Environment and Rural Affairs Monitoring & Modelling Programme (ERAMMP)

ERAMMP Technical Annex-105TA1S2: Wales National Trends and Glastir Evaluation Supplement-2: Broad Habitat Results

Emmett, B.A.[1], Bentley, L.F.[1], Bowgen, K.M.[2], Doeser, A.[1], Jarvis, S.G.[1], Kimberley, A.[2], Macgregor, C.J.[1], Maskell, L.[1], Mondain-Monval, T.O.[1], Reinsch, S.[1], Robinson, D.A.[1], Siriwardena, G.M.[2] & Smart, S.M.[1]

[1]UK Centre for Ecology & Hydrology & [2]British Trust for Ornithology

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UKCEH contact details Bronwen Williams
UK Centre for Ecology & Hydrology (UKCEH)
Environment Centre Wales, Deiniol Road, Bangor, Gwynedd, LL57 2UW
01248 374500
erammp@ceh.ac.uk

Corresponding author Bridget Emmett, UKCEH
bae@ceh.ac.uk

Authors Emmett, B.A.[1], Bentley, L.F.[1], Bowgen, K.M.[2], Doeser, A.[1], Jarvis, S.G.[1], Kimberley, A.[1], Macgregor, C.J.[2], Maskell, L.[1], Mondain-Monval, T.O.[1], Reinsch, S.[1], Robinson, D.A.[1], Siriwardena, G.M.[2], and Smart, S.M.[1]

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Contributing authors & reviewers

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Approved by Bridget Emmett (UKCEH)
James Skates (Welsh Government)

ABBREVIATIONS USED IN THIS REPORT

AES	Agri-Environment Scheme
ASPT	Average Score per Taxon
AWI	Ancient Woodland Indicators
BBMS	Butterfly Monitoring Scheme
BBS	Breeding Bird Survey
BL	Broadleaf
BOAT	Byway Open to All Traffic
BRC	Biological Records Centre
BTO	British Trust for Ornithology
CEQ	Common Evaluation Questions
CMEF	Common Monitoring and Evaluation Framework
CS	Countryside Survey
CS-DA & CS-LOW	Cattle & Sheep in the lowland and Disadvantaged Area
CSM	Common Standard Monitoring
CS-SDA	Cattle & Sheep in the Severely Disadvantaged Area
DOC	Dissolved Organic Carbon
DSH	Dwarf Shrub Heath
EBERGL	Ellenberg Light
EBERGN	Ellenberg Nutrient
EBERGR	Ellenberg Reaction
EC	European Commission
EF	Emission Factors
EIDC	Environmental Information Data Centre
EO	Earth Observation
ERAMMP	Environment and Rural Affairs Monitoring & Modelling Programme
ESA	Environmentally Sensitive Areas
EU	European Union
FMS	Fen, Marsh, Swamp
FPM	Farm Management Plans
FPS	Farm Practices Survey
GA	Glastir Advanced
GAEC	Good Agricultural and Environmental Condition
GB	Great Britain
GE	Glastir Entry
GHG	Greenhouse Gas
GMEP	Glastir Monitoring and Evaluation programme
HAP	Habitat Action Plan
HEA	Historic Environmental Asset
HEF	Historic Environmental Feature
HNV	High Nature Value Farmland
IMP	Integrated Modelling Platform
IPCC	Intergovernmental Panel on Climate Change
JNCC	Joint Nature Conservation Committee
LCM	Land Cover Map
LiDAR	Light Detection and Ranging
LULUCF	Land Use and Land Use Change and Forestry

LW	Living Wales
MA	Management Actions
MMH	Mountain, Moor and Heath
NBN Atlas	National Biodiversity Network Atlas
NFI	National Forest Inventory
NFS	National Field Survey
NGO	Non-Government Organisation
NMP	Nutrient Management Plan
NPAP	National Peatland Action Programme
NRW	Natural Resources Wales
NTAXA	Number of Taxa
NVC	National Vegetation Classification
O/E WHPT	Walley Hawkes Paisley Trigg
OS	Ordnance Survey
PROW	Public Rights of Way
RDP	Rural Development Plan
RF	Random Forest
RPW	Rural Payments Wales
RSPB	Royal Society for the Protection of Birds
RUPP	Road Used as a Public Path
SAC	Special Areas of Conservation
SAM	Scheduled Ancient Monument
SED	Soil Erosion and Disturbance
SFS	Sustainable Farm Scheme
SLM	Sustainable Land Management
SOM	Soil Organic Matter
SoNaRR	State of Natural Resource Report
SSSI	Site of Special Scientific Interest
TC	Tir Cynnal
TG	Tir Gofal
UK	United Kingdom
UK BAP	UK Biodiversity Action Plan
UKCEH	UK Centre for Ecology & Hydrology
UKGHGI	The UK Greenhouse Gas Inventory
UKRI	UK Research and Innovation
WATS	Welsh Archaeological Trusts
WEFO	Welsh European Funding Office
WFD- UKTAG	Water Framework Directive UK Technical Advisory Group
WG	Welsh Government
WGRC -RDP	Welsh Government Rural communities – Rural Development Programme
WWII	World War II

4 Contents

1 Broad Habitat Results

1.1 Woodland

In 2021, woodland and woody features cover was estimated by satellites (LCM) (where woody species dominate a 10 m^2 pixel) to be 16.9% of Wales with 10.2% representing Broadleaved Mixed and Yew Woodland and 6.7% as Coniferous Woodland. This had increased by 16% for Broadleaved Mixed and Yew Woodland but decreased by 4% for Coniferous Woodland since 2010 resulting in an overall increase of 7% in 11 years.

Going forward, the Welsh Government has a target of 2,000 ha new planting of woodland every year to help create a new National Forest. The Welsh Government commissioned ERAMMP to review the potential benefits and disbenefits of woodland creation, woodland expansion and managing undermanaged woodland, to provide an evidence base to inform this development of a National Forest for Wales. The review covered issues such as the potential contribution of new woodland for climate change mitigation, biodiversity, ecosystem services including societal benefits and the Welsh economy (Beauchamp, et al., 2020).

Here the evidence from the NFS captures ongoing change of established woodland over the period 2013 – 2022 with respect to the condition of woodland as captured in the vegetation composition, abundance and composition of pollinators and birds and soil condition. Hedges are reported in the Enclosed Farmland section. The evidence of change is reported by two Broad Habitat classes: Broadleaved Mixed and Yew Woodland and Coniferous Woodland for vegetation, pollinators, and soil. Birds are reported for the asset class as a whole.

The impact of Glastir payments is also reported. This evidence is reported as the impact of a bundle of options which included the following options, which are expected to be relevant to Broadleaved Mixed and Yew Woodland:

- Woodland Stock Exclusion
- Woodland Management

This approach captures land where any of these options have been included and will maximise detection of any change. Specific options can be tested at a later date where this is of interest.

1.1.1 Broadleaved Mixed and Yew Woodland

The Broadleaved Mixed and Yew Woodland broad habitat includes stands of native and non-native Broadleaved trees scrub, it includes yew (*Taxus baccata*) and can also contain Coniferous species up to 80% cover (Jackson, 2000). Structurally, the GMEP/ERAMMP habitats key identifies woodland as ‘consisting of over 25% canopy cover of trees and shrubs, over a metre high’. Broadleaved, Mixed and Yew Woodlands may be ancient or recent woodland and may be semi-natural with natural regeneration or planted. Scrub vegetation is included within this habitat although some species are excluded (e.g. *Ulex gallii* and *Ulex minor* are classified to the Dwarf shrub habitat). Within the Broadleaved Mixed and Yew Woodland broad habitat there are a number of priority habitats including Wood Pasture and Parkland, Lowland Mixed Deciduous, Wet Woodlands, Upland Oakwoods and Upland Mixed Ash.

Vegetation indicators

Many woodlands in Wales are undermanaged (Beauchamp, et al., 2020) leading to long term declines in plant species richness. This may occur from successional processes operating unchecked, reducing structural heterogeneity e.g. losing rides and glades excluding light loving species. For woodlands, this will result in a loss of plant species which favour high light conditions and an increase in canopy height. We assess this change in plant species composition using the Ellenberg scoring system. In brief, most plant species across Europe including the UK have been scored for a wide range of ecological requirements including light (Ellenberg Light), nutrient levels (Ellenberg fertility / N), acidity (Ellenberg R) and moisture (Ellenberg Moisture) using the Ellenberg scoring system (Ellenberg, et al., 1991) . They were adapted to the UK by (Hill, Roy, Mountford, & Bunce, 2000) . Essentially the higher the score the more a plant species favours that ecological condition so for example. A high Ellenberg fertility score indicates that the plant has a preference for highly fertile conditions, high moisture indicates a plant most suited to moist and wet habitats. Thus, in woodlands, this undermanagement and successional conditions are indicated by a decreasing Ellenberg Light score for the ground flora community as a whole.

Overgrazing and pollution contribute to increased fertility, which in turn influences the vegetation structure and overgrowth of ground flora so we also include the Ellenberg N/fertility score. Species richness indicators include total species richness of the ground flora, the richness of Ancient Woodland Indicator (AWI) plants (these may be associated with lower light levels but there will be a trade-off where excess growth of fertile plants excludes Ancient Woodland Indicators also and nectar plant richness. We also included the cover of invasive species, this includes all non-native species (including Rhododendron) and additionally, bramble (Rubus fruticosus agg.). Here we analyse both large ($200m^2$) plots and small 2m x 2m plots. Large plots are more suitable for the size of species in this habitat, small plots are more comparable to analyses in other habitats.

Pollinator indicators

Pollinators are important ecologically and, within this diverse group, butterflies also have high aesthetic value, i.e. they contribute positively to human perception of the environment. Several pollinator indicators are considered here in order to capture a range of properties of the community, for its own sake, and to capture its role in ecosystem function and the provision of the pollination service, i.e. metrics capturing the overall abundance of pollinators, their diversity and the range of ecological functions that they deliver (driving the range of flowers being pollinated). From GMEP results, (Alison, et al., 2021) found that, compared with Improved Grassland (the dominant habitat in Wales), pollinator abundance was consistently higher in woodland, especially Broadleaved Mixed and Yew Woodland. They estimated that Hedgerows could contribute up to 21% of hoverfly abundance in agriculturally improved habitats and woodland (and other semi-natural habitats) could contribute similarly, potentially enhancing the pollination ecosystem service for relevant crops.

Soil indicators

Soils were sampled from 0-15 cm; this is considered to be the most dynamic component of the soil profile but is a less robust indicator of overall change in woodland soils due to its deep rooting vegetation. In woodlands, topsoil carbon content is more reflective of ground flora, litter inputs, disturbance and management than overall carbon trends. Bulk density is highly linked to soil organic matter content but is also responsive to changes in weather, climate and management, where increased topsoil bulk density may indicate compaction. Topsoil pH and nitrogen concentration reflect soil properties needed for healthy soil function and vegetation health, and changes in these indicators can be indicative of changes to vegetation, climate, nutrient deposition rates and management change. Many native woodlands in Wales have plants which naturally are nutrient poor and acidic. Ongoing acidic and nitrogen air pollution may of concern where this are reduced soil acidity below that naturally occurring and raised nutrient conditions favouring more competitive species.

Landscape indicators

Woodland connectivity is thought to improve the movement and dispersal of species across the landscape and overall improve condition for woodland plants and mobile taxa. There are also potentially benefits for soil directly beneath new connecting woody features including increased soil organic matter and reduced compaction. An increase in woodland connectivity is therefore a positive outcome.

1.1.1.1 National Trends

Overall for National Trends there is a pattern of relative stability in the condition of Broadleaved Mixed and Yew Woodlands. Ancient Woodland Indicators and negative indicators remain stable with some improvement seen for other indicators such as a reversal of a long-term decline of total species richness. However, there is a successional trend embedded in the data which matches a GB-wide process of canopy growth and increased shading as woodlands respond to long-term decline of traditional management and widespread timber extraction at the end of WWII (Kirby, 2005). This is resulting in the observed long and short-term declines in species which require higher light levels and may also be linked to observed reductions in topsoil carbon concentrations. An increase in topsoil bulk density (i.e. compaction) is not unique to this habitat and is likely to be linked to a more widespread driver of change such as climate. The increase in woodland and woody linear features has not increased woodland connectivity suggesting a more targeted approach will be needed. With respect to pollinators, three of the indicators are stable but the two indicators relating to butterflies (abundance and species richness) have declined. One issue to explore further is whether this is related to a loss of structural heterogeneity and more open areas due to undermanagement. For birds, an overall trend of stability for woodland birds is observed which will be relevant to this specific broad habitat but this will hide a wide variety of species-specific responses.

Positive Outcomes

- Total species richness is now stable after a period of decline in the longer-term data.
- Ancient woodland indicator plant species remained stable in the recent survey period continuing the long-term trend as do negative plant indicators.
- Nectar plant species richness was stable after a decline in the longer term.
- Strong declines in plant Ellenberg light score appear to be ongoing. This is in an indicator of a loss of plants which require higher levels of light and is likely to be a response to long-term increase in canopy cover due to long term under-management.
- Plants which favour high nutrient status as indicated by the Ellenberg score were stable.
- Broadleaved Mixed and Yew Woodland connectivity remains stable. Analysis including woody linear features increases the level of connectedness but remained not significant.
- Pollinator abundance, functional group richness and generality of pollinators are all stable.
- Topsoil nitrogen concentration and pH in Broadleaved Mixed and Yew Woodland remained stable.

Areas for Concern / Need for Further Action

- There was an increase in the cover of non-native and invasive species in the small plots, however, this was not a significant increase in the large plots. There is a lot of variation in cover values which is likely to be why the large plots were not significant.
- Mean butterfly abundance and butterfly species richness have declined.
- Broadleaved Mixed and Yew Woodland topsoil carbon concentration has declined significantly by 13% in the recent survey following a long-term period of gradual carbon accrual since 1978 to 2007 but no change in carbon density due to increased bulk density. This carbon may have been redistributed to lower soils horizons which is known to be more common in woodland systems.
- There has been an increase in topsoil bulk density of 15% which is indicative of compaction.

Complex signal requiring further analysis

- Total canopy height of the ground flora increased in the long-term survey in small plots and decreased significantly in the recent survey. This indicator was not reported previously.

Table 1-1 Long-term and short-term trends in woodland vegetation indicators for Broadleaved Mixed and Yew Woodland. Both small (2m x 2m) and large (200m2 plots) were recorded. "=": no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01. No data are shown as grey boxes. Longer-term trends come from (Smart, et al., 2009).

Asset Class	Habitat	Indicator	Long term analysis using CS data 1978/1990 - 2007	Mean 2013-16	Mean 2021-23	Short term analysis using GMEP 2013-16 to 2021-23
Woodland	Broadleaf Mixed and Yew Woodland	Ellenberg fertility Large plots*	=	4.82	4.81	=
		Broad leaved Connectivity no linears	=	0.88	0.87	=
		Broad leaved connectivity with linears		0.94	0.93	=
		AWI small plots	=	1.85	1.79	=
		AWI large plots	=	4.33	4.46	=
		Ground flora total species richness large plots	-	22.3	23.8	=
		Nectar plant species richness large plots	-	11.7	12.4	=
		Ellenberg L small plots	--	5.87	5.81	--
		Ellenberg L large plots	=	6.28	6.27	=
		Invasive and Non-native species including Rhododendron, bramble (Large). Re-scaled 0 to 1*	=	0.21	0.27	=
		Invasive and Non-native species including Rhododendron, bramble (small). Re-scaled 0 to 1*	=	0.14	0.22	++
		Cover weighted canopy height Small Plots	+	2.69	2.43	--

* These are negative indicators so a '+' indicates a decrease in condition.

Table 1-2 Long-term and short-term trends in pollinator indicators for Broadleaved Mixed and Yew Woodland. "=": no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01. Longer-term trend data is available from the UK Butterfly Monitoring Scheme but indicators are not directly comparable so are not presented. No data is shown as grey cells.

Asset Class	Habitat	Indicator	Longer term analysis BBMS / BRC	Mean 2013-16	Mean 2021-23	Short term analysis using GMEP 2013-16 to 2021-23
Woodland	Broadleaf Mixed and Yew	Pollinator abundance		32.66	29.44	=
		Mean butterfly abundance		0.31	0.17	-
		Butterfly species richness		3.45	2.64	--
		Functional group richness		5.2	5.26	=
		Generality of pollinators		1.85	1.61	=

Table 1-3 Long-term and short-term trends in topsoil indicators for Broadleaf Mixed and Yew Woodland. Long-term trends in indicators for Wales were extracted from (Smart, et al., 2009). "=": no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01. No data are shown as grey boxes.

Asset Class	Habitat	Indicator	Long term analysis using CS data 1978/1990 - 2007	Mean 2013-16	Mean 2021-23	Short term analysis using GMEP 2013-16 to 2021-23
Woodland	Broadleaf Mixed and Yew	Carbon (g/kg, from Organic matter) [1]	=	80.9	70.1	-
		pH	+	4.96	4.87	=
		N (g/100g dry soil) *		0.49	0.46	=
		C density (tC/ha)[1]	+	60.8	63.6	=
		Bulk density (g/cm^3) [1]*		0.54	0.62	+

*An increase in this indicator is interpreted as a decline in condition for this habitat.
[1]Topsoil carbon sequestration or loss is most reliably indicated by a change in both carbon concentration and density (carbon concentration corrected for the bulk density which is the mass of soil expressed on a unit area basis). Caution in interpretation needs to be taken where changes in bulk density heavily influence carbon density values.

