Cyfoeth Naturiol Cymru
Natural Resources Wales

# Review of the wider societal, biodiversity and ecosystem benefits of curlew recovery in Wales

Report No: 629

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# Crynodeb Gweithredol

Cydnabyddir fwyfwy bod amgylcheddau naturiol yn bwysig nid yn unig i'r rhywogaethau planhigion ac anifeiliaid sy'n tyfu ac yn byw yn y gwyllt, ond oherwydd eu bod hefyd yn dwyn buddion uniongyrchol ac anuniongyrchol i bobl ar ystod o raddfeydd gofodol ac amserol. Mewn byd sy'n gynyddol drefol a thameidiog, mae cysylltiad dynolryw â natur a'i dibyniaeth arno yn llai amlwg i lawer o bobl. Yn erbyn cefndir bioamrywiaeth sy'n dirywio a bygythiadau i wasanaethau ecosystemau hanfodol sy'n cynnal ein heconomi a'n cymdeithas, mae gan Gymru fframwaith polisi a chyfreithiol ar gyfer dull newydd o ymateb i'r heriau amgylcheddol sy'n ein hwynebu. Mae hyn wedi'i nodi'n bennaf mewn dwy Ddeddf: Deddf Llesiant Cenedlaethau'r Dyfodol (Cymru) 2015, sy'n anelu at hybu llesiant economaidd, cymdeithasol, amgylcheddol a diwylliannol pobl Cymru; a Deddf yr Amgylchedd (Cymru) 2016, a luniwyd i hyrwyddo rheoli adnoddau naturiol yn gynaliadwy i gynnal a gwella cydnerthedd ecosystemau.

Gan ystyried y cysyniad bod rhywogaethau yn rhan annatod o ecosystemau, rydym yn canolbwyntio ar y gylfinir *Numenius arquata* i ddangos sut mae buddsoddi mewn cadwraeth y gylfinir yn cael effaith gadarnhaol ar lesiant y cyhoedd, yn atgyfnerthu ac yn cefnogi gwasanaethau ecosystemau, ac yn arwain o bosibl at fuddion sylweddol i ystod eang o rywogaethau sy'n peri pryder cadwraethol.

Mae rhai cysyniadau allweddol (e.e. gwasanaethau ecosystemau, cyfalaf naturiol, asesu gwasanaethau ecosystemau) yn cael eu diffinio a'u pennu. Mae'r rhesymeg dros sefydlu a defnyddio gwasanaethau ecosystemau a dulliau cyfalaf naturiol i gefnogi cadwraeth natur yn cael ei harchwilio ac mae profiadau blaenorol o'r dulliau o ymdrin â bioamrywiaeth a chadwraeth rhywogaethau yn cael eu crynhoi.

Roedd ein hadolygiad yn asesiad cyflym yn seiliedig ar astudiaeth ddesg ansoddol. Defnyddiwyd dogfennau a gyhoeddwyd a nas cyhoeddwyd a oedd ar gael yn rhwydd o fewn amserlen y prosiect ac, yn absenoldeb tystiolaeth wyddonol gyhoeddedig, gwnaethom gymhwyso asesiadau procsi. Ni chasglwyd unrhyw ddata yn y maes.

At ddibenion yr adolygiad hwn, rydym yn archwilio'r buddion cymdeithasol ac amgylcheddol lluosog a allai ddeillio o ymyriadau cadwraeth cadarnhaol y gylfinir. Yn benodol, gwnaethom archwilio'r pedwar cwestiwn canlynol:

i) I ba raddau y mae deddfwriaeth a pholisi Cymru yn cefnogi'r gylfinir?

ii) Beth yw'r buddion o ran bioamrywiaeth, gan gyfeirio'n benodol at rywogaethau o bryder cadwraethol, sy'n gysylltiedig â dulliau rheoli tir sy'n ffafrio'r gylfinir?

iii) A oes gan y gylfinir arwyddocâd diwylliannol a buddion llesiant/cymdeithasol i bobl yng Nghymru?

iv) Beth yw'r gwasanaethau ecosystemau allweddol sy'n deillio o arferion rheoli tir sy'n gysylltiedig â chadwraeth y gylfinir?

*Beth yw'r buddion o ran bioamrywiaeth, gan gyfeirio'n benodol at rywogaethau o bryder cadwraethol, sy'n gysylltiedig â dulliau rheoli tir sy'n ffafrio'r gylfinir?*

Mae cynefinoedd bridio a bwydo da ar gyfer y gylfinir yn gysylltiedig ag adeiladwaith tirwedd heterogenaidd, sydd fel arfer yn mynd law yn llaw â mwy o fioamrywiaeth. Ar y sail hon, awgrymir bod y canlynol yn fwy tebygol o ddigwydd:

- Porfeydd hirdymor, amrywiol a chanddynt gyfoeth o bryfed ac ychydig iawn o allyriadau carbon
- Pwysau isel o du ysglyfaethu ar lefel leol a thirwedd, sydd o fudd i adar eraill sy'n nythu ar y ddaear
- Adeiladwaith heterogenaidd y glastir a chyfansoddiad amrywiol y corlwyni
- Cymunedau ecolegol sy'n ffafriol ar gyfer ystod eang o infertebratau, mamaliaid a rhywogaethau eraill o adar
- Mae'n bosibl y bydd gan briddoedd llaith, y gellir eu stilio, gynnwys carbon uwch, mwy o infertebratau pridd, a chynnydd mewn mandylledd (yn aml yn gysylltiedig â llai o berygl llifogydd) na phriddoedd sychach
- Mae cydberthynas negyddol rhwng lefelau isel o arddwysedd amaethyddol a chynhyrchu bwyd, ond mae cydberthynas cadarnhaol rhyngddynt ac agweddau ar fioamrywiaeth ehangach, megis adar sy'n nythu ar y ddaear ac amrywiaeth a helaethrwydd pryfed

Mae ein canfyddiadau o adolygiad o'r llenyddiaeth yn cefnogi'r ddamcaniaeth bod dulliau rheoli cynefinoedd wedi'u targedu i ddiwallu anghenion ecolegol y gylfinir sy'n bridio yn dwyn buddion lluosog i fioamrywiaeth. Yma, rydym yn pennu bod mwy na 84 o rywogaethau ar draws gwahanol grwpiau tacsonomig yn elwa naill ai'n uniongyrchol neu'n anuniongyrchol. Mae hyn yn cynnwys 20 rhywogaeth o adar a restrir fel Adar o Bryder Cadwraethol Cymru a 26 rhywogaeth ychwanegol o rywogaethau adar, mamaliaid, ymlusgiaid, amffibiaid ac infertebratau a restrir yn adran 7 o Ddeddf yr Amgylchedd (Cymru) 2016.

I grynhoi, mae ein hadroddiad yn tynnu sylw at werth ehangach ymyriadau sy'n targedu buddion i'r gylfinir lle mae gofynion deddfwriaethol, effeithlonrwydd economaidd a buddion bioamrywiaeth ehangach yn cael eu cyflawni ac mae'n cefnogi ein dealltwriaeth o sut y gall y gylfinir weithredu fel rhywogaeth 'ddynodol' bwysig.

*A oes gan y gylfinir arwyddocâd diwylliannol a buddion llesiant/cymdeithasol i bobl yng Nghymru?*

Mae'r gylfinir yn rhywogaeth eiconig yng Nghymru y cyfeirir ati'n aml drwy hanes Cymru ac o fewn diwinyddiaeth, llenyddiaeth, celfyddydau a threftadaeth y wlad. Mae galwad atgofus y gylfinir, yn benodol, yn adnabyddus ac yn annwyl iawn, a chyfeirir ati gan lawer fel 'cyhoeddwr y gwanwyn'.

Yn lleoliad un prosiect, arweiniodd dull o'r bôn i'r brig a oedd hefyd yn canolbwyntio ar ffermwyr at lwyddiant ar sail natur a chyfrannodd at lesiant y gymuned. Yma, mae grwpiau sy'n canolbwyntio ar ffermwyr dan arweiniad hwylusydd cymwys yn cael eu hysgogi gan eu llwyddiant eu hunain, ac yn aml yn ysbrydoli cymunedau ehangach i drafod cadwraeth y gylfinir. Mae clystyrau cydweithredol o'r fath ar raddfa tirwedd yn datblygu i fod yn

blatfformau rhannu gwybodaeth, sy'n creu grwpiau cymdeithasol cydlynol o unigolion o'r un anian sy'n rhyngweithio'n agosach o fewn y gymuned ehangach, gan gynnwys sefydliadau addysgol lleol, ac yn dechrau cyflawni canlyniadau cadwraeth cadarnhaol drwy greu eu gwaddol eu hunain.

Canfu ein harolwg ar-lein cyflym yng Nghymru y canlynol:

- Roedd 95% o'r ymatebwyr yn cytuno bod y gylfinir yn rhywogaeth bwysig i'n diwylliant a'n treftadaeth a bod ganddo le pwysig yn ein calonnau a'n meddyliau

- Roedd 95% o'r ymatebwyr o'r farn y byddai'n gywir i Lywodraeth Cymru wneud arian cadwraeth ar gyfer adfer y gylfinir yn un o'i blaenoriaethau, o ystyried y rhagwelir y bydd y gylfinir fel aderyn bridio yn diflannu o Gymru erbyn 2033

- Roedd 95% o'r ymatebwyr yn meddwl y gallai rhywogaethau eraill elwa o dargedu adferiad y gylfinir

*Beth yw'r gwasanaethau ecosystemau allweddol sy'n deillio o arferion rheoli tir sy'n gysylltiedig â chadwraeth y gylfinir?*

Gall targedu adferiad y gylfinir fod yn sail i wasanaethau ecosystemau megis cynyddu poblogaethau peillwyr. Mae'r potensial hwn ar ei ben ei hun yn cefnogi ac yn bodloni egwyddorion rheoli adnoddau naturiol yn gynaliadwy ac agweddau pwysig ar Ddeddf Llesiant Cenedlaethau'r Dyfodol (Cymru) 2015 a Deddf yr Amgylchedd (Cymru) 2016. Wrth i gyfalaf naturiol gael ei ymgorffori fwyfwy yn y gwaith o reoli tir o ddydd i ddydd, mae gwaith wedi'i dargedu at adfer y gylfinir yn fecanwaith da i gyflwyno gwelliannau ar gyfer meysydd allweddol megis gwella iechyd pridd, amrywiaeth glaswelltir ac ansawdd dŵr. Er enghraifft, mae gwella iechyd pridd yn galluogi gylfinirod sy'n chwilota am fwyd i ddod o hyd i fwy o infertebratau, wrth wella adeiladwaith y pridd yn uniongyrchol a chynyddu deunydd organig. Cydnabyddir yn y gymuned wyddonol sy'n arbenigo ar bridd bod cynyddu deunydd organig pridd 1% yn cyfateb i ~2% o gynnydd mewn cyfraddau cadw dŵr, a allai gynorthwyo i liniaru effaith llifogydd yn ardaloedd yr iseldir.

Mae strategaethau cadwraeth modern wedi esblygu i ymgorffori mwy o bwyslais ar ddeall a chyfleu'r buddion ehangach y mae natur yn eu rhoi i gymdeithas. Rydym yn dadlau y gallai ymyriadau sy'n targedu cadwraeth y gylfinir gyflwyno nifer o fuddion cymdeithasol ac amgylcheddol i Gynllun Ffermio Cynaliadwy arfaethedig Cymru. Mae angen i'r rheini sy'n gwneud penderfyniadau gydnabod ac ystyried hyn, gan roi pwyslais arbennig ar sut mae hyn yn cynrychioli gwerth am arian cyhoeddus ar gyfer nwyddau cyhoeddus.

# Executive summary

It is becoming increasingly recognised that natural environments are important not only to the plant and animal species that occur in the wild, but because they also deliver direct and indirect benefits to people at a range of spatial and temporal scales. In an increasingly urbanised and fragmented world, mankind's connectedness to, and dependence on, nature has become less apparent to many people. Against the background of declining biodiversity and threats to vital ecosystem services that sustain our economy and society, Wales has a legal and policy framework that provides a fresh approach for responding to the environmental challenges we face. This is mainly set out in two Acts: The Well-being of Future Generations (Wales) Act 2015 that aims to further the economic, social, environmental and cultural well-being of the people of Wales; and The Environment (Wales) Act 2016 designed to promote Sustainable Management of Natural Resources (SMNR) to maintain and enhance the resilience of ecosystems.

Taking the concept that species are an integral component of ecosystems, we focus on the Eurasian curlew *Numenius arquata* to demonstrate how investment in curlew conservation provides a positive impact on public well-being, underpins and supports ecosystem services and has the potential to generate significant benefits to a wide range of species of conservation concern.

Some key concepts (e.g. ecosystem services, natural capital, ecosystem services assessment) are defined and determined. The rationale for, and use of, ecosystem services and natural capital approaches to support nature conservation are examined and previous experiences of the approaches with regard to biodiversity and species conservation are summarised.

Our review was a rapid assessment based on a qualitative desk-study; we used published and unpublished documents that were readily accessible within the project timeframe and in the absence of published scientific evidence we applied proxy assessments. No data were collected in the field.

For the purposes of this review, we determine the multiple socio-economic and environmental benefits that may be derived from curlew conservation interventions, specifically, we examined four questions:

i. To what extent are curlew supported by Welsh legislation and policy?

ii. What are the biodiversity benefits, with specific reference to species of conservation concern, associated with favourable curlew land management?

iii. Do curlews have cultural significance and well-being/societal benefits to people in Wales?

iv. What are the key ecosystem services derived from land management practices associated with curlew conservation?

*What are the biodiversity benefits, with specific reference to species of conservation concern, associated with favourable curlew land management?*

Good breeding and feeding curlew habitats are associated with a heterogeneous landscape structure, usually positively correlated with greater diversity of plants, insects and birds. On this basis the following are suggested as being more likely to occur:

- Long-term, diverse and insect-rich pastures with minimal carbon emissions.
- Low local and landscape predation pressure which benefits other ground-nesting birds.
- Heterogenous sward structure and diverse composition of dwarf shrub.
- Communities that are ecologically conducive for a wide range of invertebrates, mammals and other species of birds.
- Damp, probe-able soils may have higher carbon content, higher abundance of soil invertebrates and greater porosity (often associated with reduced flood risk) than drier soils.
- Low levels of agricultural intensity are negatively correlated with food production but positively correlated with aspects of wider biodiversity, such as ground-nesting birds and insect diversity and abundance.

Our findings from a literature review supported the hypothesis that targeted habitat management to meet the ecological needs of breeding curlew provides multiple benefits for biodiversity. Here, we determine more than 84 species across different taxonomic groups may benefit either directly or indirectly. This includes 20 species of birds listed as Birds of Conservation Concern 4 (BoCC4) Wales and 26 additional species of bird, mammal, reptile, amphibian and invertebrate listed in the Section 7, Environment (Wales) Act 2016).

In summary, our report highlights the wider value of targeted, curlew-friendly interventions whereby legislative requirements, economic efficiency and wider biodiversity benefits are delivered and supports our understanding of how curlew may act as an important ‘indicator’ species.

*Do curlews have cultural significance and well-being/societal benefits to people in Wales?*

Curlew is an iconic species of Wales referenced frequently throughout Welsh history, theology, literature, arts and heritage. The evocative curlew call, in particular is well known and loved and referred to by many as the ‘herald of spring’.

At one project location, a bottom-up and farmer-focused approach led to both nature-based success and contributed to community well-being. Here, farmer-focused groups aided by a competent facilitator become motivated by their own success and often inspire wider communities to discuss curlew conservation. Such landscape-scale collaborative clusters become knowledge-sharing platforms, creating coherent social groups of like-minded individuals who interact more closely within the wider community, including local educational institutions, and start to deliver positive conservation outcomes by creating their own legacies.

Our rapid online survey in Wales found that:

- 95% of respondents agreed that curlew is an important species for our culture and heritage and holds an important place in our hearts and minds

- 95% of respondents thought that it would be right for Welsh Government to make conservation funds for curlew recovery one of its priorities given the forecast national extinction as a breeding bird in Wales by 2033.

- 95% of respondents thought that other species may benefit from targeted curlew recovery.

*What are the key ecosystem services derived from land management practices associated with curlew conservation?*

Targeted curlew recovery has the potential to underpin ecosystem services such as increased populations of pollinators. This potential alone supports and meets the Sustainable Management of Natural Resources, important aspects of the Well-being of Future Generations (Wales) Act 2015 and the Environment (Wales) Act 2016. As natural capital becomes more integrated in day-to-day land management, work targeted at curlew recovery is well placed to act as a delivery mechanism for several key areas such as improving soil health, grassland diversity and water quality. For example, improving soil health enables foraging curlew better access to increased invertebrate numbers whilst directly enhancing soil structure and increasing organic matter. It is recognised within the soil science community that increasing soil organic matter by 1% equates to a ~2% increase in water retention, which may aid alleviation of flooding events in lowland areas.

Modern conservation strategies have evolved to incorporate greater emphasis on understanding and communicating the wider benefits that nature brings to society. We advocate targeted curlew conservation interventions that have the potential to deliver multiple socio-economic and environmental benefits in the proposed Welsh Sustainable Farming Scheme. This needs to be both recognised and considered by decision-makers, with particular emphasis on how this represents value of public money for public goods.

# 1. Introduction

Efforts to calculate the economic value of species are not new. There is now an emerging evidence base of individual or guilds of species and ecosystem function that directly benefit people (e.g. medicinal plants, pollinators, carbon and water storage). Here, species assessments often highlight a diverse set of benefits, however we recognise that we may never be able to quantify all benefits that species provide due to inherent research costs and the time required for determination. Traditional conservation arguments, based on the "intrinsic" value of species, while still fundamental, may have less impact on decision-making audiences. For this reason, and because steep declines in biodiversity have continued, modern conservation strategy has evolved to place greater emphasis on understanding and documenting the wider benefits that nature brings to society and extending the range of arguments used when communicating conservation messages to the public and governments. By linking biodiversity objectives with other ecological objectives set out by policies, conservation targets can be met in parallel with ecosystem functionality and recovery of ecosystem services. Despite the obvious challenges of this approach, there is a great need to develop the evidence base of case examples that recognise and highlight, even quantify economically, the multiple benefits delivered by species conservation.

Several species studies have demonstrated high compatibility with the ecological requirements and favourable management interventions of target species of conservation concern and other high priority species and habitats. For example, Ryland *et al.* (2012) suggested conservation management measures for red-billed *chough Pyrrhocorax pyrrhocorax*, implemented in Cornwall, may support and benefit high priority invertebrates, such as hornet robberfly *Asilus crananoniformis*, brown-banded carder bee *Bombus humilis* and silver studded blue *Plebejus argus* and priority habitats such as maritime lowland heath. Hysom *et al*. (2018) provided evidence of wider benefits to society and ecosystem services delivery through great crested newt *Triturus cristatus* conservation interventions.

Like much of the rest of the UK and Europe, Wales faces a twin climate and nature emergency. According to the *State of Nature 2019*: Wales report, 33% of the animal and plant species identified as conservation priorities in Wales have declined over the past decade, and between one-third and a half of the remainder showed no significant improvement (Hayhow *et al*., 2019). The need for species conservation has never been greater. Traditionally, the management and/or conservation of wildlife resources tended to focus on single species recovery, with the assumption that managing for one species would provide benefits, e.g. favourable habitat quality for numerous other species. In response to financial constraints, decision-makers look to both regulation and incentive instruments to advance biodiversity restoration and halting its loss. Here lies the challenge, yes, it is essential that core funds are protected for the environment and land management interventions that species require, however there is a need for conservation objectives and associated strategies to evolve to maximise outcomes of species recovery.

In common with much of the UK and many other parts of Europe, all of Wales' grassland breeding waders: Eurasian curlew (*Numenius arquata*), common redshank (*Tringa totanus*), European golden plover (*Pluvialis apricaria*) and northern lapwing (*Vanellus vanellus*) are in significant decline both numerically and spatially, as a result of a combination of three pressures: habitat loss, unfavourable habitat management and

nest/chick predation (Pritchard *et al*., 2021). Future grassland management can potentially, at a range of spatial scales, provide some solutions for both ecosystems services, particularly water quality and flood alleviation, and grassland conservation (Rhymer *et al.,* 2010). Here, grassland management in the wider countryside needs to integrate crop yield, ecosystem functionality and services and biodiversity if it is to be truly multi-functional (Firbank, 2005). To date, the extent of peer-reviewed evidence in this area is limited.

Once abundant, the combination of global conservation status, rapid decline and the global significance of the UK breeding population makes the Eurasian curlew (hereafter curlew) arguably the most urgent bird conservation priority in Wales (Johnstone *et al*., 2023, Gylfinir Cymru, 2021) and the UK (Stanbury *et al.,* 2021, Brown *et al.,* 2015). The curlew is classified as globally Near Threatened on the IUCN Red List of Threatened Species (www.iucnredlist.org) and as Endangered in GB (Stanbury *et al.,* 2021). The UK has high responsibilities for curlew, representing 19-27% of the global breeding population and 28% of the European breeding population (BirdLife International 2015, Brown *et al.,* 2015). The UK population is declining rapidly and the rate of decline is among the highest recorded across the species' range (Brown *et al*., 2015). Given the rate of decline, and the importance of the UK population, it is likely that the UK decline has a greater impact on the global population than those of any other country (Brown *et al.,* 2015).

Estimates of breeding population size are particularly challenging in cryptic species such as the curlew that occupy vegetation types where detectability can vary over time as a result of behavioural change and structural change in habitat (e.g. seasonal growth of grasslands) throughout the breeding season. In addition, population estimates based on survey methods may not be comparable between sites and are subject to potentially significant and unquantifiable amounts of uncertainty and error (Taylor *et al.,* 2020). Estimates of the Welsh curlew breeding population range from 400 (extrapolation from a small sample repeat survey, Johnstone *et al.,* 2007) to >1,000 breeding pairs, though not greater than 1,700 breeding pairs, based on extrapolation from BirdAtlas all-Wales re-survey (Taylor *et al.,* 2020). However, contemporary Breeding Bird Survey (BBS) data indicate with high certainty that the breeding population of curlew in Wales is declining at a rate of ~6% per year.

The key driver of curlew population change is predation of eggs and chicks resulting in low breeding success and population decline (Grant *et al*., 1999, Roodbergen *et al*., 2012). Though the significance of the level of abundance of meso-predators (e.g. carrion crow *Corvus corone* and red fox *Vulpes vulpes*) in Wales is not known, it is recognised that the UK has the second highest density of foxes in Europe, and the UK and Ireland the highest densities of carrion crows (Roos *et al.,* 2018). As lethal and non-lethal interventions for reducing predation are costly, Roos *et al.* (2018) advocate research to identify land-use and landscape configurations that reduce predator numbers and predation rates.

If, in Wales, we adopt a business-as-usual approach where there is little/no conservation action, breeding curlews are predicted to be on the brink of extinction within the next decade (Taylor *et al.,* 2020). The loss of biodiversity is far-reaching, complex and challenging, but it is considered by many that the loss of breeding curlew from Welsh farmed landscapes will be a loss of biodiversity too far.

There is broad agreement on the urgent need of a national plan of 'intelligent and realistic' conservation actions to halt and reverse the decline of breeding curlew in Wales. To meet

this challenge, Gylfinir Cymru[1] wrote a ten-year (2021-2031) Wales action plan for the recovery of curlew (Gylfinir Cymru, 2021). Launched by the Welsh Minister for Climate Change, November 2021, this Plan sets out the strategic direction of closely aligned actions to deliver tangible gains for Wales' remaining breeding curlews and lays the foundation of a longer-term vision to restore a sustainable population. One of these actions (**Action 6.1**), framed in the context of political thinking, is to articulate to decision-makers how targeted curlew conservation provides multiple societal and environmental benefits. Commissioned by NRW, this review addresses **Action 6.1**.

For the purposes of this review, we determine the multiple socio, economic and environmental benefits that may be derived from positive curlew conservation action, specifically, we examined four questions:

i) To what extent are curlew supported by Welsh legislation and policy?

ii) What are the biodiversity benefits, with specific reference to species of conservation concern, associated with favourable curlew land management?

iii) Do curlews have cultural significance and well-being/societal benefits to people in Wales?

iv) What are the key ecosystem services derived from land management practices associated with curlew conservation?

