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MoorFutures®

Integration of additional ecosystem services (including biodiversity) into carbon credits – standard, methodology and transferability to other regions

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AFOLU	Agriculture, Forestry and Other Land Use
ALM	Agricultural Land Management
BB	Brandenburg
BfN	Bundesamt für Naturschutz (Federal Agency for Nature Conservation)
BMUB	Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit (Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety)
BEST	Biodiversity Evaluation Site Type
CBD	Convention on Biological Diversity
CCBA	Climate, Community and Biodiversity Alliance
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
cf.	Compare
CH_4	Methane
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
CSR	Corporate Social Responsibility
DEM	Digital Elevation Model
DOC	Dissolved Organic Carbon
EEST	Evapotranspiration Energy Site Type
EIA	Environmental Impact Assessment
ERU	Emission Reduction Unit
ESS	Ecosystem Services
EU-ETS	European Union Emission Trading System
EU	European Union
GEST	Greenhouse gas Emission Site Type
GHG	Greenhouse gas
GWP	Global Warming Potential
GWT	Groundwater Table
HN	*Höhennull,* the German ordnance level
IPCC	Intergovernmental Panel on Climate Change
JI	Joint Implementation

KP	Kyoto-Protocol
LABO	Working Group on Soil Protection (Bund/Länder-AG Bodenschutz)
LANA	Working Group on Nature Conservation, Land Management and Recreation (Bund/Länder-AG Naturschutz, Landschaftspflege und Erholung)
LAWA	Working Group on Water Issues (Bund/Länder-AG Wasser)
LULUCF	Land Use, Land Use Change and Forestry
MRV	Measuring, Reporting, Verifying (quantification)
M-V	*Mecklenburg-Vorpommern*, the German Federal State of Mecklenburg-Western Pomerania
N	Nitrogen
N_2O	Nitrous oxide
NEST	Nitrogen Emission Site Type
P	Phosphorous
POC	Particulate Organic Carbon
SEA	Strategic Environmental Assessment
SH	Schleswig-Holstein
TEEB	The Economics of Ecosystems and Biodiversity
UNFCCC	United Nations Framework Convention on Climate Change
v.	Version
VCS	Verified Carbon Standard
WD	Water Supply Deficit
WLw	Long-term, median water level of the wet season
WLd	Long-term, median water level of the dry season
WRC	Wetland Rewetting and Conservation

Preface

Rewetting of peatlands implies creating synergies between nature and climate protection. Rewetting is not only a cost-effective way of reducing greenhouse gas emissions, but will also create valuable habitats, thus contributing to the protection of biodiversity. In addition, rewetted peatlands can provide numerous other ecosystem services, including nutrient retention, regulation of local climate and water resources, as well as places for recreation and leisure.

The German Federal Agency for Nature Conservation (BfN) is committed to exposing the comprehensive services that nature provides, highlighting their relevance for our economy and our well-being. 'Natural Capital Germany' is a national follow-up process to the international TEEB study, which attempts to capture both the economic importance of nature and its aesthetic, emotional and intrinsic values, by developing instruments to help society to appreciate these values. Against this background, the BfN supports the further development of MoorFutures carbon credits. Through a pilot project the additional benefits of peatland rewetting were scientifically documented, which established a basis for their inclusion in the current MoorFutures standard. Now, MoorFutures quantify not only the amount of avoided greenhouse gas emissions but also depict other ecosystem services, and the protection of biodiversity.

MoorFutures, with their well-documented additional ecosystem services, offer corporations an opportunity to offset their emissions while investing in the biological diversity and the multiple benefits of peatlands. For this reason, MoorFutures are supported by 'Enterprise Biological Diversity 2020', a project initiated by the BfN, which works together with German industry and conservation organizations to protect biodiversity.

This report provides a detailed description of the criteria and methods used to quantify the multiple ecosystem services bundled in MoorFutures. Furthermore, it provides guidance on how to transfer these criteria and methods to other regions within and outside Germany, to allow the use of extended carbon credits as a new instrument for financing peatland protection.

Learn more about MoorFutures; find inspiration and motivation in the possibilities to depict the benefits of peatlands for society and for peatland protection, globally and regionally.

Prof. Dr. Beate Jessel

President, Federal Agency for Nature Conservation

What could a sparsely populated state like Mecklenburg-Western Pomerania and its rural areas offer to public well-being? A look at gross domestic product or other economic indicators cannot fully answer this question but only provide an incomplete picture. Our nature provides comprehensive services, but their assessment and valuation is currently incomplete, because the appropriate instruments are often absent. However, these services *do* provide the basis for sustainable economic development.

The federal state of Mecklenburg-Western Pomerania has many years of experience in the rewetting of peatlands, driven mostly by nature conservation efforts. Although we knew that rewetting also benefited the climate, we could not quantify this effect. Thanks to the research of the University of Greifswald in particular, we have made considerable progress in this matter.

In Mecklenburg-Western Pomerania we have developed the *Waldaktie* ('Forest shares') and particularly also the *MoorFutures* as instruments that allow us to put a price tag on the climate benefits of forests and peatlands. Today, we are able to quantify these climate benefits (as one of many benefits) and open a market for private investment, thus further expanding our role as a pioneer federal state. We are selling MoorFutures as carbon credits on the voluntary carbon market – together with the federal states of Brandenburg (since 2012) and Schleswig-Holstein (since 2014).

I am very pleased that it is now possible to quantify other benefits of rewetted peatlands besides climate change mitigation. This document will explain the background to the first carbon credits from peatland rewetting and their development, including additional ecosystem services. The document provides concrete help to transfer this successful model within and outside of Germany.

Dr. Till Backhaus

Minister for Agriculture, Environment and Consumer Protection, Mecklenburg-Western Pomerania

1 Introduction

The Federal government of Germany co-initiated and substantially funded the international TEEB-Process (The Economics of Ecosystems and Biodiversity). TEEB aimed to make the importance of the environment more visible, and as such to raise its profile in the decision making process. A key conclusion of the TEEB study was that the explicit consideration of Ecosystem Services (ESS), including biodiversity, substantially improves the basis of decision making across a broad spectrum of political issues (TEEB 2010). ESS are direct and indirect contributions of ecosystems to human wellbeing − i.e. services and resources that offer direct or indirect economic or material returns or improvements to physical or psychological human health (NATURKAPITAL DEUTSCHLAND – TEEB DE 2012). 'Natural Capital Germany – TEEB DE' strives to build upon the international process at a national level and thus supporting the implementation of the goals of the National Strategy on Biodiversity (BMU, 2007). The present report introduces MoorFutures as a concrete example of how the TEEB recommendation on the explicit consideration of a variety of ESS, including biodiversity, can be implemented in Germany.

Rewetting of drained peatlands reduces emissions of greenhouse gases (GHG). MoorFutures are carbon credits that map these emission reductions. The credits are sold to offset unavoidable emissions produced by corporations, organisations and individuals; revenues are used to finance the rewetting. MoorFutures were introduced in Mecklenburg-Western Pomerania in 2010 as the first carbon credits issued for peatland rewetting in the world. The credits are currently sold in the German federal states of Brandenburg and Mecklenburg-Western Pomerania and Schleswig-Holstein (www.moorfutures.de).

Rewetting and the associated regeneration of peatlands offers a range of important ESS besides emission reductions, including nutrient retention, regional water and climate regulation, and the protection of biodiversity. These other ESS have so far not been considered or been accounted for as added value to the carbon benefits. Consequently, MoorFutures are competing with a range of other carbon credits on the voluntary carbon market without any advantage from their considerable additional ecological value. An integrated standard for MoorFutures should make these additional ecological values visible for a range of ESS, including biodiversity.

This report presents the findings garnered during the 'F+E' (Research and Development) Project 'Integrated Peatland Offset Standard: Certifying the ecological co-benefits of CO_2 offsets from peatland rewetting' (2011-2013), funded by the Federal Agency for Nature Conservation with the support of the Federal Ministry for the Environment. In this project MoorFutures generated by the rewetting of the Kieve Polder (Mecklenburg-Western Pomerania) were further developed, quantifying additional ESS, thus following the rationale behind the TEEB initiative. These additional ESS can now be mapped for the MoorFutures project area of the Kieve Polder. The rewetting of this polder is the first peatland rewetting that was financed through MoorFutures.

Chapter 2 offers a general overview of the climate impact of peatlands and their position in both the mandatory and voluntary carbon markets. The depiction of additional ESS is addressed as well. Following DE GROOT (1992) and JOOSTEN & CLARKE (2002), biodiversity is not viewed as an overarching term for all ecosystem functions, but rather as an informational function (cf. DE GROOT et al. 2002, BOYD & BANZHAF 2007, FISHER & TURNER

2008). Chapter 3 considers the prevailing criteria used in voluntary carbon markets, while in Chapter 4, those criteria most relevant to the MoorFutures standard are analysed. Besides the MoorFutures standard, Chapter 4 also describes the methodology used to quantify emission reductions as well as its implementation in the Kieve Polder project. A description of other ESS follows in Chapter 5, adhering to the criteria given in Chapter 3. The possibilities and limits of transferring the knowledge gained in the Kieve model area to other peatlands, including the further development of the MoorFutures standard to cover additional ESS, are considered in Chapter 6. Finally, the degree to which such a standard might be implemented in other regions and states is explored in Chapter 7.

2 Peatlands, climate and carbon markets

2.1 Peatlands and climate

Although they occupy only 3% (4,000,000 km^2) of the land area of the world, peatlands contain 500 gigatonnes of carbon in their peat (i.e. twice the total amount of carbon in the biomass of all the world's forests). The enormous soil carbon stock is the most important characteristic of peatlands: peatlands are land with peat, and peat largely consists of carbon (JOOSTEN & COUWENBERG 2008, JOOSTEN 2011). Consequently, peatlands are the most space-effective carbon store of all terrestrial ecosystems. In the boreal zone, peatlands contain on average seven times more carbon than other ecosystems; in the tropics even ten times more. Even the giant redwood forests in the Pacific Northwest of America (before they were exploited and only on a very small area) contained only half the amount of carbon found on average in peatlands − on a hectare basis.

Peat is preserved by water saturation. As long as peatlands are wet, the carbon remains stored virtually forever, and the peat changes over time into lignite (brown coal) and anthracite (black coal). The carbon store grows slowly but steadily by the addition of fresh plant material, which is converted into peat. In this way, thick layers of peat are deposited over time.

Wet, peat accumulating peatlands (mires) affect the GHG balance in two ways. They fix carbon. CO_2 is captured by the vegetation and partly deposited in the newly forming peat as carbon. Peat formation extracts CO_2 from the atmosphere 'forever'. On the other hand, they release methane (CH_4). Under the wet conditions necessary for the formation of peat, part of the plant material is decomposed anaerobically, resulting in the emission of methane (CH_4) to the atmosphere. As a greenhouse gas, methane is 25 times more potent than CO_2.

The net climate effect of these two processes differs depending on the type and age of a peatland. On a global scale, both processes are more or less in balance − i.e. natural peatlands are a global CO_2 sink of 150-250 million tonnes CO_2e and a global CH_4 source of 200 million tonnes CO_2e per year (JOOSTEN & COUWENBERG 2008). In the long-term, the climate effect of CO_2 uptake is more important than the CH_4 emission because CH_4 decays relatively quickly with an atmospheric residence time of 12 years (FORSTER et al. 2007). As a result, peatlands have had a cooling effect on the global climate for 10,000 years (FROLKING et al. 2006).

If a peatland is drained, the peat is no longer saturated with water and oxygen penetrates the peat. Under the now established oxic conditions the emission of CH_4 stops, but CO_2 and often nitrous oxide (N_2O) − a GHG 298 times stronger than CO_2 − are emitted because of aerobic decomposition of the peat. These emissions continue as long as the peatland remains drained, which usually means decades to centuries. This combination of 'large' and 'long-lasting' distinguishes the climate effect of drained peatlands from, for example, the destruction of tropical forests. Associated peat fires may increase GHG emissions even further (JOOSTEN 2011).

The drained peatlands of the world are responsible for a substantial proportion of anthropogenic GHG emissions. The 500,000 km^2 of drained peatlands worldwide emit an estimated 2 gigatonnes of CO_2 per year. In other words, 0.3% of the global land area is responsible for 5% of global anthropogenic CO_2 emissions. The major hot spots of these

emissions are Indonesia, the European Union, Russia, China and the United States. Germany also ranks high on the list of peatland CO_2 emitting countries (JOOSTEN 2009). In Germany, the annual GHG emissions from agricultural peat soils amount to 43 million tonnes CO_2e, representing 54% of the total emissions from agricultural soils, although peat soils represent only 6% of all agricultural land (UBA 2014).

Where is Mecklenburg-Western Pomerania?

The use of peatlands in Mecklenburg-Western Pomerania has a long history. Early use focussed on making rough hay for horse keeping. During the mid-18th century, the first large-scale drainage measures were carried out to produce fodder for cattle as well. Use of peatlands for dairy farming was only possible after the large-scale drainage of the 1970s. Water-regulating measures (poldering, drainage, canals) aimed at groundwater levels between 40 and 80 cm below the surface to enable growing fodder crops (sown grasslands). By the 1980s, peatland degradation and irreversible changes in soil properties became apparent, and soil subsidence required regular investment in water management facilities.

After 1990, the agricultural use of peatlands was questioned because of a significant decline in livestock, growing demands on forage quality for dairy cattle, and the increasingly dilapidated water management systems. After a Baltic Sea flood inundated large coastal areas of dyked peatland, the state government decided in late 1995 to develop a peatland protection plan, which was adopted in 1997 and updated in 2009.

The peatland rewetting measures implemented until 2008 decreased the total amount of annual emissions by about 300,000 tonnes CO_2e compared with 2000. However, the annual GHG emissions in 2009 still were about 6.2 million tonnes CO_2e. Drained peatlands remain the largest source of GHGs in Mecklenburg-Western Pomerania (MINISTERIUM FÜR LANDWIRTSCHAFT, UMWELT UND VERBRAUCHERSCHUTZ MECKLENBURG-VORPOMMERN 2009).

2.2   Peatlands in international climate protection agreements

The United Nations Framework Convention on Climate Change (UNFCCC) aims at achieving "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" (article 2 UNFCCC). Progress towards this goal is monitored by means of national GHG inventories. These inventory reports follow guidelines issued by the Intergovernmental Panel on Climate Change (IPCC). The reporting contains six sectors, including the one on Land Use. Emissions from peatlands can be reported under any of the six land use categories (forest land, cropland, grassland, wetlands, settlements, other lands).

With the Kyoto Protocol (KP), industrialized countries and countries with economies in transition (the 'Annex I countries' of the UNFCCC) have agreed to legally binding emission limitations and reductions. To achieve the reduction as efficiently as possible, the KP contains flexible mechanisms in the form of emissions (or carbon) trading. These are the flexible mechanisms that an Annex I country can use:

- If it has reduced more than the agreed amount, it can sell its surplus in emission permits to another Annex I country with a deficit (International Emissions Trading, IET).

- It may finance a GHG emission reduction project in another Annex I country (Joint Implementation, JI). In return, it receives the carbon credits achieved by that project (Emission Reduction Units, ERUs).

- It may finance a GHG emission reduction project in a developing country (Clean Development Mechanism, CDM). In return, it receives the carbon credits achieved by that project (Certified Emission Reductions, CERs).

What are carbon credits?

Carbon credits are permits for GHG emissions that are traded on markets as part of a 'cap and trade' system. The trading of pollution permits is based on the fixed-quantities approach of DALES (1968), originally developed for water quality protection. The basic idea is that a state (or, in the case of climate change, a community of states) limits (or 'caps') the amount of emissions for a given time period. The emitters receive so-called emission permits that entitle them to a fixed amount of emissions per unit of time. These permits (also known as allowances or credits) are transferable and can be traded on the market ('trade'). The price of a credit is established through supply and demand. Companies can decide whether they can avoid the emissions at lower cost or whether to buy credits on the carbon market. Thus, a politically predetermined environmental target can be achieved through the use of market mechanisms at minimal economic costs. An important condition for credits trading is that the legal and institutional frameworks are in place. Credits constitute a right of use, thus it is required to clearly state the ownership. The owner has the right either to emit or sell the specified amount of GHGs. It is important that ownership rights are fixed in the contract and recognized by an independent institution (e.g. the government) and can be enforced (SCHÄFER et al. 2012).

The main objective of the Kyoto Protocol is to reduce emissions from industrial sources. At the same time, it allows for compensating these emissions through improved land management (in the KP referred to as Land Use, Land Use Change and Forestry, LULUCF). This option was applied only to a limited extent in the first KP commitment period (2008-2012). Accounting was mandatory only for the activity of 'afforestation, reforestation and de-forestation' (ARD); the remaining LULUCF activities could be chosen on a voluntary basis. Besides the activity of 'forest management' − which was elected by about half of the countries, hardly any of the voluntary activities were accounted for. For the second commitment period (2013-2020) 'forest management' has become mandatory for all Annex I countries. Accounting for other land use activities (e.g. the new activity 'wetland drainage and rewetting') has remained voluntary.

Although the *activity* of 'wetland drainage and rewetting' − if chosen, only applies to organic soils that have been drained or rewetted since 1990 and that are not already accounted for under another mandatory or voluntary activity, the *practices* of 'draining' and 'rewetting' can occur in all LULUCF activities and must be reported and accounted accordingly (Table 1).

So far, Germany has hardly used the existing opportunities to account for emission reductions through peatland rewetting to fulfil its KP obligations. One exception is the rewetting of drained peatland forests (which falls under the activity 'forest management', elected by Germany for the first commitment period). Emission reductions from 'reforestation' in rewetted peatland areas must be accounted mandatorily. However, only the emissions and removals during the commitment period are considered under this activity, without comparing these to a reference. As a result, the long term emission reductions from avoided peat degradation are not taken into account (cf. Chapter 3.9).

In March 2012, the European Commission recommended the European Parliament and the Council of Europe to make the accounting of 'cropland and grazing land management' mandatory for all EU parties. With the decision of the Parliament and the Council of 21 May 2013, the GHG reporting and accounting rules for the LULUCF sector were established "as a first step […] towards the inclusion of the LULUCF sector in the Union's emission reduction commitment". For the second Kyoto commitment period (2013-2020) GHG fluxes from 'afforestation', 'reforestation', 'deforestation' and 'forest management' must be accurately accounted for. For 'cropland management' and 'grazing land management', the EU requires such accounting from 2021. Member states may prepare and maintain annual accounts of emissions and removals in relation to the activity 'wetlands drainage and rewetting', although accounting is not compulsory. According to the above mentioned decision, the EU "should endeavour to advance the issue [of peatlands] at the international level with a view to reaching an agreement within the bodies of the UNFCCC or of the Kyoto Protocol on the obligation to prepare and maintain annual accounts of emissions and removals from" peatlands drained or rewetted since 1990, "with a view to including this obligation in the global climate agreement to be concluded no later than 2015."

Apart from all this, emission reductions from LULUCF activities are currently not recognised under the European Union Emissions Trading System (EU-ETS) (SCHÄFER et al. 2012).

Table 1: Overview of LULUCF activities under the Kyoto Protocol with examples of the practices of 'drainage' and 'rewetting' that must be reported under the respective activity. * = mandatory accounting; # = mandatory accounting if elected by the party for the first reporting period.

Activity	Practice
Deforestation*	• Felling and draining of a forest on organic soil and subsequent conversion to cropland or grassland.
	• Timber harvesting that results in reduced evapotranspiration and consequent higher water tables that prevents re-establishment of forest.
	• Rewetting of forest that raises the water table to such an extent that the forest cannot persist or regenerate.
	• Rewetting and felling of forests, e.g. to restore a non-forested peatland.
Afforestation/ Reforestation*	• Drainage of a (non-forested) peatland for forestry, e.g. when a treeless or sparsely treed peatland is drained to stimulate tree growth.
	• Rewetting of a (non-forested) peatland for forestry, e.g. when grassland on organic soil is rewetted and afforested with Alder trees.
Forest Management*	• Drainage of forest on organic soil that remains a forest, e.g. when a forested peatland is drained to stimulate tree growth.
	• Rewetting of forest on organic soil that remains a forest, e.g. when an Ash forest on organic soil is rewetted and replaced by an Alder forest.
Cropland Management (if elected)#	• Drainage of a (non-forested) peatland and conversion to cropland.
	• Rewetting of a cropland on organic soil that remains a cropland, e.g. when a potato field on organic soil is rewetted for paludiculture.
Grazing Land Management (if elected)#	• Drainage of a (non-forested) peatland to improve grazing.
	• Rewetting of grassland on organic soil that remains grassland, e.g. when a drained grassland used for dairy cow husbandry is rewetted to a grassland for water buffalo husbandry.
Revegetation (if elected)#	• Revegetation and rewetting of a (non-forested) peatland, e.g. when a bare peat extraction site is converted to a vegetated wetland.
Wetland Drainage and Rewetting (if elected)	• Rewetting or draining (after 1990) of a (non-forested) peatland that is not yet accounted for under any other mandatory or elected activity.

2.3 Peatlands and the Voluntary Carbon Trading System

Whereas peatland rewetting and other land use activities to-date have hardly been accounted under the Kyoto Protocol, the voluntary carbon market is much more active in this area. In 2012, land use projects comprised some 32% of the voluntary market size (24 million tonnes of CO_2e; PETERS-STANLEY et al. 2013). The voluntary market offers corporations and individuals an option to compensate for their unavoidable emissions.

As nothing is more easily damaged than a good reputation, the voluntary market has developed very high quality standards. Several voluntary carbon standards have been developed in recent years, which partially lean heavily on the criteria of the CDM with respect to methodology and marketing strategy. A detailed comparison of the various standards is found in HELD et al. (2010). The Verified Carbon Standard (VCS, www.v-c-s.org) is the most important standard for land use projects; it is the only standard that has developed its own programme for peatland projects. Forest and agricultural projects have been allowed within

VCS since the beginning of 2007, whereas peatland projects are possible since March 2010 with the introduction of 'Wetland Rewetting and Conservation' (WRC) (VCS 2012, TANNEBERGER & WICHTMANN 2011). MoorFutures follow an own standard that strongly builds on VCS (see Chapter 4). MoorFutures were the first carbon credits issued for peatland rewetting in the world.

Global and regional carbon markets

In generating carbon credits, fulfilling the strict VCS criteria is associated with high costs. For new project types (like peatland rewetting) a methodology must be developed that details how emissions and emission reductions are assessed. Such methodology must then be verified by at least two independent consultants. The next step is to create a Project Design Document (PDD, or Project Description PD) that details the project objectives, estimates of emissions and practical measures. Besides the practical costs of technical implementation, management and monitoring, additional costs arise from independent validation of the project and verification of its results. The strict requirements that guarantee the high quality of the credits imply administrative costs of a voluntary carbon project of several tens of thousands of Euros. Consequently, it becomes prohibitively expensive, particularly for smaller scale projects applying a globally valid standard like VCS. Regional standards like MoorFutures offer a very good alternative to reduce costs. They usually operate within a fixed set of juridical rules and regulations that need not be assessed independently. Moreover, they address a different market that is far more personal and transparent compared with the anonymous global carbon market. Good regional standards deliver carbon credits of the same quality, but at a considerably lower cost.

2.4 Carbon Credits from Peatlands and the Mapping of other Ecosystem Services

Of the many Ecosystem Services (ESS) that peatlands offer until now only their climate regulation function has been put to the market. This commodification allows for compensation of unavoidable GHG emissions through the purchase of carbon credits (adhering to the principle of 'the polluter pays'). The possibility to quantify and put a price on the climate services of peatland conservation and rewetting provides peatland protection with quantitative financial arguments, bringing it face-to-face with peatland destruction and drainage.

However, the commercialisation of climate services carries with it the danger of a partial, single-dimensional view of peatlands. The value of a peatland may be reduced to its climate services whilst other ESS are neglected or even damaged. Outside of markets, the other services offered by peatlands are increasingly acknowledged (cf. Chapter 2.2, see also JOOSTEN & CLARKE 2002, JOOSTEN et al. 2012), quantified and monetized (cf. SCHÄFER 2009, GÓMEZ-BAGGENTHUN 2010). Generally, climate protection can coexist with effective, all-encompassing peatland protection, but in some cases optimisation for climate effect can damage other ESS. Thus far the effect on other ESS of peatland rewetting for climate benefit has hardly been considered. Yet, market research shows that the voluntary purchase of carbon credits by companies often occurs as part of a portfolio that contains other Corporate

Social Responsibility (CSR) activities, indicating a willingness to pay for additional ESS (SETTELMYER & EATON 2010).

In principle other aspects of sustainability can be taken into account in carbon projects. The CCBA Standard, developed by the Climate, Community and Biodiversity Alliance, is exemplary, as it can be used for all land use projects. However, the CCBA does not issue independent credits like VCS does, but rather provides additional certification for existing credits. The CCBA Standard identifies land use projects that, along with tradable GHG reductions, also offer positive net effects for local communities and for biodiversity. Verification demands the fulfilment of additional requirements related to biodiversity conservation and sustainable development. The criteria for the quantification of additional benefits provided by the CCBA are less comprehensive than those used in MoorFutures.

As previously mentioned, the 2010 TEEB synthesis report concluded that the explicit consideration of several ESS (including biodiversity) fundamentally improves the basis for decision making across a wide range of political tasks. Such consideration requires that ESS are better assessed and made more visible in specific situations, namely using qualitative, quantitative or monetary valuations.

There are two options for representing and selling additional ESS in form of credits: Layering and Bundling. In layering individual ESS are represented and sold separately. Besides carbon credits, additional, distinct credits (e.g. for improved water quality or increased biodiversity) would be sold. Layering is possible when the ESS can be commodified individually and a market demand for the individual services exists. In agriculture layering of by-products is a well-established practice: shepherds sell meat and wool, arable farmers sell wheat and straw, and winemakers sell both wine and pomace brandy. However, if there is no demand for a specific product − for instance, sheep wool − it must be thrown away.

Bundling is the combination of various ESS into a single, complete package. The positive effects of peatland rewetting and conservation measures (for instance, in relation to emissions, water quality, biodiversity and fire protection) are offered together as a single credit. Bundling makes sense when only single ESS can be commodified. Additional ESS must not be included for free (so-called 'piggy-backing'), but allow for charging higher, premium prices. Bundling is common in central European land use. Farmers produce marketable private goods and non-marketable public goods (biodiversity, for example) in one and the same field. Many of the additionally produced public goods cause additional production costs, resulting in higher prices (bio-production is more expensive, for example), which the consumer is in fact prepared to pay. Similarly, carbon projects in the land use sector are often more expensive than projects offered in other sectors (e.g. energy). Buyers – both individually and corporately – are usually prepared to pay a higher price when additional services are included in a transparent way.

The quantification of additional ESS is an important step in the further development of carbon credits. Well-quantified additional ESS are more easily marketed as (carbon) credits, which facilitates the acquisition of additional funds for peatland rewetting and conservation. The quantification of additional ESS is furthermore of central importance in promoting a comprehensive understanding of peatlands with all of their ESS. It allows for a transparent representation of both the private and public costs and benefits of (not) rewetting, which is fundamental to the future development of regulations and incentives for peatland utilisation

(SCHÄFER 2012). The benefits of many ESS can be monetised through suitable socio-economic evaluation methods, which have been developed over the last 50 years. For more information on this topic, and the role of economy and ecosystem services for nature conservation see HANSJÜRGENS et al. (2012), HANSJÜRGENS & HERKLE (2012) as well as in Chapter 5 of the TEEB Report (TEEB 2010).

TEEB: Why should there be an economic perspective on the ESS of peatland?

(Augustin Berghöfer)

The products and services of nature have long been seen as self-evident and used free of charge. However, the societal costs of using and damaging ecosystems are becoming more prevalent and more obvious. Clearly, conservation and the sustainable use of nature are worthwhile from an economic perspective. The 'Natural Capital Germany' project aims to make visible the value of the environment while pointing the way to a sustainable use of ESS. An economic evaluation of nature encompasses the recognition, assessment and integration of the value of nature into decision making.

Yet, an economic appraisal of the environment may be misunderstood as a call for privatisation and commodification of the services provided by nature. For this reason, TEEB and 'Natural Capital Germany' stress the 'intrinsic value' of nature besides its profitable aspects. The economic perspective should help develop a more comprehensive understanding of a fair approach to scarce goods and services, including ESS and biodiversity. In this sense, it is not so much about having a well-reasoned 'perfect' bundle of ESS that a peatland must generate. The point here is rather to show how a decision to promote one specific ESS affects other values and services, as well as how individual ESS can contribute to economic welfare.

Clearly, climate and nature conservation motives are part of the many demands we put on peatlands. A 'semi-natural', or 'intact', or 'biodiverse' peatland fulfils only one of many possible peatland target states, which might all be equally legitimately formulated. The choice of target to pursue is the result of societal negotiations, for which it is helpful to compare public costs and benefits for a particular use of peatland with private costs and benefits. For instance, are we using public money to encourage peatland use that increases societal costs (negative external effects)? And if so, how do public and private costs and benefits relate to each other? Are political instruments − like legal provisions and subventions − incentivising private profit to social detriment, albeit unintentionally?

A systematic economic analysis could clarify the benefits provided by ESS, thus allowing for a better integration of these benefits into private and societal decisions (NATURKAPITAL DEUTSCHLAND – TEEB DE 2012).

3 Criteria for the generation of credits for the carbon market

3.1 Introduction

Criteria for credits on the voluntary carbon market were developed to ensure that projects indeed achieve their planned reduction of GHG emissions in a verifiable manner (quality assurance). The most important criteria are:

- Additionality

- Measurability

- Verifiability

- Conservativeness

- Reliability

- Sustainability

- Permanence

In light of these criteria, consideration must be given to:

- Reference scenario (baseline)

- Project period

- Leakage

This chapter introduces the various ways these criteria are approached in the most frequently used standards. A *standard* (e.g. VCS Standard 3.4, October 2013) defines all the specific requirements for developing projects and methodologies, as well as for the validation, monitoring and verification of projects. A *methodology* encompasses a set of methods and rules for measuring, reporting and verifying (MRV) the effects and outcomes of the project. Next, a concrete project is presented in a *Project Description* (*PD* for VCS projects; Project Design Document, *PDD* for CDM/JI and CCB projects). Such document specifies the project measures and a monitoring plan for a defined project area. GHG emission reductions are assessed against a baseline scenario. A PD (or PDD) is used for project validation and provides the basis for the issuing of credits generated by a project.

3.2 Additionality

One of the criteria at the heart of carbon projects is additionality. Additionality means that the positive climate effect would not have occurred without the revenue from the sale of credits (RAYMOND 2010). Spontaneous developments or developments that happen anyway − e.g. because they are required by law or are attractive from an economic standpoint − are not 'additional' even if they result in a substantial reduction in GHG emissions.

Although the principle of additionality is stated in simple terms, assessing whether an individual project is additional can be difficult. In practice, a project is considered additional when it includes activities that are only possible with the economic incentive provided by the sale of carbon credits. However, not all the necessary funds must come

from the sale of carbon credits. It must only be demonstrated that the project, whether it receives additional funding or not, could only be implemented if credits are sold. With the revenue from the credits, the economic viability threshold can be crossed. Therefore, the criterion of additionality is primarily an economic criterion. It may encompass economic incentives to persuade farmers or other land users to accept rewetting of their land.

Projects may also be considered additional if, for example, limited public resources are available for an extensive project portfolio and a prompt implementation is not possible. Only an actual implementation of measures is decisive in assessing additionality. So if just a small number of peatland rewettings are carried out despite the existence of funding programmes and supporting directives, further peatland rewetting for the generation of carbon credits may be considered additional.

