Indicators and trends

Monitoring climate change adaptation

climate change
Scotland's centre of expertise connecting climate change research and policy

Indicator name				**Version**
NB18 Annual greenhouse gas (GHG) emissions from degraded peatlands				**290316**
Indicator type:	**Risk/opportunity**	**Impact**	**Action**	
		X		

SCCAP Theme	**SCCAP Objective**	**CCRA risk/opportunity**
Natural Environment	N1, N2, N3	BD1 Risk to species and habitats due to drier soils BD8 Changes in soil organic carbon AG17/AG59 Increase in greenhouse gas emissions

At a glance
• Deep peat represents a very significant carbon store - even small changes in this carbon store (a 1% loss) become comparable to other major carbon fluxes. • Projected climate change is likely to cause deterioration in the condition of deep peat habitats in some parts of Scotland, with a resulting release of stored carbon. Land management activities can compound this 'natural' process. • Current estimates of GHG emission factors are uncertain as present values are based on few relevant studies. However, evidence is increasing considerably making annual updates feasible and warranted.

Latest Figure			**Trend**
GHG emission factors	**($tCO_2e\ ha^{-1}\ yr^{-1}$)**	**Estimated annual emissions (ktCO2e)***	
a) Cultivated	37.6	**135**	Unknown, but likely to decrease slowly
b) Intensive grassland	23.2	**1020**	Unknown, but likely to decrease slowly
c) Drained	4.54 (-2.2 to 9.2)	**3320** **(-1610 to 6730)**	Unknown, but likely to be dependent upon state of drains, i.e. whether maintained
d) Regularly burnt	2.54 (-4 to 8.1)	**109** **(-172 to 349)**	Unknown

e) Afforested	-7.2 to 9.2	**-1690 to 2160**	Very dependent upon growth stage of trees; initially net sequestering but will increase as trees reach maturity
f) Bare (no vegetation)	23.84 (18 to 28.1)	**6390 (4820 to 7350)**	Unknown, but very likely to be climate dependent
g) Under extraction	12.3	**37**	Likely to decrease
a), b), e), g) from Artz et al. (2014); c), d), f) based on Smyth et al. (2014) * Estimated emissions (given to 3 s.f.) based on estimated area of each peatland category currently in Scotland (see indicator *NB13 Condition of key habitats: Area of modified deep peat soils*). Bracketed figures give potential ranges			

Why is this indicator important?

Deep peat (soils having an organic layer >50 cm deep) represents a very significant carbon store, estimated at 1620 Mt C and 56% of the total soil carbon stock in Scotland (Chapman et al., 2009). Even small changes in this carbon store become comparable to other major carbon fluxes- a loss of only 1% of the carbon in Scotland's peatland would equate to the total annual Scottish human-related emissions of greenhouse gases (Scottish Government, 2013).

The main threat for release of carbon from peatlands arises from degradation of these soils due to factors like erosion, drainage, afforestation, over-grazing, pollution and peat extraction. While land management is often at the root of these factors, this degradation can also be a 'natural 'process impacted to some extent by more recent shifts in climate. Warmer and drier conditions could increase the vulnerability of vegetation communities associated with peatlands as many species are reliant upon a very high water table. Peatland with a consistently low water table will result in the release of stored carbon, and colonisation by non-peat forming species (grasses, heather etc) which will themselves act to maintain a low water table.

This indicator uses annual GHG emissions (Emission Factors[1]) in order to calculate the total GHG emissions in CO_2 equivalents for each peatland category (areas given in indicator "NB13 Condition of key habitats: Area of modified deep peat soils"). This will then indicate where carbon losses are coming from and in which categories this is most serious. These figures also permit calculation of the carbon benefits of restoration, or, conversely, the consequences of permitting a peatland area going into a category of greater emissions. The assumption is that restoration will eventually reduce the emissions to that of a near-natural peatland, however this cannot presently be verified experimentally as there are as yet no restoration sites that have reached a near natural vegetation or hydrological status in the UK. The GHG emissions from near-natural peatland have been assessed as -3.7 to 0.3 $tCO_2e\ ha^{-1}\ yr^{-1}$ (CO_2 only; Chapman et al., 2012) or -3.1 to 5.1 $tCO_2e\ ha^{-1}\ yr^{-1}$ (including CH_4, N_2O and DOC; Smyth et al., 2014).

