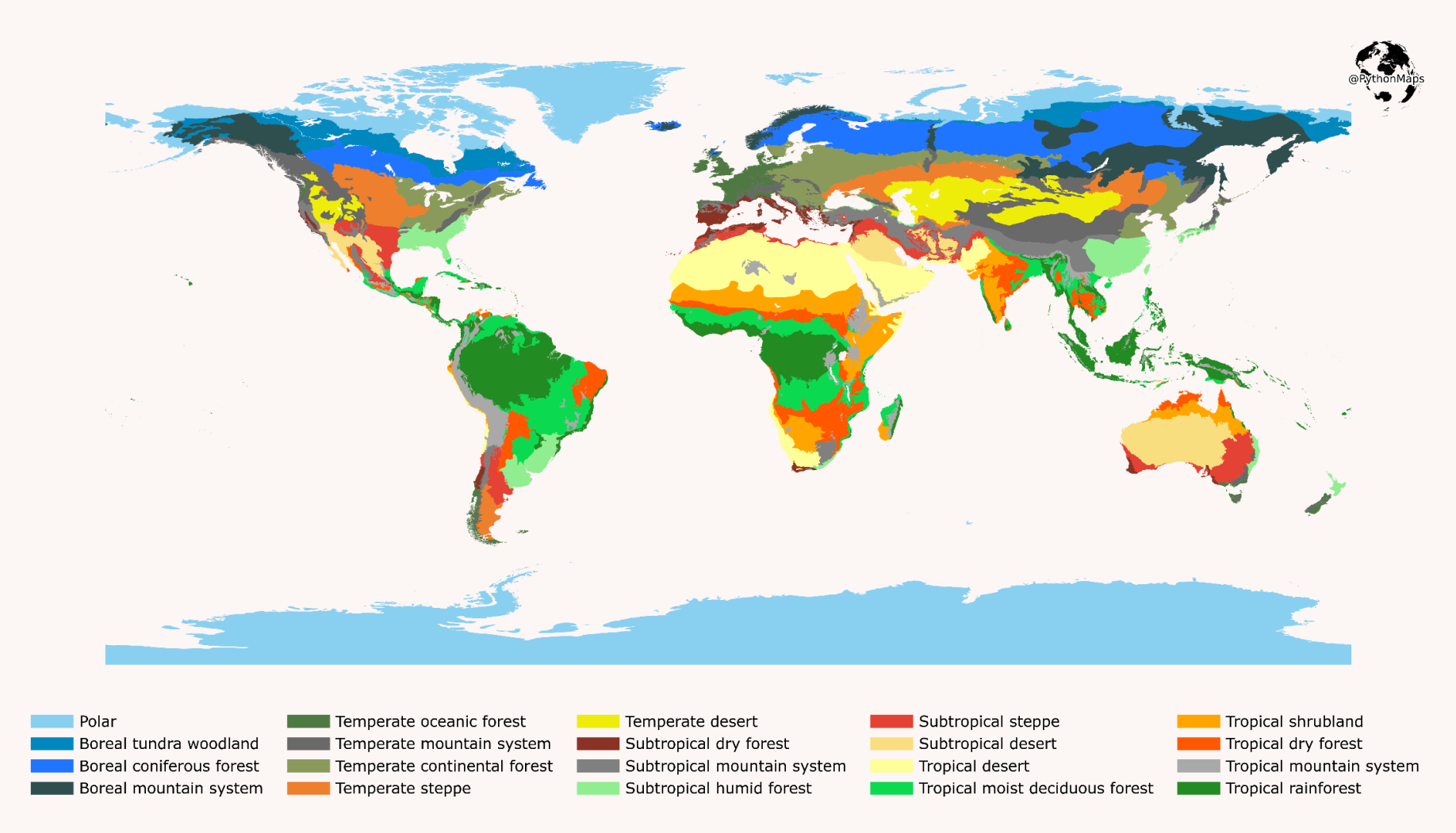
CLIMATE CHANGE INTERACTIONS WITH FOREST HEALTH

What is climate and why it’s changing?

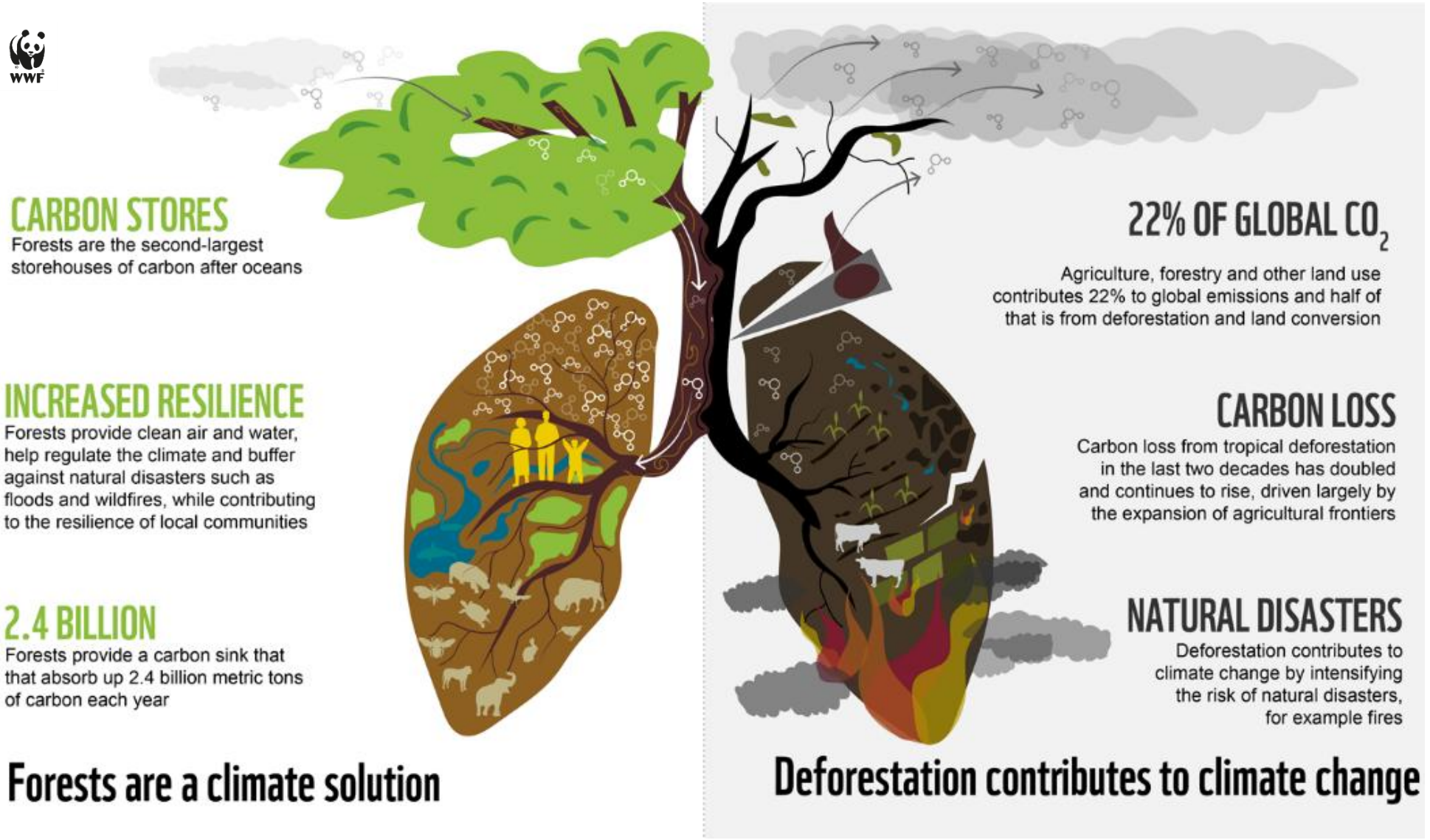


- Average global temp. is projected to increase from 1 to 6 °C from 1990 to 2100
- The past five years have been the warmest five years in centuries.
- Lead to more frequent climate events

The **gradual increase** of **Earth's surface temperature**

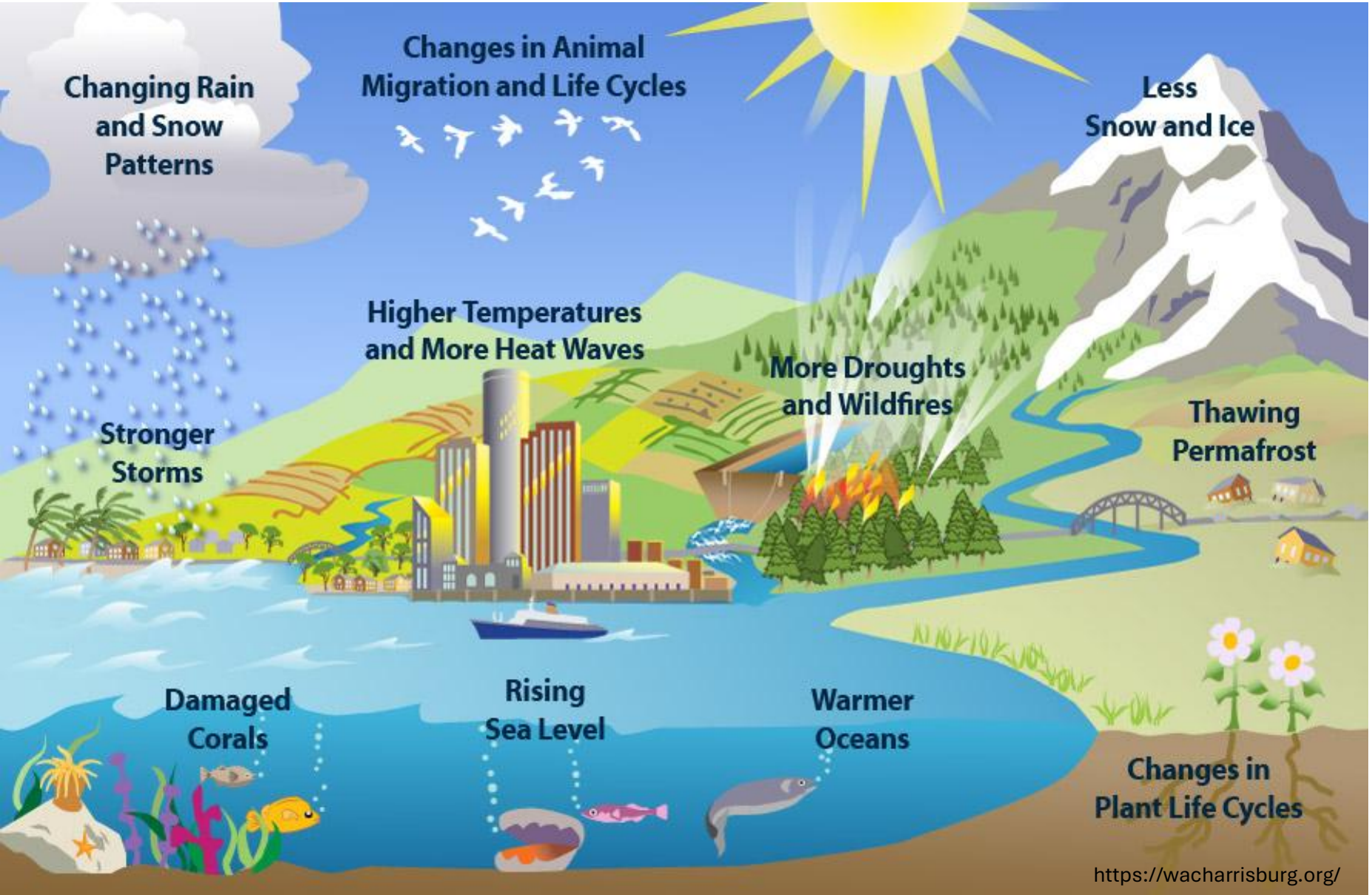
The **long-term** change in **global weather patterns**