In addition to these four questions we provide several practitioner case-studies to support our findings, these are presented in Section 6.

[1] Gylfinir Cymru, is an ambassadorial partnership consisting of 17 organisations to apply expert resource to identify and collate evidence, promote communications to decision makers and the people of Wales and set the strategic direction of curlew conservation.

# 2. To what extent are curlew supported by Welsh legislation and policy?

### Curlew in Welsh legislation

Since devolution the Welsh Government has developed a strong legislative and policy framework around sustainable development and the environment. The European, UK and Welsh legislative and policy instruments that afford curlew protection and assessments that determine their conservation status are listed in Table 1.

**Table 1.** International, European, UK and Welsh legislation, policies and conservation status assessments to protect curlew (reproduced from Gylfinir Cymru, 2021).

| Instrument | Theme | Descriptor |
|---|---|---|
| **International** | | |
| Bonn Convention | Appendix II | European legislation to conserve terrestrial, aquatic and avian migratory species |
| Berne Convention | Appendix III | European legislation that protects European wildlife and the natural habitats |
| EU Birds Directive | Annex II/B | European legislation to protect all wild birds naturally occurring in Europe and promotes site conservation |
| Convention on the Conservation of Migratory Species of Wild Animals | AEWA International strategies and Single Species Action Plans | Independent international treaty for the conservation of migratory waterbirds and their habitats |
| IUCN Global Red List | Near Threatened | Global conservation status to determine extinction risk |
| European Red List (BirdLife, 2015) | Vulnerable | European conservation status to determine extinction risk assessment |
| **Great Britain/UK** | | |
| Wildlife and Countryside Act 1981 | All wild birds are protected | UK legislation that gives protection to native species |
| GB IUCN Assessment | Endangered | GB conservation status assessment to determine extinction risk |
| Birds of Conservation Concern (UK) | Red-listed | UK conservation status assessment to determine bird conservation priorities |
| **Wales** | | |
| Environment (Wales) Act 2016 | Section 7 | Welsh legislation to plan and manage Wales' natural resources in a sustainable way |
| Well-being of Future Generations (Wales) Act 2015 | Goal 2: Resilient Ecosystems | Welsh legislation to improve the social, economic, environmental and cultural well-being of Wales |
| Birds of Conservation Concern (Wales) | Red-listed | Wales conservation status assessment to determine bird conservation |

| | | |
|---|---|---|
| | | priorities and is applied as a qualifying criterion for S7 bird species |

## Curlew in Welsh policy

*Sustainable Management of Natural Resources*

Wales' natural resources and ecosystems underpin human well-being and quality of life but are threatened by human-induced pressures such as pollution, climate change and over exploitation. The Environment (Wales) Act 2016 includes a requirement for Natural Resources Wales (NRW) to embed the nine principles of sustainable management of natural resources (SMNR) as:

"*Using natural resources in a way and at a rate that maintains and enhances the resilience of ecosystems and the benefits they provide*".

In meeting the SMNR, it is envisaged that the needs of present generations of people in Wales do not compromise the ability of future generations to meet their needs and as a result contribute to the achievement of the seven well-being goals[2] in the Well-being of Future Generations Act (2015).

NRW's State of Natural Resources Report 2020 (SoNaRR) (NRW, 2020) assessed the extent to which natural resources in Wales are being sustainably used and managed and looked at how pressures on Wales' natural resources are resulting in risks and threats to long-term social, cultural, environmental and economic well-being. It concludes that upland and grassland ecosystems, habitats occupied by breeding curlew in Wales, are unlikely to have good resilience. Being less resilient suggests ecosystems and biodiversity have a reduced ability to survive and adapt to challenges such as climate change, invasive non-native species and other anthropogenic pressures such as hydrological change and habitat fragmentation.

To make the transition to sustainable management possible, there needs to be a move away from the traditional sectoral management of natural resources and a focus instead on ecosystem resilience and the wider contribution to well-being that ecosystems can bring. Through applying the SMNR principles, NRW can maximise their contribution to the well-being goals and pursue sustainable management of natural resources.

The SMNR principles are:

- Adaptive management
- Scale
- Collaboration and engagement
- Public participation
- Evidence

[2] Well-being goals: A globally responsible Wales, a prosperous Wales, a resilient Wales, a heathier Wales, a more equal Wales, a Wales of cohesive communities, a Wales of vibrant culture and thriving Welsh language

- Multiple benefits
- Preventative action
- Long-term
- Building resilience

In undertaking this review of policy related to the management of breeding curlew, we have been mindful of these principles. Here we explore how curlew conservation actions may support each SMNR principle (Table 2) and contribute to the broader SMNR framework.

**Table 2**. Linkages between curlew conservation and the principles of SMNR.

| Principles of SMNR | Curlew conservation |
|---|---|
| ***Multiple Benefits*** | By conserving breeding curlew there are multiple socio-environmental benefits. For example, sustainable mixed-grazing, quality premium produce, traditional breeds, sustainable moorland grazing, re-wetting upland peat, hay meadow restoration, multiple species benefits, pollinators, legal predator control, farm economics and ecosystem resilience. |
| ***Collaboration and engagement*** | Curlew is a charismatic species which engages farmers and the wider community and fosters collaboration and a sense of place.<br><br>Gylfinir Cymru is a 'blueprint' for collaborative working and influencing others and will look to establish an Important Curlew Area (ICA) Network Working Group to identify and mitigate pressures and constraints acting on the ICA network population and use these assessments to identify the scale of management required to secure appropriate and sustainable management through Government policies. For example, the Working Group will determine market payments linked to curlew and environmental goods, and/or to non-public monetary funded projects (e.g. LIFE Nature, NLHF) to tackle key constraints. |
| ***Public Participation*** | In section 3 we present clear evidence of the connection between curlew and people and communities. Here, we use a community focused curlew project – Curlew Country – to illustrate how communities can quickly become engaged and involved. The project demonstrated the public enthusiasm in supporting curlew projects in a variety of ways including song and art. |
| ***Building Resilience***<br>(i) diversity between and within ecosystems;<br><br>ii) the connections between and within ecosystems;<br><br>(iii) the scale of ecosystems;<br><br>(iv) the condition of ecosystems (including their structure and functioning); | Though not a classic 'keystone' species, maintaining the characteristics of curlew breeding requirements aids sustainable ecosystem services and ecosystem resilience, evidence for this is presented in sections 4 and 5.<br><br>Curlew conservation will result in increased diversity within an area.<br><br>The species will enhance connectivity. Their feeding and breeding territories can cover wide areas spanning farms and connecting landscapes (Taylor et al., 2020).<br><br>Curlew networks will promote landscape-scale resilience. |

| | |
|---|---|
| (v) the adaptability of ecosystems | Curlews need functioning ecosystems; habitat provision and management will reverse decline and increase biodiversity. Importantly farmers and land managers become engaged in conservation through curlews as a conduit and turn their attention to holistic environmental requirements as in Curlew Country.<br><br>Demonstrating the adaptability of ecosystems to provide habitat, food and shelter to a wide range of species and in delivering wider environmental benefit such as slowing down water runoff and potentially reducing flooding |
| ***Long term*** | The Wales Action Plan for the Recovery of Curlew sets out a framework to conserve breeding curlew over a ten-year programme of action (2021 – 2031) and to stabilise the decline in breeding curlew with the aim of preventing Welsh extinction. This Plan will act as the foundation of a longer-term vision to restore sustainable populations across Wales. |
| ***Evidence*** | Detailed ecological research with long data series is the ideal basis for conservation action. However, the conservation urgency for curlew demands shorter studies, informed by intuition and knowledge to reach specific recommendations for action either at a local, regional or country level. It is anticipated that this work, if taken forward, will support the Wellbeing Future Generations objectives by:<br><br>i) Developing an integrated and common approach of data exchange and information to reinforce national actions across the species range;<br>ii) Developing a platform to set the strategic direction of curlew conservation in Wales,<br>iii) Determining populations estimates at differing spatial scales to determine the level of conservation urgency, and<br>iv) The provision of evidence required to influence land-use policy (ie AES)<br>v) Connecting curlew, an iconic species, to the people of Wales |
| ***Adaptive Management*** | See the commentary under ‘Scale’ |
| ***Preventative Action*** | The Wales Action Plan for the Recovery of Curlew sets out the conservation actions required (Gylfinir Cymru). |
| ***Scale*** | Curlew conservation needs a large and coherent network of heath and grassland landscapes that are actively managed to benefit breeding curlew, which will also provide habitats to benefit other biodiversity priorities and underpin ecosystem resilience. It is accepted that focused conservation action will be directed at a network of 12 candidate Important Curlew Areas (ICAs) in Wales. Here, each ICA will have a lead organisation and community champion responsible for the delivery of intervention measures and the assessment, monitoring and reporting against set performance criteria. This approach for large-scale intervention is designed to be closely aligned with the required approach to tackle Wales’ nature crisis and, if implemented successfully, will help the Welsh Government meet its biodiversity commitments under international and domestic legislation. |

The focus of Welsh Government land-use policy and funding has been to deliver landscape-scale environmental benefit. The Game, Wildlife and Conservation Trust (GWCT) have undertaken work with farm clusters and collaborative conservation work through the Welsh Government funded Sustainable Management Schemes (SMS). Here, our findings suggest people, whether they are farmers or other citizens in the community, respond passionately to the idea of working for a treasured species, and it is easier to inspire, motivate and communicate landscape scale work when discussing specific species. This view also complements aspects of how curlew recovery measures may have a positive impact on human well-being (Figure 1).

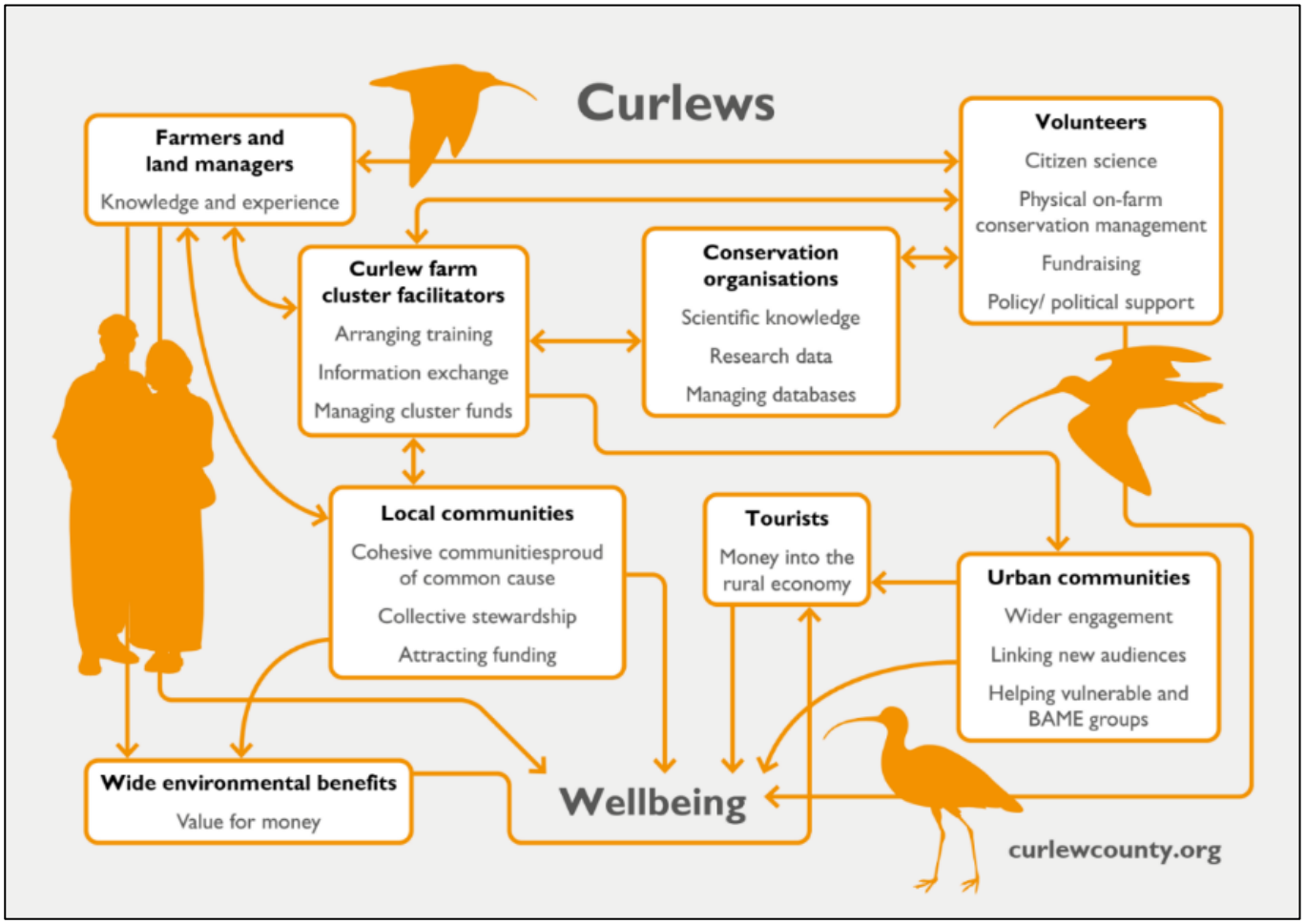


**Figure 1**. Curlew recovery and well-being, reproduced from Curlew Country[3]

*Nature Recovery Action Plan for Wales*

Building on the legal framework, presented above, Welsh Government first set out its commitments for biodiversity in the Nature Recovery Action Plan for Wales (NRAP) (Welsh Government, 2015). Here, NRAP outlined how the United Nations Environment Programme's Convention on Biological Diversity's (CBD) Strategic Plan for Biodiversity and the associated Aichi Biodiversity Targets for 2011-20 in Wales would be addressed

[3] Curlew Country is a community focused curlew recovery project within Shropshire and Powys.

and was the National Biodiversity Strategy and Action Plan for Wales under Aichi target 17. In 2020, NRAP was refreshed to take into account the growing evidence around the scale of the loss of biodiversity and the changing policy context in Wales (Welsh Government, 2020). This includes the legislative framework and the Natural Resources Policy (NRP), the expected impacts of the UK's exit from the EU, the escalating ecological crisis and the need to respond urgently to that alongside the response to the climate emergency. The 2019 report on biodiversity and ecosystems from the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) described the loss of biodiversity as a threat of equal size to the climate emergency (Bridgewater *et al*., 2019). The Coronavirus pandemic of 2020 placed fresh emphasis on the need to clarify the urgent priorities for biodiversity and a green recovery.

During the NRAP refresh there was a recognition that to recover nature there is a need to:

- build resilient ecological networks and mosaics across our whole land and seascape to safeguard species and habitats and the benefits they provide;
- address the root causes of biodiversity loss, not just the symptoms;
- understand the role that nature plays in our lives, livelihoods and well-being;
- invest in improving our evidence and monitoring for the long term;
- recognise and value biodiversity in our accounting and decision-making across sectors and portfolios and,
- demonstrate the value we place on biodiversity through governance, and support for skills and capacity.

Curlew are referred to in the refreshed Nature Recovery Action Plan for Wales 2020-21 under 'Maintaining and enhancing species of principal importance for Wales for their intrinsic value and contribution to the resilience of ecosystems', where it states '*curlew require an emergency action programme'* (Welsh Government, 2020). This comes five years after the first NRAP where curlew was referred to as showing a '*continued/ accelerated decline' alongside lapwing and golden plover'* (Welsh Government, 2016).

To respond to the the NRAP refresh, the urgent context, and the IPBES report, Welsh Government framed NRAP actions into five themes:

- Maintaining and Enhancing Resilient Ecological Networks (targeted place-based spatial action to deliver benefits for biodiversity, species and habitats, reduce negative impacts and maximise our well-being)
- Increasing Knowledge and Knowledge Transfer
- Realising new Investment and funding
- Upskilling and capacity for delivery
- Mainstreaming, Governance and Reporting our Progress

In summary, NRAP recognises the importance of identifying the root causes of biodiversity loss and the need to embed the value and importance of biodiversity throughout public service delivery. In this review we present the evidence that curlew conservation is a 'golden thread' that meets all these challenges. On this basis, the high-level context for action to address biodiversity decline are presented in the SMNR framework – the State of Natural Resources Report (SoNaRR), the Natural Resources Policy (NRP), and the Area

Statements. The NRP priorities are the current national priorities for our natural resources, for everyone to take action. They support the integration of biodiversity into decision making across Welsh Government and local delivery through area statements, where the priorities are:

- delivering nature-based solutions;
- increasing resource efficiency and renewable energy, and
- taking a place-based approach.

Area Statements provide a local evidence base to help implement these priorities, and the risks and opportunities identified in the Natural Resources Policy. Assessment of spatial data suggests curlew are not equally distributed across Wales, for example, 88% of the population and 90% of its range occurs in only three NRW Area Statements (North-East, North-West and Mid-Wales), with 48% in North-West Wales alone (Taylor *et al.,* 2020).

Within the themes, five immediate priorities have been identified for further action:

### *1. Aligning the responses to the climate emergency with the biodiversity crisis*

The refreshed NRAP report states *"There is a need to highlight the nature emergency and align it with the response to the climate emergency. Nature based solutions are key to addressing both issues. For example, clear messages are needed to ensure tree planting is with the right species in the right place to maximise biodiversity and carbon sequestration."*

While public policy has an obvious role to play in securing sustainable land management, and the multiple benefits this provides, we recognise that reliance on public money is a risk. Thus, every effort should be made to develop value-added markets and premiums that reward both sustainable production and High Nature Value farming, including that which supports breeding curlew. Here, nature-based solutions are important, including habitat management that benefits curlew and other taxa (see section 3), support for societal development goals and safeguard human well-being (see section 4) and to provide ecosystem services such as flood management (see section 5).

Throughout our report, it is recognised that natural environments are important not only to the plant and animal species that occur in the wild, but because they deliver direct and indirect benefits to people at a range of scales. We support the principle that modern conservation strategy needs to evolve to incorporate greater emphasis on understanding and communicating to the public the wider benefits that nature brings to society. On this basis, our report determines and articulates the multiple benefits of curlew conservation, framed in the context of political thinking, demonstrating wider socio-economic and environmental benefits.

A key spatial action in this theme is **Maintaining and Enhancing Resilient Ecological Networks (nature networks)**. Here, the refreshed NRAP outlines the measures required, which are:

- Restoring and maintaining the Protected Site network
- Restoring and creating habitat outside protected sites to build nature networks and mosaics

- Maintaining and enhancing species of principal importance for Wales
- Addressing direct pressures on Resilient Ecological Networks e.g. pollution, climate change and Invasive Non-Native Species
- Maintaining and improving the spatial evidence base for the state and distribution of biodiversity in Wales
- Identifying and sharing the spatial priorities for action

The newly established Important Curlew Area (ICA)[4] network complements all six measures, as referenced above, and illustrates how the ICA network could be considered a nature network. Many farmers are moving towards more nature friendly farming, here there are opportunities to complement the ICA network. Farmers/land managers/owners and occupiers want to champion a way of farming which is sustainable and good for nature ensuring our countryside is productive and thriving with wildlife, highlight that farming and nature can go hand in hand.

Anecdotal evidence from Curlew Country and GWCT cluster farm case studies suggest farmers want to support the conservation of curlew as well as other species, however, they may only be able to afford to do this by maintaining profitable businesses which will require land-based management payments to enable them to change to a different and, at least for some parts of their farms, a less productive farming system.

### *2. Addressing the post EU exit funding gap for agri-environment measures*

NRAP (2020) states "*There will also be a need to address the post EU exit governance gap to secure core environmental principles and robust governance for the environment and biodiversity. Britain's exit from the EU is also driving the future farming policy and new support for a Sustainable Farming Scheme*."

To protect the environment and natural capital upon which we all depend on, it is important that the proposed Sustainable Farming Scheme (SFS), which is set to replace Glastir by 2025/26, promotes natural resources and ecosystem resilience and facilitates species recovery as part of the response to the nature emergency. Put in context, 2026 is seven years before the predicted scenario for curlew extinction in Wales (Taylor *et al.,* 2020). There is a need to ensure that the collaborative level of the SFS enables farm-holdings into effective landscape agreements to aid curlew conversation in Wales.

### *3. Providing spatial direction for targeting action for biodiversity*

Effective conservation relies on good evidence to inform decision-making at all stages of species recovery, from identifying diagnostic reasons for decline, through devising and deploying solutions, to assessing the effectiveness of the population response. Prioritisation is essential, so that limited resources are targeted and have the greatest conservation impact.

[4] Focused conservation action will be directed at a network of 12 candidate Important Curlew Areas (ICAs) in Wales. Each ICA will have a lead organisation and community champion responsible for the delivery of intervention measures and the assessment, monitoring and reporting against set performance criteria

NRAP (2020) states *"Resilient ecological networks are needed everywhere to create mosaics across Wales, but further identification of 'core resilience areas' is needed in which to prioritise action. Area Statements provide some of the baseline for this, but further 'opportunity mapping' needs to be developed."*

Gylfinir Cymru explicitly state in the Wales Action Plan for the Recovery of Curlew that a large and coherent network of curlew-friendly breeding landscapes is required across Wales (Gylfinir Cymru, 2021). They refer to this collective as the Important Curlew Area (ICA) network. Consisting of 12 component ICAs, the network lies entirely within three NRW Area Statements (North-West, North-East and Mid-Wales) which in combination represent possibly as much as 65% of the Welsh curlew breeding population. Although the identified ICA network will form the focus of recovery efforts, Gylfinir Cymru go on to say '*any land with breeding curlew should be eligible to receive land management payments to provide favourable habitat that meet this species' ecological needs*.'

Gylfinir Cymru advocate setting performance criteria for each ICA based on metrics of abundance, demography and extent of management, and assess whether these targets are being met. They also infer the need to identify constraints acting across the ICA network to determine the favourable management required to secure appropriate and sustainable management through Government policies (e.g. market payments linked to curlew and environmental goods) and/or non-public monetary funded projects (e.g. LIFE Nature, NLHF) to tackle key constraints.

### *4. Improving the condition of the Protected Sites Network*

Welsh Government in the NRAP (2020) states '*Protected sites are at the heart of resilient ecological networks and restoration of the Natura 2000 (N2K) sites across Wales to favourable conservation status is key to reversing the decline in biodiversity.'*

Breeding curlew are a designated feature of only one protected site in Wales (Fenn's, Whixall, Bettisfield, Wem and Cadney Mosses SSSI) and are not a classified feature of any protected site within the Welsh SPA network. The third SPA Review concluded that UK SPA provision is insufficient for curlew in terms of population numbers, range coverage and ecological sufficiency (Stroud *et al.,* 2016). For Wales, hotspot analysis of data collected for the 2007-2011 Atlas together with review of other information should be undertaken to determine the strength of need for the addition of curlew to the existing upland SPAs of Elenydd – Mallaen, Berwyn and/or Migneint-Arenig-Dduallt SPAs and/or the addition of a new SPA on the Hiraethog Moors as appropriate. Survey work would need to be commissioned for the majority of locations to support classifications and/or any boundary changes.

Urgent conservation measures are needed for breeding curlew, for which the UK has particular international responsibility. The first step is to determine those nationally protected sites that hold breeding curlew and ensure appropriate management agreements are in place to maintain and/or restore favourable habitat management to meet the species' ecological needs. Such favourable intervention for curlew will aid favourable condition for the existing bird of prey features by creating quality habitats for their prey base.

### *5. Exploring new and sustainable funding mechanisms for biodiversity action.*

It will be essential to engage farmers and other land managers across each Important Curlew Area if we are to have the desired large-scale impact on curlew populations. Therefore, it will be crucial to foster good working relationships with clusters of farmers in all ICAs and to deliver a range of activities to promote participation. The Curlew Action Plan for Wales outlines a range of recovery performance criteria associated with six key outputs (Gylfinir Cymru, 2021). Two of these outputs are applicable here:

**Output 5** Co-design initiatives with the farming and game management and local communities/wider general public in parallel with developing citizen science initiatives to work together on delivery.