Related indicators:
NB11 Extent of key habitats: deep peat
NB13 Condition of key habitats: Area of modified deep peat soils
NB22a Peatland restoration area

[1] An emission factor is defined as the average emission rate of a given GHG for a given source.

What is happening now?

Current estimates show that bare and drained land accounts for the majority of annual emissions from degraded peatlands.

Present values are based on very few relevant studies; however there is a large amount of current research which is aimed at improving the estimated emission values and reducing the associated uncertainty.

What has happened in the past?

Clearly at one time peatlands were net accumulators of carbon. Most pressures are relatively recent phenomena, given that peatland formation was initiated 5,000 to 10,000 years ago. Whilst we are unable to assess past emissions from degraded peat, it is useful to consider what is known about changes in management practices that have contributed to changes in peatland degradation levels:

- Attempts to cultivate peatland were made in the eighteenth and nineteenth centuries but with little success; most of the areas now cultivated or used intensively were probably done so in the second half of the twentieth century. About this time an active programme of drainage began, funded by readily-available grants but these came to an abrupt end and there has been little further drainage (gripping) in the last thirty years.
- Management burning has probably always occurred to varying degrees in the past but took off intensively during the nineteenth century when grouse shooting became popular. This decreased considerably in the north and west of Scotland in the 1940s but continues in the south and east. Burning has also been used routinely to improve grazing, particularly for sheep, throughout the last 200 years.
- Wildfires, which can occur during drought periods and perhaps increase in frequency when drought periods coincide with the prescribed management burning period, can have significant impacts on peat condition and peatland vegetation with implications for ecosystem functionality and carbon balance.
- Afforestation of peatland began in earnest in the 1950s, particularly in south-west Scotland and continued until the 1980s, infamously in the Flow Country.
- While peat erosion is exacerbated by current land management, it may also be a ‘natural’ process, impacted to some extent by more recent shifts in climate. It is not really known when serious erosion began but there are known sites that are over 400 years old. However, many contemporary actively eroding hagg and gully systems may have been instigated by draining and burning in the recent past.
- Commercial peat extraction only took off in the early twentieth century when suitable harvesting machines were invented; however, peat cutting by hand has long been practiced, dating back to at least Roman times.

What is projected to happen in the future?

There is now considerable research on GHG fluxes from a range of peatlands within Scotland and across the UK such that we should see some reduction in uncertainties in the coming years. Effort is such that annual updates are feasible and warranted. However, there are still significant gaps where little research effort is being made currently and these will likely remain uncertainties.

The intended consequences of the drive to restore peatlands are to reduce net emissions from soils. It remains to be tested whether this can be achieved, but requires ongoing monitoring of restoration sites as these mature. Eventually we hope to be in a position to say how and where optimum restoration might be.

Patterns of change

Our current understanding is too sparse to speculate on this. A lack of current knowledge of both inter-annual variability and successional changes in peatland ecosystems means we are unable to say how these values might have or will vary both over space and time.

Interpretation of indicator trends

These are based upon knowledge of the processes involved rather than on direct measurement. Most studies have been for individual years or short runs of years, and there are almost no studies that can demonstrate changes over longer (decadal) time periods.

Limitations

The emissions data presented carry quite severe limitations. These arise as a result of the paucity of data, firstly from Scotland, secondly from the UK and similar climatic zones, and thirdly even across all non-tropical peatlands. Because Scottish peatlands are predominantly blanket peat and this peat type is globally rare, few studies are directly applicable.

In addition, the calculation of the net emission factors is based upon adding up CO2 equivalent fluxes of the GHGs CO2, CH4, N2O, and Dissolved Organic Carbon (DOC) and, in some cases, Particulate Organic Carbon (POC). It is extremely rare that all of these components are measured at any one site and hence the calculations carry a large caveat in extrapolating data across sites with different climatic conditions and management regimes. The emission factors cover CO2, CH4, N2O fluxes and DOC losses. The latter are mainly set at the IPCC Tier 1 default value of 1.14 tCO2e ha-1 yr-1 (Smyth et al., 2014). POC losses are only likely to be significant from f) (bare peat subject to erosion). None of the emission factors are based upon whole life cycle analysis, e.g. they don't include emissions due to on-site fuel use during drainage or tree harvesting, etc.

