EUROPEAN FOREST INSTITUTE

Enhancing the resilience of European forests under climate change

Marcus Lindner

Forests in Science, Practice and Education – Conference on the centenary of the Forest Faculty, Warsaw University of Life Sciences, SGGW

Warsaw, Poland, 18-19 June 2019

Outline

- Resilience – buzzword with many different interpretations
- Evidence of recent climate change and increased natural disturbance risks in forests
- The project „SURE -Sustaining and Enhancing Resilience of European Forests"
- Guiding management to enhance resilience of European forests

Forest resilience? – What exactly does this mean?

Alternative definitions of resilience

- Engineering resilience (Pimm, 1984)
  - *The time that it takes for variables to return towards their equilibrium following a disturbance.*
- Ecological resilience (Holling, 1973)
  - *The system's capacity to absorb external disturbance without changing as well as the ability to self-organize and build adaptive capacity.*
- Social-ecological resilience (Resilience Alliance, 2019)
  - *The capacity of a social-ecological system to absorb or withstand perturbations and other stressors such that the system remains within the same regime, essentially maintaining its structure and functions. It describes the degree to which the system is capable of self-organization, learning, and adaptation*.

Examples of engineering resilience

Global Change Biology (2004) **10**, 2092–2099, doi: 10.1111/j.1365-2486.2004.00870.x

Canopy recovery after drought dieback in holm-oak Mediterranean forests of Catalonia (NE Spain)

FRANCISCO LLORET*, DANIEL SISCART* and CARLES DALMASES†

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Abstract

Climate change is likely to produce more frequent and longer droughts in the Mediterranean region, like that of 1994, which produced important changes in the *Quercus ilex* forests, with up to 76% of the trees showing complete canopy dieback. At the landscape level, a mosaic of responses to the drought was observed, linked to the distribution of lithological substrates. Damage to the dominant tree species (*Q. ilex*) and the most common understorey shrub (*Erica arborea*) was more noticeable on the compact substrates (breccia) than on the fissured ones (schist). This result was consistent with

Examples of engineering resilience

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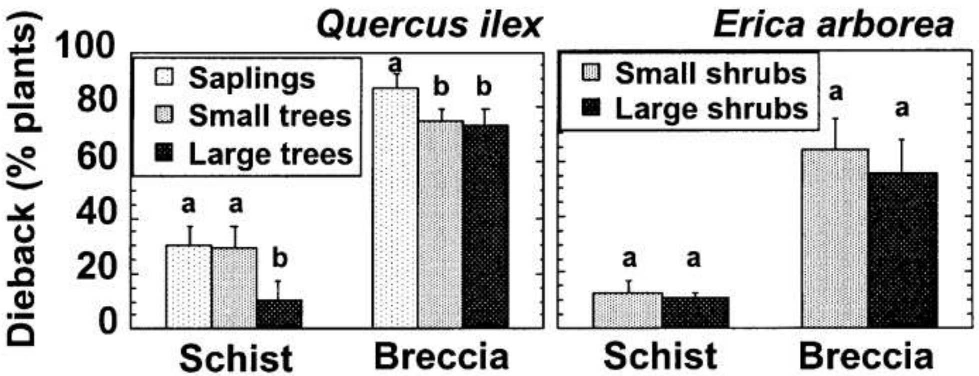

Fig. 3 Effect of the 1994 drought according to plant size and lithological substrate. The values are the percentage of *Quercus ilex* and *Erica arborea* plants belonging to the damage class 0 (no remaining green foliage). Values were obtained as the percen-

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Examples of engineering resilience

Pretzsch et al. 2013. *Plant Biology,* ***15 (3), 483-495.***

plant biology

Plant Biology ISSN 1435-8603

RESEARCH PAPER

Resistance of European tree species to drought stress in mixed *versus* pure forests: evidence of stress release by inter-specific facilitation

H. Pretzsch, G. Schütze & E. Uhl

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Examples of engineering resilience

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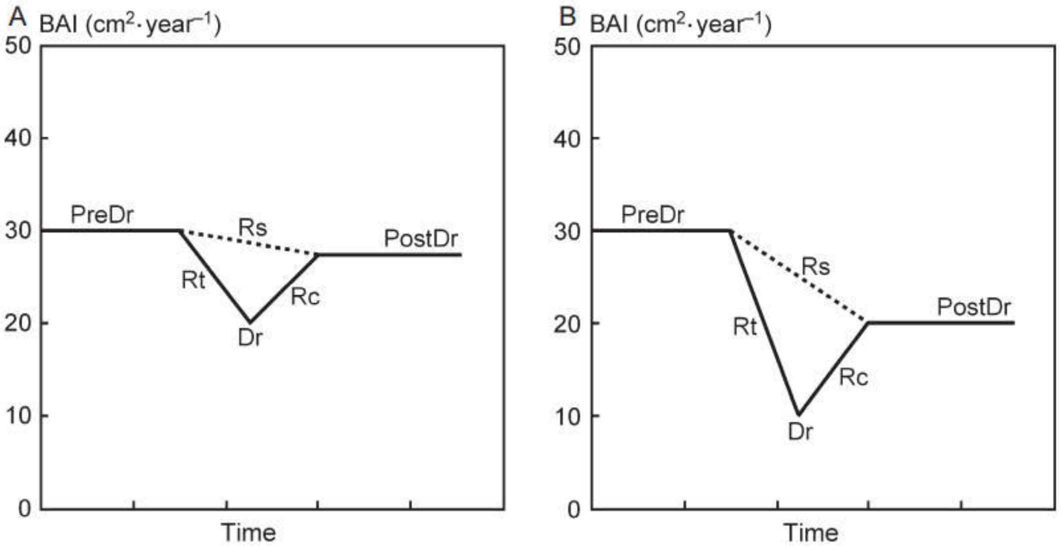


Fig. 1. Course of growth in two different stress events characterised by growth in the period before drought (PreDr) growth in the drought period (Dr) and growth after the drought period (PostDr) (modified after Lloret *et al.* 2011). Indices for resistance, Rt = Dr/PreDr, recovery, Rc = PostDr/Dr, and resilience, Rs = PostDr/PreDr, are used to characterize the stress response patterns. (A) Tree with low growth decrease by drought (PreDr = 30, Dr = 20, Post-