What is climate and why it's changing?



- Human-induced global warming is presently increasing at a rate of 0.2°C per decade.
- The world is now about 1.2C warmer than it was in the 19th Century – and the amount of CO2 in the atmosphere has risen by 50%.

What is the impact of climate change?



- Forest health and productivity are just one of the elements affected by climate change
- Changes in the frequency and intensity of forest disturbances such as insect outbreaks, invasive species, wildfires, and storms are observed

What is the impact of climate change?

How does climate change affect forests?

- **Physiology**
- **Structure**
- **Species composition**
- **Health**

Elevated CO_2

CO_2fertilization effect by human activities; Worldwide Forest–Air–CO2–Enrich-ment (FACE) experiments study impact on tree productivity

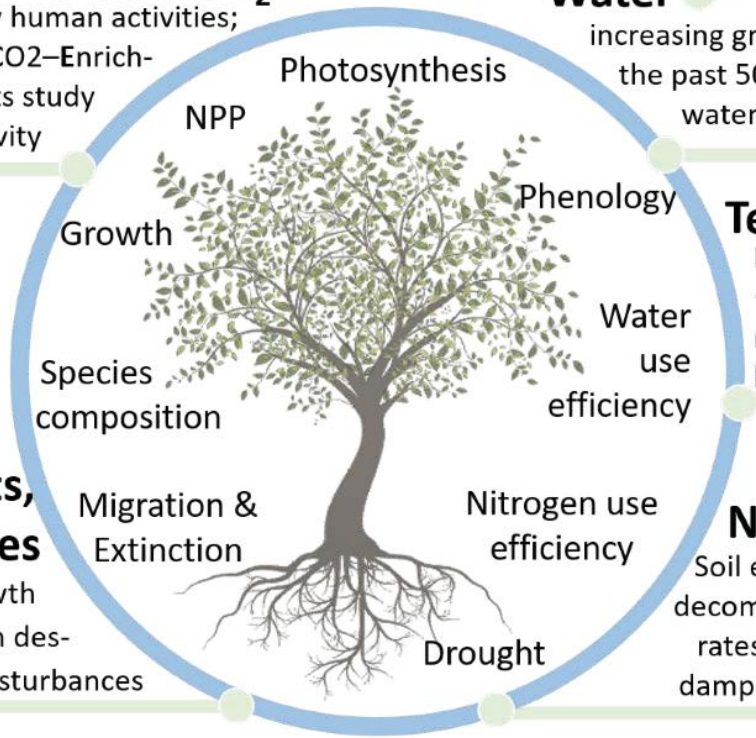
http://www.weatherworksinc.com/california-drought

Water

increasing growth trends in Europe the past 50 years but only where water is not a limiting factor

Extreme events, Pests & diseases

Benefits of increased growth trends at high risk through des-tructive abiotic & biotic disturbances

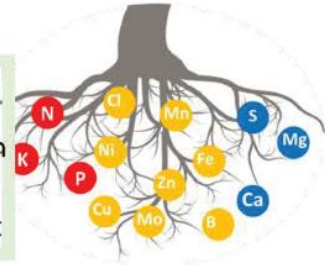


Temperature

Longer growing season, warming → increased growth; increased respiration, mineral limitations, heat stress → decreased growth

