95th percentile confidence level). Non-significant changes are in grey. Source: Fink et al. 2009.

Disturbi biotici

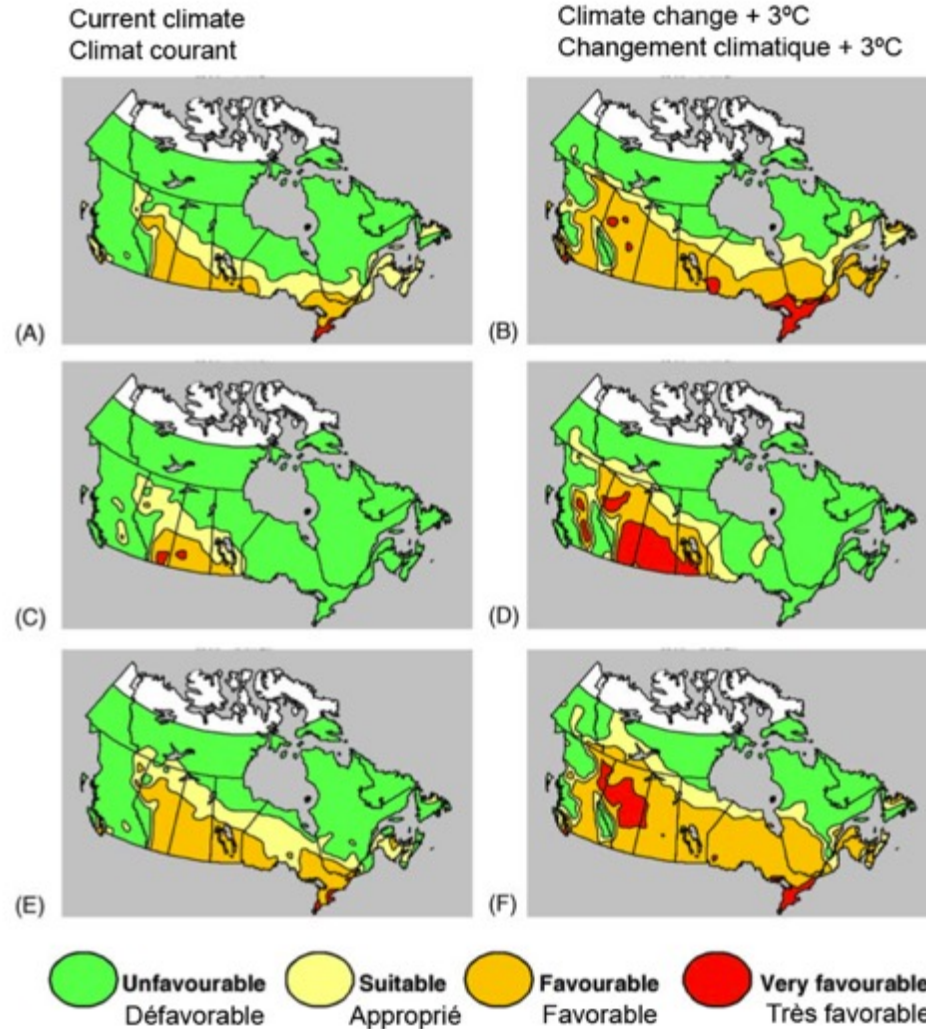
Cereal leaf beetle
Coléoptère de feuille de céréale
Oulema melanopus



Cabbage seedpod weevil
Charançon de graine de chou
Ceutorhynchus obstrictus



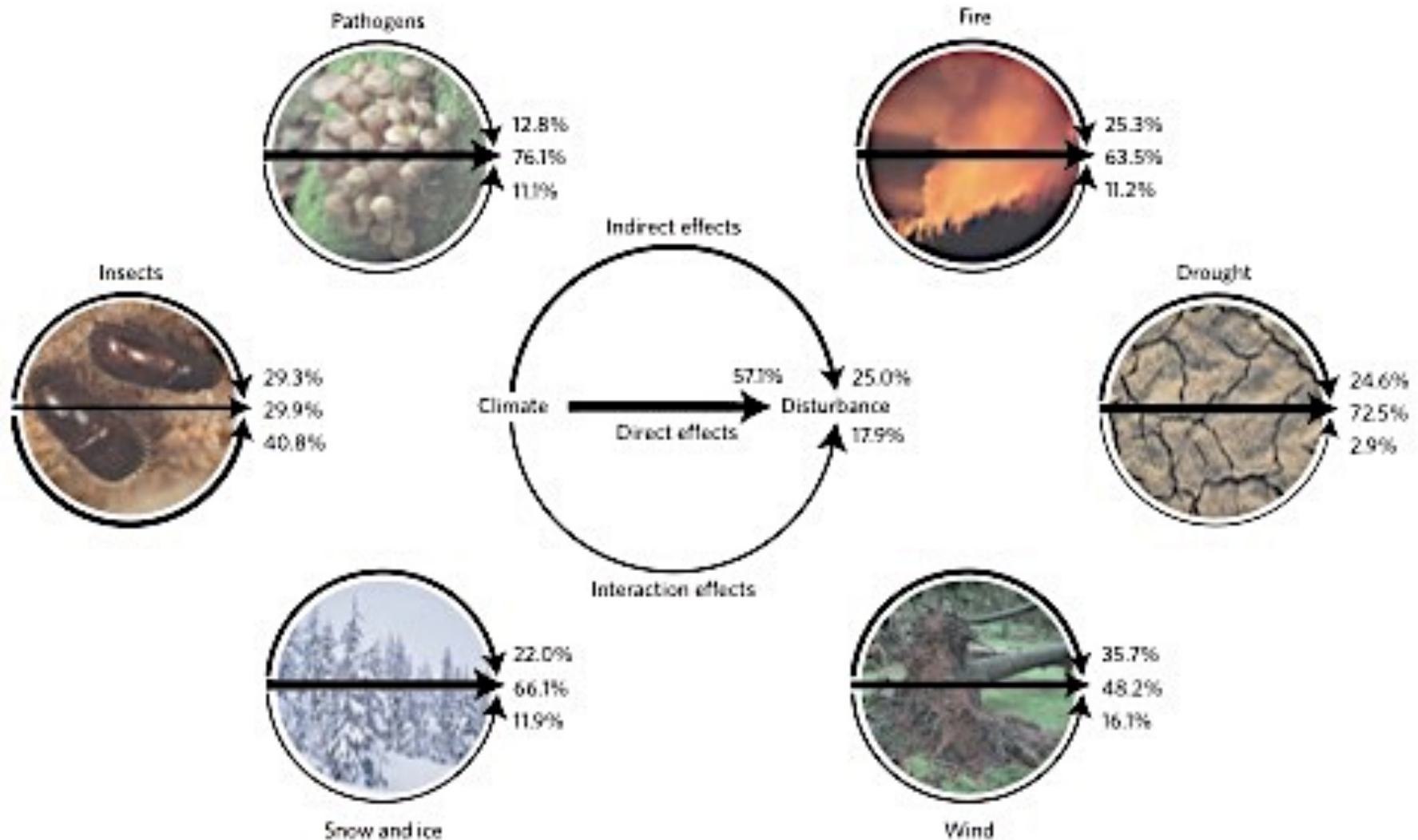
Bronzed or rape blossom beetle
Coléoptère des fleurs du colza
Meligethes viridescens



