85th Annual Conference of the Agricultural Economics Society
Warwick University
18 - 20 April 2011

The impact of nature conservation on agricultural greenhouse-gas (GHG) emissions – an economic assessment of selected German study regions

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ABSTRACT

Using a significant amount of public funding, large-scale nature-conservation projects in Germany aim to secure and develop ecologically valuable areas and endangered habitats and species. Due to the substantial land-use changes accompanying these projects, their implementation can also have relevant climate effects – one result which has not been explicitly focused upon previously. Our study analyses major cost positions in implementing such projects, particularly the expense of changing or abandoning agricultural land-use for conservation purposes. We link public funding to relevant climate effects and derive CO_2 abatement costs. Therefore we conduct plot-specific ex-post analyses of agricultural land-use and greenhouse-gas (GHG) emissions. Our study takes place in regions where changes in agricultural land-use for conservation purposes have been fully implemented in the past and where climate effects are expected to be high. Our analysis is based on data provided by regional stakeholders and our project partners. First results show that land-use changes for conservation purposes can lead to positive climate effects. The efficiency as regards "abatement costs" we derive on basis of the data set available lies within the range of costs for alternative measures of climate change mitigation. However it becomes clear that CO_2 abatement cannot be seen as the only benefit of such measures; the high cost of agricultural compensation has to be contrasted with further effects such as biodiversity and water conservation.

1. INTRODUCTION

In Germany, large-scale nature conservation projects aim to secure and develop those components of nature and landscapes which are important to be preserved. The projects are mainly funded by public money, provided either by the state or by the European Community. Over the last forty years, more than €350 million of governmental funds plus €150 million spent by federal states and project sponsors have been used for the implementation of large-scale conservation projects in Germany (BFN, 2008). Furthermore, to date the European Community has co-financed 75 German projects (under the programme "LIFE – Nature") with an investment of €72 million (European Commission, 2010a). The implementation of such projects usually involves significant land-use changes; agricultural farms are nearly always directly affected, either by having to accept conservation obligations in their area or by completely having to abandon agricultural production on the affected sites. To compensate for the loss of income which farms face due to the projects, a major part of the public funding is used for land acquisition or compensatory payments for resulting opportunity costs. In contrast, the level of funding used for management and development planning, habitat-structuring measures or staffing and materials appear to be comparatively small. However, to achieve the nature conservation goals, the resulting costs to compensate agriculture are indispensable. Until now, costs were first and foremost contrasted and justified by their benefit to aspects like biodiversity, habitat conservation, water conservation and – as a side effect – the establishment of recreation areas. Given the current focus on climate protection, a new benefit could be included: as recent science has shown, land-use changes especially in "hotspot areas", such as peatland, have significant effects on the emission of greenhouse gases (GHG). (Byrne et al., 2004; Drösler et al, 2011) Therefore, as many conservation projects are directly carried out in such "hotspot areas", the high cost in particular of compensation for agricultural losses and land acquisition could also be offset by a significant decrease in GHG emissions. Against this background, our study focuses on analysing how public funds used for the implementation of "hotspot area" conservation projects can contribute to GHG emission reduction. Furthermore, we want to assess whether the "abatement costs" of climate-change mitigation associated with nature conservation projects appear to be competitive.

As the potential contribution of nature conservation projects to climate-change mitigation can only be fully understood if the correlation between land-use strategies and GHG emissions is clear, we want to introduce our study by giving a short overview of the interrelation of land management and GHG emissions in Chapter 2. In Chapter 3, we present the sample of German regions we chose to approach our research questions; these are all regions where large-scale conservation projects have been implemented in the past or where projects are currently about to be finished. To assess the impact of public money spent for conservation projects on land-use-related emission reduction, first of all we need to analyse the amount and structure of the flow of funding. Secondly, we must investigate whether the money invested leads to significant land-use changes and whether these land-use changes have effects on GHG emissions. Finally, to derive "abatement costs" (that is, costs per ton CO_2), the money invested during the projects has to be contrasted with the changes in GHG emissions. Our approach method and database are described in Chapter 4. The results of our study are presented in Chapter 5. Here we show flow of public funding for conservation projects as well as impacts of the related conservation measures on land management. Furthermore, we assess the "efficiency" of the money spent as regards "abatement-costs". At this point we contrast relevant flow of funding of a concrete project with achieved changes of GHG emissions by using the example of one of our study objects. While discussing our results in Chapter 6 we widen our perspective and compare the performance of the study object we described in detail with the situation in the remaining study regions. A conclusion is drawn in Chapter 7.

