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Profitability of Direct Greenhouse Gas Measurements in Carbon Credit Schemes of Peatland Rewetting

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ABSTRACT

MoorFutures® is the world's first carbon credit scheme from peatland rewetting. Thus far, MoorFutures® rely on proxies (greenhouse gas emission site types or GESTs) to estimate emission reductions. Here, we tested the profitability of including direct greenhouse gas (GHG) measurements of project emissions for a range of rewetting costs and vegetation scenarios based on a hypothetical MoorFutures® project. In almost all scenarios GEST assessments underestimated emission reductions compared with direct measurements. Including direct measurements was lucrative in > 50% of all vegetation scenario/rewetting cost combinations with net profits ranging from EUR −8.18 to 26.31 per certificate. Profitability was achieved at rewetting costs of ~EUR 5400 ha^{-1} upward. More sophisticated GHG measurements became profitable at twice the rewetting costs. In cases where direct flux measurements do not generate a profit they can strengthen reliability and buyers' trust and thus support higher prices of the certificates.

1. Introduction

Since 2005, a total of ~1 billion verified emission reductions (ERs, also called "carbon credits") have been transacted by individuals, businesses and governments on a voluntary basis. ERs originating from forestry and land use made up approximately half of the voluntary emissions traded in 2014 (Hamrick and Goldstein, 2015). In this context, peatlands may play an important role: Whereas they cover only 3% of the global land area, peatlands store approximately one third of all soil organic carbon (Clymo, 1987; Joosten and Couwenberg, 2008). However, land use and associated drainage have converted many peatlands to large carbon dioxide (CO_2) sources (Joosten, 2009; Maljanen et al., 2010; Updegraff et al., 2001). Peatland rewetting could represent a valuable contribution towards meeting climate change targets in a profitable way because it may constitute a considerable source of carbon credits in the future (Dunn and Freeman, 2011; Worrall et al., 2009). For the UK, Worrall et al. (2009) have shown that sales of ERs from peatland rewetting can cover the costs of restoration projects.

In Germany, MoorFutures® are sold since 2009 as the worldwide first carbon certificates to fund peatland rewetting (Joosten et al., 2015b). Similar to other carbon credits, one MoorFutures® certificate denotes an ER of one ton CO_2-equivalents. Certificates are sold *ex-ante* to be able to cover the initial high costs of the rewetting measures. The price of the certificates depends on the achieved reduction and the rewetting costs of each project (Joosten et al., 2015b). In MoorFutures® projects, the estimates of greenhouse gas (GHG) emissions before and after rewetting are based on GHG Emission Site Types (GESTs). This approach relates dominant vegetation and soil moisture to emission factors (Couwenberg et al., 2011; Couwenberg et al., 2008). GESTs have been used to estimate the climate effects of numerous peatlands in Germany (e.g. Hargita and Meißner, 2010; Weber, 2010; Ziebarth et al., 2009) and elsewhere (e.g. Hoetz, 2013; Reed et al., 2013; Voitekhovitch et al., 2011).

Currently, GESTs are also used to monitor ERs in peatland rewetting projects (e.g. MoorFutures® or UK peatland code, Bonn et al., 2014), because direct measurements of GHG fluxes have been deemed too costly (Bonn et al., 2014; Joosten et al., 2015b; Joosten and Couwenberg, 2009). However, direct measurements would increase reliability of the monitoring and could also support the issuance of more certificates, because the estimation of ERs using GESTs follows a conservative approach. Therefore, it is possible that the costs for direct measurements could (at least partly) be refinanced with sales of additional certificates.

Abbreviations: ER, Emission reduction; GEST, Greenhouse gas emission site type; VCS, Verified carbon standard

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Here, we tested the profitability of including direct GHG measurements for a hypothetical MoorFutures® project. As input data we used an older and a newer version of the GEST approach (Couwenberg et al., 2011, 2008) together with GHG measurement data from a 15-year rewetted fen (Günther et al., 2015). Based on these data, we calculated the profitability of projects for a range of possible rewetting costs and vegetation scenarios.

2. Methods

This study was based on data from a rewetted fen of ~52 ha located in north-eastern Germany (see Günther et al., 2015). The area was rewetted in 1997 as part of an EU-LIFE funded project. Here, we assumed that the rewetting measures had instead been funded through a MoorFutures® project.

2.1. Estimates of Emission Reduction by Rewetting

We used two sets of GESTs to estimate ERs, to draw conclusions about the evolution of such emission factors. Whereas the older set (Couwenberg et al., 2008) was used in the framework of the first MoorFutures® project (Joosten et al., 2015b), an updated version was published more recently (Couwenberg et al., 2011). Direct flux measurement data were taken from Günther et al. (2015), who conducted closed-chamber measurements in the study area on three vegetation stands dominated by *Phragmites australis* (Cav.) Trin. ex Steud. (common reed), *Typha latifolia* L. (common bulrush) and *Carex acutiformis* Ehrh. (lesser pond sedge), respectively. Emission factors for each vegetation stand were calculated as the mean of the annual GHG exchange over the two measurement years (March 2011 to March 2013, Table 1). Together, the three vegetation communities covered more than half of the study area (Möhring, 2013). Other vegetation communities of the study area were omitted for lack of emission measurements. We thus based our calculations on the relative proportions of the three measured dominant stands (11% *Typha*, 58% *Carex*, 31% *Phragmites*).