There are currently no uniform guidelines for fulfilling the criterion of additionality. Authorities and organisations employ at least a dozen different interpretations, tests and criteria depending on their own needs, requirements and perspectives. Different standards use different (combinations of) criteria (STRECK 2010). The selection of these criteria determines to a great extent how many credits a project may generate, how high the associated costs are and whether or not the project is economically viable. The downside of additionality is that regions where climate action was established early on are disadvantaged by a strict interpretation of the criterion, because developments apparently 'would have happened anyway'. A case in point is Mecklenburg-Western Pomerania, which in the past has carried out many peatland rewetting projects, including climate protection purposes. Regions with a weak record of rewetting are at a comparative advantage.

3.3 Measurability

Carbon markets require that emission reductions achieved by a project are quantified in a transparent and verifiable way. A logical approach for a peatland rewetting project would be the direct measurement of GHG fluxes at the site before, during and after rewetting.

Corresponding techniques for the precise measurement of GHG fluxes exist (MINKE et al. 2011). Closed chambers allow for flux measurements on small areas (several dm^2 to 1 m^2) (LIVINGSTON & HUTCHINSON 1995, DRÖSLER 2005). The eddy covariance technique can be used to measure GHG fluxes over larger areas (typically up to 1 km^2) (BALDOCCHI et al. 1988, LENSCHOW 1995).

GHG fluxes depend on a variety of site parameters − such as water table, temperature, vegetation growth and land use, which can fluctuate greatly within and between years (ROULET et al. 2007, NILSSON et al. 2008, MALJANEN et al. 2010). To determine annual GHG balances, frequent measurements need to be carried out over a long period of time (several complete years) to account for daily, seasonal and annual variability. Furthermore, a sufficiently dense network of observation points is needed to capture small-scale spatial patterns.

These requirements and labour-intensive, complex techniques make comprehensive direct GHG measurements unaffordable as a standard monitoring tool. JOOSTEN &

COUWENBERG (2009) estimate the costs at ca. €10,000 per hectare and year. In practice, direct measurements can only be used in selected areas in order to develop, calibrate and verify models with which GHG fluxes can then be estimated over much larger areas. As these models must be practicable and verifiable (reproducible, see below) simple input parameters are preferred (i.e. the models should be based on simple proxies). Four proxies have emerged as suitable: land use, water table, subsidence and vegetation.

Land use: Current reporting to the UNFCCC and the KP commonly uses default emission factors, as defined by the IPCC for various land use categories and climate zones. For peatlands, the '2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands' (HIRAISHI et al. 2014a) and the '2013 Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol' (HIRAISHI et al. 2014b) provide the most recent guidance. The default values for the temperate climate zone include only a few land use (sub-) categories and are rather approximate. If peatland emissions make up a significant portion of their national emissions, countries are expected to develop values that are more specific.

Water table: Meta-analyses of a wide range of data from across the world have shown that mean annual water table is the best single variable explaining annual GHG fluxes from peatlands (COUWENBERG et al. 2008, 2011; COUWENBERG & FRITZ 2012). However, the use of water table as a proxy requires a high spatial and temporal density of water table data. Monitoring water tables by means of modelling is more cost-effective in the long term. At present, remote sensing cannot yet be used for direct mapping of ground water tables in drained peatlands (cf. JAENICKE et al. 2011).

Subsidence: Subsidence (loss of peat height because of shrinkage and oxidation) is a very promising proxy for GHG emissions, particularly in the tropics. Subsidence shows a linear correlation with average water table depth (VAN DEN AKKER et al. 2008, COUWENBERG et al. 2011) but rates vary in different parts of the world. A VCS methodology that, among other proxies, allows for using subsidence as a proxy, is currently in the validation phase (www.v-c-s.org).

Vegetation: Plant species and vegetation have long been used as indicators of site conditions. Especially, classification approaches that integrate floristic and environmental parameters may reach a high level of precision (e.g. the vegetation form approach, cf. KOSKA et al. 2001, KOSKA 2007). Such approaches use the combined presence (or absence) of plant species to achieve a sharper indication than offered by individual plant species (such as Ellenberg's indicator values).

Vegetation appears well suited as a proxy for GHG fluxes (COUWENBERG et al. 2008, 2011) because:

- it is a good indicator of the mean water table, which in turn correlates strongly to GHG fluxes;

- it is controlled by various other site factors which also determine GHG emissions from peatlands, e.g. nutrient availability, soil reaction (pH) and land use (history);

- it is itself directly and indirectly responsible for a major share of GHG fluxes, as it regulates the exchange of CO_2, provides organic material (including root exudates)

for the formation of CO_2 and CH_4, influences peat moisture levels and temperature, and provides potential bypasses for CH_4 fluxes via aerenchyma ('shunt species', cf. JOABSSON et al. 1999);

- it reflects long-term water tables and thereby provides an indication of average, long-term GHG fluxes;

- it allows for small-scale mapping, e.g. on a scale of 1:2,500 - 1:10,000 (JOOSTEN & COUWENBERG 2009).

Regional variation in competitive interactions and in ecotypes may result in different indicator values for the same species (KOTOWSKI et al. 1998, KOSKA et al. 2001, HÁJKOVÁ et al. 2008). Therefore, for being able to use vegetation as a proxy for GHG fluxes, the relationship between vegetation, water table and fluxes must be calibrated for separate climatic and phytogeographical regions.

3.4 Verifiability

An independent third party must be able to verify the quantification of emission reductions on the basis of previously defined criteria. This verifiability is a central requirement of most standards. Verifiability requires a detailed methodology describing the criteria for monitoring emissions and emission reductions over time (typically with annual resolution). Verifiability includes:

- the validation of the project, which ensures that the project conforms to the requirements of the standard, as well as that the proposed methodologies are suitable for this project type, and

- the verification of periodic monitoring reports (typically compiled every five to ten years) and the claim on emission reductions.

In most cases, carbon credits are only issued *ex post*, i.e. after emission reductions have been achieved and verified.

At present there are only few accredited, sufficiently experienced assessors capable of evaluating peatland projects. The VCS is currently discussing whether assessors already accredited for Agriculture, Forestry and other Land Use (AFOLU) are able to assess peatland projects as well, or whether special assessors with sufficient knowledge of peatlands should be trained and accredited.

3.5 Conservativeness

GHG fluxes from land vary greatly in time and space − for example owing to differences in temperature and water tables. Various procedures exist for calculating reductions and translating them into actual credits. The default values defined by the IPCC refer to average fluxes. In contrast, the voluntary market (e.g. the VCS) demands that emission reductions are estimated 'on the safe side' (i.e. conservatively). In this way, the promised amount of emission reductions can be guaranteed. A conservative approach means that emissions should be underestimated in the baseline and overestimated in the project scenario. Of course, an overly conservative estimate unnecessarily lowers the number of credits. Uncertainty should be reduced as much as possible to maximise the number of credits. To

this end, more precise flux assessment methods should be developed to improve measurability (including transparency and verifiability).

3.6 Reliability

Carbon credits are analogous to property rights, which must have a definite owner, who has the right to emit or sell the specified amount of GHG emissions. It is crucial that the right of ownership is established contractually, is recognised by an independent institution (e.g. the government) and can be enforced.

When selling the credits, the owner cedes all associated ownership rights. Complete and reliable documentation is necessary not only to avoid double selling but also to create confidence in the market. For this reason, the trading of carbon credits must be documented indisputably in central registries. The Bank of New York Mellon has had a registry in place since June 2006, in which the purchase and sale of voluntary carbon credits can be monitored transparently (www.bnymellon.com/foresight/pdf/vcu.pdf). Nearly all the leading global standards are accredited in this registry or in other central registries, thus ensuring the necessary trust in the carbon market.

3.7 Sustainability

Carbon projects can also contribute to improved socioeconomic conditions or, in other words, be 'sustainable' in the sense of the Brundtland Report (WORLD COMMISSION ON ENVIRONMENT AND DEVELOPMENT 1987). At the very least, projects should not contribute to the deterioration of socioeconomic conditions.

Particularly the voluntary carbon market with its focus on corporate social responsibility is very open to sustainability aspects. Lack of acceptance within the region and negative publicity can cast a cloud over the desired positive impression. A carbon project aimed at well-marketable credits should bear such risks and opportunities in mind, and address these at an early stage with appropriate local and regional awareness and information campaigns. Local and regional representatives plus stakeholders should be involved in decision-making processes as early as possible.

3.8 Permanence

In some projects, it is clear that emission reductions cannot be reversed; they are permanent. For example, methane from a rubbish dump that is captured and burned cannot be turned back into methane, and the emission reductions are permanent as a result.

In contrast, the sequestration of GHG in ecosystems can be reversed and may not be permanent. Sequestration of carbon through afforestation can be undone intentionally (by a change in land use or through timber harvesting) or unintentionally (by forest fires or natural disasters), causing the sequestered carbon to be emitted into the atmosphere again, nullifying (part of) the issued carbon credits.

To avoid or reduce this risk, reversals must be prevented with long-term contracts or legal measures (restrictions on use, designation as a protected area, etc.). In addition, credits can be guaranteed by creating a credit reserve (buffer account) or via insurance.

Because climate projects in the land use sector have been and will be dominated by afforestation projects, the VCS considers all reductions from land use projects to be reversible in principle. The VCS requires that an (often considerable) portion of the produced carbon credits be reserved as a non-permanence risk buffer, and not be sold. Consequently, the higher the risk of reversal, the greater the share of produced carbon credits that must be set aside in the buffer account.

Strict adherence to the permanence requirement ('permanence for eternity') would prevent peatland rewetting projects that do not manage to completely halt peat oxidation, as they would not fulfil the VCS criteria. Even if vast reductions in emissions were to be achieved during the project crediting period, these could not be honoured because ever-lasting protection of the peat layer cannot be guaranteed. Therefore, as a demand for absolute permanence would preclude a large number of peatland projects, this is no longer required by the VCS as of 2012. The VCS now limits 'permanence' to 100 years. The maximum amount of GHG emission reductions which can be claimed by a project corresponds to the difference in peat carbon stock between the project and the baseline scenario after 100 years. Peatland projects which do not achieve complete rewetting, and in which the peat will continue to oxidise (albeit at a much slower rate than without rewetting) may now meet the VCS criteria.

In CDM afforestation projects, the risk of non-permanence is met by issuing temporary carbon credits (which are, however, very poorly received by the market). Nonetheless, unlike the VCS, the CDM maintains the strict permanence requirement for other AFOLU projects. This stance was reconfirmed in 2009 when the Executive Board of the CDM rejected peatland project NM0297 'Carbon dioxide and methane emissions avoidance from Block-C, Central Kalimantan' (submitted under agricultural land management, ALM) with the explanation that "the permanence of GHG emission reductions cannot be ensured".

The permanence requirement means that the VCS and CDM treat AFOLU projects differently than energy projects, in which temporary emission reductions from fossil fuels can be claimed. The argument is that not burning fossil fuels (oil, gas or black coal) reduces the GHG concentration in the atmosphere compared with when they would be burned. This reduction remains even if the project fails and emissions later rise again to their previous levels (cf. Fig. 1B).

Thus, the critical question is whether AFOLU projects create carbon sinks or avoid emissions. In the case of a sink project (Figure 1A), for example afforestation, a subsequent release of the built-up carbon stocks nullifies the sink's effects. No substantial long-term effect on the climate is achieved, because ultimately the GHG concentration in the atmosphere was not reduced. If the release of the carbon stocks occurs only after a longer period of time (e.g. 50 years) there is nonetheless a positive climate effect up until that point. The decision whether this temporary effect can be certified and sold on the market is a political one.

In the case of avoided emissions in a peatland rewetting project, project reversal does not lead to a nullification of the positive effects (Figure 1B). Even if peat oxidation recommences because the damns built during the project fail, or if forest degradation continues at its previous rate after being reduced for a number years, the CO_2 concentration in the atmosphere remains permanently reduced in comparison to a non-project situation. In

contrast to sink projects, there are no issues with non-permanence in AFOLU projects that focus on avoiding emissions. The achieved emission reductions have the same climate effect as those from non-AFOLU projects, like the energy projects mentioned above. It may be expected that the VCS will share this view.
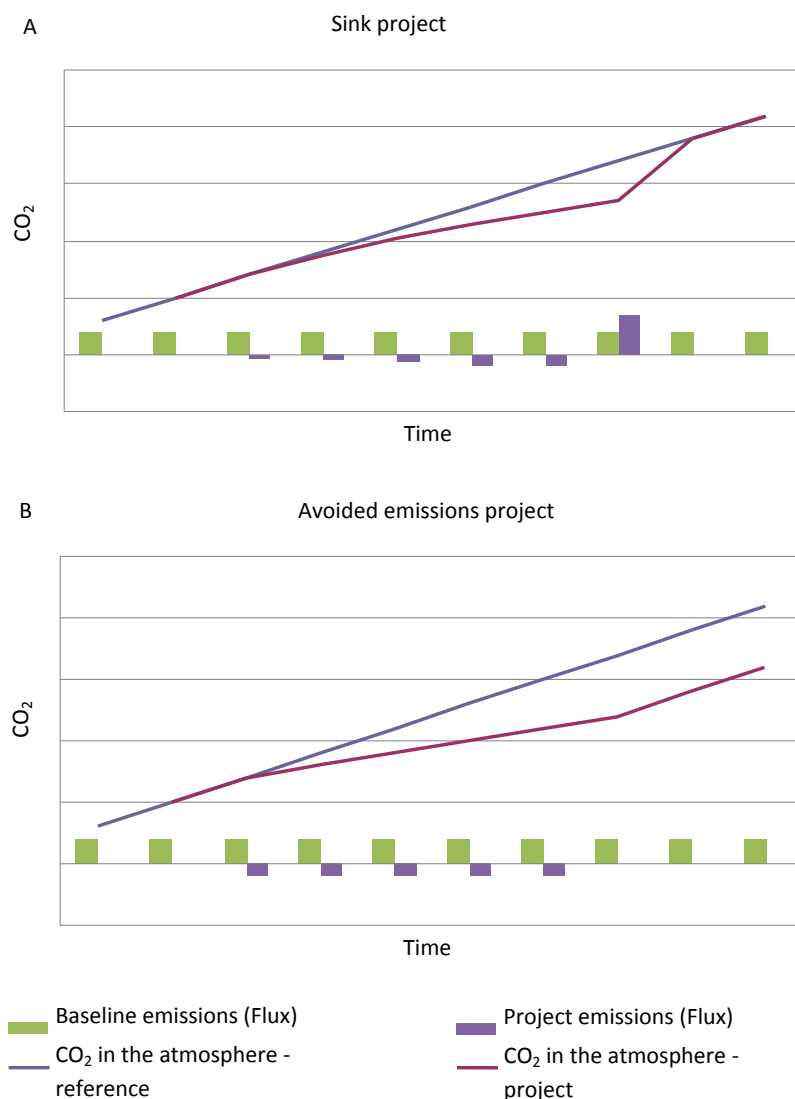
Figure 1: Emission reduction in the case of project reversal. A: In a sink project (e.g. afforestation), CO_2 is removed from the atmosphere and stored in wood biomass; the CO_2 concentration in the atmosphere is reduced. If the forest is cut after the end of the project (and the wood is not used for durable products), the stored carbon is released as CO_2 again and the atmospheric CO_2 concentration is the same as in the baseline scenario. B: In an avoided emissions project (e.g. peatland rewetting) less CO_2 is released into the atmosphere. If the peatland is drained again after the project ends, emissions return to their old (baseline) level, but the atmospheric CO_2 concentration nevertheless remains lower in comparison to the baseline scenario. Graph: I. Emmer / J. Couwenberg, modified after BONN et al. 2014.

3.9 Reference

Each emission reduction must be considered in relation to a reference ('less than what?'). The voluntary activities under Article 3.4 of the Kyoto Protocol and the related emission permits traded under Article 17 of the KP generally use a historical condition as reference − the year 1990 (base year). Taking into account both sources and sinks, the (net) GHG fluxes during the crediting period (e.g. 2013-2020) are compared with those from the base year 1990 (net-net accounting). In order to achieve an identical period of time, these must then be multiplied by the 1990 reference emissions times eight:

$$\Delta \text{GHG-flux} = \text{GHG-flux}_{2013\text{-}2020} - 8 \times \text{GHG-flux}_{1990}$$

No reference is selected for Afforestation, Reforestation and Deforestation (AR/D). The net GHG fluxes during the crediting period are taken en gross (gross-net accounting):

$$\Delta \text{GHG-flux} = \text{net GHG-flux}_{2013\text{-}2020}$$

In contrast, a hypothetical future scenario is used as a reference for Forest Management during the second commitment period of the KP. This scenario represents the situation that would have occurred during the commitment period without the implementation of additional climate measures (reference scenario). The actual GHG flux during the commitment period (with additional climate measures) is compared with the flux in the reference scenario (without additional climate measures):

$$\Delta \text{GHG-flux} = \text{GHG-reference-flux}_{2013\text{-}2020} - \text{GHG-flux}_{2013\text{-}2020}$$

A reference scenario is also used in CDM and VCS projects (called a 'baseline scenario'), and the GHG fluxes during the project are compared with the GHG fluxes that would have occurred over the same period without the project measures ('baseline').

Such a 'forward looking' reference scenario makes sense at first glance, as it does not reward what would have happened without the project anyway. However, it also presents difficulties, because estimates which are hardly verifiable must be made regarding future developments. An area of peatland could fall out of use and its water table increase when ditches become overgrown or because beavers build dams. Alternatively, an increasing demand for biomass for energy production could lead to an intensification of land use and a further lowering of the water table. Assessing such reference scenarios becomes less certain with longer project periods. Various methods and instruments for identifying the most likely reference scenario exist under the CDM and VCS. Of all possible scenarios, the one that can be best substantiated (applying the criterion of conservativeness; see Chapter 3.5) is chosen as reference. Thus, a plausible story may exert considerable influence on the amount of carbon credits produced by a project. However, the story-telling is restricted, as reference scenario estimates are periodically evaluated (e.g. every tenth project year under the VCS) and corrected if necessary.

An alternative to a reference scenario is the long-term monitoring of a reference area where the project measures (e.g. rewetting of peat grassland) are not carried out. However, such monitoring is difficult to implement in practice. Sufficiently similar areas often do not exist and high additional costs arise for the reference area (compensation). Its status as a reference furthermore determines how the area is used, and prevents it from spontaneously following regional developments. Moreover, a reference area approach does not solve the

problem that most standards require projects to provide an estimate of emission reductions in advance (*ex ante*).

3.10 Project crediting period

The project crediting period is the period of time during which a project can generate carbon credits. It may not be longer than the time over which a project can be considered *additional*. The project crediting period can influence the volume of credits considerably. A longer crediting period will generally produce a larger number of credits (see also Chapter 3.8).

Because a forward looking baseline is used, the project crediting period greatly influences the expected amount of emission reductions. If trees would encroach the project area in the reference scenario (which will be the case with some fallow land), the sometimes considerable carbon sequestration in the developing wood biomass must be accounted for in the baseline scenario, which in turn decreases the amount of emission reductions in the project. The growth rate of young trees is disproportionally high (BACKMAN 1943, PENMAN et al. 2003) before they reach an equilibrium in which their carbon stock no longer increases per unit area. Consequently, the annualised effect of carbon sequestration in woody biomass is greater the shorter the project crediting period. When the trees are fully grown, and the carbon stocks in the wood biomass and in the litter layer have achieved equilibrium, only the emissions from peat decomposition remain (LAINE & MINKKINEN 1996, JOOSTEN 2000).

3.11 Leakage

Leakage usually refers to the displacement of GHG emissions. However, the concept can also be applied to other ESS. Leakage points to a leak in the project boundaries. It covers negative effects that occur outside the project area, but as a result of the project. In the context of GHG emissions, leakage implies that emissions are displaced to areas outside the project boundary, which may partially or completely negate emission reductions in the project area. If, for example, a peat grassland used for pasturing or hay-making is rewetted, this results in emission reductions. But if the same farmer shifts his activities to a new, hitherto undrained peat area which is then drained for this purpose ('activity shifting'), the net gain may equal zero or even be negative. Market leakage is another form of leakage. If the project affects a productive area, product supply will be affected. Market demand for the produced goods may drive changes in land use outside the project area that could (partially) nullify the emission reductions achieved by the project. For example, a peatland allotted and drained for peat extraction is rewetted, but the extraction of peat intensifies abroad because the demand for peat will remain the same. A third type of leakage, called ecological leakage, can occur when rewetting causes negative effects on hydrologically connected systems outside the project area. For instance, tree growth may decrease or forests may even die-back because of increased ground water tables. Therefore, the hydrological position of the peatland within the landscape should also be taken into consideration in rewetting projects.

When projects are carried out in areas used for agriculture or forestry, an assessment of leakage effects is inevitable.

4 Standard and methodology of MoorFutures® carbon credits (v. 1.0)

4.1 Standard

A standard defines all the specific requirements for developing projects and methodologies including their validation, monitoring and verification (see Chapter 3.1). MoorFutures is a standard intended for voluntary carbon credits from small to medium sized peatland rewetting projects. MoorFutures® is a registered trademark of the state of Mecklenburg-Western Pomerania. Certificates are issued for measures that result in reduced GHG emissions or in increased carbon sequestration through agriculture or forestry, but not for the mere presence of carbon stocks.

MoorFutures is an integrated standard that is applied regionally on a decentralised basis. The standard strives for regionality in order to (i) facilitate proximity between buyers, sellers, project developers and coordinating bodies; (ii) exploit regional expertise with respect to quality control; and (iii) facilitate regional identification, specialisation and diversification. In Mecklenburg-Western Pomerania, Brandenburg and Schleswig-Holstein, the three federal states that have thus far adopted the MoorFutures concept, the respective issuing bodies and experts work closely together. Exchange of thoughts and views on projects is guaranteed through regular meetings; this also ensures that the standard is interpreted consistently and safeguards its integrity.

Carbon credits from MoorFutures projects are not related to the mandatory market and cannot be traded on the mandatory or the voluntary market; however, they can be purchased by companies to support their environmental performance. The MoorFutures criteria are clearly defined, scientifically validated, transparent, and are based on the principles of the Verified Carbon Standard and the Kyoto Protocol. Operational costs related to validation, verification and certification are minimised through the involvement of independent experts. The quality of the MoorFutures-MV credits is guaranteed by the Ministry of Agriculture, Environment and Consumer Protection of Mecklenburg-Western Pomerania, the land agency (Landgesellschaft) of Mecklenburg-Western Pomerania and the Ernst-Moritz-Arndt University of Greifswald. Similarly, the quality of the MoorFutures-BB credits is guaranteed by the Ministry of Agriculture, Environment and Consumer Protection of Brandenburg, the Brandenburg land agency (Flächenagentur) and the Eberswalde University of Applied Sciences. In Schleswig-Holstein the state compensation agency (Ausgleichsagentur) and TÜV Rheinland are responsible for the quality of the MoorFutures-SH.

The MoorFutures Standard allows 'forward selling' of credits (see below) to finance the implementation of its projects. Buyers invest in a measure which produces a specified reduction in emissions over the course of the relevant project period. If the credits are used to offset present-day emissions, buyers should be aware of this construct and advertise their contribution accordingly. As long as the permanence of the future emissions reductions is ensured and this is verified *ex post* (retrospectively), forward selling is credible and reasonable. It is limited to 50 years in advance. In the event of longer project duration, credits can be issued after 50 years in further releases if necessary. In the course of ex-post verification, it may become apparent that the number of actually generated credits deviates from the number of credits estimated and sold *ex ante* (in advance).

MoorFutures: a further milestone on the voluntary carbon market

The Forest Shares project (www.waldaktie.de) was started in Mecklenburg-Western Pomerania in summer 2007 to monetize the forests' contribution to climate protection, as well as to make this contribution comprehensible and tangible for lay people. The project was carried out by the Ministry of Agriculture, Environment and Consumer Protection in cooperation with the tourism association and the state institute of forestry. Approximately 50,000 forest shares had been sold for an individual price of €10 by autumn 2013.

In light of this successful start, the next question for the peatland-rich state was whether the climate protection function of peatlands could also be presented to the public in a similarly effective manner. Mecklenburg-Western Pomerania's extensive experience with peatland rewetting had hitherto focussed on nature conservation objectives. Although the climatic relevance of peatland rewetting was mentioned in the state climate protection concept in 1997, emission reductions could not yet be quantified at that time. With the GEST approach, an instrument was developed that allowed for a sufficiently accurate assessment of emissions before and after rewetting. Many years of experience in rewetting projects enabled the calculation of a price per avoided tonne of CO_2e.

The logo 'MoorFutures[®] – Ihre Investition in Klimaschutz' ('MoorFutures[®] – Your investment in climate protection') was registered in the official register of the European Community Trademark Office in February 2011 with the goal of increasing the appeal for the voluntary, regional carbon market. Moreover, MoorFutures presented a high-profile communication tool for the wide range of synergies between climate and nature protection. Not in the least for this reason MoorFutures received a number of awards. The climate protection aspect was clearly paramount in the decision of Germany's climate neutral hotels to award MoorFutures the climate cross of merit in July 2011. Innovative approaches were the focus of the 'Germany – Land of Ideas' competition, which awarded MoorFutures in summer 2012. Finally, in autumn 2012 MoorFutures became an official location of the UN Decade on Biodiversity, in appreciation of the positive effect of MoorFutures on biological diversity. As of May 2012, the state of Mecklenburg-Western Pomerania has granted the state of Brandenburg the right to use the registered MoorFutures trademark by means of a non-exclusive trademark licence. Since then, the land agency of Brandenburg is entitled to market projects that follow the MoorFutures Standard. Similarly, the state of Schleswig-Holstein obtained right of use in November 2014.

Its alignment with the internationally established VCS Standard, together with its regional focus, makes MoorFutures a strong trademark on the voluntary carbon market. For these reasons, the competent authorities for the federal states of Brandenburg, Bavaria, Mecklenburg-Western Pomerania, Lower Saxony and Schleswig-Holstein recommended the MoorFutures brand in their position paper 'Potentials and objectives for peatland and climate protection' (JENSEN et al. 2012). The paper is co-sponsored by nine further state authorities, the Federal Agency for Nature Conservation (BfN), the Federal Environment Agency, the Working Group on Nature Conservation, Land Management and Recreation (LANA), as well as the Working Group on Soil Protection (LABO). The position paper emphasises the services provided by peatlands, which far exceed climate protection, and recommends the introduction of MoorFutures in other states as well.

> **Forward selling**
>
> Rewetting projects incur particularly high initial costs. External financing in the form of a loan, share or bond is required so the project can be carried out and the emission reductions can be achieved. Such external financing of long-lived assets is common in everyday business. At the beginning of the 19th century joint stock corporations were founded to enable the financing of long-term, public service infrastructure projects that would span several generations. Another form of long-term external financing for public bodies as well as for private enterprises are bond loans, which are borrowed on the capital market against the issuing of bonds. The creditor grants the debtor a credit and in return receives the agreed interest, which can be paid annually. With a standard bond, repayment by the debtor takes place at the end of the term, but can also take place at regular intervals (fixed annuity). In the case of carbon credits, the buyer (creditor) waives the payment of interest and the repayment of the debt (zero perpetual) and in return receives carbon credits which can be used to offset unavoidable GHG emissions.
>
> In other words, money is borrowed to cover the initial high costs of the rewetting project and is repaid over the project period in the form of emission reductions. In return, the buyer receives a borrower's note in the form of credits. The future rendering of the service must be guaranteed by the seller. This can be achieved through sound project implementation and by setting up a risk reserve (buffer account) by holding back a certain amount of credits.
>
> On the carbon credit market 'forward selling' is generally seen as problematic if 1) emission reductions (which will only be achieved in the future) are not guaranteed; and 2) emissions that happen now are offset with reductions that happen over the future project lifetime ('forward crediting'). In this context, it is worth noting the differences between credits on the mandatory and the voluntary carbon market. The mandatory market is based on a cap and trade system; pricing is driven by the market and compensation must occur on an accrual basis. Through the purchase of a credit, the buyer obtains the right to emit a unit of greenhouse gas over a specified period. The goal of the mandatory market is to avoid GHG emissions at the lowest possible public cost.
>
> The goal of the voluntary carbon market is the voluntary offsetting of unavoidable GHG emissions by private individuals and companies. Buyers want to support climate protection projects beyond mandatory targets (caps). However, companies should only claim their acquired emission reductions once these have actually been realised. Consequently, companies must be cautious. A serious approach to CSR implies that they should merely announce that their current emissions will be offset by future emission reductions.

If emission reductions are smaller than predicted, the previously sold surplus credits must be compensated for through a buffer account. However, such a situation is not expected to occur because of the conservative approach of MoorFutures. If crediting were to prove to have been too conservative − which is more likely to be the case − the additional credits will be put in the buffer account, which can be used to compensate for the unexpected failure of subsequent projects. With an increasing number of projects, experience on setting the right amount of buffer credits will develop, and rules can be developed on how to deal with surplus buffer credits. Surplus buffer credits may be invested in additional projects, or they may be

used to upgrade already issued credits by following standard surplus sharing methods from the insurance industry.

Until now, rewetting of MoorFutures project areas was financed entirely through the sale of credits. This approach is certainly advisable during this early phase, as MoorFutures are still being established. In principle, mixed financing with public funds is possible. However, criteria for public/private mixed financing would need to be developed (Chapter 6.3).

Table 2 specifies how the MoorFutures standard follows the criteria and requirements presented in Chapter 2.

Table 2: Criteria and requirements of the MoorFutures-Standard.

Criteria	Specification for the MoorFutures Standard
Additionality	MoorFutures projects are additional. Without selling the MoorFutures credits, the project would not have been implemented. Carbon credit funding may complement other funding, which on its own would not be sufficient to finance the project. Criteria for mixed financing still need to be developed.
Project location	The geographical location and boundaries of each MoorFutures project area is clearly specified to facilitate accurate monitoring, reporting, and verification of GHG fluxes and relevant co-benefits.
Projection duration	The duration of MoorFutures projects is preassigned. All projects must have a reliable and solid plan for the management and implementation of measures throughout the project lifetime.
Measurability	MoorFutures Project use well-designed, detailed − and if possible − externally validated and scientifically accepted (peer-reviewed published) methodologies to assess the results of the project (see Chapter 3.2).
Verifiability	Monitoring and verification are performed by a designated publicly funded regional scientific research institute. The methodologies and results of MoorFutures projects are available for validation and verification by third parties.
Conservativeness	The assessment of the project results will be conservative at all levels.
Transparency	MoorFutures are explicitly linked and attributed to specific projects that can be visited on site. For every project, clear and accessible documentation is available with information on location and status of the project area, as well as on the assessment of emission reductions and additional ecosystem services. MoorFutures are registered at the regional level through regional coordinating bodies − e.g. in Mecklenburg-Western Pomerania and Brandenburg by the relevant ministries (see Chapter 3.6).
Sustainability	MoorFutures prohibits deterioration. On the one hand, improvement of one ecosystem service (climatic effect) should not negatively affect the performance of other ecosystem services. On the other hand, improvement of ecosystem services should not negatively affect the socio-economic situation of the region. The latter is of little relevance as long as only small project areas are rewetted. When large areas are rewetted, alternative sources of income should be explored, such as paludiculture and/or tourism.
Permanence	Permanence (see Chapter 3.8) of the certified environmental achievements of MoorFutures is guaranteed by adequate legal, planning and contractual instruments that may vary from region to region. In Mecklenburg-Western Pomerania, Brandenburg and Schleswig-Holstein, permanence is ensured by: a) the administrative and legal basis of the project planning and approval process; b) securing the permanent availability of the project area, either through acquisition or through registration in the land register. Alternatively, a registration of servitude with respect to the water table in the land register is possible. In addition, utilization (Paludiculture) of the project area should be sought if this contributes to maintaining or promoting achieved or potential ESS (e.g. mire typical biodiversity).
Leakage	Three types of leakage are considered: (i) activity shifting, (ii) market leakage and (iii) ecological leakage.

