Assessment of the Impacts of Climate Change on the Carpathian Forests and their Ecosystems Services

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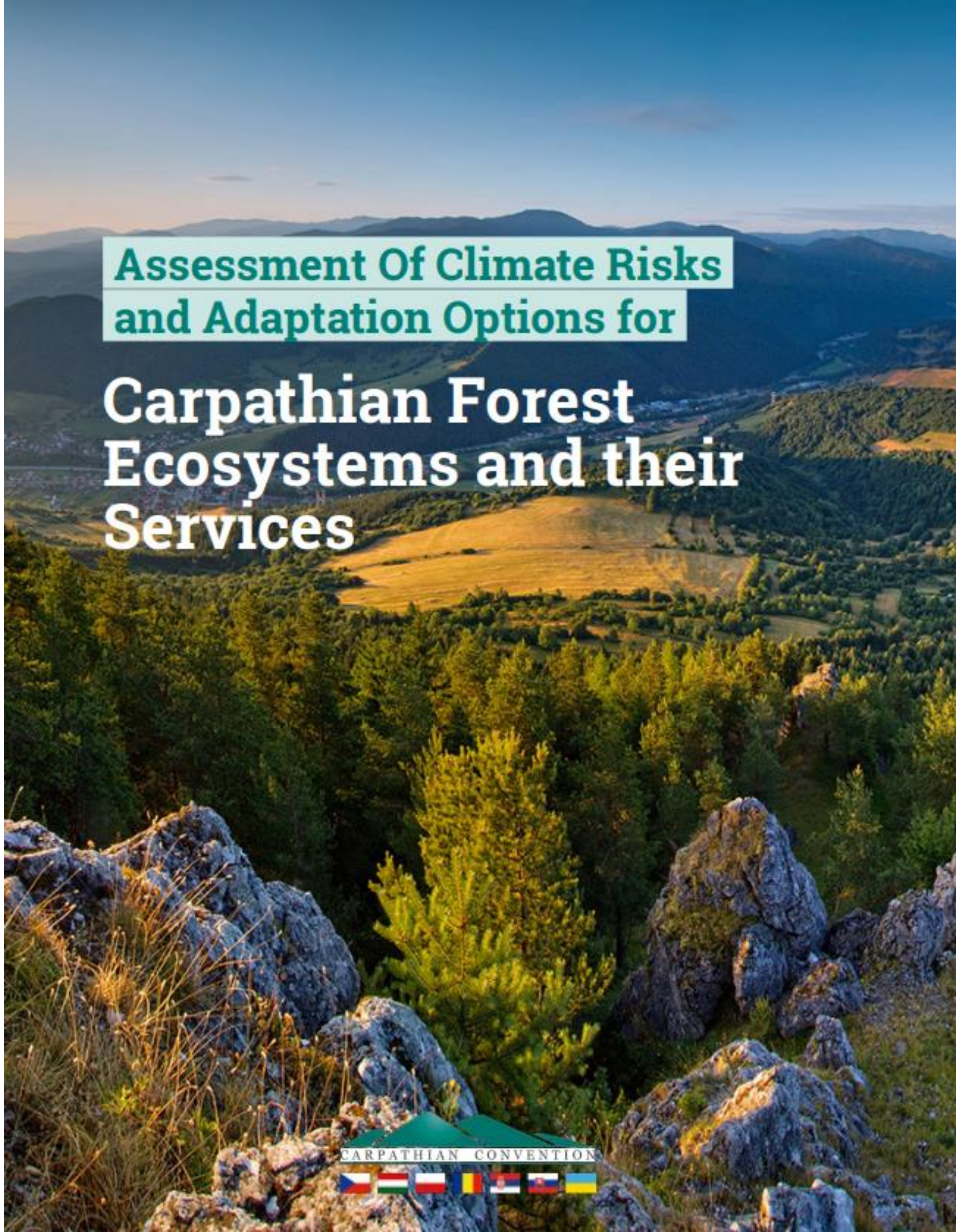
PUBLICATION: Assessment of the Impacts of Climate Change on the Carpathian Forests and their Ecosystems Services

