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Potential for Carbon Credits from Conservation Management: Price and Potential for Multi-Habitat Nature-Based Carbon Sequestration in Dorset, UK

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Abstract: Carbon offsetting is currently a major tool in managing carbon emissions and informing sustainability plans of organisations in the drive to net-zero. This study aims to identify the offsetting potential of existing conservation schemes, and whether carbon offsetting credits could provide finance these conservation activities. The results from Dorset, in the UK, indicate that many existing conservation schemes in woodlands, heathlands, and grasslands cannot only enhance biodiversity but also capture significant amounts of carbon, and while habitats differ by region and country, the general results should be applicable elsewhere. We show that the cost per additional tonne of carbon sequestered as a result of conservation activities varies considerably between different conservation projects. On average, across the conservation projects we studied, the cost of this offsetting is GBP 80 per tonne CO_2e sequestered and ranging between GBP 120 and GBP 0, depending on the project and whether existing biodiversity grants would be available. However, this figure was based on adapting and refining the existing conservation projects and did not involve expensive factors, such as purchase of land, which make the prices potentially unrealistic, especially in a Global North context. While the costs identified are higher than many offsetting schemes at present, it could present a useful option for those wishing to localise their offsetting. The concept is highly scalable and could remove significant amounts of carbon dioxide. Combining the approach with biodiversity credits or other credit schemes could make the higher costs more attractive to potential buyers.

Keywords: climate change; carbon offsetting; carbon credits; biodiversity; nature-based solutions

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1. Introduction

Despite considerable issues on the effectiveness and implementation of carbon offsetting, and its potential to weaken the focus on carbon emission reduction, carbon offsetting schemes are becoming increasingly popular [1]. Carbon offsetting schemes are designed to either remove CO_2 straight from the atmosphere or provide infrastructure that bring emission reductions over time to offset actions that produce emissions [2]. As a result, an activity that has been offset is no longer considered to contribute to atmospheric greenhouse gas concentrations [2]. Carbon credits are therefore a financial mechanism to allow offsetting. Polluters can purchase credits, which allow them to emit a certain volume of carbon which has been pre-offset [3]. Carbon offsetting is therefore an important aspect of many organisations' sustainability plans to reduce their carbon footprints, with many countries setting net-zero targets for the coming years, typically aiming to reduce emissions, but offset the remaining emissions somewhere between the years of 2030 and 2050 [4].

Despite the rise in anthropogenically produced carbon, nature still provides by far the dominant fluxes of carbon into and out of the atmosphere and oceans [5]. Ultimately, enhancing and restoring nature can benefit atmospheric carbon levels by sequestering carbon as well as increasing biodiversity, while addressing societal challenges. This is sometimes referred to as a nature-based solutions (NbS) approach [6,7].

Sequestration varies between habitats; woodlands, for example, have a greater sequestration average compared to heathlands [8,9]. Furthermore, the overall quality of the habitat will influence its ability to sequester [10]; a 30-year-old mixed native broadleaved woodland has a flux range of -2.5 to -25.5 tCO_2e ha^{-1} yr^{-1}, averaging at -14.5 tCO_2e ha^{-1} yr^{-1} [9]. A habitat in pristine condition will sequester more carbon than if it was degraded [10], so a woodland in good condition may sequester a value closer to the higher end of the flux range, and closer to the lower end if degraded. As such, traditional conservation management practices which aim to improve habitat quality and enhance biodiversity should also result in improved carbon sequestration in most habitat types.

Highly biodiverse, species-rich habitats, such as a high-quality grassland community, may also show greater ecological resilience compared to species-poor communities [11]. This means they will have a stronger potential to support and promote biodiversity and ecosystem resilience, a component which is important in the face of climate extremes [12,13]. In terms of carbon sequestration, these stronger, biodiverse habitats may provide a more consistent sequestration rate, compared to an ecologically poorer habitat that may degrade with ecological stress [10]. However, it should be noted that habitats with low biodiversity, such as a conifer plantation, have high sequestration rates [14,15]. However, the fact remains that the lack of ecological resilience makes the monoculture less resistant to change and more prone to collapse if environmental perturbations are high [12]. As a result, trade-offs may arise, especially if the management measures proposed (i.e., to maximise carbon sequestration) encourage low biodiversity options, like afforestation with non-native monocultures [16].

