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.

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

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

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

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

### Biomass and Carbon Stocks

<table>
<thead>
<tr>
<th>Rank</th>
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<th>Convergence/Divergence of Views Regarding Impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Rank</td>
<td>Disturbances</td>
<td>Consensus on increased mortality and dieback from insects, pathogens, and wind</td>
</tr>
<tr>
<td>Second Rank</td>
<td>Drought</td>
<td>Consensus on increased mortality, interaction with insects and pathogens</td>
</tr>
<tr>
<td>Third or Other</td>
<td>Altered water balance and site suitability for particular species</td>
<td>No clear tertiary theme. Some mention of water balance and general declines in site suitabilities</td>
</tr>
</tbody>
</table>

### Tree Mortality

<table>
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<th>Rank</th>
<th>Primary Risks Identified</th>
<th>Convergence/Divergence of Views Regarding Impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Rank</td>
<td>Increased flood frequency and intensity</td>
<td>Destructive flood impacts, loss of hydrologic regulation, increased peak flows, hazards to infrastructure</td>
</tr>
<tr>
<td>Second Rank</td>
<td>Increased drought frequency and intensity</td>
<td>Declines in forest vitality and productivity. Biodiversity impacts. Loss of drinking water. Increased insects and pathogens vulnerability</td>
</tr>
<tr>
<td>Third or Other</td>
<td>Disturbances, land conversion, forest decline</td>
<td>Acerbation of risks related to flooding and loss of hydrologic regulation capacity, including erosion and evapotranspiration</td>
</tr>
</tbody>
</table>

### Hydrology and Forest-Water Interactions

<table>
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</tr>
</thead>
<tbody>
<tr>
<td>First Rank</td>
<td>Increased flood frequency and intensity</td>
<td>Destructive flood impacts, loss of hydrologic regulation, increased peak flows, hazards to infrastructure</td>
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<tr>
<td>Second Rank</td>
<td>Increased drought frequency and intensity</td>
<td>Declines in forest vitality and productivity. Biodiversity impacts. Loss of drinking water. Increased insects and pathogens vulnerability</td>
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<tr>
<td>Third Rank</td>
<td>Disturbances, land conversion, forest decline</td>
<td>Acerbation of risks related to flooding and loss of hydrologic regulation capacity, including erosion and evapotranspiration</td>
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</table>
Meta-Synthesis of Survey Responses

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

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, GRID-Arendal/Studio Atlantis, 2021)
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?

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 2017³)
Climate- and successional-related changes in functional composition of European forests are strongly driven by tree mortality


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/hal), mean tree diameter (size, mm) and functional diversity (Diversity, adimensional).
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 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?