

Peatlands from Space: Earth Observation and Biodiversity Integration for Assessing Carbon Flux Dynamics in the Hudson–James Bay Lowlands

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Abstract

The Hudson–James Bay Lowlands of northern Canada form one of the world’s largest peatland complexes, shaped by extensive permafrost gradients, ecological diversity, and minimal human disturbance. However, growing pressures from hydroelectric expansion, mining, and infrastructure development are accelerating habitat fragmentation and wetland degradation. The region supports globally significant biodiversity and provides key ecosystem services, including carbon sequestration, hydrological regulation, and habitat stability. This study aims to integrate citizen science data, institutional biodiversity records, and multi-source Earth Observation (EO) datasets within the Essential Biodiversity Variables (EBV) framework to assess regional species abundance, quantify changes in community structure, and evaluate the temporal and functional dynamics of ecosystem carbon fluxes across diverse ecological, spatial, and temporal scales.

Biodiversity datasets from citizen science platforms, and institutional collections programs were harmonized to model species abundance distributions and assess biodiversity change. The study also examines the temporal variability and environmental drivers of gross primary production, ecosystem respiration, and net ecosystem production in this carbon-rich peatland. MODIS-derived indices—land surface temperature, leaf area index, and NDVI—combined with Sentinel-2–derived photochemical reflectance index were used to derive EBVs for vegetation cover, and ecosystem productivity. Machine learning models, temporal segmentation, and structural equation modelling were applied to link EO-derived indices with environmental and biotic variables.

The findings highlight the value of EO-derived EBVs for quantifying carbon flux dynamics, establishing biodiversity baselines, and informing carbon management and conservation policy. Integrating Indigenous knowledge will enhance long-term monitoring, regional stewardship, and support Canada’s implementation of the Global Biodiversity Framework.

Keywords: Remote Sensing, Biodiversity Variables, Environmental Drivers, and Peatland Ecosystems.