

COST Action CLEANFOREST, Annual Meeting, Lisbon, Portugal, 8-10 May 2024

# ICP Forests

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# Outline

- Is the monitoring network assessing forest resilience and how?
- How could the monitoring network contribute to the Forest monitoring Law (currently at the proposal stage)?
- What is the first step that should be taken to build synergies with other monitoring initiatives?





# Outline

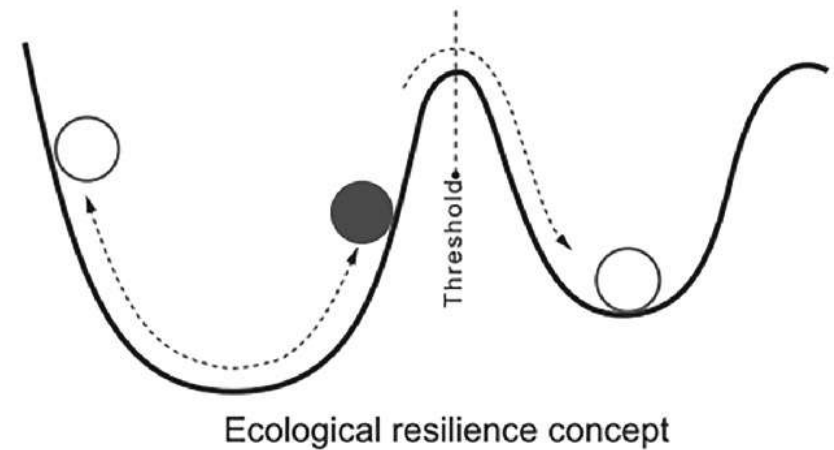
- Is the monitoring network assessing forest resilience and how?
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# Resilience

- >160 definitions.
  - Ability to endure stress and still be able to perform?
  - Capacity to recover after a catastrophe?
  - ...
- «Any decision a forest manager will need to make is heavily affected by both the ecosystem as well as by societal demands and perceptions».
- Forest managers got frustrated: how do you implement something that you are not exactly sure of what it means?

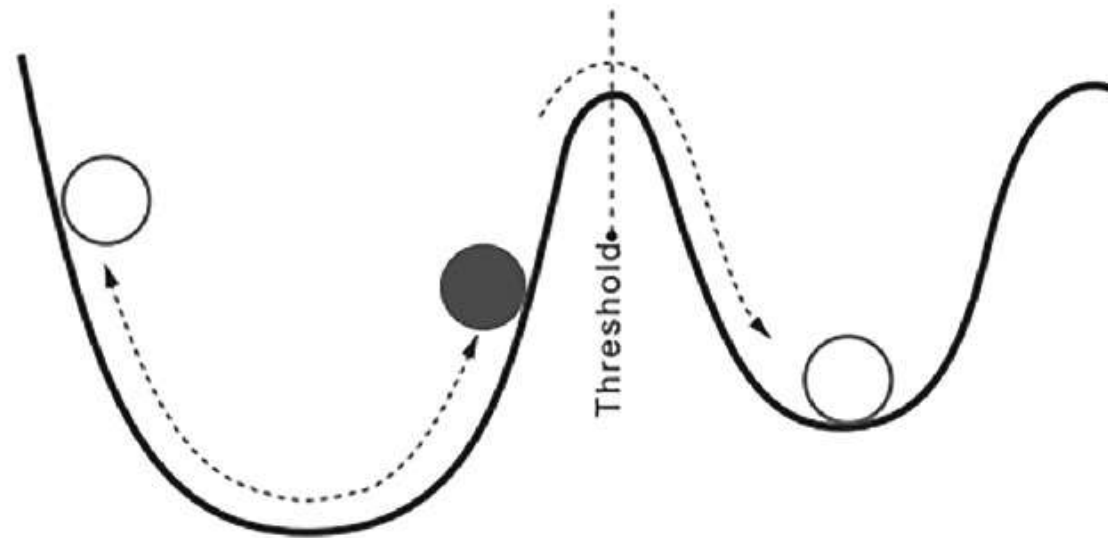
## Ball-and-cup metaphore



Holling, C. S. 1973. Annual Review of Ecology and Systematics 4:1–23.

<https://efi.int/articles/how-can-we-measure-forest-resilience>

# What forest monitoring can offer?



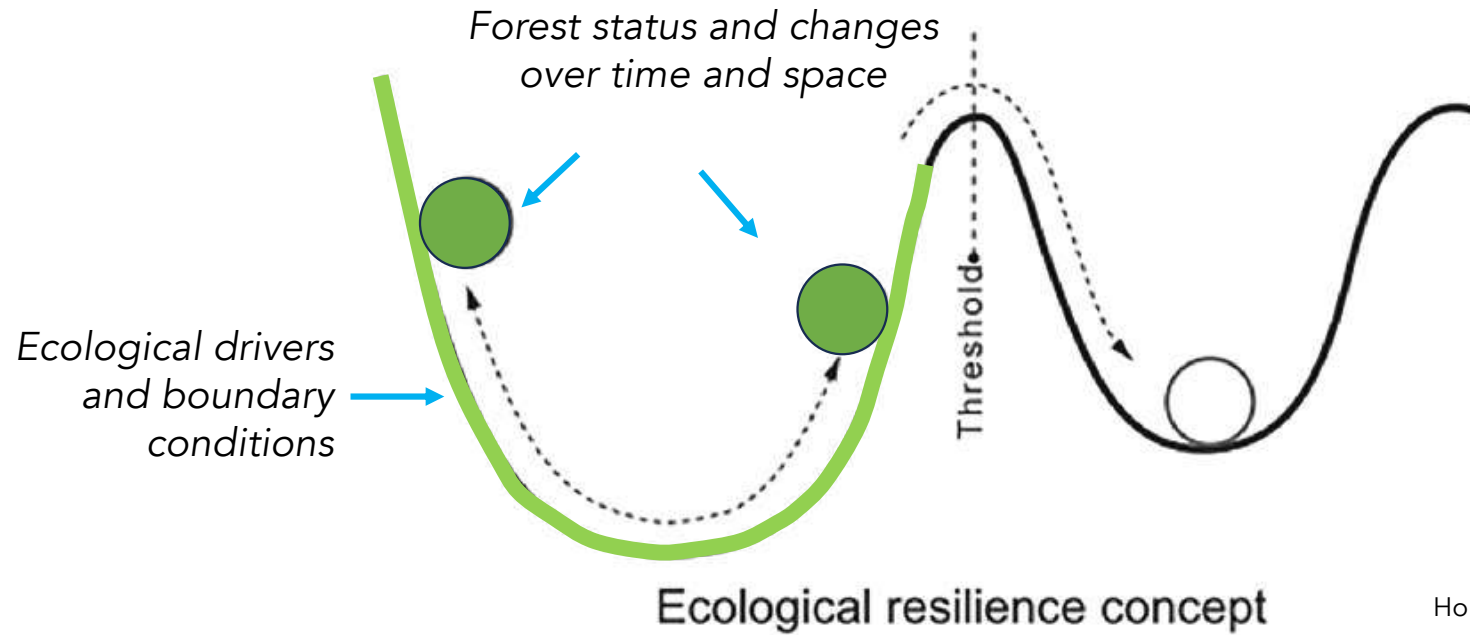
Ecological resilience concept

Holling, C. S. 1973. Annual Review of Ecology and Systematics 4:1–23.