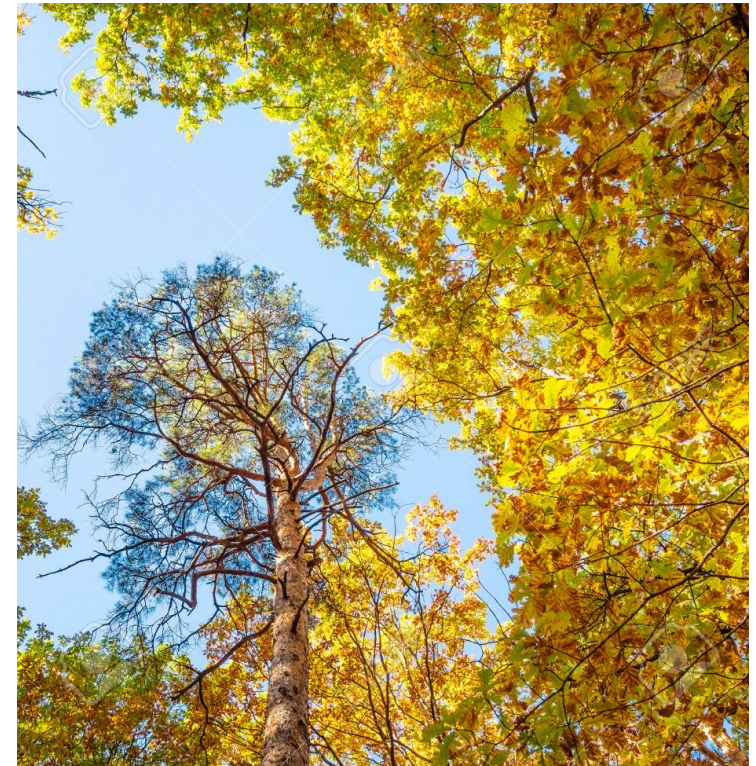
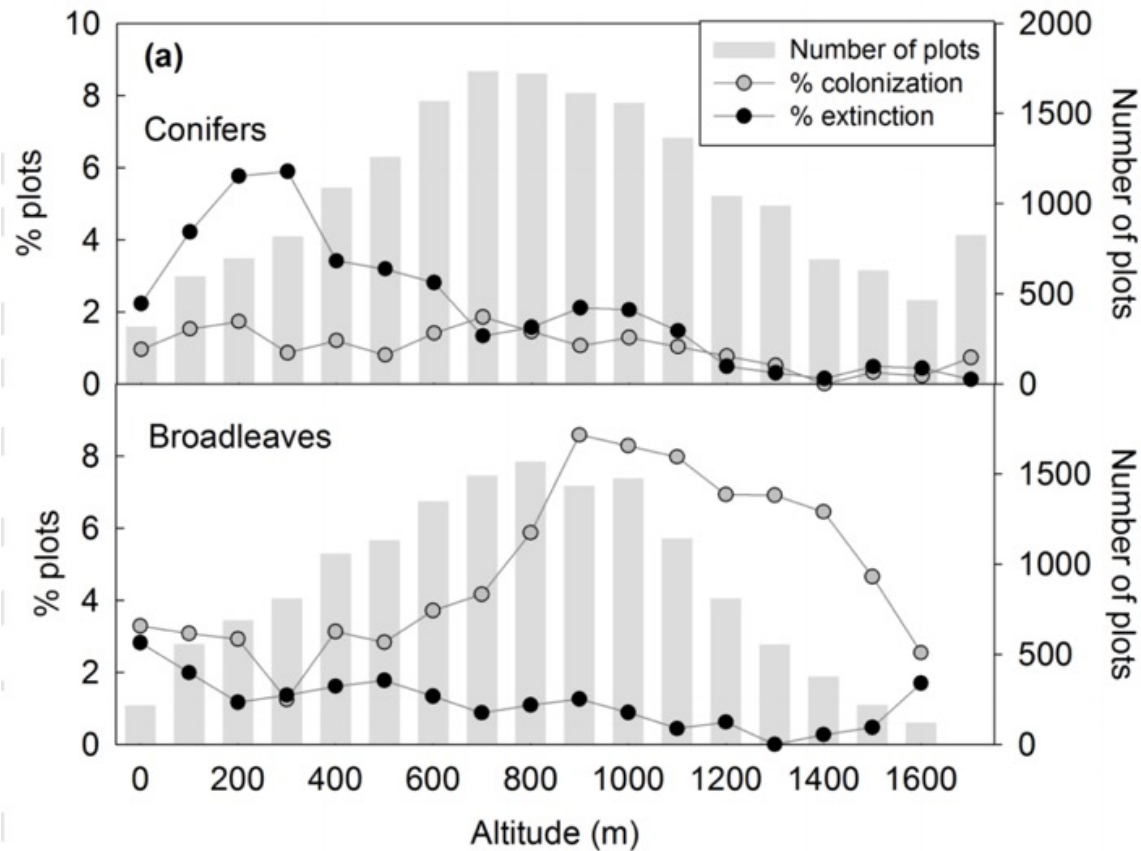
Adapted from: Offert, O., and Weiss, R.M. 2006. Impact of climate change on potential distributions and relative abundances of *Oulema melanopus*, *Meligethes viridescens*, and *Ceutorhynchus obstrictus* in Canada. *Agriculture, Ecosystems and Environment* 113: 295: 301.

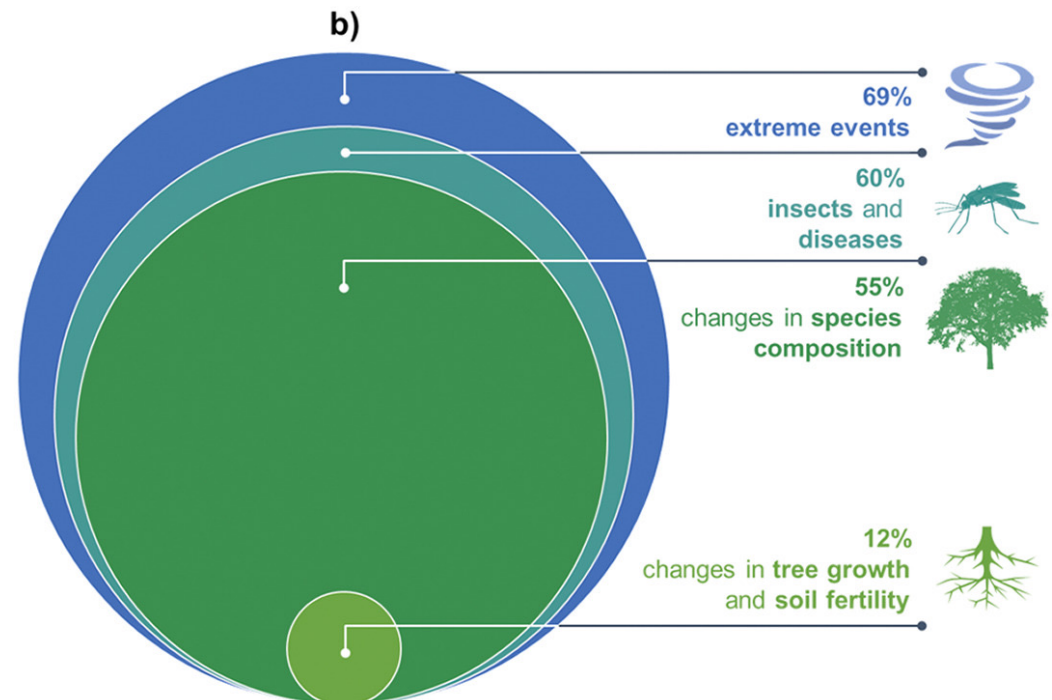
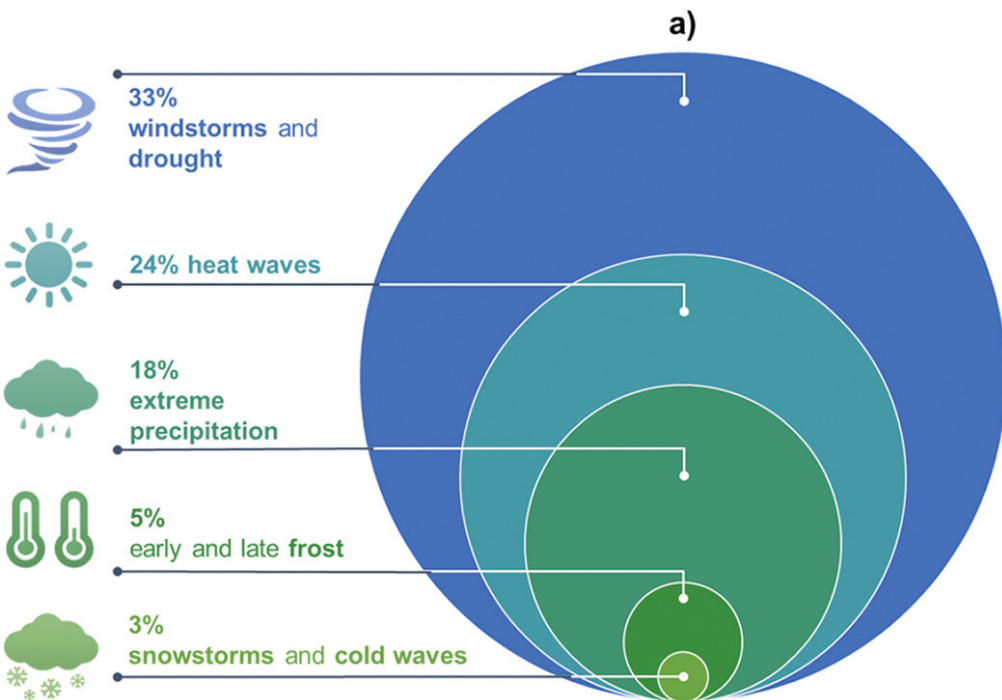


