COLLABORATION FOR ENVIRONMENTAL EVIDENCE
Systematic reviews for conservation and environmental management

CONTEXT

Peatlands accumulate organic matter and therefore fix high quantities of atmospheric carbon dioxide (CO_2) . They also fix or emit other greenhouse gases like methane (CH_4) and nitrous oxide (N_2O).

But peatlands have been drained for afforestation and agriculture, and peat has been extracted as fuel or for horticulture. Consequently, their contribution to the fixation of greehouse gases has been reduced. Is this reversible? **Could restoring peatland by re-wetting contribute to mitigation of climate change by increasing the fixation of greenhouse gases?**

*This is the brief of a **systematic review** of the scientific peer-reviewed and grey literature. A systematic review takes into account the quality of the research and possible biases, in order to provide a rigorous, transparent, replicable and updatable review of the scientific evidence.*

From the CEE Library

RE-WETTING PEATLAND & EMISSIONS OF GREENHOUSE GASES

POLICY BRIEF from Systematic Review
CEE 08-012

FINDINGS

The evidence of the effect of re-wetting on emissions of greenhouse gases is much poorer than for drainage. There are no studies measuring the flux of the three gases simultaneously in re-wetted peatland (compared to drained ones).

Evidence of the effect of rewetting on carbon dioxide and nitrous oxide flux is very poor, because of the very small number of studies and the numerous factors affecting measurements of the former (e.g. rate of photosynthesis…).

Re-wetting peatland increases emissions of methane.

Due to the above findings, the combined effect of increased methane and potentially decreased nitrous oxide and carbon dioxide emissions cannot be reliably estimated based on current evidence.

RECOMMENDATIONS

Protection of existing peatland from drainage and destruction is more effective in terms of net fixation of greenhouse gases (GHG) than the re-wetting of drained peatland.

Although a few studies measure changes in GHG emission after re-wetting, establishing the evidence will require long-term, large-scale studies, including measurement of all GHGs plus all the variables required to calculate a full carbon budget. This will require coordination accross research programmes to standardise methodologies.

The environmental cost from emissions of methane in re-wetted peatland might exceed the benefits of small increases in carbon storage. Therefore, we should be cautious in assuming that re-wetting has a net benefit for short- to medium-term climate change mitigation.

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Methodology

WHAT WAS STUDIED?
Peatland or peat-type soils.

WHAT WAS COMPARED?
Drained versus intact peatland or peat-type soils.
Re-wetted peatland or peat-type soils versus drained ones.
Peat-type soils that are naturally wetter versus those naturally drier.

WHAT WAS MEASURED?
Fluxes of the main greenhouse gases (GHGs): carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) between soil and atmosphere.

Protocol of the systematic review :

1. Peer-reviewed and grey literature sources were searched in order to obtain the largest number of articles addressing the question.
2. Articles relevant to the review were appraised according to the quality of the methodology (experimental design) and the likelihood of biases, in order to take this into account when drawing conclusions.
3. When included studies contained enough data of the same parameter (e.g. means and variance), a meta-analysis was conducted and provided a quantitative synthesis.

WARMING POTENTIAL OF GREENHOUSE GASES

The three greenhouse gases considered in this review differ in their warming potential. Methane (CH_4) has 25 times and nitrous oxide (N_2O) has 298 times the warming potential of carbon dioxide (CO_2) over 100 years (Forster et al. 2007).

To simplify the report of results, we present them in "**carbon dioxide equivalents**" by using the above conversion rules. This allows us to express the **100-year global warming potential of each gas**. More details and explanations are found in the full text of the review (see last page).

All results are expressed in mg CO_2 $m^{-2}d^{-1}$, which means "*milligrams of CO_2 per square metre of peatland, per day*" to allow for comparisons between results.

Results

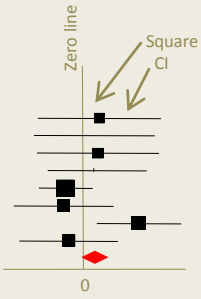
The searching and extraction of articles used for this review were completed by early 2009.

A total of **52** articles was finally included in this review.

Included studies were conducted in: Finland, Sweden, Malaysia, United Kingdom.