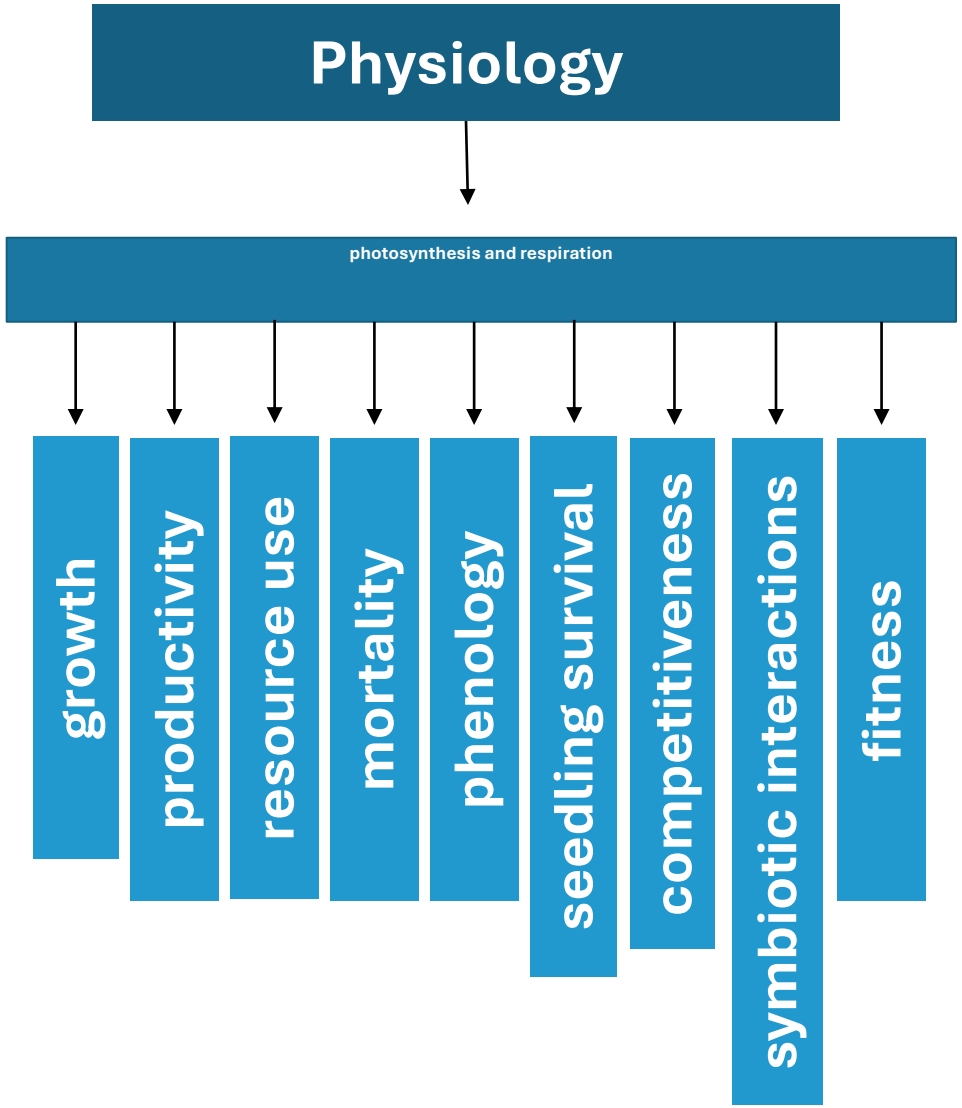
Nutrients

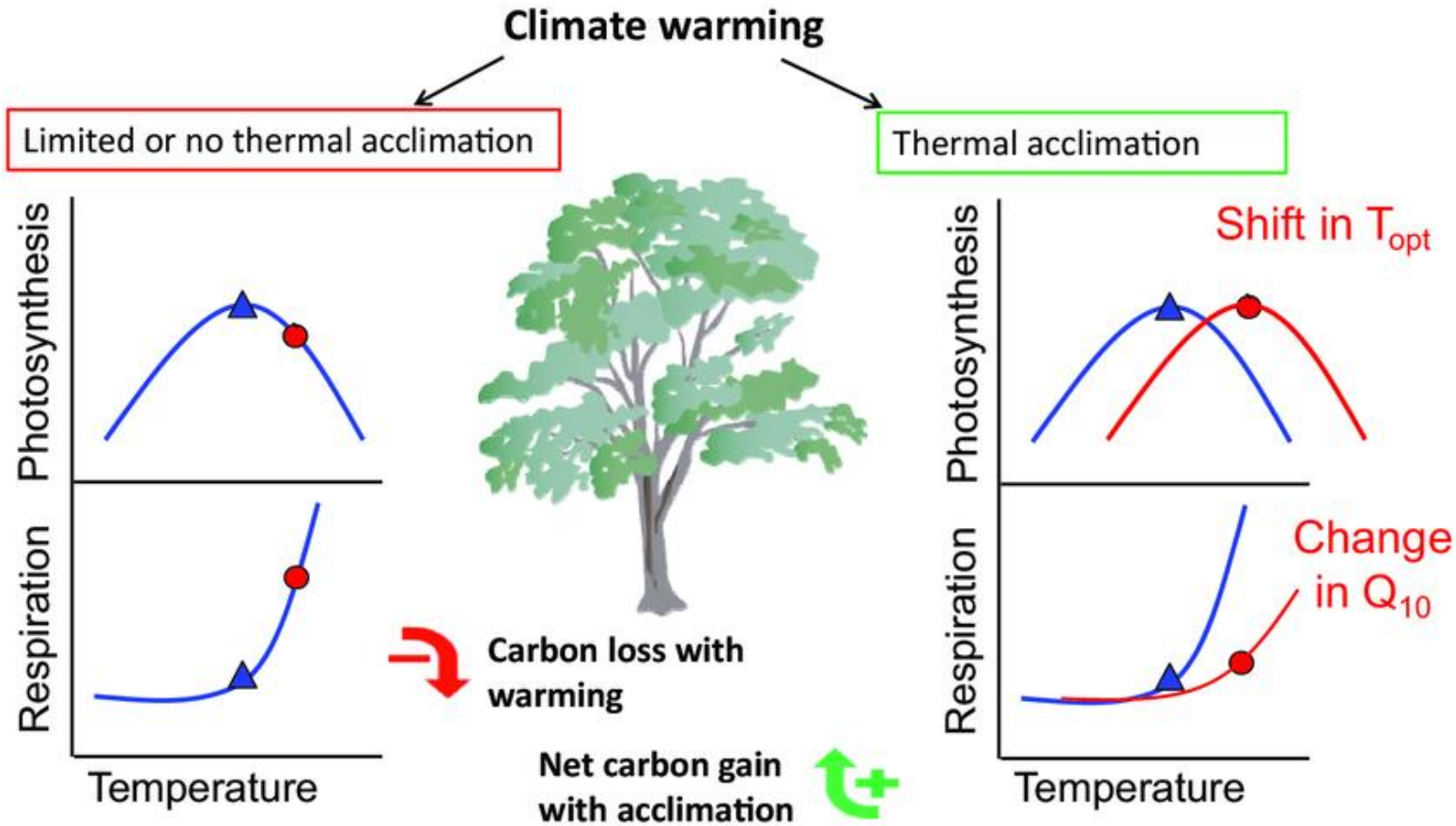
Soil erosion depleting; Faster decomposition & mineralisation rates, nutrient leaching may dampen CO2 fertilization effect



https://doi.org/10.3390/cli8120141

How does climate change affect forests?

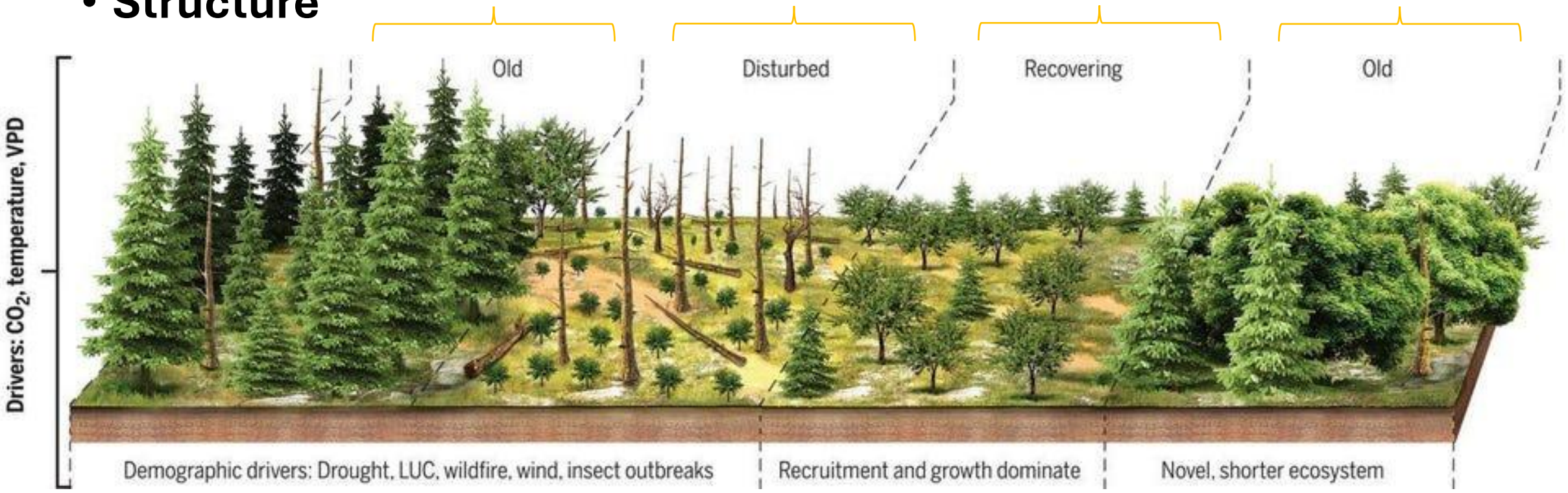




Thermal acclimation of trees as a response to climate change

How does climate change affect forests?

- **Structure**



Conca J., 2020

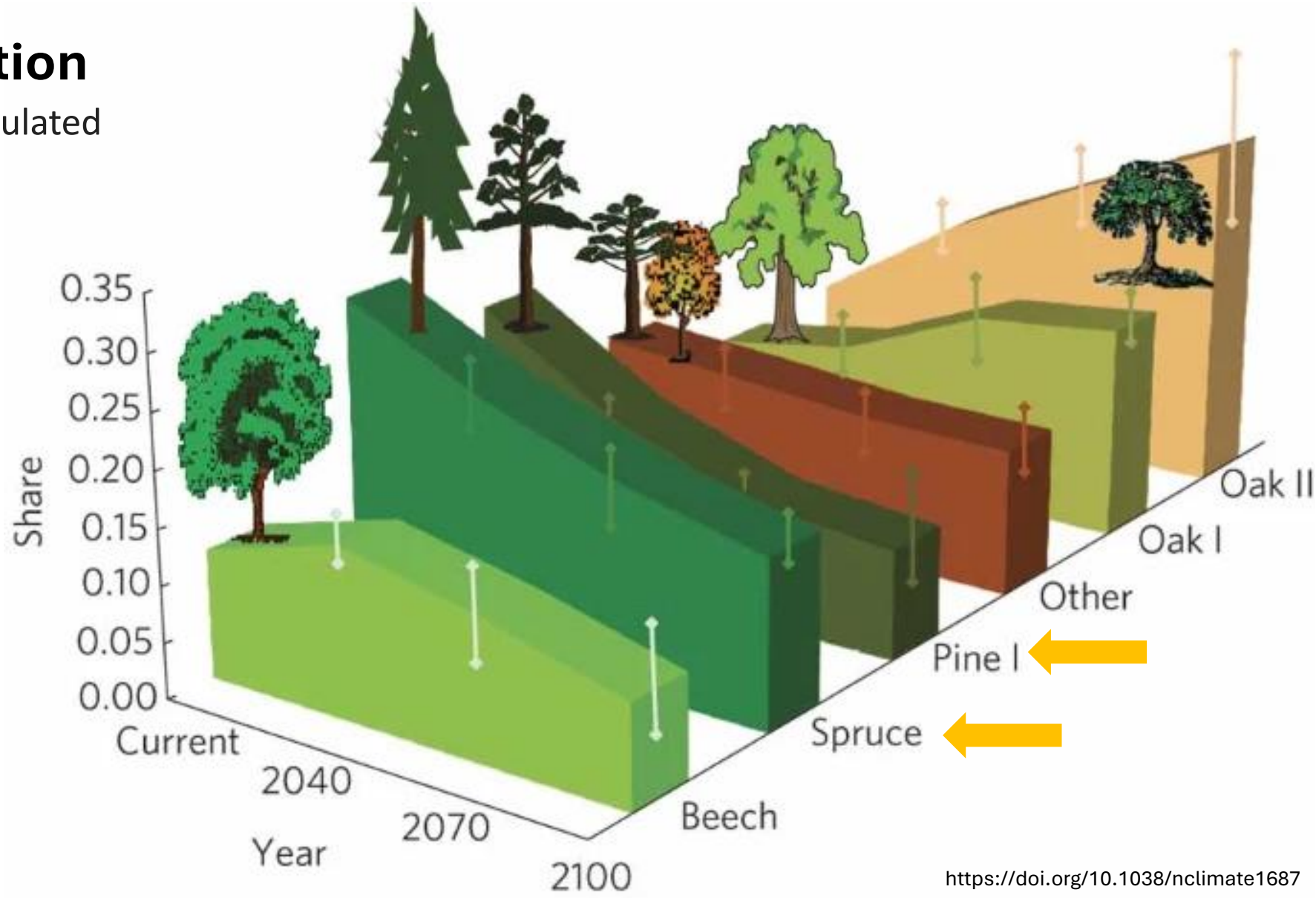
Globally, forest dynamics are changing. Environmental disturbances have negatively impacted forests, causing a deforestation loop where mortality is increasing and new growth is limited. The forests never grow back the same.

How does climate change affect forests?