Interazioni tra disturbi

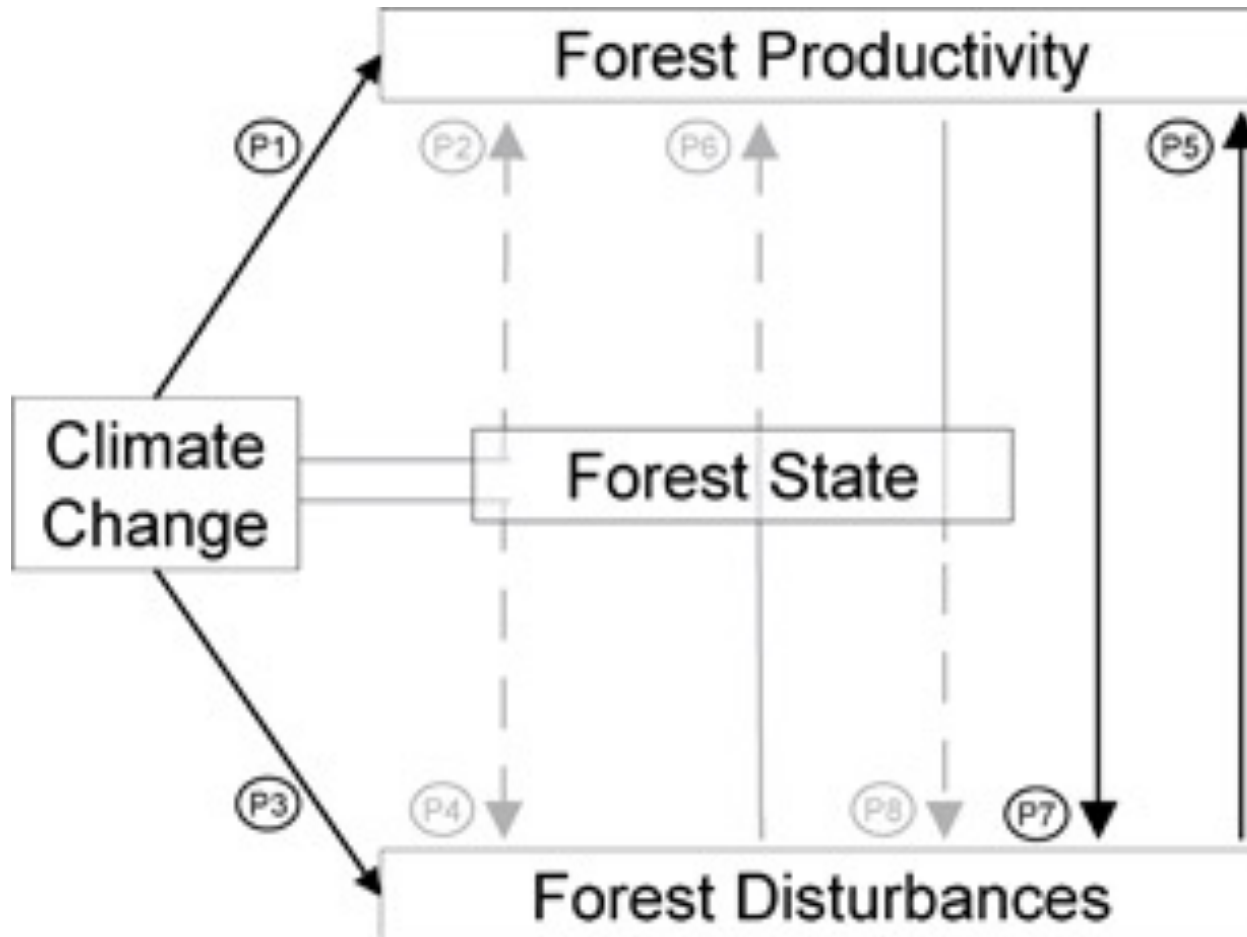


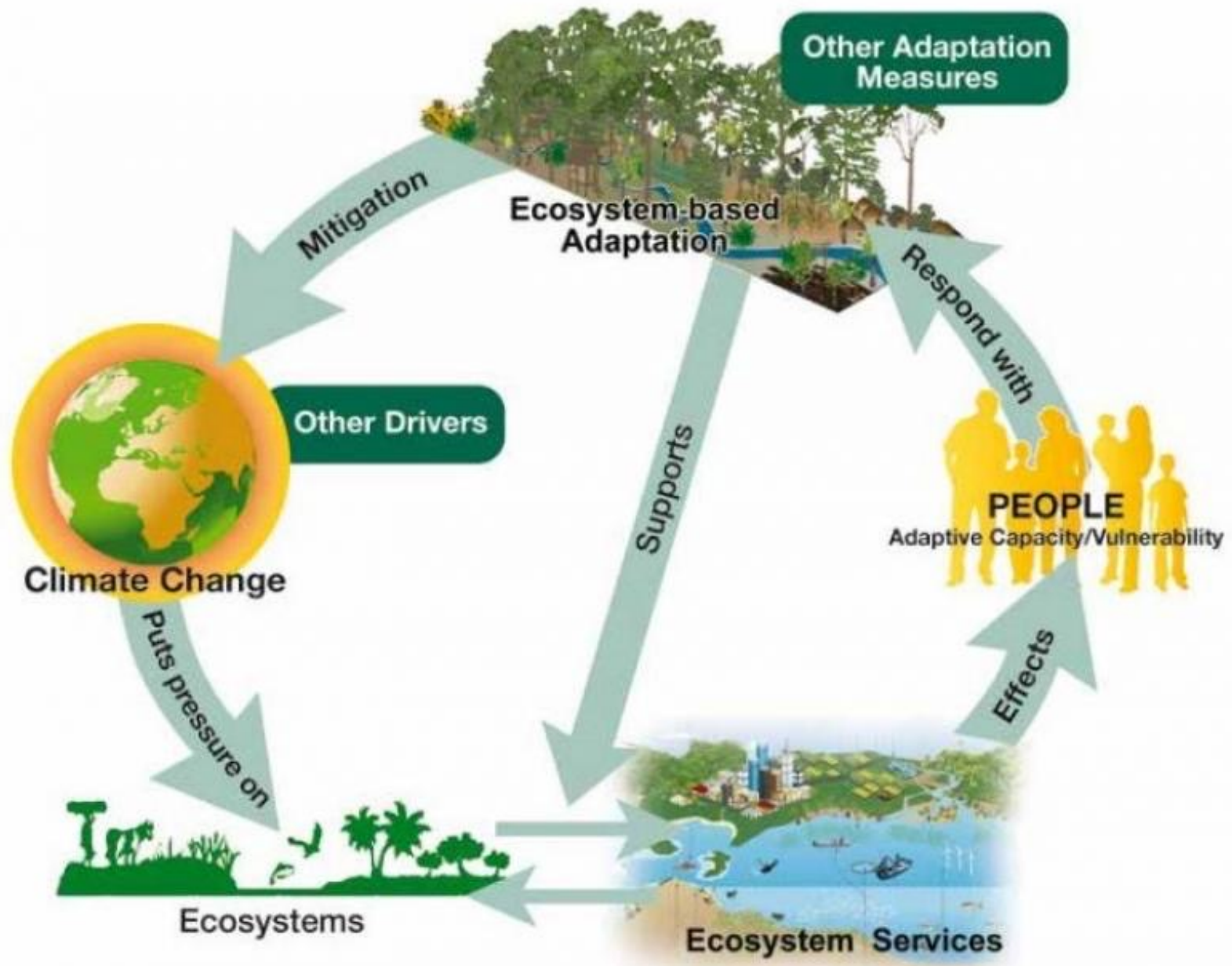
L'aumento dei disturbi altera la composizione specifica a favore delle **latifoglie**, che tendono a conquistare quote sempre più elevate