Examples of engineering resilience

Pretzsch et al. 2013. *Plant Biology, **15 (3), 483-495.***

Drought stress release by inter-specific facilitation

Pretzsch, Schütze & Uhl

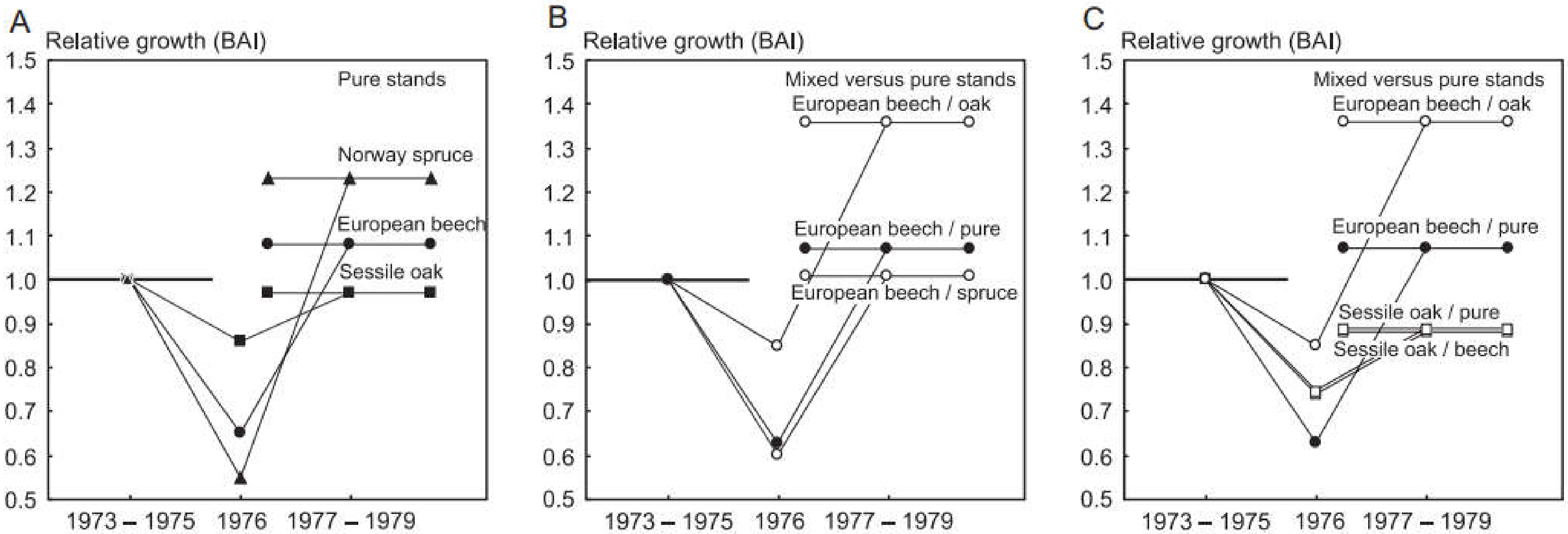
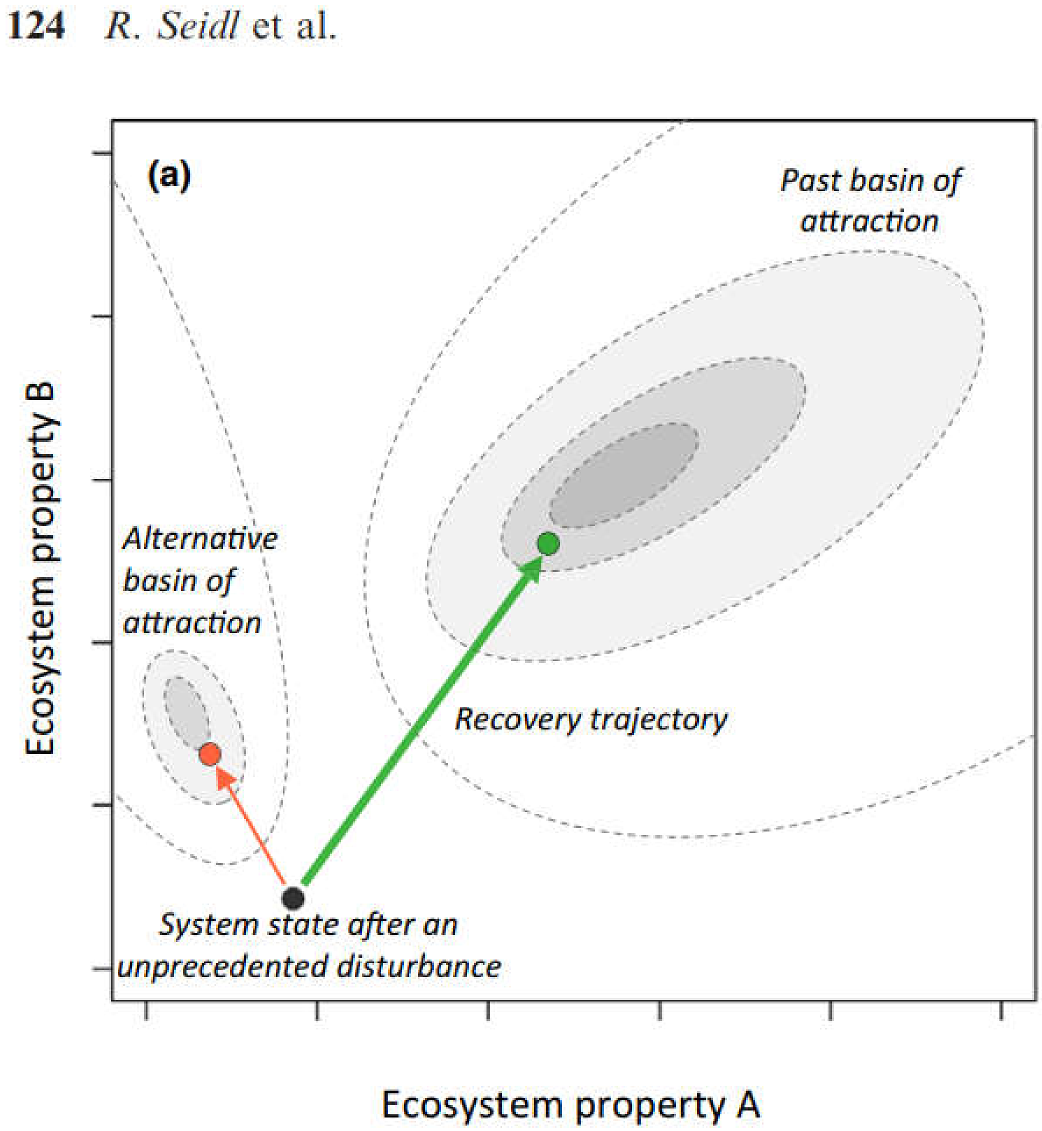


Fig. 6. Species-specific stress reactions caused by the drought year 1976 shown in relation to mean growth level in the 3-year period 1973–1975 before the drought stress (reference line = 1.0). (A) Norway spruce, European beech and sessile oak in pure stands. (B) European beech in pure and mixed stands. (C) European beech and sessile oak in pure and mixed stands. The courses represent growth in the dry year 1976, and in the recovery period (period mean of 1977–1979) in relationship to growth in the reference period (period mean of 1973–1975).

ience, Rs = PostDr/PreDr, are used to characterize the stress response patterns. (A) Tree with low growth decrease by drought (PreDr = 30, Dr = 20, Post-



Examples of studies applying ecosystem resilience

1. Seidl, R., Spies, T.A., Peterson, D.L., Stephens, S.L., Hicke, J.A. and Angeler, D. 2016. Searching for resilience: addressing the impacts of changing disturbance regimes on forest ecosystem services. *Journal of Applied Ecology,* ***53 (1), 120-129.***

Examples of studies applying ecosystem resilience

2. Cantarello et al. 2017. Quantifying resilience of multiple ecosystem services and biodiversity in a temperate forest landscape. Ecology and Evolution **7 (22), 9661-9675.**