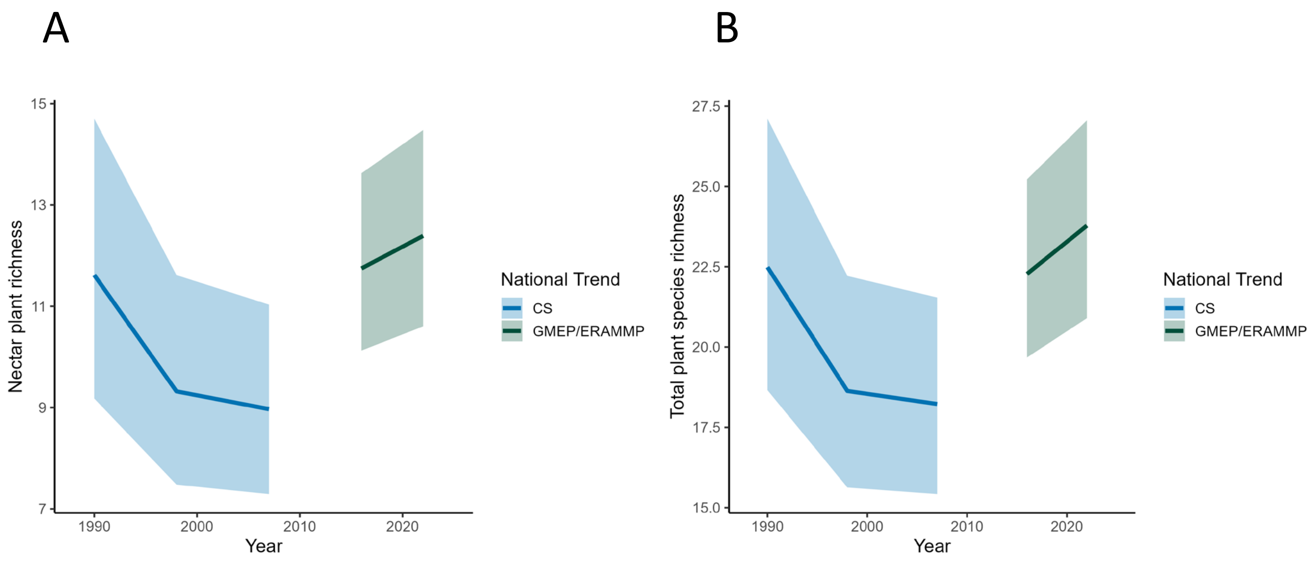

Figure 1-1 Long-term National Trends in Broadleaved Mixed and Yew Woodland in Large plots A) Nectar plant richness, B) Total species richness from Countryside Survey squares in Wales (1990 to 2007) and GMEP/ERAMMP (2013 – 16 to 2021 – 2023) from Nationally Representative squares.

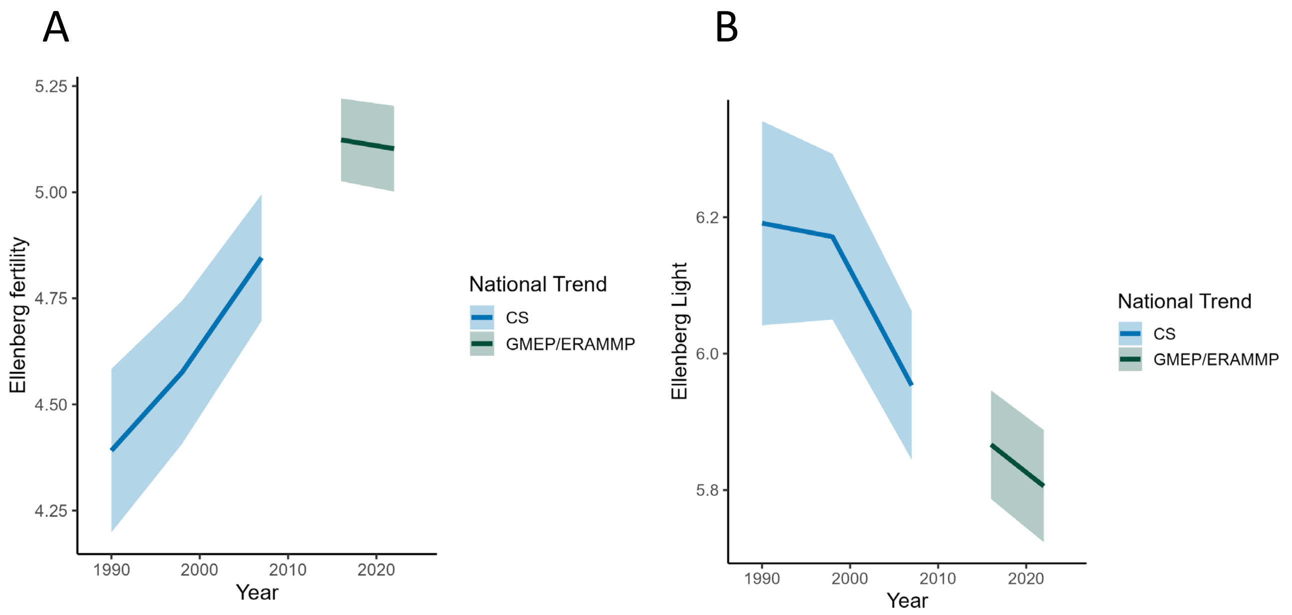

Figure 1-2 Long-term National Trends in plants which favour A) high nutrient conditions i.e. Ellenberg fertility and B) high light conditions (i.e. Ellenberg light scores) in small Broadleaf (BL) plots from Countryside Survey squares in Wales (1990 to 2007) and GMEP/ERAMMP (2013 – 16 to 2021 – 2023) from Nationally Representative squares.

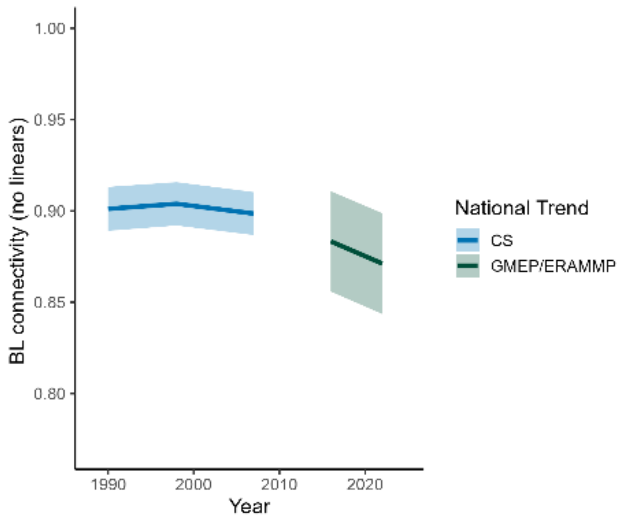

Figure 1-3 Long-term National Trends in Broadleaved Mixed and Yew Woodland connectivity from Countryside Survey squares in Wales (1990 to 2007) and GMEP/ERAMMP (2013 – 16 to 2021 – 2023) from Nationally Representative squares.

1.1.1.2 Glastir Impact

Woodland Management was the most frequent action/bundle for vegetation analysis. This bundle contains options on stock exclusion (100), rabbit guards, coppicing, there was also another bundle that contains option 40 Management of existing fence on stock excluded woodland only. For soils, the Woodland Management bundle was dominated by the action on Woodland Stock Exclusion. The effect of historic AES presence on topsoil indicators was also tested.

Overall, despite relatively low uptake of woodland options, the NFS has detected positive outcomes from the Glastir woodland bundle. This includes: an increase in Ancient Woodland Indicators and soil carbon concentrations with woodland management and a reduction in soil bulk density (i.e. compaction) with Woodland Management.

However, perhaps as important is the evidence of continued signals from historic AES schemes with ongoing benefit for vegetation for ground flora species richness and nectar plants where historic schemes had been in place. Benefits for soil from historic AES however appear to be quickly lost with soil carbon concentrations and bulk density benefits previously detected now lost where Glastir is not present which is often the case as there were low rates of retention of Broadleaved Mixed and Yew Woodland sites into the Glastir scheme. This contrast in responsiveness to historic AES schemes between the vegetation and soils illustrates the long lag time and legacy effects in realising ecological benefits in the plant community but also the very rapid response of soils should land fall outside of management.

Positive Outcomes

- There was 3,780 ha of new woodland created in response to Glastir option payments which represents an increase of 1.1% of woodland cover in 2010. This can be compared to a total increase for Wales of 7%. Agroforestry represented 5 ha of this increase.
- Broadleaved Mixed and Yew Woodland connectivity increased with the presence of Woodland Creation in the 1km survey square.
- Ancient Woodland Indicator richness increased with Woodland Management.

- Glastir Woodland Management (in this case, all actions were Woodland Stock Exclusion) increased topsoil carbon concentration compared to Broadleaved Mixed and Yew Woodland outside of scheme.
- Glastir Woodland Management decreased topsoil bulk density relative to land outside of Glastir, suggesting recovery from compaction. This runs counter to the national trend where bulk density has increased by 15% suggesting Glastir has reversed the compaction seen in the national trend.

Outcomes not as intended, trade-offs and contextual dependencies

- There was no effect of Glastir Woodland Management on: cover weighted canopy height; plant Ellenberg light scores, nectar plant species richness, invasive and non-native species cover and total ground flora species richness.
- There was no effect of Glastir Woodland Management on any pollinator response indicator.
- Glastir Woodland Management had no significant impact on topsoil carbon density. The lack of response of topsoil carbon density may be due to increasing soil depth, which is not currently measured as part of the NFS.
- There was no effect of Glastir Woodland Management on topsoil nitrogen concentrations or pH in Broadleaved Mixed and Yew Woodland.
- Historic AES reduced cover weighted height, increase nectar species richness and ground flora species richness.
- Topsoil carbon concentration significantly decreased in sites with historic AES participation, converging on similar levels to those in land without historic AES management, indicating that benefits of historic schemes have now been lost in Broadleaved Mixed and Yew Woodland.

Impact of historic AES

- Historic AES reduced cover weighted height, increase nectar species richness and ground flora species richness.
- Topsoil carbon concentration significantly decreased in sites with historic AES participation, converging on similar levels to those in land without historic AES management, indicating that benefits of historic schemes have now been lost in Broadleaved Mixed and Yew Woodland where these have not come into the Glastir scheme.
- Glastir Woodland Management and historic AES schemes did not affect topsoil pH in Broadleaved Mixed and Yew Woodland, which remained stable in line with the national trend.

Table 1-4 Glastir analysis for vegetation indicators in Broadleaved Mixed and Yew Woodland in large plots (small plots had no significant results). Glastir management bundles assessed for effects on indicators are shown, but greyed out where sample size was too small for analysis. Context effect was tested using information related to participation in historic AES. + significant increase, - significant decrease, ++ / -- strong response, = indicator remained stable over time. No data are shown as grey boxes.

Asset Class	Habitat	Indicator	Woodland stock	Woodland Management	Wildlife Corridors	Woodland Creation	Hedgerow Restoration	Context: Historic AES
Woodland	Broadleaved Mixed and Yew Woodland	Ellenberg fertility*	=	-				
		Ellenberg light	=	=				=
		Ground flora species richness	=	=				+
		AWI	=	+				=
		Cover weighted canopy height ground flora	=	=				--
		Nectar plants	=	=				+
		Non-native Rhododendron and Bramble cover*	=	=				=
		Connectivity no linears		=	=	+		
		Connectivity linears		=	=	=	=	

*These are negative indicators so a '+' indicates a decrease in condition.

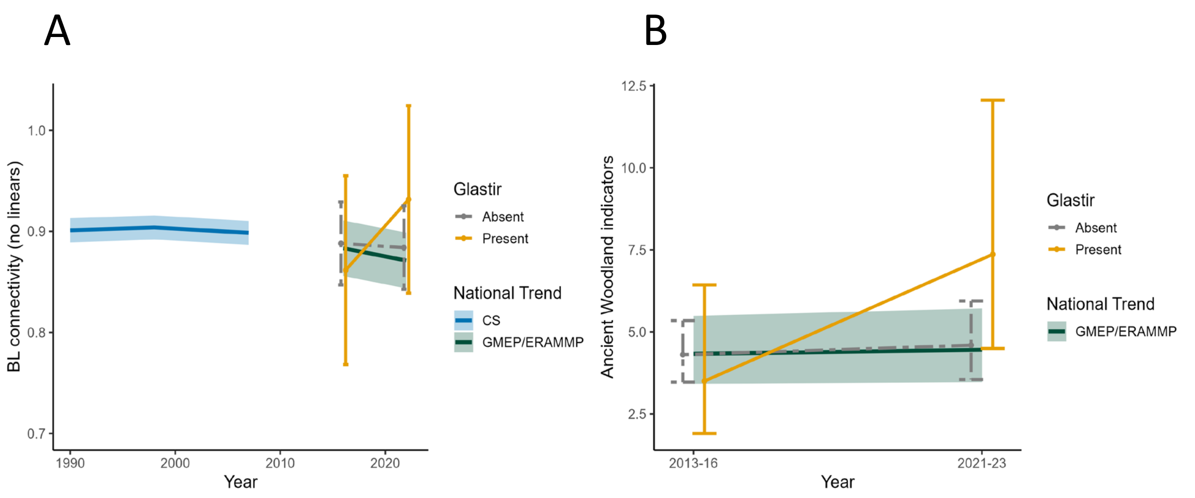

Figure 1-4 Trend in A) Broadleaved connectivity between 2013-16 and 2021-23 in Broadleaved Mixed and Yew Woodland showing both National Trends and effect of Woodland Creation bundle and B) Ancient Woodland Indicator richness between 2013-16 and 2021-23 in Broadleaved Mixed and Yew Woodland showing effect of Woodland Management bundle.

Table 1-5 Glastir analysis for topsoil indicators in Broadleaved Mixed and Yew Woodland. Glastir management bundles assessed for effects on topsoil indictors are shown. Context effect was tested using information related to participation in historic AES. + significant increase, - significant decrease, ++ / -- strong response, = indicator remained stable over time.

Asset Class	Habitat	Indicator	Woodland Management	Context: Historic AES
Woodland	**Broadleaved Mixed and Yew Woodland**	Carbon (g kg-1, from Organic matter)	++	-
		pH in water	=	=
		N (g 100-1 g dry soil)*	=	=
		Carbon density (t carbon ha-1)	=	=
		Bulk density (g cm-3)*	=	+

*An increase in this indicator is interpreted as a decline in condition for this habitat.

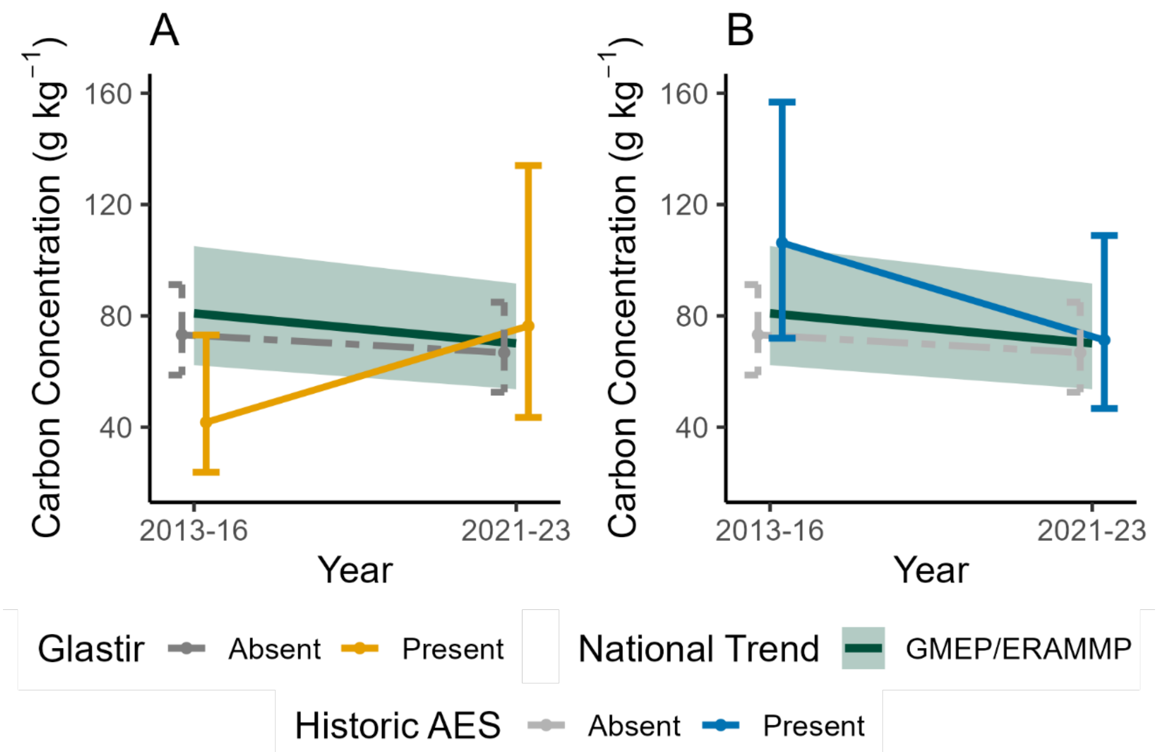

Figure 1-5 Trend in A) topsoil carbon concentration between 2013-16 and 2021-23 in Broadleaved Mixed and Yew Woodland showing both National Trends and effect of uptake of Glastir Woodland Management and B) topsoil carbon concentration between 2013-16 and 2021-23 in Broadleaved Mixed and Yew Woodland showing both National Trends and where historic AES is present or absent.

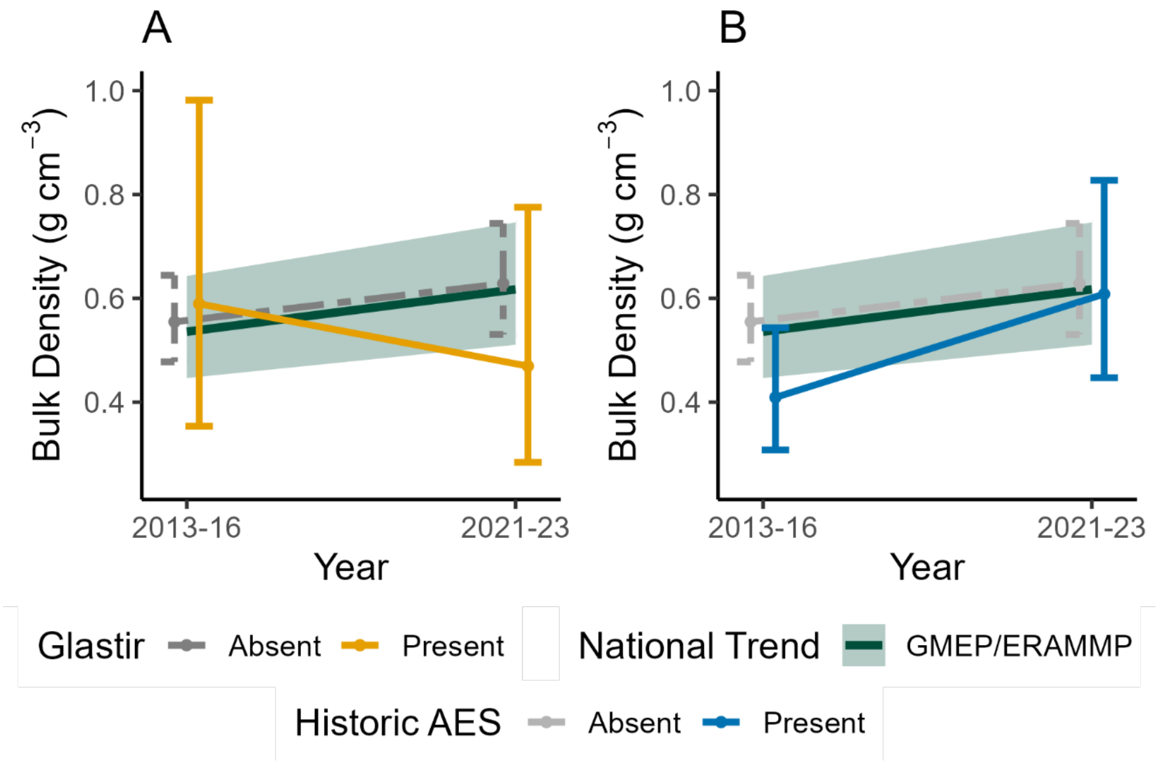

Figure 1-6 Trend in A) topsoil bulk density between 2013-16 and 2021-23 in Broadleaved Mixed and Yew Woodland showing both National Trends and effect of Glastir Woodland Management and B) topsoil bulk density between 2013-16 and 2021-23 in Broadleaved Mixed and Yew Woodland showing both National Trends and where historic AES is present or absent.