4.2 Methodology

The methodology describes how GHG emission reductions are quantified within the framework of the Standard. It encompasses a set of procedures and criteria for measuring, reporting and verifying (MRV) project effects. Typical content of internationally recognised methodologies (e.g. VCS methodologies) and its equivalent in the MoorFutures methodology are outlined in Table 3.

Table 3: Typical content of a GHG quantification methodology and specific requirements of MoorFutures.

Component	MoorFutures requirements
Applicability conditions	The methodology can be applied to projects that rewet drained peatlands in geographically defined regions in the temperate climate zone.
Project boundary	Time: The project crediting period of MoorFutures projects is 30-100 years. A minimum of 30 years is required to cover possible transient dynamics (methane spike, colonisation of new species). If the project includes afforestation/reforestation or improved forest management (including harvesting), the length of the project crediting period must include at least one complete harvest cycle. Projects shall have a reliable and well-designed plan for management and implementation over the entire project crediting period.
	Spatially: The project description must contain the name, geographical coordinates and boundaries (on maps), the total size of the project area and details of ownership. If the project applies to a group of areas, this information shall be included for each individual area.
	Area considered: In the baseline scenario, continuing subsidence could cause complete peat oxidation in some parts of the project area before the end of the project crediting period. For these sub-areas, credits are issued only for the time during which the peat would be present in the baseline.
	Carbon stocks considered: Aboveground biomass (trees or other); belowground biomass, and soil. Accounting for tree biomass of trees is mandatory in the baseline scenario, but optional in the project scenario. Tree litter, wood products and dead wood can be considered as well.
	Greenhouse gases considered: CO_2 and CH_4. N_2O is conservatively not considered. Scientific evidence shows that N_2O fluxes from wet sites are never higher than those from drained sites.
Reference / baseline scenario	MoorFutures uses a forward looking baseline. Emissions in the with-project-scenario are compared with a baseline scenario that describes what would have occurred during the project period without implementing the project. Expert opinions and publications are used to identify the most likely baseline scenario, and these findings are reviewed every 10 years. Under current socio-economic and political conditions in Mecklenburg-Western Pomerania, the most likely baseline scenario is to continue or intensify current land use. Abandonment is very unlikely (SCHRÖDER 2012). Therefore, MoorFutures presently uses current land use as a conservative estimate of the baseline scenario.
Additionality	All MoorFutures projects are additional (see Chapter 3.1).
Quantification (MRV)	GHG emission reductions are estimated using the Greenhouse Gas Emission Site Types (GEST) approach (see below).
	To ensure conservativeness, N_2O emission reductions and high methane emissions from ditches in the baseline are not considered. Low best estimates are used for the baseline, and high estimates for the project scenario. However, the same value is applied if a vegetation type occurs both in the baseline and the project scenario.
	Interannual variability in weather conditions and population dynamics is considered balanced over time. Catastrophic events are events or circumstances that are beyond the control of, and not materially influenced by, the project proponent: wildfires, insect and disease infestations, extreme weather events, earthquakes, volcanic eruptions and acts of terrorism or war. Their recurrence period is clearly longer than the project period. The effect of a catastrophic event on emissions is not considered, because it would have occurred in the

Component	MoorFutures requirements
	baseline scenario as well. If a catastrophic event occurs, the baseline scenario must be adjusted.
Leakage	Leakage is considered as follows: activity shifting is avoided by site selection and/or the provision of alternative sources of income (tourism, paludiculture, and hunting). Market leakage is irrelevant because of the small size of the projects. Ecological leakage is avoided by the site selection and the creation of hydrological buffer zones. If leakage does occur, it is quantified and accounted for.
Monitoring	Vegetation mapping to determine the area fractions of different GESTs is carried out over the entire project period, namely before rewetting, in the third year after rewetting, and then every ten years.

Methodological explanation (MRV) of the GEST approach

Basic principles: To be able to assess GHG fluxes across large peatland sites in Central Europe without comprehensive measurements on-site, the GEST approach was developed in 2008 at the University of Greifswald on behalf of the federal state of Mecklenburg-Western Pomerania. This approach describes greenhouse gas emission site types (GESTs), which are based on a comprehensive meta-analysis of available literature on measured annual GHG fluxes in central European peatlands. Fluxes were assessed in relation to site parameters like water table, trophic level, soil type, acidity and vegetation composition. Of all the available parameters, the mean annual groundwater table turned out to be the best single explanatory variable for CO_2 and CH_4 emissions. The GEST approach describes mean annual groundwater table in soil moisture classes (Table 4).

Table 4: Soil moisture classes and associated water tables (modified after KOSKA et al. 2001). Soil moisture classes are characterised by: WLw: long-term median water table in the wet season; WLd: long-term median water table in the dry season; and WD: water supply deficit. Seasonally alternating wetness is indicated by a combination of different classes, e.g. 5+/4+ refers to a WLw within 5+ range and a WLd within 4+ range. Strongly alternating wetness is indicated by a tilde-sign, e.g. 3~ refers to a WLw within 4+ range and a WLd within 2+ range.

Soil moisture class		water table relative to surface (+ above, - below)
7+	Upper sublitoral	WLw/WLd: +250 to +140 cm
6+	Lower eulitoral	WLw: +150 to +10 cm; WLd: +140 to +0 cm
5+	Wet (upper eulitoral)	WLw: +10 to -5 cm; WLd: +0 to -10 cm
4+	Very moist	WLw: -5 to -15 cm; WLd: -10 to -20 cm
3+	Moist	WLw: -15 to-35 cm; WLd: -20 to -45 cm
2+	Moderately moist	WLw: -35 to-70 cm; WLd: -45 to -85 cm
2-	Moderately dry	WD: <60 l/m^2
3-	Dry	WD: 60-100 l/m^2
4-	Very dry	WD: 100-140 l/m^2
5-	Extremely dry	WD: >140 l/m^2

The occurrence of aerenchymous plants strongly influences CH_4 emissions on wet sites. Aerenchymous tissue provides a 'shunt' that allows CH_4 to bypass oxygenated soil layers and move directly from the anoxic rooting zone to the atmosphere. These 'shunt species' include for example *Phragmites australis, Eriophorum angustifolium, Phalaris arundinacea*,

Cladium mariscus, *Carex* spp., *Juncus* spp. and *Scirpus* spp. The GEST approach does not take into account N_2O emissions as these are very erratic in time and space, and there is a lack of widely-applicable indicators. Due to a lack of measurement values, relevant management practices such as ploughing and fertilisation have not been taken into account. These aspects can be included once data become available. Consequently, the GEST values for deeply drained sites that have thus far been applied should be considered underestimations (cf. COUWENBERG & HOOIJER 2013, DRÖSLER et al. 2013).

Because vegetation reflects site conditions, vegetation types are assigned emissions factors for CH_4 and CO_2 in accordance with mean annual water tables (Figure 2).

Soil moisture class	2+	3+	4+	5+	6+
	Moderately moist	Moist	Very moist	Wet	Lower eulitoral
Median annual water table	ca. 35 to 5 cm below surface	ca. 15 to 45 cm below surface	ca. 5 to 20 cm below surface	ca. 10 cm below to 10 cm above surface	ca. 10 to 50 cm above surface
GEST	Global warming potential in t CO_2e ha^{-1} y^{-1}				
High intensity grassland	24	15	7.5		
Forb meadows	20	12.5	7.5		
Reeds			3.5	8.5	8.5
Rewetted (short) grassland				5.5	

Figure 2: Selected Greenhouse Gas Emissions Site Types (GEST) with associated Global Warming Potential (GWP) (after COUWENBERG et al. 2011).

Assigning GHG flux values to vegetation types:

1. Mapped vegetation types are compared phytosociologically and floristically with vegetation descriptions in the GHG literature. If identical, the literature values are adopted.

2. In a second step, to verify and specify the flux values, water table data from field measurements or indication (by species groups of KOSKA et al. 2001, or by the indicator values of ELLENBERG et al. 1992) are compared with regression models of fluxes against mean annual water table. If the water table data do not provide conclusive results, expert judgement is applied, taking into account similarities with well-documented vegetation types.

3. If the vegetation is not sufficiently similar to descriptions in the literature, flux values are assigned based on the regression models, taking into account water table data and the presence of aerenchymous 'shunts'.

4. If these data do not allow draw conclusions, expert judgement is applied, taking into account the general site characteristics and water table of related vegetation types.

5. For this purpose, a matrix of all possible vegetation types has been prepared, which allows extrapolation and interpolation of GHG values along the different axes of site

conditions. The data on (i) GHG fluxes in relation to vegetation types, (ii) GHG fluxes in relation to water table and (iii) vegetation types in relation to water table, allow an internal verification of this matrix.

GHG flux values for Northeast German peatlands can be found in Annex 1.

Current applications of the GEST approach: The GEST approach has been used a number of times to assess the climate effect of individual peatlands in different federal states (e.g. WEBER 2010 for Baden-Württemberg, HARGITA & MEIßNER 2010 for Brandenburg). To assess the climate relevance of peatlands in Schleswig-Holstein, Mecklenburg-Western Pomerania and Brandenburg, GESTs were carried over to the closest fitting, but less precise units of the state biotope maps (JENSEN et al. 2010). Also, at international level, the GEST approach is being applied and further developed. A VCS methodology for the rewetting of peatlands based on the GEST approach is currently in the second phase of validation (COUWENBERG et al. 2011; www.v-c-s.org). In Belarus, the GEST approach is being validated with flux measurements and calibrated with vegetation assessments for use in Central/Eastern Europe (TANNEBERGER & WICHTMANN 2011). GESTs were used to assess the climate relevance of the Zehlau peatland in Kaliningrad oblast (SCHWILL et al. 2010). An approach similar to GESTs is being pursued in the UK to develop national emissions factors (BONN et al. 2014).

4.3   Results for Kieve Polder

The project area covers 54.5 ha and is located in Kieve Polder − in the southern part of the district of Müritz on the upper course of the Elde River, directly north of the village of Kieve (Figure 3). The administrative planning for the rewetting of the polder was approved on 11 February 2008. Thus, the project area did not require planning anymore. Rewetting was originally planned in the framework of the peatland protection programme of the state of Mecklenburg-Western Pomerania, but time and funds were lacking.

Three scenarios were considered for the assessment of emission reductions:

- Baseline scenario (high intensity use, likely).

- Alternative baseline scenario (low intensity use, unlikely).

- Project scenario (rewetting).

The baseline scenario describes what the future development of the area would look like during the project crediting period (50 years) if the project were not carried out (Table 5). Up until the approval of the rewetting plans, the polder was subject to high-intensity use with deep drainage (water tables 50-70 cm below surface, soil moisture class 2+/-), and it is assumed that this use would have continued (SCHRÖDER 2012; Figure 4).

The GHG balance in the baseline scenario is estimated conservatively at 24 t CO_2e ha^{-1} y^{-1}, resulting in baseline emissions of the total project area of 1 306 t CO_2e y^{-1}. The value of 24 t CO_2e ha^{-1} y^{-1} lies at the lower end of the range for intensively used 2+/- sites, and the actual flux is likely to be significantly higher (~35 t CO_2e ha^{-1} y^{-1}; COUWENBERG & HOOIJER 2013, DRÖSLER et al. 2013). The difference of approximately 600 t CO_2e y^{-1} (>45% of total emissions) highlights the conservativeness of the approach.

Figure 3: Location of the project area in Kieve Polder. Map: C. Tegetmeyer. Source: GDI-MV; www.geoportal-mv.de.

The alternative baseline scenario anticipates low-intensity use with higher water tables (Table 5, BARTHELMES et al. 2010). A vegetation mapping from the year 2010 served as the basis for this scenario. Following approval of the administrative plan for rewetting in 2008, pumping efforts were reduced, use became less intensive, and flood grassland and wet meadows established. If the plan had not been approved, the change in land use intensity would have been highly unlikely. Total emissions for this scenario amount to 792 t CO_2e y^{-1} (Table 5)

The project scenario anticipates that, on approximately half of the area (25.5 ha), a soil moisture class of 5+ will be attained (water level just above/below the surface). The establishment of reeds dominated by common reed (*Phragmites australis*) and/or sedges (*Carex* spp.) is assumed for these areas. Similar vegetation is expected on a somewhat drier area (soil moisture class 4+) of 11.7 ha. Moist forb meadows will likely become established on an area of 17.3 ha (soil moisture 3+; Figure 4).

For the 5+ sites, a methane emission increase of 10 t CO_2e ha^{-1} y^{-1} is assumed for the first three years following rewetting. The resulting figure of 18.5 t CO_2e ha^{-1} y^{-1} (740 kg CH_4 ha^{-1} y^{-1}) is at the upper end of the range of measured values for wet, eutrophic fen sites (cf. COUWENBERG & FRITZ 2012). Significantly higher values were measured on specific, strongly eutrophied sites with ~40 cm inundation (AUGUSTIN & CHOJNICKI 2008, GLATZEL et al. 2011), which are, however, not expected here.

Table 5: Vegetation types, GHG flux values, and area ratios in the reference and the project scenario for Kieve Polder. WT = Soil moisture class, EF = Emission factor, Em = Emission per year in the baseline scenario, Em50 = Total emissions over 50 years in the baseline scenario, ER = Average emission reduction per year in the project scenario, ER50 = Total emissions reduction over 50 years in the project scenario. Each combination of a vegetation type and a soil moisture class represents a GEST.

Vegetation	WT	area	EF	Em	Em50	ER	ER50
					t CO_2e		
		ha	ha^{-1} y^{-1}	y^{-1}	[50y]$^{-1}$	y^{-1}	[50y]$^{-1}$
High intensity grassland	2+/-	54.5	24	1 305.6			
Baseline scenario		**54.5**	**24**	**1 305.6**	**65 280**	**773**	**38 655**
High intensity grassland	2+/-	8.2	24	196.8			
High intensity grassland	3+/2+	6.7	20	134.0			
High intensity grassland	3+	24.3	15	364.5			
Forb meadows	4+	10.1	7.5	105.8			
Reeds	4+	4.4	3.5	1.4			
Reeds	5+/4+	0.7	8.5	6.0			
Alternative baseline scenario		**54.5**		**792.4**	**39 620**	**260**	**12 995**
Reeds	5+	25.5	8.5	216.8			
Reeds	4+	11.7	3.5	41.0			
Tall forb meadows	3+	17.3	15	259.5			
Project scenario, no methane spike		**54.5**		**517.2**	**25 860**		
Project scenario, with methane spike		**54.5**		**532.5**	**26,625**		

In total, an average emission of 532 t CO_2e y^{-1} is assumed for the entire project area following rewetting. The corresponding emission reduction compared with the baseline scenario amounts to 773 t CO_2e y^{-1} or 38,655 t CO_2e over the entire 50 year project period. Compared with the alternative reference scenario, a reduction is achieved of 260 t CO_2e y^{-1}

or 12,995 t CO_2e over the entire 50 year project period. Based on provisional emission values (COUWENBERG et al. 2008), total emissions of 870 t CO_2e y^{-1} for the reference scenario and 584 t CO_2e y^{-1} for the project scenario were calculated in 2010. Following these provisional values, a reduction of 14,325 t CO_2e would be achieved over the project period (BARTHELMES et al. 2010). This previous estimate is 1,330 t CO_2e or < 0.5 t CO_2e ha^{-1} y^{-1} higher than the currently calculated reduction compared with the alternative baseline scenario.
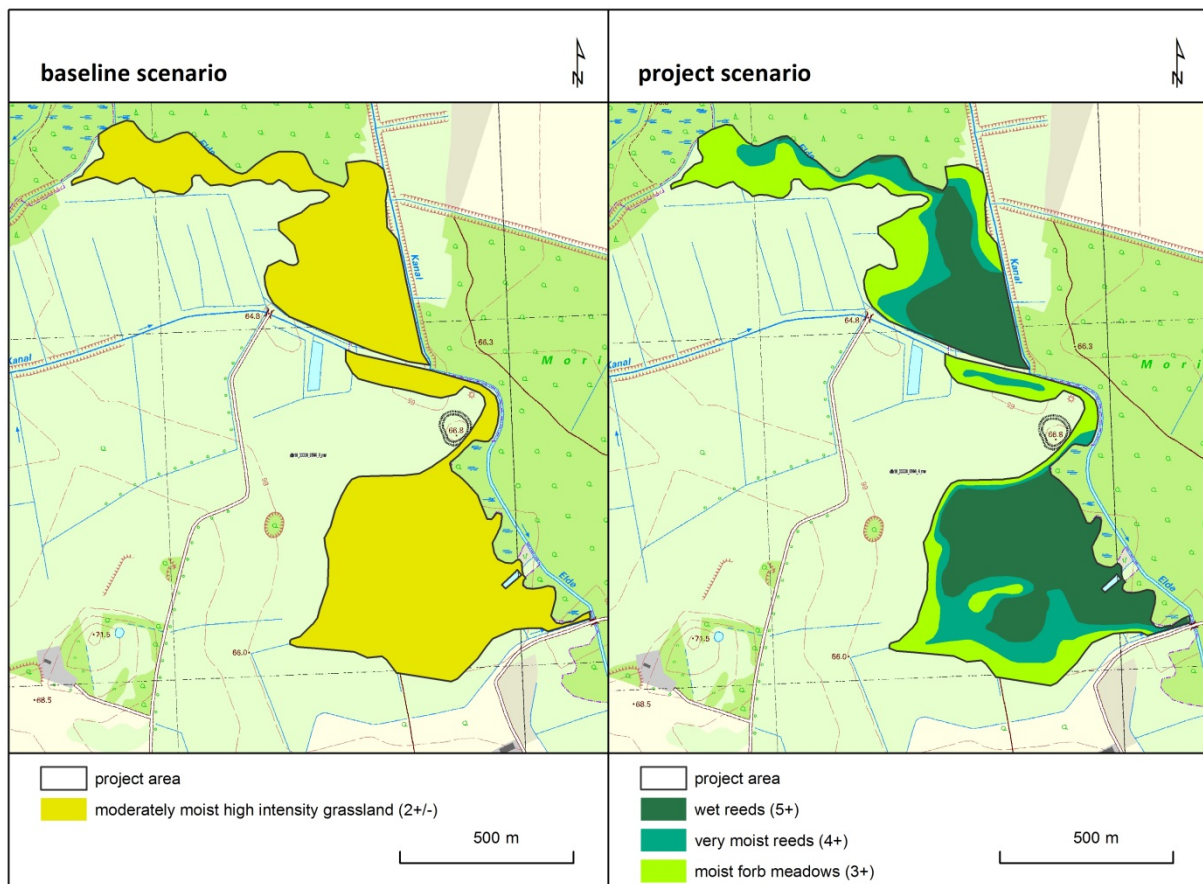
Figure 4: Vegetation types in the most probable baseline scenario and project scenario in Polder Kieve. Map: C. Tegetmeyer.

In light of the uncertainties present in the emission estimates, the reduction of 14,325 t CO_2e that was calculated as the difference between the project and the *alternative* baseline scenario was taken as the (strongly) conservative basis for the amount of certificates issued in 2010. Therefore, the project has created an ample risk reserve of 24,330 t CO_2e which can be used to buffer unforeseen problems in the project − this is after all the first project of its kind, and to guarantee the credited emission reductions sold to purchasers. Because of its exceptionally large size, the risk reserve generated by the project also offers the potential of reinsurance for subsequent projects. Pricing of the credits issued for Kieve Polder is explained below.

Pricing MoorFutures from Kieve Polder

Prices for MoorFutures are based on the costs of their production. The price for a single credit is simply calculated by dividing the costs of implementation, divided by the total amount of emission reductions over the project crediting period (€ per t CO_2e). In order to be competitive and efficient, the pricing for carbon credits should consider prices for similar products on the voluntary market (e.g. VCS credits), as well as avoidance costs. The costs for the avoidance of one t CO_2e are an indicator of the cost efficiency of peatland rewetting, and can be compared with the costs of alternative climate protection measures. Avoidance costs of rewetting are calculated on the basis of the foregone gains from goods and services no longer available because of the project (opportunity costs). The lower the avoidance costs, the more efficient the emission reduction measure.

With MoorFutures version 2.0 additional ESS are quantified and made visible and their value can be charged through a price premium.

The costs of project implementation and monitoring must be covered by the revenue from the forward selling of MoorFutures. The costs for planning and technical rewetting measures play a large role in the implementation. For instance, an evaluation of planning and construction costs in Mecklenburg-Western Pomerania and Brandenburg has shown that costs per hectare decrease for larger project areas.

Planning and construction costs in Kieve Polder amounted to €2,100 ha^{-1}. Further costs include administration, marketing, and monitoring, as well as ongoing costs (land tax, contributions to the water and soil board) plus costs related to acquisition of land and to financial compensation of land leases. The total costs for the rewetting of Kieve Polder amount to €501,375. With 14,325 credits issued, results a price of €35 per t CO_2e. Taking the area-dependency of costs into account, as well as potentials for cutting costs (particularly with respect to the acquisition of land), a price range of €10 to €70 per t avoided CO_2e seems feasible for future projects.

4.4 Comparison with other Standards

MoorFutures are based on the criteria of the VCS and the Kyoto Protocol. A comparison of requirements (Table 6) shows that it is possible to develop a regional standard for peatland projects that significantly exceeds the VCS and Kyoto Protocol. Transaction costs are greatly reduced compared with VCS and KP projects because validation and certification is carried out 'in-house' by the University of Greifswald. This approach is not uncommon on the voluntary market, but does require that emission reductions are estimated conservatively and with the greatest possible transparency (KOLLMUSS et al. 2008).

Table 6: Interpretation of criteria for carbon credits in Kyoto Protocol, VCS and Moor Futures® projects: red = worse, yellow = indifferent, green = better for the climate.

Criteria	Kyoto Protocol (Art. 3.4 p.p., Art. 17)	VCS	MoorFutures®
Additionality	Not required	Required	Required
Reference	1990	Forward looking	Forward looking
Projection duration	2008–2012; 2013-2020	20 - 100 years	30 - 100 years
Measurability	Country specific	Rough estimate allowed (IPCC tier 1 default)	Detailed GESTs
Verifiability	Only rough (tier 1)	Rough allowed (tier 1)	Detailed GESTs
Conservativeness	Best estimates	All conservative	Partially conservative
Transparency	UNFCCC registration	VCS registration	Ministry registration
Sustainability	Hardly required	Deterioration prohibited	Deterioration prohibited
Permanence	Not required	Guaranteed (> 100 years)	Guaranteed (> 100 years)
Leakage	Not taken into account	Internationally ignored	Minimised through site selection

5 Standard and methodology for other ecosystem services in MoorFutures®-Carbon credits (Version 2.0)

5.1 Overview of standard and methodology

This chapter introduces the main features of the standard and methodology of MoorFutures version 2.0. Some fundamental aspects and considerations are presented, as well as newly developed methodological elements which underpin the expanded standard.

Standard: MoorFutures version 2.0 is an extension of the existing MoorFutures standard for carbon credits (v. 1.0). In the new version, further ecosystem services are incorporated and provided in tandem with emission reductions. These services are: Improved water quality, flood mitigation, groundwater enrichment, evaporative cooling and increased mire typical biodiversity. In version 1.0 these additional ESS were incorporated only qualitatively and implicitly through the prohibition of deterioration in the sustainability criterion. In version 2.0 additional ESS are both explicitly targeted and (semi) quantitatively expressed. However, only GHG emissions reductions are commodified. Thus, MoorFutures v. 2.0 is a carbon+ standard: Additional effects are not prescribed but are targeted and, so far as possible, quantified.

Methodology: In version 2.0, MoorFutures, next to the GEST approach to quantifying GHG emissions reductions (see Chapter 3.2), employs five additional methodologies (Table 7) that are still under development and therefore were only employed in the Kieve Polder. These methodologies are further explained in the following chapters, covering a standard and a premium approach for most services. The standard approach is an estimation procedure which requires less time and fewer data; it is cheaper but less accurate. It provides a (conservative) quantitative estimate of the ESS. By comparison, the premium approach requires more time and data; it is more expensive but also produces more accurate results. In some cases, it includes the collection of the necessary data. The premium approach is well suited for quantifying an ESS that it is central to the offered credits and that allows asking a higher market price to cover the additional costs.

Table 7: Additional ESS of MoorFutures v. 2.0 and their quantification in a standard and a premium approach.

ESS	Standard	Premium
Improved water quality	Estimation using the NEST approach (kg N y^{-1})	Modelling with WETTRANS (kg N a^{-1}) and **PRisiko** (kg P y^{-1})
Flood prevention	Modelling of the **r**etention volume (m^3) – as a standard procedure if entry data are available, or else as a premium procedure. Modelling of flood peak reduction as a premium procedure only	
Groundwater enrichment	Modelling of the total available amount of water (m^3) and the water table (cm above/below surface) - as a standard procedure if entry data are available, or else as a premium procedure	
Evaporative cooling	Estimation using the EEST approach (W m^{-2} or kWh ha^{-1} y^{-1})	Modelling with AKWA-M (W m^{-2} or kWh ha^{-1} y^{-1})
Increased mire typical biodiversity	Estimation using the BEST approach	Measuring and evaluation through **i**ndicator species models

5.2 Improved water quality

5.2.1 Changes following rewetting

The nutrient dynamics of peatlands strongly depend on their hydrological embedding in the catchment, water table heights and type and intensity of land use. Near natural peatlands function as nutrient sinks, because nitrogen (N) and phosphorous (P) are either fixed in accumulating peat, or biochemically transformed, or removed. Drainage allows oxygen to enter the upper soil layers, leading to decomposition of the peat and to release of the stored nutrients. Near natural mires can store 4.4-11.9 kg N ha^{-1} y^{-1} under north German conditions (GELBRECHT et al. 2001). In contrast, around 27.5 kg N ha^{-1} are released from drained fen grasslands every winter (GERTH & MATTHEY 1991). Drainage causes changes in the peat, and nutrient dynamics cannot easily be reversed. According to SCHEFFER & BLANKENBURG (2002) the average release of N and P from rewetted peat soils amounts to > 2 kg N and < 0.1 kg P ha^{-1} y^{-1}.

Nitrogen: The extent of nitrogen retention or release depends on input, internal processes, and output. Relevant inputs are (i) fertilization, (ii) N-fixing by legumes, (iii) atmospheric deposition, and (iv) waterborne input. Relevant internal processes include (i) mineralisation, (ii) microbial immobilisation and (iii) de-nitrification and nitrification. Output involves (i) gaseous losses, (ii) harvesting, and (iii) leaching. Total nitrogen balances are known for only a few peat areas (SCHRAUTZER 2004). Calculating a plot-scale balance on the basis of input and output data from the literature produced no plausible results for rewetted areas, primarily because of uncertainties in the internal processes.

Phosphorous: Both drained and rewetted peatlands are a source of phosphorous. An increase in aerated soil depth, as well as its decrease upon rewetting can lead to a release of phosphorous (ZAK et al. 2010). Drainage releases phosphorous because organic matter is mineralised, whereas rewetting and associated oxygen deficiency often releases inorganically bound phosphorous. The amount of released phosphorous depends on a wide range of factors besides drainage depth and fertilization, including pH, redox potential, and calcium, iron and aluminium content of the soil. Following rewetting, two risks associated with a potential release of P must be assessed:

- The risk of the extinction or decline of endangered species because of changes in local nutrient supply. Rewetting changes the redox potential of the soil and nutrient availability increases. Nutrient sensitive animals and plants can be negatively affected by this eutrophication. The presence of oligo- and mesotrophic plant species or plant associations serves as an indicator for this risk.

- The risk of impairing the water quality of downstream aquatic systems. If changes in the redox potential of the soil result in the release of phosphorous, it may pollute downstream water systems. This pollution can be evaluated directly by measuring the increase in phosphorous concentration, or indirectly by mapping nutrient sensitive species (see above).

5.2.2 Methodology

Different methods of varying complexity exist to evaluate the role of peatlands in the landscape nutrient balance. In a very conservative approach, N release is assessed as a

function of site internal processes, using default values associated with vegetation types (NEST approach). A similar approach to assess P release has not yet been developed. In a more precise approach, complex modelling calculations are carried out, which take into account detailed landscape hydrology besides the site internal processes. With WETTRANS (TREPEL & KLUGE 2004) and PRisiko (TREPEL 2004) two models are available to calculate N- and P- release, respectively. Exact information on the impact of peatlands on the nutrient balance of the landscape can be gained by long-term measurements, adapted to the particular hydrological situation (TREPEL 2004).

The methodology for assessing improved water quality largely corresponds with the methodology for assessing GHG emissions (Table 3). The methodologies differ with respect to quantification (MRV), leakage, and monitoring (Table 8).

Table 8: Methodological requirements for quantifying improved water quality in MoorFutures v. 2.0. Only those aspects that deviate from the GHG methodology are shown (cf. Table 3).

Component	MoorFutures requirements
Quantification (MRV)	Standard approach: Estimates based on the NEST approach (Unit: annual N-release to water in kg N y^{-1}).
	Premium approach: Modelling with WETTRANS (Unit: annual N-release to water and retention in the area in kg N y^{-1}) and PRisiko (Unit: releasable phosphorous in kg P y^{-1})
	In order to ensure conservativeness (i) WETTRANS assumes low input of N from outside −in addition, WETTRANS is equipped with an error calculation tool for quantifying calculation uncertainties; and (ii) in PRisiko, P-release is estimated at the high end of the range.
Leakage	Activity shifting is avoided by site selection and/or the provision of alternative sources of income (tourism, paludiculture, and hunting). Market leakage is irrelevant because of the small size of the projects.
	Ecological leakage is avoided by the site selection and by the use of rewetting practices that minimise P-release. Such rewetting practices can be identified using P-Risiko. In case of a significant risk of P-release, measures to reduce it can be applied (top soil removal, mowing, downstream construction of artificial treatment wetlands).
	Should leakage occur, it will be quantified and accounted for.
Monitoring	Standard approach: Vegetation mapping (using data collected for the GEST assessment)
	Premium approach: Monitoring a set of input data (see below)

Methodological explanation (MRV) of the NEST approach

Basic principles: The NEST approach (N-Emissions-Site-Type) is a vegetation-based method of estimating the nitrogen release of a peatland at the site level. Nitrogen release correlates with the drainage depth, for which e.g. VAN BEEK et al. (2007) present a linear correlation, whereas BEHRENDT et al. (1993) found an exponential increase in N release with deeper drainage. In peatlands, vegetation integrates the factors water table and land use intensity. Vegetation types may indicate the same soil moisture class but different management practices.

In the standard approach, N release and retention are assessed using simple methods. The restoration of water exchange between a peatland and its catchment offers a high potential for N retention. Estimating release in the peatland using default values requires few data and

little time, but the actual effect of the rewetting on N retention is likely much higher. Therefore, the resulting estimate is very conservative.

The most important parameter for the nutrient balance is the soil moisture class, which correlates with the mean annual water table. Assigning N release values to single vegetation types is not yet possible on the basis of available data. Most studies used higher phytosociological units like 'short sedge reeds', 'tall reeds' or 'ryegrass meadows', to which nutrient release values can be assigned on the basis of the literature (Table 9, Appendix 2). The NEST approach assumes strongly simplified water tables and mean annual N release values. This simplification ensures that release is not overestimated in the baseline scenario. For fen peatlands under high intensity use, significantly higher releases have been measured than the default values used here. For Mecklenburg-Western Pomerania the default values presented in Table 9 and Appendix 2 are assumed to be valid for a first assessment.