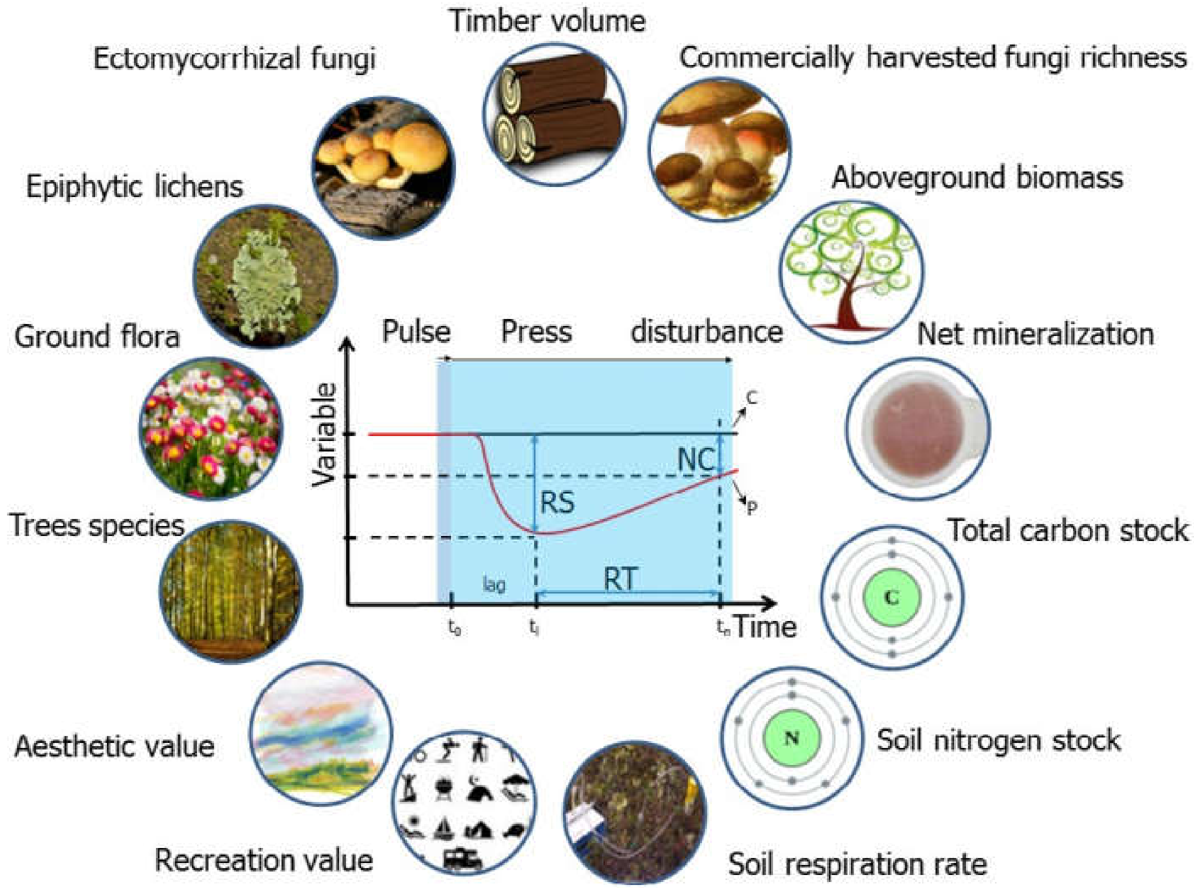


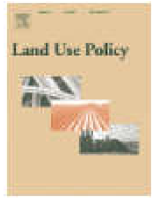
FIGURE 2 Diagram synthesizing the 13 variables selected (outside circles) and the study design employed to measure their resilience (inside graph). For explanation of graph labels, see Figure 1. For full description of the study design, see text

Examples of studies applying social-ecological resilience

: Key domains affecting community resilience (Source: authors)

ELSEVIER

Land Use Policy
Volume 46, July 2015, Pages 11-20



Community resilience and land degradation in forest and shrubland socio-ecological systems: Evidence from Gorgoglione, Basilicata, Italy

Claire Kelly [a], Agostino Ferrara [b], Geoff A. Wilson [a], Francesco Ripullone [b], Angelo Nolè [b], Nichola Harmer [a], Luca Salvati [c]

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https://doi.org/10.1016/j.landusepol.2015.01.026

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Examples of studies applying social-ecological resilience

PERSPECTIVE

PERSPECTIVE

Adapt to more wildfire in western North American forests as climate changes

Tania Schoennagel[a,1], Jennifer K. Balch[a,b], Hannah Brenkert-Smith[c], Philip E. Dennison[d], Brian J. Harvey[e], Meg A. Krawchuk[f], Nathan Mietkiewicz[b], Penelope Morgan[g], Max A. Moritz[h], Ray Rasker[i], Monica G. Turner[j], and Cathy Whitlock[k,l]

Edited by F. Stuart Chapin III, University of Alaska, Fairbanks, AK, and approved February 24, 2017 (received for review October 25, 2016)

Wildfires across western North America have increased in number and size over the past three decades, and this trend will continue in response to further warming. As a consequence, the wildland–urban interface is projected to experience substantially higher risk of climate-driven fires in the coming decades. Although many plants, animals, and ecosystem services benefit from fire, it is unknown how ecosystems will respond to increased burning and warming. Policy and management have focused primarily on specified resilience approaches aimed at resistance to wildfire and restoration of areas burned by wildfire through fire suppression and fuels management. These strategies are inadequate to address a new era of western wildfires. In contrast, policies that promote adaptive resilience to wildfire, by which people and ecosystems adjust and reorganize in response to changing fire regimes to reduce future vulnerability, are

Schoennagel et al. *2017. Proceedings of the National Academy of Sciences,* ***114 (18), 4582-4590.***

Examples of studies applying social-ecological resilience

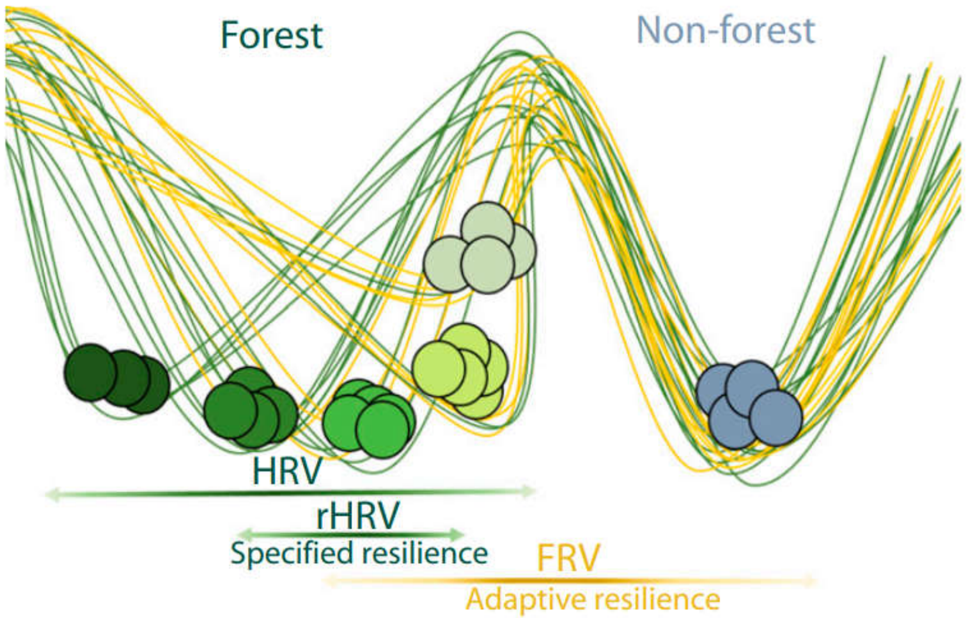

Fig. 3. Conceptual ball-and-basin representation of specified and adaptive resilience across a forested landscape. Lines defining basins depict the ranges of variation in fire regimes across forest types. Sets of green balls reflect the variation in abundance and composition within different forest types, and the set of blue balls represents nonforest ecosystems. Specified resilience of forests to wildfire is maintained within basins that fall within an rHRV of fire regimes over recent decades to centuries, typically derived from historical documents, remotely sensed data, and tree-ring data. Longer definitions of HRV reflect variation in fire regimes over the last 4,000–5,000 y, when present-day forest types were established in most regions; these data are derived from paleoecological reconstructions. Adaptive resilience to changing fire regimes is reflected within basins that fall within the FRV (yellow). Under the FRV, shifts to nonforest ecosystems remain unlikely in some cases (lower green balls) and more likely in other cases with easier transition to nonforest basin (higher green balls). Changes in the severity, frequency, and size of fire regimes and long-term regeneration following fire events reflect adaptive responses to changing fire regimes and climate conditions across broad scales.