Table 1-6 Glastir analysis for pollinator indicators for Broadleaved Mixed and Yew Woodland. Glastir Management bundles assessed for effects on pollinator indictors are shown. + significant increase, - significant decrease, ++ / -- strong response, = indicator remained stable over time.

Asset Class	Habitat	Indicator	Hedge Management	Woodland Stock Exclusion	Woodland Management	Organic
Woodland	Broadleaved Mixed and Yew Woodland	Pollinator abundance	=	=	=	=
		Mean butterfly abundance	=	=	=	=
		Butterfly species richness	=	=	=	=
		Functional group richness	=	=	=	=
		Generality of pollinators	=	=	=	=

1.1.2 Coniferous Woodland

Coniferous Woodland includes stands of Coniferous species (with the exception of *Taxus baccata*) where Coniferous species exceed 80% cover. As with Broadleaved Mixed and Yew, it is classified through the Habitats key where canopy cover is greater than 25% and vegetation height greater than 1 m. In Wales, there are no native Coniferous Forest types, with the exception of juniper scrub. It should also be noted that, where land is under a Coniferous management cycle, if trees had been felled, we tried to classify to the Broad habitat that was actually present. Other surveys, e.g. NFI, would record that to be part of the forest cycle. Whilst many Coniferous stands are single species, the rides, fire breaks and other linear elements of managed woodland provides habitat for a variety of species. Historically, efficient capture of acidic and nitrogen deposition by the evergreen canopy which is present all year round for most tree species has interacted with the high base cation use of plantation forestry to acidify both soils and streams and increase nitrate concentrations. Trends in soil acidity and nitrogen level (and plant indicators of high nutrient conditions i.e. Ellenberg fertility scores), are therefore of particular importance in this Broad Habitat.

In 2023, Coniferous Woodland represented 7% of Wales's landcover. This was a decline of 7% since 2010.

Vegetation indicators

Here we used a small number of indicators. Coniferous Woodlands are low in biodiversity value, so we do not have positive or negative indicators for this habitat. We used total species richness of the ground flora and Ellenberg fertility to understand if fertility has increased or decreased.

Pollinator indicators

Pollinator metrics considered for Coniferous Woodland matched those used for Broadleaf Mixed and Yew Woodland. As a non-native habitat, Coniferous Woodland has limited potential value for pollinator communities and the animals detected there are likely to be spilling over from adjacent habitats, or to be associated with fringe or margin grassland areas.

Soil indicators

Soil was sampled from 0-15 cm; this is considered to be the most dynamic component of the soil profile but is a less robust indicator of overall change in woodland soils due to its deep rooting vegetation. In woodlands, topsoil carbon content is more reflective of ground flora, littler inputs, disturbance, and management than overall carbon trends. Bulk density is highly linked to soil organic matter content but is also responsive to changes in weather, climate, and management, where increased topsoil bulk density may indicate compaction. Topsoil pH and nitrogen concentration reflect soil properties needed for healthy soil function and vegetation health, and changes in these indicators can be indicative of changes to vegetation, climate, nutrient deposition rates and management change. Soil pH is of particular concern due to historic acidification of soils and waters in catchments dominated by conifer plantations.

1.1.2.1 National Trends

National Trends for Coniferous Woodlands indicate these habitats are in a relatively stable condition. One positive outcome is an increase in pollinator abundance. The reasons for this are not known and required integrated analysis with the vegetation data. Main areas of concern are an increase in topsoil bulk density (i.e. compaction) and an increase in vegetation Ellenberg fertility score possibly linked to the continued efficient capture of atmospheric nitrogen pollution by evergreen canopies. Soil acidity is stable after a period of recovery following declines in acidic emissions and deposition. The bulk density signal is seen for most habitats and is not unique to Coniferous Woodland and may be related to changing rainfall patterns linked to climate change.

Positive Outcomes

- Total plant species richness and Ancient Woodland Indicator species have remained stable.
- Pollinator abundance has increased.
- All other pollinator indicators are stable.
- Topsoil pH and nitrogen levels remain stable.

Areas for Concern / Need for Further Action

- There has been an increase in the cover of plants favouring high nutrient status i.e. Ellenberg fertility scores in the short-term.
- Topsoil bulk density increased by 34% in Coniferous Woodland, indicating greater soil compaction. This increase together with a stable topsoil carbon concentration led to a 15% increase in topsoil carbon density across Coniferous Woodlands in Wales, which is not indicative of carbon sequestration due to the confounding effect of change in bulk density.

Complex signal needing further analysis

- There has been no significant change in the cover weighted canopy height of the ground flora.

Table 1-7 Long-term and short-term trends in topsoil indicators for Coniferous Woodland. Long-term trends in indicators for Wales were extracted from (Smart, et al., 2009). "=": no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01. No data are shown as grey boxes.

Asset Class	Habitat	Indicator	Long term analysis using CS data 1978/1990 - 2007	Mean 2013-16	Mean 2021-23	Short term analysis using GMEP 2013-16 to 2021-23
Woodland	**Coniferous Woodland**	Carbon (g/kg, from Organic matter)	-	146.9	134.6	=
		pH	=	4.21	4.25	=
		N (g/100g dry soil)*		0.69	0.65	=
		C density (tC/ha)[1]	=	60.6	69.7	++
		Bulk density (g/cm^3)*[1]		0.34	0.45	++

*An increase in this indicator is interpreted as a decline in condition for this habitat.
[1] As carbon concentrations have not increased this is driven by the increase in bulk density and does not reflect an increase in soil carbon storage.

Table 1-8 Long-term and short-term trends in woodland vegetation indicators for Coniferous Woodland. Long-term trends in indicators for Wales were extracted from (Smart, et al., 2009). "=": no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01. No data are shown as grey boxes.

Asset Class	Habitat	Indicator	Long term analysis using CS data 1978/1990 - 2007	Mean 2013-16	Mean 2021-23	Short term analysis using GMEP 2013-16 to 2021-23
Woodland	Coniferous Woodland	Area	TBC			TBC
		Ellenberg fertility*	=	3.67	3.87	+
		Ground flora species richness	=	12.89	14.1	=
		Cover weighted canopy height	=	0.64	0.77	=
		AWI	=	2.17	2.56	=

* These are negative indicators so a '+' indicates a decrease in condition.

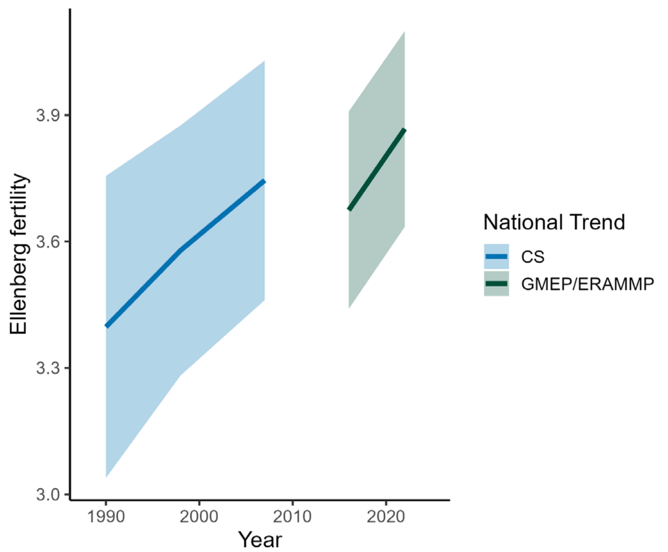

Figure 1-7 Long term National Trends in plants which favour higher nutrient status (i.e. Ellenberg N score) in Coniferous Woodland from Countryside Survey squares in Wales (1990 to 2007) and GMEP/ERAMMP (2013 – 16 to 2021 – 2023) from Nationally Representative squares.

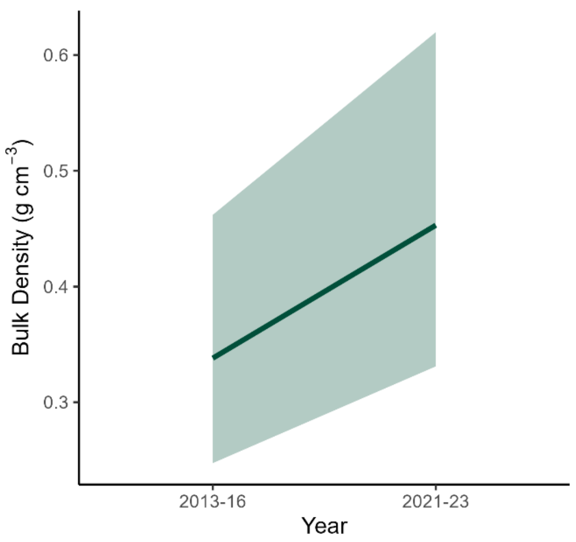

Figure 1-8 Trend in topsoil bulk density in Coniferous Woodland between 2013-16 and 2021-23 from Nationally Representative squares.

Table 1-9 Long-term and short-term trends in pollinator indicators for Coniferous Woodland. Long-term trends in indicators for Wales were extracted from (Smart, et al., 2009). "=": no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01. No data are shown as grey boxes.

Asset Class	Habitat	Indicator	Long term analysis using CS data 1978/1990 - 2007	Mean 2013-16	Mean 2021-23	Short term analysis using GMEP 2013-16 to 2021-23
Woodland	Coniferous Woodland	Pollinator abundance		22.92	35.1	+
		Mean butterfly abundance		0.15	0.13	=
		Butterfly species richness		2.24	2.07	=
		Functional group richness		4.37	4.96	=
		Generality of pollinators		1.83	1.94	=

1.1.2.2 Glastir Impact

There was only one reported outcome from Glastir for Coniferous Woodland with a negative effect of Woodland Management on pollinator abundance. This is surprising as no options were targeted towards Coniferous Woodland and may just be a random result which can occur when doing multiple tests.

Positive Outcomes

- None reported.

Outcomes not as intended, trade-offs and contextual dependencies

- There was a significant negative effect of Woodland Management on pollinator abundance.

Table 1-10 Glastir analysis for pollinator indicators in Coniferous Woodland. Glastir management bundles assessed for effects on topsoil indictors are shown. + significant increase, - significant decrease, ++ / -- strong response, = indicator remained stable over time.

Asset Class	Habitat	Indicator	Hedge Management	Woodland stock exclusion	Woodland Management
Woodland	**Coniferous Woodland**	Pollinator abundance	=	=	--
		Mean butterfly abundance	=	=	=
		Butterfly species richness	=	=	=
		Functional group richness	=	=	=

1.1.3 Birds

Here, and for other habitats, bird results are presented by asset class to map onto the proposed structure of the next State of Natural Resources Report (SoNaRR) at the time of report writing. Within these asset classes, many results are also broken down by Broad Habitat with some results also presented for more widespread Priority Habitats, although this was not always possible for birds. Overall results for biodiversity have been aggregated in Chapter 4 of the Technical Annex overview again to map onto the proposed structure of the next SoNaRR report.

Habitat preferences of the bird species that contribute to the indicators of change in woodland are broader than the woodland categories that are being considered for ERAMMP. Therefore, all woodland habitats were combined for all bird indicators.

Woodland birds have declined, at UK level, since the 1970s, with similar patterns believed to have occurred in Wales, specifically. Particular pressures have been a reduction in woodland management reducing the diversity in Broadleaf Mixed and Yew Woodland structure, and therefore habitats for birds, and increased browsing pressure from deer, especially, significantly reducing understorey and field layer structure.

Bird indicators

Six indicators were investigated in these analyses - Abundance of woodland bird species (indicator) and Abundance of woodland bird species (guild), plus four general indicators for Priority bird species and the three dietary guilds (Granivorous and Invertebrate- and Vertebrate-eating bird species). The indicator uses the policy-led standard list of species from (Burns, et al., 2023) (and so is consistent with national monitoring), whilst the guilds follow an extended list of species from (Siriwardena, Henderson, Noble, & Fuller, 2019) (providing a more complete representation of the bird community that uses woodland habitats as well as key dietary preferences). The Priority bird species list consists of all section 7 species from the Environment (Wales) Act 2016. Glastir effects shown in graphs compare predictions for the situation where Glastir covered 90% of a nominal surveyed woodland area, compared to 10% coverage. This approach was needed due to the mobile nature of birds, which will use multiple, individual habitats across a landscape, as opposed to being associated with individual fields or parcels.

1.1.3.1 National Trends

There have been no significant changes in the woodland bird abundance indicators (species list used in policy or ecological guild) since 2013. This continues a generally observed stable to increasing signal for woodland birds since 1994, although there are signs of a decline since 2014 (see ERAMMP Technical Annex-105TA1S6: Wales National Trends and Glastir Evaluation. Supplement-6: Birds section 2 (Siriwardena & Bowgen, 2025)).

Positive Outcomes

- No change seen in the National Trends, in the context of previous, long-term declines in several woodland bird species at UK level (1970s and 1980s). Conversely, the national BBS suggests a slight decline between the GMEP and ERAMMP periods.

Areas for Concern / Need for Further Action

- No specific concern and no further actions are needed but continued monitoring and investigation of potential wider impacts on woodland bird species across Wales for species of concern are important. Note that the summary metrics used here will tend to obscure species-specific variations in changes over time and it would be beneficial to examine the data at the species level. Note that Welsh birds have been monitored effectively only since 1994, but woodland species probably declined considerably before this time, on the basis that such declines were seen at the UK level.

Table 1-11 National Trends for all Woodland bird indicators. =: no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01. Priority birds and Dietary indicators can be found in Table1-12 to avoid repetition. No data is shown as grey boxes.

Asset Class	Indicator	Long term trend from BBS (1994-2013)	Mean 2013-16	Mean 2021-23	Short term analysis using GMEP 2013-16 to 2021-23
Woodland	Abundance of woodland bird species (indicator)- BBS	+	118.2	108.5	
	Abundance of woodland bird species (indicator)		7.279	7.340	=
	Abundance of woodland bird species (guild)		7.646	7.266	=

1.1.3.2 Glastir Impact

Increases are demonstrated for woodland bird species (indicator and guild) and invertebrate-eating species in response to woodland stock exclusion. Five of the six indicators (the exception being vertebrate-eating bird abundance) increased in response to Woodland Management, although the effects were too small to drive rapid population increases at the national scale. It should be noted that composite indicators may obscure species-level responses, so the results would benefit from further analyses by species. This is clearly one of the most positive Glastir outcomes for any outcome reported for the NFS.

Positive Outcomes

- An increase in the abundance of woodland species (indicator and guild) and invertebrate-eating birds in response to woodland stock exclusion options.
- An increase in the abundance of woodland species (indicator and guild), invertebrate-eating birds, granivorous birds and priority birds in response to Woodland Management.

Outcomes not as intended, trade-offs and contextual dependencies

- No impacts of Woodland Creation were seen, although this may be due to length of time needed for Woodland Creation to be at the right stage for impacts to be seen being longer than the difference between current survey periods. This will be reassessed in future survey designs. Composite indicators may obscure species-level responses, so the results would benefit from further analyses by species.

Table 1-12 Glastir analysis for biodiversity indicators – Birds for General Woodland. Glastir management bundles assessed for effects on indicators are shown. + significant increase, - significant decrease, ++ / -- strong response, = indicator remained stable over time.

Asset Class	Habitat	Indicator	Woodland Stock Exclusion	Woodland Management	Woodland Creation
Woodland	All Woodland	Abundance of woodland bird species (indicator)	+	++	=
		Abundance of woodland bird species (guild)	+	+	=
		Priority Bird Abundance	=	+	=
		Granivorous eating bird species abundance	=	+	=
		Invertebrate-eating bird species abundance	++	++	=
		Vertebrate-eating bird species abundance	=	=	=

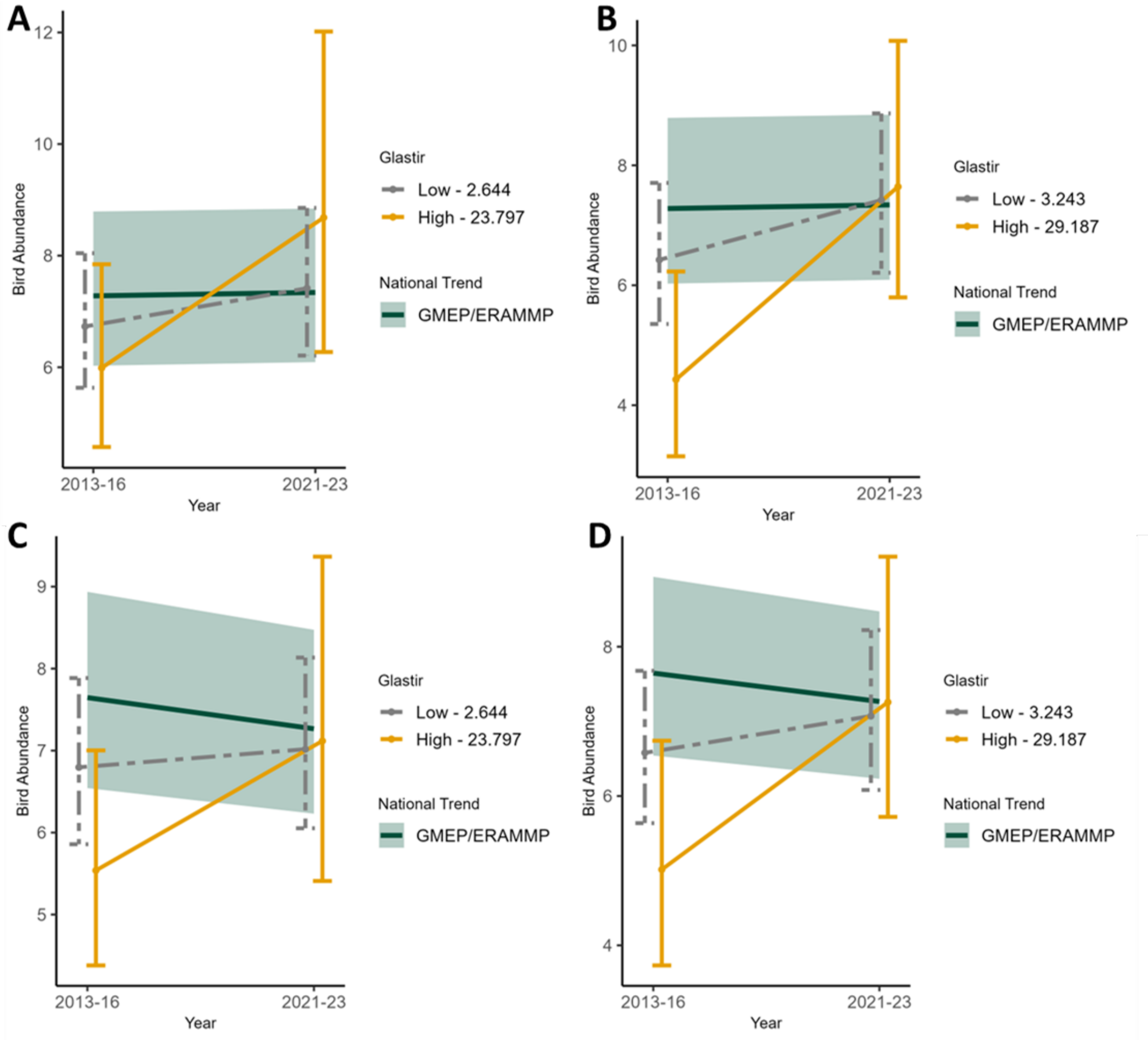

Figure 1-9 Trend in woodland bird indicator species abundance between 2013-16 and 2021-23 in all woodland showing both National Trends and effect of uptake of A) Woodland Stock Exclusion and B) Woodland Management, and woodland bird guild species abundance from GMEP to ERAMMP, in respect of C) Woodland Stock Exclusion and D) Woodland Management is low or high in proportion to specific bundle coverage maximums. Other effects not shown were small and their plots can be found in the ERAMMP Technical Annex-105TA1S6: Wales National Trends and Glastir Evaluation. Supplement-6: Birds (Siriwardena & Bowgen, 2025).

