Geophysical Research Abstracts
Vol. 21, EGU2019-11636, 2019
EGU General Assembly 2019

Trajectory of carbon accumulation in restored Canadian peatlands

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Northern peatlands are globally significant carbon sinks; however, this function can be lost through peatland disturbance. Commercial peat extraction involves vegetation clearing and peatland drainage, resulting in mineralization of stored organic matter and large carbon dioxide (CO_2) emissions. Following peat extraction, ecosystem recovery is often poor without active rewetting or restoration actions. Over 25 years of research in Canada has led to the development of the moss layer transfer technique (MLTT) for peatland restoration, that can efficiently establish plant communities dominated by peatland and wetland species and return carbon accumulation function within decades. However, the trajectory of C fluxes with time post-restoration remains unclear, as does the variation in this trajectory between the plant communities that establish post-restoration.

We compiled CO_2 and methane emission data from different ages of restored Canadian peatlands collected with manual chamber measurements and eddy covariance methods and determined the shift in annual C exchange over time. As these measurements were limited to less than five sites and vegetation establishment can vary greatly within and between restoration projects, we explored this variation by collecting over 500 samples representing of all aboveground biomass accumulated since restoration across permanent plots established in restored peatlands ranging in age from 2-20 years post-restoration and varying in vegetation outcomes. For $\sim$50 plots, we sorted all biomass into plant tissue types (wood, shrub leaves, herbs, bryophytes, litter) and calculated average net primary productivity considering the turnover rates of each tissue type.

Flux data indicates that peatlands restored via MLTT are originally large sources of carbon ($\sim$600 g C m^{-2} yr^{-1}), but this source rapidly declines over time as vegetation establishes. Measurements at one site indicate that a C sink function can be achieved by 15 years post-restoration (uptake of $\sim$80 g C m^{-2} yr^{-1}). Total biomass increased significantly over time, varying between vegetation outcomes. Calculated net primary productivity increased over time, but stabilized at older sites as biomass accumulated in early years was beginning to decompose. Future work will target carbon flux measurements on specific vegetation outcomes of various ages to determine emission factors that can be applied across mapped post-restoration vegetation establishment.