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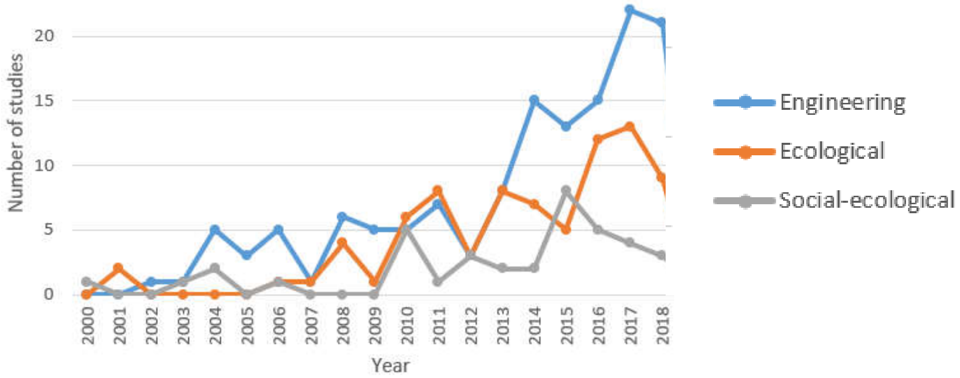
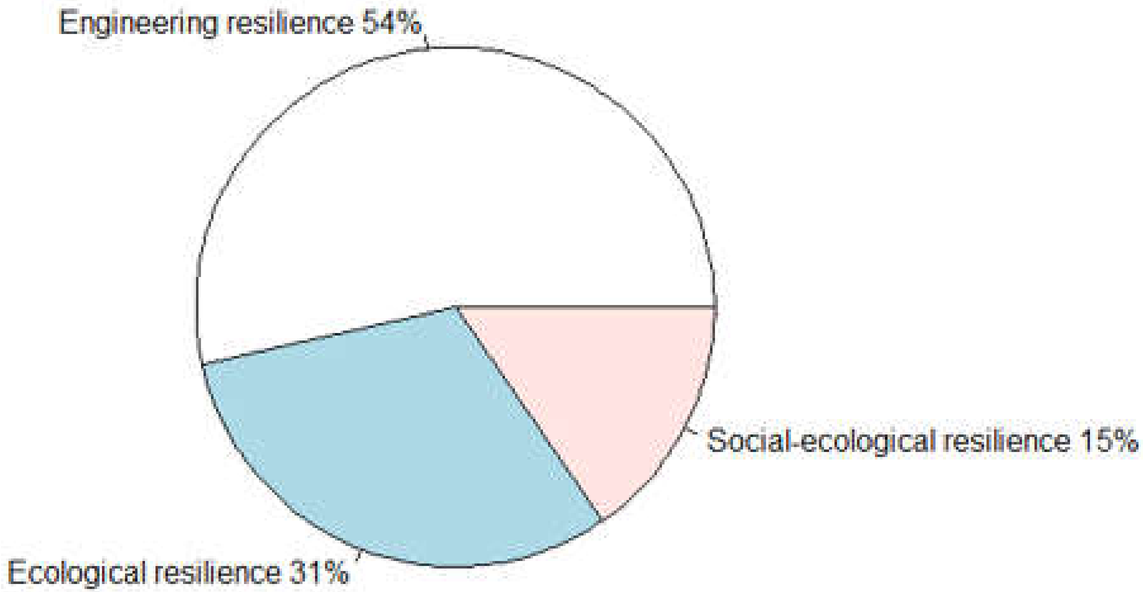
Share of resilience concepts in published forest resilience studies

- Systematic Review of 254 studies on Forest resilience





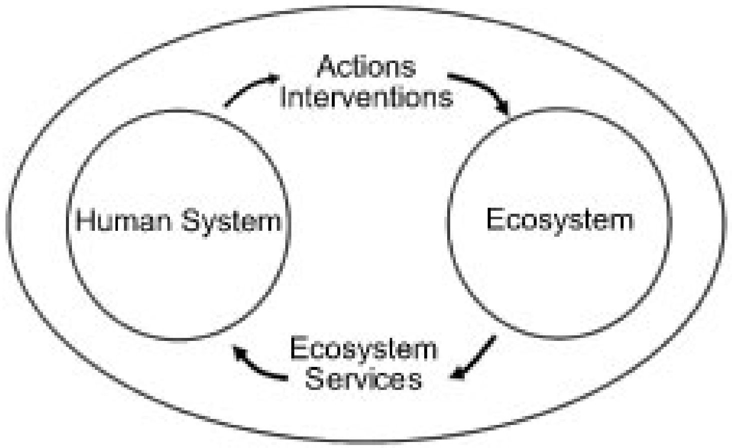
Laura Nikinmaa et al. in prep.

Resilience Programme EFI-Bonn

Resilience is the ability of forest related **social-ecological systems** to respond to change in a manner that critical interrelations (ecosystem functions/services) within the systems are maintained.

→ Combines humans and ecosystems

→ Looks into change, adaptation and learning



Social-Ecological System

Meta-analysis of resilience reviews

Moser et al. 2019. Climatic Change

1) distinction between resilience as a system trait, process, or outcome;
2) **importance of resilience as a strategy for dealing with uncertainty;**
3) **a shift from understanding resilience to active resilience building;**
4) incorporation of transformation into resilience;
5) **increasingly normative interpretation of resilience;**
6) **growing emphasis on measuring and evaluating resilience;**
7) mounting critiques of the resilience agenda demanding attention.

Moser, S., Meerow, S., Arnott, J. and Jack-Scott, E.J.C.C. 2019. The turbulent world of resilience: interpretations and themes for transdisciplinary dialogue. *Climatic Change, DOI 10.1007/s10584-018-2358-0.*

Why do we need an operational resilience concept?

- Global change challenges – Resilience as general solution?
  - Diverse definitions are confusing: everybody understands it differently
- Clarity is needed to define resilience
  - Different definitions are not necessarily conflicting, they can be understood as components of a common framework (differentiated by assumptions and system boundaries)
- Practice guidance on enhancing forest resilience requires an operational basis
  - concrete guidance and instruments for assessing forest resilience
  - indicator-based resilience assessment
    => enables targeting measures to enhance resilience
    => can be used for monitoring

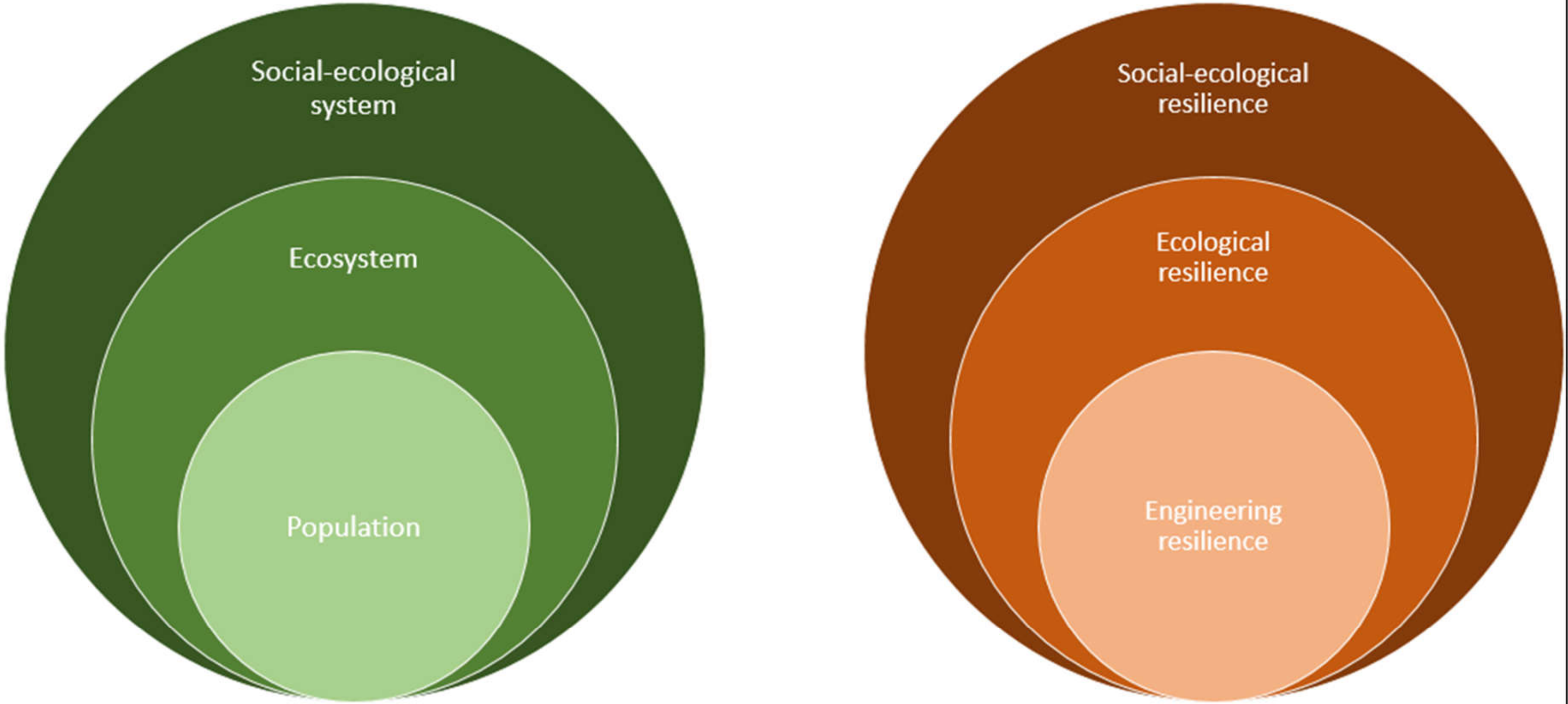


Figure 14: The parallels between the system complexity hierarchy and resilience definitions hierarchy. As populations are nested in an ecosystem that is nested in a social-ecological system, so is engineering resilience nested in ecological resilience that is nested in social-ecological resilience.

