

Impact of Natural Hazards on Forest Ecosystems and Their Surrounding Landscape under Climate Change

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1. Introduction

In the last decades, the increasing frequency of natural hazards has impacted forest ecosystems and their surroundings. It is because of climate change that the dynamics of the ecosystem structure, feedbacks, and relationships are changing. These structural changes are too complicated and complex to be entirely, or at least satisfactorily, explained. However, it is possible to explain at least some of these interconnections. Water is the primary transport medium for energy and material fluxes in ecosystems, and therefore, it is a common denominator of the complex interconnections between their partial components.

Consequently, we paid attention to water as the primary agent driving the impact of natural hazards in forest ecosystems and their surroundings. Water scarcity causes drought, and its surplus causes flood, respectively. Additionally, it is also necessary to understand temporal distribution patterns of water in a warmer climate and ecophysiological consequences in forest structures. Thus, we decided to prepare a Special Issue in which contributors tried to explain some water-related examples of natural hazard impacts on the forest and the surrounding ecosystem.

The Special Issue we introduce consists of 11 original research papers [1–11] divided into three groups based on research interests, namely, 1. hydrological and atmospheric aspects of natural hazards in changing climate and environment, 2. ecophysiological and ecological water-related impacts of natural hazards, and 3. methodological approaches in natural hazard evaluation.

2. Overview of the Special Issue Contributions

2.1. Hydrological and Atmospheric Aspects of Natural Hazards in Changing Climate and Environment

Long-term drought trend analyses provided by Vido and Nalevanková [1] implied that the drought risk evaluated from the meteorological point of view depends mostly on altitude in the area of the Central Carpathian Mountains. An interesting fact is that the beech ecosystems are predominantly located in drought-prone areas (under 1000 m above sea level). On the other hand, trend analyses of the individual months indicate an increasing trend toward wetter conditions in winter. Nevertheless, the authors discussed that it is necessary to investigate how increasing winter temperature changes the snow regime, which could negatively impact river discharge in the spring season.

Response to these challenges is partially discussed in the article by Danáčová et al. [2]. The authors deal with estimating the effect of deforestation on runoff in small mountainous basins in Slovakia. In addition to evidence that rising temperature increase river discharge in mountain creeks in early spring, they also found proof that deforestation is increasing water discharge in the area, especially in the summer months during thunderstorms or torrential rains. The most dramatic result of this study is the impact of climate change and river basin deforestation. In the Boca River basin, the estimated modeled floods increased by 59%, and in the Ipolitca River basin by 172% in the case of the 100-year return period.



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Another contribution of Fleischer et al. [3] deals with carbon balance and streamflow at a small catchment scale 10 years after the severe natural disturbance (Windthrow of 2004 followed by a forest fire and bark beetle outbreak) in the Tatra Mts, Slovakia. Authors studied carbon fluxes and streamflow 10 years after the forest destruction in three small catchments, which differ in size, land cover, disturbance type, and post-disturbance management. Interestingly, 10 years after the windstorm of 2004, most of the windthrow sites acted as carbon sinks (from -341 ± 92.1 up to -463 ± 178 gC m⁻² y⁻¹). In contrast, forest stands strongly infested by bark beetles regenerated much slowly and on average emitted 495 ± 176 gC m⁻² year⁻¹. Moreover, 10 years after the forest destruction, the annual carbon balance in studied catchments was almost neutral in the least disturbed catchment.

Authors found that different post-disturbance management has not influenced the carbon balance yet. Interesting findings are that streamflow characteristics did not indicate significant changes in the hydrological cycle.

Long-term temporal precipitation quality changes in Slovak mountain forests were studied by Mind'aš et al. [4]. Authors found significant declining trends for almost all evaluated chemical components (S-SO₄, N-NH₄, N-NO₃, Ca, Mg, and K), which can significantly affect element cycles in mountain forest ecosystems. The evaluated 41-year-period (1987 to 2018) is characterized by significant changes in the precipitation regime in Slovakia. The obtained results indicate possible directions in which the quantity and quality of precipitation in the mountainous areas of Slovakia will develop with ongoing climate change.

The last paper in this section ("Hydrological and atmospheric aspects of natural hazards in changing climate and environment") deals with the density of seasonal snow in the mountainous environment of five Slovak ski centers (Mikloš et al.) [5]. Climate change increases the role of artificial snow due to winter mountain tourism. These problems have many positive but also negative ecological consequences. The paper by Mikloš et al. brings new insights to snowpack development processes in a manipulated mountainous environment through examinations of temporal and spatial variability in snow densities and an investigation into the development of natural and ski piste snow densities over the winter season.

2.2. Ecophysiological and Ecological Water-Related Impacts of Natural Hazards

An exciting topic about the influence of warmer and drier environmental conditions on species-specific stem circumference dynamics in submontane forests has been introduced by Leštianska et al. [6]. The study's motivation was to understand better the species-specific effects of weather conditions on tree growth because this could lead to better future forest management. The results showed that studied species (*Abies alba* and *Larix decidua*) could cope with changing environmental conditions. However, the long-term increase in air temperature and more frequent heat waves, coupled with more intense and prolonged drought episodes, could affect species' ability to respond to environmental changes.

Lukasová et al. [7] studied the autumn phenological responses of European beech to summer drought and heat waves. The results showed that the meteorological drought in the warmer climate led to earlier leaf coloring of European beech. That could be in the future decades a significant ecophysiological impact on whole beech areal in the middle altitudes.

Another example of the ecophysiological impact of various meteorological components and water stress on European beech was investigated by Nalevanková et al. [8]. The study of sap flow monitoring with related environmental factors confirmed that soil water deficit leads to a radical limitation of stand transpiration and significantly affects the relationship between transpiration and environmental drivers. Additionally, it was demonstrated that a time lag exists between the course of transpiration and environmental factors on a diurnal basis. An application of the time lags within the analysis increased the strength of the association between transpiration and the variables. However, due to

the occurrence and duration of soil water stress, the dependence of transpiration on the environmental variables became weaker and the time lags were prolonged.

Ecological drought impacts demonstrated by the Carabus population in lowland oak hornbeam forest have been studied by Šiška et al. [9]. The study was carried out during meteorologically two different years—2017 and 2018. Authors found that drought negatively influenced population abundance, and the effect of drought is likely to be expressed with a two-year delay.

The last study on the ecological or ecophysiological impacts of natural hazards was proposed by Kubov et al. [10]. This study deals with the drought impact amplified by the physiological influence of hemiparasitic yellow mistletoe on the oak ecosystem. The study showed how the cumulative effect of biotic hazard represented as hemiparasitic shrub and drought as abiotic natural hazard could worsen the forest ecosystems' ecosystem stability.

2.3. Methodological Approaches in Natural Hazard Evaluation

A methodological contribution to water-related natural hazard impact on forest ecosystems is represented study of Středová et al. [11]. Forest ecosystems and their surroundings faced a variety of natural hazards. That includes abiotic hazards as floods, drought episodes, torrential rains or windstorms, and biotic hazards represented by pathogen outbreaks or changing ecosystem structures. Due to this, the authors decide to define crucial abiotic stressors affecting central European forest ecosystems and, concerning their possible simultaneous effect, develop a universal method of multi-hazard evaluation. That could be helpful in future natural hazard management in forest ecosystems.

We hope that the Special Issue combines many viewpoints on water-related natural hazards impacts on forest ecosystems. Looking at the Special Issue's content, we see that it is not possible to cover this topic with one or even more editions. Further and systematic research is needed. We wish you a pleasant reading.

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