STRATEGIC ACTIVITY OF A SUB-WORKING GROUP: SUSTAINABLE FOREST MANAGEMENT & CLIMATE CHANGE

- *Developed by Dr. William Keeton, Vermont University, and the Secretariat*

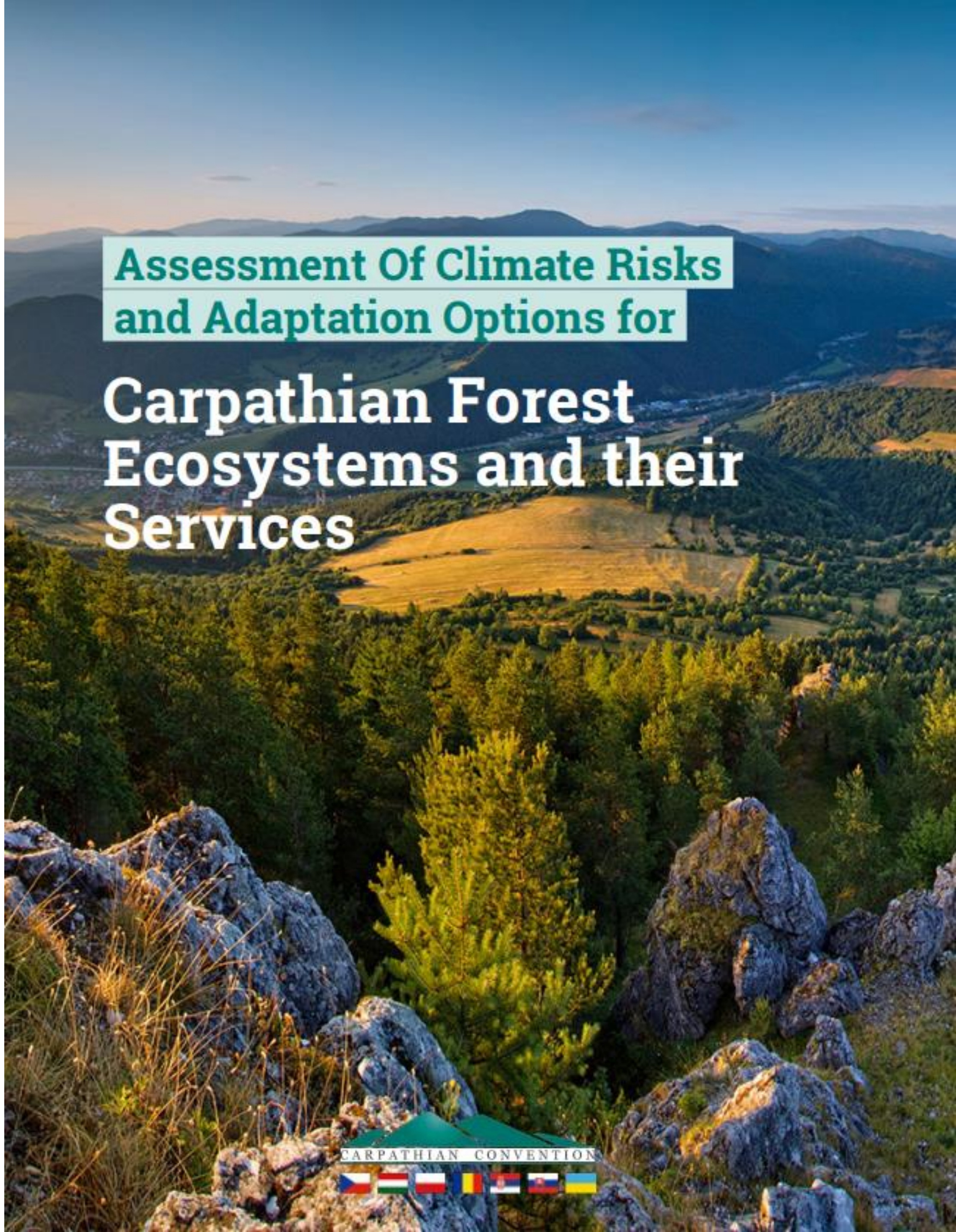
NEED FOR EXPERT INPUT TO THE CARPATHIAN CONVENTION, THUS AIMED TO:

- *Collect information on consequences of climate change on Carpathian forest ecosystems, including environmental, economic and cultural aspects*
- *identify common climate risks and related impacts*
- *share knowledge on effective adaptation responses for long-term conservation*
- *detect restoration needs*
- *propose policy recommendation*



PUBLICATION:
Assessment Scope

- *Forest ecosystems*
- *Forest sector, including forest-based industries and infrastructure*
- *Forest-derived services, including:*
  - *wood products,*
  - *climate regulation,*
  - *biodiversity,*
  - *flood control,*
  - *recreation,*
  - *others*



METHODOLOGY: Online workshops and meetings, survey, literature review, and interviews

- **JUNE 2021:** Online workshop at Forum Carpaticum on forest ecosystem vulnerabilities to climate change in the Carpathians
    - Collected and condensed a list of areas of concern, priority risks and proposed adaptation responses
- **NOVEMBER 2021:** Online expert subgroup meeting, decided on 7 priority topics of concern, or themes to structure the survey around
- **JAN - JULY 2022:** Administered survey to experts on (1) priority risks and (2) adaptation responses according to the 7 priority topics of concern
- **2022 – 2023:** Conducted literature review and processed data
- **OCTOBER 2023:** Assessment adopted at COP7