References

Artz, R., Saunders, M., Yeluripati, J., Potts, J., Elston, D. & Chapman, S. (2014) *An assessment of the proposed IPCC "2013 Supplement to the 2006 guidelines: Wetlands" for use in GHG accounting of Scottish peatland restoration*. CXC briefing. Edinburgh, Scottish Government. Available online at: http://www.climatexchange.org.uk/files/7114/1891/9640/CxCbriefing_on_the_application_of_the_2013_IPCC_wetlands_supplement.pdf

Chapman, S.J., Bell, J., Donnelly, D. & Lilly, A. (2009) Carbon stocks in Scottish peatlands. *Soil Use and Management* 25, 105-112.

Chapman, S., Artz, R. & Donnelly, D. (2012) *Carbon Savings from Peat Restoration*. ClimateXChange enquiry number 1205-02, 1-17. ClimateXChange, Edinburgh. Available online at: http://www.climatexchange.org.uk/files/4813/8356/7066/Carbon_savings_from_peat_restoration.p df

Scottish Government (2013) *2020 Challenge for Scotland's Biodiversity: A Strategy for the conservation and enhancement of biodiversity in Scotland*. Available online at: http://www.gov.scot/Resource/0042/00425276.pdf

Smyth, M.-A., Taylor, E., Artz, R., Birnie, R., Evans, C., Gray, A., Moxey, A., Prior, S., Dickie, I. & Bonaventura, M. (2014) *Developing Peatland Carbon Metrics and Financial Modelling to Inform the Pilot Phase UK Peatland Code*. Project NR0165, 1-23. Dumfries, Crichton Carbon Centre.

Further information

Lindsay,R. (2010) *Peatlands and carbon: A critical synthesis*. RSPB Scotland. http://www.rspb.org.uk/Images/Peatbogs_and_carbon_tcm9-255200.pdf

Bain, C.G., Bonn, A., Stoneman, R., Chapman, S., Coupar, A., Evans, M., Gearey, B., Howat, M., Joosten, H., Keenleyside, C., Labadz, J., Lindsay, R., Littlewood, N., Lunt, P., Miller, C., Moxey, A., Orr, H., Reed, M., Smith, P., Swales, V., Thompson, D.B.A., Thompson, P.S., Van de Noort, R., Wilson, J.D. & Worrall, F. (2011) *IUCN UK Commission of Inquiry on Peatlands*. Edinburgh, IUCN UK Peatland Programme.
http://www.iucn-uk-peatlandprogramme.org

Acknowledgements

Primary author of this document: Steve Chapman (James Hutton Institute)

Rebekka Artz (James Hutton Institute)

Appendix One: Indicator metadata and methodology

Table 1: Indicator metadata

	Metadata
Title of the indicator	Annual greenhouse gas (GHG) emissions from degraded peatlands
Indicator contact: Organisation or individual/s responsible for the indicator	Anna Moss (CXC/ University of Dundee)
Indicator data source	(Artz et al., 2014; Chapman et al., 2012; Smyth et al., 2014)
Data link: URL for retrieving the indicator primary indicator data.	http://www.climatexchange.org.uk /files/1513/7339/0076/Carbon_savings_from_peat_restoration.pdf

Table 2: Indicator data

	Indicator data
Temporal coverage: Start and end dates, identifying any significant data gaps.	Not applicable
Frequency of updates: Planned or potential updates	The recommendation in Smyth et al. (2014) is that emission rates are updated annually.
Spatial coverage: Maximum area for which data is available	Scotland
Uncertainties: Uncertainty issues arising from e.g. data collection, aggregation of data, data gaps	These are considerable and in some cases exceed 100%. The issues are complex and the reader is best referred to the indicator data sources.
Spatial resolution: Scale/unit for which data is collected	This depends on the individual measurements methodologies, which vary considerably in scale. However these are usually presented in terms of tCO_2e ha^{-1} yr^{-1}.
Categorical resolution: Potential for disaggregation of data into categories	No potential for this at present.
Data accessibility: Restrictions on usage, relevant terms & conditions	None

Table 3 Contributing data sources

Contributing data sources Data sets used to create the indicator data, the organisation responsible for them and any URLs which provide access to the data.
None

Table 4 Indicator methodology

Indicator methodology The methodology used to create the indicator data
Values are taken directly from tables in the indicator source data. The latter should be consulted to obtain the more precise origins of the summarised data.