2. THE INFLUENCE OF AGRICULTURAL LAND-USE MANAGEMENT ON THE EMISSION OF GREENHOUSE GASES

As pointed out earlier, our study focuses on areas where money spent for conservation projects and the related land-use changes are expected to cause significant changes in GHG emissions. Therefore the "hotspot areas" we investigate are exclusively peatland areas. The reason why peatland areas are such "hotspot areas" is because of the functional principle of these ecosystems: Peatlands have accumulated and stored carbon over many centuries, as under flooded conditions decomposition of organic matter is suppressed by the absence of oxygen (Smith et al, 2007). By draining and cultivating the peat soils the process of decomposition commences. Large fluxes of potential greenhouse gases going back into the atmosphere are the consequence - with a significant influence on the climate (Limpens et al., 2008). Byrne at al. (2004) demonstrate that emission factors (fluxes) vary significantly for bogs (nutrient poor, ombrotrophic and oligotrophic peatlands) and fens (nutrient rich, minerotrophic, mesotrophic and eutrophic peatlands) and because of different management practices. For intensive grassland sites, Global Warming Potentials (GWP) (100yr) were numbered as 2.367 for bog and 4.794 CO_2-C Equivalents kg $ha^{-1}yr^{-1}$ for fen sites. The carbon losses of intensive grassland are even exceeded by the losses observable for arable-land use, due to enhanced aeration and related mineralisation via ploughing. Arable management shows GWPs with 4400 (bog) and 5634 (fen) CO_2-C equiv. kg $ha^{-1}yr^{-1}$. In contrast, restoration of the sites via rewetting – dependent on the water level – limits or stops aerobic mineralisation as well as carbon losses. Here GWPs make up 192 and. 736 CO2-C equiv. kg $ha^{-1}yr^{-1}$for bogs and 559 and 179 CO2-C equiv. kg $ha^{-1}yr^{-1}$ for fens. In order to develop more detailed and stable emission factors and restoration recommendations, in 2006 the project "Climate Protection – Strategies of Peatland Management" (Pfadenhauer & Drösler, 2005) measured, monitored and modelled GHG fluxes of representative land-use strategies within representative German peatland areas. The results of this study draw a clear picture in which restoration strategies of peatlands lead to significant GHG emission reduction: climate protection via peatland conservation can only be reached by converting the arable land into low-intensive grassland and by significantly decreasing the land-use intensity of intensive grassland sites. However, such management strategies are still not enough. To achieve significant reduction potentials, it is essential to reestablish natural groundwater table, with an optimal water level of 10 cm below ground (annual average). Such measures can cut emissions almost completely and therefore achieve mitigation potentials which lie within a maximum range of about 30 t CO_2-C equiv. $ha^{-1}a^{-1}$ (Drösler et al, in prep.)

3. STUDY OBJECTS – PROJECTS AND REGIONS

As our study objects, we look at three different German peatland regions where large-scale, public funded conservation projects have previously been fully implemented or are about to be finished. Table 1 gives a short overview of the main characteristics of the study regions and projects.

Table 1: Characteristics of the study regions and conservation projects

Region	***"Pfrunger-Burgweiler Ried"***	***"Wurzacher Ried"***	***"Ochsenmoor"***
Location	State of Badem-Württemberg	State of Badem-Württemberg	State of Lower Saxony
Area	Core area: 1.453 ha Buffer zone: 1.392 ha	Project area: 1.700 ha	Core area: 800 ha Project area: 1.116 ha
Type of project	German large-scale conservation project	German large-scale conservation project	Project I: German large-scale conservation project Project II: EU Project "LIFE – Nature"
Duration	2002 - 2012	1987 - 1997	1987 - 1995 1998 - 2000
Funding	German Federal Agency for Nature Conservation State of Badem-Württemberg Project sponsor "Stiftung Naturschutz Pfrunger - Burgweiler Ried"	German Federal Agency for Nature Conservation State of Badem-Württemberg Project sponsor "Landkreis Ravensburg" Project sponsor "Zweckverband"	Project I: German Federal Agency for Nature Conservation Project sponsor "Landkreis Diepholz" Project II: European Commission State of Lower Saxony

Region 1 *"Pfrunger-Burgweiler Ried"* is located in the state of Baden-Württemberg within the upper Swabian hills. The conservation project taking place in this region started in 2002 and will be finished in 2012. Funding of this project is shared among the German Federal Agency for Nature Conservation, the federal state of Badem-Württemberg and the project sponsor "Stiftung Naturschutz Pfrunger-Burgweiler Ried". The whole project region covers a core area of 1,453 ha which is surrounded by a buffer zone of 1,392 ha. The core area contains predominantly raised bogs, transition mires, and fens as well as the Ostrach river valley. The main objectives of the project are to restore the original hydrology, to regenerate the intact, peat-forming ecosystems and to maintain and develop elements of the flora and fauna characteristic which are typical of peatlands (BFN 2011). Therefore, the whole core region is brought under public ownership. Within the core region three conservation zones are implemented: within a "restoration zone" of 642 ha, natural conditions allowing for peat-forming, with water tables at about 10 cm below ground and without any further "human" management, is implemented. Within a "stabilization zone" of 472 ha, quasi-natural situations with water tables at about minus 20 cm are implemented. Here maintenance measures, also in the form of agricultural maintenance, guarantee peat-preservation. The third zone of 357 ha allows for adapted, low-intensive, culture-orientated agricultural land use, for example litter meadows or low-intensive pasture management. The buffer area surrounding the core region stays under the ownership of the local farmers. The target management for this area is adapted agricultural land use and forestry.

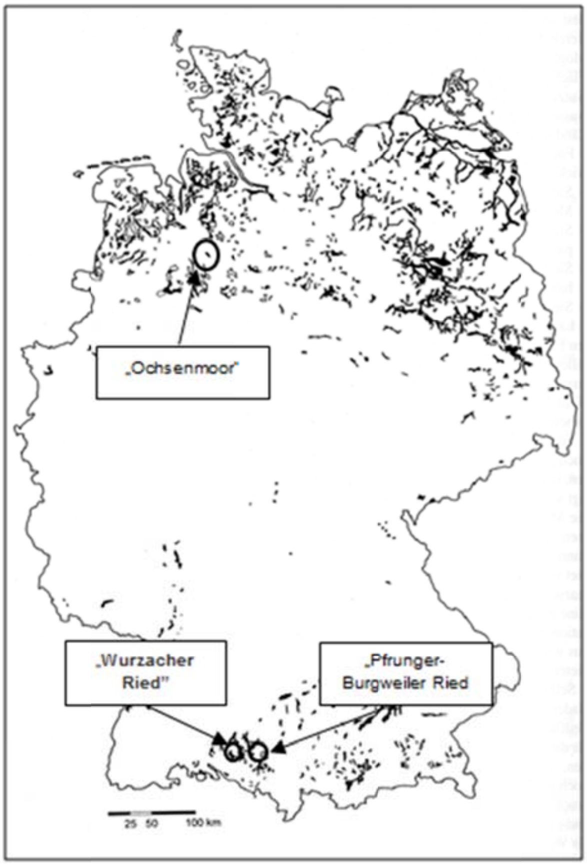


Figure 1: Location of the sample regions (modified from Pfadenhauer & Drösler, 2005)

With Region 2 *"Wurzacher Ried",* also in Baden-Württemberg, we look at a region where the nature conservation project was implemented a comparatively long time ago, namely in the years 1987 to 1997. It was funded by the German Federal Agency for Nature Conservation, the state of Baden-Württemberg, the local administrative district "Landkreis Ravensburg" and, to a smaller degree, by a local administration union. The project area covers about 1,700 ha of peatland of which – at the beginning of the project – one third could be described as natural bog-sites, one third as human-influenced bog sites and one third as human-influenced fen sites. Already then, the natural sites were one of the largest intact bog areas in Central Europe. However, the effects of human impact on this region were obvious. As a result of drainage, intensive agricultural land use and peat cutting, the edges of the area in particular were highly degraded. To restore the area, the project was aimed first and foremost at the reestablishment of the original water tables, the termination of peat cutting and the environmentally sustainable reorganisation of grassland management, in particular within a buffer zone surrounding the area.

