

CO₂ surface exchange and soil emission fluxes in disturbed northern ecosystems of Central Siberia

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Current observations demonstrate significant depletion of carbon stocks in terrestrial ecosystems. Forest soils are known to store vast amounts of carbon, significantly exceeding other atmospheric reservoirs and the phytomass of living plants. There is high uncertainty regarding the magnitude of the response of high-latitude ecosystems to ongoing climate change, particularly carbon emissions. Furthermore, the presence of additional disruptive external factors could potentially significantly increase atmospheric CO₂ concentrations, thereby amplifying future global trajectories. It has not yet been reliably determined what changes will occur in high-latitude ecosystems under current climate conditions and the intensification of anthropogenic pressures. Forest fires and logging are the main factors destabilizing forest ecosystems. Currently, due to the increasing frequency and intensity of forest fires, the long-term carbon sequestration of boreal ecosystems is under threat. The shortening of fire intervals in boreal forests is increasingly inhibiting their ability to accumulate and store carbon over the long term. Clear-cutting is a common anthropogenic disturbance that shifts carbon from a carbon sink to a carbon source through direct biomass removal and increased heterotrophic soil respiration. Furthermore, clear-cutting causes profound landscape changes, significantly affecting habitat structure and biodiversity. In our study, we examined CO₂ emission and exchange fluxes in the ground cover layer of disturbed areas. Ground fires of varying intensity and clear-cutting were selected as the main disturbing factors. We found that, in both natural and disturbed areas, the emission component predominates in the exchange flux. The contribution of CO₂ emissions to the total flux from the ground cover can reach up to 80–85%, depending on the specific ground cover. In disturbed stands burned by a high-intensity ground fire, emissions and exchange are minimal. Next comes a clear-cut site burned by a fire. The highest CO₂ fluxes from the studied disturbed areas were observed for clear-cut forests with a 6-year logging interval. Differences from fluxes in natural ecosystems can reach approximately 50–60% in the middle of the growing season. Thus, analysis of existing patterns in CO₂ fluxes from the ground cover allowed us to assess the contribution of disturbances and natural environmental factors to the formation of CO₂ fluxes. This study has been supported by the grant from the Russian Science Foundation, RSF 24-74-00159.

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