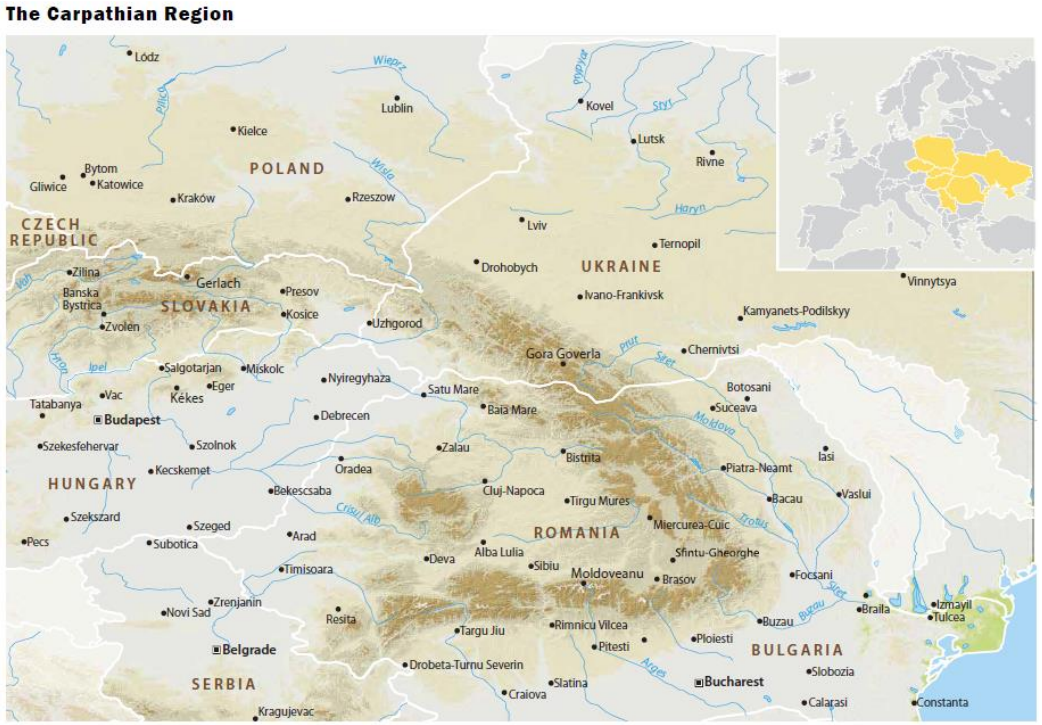
CLIMATE CHANGE IMPACTS AND RISKS ASSESSMENT FOR CARPATHIAN FORESTS

- The Carpathian Convention Conference of the Parties at its 6th meeting (COP6, 2020) encouraged the development of an **assessment of the impacts of climate change on the Carpathian forests and their ecosystems services**

- Included in the Implementation Framework 2030 accompanying the Long-term Vision towards combating climate change in the Carpathians.

- Workplan for the implementation period 2021-2023 of the Working Group on Climate Change sets out concrete activities and expected results with regard to achieving the strategic objectives and related targets