- **Species composition**

projected species ranges as calculated for scenario A1B

- Spruce - decreases by almost 50% of its present area
- Pine I group - loses close to 60% of its present range
- one of the options for mitigating climate change is to adapt by planting new non-European species

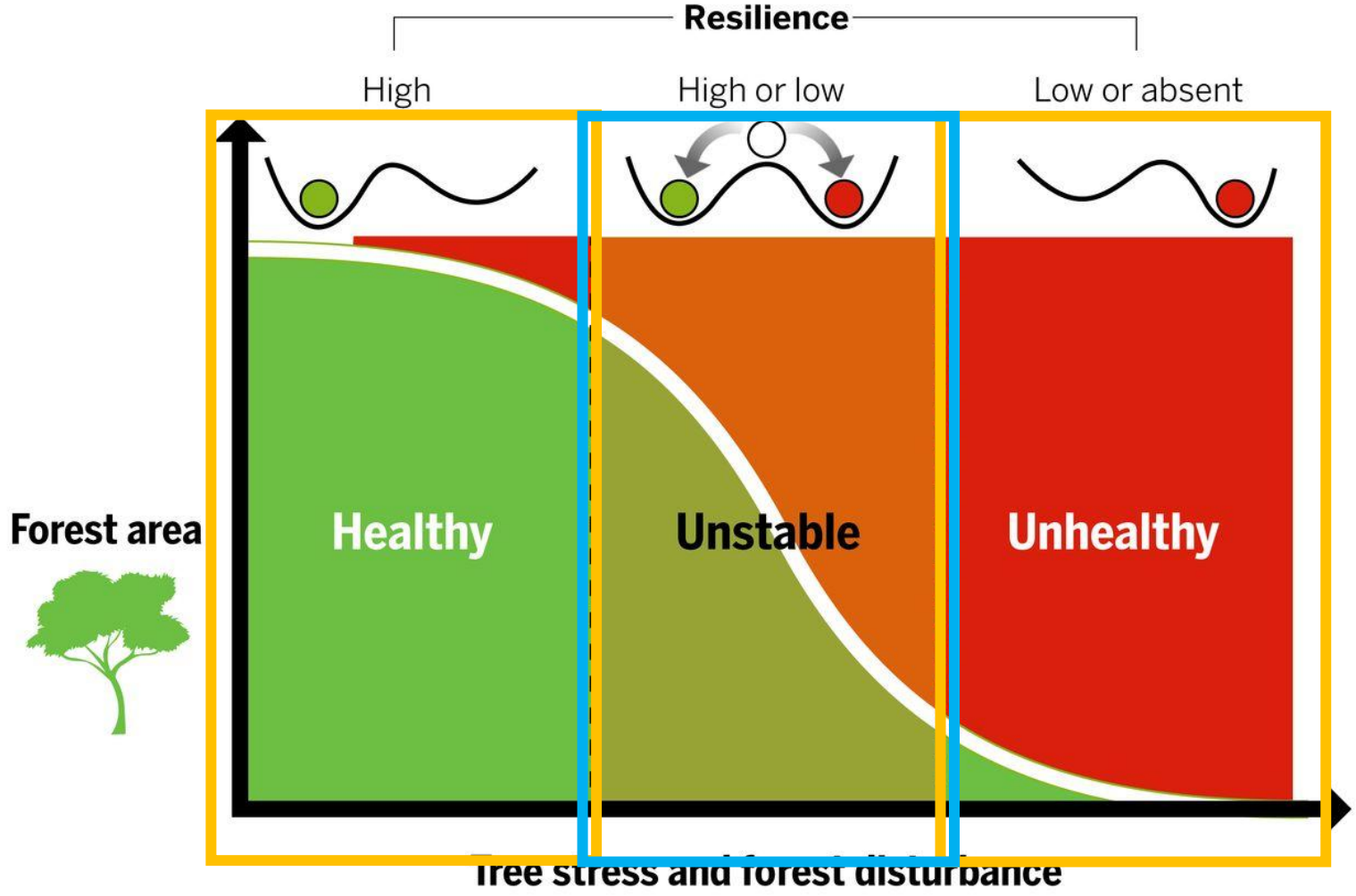


https://doi.org/10.1038/nclimate1687

What are the interactions of climate change with forest health?

Forest disturbance factors

- Droughts
- Fires
- Storms
- Insect pests
- Diseases
- Invasive species



https://doi.org/10.1126/science.aac6759

What are some of the most prominent forest health challenges related to climate change?

Severe Droughts

The summer of 2022 saw Europe's worst drought in 500 years


Po River basin in northern Italy, June 2022


Lake Powell, Arizona


Nevada’s drought-stricken Lake Mead


Colorado River, Arizona

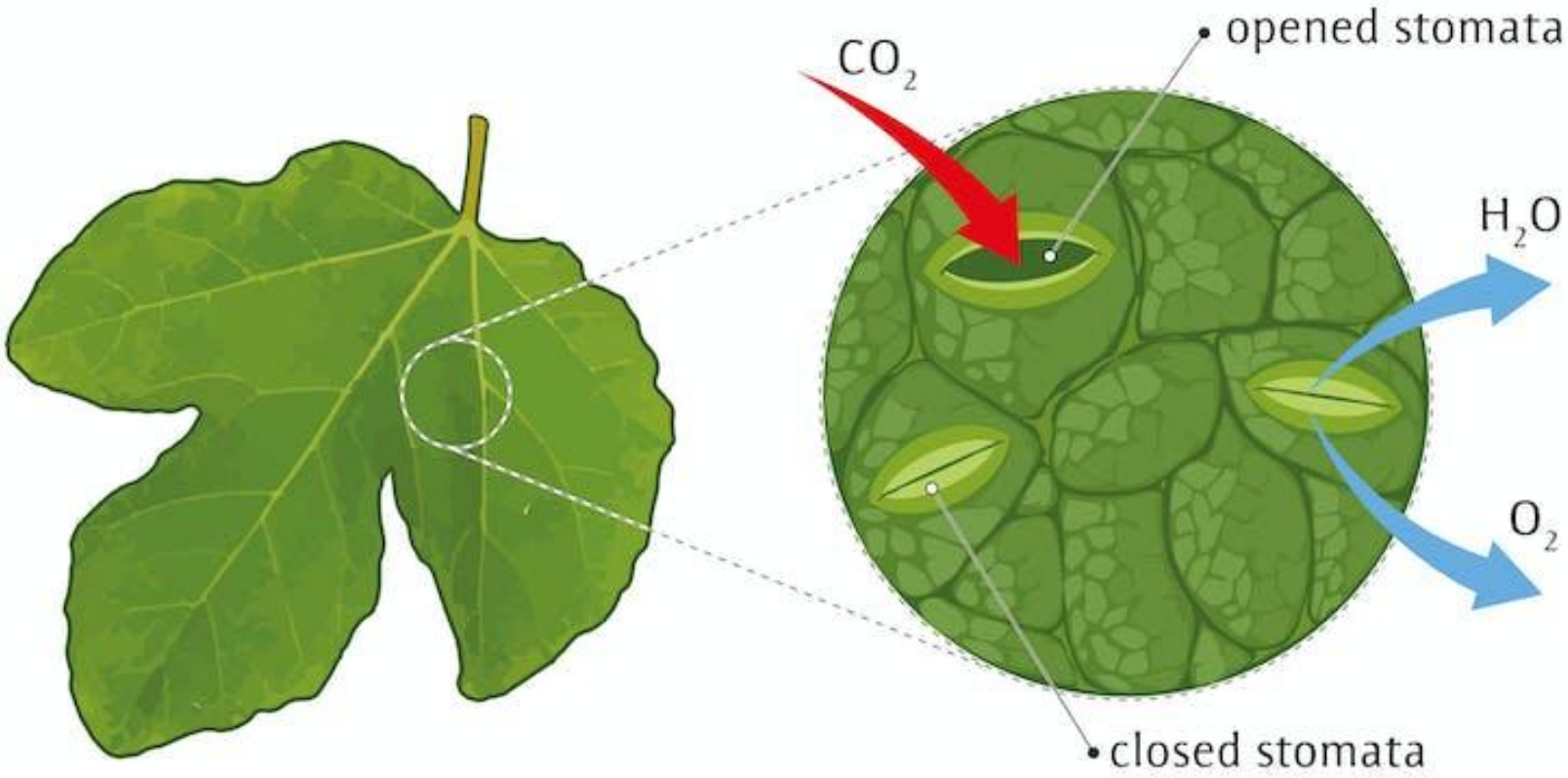
The most extreme drought conditions in 1,200 years were recorded in the American west

Severe Droughts

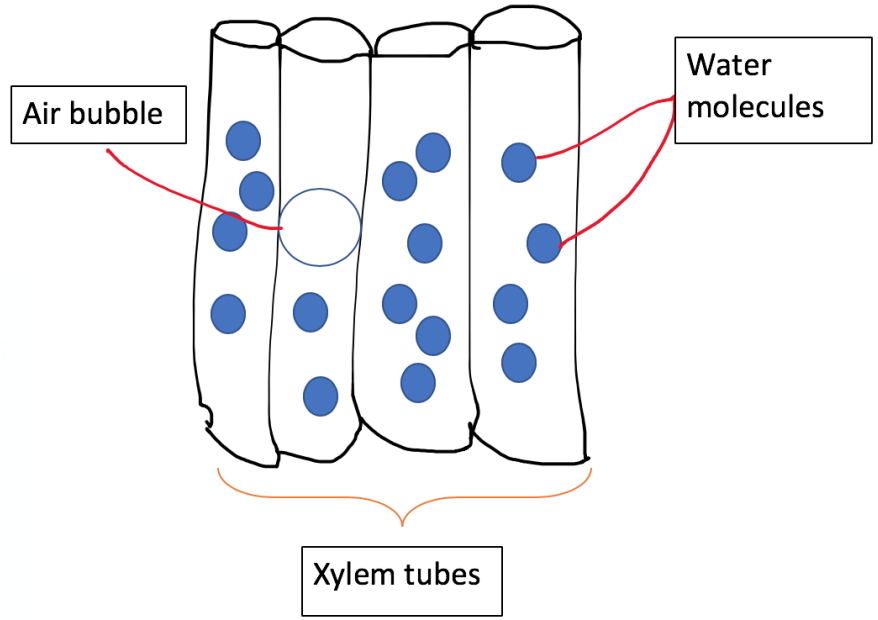
- Last year, the regions most affected by severe droughts in Europe were the Italian lowlands, southern, central, and western France, central Germany and eastern Hungary, Portugal, and northern Spain.