1.2 Mountain, Moor and Heath

Mountains, Moor and Heath (MMH) is a complex category which encompasses most of the iconic habitats of the Welsh uplands, including Dwarf Shrub Heath, Inland Cliff and Ledge habitats, Bog/Blanket Bog, Flush and Fen and Montane habitats (Natural Resources Wales, 2020). The majority of MMH occurs in the uplands, defined as land lying above the upper limit of agricultural enclosure. MMH includes a proportion of the upland margins or ffridd, a distinct transition zone between intensively farmed lowlands and open hill habitats. Ffridd comprises a mosaic of habitats: heath, grassland, peatland, bracken, rock and woodland (Blackstock, Howe, Stevens, Burrows, & Jones, 2010). Note that, because birds use landscapes at large spatial scales and cut across habitat patches, their data could not be analysed below the broad asset-class level, so analyses are presented integrating all the component habitats. Since the bulk of relevant habitat in the sample will be in upland areas, analyses are then conducted only for upland bird indicators.

1.2.1 Dwarf Shrub Heath

Dwarf Shrub Heath is characterised by vegetation where the cover of dwarf shrub species (e.g. heather, cross leaved heath, bell heath) is > 25%. This also includes *Ulex gallii* and *Ulex minor* but not *Ulex europaeus* which is classified to the Broadleaved Woodland habitat. It generally occurs on well drained nutrient poor acid soils (Jackson, 2000). Dwarf Shrub Heath includes both dry and wet types and can be found in the uplands and lowlands (including coastal habitats).

In 2021, Dwarf Shrub Heath represented 4% of land use in Wales. This is an increase of 3% since 2010.

Vegetation indicators

Pressures on Dwarf Shrub Heath include burning, cutting, inappropriate grazing, recreational pressures andscrub encroachment. Climate change may lead to extreme changeable weather which will be an additional pressure. We use positive plant indicator species presence initially collated from Common Standard Monitoring species (CSM) and refined from discussions with NRW specialists, Dwarf Shrub Heath cover to indicate where we have ‘appropriate diversity’ i.e. the right species in the right place. We also use negative plant indicators We also use Ellenberg fertility and moisture to indicate change in environmental conditions.

Pollinator indicators

Pollinator metrics considered here matched those used for Broadleaf Mixed and Yew Woodland; see section 1.1.1. Pollinators largely depend on plant diversity and vegetation quality, so the pressures on them will follow those described for vegetation.

Soil indicators

Soils were sampled from 0-15 cm; this is considered to be the most dynamic component of the soil profile, responding to land use, climate and management change. As such, topsoil indicators such as for carbon density do not capture the complete soil profile but serve to indicate the direction of change. Topsoil change in carbon density is a less robust indicator of overall change in habitats with deep rooting vegetation. Additional care must be taken when interpreting measurements of topsoil carbon density as it is partially determined by bulk density, which changes with soil wetness (wet and dry years) and with compaction. Changes in bulk density can cause an apparent change in carbon density that does not reflect additional carbon storage. The best evidence for an increase in topsoil carbon density occurs when an increase in both carbon concentration and carbon density has occurred, with stable or decreasing bulk density. Topsoil pH and nitrogen concentration reflect soil properties needed for healthy soil function and ecosystem health, and changes in these indicators can be indicative of changes to vegetation, climate, nutrient deposition rates and management change. Naturally, these systems in Wales tend to be on nutrient poor, acidic soils.

1.2.1.1 National Trends

There is an overall picture of stability for Dwarf Shrub Heath, which occur in both the lowlands and uplands and include coastal heaths. Cover of Dwarf Shrub Heath species (which defines the habitat with a requirement for 25% cover or over) remained stable as did all pollinator indicators. Positive outcomes include a recent shift to plants which favour less nutrient rich conditions suggesting reduced flow of nutrients into the habitats either from the atmosphere (e.g. nitrogen deposition) or from adjacent land or improved management which is removing nutrients. This will benefit this typically nutrient-poor habitat. A trend for a decrease in negative plant indicators is also observed. One area of concern is a reversal of the previous recovery from acidification with topsoil pH now at levels not seen since the 1970s. This pattern of increased soil acidification in unmanaged land is seen across GB and has been linked to wetter conditions associated with climate change.

Positive Outcomes

- The cover of Dwarf Shrub Heath shrubs has increased.
- There has been a recent decrease in plants which favour high nutrient status (i.e. Ellenberg fertility).
- All pollinator indicators are stable.
- Topsoil carbon concentration, bulk density, nitrogen levels and carbon density remain stable in Dwarf Shrub Heath

Areas for Concern / Need for Further Action

- Topsoil acidity (i.e. soil pH decreased) increased significantly back to levels measured in 1978 when soils experienced high levels of acidic deposition.

Table 1-13 Long-term and short-term trends in vegetation indicators for Dwarf Shrub Heath. Long-term trends in indicators for Wales were extracted from (Smart, et al., 2009). "=": no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01.

Asset Class	Habitat	Indicator	Long term analysis using CS data 1978/1990 - 2007	Mean 2013-16	Mean 2021-23	Short term analysis using GMEP 2013-16 to 2021-23
Mountain, Moor and Heath	Dwarf Shrub Heath	CSM positive indicators	=	2.47	2.66	=
		Negative indicators*	=	2.37	1.97	=
		Ellenberg fertility*	=	2.72	2.57	--
		Ellenberg moisture	=	6.06	6.01	=
		DSH cover	=	35.08	36.72	=

*These are negative indicators so a '+' indicates a decrease in condition.

Table 1-14 Long-term and short-term trends in topsoil indicators for Dwarf Shrub Heath. Long-term trends in indicators for Wales were extracted from (Smart, et al., 2009). "=": no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01. No data is shown as grey boxes.

Asset Class	Habitat	Indicator	Long term analysis using CS data 1978/1990 - 2007	Mean 2013-16	Mean 2021-23	Short term analysis using GMEP 2013-16 to 2021-23
Mountain, Moor and Heath	Dwarf Shrub Heath	Carbon (g/kg, from Organic matter)	=	178.4	177.5	=
		pH	=	4.47	4.20	--
		N (g/100g dry soil)*		1.01	1.01	=
		C density (tC/ha)	-	76.1	83.0	=
		Bulk density (g/cm^3)*		0.34	0.38	=

*An increase in this indicator is interpreted as a decline in condition for this habitat.

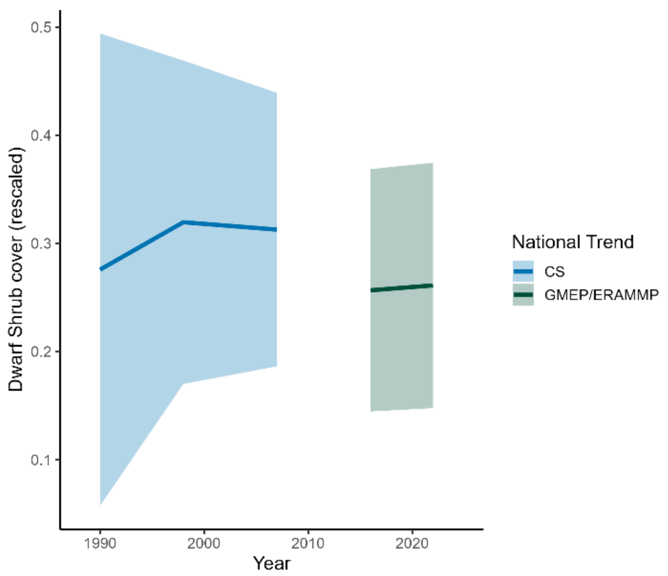

Figure 1-10 Long term National Trends in plants for Dwarf Shrub Heath cover (values have been rescaled) for analysis from Countryside Survey squares in Wales 1990 to 2007 and GMEP/ERAMMP (2013 – 16 to 2021 – 2023) from Nationally Representative squares.

Table 1-15 Long-term and short-term trends in pollinator indicators for Dwarf Shrub Heath. Long-term trends in indicators for Wales were extracted from (Smart, et al., 2009). "=": no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01. No data is shown as grey boxes.

Asset Class	Habitat	Indicator	Long term analysis using CS data 1978/1990 - 2007	Mean 2013-16	Mean 2021-23	Short term analysis using GMEP 2013-16 to 2021-23
Mountain, Moor and Heath	Dwarf Shrub Heath	Pollinator abundance		16.23	12.77	=
		Mean butterfly abundance		0.14	0.09	=
		Butterfly species richness		2.63	1.53	=
		Functional group richness		3.58	3.07	=
		Generality of pollinators		1.71	1.54	=

1.2.1.2 Glastir Impact

For vegetation, bundles used included the Habitat Management bundle which contained options for grazing management of open country (41a, and 41b), additional management payments for stock reduction and stock management (400, 401, 411). Bracken control and some habitat specific actions. We also analysed the Grazing Lo/No Inputs management bundle (15) and the Commons bundle.

For soils, the Glastir impact on Dwarf Shrub Heath was tested using the Habitat Management bundle, Organics and Commons bundles, and presence in historic AES. The Habitat Management bundle was dominated by actions on "Additional Management Payment – Reduced stocking" and "Grazing Management of open country". The Organics bundle contained the action on "Glastir Organics Interventions", and the Commons bundle was covered by the action "Commons Management of options combined".

Glastir bundles have had little positive impact on the Dwarf Shrub Heath Broad Habitat. No significant benefits were observed for Dwarf Shrub Heath indicators due to Glastir. A negative outcome for Commons management was also observed for butterfly species richness.

Positive Outcomes

- None reported.

Outcomes not as intended, trade-offs and contextual dependencies

- There are no significant changes in the vegetation indicators with Glastir Butterfly species richness having declined, where Commons Management was applied.
- There are no reported impacts of Glastir on topsoil indicators in Dwarf Shrub Heath.

Status of land coming into scheme and status of land where bundles / options are present

- Land under Grazing Lo/No Input options tends to have lower positive plant indicator species, higher negative indicators and an initially higher Ellenberg fertility suggesting payments have been targeted at habitat with poorer vegetation condition.
- Pollinator abundance was higher here where the Grazing Lo/No Inputs option was applied but had no effect on trends observed.
- Mean butterfly abundance had a higher baseline where the Hedgerow bundle was applied but trends were not affected.
- Dwarf Shrub Heath soil entering Glastir was generally in better condition than land out of Glastir, having lower topsoil bulk density, and higher carbon concentrations, and this has remained the case

Table 1-16 Glastir analysis for vegetation biodiversity indicators for Dwarf Shrub Heath. Glastir management bundles assessed for effects on indictors are shown. Context effect was tested using information related to participation in historic agri-environment schemes. + significant increase, - significant decrease, ++/-- strong response, = indicator remained stable over time.

Asset Class	Habitat	Indicator	Habitat Management (General)	Commons	Grazing Lo/No Input	Context: Historic AES
Mountain, Moor and Heath	Dwarf Shrub Heath	Ellenberg fertility*	=	=	=	=
		Ellenberg moisture	=	=	=	=
		Dwarf Shrub Heath cover	=	=	=	=
		Positive indicator richness	=	=	=	=
		Negative indicator richness*	=	=	=	=

*These are negative indicators so a '+' indicates a decrease in condition.

Table 1-17 Glastir analysis for topsoil indicators for Dwarf Shrub Heath. Glastir management bundles assessed for effects on topsoil indictors are shown. + significant increase, - significant decrease, ++/-- strong response, = indicator remained stable over time.

Asset Class	Habitat	Indicator	Habitat Management	Organic	Commons	Historic AES
Mountain, Moor and Heath	Dwarf Shrub Heath	Carbon (g kg-1, from Organic matter)	=	=	=	=
		pH in water	=	=	=	=
		N (g 100-1 g dry soil)*	=	=	=	=
		Carbon density (t carbon ha-1)	=	=	=	=
		Bulk density (g cm-3)*	=	=	=	=

*An increase in this indicator is interpreted as a decline in condition for this habitat.

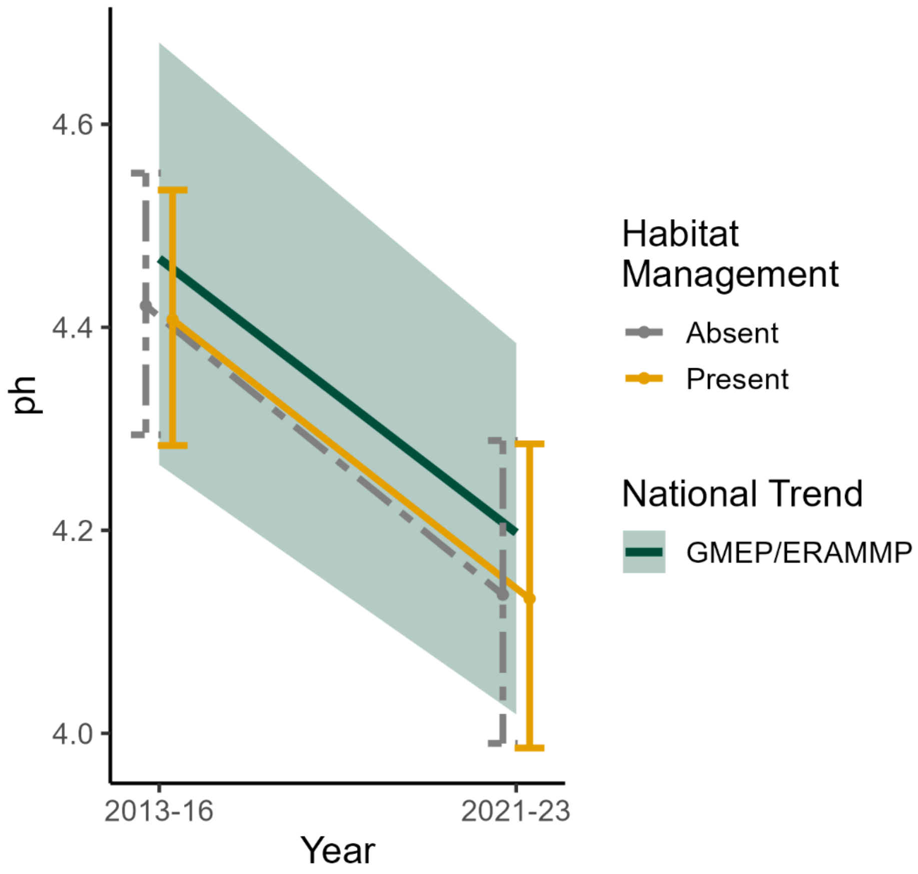

Figure 1-11 Trend in topsoil pH between 2013-16 and 2021-23 in Dwarf Shrub Heath showing both National Trends and effect of the Glastir Habitat Management bundle.

Table 1-18 Glastir analysis for pollinators indicators for Dwarf Shrub Heath. Glastir management bundles assessed for effects on pollinator indictors are shown. + significant increase, - significant decrease, ++/-- strong response, = indicator remained stable over time. No data is shown as grey boxes.

Asset Class	Habitat	Indicator	Grazing Lo/No Inputs	Habitat Management (General)	Hedge Management	Habitat Management Peat and Heath	Organic	Commons
Mountain, Moor and Heath	Dwarf Shrub Heath	Pollinator abundance	=	=	=	=	=	=
		Mean butterfly abundance	=	=	=	=	=	=
		Butterfly species richness	=	=	=	=	=	--
		Functional group richness	=	=	=	=	=	=
		Generality of pollinators	=	=		=	=	

1.2.2 Bog

This Broad Habitat covers wetland that support vegetation consisting of peat forming species that receive water and mineral nutrients from rainfall rather than ground water (Jackson, 2000). Peat depth should be greater than 0.5m. This habitat includes raised Bog and Blanket Bog priority habitats as well as topogenous and soligenous mires e.g. Valley Mires. Blanket Bog is defined by the presence of acidophilous indicators such as *Sphagnum, Eriophorum vaginatum*, water is likely to be at or near the surface. In other types of Bog *Eriophorum vaginatum* is absent although other *Eriophorum* spp. may be present, may also include *Myrica gale, Narthecium ossifragum* and *Trichophorum* species. Modified Bog that includes impoverished vegetation and lacking key indicators may be included but where Molinia dominates it is likely to have been included in Acid Grassland (moorland grass).

In 2021, Bog represented 20.4% of Wales's land surface. This was an increase of 1% since 2010 – a difference which is probably within detection limits of the satellite approach used.

Vegetation indicators

Pressures include inappropriate grazing, recreational pressures, encroachment of invasive native species e.g. *Molinia* and planting of Coniferous plantations. In addition, for many years they have been drained, resulting in loss of unique habitat specialists and species poor habitats often dominated by *Molinia*. Grip blocking and restoration of natural function in Bogs has been occurring (ERAMMP Technical Annex-105TA1S9: Wales National Trends and Glastir Evaluation Section 9 (Emmett & the ERAMMP Team, 2025)). Climate change also will have an impact on these habitats. As with Dwarf Shrub Heath, we use the presence of positive plant Common Standard Monitoring species, Dwarf Shrub Heath cover and negative plant indicators to indicate where we have 'appropriate diversity' i.e. the right species in the right place. We also use Ellenberg fertility to indicate fertility conditions particularly relating to Nitrogen pollution and Ellenberg moisture to understand whether the underlying hydrological regime is changing.