# What forest monitoring can offer?

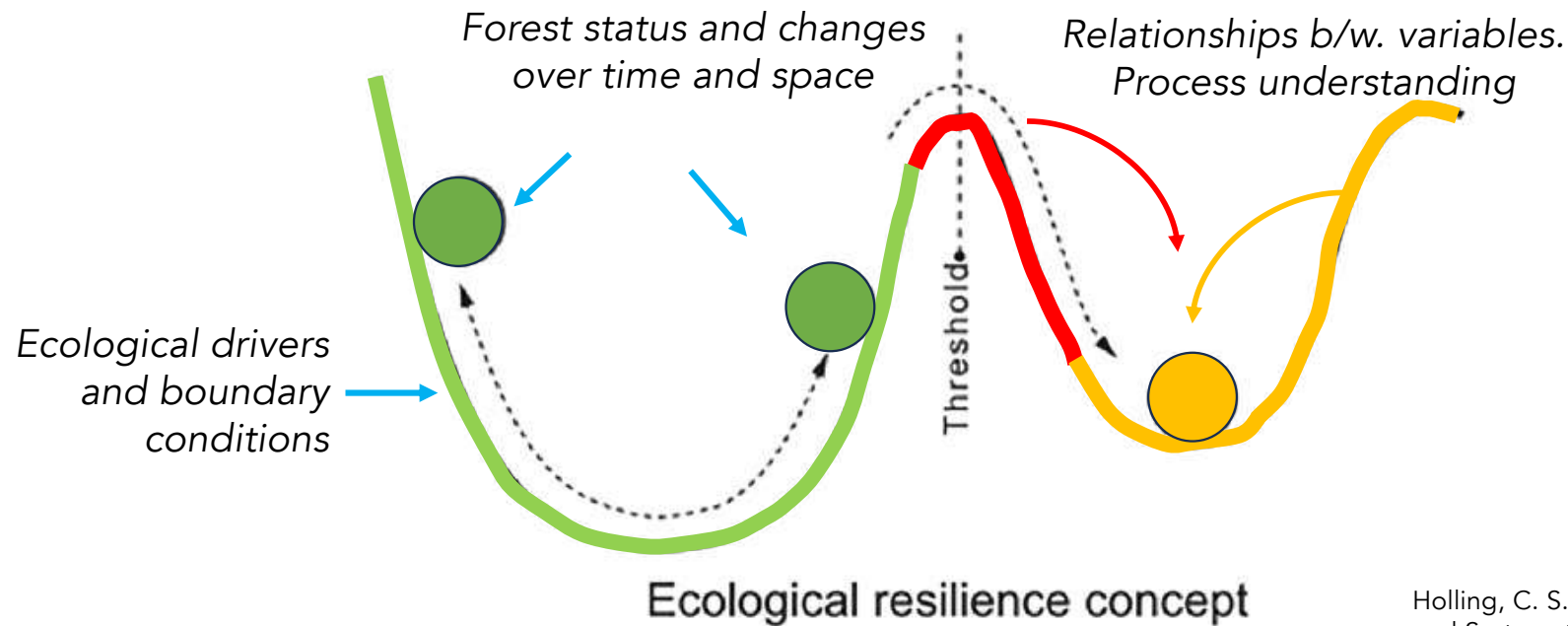
## Measurements



Holling, C. S. 1973. Annual Review of Ecology and Systematics 4:1–23.

# What forest monitoring can offer?

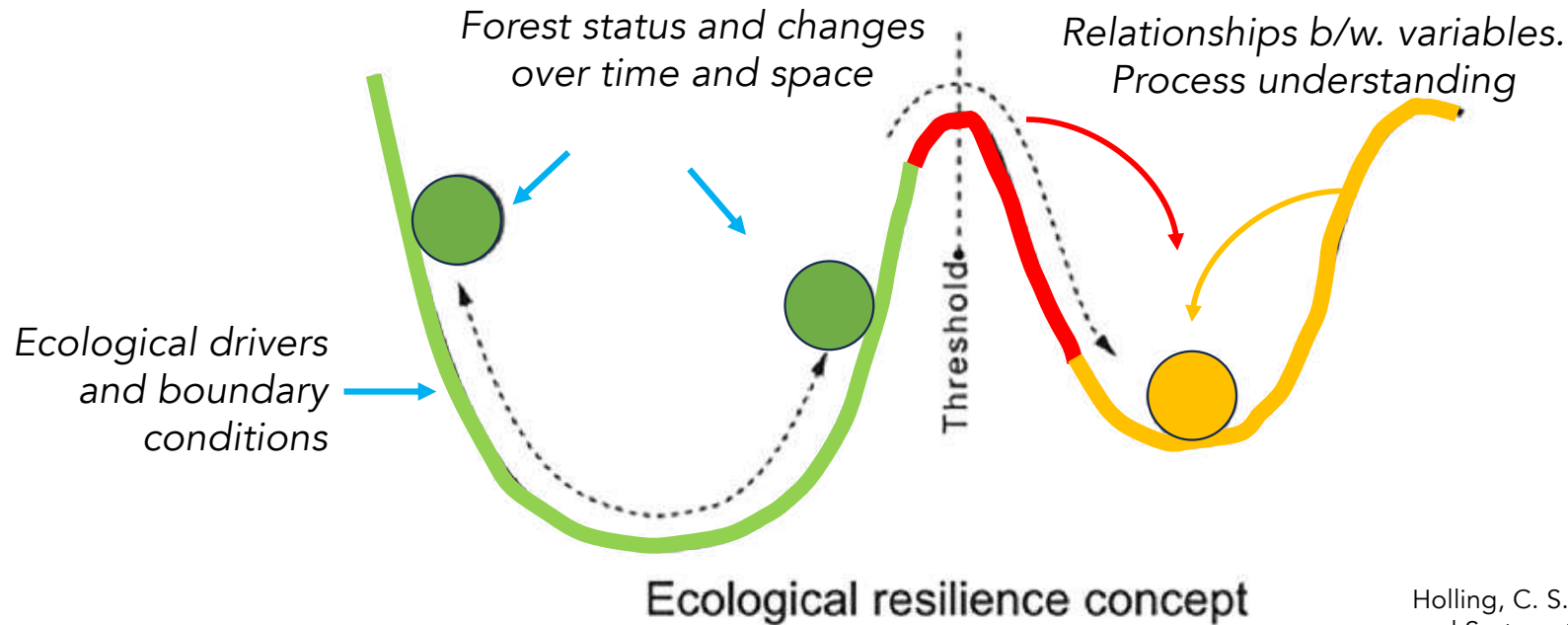
Measurements  $\longrightarrow$  Understanding



Holling, C. S. 1973. Annual Review of Ecology and Systematics 4:1–23.