Region 3 *"Ochsenmoor"* is located in Lower Saxony consisting of fen sites originating from the aggradation of the nearby lake "Dümmer". The area has been the focus of two large-scale conservation projects, both targeting not particularly "peatland conservation" but rather the establishment of a bird-life habitat. In line with the projects, an area of 1,116 ha, including a core region of about 800 ha, was changed from high-intensive grassland and arable land into a cultural landscape mainly characterised by low-intensive pastures and meadows and species-rich wet grassland sites which are now well accepted by the target bird species as breeding and resting grounds. In central areas of the "Ochsenmoor", groundwater tables are artificially kept above ground until early summer. The meadows and pastures are leased to local farmers who manage the land under nature conservation obligations but who do not have to pay for the lease. The two projects which resulted in the development of the region took place in the periods from 1987 to 1995 and 1998 to 2000. The first project was again funded by the German Federal Agency for Nature Conservation; together with the administrative district "Landkreis Diepholz". During this first project, funding was mainly used to bring the core area under public ownership. in line with the second project, funded by the European Union and the Federal State of Lower Saxony under the European programme "LIFE – Nature", true conservation measures like re-wetting and the implementation of low-intensive land use were completed.

4. METHOD AND DATABASE

As indicated before, our study is aimed at analysing the flow of public money used for conservation projects in general and for agricultural compensation in particular, and our focus is the assessment of costs per ton CO_2 saving which result from the implemented changes in land-use strategy. To be able to do an accurate "abatement cost" assessment, it is essential to have information about the complete flow of funding spent over the entire duration of each project. Exhaustiveness in this respect can only be guaranteed if the total amount of money spent during the different phases of a project (e.g. the planning phase as well as the implementation phase) is known. Furthermore, if one wants to assign achieved climate-change mitigation to the efforts of different donors, the flow of funding must be split as regards their origin. In our study we use project-related statements of implementation costs which are provided by the respective regional project management and by the German Federal Agency for Nature Protection (BFN). We analyse the flow of funding in separate steps. First of all, we determine the total amount of funds channelled into the various projects. To be able to compare our different study objects which took during different periods of time, we add accrued interest to the money spent in the past, using the reference year 2010.

Furthermore, we analyse the sources of the money spent. Normally, funding is shared among different partners; neither in the German governmental nor in the European Commission's nature conservation schemes is funding fully provided by one "public" source. For large-scale nature conservation projects in Germany, the federal government assumes up to 75 % of the overall costs. The German federal states (Bundesländer) usually pick up 15 % and project sponsors (district authorities, self-governing corporations set up by a group of local authorities) and registered associations the remaining 10 % (BFN 2011b). As regards contributions from the European Commission to federal nature-conservation projects, it is mainly the funding scheme "LIFE-Nature" that has to be considered. LIFE-Nature supports "nature conservation projects that contribute to maintaining or restoring natural habitats or species populations to a favourable conservation status within the meaning of the Habitats Directive" (European Commission, 2011c). Generally EU co-financing covers up to 50% of the costs, while the remaining expenditure has to be covered by the respective beneficiaries. Exceptions are made if projects concern priority natural habitats or priority species defined in the Habitats Directive the Commission; in that case projects can receive European financing up to 75% of the eligible costs (European Commission, 2011c).

As a second step we aim to assign the flow of funds to their designated use. This is indispensable in contrasting costs which result in different levels of land-use changes with the respective benefits derived through changes in GHG emissions. If one looks at the typical flow of public funding in large-scale conservation projects, the regulations of the different funding schemes show that funding is largely used for the purchase of land or for entering into long-term leases, paying compensation and covering the costs of management and development planning (including socio-economic studies and, where necessary, mediation). In addition, habitat-structuring measures, staffing and materials, project-related information activities and project evaluation are funding objects (BFN, 2011; European Commission, 2010b). In our study, as far as the database allows, we divide public funds into **"*site-specific costs*"**, which can be directly allocated to the plots within the project area, and into **"*site-independent costs*"**, which are necessary for the implementation of the project but which lack the possibility of site-specific assignment. As regards "***site-specific costs",*** on the one hand we calculate those costs which directly refer to an area but which have no effects on land-use changes and therefore on changes in GHG emissions. Here, mainly those expenses necessary to make the conservation area available for any implementation of measures are analysed (e.g. cost of land-acquisition or agricultural compensation). On the other hand, we analyse those costs which lead to site-specific land-use changes with related climate effects. Here, the cost of – for example – the technical implementation of re-wetting or further habitat structuring measures is considered. As regards **"*site-independent costs",*** mainly planning costs and "project overheads" such as organisation and management (personnel costs) are considered. These costs have to be allocated to the area via average rates.