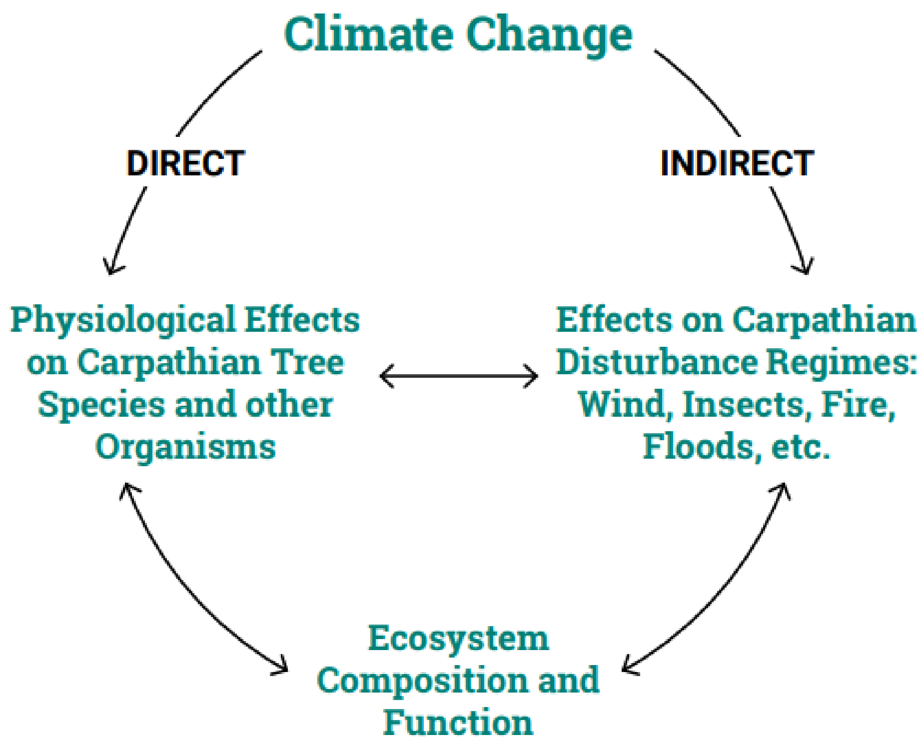


Figure 3. Climate change will affect Carpathian forests through both direct effects on the physiology, reproduction, and behavior of organisms and indirect effects on disturbance regimes that alter the competitive environment and, in some cases, increase exposure to the direct effects of climate change (e.g., temperature, precipitation, etc.). Figure modified from Keeton et al. (2007).

METHODOLOGY: Online workshops and meetings, survey, literature review, and interviews

- **BUILDS UPON PREVIOUS ASSESSMENTS ->**

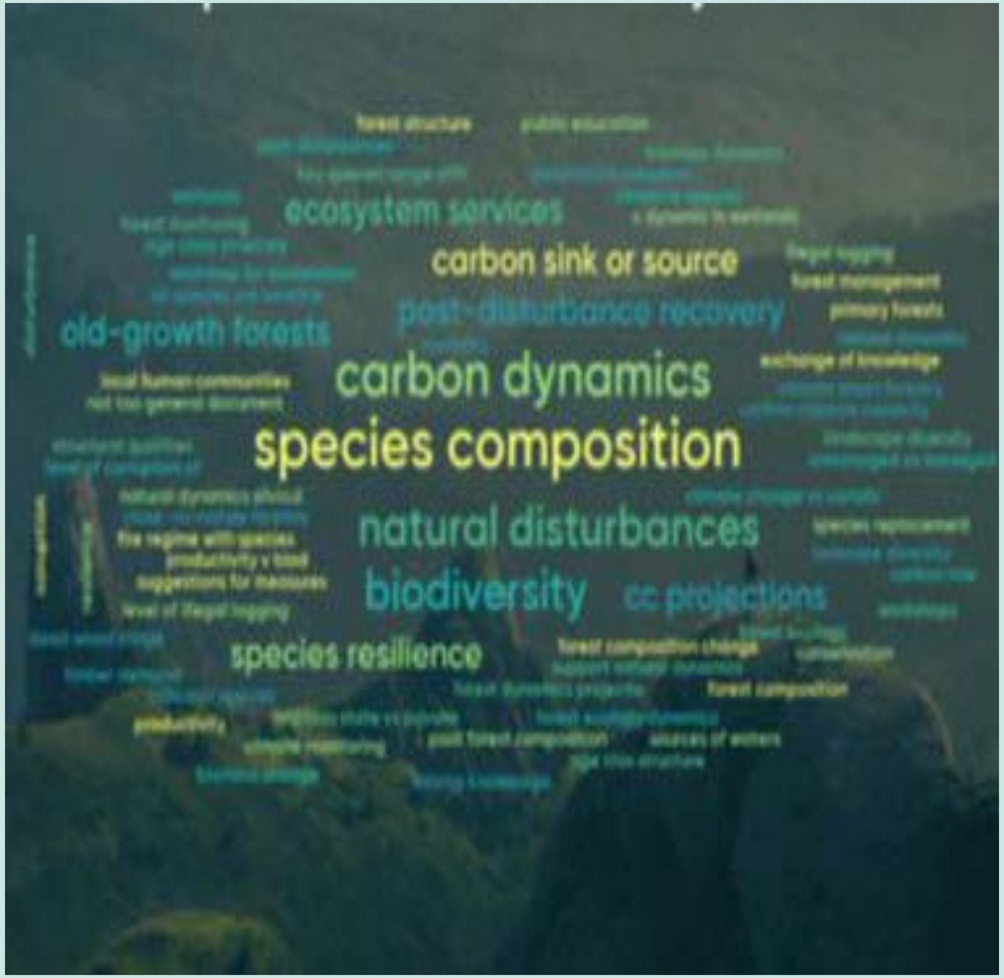
- **SURVEY OF REGIONAL EXPERTS** (N=18)
  - Supported by structured interviews with major research groups
  - Survey responses were coded to indicate the number of times particular risks, impacts, and adaptation options were mentioned