# What forest monitoring can offer?

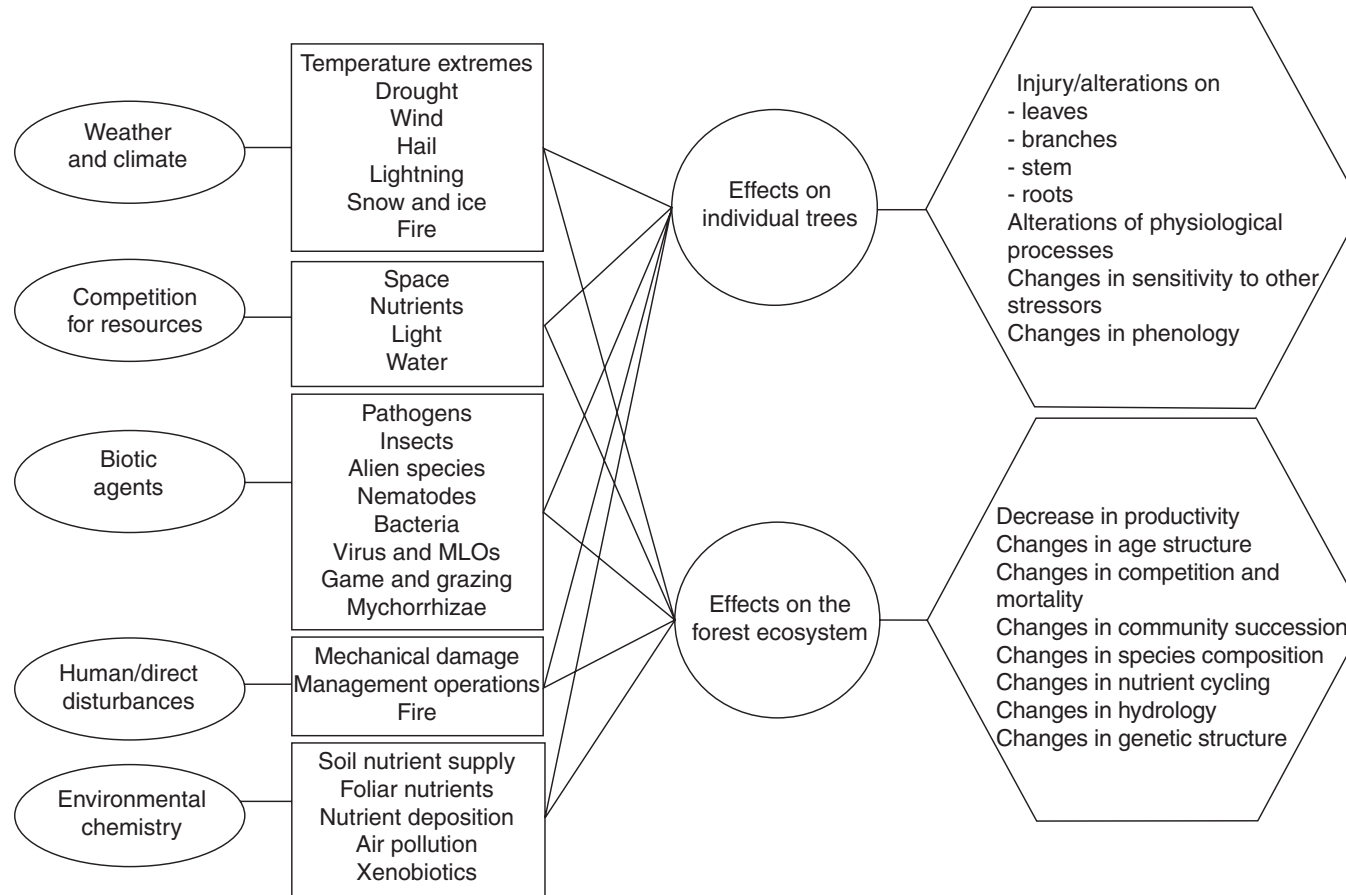
Measurements → Identifying the conditions that are conducive to thresholds and/or tipping points ← Understanding



Holling, C. S. 1973. Annual Review of Ecology and Systematics 4:1–23.



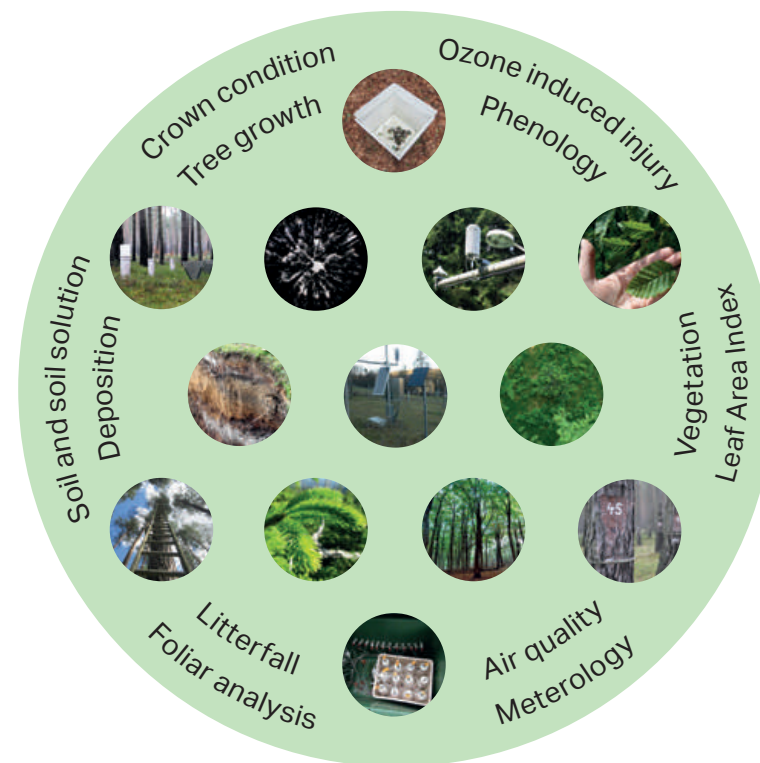
# What to measure and how?



Ferretti, 2004, in Evans, Youngquist, Burley, Encyclopedia of Forest Sciences

# The UNECE International Co-operative Program (ICP) on Assessment and Monitoring of Air Pollution Effects on Forests

- Collect, validate, store, process and provide data on forest health, growth, diversity, phenology, soil and foliar nutrients, climate, deposition and ozone.
- Long-term, large-scale forest condition.
- Large-scale 42 participating countries (lead: Germany).
- Drivers-response relationships.
- Standard Operating Procedures (SOPs) and Quality Assurance (QA) on a continuous basis.
- [www.icp-forests.net](http://www.icp-forests.net)



Credit: Michel et al., 2018.

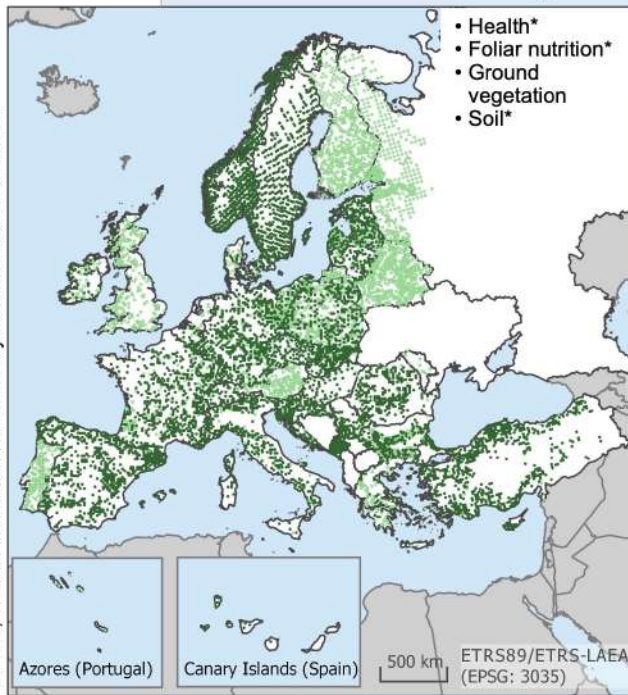


# ICP Forests in brief

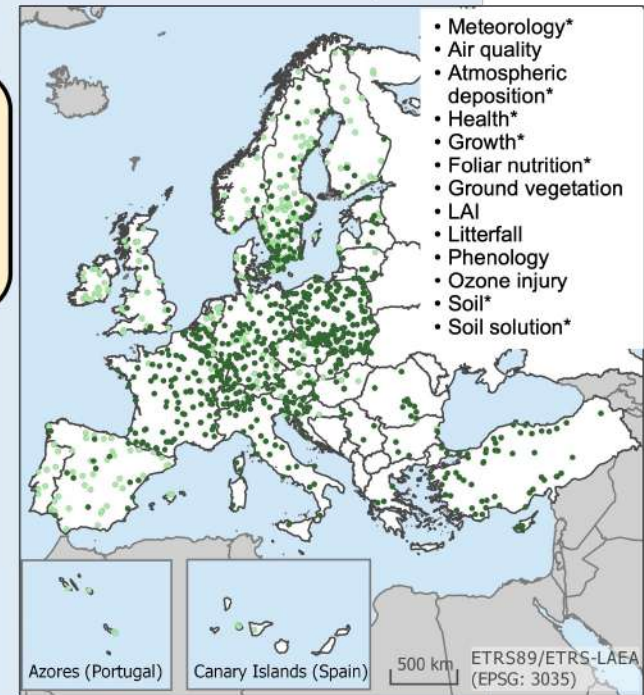
Ferretti et al., For Ecol Manage, 2024

## A. The ICP Forests terrestrial forest monitoring system

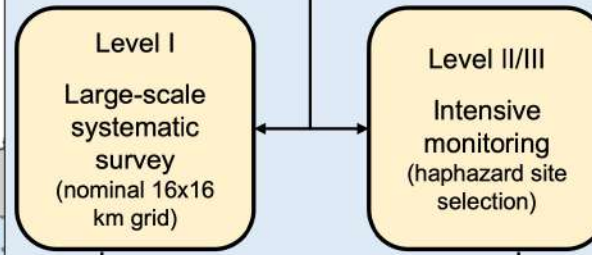
### B. Level I: ca 6,000 active plots\*



### C. Level II: ca 700 active plots\*



Governance, harmonized methods, manuals and Quality Assurance (international level)