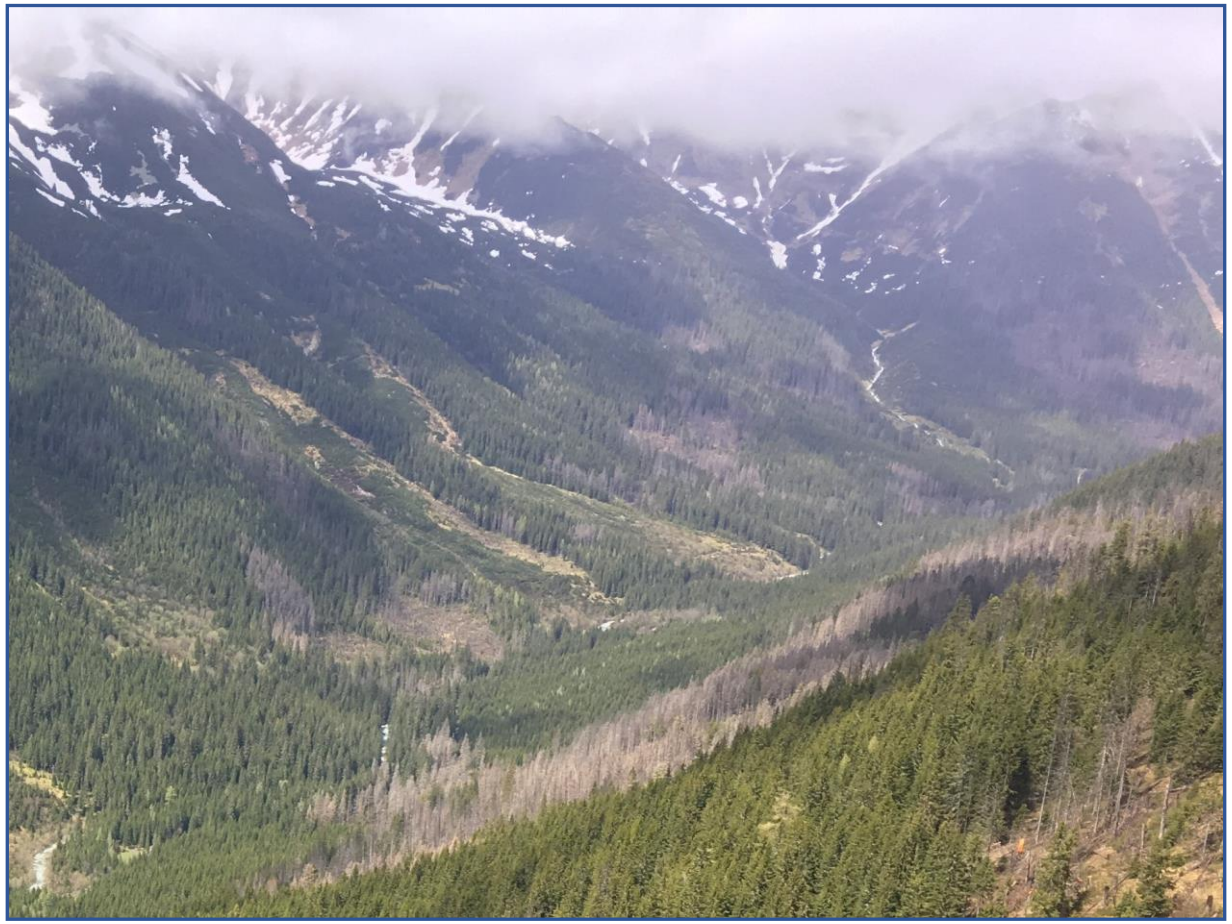


From: Werners et al. 2014. Future imperfect: climate change and adaptation in the Carpathians

Guiding assumptions:

- The assessment will not “reinvent the wheel” → It is a synthesis of existing knowledge
- Utilize previous assessments at the European and national scales → Up-scale and down-scale to produce a regional scale assessment applicable to the Carpathians
- Gather input for the assessment through participatory workshops, surveys, and stakeholder forums
- Focused on vulnerabilities and adaptation, not mitigation or “natural climate solutions”

ASSESSMENT APPROACH



An uncleared primary forest landscape, shaped by centuries of compounded natural disturbances. Koprova Valley, Slovak Republic, High Tatras Mtns. Photo credit: W.S. Keeton

1. Workshop at the Forum Carpaticum June 2021
2. Information gathering workshop for “focal points” (national level representatives and stakeholders) – November 2021
3. Survey sent to national level representatives – January 2022
4. Interviews with key academic research groups throughout Europe – Spring 2022
5. Review of previous assessments at European, regional, and national scales – Spring 2022
6. Synthesis of survey responses by theme or topic – August – Sept. 2022
7. Development of assessment report based on stakeholder input and synthesis of research, focused on the key topics identified through workshops and surveys

WORKSHOP ON FOREST ECOSYSTEM VULNERABILITIES TO CLIMATE CHARGE IN THE CARPATHIAN MOUNTAIN REGION – FORUM CARPATICUM 2021

Recommendations

- Support the on-going assessment by the Carpathian Convention Secretariat of the risks and impacts of climate change to forest ecosystems in the Carpathian region. Synthesize and review existing information, addressing goals identified by regional experts and stakeholders.
- Downscale from European-scale assessments and up-scale/aggregate from national-scale assessment.
- Enhance resilience to increasing forest disturbances (e.g. fire, wind, insects and pathogens, and drought)
- Develop adaptation responses to climate impacts on forest growth and productivity
- Anticipate future changes in dead wood dynamics (recruitment and loading; differences between managed and unmanaged stands; relationships with insect and other mortality agents, etc.) in Carpathian forests
- Anticipate changing/reduced carbon uptake and storage dynamics, development adaptive carbon forestry techniques accordingly
- Enhance ecosystem resilience to shifts in species ranges and abundance; expand geophysical representation within the region's protected areas network. Manage for high beta diversity in habitats, stand ages and structural conditions, and seral stages at landscape scales.
- Anticipate shifts in habitats and plant species composition and resulting impacts on flagship species (esp. large carnivores)
- Expand the use of retention forestry practices and close-to-nature forest management. Move away from salvage logging in beetle and windthrow areas as appropriate.
- There is a need for landscape diversification to enhance resilience to disturbances
- Reduce vulnerabilities to the increase in forest fires, for example through stand density management, use fire-resistance species in tree planting, and creation of fuel breaks

Key questions in survey derived from discussion at the expert ("focal point") workshop held in November 2021:

1. **Planting and management of exotic species as adaptation**. Should use of exotic, non-European species comprise an element of adaptative management? Where, when, and how?
2. **Role of landscape level planning, including a diversity of forest zonation and management strategies.** What is your view on the role of protected areas vs. active adaptive management?
3. **Expanded use of "close-to-nature" silviculture (e.g. selection harvesting, continuous cover forestry, retention forestry, etc.).** How is the forest sector in your country considering broadening its portfolio of forest management practices to adapt to climate change, including altered disturbance regimes?
4. **Forest road density, design, and location.** How should we manage the forest road system to reduce vulnerabilities to flooding?
5. **Forests and water.** What are other important linkages between adaptive forest management and water with which you are particularly concerned?
6. **Long-term adaptive forest management objectives**. Should we manage for the historic, current, or future potential vegetation? How is the forest sector in your country approaching these challenging questions?
7. **Public policy, perception, and science**. What are the greatest challenges you face relating to formulating adaptation approaches, given the interplay between public perception and public policy that may or may not always be consistent with the science?
8. **Forest harvest rotations.** Is the forest sector in your country considering reducing or increasing forest harvest rotations? Why or why not?
9. **Adaptation to altered natural disturbance regimes.** How is the forest sector in your country adapting to increasing risks of bark beetles, wind, fire, and drought?
10. **Mix of old vs. younger forest stands.** How is the forest sector in your country adjusting the mix of forest ages as adaption to disturbance risk, for the purpose of carbon management, or to conserve biodiversity in the face of climate change?