Table 9: Examples of default values for N release (following SCHEFFER 1994).

NEST	Average annual water table (in cm below surface)	Average annual nitrogen release (in kg N ha^{-1} y^{-1})
Ryegrass meadow	-50	20
Periodically flooded grassland	-20	15
Moist meadow	-10	10
Alder carr	-10	10
Tall reed	-5	5

Two exceptions from the default values in Table 9 are defined. Nitrogen release from *pastures* is generally higher than that released from hay grasslands. An additional 5 kg of N release is assumed for grassland with a mean annual water table of 10 cm below surface if it is used as pasture. As pasturing is standard practice on periodically flooded grasslands and ryegrass meadows, the effect is already covered in the default value. In addition, N release can be higher in *sites with groundwater upwelling* because of higher throughflow rates. The default value is increased by 20 kg N ha^{-1} y^{-1} for sites with upwelling groundwater.

An additional component of the NEST approach is a simplified calculation of retention of nutrient input from the catchment using a statistical approach (developed in Sweden) on the basis of retention data measured from wetlands (STRAND & WEISNER 2013). Following this approach, N retention (R_N) depends on the N load from the catchment (F_N) and can be calculated as:

$$R_N = -5 \times 10^{-7} F_N^2 + 0.0541 F_N$$

The Swedish retention values are conservative, because temperature, which is a key factor in denitrification, is lower in Sweden than in northern Germany.

Input data: The NEST approach is based on vegetation maps. The vegetation data collected for the GEST assessment of emission reductions can be used for the NEST calculation as well. For entry data, the NEST approach depends on:

- List of all vegetation types occurring on the rewetted peatland area;
- Area coverage of each vegetation type;
- Water table before and after the rewetting with area cover;
- Projected vegetation development following the rewetting.

As a rule, the information is already collected as part of the project planning so that no additional fieldwork is necessary.

Methodological explanation (MRV) of the WETTRANS and PRisiko approach

Basic principles: The premium approach considers peatland nutrient dynamics in their landscape hydrological context, which may at times result in significantly higher calculated retention rates because denitrification rates are strongly affected by N input from the catchment. For example, analysis of nitrogen input and release in the Pohnsdorfer Stauung (a rewetted peatland area in NW Germany) revealed a retention of 132 kg N ha^{-1} y^{-1} in the eastern part of the polder, where throughflow is larger (KIECKBUSCH 2003). Accounting for potential nitrogen retention is only rudimentary in the NEST approach.

Models allow taking into account these landscape hydrological aspects next to site specific internal processes. The decision-support models WETTRANS (TREPEL & KLUGE 2004, http://www.wettrans.org/) and PRisiko (TREPEL 2004, http://www.pixelrauschen.de/ prisiko/prisiko.php) are both available on the internet. WETTRANS, which calculates nitrogen retention (Figure 5), requires one to several days to compile the input data, depending on their availability, while PRisiko provides an estimation of the risk of increased phosphorous release within a few hours. PRisiko estimates the risk of P release based on the concentration change three years after rewetting (t = 3). The concentration increase caused by rewetting is grouped into classes according to percentage increase. The class boundaries and the methodology are included as supporting texts, which are shown in the computer program if the cursor hovers over a parameter

Input data: WETTRANS requires soil maps showing: occurrence and depth of peat soils, an elevation model, a map of water courses and structures, artificial shorelines and potentially flooded areas, a vegetation map, and a land use map, as well as maps showing the project area and project scenarios. Much of the required data is already available from information gathered during the planning stage of rewetting. Information on land use can be derived from aerial photos, the integrated administration and control system (InVekoS data) or from vegetation maps.

The PRisiko model requires information on the size of the basin, the mean drainage depth and the land use intensity, as well as on the size of the catchment area. All required data is typically available in the planning documents.
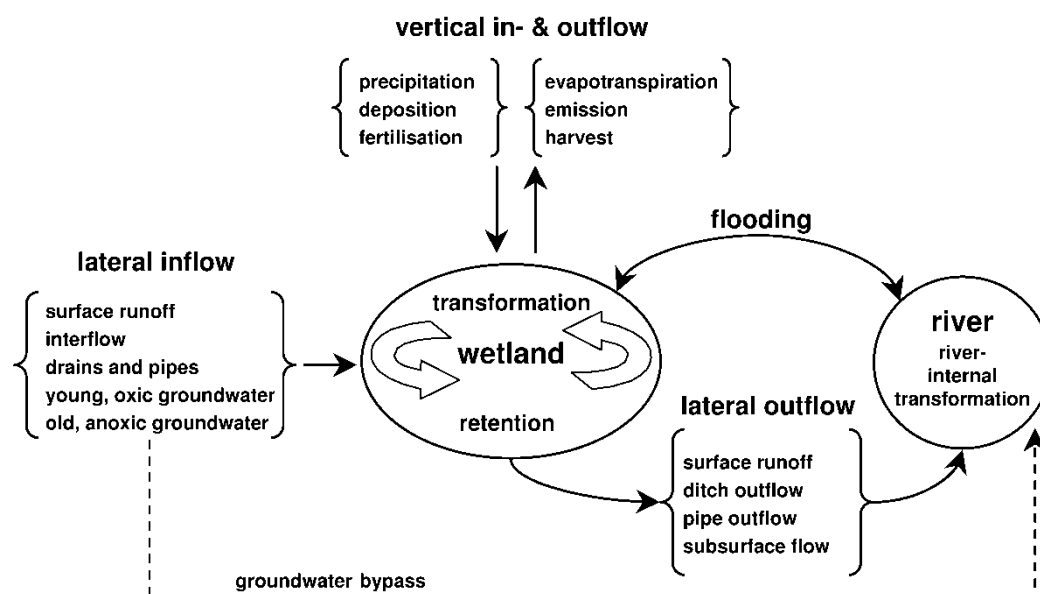
Figure 5: Structure of the WETTRANS-Model (modified after TREPEL & KLUGE 2004).

Additional (theoretical) quantification option: direct measurements

In principle, nutrient retention rates can also be measured directly. Measurements are needed on the amount of water flowing in and out of the area, as well as on nutrient concentrations in these water flows over the course of at least one year. Under favourable conditions measurements can be restricted to ditches. Usually, below-ground water flow needs to be considered and can be calculated on the basis of groundwater tables and hydraulic conductivity of the soil. If sampling is not automated, measurement during flood events is most important, because the major part of annual P flux occurs during such short-lived flood events. In order to derive a realistic annual nutrient balance, it is usually necessary to collect measurement data over the span of multiple years, as almost every year shows occasional but significant deviations from the average weather (RÜCKER & SCHRAUTZER 2010).

Comparison of methods

A comparative overview of the methods is shown in Table 10.

Table 10: Comparison of methods for quantifying improved water quality.

Criterion	NEST estimate	WETTRANS/PRisiko Modelling	Measurement
Data requirements	Low	Medium to high	Low to medium
Costs	Low	Low to medium	High
Time required	Low	Low to medium	High
Accuracy	Low	Medium	High
Verifiability	Vegetation mapping	Measurement of input data	-
Suitability for MoorFutures	Standard approach	Premium approach for projects with a focus on water quality	Not suitable

5.2.3 Results for the Kieve Polder

NEST approach: The NEST approach indicates that in the baseline scenario ~1,090 kg N y^{-1} will be discharged from the Kieve Polder, and in the alternative baseline scenario ~790 kg N y^{-1}. Once vegetation adapted to the rewetted situation has established, ~360 kg N y^{-1} will be discharged in the project scenario. Rewetting thus results in a reduction of 730 kg N y^{-1} compared with the baseline scenario, and of 430 kg N y^{-1} compared with the alternative baseline scenario (Table 11).

In addition, N retention occurs in the project scenario. For the 5+ sites (total 25.5 ha of the project area), the 340,7 ha large catchment (total catchment 366.25 ha of LAWA area classification number 5921540000 minus 25.5 ha) with a N-release of 10 kg ha^{-1} y^{-1} (total load of 3407 kg N y^{-1}) a retention of 185 kg N y^{-1} can be calculated.

Thus, on the basis of the NEST approach, the total net change in N-retention/release after rewetting amounts to a reduction of ~915 kg N y^{-1} or ~45 750 kg N over the 50 years project lifetime compared with the baseline scenario. Compared with the alternative baseline scenario, the net reduction is ~615 kg N y^{-1} or 30 750 kg N over the project lifetime.

Table 11: Yearly nitrogen release (in kg N y^{-1}) from the Kieve Polder in the baseline (high intensity use), the alternative baseline (low intensity use) and the project scenario (rewetting) calculated using the NEST approach. * = high intensity grassland 2+/- in Chapter 4.3; ** = high intensity grassland 3+ and forb meadows 4+ and 3+; *** = tall reeds 4+ and 5+.

NEST	Baseline	Alternative baseline	Project	Baseline	Alternative baseline	Project
	area (ha)			Total N release (kg N y^{-1})		
Ryegrass meadows*	54.5	1.9	0	1090	~ 298	~ 0
Periodically flooded grasslands**	0	24.3	0		~ 365	~ 0
Wet meadows**	0	10.1	17.4		~ 101	~ 174
Tall reeds***	0	5.1	37.2		~ 26	~ 186
Total N release				1090	~ 789	~ 360
Reduction through rewetting				~730	~ 430	
Retention with 3407 kg N y^{-1} input						-185
Total net reduction				915	615	

WETTRANS: The above-ground catchment area of Kieve Polder is 366.25 ha large. The catchment is crossed by the River Elde, which flows through the area from west to east and which turns south at an almost right angle at the eastern border of the catchment. Around 91 ha lies south of the Elde canal and the remaining 275 ha lie to the north. The area directly east of the Elde already belongs to the neighbouring catchment. The areas south and north of the Elde are assumed to be hydrologically connected in the calculations, even if water exchange can only occur via a culvert under the Elde. The upstream catchment of ~138.4 km^2 is hydrologically not connected to the basin because of the dyking system.

Although the WETTRANS model produces additional results, only the nitrogen release from the area is shown here (Table 12). Two rewetting scenarios were analysed, one where the

water table in those areas that are not flooded in the project scenario is assumed to be -20 cm, and one where it is assumed to be -10 cm. Rewetting of the Kieve Polder reduces the N release to the surface water (the Elde River) by ~6,000 kg N y^{-1} compared with the baseline scenario, or ~300,000 kg N over the 50 year project lifetime. In comparison, the alternative baseline scenario results in a reduction of 2,500 kg N y^{-1} or 125,000 kg N over 50 years.

Table 12: WETTRANS- results for various discharge and rewetting scenarios.

	Baseline scenario	Alternative baseline scenario	Project scenario (-20 cm)	Project scenario (-10 cm)
Total input in basin [kg N y^{-1}]	21 368	12 466	4 909	3 656
Harvest [kg N y^{-1}]	6 813	2 523	621	621
N released to surface waters [kg N y^{-1}]	8 028	4 516	1 999	1 962
Total output from the basin incl. water bodies (harvest + release to surface waters) [kg N y^{-1}]	14 841	7 039	2 620	2 583
N retention in the system [kg N y^{-1}]	6 527	5 427	2 289	1 072
Retention coefficient [%]	30.55	43.53	46.63	29.33
Difference between alternative baseline and project scenario [kg N y^{-1}]			2 517	2 554
Difference between baseline and project scenario [kg N y^{-1}]			6 029	6 066

PRisiko: For the calculations in the PRisiko model, the default setting of 0.1 mg l^{-1} was used for the current concentration of P in water courses, as no direct measurements are available for the studied area. This default value is the same as that used for total P in water courses by the States' Working Group on Water (LAWA). Phosphorous release was calculated for water tables of -10 cm in the project scenario (for all areas not expected to become flooded), because this scenario results in higher release than the -20 cm scenario. A high estimate for the project scenario fulfils the criterion of conservativeness. The model calculates a releasable amount of 2.4 t P for the total project area (Table 13). The assumed size of the catchment will determine the dilution effect. The calculation shows that the P concentration in downstream water courses will increase by less than 0.02 mg l^{-1} in the third year after rewetting (t=3), so that the risk of polluting downstream waters is judged extremely low (see Chapter 5.2.2 and TREPEL 2004).

Table 13: The impact of various assumptions on the estimated risk of P release after rewetting. Case A uses the alternative baseline scenario; case B the baseline scenario; and case C the alternative project scenario (water table -20 cm). Grey shading shows aberrant settings compared with B (E = Low intensity use, I = Intensive use).

Parameter	A	B	C
Rewetted area (ha)	54.4	54.4	54.4
Catchment area of the Elde outflow of the project area (1000 ha)	13.8	13.8	13.8
Prevailing land use intensity in the baseline	E	I	E
Mean annual water table in the baseline (cm below surface)	30	60	30
Mean annual water table in the project scenario (cm below surface)	10	10	20
Mean daily outflow per ha of catchment (m^3 ha^{-1} d^{-1})	5	5	5
Mean annual P concentration at the outflow before rewetting (mg l^{-1})	0.1	0.1	0.1
Releasable P per soil layer (%)	7.5	7.5	7.5
Effective phosphorous release rate	0.1	0.1	0.1
Results			
Total P stock of the top 1 m of soil (t P)	83.4	163.9	83.4
Releasable P in the top 1 m of soil (t P)	2.4	4.4	1.0
Mean annual P concentration at outflow (mg l^{-1}) in the 3rd year after rewetting	0.106	0.111	0.102
Risk of polluting downstream waters; t = 3	very low	very low	very low

5.3 Flood mitigation

5.3.1 Changes following rewetting

The goal of peatland rewetting is to reinstate near-natural conditions. Following the first axiom of peatland hydrology (EDOM 2001) the water table must, on average, be close to the surface for peat to be able to accumulate and the peatland to grow. After rewetting the peat should ideally be permanently saturated with water. Consequently, the peatland could not store any additional water in case of flooding (unless the peat is very loose and elastic) and, in this sense, its value for flood mitigation is limited. However, mires − particularly flood mires, but also mires located in kettle holes or on lake shores and fens in discharge areas − can withstand inundation for longer periods of time.

On the one hand, rewetted peatlands mitigate floods and associated damages to their area itself, which can store water and no longer supports drainage based crops. Furthermore, the dismantling and abandonment of flood prevention structures (e.g. dykes) means that their maintenance is no longer necessary. The scale of the flood mitigation effect depends on the actual situation in the area.

On the other hand, rewetted peatlands function as retention areas. If water courses can widen, their flow rate is reduced; this, in turn, reduces peak flow downstream. The potential for damage reduction depends on the presence of flood-prone areas downstream, as well as on the potential damage caused in these areas. In large areas of Mecklenburg-Western Pomerania a significant flooding risk is generally not given (BIOTA 2012). Consequently, no additional mitigation effect can be identified for these areas. Damage reduction would otherwise depend on the achievable reduction in peak flow.

5.3.2 Methodology

A sound quantification of flood peak reduction requires hydrodynamic modelling, which incorporates the temporal dynamics of the stream network. A flood peak reduction in a single water body assumes, for example, that the retention volume is not exhausted at the time of peak through-flow. A controlled flooding is no longer possible after dykes have been dismantled, which limits considerably the effectiveness of rewetted areas in terms of flood peak reduction. In Mecklenburg-Western Pomerania there are hardly any drained fens used for controlled flooding in flood mitigation measures.

The methodology for assessing the flood mitigation potential largely corresponds with the methodology for assessing GHG emissions (Table 3). The methodologies differ with regard to quantification (MRV), leakage and monitoring (Table 14).

Table 14: Methodological requirements for quantifying improved flood mitigation potential in MoorFutures v. 2.0. Only those aspects that deviate from the GHG methodology are shown (cf. Table 3).

Component	MoorFutures Requirements
Quantification (MRV)	Standard approach: Flood mitigation is quantified as the retention volume of the rewetted area, which is derived from available elevation models and historic data on flood heights (unit: absolute retention volume m^3).
	Premium approach: Flood mitigation is calculated using a hydrodynamic model and quantified as the delay in the time of peak flood (Δt [h]), as well as the size of the flood peak reduction (Δh [m]) (h=water table). The outlet of the project area is used as reference cross section. The potential mitigation downstream is not considered.
Leakage	Activity shifting is avoided by site selection and/or the provision of alternative sources of income (tourism, paludiculture, and hunting). Market leakage is irrelevant because of the small size of the projects.
	Ecologically leakage can occur in association with flood mitigation if in the baseline the project area acts as an inundation area in times of flood. Because this service is compromised by the rewetting, the flooding pressure increases downstream. Such situations should be avoided by proper site selection.
	Should leakage occur, it will be quantified and accounted for.
Monitoring	At specific time intervals, it should be checked whether changes in surface elevation have occurred or whether the digital terrain model has been updated.

Methodological explanation (MRV)

Hydrodynamic modelling of flood peak reduction is complex and associated with high uncertainties: when input data are of low quality (with respect to flow channel surveys and hydrographs for the design basis flood) and conservativeness must be guaranteed. Moreover, results are not easily transferred to downstream areas, as the flood mitigation effect downstream depends on volume and temporal dynamics of in between tributaries. This complex analysis should only be undertaken within the framework of a MoorFutures (v. 2.0) project if the necessary hydraulic models are already available. It is recommended to limit the evaluation of flood mitigation in MoorFutures (v 2.0) projects to the standard approach of assessing the retention volume of the rewetted area, which is provided by a storage hydrograph, and can be determined with little cost or time expenditure.

Determining retention volume: The above ground storage volume (flooding) is a function of the geometry of the landscape and the water level. In simplified terms a single, horizontal water level can be assumed for small or only slightly sloping areas. For larger water areas, it should be noted that the water level shows a gradient. In a first approximation, this slope can be deemed equal to the slope of the ground surface. A determination of the water level dependent retention volume is then based on this uniform water level. A digital elevation model (DEM) of the rewetted area must be available. It allows for calculation of the relevant retention volume for each user defined water level, using appropriate GIS-Tools (e.g. GRASS, GRASS DT 2012; ARCGIS + 3D-Analyst, ESRI 2012; SAGA-GIS, SAGA UGA 2008). Thus, this first analysis provides the retention volume, as well as the area flooded for a range of river water levels.

Determining flood peak reduction: It is assumed that the rewetted area is percolated or is part of the catchment of a water course section. The reference profile for the estimation of peak flow reduction is the outlet of the rewetted area into the downstream water system. A potential mitigation for downstream sections of the water course is not considered yet. For an evaluation of flood peak reduction, flood hydrographs for the project area must be created, ideally for a range of statistical probabilities. The most important design flood is the HQ (100), which statistically occurs once every 100 years. The flood hydrographs can be developed from measurement data or from precipitation discharge of the effective catchments. The through flow of the project area and the connected water course can then be assessed using a range of model approaches of differing complexity (cf. DYCK & PESCHKE 1995). Instationary models for flood wave dynamics require more intricate parameterisation input data, including: (i) kinematic wave projections; (ii) diffusive wave projections; and (iii) complete dynamic wave projections / hydrodynamic modelling (e.g. Hec-Ras, USACE 2010). A comprehensive overview of modelling options for retention in natural wetlands is provided by MALTBY (2009).

If the area acted as a retention area prior to rewetting, calculations must be performed not only for the project scenario (with rewetting), but also for the baseline scenario (without rewetting), and only the change in retention performance should be evaluated.

Comparison of methods

A comparative overview of the methods is presented in Table 15.

Table 15: Comparison of methods for quantifying flood mitigation.

	Retention volume	Flood peak reduction
Data collection	Medium (DEM along small waterways is not standard; Alternative: TK10)	High (channel surveys required)
Costs	Low	High
Time requirements	Low	Medium to high
Accuracy	According to the available elevation model	According to the quality of the channel survey and the design flood hydrographs
Verifiability	If water gauge data are available	If water gauge data are available
Applicability to MoorFutures	Standard approach	Premium approach for projects that focus on flood prevention

5.3.3 Results for the Kieve Polder

Input data: The Kieve Polder is located upstream of the Kieve Lake and west of the Kieve Elde and the Kambser canal. Hydrologically, the area is part of the upper catchment of the Elde. The catchment consists of an undulating ground moraine landscape, which the Elde valley has cut. Surface elevation varies between 63 m HN (basins) to 68 m HN (Kieve village). The Wittstocker Heide (state of Brandenburg), a large forest-rich area growing on outwash plain soils, is located directly to the southwest; in other directions a series of small hills (73-89 m HN) forms the catchment border. The catchment is almost entirely under agricultural use, predominantly grassland. Part of the Polder is a small forested area in the north with alder carrs and pine plantations. The Elde constitutes the main drainage channel for the fen areas on both sides of the canalised Elde River. Both parts of the Kieve Polder were drained into the Elde by the Kieve pumping station (IHU 2003).

The nearest weather station offering freely available data is the Marnitz station, about 50 km west of Kieve. It provided data on the mean annual cycle of rainfall, temperature, relative atmospheric humidity and sun hours, as well as on land use specific evaporation, for the period 1997-2011. Evaporation of the polder prior to rewetting amounted to 482 mm y^{-1}.

The above ground catchment area of Kieve Polder is 366.25 ha large (LAWA area classification number 5921540000, States' Working Group on Water). As a result of ice-age glaciation stages there are six aquifers in the Kieve Polder area. From peat depths and the depth of the first aquifer, and the spatial extent of the impermeable layer between the first and second aquifer, it follows that only the first aquifer provides water to the polder. The first aquifer consists of sands of the Weichsel glacial stage deposited during glacial retreat, and locally has a depth of 5-10 m. The hydraulic conductivity of the sand is $10\text{-}25 \cdot 10^{-5}$ m s^{-1}; small extents have a hydraulic conductivity of $1\text{-}10 \cdot 10^{-5}$ m s^{-1}.

The geo-hydraulic survey during the planning stage of the Kieve Polder rewetting has not been very extensive. In a feasibility study (IHU 2003) groundwater recharge rates were determined (on average ca. 47 mm y^{-1}), assuming that the above- and belowground catchment largely coincide. Continuous groundwater data are not available. The relevant permanent measurement posts of STALU Mecklenburg-Strelitz (2012) provide long-term data on (i) the Elde gauge at Wredenhagen (aboveground catchment = 78.6 km², water level and flow rate, 1983-2011), and (ii) the lake level of the Kiever Lake (water level, 1983-2011).

Applying the average discharge rate from the Wredenhagen gauge (5.5 l s^{-1} km^{-2}; 177 mm y^{-1}) to the area of the Polder Kieve catchment (366.25 ha), an average discharge rate of about 20 l s^{-1} results. Thus, the project area (54.5 ha), which comprises only 15% of the aboveground catchment area, receives around 1,000 mm y^{-1} of run-off water. As a potential flooding area, the rewetting of the peatland will primarily be achieved by river water. Water availability for the area is secured, and inflow from the above- and belowground catchment is not essential for guaranteeing ground water tables near the surface.

From the 2010 mapping of vegetation types and associated soil moisture classes, used for the estimation of GHG emissions (see Table 5), the groundwater depth was deduced following Succow & Joosten (2001) for the alternative baseline scenario. After rewetting the following vegetation is expected: tall reeds on flooded areas (25.5 ha); tall reeds on very wet areas (average water table of 0-20 cm below surface; 11.7 ha); and moist tall forb meadows (average water level 20-50 cm below ground level; 17.3 ha).

Results: The results cover calculations for the retention volume (standard approach) and, for demonstration purposes, a very rough estimate of flood peak reduction (simplified premium approach). BIOTA (2012) presents preliminary flood risk areas following EU-HWRM-RL. According to this assessment, no significant flooding risk exists for areas downstream of the Kieve Polder (Figure 6). In other words, rewetting provides no noteworthy benefit with respect to reducing flood damage. Nevertheless, the effect of rewetting on flood mitigation is calculated here on the basis of available data.
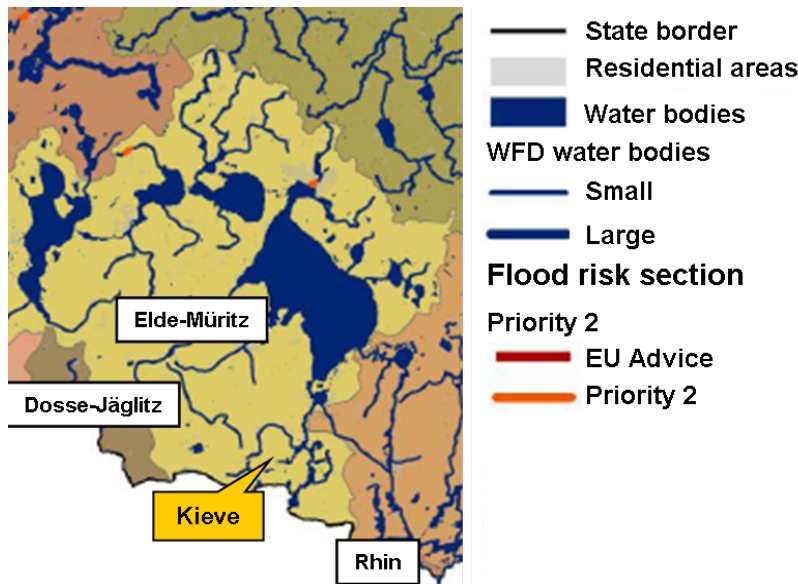
Figure 6: Provisional flood risk areas following EU Flood Directive, after BIOTA (2012).

The relation between water level and stored water volume is shown in Figure 7, taking the highest point in the rewetted area (65 098 m HN) as the maximum water level for retention. This height is derived from the survey data of the rewetting plan (IHU 2003). For an evaluation of the retention volume, flood water volumes of all flood events for the measurement period 1983-2011 of the Wredenhagen gauge were determined. Figure 8 shows the empirical probability of individual events, and whether they would have led to flooding of the project area. The graph clearly shows that the Kieve Polder could have completely absorbed 92% of the events.
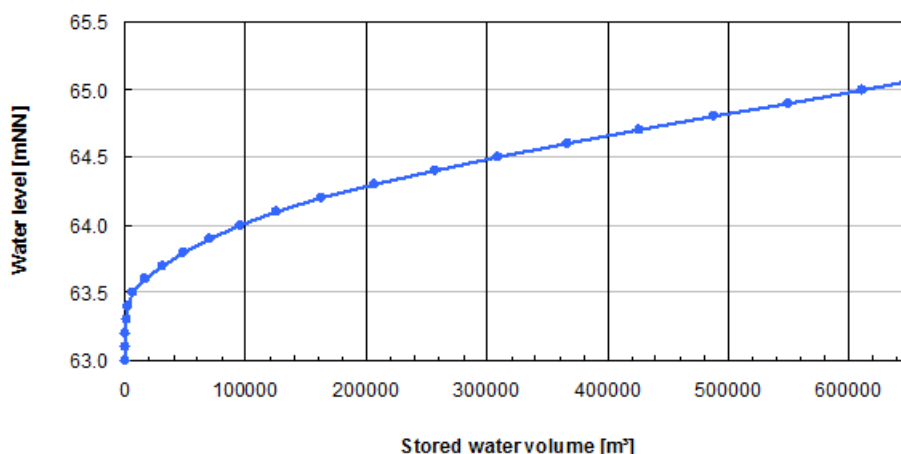
Figure 7: Depth volume curve for the Kieve Polder (Relation between water level and stored water volume) generated from DEM (© GeoBasis-DE/M-V 2013). Figure: A. Wahren.

For flood peak reduction, full buffering of a flood water volume is not necessary. A temporary retention can significantly reduce peak flow downstream. For example, the peak flow on 1 January 1986 was 2,160 m³ s⁻¹ (daily value). Under the assumptions taken (see also Figure 9) this peak flow would, through retention, have been reduced by 830 m³ s⁻¹ to 1 330 m³ s⁻¹. Thus, the flood peak would have been delayed by two days.
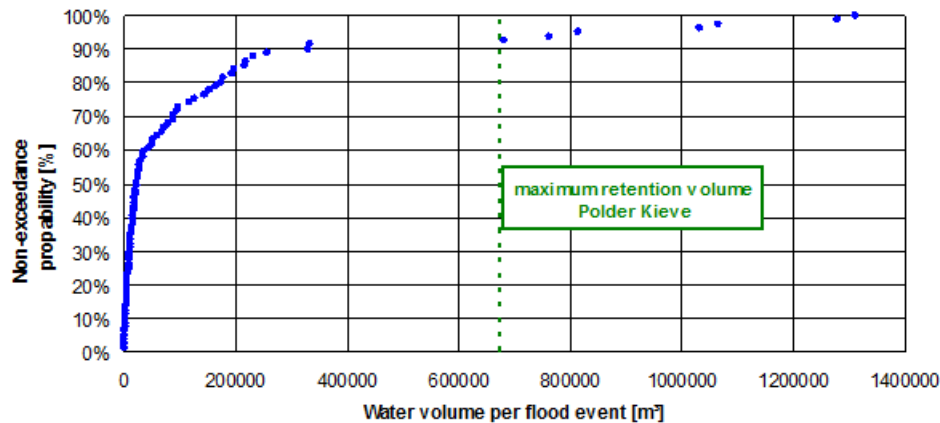
Figure 8: Empirical probability of flood water volumes from the Elde on the Wredenhagen gauge (1983-2011). Figure: A. Wahren.
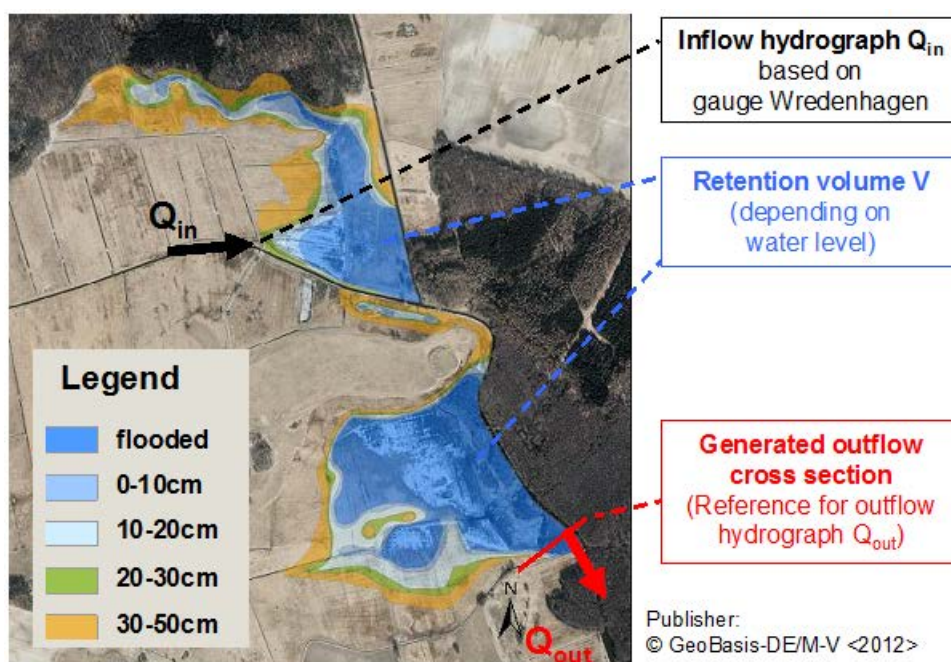
Figure 9: Schematic concept of the calculation of flood peak reduction (December 1986 to January 1987) by the Kieve Polder. Water tables in the legend in cm below surface. Map: A. Wahren, K. Brust.

5.4 Increased groundwater store

5.4.1 Changes following rewetting

Peatlands can interact with groundwater in the following (simplified) ways:

- Aquifers can feed peatlands (Figure 10 A).

- High groundwater tables can limit exfiltration from peatlands (the groundwater table in the surroundings lies above the bottom of the peatland) and thus can contribute to the expansion of peatlands (Figure 10 B).