Data collection (national level)

International Data Portal



Documentation Access/download Reporting

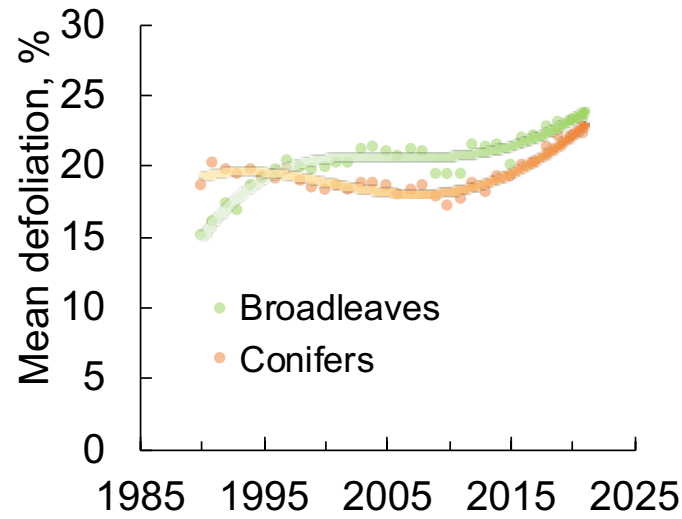
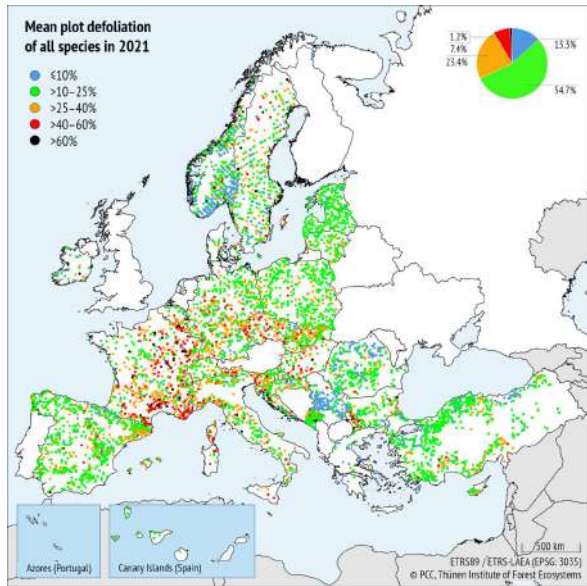
Statistics on forest condition

Upscaling

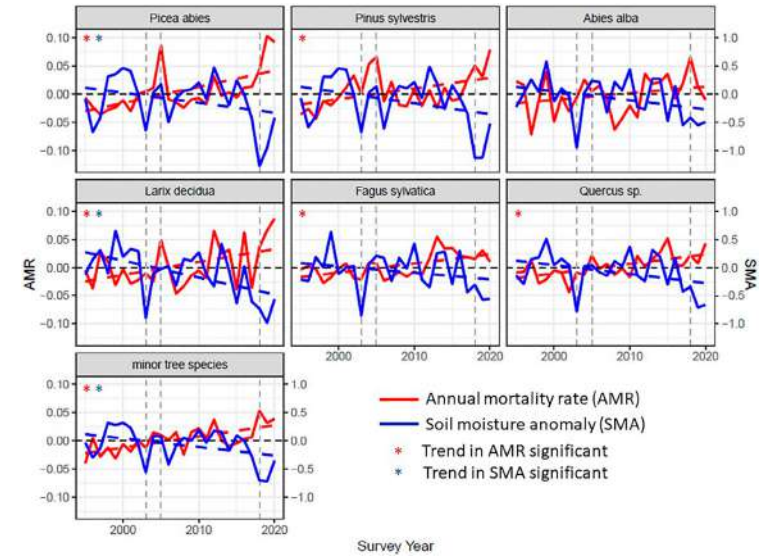
Relationship b/w drivers and forest response

# Forest health

## Mean plot defoliation



## Mortality and soil moisture anomalies

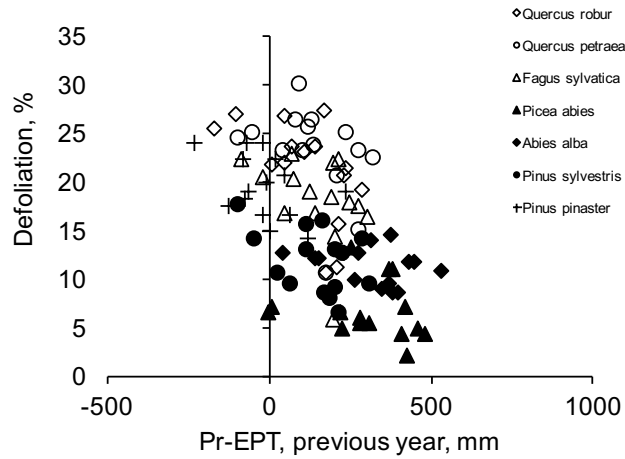


Michel *et al.*, ICP Forests TR, 2022  
Potocic *et al.*, ICP Forests Brief, 2022  
George *et al.*, Plant Biology, 2022