Traditional conservation, especially within the UK, has been based on managing a diverse range of habitats, often in different stages of ecological succession [17], with the focus being on protecting biodiversity as a whole, or a taxonomic group (e.g., birds) or even a particular species (e.g., Dartford Warbler) [18]. As such, a rich mosaic of landscapes and habitats exist. Despite this, conservation in the UK is considered underfunded, and overall biodiversity trends are poor [19]. However, almost all habitats offer the potential to sequester carbon [20], and the selling of carbon credits could provide a vital funding mechanism to finance conservation, resulting in reduced atmospheric carbon, enhanced biodiversity, and more resilient habitats. With targets to conserve and protect 30% of land and sea by 2030 being adopted by many countries [21], understanding the extent to which conservation measures for biodiversity can sequester carbon is also important. We focus this study in Dorset, UK, a county with high levels of biodiversity and habitat types, and a wide range of ongoing conservation incentives from local and national organisations, including rewilding schemes and creation of large nature reserves [22,23]. This provides the opportunity to assess carbon sequestration across multiple habitat types, with similar habitats occurring across much of northern Europe. To our knowledge, this is the only study to examine carbon sequestration from conservation activities across multiple habitat types in a northern European setting. As such, the aim of this study is to obtain preliminary data on likely carbon sequestration of different conservation projects across different habitat types, and to calculate the cost of these conservation initiatives. As such, we can estimate necessary costs to sequester a tonne of CO_2e and see if a conservation-based approach to carbon sequestration is financially viable.

2. Materials and Methods

This study was fully approved through the Bournemouth University ethics process.

2.1. Site Selection

We selected Dorset for this case study due to the wide range of habitats available and the number of conservation initiatives currently ongoing in the area. We examined a range of nationally and locally owned nature reserves, run by conservation charities, as well as privately owned areas. Many habitats are similar to those found across northern Europe, and it is likely that similar sequestration rates will result from similar activity on similar habitat types. Purchase of land is expensive in Dorset, compared to many other areas of the UK, but labour costs provided are likely to be broadly equivalent across northern Europe and North America (Canada and USA).

The chosen sites are shown in Figure 1:

1. Rempstone Estate, Purbeck Heath—Private Estate (491.66 ha).
2. Studland, Purbeck Heath—Nature Reserve (308.18 ha).
3. Slepe Heath, Purbeck Heath—Nature Reserve (90.22 ha).
4. Wild Woodbury, Bere Regis—An old farm now managed as a rewilding site (157.69 ha).
5. Chapel Gate, Christchurch—University Sport Facility (23.05 ha).

Figure 1. Locations of chosen sites situated across Dorset, UK. Scale 1:100,000.

2.2. Data Collection

After landowner permissions were obtained, site visits were conducted. Habitat surveys provided habitat types for each hectare of land across the five sites. Where available, the habitats were cross-referenced against the data provided by the landowner.

CO_2e sequestration values were then categorised by habitat type (Table 1). Reports from Natural England [8,9] and the British Ecological Society [20] provided the foundation for this, for a wide range of habitats, and the remaining information was supplemented with other literature. Together, the datasets provided a comprehensive set of sequestration values required for our analysis.

Table 1. Carbon flux rates ordered by habitat, with confidence and source. Data collated from Natural England reports [8,9] and other sources [15,24]. Negative values denote sequestration; positive values denote emissions.