- Peatlands need not be fed by groundwater, and infiltration rates can contribute to groundwater enrichment (Figure 10 C).

Depending on topography and the available groundwater, a wide range of site types can be defined from these three basic types of interaction between peatlands and groundwater. The resulting water regime types are described in SUCCOW & JOOSTEN (2001).

A) Groundwater discharge

$(h_{GW} > h_{peatland})$

h_{GW}
$h_{peatland}$

peat
aquifer

B) Limited recharge

$(h_{peatland} > h_{GW} > z_{bottom\ peat})$

$h_{peatland}$
h_{GW}
$z_{bottom\ peat}$

C) No influence of groundwater
(recharge, $h_{peatland} > z_{bottom\ peat}\ h_{GW}$)

$h_{peatland}$
$z_{bottom\ peat}$
h_{GW}

h_{GW} = Regional groundwater table - $h_{peatland}$ = Peatland water table - $z_{bottom\ peat}$ = Peatland bottom

Water flow (reduced to the vertical);   Peat   Aquifer

Figure 10: Types of interaction between peatland and groundwater. Figure: A. Gerner

Drainage of peatlands leads to faster discharge of water from the landscape to the receiving waters. The peatland water table decreases, which results in:

- The loss of water stored in the peatland.

- An increase in the hydraulic gradient between the supplying aquifer (if present) and the peatland, with a consequent increased outflow from the aquifer until a new, lower dynamic equilibrium establishes.

- Reduced infiltration (recharge) in the peatland, which, insofar the peatland feeds the aquifer, results in lower water tables in the aquifer.

- Subsidence of the peatland surface and the consequent impossibility to restore the water level to its original height before drainage.

- Rewetting inhibits the accelerated run off and loss of water from the landscape and increases the amount of water stored in the landscape. In coupled groundwater systems, these changes in landscape hydrology locally result in higher groundwater tables up- and downstream compared with the situation prior to rewetting (Figure 11).
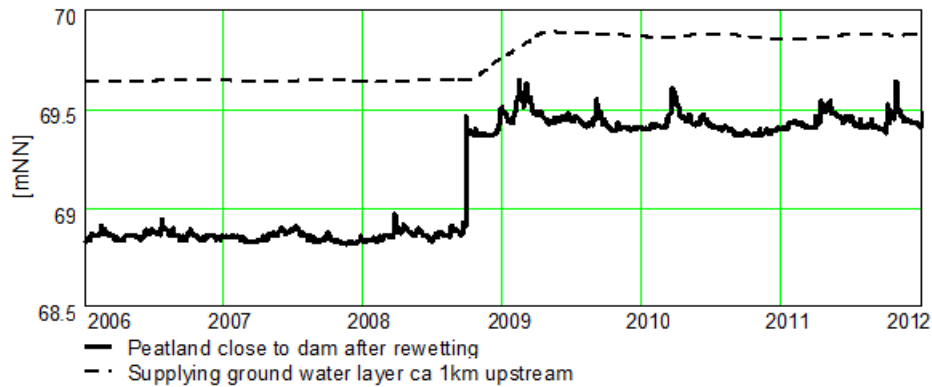
Figure 11: Calculated groundwater increase following rewetting (schematic diagram based on synthetic data). Figure: A. Wahren.

5.4.2 Methodology

In a drained peatland, drainage measures (ditches, pumping stations, etc.) keep the groundwater table artificially below the level it would reach without these measures. Rewetting means that drainage is stopped, e.g. by filling in ditches or switching off pumps. Initially, rewetting will cause an immediate rise in the groundwater table close to the rewetting measures (in the peatland). Over time, the groundwater table will rise also in the wider surroundings (in the catchment). The change in groundwater table and the area affected by the measures depend on the drained volume, which is determined by the slope (in case of gravity drainage) or the pumping performance. The effect of the rewetting depends on the natural water supply of the catchment (precipitation, climate parameters and soil properties) and the hydraulic characteristics of the aquifer (hydraulic conductivity, porosity). Consequently, a sound analysis strongly depends on the availability of hydrological and hydrogeological data. An initial estimate can be made using generally available maps, digital data and field visits. However, a detailed assessment requires investigation of the stratigraphy of all involved aquifers and of the peatland itself, as well as (ideally) a long time series of groundwater data with fine spatial resolution. Then, this information is fed into a geo-hydraulic model, which can predict the effects of rewetting.

Extensive monitoring is appropriate, at the latest with the start of rewetting, as it may adversely affect third parties. Third party damage should be avoided as far as possible by site selection and appropriate protective measures, because it would oppose the desired positive effect of increased groundwater storage. Potential negative side effects must be evaluated as accurately as possible in the preparatory stage, and, if necessary, they should be monitored by groundwater measurements after rewetting.

The methodology for assessing increased groundwater stores largely corresponds with the methodology for assessing GHG emissions (Table 3). The methodologies differ with respect to quantification, leakage and monitoring (Table 16).

Table 16: Methodological requirements for quantifying increased groundwater stores in MoorFutures v. 2.0. Only those aspects that deviate from the GHG methodology are shown (cf. Table 3).

Component	Requirement in MoorFutures
Quantification (MRV)	Standard approach: Qualitative evaluation of the expected effects based on all available relevant hydrogeological data; if possible, quantitative estimation should be done using conceptual geo-hydraulic models.
	Premium approach: Numerical groundwater modelling based on extensive hydrogeological investigation.
	The estimated rise in groundwater tables (and storage) suffers from considerable uncertainty for methodological reasons. As a result, a conservative approach will predict only minimal changes.
Monitoring	Standard approach: At specific time intervals, it should be checked whether changes in surface elevation have occurred or whether the digital terrain model has been updated
	Premium approach: Continuous long term monitoring (monthly ground water tables, initially at weekly intervals) to evaluate the desired effects and potential negative side effects.

Methodological explanation (MRV)

Basic principles: Using a method developed by MALTBY (2009), a qualitative estimate can be made with the help of field measurements to assess whether and to what degree a peatland site contributes to groundwater recharge or is fed by groundwater discharge. This method allows for roughly estimating the expected additional positive effects, as well as for evaluating if further quantitative research is needed.

Delineation of the catchment is an important prerequisite for quantifying the interaction between ground- and surface water. Water divides between aboveground catchments can be identified from the surface relief. Depending on precipitation and catchment morphology, a larger or smaller number of relevant above ground inflow paths into the peatland may be derived. The belowground catchment (aquifers) can differ significantly from the aboveground catchment, depending on the character of the subsoil. Hydrogeological maps, like the HK50, provide an initial insight on the position of belowground catchments. As far as they are available, the results of hydrogeological studies can be used and they can be improved with existing data from soil cores. Ideally, depth contour lines can be constructed that allow for a delineation of the belowground catchment, in a manner analogous to the delineation of the aboveground catchment.

Although changes in the groundwater table of the catchment may have consequences for other ESS as well, these effects are not considered here. However, the potential negative side effects of rising water tables, for instance on buildings or land use, should be considered. These potential side effects should be identified using spatial analyses during project preparation, and be considered in the planning of the project measures.

An alternative to the premium approach is the numerical modelling of groundwater. It requires a hydrogeological model which describes the geometry and hydraulic characteristics of the aquifer with sufficient accuracy. It is ultimately based on available soil cores. The initial settings, selected boundary conditions, and not least, the calibration of the model, are based on observed groundwater tables. Therefore, reliability of the model strongly depends on the spatial resolution of soil cores and groundwater monitoring sites. Popular software packages are MODFLOW (HARBAUGH et al. 2000) and FEFLOW (DIERSCH 2009). To include the

interaction between ground and surface water, which plays a major role in peatlands, groundwater flow models are expanded by or coupled to other models that inter alia describe channel flow; see WILSNACK et al. (2001), BAKKER (2007) and MONNINKHOFF & LI (2009) for examples.

Input data: An initial characterisation of the baseline conditions can be done using topographic and hydrogeological maps, as well as available groundwater data. On site, soil moisture, the presence or absence of surface water, water temperature, and hydrochemical and vegetation data provide information on groundwater influence. If available, long term groundwater data could provide information on temporal dynamics and on the extent of anthropogenic influences such as drainage and damming. Data are available for surface waters and land ecosystems that are linked to groundwater; these data were collected in relation to the European Water Framework Directive (UMWELTPLAN 2003).

The effect of the rewetting measures (compared with the baseline situation) is evaluated by the predicted changes to groundwater tables and the corresponding change in water volume integrated over the catchment area. With regard to the interaction between ground and surface water, the (stationary) steady state that establishes after rewetting is of interest.

Infiltration occurs when the water table in the peatland lies above the surrounding groundwater table. Besides the hydraulic potential, hydraulic conductivity is crucial in determining infiltration from the peatland into the aquifer below. On the basis of available data, a simple estimate can be made by drawing up a water balance that incorporates above ground flow in and out of the area, as well as the evapotranspiration of the area (Standard approach).

The data requirements for the premium approach are relatively high. However, for the evaluation of rewetting measures the (qualitative) changes in the system are most relevant, and alternative, reduced model approaches which require less data can be used as well. For instance, step response functions (BUSCH et al. 1993) make it possible to substitute a numerical groundwater model by a set of transitional functions, which translate a change in boundary conditions to a change in the system. Yet, a detailed description of the baseline state is not possible when using this method.

If the data needed for groundwater modelling are not easily available, it should be considered whether the funds and time required to gathering the necessary data are justifiable within the framework of a MoorFutures project. As an alternative to a quantitative estimate, a qualitative evaluation of the expected effects is feasible. At comparatively low cost, groundwater tables can be monitored after rewetting to check the validity of the estimate.

Comparison of methods

A comparative overview of the methods described above is shown in Table 17.

Table 17: Comparison of the methods to asses increased groundwater storage.

	Qualitative evaluation and simple estimate based on existing data	**Numerical groundwater modelling**
Data collection	Low to medium (optimal usage of existing data)	High
Costs	Medium	High
Time requirements	Medium	High
Accuracy	Medium	Medium to high (depending on the quality of the data)
Verifiability	Long term monitoring	Long term monitoring
Applicability to MoorFutures	Standard approach	Premium approach for projects with a focus on increasing the groundwater store

5.4.3 Results for Kieve Polder

Input data: See Chapter 5.3.3

Results: For the rewetting of Kieve Polder, no geo-hydraulic study was carried out as the peatland can be supplied with water from the Elde River during dry periods (IHU 2004), and the availability of water from the aquifer is less relevant. There are no groundwater gauges in the catchment area of the peatland. Adequate input data for geo-hydraulic modelling are thus not available and could only be gathered by additional research in a premium approach. For the protection of nearby properties (particularly the drainage and sewage system of the Kieve village), the drainage systems south of the rewetted area have been preserved and partly improved. From a qualitative perspective, the influence of the rewetting on the first aquifer remains slight. The additional amount of water stored in the aquifer was estimated based on geo-hydraulic principles (standard approach).

Using the step response function (see above), the increase in the water table in the first aquifer in response to the rewetting can be estimated. Based on the HK50 map and additional data mentioned above, the following values are assumed for an exemplary calculation:

Depth of first aquifer (following HK50): 5 m

Permeability of first aquifer (following HK50): $1 \cdot 10^{-4}$ m s^{-1}

Storage coefficient/porosity of first aquifer: 0.25

Figure 12 shows how the average groundwater table in the first, connected aquifer would change over time as a function of the distance to the polder (100, 200, 600, 1000 m), if the average ground water table in the ditches were raised by 0.5 m.
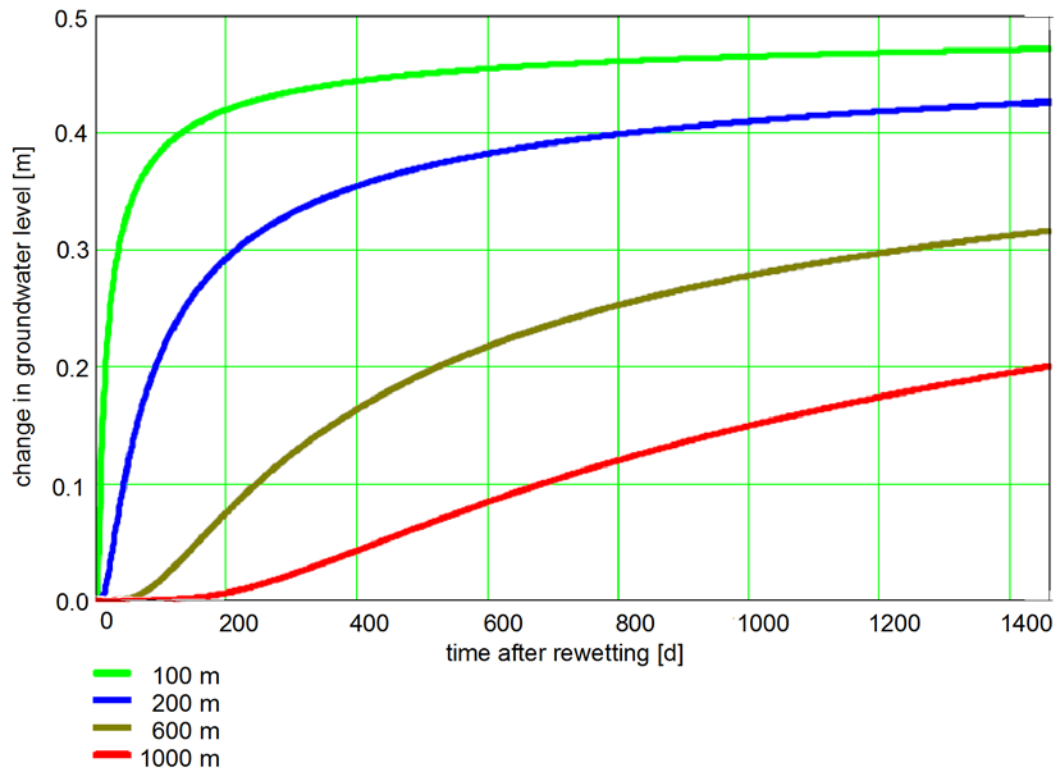
Figure 12: Change in the average groundwater table in the first aquifer, after raising the water table in the peatland by 0.5 m as a function of the distance to the polder based on the step response function (BUSCH et al. 1993). Figure: A. Wahren.

Based on the geometry of the belowground catchment (first aquifer from the hydrological map of the GDR - HK50) and the distance-dependent increase in the groundwater table in this catchment, the additionally retained water volume in the aquifer was estimated to amount to 150,000 m³. However, because the southern and the south part of the northern belowground catchment are still drained by several ditches, the increase in groundwater retention will turn out to be considerably lower. However, the effect of these ditches cannot be represented in a fixed way, and accurate quantification inevitably requires a premium approach.

5.5 Evaporative cooling

5.5.1 Changes following rewetting

The energy balance on the Earth's surface is determined by the available energy (or net radiation), which is governed by the sensitive heat flux, the latent heat flux (evaporative heat) and the soil heat flux. The proportions at which the available energy contributes to the warming of the air, soil or vegetation, or to evaporation, depends on the type of soil, the condition and moisture content of the soil, and the ground cover/vegetation.

The rewetting of a peatland results in the following evaporation-related changes:

- An increase in the available water (increased groundwater tables).

- A change in vegetation and its cover (including the creation of additional water bodies because of inundation), and its influence on the energy input (radiation balance).

- An increase in the thermal conductivity of the soil/peat because of an increase in soil moisture.

As a result, rewetting changes the mean annual partitioning of available energy towards increased evaporation and reduced warming. A change in the vegetation cover or the establishment of a new water body alters heat reflection and emission properties of the surface, which in turn reduces the total amount of available energy. Furthermore, the changes in heat flux alter the vegetation temperature. Evaporative cooling occurs when the sensible heat flux (where appropriate, coupled with the soil heat flux) is lower than before rewetting.

The extent to which rewetting influences local heat fluxes always depends on how the peatland is embedded into the landscape (dry/wet environment). The effect is also subject to strong fluctuations, both within and across years, as determined by climatic input (precipitation, temperature, relative humidity, sunshine duration, and wind speed). The actual evaporative cooling of a rewetted peatland site is a complex process involving a range of local and regional feedbacks. The microclimatic effect of peatlands is often touted, but thus far has rarely been quantified

5.5.2 Methodology

The site-specific net radiation (Rn) and latent energy (L.E) must be determined for the situation before and after rewetting. Assuming that the soil heat flux (G) is balanced out over the course of the year, the annual average sensible heat flux can be determined as the difference between these two variables.

If:

$$Rn = H + L.E + G \qquad \qquad \text{Eq. 1}$$

Then, if G = 0:

$$H = Rn - L.E \qquad \qquad \text{Eq. 2}$$

The difference between H_0 before rewetting and H after rewetting is the cooling achieved by rewetting. The cooling effect can be estimated, modelled, and measured using default values (Evapotranspiration Energy Site Types, EEST approach). The methodology for assessing evaporative cooling largely corresponds with the methodology for assessing GHG emissions (Table 3). The methodologies differ with respect to quantification, leakage and monitoring (Table 18).

Table 18: Methodological requirements for quantifying evaporative cooling in MoorFutures v. 2.0. Only those aspects that deviate from the GHG methodology are shown (cf. Table 3).

Component	Requirement in MoorFutures
Quantification (MRV)	Standard approach: By means of EESTs (Evapotranspiration Energy Site Types), which quantify the 'net thermal energy' in a model-based matrix (cf. EDOM 2001, EDOM et al. 2010) and which are derived from representative climate data (units: annual energy balance in $W\ m^{-2}$ or $kWh\ ha^{-1}\ y^{-1}$).
	Premium approach: Modelling (e.g. with AKWA-M®)
	In order to ensure conservativeness:
	(i) The dampening effect of wet areas on temperature amplitudes (diurnal and seasonal) is neglected by using annual averages (neglecting both the diurnal and seasonal variation in evaporation, as well as the better thermal conductivity of moist vs. dry peat). The cooling effect is greatest in summer or during warm and sunny parts of the day, i.e. when cooling is most required.
	(ii) Heat production due to peat oxidation in the baseline scenario is neglected
Leakage	Activity shifting is avoided by site selection and/or the provision of alternative sources of income (tourism, paludiculture, and hunting). Market leakage is irrelevant because of the small size of the projects.
	Ecological leakage is irrelevant because of the spatially limited effect.
	Should leakage occur, it will be quantified and accounted for.
Monitoring	Standard approach: updating of EEST values every 10 years using current data from climate stations.
	Premium approach: updating of the model input data at appropriate intervals.

Methodological explanation (MRV) of the EEST approach

Basic principles: The quantification approach presented here makes a series of simplifying assumptions which are conservative in accordance with the MoorFutures Standard:

- Advective air flow over the peatland is neglected. Therefore, the modelled evaporation for sites with a groundwater table close to the surface quasi corresponds to the equilibrium evaporation of a large wetland area with optimal water supply.

- Only total annual evaporative cooling is considered, which effectively cancels changes in heat stored in the soil.

- Mean groundwater table depths are applied for vegetation and land use types in the baseline and project scenarios.

- The availability of water for maintaining future groundwater table depths is outside of the scope of this investigation, and must be ensured in advance through hydrogeological and hydrological surveys.

Determining net radiation: The net radiation describes the amount of energy available at the Earth's surface, and consists of five main radiation fluxes − direct and diffuse short-wave radiation; reflected short-wave radiation; long-wave atmospheric counter-radiation; and long-wave radiation lost from the Earth's surface. Using climate data from seven climate stations in or in close proximity to Mecklenburg-Western Pomerania (1997-2011), the net radiation was calculated for the following land use types: bare peat, bare sand,

arable land, grassland, peatland forest (carr), bog, fen, sedges, reeds, and open water. The average net radiation for the growing season (April to September) and the annual mean are illustrated here because of their relevance for evaporation processes. The net radiation for the individual land use types varies considerably. Figure 13 demonstrates this variation in an example based on the climate data from the Marnitz station.

The typical seasonal variation in net radiation for all of the land use types considered is illustrated in Figure 14 (Marnitz station). It is evident that the net radiation is greatest for open water bodies (least atmospheric heating), while bare sandy soil and arable land exhibit the lowest net radiation (largest atmospheric heating). Depending on the global radiation reaching the Earth's surface, net radiation is at its annual maximum in June.
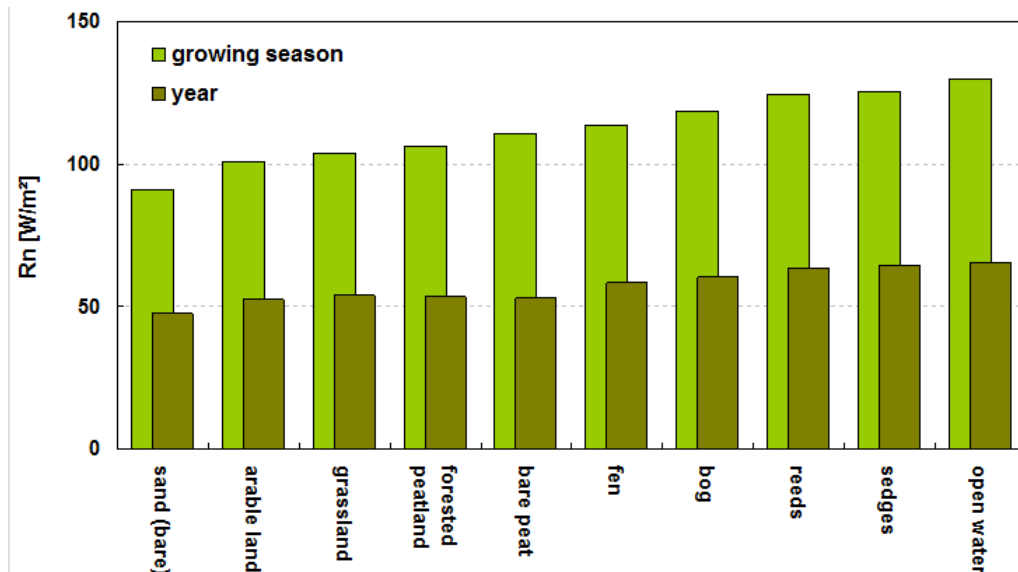
Figure 13: Net radiation for various types of land use in an example for the Marnitz climate station. Higher values correspond to lower warming of the lower atmosphere. Figure: K. Brust.
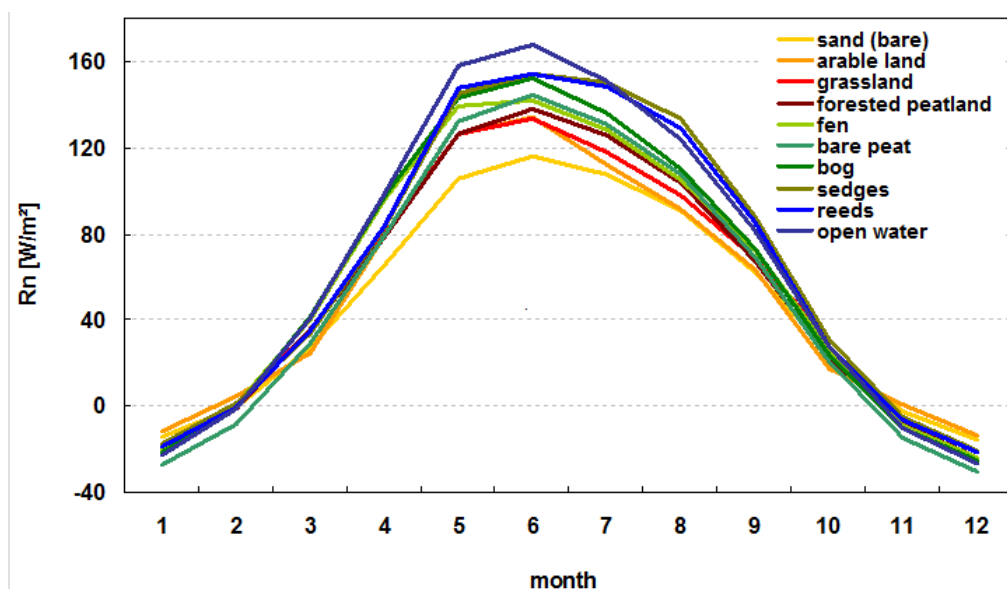
Figure 14: Seasonal variation in net radiation for various land uses. Figure: K. Brust.

EEST approach: Components of the energy balance were calculated for various land use types and groundwater table depths, using climate input data from stations that cover the west-east gradient for Mecklenburg-Western Pomerania (inland), as well as from two stations near the coast. These input data were used to create a matrix (Appendix 3) with which the cooling energy of so-called Evapotranspiration Energy Site Types (EEST) can be determined in relation to location and vegetation cover. A specific groundwater table depth is assigned to each of the vegetation types in the matrix. The matrix shows values for various climate stations to illustrate the climate-induced west-east gradient of evaporative cooling in Mecklenburg-Western Pomerania. The energy balance components and their area weighted average are determined for the baseline and project scenario. The difference between the energy balance of the baseline and project scenarios provides an annual average amount of energy, which will no longer contribute to the warming of the lower atmosphere in future.

It should be noted that the cooling effect of a wetland area strongly depends on its surroundings. If the wetland is located in a dry landscape, the cooling effect will be larger than in a wet landscape. A dry landscape would furthermore bring dry air to the wetland through advection, resulting in an additional increase in evaporation. Besides, during winter, rewetted areas may contribute to a decreased cooling of their surroundings. Accordingly, rewetting weakens the continentality of the climate (which increases when moving eastward) over the full year as temperature extremes are attenuated both during summer and winter. With EESTs, evaporative cooling is assessed using the simplest approach. The approach is well suited and feasible for use in MoorFutures v. 2.0.

Methodological explanation (MRV) of the modelling approach

The evaporative cooling of rewetted wetland areas can be quantified using modelling approaches of varying complexity. The development of complex atmospheric boundary layer models requires high resolution input data, which are unavailable for unmonitored areas. The modelling of energy fluxes using simplified, established approaches is more efficient. Calculations can be repeated using climate data from other stations and other measurement periods. In addition, the parameterisation of the evaporation approaches presented below can be extended to include further peat and vegetation types.

The Penman-Monteith approach is the method most widely used for the modelling of evaporation from land surfaces. The approaches of SHUTTLEWORTH & WALLACE (1985) and PRIESTLEY & TAYLOR (1972) are similar. Application of these approaches assumes that representative relative humidity measurements are available for the area under examination. It is precisely these data which are problematic for peatland areas. The air over a wet peatland area has a higher moisture content than the surrounding area. The resulting lower atmospheric moisture demand reduces evaporation. The difference between the atmospheric moisture demand over the peatland, compared with its environment, depends on the size of the peatland and the water supply of the surrounding area. The difference is greater in the case of small peatlands in dry landscapes than for large peatlands in wet landscapes. Consequently, the Penman-Monteith approach will always overestimate the potential evaporation from peatlands when climate data from conventional climate stations are used.

The approach of MORTON (1983) differs from other methods in that it views measured humidity not as a driver but rather as a result of evaporation. This approach calculates an

equilibrium temperature at which an area with an unlimited supply of water (i.e. which has unrestricted evaporation) achieves the same result for the energy balance equation and the water transfer equation. Advection is neglected in this approach; strictly speaking, it only applies to large wetland areas or wetlands within a wet landscape. Evaporation increases in areas where advection exerts a significant influence, which means that wetland evaporation calculated after MORTON (1983) always represents the lower limit of evaporation in an area with an optimal water supply. In other words, the MORTON approach presents a conservative estimate of wetland evaporation rates, which will certainly be achieved. However, this approach cannot be used for different types of land use or take into account different ground water tables. Here, the approach is used only for comparison with other calculations.

SUCCOW & JOOSTEN (2001) describe a peatland-specific approach for calculating evaporation put forward by ROMANOV. Within this procedure, an advective influx from areas bordering the peatland can be taken into account, resulting in a corresponding increase in evaporation. However, determining this empirical value is very laborious. Evaporation is specified according to groundwater table depth. If evaporation is calculated according to ROMANOV without factoring in the advection component, evaporation for small peatland areas is underestimated (like with the MORTON approach). Dry air is transported over the peatland via advection from neighbouring dry areas, which causes a considerable increase in evaporation over the wet site. In general, the ROMANOV approach is valid for wet peatlands only, and thus far has not been calibrated for drained and mineralised sites. Accordingly, further development would be required for this approach to be used within the MoorFutures methodology.

The AKWA-M® model (MÜNCH 2004) is a modular water balance model which enables the user to choose between various evaporation approaches. Besides a range of further approaches with larger empirical model components, the model offers the evaporation approach of PENMAN-MONTEITH, as well as that of ROMANOV. Like the ROMANOV approach, it takes into account the direct dependency of peatland evaporation on the groundwater table depth, thus it is well suited for the MoorFutures methodology.

The evaporation rates L.E for various land use types with varying groundwater table depths were modelled using the AKWA-M® water balance model (MÜNCH 2004). The sum of the sensitive heat flux H and the soil heat flux G is calculated as the difference between the net radiation Rn for these land use types (determined in advance) and L.E (*cf.* Eq. 1). Figure 15 shows the components of the energy balance for grassland with different drainage depths; Figure 16 for other types of land use.
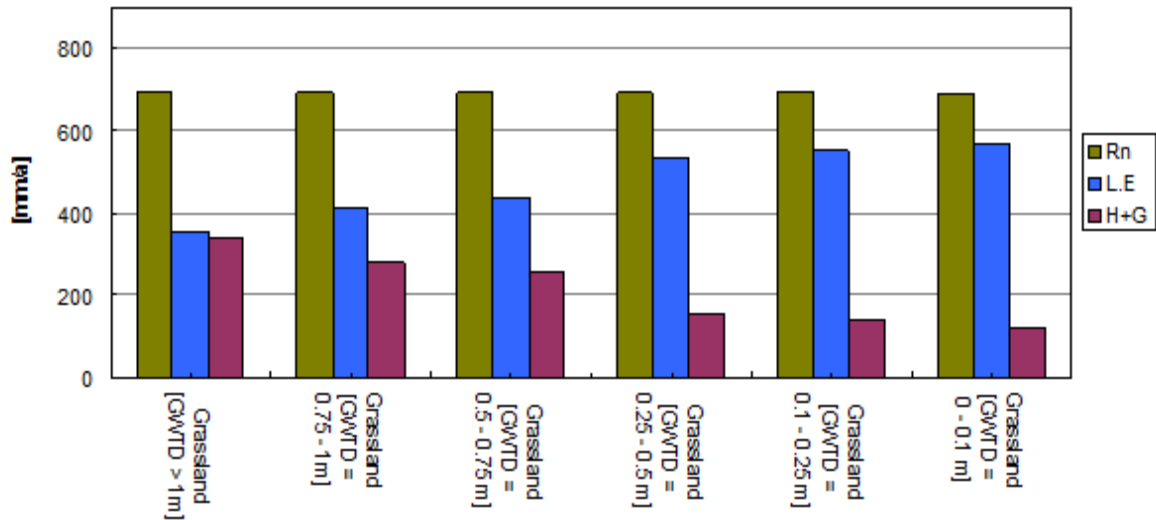
Figure 15: Components of the energy balance over grassland with different drainage depths (L.E calculated according to Romanov with AKWA-M®, H+G as the difference between Rn and L.E). Figure: K. Brust.
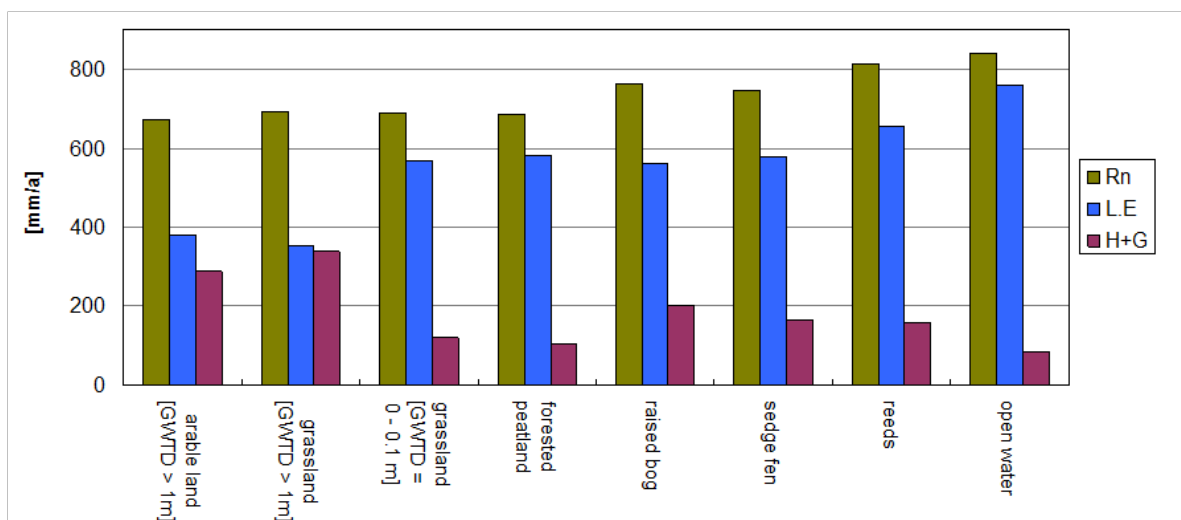
Figure 16: Components of the energy balance for different vegetation / land use types (L.E calculated according to Romanov with AKWA-M®, H+G as the difference between Rn and L.E). Figure: K. Brust.