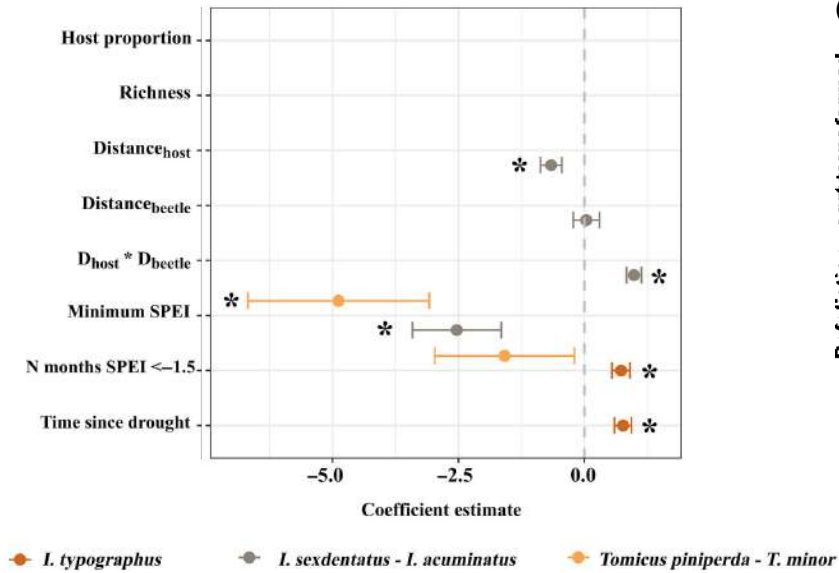
# Forest health

## Climate and weather

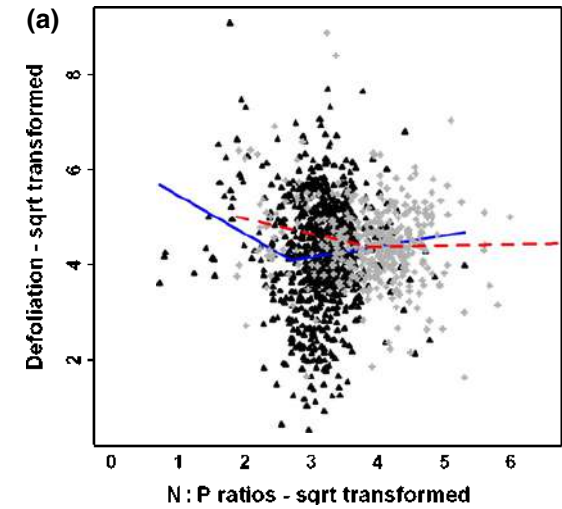


## Biotic stressors

### (b) Mortality



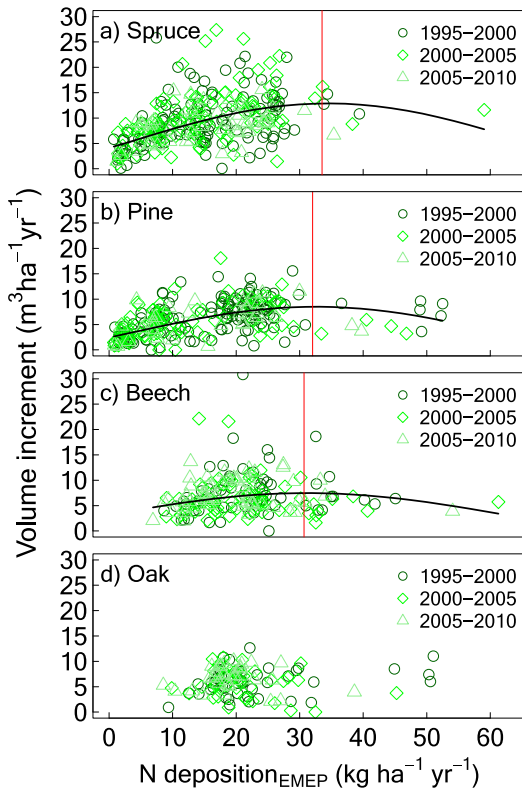
## Nutrition



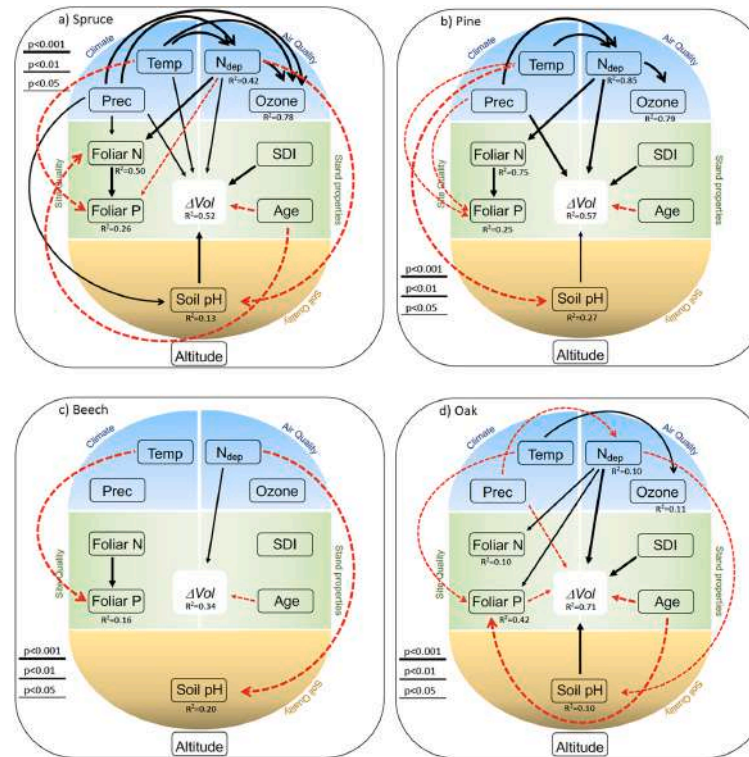
Ferretti et al., For Ecol Manage, 2013  
 Veresoglou et al., New Phytol, 2014  
 Jaime et al., Global Change Biology, 2021

# Forest growth

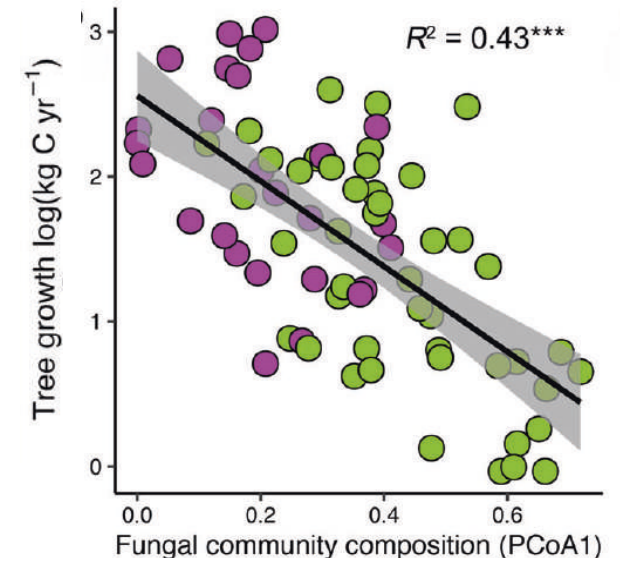
## Role of N deposition



## Role of multiple factors



## Role of EM fungal community

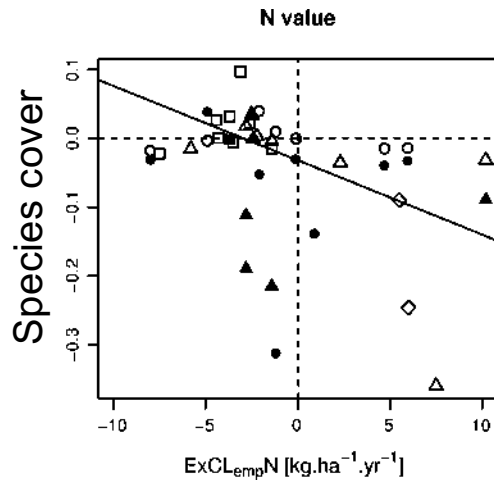


Etzold et al., For Ecol Manage, 2020.  
Anthony et al., ISME Journal, 2022



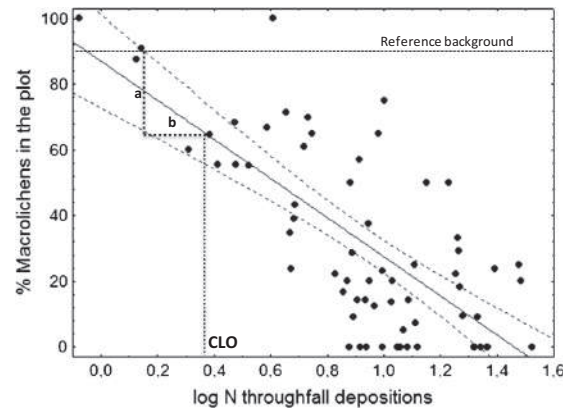
# Forest species diversity

Vascular plants



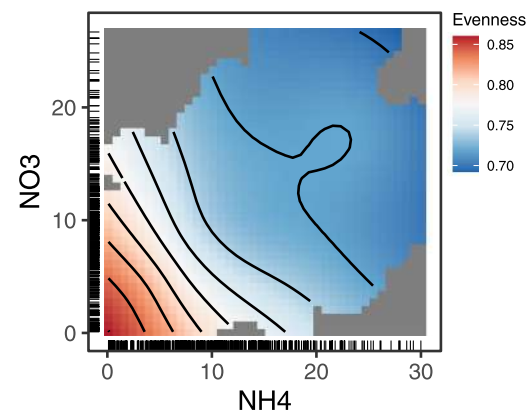
*Decrease cover of oligotrophic species (open symbols)*