Dead spruce in Harz National Park, Germany, after a drought in 2019

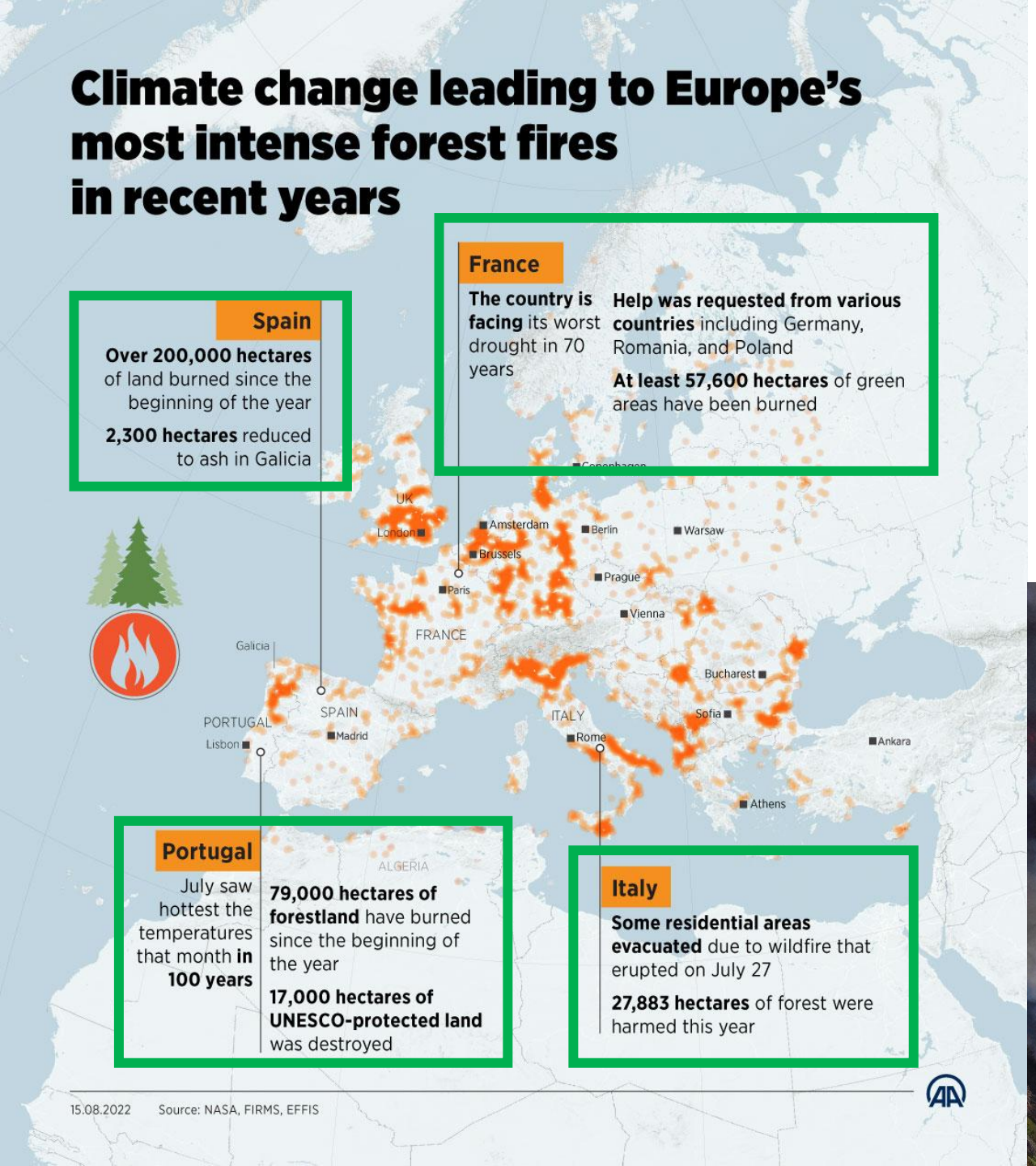
Severe Droughts



Stomata allow trees to inhale carbon dioxide (CO_2) and exhale oxygen (O_2) and water (H_2O)



A diverse range of strategies for coping with stress is what gives forests some of their essential stability and resilience

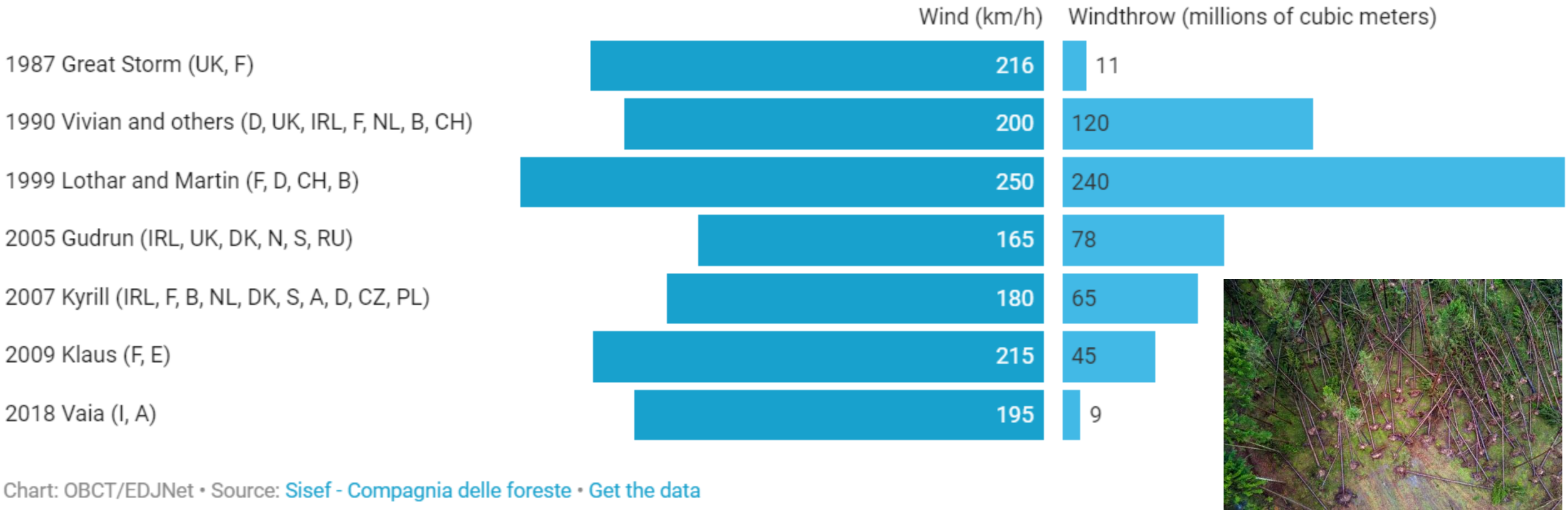


Fires

- Almost 346,000 hectares (1,370 sq miles) of land have been recorded as burnt (as of 16 July), according to the European Forest Fire Information System (EFFIS).

Storms

Major storms of the last thirty years in Europe



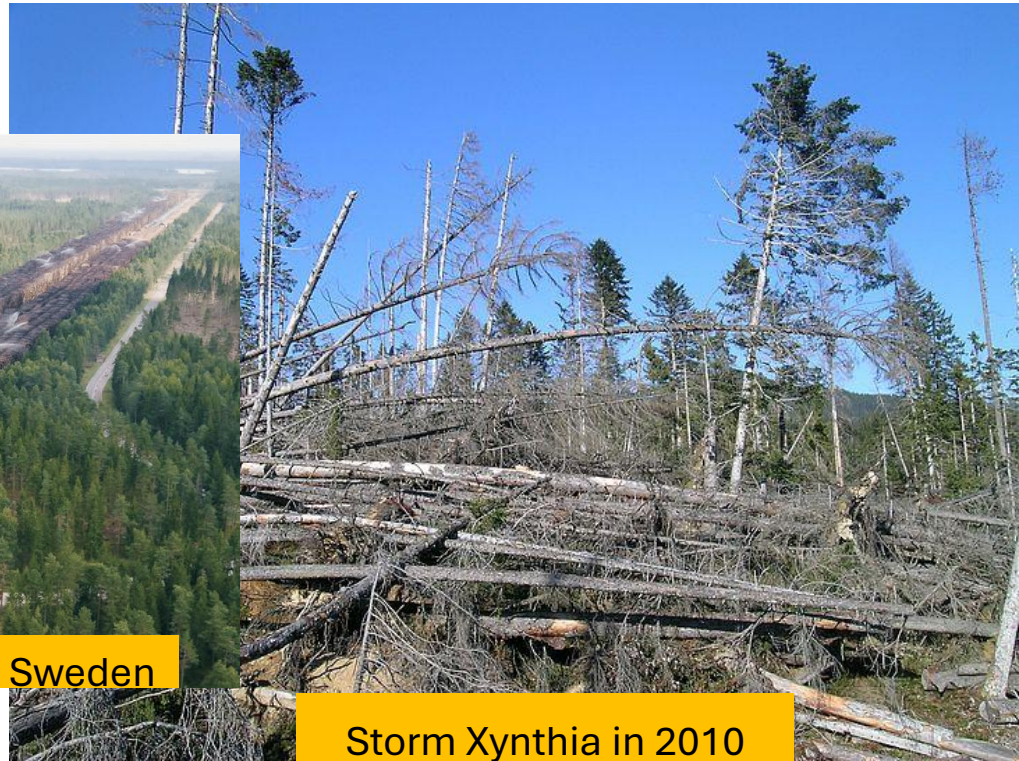
- Storm-related disturbances were most prevalent in western and central Europe, where they locally accounted for >50% of all disturbances

Storms

Storm Lothar and Martin in 1999

Storm Klaus in 2009

Storm Gudrun in 2005, Sweden



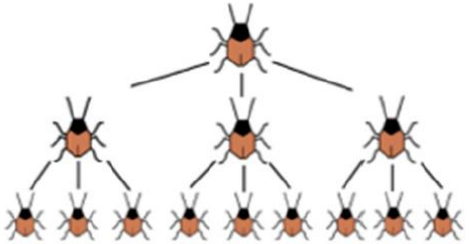
Storm Xynthia in 2010

- The storm Gudrun, in Sweden in 2005, felled 100 million cubic meters of forest

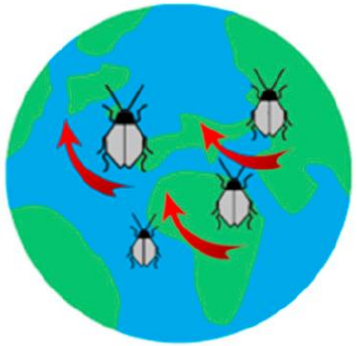
Insect pests and disease

Climate change can affect forest pests and the damage they cause by:

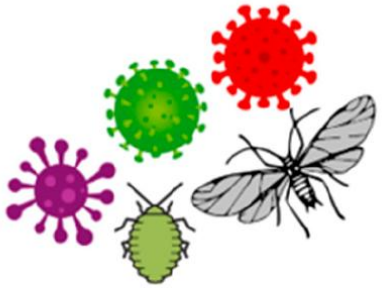
- development, survival, reproduction, distribution, and spread;
- host physiology and defenses;
- relationships between pests, their environment, and other species such as natural enemies, competitors, and mutualists.