As the long term annual soil heat flux G is assumed to be around zero, the calculated remainder (H+G) represents the sensitive heat flux H. The smaller H+G, the lower the warming of the atmosphere close to the ground is, and the greater the cooling of the lower atmosphere. As can be seen in Figure 15 and Figure 16, the lowest evaporation values are associated with land use types involving deep drainage, such as arable land and grassland. With higher groundwater tables the evaporation rate increases. The natural vegetation on the water-saturated peat soil (trees, sedges, reeds) shows high evaporation values − and lower values for H+G.

Methodological explanation (MRV) of measurements

Evaporation can be measured indirectly using a variety of methods (cf. BERNHOFER & MIEGEL 1997 and DREXLER et al. 2004) – for instance, using aerodynamic methods, the Bowen ratio method, or turbulent diffusion methods (e.g. by eddy covariance). Regardless of the chosen method for measuring evaporation, the measurement process always involves considerable effort and expense. For a qualified quantification of the change in local heat fluxes, sufficiently long measuring periods before and after rewetting must be compared.

Comparison of methods

A comparative overview of the presented methods is shown in Table 19.

Table 19: Comparison of methods for quantifying evaporative cooling.

	Estimation using EEST	Modelling	Measurement
Data requirements	Low	Medium to high	Low
Costs	Low	High	Very high
Time requirements	Low	Medium	High
Accuracy	Low	Medium	High
Verifiability	Vegetation mapping, survey of land use	Measurement of input data	-
Suitability for MoorFutures	Standard approach	Premium approach for projects that focus on evaporative cooling	Not suited

5.5.3   Results for Kieve Polder

Input data: see Chapter 5.3.3

EEST approach: The evaporative cooling brought about by rewetting is presented for Kieve Polder as an illustrative example. The vegetation in the baseline and the project scenario serves as input (see Table 5). Net radiation was determined as described in Chapter 5.5.2. Evaporation from the various types of land use was calculated using AKWA-M®. Table 20 illustrates the resulting energy balance after rewetting compared with the baseline scenario.

Calculating the balance using the AKWA-M® model actually belongs to the premium approach. However, the energy balance components that were established using the climate input data from Marnitz station are also part of the EEST matrix (Appendix 3).

Table 20: Change in the energy balance remainder ($\Delta(H+G)$) for Kieve Polder after rewetting. The ground water table (GWT) before (baseline scenario) and after rewetting (project scenario) is given for different sub-areas together with their area cover.

	Baseline scenario GWT	Project scenario GWT	Area (ha)	$\Delta(H+G)$ (kW ha^{-1})	Area-related $\Delta(H+G)$ (kW)	$\Delta(H+G)$ (kWh y^{-1})
Tall reeds (inundation)	40	0	25.5	59	1 499	13 130 556
Tall reeds	40	10	11.7	28	322	2 824 936
Forb meadows	40	40	17.3	0	0	0
Total			54.5		1 821	15 955 491

Because of increased evapotranspiration, the rewetting of the polder area results in a decrease of 15.96 GWh y^{-1} of energy that would otherwise warm the lower atmosphere. This amount of energy corresponds to the remainder of the energy balance (H+G).

The rewetting of the polder area results in a mean cooling effect of 3.34 W m^{-2} (33.4 kW ha^{-1} or 1,821 kW on 54.5 ha). This value can be compared with the anthropogenically caused radiative forcing by the emission of greenhouse gases. Globally, the average change in radiative forcing because of greenhouse gas emissions since preindustrial times is estimated at approximately 2.6 W m^{-2} (IPCC 2007). Rewetting thus more than compensates for this change on the polder area (but only there). The evaporative cooling brought about by rewetting can therefore be considered high; the tangible effect is geographically very limited though.

5.6 Increased mire-typical biodiversity

5.6.1 Changes following rewetting

Definition of mire-typical biodiversity: According to the Convention on Biological Diversity (CBD), biological diversity or biodiversity means "the variability among living organisms from all sources (...); this includes diversity within species, between species and of ecosystems." Hence, biological diversity is not confined solely to species of animals, higher plants, mosses, lichens, fungi and microorganisms. Many species are further subdivided into sub-species and regional varieties, and are divided into different genetic populations. For this reason, biological diversity also includes genetic diversity within a species, as well as the habitats of organisms and the ecosystems in which these are organised. Ultimately, biological diversity, or biodiversity, encompasses everything that contributes to the diversity of living nature (BMU 2007).

Because of the different interpretations of the biodiversity concept and the different goals pursued with its conservation, there is often little consensus as to *which* biodiversity should be conserved. MoorFutures v. 2.0 aims to increase mire-typical biodiversity, which is defined as the biodiversity that would occur without drainage, spontaneously, or under adapted land use. However, an assessment of the effects of rewetting must also take into account protected species not typical to peatlands. Alternatively, the loss of biodiversity and the resulting 'deficit' or 'need' could be identified for a MoorFutures region. Yet, because (near-)pristine peatlands are always already severely reduced in those regions where carbon credits from the rewetting could reasonably be established, a great need for mire-typical diversity can, in principle, be presumed for each MoorFutures region. The subordination of ESS to biodiversity, as done in the context of the MILLENNIUM ECOSYSTEM ASSESSMENT (2003), is not followed here because the essential ESS of rewetted peatlands are presented and quantified separately.

With regard to the integration of mire-typical biodiversity into MoorFutures, the following aspects should be considered in comparison to the ESS mentioned above:

- Biodiversity is affected even by minimal degradation, but shows a great capacity for regeneration at the same time.

- The actual occurrence of mire-typical species depends not only on the (re-)establishment of suitable habitats, but also on the ability to colonise the area (e.g.

availability of propagules, presence of vital populations, and potential for reproduction). For migratory animals, living conditions along the entire migration cycle play a role (which affects the conservativeness criterion).

Indicators: In order to assess the effect of peatland rewetting on biodiversity, suited indicators to evaluate the development of the area must be identified. Indicators are species, species groups, or communities, which are expected to react to rewetting within an appropriate period of time (project period) (cf. CARO 2010). The lower such indicators are in the food chain, the more likely a rapid and direct reaction. Ideally, a large number of indicators with spatially and temporally varying reactions would be used (CHAPMAN et al. 2003). The selection of indicators strongly depends upon the primary motivation for rewetting. For instance, if the focus is on water quality, species or communities that respond quickly and specifically to water quality should be selected (such as aquatic beetles, aquatic plants, and diatoms). If the focus is on habitat, or on species protection, the abundance of the desired species or communities should be chosen. Such species are called flagship species (if they are especially charismatic and are representative of a certain community) or umbrella species (if they are at the top of the food chain and are indicative of its functioning). Of particular importance are ecosystem engineers such as peatmosses (*Sphagnum* spp.), which are themselves an integral part of the ecosystem's development (particularly peat formation) (LINDSAY 2010)**.**

The following criteria apply to the selection of indicators:

- Mobility (rapid colonisation of new habitats, e.g. dragonflies, ground beetles, butterflies).

- Range and precision of the indication (groups that precisely indicate a wide range of peatland conditions and can be recorded using the same simple methods, e.g. dragonflies).

- Affiliation to existing monitoring or certification programmes.

- Simplicity and costs of data capture (limited by expected revenue; therefore, indicators which can be captured along with the monitoring of other ESS should be chosen to the greatest possible extent).

Based on these criteria, it would be appropriate – at least for north-eastern Germany – to select the following groups as indicator: *vascular plants/mosses*, *birds*, *amphibians* and *arthropods* (especially spiders, moths, ground beetles, bugs, locusts and cicadas). These groups also exhibit a high indicator value for the habitat type 'fens, moist and wet areas' (STICKROTH et al. 2003). Birds and butterflies are considered 'particularly well-suited' indicators because of their potential for standardisation, representation, practicability, and their share of endangered species (STICKROTH et al. 2003). Regional indicator values should be used for the assessment (north-east Germany: plants according to SUCCOW 1988 and SUCCOW & JOOSTEN 2001; breeding birds according to FLADE 1994; arthropods according to GÖRN & FISCHER 2011).

Research results from Mecklenburg-Western Pomerania: The vegetation of rewetted fens in Mecklenburg-Western Pomerania is often determined by strongly eutrophic or polytrophic conditions. Inundated fens initially exhibit stretches of open water with low cover of *Typha angustifolia* or *T. latifolia* (Figure 17). They later develop into tall reeds of

Phragmites australis, *Glyceria maxima* and *G. fluitans*, and only after a longer period of time sedges become established (*Carex* spp.; SCHULZ 2005, TIMMERMANN et al. 2006, STEFFENHAGEN et al. 2008). A slow and controlled rewetting such as that carried out in the Randow-Rustow Polder, more quickly leads to less nutrient rich conditions (within 4-8 years).

Water level class	Nutrient availability	1995	1998	2003	2030
6+	polytroph sr-er		Typha latifolia reed	Typha latifolia reed	
	eutroph k-r		Schoenoplectus-Phragmites reed	Schoenoplectus-Phragmites reed	Schoenoplectus-Phragmites reed
5+	polytroph sr-er		Rorippa-Typha-Phragmites reed	Rorippa-Typha-Phragmites reed	
	eutroph r		Cicuta-Carex reed	Cicuta-Carex reed	Cicuta-Carex reed
	eutroph k				Ranunculus lingua-Carex reed
4+	polytroph sr-er		Solanum-Phragmites forbs	Solanum-Phragmites forbs	Solanum-Phragmites forbs
	eutroph r				Caltha-Filipendula forbs
	eutroph k-r				Thelypteris-Salix shrub
3+	polytroph sr-er	Phalaris grassland			
	eutroph r	Ranunculus-Cirsium meadow			
	mesotroph m	Sanguisorba-Molinia meadow			
2+	polytroph sr-er	Urtica-Dactylus grassland			

→ Real development
⋯→ Proposed development

Figure 17: Vegetation development in Anklamer Stadtbruch nature conservation area (modified after SCHULZ 2005).

In the first years after rewetting, many fens in Mecklenburg-Western Pomerania are moderately inundated. They accommodate large numbers of roosting ducks, and the three 'swamp tern' species (*Chlidonias* spp.) occur as regular breeding birds (e.g. SELLIN & SCHIRMEISTER 2004). Rewetted, inundated polders offer great potential for crakes. HEROLD (2012) recorded high densities of Spotted Crake (*Porzana porzana*), Little Crake (*Porzana parva*), and the first evidence of nesting by Baillon's Crake (*Porzana pusilla*) in eastern Germany since 90 years. A slow, 'controlled' rewetting leads to the occurrence of numerous species listed in Annex I of the Birds Directive (Figure 18) within just a short number of years.
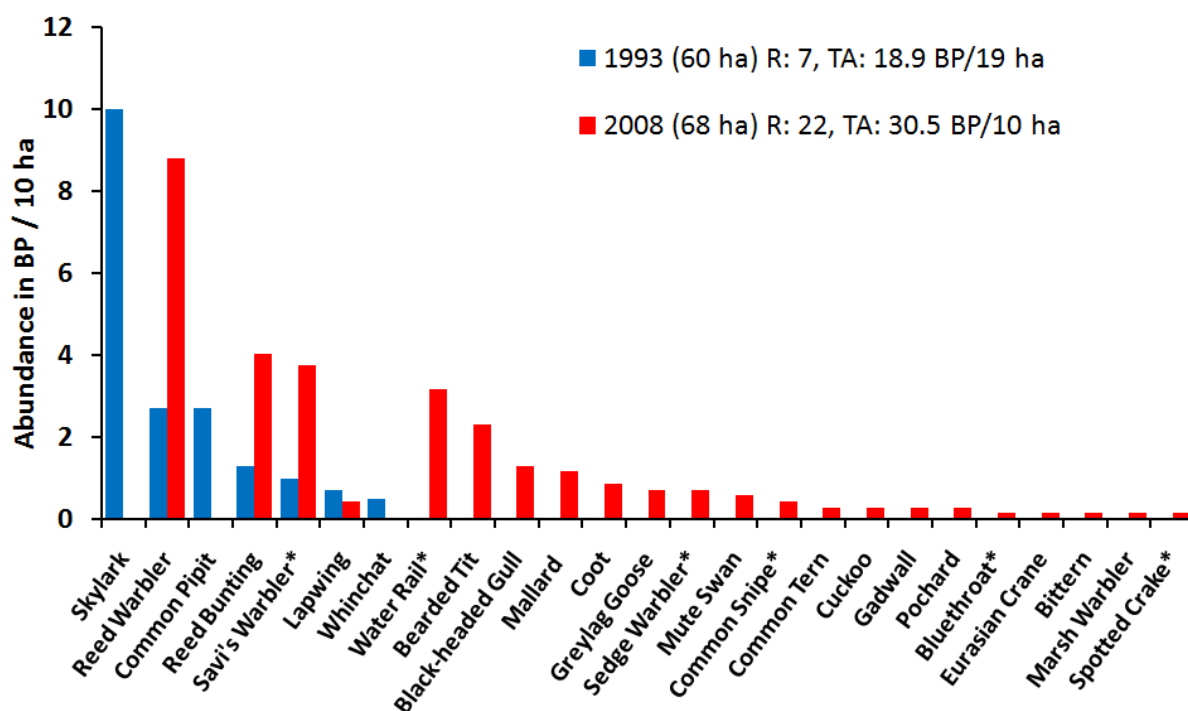
Figure 18: Abundance of breeding birds prior to (1993) and eight years after rewetting (2008) in Randow-Rustow Polder, Mecklenburg-Western Pomerania (from HEROLD 2012). * = indicator species for river valley mires, A = abundance, BP = breeding pair, R = number of recorded species, TA = total abundance.

Likewise, amphibians demonstrate an increase in species diversity and population size, in rewetted fens. At Randow-Rustow Polder, which was rewetted section-by-section in three phases, VEGELIN et al. (2009) recorded 5 species of amphibians − which were likely not previously present (Table 21), already in the first year after rewetting (2000). Two of these species (Common Toad and Edible Frog) have shown a large population increase by 2008.

Table 21: Occurrence of amphibians in a study plot in Randow-Rustow Polder during controlled rewetting from 2000-2004 and in 2008 (VEGELIN et al. 2009).

Scientific name	English name	Hab Dir.	2000	2002	2003	2004	2008
Lissotriton vulgaris	Smooth Newt						X
Pelobatus fuscus	Common Spadefoot	IV		X		X	
Bufo bufo	Common Toad		X	X	X		X
Hyla arborea	European Tree Frog	IV	X	X	X	X	X
Rana arvalis	Moor Frog	IV	X	X	X	X	X
Rana temporaria	Common Frog		X	X	X	X	X
Rana esculenta	Edible Frog	V	X	X	X	X	X

Research on arthropods in rewetted coastal flood peatlands in north-eastern Germany showed that beetles (Coleoptera) already reacted to changes within the first year, and spiders (Arachnida) in the third year (MÜLLER-MOTZFELDT 1997). Rewetting can exert a positive influence on the occurrence and reproduction of dragonflies (MAUERSBERGER et al. 2010). Mobile species usually colonise new habitats more quickly than more sedentary species. However, eight years after rewetting in Randow-Rustow Polder, VEGELIN et al. (2009) observed only six ubiquitous species of butterflies (Papilionoidea) and no occurrence of the Large Copper (*Lycaena dispar*), despite wide-scale availability of its forage.

5.6.2 Methodology

Also for the assessment of the change in mire-typical biodiversity between the baseline and project scenario, a cost-effective standard approach is proposed, as well as a premium approach that requires additional field surveys. Assessment must take into account both gains and losses in biodiversity values. In the baseline scenario, project areas typically exhibit a meagre inventory of species that are atypical to wet peatlands. Such a poor inventory of atypical species is characteristic of degraded fen grasslands. Nonetheless, these areas are important to a certain extent as resting grounds for migratory bird species: for example, the drained river valley peatland Randow-Welse-Bruch was designated a European protected bird area because of its global significance as a resting ground for the European Golden Plover (*Pluvialis apricaria*) with >14,000 resting individuals, and similarly high numbers of Common Crane (*Grus grus*), Greater White-fronted Goose (*Anser albifrons*), Bean Goose (*A. fabalis*), and Northern Lapwing (*Vanellus vanellus*). Such areas lose their capacity as resting areas after they are rewetted.

A reduced gain (or even loss) of species richness may occur if there is a shift in site-internal nutrient conditions (see Chapter 5.2.1). Such potential losses, which could be reduced through appropriate site selection, offset the expected gains in mire-typical biodiversity. Data on species for which there are national or international monitoring obligations (e.g. Habitats Directive annex species, see e.g. SACHTELEBEN & BEHRENS 2010) should be incorporated in the assessment, but are not sufficient on their own.

The methodology for increased mire-typical biodiversity largely corresponds to the methodology for assessing GHG emissions (Table 3). The methodologies differ with respect to quantification (MRV), leakage, and monitoring (Table 22).

Table 22: Methodological requirements for quantifying mire-typical biodiversity in MoorFutures v. 2.0. Only those aspects that deviate from the GHG methodology are shown (cf. Table 3).

Component	MoorFutures guidelines
Quantification (MRV)	Standard approach: Estimation using the BEST approach (Biodiversity Evaluation Site Type), which employs regionally accepted methods of impact regulation or other biotope assessment procedures (unit: biotope value).
	Premium approach: Measurement of the number of indicator species and evaluation using an indicator species model (unit: number of species or scores).
	To ensure conservativeness: (i) the standard approach uses high estimates for the baseline and low estimates for the project scenario; and (ii) the gain in indicator species is underestimated *ex ante* except in cases in which colonisation is highly likely (e.g. because the species is present on adjacent areas).

Component	MoorFutures guidelines
Leakage	Activity shifting is avoided by site selection and/or the provision of alternative sources of income (tourism, paludiculture, and hunting). Market leakage is irrelevant because of the small size of the projects. Ecological leakage is avoided by proper site selection that guarantees that biodiversity losses do not affect protected species.
	Should leakage occur, it will be quantified and accounted for.
Monitoring	Standard approach: Re-estimation of the project scenario every ten years.
	Premium approach: Re-mapping of indicator species every ten years.

Methodological explanation (MRV) of the BEST approach

The BEST approach (Biodiversity Evaluation Site Type) uses regionally accepted methods of impact regulation, which are modified slightly if necessary, or other biotope evaluation procedures. In some cases, these vary considerably from state to state. In Mecklenburg-Western Pomerania the 'Guidelines for Impact Regulation' (LUNG 1999) present the general and legal basis used to evaluate unavoidable impacts, to determine the need for compensation, and to assess compensation or substitution measures. Evaluation rules (as they apply to the relevant situation) are always the same for the impact and its corresponding compensation.

The impact regulation assigns a value to the impacted area based on biotope types and their particular functions for nature and landscape. The required compensation is expressed as compensation area equivalent and compared with the planned compensation measures. In principle, ancillary consideration of faunistic aspects is possible, but in practice is rarely used or not used at all, at least in Mecklenburg-Western Pomerania. In the MoorFutures assessment, an evaluation of the project area without rewetting (baseline scenario) is compared with an evaluation of the project area after rewetting (project scenario) (Table 23).

Table 23 Assessment of biodiversity value in the Impact Regulation (LUNG 1999) and in MoorFutures v. 2.0.

Impact Regulation	MoorFutures
Assessment of the impacted area and determination of the required compensation.	Assessment of the project area without rewetting (baseline scenario).
Assessment of compensation and substitution measures.	Assessment of the project area after rewetting (project scenario).
Unit: compensation points, compensation equivalents.	Unit: biotope value, defined using compensation area´ equivalents.

The biotope type can be determined using the vegetation data collected for the GEST assessment − i.e. no additional collection of data is required for the BEST assessment. Mire-typical biotope types are represented as biotope types in impact regulation guidelines (Table 24).

Table 24: Examples of biotope types on peat soil in impact regulation guidelines of Mecklenburg-Western Pomerania (LUNG 1999) and North Rhine-Westphalia (LANUV 2013). * = the relative values are based on regenerative capacity, occurrence of endangered biotope types (Red List), typical species assemblage, occurrence of endangered species and other factors; typical values are shown here.

Mecklenburg-Western Pomerania (LUNG 1999)		North Rhine-Westphalia (LANUV 2013)	
Biotope type	Relative value	Biotope type	Relative value
9.3.1 High intensity grassland on peat	0*	Cultivated grassland	2-4
9.1 Moist and wet grassland	2	Species rich hay meadow	2
6.1 Tall sedges	2	Reeds, short and tall sedges	2
6.2 Reeds	2		2
7.3 Near-natural base rich and calcareous transition mire	4	Peatland	4

* the value of this biotope type is actually 1, but is treated as 0 in case the biotope is upgraded, which is the premise of MoorFutures projects.

Methodological explanation (MRV) - measurement and evaluation with an indicator species model

In north-eastern Germany, indicator species models for evaluating peatlands are currently available for birds and arthropods. A model for vascular plants/mosses could be developed using existing data (see below); a model for amphibians would also need to be developed.

Vascular plants and mosses: For these groups, finely differentiated site data − which could be used as an indicator of biodiversity, are available for north-eastern Germany (SUCCOW 1988 and SUCCOW & JOOSTEN 2001). A model for assessing the effects of rewetting could be developed based on these data and on comprehensive monitoring data from rewetted peatlands. In a simplified form, the model possibly could be based on Natura 2000 habitat types.

Amphibians: There is currently no indicator species model for this group to assess the effects of rewetting in north-eastern Germany.

Birds and arthropods: GÖRN & FISCHER (2011) have developed a faunistic indicator species model and an assessment procedure for the fens of north-eastern Germany. The model takes into account the occurrence of the ground beetle, butterfly, locust and bird species groups. These groups were selected based on the following criteria (after GÖRN & FISCHER 2011):

- Relative ease of detection and identification.

- Availability of standardised survey methods (e.g. MITSCHKE et al. 2005, WRANIK et al. 2008).

- High indicator value because of very well-known ecology (e.g. BLAB & KUDRNA 1982, FLADE 1994).

- Suitability for assessment on various spatial scales (ground beetles: biotope; locusts: biotope to biotope complex; butterflies: biotope complex; birds: biotope complex to landscape).

- High representation in peatlands.

- Where possible, taxa that are popular with the public.

Only species typical of fen sites in Western Pomerania were considered (other species, e.g. those eurytopic or alien to the biotope were not):

- Ground beetles with their main or secondary occurrence in the following habitat types: oligo- to mesotrophic fens, and short and tall sedges and reeds; moist and wet forb meadows, and moist and wet grasslands (GAC 2009).

- Butterflies belonging to the groups 'hygrophilic open land species' and/or 'broadly tyrphophilic' (BLAB & KUDRNA 1982).

- Locusts occurring in habitat types 'peatlands' and/or 'moist or wet meadows' (Wranik et al. 2008).

- Birds that are indicators for the habitat types 'reeds', 'tall sedges', 'moist meadow', 'fens/floodplains', and 'wet fallow lands' (Flade 1994).

A total of 158 species (81 ground beetles, 26 butterflies, 12 locusts and 39 birds) were identified as potential indicators for Western-Pomerania (the former districts of Nordvorpommern, Ostvorpommern, Uecker-Randow and Demmin). These habitat-typical species were assigned a specific score on a scale of 1 to 100, based on the criteria of (1) distribution (incl. frequency for ground beetles and butterflies); (2) national red list status (state- and nationwide); and (3) international red list status. The assessment of a given habitat was initially broken down according to species group (breeding birds, butterflies, locusts, ground beetles). The total sum of points for each habitat was calculated from the scores of the observed species. The significance of an area is assessed as follows: ≤ 32 points local significance; 33-66 regional significance; 67-99 state-wide significance; ≥ 100 national significance. If more than one indicator group is used for the assessment, scores are summed and assessed against the above ranges, then multiplied by the number of indicator groups. For example, in the case of two indicator groups, ≤ 64 points indicates local significance. Thus, the overall higher number of available indicator species is taken into account. To avoid that species of international importance lose their priority status, their scores are also multiplied by the number of species groups (in the case of two species groups = 200 points). In this way, the occurrence of a species of international importance still results in national significance of the biotope. A similar approach is applied to species that are threatened by extinction, or thought extinct on a national scale; scores of these species are increased by half the basic score with each additional indicator group (e.g. 75 points instead of 50 for two species groups, 100 points for three species groups) (GÖRN & FISCHER 2011).

According to GÖRN & FISCHER (2011), significant advantages of this procedure include that it:

- considers only habitat-typical species (no ubiquists or species alien to the biotope, as these are unsuitable for the assessment);

- is additive (no averaging, as this does not take into account the completeness of a coenosis);

- includes the national and international red list status of species.

However, the procedure does require the collection of comprehensive monitoring data. The following monitoring procedure is recommended for the individual species groups: breeding birds, three times annually; butterflies, once in May/June and once in August/September; locusts, three times annually; ground beetles, over a long survey period. For use in the context of MoorFutures v. 2.0, a reduced number of target species can be surveyed rather than entire species collectives to simplify the procedure and reduce costs. Criteria for their selection have yet to be developed.

Comparison of methods: Monitoring costs are very low in the standard approach because the biotope types can be assessed using the vegetation maps created for the GEST assessment. However, the impact regulation procedure in its current form is a very arbitrary one, which depends largely on the person applying it. For this reason, an additional assessment that follows the premium approach (in its entirety or reduced to specific species groups) is desirable. The premium approach incurs additional costs for faunistic data collection, but in return produces a considerably more accurate and consistent result. A regular monitoring of indicator species may enable MoorFutures to gain a foothold, not just in the voluntary carbon market but also in the 'biodiversity market', which has been developing over the past few years. Out of all the considered additional ESS, the demand for biodiversity will likely be the greatest. Biodiversity is explicit and tangible, and fits best with the increasing CSR efforts of environmentally conscious companies. The monitoring should be used for further developing the methodology, and may serve as 'in kind' co-financing for research projects.

5.6.3   Results for Kieve Polder

Data basis: In Polder Kieve, only the vegetation has been mapped once (2010, alternative baseline scenario in Table 5); faunistic data have yet to be systematically collected. Sporadic ornithological surveys are, nonetheless, available (see below).

Assessment using the BEST approach: Based on the vegetation assessment for determining the GHG emission reductions (Table 5), the biotope value of the baseline scenario is 0 (area equivalent 0 ha); the one of the alternative baseline scenario is 0.56 (area equivalent 30.5 ha); and that of the project scenario is 2.52 (area equivalent 137.6 ha; Table 25). Thus, rewetting results in an increase of 2.52 biotope value points compared to the baseline, and of 1.96 compared to the alternative baseline scenario.

Table 25: Assessment of biodiversity in Kieve Polder in the baseline, alternative baseline and project scenarios, using the BEST approach (based on LUNG 1999). * = based on corridor function, landscape value and occurrence of valuable species.

Biotope type	Area (ha)	Value	Compensation value	Biotope value	Area equiv. (ha)
Baseline scenario					
9.3.1 High intensity peat grassland	54.5	0	0-0.9	0	0
Average/total				0	0
Alternative baseline scenario					
9.3.1 High intensity peat grassland	39.2	0	0-0.9	0	0
6.4.2 Forbs of moist peatlands and marshes	10.1	1	1-1.5	1.5*	15.2
6.1 Tall sedges and 6.2 Reeds	5.1	2	2-3.5	3*	15.3
Average/total				0.56	30.5
Project scenario					
6.1 Tall sedges and 6.2 Reeds	25.5	2	2-3.5	3*	76.5
6.1 Tall sedges area and 6.2 Reeds	11.7	2	2-3.5	3*	35.1
6.4.2 Forbs of moist peatlands and marshes	17.3	1	1-1.5	1.5*	26.0
Average/total				2.52	137.6

Evaluation using indicator species model: An evaluation of Kieve Polder using indicator species is not currently possible because evaluation models and data are lacking. For *vascular plants/mosses*, only the mapping data from the year 2010 are available, when water tables were already somewhat elevated compared to the baseline. If a vegetation map of the polder in its drained condition were available, it could be used as a baseline scenario. Then, the difference in vegetation compared with the project scenario could be assessed using an indicator species model. However, an indicator species model for *plants/mosses* is not available. Such a model does exist for *birds* and *arthropods* for the region, as well as unsystematic observations from the years 2012 and 2013 (Table 26). For the most part, these observations reflect a state of transition with high water levels in the first years following rewetting.

Table 26: Occurrences of birds in Kieve Polder in 2012 and 2013 (unsystematic observations; * = SCHWARZ & BOLDT 2012). Ind. = individuals. x denotes presence.

	Observations 2012 R. Schwarz	Observations 2013 W. & S. Marquardt	Observations 29/05/2013 B. Holsten
Mute Swan	12/01 2 ind.	Breeding, 5. juv.	2 ind.
Whooper Swan	28/02 7 ind. and later roost with 47 ind.	01/13 64-136 ind.	
Bewick's Swan		Winter guest	
White-fronted Goose		x	
Bean Goose		x	
Greylag Goose		Breeding	
Gadwall		Suspected breeding, 08/08 approximately 30 ind.	approx. 15 ind.
Mallard		Breeding, on 08/08 approximately 200 ind.	approx. 15 ind.
Tufted Duck			1,1
Eurasian Wigeon		x	
Northern Shoveller		4 ind. at breeding time	
Garganey		x	
Common Pochard		x	
Eurasian Teal		08/08 e.g. 30 ind.	
Eurasian Coot		Breeding (at least 3 BP)	3 ind.
Red-necked Grebe		BP with juv.	
Grey Heron		Always present (07/08 13 ind.)	1 ind.
Great Egret	31/10 1 ind.	29/06 2 ind.	1 ind.
Common Crane	09/01 2 ind., 12/01 4 ind., 22/01 25 ind., 21/10 600 ind., 27/10 15 ind., roosting*, 19/01 1 BP	Roost, 07/08 90 ind.	2 ind.; likely breeding
Northern Lapwing	09/01 310 ind., 12/01 385 ind., 15/01 16 ind., 20/01 130 ind., 25/02 2 ind., 5/10 800 (with adjacent meadows)	At least 3 BP	4 ind.
Ruff		16/06, 23/06/13, 08/08; max. 5 ind.	
Spotted Redshank		04/08/13, max. 2 ind.	
Wood Sandpiper		26/06, 08/08; max. 2 ind.	
Common Snipe		x	
White-tailed Eagle	25/02 1 pair flying over		
Osprey		x	
Western Marsh-harrier		x	
Whinchat		x	1 ind.
Eurasian Reed Warbler		x	
Great Reed Warbler		x	
Common Reed Bunting		x	

To demonstrate the assessment method of GÖRN & FISCHER (2011) for birds, values that are typical for high intensity, drained peat grassland in Western Pomerania (after HEROLD 2012), are used in the baseline scenario (Table 27). Assumptions that appear realistic for Western Pomerania (based on observations of HEROLD 2012), and the ornithological data of Table 26, are used to predict the project scenario (with/without mowing). The effect of rewetting on bird diversity is shown in Table 27.