PUBLICATION DATE	ASSESSMENT TITLE	GEOGRAPHIC SCOPE	CITATION
2014	Climate change vulnerability and ecosystem-based adaptation measures in the Carpathian region	Carpathians	Saskia et al. (2014)
2014	Future imperfect: climate change and adaptation in the Carpathians	Carpathians	Werners et al. (2014)
2016	Climate change adaptation in the Carpathian Mountain Region	Carpathians	Werners et al. (2016)
2017	Outlook on climate change adaptation in the Carpathian Mountains	Carpathians	Alberton et al. (2017)
2018	National climate change vulnerability and risk assessments in Europe, 2018	Compilation of national-level data for 33 countries	Füssel et al. (2018)
2020	Adaptation to climate change in sustainable forest management in Europe	Pan-European	Lindner et al. (2020)
2021	Vulnerability of European forests to natural disturbances	Pan-European	Forzieri et al. (2021)
2021	European forests for biodiversity, climate change mitigation and adaptation	Pan-European	Science for Environment Policy (2021)

RESULTS: 7 key themes derived as priority topics of concern:

7 PRIORITY TOPICS OF CONCERN

- Forest Growth & Productivity
- Biomass & Carbon Stocks
- Tree Mortality
- Changes In Species Range & Abundance And Habitat Shifts
- Invasion By Non-native Species
- Forest Ecosystem Services
- Forest-water Interactions, Including Hydrologic Regulation & Riparian Dynamics



RESULTS: 6 priority risks identified based on the 7 key themes

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Key Risk(s) — Potential Impacts (consequences, outcomes)

Adaptation Response(s)

6 PRIORITY RISKS

- Altered Disturbance Regimes
- Altered Hydrologic Regimes and Flood Impacts
- Invasive Species
- Declines in Forest Growth and Productivity
- Altered Species Composition and Distribution
- Feedback Mechanisms and Effects on Ecosystem Services, including Carbon Storage

ALTERED DISTURBANCE REGIMES:

- Increased Pest and Disease Outbreaks
- Increased Windstorms
- Increased Drought
- Increased Wildfires

6 PRIORITY RISKS OF CONCERN IDENTIFIED BY THE SURVEY:

- **Altered Disturbance Regimes**
- **Altered Hydrologic Regimes and Flood Impacts**
- **Invasive Species**
- **Declines in Forest Growth and Productivity**
- **Altered Species Composition and Distribution**
- **Feedback Mechanisms and Effects on Ecosystem Services, including Carbon Storage**

ALTERED HYDROLOGIC REGIMES AND FLOOD IMPACTS:

- Caused by altered disturbance risks and human impairment of watershed functioning
  - e.g. poorly designed forest roads, development, and impervious surfaces

6 PRIORITY RISKS OF CONCERN IDENTIFIED BY THE SURVEY:

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- Feedback Mechanisms and Effects on Ecosystem Services, including Carbon Storage

6 PRIORITY RISKS OF CONCERN IDENTIFIED BY THE SURVEY:

INVASIVE SPECIES:

- Warmer temperatures and altered precipitation patterns -> increased invasive insect pests, tree pathogens, and noxious plants, such as mistletoe