Survey Questionnaire

National level focal experts asked about climate risks, impacts, and adaptation responses regarding:

- Forest growth and productivity
- Biomass and carbon stocks
- Tree Mortality
- Biodiversity: species ranges and abundances
- Invasive species
- Ecosystem services
- Forest – water interactions
- Cross-cutting adaptation themes

ASSESSMENT OF CLIMATE CHANGE RISKS AND IMPACTS ON CARPATHIAN FOREST ECOSYSTEMS AND THEIR SERVICES

SURVEY

INTRODUCTION

The Carpathian Convention Conference of the Parties at its 6th meeting (COP6, 2020) through its decisions[1] encouraged the development of an **assessment of the impacts of climate change on the Carpathian forests and their ecosystems services** by relevant Convention Working Groups and partners and with support of the Convention Secretariat. Subsequently, this activity has been included in the Implementation Framework 2030 accompanying the Long-term Vision towards combating climate change in the Carpathians.

This survey aims to gather information for developing the **assessment of climate change risks and impacts on Carpathian Forest ecosystems and their services** along a draft table of contents (see Annex) that has been presented and agreed at the 1rst Expert Workshop on 16 November 2021 (online).

There are **4 sections** of the survey:

A: CONTACT and CONTRIBUTORS
B: KNOWLEDGE BASE on CLIMATE CHANGE RISKS and IMPACTS on CARPATHIAN FOREST ECOSYSTEMS and their services
C: PRACTICAL EXAMPLES / CASE STUDIES
D: REFERENCES

The Secretariat of the Carpathian Convention together with Dr. William Keeton, University of Vermont and Member of the Science for the Carpathians, highly appreciates your willingness to contribute to assessment by sharing your insights and expertise through this survey. We would also encourage you to consult with national colleagues for further contributions.

Please return the filled in survey until **28.01.2022**. Many thanks in advance for your valuable inputs!

Ranked Summary of Responses to 4 of 7 Topics

Forest Growth and Productivity

SYNTHESIS	Primary Risks Identified	Convergence/Divergence of Views Regarding Impacts
First Rank	Drought and forest disturbances	Consensus that forest productivity will decline due to this risk
Second Rank	Temperature increase and variability	Variable effects on forest productivity depending on elevation, forest type, and interaction with other factors such as nitorgen deposition and CO2 fertilization
Third Rank/Other	No consensus on tertiary risks; each country cites its own concerns, including altered phenology, salvage logging, and erosion	General consensus that tertiatry risks will reduce forest productivity

Biomass and Carbon Stocks

SYNTHESIS	Primary Risks Identified	Convergence/Divergence of Views Regarding Impacts
First Rank	Drought and reduced precipitation	Consensus that impact will be reduction in carbon stocks
Second Rank	Disturbances including fire, bark beetles, and insects	Consensus that impact will be reduction in carbon stocks
Third Rank or Other	Forest aging: pro and con views	Responses express the view that older forests and a growing proportion of older stands will store less carbon. This is not in agreement with the science and will be an important issue to address in a balanced manner.

Tree Mortality

SYNTHESIS	Primary Risks Identified	Convergence/Divergence of Views Regarding Impacts
First Rank	Disturbances	Consensus on increased morality and dieback from insects, pathogens, and wind
Second Rank	Drought	Consensus on increased mortality, interaction with insects and pathogens
Third Rank or Other	Altered water balance and site suitability for particular species	No clear tertiary theme. Some mention of water balance and general declines in site suitabilities

Hydrology and Forest-Water Interactions

SYNTHESIS	Primary Risks Identified	Convergence/Divergence of Views Regarding Impacts
First Rank	Increased flood frequency and intensity	Destructive flood impacts, loss of hydrologic regulation, increased peak flows, hazards to infrastructure
Second Rank	Increased drought frequency and intensity	Declines in forest vitality and productivity. Biodiversity impacts. Loss of drinking water. Increased insects and pathogens vulnerability
Third Rank	Disturbances, land consersion, forest decline	Accerbation of risks releated to flooding and loss of hydrologic regulation capacity, including erosion and evapotranspiration

Meta-Synthesis of Survey Responses

Key for Synthesis		
	Top rated, most frequent mention	
	Second rated, next most frequently	
	Third rated, intermediate mention	
OVERALL SYNTHESIS	**Primary Risks Identified**	**Convergence/Divergence of Views Regarding Impacts**
	Drought	Forest decline, dieback, and reduced productvity. Shift in species distributions, exacerbation of insect and fire risks, and diminished ecosystem services
	Disturbances	Reduced carbon storage and climate regulation. Accelerated shifts in species distributions. Accelerated spread of invasive species
	Flooding, invasive species, land use pressure	Interations across a range of ecosystem services and habitat provisioning, including carbon sequestration, hyrdologic regulation, and wood production as well as biodiversity
ADAPTATION SYNTHESIS	**Theme**	**Convergence/Divergence of Views Regarding Impacts**
	Forest restoration	High agreement on need for restoration and regeneration practices
	Sustainable management include close to nature and continuous cover	High agreement on need for broader use of sustainable forest management practices including ecological silviculture
	Landscape heterogeneity to increase resilience to disturbance	High agree on need to address altered disturbance regimes and invasive species

Key Climate Vulnerability Issues Emphasized in Previous Assessments and Peer-Reviewed Literature

1. Effects on natural disturbance regimes
   - Abiotic (wind, fire, floods, drought)
   - Biotic (insects, pathogens)
   - Interactions (acceleration of change)
2. Biodiversity
3. Forest composition and species ranges
4. Forest growth
5. Ecosystem services including carbon storage
6. Attitudes and governance: adaptation capacity

The mid-term review of the EU Biodiversity Strategy to 2020 presents trends in the major pressures on Europe's forest ecosystems.