Understanding the figures

- Each square ■ represents the result of one study. It is the standardised mean difference between the parameter measured in a type of peatland (e.g. drained) and similarly measured in the comparator site (e.g. undrained).
- The zero line represents a null difference (no effect).
- The size of a square reflects the weight given to each study according to the size/variance of the study sample (larger = result more reliable).
- The horizontal lines represent the 95% confidence interval, **CI** (a measure of variability) around the means.
- The diamond ◆ represents the weighted average overall effect of the intervention.



The position of each square indicates the direction and magnitude of the effect. But the average value (diamond) also depends on the respective weight of each study (size of the square)

CAUTION: we present results for each GHG separately and do not recommend combining them to estimate a combined global warming potential because the quality of evidence (uncertainty in outcome) varies greatly between the gases (see overleaf).

NOTE: Results on impact of draining are presented to provide context in terms of the extent to which re-wetting reverses the effect of draining.

Carbon dioxide (CO_2)

NATURALLY WETTER/DRIER PEATLAND

(1 article - 2 results) - low confidence

Wet areas emit less CO_2 compared with drier ones by 78.4 mg CO_2 $m^{-2}d^{-1}$.

DRAINING *see figure*

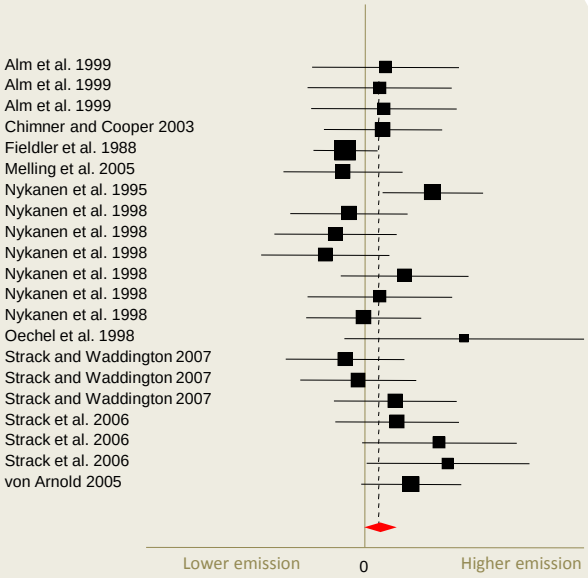
(10 articles - 21 results) - medium confidence

The overall emission of CO_2 (total respiration, measured in the dark) is greater by 141 mg CO_2 m^{-2} d^{-1} (± 100) in drained compared with undrained peatland.

RE-WETTING

(1 article) - very low confidence

There were no studies measuring total respiration. One study measured CO_2 flux over 24 hours (light+dark conditions) and did not detect any significant change in re-wetted compared with drained peatland.



Emissions of CO_2 are higher when peatland is drained compared with undrained.

Nitrous Oxide (N_2O)

NATURALLY WETTER/DRIER PEATLAND

(*1 article - 2 results*) - *very low confidence*

No significant overall difference in N_2O emissions was observed.

DRAINING *see figure*

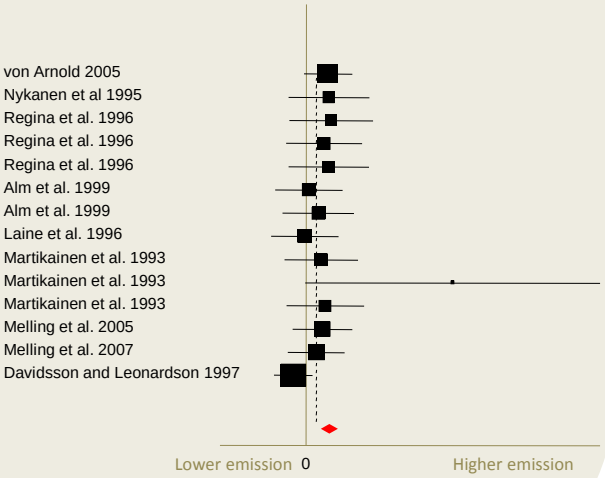
(8 articles - 14 results) - medium confidence

The emission of N_2O was higher by the equivalent of 28.3 mg CO_2 m^{-2} d^{-1} (± 37) in drained compared with intact peatland. However, the results are affected by differences in the conditions and methodologies between the studies).

RE-WETTING

(1 article) - very low confidence

Emissions of N_2O were lower by the equivalent of 2100 mg CO_2 $m^{-2}d^{-1}$ in re-wetted compared with drained peatland.