- Altered Disturbance Regimes
- Altered Hydrologic Regimes and Flood Impacts
- Invasive Species
- Declines in Forest Growth and Productivity
- Altered Species Composition and Distribution
- Feedback Mechanisms and Effects on Ecosystem Services, including Carbon Storage

DECLINES IN FOREST GROWTH AND PRODUCTIVITY:

- **Altered Phenology** (earlier budburst and foliage production) leads to:
  - increased water uptake by trees and soil moisture deficits (if precipitation decreases)
  - decreased forest productivity
  - Shifts in insect emergence and bird migration, posing risks for biodiversity
- **Altered CO2 Fertilization:** Respondents' views differed
  - Increased photosynthesis -> increased forest productivity
  - depends on interactions with moisture and nutrient stressors -> decreased productivity

6 PRIORITY RISKS OF CONCERN IDENTIFIED BY THE SURVEY:

- **Altered Disturbance Regimes**
- **Altered Hydrologic Regimes and Flood Impacts**
- **Invasive Species**
- **Declines in Forest Growth and Productivity**
- **Altered Species Composition and Distribution**
- **Feedback Mechanisms and Effects on Ecosystem Services, including Carbon Storage**

ALTERED SPECIES COMPOSITION AND DISTRIBUTION:

- Overall accelerated rates of forest change
- **Altered species ranges:** concern for species with low dispersal rates and species in isolated habitats
  - e.g. on mountain tops and in highly fragmented landscapes

6 PRIORITY RISKS OF CONCERN IDENTIFIED BY THE SURVEY:

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FEEDBACK MECHANISMS AND EFFECTS ON ECOSYSTEM SERVICES, INCLUDING CARBON STORAGE:

- **Disturbance Feedbacks:** reduced ecosystem services (e.g. timber production, carbon storage, hydrologic regulation)
- **Carbon Feedbacks:** increased carbon flux to the atmosphere
- **Hydrologic Feedbacks:** changes in precipitation and evapotranspiration affecting freshwater quantity and quality
- **Albedo Feedbacks:** altered surface reflectivity
- **Productivity and Related Economic Feedbacks:** negative economic effects

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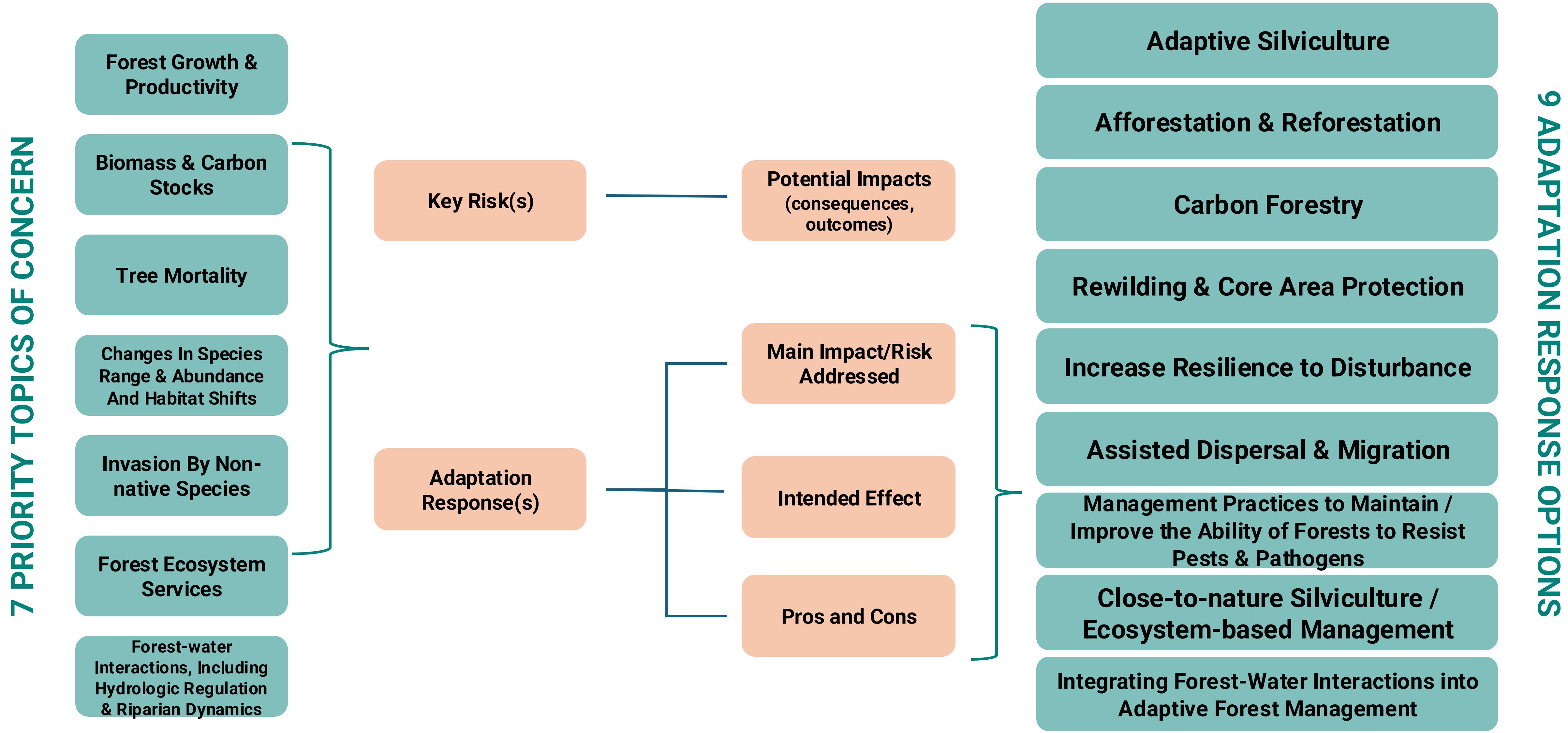
RESULTS: 9 adaptation options identified based on the 7 key themes