*Success criteria*:

- **Established or strengthened local networks of farmers** and other land managers in each ICA to facilitate collaborative working.

- **Identified and supported 'Curlew Champions'** who facilitate community engagement in each ICA.

- **Community engagement in each ICA to bring about a step-change in community awareness and appreciation of curlew** (e.g. demonstration days, guided walks).

- **Strong community ethic** across the ICA network enables knowledge exchange, the sharing of progress and a 'can do' approach to curlew conservation.

**Output 6** Influence policy development of a package of support to assist land-managers to deliver for breeding curlew and wider environmental/societal benefits supporting the concept of public goods and public services.

*Success criteria*

- **Policy and strategy development,** such as the Sustainable Farm Scheme, Future Wales (the National Development Framework), NRW Area Statements etc that are designed to ensure space to live, work and play, food production, and sustainable use of natural resources, enabling curlews to flourish.

The iconic status of the curlew may attract funding from individuals and private trusts as well as good will measures i.e. voluntary action on the ground. As demonstrated by Curlew Country, the curlew has the capacity to instigate community curlew-focused action where the 'sum of the parts' becomes greater than the contributions of individuals (see Section 3). There is a need for all to work together to conserve curlew. The Wales Action Plan for the Recovery of Curlew provides the key strategic objectives and actions to support curlew conservation now and, in the future, but provides a guide to all partners who have an opportunity to make a difference. Whilst, NRW has a statutory duty to preserve species for future generations, we all have a responsibility to help conserve species for their own intrinsic values.

# 3. What are the biodiversity benefits associated with favourable curlew land management?

**Introduction**

Two major classes of biodiversity indicator have been distinguished; the role of the first is to “reflect community composition” while that of the second is to “reflect environmental change” (Sewell and Griffiths, 2009). As further outlined by Sewell and Griffiths (2009), the use of any single species, as an indicator is immediately problematic for two criteria that necessitate consideration of multiple species. Here, they suggest ‘*Patterns of species richness should be closely correlated with those of other, non-related groups*” and *the species should be sufficiently sensitive to provide early warning of change in the environment*.’

A site protected for the purpose of curlew conservation is likely, by virtue of the habitats that will be secured for that purpose, to deliver a number of other benefits to people and other taxa. Here, the mix of potential services maybe dominated by regulatory and cultural services, but a contribution to provisioning services is possible. For example, if grasslands are present, it may be managed to support livestock, the production of hay or silage, the ecological needs of species, in this case breeding curlew, or a combination of all three. All these outputs have a market and may contribute to livelihoods, cultural heritage and biodiversity restoration.

We are not aware of any study that has quantified the biodiversity benefits associated with favourable curlew land management, but it is evident that appropriate species interactions exist, and it is reasonable to presume that some contribution is likely. In this section we explore such species interactions using peer-reviewed literature combined with a logical interpretation of species ecology and more important their ecological needs. We identify and present these interactions across five key themes: lowland grassland, upland grassland, heather management and bog restoration, predator management and landscape and temporal effects. To put our findings into context, we first provide the narrative under three sub-headings, these are habitat requirements and diet, factors limiting curlew numbers and management for curlew.

*Habitat requirements and diet*

Curlew breeding sites are currently most often located in upland areas and moorland, or moor edge is regarded as the species’ traditional habitat in the UK. Curlew also breed on lowland and in-bye grasslands, but these lowland habitats now show some of the largest range contractions and population declines. Preferred breeding habitats include fens, peat bogs, heathlands, coastal marshes and damp river valley grassland, but curlew also breed on agricultural grasslands and even arable fields. Criteria for breeding sites include appropriate altitude and climatic conditions, little human disturbance, and a heterogeneous vegetation structure including available shelter from taller stands of heather, tussocky grass or rush areas, within a landscape of intermediate sward height (10-25 cm) to allow feeding (Pearce-Higgins and Grant, 2006). Curlew also prefer heterogeneity regarding the

wetness of their breeding environment, choosing either wet terrain with dry patches, or drier landscapes with boggy or wet areas to allow dry nest sites and damp feeding areas in close proximity (Cramp *et al.,* 1988).

Different habitats vary in their capacity to accumulate carbon, due to soil type, vegetation type, climate and typical disturbance pattern. The potential of different habitats to contribute to global climate regulation has been reviewed in greater depth than is possible here, including through life-cycle analysis of typical management operations associated with those habitats (see e.g. Warner 2008, Ostle *et al.,* 2009, Alonso *et al.,* 2012).

Curlews are omnivorous and versatile feeders, with diet composition varying depending on the availability of local food sources. At inland breeding sites the diet seems to consist predominantly of earthworms, Tipulid larvae, and larval and adult beetles, although a wide range of other invertebrate orders, berries, small fish, frogs, toads and lizards may be taken (Boschert, 2004 in Brown, 2015).

*Factors limiting curlew numbers*

Before industrialization, semi-natural grassland comprised the nutrient base for farming and food production in most of Europe. Historically, pastures and hay meadows provided fodder for livestock, which in turn transformed the grass into food products and manure, the latter providing a major nutrient source for arable crops. The intensification of farming, particularly since the 1970s, involving the use of inorganic nitrogen fertilizer, seeding of fields with ryegrass, more frequent grass cutting for silage and higher livestock densities, has transformed landscapes across Wales and many parts of Europe to provide much higher agricultural yields, but much poorer habitat for curlew and many other species.

The curlew is a ground-nesting species, laying a clutch of three or four eggs in late April-early May. In addition to the loss and impoverishment of habitat for breeding, modern farming landscapes support higher densities of generalist predators. Curlew eggs and chicks are vulnerable to predation, with the main egg predators being carrion crow and red fox and the main predator of chicks being the fox, although young curlews are also taken by short-eared owl, hen harrier and peregrine (Nethersole-Thompson and Nethersole-Thompson, 1986). In areas of upland rough grazing, eggs can be eaten or trampled by sheep when present at high densities. On lowland grasslands, rolling can crush early clutches and cutting for silage grass destroys both eggs and chicks. Roodbergen *et al.* (2012) concluded that low breeding productivity, rather than a change in annual adult survival rate, was driving the declines of curlew and other grassland waders across Europe.

The black-tailed godwit *Limosa limosa* provides a well-documented example of the issues facing grassland waders in Europe, which are thought to be very similar, but less well studied, for curlew. In Dutch grasslands, numbers of breeding black-tailed godwits are declining rapidly (Kentie*,* 2015; Roodbergen and Teunissen 2019), and densities increase along a gradient of land-use intensity from herb-poor meadows and grassland monocultures to herb-rich meadows (Groen *et al.,* 2022), with important habitat-specific differences in demographic rates. Black-tailed godwits breeding in monocultures tend to experience lower nest survival and lower survival of chicks, possibly due to a combination of low food availability and higher predation rate (Kentie, 2015), compared to herb-rich meadows where population growth rates can be positive (Kleijn *et al.*, 2010). Landscape-scale variation in land-use intensity is having population-level effects through complex

interactions between management, predation and breeding success, and strategic management of landscape structure could alter these relationships.

*Management for curlew*

While the issues facing curlew have started to be documented over the last twenty years, the scale of declines and urgency of actions required to recover curlew populations has only been fully recognised in the last five years. Consequently, although many local initiatives have started in recent years, most are in their infancy with few results to date. There are, therefore, few published studies showing how curlew and other species have responded to the managements being trialled. However, the species' requirements and the changes in land use that have caused declines are sufficiently well understood for recommendations on corrective management to be applied. Management practices for curlew conservation differ between upland and lowland situations, but to be successful they need to address sward height and vegetation density for nesting, feeding areas for adults and broods, and predation by generalist predators such as foxes and carrion crows.

Strategic habitat management in landscapes that support breeding waders aims to create open areas with suitable vegetation height and structure for a range of species to nest, with wetter areas and bare mud for broods to forage nearby. It can also influence how predators interact with waders and other prey. Relatively simple forms of strategic habitat management aim to reduce accessibility of sites to predators, availability of predator breeding locations (e.g. trees, dry banks or reedbeds) and/or opportunities for predators to hunt effectively (e.g. through removal of perches for avian predators). Through less intensive livestock grazing and a reduced frequency of grass cuts, trampling of nests and mechanical destruction of nests and chicks is reduced. To effect curlew recovery in Wales will require support for a change in the intensity of farming across landscape scale areas coupled with measures to reduce rates of predation.

The purpose of this section is to examine the potential wider ecological benefits of large-scale change in land use aimed at curlew recovery, and to summarise evidence from the scientific literature for benefits to other species and mechanisms for change in abundance.

## Methods

We compiled a list of search terms considered likely to produce literature with information on the wider possible benefits of management to conserve curlews (Table 3). Google Scholar was used to search each combination of terms and the first five pages of each search were examined for relevant scientific papers. Papers were saved in Mendeley reference software, and an Excel spreadsheet was used to document bibliographic details with a note of whether curlew was a focal species. For each search term, the number of results and number of relevant papers found was recorded. The searches resulted in 144 relevant papers. Several additional papers known to the authors or found within the reference lists of papers produced by the searches were added, bringing the total to over 200.

The papers were initially filtered by an experienced wader ecologist to look for relevance to the topic. The program NVivo was used to code all relevant information within the papers according to different key themes.

**Table 3**. Search terms used to identify literature relevant to the theme of 'wider benefits associated with curlew management'.

| | |
|---|---|
| Curlew AND environmental benefits | Waders AND grazing |
| Wader management AND environmental benefits | Wader management AND vegetation change |
| Breeding waders AND environmental benefits | Wader management AND invertebrates |
| Breeding waders AND benefits for other taxa | Wader scrapes |
| Breeding waders AND ecosystem services | Curlew AND heather burning |
| Breeding waders AND ecosystem function | Waders AND heather burning |
| Management for breeding waders | Predator control AND waders |
| Lapwing AND wider biodiversity | Predator control AND ground-nesting birds |
| Redshank AND wider biodiversity | Predator management AND waders |
| Snipe AND wider biodiversity | Effect of conifer planting on moorland |
| Black-tailed godwit AND wider biodiversity | Rush management AND waders |
| Meadow birds AND management | Rush management AND curlew |
| Effects of rush management | Hay silage management AND waders |
| Effects of grass cutting | Hay and silage management AND |
| Grassland management AND wildlife benefits | Grass cutting management AND waders |
| Hay meadow biodiversity | Grass cutting management AND curlew |
| Hay AND silage | |

# Results

## Grassland management

Tracking studies have shown that breeding curlew use a mosaic of habitats, including improved grasslands and agricultural fields for feeding when away from the nest (Ewing *et al.,* 2018; Potts *et al.,* 2019; Taylor *et al.,* 2020). Curlew prefer semi-natural habitats with low vegetation density for nesting, which are often provided through grazing (Johnstone *et al.,* 2017). Semi-natural grassland has been shown to support high densities of breeding curlew (Franks *et al.,* 2017a).

The aim of grassland management for curlew should be to revert agriculturally improved grassland that has been heavily grazed (MG6) or reseeded (MG7) to more natural swards through less frequent cutting and reducing livestock densities (i.e. MG3, MG4, MG5, MG8 swards dependent on soil wetness). Careful management of vegetation through rotational grazing regimes and late cutting is critical for most waders to create a diverse sward with a mosaic of long and short vegetation (Atkinson *et al.,* 2005; Fisher and Walker, 2015).

## i) Lowland grassland

*Use of fertilizer*

On newly established leys, herbicides to control perennial weeds account for 60% of pesticide usage and on established grassland herbicides account for 90% of pesticide usage. Weed removal by herbicide use has been shown to be highly detrimental to insects that comprise the food of many birds, with good evidence for their effect on grey partridge chick food in arable systems (Potts, 1980; Potts, 2012).

Fields cut for silage, but not grazed, receive over twice as much inorganic N as fields cut for hay. The addition of nitrogen fertilizer encourages the growth of competitive species at the expense of slower growing species. High phosphorus inputs can severely reduce species diversity of grassland. Moving from a silage system to less intensive grass management would increase plant species diversity and sward structural complexity. In general, reductions in inorganic fertilizer, phosphorus, potassium and lime (calcium/magnesium carbonate) would result in increased numbers and diversity of grassland invertebrates. Groups experiencing moderate to severe population reductions under these chemical applications, and hence most likely to benefit from more sensitive grassland management with much lower chemical inputs, include Acari, Collembola, Diptera, Coleoptera, Orthoptera and Myriapoda (Edwards and Lofty, 1975; Van Wingerden *et al.,* 1992). Earthworm numbers benefit from moderate fertilizer applications but decline under high application rates (Edwards and Lofty, 1982; Standen, 1984; Unwin and Lewis, 1986), while numbers increase with soluble soil phosphorus (Nuutinen *et al.,* 1998). As with inorganic fertilizer, earthworm populations seem to increase with moderate applications of farmyard manure and slurry but decrease under high applications. Organic fertilizers provide extra food for the decomposer communities compared to inorganic fertilizers, and grassland soil invertebrate populations generally benefit from moderate applications of organic manures (Marshall, 1977). Input of readily assimilated nutrients may raise the productivity of soil and turf invertebrates (Keiller *et al.,* 1995).

A reduction in grassland management intensity is likely to be beneficial for the conservation of larger insect species as management intensity influences the size, as well as the abundance and diversity, of invertebrates. Intensive grassland management with high inputs of fertilizer and intensive grazing or mowing may be particularly detrimental to larger insect species (Beintema *et al*., 1990). Blake *et al*. (1994) and Blake & Foster (1998) showed that, although beetle numbers increased with increasing intensity of grassland management, size declined. The foraging efficiency of birds may be influenced by prey size. Wader chicks forage more profitably on large prey items (Beintema *et al*., 1990) and hence less intensive grassland management should shift the prey community towards greater availability of larger, more profitable prey.

Species such as skylark *Alauda arvensis*, meadow pipit *Anthus pratensis* and starling *Sturnus vulgaris* tend to select open areas of low vegetation cover for foraging (Feare, 1984; Cramp, 1988; Cramp & Perrins, 1994; Wilson *et al*., 1997; Schön, 1999). These are more likely to be found in unimproved and unfertilized fields managed with curlew in mind which will have a greater range of sward heights than relatively uniform, fertilized grass swards managed for silage. Declines in the breeding numbers of yellow wagtail *Motacilla flava*, which also favour short vegetation, have been attributed to changes in management resulting in tall and dense swards (Cramp, 1988). Greater botanical diversity in unfertilized fields will increase seed availability in summer and winter for birds such as the linnet *Carduelis cannabina* and bunting species. More heterogeneous swards with tussocks, as

favoured by curlew, will also provide suitable nesting places for meadow pipits and reed buntings which nest close to the ground in tussocks.

Moderate use of organic fertilizer in the form of farmyard manure may benefit grassland birds by increasing the abundance of soil-dwelling invertebrates, or their accessibility, by bringing them closer to the surface (Scullion and Ramshaw, 1987; Tucker, 1992). In winter, unimproved meadows support higher numbers of invertebrate feeders, including starling, redwing *Turdus iliacus*, lapwing, golden plover, snipe, teal *Anas crecca*, and wigeon *Anas penelope*, than improved fields (Barnett *et al.,* 2004). Winter field use by lapwing, starling, fieldfare and redwing is positively associated with frequent addition of farmyard manure on permanent grassland (Tucker, 1992), although associated increases in sward height may counteract these benefits for some species (Milsom *et al*., 1985, Milsom *et al*., 1998).

*Cutting and grazing*

Silage cutting in England has been shown to destroy curlew eggs and chicks (Colwell *et al.*, 2020). One study in the Upper Thames has found that delaying grass cutting in meadows managed for hay until 30 June allows chicks to fledge before fields are cut (McVey, 2011). Studies on black-tailed godwit in the Netherlands have found the timing of grass cutting is critical to reduce destruction of nests and chicks (Melman *et al.*, 2008). Moving away from intensive silage production, typically involving three grass cuts per year, to more extensive grassland management involving a single hay cut and low-density cattle grazing would have far-reaching benefits for a range of wildlife.

The first silage harvest is usually taken in May in much of lowland Britain, a month or more before hay, which is usually cut in late June–August. Haymaking, in contrast, allows considerable flowering (Smith and Jones, 1991). The removal of flowers has significant effects on nectar feeding invertebrates such as butterflies (Lepidoptera) (Feber *et al.,* 1996). The structure of grassland vegetation has a large influence on arthropod diversity and, in general, the abundance and diversity of most arthropod groups increases with taller swards (Morris, 2000). Cessation of cutting for silage and a move towards hay, or seasonal grazing focused mainly in autumn, would therefore increase the floristic diversity of swards and their suitability for a wide range of invertebrates. Increased invertebrate density and richness is seen within more complex swards (Atkinson *et al.,* 2005). Thomas and Jepson (1997) showed that cutting for silage significantly depleted linyphiid spider populations after each cut. Most of the immediate deleterious effects of cutting, for example on the species richness of Auchenorrhyncha, have been attributed to loss of vegetation structure (Morris, 1981).

The creation of short swards through regular mowing may increase the accessibility of prey for invertebrate feeders such as starling, pied wagtail *Motacilla alba* and meadow pipit, but this is typically just a short flush of invertebrates. Unlike moderate grazing, which can also increase accessibility for these birds, these flushes are likely to be offset by overall reductions in both the abundance and diversity of invertebrates. A uniform sward structure resulting from cutting will almost certainly increase the likelihood of a generalist predators, particularly corvids, detecting songbird and wader nests and chicks. Even for species that lay replacement clutches, such as lapwing, or multi-brooded species, such as skylark, breeding success will be higher if first clutches are successful as is more likely to be the case without frequent cutting.

Intensive modern farming practices have been shown to have negative effects on several species of breeding waders, with the case of the black-tailed godwit in the Netherlands probably the best documented (Schekkerman and Beintema 2007; Melman *et al.,* 2008). Reducing the intensity of grassland management to create suitable habitat for curlew should create better conditions for other waders such as snipe, redshank and lapwing. Although these waders have different preferences for sward height when nesting, they all need patches of shorter sward for foraging and brood-rearing. While lapwing typically nest in much shorter swards than the other species, heterogeneous swards that have suitable tussocks for curlew will provide suitable nest sites for redshank and snipe.

Semi-natural hay meadows are extremely rich in biodiversity, especially when managed for conservation purposes (Dahlström *et al.,* 2013). Well-managed hay meadows, often managed for breeding waders, are important habitats for invertebrate communities which in turn provide an important part of the food web, including earthworms that are an important food for breeding waders (McVey, 2011). Hay meadows important for yellowhammer and corn bunting for nesting and provide seeds for granivorous birds such as yellowhammer and linnet which they cannot obtain from silage fields. Small mammals, such as field voles, are more abundant in semi-natural grasslands with more diverse swards and patches of taller vegetation (Birney *et al.,* 1976; Askew *et al.,* 2007). A greater abundance of voles across the landscape will support those species for which they form a staple food, such as kestrel *Falco tinnunculus* and barn owl *tyto alba*. The breeding success and abundance of these birds has been directly linked to vole abundance in several studies (e.g., Village, 1982a,b; Korpimaki and Norrdahl, 1991; Taylor, 1994; Askew *et al.,* 2007).

Grazing acts upon individual plants and plant communities through defoliation, trampling, deposition of dung and urine, and poaching, which alter the relative abundance and competitive abilities of the different plant species (Jensen, 1985). Swards grazed intensively by sheep are extremely uniform, whereas cattle-grazed swards are more spatially heterogeneous, principally due to the patchier distribution of dung and the lack of grazing around freshly deposited dung (Richards and Wolton, 1976; Kiehl *et al*., 1996). The size and extent of patches of heavily grazed and lightly grazed swards depends upon stocking density. Because grazing is selective, insects associated with plants that are resistant to defoliation may survive intensive grazing but not intensive mowing (Morris, 1990). Low and moderate intensity grazing can promote higher species richness within plant communities because some bare patches are created by poaching and trampling of vegetation (Tälle *et al.,* 2016).

In general, grazing has been shown to have a more positive effect on the conservation value of semi-natural grassland over mowing, but there are both positive and negative interactions with species under both styles of management (Tälle *et al.,* 2016). Abandonment or relaxation of grazing quickly results in changes in the abundance and species composition of invertebrates in grasslands (Morris, 1971; Gibson *et al.,* 1992). For instance, acid grasslands support many species of leafhoppers and increased vegetation height increases overall abundance (Waloff and Solomon, 1973). Spiders increase in abundance due to both the greater plant architecture for web building and increased prey availability (Coulson, 1988).

To create suitable swards for curlew but keep trampling of nests to a minimum, low intensity grazing preferably by cattle rather than sheep will be required in spring, followed by higher stocking densities in late summer and autumn. Seasonal, rather than continuous,

grazing will promote sward heterogeneity, and hence invertebrate diversity (Morris 1971, 1973). Grazing in autumn is less deleterious than grazing in spring in terms of overall insect diversity. Heteroptera are enhanced by autumn grazing but reduced by spring grazing (Brown *et al.,* 1990). Selective moderate grazing can result in structurally heterogeneous swards, which support a range of herbivorous invertebrates such as Auchenorrhyncha (Morris, 1971; Strong *et al.,* 1984). Intensive grazing reduces numbers and biomass of phytophagous grassland invertebrates (East and Pottinger, 1983). Several soil-dwelling invertebrates, such as soldier flies *Inopus rubriceps* (Stratiomyidae) and some chafers (Scarabaeidae), are also affected through the indirect effects of defoliation or through trampling (Duffey, 1975; East and Pottinger, 1983). Low intensity, seasonal grazing should allow higher populations of these invertebrates, providing prey for mammals such as shrews and bats as well as insectivorous birds. Amphibians and reptiles are likely to capitalise on these invertebrates, with reasonable populations persisting at low stocking densities, whereas their preferred habitat structures are severely damaged by heavy grazing and regular mowing.

Grazing can impact on bird populations through several mechanisms. Interactions between these mechanisms are complex and their relative importance is difficult to assess, but three seem central: changes in vegetation structure, food resources and predation pressure. The timing of stock turn-out onto grassland is known to influence the vulnerability of nests. For waders, where early turnout of cattle or early mowing is precluded (for example by wet soil conditions in spring), early nesters will benefit over late nesters, particularly as the opportunities for successful replacement clutches become much reduced as the season advances (Beintema and Muskens, 1987; Green, 1988). Grazing can benefit breeding waders by creating a more heterogenous and less dense sward, but as with curlew, stocking densities and timings are important for most grassland-nesting waders (Franks *et al.,* 2017b; Johnstone *et al.,* 2017). There is some evidence for an interaction between grazing intensity and nest predation rate (MacDonald and Bolton, 2008). Low intensity grazing should result in minimal disturbance of nesting birds and hence not have a large influence on nest predation rate.

*Water level management*

Management of water level and the creation of wet features is important for increasing the densities and breeding success of waders on grassland (Eglington *et al.,* 2008, 2009; Franks *et al.,* 2017b; Żmihorski *et al.,* 2018). There is little information on the importance of such features for curlew but given the use of bog and flush habitat by broods in upland areas it seems highly likely that wet features would be beneficial for broods on lower-lying grassland. Moist soils retain important invertebrate communities such as earthworms, ensuring they are within reach of probing birds (Rhymer *et al.,* 2010), although prolonged surface flooding can cause negative effects on soil invertebrate populations (Ausden *et al.,* 2001). Whilst farmers are generally reluctant to increase water levels across whole fields, the use of shallow surface channels (foot-drains) and small in-field features such as scrapes place in naturally wet parts of fields are often acceptable and do not impact livestock grazing. (Ausden and Hirons, 2002). Ditches and scrapes provide a number of other ecosystem services (Wilson *et al.,* 2007; Rhymer *et al.,* 2010; Fisher *et al.,* 2011; Franks *et al.,* 2017a). Newly-constructed ponds rapidly develop invertebrate biomass in as little as three months (Sanders, 2000). Similarly, ditches and scrapes support a wide range of aquatic invertebrates, dragonflies and damselflies.