Increased number of generations

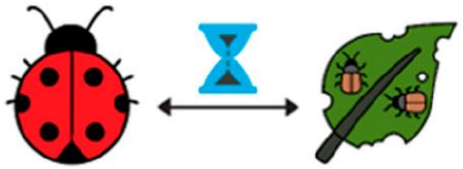


Expansion of geographic range



Outbreak of plant diseases transmitted by insects

Increased overwintering survival



Desynchronization of insects and their natural enemies

Loss of synchrony with the host plant

Skendžic et al., 2021

Insect pests and disease

*Direct impacts on **Physiology***

- **Temperature** → important for insect pests
  - Polyphagous are less affected than more specialist species
  - ↑ summer temp → accelerates the rate of development (1 vs 2 lifecycles per year)
  - ↑ winter temp → Increase overwinter survival
- **Precipitation** → more important for pathogens

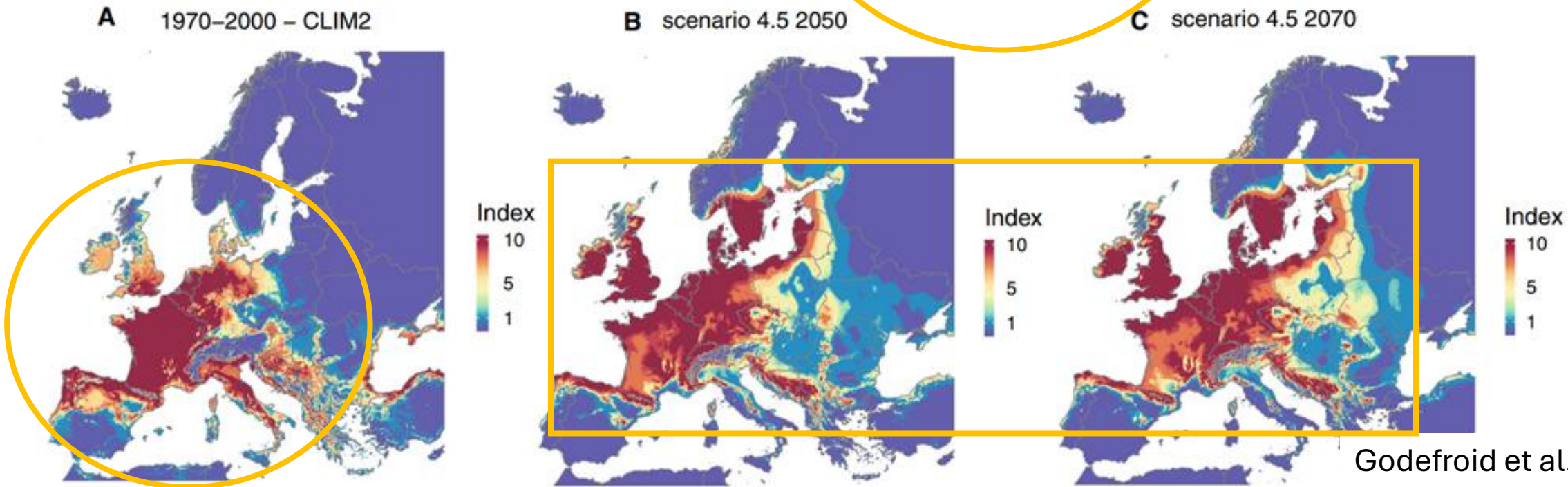


Insect pests and disease

Direct impacts on Distribution

Example:

Oak processionary moth
(*Thaumetopoea processionea*)



Godefroid et al., 2019

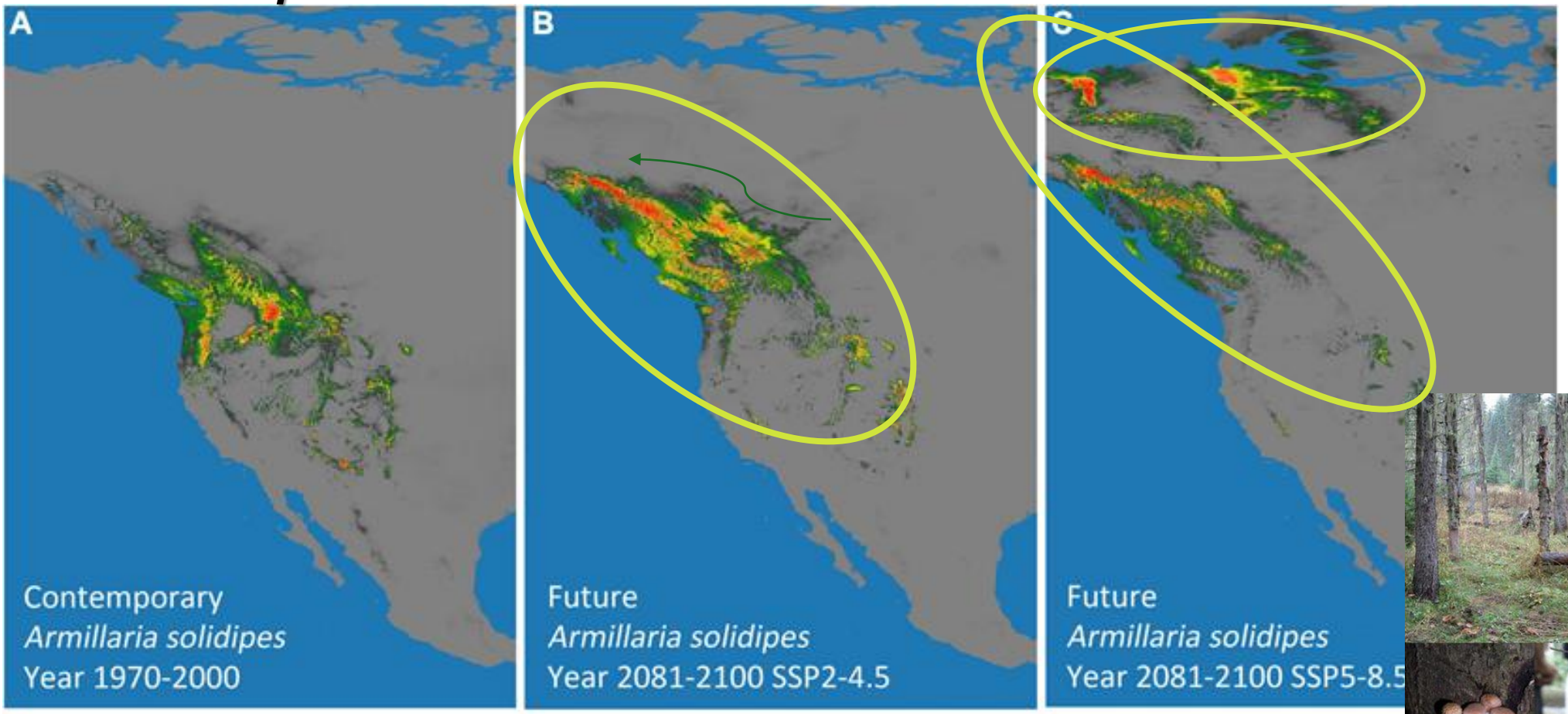
Insect pests and disease

Direct impacts on Distribution

- *Melampsora allii-populina* on cultivated poplar
- Likely spread northwards with increased summer temperatures