Pollinator indicators

Pollinator metrics considered here matched those used for Broadleaf Mixed and Yew Woodland; see section 1.1.1. Pollinators largely depend on plant diversity and vegetation quality, so the pressures on them will follow those described for vegetation.

Soil indicators

Soil was sampled from 0-15 cm; this is considered to be the most dynamic component of the soil profile, responding to land use, climate and management change. As such, topsoil indicators such as carbon density do not capture the complete soil profile but serve to indicate the direction of change. Care must be taken when interpreting measurements of topsoil carbon density as it is partially determined by bulk density, which changes with soil wetness (wet and dry years) and with compaction. Changes in bulk density can cause an apparent change in carbon density that does not reflect additional carbon storage. The best evidence for an increase in topsoil carbon density occurs when an increase in both carbon concentration and carbon density has occurred, with stable or decreasing bulk density. Topsoil pH and nitrogen concentration are soil properties needed for healthy soil function and ecosystem health, and changes in these indicators can be indicative of changes to vegetation, climate, nutrient deposition rates and management change. Naturally, Bog systems are both nutrient poor and acidic which means atmospheric deposition of both acidity and nitrogen are of particular concern where this depresses acidity below natural conditions and raises nitrogen levels encouraging taller and more competitive plant species at the expense of 'appropriate' biodiversity.

1.2.2.1 National Trends

Most indicators for Bogs suggest stability in this habitat with one critical exception of the Bog building plant *Sphagnum* which is a fundamental keystone genus for Bogs. As the overall score for plants which favour high moisture is stable, the driver behind this fall in *Sphagnum* abundance is unclear. It may be more sensitive than other plants to changing patterns in rainfall.

Positive Outcomes

- Most plant condition indicators for Bogs remained stable with one critical exception: Sphagnum cover.
- All pollinator indicators are stable.
- Topsoil carbon concentration and nitrogen concentrations, bulk density and carbon density have remained stable in Bogs.

Areas for Concern / Need for Further Action

- There has been a recent significant decline of 10% in *Sphagnum* cover in Bog between 2013-16 and 2021-23. The pH of Bog topsoil has recently decreased.

Table 1-19 Long-term and short-term trends in vegetation indicators for Bog. "=": no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01.

Asset Class	Habitat	Indicator	Long term analysis using CS data 1978/1990 - 2007	Mean 2013-16	Mean 2021-2023	Short term analysis using GMEP 2013-16 to 2021-23
Mountain, Moor and Heath	Bog	CSM positive indicators	=	3.53	3.17	=
		Negative indicators*	=	0.16	0.17	=
		Ellenberg fertility*	=	2.07	2.1	=
		Ellenberg moisture	=	7.2	7.19	=
		Sphagnum cover	=	32.55	22.98	--
		Sphagnum rescaled 0 to 1	=	0.18	0.12	--
		DSH cover	=	14.39	14.36	=

*These are negative indicators so a '+' indicates a decrease in condition.

Table 1-20 Long-term and short-term trends in topsoil indicators for Bog. Long-term trends in indicators for Wales were extracted from (Smart, et al., 2009). "=": no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01. No data is shown as grey boxes.

Asset Class	Habitat	Indicator	Long term analysis using CS data 1978/1990 - 2007	Mean 2013-16	Mean 2021-23	Short term analysis using GMEP 2013-16 to 2021-23
Mountain, Moor and Heath	Bog	Carbon (g/kg, from Organic matter)		343.0	364.2	=
		pH		4.27	4.03	--
		N (g/100g dry soil)*		1.53	1.78	=
		C density (tC/ha)		66.3	73.2	=
		Bulk density (g/cm^3) *		0.15	0.15	=

*An increase in this indicator is interpreted as a decline in condition for this habitat.

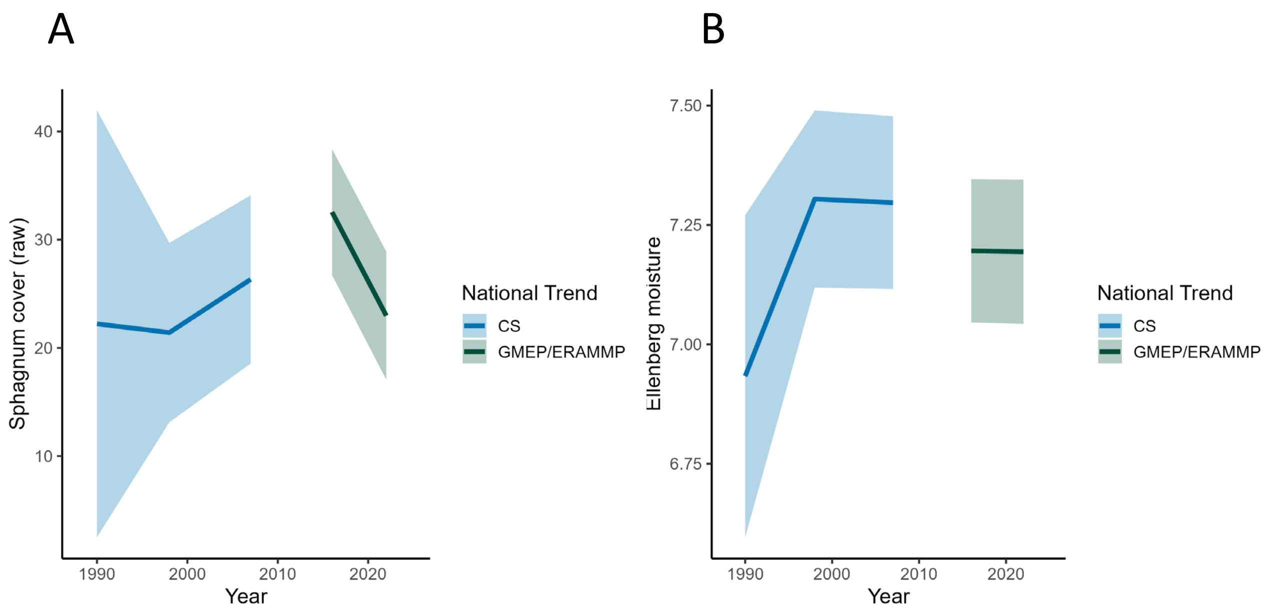

Figure 1-12 Long-term National Trends in A) Sphagnum cover (%) and B) Ellenberg moisture from Countryside Survey squares in Wales (1990 to 2007) and GMEP/ERAMMP (2013 – 16 to 2021 – 2023) from Nationally Representative squares.

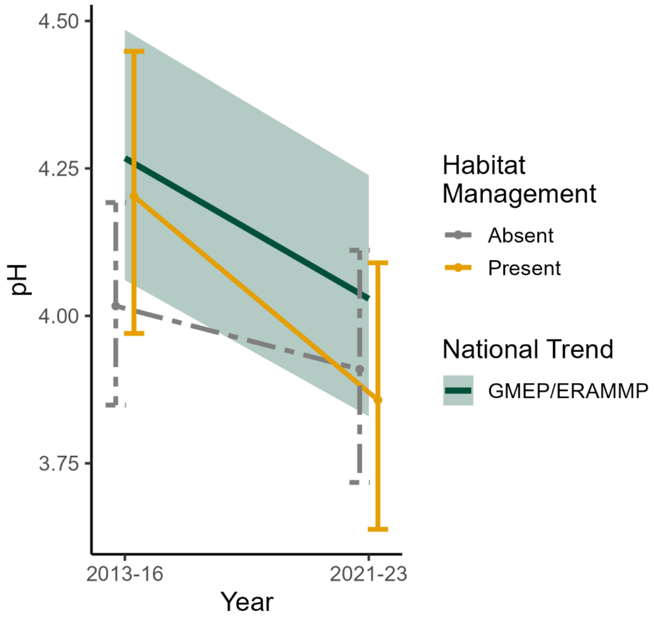

Figure 1-13 Trend in topsoil (i.e. peat) pH between 2013-16 and 2021-23 in Bog showing both National Trends and effect of Glastir Habitat Management.

Table 1-21 Long-term and short-term trends in pollinator indicators for Bog. Long-term trends in pollinator indicators for Wales were extracted from (Smart, et al., 2009). "=": no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01o. No data is shown as grey boxes.

Asset Class	Habitat	Indicator	Long term analysis using CS data 1978/1990 - 2007	Mean 2013-16	Mean 2021-23	Short term analysis using GMEP 2013-16 to 2021-23
Mountain, Moor and Heath	Bog	Pollinator abundance		10.21	11.86	=
		Mean butterfly abundance		0.12	0.09	=
		Butterfly species richness		1.56	1.69	=
		Functional group richness		2.48	3.12	=
		Generality of pollinators		1.31	1.3	=

1.2.2.2 Glastir Impact

For vegetation, the Glastir effect was assessed using the Habitat Management bundle which contained options for grazing management of open country (41a, and 41b), additional management payments for stock reduction and stock management (400, 401, 411), re-wetting (403) and some habitat specific actions. The Grazing Lo/No Inputs management bundle (15), and the Commons bundle were also analysed. For soils, the Glastir effect on Bog was assessed using the Habitat Management bundle, Organics and Commons bundles.

The impact of presence in historic AES schemes on soil health indicators was assessed too, although the representation of data in the soils dataset was low. The Habitat Management bundle was predominantly composed of the actions on reduced stocking and grazing management of the open country. The Organics bundle was represented by the action on “Glastir Organic Interventions”, and the Commons bundle was represented by the action on “Commons Management of options combined”.

There were some positive outcomes for vegetation, with the Habitat Management bundle Ellenberg fertility significantly decreased. No impact was observed for most soil indicators for the bundles tested with the exception of soil acidity which had a higher rate of acidification where the Habitat Management bundle was present.

Positive Outcomes

- Ellenberg fertility decreased in parcels subject to Habitat management.

Outcomes not as intended, trade-offs and contextual dependencies

- There were no reported positive outcomes for other plant indicators in the Habitat Management Commons or Grazing Lo/No Input management bundles.
- The Habitat Management bundle (primarily consisting of reduced stocking density) showed an increase in topsoil acidity compared to those without Glastir option uptake.
- Glastir Habitat management had no measurable impact on topsoil carbon or nitrogen concentrations, carbon density or bulk density in Bogs.

Status of land coming into scheme and status of land where bundles / options are present

- Land under Grazing Lo/No Input options tends to have higher negative indicators and an initially higher Ellenberg fertility and land under Commons management has fewer positive indicators suggesting payments have been targeted at habitat with poorer vegetation condition.

Table 1-22 Glastir analysis for vegetation biodiversity indicators for Bog. Glastir management bundles assessed for effects on biodiversity indicators are shown. Context effect was tested using information related to participation in historic agri-environment schemes. + significant increase, - significant decrease, ++/-- strong response, = indicator remained stable over time.

Asset Class	Habitat	Indicator	Habitat Management (General)	Commons	Grazing Lo/No Input Management	Context: Historic AES
Mountain, Moor and Heath	Bog	Ellenberg fertility*	--	=	=	=
		Ellenberg moisture	=	=	=	=
		Sphagnum cover	=	=	=	=
		Dwarf Shrub Heath cover	=	=	=	=
		Positive indicator richness	=	=	=	=
		Negative indicator richness*	=	=	=	=

*These are negative indicators so a '+' indicates a decrease in condition.

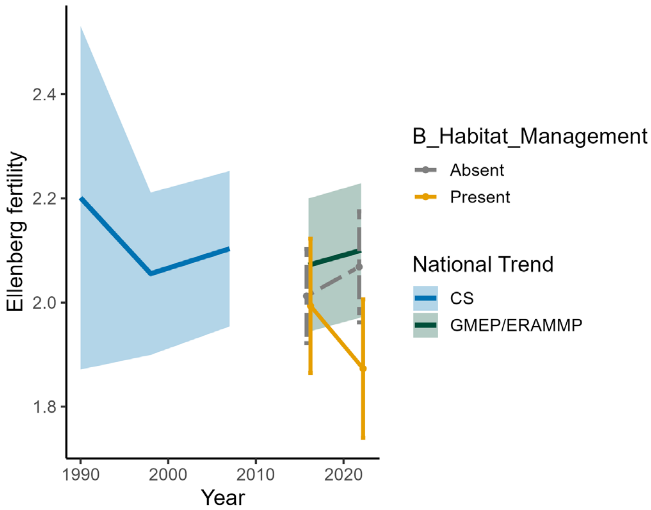

Figure 1-14 Trend in Ellenberg fertility between 1990-2007 and 2021-23 in Bog showing both National Trends and effect of Glastir Habitat Management.

Table 1-23 Glastir analysis for topsoil indicators for Bog. Glastir management bundles assessed for effects on topsoil indictors are shown. Context effect was tested using information related to participation in historic agri-environment schemes. + significant increase, - significant decrease, ++/-- strong response, = indicator remained stable over time.

Asset Class	Habitat	Indicator	Habitat Management	Organic	Commons	Context: Historic AES
Mountain, Moor and Heath	Bog	Carbon (g kg-1, from Organic matter)	=	=	=	=
		pH in water	-	=	=	=
		N (g 100-1 g dry soil)*	=	=	=	=
		Carbon density (t carbon ha-1)	=	=	=	=
		Bulk density (g cm-3)*	=	=	=	=

*An increase in this indicator is interpreted as a decline in condition for this habitat.

Table 1-24 Glastir analysis for pollinator indicators for Bog. Glastir management bundles assessed for effects on pollinator indictors are shown, but greyed out where data did not allow for analysis. Context effect was tested using information related to participation in historic agri-environment schemes. + significant increase, - significant decrease, ++/-- strong response, = indicator remained stable over time.

Asset Class	Habitat	Indicator	Habitat Management (General)	Habitat management peat/heath	Organic
Mountain, Moor and Heath	Bog	Pollinator abundance	=	=	=
		Mean butterfly abundance	=	=	=
		Butterfly species richness	=	=	=
		Functional group richness	=	=	=
		Generality of pollinators	=	=	

1.2.3 Blanket Bog

Blanket Bog is a priority habitat that is a subset of the Bog broad habitat. Others define Blanket Bog quite broadly as wetland on deep peats, including the landscape context as well as species. It is defined in this survey by the presence of acidophilous indicators such as *Sphagnum* and particularly *Eriophorum vaginatum* and does not include species poor rank vegetation dominated by Molinia. Water is likely to be at or near the surface and peat should be >0.5m. It is rainfall fed and can be extensive in upland areas.

The vegetation indicators are the same as for Bog.

1.2.3.1 National Trends

As for the Bog broad habitat, Blanket Bogs remained relatively stable with one critical exception of a decline in the Bog building plant *Sphagnum.* As the overall score for plants which favour high moisture is stable the driver behind this fall in *Sphagnum* abundance is unclear. It may be more sensitive than other plants to changing patterns in rainfall.

Positive Outcomes

- Most plant indicators remained stable (with the exception of *Sphagnum cover*).

Areas for Concern / Need for Further Action

- *Sphagnum* cover has significantly decreased by approx. 10% between 2013-16 and 2021-23. This downwards trend returns to levels shown in the longer-term Countryside Survey. There is very high uncertainty in the Blanket Bog results probably due to low sample size (ERAMMP Technical Annex-105TA1S3: Wales National Trends and Glastir Evaluation. Supplement-3: Vegetation Results (Maskell, et al., 2025)).

Table 1-25 Long-term and short-term trends in vegetation indicators for Blanket Bog. Long-term trends in indicators for Wales were extracted from (Smart, et al., 2009). "=": no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01. Note: Countryside Survey sample population was sampled from, on average, a higher latitude than the sample population in 2013-16 and the re-survey in 2021-23. Sample size for Blanket Bog in CS1990 was very small so here only samples from 1998 are shown.

Asset Class	Habitat	Indicator	Long term analysis using CS data 1998 - 2007	Mean 2013-16	Mean 2021-2023	Short term analysis using GMEP 2013-16 to 2021-23
Mountain, Moor and Heath	Blanket Bog	CSM positive	=	3.63	3.26	=
		Negative indicators*	=	0.14	0.2	=
		Ellenberg fertility*	=	2.02	2.05	=
		Ellenberg moisture	=	7.21	7.19	=
		Sphagnum cover	+	32.81	21.71	--
		Sphagnum cover (rescaled 0 to 1)	+	0.17	0.12	--
		DSH cover	=	0.13	0.14	=

*These are negative indicators so a '+' indicates a decrease in condition.