Lapwing, redshank and snipe have all shown increases across reserves restored to wet grassland in UK (Fisher *et al.,* 2011). An increase in the floristic diversity of fields with higher levels of soil moisture, even if restricted to small parts of fields near scrapes, will in turn facilitate greater insect diversity and potential nesting or feeding areas for birds. Species such as swallows will benefit from bare mud and aerial invertebrates resulting from more wet areas. Amphibians are likely to colonise provided the water is not disturbed too frequently and there is some emergent vegetation at the edge of pools. In Estonia, Rannap *et al.* (2017) demonstrated that targeted management for a wader of conservation concern, the dunlin *Calidris alpina,* involving extensive grazing regimes and water level management, also supported other wader species, amphibian populations and more diverse plant communities.

Increasing the capacity of fields across the landscape to hold more water in winter and spring will have catchment-scale benefits for water courses by reducing soil water run-off. This will undoubtedly have knock-on benefits in terms of reduced stream siltation, with improved conditions for aquatic invertebrates and consequently for fish populations and birds such as grey wagtail *Motacilla cinerea* and dipper *Cinclus cinclus*.

The mechanisms by which habitat restoration for curlews on lowland grassland could benefit a wide range of taxa are indicated in Figure 2. Examples of key species most likely to benefit from less intensive grassland management are listed in Table 4.

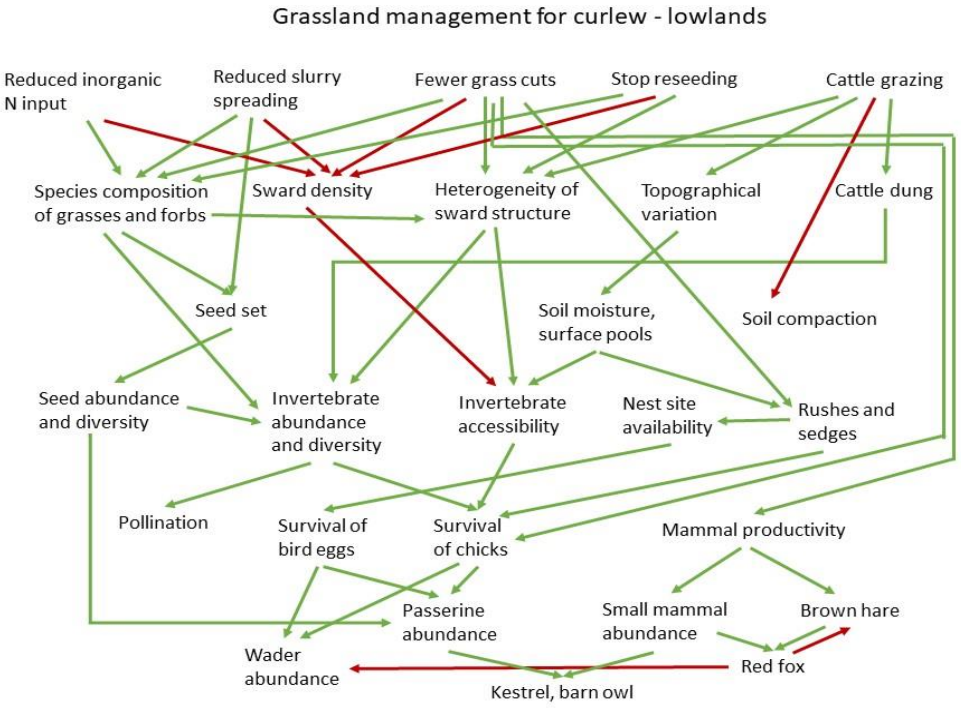


**Figure 2**. Likely mechanisms for changes in biodiversity resulting from management of lowland grasslands for curlew. Green arrows indicate positive effects and red arrows the main negative effects.

**Table 4**. Species likely to benefit from management of lowland grasslands to suit breeding curlew in Wales.

| Taxon | Name | Scientific name | Conservation status |
|---|---|---|---|
| Plant | Meadow buttercup | *Ranunculus acris* | |
| | Lesser spearwort | *Ranunculus flammula* | |
| | Marsh marigold | *Caltha palustris* | |
| | Cuckoo flower | *Cardamine pratensis* | |
| | Marsh stitchwort | *Stellaria pallustris* | Section 7[1], Vulnerable[2] |
| | Knotted pearlwort | *Sagina nodosa* | |
| | Grass-of-parnassus | *Parnassia palustris* | |
| | Dyer's greenweed | *Genista tinctoria* | |
| | Pepper saxifrage | *Silaum silaus* | |
| | Whorled caraway | *Carum verticillatum* | |
| | Tubular water-dropwort | *Oenanthe fistulosa* | Section 7[1], Vulnerable[2] |
| | Meadow saffron | *Colchicum autumnale* | Near threatened[2] |
| | Wood bitter vetch | *Vicia orobus* | Section 7[1], Near Threatened[2] |
| | Green-winged orchid | *Anacamptis morio* | Near threatened[2] |
| | Bog orchid | *Hammarbya paludosa* | Section 7[1] |
| | Early marsh orchid | *Dactylorhiza incarnata* | |
| | Common spotted orchid | *Dactylorhiza fuchsii* | |
| | Southern marsh orchid | *Dactylorhiza praetermissa* | |
| | Northern marsh orchid | *Dactylorhiza purpurella subsp. cambrensis* | Section 7[1] |
| Invertebrate | Painted lady | *Vanessa cardui* | |
| | Meadow brown | *Maniola jurtina* | |
| | Orange-tip | *Anthocharis cardamines* | |
| | Golden-ringed dragonfly | *Cordulegaster boltonii* | |
| | Black-tailed skimmer | *Orthetrum cancellatum* | |
| | Large red damselfly | *Pyrrhosoma nymphula* | |
| | Common blue damselfly | *Enallagma cyathigerum* | |
| | European cranefly | *Tipula paludosa* | |
| | Dung beetle sp. | *Onthophagus coenobita* | |
| | Dung beetle sp. | *Onthophagus similis* | |
| | Red-tailed bumblebee | *Bombus lapidarius* | |

| | | | |
|---|---|---|---|
| | Western honey bee | *Apis mellifera* | |
| | Brown-banded carder bee | *Bombus humilis* | Section 7[1] |
| | Hornet robberfly | *Asilus crabroniformis* | Section 7[1] |
| | Soldier fly | *Stratiomyidae family* | |
| **Amph.** | Common frog | *Rana temporaria* | |
| | Common toad | *Bufo bufo* | Section 7[1] |
| | Palmate newt | *Lissotriton hevleticus* | |
| **Bird** | Lapwing | *Vanellus vanellus* | Section 7[1], Red-listed BoCC4 Wales[3] |
| | Redshank | *Tringa totanus* | Red-listed BoCC4 Wales[3] |
| | Snipe | *Gallinago gallinago* | Amber-listed BoCC4 Wales[3] |
| | Barn owl | *Tyto alba* | |
| | Kestrel | *Falco tinnunculus* | Section 7[1], Red-listed BoCC4 Wales[3] |
| | Hobby | *Falco subbuteo* | |
| | Skylark | *Alauda arvensis* | Section 7[1], Amber-listed BoCC4 Wales[3] |
| | Meadow pipit | *Anthus pratensis* | Amber-listed BoCC4 Wales[3] |
| | Pied wagtail | *Motacilla alba* | |
| | Yellow wagtail | *Motacilla flava* | Section 7[1], Red-listed BoCC4 Wales[3] |
| | Swallow | *Hirundo rustica* | |
| | House martin | *Delichon urbica* | Amber-listed BoCC4 Wales[3] |
| | Reed bunting | *Emberiza schoeniclus* | Section 7[1] |
| **Mammal** | Brown hare | *Lepus europaeus* | Section 7[1] |
| | Field vole | *Microtus agrestis* | |
| | Common shrew | *Sorex araneus* | |
| | West European hedgehog | *Erinaceus europaeus* | Section 7[1] |
| | Daubenton's bat | *Myotis daubentonii* | |
| | Greater horseshoe bat | *Rhinolophus ferrumequinum* | Section 7[1] |

[1] Section 7 listed species. https://www.biodiversitywales.org.uk/File/56/en-GB

[2] Cheffings, C. M., Farrell, L., Dines, Jones, R. A., Leach, S. J., McKean, D. R., and Taylor, I. (2005). *The Vascular Plant Red List for Great Britain*. JNCC Report.

[3] Johnstone *et al.* (2023). Birds of Conservation Concern 4: the population status of birds in Wales. Milvus 2:1 (online)

### ii) Upland grassland

Curlew declines in the uplands have been associated with changes in vegetation cover, with larger declines seen on heather-dominated plots and lower ones on bog–dominated plots (Amar *et al.,* 2011). Increased grazing pressure during the 1990s-2000s has impacted vegetation composition in upland habitats (Marriot *et al.,* 2004; Worrall *et al.,* 2010) leading to a greater polarisation in vegetation heights. Rush expansion has been recorded within marginal upland grasslands (Ashby *et al.,* 2020), possibly due to changing management leading to soil compaction from machinery or reduction in management intensity, where drainage systems are not maintained.

Intensive sheep grazing in the English and Welsh uplands during the 1990s and 2000s has been associated with declines in several bird species (Fuller and Gough, 2009). The reduction in sward heterogeneity has reduced the availability of nest sites and invertebrate food. There have also been documented instances of sheep predating curlew nests (Fisher and Walker, 2015) and there is an increased risk of trampling at high sheep densities (Robson and Allcorn, 2006). In-bye fields and areas of marginal hill grazing are likely to be the most important habitats for curlew in Wales. The current stronghold for breeding curlew in England is on the moorland fringe in the Pennines and similar areas in Wales could support high densities of curlew with appropriate management. Fisher and Walker (2015) found that in-bye land manged for curlew bordering moorland in Wales was used by foraging curlew during the breeding season and contained a greater soil invertebrate biomass compared to adjacent moorland. In England, in-bye and marginal grazing are also used by black grouse and grey partridge. These species feed on sawflies specific to rushes and their niche requirements overlap with curlew, so all three species would be expected to benefit from management aimed at curlew. Other waders such as lapwing, for which the detrimental impacts of agricultural improvement of marginal upland grassland have been documented (Baines, 1989; Baines, 1990), will also benefit.

Curlews tracked with GPS tags in Deeside, Scotland made intensive use of hay meadows when rearing broods (Hoodless, unpublished data), probably because these supported higher invertebrate densities than adjacent heavily grazed pastures. Upland hay meadows are widely recognised for their value for floral and pollinator diversity and abundance. As in lowland areas, hay meadows will not only be important for curlews but a wide range of bird and mammal species.

In parts of upland Wales, more active habitat management will be required to improve habitat for curlew. Reduction in management intensity and reduction in drainage systems in some areas have led to an increase in rush species in the UK (Ashby *et al.,* 2020). High levels of rush can cause declines in bird biodiversity, but curlew tend to nest in rush pasture (Ashby *et al.,* 2020). To maintain suitability for curlew, periodic cutting of rushes to maintain 30%-60% rush cover is likely to be needed. Lapwing and redshank have responded positively to the opening up of rush beds by cutting, with lapwing nesting on freshly cut patches and these being used by broods of lapwing, redshank and snipe (Robson and Allcorn, 2006). The key is maintaining a mosaic of sward structures within the landscape so that there are niches for a range of bird species. Examples of key species most likely to benefit from less intensive upland grassland management are listed in Table 5.

**Table 5**. Species likely to benefit from management of upland grasslands to suit breeding curlew in Wales.

| Taxon | Name | Scientific name | Conservation status |
|---|---|---|---|
| Plant | Red bog-moss | *Sphagnum capillifolium* | |
| | Papillose bog-moss | *Sphagnum papillosum* | |
| | Rusty bog-moss | *Sphagnum fuscum* | |
| | Varnished hook-moss | *Hamatocaulis vernicosus* | |
| | Grass-of-parnassus | *Parnassia palustris* | |
| | Knotted pearlwort | *Sagina nodosa* | |
| | Common butterwort | *Pinguicula vulgaris* | |
| | Marsh violet | *Viola palustris* | |
| Fungi | Marsh honey fungus | *Armillaria ectypa* | Section 7[1] |
| Invertebrate | European cranefly | *Tipula paludosa* | |
| | Ground beetle sp. | *Elaphrus lapponicus* | |
| | Spider sp. | *Maro lepidus* | |
| | Small pearl-bordered fritillary | *Boloria selene* | Section 7[1] |
| | Haworth's minor | *Celaena haworthii* | Section 7[1] |
| | Argent and sable | *Rheumaptera hastata* | Section 7[1] |
| Reptile | Adder | *Vipera berus* | Section 7[1] |
| | Common lizard | *Zootoca vivipara* | |
| Bird | Red grouse | *Lagopus lagopus* | Section 7[1], Red-listed BoCC4 Wales[3] |
| | Black grouse | *Tetrao tetrix* | Section 7[1], Red-listed BoCC4 Wales[3] |
| | Grey partridge | *Perdix perdix* | Section 7[1], Red-listed BoCC4 Wales[3] |
| | Golden plover | *Pluvialis apricaria* | Section 7[1], Red-listed BoCC4 Wales[3] |
| | Oystercatcher | *Haematopus ostralegus* | Amber-listed BoCC4 Wales[3] |
| | Lapwing | *Vanellus vanellus* | Section 7[1], Red-listed BoCC4 Wales[3] |
| | Redshank | *Tringa totanus* | Section 7[1], Red-listed BoCC4 Wales[3] |
| | Snipe | *Gallinago gallinago* | Amber-listed BoCC4 Wales[3] |
| | Dunlin | *Calidris alpina* | Red-listed BoCC4 Wales[3] |
| | Hen harrier | *Circus cyaneus* | Section 7[1], Red-listed BoCC4 Wales[3] |
| | Merlin | *Falco columbarius* | Red-listed BoCC4 Wales[3] |
| | Kestrel | *Falco tinnunculus* | Section 7[1], Red-listed BoCC4 Wales[3] |
| | Short-eared owl | *Asio flammeus* | Amber-listed BoCC4 Wales[3] |
| | Barn owl | *Tyto alba* | |
| | Cuckoo | *Cuculus canorus* | Red-listed BoCC4 Wales[3] |

| | | | |
|---|---|---|---|
| | Meadow pipit | *Anthus pratensis* | Red-listed BoCC4 Wales[3] |
| | Skylark | *Alauda arvensis* | Section 7[1], Amber-listed BoCC4 Wales[3] |
| | Swallow | *Hirundo rustica* | |
| | Wheatear | *Oenanthe oenanthe* | Amber-listed BoCC4 Wales[3] |
| | Stonechat | *Saxicola rubicola* | |
| | Whinchat | *Saxicola rubetra* | Red-listed BoCC4 Wales[3] |
| **Mammal** | Brown hare | *Lepus europaeus* | Section 7[1] |
| | Field vole | *Microtus agrestis* | |
| | Pygmy shrew | *Sorex minutus* | |

[1] Section 7 listed species. https://www.biodiversitywales.org.uk/File/56/en-GB

[2] Cheffings, C. M., Farrell, L., Dines, Jones, R. A., Leach, S. J., McKean, D. R., and Taylor, I. (2005). *The Vascular Plant Red List for Great Britain*. JNCC Report.

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### iii) Heather management and bog restoration

The vegetation heterogeneity required by breeding curlew can be created by rotational heather cutting and burning along with grazing (Glaves *et al.,* 2013; Ludwig *et al*., 2019). In the Welsh uplands curlew density has been found to be negatively related to vegetation density, with moderate height swards preferred (Johnstone *et al.,* 2017). Rotational cutting has been employed at the Lake Vyrnwy reserve for habitat restoration to create a fine mosaic of short and long vegetation (Fisher and Walker, 2015). In England and Scotland, some of the highest breeding densities of curlew are associated with moorland managed for grouse shooting, with 74% of upland SPAs managed as grouse moors (Tapper, 2005). In a large-scale study across the UK uplands, Tharme *et al.* (2001) demonstrated that breeding densities of curlew were twice as high on grouse moors compared to other moors. Densities of golden plover and lapwing were also five times higher on moorland managed for grouse shooting. Grouse moor management includes rotational burning of heather to create a mosaic of different-aged stands and lethal predator control, both of which have been shown to benefit waders including curlew (Tharme *et al.,* 2001; Fletcher *et al.,* 2010). Increases in breeding wader densities were seen during the restoration of Langholm moor primarily for red grouse over a 10-year period when wider declines were seen across Scotland (Ludwig *et al.,* 2019).

Negative effects of afforestation have been documented in the uplands, through direct loss of curlew habitat, increased predator abundance from habitat change and the knock-on effect of reduction in grouse moor management practices, including predator control (Amar *et al.,* 2011; Douglas *et al.,* 2014; Franks *et al.,* 2018). Increases in generalist predators (foxes and crows) have been documented as an 'edge effect' for up to 1 km from forest edges, affecting curlew densities and nesting success (Douglas *et al.,* 2014; Brown *et al.,* 2015). It has been suggested that removal of commercial plantations in the Scottish uplands for blanket bog restoration could be beneficial for breeding waders including curlew (Douglas *et al.,* 2014). A landscape-scale approach in Wales whereby some

strategically selected forests are not replanted following felling but left for moorland regeneration could benefit breeding waders, red grouse *Lagopus lagopus* and black grouse *Tetrao tetrix*, short-eared owl *Asio flammeus* and merlin *Falco columbarius*.

Management of upland heath and bog/peatland restoration for biodiversity and carbon sequestration (e.g. re-vegetating bare peat and blocking drains) would also benefit breeding curlew, golden plover and snipe by increasing the quality of nesting and chick rearing habitats (Carroll *et al.,* 2015; Franks *et al.,* 2017a). Craneflies are important as food for many upland birds, providing a summer flush of prey for adults and chicks of species as meadow pipit and golden plover, and populations would be expected to increase with bog restoration (Coulson, 1988; Pearce-Higgins and Yalden, 2004). Wet flushes on moorland are frequently used by red grouse broods and breeding snipe (Hoodless *et al.,* 2007).

### iv) Predator management

Predation is one of the main factors limiting curlew recovery in the UK (Brown *et al.,* 2015; Zielonka *et al.,* 2019). Foxes, corvids and mustelids have been regularly identified as predators of eggs and chicks of a range of waders (Moore *et al.,* 2003; Bolton *et al.,* 2007; Bodey *et al.,* 2011; Roos *et al.,* 2018) and the UK has some of the highest densities of foxes and crows of European counties (Roos *et al.,* 2018). The type of predator management implemented will affect the extent of effects on species other than curlew, with habitat manipulation likely to influence the broadest range of species, lethal control of predators potentially benefitting other ground-nesting birds, and electric fencing having less of an effect on other species, dependent on the area enclosed.

There is good evidence that predators take a higher proportion of nests and chicks in homogenous grass swards (MacDonald and Bolton, 2008). Simply creating more heterogeneous swards for curlew is likely to be beneficial for nest and brood survival of other birds, particularly waders. Manton *et al.* (2016) provide evidence that corvid species are more numerous in anthropogenic wetlands and there is greater species richness and abundance of birds of prey in these wetlands than near-natural landscapes. Creating more extensive areas of near-natural curlew habitat could therefore result in fewer avian predators, with consequent benefits for the species comprising their prey.

*Habitat restoration and modification*

Landscape-scale habitat management can be used to influence the behaviour of predators and their impact on breeding waders. Opening up field boundaries and tree removal in lowland landscapes is likely to have mixed effects. For instance, the removal of bramble and willow will reduce nesting opportunities for warblers but if wet ditches are reinstated in its place, these are likely to be more valuable in terms of overall species diversity at the catchment scale. Removal of trees might result in the loss of nesting sites for birds, and roosts and foraging for bats, but if dry field boundaries are replaced with wet ditches there will be alternative bat foraging habitat. More open landscapes will be attractive to lapwing and skylark as well as curlew.

Scrapes and foot-drains have been widely implemented on lowland wet grassland reserves, primarily to provide foraging areas for lapwing and redshank broods. The abundance of wet features positively influences the breeding density of these species on wet grasslands (e.g. Smart *et al.,* 2006; Eglington *et al.,* 2008), but, importantly, density-dependent reductions in predation rates of nests and chicks have been recorded

(MacDonald and Bolton, 2008; Eglington *et al.,* 2009; Laidlaw *et al.,* 2017). In most instances, wet feature creation for curlew would not be on the scale implemented on nature reserves, but it is likely to attract and support broods of lapwing, redshank and snipe.

Habitat manipulations focused on providing appropriate habitat features for wader chicks have been shown to reduce encounters with predators (Eglington *et al.,* 2009; Bodey *et al.,* 2011). Laidlaw *et al.* (2015) found that predation rates of lapwing nests was reduced closer to patches of taller vegetation. This suggests that predator behaviour and distribution may be influenced by patches of taller vegetation, possibly supporting small mammal populations as an alternative prey. A combination of water level management and verge creation across a reserve scenario has been predicted to reduce long-term nest predation by 50–70% for breeding lapwing (Laidlaw *et al.,* 2017). A few studies have identified an association between water levels and predation pressure on waders, as seen on wet grassland in Denmark (Møller *et al.,* 2018).

Outcomes from modelling have suggested that an increase in woodland cover from 0% to 10% of land area in the uplands within 1 km of curlew breeding sites would require a 50% increase in predator control effort to maintain a stable curlew population (Douglas *et al.,* 2014; Brown *et al.,* 2015). Selective felling of forestry plantations in upland areas near curlew breeding sites might reduce overall landscape biodiversity, but the loss of habitat for relatively few bird species inhabiting the forests (e.g. song thrush *Turdus philomelos*, mistle thrush *Turdus viscivorus*, crossbill *Loxia curvirostra* would likely be outweighed by a greater abundance of moorland specialists (e.g. snipe, golden plover, lapwing, meadow pipit, merlin, short-eared owl).

*Lethal control*

Lethal predator control at the scale needed for curlew recovery at the landscape scale would be an expensive and controversial approach (Colwell *et al.,* 2020). It would also need to continue for many years for positive effects to persist. However, in the short-term at least, focused, effective predator control will be needed at key sites to raise curlew breeding success from the very low levels currently being recorded. Lethal predator management would be expected to have positive or neutral effects on other ground-nesting birds using the same habitats as curlew, although outcomes are likely to be site dependent. Lethal predator control can be used to dramatically reduce the number of generalist predators, namely foxes and carrion crows (Bolton *et al.,* 2007; Baines *et al.,* 2008; Fletcher *et al.,* 2010; Douglas *et al.,* 2014). When implemented at the landscape level, lethal control can result in local and regional predator suppression (Heydon and Reynolds, 2000a; Heydon and Reynolds, 2000b; Heydon *et al.,* 2000). Lethal control has been shown to be effective at increasing breeding productivity of several wader species above the level required for stable populations in different countries and situations (e.g. Tharme *et al.,* 2001; Baines *et al.,* 2008; Fletcher *et al.,* 2010; Douglas *et al.,* 2014; Niemczynowicz et al., 2017). In Northumberland, for example, experimental control of foxes, corvids and small mustelids resulted in an average three-fold increase in the breeding success of lapwing, golden plover and curlew. Importantly, greater breeding success translated into increases in breeding numbers (≥14% per annum) for these three species, compared to ongoing declines in numbers (≥17% per annum) in the absence of predator control, although no effect was recorded for snipe (or meadow pipit or skylark) (Fletcher *et al.,* 2010). Large-scale surveys indicate that predator control on grouse moors

in the UK uplands leads to higher breeding wader densities than on moorland with no predator control, and increases in wader populations have been documented following the reinstatement of predator control (Tharme *et al.,* 2001; Littlewood *et al.,* 2019; Ludwig *et al.,* 2019).

On lowland wet grassland at the Dümmer reserve, NW Germany, black-tailed godwit fledging success during six years of fox control averaged 0.83 chick/pair (n = 136 pairs), compared to 0.27 chick/pair (n = 62 pairs) over seven years without fox control (Belting pers. comm.). Across Lower Saxony, monitoring of 2,537 pairs of black-tailed godwit over 14 sites during 2012-2017 revealed fledging success greater than 0.7 chick/pair only at the four sites, supporting 853 pairs, where efficient fox control was undertaken (Belting pers. comm.). However, an effect of predator control is not always apparent (e.g. Bodey *et al.,* 2011). In an eight-year experiment across 11 nature reserves, Bolton *et al.* (2007) found that reducing fox and carrion crow numbers had no overall effect on lapwing nest survival rates or population trends, although twice as many pairs fledged young at six sites during periods of predator control. In addition, reductions in nest survival in the presence of predator control were apparent when controlling for the background density of foxes and carrion crows, indicating that the impact of predator control on nest survival rates may vary depending on the density of predators present at that time (Bolton *et al.,* 2007).