Lichens



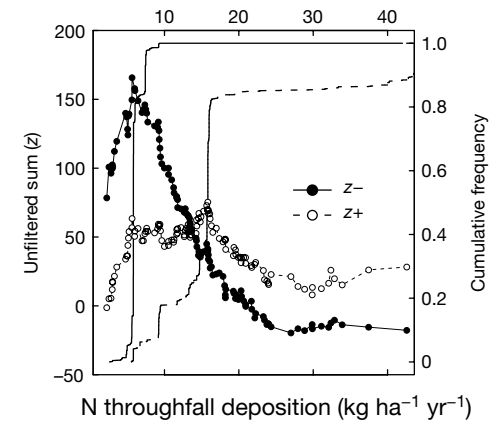
*Decrease frequency of macrolichens*

Bryophytes



*Decrease of evenness*

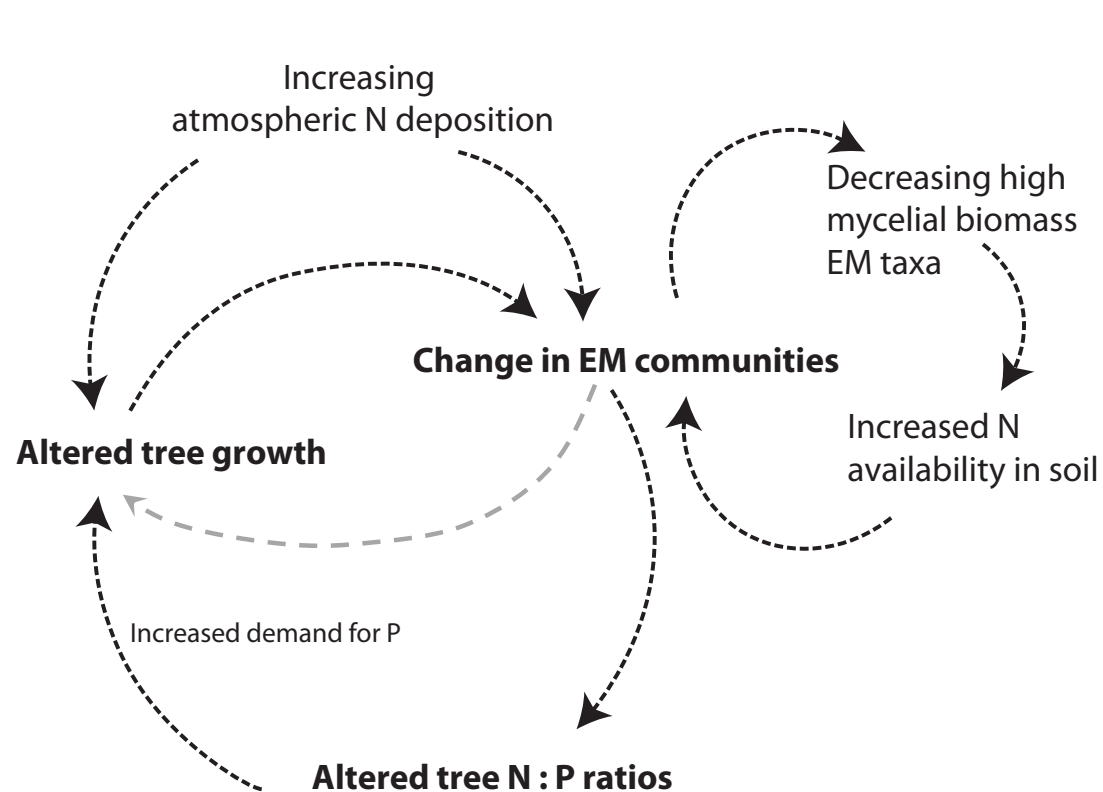
Ectomycorrhiza (EM)



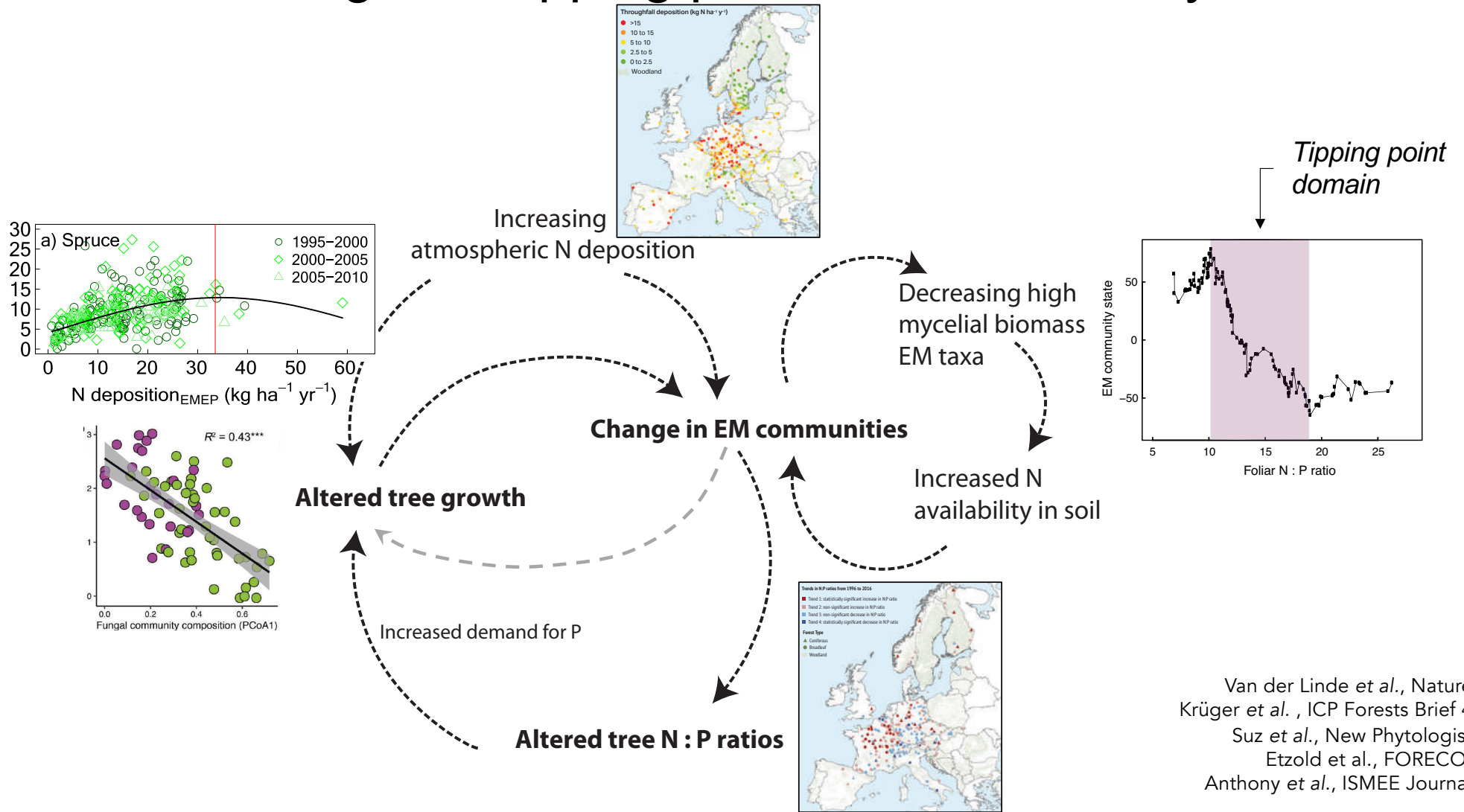
*Change in EM fungal communities*

Dirnböck et al., Global Change Biology, 2013; Giordani et al., For. Ecol. Manage., 2013; Welldon et al., Annals of Forest Science, 2022; Van der Linde et al., Nature, 2018.

# EM fungi and tipping points in forest ecosystem



# EM fungi and tipping points in forest ecosystem



Van der Linde *et al.*, Nature, 2018.  
 Krüger *et al.*, ICP Forests Brief 4, 2020.  
 Suz *et al.*, New Phytologist, 2021.  
 Etzold *et al.*, FORECO, 2021.  
 Anthony *et al.*, ISMEE Journal, 2022.