As the basis for the estimation of changes in GHG emissions, we analyse which land-use changes took place in line with the projects, and – as emission factors differ for bog and fen sites – which soil-types were affected by these land-use changes. We have chosen an ex-post analysis, comparing the land-use strategies after the implementation of the conservation measures with the situation beforehand. For the analysis of land-use changes, we use data mainly consisting of results of biotope and land-use mapping, as well as management and development planning. Data is provided by regional stakeholders and local project sponsors involved in the implementation of the projects. For the identification of changes in agricultural management, land-use related data is processed, analysed and visualised via GIS-analysis. To balance the changes in GHG emissions, we use land-use-specific emission factors expressed in tons CO_2 equivalent per hectare and year (t CO_2 equiv. ha-1a-1). The backgrounding data used for assessing emission reductions in line with the implementation of conservation measures is based on data collected during the project "Climate Protection – Strategies of Peatland Management" (Pfadenhauer & Drösler, 2005). In this project GHG-fluxes of common land-use strategies on representative German peatland sites were measured. As the outcome of the measurements, Global Warming Potentials (GWP) (measured over the timescale of 100 years) are assigned to the different land-use strategies. Consequently the mitigation potentials of management changes are determined. In peatlands particularly, the fluxes of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) have to be considered. To derive total GWPs, the import and export of C is also included (Drösler et al., 2008). GWPs are quantified by the unit of carbon dioxide equivalent (CO_2-C equiv.). GWP-factors for CH_4 and N_2O correspond to the internationally accepted quantification of the Second Assessment Report (SAR) of the International Panel of Climate Change. According to SAR, CH_4-C holds a multiplication factor of 7.6, N_2O-N of 133. (IPCC, 1995). The GWP balance (gas-exchange) of the land-use types (LU) is calculated as:

$$GWP_{LU} \text{ (in } CO_2\text{-C equiv.)} = CO_2\text{-C } bal_{LU} + CH_4\text{-C } bal_{LU} * 7.6 + N_2O\text{-N } bal_{LU} * 133 + (C\text{-}Import_{LU} - C\text{-}Export_{LU})$$

Mitigation potentials emerging from land-use changes are derived by comparing the specific GWPs of the single land-use types to each other. Again, the amount of reduction (ER) can be expressed by CO_2-equivalencies.

$$ER_{LU1 \rightarrow LU2} \text{ (in } CO_2\text{-C equiv.)} = GWP_{LU1} - GWP_{LU2}$$

Analysing the extent of mitigation achievable due to shifts between land-use types, a cascade was developed which quantifies relevant climate-effective land-use conversions.

Consequently, as regards the analysis of "abatement costs" we contrast the flow of funding for agricultural compensation, implementation measures and project overheads and with the project related changes of GHG emissions. Finally we assess land-use management-related costs for CO_2 – mitigation achieved and upscale our results to the level of the total project region.

5. RESULTS

Our results show, first of all, the amount and structure of flow of public funding used in those conservation projects in our study objects. Secondly, we present emission mitigation potentials which can be achieved by implementing conservation measures on peatland sites. Thirdly, we assess the "efficiency" of the money spent as regards "abatement costs" by using the example of our study object "Wurzacher Ried".

Flow of funding

Analysing the flow of funding within our different study objects, it becomes clear that the implementation of conservation goals in line with public-funded projects – even if these conservation goals are thematically the same – demand fundamentally different amounts of money and, surprisingly, these different amounts of money do not correlate with the different extents of the project area. Furthermore – in spite of the generally fixed funding schemes as described in Chapter 4 – one can see that the projects vary greatly with regard to the sharing of funding between the different governmental, federal and "private" project sponsors. It also becomes obvious that for such projects to be implemented, at least in some cases "project funding" does not cover the expenses necessary to reach the complete targets. In such cases the projects have to be supported by external money, for example from the federal States, in addition to the federal contribution in line with the projects. Table 2 gives an overview of the money spent on the implementation of the aspirated conservation targets within our three objects of study.

Table2: Funding for nature conservation within the study objects; values displayed are net present values of the money invested for the reference year 2012 (in Million Euro, numbers rounded)

WURZACHER RIED						
		"site specific costs"			**"site independent costs"**	
		Without climate effect:		With climate effect:		
	Overall costs	Land acquisition	Peat cutting rights	Rewetting/ habitat structuring	Planning costs	Overhead for land acquisition
Funding scheme: German large scale conservation project (GR-Project)						
∑	**26.4**	**16.1**	**2.3**	**7.2**	**0.3**	**0.5**

OCHSENMOOR						
		"site specific costs"		**"site independent costs"**		
	Overall costs	Without climate effect: Land acquisition	With climate effect: Rewetting/ habitat structuring	Planning costs	Organisation/ management	Other unknown
Funding scheme: German large scale conservation project (GR-Project)						
∑	**15.2**	**13.0**	**0.25**	**0.08**	**No data**	**1.9**
Funding scheme: EU - LIFE						
∑	**1.35**	**0.15**	**1.1**	**-**	**0.07**	**-**
Funding outside projects						
∑	**2.2**	**2.2**	**-**	**-**	**-**	**-**

PFRUNGER – BURGWEILER RIED						
		"site specific costs"		**"site independent costs"**		
	Overall costs	Without climate effect: Land acquisition	With climate effect: Rewetting/ habitat structuring	Planning costs	Organisation/ management	Other*
Funding scheme: German large scale conservation project (GR-Project)						
∑	**8.0**	**3.2**	**3.1**	**0.3**	**1.2**	**0.2**

* Public relations, Evaluation, Travel and material expenses

As described earlier, the project ***"Wurzacher Ried"*** is the oldest of the analysed projects and affects a core area of 1.700 ha. Compared to the other regions, the project is characterised by the highest amount of funding. With about €26,400,000 of overall costs, it exceeds the complete sum spent for the "Ochsenmoor" by 40 % and the sum spent for the "Pfunger-Burgweiler Ried" by nearly 200%. By comparison, as regards project area, the "Wurzacher Ried" exceeds the "Ochsenmoor" only by 112% and the "Pfrunger Ried" by 17 %. Within "Wurzacher Ried", the lion's share of the funding was spent as "site specific costs" without climate effect: 70% of costs were created for the acquisition of land and the purchase of peat-cutting rights. About 27% of the money was spent on rewetting and habitat structuring, that is site-specific costs which are supposed to create a climate effect. Only 3 % of the money flowed into site-independent costs such as planning and the personal costs for land acquisition. As regards share of funding, most money came from the government (83 %), followed by 13% from the local administrative district "Landkreis Ravensburg". The remaining 4 % was shared between the State of Badem-Würtemberg and a local administration union.