Laura Nikinmaa et al. in prep.

Resilience to what?

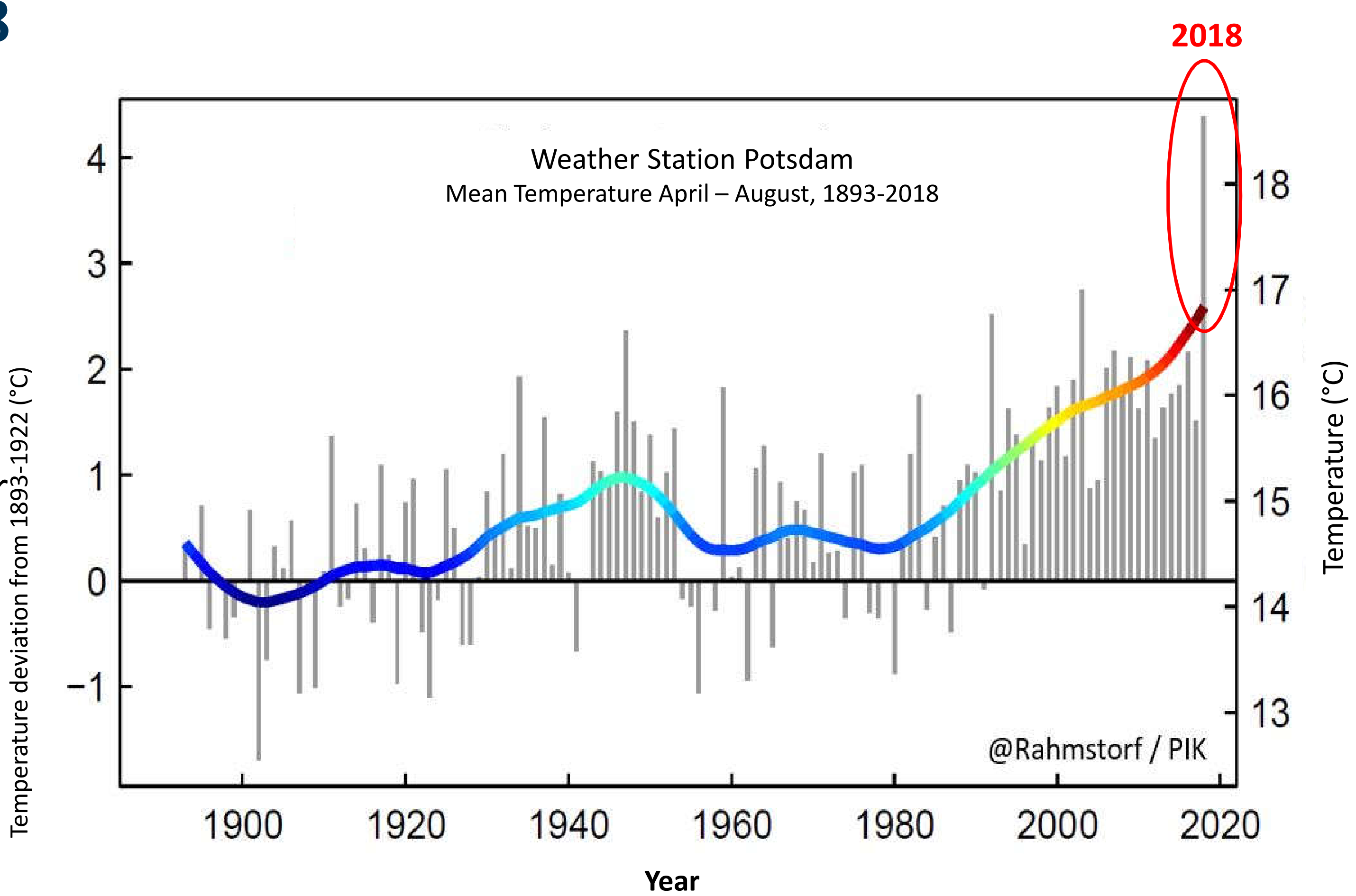
Carpenter, S., Walker, B., Anderies, J.M. and Abel, N. 2001. From Metaphor to Measurement: Resilience of What to What? *Ecosystems,* ***4 (8), 765-781.***

Forest disturbances in 2018: rare extreme events or climate change?

Climate change becomes real: exceptional heat and disturbances affecting Europe in 2018

- Multiple **windstorms** in the winter 2017/2018 and November 2018 (storm Vaia, Northeastern Italy)
- Devastating **wildfire** in Greece, July 2018; large wildfires in Sweden (25000 ha), Latvia, UK, …
- **Bark beetle outbreak** with unprecedented damage in many Central European countries, summer 2018 (and sobering forecast for 2019)

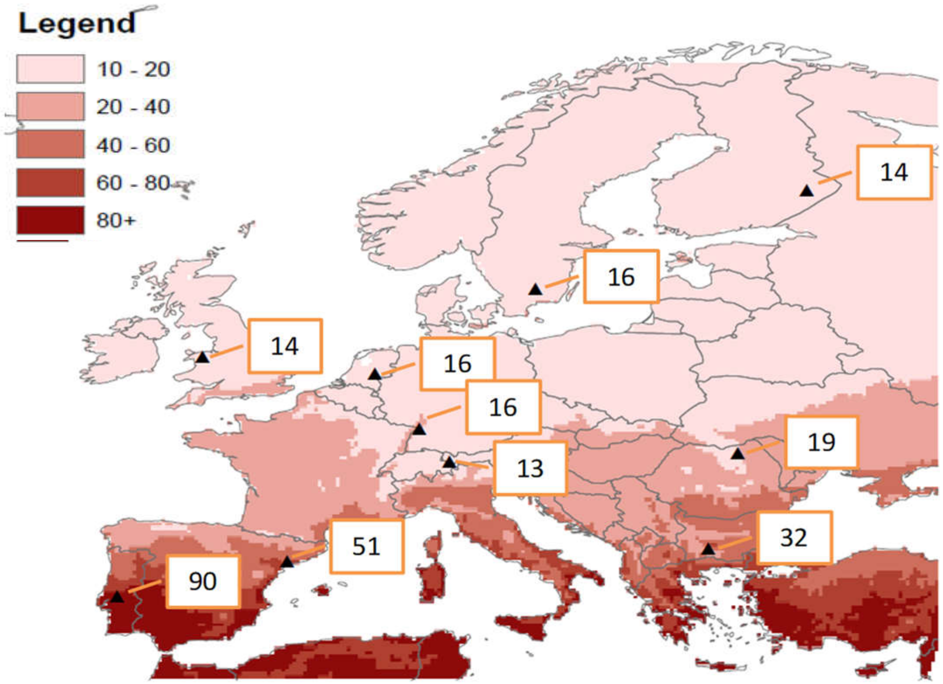
- The **unprecedented intensity** and **spatial coverage** of forest disturbance impacts across Europe **poses a significant challenge to forest policy and the forest sector in Europe**

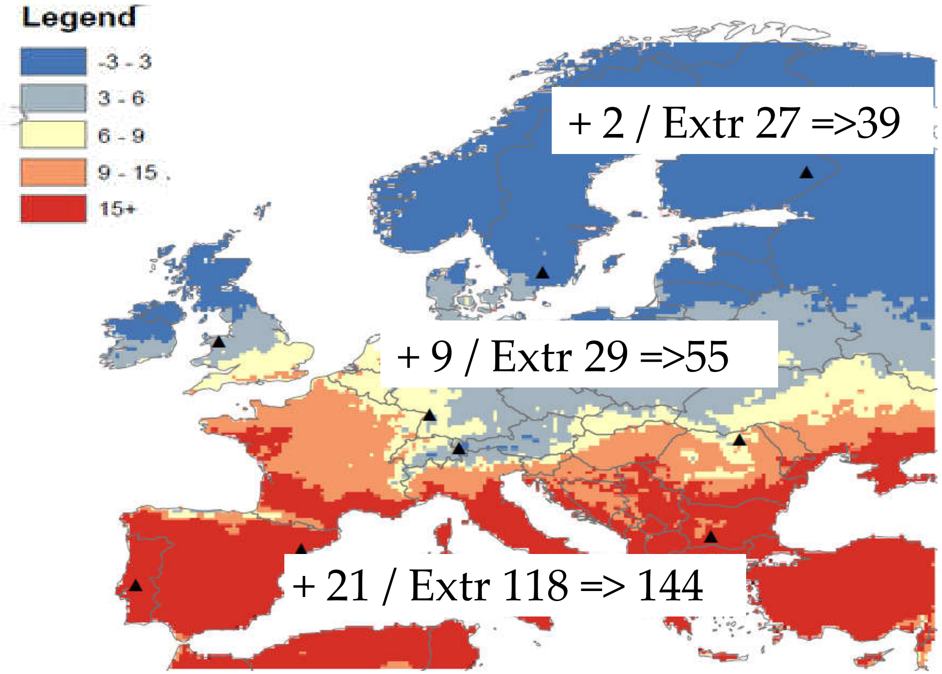


Abiotic risk - Drought

Annual Maximum Number of Continuous Dry Days (Mean 1961-1990)

Change (2070-2099 vs. 1961-1990)





Lindner et al. 2014. *Journal of Environmental Management*, **146**, 69-83.