Habitat	Sub-Habitat	Carbon Flux Rate ($t\ CO_2e\ ha^{-1}\ yr^{-1}$) [Range]	Confidence	Source
Woodland *	30 yr Mixed Native Broadleaved Woodland	−14.5 [−2.5 to −25.5]	Medium	Gregg et al. (2021) [9]
	100 yr Mixed Native Broadleaved Woodland	−7 [−2 to −13]	Medium	Gregg et al. (2021) [9]
	30 yr Oak Woodland	−15 [−1 to −18]	Unknown	Gregg et al. (2021) [9]
	Conifer Plantation (Commercial Forest)	−12.5 [−5 to −20]	Low	Anderson (2021) [15]
Scrub/Bracken	Scrub	0—Soil only	Unknown	Gregg et al. (2021) [9]
	Bracken	0—Soil only	Unknown	Gregg et al. (2021) [9]
Heathland **	Lowland Heath—Maintained: Burning, grazing, scrub clearance	−0.07	Low	Alonso et al. (2012) [8]
	Lowland Heath—Restored: Scrub removed	+2.56	Low	Alonso et al. (2012) [8]
	Lowland Heath—Restored: Trees removed	+4.46	Low	Alonso et al. (2012) [8]
Semi-Natural Grassland ***	Acid Grassland (*Molinia caerulea* swards: Low-level grazing)	−0.5	Low	Gregg et al. (2021) [9]
	Acid Grassland (*Molinia caerulea* swards: Ungrazed)	−0.53	Low	Gregg et al. (2021) [9]
	Calcareous Grassland	−0.24	Low	The Lake District National Park Authority (ca. 2022) [24]
	Neutral Grassland	0	Low	Gregg et al. (2021) [9]
	Undisturbed semi-natural grassland under long-term management	0	Low	Gregg et al. (2021) [9]
Farmland	Arable/Cultivated Land	+0.29	Low	Gregg et al. (2021) [9]
	Improved Grassland	−0.36 [−1.28 to +0.92]	Low	Gregg et al. (2021) [9]
Semi-Natural Peat Habitats	Fens on Deep Peat (Near Natural Fen)	−0.93	Medium	Gregg et al. (2021) [9]
Floodplains	Floodplain	−3.365 [−2.13 to −4.19]	Low	Gregg et al. (2021) [9]
Coastal	Sand Dunes	−2.18 [−2.13 to −2.68]	Low	Gregg et al. (2021) [9]
	Salt Marsh	−5.19 [−2.35 to −8.04]	Low	Gregg et al. (2021) [9]
Lake	Mesotrophic Lake	−7.1 [−0.46 to −23.6]	Low	Gregg et al. (2021) [9]

* Sequestration rate after 10 years. ** 5-year average. *** There is limited evidence regarding carbon flux data for semi-natural grasslands in England, most notably, calcareous grasslands (Gregg et al., 2021 [9]).

2.3. Sequestration Calculations

Analysis was conducted using QGIS (version 3.28.7), an open-source geospatial software that enables data to be examined in relation to its location. The National Trust provided data for their three sites, denoting extent, and habitat information. For Chapel Gate and Wild Woodbury, sketch maps created during the site visits were digitized to create similar datasets to the other sites.

For all five sites, the area was calculated for each habitat polygon. Then, each polygon was assigned an averaged CO_2e sequestration value based on its assigned habitat (Table 1). Using the area and sequestration rates, the annual sequestration was then calculated for each habitat polygon, for each site. Next, changes to improve sequestration rates were determined (i.e., planned or potential conservation work), a new averaged CO_2e sequestration value was assigned to each polygon, and the annual sequestration rate was then re-calculated. The average sequestration rate per hectare for each site was then calculated, for both before and after the changes suggested.

2.4. Cost Calculations

Cost calculations were based on the area of land within each site subject to changes in management and habitat (detailed in Section 3.1) and did not include the entire area of the site. This meant that sequestration measures referred to the changes in carbon sequestration or 'additionality' (i.e., the management of the site resulted in additional carbon sequestration, and this additional carbon, not the existing background levels of carbon sequestration, was the only carbon used in the sequestration and cost calculations). Some long-term estimates of carbon sequestration and emission are uncertain, for example, how long deforested land will emit carbon [9]; as such, we conservatively confine our calculations to sequestration taking place over five years (although we do discuss these implications on the cost of land).