Climate change: Low impact but rapidly increasing

- E.g. Fires, storms, drought and increasing range of pests.
- Changes in temperature
- Changes in rainfall and soil moisture

Habitat change: High impact but decreasing

- Forest cover change
- Tree loss
- Forest fragmentation

Invasive species: Moderate impact, continuing

- Introduction of invasive, alien species

Over-exploitation: Moderate impact, continuing

- Land use changes that encroach on forest land
- Reduced forest area
- Ratio of fellings to increment

Pollution and nutrient enrichment: Moderate impact, increasing

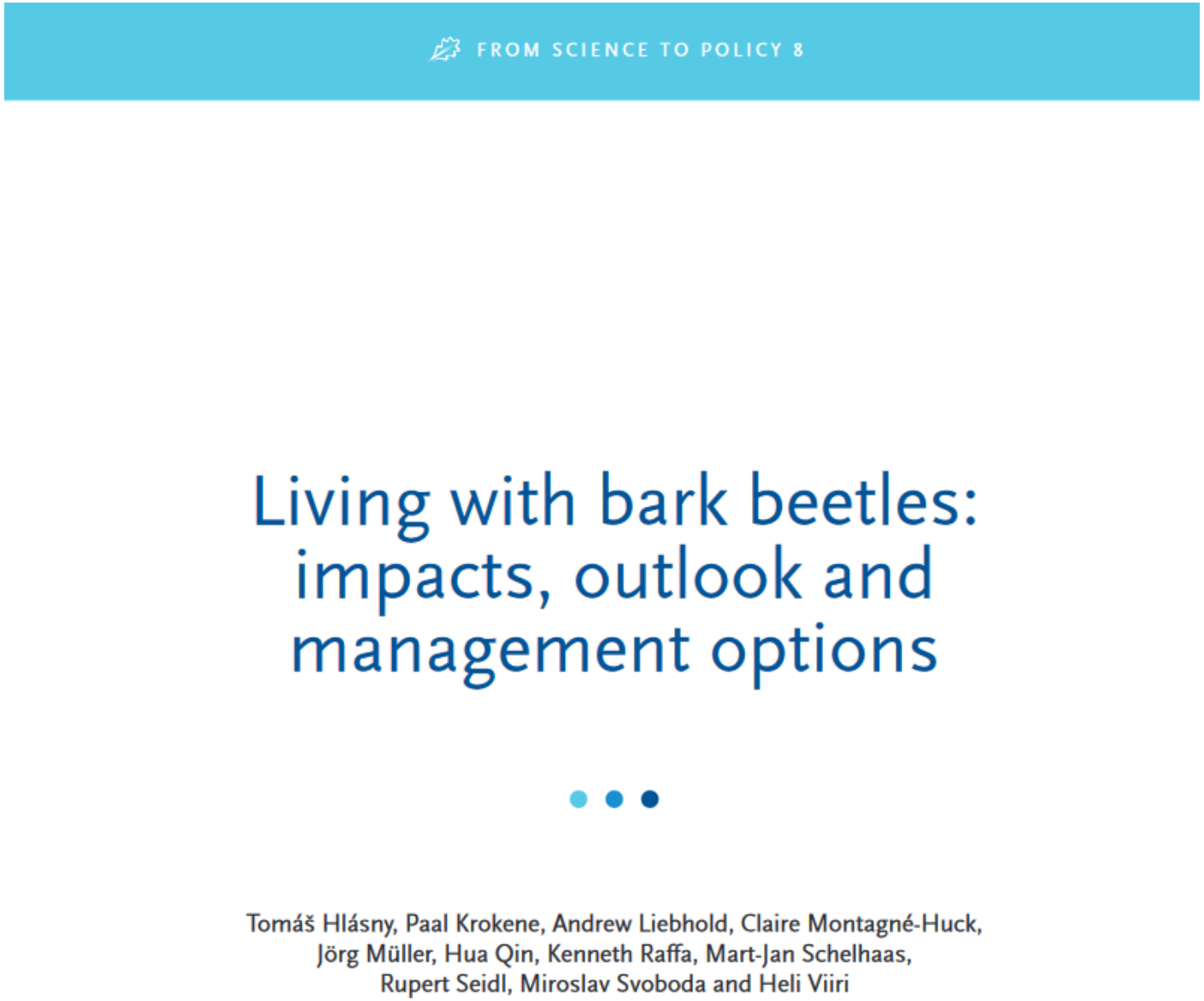
- Acidification
- Eutrophication
- Tropospheric ozone (smog)

(EEA/EC, n.d.)