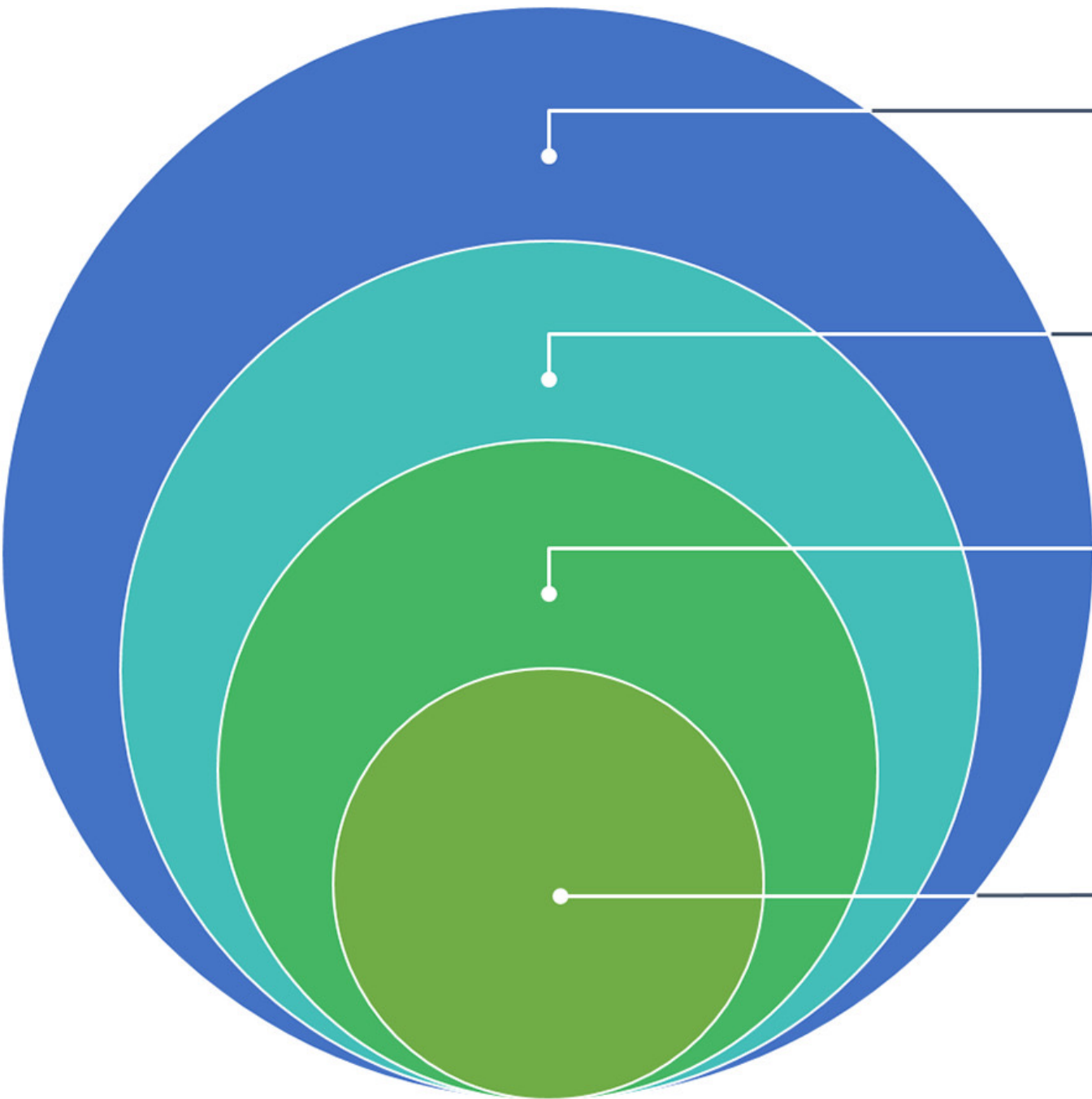




Gli effetti del cambiamento climatico su produttività e disturbi si sommano tra loro, creando nuove dinamiche per gli ecosistemi forestali