Several meta-analyses of the effect of lethal control on bird populations, all including studies on breeding waders and other ground-nesting birds, have concluded that the average overall effect is positive but that there is great variation in effect sizes among species and locations (Côté and Sutherland, 1997; Smith *et al.* 2010). There are many possible causes for these variable responses to predator removal, including annual variation in the abundance of predators or alternative prey, abiotic factors, such as poor weather at hatching or catastrophic losses due to flooding, an impact from other predators which have not been targeted, density-dependent effects, individual variation in predator behaviour, or inefficient predator control.

*Predator fencing*

Temporary electric fences have been used as a management technique to individually fence curlew nests and has been successful at increasing hatching rates on lowland meadows in Germany (Meyer and Jeronin, 2017). This can offer increased protection to nests from mammalian predators with lower levels of effort than lethal control (Colwell *et al.,* 2020), but it does not protect chicks once they leave the nest. Large-scale predator exclusion fences around wet grassland reserves, designed to reduce incursion by foxes and badgers, have been shown to improve the daily nest survival rate of lapwings and the number of chicks fledged (Malpas *et al.,* 2013). However, such large-scale fencing is not practical for curlew which typically nest at much lower densities and the small-scale fences which have been trialled successful for protecting individual curlew nests will have no benefit for other ground-nesting birds.

**v) Landscape and temporal effects**

Agricultural intensification in Sweden provides a useful example of the effects on wader populations and ecosystems. In southern Sweden traditional farming practices based on livestock husbandry and the associated large area of mowed and grazed wet grasslands

has been turned into intensively cropped land (Ihse, 1995; Wretenberg *et al.,* 2007). There is now a gradient of wader population viability from northern Sweden with near-natural systems such as mountain heaths and boreal wetlands where wader numbers are stable or even increasing to southern Sweden where numbers are generally declining. For ten wader species found in both regions, there was a 2% increase per annum in the north and a 3.5% decline per annum in the south during 1998-2012 (Lindström and Green, 2013). A study comparing wader abundance in these two landscapes concluded that predictions linked to predation on wader nests and chicks were supported but that predation may not be the ultimate factor causing wader population declines (Manton *et al.,* 2016). The authors of this study suggest that cumulative effects of landscape change linked to increased food resources for predators and reduced wet grassland patch size and quality are likely to be the ultimate drivers of wader declines.

Addressing the dramatic decline of curlew in Wales will require a landscape-scale approach to address the sort of issues seen in Sweden of habitat fragmentation and deterioration. The approach of targeting recovery interventions in ICAs may address this requirement coupled with sufficient fiscal support to farmers and land managers to fund appropriate habitat restoration on moorland and lowland farmed habitats. If effectively implemented, such a package of measures would not only deliver the biodiversity benefits documented above but could make a substantial contribution to delivery of a broader range of ecosystem services.

## Knowledge gaps

Although the effects of less intensive grassland management on more common and widespread invertebrates is well known, it is unclear how large-scale adoption of more sensitive farming across landscapes could aid the recolonisation of rarer insect species or the timescale over which this might be expected. A landscape-scale curlew recovery package should include support for a monitoring programme of selected species, which could include recording of more obvious species or those not requiring specialist skills by farmers and the public, as well as specialist surveys of key groups or species.

There are plausible theoretical mechanisms for amphibians and bats to benefit from widescale management for curlew and other waders, but there have been very few studies looking at synergies in management benefits across these taxa. Bat populations, in particular, could benefit from reduced intensity farming through the resulting increase in aerial insect abundance, providing roosts are maintained, but there is little evidence linking population growth to food availability.

Because predator control benefits a relatively small number of other species compared to habitat management, we need to understand the minimum level of lethal predator control effort required to push curlew chick survival above the threshold for a stable population. There have been no intensive studies of curlew chick survival and there is little knowledge of chick predators and how to effectively protect curlew broods to fledging. There is now some evidence that electric fencing relatively small areas around curlew nests can substantially increase hatching success on grassland, but this does not protect broods. In most situations, it is not feasible to fence large enough areas to protect broods from mammalian predators and avian predators may play a more important role in chick depredation. We need to better understand the impacts of different predator species on

chick survival and the extent to which restoring habitat can improve chick survival by making it harder for predators to locate chicks and increasing insect food availability.

Since curlew and other ground-nesting birds do not comprise the main prey of predators, we need to better understand how what foods are supporting high predator densities in the landscape and how altering land management affects predator numbers. A landscape-scale solution is needed to reducing predation rates on declining prey species.

Because the perilous state of curlew populations in the UK and elsewhere in Europe has only been fully appreciated in the last 5-10 years, there is little direct evidence from management aimed at curlew for wider species and ecosystem service benefits. However, management for curlew has many elements in common with the management directed at other declining breeding wader populations for which actions have been ongoing for much longer and benefits to other taxa have been recorded. There is also a large body of evidence in the published scientific literature linking plant diversity and invertebrate abundance and diversity to vegetation structure and different forms of management. Since the ecology of most birds and mammals is well documented, it is not difficult to draw inferences on the likely outcomes from changes in plant diversity, vegetation structure and invertebrate abundance for birds and mammals utilising the same habitats as curlew with reasonably high confidence.

**Summary**

Based on the literature reviewed and habitat-management relationships, we conclude that successful delivery of curlew breeding success of >0.5 chick/pair/year, and increasing breeding numbers at the landscape scale may provide:

- A heterogenous landscape structure with connected breeding and feeding areas.
- Relatively stable landscape structure and land use. This will be good for land use economics, but stability can be good for biodiversity too, e.g. benefits accruing from long-term pastures (increased species diversity and, in many cases, abundance), and minimal carbon emissions through reduced ploughing.
- Low local and landscape predation pressure. This should benefit other ground-nesting species.
- Specific outcomes for species and ecosystem services such as heterogenous structure and composition in grass and dwarf shrub habitats which will benefit floral diversity, spiders and invertebrate diversity and abundance, mammals and up to 20 birds of conservation concern.
- Soils will be more porous and more easily probed, resulting in healthier soil invertebrate populations, reduced flood risk, reduced soil erosion and possibly higher carbon content.
- Low livestock trampling and grazing pressure which will benefit other ground-nesting birds, small mammals, but lower livestock numbers may impact farm profitability.
- Reduced grass rolling and cutting pressure will increase survival of nests and chicks of curlew and other ground-nesting birds, increase leveret survival and is expected to lower carbon emissions. However, there may be reduced hay or silage production. Socio-cultural services will need to be carefully managed.

# 4. Do curlew have cultural significance and well-being/societal benefits to people in Wales?

*Curlew in Welsh theology, literature and arts*

The curlew, or gylfinir in Welsh, has a distinctive long curved bill and evocative call – an eerie 'cur-lee' that is thought to be the origin of its name.

In winter, we are familiar with their presence on saltmarsh and estuarine habitats with almost a fifth of Europe's curlew visiting UK coasts when their own breeding habitats are too frozen to allow effective foraging. By the spring, our coasts become mainly emptied of curlew, where European birds return to the continent and our resident birds head inland to breed on heaths, moors, bogs, meadows and lowland grass pastures. It is here, at this time of the year, when many of our rural communities witness the sight and sound of courting curlew and consider their first curlew sighting as the herald of spring. It is the piping, bubbling sound of the calling curlew that touches you, strangely eerie yet evocative. To many residents of rural Welsh communities, the plaintive song of the curlew denotes wilderness, mystery and now, sadly due its absence - tragedy.

Those who know curlew hold deep emotive feelings for them borne of memories of 'better' times in landscapes less detrimentally affected by the trappings of human demands. They long to re-connect with these landscapes and curlew encounters (Colwell, 2018). It is in the uplands particularly that curlew contribute to the sense of wilderness.

To many people of Wales, their awareness of the curlew is also ingrained in history, folklore and theology. St. Beuno (pronounced Bayno) was a sixth-century Welsh Abbot, recognised as a key figure for establishing Christianity throughout north Wales, where stories suggest he had a connection with curlew. The Legend of St Beuno describes the story where he was sailing off the coast of Wales and dropped his prayer book into the water. A curlew flew over, scooped it up and took it to the shore to dry. The saint was so grateful he blessed the bird and said curlews should always be protected - which was said to be why it was so difficult to find their nests.

Many locations in north Wales have firm connections with St Beuno, for example the Pistyll hills on the Llyn Peninsula and Eglwys St Beuno Trefdraeth on Anglesey (Figure 3). There is also a painting of the story of St Beuno and the curlew painting in St Beuno's Jesuit spiritual retreat centre, Tremeirchion, St Asaph (see http://www.curlewmedia.com/st-beuno-and-the-curlew).

Colwell (2018) suggests curlews in Wales were traditionally associated with doom and often thought of as a harbinger of death. Here, a cry of the curlew, particularly at night heralded death in the family and a curlew calling over a fishing boat would forewarn of a storm at sea, thus signalling to fishermen to head for home.

'Memories of the Curlew' the fictionalised account by Helen Spring (2009) of the life of the Princess Gwenllian, known as the Welsh Warrior Princess, frequently references curlew at each stage of the story as it unfolds Gwenllian's life in the early 12th Century.

**Figure 3**. Eglwys St Beuno Trefdraeth on Anglesey. Photograph courtesy of Sue Evans.

Curlew have inspired many great literary successes. The Welsh poet Dylan Thomas referred to curlew in several pieces of prose, for example in the monologue 'Under Milk Wood' (Thomas and Sinclair, 1954):

*"Oh, the Spring whinny and morning moo from the clog dancing farms, the gulls' gab and rabble on the boat-bobbing river and sea and the cockles bubbling in the sand, scamper of sanderlings, curlew cry, crow caw, pigeon coo…."*

And in his poem 'The White Giant's Thigh':

"*Through throats where many rivers meet, the curlews cry*
*Under the Conceiving moon, on the high chalk hill*"

(listen https://www.youtube.com/watch?v=Ei9YuFtbHcc)

Vernon Watkins, a close friend of Thomas, wrote:

*Alone I hear it now, lone I hear,*
*A curlew call the unreturning year.*

Colwell (2018) alludes that R.S. Thomas often captured in his prose the Welsh word – *Hiraeth* - there is no English equivalent - but it is fair to assume it can be roughly translated as a yearning or homesickness. Colwell goes on to suggest "*The call of the curlew, piping, bubbling, crying in the wind, is quintessentially the sound of this deeply experienced sense of hiraeth*".

In song, Dafydd Iwan's 'Ai Am fod Haul yn Machlud', makes reference to the curlew and the sadness of its call (listen https://www.youtube.com/watch?v=N4ycHbXa-JE), the lyrics are listed in Annex 1). Based on St Beuno's tale is the folk song 'Saint Beuno and the Curlew' by Barron Brady (listen https://soundcloud.com/rosalind-brady/st-bueno-and-the-curlew).

Artists in Wales have also been influenced by the allure of curlew. Not far from Eglwys St Beuno Trefdraeth, at Shorelands, lived the great wildlife artist Charles Tunnicliffe. His work 'Curlew alighting' portrays the significance of a flock of curlew alighting in a field with a backdrop of the Cefni estuary.

UK Curlew Champion and convener of the Welsh Curlew Summit, Mary Colwell walked across the Republic of Ireland, Wales and England to raise awareness of the plight of Curlew. An incident described in her book 'Curlew Moon' (2018), describes meeting a man on a bench in a town whilst taking a rest from her 500-mile trek. The pair struck up a conversation and Mary told the man what she was doing and asked if he knew what a Curlew was. He was not certain, so she played a recording of a 'bubbling' curlew at which point the man started to cry. When Mary apologised for upsetting him, he explained that he was overcome with emotion as he thought that he would never hear the sound of a curlew calling, again. He went on to explain that the sound of the curlew had evoked a powerful longing in him for former days when the sounds and sights of curlews were usual to him.

Andrew Foregrave wrote in the Daily Post in 2016 about Mary Colwell's trip across Wales raising awareness of the plight of the curlew, quoting Mary:

"*I can't quite explain how I came to do this," admits Mary Colwell, as we sit in the May sunshine on a green hillside in the Berwyn Mountains. For me, Curlews embody those lonely places. They live on wild coasts, cold and bleak, in the winter, muddy places that are theirs and not ours – we can't easily visit the middle of an estuary at low tide.*

*And in summer, they are the essence of flower-rich meadows, spotted with colourful buttercups, daisies and orchids.*

*Perhaps I like them because they're not showy, they're understated; they don't demand attention like Eagles or Puffins*."
(see - https://www.dailypost.co.uk/news/local-news/mission-save-curlews-north-wales-11569056)

*Societal benefits: Curlew Country case study*

Before promoting a curlew project as part of a Heritage Lottery Funded Landscape Partnership Scheme on the Welsh/Shropshire Border, the Stiperstones and Corndon Hill Country Landscape Partnership Scheme (LPS) consulted the local community on a range of natural and cultural heritage project possibilities. Such a consultation showed that 98% of the local communities that were consulted voted for a Curlew Recovery Project. This overwhelming finding suggested local people were already connected to curlews and were conscious that managing land for this species will deliver multiple societal and environmental benefits because they remember and connect them to the landscapes in which they have heard or seen curlews.

Significant new funding was sourced for breeding curlew and culminated in Curlew Country initiating work in 2015. This project covers a core area of 200km$^2$, focusing on a lowland curlew 'hotspot' of around 40 breeding pairs and engages the farming communities. Here, participants have expressed:

- A **sense of loss and anguish** on learning of the plight of a bird so beloved
- A **strong desire to prevent curlews from becoming extinct**, allied to an awareness that if it is possible to save this species it will deliver much wider environmental benefits particularly allied to the loss of other species that will thrive in land managed beneficially for curlew.
- A **wish to do more** and become more involved in curlew recovery work
- A **sense of community**, where all are working together to help save curlews
- A **sense of well-being** from becoming involved in arts activities with a wider species recovery focus
- A **greater understanding of the management of the countryside** and the drivers for modern agriculture.
- A **focus upon an area which makes it proud** to be engaged in conservation work.

This is a "grassroots" initiative with a multi-disciplinary programme including a programme of arts awareness. Arts are used as a tool to tackle more sensitive subjects related to curlew recovery such as predation and societal attitudes. A small bespoke project called Curlew Conservations, has helped farmers understand the changes in farming which may have contributed to curlew decline in a non-judgemental way (Figure 4). As a long-term industry, it is often difficult for farmers to remember the extent of change that has occurred both in farming practices and to the land that they manage. Such changes have its admirers and its detractors for market-driven changes in response to public demand for more and cheaper food. Opening such conversations on change outside an environment which farmers perceive to be safe and trusting can be challenging.

**Figure 4**. Curlew choirs and sculpture workshops. Photograph courtesy of www.curlewcountry.org

Curlew Country designed and managed a complementary project called "Buzz in the Borders". This project worked with primary school children to encourage children to

understand and appreciate native pollinators better and to help them to understand the important role pollinators have in many ecosystems. The project used local specialist professionals to work with the children on a range of activities which spanned key areas of the national curriculum including English, Mathematics, Art and Design, Science, and Computing. It also used a confidence building programme which trained children in public speaking. Individual children presented a piece on a pollinator on the local radio each day for the month of June in the breakfast time show. The engagement quality of this project was extensive. This project also linked the children of local farmers with the curlews on their land, including encouraging their families and carers to become even more involved with curlew recovery work (Figure 5). Link to a short film on Buzz in the Borders first year work in schools: https://player.vimeo.com/video/137363326?title=0&byline=0&portrait=0

**Figure 5**. 'Buzz in the Borders' educational party. Photograph courtesy of www.curlewcountry.org

*Societal benefits: Contemporary Welsh public opinion survey*

As part of this report, we conducted a questionnaire survey titled "Curlew conservation in Wales - have your say". This was an online survey using multiple social media platforms distributed to interested parties, with the help of the Farmers' Union of Wales and NFU Cymru. In a four-week period (January-February 2021) a total of 361 survey responses were submitted.

The questions were designed to collect public opinion, with a focus on the rural farming community, regarding curlew in Wales, and respondents were informed of the plight of curlew within the questions. Questions gave respondents multiple-choice answers to choose from, such as simple yes or no answers, or optional answers along a scale such as not important, fairly important and very important as examples. In addition, questions were designed to capture public knowledge regarding the wider benefits of curlew recovery and

opportunity was given to provide additional comments so that testimonials could be gathered. The full list of questions is provided in Annex 2

Though there are inherent biases in questionnaire surveys often as a result of how the question is posed and how the survey sample was selected it is very difficult to eradicate bias as each person's opinion is subjective. However, the results from our survey provide some anecdotal evidence of the cultural importance of curlew to people who live and work in rural Wales. Key headlines were:

- 99% of respondents agreed that curlew is an important species for Welsh culture and heritage, holding an important place in the hearts and minds of Welsh rural communities.
- 93% of respondents stated that the survival of curlew as a breeding bird in Wales was very important to them.
- 94% of respondents stated that urgent curlew recovery work in Wales is very important.
- 99% of respondents thought that curlew recovery work would have wider benefits to additional species.
- 98% of respondents felt that conservation funding should be prioritised for curlew recovery in Wales.
- 79% of respondents emphasised with the decline of the curlew and felt more inspired to carry out conservation work, if it was focussed on a certain species, such as curlew, rather than a broader environmental focus.

Anecdotal evidence suggests that curlew have stronger emotive ties and increased relevance to the >60 age group through associated childhood memories of high curlew numbers (Gylfinir Cymru pers. comm.). It was therefore encouraging to find that 51% of respondents were <60 years old and of those 20% were <40 years old. Furthermore, it was also encouraging to find that 67% of the respondents had seen or heard curlew in Wales within the last two years, of which 55% were <60 years old and 11% were <40 years old.

A word cloud[5] was generated from personal testimonials of respondents to the survey (Figure 6).

[5] Word cloud is an image composed of words used in a particular text or subject, in which the size of each word indicates its frequency of use or importance

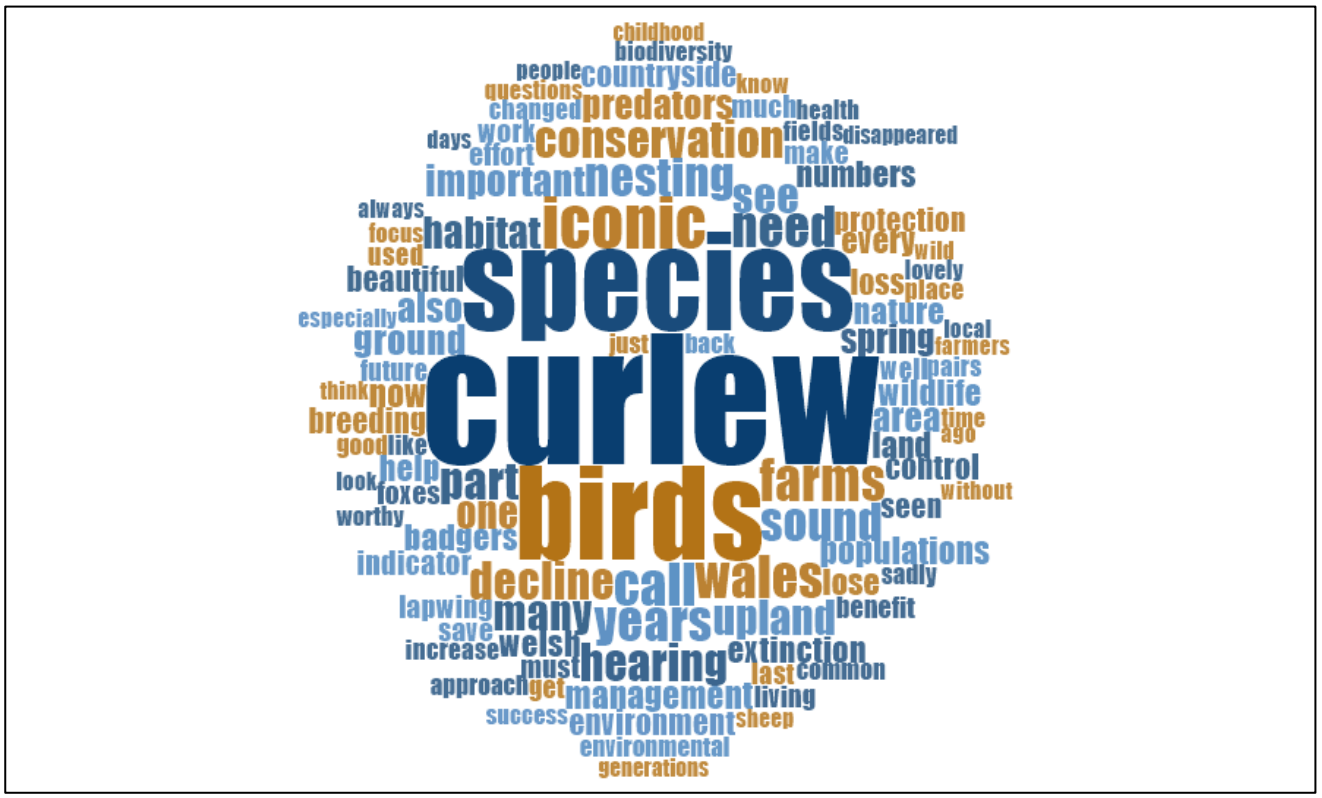


**Figure 6**. Word cloud created from respondent testimonials to the survey questionnaire “Curlew conservation in Wales - have your say”.

The importance of curlew in Welsh Heritage have been outlined above. As expected, the contemporary Welsh peoples’ views and opinions on the importance of the curlew’s continued existence in the Welsh landscape is closely aligned to that Welsh cultural heritage. On this basis, it is fair to assume that our online survey, even with a relatively small sample size of the Welsh population, provides further evidence to demonstrate the important cultural and emotive ties curlew have with the Welsh public. To extend this thinking, respondents were also asked what other taxonomic species would possibly benefit from curlew-focused conservation and habitat management. Species commonly identified included other grassland breeding waders, such as lapwing, snipe, redshank and golden plover, with over 50% of respondents suggesting wider benefits to invertebrates, such as pollinating insects, and flowering plants, such as those associated with hay meadow management (Figure 7).