From: Science for Environment Policy (2021) *European Forests for biodiversity, climate change mitigation and adaptation.* Future Brief 25. Brief produced for the European Commission

Bark beetle risks top the list of Web of Science “hits” in published research

→ Interactions with drought
→ Forest attributes creating both risk and resilience
→ Growing understanding of climate niches that increase both vulnerability of host trees and optimal pest reproductive success



There is increasing concern within the science of forest fire risks and their shifting spatial distribution

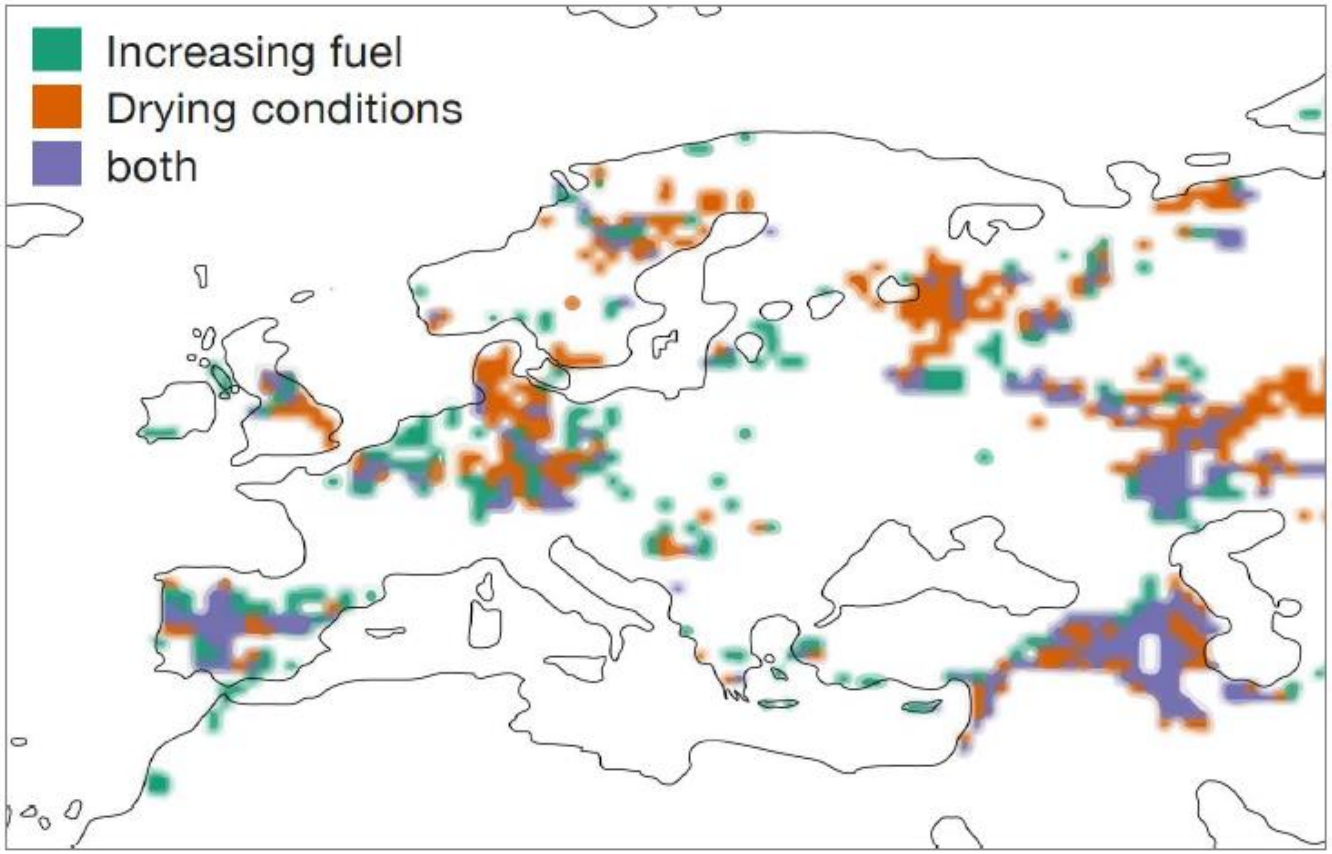


Figure 2: Areas with increases in burnt area due to changing fuel and/or moisture, 2001-2014 (Source: Kelley et al. 2019[2], GRID-Arendal/Studio Atlantis, 2021[1])