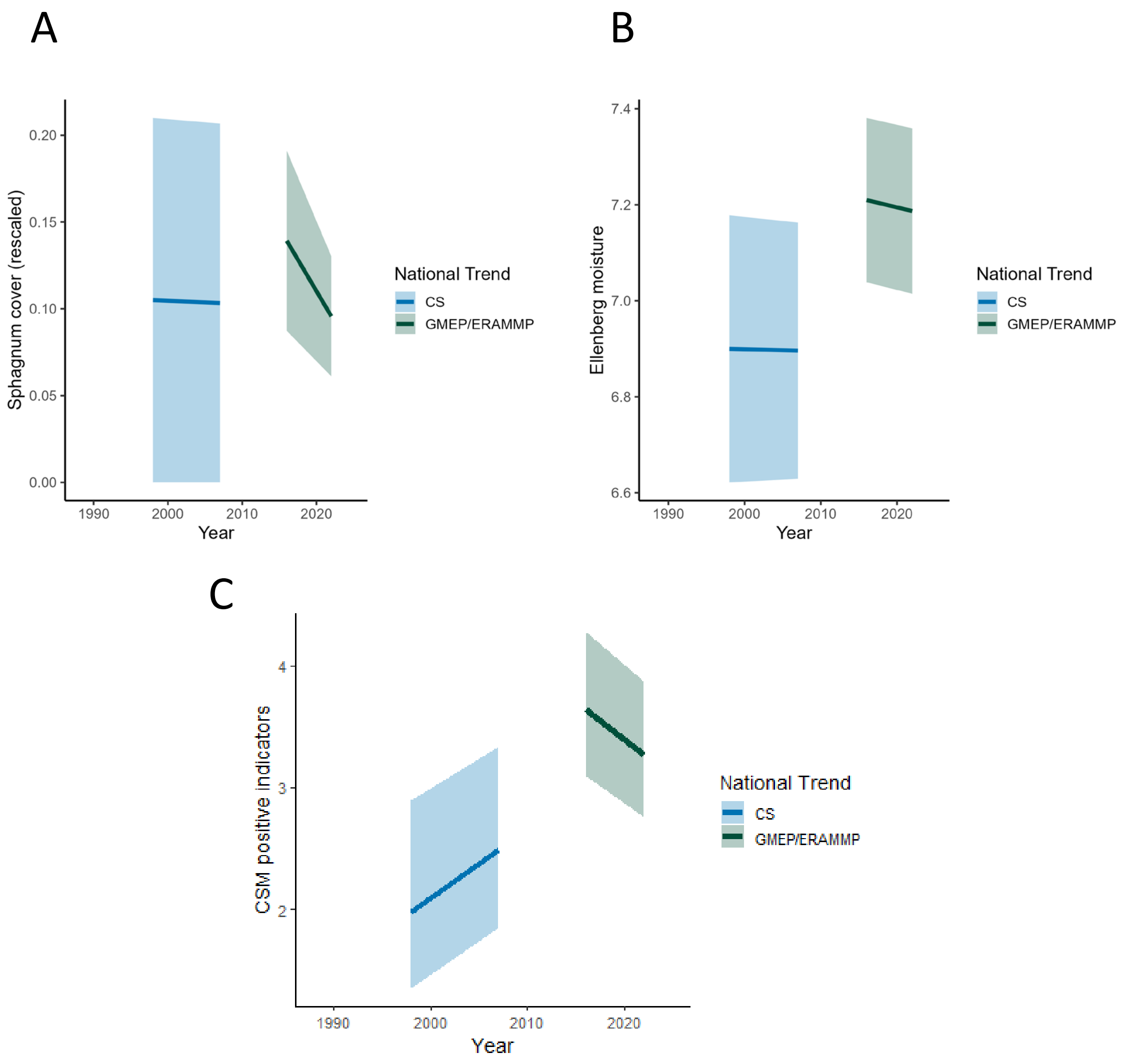

Figure 1-15 Long-term National Trends in plants in Blanket Bog between 1998-2007, 2013-16 and 2021-23 for A) Sphagnum cover B) plants favouring high moisture conditions (i.e. Ellenberg moisture score) and C) positive plant indicator (CSM) richness from Countryside Survey squares in Wales (1990 to 2007) and GMEP/ERAMMP (2013 – 16 to 2021 – 2023) from Nationally Representative squares.

1.2.3.2 Glastir Impact

Bundles are the same as Bog.

There were some significant effects of Glastir in condition indicators, i.e. Ellenberg fertility decreased with habitat management and positive and negative indicators, Sphagnum and DSH cover improved with commons management.

Positive Outcomes

- Ellenberg fertility decreased with Habitat management.
- There were several positive outcomes on land under Commons management. Sphagnum cover, DSH cover, and positive plant indicators increased with the Commons bundle.

Outcomes not as intended, trade-offs and contextual dependencies

There were no significant effects of change with the Glastir habitat management bundle on Blanket Bog for CSM positive indicators, moisture levels, sphagnum cover despite there being some re-wetting and habitat specific management. Status of land coming into scheme and status of land where bundles / options are present

- Land under Grazing Lo/No Input options tends to have higher negative indicators and an initially higher Ellenberg fertility, lower DSH cover and land under Commons management has lower DSH cover suggesting payments have been targeted at habitat with poorer vegetation condition.

Table 1-26 Glastir analysis for vegetation biodiversity indicators for Blanket Bog. Glastir management bundles assessed for effects biodiversity indicators are shown. Context effect was tested using information related to participation in historic agri-environment schemes. + significant increase, - significant decrease, ++/-- strong response, = indicator remained stable over time.

Asset Class	Habitat	Indicator	Habitat Management (General)	Commons	Grazing Lo/No Input Management	Context: Historic AES
Mountain, Moor and Heath	Blanket Bog	Ellenberg fertility*	--	=	=	=
		Ellenberg moisture	=	=	=	=
		Sphagnum cover	=	+	=	=
		Dwarf Shrub Heath cover	=	+	=	=
		Positive indicator richness	=	++	=	=
		Negative indicator richness*	=	=	=	=

*These are negative indicators so a '+' indicates a decrease in condition.

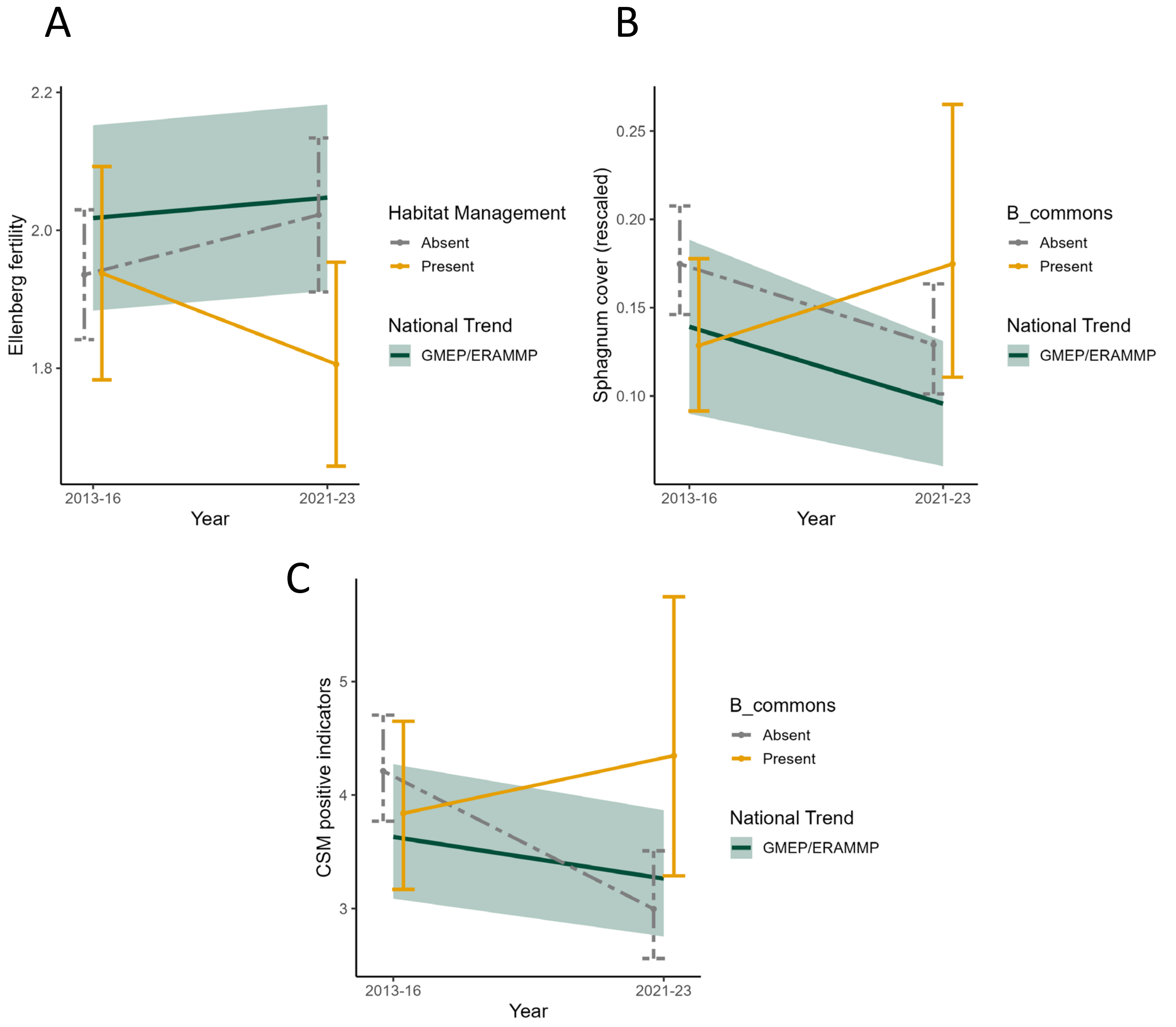

Figure 1-16 Trends between 2013-16 and 2021-23 in Blanket Bog showing both National Trends and effect of A) Ellenberg fertility and the Habitat Management bundles B) Sphagnum cover (rescaled from 0 to 1) and C) Positive plant indicators with the Commons bundle.

1.2.4 Bracken

This Broad Habitat consists of areas where Bracken is greater than or equal to 95% cover at the height of the growing season. It requires surveyors to predict bracken cover.

No information on current cover or change in bracken cover.

Vegetation indicators

Bracken is not a desirable target habitat so does not have CSM indicators, indeed bracken itself tends to be a negative indicator in many habitats. Here we use total species richness to indicate biodiversity value, Grass: Forb value to indicate the ratio of flowering plants to grass species i.e. more grass is negative and Ellenberg fertility to detect whether fertility is higher than would be expected in upland infertile habitats.

Pollinator indicators

Pollinator metrics considered here matched those used for Broadleaf Mixed and Yew Woodland; see section 1.1.1.

Soil indicators

Soil was sampled from 0-15 cm; this is considered to be the most dynamic component of the soil profile, responding to land use, climate and management change. As such, topsoil indicators such as for carbon density do not capture the complete soil profile but serve to indicate the direction of change. Care must be taken when interpreting measurements of topsoil carbon density as it is partially determined by bulk density, which changes with soil wetness (wet and dry years) and with compaction. Changes in bulk density can cause an apparent change in carbon density that does not reflect additional carbon storage. The best evidence for an increase in topsoil carbon density occurs when an increase in both carbon concentration and carbon density has occurred, with stable or decreasing bulk density. Topsoil pH and nitrogen concentration reflect soil properties needed for healthy soil function and ecosystem health, and changes in these indicators can be indicative of changes to vegetation, climate, nutrient deposition rates and management change.

1.2.4.1 National Trends

It is a mixed story for bracken with a halt in the decline of total plant species richness but an increase in topsoil bulk density (i.e. compaction).

Positive Outcomes

- The trend in total plant species richness was stable.
- The Grass:Forb ratio and cover of plants which favour high nutrient status (i.e. Ellenberg N score) were stable.
- Topsoil carbon and nitrogen concentration in Bracken remain stable, as well as topsoil pH and carbon density.

Areas for Concern / Need for Further Action

- Topsoil bulk density in Bracken, which indicates compaction, increased significantly by 15.5% across Wales.

Table 1-27 Long-term and short-term trends in vegetation indicators for Bracken. "=": no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01.

Asset Class	Habitat	Indicator	Long term analysis using CS data 1978/1990 - 2007	Mean 2013-16	Mean 2021-23	Short term analysis using GMEP 2013-16 to 2021-23
Mountain, Moor and Heath	Bracken	Grass: Forb ratio*	=	1.13	1.35	=
		Species richness	=	7.89	7.92	=
		Ellenberg fertility*	=	4.21	4.17	=

*These are negative indicators so a '+' indicates a decrease in condition.

Table 1-28 Long-term and short-term trends in topsoil indicators for Bracken. Long-term trends in indicators for Wales were extracted from (Smart, et al., 2009). "=": no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01. No data are shown as grey boxes.

Asset Class	Habitat	Indicator	Long term analysis using CS data 1978/1990 - 2007	Mean 2013-16	Mean 2021-23	Short term analysis using GMEP 2013-16 to 2021-23
Mountain, Moor and Heath	Bracken	Carbon (g/kg, from Organic matter)		71.4	64.7	=
		pH		4.74	4.74	=
		N (g/100g dry soil) *		0.49	0.45	=
		C density (tC/ha)		56.9	58.9	=
		Bulk density (g/cm^3)*		0.55	0.63	++

*An increase in this indicator is interpreted as a decline in condition for this habitat.

1.2.4.2 Glastir Impact

For vegetation, the Glastir effect was assessed using the Grazing Lo/No Input bundle and Habitat Management Mountain Moor and Heath.

For soils, the Glastir effect was assessed using the Habitat Management bundle, the Grazing Lo/No Input management bundle, and the Commons bundle. Presence in historic AES schemes was assessed too. The Commons bundle with the action on "Commons management options combined" and the Habitat Management bundle with the actions on reduced stocking and grazing management of open country were well represented within the soil dataset. The Grazing Lo/No Inputs management bundle was associated with the actions on grazed permanent pasture with no inputs and with low inputs and presence in historic AES schemes were less well represented in the dataset.

Grazing Lo/No Input management was found to significantly increase total plant species richness. Grass:Forb ratio increased with habitat management. Commons management was found to increase topsoil carbon concentration.

Positive Outcomes

- Grazing Lo/No Input management increased plant total species richness.
- Commons management increased topsoil carbon concentration compared to areas without Commons management.

Outcomes not as intended, trade-offs and contextual dependencies

- There was a significant increase in Grass:Forb ratio with Habitat Management.
- There was a decline in plant species richness with historic AES.
- Glastir options had no effect on topsoil condition in Bracken.

Table 1-29 Glastir analysis for vegetation indicators for Bracken. Glastir management bundles assessed for effects on vegetation indicators. Context effect was tested using information related to participation in historic agri-environment schemes. + significant increase, - significant decrease, ++/-- strong response, = indicator remained stable over time. + significant increase, - significant decrease, ++/-- strong response, = indicator remained stable over time.

Asset Class	Habitat	Indicator	Habitat Management	Grazing Lo/No Input Management	Context: Historic AES
Mountain, Moor and Heath	Bracken	Ellenberg fertility*	=	=	=
		Grass: Forb ratio*	+	=	=
		Total species richness	=	+	=

*These are negative indicators so a '+' indicates a decrease in condition.

Table 1-30 Glastir analysis for topsoil indicators for Bracken. Glastir management bundles assessed for effects on topsoil indictors are shown Context effect was tested using information related to participation in historic agri-environment schemes. + significant increase, - significant decrease, ++/-- strong response, = indicator remained stable over time.

Asset Class	Habitat	Indicator	Habitat Management	Grazing Lo/No Input Management	Commons	Context: Historic AES
Mountain, Moor and Heath	Bracken	Carbon (g kg-1, from Organic matter)	=	=	++	=
		pH in water	=	=	=	=
		N (g 100-1 g dry soil)*	=	=	=	=
		Carbon density (t carbon ha-1)	=	=	=	=
		Bulk density (g cm-3)*	=	=	=	=

*An increase in this indicator is interpreted as a decline in condition for this habitat.

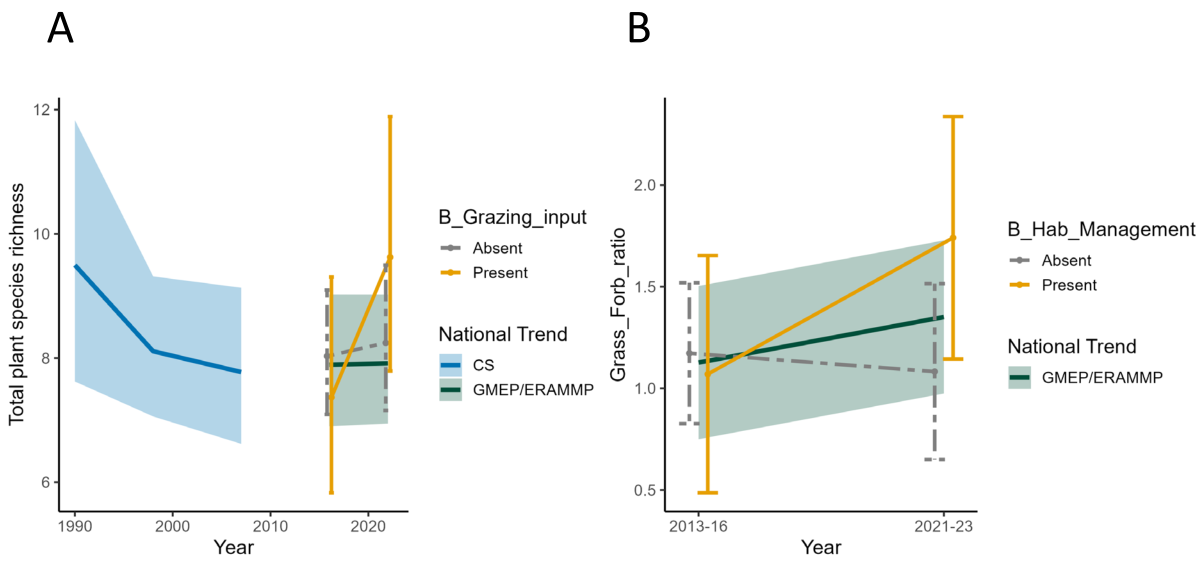

Figure 1-17 Trend in A) total plant species richness between 2013-16 and 2021-23 in Bracken showing both National Trends and effect of Grazing Lo/No Inputs management bundle and B) Grass:Forb ratio with Habitat Management bundle.

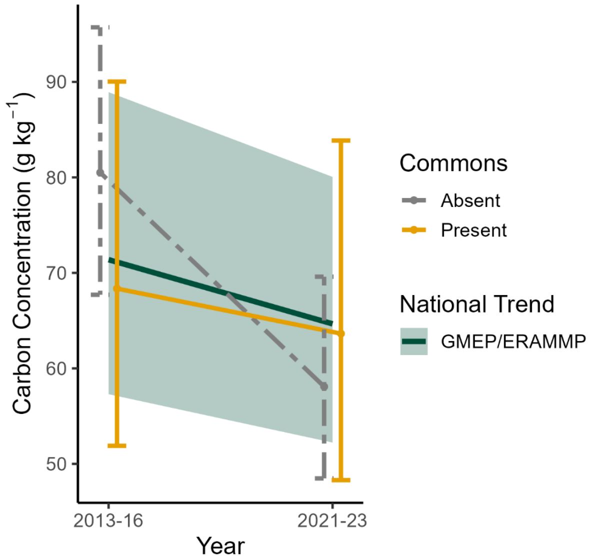

Figure 1-18 Trend in topsoil carbon concentration between 2013-16 and 2021-23 in Bracken showing both National Trends and effect of Commons management bundle.

1.2.5 Montane

The survey is not optimal for estimating highly localised habitats. Hence, we do not have sufficient data to analyse the Montane Broad Habitat.

1.2.6 Fen, Marsh, Swamp

Fen, Marsh, Swamp is a complex set of habitats but all with the common characteristic of being groundwater rather than rainfall fed and dominated by plants which favour high moisture status (i.e. they have a high Ellenberg moisture score). They can be found on peat or mineral soils and include the priority habitats Fen, Flush (lateral water movement), Reedbed and Purple Moor Grass Rush Pasture. Fen, Marsh, Swamp habitats do not include areas of dense soft rush (*Juncus effusus*) with no other wetland species; these are likely to be recorded as Acid Grassland with rush as an accompanying attribute. Fen, Marsh, Swamp habitats can be found in the uplands and lowlands, and we have not split them by altitude.

Fen, Marsh, Swamp covered 1% of Wales in 2021 which was a decline of 11% since 2010 but areas are so small this may have been within the detection limits of the satellite data and approach.