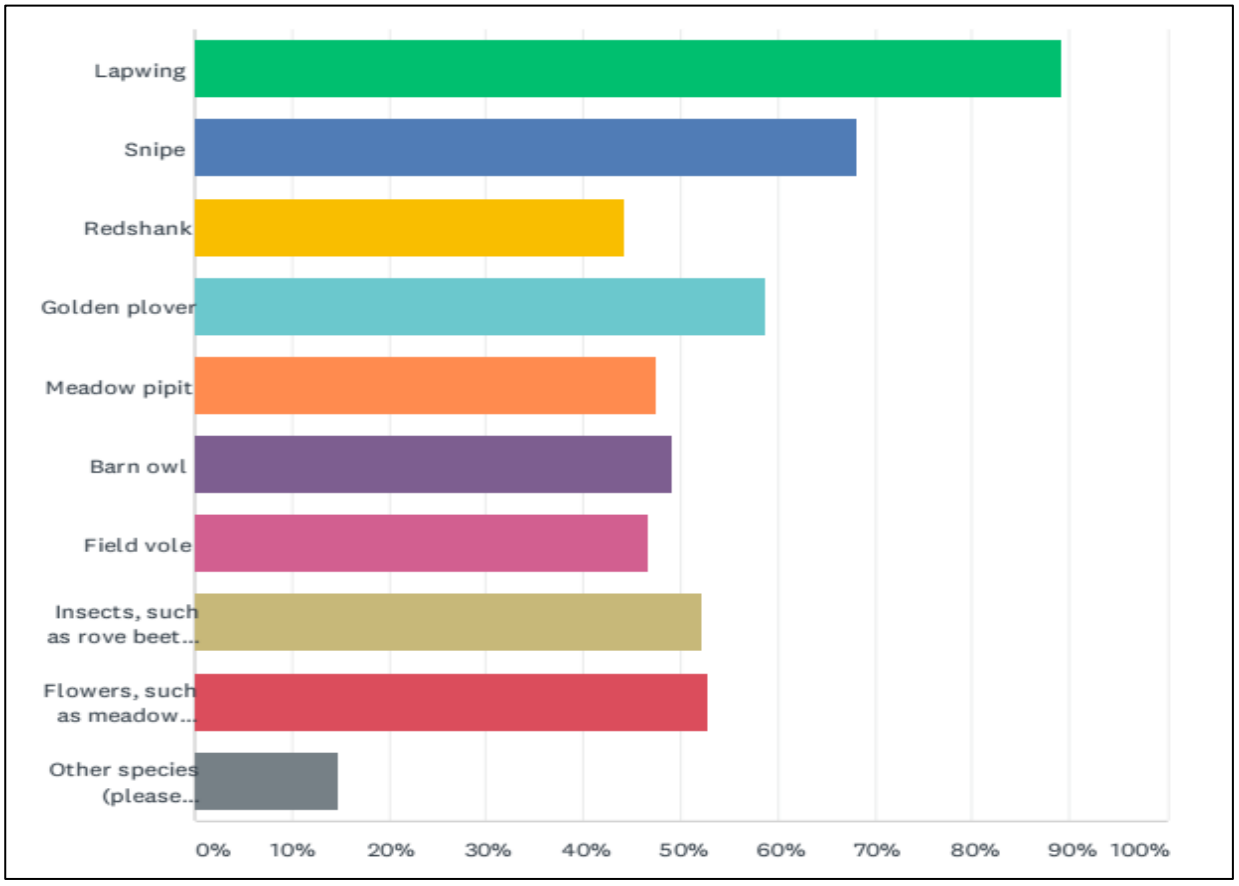


**Figure 7**. Proportion of survey responses detailing additional species believed to benefit from curlew recovery.

Finally, respondents were given the opportunity to express their own thoughts on the importance of curlew in Wales. These are a few testimonials that were provided:

*"They are an integral part of the Welsh ecosystem, and we owe it to ourselves and future generations to maintain this."*

*"The curlew is the iconic breeding wader of the uplands, and its survival would be a reflection of a society committed to preserving and enhancing a magical, diverse and thriving upland environment which was prevalent in previous generations. Its loss would reflect yet another dereliction of duty whilst its revival would be a triumph of action over good intentions and complacency. Restore the curlew and restore so much more of the natural magic of the uplands, as well as uplift the human spirit."*

*"I haven't seen these birds on any of Wales' uplands, I have to go to Scotland to see these iconic birds".*

*"With curlew populations declining drastically across Europe, surely Wales has the optimum habitat and should trailblaze conservation of ground nesting bird species".*

*"I have worked hard to get the farm suitable to draw in the curlew after an absence of around 30 years without hampering on food production and last spring they came back to*

*my delight. Sadly, after hatching the chicks were destroyed by the predators that are in the area."*

*"Every year around mid-Feb I wait for the call of the Curlew, coming to nest in the field near me. The first sign of Spring for me. It would be a tragic loss. They are part of our countryside."*

Further respondent testimonials are found in Annex 2.

The infographic presented in Figure 8 reflects some of the key statistics drawn from the survey, reflecting respondents' views and opinions of the importance of curlew to them and to Wales.


**Figure 8**. Infographic of several key headlines from the online survey: "Curlew conservation in Wales - have your say".

## Summary of the cultural and societal importance of curlew in Wales

- Curlew, are frequently referred to throughout Welsh history, theology, culture and heritage, dating back to the 7th century Welsh Abbot, Saint Beuno.
- There are strong ties within Welsh culture and the arts.
- Evidence that curlew act as an enabler and influencer, bringing communities together under a common cause. Evidence from the Curlew Country Project community engagements projects included the acknowledgement of a sense of loss and anguish regarding the plight of curlew, coupled with a desire to prevent localised extinction, a wish to do more and a newfound sense of pride found in conservation engagement. These findings were in addition to the sense of well-being derived from involvement in curlew focussed art activities with a wider species recovery focus.
- A GWCT curlew survey of 361 respondents found that:
  - More than 95% of respondents agreed that the curlew is an important species for our culture and heritage and hold an important place in our hearts and minds.
  - More than 99% of respondents thought that other species may benefit from targeted curlew recovery.

# 5. What are the key ecosystem services derived from land management practices associated with curlew conservation?

Against the background of declining biodiversity and threats to vital ecosystem services that sustain our economy and society, Wales has a legal and policy framework that provides a fresh approach for responding to the environmental challenges we face. This is mainly set out in two Acts: The Well-being of Future Generations (Wales) Act 2015 that aims to further the economic, social, environmental and cultural well-being of the people of Wales; and The Environment (Wales) Act 2016 designed to promote Sustainable Management of Natural Resources (SMNR) to maintain and enhance the resilience of ecosystems, as summarised in section 2.

Breeding curlew is a species which has ecological needs that align closely with natural capital and ecosystem services delivery. For example, curlews need wet ground, pollinator-dense and species-rich grassland. Improved soil quality, water and air quality are all associated with these habitats. Managing habitats appropriately for breeding curlews will be long-term, gradually repairing ecosystems and increasing biodiversity. These extensively managed areas in both upland and lowland farmed landscapes have great potential to be attractive to both residents and visitors bringing health benefits and income into rural communities.

**Natural capital**

Natural capital can be defined as the suite of natural assets which include geology, soil, air, water and all living things. It is from this natural capital that humans derive a wide range of services, often called ecosystem services, which make human life possible.

The most obvious ecosystem services include the food we eat, the water we drink and the plant materials we use for fuel, building materials and medicines. There are also many less visible ecosystem services such as the climate regulation and natural flood defences provided by forests, carbon storage in peatlands, or the pollination of crops by insects. Poorly managed natural capital therefore becomes not only an ecological liability, but a social and economic liability too. Working against nature by overexploiting natural capital can be catastrophic not just in terms of biodiversity loss, but also catastrophic for humans as ecosystem productivity and resilience decline over time and some regions become more prone to extreme events such as floods and droughts.

The concept of natural capital was first presented by E.F. Schumacher in his book *Small is Beautiful: a study of economics as if people mattered* (1973):

*“Now, we have indeed laboured to make some of the capital which today helps us to produce - a large fund of scientific, technological, and other knowledge; an elaborate physical infrastructure; innumerable types of sophisticated capital equipment, etc. - but all this is but a small part of the total capital we are using. Far larger is the capital provided by nature and not by man - and we do not even recognize it as such. This larger part is now*

*being used up at an alarming rate, and that is why it is an absurd and suicidal error to believe, and act on the belief, that the problem of production has been solved."*

Schumacher's remarks in the early 1970's heralded a rapid evolution in critical thinking and development around 'natural capital'. These initiatives have more recently been fuelled by global concerns regarding climate change and biodiversity loss. However, whilst natural capital is now rarely far from debate around land and business management, much remains to translate this energy into a sound, deliverable blueprint for oversight of our natural resources at farm, estate, or landscape-scale.

By 2012, the UK established a Natural Capital Committee and economists began preparing to include a value for 'natural capital' in Britain's GDP calculations by 2020. Meanwhile, at an international level, the Bank of Natural Capital website was launched in 2011 by The Economics of Ecosystems and Biodiversity (TEEB) project, a programme supported by the United Nations and European Union.

Managing breeding curlew habitat holistically would deliver wider biodiversity (see section 5), aid restoration of eco-systems and be an enabler of ecosystem services (see below). Here, beneficiary species would be across taxa, improved water and soil quality (reduced run-off and nitrates) and carbon capture would all be outcomes. If we adopt this thinking breeding curlew has the potential to attract funding as an additional incentive within a future monetised system for soil carbon capture. In turn, this principle, together with the implementation of curlew habitat management measures would be in line with Welsh Government and NRW policy in meeting the objectives of SMNR, the Environment Act (Wales) 2016 and the Wellbeing of Future Generations (Wales) Act 2015. Curlew require landscapes to breed successfully, occupying large home ranges to meet their breeding ecological needs and thus travel across farm boundaries to feed and raise their young (Taylor *et al.,* 2020). This requirement results in the need for landscape scale collaboration, where neighbouring farmers work together to help breeding curlew to rear a sustainable number of chicks each year to maintain a population. Applying the Important Curlew Area network both ecosystem services and natural capital opportunities can be maximised, delivered at scale that create natural networks, stepping-stones and corridors. Loss of traditional agricultural income could be offset by the natural capital resources that managing curlew would provide but would need a strong financial and environment benefits connection to the proposed Sustainable Farm Scheme. Such an approach supports the ethos and principles of such a scheme i.e the cost of multiple environmental outputs provides value per £ invested.

**Ecosystem Services**

It is becoming increasingly recognised that natural environments are important not only to the plant and animal species that occur in the wild, but because they also deliver direct and indirect benefits to people at a range of scales. Regulating ecosystem services are the benefits we derive from ecosystem processes (e.g. carbon storage, water quality and disease regulation). Provisioning ecosystem services are the ecosystem benefits that result in consumable products (e.g. food, fibres, biofuels). An example of this is the role of pollinators to increase crop yields. Contemporary thinking demonstrates the importance of species to ecosystem function, here such evidence is often associated with multiple habitat types (Gascon *et al.,* 2015). This raises an interesting question: what would be the consequence if certain species were missing from a given ecosystem? To address this question the importance of the species to ecosystem function and ultimately would have to

be determined through either theoretical thinking or experimental design. For example, the consequences of the loss of European beaver *Castor fibre* from certain types of freshwater environments would be probably immediate and apparent. This view is supported by the beaver's environmental role as an ecological engineer, modulating the availability of resources to other species and preventing flooding episodes downstream. However, what happens when a species, in either decline or extinct, is part of a complex chain of interactions, in the absence of underpinning science the ecological role of that species may become uncertain. It is fair to suggest the role of curlew in both Welsh upland and lowland farmed landscapes is obscure. In this section we examine both the theoretical and experimental evidence to support the view that maintaining or restoring favourable curlew grassland habitats has specific benefits for ecosystem services. Measuring cultural ecosystem services is notoriously hard to measure and is out of scope of this work.

*Grassland management*

Several of the management strategies proposed for curlew could enhance existing ecosystem services. The recommended changes to the management of lowland floodplain grasslands, for example, may reduce the frequency and severity of flooding. Management that seasonally increases grassland water levels and encourages the creation of reservoirs, such as ponds and scrapes, slows drainage and reduces peak flow (Grygoryuk *et al.,* 2013; Funk *et al.,* 2021). Peat bog restoration and the re-wetting of upland habitats for waders has the potential to either increase or decrease flood risk depending upon the topography and soil moisture of restored sites (Holden, 2005; Ballard *et al.,* 2012; Acreman and Holden 2013).

Discouraging more intensive forms of grassland management, such as silage production, will minimise fertilizer use in wet grassland habitats. The application of both organic and inorganic fertilisers can result in high levels of phosphorus and nitrogen run-off which lead to the eutrophication of rivers and streams (Steenvoorden, 1986; Withers and Lord, 2002; Withers *et al.* 2014). Pretty *et al.* (2002) estimated that the damage caused by freshwater eutrophication in England and Wales costs £75−114 million $yr^{-1}$. Increased phosphorus levels are harmful to freshwater fish (Salmon & Trout Conservation, 2017) which may impact economically important natural resources: salmon and trout fishing make a gross value-added contribution of £14 million to the Welsh economy (Mawle, 2018).

As well as fertilizer application, reducing agricultural intensity in floodplain grasslands may also mean reducing livestock densities and the frequency of soil cultivation. Reduced stocking and tilling leads to less compacted soils (Soane and Ouwerkirk, 1995) and higher earthworm densities (Kuntz *et al.,* 2013), which in turn improves soil quality. Improved soil structure slows surface run-off (Palmer and Smith 2013) and presents another means of reducing flood risk (Archer *et al.,* 2010; Palmer and Smith 2013) and soil erosion (Batey, 2009). Increased plant diversity in grassland habitats has been shown to minimise soil erosion (Berendse *et al.,* 2015).

Removing the need for disruptive management and more intensive forms of cultivation can improve the ability of grassland to sequester carbon (Conant, 2010; Bengtsson *et al.,* 2019). Intensively managed grasslands are more efficient at capturing carbon, but this is often outweighed by carbon release associated with their management (increased fuel use, etc.) and because carbon is only temporarily captured if land is periodically cultivated for resowing (Bengtsson *et al.,* 2019). The effective capture of carbon in semi-natural grasslands lies in the permanence of the system and lack of soil disturbance.

In the uplands, peatland habitats can provide an efficient means of carbon sequestration, but only if healthy, wet blanket bog habitats are preserved (Holden, 2005; Natural England, 2021). Conserving these habitats requires sympathetic management that is likely to be beneficial to breeding waders (Douglas *et al.,* 2014). The potential to sequester carbon through the restoration of former peat bogs depends on the relative rate of carbon sequestration of the current land use (often drained and afforested) and the carbon cost associated with restoration of the bog (e.g. drain blocking and felling). Lindsay (2010) states that restored peat bogs on formerly forested sites will have captured more carbon than lost during their creation after approximately fifty years, and thereafter provide a more effective method of carbon capture than an equivalent area of conifer trees. As such, curlew conservation recommendations to fell and re-wet areas currently occupied by forestry could increase carbon capture in the long-term providing the resulting blanket bog habitats are in good condition.

Curlew conservation still necessitates land management, albeit at a lower intensity, and these activities can provide ecosystem services through the utilisation of natural resources. Upland management techniques that benefit curlew, such as rotational heather burning or cutting and predator control (Tharme *et al.,* 2001; Fletcher *et al.,* 2010), overlap with the requirements of red grouse. Grouse shooting makes a gross value-added contribution of £23 million to the Scottish economy and creates 2,500 full-time jobs in Scotland (Thomson *et al.,* 2018).

Grassland management may provide fodder for livestock via a late-season crop of hay, although energy levels, digestibility and nutrient content of fodder derived from semi-natural habitats are significantly poorer than those derived from intensively managed grassland (Bullock *et al.,* 2011). Removing grass in the form of hay can counter locally elevated nitrogen levels as a result of past fertiliser application but grazing may prove to be a more efficient way of achieving this (Walker *et al.,* 2004). At lower stocking densities, livestock grazing is also an important tool to maintain and restore diverse sward structures in both upland and lowland habitats (Olff and Ritchie, 1998; Bullock *et al.,* 2011). Livestock grazing provides a source of food and income from a semi-natural habitat, but the viability of this depends on the ability to maintain profitability at lower stocking densities.

Less intensive forms of grassland management may encourage the use of rare breed livestock, such as Welsh cattle, which are said to be better adapted to lower-quality forage (Kent Wildlife Trust 2021). The reversion to traditional livestock and grazing methods preserves agricultural heritage and genetic diversity (Bullock *et al.,* 2011) and may offer a way of providing higher-value products that can partly offset lower productivity. The agricultural heritage of traditional grazing or hay-meadow management is also reflected in the appearance of the rural landscape and the preservation of traditional skills.

In these changing times regenerative agriculture is also gaining in popularity and focuses on improving soil health as the core objective which leads to many other ecosystem benefits. These include increased soil carbon storage, greater soil resilience to flooding and drought through higher organic matter levels and improved soil structure, improved nutrient recycling and improved soil biota that improves plant health and supports biodiversity up the food chain. A healthy crop also increases its resistance to pathogens. The link between higher profitability and higher organic matter is crucial to encourage adoption by farmers and there is also a compelling argument for reversing climate change.

It is hard to measure the direct contribution curlew make to local economies through eco-tourism, but they are one of a suite of species that defines the character of upland areas and makes them popular for recreation (Defra, 2013). The loss of iconic species from upland areas could contribute to public perceptions of an impoverished or over-exploited landscape and may lessen their appeal as tourist destinations.

The range of beneficiary species and ecosystems services that are considered to derive from curlew recovery measures are illustrated in the infographic (Figure 9)

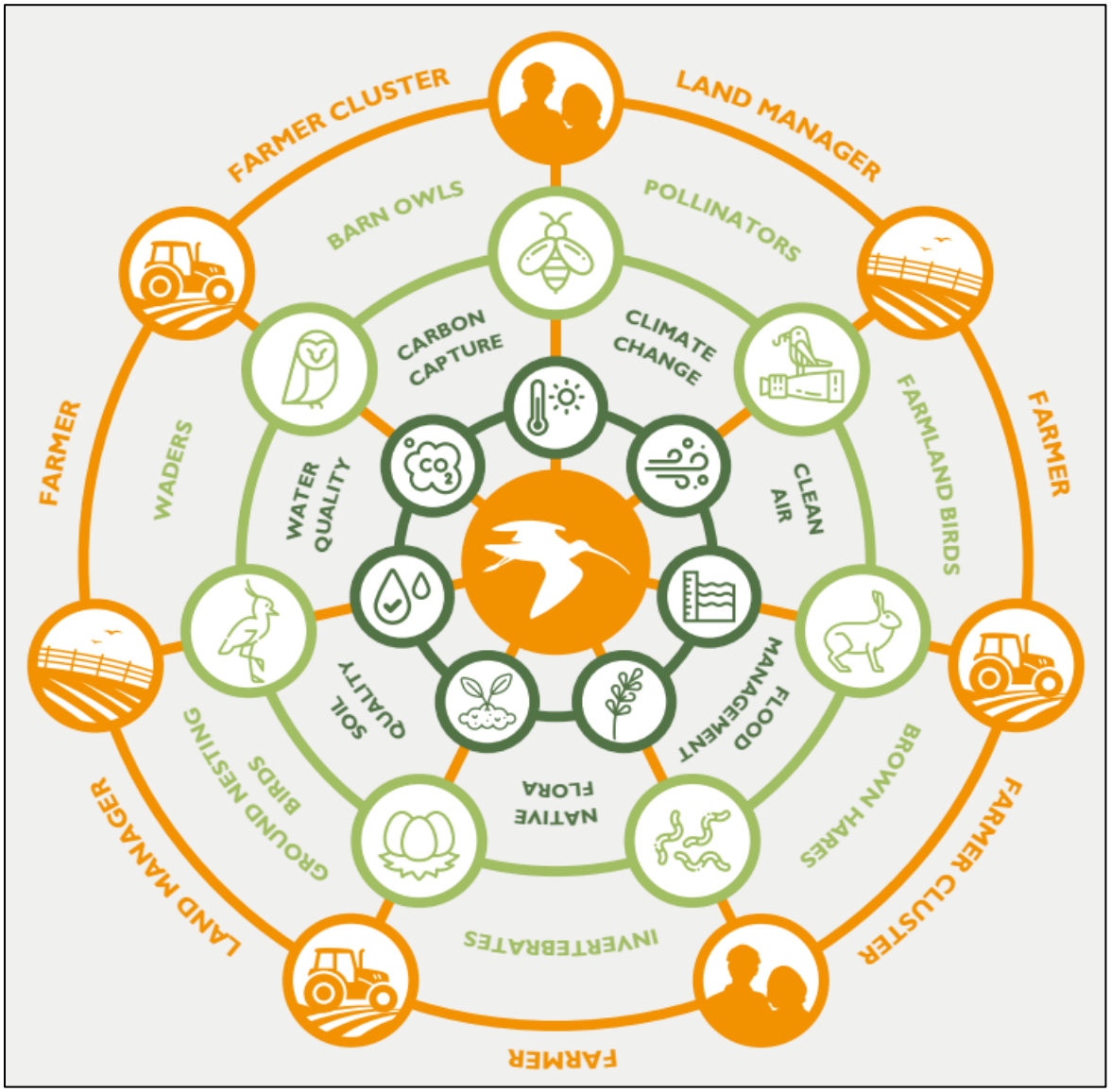


**Figure 9**. Infographic illustrating the wide-reaching benefits that have the potential to be associated with curlew recovery

The specifics for curlew conservation measures to be incorporated into any future farming scheme could play a significant part in preventing curlew extinction in Wales, but urgent measures are required before such a scheme is operational.

**Summary**

- Conservation work for curlew could provide multiple ecosystem services in line with Welsh Government and NRW policy in meeting the objectives of SMNR, the Environment Act Wales and the Wellbeing of Future Generations Act.
- Curlew is potentially a good biodiversity indicator species as their presence in a locality is only possible if other elements of that ecosystem are in balance, and other species are also thriving.
- Curlew as an iconic species has potential value when measuring Natural Capital and has the potential to attract funding as an additional incentive within a future monetised system for carbon capture within soils

# 6. Practitioner Case Studies

**Case Study 1: Curlew Country (Amanda Perkins, Project Manager)**

*Background*

Curlew Country was originally one of 15 projects which formed part of a Heritage Lottery funded Landscape Partnership Scheme in 2014. The project was re-designed to work in partnership with farmers and land managers, listening to their concerns and respecting their views. Significant new funding was sourced and culminated in Curlew Country initiating work in 2015. This project covers a core area of 200km$^2$, straddling the Shropshire/Powys border and focuses on a lowland curlew 'hotspot' of around 40 breeding pairs. At the heart of the project is community engagement.

*Crucial partnership between farmers/land managers and curlews*

The success of managing for curlew will only be realisable by developing confidence and trust in partnerships with farmers, land managers and owners and occupiers. Such an approach may facilitate the implementation of strategy into reality. By enabling and supporting farmers and land managers to take the lead will result in tangible outcomes that may otherwise be lost if the farming sector feels subjected to top-down pressure, in summary, farmers may be deterred if they do not feel able to make informed decisions about the land they manage.

In my working experience as a land agent and as project manager for Curlew Country, the farming sector has become weary of different organisations advising (they perceive 'telling') them what to do. It is fair to assume that, generally farmers are not working with conservation organisations regularly enough to understand the difference between them, their purposes, or their names and acronyms. In our dialogue with farming communities, they report that when they have engaged with conservation organisations, they have received advice that is:

- Conflicting
- Impractical
- Criticises farm business management without demonstrating an understanding of it
- Does not achieve mutual desired outcomes
- Costs farmers time and energy

Whilst often sceptical of conservation advice, which can be unwelcome to them, farmers and land managers are keen to engage with curlew recovery interventions. In the Curlew Country project, despite past difficulties with farmer engagement in previous attempts to discuss conservation initiatives, farmers and land managers were so keen to engage in curlew recovery that they were persuaded to put past negative experiences aside. Furthermore, farmers and land managers demonstrate the commitment and desire to want a scheme of curlew recovery which would benefit a range of other species and deliver multiple beneficial environmental outcomes. For example, in the Camlad Valley in Montgomeryshire, a successful Sustainable Management Scheme (SMS) application by a farm cluster to deliver multiple environmental outcomes was developed from work started

by the Curlew Country project. I see curlews are pivotal in initiating ‘conversations’ and as a species that galvanises spirit amongst communities in much wider conservation delivery. In Shropshire Curlew Country partners have applied to the Facilitation Fund[6] scheme to progress environmental outcomes that will benefit curlew. ‘Grass roots up’ farmer cluster work has proved essential to establishing, effective, trusting and action-based relationships at landscape scale between conservation practitioners and farming communities. A good example of the farmer cluster approach is the work on Martin Down, Hampshire, in boosting turtle dove *Streptopelia turtur* numbers. This collaborative approach allowed farmers, foresters and other land managers to develop a shared ambition, informed by evidence-based priorities, leading to an increase in knowledge to farm for the benefit of both people and wildlife. Farmer clusters are becoming recognised as a best practice model of progressive environmental activity European farmed landscapes.

Predation control is another key Curlew recovery tool but one that is not widely practiced outside moorland management. Lawful predator management is considered by many curlew practitioners to be a mechanism to improve curlew breeding success. In the Curlew Country project area farmers and land managers were initially reluctant to engage and frequently asked “Why should I bother to put effort into helping Curlews when the nests and chicks will all be predated?” Here, we persuaded many farmers to consider working on a bottom-up farmer-led basis with Curlew Country and we pledged to take lawful predation control equally as seriously as habitat management. On the flip side, local volunteers involved with curlew conservation frequently expressed reservations of the need for lethal predator control. After careful conversations explaining the supporting science, many considered predator control to be necessary to improve curlew breeding success.