Table 27: Occurrence and evaluation (after GÖRN & FISCHER 2011) of bird species in Kieve Polder using hypothetical scenarios. 0-35 = occurrence (qualitative only) and score of the species, - = no occurrence.

Species name	Reference scenario	Project scenario, without mowing	Project scenario, with mowing
Sky Lark	0	-	-
Eurasian Reed Warbler	1	-	-
Meadow Pipit	0	-	-
Savi's Warbler	2	-	-
Northern Lapwing	20	20	20
Sedge Warbler	-	5	5
Corn Crake	-	-	10
Common Snipe	-	35	35
Common Crane	-	1	1
Common Redshank	-	-	20
Total scores for the area	23	61	91
Significance	local	Regional	national

There is neither an indicator species model nor reference data available for *amphibians*.

6 Challenges for future development

6.1 Standard

The MoorFutures Standard version 1.0 is based on recognised and approved criteria and requirements for GHG emission reduction projects in the land use sector (Chapter 3). As such, the MoorFutures Standard can be used for GHG emission reduction projects in other regions. The criteria for GHG emission reduction projects were transferred to other ESS and biodiversity, and applied in the assessment of the Kieve Polder project area. Like the VCS Standard, the MoorFutures Standard should not be seen as static. Until now, it has been a standard practice to certify ecological and social aspects separately (e.g. CCBA Standard). Integrating quantified ecological and social aspects in an existing standard for the generation of carbon credits has no precedent, and requires further development. In order to establish the MoorFutures Standard (v. 2.0), the approach developed for Kieve Polder must be tested at other sites and adapted where necessary. Experience gained with actual projects provides a basis for the continual development and improvement of the integrated standard.

The rewetting of Kieve Polder has proven to be positive in terms of all the considered ESS, which need not necessarily be the case. The criterion of sustainability (prohibiting deterioration) cannot always be adhered to in other types of peatland and at other sites. For instance, when a dyked peatland in an area prone to flooding is rewetted, its flood retention capacity decreases and this ESS is compromised. Biodiversity values may also be compromised through rewetting. In contrast, a reduction in emissions associated with rewetting will always lead to increases in nitrogen retention, evaporative cooling and groundwater recharge. The matter of how to deal with conflicting aims between ESS in the light of the sustainability criterion (prohibiting deterioration) has not been solved yet, so further research is needed.

Taking into account its many facets, sustainability not only means maintaining sources of income but also a long-term reliability of the production base. The Federal Soil Conservation Act requires preserving soil-fertility and soil-performance. When peatlands are drained and used for agriculture, their soil degrades and the legal requirement is not fulfilled. Only rewetting could prevent further soil degradation. Consequently, clarification is needed regarding the interplay between the MoorFutures Standard and existing statutory requirements, as well as the agricultural policy framework (e.g. good farming practices, cross compliance). A further aspect to be considered is the inclusion in the standard of the use of rewetted areas for agricultural or forestry (paludiculture).

Even if the criterion of sustainability (prohibiting deterioration) is adhered to, an implementation that will optimise one ESS does not necessarily lead to the optimisation of other ESS. These conflicts, or 'trade-offs', between different aims or benefits must be considered in the further development of the standard. Theoretically, a set of standards could be established, with specific standards for different types of projects that aim at optimising individual ESS. Together, these standards would be administered under a single 'meta-standard'.

There is the potential for conflict not only between but also within individual ESS; for example when deciding which (Red List) species should be attributed a higher value in biodiversity assessments. A more formalised approach to each ESS should be the main objective here. Emission reduction assessment has already undergone such a formalisation when it was

agreed that the varying climate impact of different gases would be expressed as their cumulative effect over 100 years (Global Warming Potential, GWP). This convention made it possible to compare the climate effect of different GHGs and evaluate them consistently (MICHAELIS 1997).

A standardised metric of this type is still pending for other ESS. Standardisation is rather straightforward if the service is independent of location, and can be measured along one single axis. For the global climate, it is irrelevant where the emission reduction takes place, because GHGs are well mixed in the atmosphere. However, most ESS depend on location and on time, and cannot be evaluated independently of their spatio-temporal context. If the context changes, so do the values. Finding a standardised metric (one value, one axis) will be easier for some ESS than for others.

A commodification of the climate-ESS − i.e. making the ESS into a good that can be sold on a market − became possible because binding global and regional GHG reduction goals were agreed upon, and corresponding economic instruments to achieve the objectives were established (e.g. eco-taxes, EU Emissions Trading System). An unbundling of the ESS would enable selling the other ESS on a dedicated market as well. Such a commodification requires market potential and willingness to pay on a voluntary ESS market. Further development of the MoorFutures standard should consider whether these requirements can be fulfilled, and whether unbundling is feasible. Then, commodification of individual ESS would pose the question of how these ESS should be priced.

6.2   Methodologies

The MoorFutures Standard was adapted to include additional ESS, and methodologies have been developed for each of these ESS. The applicability of these methodologies must be tested for all types of peatland that may be eligible for rewetting under MoorFutures. Testing and improving the methodologies will allow for the transition from MoorFutures version 1.0 as a 'carbon' standard to a 'carbon +' version 2.0 standard, which depicts and quantifies additional ESS. For each ESS of MoorFutures v. 2.0, the main directions in further development of the methodologies and site selection criteria are presented in the following chapters. Different methodologies than those presented here may be used, but they should meet the criteria. An example for alternative quantification and monitoring methods are those developed in the F+E project 'Moorschutz in Deutschland' (Peatland Protection in Germany; 2011-2014; http://www.moorschutz-deutschland.de).

6.2.1   Greenhouse gas emission reduction

Vegetation is generally a good indicator of the water table. In strongly altered systems, the type of land use (in combination with water table) is a better indicator because the vegetation has largely been changed and hence is not indicative of local abiotic conditions. GESTs are well-defined both for deeply drained and for wet conditions. Indication is less precise for intermediate groundwater tables; for these, the assessment can resort to the well-defined correlation between CO_2 flux and groundwater table. Sometimes, water table measurements may be required, but they can be carried out with little effort or expense. CO_2 emissions from ditches are significant, but are not addressed in the current GEST approach. Quantifying these fluxes and accounting for them could prove advantageous.

The current GEST approach conservatively neglects potential carbon sinks from peat formation, because it is difficult to predict and prove whether a sink actually develops. However, the establishment of vegetation on previously vegetation-free peat soil could be easily taken into consideration as a (temporary) carbon sink.

Methane emissions clearly depend on water table and vegetation. A better understanding of how vegetation types determine methane fluxes would be beneficial. For example, it is still unclear if some tall monocots function as shunts, and under what circumstances they do so. Episodic methane losses due to ebullition are not yet specifically addressed in the GEST approach. Spikes in methane emissions are occasionally observed following rewetting. Such spikes are largely restricted to highly eutrophic shallow lakes, that develop when sites are flooded that were previously used for high intensity agriculture. Research at the University of Rostock has shown that fluxes decrease in subsequent years (GLATZEL et al. 2011; G. Jurasinski pers. comm.). It would be helpful to obtain better estimates for the duration and size of initial methane spikes.

Methane spikes are much less pronounced on sites that are not flooded, particularly if these are furthermore not eutrophic areas previously used for agriculture. The rewetting of (largely) vegetation-free sites following peat extraction results in low CH_4 emissions that only increase as vegetation establishes over time. The recent meta-analysis by the IPCC (HIRAISHI et al. 2014) shows that, over time, CH_4 emissions become identical or similar to those from undrained, pristine sites. CH_4 emissions from drainage ditches are large compared with those from in-between drained areas. These fluxes are conservatively not accounted for in the present MoorFutures Standard.

Using vegetation and land use as key indicators, the GEST approach allows presenting the expected GHG fluxes consistently and in a transparent manner. The project documentation must assess the development of vegetation *ex ante*. This assessment is based on the conditions before rewetting, and on the potential of plant species to become established in the project area after rewetting. Further research on vegetation succession in drained and rewetted peatlands will help improve the prediction of vegetation development and associated GHG fluxes, both in the baseline and in the project scenario. The development of succession models will enable a further objectification of results.

Monitoring should be carried out regularly to verify the development after rewetting and to adjust the project scenario, if necessary. The results of this monitoring must be presented in a transparent way. Currently, the verification of *ex ante* emission reduction estimates is based on repeated GEST mapping (i.e. vegetation monitoring). Additionally, direct gas flux measurements could be carried out, although these are generally too expensive to be financed by revenue from the sale of carbon credits (see Section 3.3). Additional data from literature that become available after the start of the project can be used to re-assess and improve emission reduction estimates (see below). Direct measurement of groundwater tables could also be a realistic option, but requires an optimal stratification of the project area according to terrain elevation and rewetting prospects, as well as a correspondingly detailed monitoring strategy.

The MoorFutures risk reserve was created by the very conservative approach to the assessment scenarios (see Section 4.3). A regulated withholding of credits, as applied by the VCS, would be a preferable as soon as the project portfolio has reached a certain size, and

sufficient experience is available to decide how many credits are necessary and reasonable as a risk reserve for each project. Thus far, leakage has been avoided through careful site selection. A methodological embedding of leakage would enable the quantification of losses, and project sites where leakage cannot be ruled out could be taken into consideration as well.

6.2.2 Improved water quality

WETTRANS is a well-established method to assess nitrogen retention and the NEST approach simplifies it significantly. NEST-based estimates of the reduction in N-release after rewetting are very conservative. A decision-support system would be welcome to help decide whether to use the NEST approach or WETTRANS. PRisiko provides a model for assessing the release of phosphorus after rewetting. A simplified version of this model, parallel to NEST approach, does not yet exist.

Some aspects of the N and P cycle have yet to be taken into account. A procedure to evaluate the reduced nitrogen input in water bodies downstream is not yet available. The permanent storage of phosphorus in lakes was not taken into consideration either. In forested peatlands or acid fens, pH and hydrochemical components such as dissolved organic carbon (DOC) and sulphate SO_4^{2-} strongly determine water quality, which should be given greater consideration using more advanced procedures.

The EU Water Framework Directive and the EU Marine Strategy Framework Directive emphasise the need for action to reduce nutrient loads to surface waters. Regional and local need for action can be inferred when the physicochemical reference values used in the status assessment of the Water Framework Directive are exceeded. Regional or local need for action can support the selection of project areas.

The rewetting of peatlands contributes to the re-establishment of their original function as nutrient sinks in the landscape. Flood mires, terrestrialisation mires and groundwater fed spring mires are particularly appropriate for nitrogen retention. The reestablishment of an undisturbed flooding regime is necessary to improve phosphorus retention.

6.2.3 Flood retention

The assessment of flood retention strongly depends on available data (digital elevation models [DEM] and design water levels). The premium approach furthermore requires channel cross-sections in sufficient resolution (at least one cross-section per 100 m) as input to hydrodynamic models. The relevant state authorities should be asked which (sections of) watercourses have the necessary data available. For example, flood hazard/risk maps have recently been developed for Mecklenburg-Western Pomerania. In this framework, the necessary data for the standard approach have been collected for class I and II watercourses. Possibly the necessary data for the premium approach will be available to some extent as well. Lower order watercourses need not be considered in flood risk management, and they can be assumed irrelevant for flood retention in the north German lowlands.

6.2.4 Groundwater recharge

Large scale drainage in the past has led to an overall lowered groundwater table in the north German lowlands. Rewetting would initially only affect the groundwater table in the direct surrounding of the project area. Yet, combined rewetting projects can become effective at the regional level as well. The additive effect on groundwater retention of multiple rewetting projects affecting the same aquifer could be reflected in the selection criteria for project sites.

Besides the positive aspect of increased water storage, a risk of damage to third parties exists. The question whether and to what extent settlements may be affected by the rewetting should be considered during the planning approval procedure.

6.2.5 Evaporative cooling

A dynamic representation of the interannual course of evaporative cooling would make sense, and can be based on additional data on soil heat fluxes and on a validation of the current approach. Further research should test whether the use of annual averages of the cooling effect is not too conservative. The intra- and inter-annual variation in the energy balance should be examined more closely in this regard. A worthwhile area of research concerning the spatial effect of the cooling on its surroundings raises a number of complex questions: Do rewetted areas have 'cooling shadows'? How do adjacent rewetted areas affect one another? What are the feedbacks with the local climate?

Validation of the results and a more exact assessment of the albedo could be achieved using data from Fluxnet (http://fluxnet.ornl.gov/) and CarboEurope (http://www.carboeurope.org/). These data could also be used to provide the EEST approach with more exact values for other vegetation types. The question of whether the cooling effect can be meaningfully translated from $W\ m^{-2}$ or $kWh\ ha^{-1}\ y^{-1}$ into CO_2e needs further examination. A comparison with values of radiative forcing is certainly sensible to judge the magnitude of the effect.

6.2.6 Increased mire-typical biodiversity

The assessment of biodiversity needs (further) development of evaluation models for vascular plants/mosses, which can be based on Succow (1988), Succow & Joosten (2001) and monitoring data from rewetted peatlands in the relevant regions. The goal should be to enable an assessment based on the vegetation data anyhow collected for estimating emission reductions − i.e. to link vegetation types with an evaluation of mire-typical biodiversity. Amphibians are also well-suited as indicators of rewetting effects, but an evaluation model still needs to be developed for north-eastern Germany.

Accompanying research on so-called 'ecological traps' should be carried out in the coming years as well. The presence of species does not necessarily equate to successful reproduction at the site. Good habitat conditions may allow species to colonise the area where they nonetheless have little or no reproductive success. If the colonising species move out from an area where it was reproducing successfully, the species is said to be caught in an 'ecological trap'. If reproductive success in the rewetted area is substantially lower than in the source areas, it is essential to prevent such traps. The question whether rewetting may open ecological traps and if so, for which species, should be investigated at one or more

rewetted sites. At the same time, management options should be developed that help avoid ecological traps or minimize their effects.

Sites should be selected for the maximum possible gain in biodiversity, in projects where biodiversity is the main ESS next to reducing GHG emissions. The demand for such projects will likely be large. Projects that are particularly promising for mire-typical biodiversity can be offered selectively to potential buyers who are specifically interested in biodiversity. A screening of potential MoorFutures project areas with a focus on mire-typical biodiversity should:

- Review available biotope type maps for regional frequency and rarity of biotope types found in the baseline and project scenarios.

- Review available data on potential losses and gains of protected species. Potential losses can either be accepted, be offset through compensation, or be avoided by rejecting the area. Potential gains can be quantified using the assessment procedures (standard or premium approach).

6.3   Financing and pricing

So far, in rewetting projects carried out in Mecklenburg-Western Pomerania, land acquisition has been a standard practice. Even if conventional agricultural land use was no longer feasible, the land was bought and transferred to the Nature Conservation Trust Mecklenburg-Western Pomerania (Stiftung Naturschutz M-V).

However, as a general principle, the costs of acquiring land should not be included when setting the price of MoorFutures carbon credits. After all, the voluntary carbon market deals in ESS for climate protection and not in real estate. Moreover, land prices are to a large extent driven by transfer payments (e.g. direct payments) without return services. When land is purchased to generate MoorFutures and the costs of acquisition are included in the price of the carbon credits, a buyer of such credits would not only pay for the ESS, but would also support the economically counterproductive politics of subsidising environmentally harmful activities. However, crediting approaches were actually established to achieve the economically most efficient solution to an environmental problem. In keeping with this principle, the financial means invested in the protection of peatlands should be used as efficiently as possible. Private financing of counterproductive politics is certainly far from being economically efficient. MoorFutures cannot exist outside of this reality though. To circumvent perverse situations, it may be possible to establish adapted forms of land use on the rewetted peatland (paludiculture). The costs of acquiring land could then be saved or be compensated via lease income. Besides these general concerns, care should be taken that transaction costs of the credit trade are minimised.

Chapter 4.1 raised some questions on combining private and public funds to finance rewetting measures. In principle, such mixed financing of carbon credit projects is possible and commonly applied. Following the criterion of additionality, a project is considered additional if it includes activities that are possible only through revenue from carbon credits. However, the criterion does not demand that the project should be financed by the sale of credits alone. The project must simply demonstrate that the revenue from the sale of credits is necessary to exceed the viability threshold.

Consequently, a transparent account of the funding should be provided to demonstrate additionality of the project. Transparency presents no difficulty where public funding is involved (e.g. from agri-environment programmes) and many costs can be linked to specific works or services (e.g. planning services for public works). More difficult to account for are the contributions of public institutions (e.g. governmental departments, administrations, public agencies) and voluntary activities (e.g. nature conservation organisations). Their contributions may be delivered in preparation for or during the implementation of the project, are often indirect, and cannot be quantified on a project basis. The question of mixed financing should be considered in the further development of MoorFutures. Whether and to what extent buyers will accept mixed financing should be reviewed empirically by a survey. Moreover, criteria need to be developed for mixed financing − for example addressing the amount of tradeable credits.

7 Advice on transfer to other regions

7.1 Introduction

With MoorFutures, an individual, regionally valid standard was developed, inspired by internationally recognised standards of the voluntary carbon market − VCS in particular, without fully adopting them. Because MoorFutures projects are entirely carried out in Germany, they are subject to and must comply with German law. For instance, rewetting projects are subject to public planning and approval procedures, and land easement can be entered into the land register. These issues need not be regulated by a standard for projects carried out in Germany (or in countries with a similar legal structure). The intensive level of regulation in Germany cannot always be presented in such a positive light.

The development, validation and verification of the MoorFutures project are performed 'in house' − i.e. by the providers themselves: the Ministry of Agriculture and the Environment of Mecklenburg-Western Pomerania and the University of Greifswald together develop the rewetting projects and guarantee the provided ecosystem services, putting their reputation at risk; in Brandenburg, the Ministry of the Environment, Health and Consumer Protection and the University of Applied Sciences in Eberswalde are responsible and in Schleswig-Holstein the state compensation agency and TÜV Rheinland. On the international voluntary market, the costs associated with project development, central registration and verification by independent assessors is much higher (KAPP & SCHNURR 2004). These fixed costs make the price per credit too high for small projects to be competitive.

A regional standard carries an additional significant advantage: it creates trust because projects are carried out 'in the neighbourhood' and the buyer can visit the site easily. The projects and their quality are close and tangible, which distinguishes them from more anonymous projects on the international voluntary carbon market. Supplier and buyer are in direct personal contact. To guarantee unambiguous crediting, a project register allocates each single sold credit to its buyer.

In all peatland rich regions of Germany (e.g. Schleswig-Holstein, Lower Saxony, Bavaria) and Europe (e.g. Poland, Ukraine, The Russian Federation, Scandinavia, The Netherlands, the UK, Ireland) prospects are essentially good for the development of voluntary carbon credits from regional peatland rewetting projects. However, the trustworthiness of voluntary credits can vary between countries. For example, in Poland, consumer trust in the state, as well as in private structures, is assumed to be low (W. KOTOWSKI, pers. comm.). Yet, the development of voluntary credits should be pursued in these countries, as they offer considerable potential (e.g. there are about 1 million ha of peatlands that could be rewetted in Poland).

7.2 Transferability of the approach

Many potential investors are unfamiliar with the relationship between peatland protection and climate change mitigation. In contrast to forest projects, an extensive information campaign is still necessary. Regional embedding offers an instrument to communicate content and increase awareness with high public visibility. The strength of a brand also depends on its market penetration; there is no such thing as an unknown successful brand. The same is true for concepts and approaches. MoorFutures successfully introduced the concept of carbon

credits from peatland rewetting as a regional product. From this perspective, MoorFutures has provided the groundwork for the establishment of similar products in other regions. If the MoorFutures standard is transferred, the legal and administrative framework should be checked, and, where necessary, additional requirements should be integrated into the standard (Chapter 6.1). The operational organisation established in Mecklenburg-Western Pomerania and Brandenburg, uniting ministry, land agency, and a regional university, can be altered according to requirements and possibilities.

7.3 Transfer of the principles of the standard

The criteria set out in Chapter 3 for carbon credits are based on ISO Standards 14064 and 14065, are internationally recognised and approved, and have been transferred multiple times. Keeping to these criteria is inevitable for serious carbon credits. There is some leeway in the implementation of the criteria in methodologies and projects. For instance, the criterion of conservativeness can be applied at every single step of a methodology, or be restricted to a few assumptions.

The criteria for emission reduction projects were simply transferred to other ESS, which poses the basic question whether such a mirroring of criteria is allowed, and whether the criteria are exhaustive for other ESS. Regarding the Kieve project presented in this report, no problems have been identified in this sense. The criteria are probably universally valid for the commodification of ESS. Transferring the criteria and principles of the MoorFutures Standard v. 2.0 to another region offers the opportunity to further consider the question. Exchange between regions is both desirable and necessary to test, refine and where necessary, supplement the standard.

7.4 Transfer of the additional ESS

7.4.1 General remarks

The identification of peatland ESS does not only depend on biophysical features, but also on their significance for society, at local, regional, and national levels. Regulation of surface waters is far more relevant in farming areas suffering from periodic droughts − like those in Brandenburg − than in the coastal regions of Schleswig-Holstein. Similarly, nitrogen retention by peatlands only becomes an ESS to society in areas where water quality suffers from nitrate pollution in the catchment. The goals of climate protection, nature protection, water protection and agriculture do not always match, and their respective relevance much depends on the local and regional context. From a climate protection perspective, raising the water table in a deeply drained intensively used peatland is a far more effective measure to reduce GHG emissions, than rewetting a shallow drained area where only low-intensity grazing occurs. However, in the baseline, such shallow drained areas already show far greater mire-typical biodiversity, which can be increased even further by rewetting. Yet other areas are particularly relevant for an effective improvement in water quality − e.g. minimising nitrogen release to the North and Baltic Sea (TREPEL 2010).

7.4.2 Improving water quality

N release is less relevant in forested peatlands or in slightly acidic fens and blanket bogs. In these systems, other hydrochemical components are more important for water quality − e.g. pH values and the concentration of dissolved organic carbon (DOC) and sulphate (SO_4^{2-}). For example, in Lusatia, in central Germany, and also in the UK, these aspects should be considered, and procedures to assess them should be developed.

7.4.3 Flood mitigation

The concept presented here is valid primarily for regularly flooded peatlands close to rivers, but can similarly be used for percolated lakes, kettle-hole peatlands, or fens in groundwater discharge areas. The flood mitigation potential in such areas should be considered on a case by case basis. For example, the flood water retention of a kettle-hole peatland will not necessarily result in reduced flood damage. The value that can be attributed to additional retention areas for flood damage control depends on the damage potential in areas downstream.

The retention capacity of rewetted areas should be assessed if they are located upstream from areas with a significant flood risk. This retention assessment should refer to the likelihood of flooding downstream sections of the water course. A sound assessment will ultimately require a hydrodynamic model that takes the flow dynamics in the stream network into account. Peak flow reduction by a single water body requires that the retention volume is not yet exhausted by the time the peak reaches it. If a flood prone area with considerable risk of damage is fed by more than one tributary, peak flow reduction at this area takes priority over peak flow reduction in any of the tributaries.

For projects with a focus on flood mitigation, regulated flooding can help optimise peak flow reduction (see BRONSTERT 2004 for the Oder and the Havel Rivers). However, regulated flooding does assume that retention areas are separated from the water course by dykes that are opened when necessary. Because peatland rewetting usually involves the removal of dykes, such controlled flooding will not be possible as a mitigation measure. Therefore, the effectiveness of rewetted areas is considerably limited.

Consideration and quantification of flood mitigation potential makes particular sense if rewetting takes place along river courses, coasts, and lake shores. Significantly, peatland rewetting should never be seen as a technical flood mitigation measure to maximise retention in the event of a flood, but rather as a regeneration of anthropogenically damaged water retention areas.

7.4.4 Groundwater recharge

Peatland drainage leads to increased run-off of water and to less water stored in the landscape. In most regions, peatland rewetting aims to reduce run-off and increase water stores. On surrounding mineral soils, peatland rewetting may improve water availability for plants or, for example, increase groundwater discharge. The additional water stored in the landscape reduces vulnerability to dry weather periods. The concept presented here is valid for all peatlands in the temperate climate zone.

7.4.5 Evaporative cooling

Demand for the cooling effect of peatlands will most likely exist in agricultural areas in continental climates − for example in East Germany, Poland, Ukraine and southern Russia. Potential for a substantial increase in evaporative cooling is found in the drained fen peatlands of these areas.

7.4.6 Increased mire-typical biodiversity

Intact, wet peatlands provide habitats for rare species. In many cases, restoring wet conditions will have a positive effect on species diversity. Currently, there is a growing awareness that a dramatic loss of animals, plants and habitats also diminishes the capacity of ecosystems to provide important services. Many companies are aware that their performance likewise depends on the performance of ecosystems − clean air, clean water, fertile soil, and other benefits are basic requirements for the production of numerous goods. Furthermore, biodiversity conservation has become increasingly important in social policy. Consequently, demand for biodiversity will likely rise, and its valuation will become ever more important, also on ESS markets.

7.5 Transferring the methods

7.5.1 General

The following recommendations are valid for a transfer of all methods and methodologies:

- Make use of higher level planning and freely available (international/regional) data sets.

- Make use of data gathered during the planning phase of the rewetting.

- If additional data collection is required, the associated costs and procedures should be regularly evaluated, because costs for new technologies may drop quickly.

- Similarly, the use of improved or newly developed methods should be evaluated to keep up with the development of scientific knowledge.

- In selecting appropriate methods, make use of regional/national approaches that are scientifically accepted and well established, as long as they produce scientifically reliable and valid results.

7.5.2 Greenhouse gas emission reductions

The GEST approach was developed for the lowlands of north-west Europe, and has to be calibrated for other biogeographical and climatic zones. Calibration is presently carried out for Belarus and Ukraine, and it is being considered in the UK (BONN et al. 2014) and Russia. Recent studies in the UK have indicated that the GEST approach can be applied there. The key challenges for transferring the approach to other regions are the use of different vegetation typologies and a lack of direct flux measurements from the region. Some vegetation typologies depart from other concepts apart of the vegetation-form approach of the current GESTs, and often do not allow equally sharp indication of site conditions. Regional flux data are not always clearly linked to vegetation. Then again, the meta-analyses

of flux data carried out in the framework of the new IPCC wetland guidelines (IPCC 2014) show a consistent relation between fluxes and water tables. This consistency in the behaviour of fluxes means that perspectives for inter- and extrapolating available flux values to new regions are good. Few, targeted flux measurements will be needed for calibration and for filling gaps in the GEST matrix. Furthermore, the avaible amount of flux data is growing rapidly with new research around the globe. Research in the framework of carbon projects should be stimulated to improve the data underlying GHG assessments in a targeted fashion.

Currently, waterborne losses of carbon in the form of dissolved and particulate organic carbon (DOC, POC) are not covered by the GEST approach. For some peatland types (e.g. blanket bogs in mountain regions) these losses can be considerable. Vegetation, surface run-off (determined by precipitation and slope) and the type of land use, including the presence of trees, may be good indicators both for DOC and POC losses; the relative area of vegetation-free, bare peat is a good indicator for POC losses. It is still unclear if and to what extent the POC lost from the peatland is eventually emitted into the atmosphere or else is deposited downstream in an emission-neutral way.

7.5.3   Improved water quality

The NEST approach: The NEST approach was developed for the vegetation types of the Kieve Polder, and can be applied to peatlands with moderate land use intensity across wide stretches of the north German lowlands. In general, the eastern part of Germany uses less fertilizer than the western part. Nitrogen release from very intensively used land, which is common in the west, will be higher; accordingly, NEST values would need to be higher. In the Netherlands, land use intensity may be higher for sites with similar drainage depth; in Poland it may be far lower. NEST values should be added for hardly disturbed areas, which are not found in Kieve Polder. With respect to forested peatlands, only Alder carrs are covered, because published values for other forest types do not exist.

WETTRANS: The WETTRANS model was developed for Schleswig-Holstein, and generates data on precipitation and evaporation on the basis of the hydrological atlas of Germany. For areas outside Schleswig-Holstein, these data can be entered manually. WETTRANS standard values for the concentration of nutrients in different water bodies should generally be checked when the model is applied outside Schleswig-Holstein. Some of the standard values have already been adapted for Mecklenburg-Western Pomerania. For areas where precipitation and evaporation are clearly different, general modifications of the model would be needed. If the amount of applied fertiliser differs strongly from the standard amounts of the model, this can be changed manually.

PRisiko: The PRisiko model can be used nationwide without further modification. The parameters used to estimate P-release can be adjusted to regional and local conditions.

7.5.4   Flood mitigation

In connection with the EU Flood Directive water sections with a significant risk of flooding were recently designated in Mecklenburg-Western Pomerania (BIOTA 2012). Similar maps have been developed in other federal states. Thus, available maps make it possible to asses for each site whether a significant flood risk exists downstream or not. A general scheme for the identification of flood retention as an ESS is shown in Figure 19.

In Germany, the relevant hydrological data for the standard and (in part) for the premium approach are compiled during the administrative planning process. Therefore, the data should be available from the relevant authorities. In other areas with high flood risk, relevant input data are available as well. For example, in Poland, long term plans for flood regulation exist, providing detailed maps of flood risk and of retention potential. However, whether the elevation model is detailed enough to support calculations on specific project areas needs to be checked (W. KOTOWSKI personal communication). Similarly, in Slovakia land planning is very well developed with respect to flood regulation (E. GOJDICOVÁ personal communication).
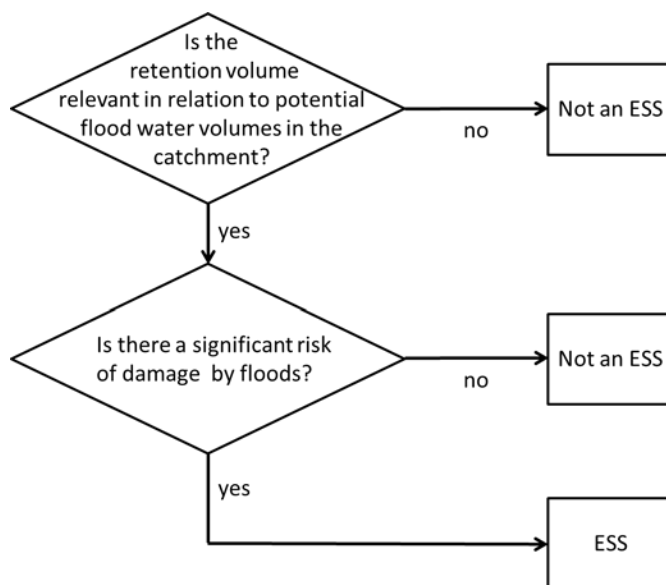
Figure 19: Identification of flood retention as an ESS. Figure: A. Gerner.