As regards ***"Ochsenmoor"***, the two projects which implemented the conservation targets offered a funding sum of about €15.200.000 and €1.350.000. In the GR project again, the highest amount money was spent on the acquisition of land (81 %). Site-specific, "climate-effective" costs made up only 1,7 %, whereas the rest of the costs could not be specified except as planning costs with 0,5 %. In the EU-LIFE project, most of the money was actually spent on site-specific measures which would most probably create a climate effect. Here 83 % of the funding was used for rewetting and habitat structuring, while land acquisition had a share of only 11 %. This is due to the fact that the EU-LIFE project should complete the conservation targets that could not be reached in line with the GR Project, as more money than planned had to be spent on the acquisition of land. However, in the "Ochsenmoor" not all the area could be purchased in line with the money available through the two projects. Another €2.210.000 was spent on land acquisition by the state and the local administrative district "Landkreis Diepholz" parallel to and also before the duration of the project. As regards share of funding, during the GR Project, 90 % of funding was guaranteed by the government and 10 % by the local administrative district "Landkreis Diepholz". During EU-LIFE, 36% of funding was given by the EU while the remaining 64 % was provided by the state of Lower Saxony.

Our last study object ***"Pfrunger-Burgweiler Ried"*** will be finished in the year 2012. As regards the funding spent (until now and until the end of 2012), this project has revealed itself to be "the cheapest" of the three. Here the total project sum of about €8,000,000 is not first and foremost spent on the acquisition of land; on the contrary, the percentages of money spent on land acquisition and the implementation of conservative measures are, at 41% and 37%, almost equal. The remaining funding is mainly used to cover personal costs (15%). In this project, funding is shared following the "normal" sharing in the funding scheme of a German GR-Project, i.e. 65 % of funding is provided by the government, 25 % by the federal state and 10% by the local project sponsor.

CO_2 mitigation via land-use strategies

With respect to CO_2 emissions, it had already been demonstrated in the past that the intensity of agricultural land use and the level of groundwater tables are the main factors which influence GHG emissions (cf. Byrne et al., 2004). The results of the GHG measurements carried out during the project "Climate Protection – Strategies of Peatland Management" confirm this assumption. In Table 3 – which displays the results of measurements in line with the project – one can see that the water table in particular dominates the exchange of CO_2, N_2O and CH_4 within the ecosystem.

Table 3: Results of measurements: GHG balances (in t CO_2 equivalent ha^{-1} a^{-1}) for bogs and fens for different land-use classes. The data displays average as well as minimum-to-maximum global-warming potentials); Water tables are the same for bog and fen sites.

	Fen Sites	**Bog Sites**	**Water Table**
Arable land	33,8 (14,2 to 50,0)	No data	-70 (-29 to -102)
Grassland; Intensity high/medium	30,9 (21,3 to 40,7)	28,3	-49 (-39 to -98)
Grassland; Intensity low; Dry conditions	22,5 (19,5 to 30,9)	20,1	-29 (-14 to -39)
Grassland; Intensity low; Wet conditions	10,3 (5,8 bis 16,3)	2,2 (0 to 4,4)	-11 (6 to -25)
Bog Sites; Dry conditions	-	9,6 (5,3 to 12,1)	-18 (-9 to-25)
Close to nature/ Restored	3,3 (-4,3 to 11,9)	0,1 (-1,8 to 2,9)	-10 (-7 to -14)
Flooded conditions	28,3 (10,6 to 71,7)	8,3 (6,1 to 10,4)	14 (-8 to 36)

Source: Drösler et al. (2011)

Peat profiles which hold water tables close to the surface are characterised by anaerobic conditions below the mean water table, while aerobic conditions are limited to a shallow upper layer. If the water table drops down (e.g. through drought or drainage), the aerobic zone in the profile extends, resulting in rising soil respiration and mineralisation. The degradation of the carbon [C] and nitrogen [N] stocks in the peat transforms the peatland from a strong C and N sink to a potentially very strong C and N source in terms of CO_2 and N_2O emissions. Even if emissions of CH_4 are usually discontinued or are even changed to a small CH_4 uptake after draining, this effect is outweighed by the pronounced increases in the other two gases. Therefore the thickness of the upper aerobic zone is of major importance for the gas fluxes. The project results prove that the land-use types necessitating the lowest water tables, namely arable land and high-intensive grassland, are accompanied by the highest GWPs.

As regards climate footprint, arable land and intensive grassland on average are almost comparable: the difference in GWP stands at a maximum of about 5 to 10 t CO_2-C equiv. $ha^{-1}a^{-1}$. Significantly lower GWPs occur on grassland sites which hold higher water tables and are either managed with low agricultural intensity (1 to 2 cuts, low fertilisation, low stocking rate) or kept under maintenance. Here GWPs stand at about 30 % to 60 % below the GWPs of intensive land-use types. Quasi-zero emission occurs on sites which have been restored by withdrawing any land use and enhancing the water table to an annual average of about 10 cm below ground. The table also shows that restoration measures resulting in flooded conditions do not lead to low GHG emissions. Here a significant increase in CH_4 emissions results in very high GWPs. These results apply to bogs as well as to fen sites, while generally emissions on fen sites exceed emissions on bog sites. With regard to recommendations of land-use changes which imply the highest mitigation potentials, the results of the measurements reveal three major "mitigation steps", as shown in Table 4. First of all, even if mitigation potentials are limited, arable land use should be abandoned and changed into grassland use, as aeration resulting from ploughing strongly accelerates soil degradation. Secondly, implying high mitigation potential, arable land as well as intensive grassland should be changed into grassland with low-intensive agricultural management or into grassland maintained under nature-conservation programmes. Thirdly, as the most drastic though the most climate-effective step, a change from arable or intensive grassland to complete and adapted restoration is recommended - resulting in the complete abandonment of agriculture.