Farmers passionate about helping curlews will often enter a ‘honeymoon’ period where they often sustained economic losses from silage grass crop sacrifices (c.4 hectares) in fields where curlew chicks were present. However, this often provided to be economically inviable over a period of 1-2 years.

Photograph courtesy of www.curlewcountry.org

[6] Facilitation funding is designed to support land managers working together towards achieving positive gains for their natural environment at a landscape scale.

Farmer engagement must dovetail with real recovery action. Enabling farmers to drive and make motivated and creative decisions about the future of their land through facilitated group working, in our experience, ensures confident, robust action that may ensure sustainability of some our natural resources.

One possible solution is multi-annual management for key conservation priorities, such as curlew, across farmed landscapes. This would be part of a wider plan to create a curlew recovery network delivering landscape scale environmental benefits. Each farmed landscape would be managed by a Farmer Cluster, under the guidance of a lead farmer and conservation advisors. Additional funding will be required to engage specialists to help identify curlew territories and measure other environmental outcomes.

Whilst it is the older generation who hold nostalgic memories of curlew abundance, young farmers invest in farm resilience and have embraced curlew as a keystone species, exploring the new environmental opportunities they will bring.

*Curlew headstarting*

There is widespread interest in the potential for headstarting, and related techniques, to contribute to curlew recovery in the UK and Ireland. Avian headstarting is the hatching, rearing and release into the wild of birds that have been harvested from the wild at the egg stage. It aims to increase productivity – and hence population growth rate - by rearing birds in captivity to increase survival during the egg and chick phase, when mortality in the wild is high. Headstarting has proved very successful in supplementing the Ouse Washes and Nene Washes black-tailed godwit *Limosa limosa* populations Headstarting – Project Godwit

Technically, headstarting returns captive-reared birds to the population from which they were taken. Headstarting is a intervention tool and is often seen as a last resort to prevent a population extinction. Curlews are long-lived birds and headstarting can buy time to get more complex measures in place to ensure natrual breeding success is sufficent to maintian populations.

Headstarting is complex and risky, and therefore requires detailed planning. Curlew Country have been developing and applying head starting techniques for curlew over the past five years. Other, pilot trials are currently being undertaken in England under the governance of Natural England, the UK and Ireland Curlew Action Group and a scientific working group.

A public engagement benefit of headstarting is that it is a good news story and good news captures peoples imaginations and expectations. Headstarting succes messages can also be deployed as a motivational tool to boost land managers trying to recover curlew populations on their land.

**Case study 2: Sustainable Management Schemes, farmer clusters and landscape scale conservation (Matthew Goodall, GWCT Wales Advisor)**

Farmers do a lot for Britain's rural environment, but there is only so much that an individual, acting in isolation, can do on his or her own farm. The Farmer Cluster concept, developed by the Game Wildlife and Conservation Trust (GWCT) in association with Natural England, is a plan to help a number of farmers work more cohesively together in their locality, enabling them to collectively deliver greater benefits for soil, water and wildlife at a landscape scale (Annex 4).

A Farmer Cluster is designed to start life at a bottom-up, farmer level, under the guidance of a lead farmer. They devise their own conservation plans, helped by their own chosen conservation advisors, whom they already know and trust. Although the work is often supplemented by existing agri-environment schemes, several Clusters have set up with no funding

The GWCT had seen success in involving farmers nationwide in conservation through the Partridge Count Scheme. GWCT developed the Farmer Cluster concept in 2011 working with the Marlborough Downs Nature Improvement Area (NIA) trialling the bottom-up approach and using hotspot farms to convert "farm-scale" conservation into "landscape-scale" conservation.

How do Farmer Clusters work? The establishment of a new Farmer Cluster begins with the identification of a lead farmer – a good farmer, respected in the community and prepared to lead, with strong green credentials. Farmer Clusters are designed to be farmer-led from the ground up, so the right choice of lead farmer is important. It is then important to determine what wildlife do you they want on their farms. This is the first step in generating a farmer-led and outcome-oriented approach, in which farmers appoint a lead farmer, choose their own advisor, set their own targets, and record their own progress.

Following this new approach to farmland conservation the concept of Farmer Cluster was presented to Defra in June 2013 and the Natural England Facilitation Fund was introduced in 2015. To date there are now circa 100 Facilitation Fund farmer Clusters in England with approximately 1700 farms involved, managing over 500,000 ha.

In Wales GWCT have used the Sustainable Management Scheme (SMS) to develop two farmer clusters which both aim to holistically deliver wider ecosystem services at a landscape scale, whilst enhancing each farms delivery of public goods within a productive farm business.

Whilst the overall scope of the SMS mirrors the objectives of SMNR it applies the bottom-up, farmer led approach where farms are asked which species, they are passionate about and which species they have seen decline on their farms. By focussing on the individual species level, each farm is inspired and motivated to take ownership, enabling greater results and increased success which in turn promotes their investment.

Farmer Clusters form the bedrock of major GWCT research projects including Waders For Real, where local farmers responded voluntarily to GWCT concerns about the conservation status of breeding waders, forming the Avon Valley Breeding Wader Project and securing EU LIFE+ funding. There are also Farmer Clusters centred on our

demonstration farms at Loddington, Leicestershire, and the Howe of Cromar, Aberdeenshire, the latter being the first of its kind in Scotland.

**Case Study 3: LIFE Waders for Real – case study for wader recovery (Matthew Goodall, GWCT Wales Advisor)**

*Background*

The Avon Valley is recognised as an important lowland wet grassland site in England and Wales for breeding waders. The LIFE Waders for Real project starting in 2015, was a four-year project to reverse the decline of breeding waders, namely lapwing and redshank, in the Avon Valley, a river floodplain of high biodiversity interest, part of which is designated as a Special Protection Area (SPA).

Habitat restoration measures, implemented on hotspot sites, included creating new scrapes and ditches in fields to increase surface water availability, sward height management, and removal of scrub and trees. These measures created suitable conditions for waders by providing a food source for chicks, appropriate cover within grassland, and reduced perches (trees and fences) for avian predators. Temporary electric fencing proved to be effective in protecting waders during the breeding period from mammalian predators.

*Findings*

The project team developed conservation plans for six sites in the Avon Valley and completed restoration actions on five of these. This improved 229 ha of habitat by creating water-meadows, and in-field scrapes and ditches, making it better suited to lapwing and redshank nesting/brood rearing. A reverse in the decline of lapwing in the Avon Valley was achieved, with the population increasing from 61 pairs in 2015 to 105 pairs in 2019. Productivity on hotspot sites averaged 0.75 chick/pair over the course of the project compared to 0.52 chick/pair on comparison farms elsewhere in the Avon Valley, this is about the critical level required to maintain a stable breeding population (0.7 chicks per/pair). However, lapwing densities are still at a level that will require continued intervention to exclude predators. Redshank breeding pairs increased from 19 to 35 pairs during the project. The enhanced habitat management created more suitable conditions for snipe over 32 ha. In the last two years of the project, snipe recorded displaying in May and June indicating that this species is returning to breed in the Avon Valley, although breeding was not confirmed.

One innovative aspect of the project was fox tracking using GPS collar. This showed a high fox density in the upper Avon Valley and the movement of foxes away from apparent territories in spring. The project team produced a best practice guide to erecting temporary electric fencing to protect wader nests from fox and other predators. The project implemented the EU Birds Directive, by focusing on three species (lapwing, redshank and snipe) listed in Annex II. At national level, the projects methods have informed Defra's approach for predator management, to be included in the new Environmental Land Management agri-environment scheme. The project has also influenced the Countryside Stewardships Facilitation Fund, which provides payment for a facilitator to help groups of farm managers work together at a landscape scale to effect greater environmental improvement, by demonstrating the farmer cluster concept.

Building trust and a feeling of cooperation between everyone involved, from estate owners to tenant farmers, gamekeepers and riverkeepers, ecologists and the local community was a crucial objective. The project was a joint effort from its very inception. The projects socio-economic assessment used the Theory of Change model to show how four key stakeholder groups benefitted from the conservation measures: farmers and landowners, gamekeepers, students and the wider community, and the Game and Wildlife Conservation Trust. Farmer practices have been influenced by the project, given that they are seeking to continue to cooperate as part of a 'farmer cluster' to help deliver continued benefits for waders. The students who gained practical skills and experience from the project were shown to have improved employment prospects in conservation and/or research.

To achieve long-lasting wader recovery, required the experience and knowledge from all of these groups. Regular meetings allowed farmers and wildlife managers to discuss the challenges faced and gave them the opportunity to share their valuable experience. This was very much a two-way conversation, with land mangers able to gain advice and support from our ecologists on topics from effective predator control to AES derogations and our ecologists were able to gain important insights from the people who see their land and birds every day. School visits were made to educate and enthuse local children and students about waders and the wider benefits of conservation, 31 undergraduate or master students conducting their own projects. Over 40 networking events, with over 50 conservation projects/organisations and government conservation agencies were organised or attended over the course allowing the message of working together for conservation to reach policy makers and scientists alike.

*Multiple species benefits*

Throughout the Waders for Real project, surveys of other species characteristic of floodplain habitats were carried out to understand any positive or negative impacts of the project's actions on the ecosystem functions.

Vegetation surveys indicated management over a ten-year period improved the quality score of vegetation communities of hayed fields more so than grazed fields. Fields with a high percentage of positive indicator vegetation species showed increases in earthworm abundance, highlighting the importance of floral biodiversity to earthworm species. High numbers of ground invertebrates were found through pitfall sampling representing a diverse invertebrate community, with denser, higher swards supporting larger invertebrates that may be useful for a wader's diet. This indicates the importance of creating a heterogeneous sward.

Increasing the size of the water body was found to contribute to greater abundance and diversity of invertebrates. This aligns with the traditional management of ditches recommended for breeding waders. Here, targeted re-wetting management for breeding waders would be totally compatible with good management for aquatic invertebrates. For example, producing gently sloping (30-45 degrees) banks with areas of bare sediment that are accessible to grazing stock is a specific recommendation for aquatic invertebrates and aligns well with good management for producing feeding edge habitat for both adult and juvenile waders.

Throughout the Avon Valley, winter wildfowl surveys were undertaken. Rainfall and associated flooding were positively correlated with winter occupancy by wildfowl such as

wigeon, teal and pintail *Anas acuta*. Ten species of ducks were recorded in the winter wildfowl surveys between 2015 and 2019. Mallard *Anas platyrhynchos* increased throughout the 2015-2019 period and gadwall *Anas strepera* sustained a small, increasing wintering population.

*Ecosystem Services and Restoration of Ecosystem Function*

The Millennium Ecosystem Assessment (MA), a major UN-sponsored effort to analyse the impact of human actions on ecosystems and human well-being, identified four major categories of ecosystem services: provisioning, regulating, cultural and supporting services. The Avon Valley provides all of these services.

Wetlands were one of the first ecosystems to be recognised in the early 1970s for their implicit values (Mitsch *et al.,* 2015). In fact, wetlands are sometimes documented as the '*kidneys of the landscape'* on the basis that they function as the downstream receivers of water and waste from both natural and human sources. Wetlands play a major role in the landscape by providing unique habitats for a broad spectrum of flora and fauna. Wader species associated with wet/damp lowland grasslands, such as curlew, redshank and snipe, are intrinsically reliant on some of the ecosystem services provided by wetland habitats; services such as water purification and storage, soil development, and the provision of habitat for diverse vegetation and invertebrate communities.

Evidence of breeding wader decline in the Avon Valley since the 1980s may be used as a proxy to indicate degradation in habitat quality and a reduction in the natural resources provided by these wetlands. Conversely, the positive habitat interventions (e.g. habitat creation, predator management, farmer liaison (through expert advisors) and community engagement) as part of the Waders for Real project increased breeding wader populations and helped to maintain a rich wet meadow vegetation composition and sward heterogeneity that supported diverse invertebrate communities, an important food resource for wader chicks and other breeding birds. In addition, the project most likely enhanced ecosystem services and alleviated ecosystem function degradation. For example, through positive farmer liaison sympathetic grazing regimes and stocking levels were addressed and grassland sward levels were favourably managed to provide the suite of ecological requirements of breeding waders.

*What were the key take-home messages?*

On damp grasslands, loss of botanical heterogeneity and invertebrate species-richness is often associated with improved drainage and the subsequent increased use of fertilizers, rye grass reseeding and increased stocking densities. (Morris, 2000). The Waders for Real project supported the findings of others that suggested retained or enhanced wet features retain water throughout the bird breeding season, maintaining a higher water table in the surrounding soil column than in other parts of the landscape. This is important as lowering of field water levels reduces densities of soil invertebrates (Milsom *et al.,* 2000) and soil penetrability, making the ground too hard for surface probing by breeding waders.

Waders for Real demonstrated how, given the right kind of funding, advice, and encouragement and by working closely with conservation bodies, experts and farming communities' biodiversity losses can be reversed over relatively large landscapes. This is important for two reasons: 1) restoration models for wetlands can be applied to other ecosystems such as peatlands and lowland and upland farmland and 2) nature reserves

are not enough to meet the challenges of the biodiversity emergency. It is estimated that 72% of the landmass in Great Britain is farmed, therefore it is essential that private land managers are properly supported to carry out favourable conservation interventions on a landscape scale.

The communication work undertaken as part of the Waders for Real project provided several opportunities for environmental education, another important cultural ecosystem service (Scholte, 2016). The Waders for Real project worked closely within the rural communities, visiting schools, country shows and other conservation organisations to share the project and highlight the importance of restoring wetland habitats for public health and wellbeing. By setting the scene and demonstrating key outcomes the Avon Valley farmer cluster which successful established and received Facilitation Funding in 2020.

**Summary**

Based on practitioner case studies it is clear:

- To aid curlew recovery there is a continued need for landscape-scale collaborative advice, support, and management.
- People care and are willing to work together towards a common goal.
- Single species recovery can deliver and benefit wider cultural, societal and environmental benefits, on the condition recovery projects are well designed.
- Working collaboratively at scale requires effective resourcing and benefits may take time to be realised. Inappropriate bureaucracy and time delays have the potential to damage already fragile working relationships.
- Collaborative working enables an influx of skillsets to meet the variable requirements of such projects. In doing so, many varied targets are achieved, from nature based, biodiversity targets to socio-economic targets and well-being objectives.

# 7. Conclusions

It is clear that Wales is important for a wide variety of species and habitats and in some cases have global, European and/or UK responsibilities. It is also becoming increasingly recognised that natural environments are important not only to the plant and animal species that occur in the wild, but because they also deliver direct and indirect benefits to people at a range of spatial and temporal scales. However, debate around the importance of single species recovery and the significance of delivered multiple benefits is highly topical. Here we have shown that there is evidence that targeted single species recovery projects can provide wider cultural, societal and environmental benefits.

In our review we identify and present the evidence that curlew conservation interventions can provide such multiple benefits:

1) To what extent are curlew supported by Welsh legislation and policy?

Against the background of declining biodiversity and threats to vital ecosystem services that sustain our economy and society, Wales has a legal and policy framework that provides a fresh approach for responding to the environmental challenges we face. This is mainly set out in two Acts: The Well-being of Future Generations (Wales) Act 2015 that aims to further the economic, social, environmental and cultural well-being of the people of Wales; and The Environment (Wales) Act 2016 designed to promote Sustainable Management of Natural Resources (SMNR) to maintain and enhance the resilience of ecosystems. Building on this legislative framework, Welsh Government has set out its commitments for biodiversity in the Nature Recovery Action Plan for Wales (NRAP). This recognises that a key requirement of the Sustainable Management of Natural Resources (SMNR) is to ensure that, through the underpinning principle of resilient ecosystems, Wales can continue to deliver its key UK, European and international obligations for biodiversity.

In Wales, breeding and non-breeding curlew are fully protected by law throughout the year. The species is listed as Near Threatened on the IUCN Global Red List based on its adverse global conservation status and as Endangered in Britain by Stanbury *et al*. (2021). In addition, curlew is a red-listed Bird of Conservation Concern in the UK (Stanbury *et al*., 2021) and Wales (Johnstone *et al.,* 2023).

2) What are the biodiversity benefits, with specific reference to species of conservation concern, associated with favourable curlew land management?

Good breeding and feeding curlew habitats are associated with a heterogeneous landscape structure, usually positively correlated with greater biodiversity. On this basis, the following are suggested as being more likely to occur:

- Long-term, diverse and insect rich pastures with minimal carbon emissions.
- Low local and landscape predation pressure which benefits other ground nesting birds.
- Heterogenous sward structure and diverse composition of dwarf shrub.
- Communities that are ecologically conducive for a wide range of invertebrates, mammals and other species of birds.

- Damp, probe-able soils may have higher carbon content, higher abundance of soil invertebrates and greater porosity (often associated with reduced flood risk) than drier soils.
- Low levels of agricultural intensity are negatively correlated with food production but positively correlated with aspects of wider biodiversity, such as ground-nesting birds and insect diversity and abundance.

Our findings from a literature review and an ecological interpretation support the hypothesis that targeted habitat management to meet the ecological needs of breeding curlew provides multiple benefits for biodiversity. Here, we determine more than 84 species across different taxonomic groups may benefit either directly or indirectly. This includes 20 species of Birds of Conservation Concern4 Wales and 26 additional species of bird, mammal, reptile, amphibian and invertebrate species listed in the Section 7, Environment (Wales) Act 2016). The examples in our review highlight a diverse set of potential beneficiary species, in ways that, though unquantified in many cases, are complex and are indirectly and directly associated with curlew recovery interventions.

In summary, our report highlights the wider value of target curlew friendly interventions whereby, legislative requirements, economic efficiency and wider biodiversity benefits are delivered and supports our understanding of how curlew may act as an important 'key stone' and 'indicator' species.

3) Do curlew have cultural significance and well-being/societal benefits to people in Wales?

Curlew is an iconic species of Wales referenced frequently throughout Welsh history, theology, literature, arts and other literal heritage. The evocative curlew call, in particular is well known and loved and referred to by many as the 'herald of spring'. As expected, the views and opinions of the people of Wales, as demonstrated by our online survey, on the importance of the curlew's continued existence in the Welsh landscape is closely aligned to Welsh cultural heritage and significance.

At one project location on the Shropshire/Powys border, a bottom-up and farmer focussed approach led to both nature-based success and contributed to community well-being. Here, farmer focused groups aided by a competent facilitator become motivated by their own success and often inspire wider communities to discuss curlew conservation. Such landscape scale collaborative clusters become knowledge sharing platforms, creating coherent social groups of like-minded individuals who interact more closely within the wider community, including local educational institutions, and start to deliver positive conservation outcomes by creating their own legacies. This work demonstrates a strong link between curlew recovery that can directly benefit human well-being, underpinning the importance and intrinsic value of curlew, today and tomorrow. We were unable to quantify the economic or human well-being value of preserving curlew as a means to facilitate policy and/or restoration measures, this was out of scope of our work.

4) What are the key ecosystem services derived from land management practices associated with curlew conservation?

We have shown that targeted curlew recovery has the potential to underpin ecosystem services such as increased populations of pollinators. This potential alone, supports and

meets all nine principles of Sustainable Management of Natural Resources, important aspects of the Well-being of Future Generations (Wales) Act 2015 and the Environment (Wales) Act 2016. As natural capital becomes more integrated in day-to-day land management, work targeted at curlew recovery is well placed to act as a delivery mechanism for other key areas such as, improving soil health, grassland diversity and water quality. For example, we advocate improving soil health enables foraging curlew better access to increased invertebrate numbers whilst directly enhancing soil structure, soil moisture and increasing organic matter. Favourable grassland management can potentially, at a range of spatial scales, provide solutions for both ecosystem services (e.g. water quality, carbon sequestration, soil health and flood alleviation) and grassland wader conservation.

Though over the past decade there has been disagreement over the importance of biodiversity in promoting human health, modern conservation strategies are now evolving to incorporate greater emphasis on understanding and communicating the wider benefits that nature brings to society. Here, we support the principle that ecosystem services can work towards a more sustainable society by which threats to species might be reduced whilst improving human well-being. Our curlew focused case studies support some of the benefits people derive from ecosystems and how ecosystems services can benefit through targeted and focused species recovery interventions, such as those connected to curlew conservation.

As the proposed Sustainable Farming Scheme in Wales is linked to wider ecosystem goals and biodiversity enhancement, we highlighted the importance of addressing the issue of co-ordinated implementation at the appropriate scale for curlew conservation through the proposed collaborative layer.

Targeted curlew conservation interventions have the potential to deliver multiple socio and environmental benefits in the proposed Sustainable Farming Scheme in Wales (current Glastir options that may benefit breeding curlew are presented in Annex 3). This view needs to be both recognised and considered by decision-makers, with particular emphasis on how this represents value for public money for public goods. However, the attempt to assign a value to ecosystem services may result in different species having differing intrinsic and monetary values (Gascon *et al*., 2015). In summary, in cases where it is inherently difficult or time consuming to demonstrate quantifiable links between individual species (such as breeding curlew) and critical ecosystem services we should give way to an intelligent “by proxy” or precautionary approach until evidence is provided. For example, application of sensible ecological interpretations may conclude that curlew recovery initiatives at the landscape scale have the capability to deliver a diverse set of services (e.g. soil moisture, soil health, invertebrate diversity (including pollinators), grassland composition and flood alleviation).

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**Annex 1.** Dafydd Iwan's song 'Ai Am fod Haul yn Machlud' which makes reference to the curlew and the sadness of its call being silenced.

Ai Am Fod Haul yn Machlud?

Ai am fod haul yn machlud
Mae deigryn yn llosgi fy ngrudd?
Neu ai am fod nos yn bygwth
Rhoi terfyn ar antur y dydd?
Neu ai am fod côr y goedwig
Yn distewi a mynd yn fud?
Neu ai am i rywun fy ngadael
Rwyf innau mor unig fy myd?

Ai am fod golau'r lleuad
Yn oer ar ruddiau'r nos?
Neu ai am fod oerwynt gerwin
Yn cwyno uwch manwellt y rhos?
Neu ai am fod cri'r gylfinir
Yn distewi a mynd yn fud?
Neu ai am i rywun fy ngadael
Rwyf innau mor dywyll fy myd?

Ond os yw yr haul wedi machlud
Mae gobaith yng ngolau'r lloer,
A chysgod yn nwfn y cysgodion
I'm cadw rhag y gwyntoedd oer,
Ac os aeth cri'r gylfinir
Yn un â'r distawrwydd mawr,
Mi wn y daw rhywun i gadw
Yr oed cyn toriad y wawr.

Dafydd Iwan

*Is it because of the setting sun*
*That tears sear my cheek?*
*Or is because night threatens*
*To end the adventures of the day?*
*Or is it because the woodland choir*
*Have ceased and become silent?*
*Or because someone has left me*
*That I am so lonely?*

*Or because the light of the moon*
*Is cold on the cheeks of the night?*
*Or because a cruel wind*
*Is moaning above the moorland?*
*Or because the cry of the curlew*
*Has silenced and become mute?*
*Or because someone has left me*
*That my world is so dark?*

*But although the sun has set,*
*There is hope in the light of the moon,*
*And shelter deep in the shadows*
*To keep me from the cold winds,*
*And although the curlew's call*
*Has melted into the great silence,*
*I know that someone will*
*Return before the break of dawn*

Dafydd Iwan

**Annex 2a.** Questions used in GWCT curlew questionnaire for Wales

Q1) In which county do you live/work?