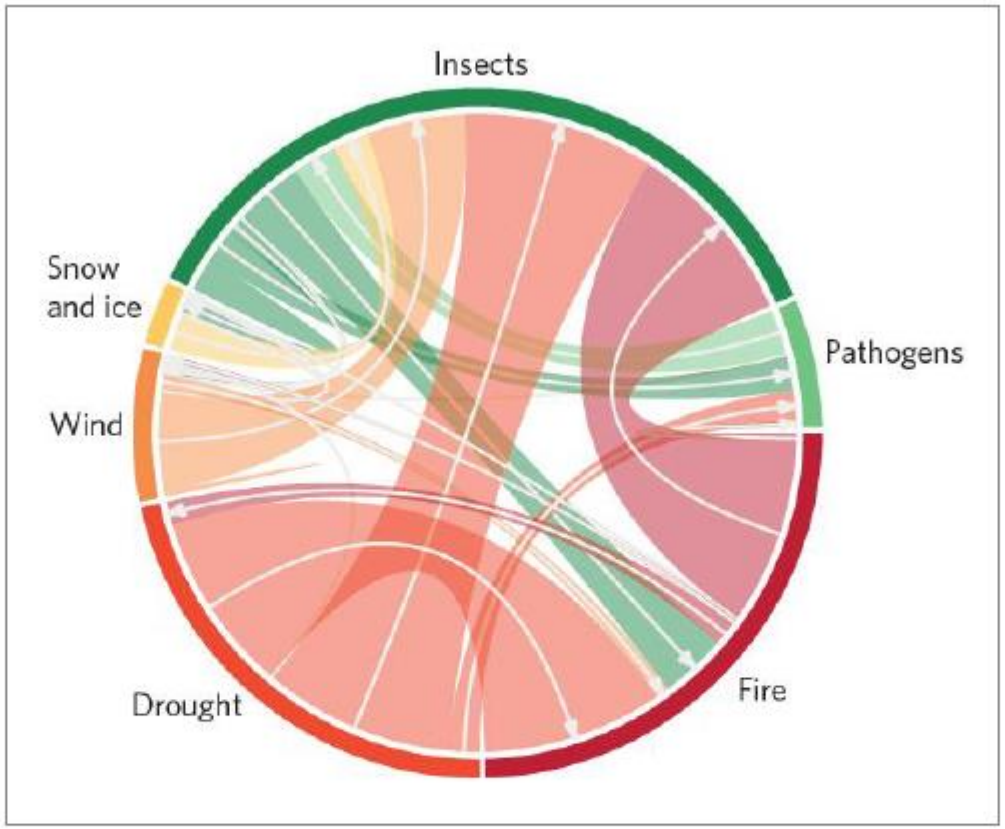


Figure 3: The sector size in the outer circle indicates the distribution of interactions over agents, while the flows through the centre of the circle illustrate the relative importance of interactions between individual agents (as measured by the number of observations reporting on the respective interaction). Arrows point from the influencing agent to the agent being influenced by the interaction. (Source: Seidl et. Al 2017[3])

Cutting-edge scientific research focuses on the effects of climate change on interactions among disturbance agents

Will these accelerate forest change?

Will these increase or decrease forest resilience?

Received: 12 August 2016 | Revised: 6 February 2017 | Accepted: 6 April 2017

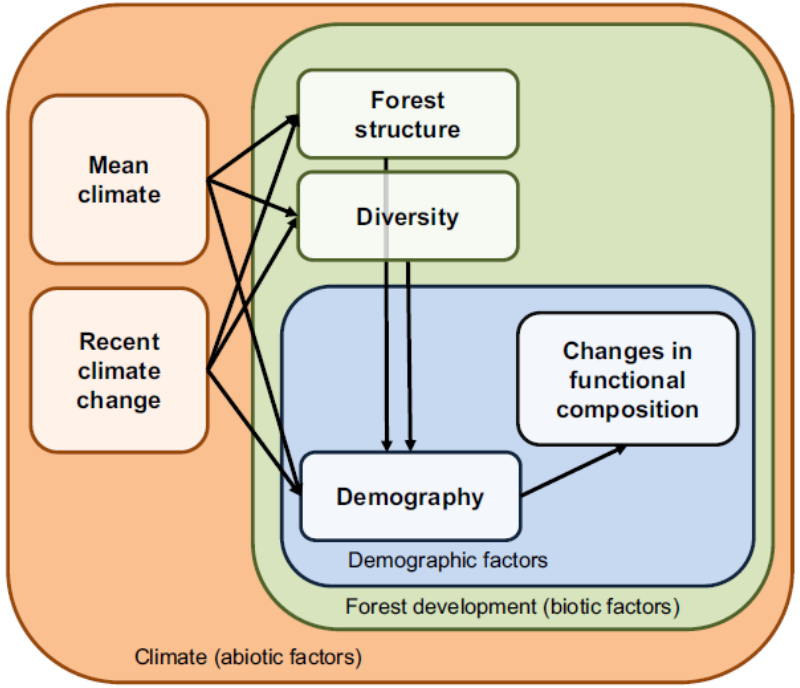
DOI: 10.1111/gcb.13728

PRIMARY RESEARCH ARTICLE

WILEY Global Change Biology

Climate- and successional-related changes in functional composition of European forests are strongly driven by tree mortality

Paloma Ruiz-Benito[1,2] | Sophia Ratcliffe[3] | Miguel A. Zavala[2] | Jordi Martínez-Vilalta[4,5] | Albert Vilà-Cabrera[6] | Francisco Lloret[4,5] | Jaime Madrigal-González[2] | Christian Wirth[3,7] | Sarah Greenwood[1] | Gerald Kändler[8] | Aleksi Lehtonen[9] | Jens Kattge[7,10] | Jonas Dahlgren[11] | Alistair S. Jump[1,4]