7.5.5 Groundwater recharge

In principle, the standard approach to groundwater recharge (qualitative evaluation and simple assessment) can be applied without adjustment to any other site. However, as previous sections (5.4, 6.2.4) have already made clear, the assessment strongly depends on the individual site characteristics, mainly because of the great spatial heterogeneity in hydrogeological conditions. Accordingly, every area must be assessed in all possible details. The peatland and its hydrogeological embedding should be characterised in the best possible way to achieve a high-quality assessment of the potential ESS of groundwater recharge. Presumably, the availability of the necessary data will be limited in most cases. The premium approach of numerical modelling of groundwater requires a geohydraulic analysis based on numerical models, and it will remain an exception for MoorFutures projects because of the high costs involved.

7.5.6 Evaporative cooling

The standard (EEST) and the premium approach are both essentially transferable to other regions, when climatic gradients are taken into account. Like net radiation, temperature and precipitation show a west-to-east gradient across Germany, which results in a similar gradient in evaporation, and thus in evaporative cooling (Figure 20). The lowest values are

found for climate stations in the west, and the highest (and thus the largest cooling effect), in the east.

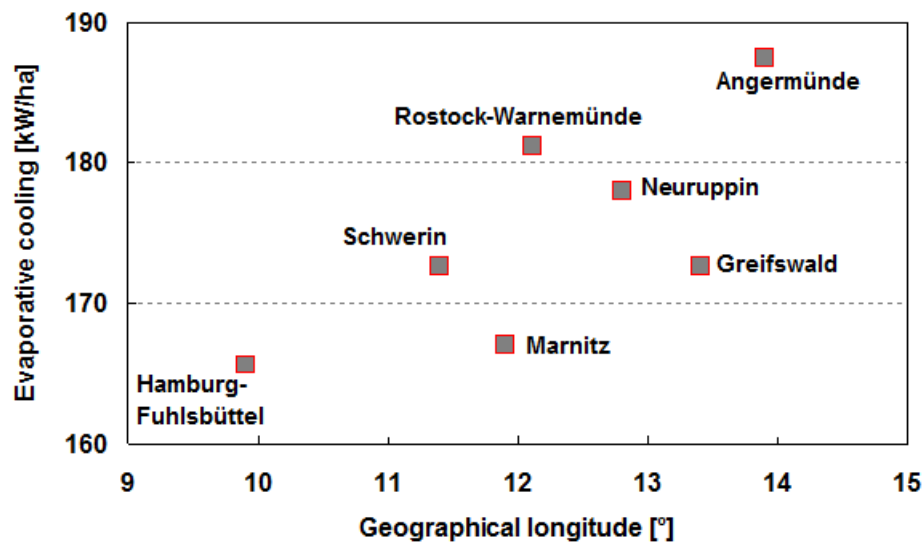Figure 20: Evaporative cooling caused by the rewetting of grasslands on peat soil. Cooling is for rewetting that raises the water table depth from 1 m to 0-0.1 m below the surface.

7.5.7   Increased mire-typical biodiversity

Impact regulations are in force in all German federal states. Partly, even more detailed subdivisions with more specifically defined biotope types are available, which allows for corresponding finer valuation. Consequently, the transferability of the standard approach to other parts of Germany is certain. Evaluation procedures for biodiversity are used internationally − e.g. in Environmental Impact Assessments (EIA) and Strategic Environmental Assessments (SEA), as well as in 'Habitat banking', which is common in the USA and the UK. Habitat banking was originally introduced as 'Wetland banking', a trading platform where companies who create wetlands or other habitats valuable for nature conservation offer credits to companies who need to compensate for habitat losses. For example, the Environment Bank (UK) calculates the net-loss of ESS on the basis of the area impacted by a land conversion. Depending on the type and form of the ESS that are lost, this loss is converted into a sum that must be invested in compensation measures. The required investment is based on the costs for creating new habitats or ESS, or for improving the existing ones (by land purchase or management). The compensation procedure is regulated by an accreditation body together with the land planning authorities. Similar accounting provisions could be used for assessing the added value for biodiversity of carbon credits from peatland rewetting.

The premium approach requires regionally valid models for indicator species. The availability of such models needs to be verified. Identification of indicator species and species groups should take into account regional and national biodiversity strategies and action plans.

7.6 Considerations for the introduction of carbon credits that depict additional ecosystem services

As already mentioned in Section 7.2, the relationship between peatland protection and climate change mitigation is still relatively unknown, at least among potential investors. The relationship with other ESS (including biodiversity) is even less well known. Not every investor will want or will be able to understand all the details. Instead, they will want to rely on trust. It is the task of the seller to guarantee a serious, trustworthy product. Moreover, the offered credit must make an interesting and pleasant impression. The following two points are particularly important:

- The regional structure: The product developer, the seller and the buyer know each other. The product is not an anonymous credit, but a credit with an interesting story; corporate buyers can communicate their compensation activates to their customers in a tangible manner − e.g. by site visits.

- The establishment of a recognised, strong brand, which stands for quality and is known to be under continuous further development and evaluation ('branding').

Further essential components include:

- A central register (which makes each sold tonne of CO_2e transparent and traceable). Maintaining a central register is also key to carbon credits with additional ESS. In its simplest form, the register contains two columns (like the MoorFutures Register): the first lists each credit (or tonne) sold, and the second its buyer. A reference to the origin of the credit (the project area) provides a link to the additional ESS.

- Guaranteeing the project on the long-term − i.e. fulfilling the permanence criterion through appropriate entries in the land register. An entry in the land register means that the institution that guarantees the long-term rewetting does not need to buy or to own the land.

- Avoiding conflict. Peatland rewetting may affect large parts of the landscape and at times become a cause of conflict. Planning and, where appropriate, implementation should be carried out by experienced institutions, involving local stakeholders from an early stage of the project to help avoid conflict.

- The possibility to visit a project site and experience, observe and understand it. If a public planning procedure is undertaken, plans should remain available for viewing.

8 Summary

The international TEEB-Process (The Economics of Ecosystems and Biodiversity) aims to make more visible the importance of nature, as well as to strengthen its role in decision making. The national follow-up process 'Natural Capital Germany – TEEB DE' wants to stimulate this vision in Germany, and in this way support the implementation of the National Strategy on Biodiversity (BMU, 2007).

Against this background, a project was developed in the framework of the 'F+E' (Research and Development) programme. The project 'Integrated Peatland Offset Standard: Certifying the ecological co-benefits of CO_2 offsets from peatland rewetting' (2011-2013) was funded by the Federal Agency for Nature Conservation with the support of the Federal Ministry for the Environment. It aimed to develop carbon credits that depict the synergies that arise between climate, environment, and nature when peatlands are rewetted.

The drained peatlands of the world (0.3% of the global land area) are responsible for 5% of the anthropogenic CO_2 emissions worldwide. In Germany, annual greenhouse gas (GHG) emissions amount to more than 900 million t CO_2e, with almost 43 million t CO_2e from the agricultural use of peatlands. Although they cover only 6% of the agricultural land area, peatlands are responsible for 54% of agricultural soil emissions or 37% of total agricultural emissions (including animal husbandry) and hence are the largest source in this sector, before animal husbandry (32%) and fertilizer application (27%). In Mecklenburg-Western Pomerania, GHG emissions from drained peatlands in 2009 amounted to 6.2 million t CO_2e, making them the largest source in the federal state (total emission ca. 16 million t CO_2e).

The rewetting of drained peatlands reduces GHG emissions. MoorFutures are carbon credits that represent the emission reductions from peatland rewetting. MoorFutures were introduced in Mecklenburg-Western Pomerania in 2010, and were the first carbon credits from peatland rewetting on the voluntary market in the world.

Besides emission reductions, the rewetting and associated regeneration of peatlands also provides other ecosystem services (ESS), including, among others, nutrient retention, regional water and climate regulation, and increased mire-typical biodiversity. Accordingly, peatlands offer an effective combination of climate and nature protection that has thus far not been considered in the credits. MoorFutures in Mecklenburg-Western Pomerania were developed further in the above-mentioned 'F+E' Project to expose the additional ecological value of rewetting in form of ESS, including biodiversity. The additional ESS have now been quantified for a specific area, namely the Kieve Polder.

This report presents the MoorFutures standard and methodology for the assessment of emission reductions, as well as the advanced standard and methodologies for the additional ESS. Furthermore, the challenges and opportunities associated with the transfer of standard and methodologies to other regions are presented.

The MoorFutures standard has been developed for small and medium sized peatland rewetting projects, within geographically limited areas in the temperate climate zone. MoorFutures were developed for a decentralised, regional implementation. MoorFutures are non-tradeable credits for the voluntary carbon offset market. MoorFutures[®] is a registered trademark of the federal state Mecklenburg-Western Pomerania. Meanwhile, the standard is also used in the federal states of Brandenburg and Schleswig-Holstein. To enable project

implementation, credits are sold *ex ante*: buyers invest in a project that will achieve a certain amount of emission reductions over a certain period of time (the project life-time). The credits are registered at the regional level by regionally coordinating institutions. MoorFutures are based on the principles of the VCS and the Kyoto Protocol. Consistent, detailed and scientifically accepted methodologies are used to evaluate project results. The in-house knowledge and expertise guarantees high quality at minimal operational costs.

The criteria on the current voluntary carbon market have been developed to ensure that project measures to reduce GHG emissions are really implemented in a verifiable way (quality assurance). In the above mentioned 'F+E' project, the same criteria were applied to other ESS. Thus, the added ecological value of MoorFutures was assessed following a set of criteria (i.e. a standard). The most important criteria of this standard are: additionality, measurability, verifiability, conservativeness, reliability, sustainability and permanence. In light of these criteria, consideration must also be given to the baseline scenario, the project duration, and leakage. A standard defines all the specific requirements for the development of projects and methodologies, as well as for project monitoring and verification. A methodology comprises a set of methods and procedures for measuring, reporting and verifying (MRV) the project effects subject to certification. The expected outcome of a project is presented (*ex ante*) in a Project Description (or Project Design Document). This document contains a description of the measures undertaken in the project area plus a monitoring plan. Monitoring ensures (*ex post*) that the (*ex ante*) envisaged GHG emission reductions and other ESS are delivered. Assessment of ecological benefits is based on a comparison between the project scenario and a baseline scenario that describes the future condition of the peatland if rewetting would not take place. The Project Description provides the basis for the project validation and for the issuance of credits.

The existing MoorFutures standard for carbon credits (version 1.0) only quantifies GHG emission reductions, taking into account carbon stocks in the aboveground biomass, the belowground biomass, and the soil. The greenhouse gases considered are CO_2 and CH_4 − conservatively, N_2O is not included. Emission reductions are assessed using the Greenhouse Gas Emissions Site Type (GEST) approach. The GEST approach assigns CO_2 and CH_4 emission values to regionally elaborated vegetation types (here: vegetation forms sensu KOSKA 2007), based on associated mean annual water tables, vegetation composition and land use. A matrix of all possible vegetation types allows for extra- and interpolation of emission values along the various axes of site parameters.

For the Kieve Polder, emissions after rewetting will amount to 532 t CO_2e y^{-1}. In comparison to the baseline scenario and over the full project lifetime of 50 years, the expected emission reduction is 38 655 t CO_2e (773 t CO_2e y^{-1}). When compared with an unlikely alternative baseline scenario, which assumes low intensity land use and shallow drainage, emission reductions would amount to 12 995 t CO_2e over the 50 year project duration (260 t CO_2e y^{-1}). Based on provisional emission factors, an earlier assessment against the alternative baseline, made in 2010, estimated total reductions at 14 325 t CO_2e.

The price of the credits was calculated based on the costs involved and the emission reduction estimate of the earlier (2010) assessment. For Kieve Polder, total costs of rewetting − including planning and construction as well as running costs − amount to € 501,375. With a projected emission reduction of 14,325 t CO_2e, the cost for a single tonne CO_2e (1 carbon credit) was calculated at € 35.

Version 2.0 of MoorFutures was developed in the framework of the aforementioned 'F+E' project. MoorFutures v. 2.0 is an extension of the existing MoorFutures carbon credits standard (v. 1.0). The new version includes additional ESS and increased mire-typical biodiversity that occur after rewetting in association with emission reduction. The additional ESS are: improved water quality; flood retention; groundwater recharge; evaporative cooling; and increased mire-typical biodiversity. These additional effects were only implicitly covered and only qualitatively expressed in version 1.0, where the sustainability criterion prohibited deterioration of the environment. In version 2.0, the additional ESS are explicitly aimed at and quantitatively expressed. MoorFutures v. 2.0 still offers carbon credits, but now these also represent additional ESS. Assessment of the additional ESS is not prescribed, but desired and, if reasonable, the ESS should be quantified. Next to the GEST approach to assess emission reductions, MoorFutures v. 2.0 uses five additional methodologies. These methodologies are subject to continuous further development. They all cover a standard and a premium approach and thus far have only been tested in the Kieve Polder. The standard approach offers an estimate at low expenditure (time, data, money, and accuracy). It provides a conservative quantification of the additional ESS sold with the carbon credits. The more laborious premium approach allows quantification of ESS when credits focus on these aspects to achieve a higher price on the voluntary ESS market.

The improvement in water quality through the rewetting of a peatland is essentially determined by its hydrological situation in the catchment, water table heights, and the type and intensity of land use. The standard approach considers only nitrogen (N) and is based on default values for N release of different vegetation types, whose extent is assessed by vegetation mapping (N Emission Site Type approach: NEST). Default values were developed on the basis of a literature review. In a further step, more complex assessments can be made using models that, next to site specific internal processes, also take into account landscape hydrological aspects. For such a more complex, premium approach, two suitable models are available: WETTRANS (for N) and PRisiko (for phosphorous, P). Estimates based on the NEST approach indicate that rewetting of the Kieve Polder reduced N release by about 900 kg N y^{-1} compared with the baseline scenario, and by about 600 kg N y^{-1} compared with the alternative baseline scenario of low intensity land use. WETTRANS modelling suggests that rewetting reduces N release into the Elde River by about 6 000 kg N y^{-1} compared with the baseline scenario, or by about 2 500 kg N y^{-1} compared to the alternative baseline scenario. The PRisiko model indicates that the phosphorous concentration in downstream water courses increases by less than 0.02 mg l^{-1} in the third year after rewetting. Therefore, the risk of deteriorating water quality downstream can be considered negligible. The validity of the standard and premium approaches is in principle given for Central Europe, but should be tested if used outside northern Germany: calibration may be required.

Rewetted peatlands contribute to flood mitigation, firstly because floods no longer cause damage to the area itself anymore (e.g. crop failure). Secondly, they function as retention areas that mitigate flood damage downstream. The standard approach quantifies the retention volume of the peatland, which is derived by hydrodynamic modelling on the basis of digital terrain models. The standard approach can only be applied if input data (digital terrain model, design water levels) are available. The premium approach in addition calculates flood peak reduction using hydrodynamic modelling. Quantification of the retention volume of the Kieve Polder reveals that it could absorb 92% of all flood events from 1983 to 2011 at the

nearby Wredenhagen gouge. Peak flood reduction was calculated for an example flood. The peak flow on 1 January 1986 of 2 160 m³ s⁻¹ would have been reduced by 830 m³ s⁻¹ to 1 330 m³ s⁻¹ and the flood peak would have been delayed by two days. The potential benefit of increased retention and reduced peak flow depends on whether a potential for damage exists downstream of the rewetted area. The standard and premium approaches use hydrological modelling methods that can be applied anywhere where sufficient input data are available.

Rewetting may result in increased groundwater recharge in the catchment, because particularly the outflow of water from the landscape is delayed. In the standard approach, these effects are assessed qualitatively on the basis of available hydrogeological data. The data may enable running a conceptual geohydraulic model that allows quantitative assessments. The premium approach uses numerical modelling on the basis of comprehensive hydrogeological data. For methodological reasons, an assessment of the increase in groundwater table and related groundwater store is associated with considerable uncertainties. Accordingly, a conservative assessment will predict only small changes. Modelling results suggests that after rewetting, an additional volume of 150 000 m³ of water would be stored in the belowground catchment of the Kieve Polder. However, because parts of the belowground catchment are still drained by ditches, the increase in groundwater retention will turn out to be considerably lower. The models used to assess groundwater recharge can be used in any other region as long as the required input data are available.

Rewetting may lead to increased evaporative cooling, because the distribution of available energy changes in favour of more evaporation and less warming, when averaged over the year. A change in the vegetation cover or the establishment of new open water areas changes reflection and emission characteristics, which in turn influence the amount of available energy. The effect of rewetting on local heat fluxes depends on how the peatland is embedded in the landscape (dry/wet environment). The standard approach estimates the cooling effect using EESTs (Evapotranspiration Energy Site Types) which quantify the 'net thermal energy' in a model-based matrix. They are based on data from weather stations that are representative of the area. The premium approach uses hydrological models − e.g. AKWA-M®. This modular hydrological balance model allows using different theoretical approaches to evaporation, and determines the rate of evaporation for various types of land use with different groundwater tables. Following the EEST approach, rewetting of the Kieve Polder resulted in a reduction of the energy available for the warming of the lower atmosphere of 16 GWh y⁻¹; the average cooling effect of the area amounts to ~3 W m⁻². Both the standard and premium approach can be used in other areas when taking climatic gradients into account.

Mire-typical biodiversity refers to the species and habitats that would spontaneously occur if the peatland were undrained and without or with adapted land use. The increase in mire-typical biodiversity was assessed using indicator species and groups. In northeast Germany, vascular plants, mosses, birds, amphibians and some arthropods are particularly suited for such an approach. These groups provide good indicators for the habitat type 'fens, moist and wet areas'. A cost efficient standard approach and a premium approach that requires additional field surveys are proposed to assess the difference in biodiversity between the baseline and project scenario. This difference should take into account not only the gains, but also the losses in biodiversity values. The standard approach uses BESTs (Biodiversity

Evaluation Site Types), which employs regionally accepted methods of impact regulation or other biotope assessment procedures. The premium approach measures the number of indicator species, and evaluates them using a regional indicator species model. The BEST assessment arrives at a biotype value of 0 (area equivalent 0 ha) for the baseline scenario; a mean biotype value of 0.56 (area equivalent 30.5 ha) for the alternative baseline scenario; and a mean biotype value of 2.52 (area equivalent 137.6 ha) for the project scenario. Consequently, rewetting increases the biotope value of the polder by 2.52 points compared with the baseline scenario, and by 1.96 points compared with the alternative baseline scenario. The premium approach could not be applied for evaluation because of a lack of data (however, the approach is demonstrated using hypothetical data). As virtually all German federal states have lists of biotope types with associated biotope values, the BEST approach can easily be applied in other German regions. In principle, the premium approach can be used elsewhere, but will require an indicator species model that is valid for the specific region.

As already mentioned when discussing transfer of the quantification methods, a transfer of the MoorFutures standard and methodologies to other regions must evaluate whether the methods can be applied in a particular project case. Furthermore, different ESS may be important in different types of peatland and in different regions, and 'trade-offs' between ESS may be different as well. Therefore, a transfer of standard and methodologies requires an evaluation of which ESS should be assessed. Different methods from those presented here may be used in assessing, valuing and monitoring ESS. Yet, any alternative method should be tested against the criteria of the MoorFutures standard.

For any transfer of methods and methodologies, it is wise to (i) use superordinate planning and freely available data sets (international / regional); (ii) use the data compiled during the planning phase of the rewetting; (iii) evaluate the costs associated with the collection of additional data (if such data is necessary), because costs for new technologies may drop rapidly; (iv) evaluate the use of improved or newly developed methods to keep up with scientific developments; and (v) use regional/national approaches that are scientifically accepted, as long as they produce scientifically reliable and valid results.

When the standard is transferred and a project is developed, it is important to establish a regional structure. The establishment of a strong brand − which stands for quality and which is known to be under continuous further development and evaluation − should be pursued. Maintaining a central register, which makes each sold tonne of CO_2e transparent and traceable, is highly recommended. It should also be ensured that the credits cannot be sold on by the original buyer. A long-term guarantee against reversal of the project can be achieved for example through entries in the land register. Furthermore, planning and − where appropriate − implementation, should be carried out by experienced institutions and involve local stakeholders from an early stage of the project, to help avoid conflict. Buyers and the general public should be able to visit a project site to experience, observe and understand it.

9 Acknowledgements

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Annex 1: Greenhouse Gas Emission Site Types (GEST) for north-east Germany with typical vegetation types, estimates of GHG fluxes and emission factors (changed after COUWENBERG et al. 2011).

GEST	Soil moisture class	Typical vegetation type	CO$_2$-flux (t CO$_2$e ha^{-1} y^{-1})	CH$_4$-flux (t CO$_2$e ha^{-1} y^{-1})	Emission factor (t CO$_2$e ha^{-1} y^{-1})
Bare peat	3+	-	7.0 (±2.6) for active extraction sites (*n* = 12) / 7.4 (±0.9) for abandoned extraction sites (*n* = 3); MALJANEN et al. (2010)	0.4 (±0.6) for active extraction sites (*n* = 13) / 0.06 (±0.0 for abandoned extraction sites (*n* = 2); MALJANEN et al. (2010)	7.5
Eriophorum	3+		3.3 (±2.1) (*n* = 8); TUITTILA et al. (1999), MALJANEN et al. (2010)	0.3 (±0.1) (*n* = 8); TUITTILA et al. (2000), MALJANEN et al. (2010)	3.5
Moist bog heath	3+		12.6 (±4.0) (*n* = 3); DRÖSLER (2005)	Negligible; DRÖSLER (2005)	12.5
Very moist bog heath	4+		9.0; DRÖSLER (2005)	0.7; DRÖSLER (2005)	10.0
Moderately wet *Sphagnum* hummocks	4+/5+		Negligible	0.7 (±0.2) (*n* = 4); BORTOLUZZI et al. (2006)	0.5
Wet *Sphagnum* lawn	5+		Negligible	5.2 (±3.2) (*n* = 5); DRÖSLER (2005)	5.0
Very wet *Sphagnum*-hollows	6+		Negligible	12.8; DRÖSLER (2005)	12.5
Moderately moist forb meadows	2+, 3+/2+	Cirsium oleraceum-Arrhenatherum meadow, Molinia-Deschampsia forbs	No data; assumed somewhat lower than moderately moist grassland	Negligible; COUWENBERG (2009), MALJANEN et al. (2010)	20.0
Moist forb meadows	3+	Filipendula-Cirsium oleraceum forbs, Galeopsis-Molinia forbs	No data; similar bog areas: 12.6 (±4.0) (*n* = 3); DRÖSLER (2005)	Negligible; COUWENBERG (2009)	12.5
Very moist reeds	4+	Solano-Phragmitetum, *Carex acutiformis* marsh	No data; assumed negligible	3.5 (±1.6) (*n* = 12); VAN DEN POL-VAN DASSELAAR et al. (1999), VAN HUISSTEDEN et al. (2006), HENDRIKS et al. (2007)	3.5
Wet reeds	5+	Ranunculus lingua-Carex marsh, Carex gracilis marsh	-4.1 (±4.3) (*n* = 4); BONNEVILLE et al. (2008), DRÖSLER (2008)	12.7 (±8.4) (*n* = 10); AUGUSTIN (2003, unpubl.), DRÖSLER (2008)	8.5
Moderately moist grassland	2+		24.1 (±8.2) (*n* = 14); MUNDEL (1976), JACOBS et al. (2003), VEENENDAAL et al. (2007), DRÖSLER (2008), AUGUSTIN (unpubl.)	negligible; COUWENBERG (2009), MALJANEN et al. (2010)	24.0
Moist grassland	3+		15.5 (*n* = 2) VEENENDAAL et al. (2007)	Negligible; COUWENBERG (2009)	15.0
Very moist grassland	4+		No conclusive data; assumed between 0 and ~15 (JACOBS et al. 2003)	Negligible; COUWENBERG (2009)	7.5
Wet grassland	5+		1.4 (±3.5) (*n* = 4); AUGUSTIN (unpubl.)	3.1 (±3.5) (*n* = 4); AUGUSTIN (unveröff.)	5.5
Very wet grassland	6+		No data; assumed negligible	Can be extremely high, up to 77 (AUGUSTIN & CHOJNICKI 2008; AUGUSTIN, unpubl.)	

Annex 2: Overview of published values of N-release from peatlands differing in vegetation cover and water table. The values form the basis for the Nitrogen Emission Site Types (NEST) for central Europe.

Vegetation type	Water table cm below surface	N-release kg N ha^{-1} y^{-1}	Source
Raised bog			
Not used		8-13	Scheffer & Blankenburg (2002)
Grassland		2-30	Scheffer & Blankenburg (2002)
Arable land		10-40	Scheffer (1994)
Fen			
Not used		0-10	Scheffer & Blankenburg (2002)
Near natural (mean)		12	LAWA (2012)
Near natural (max)		62	LAWA (2012)
Alder carr	-42	16	KALBITZ (1998)
Alder carr	-42	11	KALBITZ (1998)
Alder carr		5	Schleuß et al. (2002)
Alder carr		20	Schleuß et al. (2002)
Alder carr	Near surface	25	Busse & Gunkel (2002)
Short sedge fen		21	Koerselmann & Verhoeven (1992)
Short sedge fen		8	Koerselmann & Verhoeven (1992)
Moist meadow, low alkalinity, eutrophic	-24 bis -41	2	Ruville-Jackelen (1996)
Periodically flooded grassland		14	Hendriks (1993)
Periodically flooded grassland		19	Hendriks (1993)
Periodically flooded grassland		16	Hendriks (1993)
Periodically flooded grassland		4	Ruville-Jackelen (1996)
Periodically flooded grassland		4	Ruville-Jackelen (1996)
Periodically flooded grassland		2	Hoffmann et al. (1993)
Periodically flooded grassland with reeds	- 8 bis -19	< 10	SACH (1999)
Fallow land	-32	0.4	KALBITZ (1998)
Fallow land	-32	0.6	KALBITZ (1998)
Tall reed		10	Koerselmann & Verhoeven (1992)
Low intensity grassland	-43	0.2	KALBITZ (1998)
Low intensity grassland	-43	2	KALBITZ (1998)
Grassland, acid		10-30	Scheffer & Blankenburg (2002)
Grassland, alkaline		10-20	Scheffer & Blankenburg (2002)
Grassland		18	Wild & Pfadenhauer (1997)
Grassland		32 (1/2 a^{-1})	Gerth & Matthey (1991)
Grassland		23 (1/2 a^{-1})	Gerth & Matthey (1991)

Vegetation type	Water table cm below surface	N-release kg N ha^{-1} y^{-1}	Source
Grassland		21-52	Fraters et al. (2012)
Grassland		30	Fraters et al. (2012)
Grassland	-48	38	Van Beek et al. (2007)
Grassland		18	Kirkham & Wilkens (1993)
Grassland		30	Kirkham & Wilkens (1993)
Grassland		88	Kirkham & Wilkens (1993)
Grassland	-25 bis -36	< 10	Sach (1999)
Grassland		32	van Beek et al. (2004)
Grassland		15-32	van Beek et al. (2004)
Fen, arable land, alkaline		20-40	Scheffer & Blankenburg (2002)
Fen, arable land, calcareous		40-80	Scheffer & Blankenburg (2002)
Arable land (maize)	-80 bis -120	122	Behrendt et al. (2004)

Annex 3: Vegetation-specific values for energy balance components (RN, ET and H+G) for climate stations in and near Mecklenburg-Western Pomerania (period 1997-2001) that serve as a basis for Evapotransipration Energy Site Types (EEST).

Land use	annual average [W/m²]	Hamburg-Fuhlsbüttel	mm/a	kW/ha	Schwerin	mm/a	kW/ha	Marnitz	mm/a	kW/ha	Rostock-Warnemünde	mm/a	kW/ha	Neuruppin	mm/a	kW/ha	Greifswald	mm/a	kW/ha	Angermünde	mm/a	kW/ha
open water	RN	63	806		66	845		66	845		70	896		70	896		68	870		68	870	
	ET	62	790		62	796		59	759		68	864		61	786		61	784		63	808	
	H+G	1	16	13	4	49	38	7	86	67	3	32	25	9	110	86	7	86	68	5	62	49
forested peatland	RN	51	653		54	691		54	691		57	730		57	730		55	704		56	717	
	ET	45	581		46	595		45	582		48	615		46	593		48	611		48	614	
	H+G	6	72	56	8	96	75	9	109	85	9	115	90	11	137	107	7	93	73	8	103	80
reeds	RN	62	794		64	819		64	819		67	858		67	858		65	832		66	845	
	ET	48	616		49	633		51	656		51	658		50	640		50	638		49	630	
	H+G	14	178	139	15	186	145	13	163	128	16	200	156	17	218	170	15	194	152	17	215	168
sedge fen	RN	56	717		59	755		58	742		62	794		62	794		60	768		61	781	
	ET	45	573		46	589		45	580		48	612		46	594		46	594		46	585	
	H+G	11	144	112	13	166	130	13	162	127	14	182	142	16	200	156	14	174	136	15	196	153
raised bog	RN	57	730		60	768		60	768		63	806		63	806		61	781		62	794	
	ET	43	554		45	570		44	562		46	587		44	568		45	573		44	558	
	H+G	14	176	137	15	198	155	16	206	161	17	219	171	19	238	186	16	208	162	18	236	184
arable land drained [GWTD > 1m]	RN	50	640		53	678		52	666		56	717		56	717		54	691		55	704	
	ET	32	411		31	403		30	382		35	449		31	395		32	406		30	390	
	H+G	18	229	179	22	275	215	22	284	222	21	268	209	25	322	251	22	285	223	25	314	245
fen grassland [GWTD > 1m]	RN	52	666		54	691		54	691		57	730		58	742		56	717		56	717	
	ET	27	350		28	355		28	354		29	370		28	357		28	362		26	333	
	H+G	25	316	247	26	336	263	26	337	263	28	360	281	30	385	301	28	355	277	30	384	300
fen grassland [GWTD = 0.75 - 1m]	RN	52	666		54	691		54	691		57	730		58	742		56	717		56	717	
	ET	32	415		33	416		32	411		33	424		37	474		36	459		33	421	
	H+G	20	251	196	22	275	215	22	280	219	24	306	239	21	268	210	20	258	201	23	296	231
fen grassland [GWTD = 0.5 - 0.75 m]	RN	52	666		54	691		54	691		57	730		58	742		56	717		56	717	
	ET	35	447		35	449		34	436		36	464		38	486		37	475		35	445	
	H+G	17	219	171	19	242	189	20	255	199	21	266	208	20	256	200	19	242	189	21	272	212
fen grassland [GWTD = 0.25 - 0.5 m]	RN	52	666		54	691		54	691		57	730		58	742		56	717		56	717	
	ET	41	527		42	534		42	534		44	559		43	548		43	544		40	509	
	H+G	11	139	108	12	157	123	12	157	123	13	171	133	15	194	152	14	173	135	16	208	162
fen grassland [GWTD = 0.1 - 0.25 m]	RN	52	666		54	691		54	691		57	730		58	742		56	717		56	717	
	ET	43	546		43	553		43	552		46	584		44	565		44	561		44	558	
	H+G	9	120	93	11	138	108	11	139	109	11	146	114	14	177	139	12	156	122	12	159	124
fen grassland [GWTD = 0 - 0.1 m]	RN	52	666		54	691		54	691		57	730		58	742		56	717		56	717	
	ET	44	562		45	576		44	568		47	602		46	585		46	583		45	573	
	H+G	8	104	81	9	115	90	10	123	96	10	128	100	12	157	123	10	134	105	11	144	112

Note: 1 kW ha^{-1} = 0.1 W m^{-2}. GWTD = groundwater table depth to the surface. Annual averages (W m^{-2}) for RN (net radiation), ET (actual evapotranspiration) and H+G (remainder of the energy balance) are given below the name of the respective climate stations