Technical note: Wetland carbon abatement

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Dr Jordan Goodrich (Senior Scientist, MfE); Dr Hugh Robertson (Principal Science Advisor-Wetlands, DOC)

Purpose

This technical note provides a summary of the contribution of peatland rewetting and restoration to the reduction of greenhouse gas (GHG) emissions, including the long-term benefit of wetland restoration and management. It also provides a brief commentary on mineral soils and coastal wetlands. Therefore, this note intentionally does not cover the potential implications of recognising wetlands and drained peatlands (and other non-forest land use) in New Zealand's NDC. Any consideration of policy options must include consideration of these implications, alongside the scientific evidence and context.

Restored peatlands have overall climate benefit

The consensus from international literature is that the favourable cooling effect of CO_2 removal is greater than the unfavourable warming effect of methane emissions from restored peatlands.

The timescale to achieve the net climate benefit depends on the emissions reduced by rewetting and restoring drained peatlands and the balance between methane emission and CO_2 removal (sequestration) following restoration (this determines the ongoing net carbon dioxide equivalents (CO_2-e) emission/removal). Data we have for New Zealand's drained organic soils and intact peatlands suggest net greenhouse gas removal (when CO_2 emission reduction overcomes methane emission) is expected to be immediate.

Data from NZ studies on drained organic soils being used for dairy grazing, indicate those soils are a large source of CO_2 emissions, so the potential abatement from rewetting and restoration is high (Campbell et al., 2015; Campbell et al., 2021). Stopping these emissions would result in a net greenhouse gas reduction despite the associated increase in methane emissions. The CO_2 and N_2O emissions from re-wetting are reduced by 21.4 t CO_2-e/ha/yr, whereas the methane emissions from intact wetlands are around 5.5 t CO_2-e/ha/yr (Goodrich et al., 2015). The net result would be an emissions reduction of roughly 15.9 tCO_2-e/ha/yr without relying on the area to become a net CO_2 sink in the near term.

Research from intact NZ peatlands also shows they are large CO_2 sinks (Campbell et al., 2014), CO_2 sequestration can range from 5.9 to 9.2 tCO_2-e/ha/yr (Goodrich et al., 2017). Therefore, the result of restoring NZ peatlands would be a net cooling effect of approximately 23.4 tCO_2-e/ha/yr taking into account all GHG fluxes from restoring drained peatlands (refer to Table below). The cooling effect of a peatland will continue to build through time because of ongoing carbon sequestration. Intact peatlands in New Zealand have been accumulating carbon for 10,000-15,000 years (Newnham et al., 1995).

A technical synthesis on the benefits of restoring peatlands published by the Ramsar Convention on Wetlands (2021a) further stated:

> "In an intact or rewetted peatland, a small part of the accumulating plant material is decomposed anaerobically (without oxygen) resulting in the emission of methane (CH4), a greenhouse gas 28 times stronger than carbon dioxide, but with a much shorter residence time in the atmosphere. There can sometimes be an initial methane peak upon rewetting, but the longer-term climate effect of rewetting is always better than maintaining the drained status quo. This is because of methane's shorter atmospheric lifetime compared to carbon dioxide and nitrous oxide, which build up cumulatively over time in the atmosphere.
>
> Usually, rewetting drained peatlands quickly leads to overall climate benefits (expressed as the combined fluxes of carbon dioxide, methane, nitrous oxide and dissolved organic carbon)"

Abatement potential of peatland rewetting and restoration in New Zealand

The table below provides a summary of the overall potential of organic soil wetlands (peatlands) to reduce GHG emissions. We have used 2013 IPCC Wetlands Supplement default emission factor to estimate the impact of stopping emissions from drained peatlands because it is the most robust number available. This figure is comparable to available NZ data (Campbell et al., 2015; Campbell et al., 2021, Nieveen et al., 2005). The estimate for net GHG removal from intact peatlands is approximated from NZ data (Goodrich et al., 2017).