Most results suggest that emissions of N_2O are higher when peatland is drained.

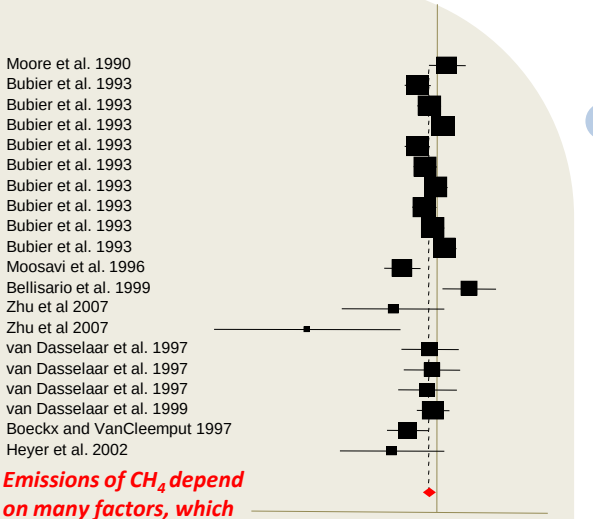
Methane (CH_4)

NATURALLY DRIER/WETTER PEATLAND

(9 articles - 20 results) - medium confidence

Wet areas emit more CH_4 than dry areas by the equivalent of 50.7 mg CO_2 m^{-2} d^{-1} (± 25).

But these results are significantly heterogeneous, meaning that factors like the mean annual temperature, soil temperature, mean annual precipitation, latitude and pH affect the emissions and, in some cases, drier areas emit more CH_4 than wetter areas.



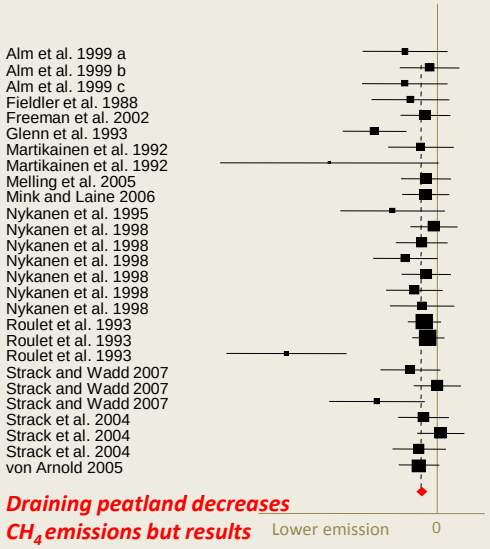
Emissions of CH_4 depend on many factors, which explains the variability of results.

DRAINING

(13 articles - 27 studies) - high confidence

Emissions of CH_4 are lower by the equivalent of 201 mg CO_2 m^{-2} d^{-1} (± 80) in drained compared with intact peatland.

Although 26 of the 27 results were less than 0 the results are significantly heterogeneous, meaning that this result cannot be generalized to all cases as other factors affect the emissions.

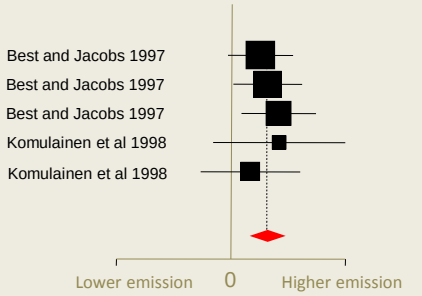


Draining peatland decreases CH_4 emissions but results are highly variable.

RE-WETTING

(2 articles - 5 studies) - low confidence

The emission of CH_4 is significantly higher by the equivalent of 403 mg CO_2 m^{-2} d^{-1} (±392) in re-wetted compared with drained peatland.



Re-wetting increases CH_4 emissions.

Brief-master: B. Livoreil, CEBC

Please note: the opinions expressed in this document are those of the Centre for Evidence-based Conservation and do not necessarily reflect the views of any persons or other organisations involved in the review.

MORE INFORMATION …

About this review: Bussell, J. , Jones, D.L., Healey, J.R. & Pullin, A.S. How do draining and re-wetting affect Carbon stores and greenhouse gas fluxes in peatland soils? *Environmental Evidence CEE 08-012*

Available at the CEE library: www.environmentalevidence.org/SR49.htm

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