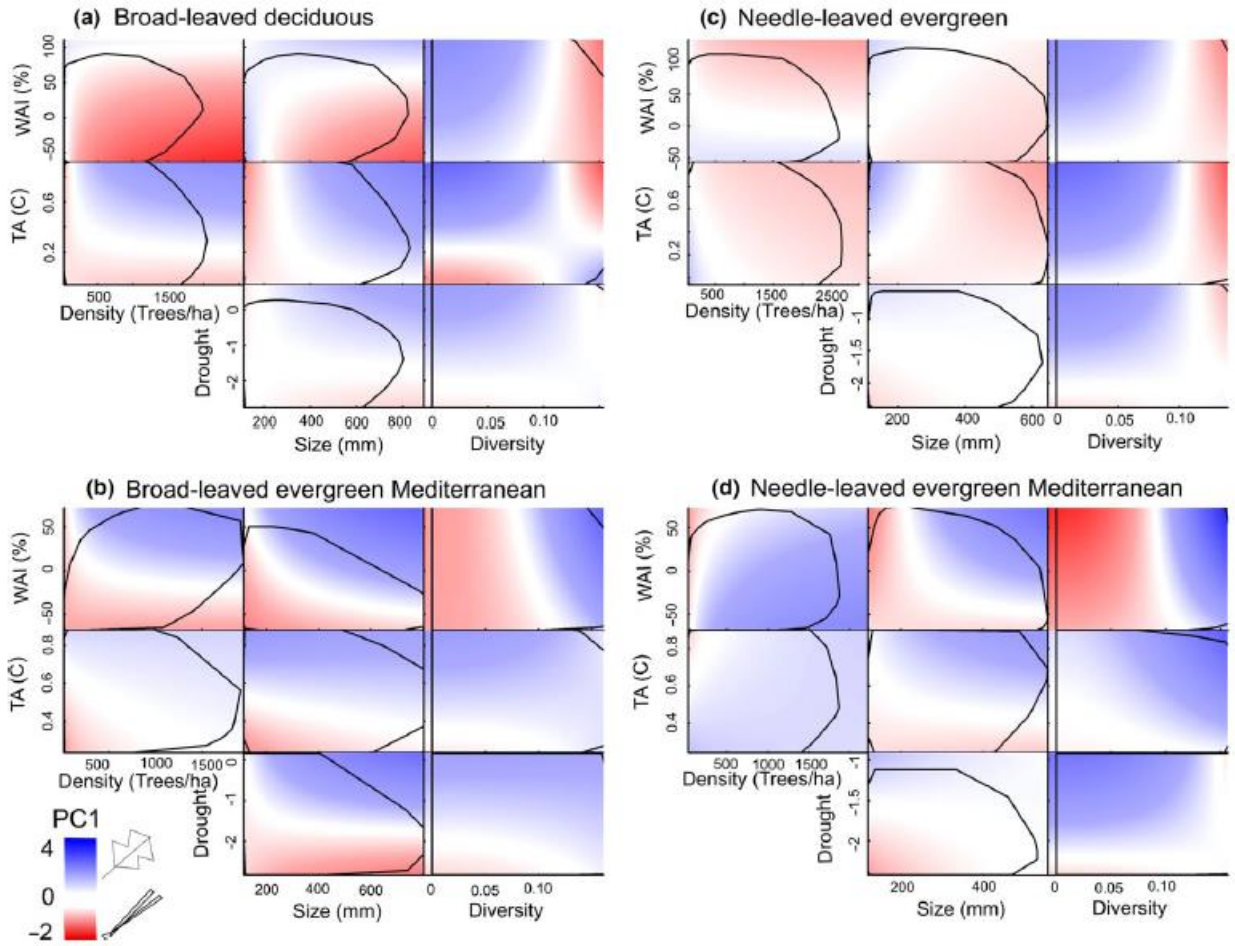


FIGURE 3 Interactive effects of climatic and structural variables on the first axis of the PCA (PC1) in each forest type studied: (a) broad-leaved deciduous, (b) broad-leaved evergreen, (c) needle-leaved evergreen and (d) needle-leaved evergreen Mediterranean forests. Blue colour represents positive values in the PC1 indicating changes towards lower LMA and higher WD, while red colour represents changes towards lower WD and higher LMA. The variables vary between the observed 99% percentiles in each forest type. Convex hull lines covering the presence of data points in each panel are represented using black lines, and density plots are shown in Fig. S8. Climatic and structural variables include water availability (WAI, %), temperature anomaly (TA, °C), drought intensity (drought, more negative values of SPEI mean more intense droughts, adimensional), tree density (Density, no. of trees/ha), mean tree diameter (size, mm) and functional diversity (Diversity, adimensional)

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Research article

Harnessing landscape heterogeneity for managing future disturbance risks in forest ecosystems