91%
believe in
climate change



72% expect
further impacts
on forests

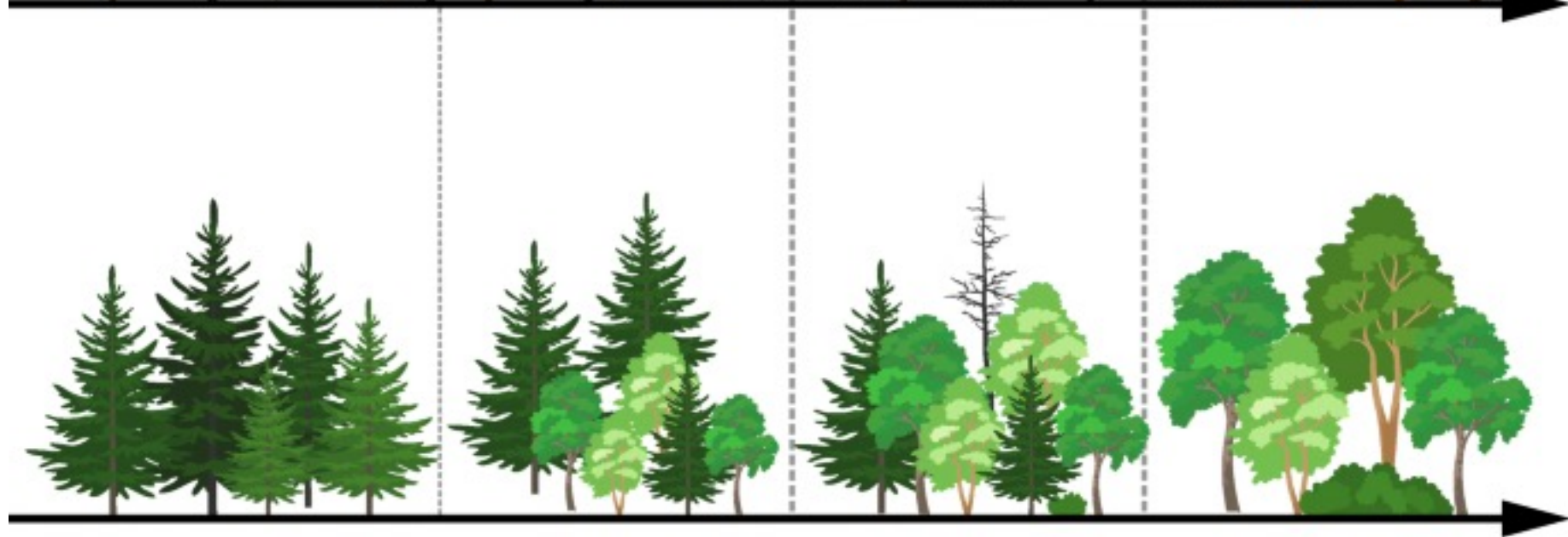


55%
have experienced
its impacts



36%
have adapted





Time

t1

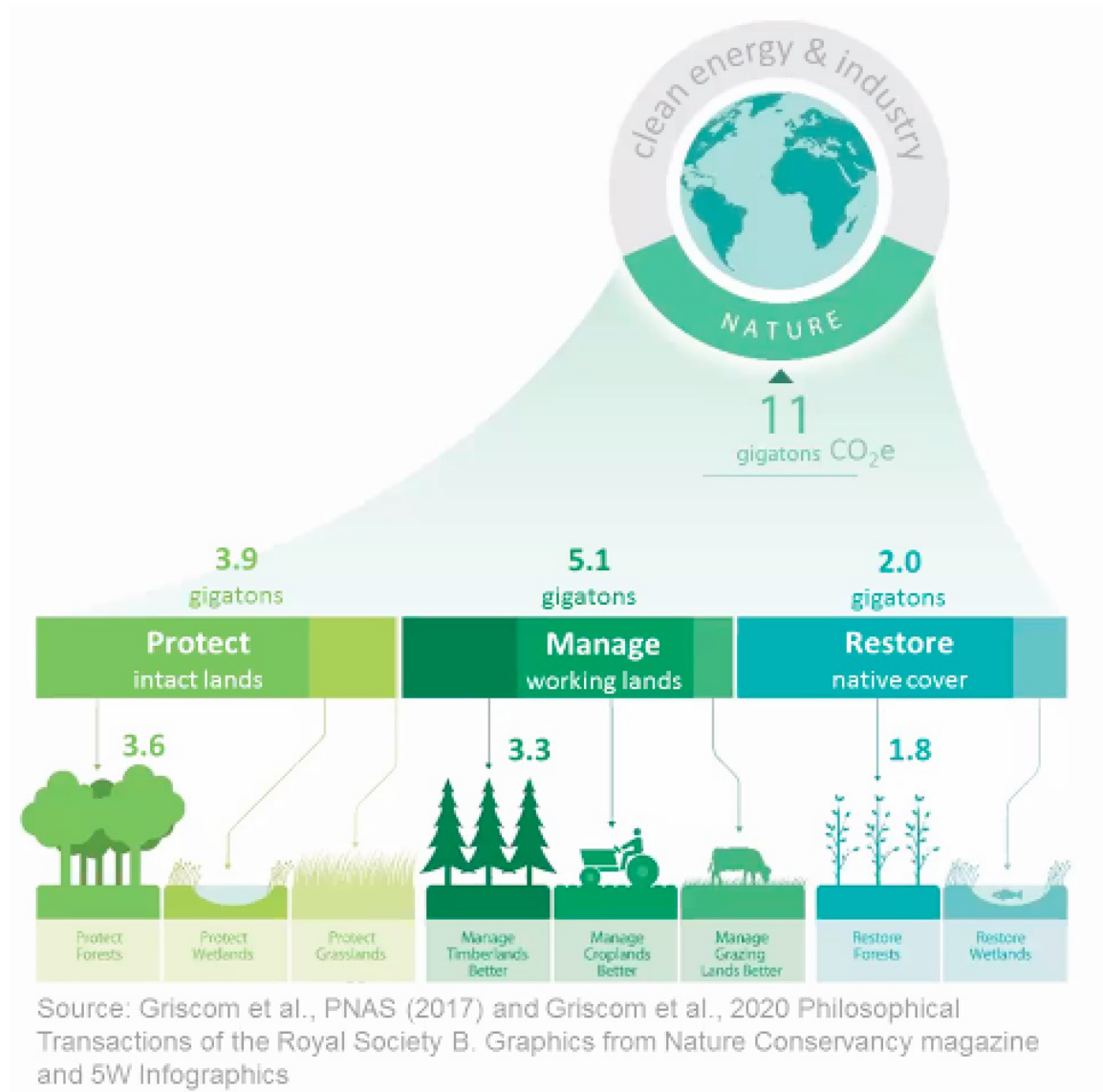
t2

t3



Nature based solutions #Naturenow

<https://www.youtube.com/watch?v=uQm3XPtjrS4>



Strategie di adattamento

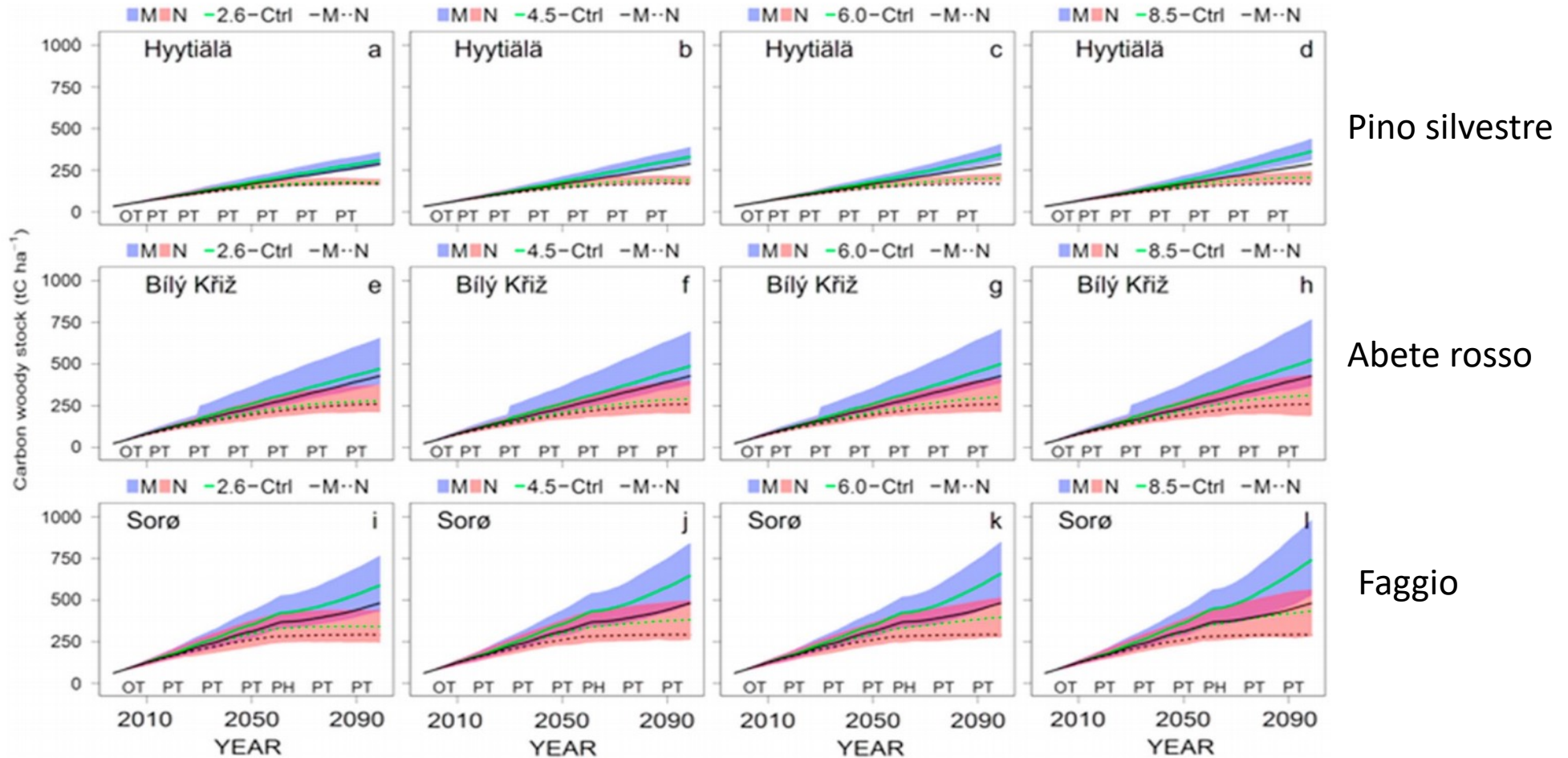
- Rinnovazione naturale
- Rinnovazione artificiale (provenienze)
- Preparazione del sito
- Gestione della vegetazione erbacea
- Gestione della composizione specifica
- Regolazione della competizione (diradamenti)
- Gestione della stabilità meccanica
- Gestione dei combustibili
- Regolazione della luce al suolo (intensità dei tagli, turno)

Il **diradamento** può riportare il numero di piante a ettaro in equilibrio con la ridotta disponibilità idrica del sito, evitando brusche interruzioni di incremento o ondate di mortalità in occasione di annate siccitose



Effetti del diradamento (blu) vs non gestione (rosso) in foreste europee

<https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1029/2018MS001275>



RCP2.6

RCP4.5

RCP6.0

RCP8.5

L'aumento della **resistenza ai disturbi** si basa sulla promozione degli elementi che conferiscono resistenza o resilienza alla foresta in occasione di grandi disturbi naturali.





In a forest where fires rarely happen, fuel builds up: There's **surface fuel** (grass, logs, woody debris, brush); **ladder fuel** (shrubs, small trees, snags); and **tree crowns**.

1 Surface fires spread quickly through brush and woody debris.

2 Ladder fuels allow the fire to move up toward the forest canopy.

3 Tree crown fires are so intense, they're difficult to control.

Gestione dei combustibili forestali



Selvicoltura a rilascio variabile





Gestione della vulnerabilità al vento





Aumento mescolanza e
eterogeneità



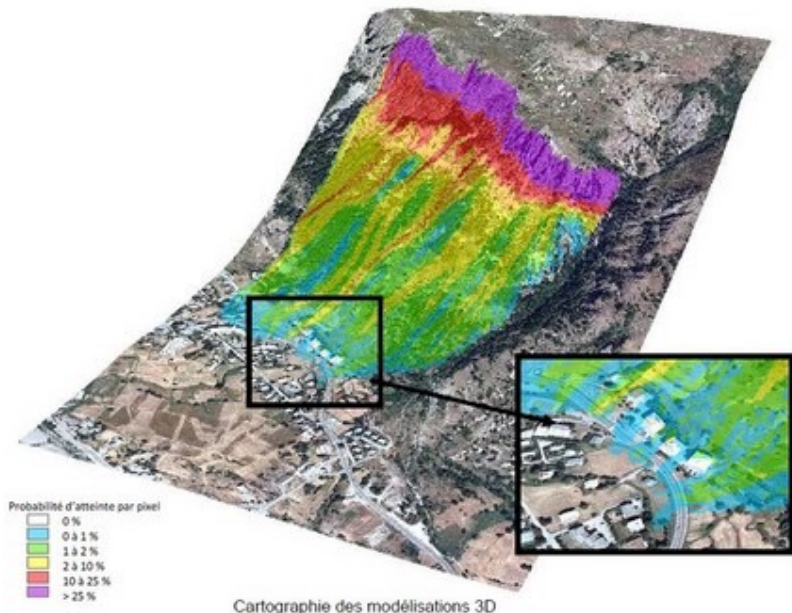
Rilascio elementi di habitat e
regolazione del microclima

Foreste con funzione di **protezione diretta**



Pericolo
naturale

Bene da
proteggere



Cartographie des modélisations 3D



L'aumento della **diversità specifica** e dei **paesaggi** fornisce alle foreste un numero maggiore di “carte” da giocare in caso di ondate siccitose o disturbi naturali (“ipotesi dell'assicurazione”)