Our cost calculations are based on the 'Base Rate', meaning that they comprise just the costs involved in habitat creation (e.g., cost of saplings, seed, equipment hire) and maintenance of habitats over the five-year period. In addition, we estimate labour costs of habitat creation and maintenance and land purchase costs (average land price in Dorset, UK, per Hectare, based on 2022 data), and account for any government grants available to enhance biodiversity (see Section 3.1 for details). Cost parameters are provided in Table 2.

Table 2. Cost parameters used in the cost calculations.

Parameter and Units	Value
Time frame considered for offsetting (years)	5
Basic wage (GBP)	20
Skilled wage (GBP)	40
Cost of Trees (GBP/Ha)	649
Grassland seed (GBP/Ha)	189
Cost of land (GBP/Ha)	9000
Tree planting (number per hour)	12
Price of tree (GBP)	0.59
Tree density (per Ha)	1100
Grassland seeding (hours per hectare)	1
Cost of heathland creation (GBP/Ha)	370
Labour for heathland creation (hours per Ha)	50

3. Results

3.1. Proposed Conservation Measures

Below are the proposed conservation measures to be implemented at each site. Detailed maps of how sequestration is predicted to change between 2022 and 2032 are provided in the Supplementary Materials (Figure S1). Government grant information is correct as of August 2022.

3.1.1. Rempstone Estate Improvements

Rempstone Estate had notable tree cover until recently, when parts of the plantation were cleared; this has led to those areas emitting carbon, which needs to be addressed if sequestration gains are to be achieved, although it should be noted that as the plantation was planted on shallow peat, net carbon flux was likely positive (emitting, rather than sequestering) prior to clearance. It is proposed that the 93.21 ha of the cleared conifer plantation is converted to heathland and maintained with burning, grazing, and scrub clearance. This will stabilise the carbon stores in the soil (reducing the current 416 t $CO_2e.yr^{-1}$ emissions) as well as sequestering a small amount of carbon through the heathland habitat (net sequestration by 2032 estimated as 6.52 t $CO_2e.yr^{-1}$. Government grants (LH1) of GBP335/ha are currently available for this work.

3.1.2. Studland Improvements

Studland is a well-established biodiversity hotspot, and already has a good sequestration ability. Some changes could be made to enhance sequestration, which would involve cutting back some of the larger patches of bracken and scrub and restoring to sand dune habitats (a total of ~10 ha). In total, net sequestration would increase by 21.69 t $CO_2e.yr^{-1}$ across the site. Government grants (CT1) of GBP299/ha are currently available for this work.

3.1.3. Slepe Heath Improvements

Slepe Heath also had notable planation cover until recently, with the cleared areas currently emitting carbon; this needs to be addressed to bring about sequestration benefits. It is proposed that the 27.1 hectares of the cleared conifer plantation is converted to heathland and maintain with burning, grazing, and scrub clearance. As for Rempstone, this will stabilise the carbon stores in the soil (reducing the current 121 t $CO_2e.yr^{-1}$ emissions) as well as sequestering a small amount of carbon through the heathland habitat (net sequestration by 2032 estimated as 1.9 t $CO_2e.yr^{-1}$. Government grants (LH2) of GBP214/ha are currently available for this work.

3.1.4. Wild Woodbury Improvements

Wild Woodbury, an old farm, has large areas of arable and cultivated land cover, as well as some poor-quality neutral grasslands. These land cover types have poor sequestration abilities, emitting carbon, and they also have very low biodiversity. Suggested changes include planting 15 ha of oak woodland, natural regeneration of 95 ha of arable land to a low-input grassland, and 0.68 ha of mixed native broadleaf trees. A Government grant (SW7) of GBP321/ha is available for the arable conversion.