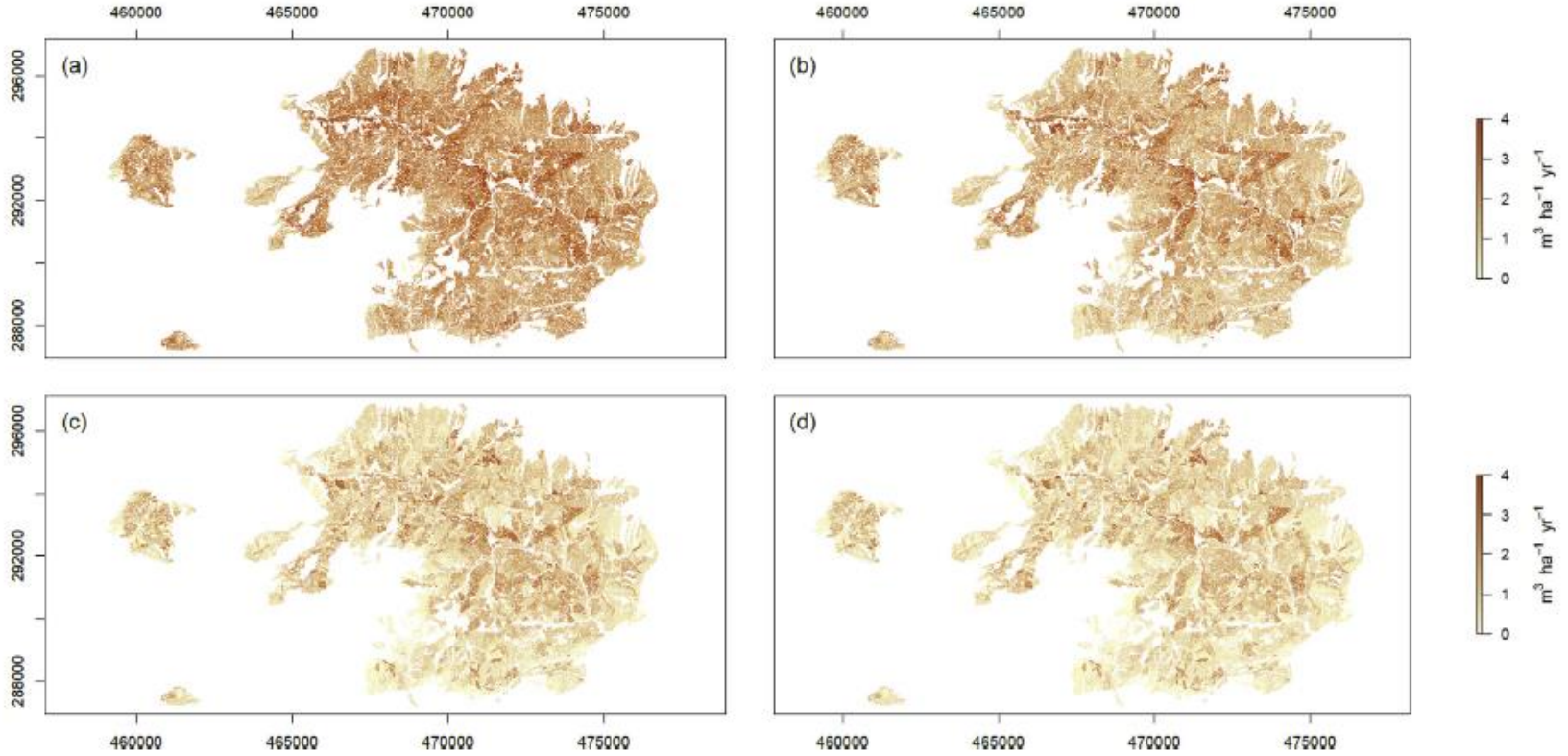


Fig. 3. Disturbance risk under future climate, expressed as the average amount of timber affected by wind and European spruce bark beetle per hectare and year over a 200 year simulation period. (a) Norway-spruce focused forest management (PA). (b)–(d) risk management strategies RM1-RM3, focusing on increasing the level of mixed and deciduous forests, and increasing the management intensity (see Table 1 for details). Shown is the stand-level mean over six different climate scenarios and 20 replicated simulations per scenario.

Learning from natural dynamics:

To limit disturbance risk and spread, restore landscape heterogeneity

Forest Europe is conducting a pan-European forest risk assessment

Sub-Groups:

(1) Abiotic forest damages;
The focus will be on wildfires, storms and droughts.

(2) Biotic forest damages;
The focus will be on focus on insects, further pests and diseases as well as ungulates.

(3) Forest adaptation;
The focus will be on forest damage prevention and long-term restoration.

Like much of the current academic research, the emphasis is on natural disturbance risks and benefits

Pilot phase #1 “Wildfire” (9/2022 - 2/2023) .....

Pilot phase #2 “Pests & diseases” (3/2022 - 8/2023).....

Pilot phase #3 “Storms” (9/2023 - 2/2024) .....

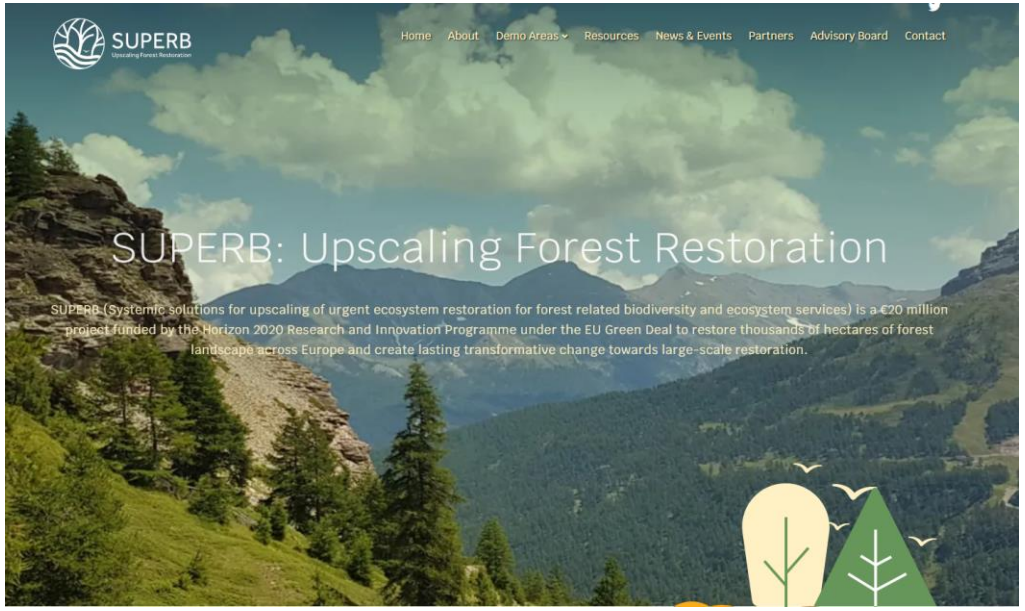
Pilot phase - forest risk interrelations (9/2022 - 2/2024) ..

Preliminary conclusions based on the Climate Change Impacts and Risks Assessment for Carpathian Forests

1. Climate change effects on disturbances such as fire, wind, insects, and pathogens is of fundamental importance for forest ecosystems and biodiversity

2. Climate change effects on drought and flood frequency and intensity also of great concern

3. Effective adaptation responses are critical:
   e.g.
   - Restore landscape heterogeneity to increase system resilience
   - Adaptive forest management approaches
   - Reforestation and endemic species restoration
   - Anticipating novel ecological communities of the future



Discussion and Feedback

Discussion points:

1. Are the priority concerns identified in the survey similar to yours? What are we missing?

2. Please describe practical examples of adaptation in your respective countries

3. What else you like to see included in the assessment?