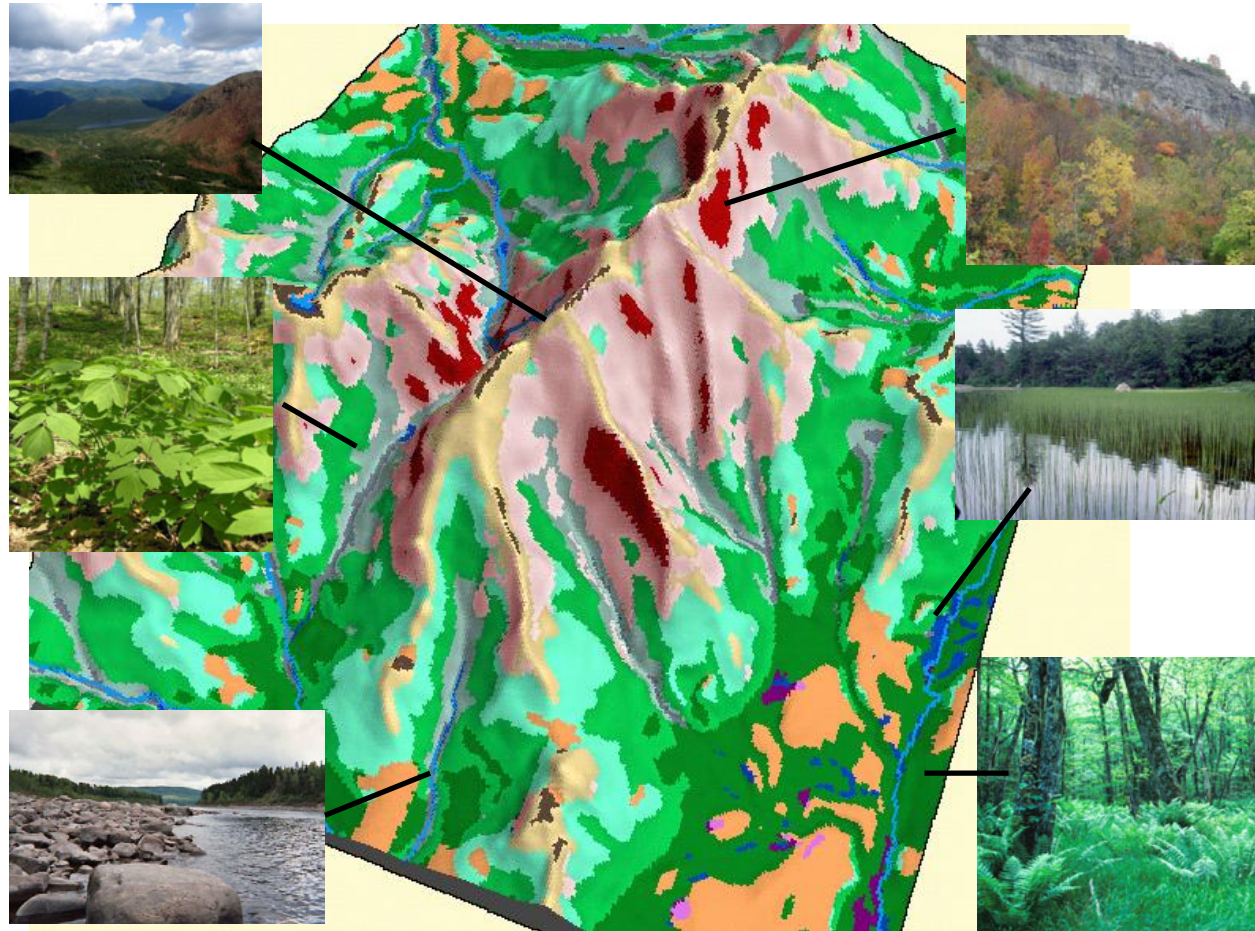
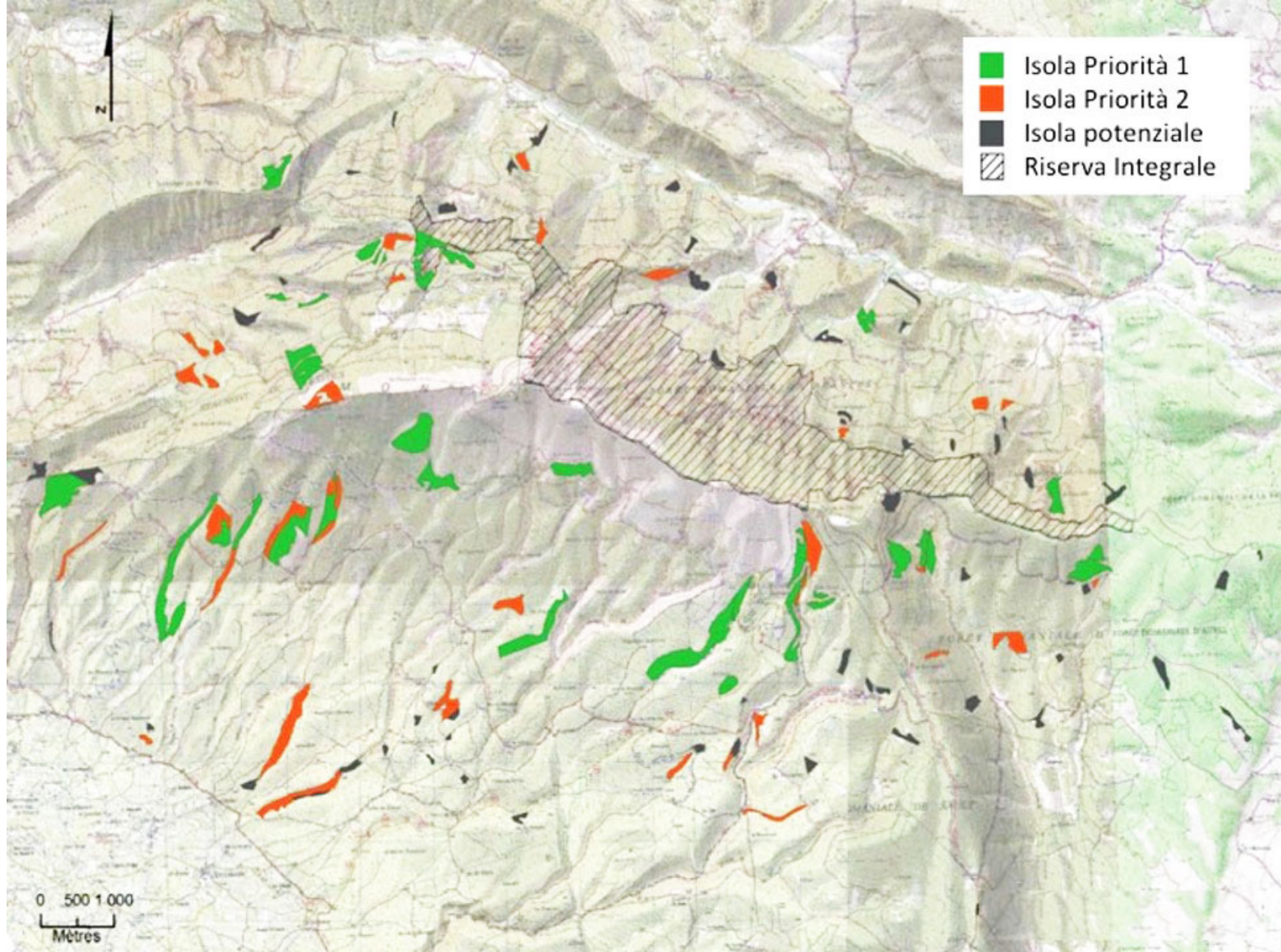


Figure 4. Landscapes with greater heterogeneity provide more options for species to move and rearrange at a given site.





Il mantenimento o il ripristino della **connettività ecologica** fornisce alle specie vegetali e animali maggiori possibilità di migrazione e mescolanza genetica, promuovendo la selezione e la conservazione dei **tratti adattativi**.



Rimboschimento

Why?

Sempre necessario?

Where?

Prioritizzazione aree

What?

Quali specie?

How?