EXAMPLE:

1 FOREST GROWTH AND PRODUCTIVITY

ADAPTIVE SILVICULTURE

MAIN RISKS ADDRESSED

- Spruce mortality and decline in vigor of other forest types, including beech.
- Drought and increased disturbance risks, such as bark beetles, wind, and forest fires.
- Increased physiological stress in trees leading to reduced growth and vigor.
- Landscape-scale continuity of vulnerable host trees for insect pests.

CHARACTERISTICS

Emphasizes ecological principles and aims to maintain or enhance the natural processes and functions of the forest ecosystem, such as biodiversity, soil health, water quality, and habitat connectivity.

Balances multiple objectives, such as timber production, wildlife habitat conservation, water balance and carbon sequestration, disturbance processes and recreational opportunities, based on the specific context and goals of forest management.

Harnesses both natural and artificial regeneration to shift or convert species composition to mixed forests where these were historically endemic or where they will be future adapted. This may take the form of a variety of silvicultural approaches, including but not limited to close-to-nature forest management, which is a set of practices to confer resistance or resilience to climate change:

- Continuous cover forestry with uneven aged, diverse forests.
- Stocking management, including thinning to reduce stand densities.
- Diversified landscape mosaics in terms of patch structure and composition
- Gap- and retention-based regeneration harvesting systems.
- Use of prescribed burning in forest types and drier sites that once supported low intensity, ground fires.

Requires ongoing monitoring of forest conditions and response to management actions. This helps in assessing the effectiveness of different approaches and making informed decisions.

INTENDED EFFECTS

Better adaptation to future climatic conditions and resilience or resistance to a variety of stresses.

Decreased drought- and disturbance-related risks.

Reduced wildfire risk.

Managing tree density and thinning removes shrubs and flammable vegetation in between the ground and the crown level (vertical continuity). Species with a higher age mix and species mix tend to be less vulnerable to wildfires compared to mono-age and mono-species stands, since their more complex structure can slow fire spread. Restores capacity for low intensity fires that do not "canopy out" and become high intensity, stand replacing burns.

Rehabilitated and sustainable ecosystems.

Continuation of native tree cover having usually better productivity than invasive species.

Increased functional and structural diversity.

KEY ADVANTAGES:

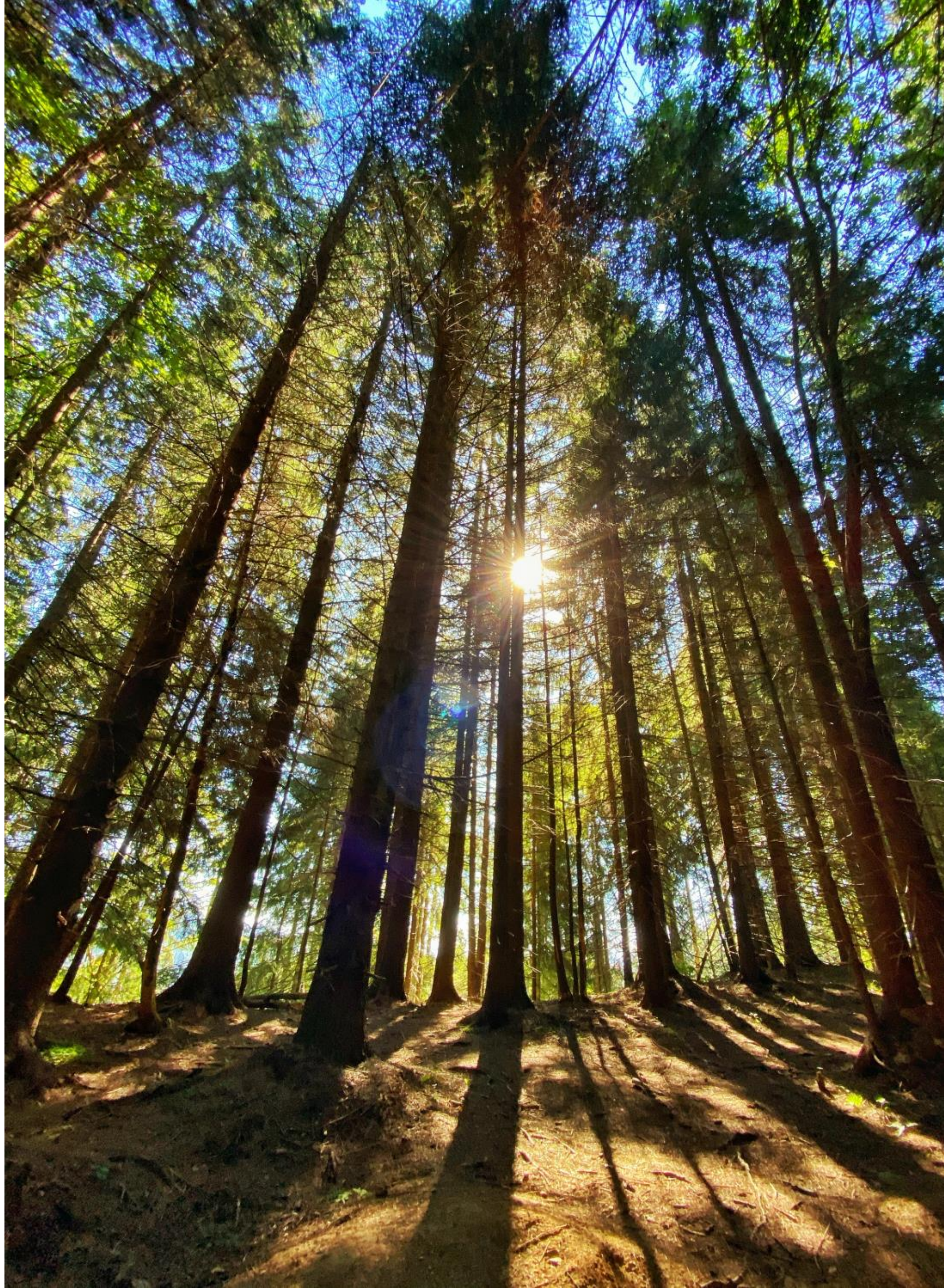
- Creates greater resilience to abiotic damage in comparison with even-aged stands.
- Improves biodiversity through the creation of a vertically and horizontally diverse habitats at stand scales and mosaics of seral habitats at landscape scales.
- Leads to more diverse landscape that limit disturbance spread and optimize ecosystem services such as carbon sequestration and storage.

POTENTIAL DISADVANTAGES:

- Time constraints and costs in achieving irregular structures through lost production during the transformation period.
- Lack of knowledge of the process of transformation.
- Limited range of sites where transformations may be possible.

RECOMMENDATIONS: Opportunities and Pathways

- **Forest restoration and reforestation efforts**
  - Diversifying landscapes to reduce disturbance risks and restoring site-specific endemic species
- **Protecting and conserving natural forests**
  - Establishing and effectively managing protected areas, national parks, and nature reserves, also contributing to carbon sequestration and storage
- **Enhancing forest landscape connectivity**
  - Vital for allowing species to migrate and adapt to changing climate conditions
- **Forest fire management and prevention**
  - Developing national and regional early warning systems, improving fire suppression capabilities, and promoting community-based fire management approaches
- **Sustainable wood utilization and value chains for forest products**
  - Encouraging responsible harvesting practices, supporting local processing industries, and promoting the use of sustainably sourced wood products to enhance economic viability of forests while supporting climate change adaptation



RECOMMENDATIONS: Knowledge Gaps and Research Needs

- **Improved regional-scale forest monitoring:**
  - harmonizing monitoring programs and sharing data across borders to facilitate coordinated adaptation
- **Monitoring physiological and phenological responses** of trees to climate change over time
- **Investigating the role of genetic diversity** in forest ecosystems for adaptation,
  - e.g. assessing the adaptive potential of different genetic lineages, and effects of genetic diversity on ecosystem resilience

RECOMMENDATIONS: Knowledge Gaps and Research Needs

- **Assessing the effectiveness of adaptive silviculture practices** in Carpathian forests.
  - Long-term monitoring of adaptive practices to continuously (re)evaluate their success

- **Assessing the economic viability and costs** associated with different adaptation approaches

- **Understanding the social acceptability and equity** implications
  - considering the impacts of adaptation on local communities and livelihoods

DISCUSSION: NEXT STEPS

HOW DO WE DISSEMINATE THE ASSESSMENT?