3.1.5. Chapel Gate Improvements

Chapel Gate, being a sports facility, is predominantly a managed grassland as it is required for sports fixtures. As such, enhancing sequestration is slightly more challenging, with small pockets of land (total ~1.3 ha) being repurposed, with native broadleaf woodland being the main strategy here. Due to the purpose of this site, no grants are available for this work.

3.2. Overall Changes in Sequestration

The changes outlined above only demonstrate the changes in carbon flux obtained as a result of specific management measures on parts of the sites. Over the entire sites, the carbon flux did increase for each of the different sites investigated, with an average change across all sites of an additional 0.93 t $CO_2e.yr^{-1}$ being sequestered (Figure 2).

3.3. Cost of Conservation Measures

The costs of conservation measures range from base costs of ~GBP 30 to ~GBP 120 tCO_2e^{-1} (Table 3), with additional labour costs between GBP 3 and GBP 100 tCO_2e^{-1}. The addition of land costs greatly increases the cost of a tonne of carbon dioxide equivalent, even with the inclusion of existing biodiversity grants. However, without land costs, the overall cost of some changes in conservation management, alongside government grants for biodiversity, can result in low or even negative costs per tonne of carbon. Across all sites and interventions examined, the mean average cost of a tonne of carbon dioxide equivalent offset would be GBP 79.62 without labour, GBP 123.70 with labour, and GBP 664.48 including purchasing land (based on five years of offsetting). Including government grants, the mean average is −GBP 4.48 without labour, GBP 39.59 with labour, and GBP 580.38 including purchasing land.