Table 4: Recommended land-use changes implying relevant GHG mitigation potentials (average in t CO_2 equivalent ha^{-1} a^{-1})

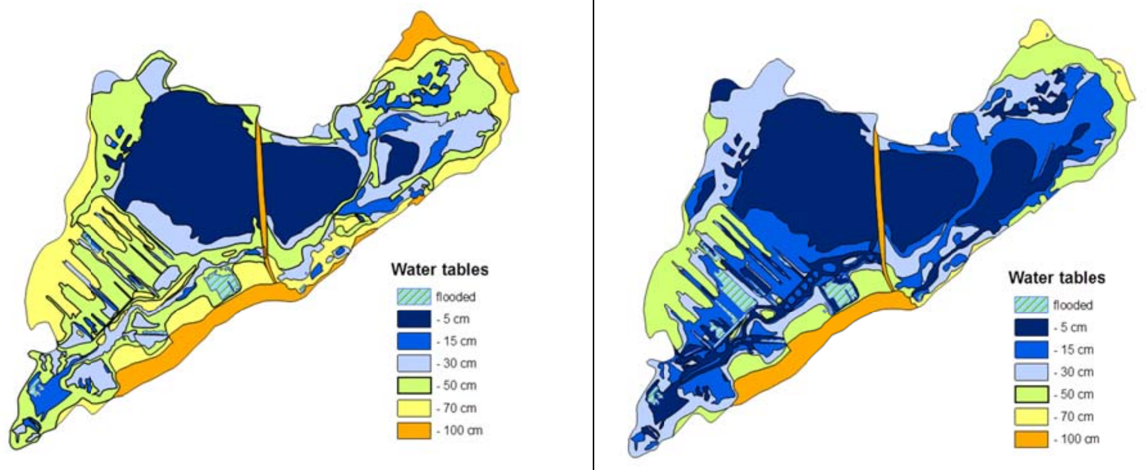
	Initial land use	**Target land use**	**GWP mitigation potential**
(I)	Arable land	Grassland (Intensity high or medium)	2,9
(II) (a) (b)	Arable land / High-intensive grassland	Low-intensive grassland [(a) agric. use: 1 to 2 cuts or low-intensive grazing; (b) maintenance]	(a) 8,2 – 11,3 (b) 20,6 – 26,1
(III)	Arable land / High-intensive grassland	Restoration (Abandonment of land use, average annual water table at 10cm below surface)	27,6 – 30,5

If we consider the results of Drösler et al. (in prep.), we see that nature conservation projects on peatland sites which target climate protection need to establish measures which clearly reduce the intensity of agricultural land use in combination with an optimised enhancement of the water tables. "Optimised" in this sense means that flooded conditions must be avoided and the annual average water table must be installed at a level of about 10 cm below ground.

Emission mitigation and mitigation costs in line with the large scale nature conservation project "Wurzacher Ried"

Having described the flow of funding within our different study objects and the emission mitigation achievable during the "cascade" of restoration steps, in this section we aim to assess the "efficiency" of the money spent as regards "CO_2 abatement costs". Using the example of our "most expensive" project "Wurzacher Ried", we contrast the flow of funding with changes in GHG emissions which have been achieved in line with the restoration measures implemented during the project. In Chapter 3 we outlined already the targets of restoration for the core area of "Wurzacher Ried", namely, the reestablishment of the original water tables, the termination of peat cutting and the environmentally sustainable reorganisation of grassland management within the buffer zone. Figure 2 presents the effects of the restoration measures in "Wurzacher Ried" on the main target "reestablishment of groundwater tables".

Figure 2: Change of groundwater tables resulting from restoration measures in "Wurzacher Ried"



Groundwater tables in 1993

Groundwater tables in 2004

Looking at the figures, the success of the measures is obvious. While in 1993 – that is, halfway through the project – only a small amount of the area held water tables at 5 to 15 cm below ground, in 2004 the extent of the area showing such "wet" conditions has significantly increased. So-called "dry" areas with water tables at 50 to 100 cm below ground are limited to a very small extent in 2004 and can only be found at the edges of the bog. With regard to extents, Table 5 numbers the change in area extents characterised by the different groundwater levels (Columns 4 and 5). The table also shows the site-specific emissions associated with the water levels.

Table 5: Wurzacher Ried: extents of area with specific ground-water levels and related emissions for the years 1993 and 2004

Code Water table	Water-level status quo (m below ground)	GWP Status quo (tCO2-eq.ha^{-1}a^{-1})	Extent 1993 (ha)	Extent 2004 (ha)	Total emissions 1993 (tCO$_2$-eq.ha^{-1}a^{-1})	Total emissions 2004 (tCO$_2$-eq.ha^{-1}a^{-1})
water	0,20	10,48	15	35	154	370
1a	0,05	-0,05	405	600	-20	-30
1b	0,15	5,04	93	355	467	1.789
2	0,30	14,14	298	307	4.212	4.340
3	0,50	22,72	437	245	9.925	5.569
4	0,70	26,99	280	24	7.556	647
5	1,00	29,33	120	80	3.516	2.356
			1647	1647	25.810,70	15.040