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- Is the monitoring network assessing forest resilience and how?
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# Information needs

## 1. Detection and quantification of status and changes of forest resources.



- “Traditional” meaning in the forest community
- Spatial coverage
- Emphasis on statistical design
- NFIs, ICP Forests Level I

## 2. Identification and understanding of drivers and processes



- “New” meaning for a broader range of scientists
- Time resolution
- Emphasis on models.
- ICP Forests Level II; ICOS;...

# Information needs

## 1. Detection and quantification of status and changes of forest resources.



## 2. Identification and understanding of drivers and processes



## 3. Model future development

- “Traditional” meaning in the forest community
- Spatial coverage
- Emphasis on statistical design
- NFIs, ICP Forests Level I

- “New” meaning for a broader range of scientists
- Time resolution
- Emphasis on models.
- ICP Forests Level II; ICOS;...



# Three possible advantages for the new regulation

## (i) Operational

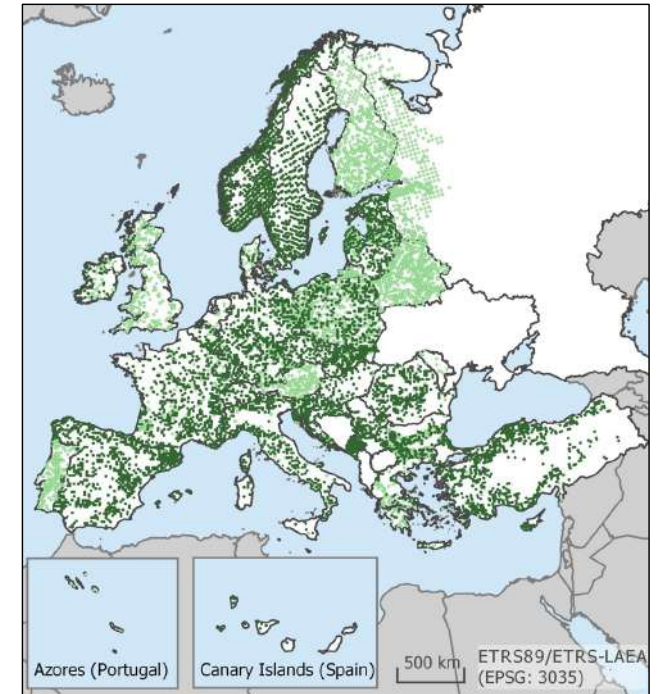
- Existing ground-based plots infrastructure with long-term data legacy:
  - covering all fields considered by the draft regulation (+ soil);
  - for the validation of data originated by the remote sensing component.
- Already harmonized methodologies.
- Already established formal QA/QC procedures.
- Model for governance and data access policy.

## (iii) Financial

See (i) + capitalizing the past EC investments after the EC Regulation 3528/86.

## (iii) Conceptual

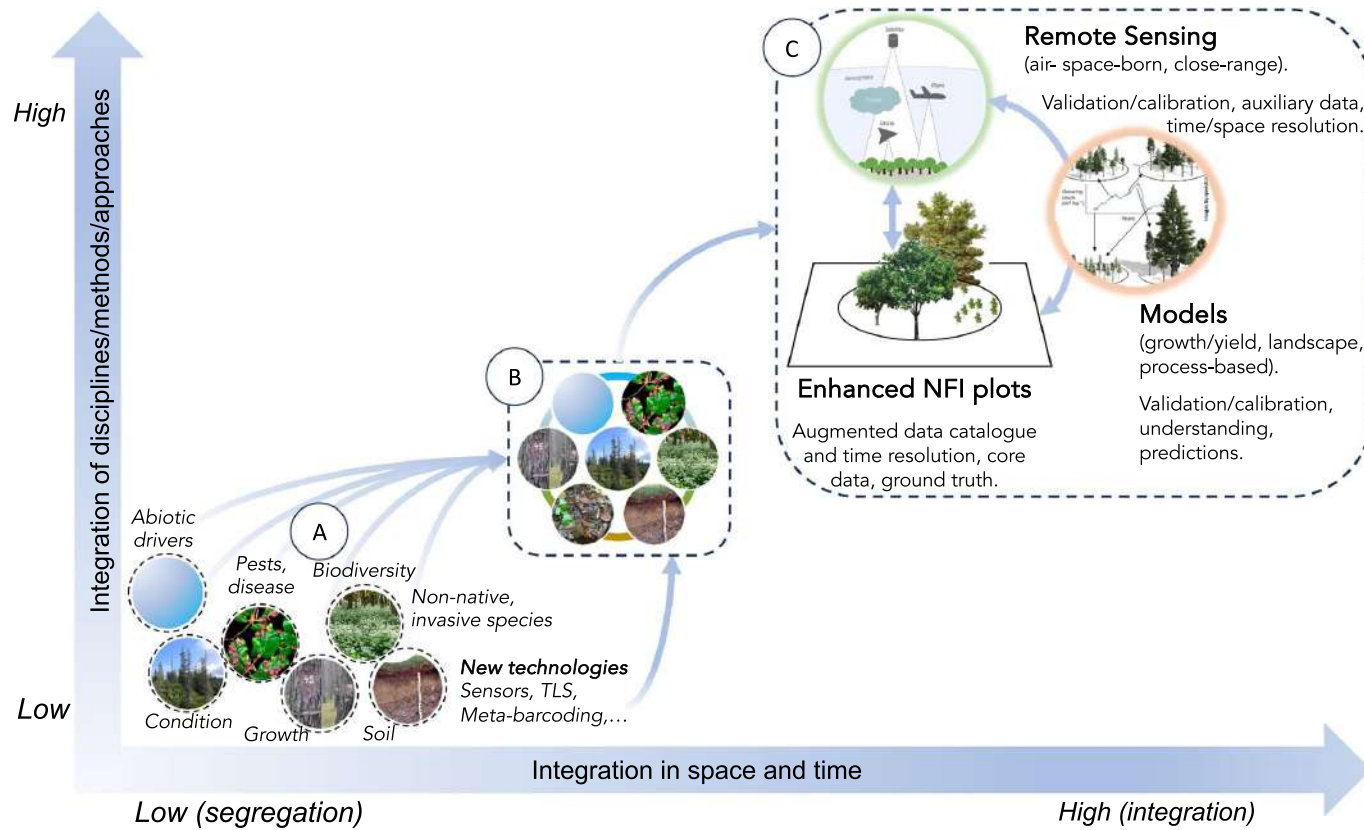
- Bridging the gap between detection/quantification and understanding.



Ferretti et al., FORECO, 2024.

© PCC, Thünen Institute of Forest Ecosystems. Status: 2024-01-09

# A possible example: the SwissAIM initiative



Ferretti et al. *Annals of Forest Science* (2024) 81:6



# Outline

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# Three main steps

- (i) Revising, further developing, and updating the suggested monitoring concept also beyond the NFIs.
  - by leveraging the existing and available internationally co-ordinated monitoring networks.
- (ii) Identifying and exploiting complementarities and synergies
  - between existing and available internationally co-ordinated monitoring networks, **filling gaps** when necessary.
- (iii) Developing an institutional framework
  - for a collaborative multi-level, multi-tier integrated ground-based and remote sensing forest monitoring system.



## Correspondence

### Europe must join forces to monitor its forests

Marco Ferretti

| Nature | Vol 626 | 29 February 2024

# Two important quotes: monitoring is simply essential

"...monitoring is a crucial part of environmental science, costs very little relative to the value of the resources it protects and the policy it informs, and has added value in that basic environmental monitoring data can be used for multiple purposes." (Lovett et al., 2007)

"Forest science relies on the long-term data that scientists wring from forests over decades. Our chances of overcoming climate change are small, but they will diminish further if we forget the basics monitoring of our home planet" (Nature, 608, 2022).