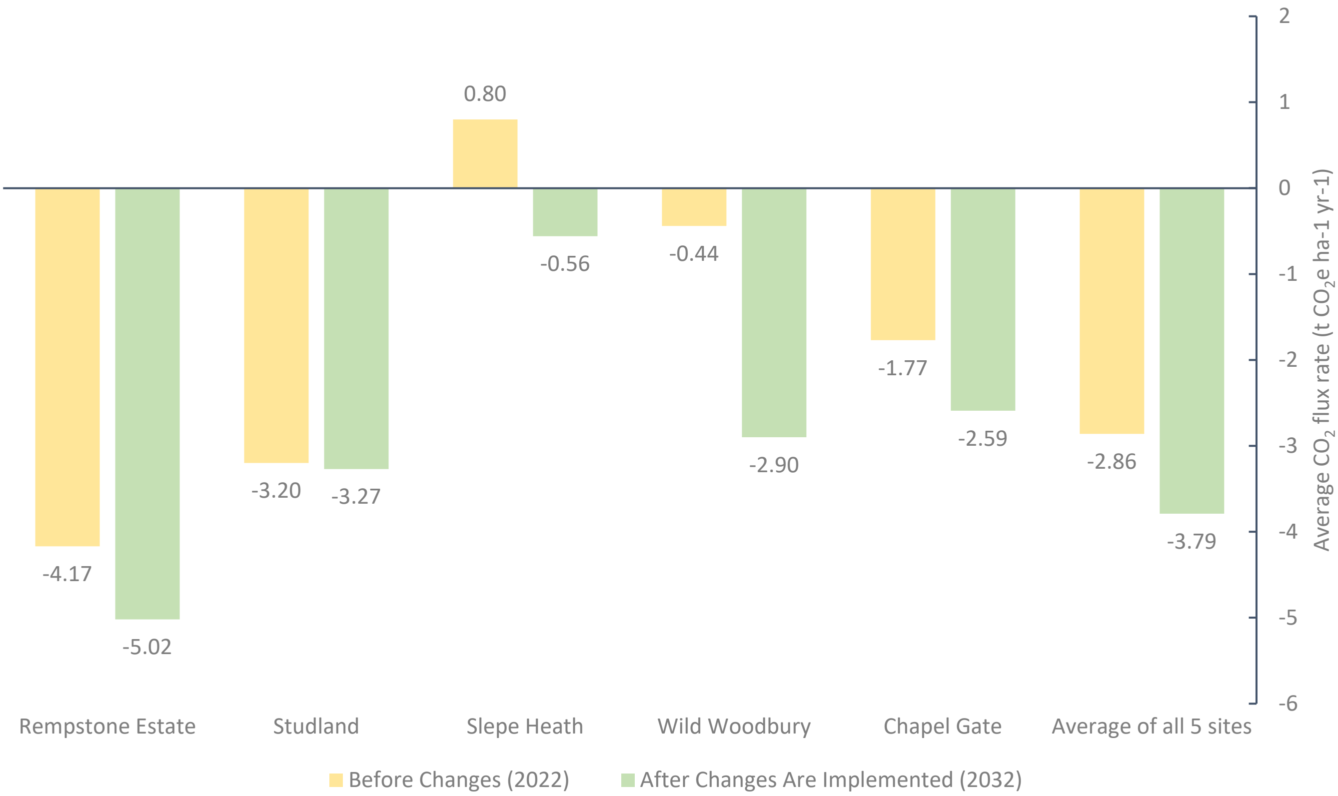

Figure 2. Carbon flux rate per hectare per year by site, both now (April 2022) and in ~10 years' time. Negative values (-) depict sequestration, and positive values (+) indicate emissions.

Table 3. Calculation of costs associated with carbon offsetting based on the different conservation interventions proposed. Land cost and available grant are total values, based on the figures in Table 2 and Section 3.1 multiplied by the total intervention area. Table shading is to enhance readability and grey/white colouration does not convey additional information.

Site	Chapel Gate	Wild Woodberry	Wild Woodberry	Slepe Heath	Rempstone	Studland
Description of work	Plant/extend broadleaf woodland	Convert arable land to grassland	Plant/extend broadleaf woodland	Restore and maintain heathland	Restore and maintain heathland	Sand dune conversion
Total area	1.3	94.7	15.6	27.1	93.2	4.7
Total sequestration of intervention (t CO_2e.y^{-1})	18.95	123.45	233.77	122.76	422.21	10.34
Yearly maintenance cost proportion	0.1	0.1	0.1	0.2	0.2	0.1
Base cost of work (GBP)	590.59	12,534.10	7077.99	12,032.40	41,385.24	1227.66
Base cost of work (GBP.tCO_2e^{-1})	31.17	101.53	30.28	98.02	98.02	118.73
Hours of labour	131.1	94.7	1571.0	1626.0	5592.6	260.7
Cost of labour (GBP)	2621.67	1894.80	31,419.67	32,520.00	111,852.00	5214.00
Cost of labour (GBP.tCO_2e^{-1})	27.67	3.07	26.88	52.98	52.98	100.85
Land costs (GBP)	11,700	852,660	140,220	243,900	838,890	42,660
Land costs (GBP.tCO_2e^{-1})	123.48	1381.39	119.96	397.36	397.38	825.15
Available grants		30,411.54		5799.40	31,225.35	1417.26
Base cost of work with grants (GBP.tCO_2e^{-1})	31.17	−144.82	30.28	50.77	24.06	−18.34

4. Discussion

In this study, we demonstrate the enhanced carbon sequestration which can be obtained from small changes in management to conservation sites (herein conservation-based sequestration or conservation-based offsetting). Sequestration applies across multiple habitats and is not restricted solely to tree planting. Our estimated costs of sequestration are typically higher than many cheap carbon offset schemes, but well within the suggested ranges proposed by the UK government [25], even when including labour costs, but not when purchase of land is required. As such, conservation-based offsetting could be used as a mechanism to drive conservation funding in the UK, as long as the work is based on habitat creation and enhancement on existing land.