The numbers show that the area holding those high water tables associated with low GHG emissions (5 to 15 cm below ground) has increased by nearly 70 % while extents of area with low water tables inducing high emissions has decreased by about 41 %. This change has a significant effect on the emissions over the whole area. Compared to the situation before the project measures, for the whole region an annual emission reduction of about 10.770 t CO2-equivalent was achieved (6.5 t CO$_2$-equiv. ha^{-1} a^{-1}). As the last section outlines, the cost positions which we can contrast these emissions with are site-specific costs having no climate effect ("land acquisition" and "peat-cutting rights") as well as the site-specific cost position "rewetting/habitat structuring" which is supposed to cause a climate effect. On the other hand, we hold data about the site-independent cost positions which are "planning costs" and "overhead costs for site acquisition". To be able to contrast the annual reductions in emission with the annual investment costs of the project, we modelled annual investment costs under two scenarios: In *Scenario 1* we assume that the net present value of the investments for land acquisition and peat-cutting rights will not be subject to devaluation. This means that the investors will be able to sell area and peat-cutting rights after the observation period for prices equal to when they bought (price level 2012). Our assumption came about for different reasons: first of all, in general land is a fixed asset whose value normally stays stable in the sense that area cannot decrease, be damaged or be lost. Normally area cannot be amortised. Secondly, for peatland area we can further assume that with the start of conservation measures targeting peatland conservation, the soil itself is taken out of the vortex of degradation and is literally "conserved" in the condition in which it was bought. Thirdly, even if the peatland was used for agriculture when it was bought and the monetary value for the agricultural land might be reduced after the observation period, the value of the created conservation area could be comparable as the ecosystem services provided by the conservation area have an ecological and macroeconomic values well (e.g. the value of water-retention, biodiversity, etc.). To model an annual value for these positions, we use the perpetual annuity of a long-term capital investment. For the remaining cost positions, we assumed a depreciation period of 30 years, after which new investments such as adaptation measures or the restoration of infrastructure will become necessary again. We depreciate the net present values of these positions over the observation period. Furthermore, taking into account the opportunity costs of capital, we calculate the annual interest of the money invested. *Scenario 2* assumes that the land purchased in line with the project will lose its initial value, since the usability for agriculture will significantly decrease after the implementation of conservation measures and the investors will not be able to sell the land after the observation period for the same price. We use a 40% reduction to the net present value, corresponding to the prices for agricultural land with comparable quality and depreciate the reduction assuming a depreciation period of again 30 years. The assumptions for the remaining cost positions are the same as under *Scenario 1*. Table 6 summarises the scenarios and outlines the corresponding annual costs resulting from the investment.

Table 6: Scenario assumptions for the cost position and annual costs of investment.

	Land acquisition	**Peat cutting rights**	**Rewetting/habit at structuring**	**Planning costs**	**Overhead for land acquisition**
Scenario 1	Perpetual annuity	Perpetual annuity	Amortisation Interest	Amortisation Interest	Amortisation Interest
Annual costs	403.000	85.350	450.220	18.000	31.900
Scenario 2	Annual amortisation of the amortisation value Interest for amortisation value Perpetual annuity for residual value	Perpetual annuity	Amortisation Interest	Amortisation Interest	Amortisation Interest
Annual costs (€)	645.000	85,350	450,220	18.000	31.900

For the two different *scenario*s, the sum of annual costs differs by the amount of €242.000. As regards "abatement costs", under *Scenario 1* the measures of the conservation project – leading to an annual emission reduction of 10.770 t CO_2-equivalent – create a monetary value of €90 per t CO_2-equivalent. If one only considered the money spent on the site-specific measures which actually caused the emission reduction, the cost is €42 per t CO_2-equivalent. With almost 47%, the share of the site specific, climate-effective position is with almost 47% the biggest, whereas land-acquisition costs are even lower with 43%, however high the net capital value of the initial investment. Under the conditions of *Scenario 2*, "abatement costs" are naturally higher. Here the total sum of annual investment leads to costs per ton Co_2-equvalent of about €112. The share of costs causing emission reductions decreases to 37% of total annual costs – while the costs for land make up 53% of the whole sum. At the present moment, annual emission reductions for "Wurzacher Ried" are only modelled by assessing the changes in groundwater levels. In the course of the study management changes will also be considered. For "Wurzacher Ried" we assume the emission reduction to increase further by about 20%. Such an increase of the mitigation potential will lower the costs per ton CO_2-equivalent by about 17 to 18%, which means €74 per t CO_2-equivalent under *Scenario 1* and €93 per t CO_2-equivalent for *Scenario 2*.

6. DISCUSSION

The aim of our study is to analyse how the high level of public funds used for the implementation of "hotspot area" conservation projects can contribute to GHG emission reduction and whether the "abatement costs" of climate-change mitigation associated with nature conservation projects appear to be competitive. The results we present – using the example of one of our study objects – indicate that the costs per ton CO_2-equivalent associated with emission reductions due to conservation measures actually lie within an acceptable range of abatement costs. Even if prices of CO_2 certificates currently traded are remarkably lower – the price per ton CO_2-equivalent at the European Energy exchange varied between €13,50 and €17 per ton for the period May 2010 to April 15, 2011 (EEX, 2011) – our results, in varying between €70 and €115, can compete with common abatement strategies. For example, strategies within the transport sector cause abatement costs which vary from €20 to €400 (e.g. biodiesel, plant oils, cellulose-bioethanol, biogas) up to more than €1000 per ton CO_2 equiv. (bioethanol from wheat or sugar beet, hybrid drives). In addition, within the energy sector, abatement costs often exceed the €200 mark (e.g. geothermal energy, electricity produced from biomass, hydropower) (Wissenschaftlicher Beirat Agrarpolitik, 2007). Furthermore, there are also other approaches to assessing the costs of GHG emissions which justify those costs we derived as acceptable: The German Federal Agency for Environment, for example, refers to the external costs of CO_2-emissions when assessing the monetary value per ton CO_2 equivalent. In its "Methodological Convention for Estimates of Environmental Externalities" (German Federal Environment Agency, 2007), the Agency promotes the results of a study commissioned by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. In line with this study, the authors recommend the use of a best estimated value of €70 per ton CO_2 for the internalisation of the external costs of GHG emissions. As the variation of estimates available is great, in addition to the value of €70 per ton CO_2, the Agency suggests performing sensitivity calculations based on the values of €20 and €280 per ton CO_2 – a range our results are definitely within (German Federal Environment Agency, 2007). Whatever the nature of the assessment of our results as regards the competitiveness of GHG mitigation costs, there are various important points which must be considered when interpreting our results. First of all, when describing our method and database, we stressed that for accurate "abatement-cost" assessment, it is essential to have information about the complete flow of funding spent over the entire duration of each project. When gathering our data it became clear that particularly for "old" projects, even if the funding spent was remarkably high, no full record of the amounts of money and the flow of funding are kept. For the region "Wurzacher Ried", for example, we were not able to gather data which depict the personnel costs for the organisation and management of the project. The reason is that this cost position was not subject to funding in line with the project. However, it is clear that the project could not have been implemented without organisation and management and the related personnel costs. Bearing in mind that the project had a duration of 10 years; the personnel costs therefore would presumably be significant in calculating abatement costs. Furthermore, for "Wurzacher Ried", we have no data on annual follow-up costs which are necessary, for example, for the compensation of agricultural maintenance measures, the maintenance of infrastructure, evaluation, etc. In our other regions we have such data and we can see that follow-up costs do have a significant influence on the total amount of annual costs. In the region "Ochsenmoor", for example, such costs make up about 15-20%, in the region "Prunger/Burgweiler Ried" follow-up costs make up even more than 50% of the total annual costs. Despite having this additional information in "Ochsenmoor", even here we lack essential data. For the GR and LIFE projects in the region "Ochsenmoor", we only have data on the total sums of the single cost positions. Therefore, adding accrued interest to derive the net present value of the investment could only be done by distributing the investment costs evenly over the duration of the project. Furthermore, for the GR project in "Ochsenmoor", we again lack data on personnel costs – with the same consequences on the derivation of the accurate abatement costs which we assumed for "Wurzacher Ried". The best economic data set we have is for the "newest" project "Pfrunger/Burgweiler Ried". We assume that here the stricter controlling guidelines of the very latest funding programmes lead to a better recording of expenditures.