Vegetation indicators

Similar pressures to other MMH habitats occur here including, inappropriate grazing, drainage, impacts of climate change on sub-optimally managed habitats, eutrophication from runoff and atmospheric deposition leading to loss of species richness. Indicators include total species richness as well as CSM positive and negative indicators and Grass:Forb ratio. We also include Ellenberg moisture as water levels are critical for this habitat (as with Bog)

Pollinator indicators

Pollinator metrics considered here matched those used for Broadleaf Mixed and Yew Woodland; see section 1.1.1. Pollinators largely depend on plant diversity and vegetation quality, so the pressures on them will follow those described for vegetation.

Soil indicators

Soil was sampled from 0-15 cm; this is considered to be the most dynamic component of the soil profile, responding to land use, climate and management change. As such, topsoil indicators such as for carbon density do not capture the complete soil profile but serve to indicate the direction of change. Care must be taken when interpreting measurements of topsoil carbon density as it is partially determined by bulk density, which changes with soil wetness (wet and dry years) and with compaction. Changes in bulk density can cause an apparent change in carbon density that does not reflect additional carbon storage. The best evidence for an increase in topsoil carbon density occurs when an increase in both carbon concentration and carbon density has occurred, with stable or decreasing bulk density. Topsoil pH and nitrogen concentration reflect soil properties needed for healthy soil function and ecosystem health, and changes in these indicators can be indicative of changes to vegetation, climate, nutrient deposition rates and management change. Nutrient status is usually higher in this habitat relative to Bogs due to the supply from underlying soil as is soil pH with more neutral soil conditions prevalent compared to the acidic condition which typify Bog habitats.

1.2.6.1 National Trends

National Trends suggest that there are some areas of concerns for this habitat with a significant decrease in total plant species richness, an increase in the Grass:Forb ratio (a negative plant indicator) and a decrease in the Ellenberg moisture score. Butterfly abundance and species richness have also declined.

Positive Outcomes

- Plants which favour high nutrient status (i.e. Ellenberg fertility score) have remained stable as have positive plant species indicators.
- Pollinator abundance, functional group richness and generality of pollinators are stable.
- Topsoil carbon and nitrogen concentrations have remained stable in Fen, Marsh, Swamp

Areas for Concern / Need for Further Action

- There has been a significant decrease in total plant species richness.
- There has been an increase in Grass:Forb ratio which is a negative indicator of condition (signalling the increase of grasses at the expense of flowering plants).
- There has been a decrease in plant Ellenberg moisture score.
- Mean butterfly abundance and butterfly species richness show significant declines.
- Topsoil bulk density (i.e. soil compaction) increased by 27% which, with topsoil carbon concentrations remaining stable in Fen, Marsh, Swamp, driving a 17.3% increase in carbon density. This does not reflect an overall increase in soil carbon storage.

Table 1-31 Long-term and short-term trends in vegetation indicators for Fen, Marsh, Swamp. "=": no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01. No data are shown as grey boxes.

Asset Class	Habitat	Indicator	Long term analysis using CS data 1978/1990 - 2007	Mean 2013-16	Mean 2021-23	Short term analysis using GMEP 2013-16 to 2021-23
Mountain, Moor and Heath	Fen, Marsh, Swamp	CSM positive indicators	=	9.29	8.78	=
		Total species richness	=	13.44	12.43	-
		Grass: Forb ratio*	=	0.14	0.78	++
		Ellenberg fertility*	=	3.98	4.02	=
		Ellenberg moisture	=	7.14	7.04	--

*These are negative indicators so a '+' indicates a decrease in condition.

Table 1-32 Long-term and short-term trends in topsoil indicators for Fen, Marsh, Swamp. Long-term trends in indicators for Wales were extracted from (Smart, et al., 2009). "=": no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01. No data are shown as grey boxes.

Asset Class	Habitat	Indicator	Long term analysis using CS data 1978/1990 - 2007	Mean 2013-16	Mean 2021-23	Short term analysis using GMEP 2013-16 to 2021-23
Mountain, Moor and Heath	Fen, Marsh, Swamp	Carbon (g/kg, from Organic matter)		156.6	149.1	=
		pH		5.37	5.21	=
		N (g/100g dry soil) *		0.98	1.03	=
		C density (tC/ha) [1]		55.9	65.6	++
		Bulk density (g/cm^3) [1]*		0.24	0.30	++

*An increase in this indicator is interpreted as a decline in condition for this habitat.

[1]As carbon concentrations have not increased this is driven by the increase in bulk density and does not reflect an increase in soil carbon storage.

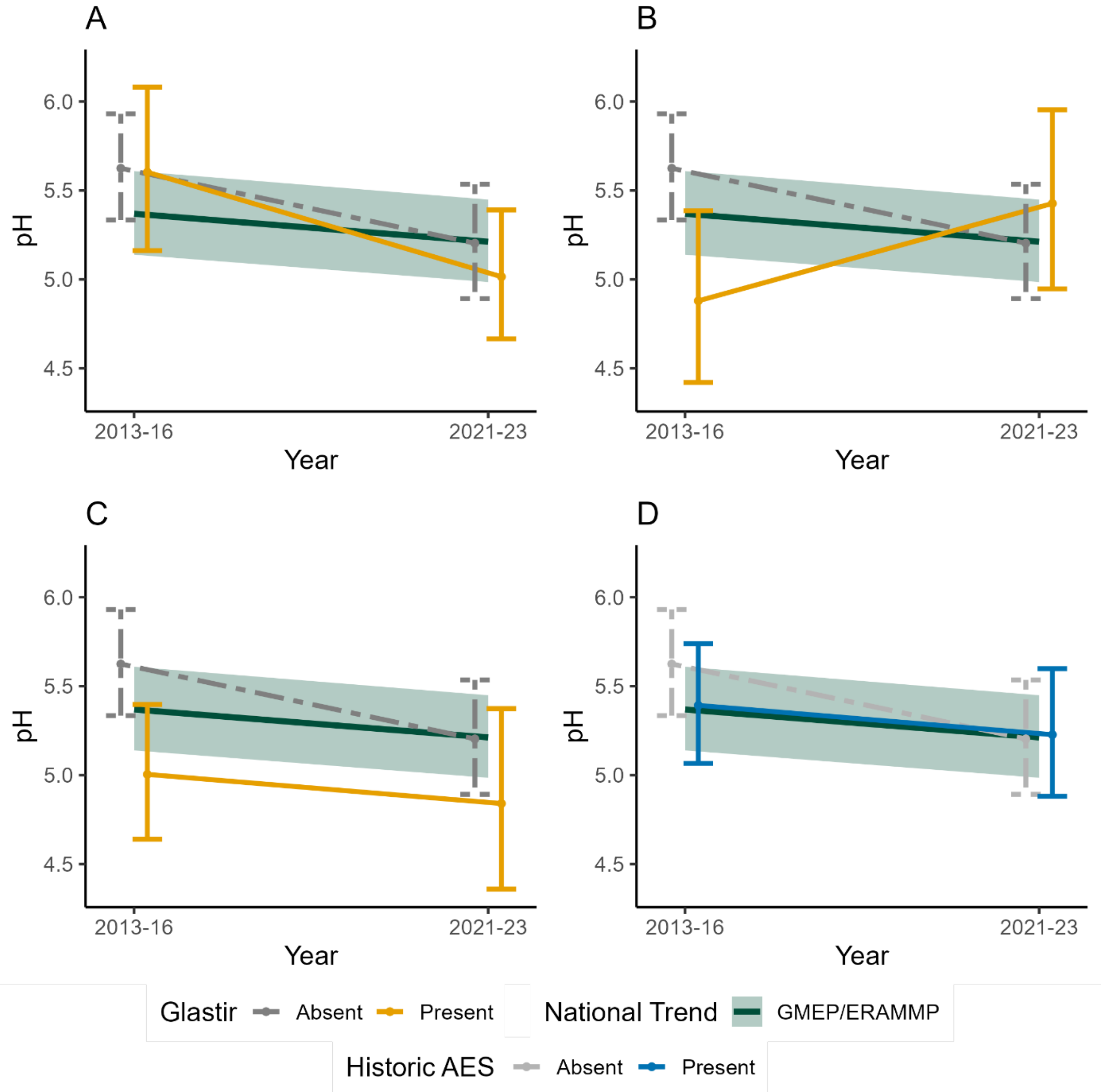

Figure 1-19 Trend in topsoil pH between 2013-16 and 2021-23 in Fen, Marsh, Swamp showing both National Trends and A) effect of *Glastir Habitat Management*. B) *Glastir Grazing Lo/No Inputs management. C) Commons*. And D) where historic AES is present or absent.

Table 1-33 Long-term and short-term trends in pollinator indicators for Fen, Marsh, Swamp. Long-term trends in pollinator indicators for Wales were extracted from (Smart, et al., 2009). "=": no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01. No data are shown as grey boxes..

Asset Class	Habitat	Indicator	Long term analysis using CS data 1978/1990 - 2007	Mean 2013-16	Mean 2021-23	Short term analysis using GMEP 2013-16 to 2021-23
Mountain, Moor and Heath	Fen, Marsh, Swamp	Pollinator abundance		17.29	17.13	=
		Mean butterfly abundance		0.31	0.14	--
		Butterfly species richness		3.41	1.97	-
		Functional group richness		4.25	4.08	=
		Generality of pollinators		1.71	1.47	=

1.2.6.2 Glastir Impact

Fen, Marsh, Swamp land entering Glastir was already in better condition than land not in Glastir as reported previously (Emmett & team, 2017).

Grazing Lo/No Inputs management has an almost significant decrease in Grass:Forb ratio (a negative indicator) suggesting an improvement in vegetation condition. The same management bundle also increases topsoil pH. Plants which favoured high nutrient status increased with Habitat Management although fertility was lower in land in scheme than wider Wales.

Overall, Grazing Lo/No Inputs management bundle may have had a positive outcome.

For soils, Glastir impacts on Fen, Marsh, Swamp soils was assessed using the Habitat Management bundle, the Grazing Lo/No Inputs management bundle, and the Commons bundle. The presence of historic AES schemes on topsoil indicators was assessed too. The Habitat Management bundle was the largest bundle and associated with a total of seven actions, the three most common actions being: reduced stocking, grazing management of open country, and lowland marshy grassland. The Grazing Lo/No Inputs management bundle was mainly associated with the option of grazed permanent pasture with no inputs. The Commons bundle is represented by the action "Commons management of options combined".

For vegetation Glastir impacts on Fen, Marsh, Swamp were assessed using the Grazing Lo/No Inputs bundle, the Habitat Management bundle, that included options on reduced grazing payments (411), grazing management of open country and habitat specific options e.g. management of lowland marshy grasslands, commons management and organic.

Positive Outcomes

- That could suggest an improvement in vegetation condition.
- Grazing Lo/No Input management significantly increased topsoil pH in Fen, Marsh, Swamp. The reasons for this need further exploration.

Outcomes not as intended, trade-offs and contextual dependencies

- Plants which favoured high nutrient conditions (i.e. Ellenberg fertility score) increased under Habitat Management although fertility was lower in land in scheme than land outside of scheme. Ellenberg moisture was also higher in land under habitat management so targeting appears to have been towards higher quality land.
- There was no impact of Organic management on vegetation condition.
- There were increases in the Grass:Forb ratio (a negative indicator) with Commons management.
- There was no effect of Glastir bundles on pollinator abundance. There was a lower baseline where Glastir Commons Management was occurring.

Table 1-34 Glastir analysis for vegetation indicators for Fen, Marsh, Swamp. Glastir management bundles assessed for effects on vegetation indicators are shown. Context effect was tested using information related to participation in historic agri-environment schemes. + significant increase, - significant decrease, ++/-- strong response, = indicator remained stable over time.

Asset Class	Habitat	Indicator	Habitat Management	Commons	Grazing Lo/No Input Management	Organic	Context: Historic AES
Mountain, Moor and Heath	Fen, Marsh, Swamp	Ellenberg fertility*	+	=	=	=	=
		Ellenberg moisture	=	=	=	=	=
		Grass: Forb ratio*	=	+	=	=	+
		Total species richness	=	=	=	=	=
		Positive indicator richness	=	=	=	=	+

*These are negative indicators so a '+' indicates a decrease in condition.

Table 1-35 Glastir analysis for topsoil indicators for Fen, Marsh, Swamp Glastir management bundles assessed for effects on topsoil indictors are shown. Context effect was tested using information related to participation in historic agri-environment schemes. + significant increase, - significant decrease, ++/-- strong response, = indicator remained stable over time.

Asset Class	Habitat	Indicator	Habitat Management	Grazing Lo/No Input Management	Commons	Context: Historic AES
Mountain, Moor and Heath	Fen, Marsh, Swamp	Carbon (g kg-1, from Organic matter)	=	=	=	=
		pH in water	=	++	=	=
		N (g 100-1 g dry soil)*	=	=	=	=
		Carbon density (t carbon ha-1)	=	=	=	=
		Bulk density (g cm-3)*	=	=	=	=

*An increase in this indicator is interpreted as a decline in condition for this habitat.

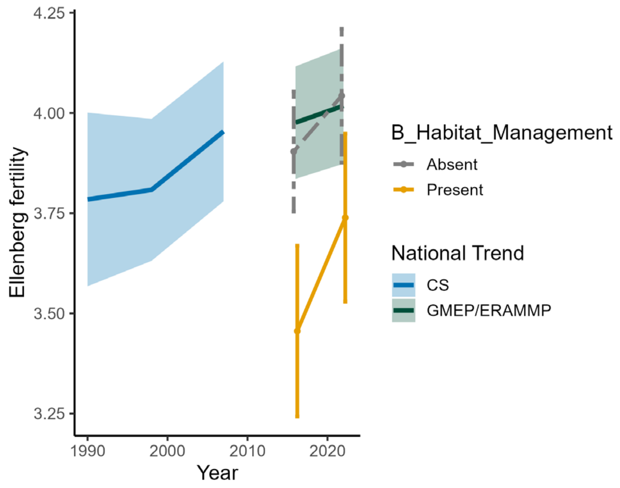

Figure 1-20 Trend in Ellenberg fertility between 2013-16 and 2021-23 in Fen, Marsh, Swamp showing both National Trends and effect Habitat management bundle.

Table 1-36 Glastir analysis for pollinator indicators for Fen, Marsh, Swamp Glastir management bundles assessed for effects on pollinator indictors are shown, but greyed out where data did not allow for analysis. Context effect was tested using information related to participation in historic agri-environment schemes. + significantly positive effect, - significantly negative effect, ++/-- strong response, = no detectable effect on the indicator.

Asset Class	Habitat	Indicator	Habitat Manageme nt	Habitat manageme nt peat/heath	Organic	Commons
Mountain, Moor and Heath	**Fen, Marsh, Swamp**	Pollinator abundance	=	=	=	=
		Mean butterfly abundance	=	=	=	=
		Butterfly species richness	=	=	=	=
		Functional group richness	=	=	=	=
		Generality of pollinators	=	=	=	

1.2.7 Purple Moor Grass Rush Pasture (Marshy Grassland)

Purple Moor Grass and rush pastures occur on poorly drained, usually acidic soils in lowland areas of high rainfall. Purple Moor Grass *Molinia caerulea,* and rushes, especially sharp-flowered rush *Juncus acutiflorus*, are usually abundant. Key indicator species associated with Purple Moor Grass and rush pastures include: *Carum verticillatum*, *Cirsium dissectum*, *Platanthera chlorantha and Achillea ptarmica.* The term 'marshy grassland' is used within Glastir and we have used the priority habitat Purple Moor Grass Rush Pasture as a surrogate for marshy grassland.

There is no information on current of historic change in cover from satellite information.

Vegetation indicators

Pressures on Purple Moor Grass Rush Pasture include inappropriate grazing, drainage, eutrophication and loss of species richness. Indicators include total species richness as well as CSM positive and negative indicators. We also include Ellenberg moisture to detect changes in water level.

There are no pollinator or soil data available for Purple Moor Grass Rush Pasture.

1.2.7.1 National Trends

There are early indicators of a decline in condition of this habitat after a period of stability. This is indicated by an increase in the Grass:Forb ratio (a negative indicator) and a decline in plants which favour high moisture status (i.e. Ellenberg moisture scores).

Positive Outcomes

- The total species richness, number of positive indicators and number of plants which favour high nutrient status have remained stable.

Areas for Concern / Need for Further Action

- Plant Ellenberg moisture scores have decreased which is a negative indicator for this wet habitat.
- The plant Grass:Forb ratio has increased which is a negative indicator of vegetation condition.

Table 1-37 Long-term and short-term trends in vegetation indicators for Purple Moor Grass Rush Pasture (Marshy Grassland). Long-term trends in indicators for Wales were extracted from (Smart, et al., 2009). "=": no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01. No data are shown as grey boxes. Note: Countryside Survey sample population was sampled from, on average, a higher latitude than the sample population in 2013-16 and the re-survey in 2021-23.

Asset Class	Habitat	Indicator	Long term analysis using CS data 1978/1990 - 2007	Mean 2013-16	Mean 2021-23	Short term analysis using GMEP 2013-16 to 2021-23
Mountain, Moor and Heath	Purple Moor Grass Rush Pasture (Marshy Grassland)	Grass: Forb ratio*	=	0.24	0.99	++
		CSM positive	=	3.36	3.29	=
		Total species richness	=	14.86	13.98	=
		Ellenberg fertility*	=	3.91	3.88	=
		Ellenberg moisture	=	7.1	7	--

*These are negative indicators so a '+' indicates a decrease in condition.

1.2.7.2 Glastir Impact

There is little evidence Glastir has improved this Priority Habitat with no change in most plant indicators.

Positive Outcomes

- None recorded.

Outcomes not as intended, trade-offs and contextual dependencies

- No improvement in Ellenberg indicators, positive plant indicator richness, species richness or decline in Grass: Forb ratio with Glastir bundles.

Table 1-38 Glastir analysis for vegetation indicators for Purple Moor Grass Rush Pasture (Marshy Grassland). Glastir management bundles assessed for effects on vegetation indictors are shown. Context effect was tested using information related to participation in historic agri-environment schemes. . + significant increase, - significant decrease, ++/-- strong response, = indicator remained stable over time.

Asset Class	Habitat	Indicator	Habitat Management General	Commons	Grazing Lo/No Input Management	Organic	Context: Historic AES
Mountain, Moor and Heath	Purple Moor Grass Rush Pasture (Marshy Grassland)	Ellenberg fertility*	=	=	=	=	=
		Ellenberg moisture	=	=	=	=	=
		Grass: Forb ratio*	=	=	=	=	=
		Total species richness	=	=	=	=	=
		Positive indicator richness	=	=	=	=	=

*These are negative indicators so a '+' indicates a decrease in condition.