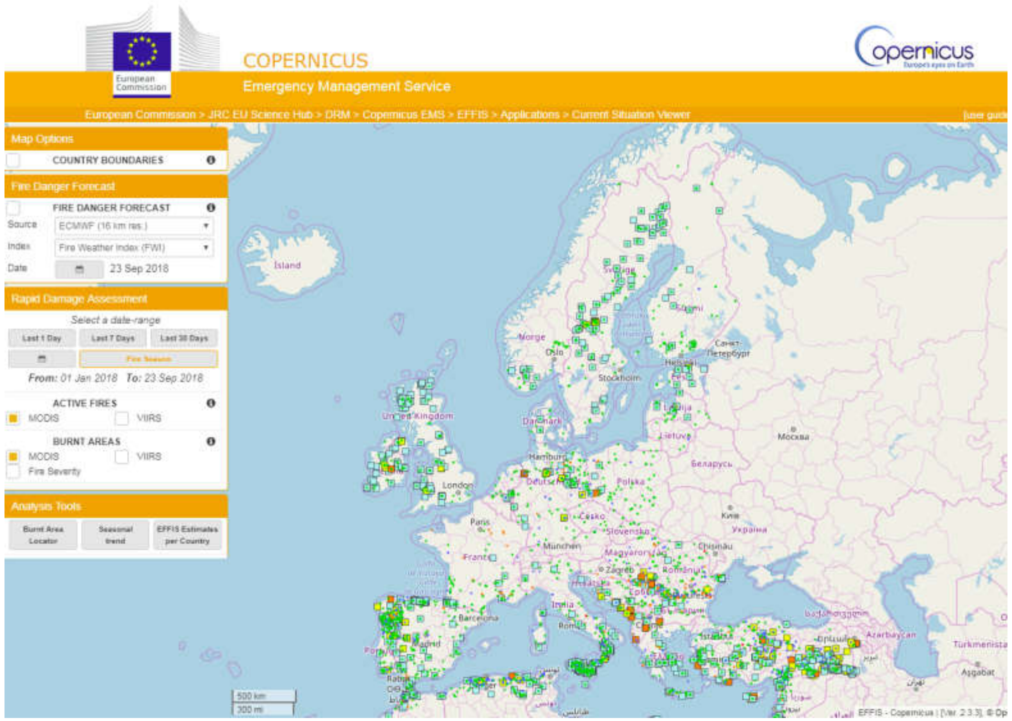
Abiotic risk - Change in fire regimes (2)

<u>Climate change affects on fire risk</u>

- Air humidity, temperature, precipitation & wind speed all change towards higher risks
- Drought = dry fuel + more flammable biomass
- Thunderstorms with more lightnings (ignition)
- Fast fire spread under extreme temperature & locally very strong wind
- Forest fire risk increases in all of Europe – not only in summer

➢ **Strongly enhanced risk of mega fires**

Copernicus Forest Fire Data 2018

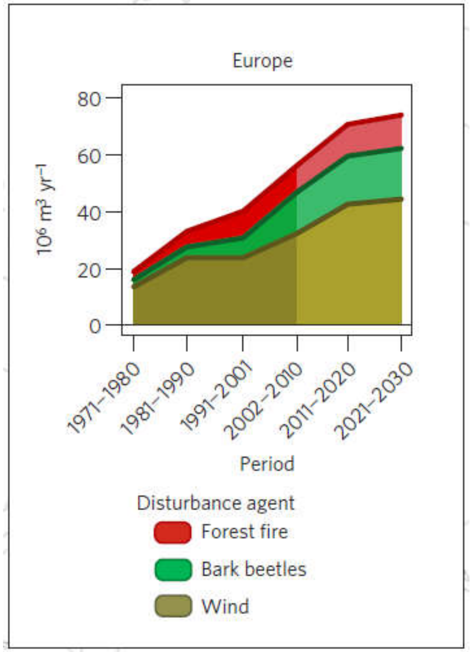


Climate Change and natural disturbance dynamics (3)

- Climate change does not increase frequency of storms, but intensive storms get more severe
- Drastic increase in bark beetle damages challenges sustainable forest management in Central Europe

Foto:Heli Peltola

Borkenkäferschäden in Polen
(Foto Agata Konczal)



Seidel et al. 2014

What we know (or not yet know) about climate change and European forests

- Even if we manage to keep the Paris 2015 targets, we will face significant climate change affecting
  European forests


Journal of Environmental Management 146 (2014) 69–83

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Review

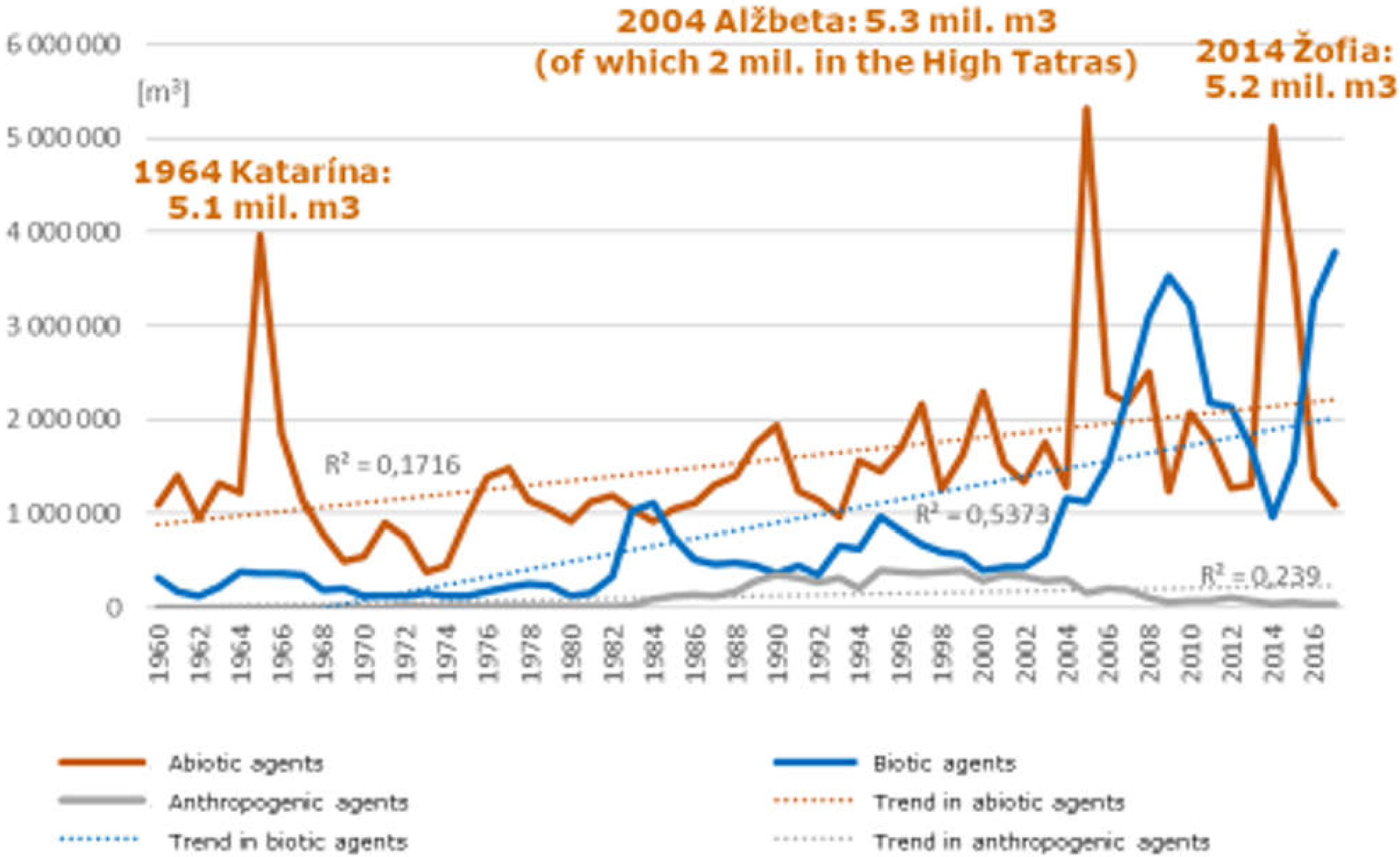
Climate change and European forests: What do we know, what are the uncertainties, and what are the implications for forest management?