Lovett et al., Front Ecol Environ, 2007

REVIEWS REVIEWS REVIEWS

## Who needs environmental monitoring?

Gary M Lovett<sup>1</sup>, Douglas A Burns<sup>2</sup>, Charles T Dretzoi<sup>3</sup>, Jennifer C Jenkins<sup>4</sup>, Myron J Mitchell<sup>5</sup>, Lindsay Rustad<sup>6</sup>, James B Ghanley<sup>7</sup>, Gene B Likens<sup>8</sup>, and Richard Hamrick<sup>9</sup>

Environmental monitoring is often criticized as being unscientific, too expensive, monitoring studies do suffer from these problems, there are also many highly success programs that have provided important scientific advances and crucial information. Here, we discuss the characteristics of effective monitoring programs, and contend that a fundamental component of environmental science and policy. We urge monitoring programs to plan in advance to ensure high data quality, accessibility, and we urge government agencies and other funding institutions to make greater commitment and long-term stability of funding for environmental monitoring programs.

Front Ecol Environ 2007, 5(5): 253-260

We use monitoring data routinely in our daily lives: we monitor the stock market, the weather, our blood pressure, and baseball statistics. But, does monitoring have a place in environmental science? Common criticisms of environmental monitoring are (1) that it is not really science, but merely a fishing expedition that diverts funds from "real" science, (2) that most monitoring data are never used, and (3) that we can't possibly know today what critical questions will need to be answered in the future. Some people feel that monitoring has no place in rigorous environmental science, and mindless monitoring gives the discipline a bad reputation. Who needs it?

### In a nutshell

- Environmental monitoring is often criticized as being unscientific, expensive, and wasteful
- We argue that monitoring is a crucial part of environmental science, costs very little relative to the value of the resources it protects and the policy it informs, and has added value in that basic environmental monitoring data can be used for multiple purposes
- Effective monitoring programs address clear questions, use consistent and accepted methods to produce high-quality data, include provisions for management and accessibility of samples and data, and integrate monitoring into research programs that foster continual examination and use of the data
- Government agencies should commit to long-term support for valuable monitoring programs, and funders of basic ecological and environmental research should recognize that monitoring is a fundamental part of environmental science

<sup>1</sup>Institute of Ecosystem Studies, Millbrook, NY (lovett@ecostudies.org); <sup>2</sup>US Geological Survey, Troy, NY; <sup>3</sup>Syracuse University, Syracuse, NY; <sup>4</sup>University of Vermont, Burlington, VT; <sup>5</sup>College of Environmental Science and Forestry, State University of New York, Syracuse, NY; <sup>6</sup>US Department of Agriculture Forest Service, Cumberland, ME; <sup>7</sup>US Geological Survey, Montpelier, VT; <sup>8</sup>US Environmental Protection Agency, Washington, DC

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The international journal of science / 18 August 2022

## nature

### We must get a grip on forest science – before it's too late

Trees are one of our biggest carbon hopes. Supporting the scientists who study them should be a high priority.

Humanity's understanding of how forests are responding to climate change is disconcertingly fragile. Researchers don't fully understand how climate change interacts with a multitude of forest processes. Complex, unsolved questions include how climate warming affects forest health; how it affects the performance of forests as carbon sinks; and whether it alters the ecosystem services that forests provide. Forests are our life-support system, and we should be more serious about taking their pulse.

Six papers in this week's *Nature* provide important insights into those questions. They also underline some of the challenges to fully understanding forests' potential in the fight against climate change. These challenges are not only in the science itself, but also relate to how forest scientists collaborate, how they are funded (especially where data collection is concerned) and how they are trained. Many disciplines are involved in forest science and contribute to dynamic global vegetation models (DGVMs). These simulate how carbon and water cycles change with climate and, in turn, inform broader Earth-system and climate models of the type that feed into policymaking. Different DGVMs make different predictions about how long forests will continue to absorb anthropogenic carbon dioxide. One reason for these differences is that models are sensitive to assumptions made about the processes in forests. There are many influences – including temperature, moisture, fire and nutrients – that are generally studied in isolation. Yet they interact with each other.

For example, not all DGVMs account for the dampening effect that a lack of soil phosphorus can have on carbon fertilization – the phenomenon by which plants absorb more CO<sub>2</sub> as its concentration in the atmosphere increases. Parts of Amazonia are poor in phosphorus, and research has shown that introducing phosphorus limitation into DGVMs can cut the carbon-fertilization effect<sup>1</sup>. Hellen Fernandes Viana Cunha at the National Institute for Amazonian Research in Manaus, Brazil, and her colleagues report<sup>2</sup> a powerful experimental demonstration of how the soil's poor phosphorus content limits carbon absorption in an old-growth Amazonian forest (see page 558).

Models simulating the northward spread of boreal forest as temperatures rise are also missing key drivers<sup>3</sup>, according to Roman Dial at Alaska Pacific University in Anchorage and his colleagues. They report that a white spruce

population has migrated surprisingly far north into the Arctic tundra (see page 544). To explain this, it is necessary to take into account winter winds (which facilitate long-distance dispersal) along with the availability of deep snow and soil nutrients (which promote plant growth).

Models are often based on a small number of functional tree types – for example, evergreen broadleaf or evergreen needle leaf. These are chosen as a proxy for the behaviour of the planet's more than 60,000 known tree species. But the biology of individual species matters when it comes to a tree's response to climate change.

David Bauman at the University of Oxford, UK, and his co-workers reported in May that tree mortality on 24 moist tropical plots in northern Australia has doubled in the past 35 years (and life expectancy has halved)<sup>4</sup>, apparently owing to the increasing dryness of the air (see page 528). But that was an average of the 81 dominant tree species; mortality rates varied substantially between species, a variation that seemed to be related to the density of their wood. Peter Reich at the Institute for Global Change Biology at the University of Michigan in Ann Arbor and his colleagues now report that modest alterations in temperature and rainfall led to varying rates of growth and survival<sup>5</sup> for different species in southern boreal forest trees (see page 540).

Forest science relies on the long-term data that scientists wring from forests over decades.

Failure to examine multiple factors at once means that scientists are making findings that challenge the assumptions in models. Spring is coming earlier for temperate forests and most models assume that, by prolonging the growing season, this increases woody-stem biomass. However, a study<sup>6</sup> carried out in temperate deciduous forests by Kristina Anderson-Teixeira at the Smithsonian Conservation Biology Institute in Front Royal, Virginia, and her colleagues found no sign of this happening (see page 552).

To obtain comprehensive data for the models, continuous, long-term observations need to be made, and that depends on the availability of long-term funding. Achieving such continuity is a problem for both remote-sensing and ground-based operations. The former can cost hundreds of millions of dollars, but the value of its long-term data sets is immense, as is demonstrated<sup>7</sup> by a team led by Giovanni Forzieri at the University of Florence in Italy. The authors used 20 years of satellite data to show that nearly one-quarter of the world's intact forests have already reached their critical threshold for abrupt decline (see page 534). But even field-based data collection, which costs a pittance by comparison, struggles to achieve financial security.

Forest science relies on the long-term data that scientists wring from forests over decades. Our chances of overcoming climate change are small, but they will diminish further if we forget the basics of monitoring our home planet.

1. Dial, R. S. et al. *Biogeochemistry* **9**, 2547–2559 (2015).
2. Cunha, H. V. et al. *Nature* **608**, 552–557 (2022).
3. Dial, R. J., Naylor, C. T., Hewitt, R. E. & Sullivan, P. F. *Nature* **608**, 548–551 (2022).
4. Bauman, D. et al. *Nature* **608**, 538–543 (2022).
5. Reich, P. B. et al. *Nature* **608**, 522–527 (2022).
6. Dow, C. et al. *Nature* **608**, 522–527 (2022).
7. Forzieri, G., Delacour, V., Michonnet, N., G. Bonifazi, A. & Cacciari, A. *Nature* **608**, 534–539 (2022).

Nature | Vol 608 | 18 August 2022 | 449

Nature, 608, 2022



Swiss Federal Research Institute WSL



# FORECOMON Conference and Task Force Meeting of the ICP Forests 2024

FORECOMON 2024 – The 11th Forest Ecosystem Monitoring Conference

Monitoring for future forests

Prague, Czech Republic

10–12 June 2024



<http://icp-forests.net/events/forecomon-2024-the-11th-forest-ecosystem-monitoring-conference>