Following the MoorFutures® approach, we estimated ERs as the cumulative difference between emissions of CO_2 and CH_4 of the drained state (baseline scenario) and the rewetted state (project scenario) over a project period of 50 years. The baseline scenario assumes that the study area was used as high-intensity grassland with deep drainage (as it was before rewetting: Bönsel and Runze, 2005; Schröder, 2012) over the project period. Because no direct measurements of GHG exchange before rewetting were available, GEST-based emission estimates for deep-drained grassland (high-intensity, soil moisture: 2+/moderately moist, 24 t ha^{-1} a^{-1} CO_2-equivalents) were assumed as baseline emissions for both the GEST- and the measurement-based assessments. Further following the MoorFutures® methodology, we included a CH_4 emission spike by adding 10 t ha^{-1} a^{-1} of CO_2-equivalents to the emissions for the first three years of the project scenario (Joosten et al., 2015b). To meet a broad range of succession scenarios, we calculated ERs for all combinations of proportional coverage of the three vegetation stands after rewetting.

Table 1
Estimated and measured emissions (in t ha^{-1} a^{-1} CO_2-equivalents) for dominant stands of *Typha* (soil moisture: 5+/wet), *Carex* (soil moisture: 5+/wet) and *Phragmites* (soil moisture: 4+/very moist). Values were calculated using a global warming potential of 28 for CH_4 (Myhre et al., 2013).

	GEST 2008	GEST 2011	Measured
Typha	13.3	10.1	3.0
Carex	9.3	10.1	11.0
Phragmites	12.0	3.9	2.0
	(Couwenberg et al., 2008)	(Couwenberg et al., 2011)	(Günther et al., 2015)

To evaluate the difference between the two approaches, we subtracted GEST-based from measurement-based monitoring estimates. If the resulting difference is positive, the direct measurements reveal a larger ER than estimated by the customary GEST method.

2.2. Cost Estimation for Rewetting and GHG Measurements

The study area was rewetted as part of a larger peatland restoration project (Ministerium für Bau, Landesentwicklung und Umwelt, 1998). Consequently, the costs for the rewetting of the actual study area are not known. For this reason, we used a range of rewetting costs derived from literature values (Table 2). To account for the fact that costs from the literature do not include costs of sales and registration of carbon credits (which are inherent parts of the MoorFutures® scheme) an increased lower bound was used for the project implementation costs, leading to a wide range (EUR 200,000–2,000,000) of project implementation costs for our study. We chose a lower upper bound compared with the highest literature values (EUR 2,422,000), because these derive from a very small MoorFutures® project (9.7 ha) and the resulting costs will likely not be representative for larger projects. Also, the important trends should be already apparent using a tenfold range of implementation costs. We have made our calculations available as an R script in the electronic supplement. In this way, the analyses can easily be repeated with different input costs.

Joosten and Couwenberg (2009) estimate the costs for GHG monitoring on rewetted peatlands at about EUR 10,000 per hectare and year. Based on this estimate and our own experience of past monitoring projects we set the total costs of direct flux measurements in two programs of differing complexity (regarding e.g. duration or equipment, see Table 3) at EUR 150,000 ("standard") and EUR 300,000 ("scientific") for our study area. The "standard" program represents the estimated costs for basic GHG measurements aiming at the mere verification of the emission reductions in an individual project. Meanwhile, the "scientific" program aims at generating additional knowledge about the system functioning of rewetted peatlands, which could e.g. help with the planning of future rewetting projects. The "scientific" program, thus, involves more comprehensive measurements including longer duration and more ancillary data.

2.3. Estimation of Price and Profit per Certificate

For price calculations, we used the most recent GEST version (Couwenberg et al., 2011). The price of one certificate was calculated for each vegetation scenario as the total project costs divided by *ex-ante* (GEST-based) projections of ERs in tons CO_2-equivalents (see Eq. (1)).

$$Price\ (EUR/t\ CO_2eq) = \frac{Total\ project\ costs\ (EUR)}{Ex-ante\ estimate\ of\ emission\ reduction\ (t\ CO_2eq)} \tag{1}$$

Direct GHG measurements add expenditures to the total project costs, but may increase the (*ex post*) amount of certificates that can be sold.

We calculated the profitability of conducting direct measurements by multiplying the difference between GEST- and measurement-based ERs (Δ *ER*) with the price of the certificates. This value represents the total amount of money that could be gained (or lost) by conducting direct measurements. Dividing the result by the number of certificates (from the *ex-ante* GEST estimation) then yields the profit per initial certificate (see Eq. (2)).

$$Profit\ per\ certificate\,(EUR) = \frac{\Delta\ ER \times Price\ (EUR/certificate)}{Number\ of\ certificates\ (GEST\ estimation)} \tag{2}$$