GHG Flux Type	Carbon abatement (GHG removal)	Does carbon abatement continue? (longevity)
Stopping CO_2 and N_20 emissions from drained peatlands	21.4 t CO_2-e/ha/yr (CO_2 19.4 t; N_2O 2 t)	Carbon abatement potential of peatland restoration grows through time. Even if methane emissions increase after a site is restored and carbon sequestration is neutral, the avoided emissions outweigh the increase in methane. Over time, a restored system will also regain its carbon sink status and the cumulative cooling effect will continue to grow.
Methane emissions from intact/restored wetlands	- 5.5 t CO_2-e/ha/yr	
Potential CO_2 sequestration from intact/restored peatlands	7.5 t CO_2-e/ha/yr	
Net GHG reduction	**23.4 t CO_2-e/ha/yr**	

Notes:

- The IPCC wetland supplement (IPCC 2014) default emission factors suggest that rewetting a drained organic soil will halt CO_2 emissions in the short term. New Zealand does not estimate emissions or removals from re-wetted or restored peatlands.
- There is no IPCC guidance for estimating how long a system takes to return to its undisturbed carbon sequestration status.

Climate Change Implications

Climate change is reducing the ability of all ecosystems to function as carbon sinks (e.g., Hammond et al., 2022; Duffy et al., 2021; Barnard et al., 2021), including peatlands (Bao et al., 2023). However, New Zealand's peatlands are formed by a globally unique vascular plant (*Empodisma robustum*). The plant forms a dense, short-statured canopy that reduces evaporation from the surface peat, limiting water loss during dry periods (Campbell et al., 1997). This also contributes to drought resistance, allowing them to maintain their carbon sequestration function (Goodrich et al., 2017). Therefore, healthy New Zealand peatlands may be relatively buffered from climate change impacts compared to their northern hemisphere counterparts. Drained organic soils under pasture do not retain this buffer. The primary source of emissions from drained organic soils is CO_2 respiration, which is directly related to temperature (Sierra, 2012). Therefore, as long as water table depth is kept low by drainage, emissions will continue and likely increase with warming.

Summary for Policy:

- Drained organic soils (drained peatlands) are a large source of emissions in New Zealand (in the form of CO_2 emissions).
- Drained organic soils can be 're-wetted' by ceasing drainage and maintaining a water table near the surface. These areas can also be restored, which implies an active attempt to return the area to its native vegetation (e.g., through planting) and a more natural hydrological regime (e.g., filling/removing drains).
- The emissions from drained organic soils can be halted by re-wetting the soils. While methane emissions will increase with re-wetting, there will also be an immediate reduction of CO_2 emissions as higher water levels reduce peat decomposition. International and New Zealand-specific data indicate the net greenhouse gas removal will be beneficial overall.
- A global review of peatland rewetting concluded that "the sooner drained peatlands are rewetted, the better it is for the climate. Although the methane cost of rewetting may temporarily be substantial, the CO_2 cost of inaction will be much higher" (Gunther et al. 2020). Data we have for New Zealand's drained organic soils and intact peatlands suggest the net greenhouse gas removal (when CO_2 emission reduction overcomes methane emission) is expected to be immediate. However, more data would be required to determine this timescale for other NZ wetland types.
- The greenhouse gas benefit is even greater when rewetted sites are restored (i.e., regeneration of peat-forming vegetation) and their carbon sequestration function is re-established (in addition to reducing emissions).
- The net climate benefit continues to increase through time because of 1) the shorter atmospheric lifetime of methane and 2) peatlands in NZ accumulate carbon for very long time periods (>10,000-15,000 years).

Inland wetlands on mineral soils

More research on mineral wetlands is recommended to understand greenhouse gas balances and the timeframes to put these into the same context. We need to know the emissions associated with degraded mineral soil wetlands to establish the abatement opportunity, and we need to know the ratio of methane emissions to carbon sequestration of the restored wetland to estimate the timespan required for the ecosystem to become an overall net greenhouse gas sink. Furthermore, New Zealand-specific measurements from sites that are undergoing re-wetting or restoration would also inform emissions estimates.

Coastal wetlands

International and NZ scientific literature also recognises the role of coastal wetlands in removing and storing carbon (IPCC 2014, Ross et al. 2003). This makes their restoration potentially beneficial for climate change mitigation (Convention on Wetlands 2021b). If undisturbed, the carbon stored in sediments of coastal wetlands may remain for thousands of years (Convention on Wetlands 2021b).

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