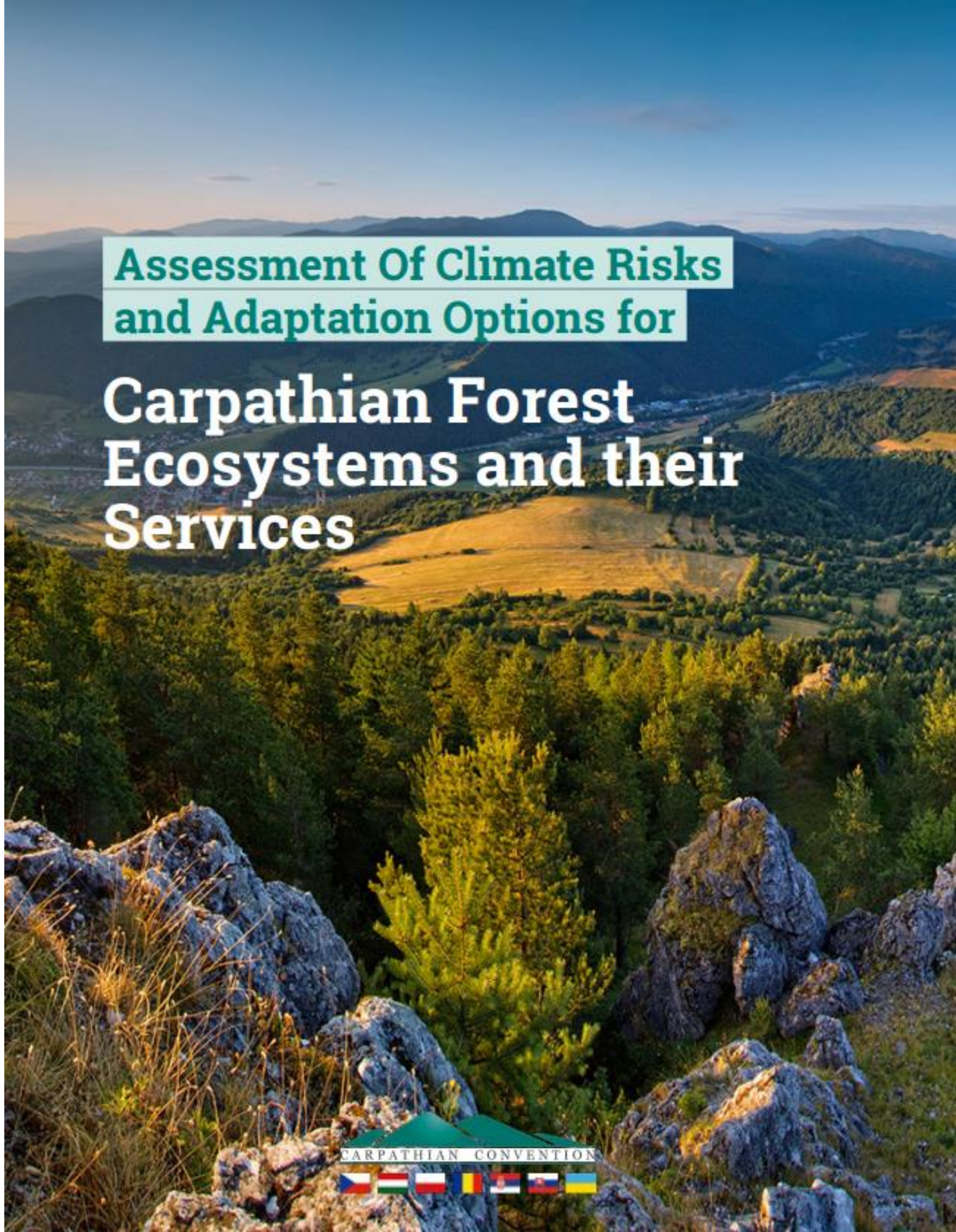
- *Print?*
- *Climate ADAPT Platform?*
- *Official Launch?*
- *Facilitation by Forest Europe?*

FOLLOW-UP PROJECTS?

- *Implementing recommendations*
- *Addressing identified gaps*

An Example: *Integrating relevant activities into the Transnational LIFE Carpathian SNaP Application*

  - *These activities would be included into the Carpathian Biodiversity Framework Action Plan*



Thank You!

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