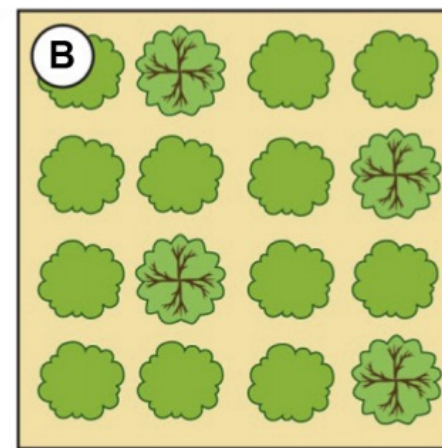
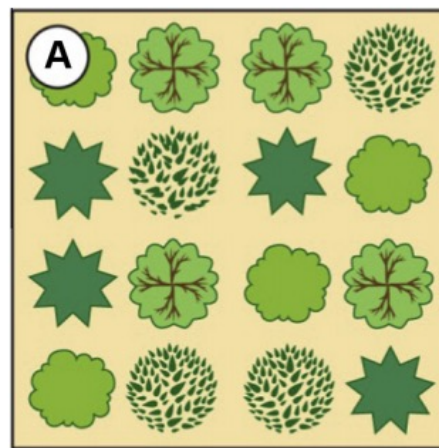
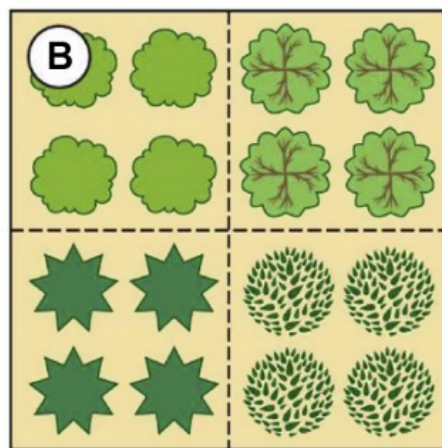
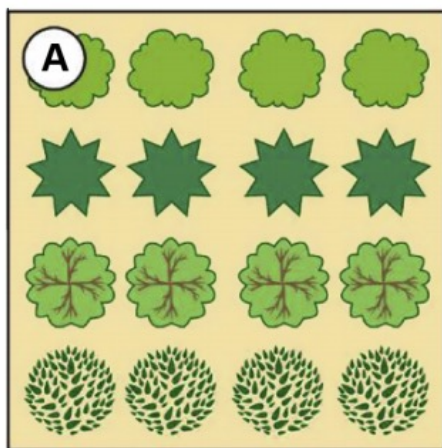
Con che struttura?



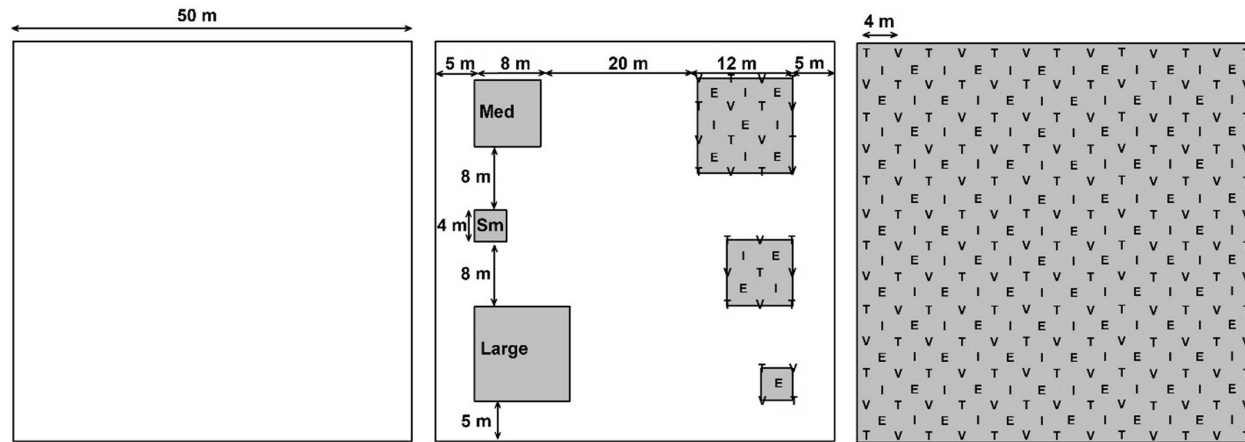
CHALLENGE



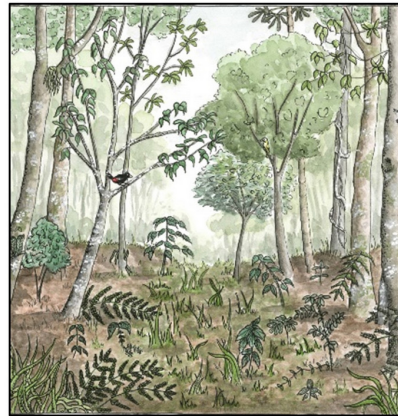
Scelta delle specie e mescolanza



Distribuzione delle piantine



Natural regeneration



Applied nucleation



Plantation

Protezione dei semenzali da brucamento, siccità



Ricostituzione basata sugli elementi che favoriscono la rinnovazione naturale





Quaking aspen

Paper birch

Sitka spruce

White Engelmann spruce

Western larch

Douglas fir

Lodgepole pine

Western white pine

Ponderosa pine

Subalpine fir

Pacific silver fir

Grand fir

Western red cedar

Alaska yellow cypress

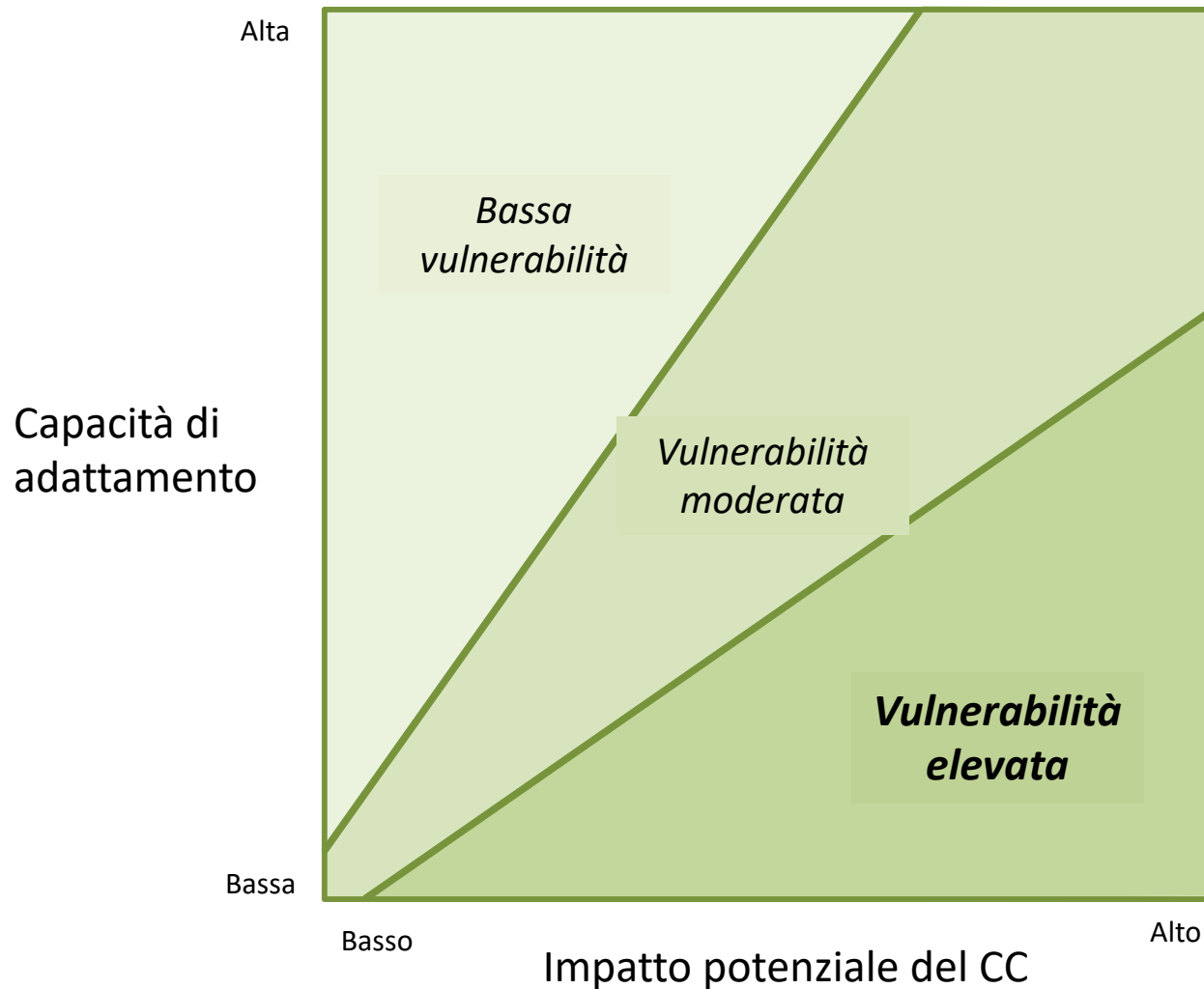
Western Hemlock

Selezione di specie e provenienze meglio adattate al cambiamento climatico (es. diverse popolazioni di abete bianco in Europa), da utilizzare nella migrazione assistita o favorire nella gestione forestale