The conservation-based sequestration rates found in this study can, on average, be considered modest when compared to typical tree planting schemes (across the entire site, ~1 t $CO_2e.ha^{-1}.yr^{-1}$ compared to ~10 t $CO_2e.ha^{-1}.yr^{-1}$ for a typical tree planting scheme). However, the sites used in this study do cover a range of habitats and uses of land and illustrate how these habitats can be managed for biodiversity and carbon sequestration. While this is a small proof of concept study based in a single county in the UK, the 30 by 30 initiative to protect 30% of land by 2030 is an international effort [21]. If similar improvements to carbon sequestration were made to 30% of the Earth's landmass, then an additional ~4.5×10^9 t $CO_2e.yr^{-1}$ would be sequestered, or a little over 10% of global emissions, based on 2021 data. Clearly, this figure is a very rough estimate, and is provided solely to show that additional carbon sequestration through well-managed conservation of what should be ear-marked protected sites can have a considerable impact on any drive to net-zero emissions and as such have global consequences in fighting the biodiversity and climate crises.

The main purpose of this study was to examine the market potential of conservation-based offsetting to finance conservation work. Averaged across the five sites studied, the costs, excluding labour, of creating or restoring habitats are ~GBP 80 t CO_2e^{-1}. Compared to many offsetting schemes, this cost is considerably higher (as of 12th September 2023, the top sponsored offset cost from a Google search was from Carbon Neutral Britain at GBP 7.55 t CO_2e^{-1}, or ~10 times lower). However, carbon offsetting has come under considerable criticism in the recent year, with journalists and academics finding that most carbon credits sold fail to sequester any additional carbon (or lack 'additionality' in terms of carbon offsetting policy [26,27]). This is on top of additional concerns surrounding land grabbing for afforestation and neo-colonialist approaches to carbon offsetting in the global south [28]. While the values in this study are estimates, based on typical carbon sequestration rates per habitat, and would need quantitative verification before carbon credits were sold, they are based on additional gains in sequestration (true additionality) over the current base rates, and prices based on the cost of achieving these additional gains.

However, in terms of the valuation of a tonne of carbon, the UK government suggests the value should lie between GBP 126 and GBP 378, with a typical value of GBP 252 for 2023 values [25]. Our figures, including labour costs, fall well within this range, although as noted by the UK government [25], valuation and market price can and do show high degrees of discrepancy. While Rodemeier [29] suggested a 'public willingness to pay' valuation, based on typical ecosystem service valuation methods, for carbon offsets of up to EUR 200 per tonne, he suggests that these valuation mechanisms are flawed and a realistic market price at present is ~EUR 16 per tonne.

While habitat types vary from location to location, our study in Dorset has examined conservation across multiple habitat types. While sequestration benefits and labour costs for a given intervention in each habitat are likely to be broadly the same across the UK and much of northern Europe, it is clear that different areas have different habitat types. For example, the large number of peatlands in areas such as Scotland and Ireland would result in different conservation priorities, and successful management of those peatlands for conservation (including rewetting) would likely create significantly more emission reductions and more potential for carbon credits [20], likely costing a lower amount per tonne. While labour costs are likely to be similar in Dorset to other regions in the Global North, land prices are very high, inflating the costs in this study when land is included. However, within Global North countries such as the UK, where land prices are high (if not quite as high as our study location), conservation-based offsetting appears to be overly costly, without a multi-facetted approach to justify the high costs above market value. Currently, government grants under land stewardship schemes can be applied for, which can greatly reduce the cost of conservation work which can also sequester carbon. Our estimates show that, on average, these grants can fully cover the cost of any work, excluding labour costs, or that with these grants a tonne of carbon could cost ~GBP 40 with paid labour. However, if carbon offsetting was routinely used for generating conservation funding, it is highly possible that grants such as these would be reduced or limited, given an additional funding mechanism had been put in place.