Q2) What is your age?

a) Under 25
b) Between 25 – 40
c) Between 40 – 60
d) Over 60

Q3) When was the last time you saw or heard a curlew in Wales?

a) Within the last 2 years
b) Within the last 5 years
c) Within the last 10 years
d) More than 10 years ago

Q4) Curlew are classed as being an important species for our culture and heritage, holding an important place in the hearts and minds of our rural communities. Would you agree?

a) Yes
b) No

Q5) How important is the continued existence of curlew in Wales to you?

a) Not important
b) Fairly important
c) Very important

Q6) On current trajectory curlew are estimated to be extinct as a breeding bird in Wales by 2033. Based on this statistic do you think urgent curlew recovery work in Wales is either

a) Not important
b) Fairly important
c) Very important

Q7) Given that curlew is such an important species, and are likely to be extinct as a breeding bird in Wales by 2033, do you think that it would be right for government to prioritise conservation funds to curlew recovery?

a) Yes
b) No

Q8) Do you think that other species might also benefit from a recovery package aimed at curlew?

a) Yes
b) No

If yes, please select which species you think may benefit from the list below:

a) Lapwing
b) Snipe
c) Redshank
d) Golden plover

e) Meadow pipit
f) Barn owl
g) Field vole
h) Invertebrates including field grasshopper, rove beetles and spider communities
i) Flora including marsh marigold and cuckoo flower

j) Other

If you selected other, please use the box below to list any other species you think may benefit from curlew conservation.

Q9) Please use this box to provide your personal opinion as to why curlew is worthy of conservation efforts in Wales.

**Annex 2b.** Testimonials received in response to question 9.

1. I think people need to on top of vermin a lot more especially of the corvid family, very little is done about them in North Wales Farming is bad for them in North Wales also ,silage is cut so early and with up to 3 cuts per season anything ground nesting doesn't really stand a chance as mowers shave the grass off so tightly Maybe have a look down the avenue persuading farmer's for better conservation

2. Loss of our history and tragic extinction of species should be stopped

3. To save them from extinction & increase the population. Unable to answer Questions 11 & 12 not knowing what the recovery package includes...does it include badger control?

4. We have lost so many of our once very common farmland birds. Instead of a joined-up effort to help critically endangered birds such as Curlew and Grey Partridges we are seeing illogical, irrational, knee jerk changes to how we can assist these birds. Changes to the relevant general licence are I'll thought out as they now only allow reactionary culling of very common Corvids known to predate nests for eggs, chicks and fledglings. There needs to be a change back to preventative culling as the numbers of these very common Corvids means that if we are only able to rely on reactionary rather than proactive culling the Curlew et cetera will simply not survive

5. The curlew is the iconic breeding wader of the uplands and its survival would be a reflection of a society committed to preserving and enhancing a magical, diverse and thriving upland environment which was prevalent in previous generations. Its loss would reflect yet another dereliction of duty whilst its revival would be a triumph of action over good intentions and complacency. Restore the curlew and restore so much more of the natural magic of the uplands, as well as uplift the human spirit.

6. I manage circa 4000ha of heather moorland in SE Wales where both Curlew and Lapwing were once prolific. This haunting and iconic bird would be an enormous loss to Wales. I am currently trying to improve habitat and conditions to attract breeding birds. The difficulty is

that Curlew are quite faithful to breeding sites so brood management might be worth considering.

7. I haven’t seen these birds on any of Wales uplands, I have to go to Scotland to see these iconic birds

8. With curlew populations declining drastically across Europe, surely wales have the optimum habitat and should trailblaze conservation of ground nesting bird species- lets protect all not focus on one species alone.

9. They are an integral part of the Welsh ecosystem and we owe it to ourselves and future generations to maintain this.

10. Before anything is done, we need to know what is there. No survey has been carried out on my farm I know there are woodcock, spotted flycatchers and skylarks. Curlew are worthy of conservation but not near me where other species need support. The questions in the survey are too black and white and assume a high degree of knowledge of an involved and intricate subject.

11. There are too many red kites around i have seen kites kill curlew chicks on our land.

12. I have worked hard to get the farm suitable to draw in the curlew after an absent of around 30 years without hampering on food production and last spring they came back to my delight. but sadly, after hatching the chicks were destroyed by the predators that are in the area.

13. They are part of the hills and were here long before humans. Love to see and hear them

14. Iconic bird that has reduced dramatically as badgers have increased

15. Part of the sound and sight of the countryside.

16. The loss of any species is a tragedy, Curlew are part of a natural system that should be protected for all our futures. The sight and sound of this bird connects with nature.

17. I grew up seeing and Hearing Curlew and would love this to continue

18. All wildlife conservation is important because of modern pressures on the environment

19. Every year around mid-February. I wait for the call of the Curlew, coming to nest in the field near me. The first sign of Spring for me. It would be a tragic loss. They are part of our countryside.

20. All species are important for each species would not exist if it didn't play a role somewhere in nature.

21. Sadly, they haven't been here for many years and it is probably too late to get them back but this iconic bird with its melodic mournful call should not be lost to Wales

22. The evidence of a decline in inland nesting on local farmland has declined over the last ten years. Why? A reason needs to be found

23. Curlew are iconic to wild open areas in wales can be enjoyed by many from a distance without even being seen! conservation work would force areas to be set aside for wildlife and waders to re-establish.

24. The cry of the curlew is haunting and one I remember rom my childhood in Scotland. After living in Wales for 44 years I have never heard it - and neither have my children- how sad for them.

25. The presence of Curlew in both Wales and Herefordshire have been a most memorable aspect of my past life in the countryside

26. Because their seasonal change of habitat brings them to the notice of numerous persons with their distinctive wild call which, at present, is so seldom heard

27. Because they are part of the overall species balance. There is a need to maintain a balance of all species, rather than picking on particular species. As example the Red Kite is now overpopulated, resulting in pressure on other species such as Buzzard which has now has a reduced population. Grey Squirrels and Mink need to be eliminated being a non-endemic species predating other natural species such as small birds and water voles.

28. Iconic sound and sight for our uplands and estuaries.

29. Every species is worth preserving and saving for the future. The targeted approach for this is to ensure those species including curlews, have areas available to ensure reproductive success, and adequate food source. I believe that one of the curlew’s biggest causes of their current demise are wind turbines built in areas that they previously nested at. Unless designated zones are saved from future planning development, then curlews and many other species at those sites are at a real risk of extinction.

30. Curlew have been a much-enjoyed part of country living. Their decline points at farm support policy which has been focused too narrowly on sheep in Wales, without consideration of other public goods: biodiversity, water retention, carbon storage. Many farmers would appreciate working in a more balanced policy framework.

31. I can't bear the thought of any creature becoming extinct. I'm sorry I can't really answer some of the the questions ie questions 11, 12, 14 as I'm not educated enough about those issues. But I want to support the conservation of curlews if I can - not sure I have helped by filling this in. But where I live, I would say I hear curlews a few times a year at least in the winter.

32. They're a flagship species with a range of reasons for their decline. If all the reasons can be addressed multiple benefits for biodiversity can be achieved

33. Such an iconic bird and sound on the Welsh estuary and uplands

34. Extinction must be avoided at all costs.

35. This is an iconic upland species. Without the sound of its bubbling call our marshland would feel much emptier. Moreover, curlews are a sign that some of our wild places are still intact.

36. They are an iconic species to Wales and are an important part of a healthy upland ecosystem. They are beautiful bird and their call is sublime.

37. Beautiful bird whose sound tells us that summer is here!

38. I believe the Curlew is a much-loved bird of marsh and marginal land in coastal and upland areas. To lose this iconic bird would be a tragedy, however, it is not surprising that it has declined to such an extent. The loss of marginal upland by farmers seeking to improve grassland is one of two principal reasons for the decline in numbers. The other reason being reduction in the number of gamekeepers and hunt packs which kept predators in check. There are vast areas of Welsh countryside that have no keepers or hounds. I would not wish to never hear the cry of the Curlew again. The bird has been protected since 1981 but we are so close to losing it forever, funding from some source must be made available in a bid to save this wonderful bird.

39. Any loss of species has a knock-on effect on other species and environments. Keeping as many varieties as possible is important to maintain the balance of a healthy sustainable environment.

40. The distinct call of the curlew is something special and represents the uplands of Wales, unfortunately the loss of habitat is the reason why the numbers are falling. Where there was once wild marsh upland now there are ploughed fields plastered with chicken muck from intensive poultry sheds.

41. It’s not about curlews per se - most farmland species are in decline, but curlew is one of the most iconic. We should not be having targeted packages at single species because that would be a waste of money and would not address the wider causes for species decline which is primarily habitat loss/intensive farming regimes/pollution and mismanagement of

farmland at the expense of the broader health of the environment - if the new agricultural scheme addresses broader biodiversity destruction then the curlew will make a comeback as will most other things - we need nature friendly farming

42. Q 14 is not applicable as I do not own a farm, though I'd be happy to help others. I'm a wildlife photographer as well as qualified in conservation. Curlews, as with other species, are here for a purpose in nature and conservation in their own right. With their loss, not only do we lose a beautiful bird, but we must ask what role they now play in the environment that would ultimately be lost to the detriment of all. Also, if treated as a keystone species, any protection programme will provide some protection for other vulnerable species. My favourite stretch of coastline photographically has a colony of curlews, a resident kingfisher and at least one barn owl uses this coastline as part of its hunting territory. In focusing on the curlew, this adds protection to these vulnerable species also, without disclosing to the wider world where they are (in case of persecution - especially to the owl(s)).

43. It's important that we preserve all our species native to Wales

44. Helping curlew will help other species to flourish as well. Vermin control is one of the key factors. Personally, I remember hearing the curlew which was recognised as heralding spring - I never hear it now.

45. Exterminating every predator is not the key to curlew survival and I’m outraged you can call yourselves a conservation group! You know full well that it is modern farming techniques that is the demise of the curlew! Stop trying to spin your slaughter of native wildlife to justify introducing millions of non-native game birds to kill for “fun”! You do not fool anyone but the mindless psychopaths that kill for fun! Your organisation is disgusting!

46. Any species with dwindling numbers needs to be supported. I have wonderful childhood memories of these birds.

47. Loss of any species leaves our lives poorer

48. Moving to Wales last year from Staffordshire it was nice to see curlews again and even more of a joy to see them, there wasn’t many, and it would be nice to see them increase in population.

49. Beautiful and traditional part of countryside. Important reflectors of the environmental health of the countryside.

50. It's a wonderful bird to watch and listen to. Important part of our eco system.

51. Iconic update birds. The sound of summer and good indicator species.

52. An iconic and beautiful bird with a wonderful call. Must be preserved for future generations

53. I miss them... They were an important part of my childhood and younger years

54. They're a part of the old heathland

55. Sound of curlew calling is always evocative of wild places

56. All wildlife and nature in Wales is worthy of conservation efforts. It is well known that the UK in general is probably the most wildlife and nature depleted countries in the world - in particular Wales and Ireland. We cannot just be content with domestic animals only in our countryside - especially when that comes at the detriment to wildlife and nature, all of which is facing an extinction event. We need to rebalance the scales; nature needs re-establishing and re-introducing - Rewilding in fact. The EU habitats directive makes it clear - we should be bringing back all the species we have eradicated in our countryside, and we need to make absolutely sure we do not lose any other species, we lessen our own loves when we do this. I am sick of driving around Wales and all you see is domestic animals (sheep and cattle) in fields rather than real wildlife.

57. It is a familiar sound of the past which is sadly disappearing, I hear from time to time on the mountains near Brecon, it’s so important to protect their habitat from shooting and vehicle

58. Since childhood always heard sound of curlew, big part of countryside. Main problem for number decline is badgers and raptors.

59. The sound of the Curlew is one of the first sound of spring. Heard at the end of February often after dark. Penybont Common where I live used to have over 100 pairs in the early 80’s now only 2 pairs. If we cannot save the Curlew it is a damming indictment of failure by Government, RSPB, farming, and land managers. Some organisations are full of talk and extraordinarily little action. The only hope for this iconic bird is habitat management, working with farmers to preserve chicks in June by later cutting and predation control. Without all three addressed and financing from Welsh Government it is inevitable that the extinction by 2033 will happen. But just as importantly in Wales it will not be just the curlew we will lose.

60. It's part of our culture and landscape, especially our estuaries, beaches and moorland. Its call is atmospheric and beautiful.

61. Iconic species and an indicator of wider environmental health

62. Curlew and all the other species that are in danger are worthy of conservation efforts. We can't continue destroying habitat that our wildlife depends on for a farming industry which is failing us. Sheep farming in Wales is especially damaging to higher ground and contributes very little to our food needs whilst also being massively grant funded.

63. They are vulnerable as are all ground nesting birds to badgers and foxes and newer agricultural practices especially earlier grass cutting for silage. Emotively, the country-side would be the poorer without their plaintive calling

64. All wildlife deserves preservation

65. Every species plays an important role in the natural environment, we should make every effort not to let any endemic species disappear from our landscape.

66. Curlew are an iconic bird, their calls bringing joy. Our local breeding birds have been unable to stay and nest in the fields due to dry conditions in spring. If they can't get their beaks into the ground, they can't feed. Global climate change is a huge part of the story

67. Beautiful birds love to hear and see them

68. A very attractive and unique bird with a distinctive call must be encouraged

69. Not sure where you get your statistics from, but I saw around 20 pairs flying by estuary in Porthmadog

70. This beautiful bird is worth more than money can buy, it's happy bubbly voice, lifts the lowest of low in spirit. They used to nest here, but only hear them about a mile away.

71. Because they are Beautiful and are vital birds in the ecology of our environment. And it would be a pity to lose them. And there have been many success stories of recovery of some rare birds, let's not lose another one!

72. A wonderful bird with a Mesmerising call.

73. Every species should worthy

74. I am curious as to how this decline occurred. When I was young 1950 to1960's the upland a of the Nantlle Valley was a breeding ground for hundreds of Curlews. Their calls enlivened the air. Then all of a sudden they disappeared. The environment has changed but not that much there are less sheep moorland grows wilder. No more grass fires. So ground cover is better. Land drainage is poorer. More horses, less cows. More trees. About the time of the decline oregano phosphate sheep dips were used, perhaps coincidence. Though on the whole one would think things have improved for birdlife. Wild duck and geese have appeared. Buzzards, peregrine, red kites have made slow comeback; though not in significant numbers. Since the scrape, mad cow disease period, the disposal of fallen animals has changed. Pressure on predators such as foxes, corvids, mustelines etc has increased due to the loss of this food supply. I am not convinced that this contributed to the decline of curlew population, but it would make re introduction difficult. We need meaningful answers and quick. This great bird has been decimated. We need it back.

75. Iconic bird, who in my lifetime have disappeared from many locations. Thank God for Newport Wetland lagoons and tidal area, often see them there.

76. It's all species that are worthy of conservation and hats off to the shooting fraternity in Wales for all their hard work although it's not recognised by all bodies

77. They’re an iconic bird that have been part of our landscape for years. Is it possible so many turbines on our uplands, especially in South Wales is having a detrimental impact on upland birds?

78. All of our birds, insects and mammals need our help, we are lost if we neglect our natural world. This current Pandemic should be telling us that, we must learn the lesson!!!!!!

79. Curlews like cuckoos Are the messengers of spring and early summer and I am fortunate to be able to listen to them every morning and evening through the spring and early summer

80. My last chosen answer might seem inconsistent with those that preceded it, but it is not the case. Please let me explain. I think your questions are loaded to provide a case for species-specific conservation approaches. While I appreciate and understand the value of such approaches (whether it be for Curlew, Lapwing, Hen Harrier, Black Grouse, etc) my experience in nature conservation (a career of 40 years) is that this species-focused approach, while it may have had some spectacular successes (e.g. Osprey, Red Kite, Sea Eagle), has, as an approach, contributed to a much wider failure for nature conservation in the UK and elsewhere. The best time to conserve species is when they are common, or at least not as rare as they have now become. That is not to take a defeatist position. We can hopefully see Curlew recover but it will need a bold whole-ecosystem approach. And that needs confronting the cause of Curlew (and other shorebird species) declines from our uplands and agricultural lands in Wales. The last 40 years + we have seen upland land-uses in Wales dominated by agricultural measures that have focused on sheep as a monoculture with practices such as destructive intensification of upland grassland management, drainage, fertilizer and pesticide applications, burning - all of which have contributed to degrading vegetation structure and ecological function, peatland hydrology, soil health and associated invertebrate populations, and so on. That is what has accumulatively ruined the Welsh uplands for Curlew and other species. Focusing on remnant Curlew populations with postage-stamp scale schemes are unlikely to succeed, and the approach may well lead to calls for intensifying predator management (Foxes, Ravens and maybe even raptor species). It is not the way to go. However, I appreciate that Curlew can be both useful flagship and indicator species by which we can measure the success of broader environmental habitat improvement programmes. So, I believe you need both: broader approach to more holistic environmental sustainability for our uplands as well as a holistic focus on key species such as Curlew. We used to have breeding Golden Plover and Dunlin in Wales. Why did we lose them? Why are we losing Curlew? Unless we go to the Welsh government with honest assessments and answers to these questions, we will likely fail. Good luck.

81. Any endangered species is worthy of conservation measures, but the curlew is iconic and breeds on a habitat that is also endangered.

82. We have a flock of about 50 curlew I see here very often and would like to see them increase

83. Play important role in the ecosystem

84. They are a special beautiful bird that desperately needs our help now to survive.

85. It's an iconic species but we cannot afford to lose any biodiversity.

86. We are losing far too many of our iconic birds and wildlife. Curlew are the epitome of wilderness

87. Curlews will survive if left alone rattler than being people trying to find their nests etc filming crews getting people too interested in seeing for themselves.

88. A focussed approach to conserve curlew by improved habitat and predator control will benefit a wide range of other endangered species. Wales has a substantial area of potentially suitable habitat for curlew which makes it a good starting point for better protection. Many, farmers and landowners are more likely to be motivated to join in conservation work with a focus on such an iconic species.

89. They are a lovely bird and need all the help they can get. Wind Farms have devastated some breeding ground also Hare breeding is being affected by wind turbines!

90. I believe conserving the environment as a whole is important but if certain species are declining at an advanced rate then a focus should be on stabilising those populations. Curlews are an important part of the environment and few things are as hauntingly beautiful as hearing their call whilst walking in the hills. It would be a tragedy to lose that.

91. They are on the brink of extinction in Wales and the rest of the UK are aware of this crisis

92. We have curlew nesting here annually; it is important to me that we keep their habit to preserve their breeding grounds

93. Biodiversity

94. Due to extinction

95. This bird was indigenous to my local area when I grew up in this area in the fifties, and it's longing flute sounding call mesmerizingly tuneful.

96. Because their numbers have plummeted, we are an organic farm and hardly changed our farming practice over the years, 2 years ago we had a fairly successful breeding year. Last year not so good. Corvids are a significant problem to their breeding success.

97. If we fail to conserve the population we have left and even increase it we will have failed to save an iconic bird while we've still got thus proving with all shooting, conservation, farming organisations and government working together we might have a chance of helping other red and amber listed birds, mammals and habits of still being enjoyed by future generations

98. Such an unusual bird with it's looks and haunting sound. I feel honoured to have them attempt to nest on our farm. Sadly, I think badgers or foxes are finding the nests.

99. I don’t want the Curlews to die out, I enjoy watching them when I see them about

100. First of all its my favourite bird, we have many on our farm and look forward to hear and see it every year.

**Annex 3**: Glastir Options 164-6 Pages 128 – 131 Glastir Rules Booklet 2: Whole Farm Code and Management Options).

Option 164 **– Grassland Management for Curlew (Nesting and Chick Feeding)**

 Maintain as grassland by grazing

 From 1 April to 15 July 25% of the sward must be less than 5 centimetres in height, 25% of the sward must be between 20 centimetres and 30 centimetres in height, the remaining 50% of the sward must be less than 20 centimetres in height.

 Develop a sward that contains at least 3 plant species by year three of the contract and at least 4 plant species by the end of the contract, excluding ryegrass, white clover, notifiable weeds and non-native invasive plant species

 Rushes must be maintained but must not exceed 30% of the area.

 Farmyard manure may be applied between 16 July and 31 March of the following year.

 Keep a record any field operations including cutting or topping in the Activity Diary and make it available as required.

Do not:

 Apply inorganic or artificial fertilisers, slurry or dirty water at any time.

 Apply any herbicides, insecticides, fungicides or molluscicides.

 Apply lime or any other substance to alter the soil acidity.

 Plough, cultivate, reseed or broadcast seed.

 Carry out any field operations (including cutting or topping) in enclosed fields between 1 April and 15 July

 Install new drainage, modify existing drainage or clear out existing ditches.

 Burn vegetation or other materials.

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 Roll or chain–harrow.

 Supplementary feed.

 Plant trees.

 Carry out any earth moving activities.

 Use for vehicle activities or as a track.

 Construct tracks, roads, yards, hard-standings or any new structures.

 Store materials or machinery.

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**Option 165 – Grassland Management for Curlew (Adult Feeding)**

 Maintain as grassland by grazing.

 From 1 April to 15 July 80% of the sward must be less than 5 centimetres in height.

 From 31 July to 15 March of the following year at least 20% of the sward must be less than 7 centimetres in height and 20% of the sward must be more than 7 centimetres in height.

 Develop a sward that contains at least 3 plant species by year three of the contract and at least 4 plant species by the end of the contract, excluding ryegrass, white clover, notifiable weeds and non-native invasive plant species.

 Rushes must be maintained, but must not exceed 30% of the area.

 Farmyard manure may be applied between 16 July and 31 March of the following year.

 Keep a record of any field operations including cutting or topping in the Activity Diary and make it available as required.

Do not:

 Apply inorganic or artificial fertilisers, slurry or dirty water at any time.

 Apply any herbicides, insecticides, fungicides or molluscicides.

 Apply lime or any other substance to alter the soil acidity.

 Plough, cultivate, reseed or broadcast seed.

 Carry out any field operations (including cutting or topping) in enclosed fields between 1 April and 15 July

 Install new drainage, modify existing drainage or clear out existing ditches.

 Burn vegetation or other materials.

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 Roll or chain–harrow.

 Supplementary feed.

 Plant trees.

 Carry out any earth moving activities.

 Use for vehicle activities or as a track.

 Construct tracks, roads, yards, hard-standings or any new structures.

 Store materials or machinery.

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**Option 166 – Hay meadow Management for Curlew (Nesting)**

 The rules for habitat under the Whole Farm Code apply to all the land within this option except that farmyard manure may be applied every other year.

 Maintain as grassland by grazing and hay cutting. Cut once every year, after 15 July.

 The field must be shut off to livestock by 1 April every year.

 Maintain an aftermath sward height after cutting where 80% of the grasses are between 5 centimetres and 15 centimetres high.

 It is acceptable to make hay or haylage but not silage. Hay or haylage must

be turned at least twice.

 The cut material must be removed from the site, even if spoiled by rain.

 Keep a record of the date on which the meadow is shut off to livestock, cut and when cut material is removed in the Activity Diary and make it available as required.

Do not:

 Cut below 2 centimetres.

 Graze until 4 weeks after cutting.

 Carry out any field operations between 1 April and 15 July

 Clear out existing ditches.

 Apply any insecticides, fungicides or molluscicides.

 Apply lime or any other substance to alter the soil acidity.

 Burn vegetation or other materials.

 Roll or chain–harrow.

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 Supplementary feed.

 Plant trees.

 Carry out any earth moving activities.

 Use for vehicle activities or as track.

 Construct tracks, roads, yards, hard-standings or any new structures.

 Store materials or machinery.

**Annex 4.** Methodology for starting and maintaining effective Curlew Focused Farm Clusters

## Data Archive Appendix

Data outputs associated with this project are archived in [NRW to enter relevant corporate store and / or reference numbers] on server–based storage at Natural Resources Wales.

Or

No data outputs were produced as part of this project.

The data archive contains: [Delete and / or add to A-E as appropriate. A full list of data layers can be documented if required]

[A] The final report in Microsoft Word and Adobe PDF formats.

[B] A full set of maps produced in JPEG format.

[C] A series of GIS layers on which the maps in the report are based with a series of word documents detailing the data processing and structure of the GIS layers

[D] A set of raster files in ESRI and ASCII grid formats.

[E] A database named [name] in Microsoft Access 2000 format with metadata described in a Microsoft Word document [name.doc].

[F] A full set of images produced in [jpg/tiff] format.

Metadata for this project is publicly accessible through Natural Resources Wales' Library Catalogue https://libcat.naturalresources.wales (English Version) and https://catllyfr.cyfoethnaturiol.cymru (Welsh Version) by searching 'Dataset Titles'. The metadata is held as record no [NRW to insert this number]

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