



Conference Abstract

Dynamics of carbon fluxes after natural disturbances in the Tatra Mts., Slovakia

Martin Kubov^{‡§}, Peter Fleischer Jr.^{‡|}, Soňa Grenčíková[‡], Peter Fleischer, Sr.^{‡|}

[‡] Faculty of Forestry, Department of Integrated Forest and Landscape Protection, Technical University in Zvolen, T.G. Masaryka 24, 96001 Zvolen, Slovakia, Zvolen, Slovakia

[§] Slovak Academy of Sciences, Institute of Forest Ecology, L' Štúra 2, 96001 Zvolen, Slovakia, Zvolen, Slovakia

| Research Station of Tatra National Park, Tatranská Lomnica 14 066, 05960 Vysoké Tatry, Slovakia, Tatranská Lomnica, Slovakia

Corresponding author: Martin Kubov (mkubov5@gmail.com)

Received: 10 Feb 2025 | Published: 28 May 2025

Citation: Kubov M, Fleischer Jr. P, Grenčíková S, Fleischer, Sr. P (2025) Dynamics of carbon fluxes after natural disturbances in the Tatra Mts., Slovakia. ARPHA Conference Abstracts 8: e149276.

<https://doi.org/10.3897/aca.8.e149276>

Abstract

An increase in natural disturbances (windthrow, bark beetle, and fire) in mountain spruce forests throughout Central Europe can have a significant negative impact on forest ecosystem services especially carbon sequestration. Forest disturbances alter carbon fluxes by affecting the balance between carbon uptake through gross primary production (GPP) and loss via ecosystem respiration (Reco), determining whether an ecosystem acts as a carbon sink or source. Initially, disturbances typically shift ecosystems to carbon emission, with recovery leading to increased sequestration, depending on disturbance type and intensity. While climate change impacts on carbon sequestration are well studied, the role of post-disturbance forest management in regulating carbon fluxes remains less explored, despite the recognized importance of reforestation.

The study analyzes carbon fluxes in Tatra National Park (TANAP), a member of the international Long-Term Ecological Research (LTER) network. In 2004, a large area of forest was heavily disturbed by wind. And subsequently, by fire and bark beetle outbreaks. The study was realized on sites representing different disturbance agents, fire (FIR), bark beetle (IPS) as well as different post-disturbance management - traditional salvage logging (EXT), natural processes (NEX), and intact reference conditions (REF). Study sites, each covering 100 ha, were situated in areas with comparable windthrow

impact, ecological conditions, and climate. They were located on south and southeast-facing slopes with inclinations up to 15° at an altitude of 1050–1100 m a.s.l. The sites featured a larch-spruce forest (*Lariceto-Piceetum* community) growing on shallow, rocky dystrophic/podzolic cambisols.

Carbon flux measurements were conducted using two methods during different periods. Chamber transparent custom-built Vaisala probe (Vaisala, CarboCap 343) for micro ecosystem scale and Li-6400XT (LI-COR, Lincoln, NE, USA) for leaf scale were used from 2010 to 2015. Since 2018, eddy covariance methods (EC, model 7500-DS) have been used at the ecosystem-wide scale.

Chamber gas-exchange measurements revealed that herbaceous species such as *Calamagrostis villosa* and *Rubus idaeus* exhibited photosynthetic rates up to 19 $\mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$, significantly exceeding those of tree seedlings like *Picea abies* (8–13 $\mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$). Chamber-based soil respiration measurements also indicated substantial variability across ecosystem types, with fluxes of 953 $\text{gC m}^{-2} \text{ y}^{-1}$ in mature spruce forests, 905 $\text{gC m}^{-2} \text{ y}^{-1}$ in unmanaged windthrow, 617 $\text{gC m}^{-2} \text{ y}^{-1}$ in burnt windthrow areas, and 596 $\text{gC m}^{-2} \text{ y}^{-1}$ in managed windthrow sites. Additionally, chamber-based net ecosystem exchange (NEE) data highlighted variations in carbon balance across land cover types, with burnt windthrow acting as the strongest carbon sink ($-463 \pm 178 \text{ gC m}^{-2} \text{ y}^{-1}$), followed by managed windthrow ($-352 \pm 81 \text{ gC m}^{-2} \text{ y}^{-1}$) and unmanaged windthrow ($-341 \pm 92 \text{ gC m}^{-2} \text{ y}^{-1}$), whereas bark beetle-infested stands remained a net carbon source ($+495 \pm 176 \text{ gC m}^{-2} \text{ y}^{-1}$).

EC data showed that gross primary production (GPP) in unmanaged stands was 25% higher than in managed stands due to increased vegetation diversity and greater leaf area index (LAI). The maximum GPP recorded by EC was 14 $\text{gC m}^{-2} \text{ y}^{-1}$ in unmanaged sites and 12 $\text{gC m}^{-2} \text{ y}^{-1}$ in managed sites. However, total ecosystem respiration (Reco) was 104% higher in unmanaged sites compared to managed sites, with annual Reco values of 846 $\text{gC m}^{-2} \text{ y}^{-1}$ in managed stands and 1725 $\text{gC m}^{-2} \text{ y}^{-1}$ in unmanaged stands. EC-based NEE values indicated that managed stands transitioned to a carbon sink by 2019, while unmanaged stands remained a carbon source until 2020 and only became a net sink by 2021. Annual NEE values were $-206 \pm 115 \text{ gC m}^{-2} \text{ y}^{-1}$ in unmanaged stands and $-136 \pm 84 \text{ gC m}^{-2} \text{ y}^{-1}$ in managed stands.

These findings indicate that managed sites sequestered carbon more efficiently in the short term, while unmanaged stands exhibited higher long-term assimilation potential due to increased vegetation diversity. The study highlights the trade-offs in post-disturbance forest management, where salvage logging accelerates carbon sequestration but may reduce future stand diversity and resilience.

Keywords

Disturbances, Forest Management, Spruce, Carbon Fluxes, Eddy Covariance Methods, Chamber Method

Presenting author

Martin Kubov

Presented at

POSTER

Conflicts of interest

The authors have declared that no competing interests exist.