Conservation work has been shown to provide a wide range of benefits, well beyond carbon capture alone. Through policy initiatives such as Biodiversity Net Gain (BNG) in England and similar approaches in other regions of the UK and throughout Europe, markets for biodiversity credits are beginning to open, creating additional market mechanisms for conservation funding. Practical conservation work can also form a key part of a green workforce and Green New Deal strategies [30], yet many practical conservation skills are lacking in the general public, and even in graduates from degrees such as Ecological or Environmental Sciences [31]. In addition, working on practical conservation in a volunteering role has been shown to have physical and mental well-being benefits, often beyond those found from just being in nature [32]. Creating paid placement or apprenticeship places for students and trainees, as well as providing volunteering opportunities for conservation creates a low wage yet high-value workforce, considering the social, biodiversity, and carbon benefits which can be created. As such, a credit system encompassing biodiversity, carbon, and social benefits could be marketed, commanding a higher cost which would justify the full price (likely excluding additional land purchase) of the work. Such credit schemes may be attractive to companies, especially if they are local to the conservation projects, as a measure of cooperate social responsibility and supporting local access to nature schemes.

Carbon offsetting schemes are controversial, with many people expressing concern that they can prevent urgency in reducing carbon emissions [2]. However, carbon removal forms part of all IPCC scenarios, and nature-based processes to remove carbon are essential alongside large emission cuts to mitigate climate change [33]. Conservation-based gains in carbon sequestration can provide large areas of land to enable carbon removal but also provide additional ecosystem services, including increasing biodiversity, reducing nutrient input into fresh and coastal waters, and human welfare benefits [20]. Furthermore, the additionality of carbon sequestration as calculated in this study (rather than the background rate of sequestration from the land in its current form) creates a genuine decrease in atmospheric carbon dioxide. While our results are obtained in a local context, the concept of conservation-based carbon credits can apply globally, and, in many cases, can be utilised by local industries, thereby helping mitigate some of the ethical and neo-colonial issues resulting from buying land for tree planting alone.

At present, the role of conservation-based offsetting is likely to be small-scale and unlikely to make a big impact on global carbon budgets. However, there is potential for the approach to play a powerful role in reducing atmospheric carbon dioxide, as estimated above. Currently, while some premium carbon offset schemes do exist, charging prices in line with the UK government's valuations, most prices are significantly lower than both this figure and the typical figures estimated in this study (~GBP 80 t CO_2e^{-1}). Policy changes are necessary for conservation-based offsetting to play a significant role in carbon budgets, but such policy changes may also help to regulate other carbon offset markets. For example, while codes of best practice for carbon offsetting exist (e.g., the International Carbon Reduction and Offsetting Accreditation, which large organisations such as Verra align with [34]), compliance with these codes is not compulsory. While flaws in verified carbon markets have been identified, especially around the principal of additionality [27], these codes do help to ensure social and ethical issues are considered in the establishment and running of offsetting projects, and it would make sense for such codes to be mandatory for any official offsetting activity (e.g., reaching net-zero in the UK). A greater understanding of an individual and organisational biodiversity footprint (e.g., [35]) and an equivalent drive to net-zero for biodiversity loss would also strengthen biodiversity credit systems (the existing net gain approach is only required for developments such as housing or infrastructure, whereas most supply chains for any organisation have negative effects on biodiversity [35]) and would allow for duel credits from conservation-based sequestration, which would help justify the higher price and drive markets for integrated credit systems as discussed above. Finally, maintaining government funding for biodiversity actions, even if additional money would be obtained from environmental credits, helps to keep costs of conservation work manageable. While land purchase may be expensive, utilising much of the area inside of a protected area network would enable using land already set aside for nature to its maximum potential for biodiversity and carbon sequestration.

5. Conclusions

This study has demonstrated the potential for biodiversity conservation schemes to also sequester additional carbon, which could be used as carbon offset credits. The concept has potential for scalability around the globe and could provide significant levels of carbon reduction. However, the costs of offsetting using a wide range of conservation schemes are significantly higher than the current market value. The incorporation of multiple credits for biodiversity, nutrient reduction, and even social and welfare benefits to people may make these costs more attractive. Moreover, government policies to ensure these additional benefits are accounted for would help to improve the uptake of these multi-use credits.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su16031268/s1, References [36,37] are citied in the Supplementary Materials.

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