Apart from the lack of data on flow of funding, during the study other data gaps became obvious: on the one hand, there are only few, particularly site-specific mapping data on the ecological and land-use situation at the start of the projects. Furthermore, surprisingly, even after the implementation of the projects, evaluation of the achievement of the defined conservation objectives does not necessarily take place or at least not sufficiently precisely. Therefore, the ex-post analysis of land-use changes and the changes to groundwater tables in order to derive emission-mitigation potentials presented a particular problem. In some cases we had to introduce complete new mapping of the ecological status-quo situation in line with our study. Therefore, the mitigation potentials we derive can only be as exact as the database we are able to access. As an example, the case of the "Wurzacher Ried" can again be used: Here we have only now received data on the changes in land-use management. This data, however, will allow the modelling of mitigation potentials to a much greater degree than when using only changes of water levels as the indicator for changes in GWP. Currently we assume that the difference between "groundwater model" and "groundwater plus land-use model" will account for about 20% fewer emissions; a result which will definitely influence the assessment of the "efficiency" of funding.

Another area to draw attention to when assessing mitigation costs would be the system boundaries within which our study is conducted. At the moment we calculate project-individual costs which occur for the development of a defined conservation area. By doing so, the effects accompanied by the measures outside the region are not considered. Fundamental, large-scale changes in area-structures and -functions of partially extensive ecosystems can have far-reaching consequences within the surrounding area. On the one hand, the changes in agricultural usability can cause production-"exports" or an intensification of production on alternative area. Naturally such adaptation measures can also show negative climate effects (e.g. intensified fertilisation, enhanced transport, land-use changes for the creation of alternative UAA, etc.). On the other hand, they can result in further macroeconomic consequences, such as a lack of water in the surrounding area or – as a positive result – enhanced regional water retention or reduced flood peaks. Therefore, for the derivation of macroeconomic and even global cost-benefit relations as a basis for abatement-cost modelling, profound scenarios involving effects within much broader system boundaries would have to be analysed.

Last but not least, it has to be said that the high level of public funding which is necessary for implementing the projects cannot only be contrasted by the benefits of GHG emission reduction. Such projects were, for the most part, implemented not against the background of climate-change mitigation but in favour of conserving ecologically valuable areas to save biodiversity, endangered species or cultural landscapes. Therefore it becomes obvious that a retrospective valuation of CO_2 abatement cannot be the only indication of the success of such projects; further benefits such as biodiversity, water conservation etc. have to be included in the monetary evaluation.

SUMMARY AND CONCLUSION

In Germany a significant amount of public funding is used to support large-scale nature-conservation projects. Our study – taking place in three German project regions – shows that the substantial land-use changes accompanying these projects have relevant climate effects. To analyse the "efficiency" of the money spent as regards "abatement costs" per ton CO_2-reduction, we contrasted the funding spent with the achieved emission mitigations. The results we present in this paper focus on the example of one project region. Here we derive abatement costs within a range of €70 to €115 per ton CO_2-equivalent – depending on the scenario of the development of monetary value of area . This range would actually lie within the range of levels of common alternative abatement costs; the costs we derive therefore appear to be competitive. However, our results must be interpreted with caution. It became obvious to us that even though such projects are funded by public money, in many cases a full record describing the complete flow of money into the regions are either not kept or are at least very difficult to access. Additionally, records of site-specific pre- and post- descriptions of the ecological situation within the areas are partly lacking. We assume that this lack of data has significant effects on the assessment of "abatement costs", as well as on the assessment of emission-mitigation potentials. The aspiration to evaluate large-scale conservation projects as regards their benefits for climate-change mitigation and as regards the related "abatement costs", can only be satisfied in the future, in our opinion, if there is a full record of flow of funding as well as improved evaluation of the ecological situation of the areas before and after project implementation. Besides the lack of essential data, we must point out that our results were created within narrow system boundaries which do not allow for consideration of further relevant macroeconomic cost and benefit positions, which will have a significant influence on abatement costs. To derive realistic macroeconomic abatement costs in future research projects, these system boundaries need to be adjusted.

ACKNOWLEDGEMENTS:

Work has been granted by the Federal Agency for Nature Conservation (BfN) (FKZ 3509 85 0500)

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