Insect pests and disease

Direct impacts on Distribution



- Example: Armillaria root disease

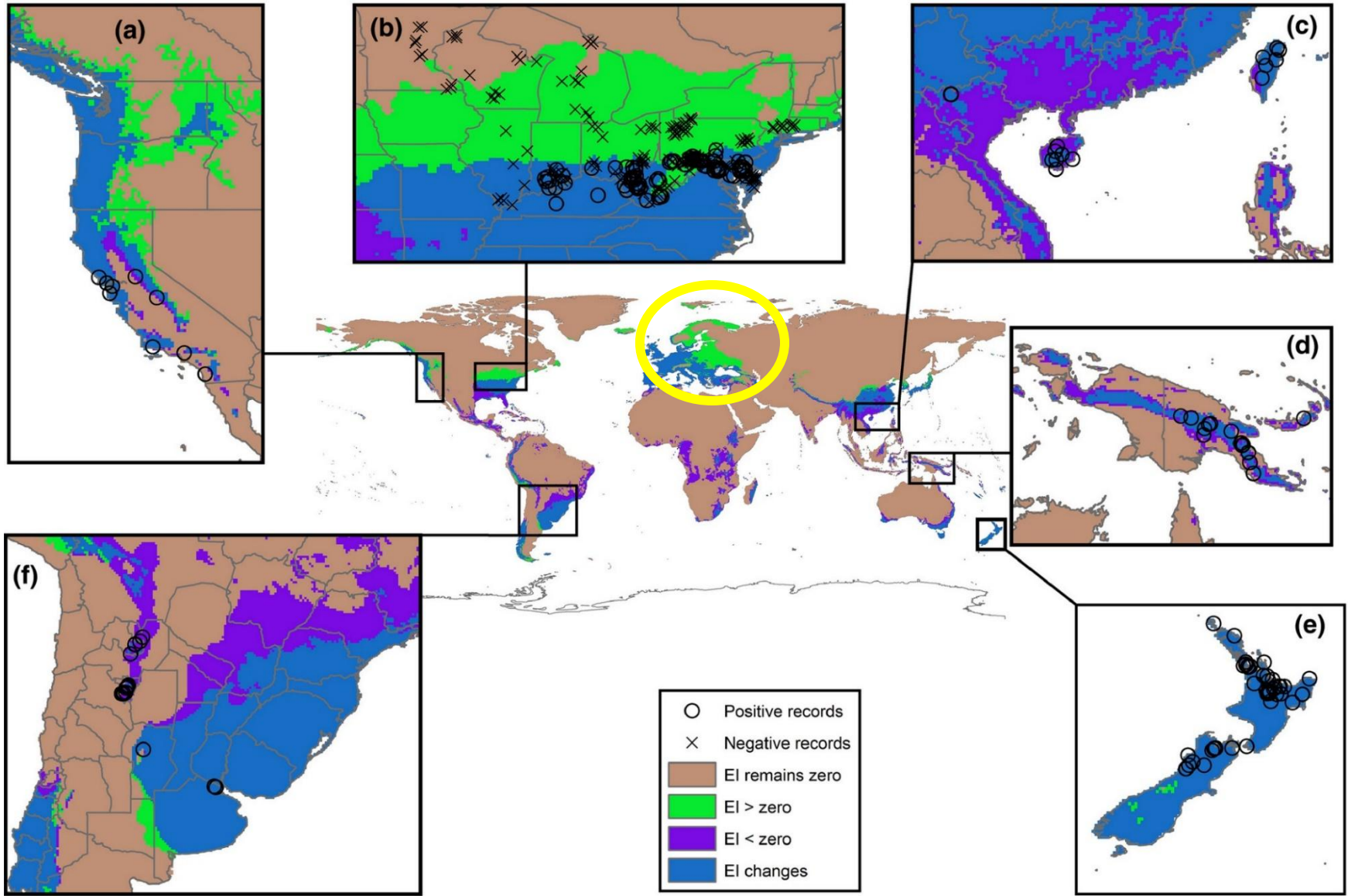
Kim et al., 2021; Hanna et al., 2019

Insect pests and disease

Direct impacts on Distribution

- *Phytophthora cinnamomi* – one of the world's worst invasive species
- Is Southern Sweden climatically suitable in the future?!

Burgess et al., 2017



Insect pests and disease

Direct impacts on Phenology

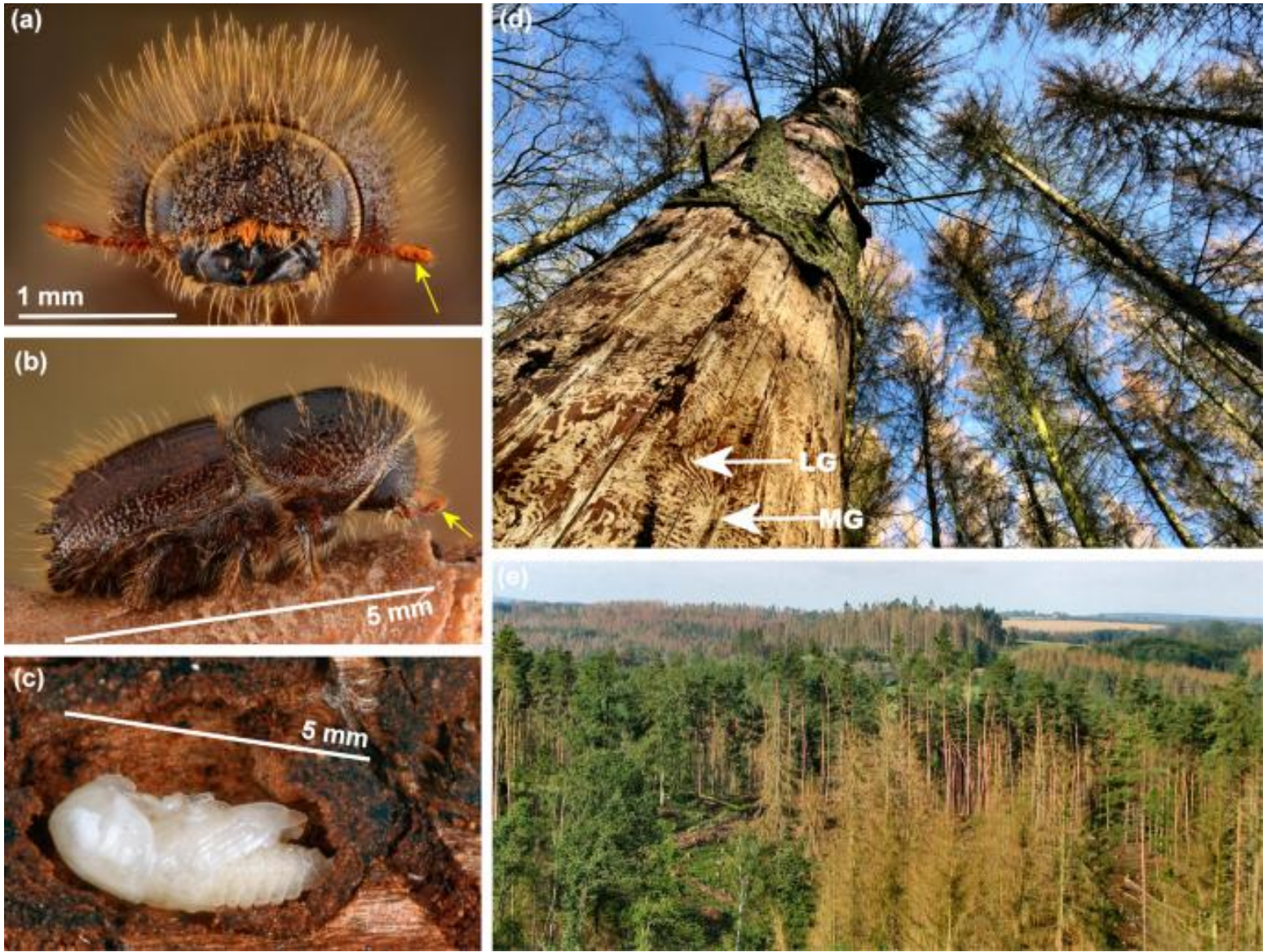
- Insect life cycles may occur earlier
- Extended periods of activity at both ends of the season
- Advance in the timing of larval and adult emergence

Insect pests and disease

Direct impacts on Phenology

- outbreaks are expected to increase in frequency and severity
- can destroy >100 million m3 of spruce in a single year
- additional generation per year

https://doi.org/10.1038/s42003-021-02602-3



Insect pests and disease

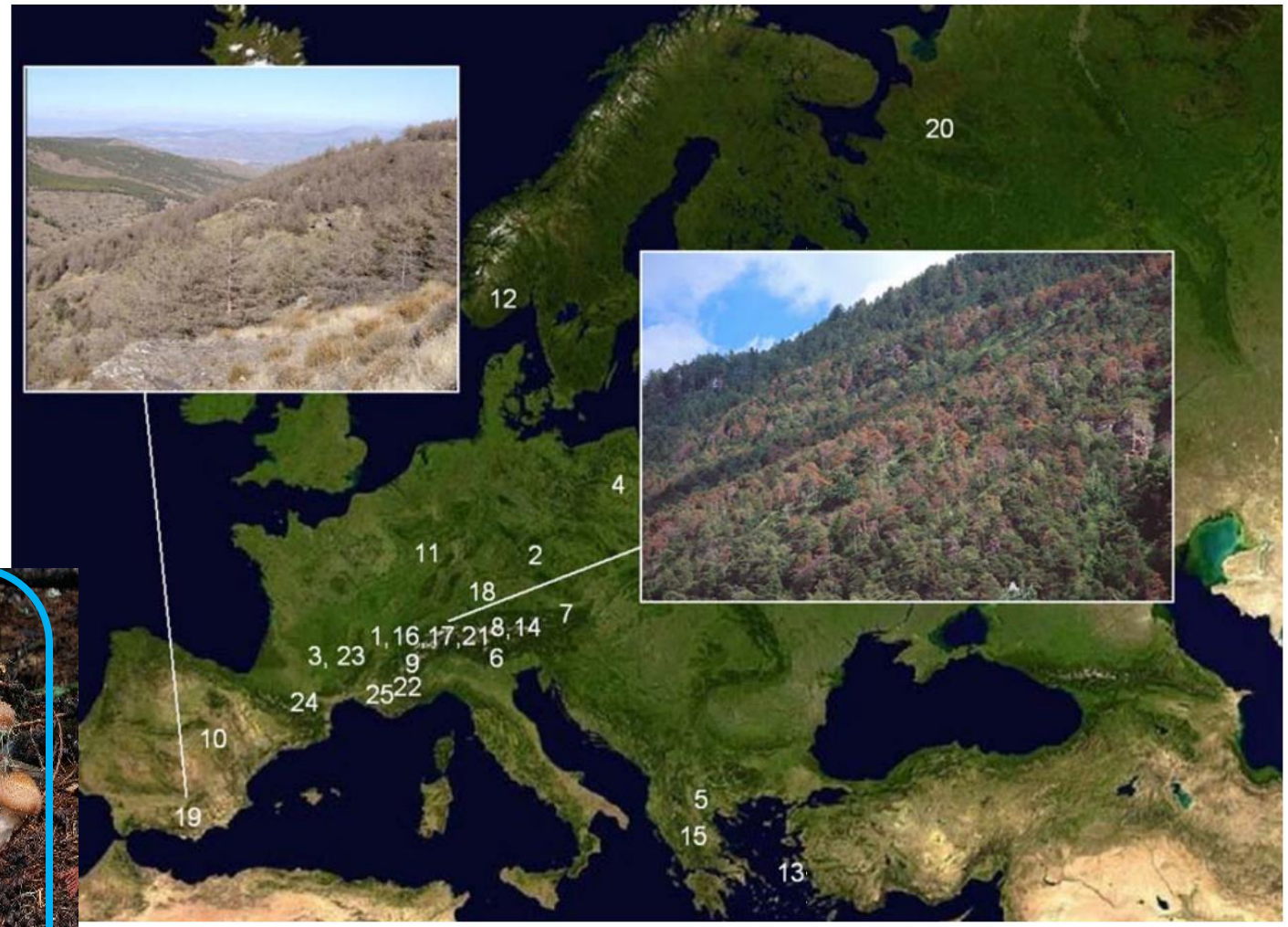
Indirect impacts on host trees

Example: Drought

→ increased susceptibility to insect pests and pathogens

→ limited by host defenses

→ alter tree physiology that may impact pest disturbance dynamics; and secondary metabolism



Allen et al. 2010

Agrilus biguttatus

Armillaria spp.

