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Systematic Review of Greenhouse Gas Emissions from Peat and Organic-Rich Soils under Grassland and Cropland Management

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Peat and organic-rich soils are critical carbon stores but are also major sources of greenhouse gas (GHG) emissions when drained for agriculture. In temperate and boreal regions, the conversion of cropland to grassland has been proposed as a strategy to mitigate emissions of carbon dioxide (CO□), methane (CH□), and nitrous oxide (N□O). However, the effectiveness of this approach remains uncertain due to the complex interactions between soil properties, land management practices, and environmental conditions. This systematic review synthesises evidence from peer-reviewed field studies to assess the impact of grassland conversion on GHG emissions from peat and organic-rich soils.

Out of 10,352 records initially screened, 28 studies comprising 34 comparisons met the inclusion criteria, focusing on GHG fluxes under comparable field conditions. The analysis revealed that grassland systems do not universally reduce CO□ or CH□ emissions compared to croplands, with no statistically significant differences observed. In contrast, N□O emissions showed a mean reduction of 7.55 kg N□O ha□¹ yr□¹ in grasslands. However, this reduction was not robust across all scenarios and was influenced by key factors such as crop type, fertilisation, and drainage management. For example, excluding root crops from the cropland comparator significantly narrowed the observed differences in N□O emissions, highlighting the critical role of cropping systems.

Grasslands with fertilisation often exhibited higher net ecosystem exchange (NEE) and net ecosystem carbon balance (NECB), indicating increased carbon losses that could counteract the benefits of reduced N□O emissions. Furthermore, the findings challenge the Intergovernmental Panel on Climate Change (IPCC) guidelines, which assume consistently lower emissions from grasslands on organic soils. These results emphasise the need to reassess emission factors and refine policy recommendations for managing peatlands.

The review underscores the complexity of GHG fluxes in managed organic soils and highlights the

limitations of grassland conversion as a standalone mitigation strategy. The variability in outcomes demonstrates the importance of considering site-specific factors, such as soil properties, hydrology, and climate, alongside management practices. Strategies like optimised water table management, reduced fertiliser inputs, and mixed cropping systems could complement grassland conversion to enhance its effectiveness in reducing GHG emissions.

Future research should prioritise long-term field experiments incorporating detailed soil and environmental characterisation, consistent methodologies, and comprehensive management data. Emphasis on cross-regional studies would also help address gaps in understanding how local conditions influence GHG dynamics. These efforts are essential for developing tailored, evidence-based strategies for mitigating emissions from peat and organic-rich soils.

This review provides valuable insights into the trade-offs and opportunities associated with grassland conversion, offering guidance for policymakers and land managers aiming to balance agricultural productivity with climate goals.