Marcus Lindner[a], Joanne B. Fitzgerald[a,*], Niklaus E. Zimmermann[b], Christopher Reyer[c,d], Sylvain Delzon[e,f], Ernst van der Maaten[g,h], Mart-Jan Schelhaas[i], Petra Lasch[c], Jeannette Eggers[a,j], Marieke van der Maaten-Theunissen[g,h], Felicitas Suckow[c], Achilleas Psomas[b], Benjamin Poulter[b,k], Marc Hanewinkel[b,l]

Salvage Felling in Slovakia: disturbance agents drive most cuttings

- Cumulative amounts of salvage fellings across all damaging agents exceeded 50% of all recorded fellings since 2005
- Over the decade 2008-2017, share of salvage fellings in total harvest was on average 54.7% (all species) and 77.2% (coniferous species).

Source: National Forest Centre; Forest Protection Service, 2018



Can we enhance resilience of European forests?

SURE

SUstaining and Enhancing REsilience of European Forests

Building capacity to better cope with forest disturbance risks – Towards a European Forest Risk Facility

EFI

sure.efi.int

Managing forest disturbance impacts and building forest resilience

- Experience with managing large devastating disturbances mostly exists locally
  - ➢Most forest managers experience only one such disaster in their professional life
  - ➢We need to learn from others, who went through similar experiences elsewhere
- Supressing disturbances and trying to controll them has proven insufficient
- **Preventing disturbances** and **increasing forest resilience** are now moving into focus as more effective strategies in disturbance risk management

Moving from technological fixes to enhancing resilience

- Disturbance risk management was dominated in recent decades by
  - Wish to undo the disturbance impact (restoration to pre-disturbance condition as fast as possible),
  - Supression (e.g. removing wildfire from the landscape),
  - Technical support (Sending airplanes to fight fires across Europe)
- Ever more extreme wildfires and uncontrollable bark beetle outbreaks proof that technical fixes fail under climate change and changing land use patterns
- Active land use and targeted pro-active management to enhance forest resilience are promising alternative approaches
- Management can minimize disturbance risks, but natural disturbance dynamics need to be understood to enhance forest resilience

Need for and Vision for a European Forest Risk Facility

The challenges from increased disturbance risks - amplified by climate change - can only be successfully addressed through **increased trans-national collaboration** and support, **capacity building** and **knowledge transfer**,

- leading to better informed decision making in a holistic forest disturbance risk management with **strong emphasis on prevention and preparedness**.

Vision

To enhance the **resilience** and **adaptive capacity** of European forest landscapes by promoting intelligent handling of natural disturbance related **risks as an integral part of sustainable forest management**.

European Forest Risk Facility initiative

- Platform of exchange and knowledge transfer on forest disturbances, risk prevention and management.
- Connecting science, practice and policy.
- Supports disturbance risk management systems built upon ***mitigation*** and ***resilience***.

European Forest Risk Facility

Collect - Connect - Exchange

SURE - Implementing the European Forest Risk Facility Vision

- Defining forest resilience
- Targeted training how to better deal with risks in SFM
- Exchange of experts
- Communication on forest disturbance risks
- Practical science-based decision support


Exit Survey »

Questions marked with an * are required

44%

FRISK-GO Expert Assessment

Observations across Europe show that forest disturbance regimes have intensified in the last decades. Policy and science have recognized the need for action towards mainstreaming forest disturbance risks as an integral part of sustainable forest management.

This survey is part of a scoping study for a "European Forest Risk Facility" (FRISK-GO). The project targets to define and elaborate the core work pillars of a potential future 'European Forest Risk Facility'.

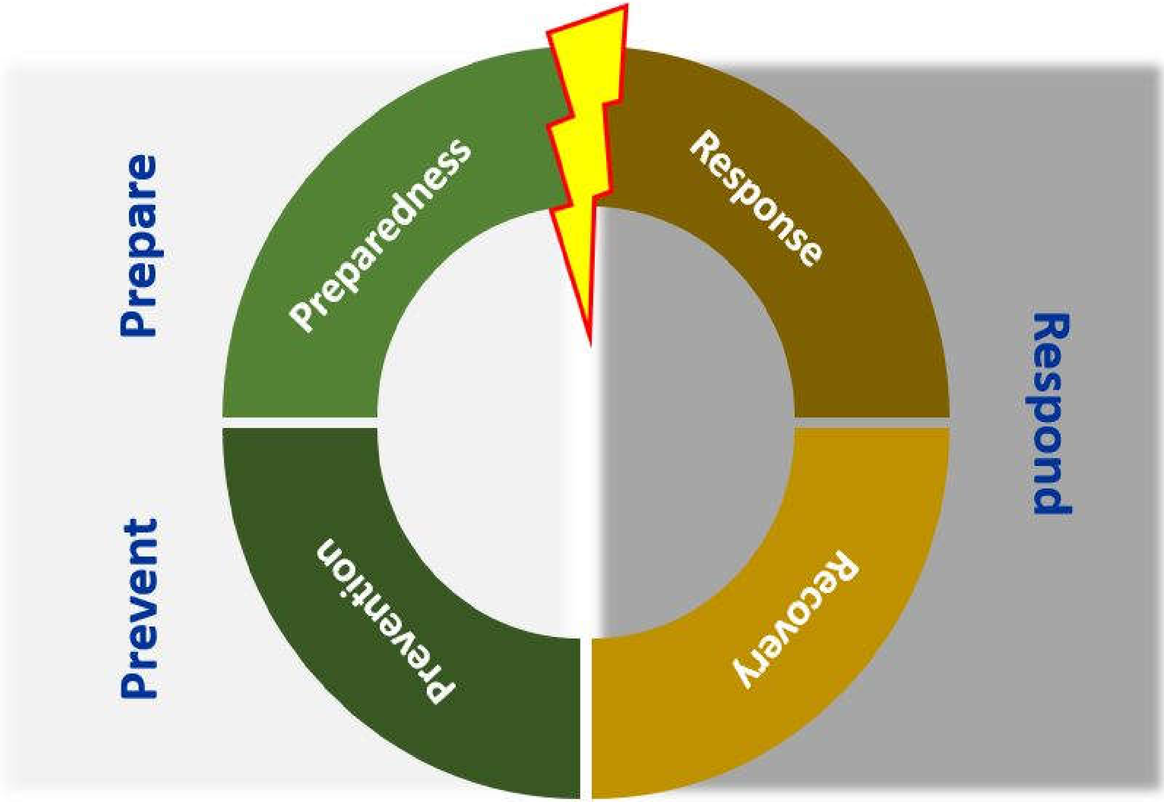
The objective of this survey is to map European experts and expertise on forest disturbances and risk management, and related information needs (and potential gaps thereof).

Thank you for taking part in this survey. We contacted you either because you were referred as an expert by an EFI Associate Member focal point or because you were already invited to one of the FRISK-GO expert workshops.

For more information on the FRISK-GO scoping study, please click here to visit the project website.