Insect pests and disease

Indirect impacts on host trees

- Extreme events, e.g. windstorms, increased warm air mass movements

Diversity and Distributions
Open Access
A Journal of Conservation Biogeography

Open Access

Aerial colonization of high Arctic islands by invertebrates: the diamondback moth *Plutella xylostella* (Lepidoptera: Yponomeutidae) as a potential indicator species

S. J. Coulson ✉, I. D. Hodkinson, N. R. Webb, K. Mikkola, J. A. Harrison, D. E. Pedgley

First published: 22 October 2002 | https://doi.org/10.1046/j.1472-4642.2002.00157.x | Citations: 57

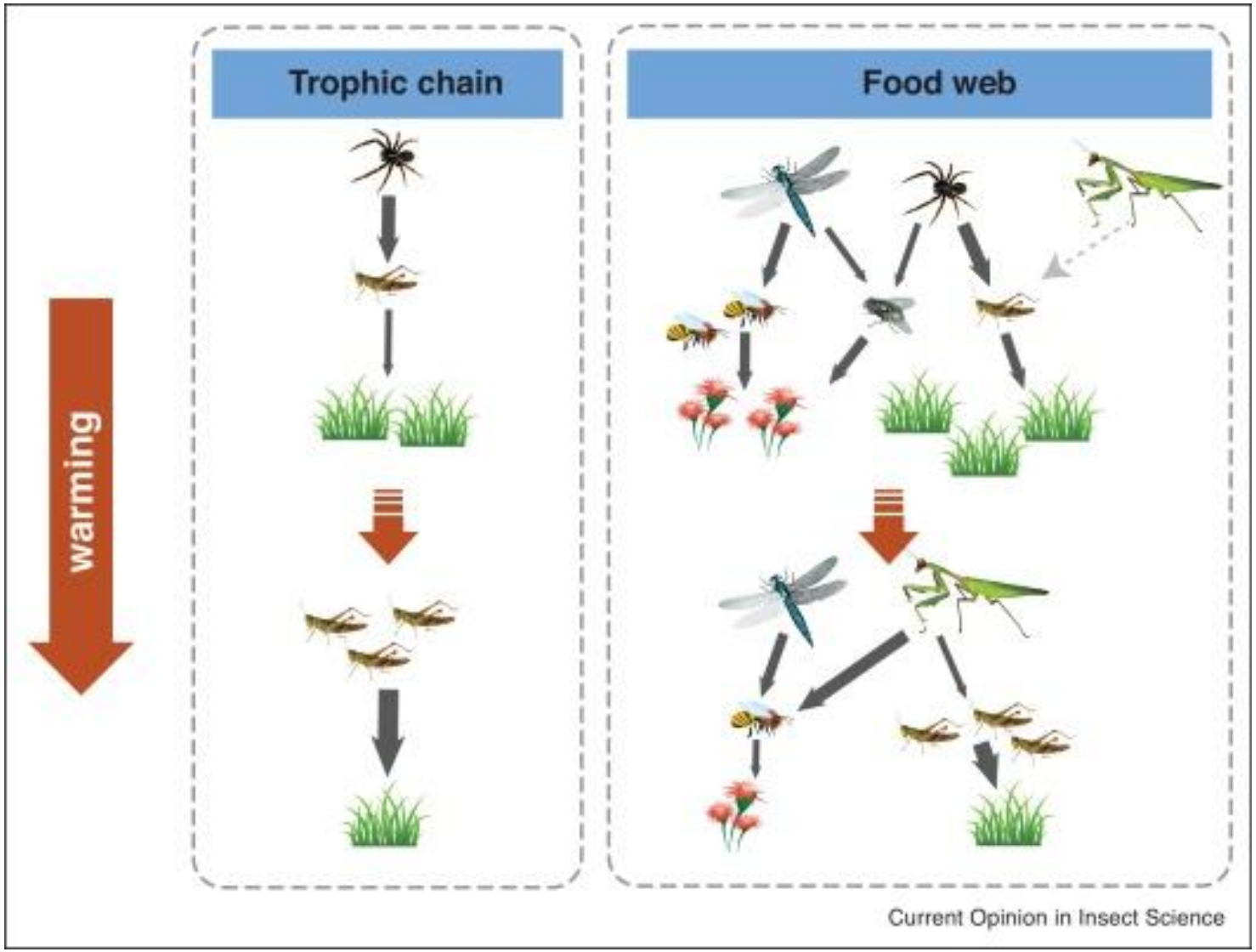
Go here for Primo

Plutella xylostella

Insect pests and disease

Indirect impacts on community ecology

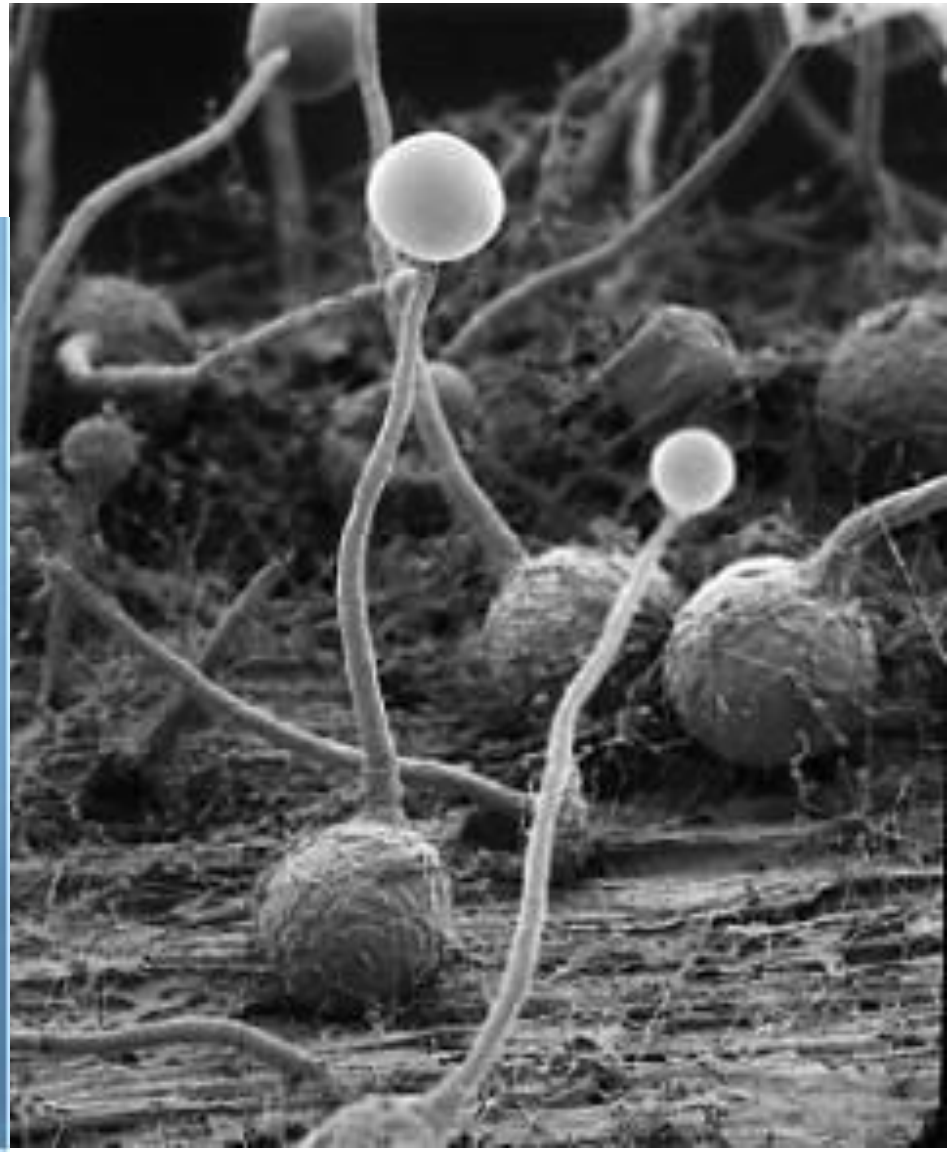
- Alter relationships between pests and other species
- Individual species respond to climate change in different ways and at different temporal scales
- Synchronization between host and natural enemy or parasitoid may not be maintained under new temperature conditions



Insect pests and disease

Pathogen-insect vectors interaction

- *Ophiostoma novo-ulmi* and *Scolytus* spp.



Plant microbiome


Phyllosphere


Endosphere


Rhizosphere


Litter microbiome


Soil microbiome

Growth rate / Nutrients uptake / Stress resistance / Interactions with other organisms

Fitness, Competitive Interactions



Community composition / Biodiversity

Ecosystem functioning

- Organic matter breakdown
- Carbon and nutrient cycling
- Nutrients availability

PLANT MICROBIOM

Forest management - key element of forest health

- **Monitoring**
  - Early detection
  - Continued and improved surveillance
- **Forecasting**
  - Models – project potential impacts; indicate the magnitude and direction of change; help focus monitoring activities;
  - Risk analysis and risk rating systems
- **Planning and Mitigation Strategies**

– Increasing species/age class diversity

– Silvicultural interventions to increase tree vigour and reduce pest/pathogen impacts

– Increase tolerance and resistance to pests/pathogens in breeding programs

Summary

- Climate change is already having considerable and widespread impacts on forest health globally
- More information is needed on the impacts on forests, forest pests, and complex relationships
- Much is known about climate effects on some limited number, but not all organisms

Summary

- Increased diversity of pests/pathogens at higher latitudes and altitudes → increase feeding on hosts
- Droughts can be the starting point for outbreaks.
- Extreme weather events can lead to outbreaks
- New invasions by non-native pathogens → new epidemics


Thank you for your time!