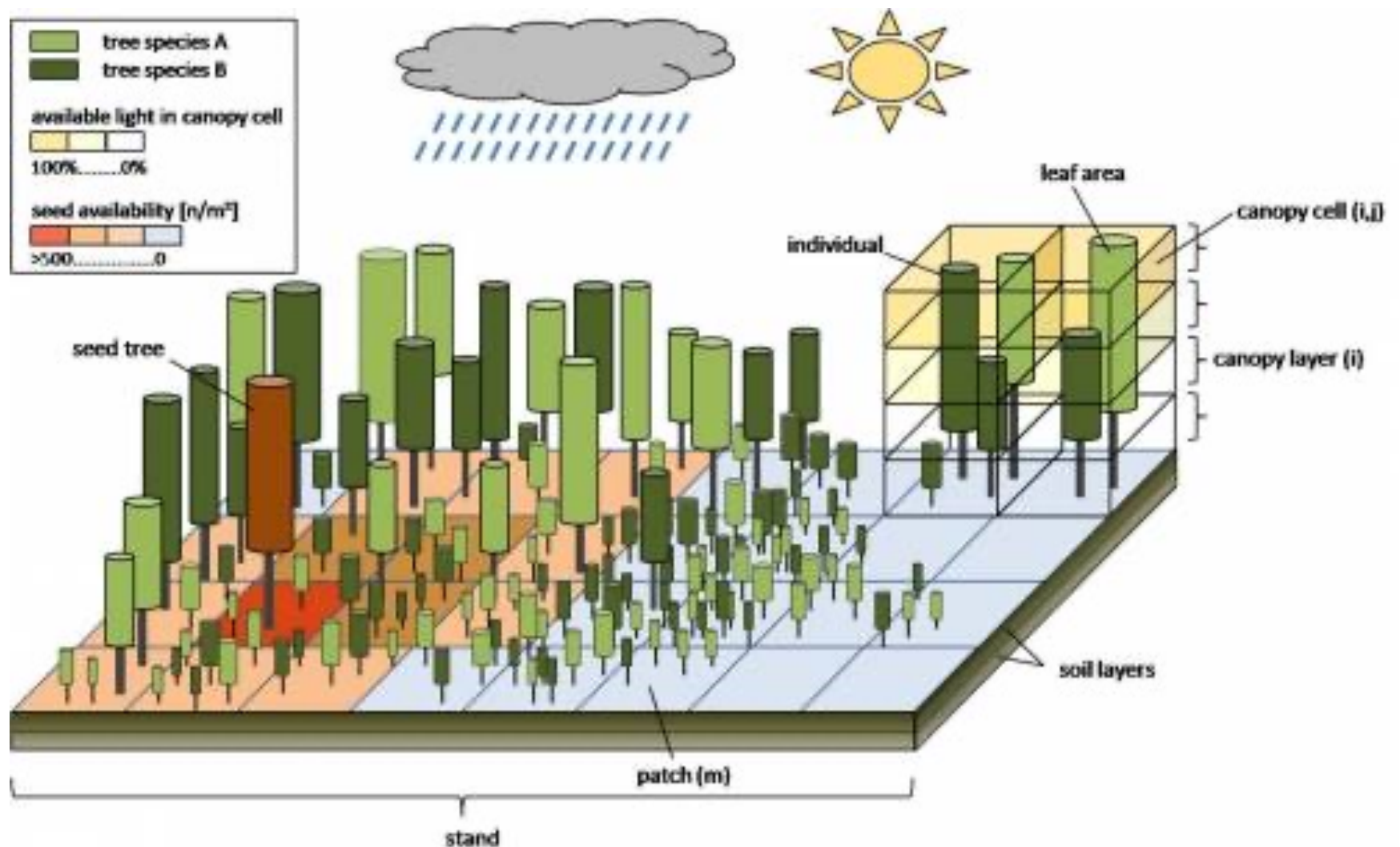


Analisi della vulnerabilità delle foreste

Associa gli impatti sui servizi ecosistemici alla capacità di adattamento



Modellistica forestale





FE19 CCM/IT/001201



[IL PROGETTO](#) ▾

[PES](#)

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[AZIENDE](#) ▾

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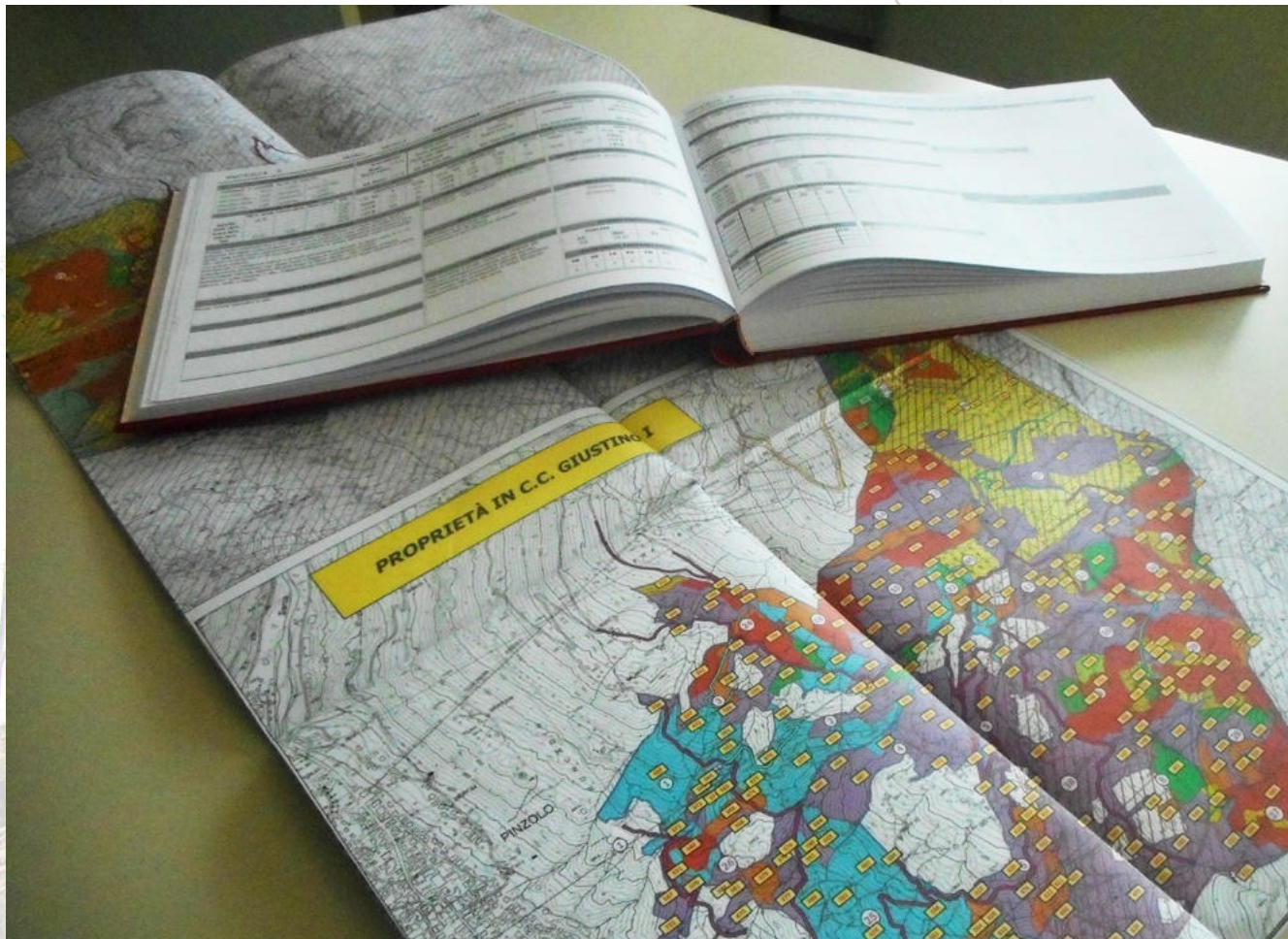
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PROGETTO LIFE CO2PES&PEF

Le foreste rappresentano una risorsa primaria per il sostentamento della vita stessa sul pianeta

[APPROFONDISCI](#)



Inserire nella pianificazione forestale
una **analisi dei rischi** per i servizi
forniti dalla foresta