SURE Capacity Building Workshops

- Dealing with *Storm Damages*, Freiburg, Germany, 10-12 October 2018
- Pro-active *Wildfire Management*, Wales, UK, 22 November 2019
- Managing *Biotic Risks* - Prague, Czech Republic, 1-3 April 2019



Disaster risk management cycle

SURE risk management workshops (1-2 days)

Series of workshops to elaborate risk management best practices in all four phases of the disaster risk management cycle:

- Prevention
- Preparedness
- Intervention / Response
- Restoration / Recovery

Applied to three levels

- Forest stand level
- Forest Enterprise level
- Society / Policy level

With the combination of phases and levels a 12-chapter "risk management compendium" will be developed to provide a tool box for each phase and level of forest risk management.

- Target audience: 30-40 participants from practice, policy and research

Exchange of Experts & Rapid Response

Example Belarus 2018:

- Exchange of Experts “EoE Forest”: Belarus-Germany-France-Basque Country

  Topics: Storm, Disturbance and Forest Resilience Management (15-21 April 2018)

➢The network can react on short notice!

Possible adaptation strategies in forest management

(Examples, very context dependent)

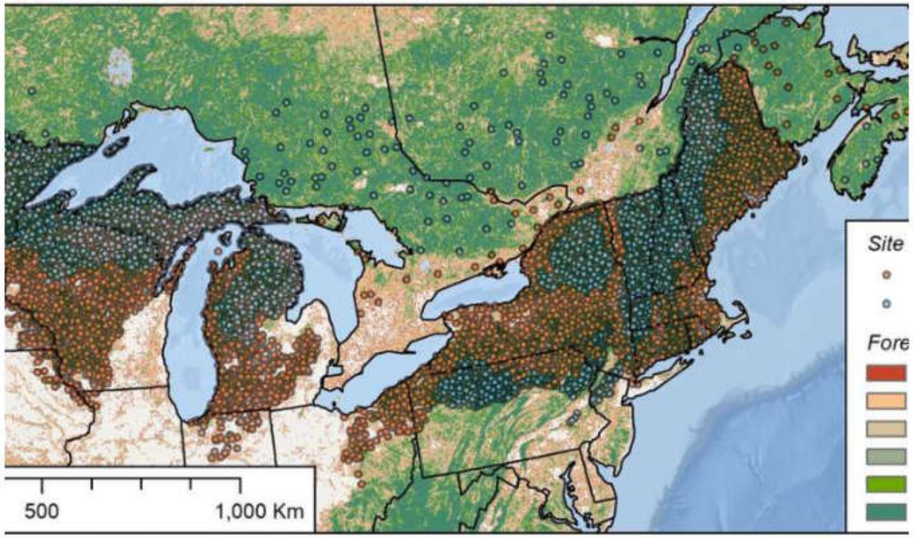
- Shorter rotation periods
- More diversity (species, mixtures, structures, genetics…)
- Selecting climate-adapted proveniences and species
- Improving site water balance (e.g. thinning to mitigate drought stress, favour species with higher water infiltration rate)
- Reduce amount of flammable biomasse (”fire smart landscapes”)
- Many more strategies...

(Kolström et al. 2011; Forests 2, 961-982)

JUNE 7, 2019

Older forests resist change—climate change, that is

by University of Vermont



Analyzing large amounts of field data from 18,500 forest plots - from Minnesota…

Older forests in eastern North America are less vulnerable to climate change than younger forests—particularly for carbon storage, timber production, and biodiversity—new University of Vermont research finds.

Thom, D. *et al. 2019. The climate sensitivity of carbon, timber, and species richness covaries with forest age in boreal–temperate North America. Global Change Biology,* ***25 (7), 2446-2458.***

Older forests more resilient than young ones?

Inventoried older forests were more structurally complex, with trees growing at multiple heights and larger canopy gaps, which free up growing space and increasing light availability for a mix of species.

- Increased structural complexity and higher species diversity leads to increased resilience
- Lessons for adaptive forest management

Conclusions (1): How to enhance forest resilience?

Forest management needs a strong evidence base:

- Data on past and future climate variability, extreme events and disturbance regimes
- Understanding of changing species suitability and evolving disturbance risks
- Assessment of current and future forest resilience and how this can be enhanced with targeted management practices
- Knowledge on adaptation strategies tailored to the local forest conditions

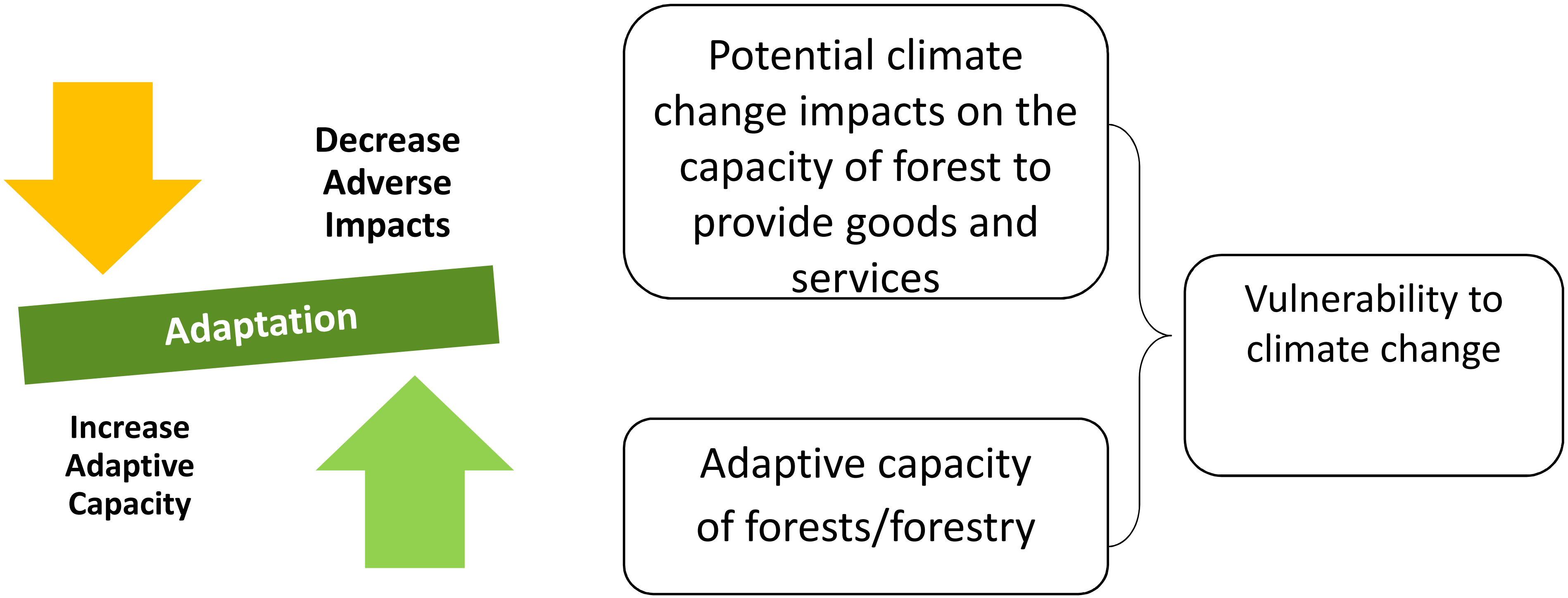
The implementation of climate change adaptation lacks sufficient 'climate intelligence' in forest management decision making processes

Rodney Keenan (2015). Climate change impacts and adaptation in forest management: a review. Annals of Forest Science, 72, 145-167.

Conclusions (2): How to enhance the evidence base in forest management decision making?

- Simulate forest relevant bio-climatic variables (drought stress, late frost, etc.)
- Consider relevant forest disturbances (wildfire, storm, insects & pathogenes, browsing, …)
- Account for genetic diversity and adaptation (proveniences and adaptive processes)
- Adapting forest management to prevent main disturbances (landscape level important)
- Simulate resilience indicators and decision making of key actors (forest owners, societal demands/pressures, e.g. between nature conservation and forestry)

Adaptation for reduced CC vulnerability



Adaptive management in practice (decision makers)

- Monitor climate change impact at regional level accurately
- Actively prepare for extreme events
- Adapt policy on genetic material use
- Prepare forest sector to changes in wood supply
- Support all mitigation actions to reduce speed and intensity of changes

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Thank you for the attention!

Contact: Marcus.Lindner@efi.int or
sure@efi.int

EFI-Bonn Resilience Blog : https://resilience-blog.com/

Web: www.efi.int