1.2.8 Inland Rock

This Broad Habitat includes both natural and artificial exposed rock surfaces where these are almost entirely lacking in vegetation, it includes inland cliffs, ledges and caves, screes, quarries and quarry waste. The priority habitats included within this Broad Habitat are Limestone Pavement (of geological and biological importance with vegetation rich in vascular plants, bryophytes, ferns and lichens), Inland Rock Outcrop and Scree habitats-characteristic of high altitudes, (coastal cliff and ledge habitats are excluded as they form part of the maritime cliffs and slopes priority habitat). Screes are typically dominated by *Cryptogramma crispa* and other ferns, lichens and bryophytes. Calaminarian grassland includes a range of semi-natural and anthropogenic sparsely vegetated habitats on substrates characterised by high levels of heavy metals such as lead, chromium and copper, or other unusual minerals.

Inland Rock represented 0.2% of land cover in Wales. This is a 56% decrease in cover since 2010 but this may be within the detection limits of the satellite data and approach.

Pressures on Inland Rock include inappropriate grazing, eutrophication and loss of species richness. Indicators include Ellenberg fertility and reaction (pH), total species richness as well as CSM positive indicators, however, CSM indicator models would not converge.

1.2.8.1 National Trends

There is a low sample size for this habitat but the data available has identified this habitat is showing a decline in overall plant species richness. Pollinator indicators are stable.

Positive Outcomes

- Most plant and pollinator indicators are stable.

Areas for Concern / Need for Further Action

- There has been a recent decline in total plant species richness.

Table 1-39 Long-term and short-term trends in vegetation indicators for Inland Rock. "=": no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01. No data are shown as grey boxes.

Asset Class	Habitat	Indicator	Long term analysis using CS data 1978/1990 - 2007	Mean 2013-16	Mean 2021-23	Short term analysis using GMEP 2013-16 to 2021-23
Mountain, Moor and Heath	Inland Rock	Fertility*	=	4.04	3.69	=
		Ellenberg reaction	=	4.56	4.58	=
		Total species richness	=	7.96	5.74	-

*These are negative indicators so a '+' indicates a decrease in condition.

Table 1-40 Long-term and short-term trends in pollinator indicators for Inland Rock. "=": no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01. No data are shown as grey boxes.

Asset Class	Habitat	Indicator	Long term analysis using CS data 1978/1990 - 2007	Mean 2013-16	Mean 2021-23	Short term analysis using GMEP 2013-16 to 2021-23
Mountain, Moor and Heath	Inland Rock	Pollinator abundance		9.35	6.34	=
		Mean butterfly abundance		0.12	0.05	=
		Butterfly species richness		1.62	0.9	=
		Functional group richness		3.46	1.62	=
		Generality of pollinators		1.83	1.78	=

1.2.8.2 Glastir Impact

There was a decline in plants that favour more alkaline conditions under Commons management but no other significant impacts on the vegetation. No effect on pollinator indicators was observed.

Positive Outcomes

- Commons Management resulted in a decline in plants which favour more alkaline conditions i.e. towards acidic species (Ellenberg reaction scores).

Outcomes not as intended, trade-offs and contextual dependencies

- No impact on pollinator indicators were observed

Table 1-41 Glastir analysis for vegetation indicators for Inland Rock. Glastir management bundles assessed for effects on indictors are shown. Context effect was tested using information related to participation in historic agri-environment schemes. + significant increase, - significant decrease, ++/-- strong response, = indicator remained stable over time.

Asset Class	Habitat	Indicator	Habitat Management General	Grazing Lo/No Input Management	Commons Management
Mountain, Moor and Heath	Inland Rock	Ellenberg fertility*	=	=	=
		Ellenberg reaction	=	=	-
		Total species richness	=	=	=

*These are negative indicators so a '+' indicates a decrease in condition.

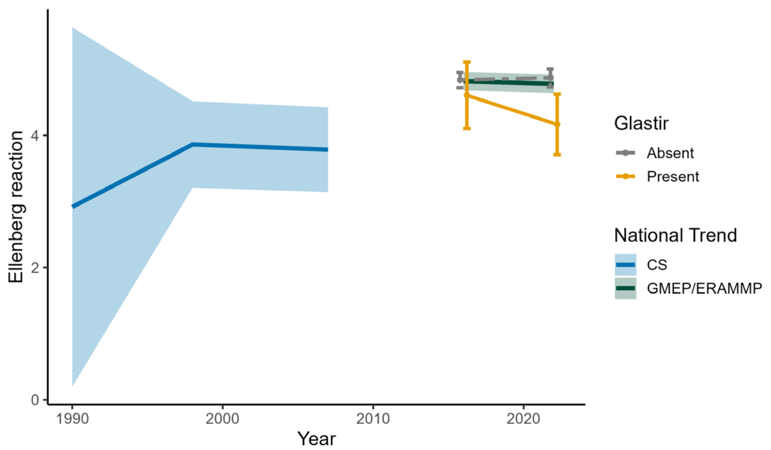

Figure 1-21 Trend in plants which favour more acidic condition (i.e. Ellenberg R reaction scores) between 2013-16 and 2021-23 in Inland Rock plots showing both national trends and effect of Commons management.

Table 1-42 Glastir analysis for pollinator indicators for Inland Rock. Glastir management bundles assessed for effects on indictors are shown. Context effect was tested using information related to participation in historic agri-environment schemes. + significant increase, - significant decrease, ++/-- strong response, = indicator remained stable over time. No data is shown as grey boxes.

Asset Class	Habitat	Indicator	Habitat Management (General)	Habitat management peat/heath
Mountain, Moor and Heath	Inland Rock	Pollinator abundance	=	=
		Mean butterfly abundance	=	=
		Butterfly species richness	=	=
		Functional group richness	=	=
		Generality of pollinators	=	

1.2.9 Birds

Six upland bird indicators were investigated in these analyses - Abundance of upland farmland bird species (indicator) and Abundance of upland bird species (guild), plus four general indicators for Priority bird species and the three dietary guilds (Granivorous-, Invertebrate- and Vertebrate-eating bird species). The indicator follows a policy-led, standard list of species from (Burns, et al., 2023), whilst the guilds follow an extended list of species from (Siriwardena, Henderson, Noble, & Fuller, 2019) and aim to cover wider ranges of habitat and dietary preferences in an upland context than are reflected by upland farmland alone, as well as key dietary preferences. The priority bird species list consists of all section 7 species from the Environment (Wales) Act 2016.

Long-term pressures on upland birds, cutting across various broad habitats within the relevant landscapes, include grazing pressure from sheep reducing vegetation cover and diversity, and climate change causing drying and decline of peatland habitats. Afforestation in some areas has facilitated the spread of predators, with negative effects particularly on some ground-nesting species.

1.2.9.1 National Trends

National Trends of the six upland bird indicators are stable. Note that the summary metrics used here will tend to obscure species-specific variations in changes over time and it would be beneficial to examine the data at the species level. Several important upland farmland species, such as Curlew, remain at historically low levels and Glastir has not supported a population recovery.

Positive Outcomes

- No change seen in the National Trends, a more positive pattern than is apparent from the national BBS. ERAMMP is likely to sample upland habitats better than BBS, because volunteer observers are harder to find in the uplands.

Areas for Concern / Need for Further Action

- None

Table 1-43 National Trends for all Upland bird indicators. =: no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01. Priority birds and Dietary indicators can be found in Table 1-12. No data is shown as grey boxes.

Asset Class	Habitat	Indicator	Long term trend from BBS (1994-2013)	Mean 2013-16	Mean 2021-23	Short term analysis using GMEP 2013-16 to 2021-23
Mountain, Moor and Heath	**Upland farmland**	Abundance of upland farmland bird species (indicator) -BBS	=	103.0	89.2	
		Abundance of upland farmland bird species (indicator)		8.190	8.099	=
		Abundance of upland bird species (guild)		4.536	4.357	=

1.2.9.2 Glastir Impact

Decreases are demonstrated for vertebrate-eating bird species in response to habitat management for Mountain, Moor and Heath, although the effect was small in magnitude.

Positive Outcomes

- None

Outcomes not as intended, trade-offs and contextual dependencies

- Slight decline in vertebrate-eating birds with Habitat Management. It is important to understand which specific vertebrate-eating species are driving the negative association with Glastir and whether this shows a genuine negative effect of certain options or a chance correlation with an unforeseen background influence.
- No positive effect of Glastir bundles was observed. Continued monitoring and investigation of potential wider impacts on upland bird species across Wales for species of concern remains important. Note that the summary metrics used here will tend to obscure species-specific variations in changes over time and it would be beneficial to examine the data at the species level. Several important upland farmland species, such as Curlew, remain at historically low levels and Glastir has not supported a population recovery.

Table 1-44 Glastir analysis for bird indicators for Mountain, Moor and Heath. Glastir management bundles assessed for effects on bird indicators are shown. + significant increase, - significant decrease, ++/-- strong response, = indicator remained stable over time.

Asset Class	Indicator	Habitat Management
Mountain, Moor and Heath	Abundance of upland farmland bird species (indicator)	=
	Abundance of upland bird species (guild)	=
	Priority Bird Abundance	=
	Granivorous eating bird species abundance	=
	Invertebrate-eating bird species abundance	=
	Vertebrate-eating bird species abundance	--

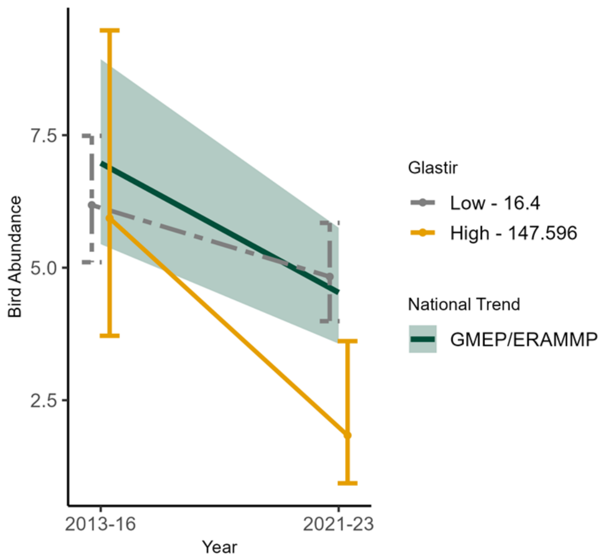

Figure 1-22 Trend in Vertebrate-eating bird species abundance between 2013-16 and 2021-23 in Mountain, Moor and Heath showing both national trends and effect of uptake of Habitat Management is low or high in proportion to specific bundle coverage maximums.

1.3 Semi-Natural Grassland

Semi-Natural Grassland is a mix of grassland types including Unimproved Neutral Grassland; Calcareous Grassland and Acid Grassland. High levels of grazing and impacts of atmospheric acidic and nitrogen deposition are two important pressures on this asset class.

1.3.1 Unimproved Neutral Grassland

This habitat was re-defined to exclude semi-improved neutral grassland. In (Alison, et al., 2021) plots were assigned using their NVC class, here we used the priority habitat hay meadow to signify high quality Unimproved Grassland. Hence the sample size is quite low (see ERAMMP Technical Annex-105TA1S3: Wales National Trends and Glastir Evaluation.

Supplement-3: Vegetation Results). These habitats consist of traditionally managed lowland hay-meadows and pastures in which grasses such as *Cynosurus cristatus, Festuca rubra, Agrostis capillaris* and *Anthoxanthum odoratum* typically occur in a species-rich sward with a high cover of associated herbs. Cover of grass species and clover are usually less than 50%. Typically, rich in forb species with frequent low soil pH (i.e. high acidity) lowland meadow indicators including *Lathyrus pratensis, Lotus corniculatus, Leucanthemum vulgare, Primula veris,* or on flood meadows some of *Caltha palustris, Sanguisorba officinalis, Filipendula ulmaria* and *Alopecurus pratensis*. It also includes upland hay meadow, *Anthoxanthum odoratum* - *Geranium sylvaticum* grassland. Pressures on this habitat include intensification of use e.g. application of fertilisers, overgrazing and fragmentation. As this habitat is high quality and targeted for conservation, positive and negative plant species richness have been used to measure condition. Ellenberg fertility indicates plant response to changing nutrient conditions which may be a pressure here and total species richness enables comparison to other less high-quality habitats.

Unimproved Neutral Grassland represented 2% of land cover of Wales in 2021 according to UKCEH Land Cover Map. This presented a 2% increase from 2010 although this is likely to be within the detection limits of the satellite data and approach.

1.3.1.1 National Trends

There are a few early warning signs of an onset of decline in condition of Unimproved Neutral Grassland habitat. This includes a decline in overall plant species richness, pollinator, and mean butterfly abundance. Positive and negative plant species indicators, butterfly species richness and functional group richness however currently remain stable. No change was detected in Lowland farmland bird indicator species, which showed no significant difference in abundance between the survey periods of GMEP and ERAMMP.

Positive Outcomes

- Positive and negative Common Standard Monitoring plant species remain stable.
- Plants which favour high nutrient status (i.e. Ellenberg fertility scores) and acidic conditions (i.e. Ellenberg reactive scores) have remained stable.
- Butterfly species richness and functional group richness were stable.

Areas for Concern / Need for Further Action

- There has been a decline in total plant species richness.
- Pollinator abundance and mean butterfly abundance show significant declines.

Table 1-45 Long-term and short-term trends in vegetation indicators for Unimproved Neutral Grassland. "=": no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01. No data are shown as grey boxes.

Asset Class	Habitat	Indicator	Long term analysis using CS data 1978/1990 - 2007	Mean 2013-16	Mean 2021-23	Short term analysis using GMEP 2013-16 to 2021-23
Semi-Natural Grassland	Unimproved Neutral Grassland	CSM positive		2.23	1.57	=
		Negative indicators*		6	6.26	=
		Ellenberg fertility*		4.36	4.55	=
		Total species richness		19.78	16.91	-

*These are negative indicators so a '+' indicates a decrease in condition.

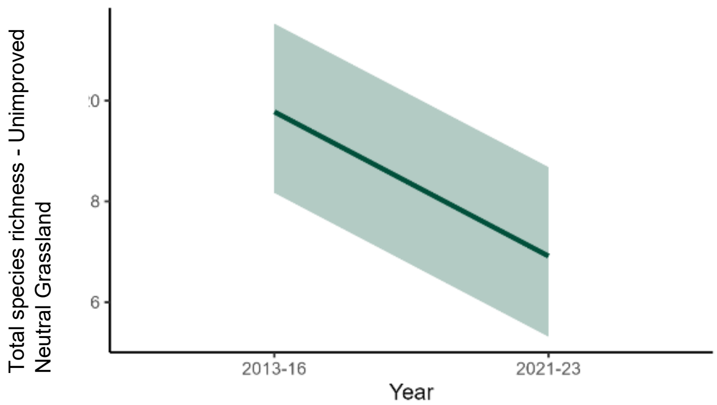

Figure 1-23 Trend between 2013-16 and 2021-23 in total species richness in Unimproved Neutral Grassland from nationally representative survey squares.

Table 1-46 Long-term and short-term trends in pollinator indicators for Unimproved Neutral Grassland. "=": no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01. No data are shown as grey boxes. Data availability did not support testing for Generality of pollinators.

Asset Class	Habitat	Indicator	Long term analysis using CS data 1978/1990 - 2007	Mean 2013-16	Mean 2021-23	Short term analysis using GMEP 2013-16 to 2021-23
Semi-Natural Grassland	Unimproved Neutral Grassland	Pollinator abundance		49.35	20.92	-
		Mean butterfly abundance		0.53	0.15	-
		Butterfly species richness		3.93	2.63	=
		Functional group richness		6.38	5.51	=

1.3.1.2 Glastir Impact

The bundles Grazing Lo/No Input management and Habitat management were the main Glastir effect tested here, this was due to low sample size so not many options were represented.

No effect of Glastir was reported for Unimproved Neutral Grassland for pollinators but effects were seen for vegetation and birds. There was an increase in positive plant indicators with Habitat management although it should be noted that initially positive indicators were lower in land under Habitat Management.

Lowland farmland bird indicator species, grassland guild species and invertebrate- and vertebrate-eating bird species abundances were positively associated with Glastir grazing/input management.

Positive Outcomes

- There was an increase in positive plant indicators with Habitat Management.
- None reported for pollinators.

Outcomes not as intended, trade-offs and contextual dependencies

- There were no significant Glastir effects for pollinators and only one for vegetation but note there was a low sample to analyse (see annexe).

Table 1-47 Glastir analysis for vegetation indicators for Priority Habitats 30 and 31: Upland and Lowland Hay Meadow Neutral Grassland. Glastir Management bundles assessed for effects on indictors are shown. Context effect was tested using information related to participation in historic agri-environment schemes.

Asset Class	Habitat	Indicator	Habitat Management	Grazing Lo/No Input Management	Context: Historic AES
Semi-Natural Grassland	Unimproved Neutral Grassland	Ellenberg fertility*	=	=	=
		Ellenberg reaction	=	=	=
		Total species richness	=	=	=
		Positive indicators	+	=	=
		Negative indicators*	=	=	=

*These are negative indicators so a '+' indicates a decrease in condition.

Table 1-48 Glastir analysis for pollinator indicators for Priority Habitats 30 and 31: Upland and Lowland Hay Meadow Neutral Grassland. Glastir management bundles assessed for effects on indictors are shown, but greyed out where data did not allow for analysis. Context effect was tested using information related to participation in historic agri-environment schemes. No data are shown as grey boxes.

Asset Class	Habitat	Indicator	Grazing Lo/No Inputs	Habitat Management (General)
Semi-Natural Grassland	Unimproved Neutral Grassland	Pollinator abundance	=	=
		Mean butterfly abundance	=	=
		Butterfly species richness	=	=
		Functional group richness	=	=
		Generality of pollinators		

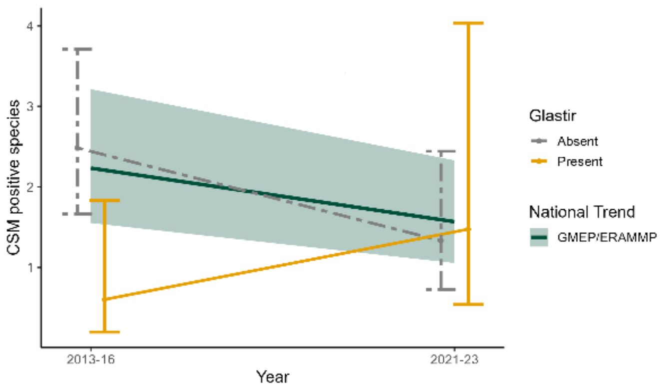

Figure 1-24 Trend in positive plant indicators between 2013-16 and 2021-23 in Unimproved Neutral Grassland plots showing both national trends and effect of Habitat Management.

1.3.2 Calcareous Grassland

A Broad Habitat characterised by vegetation dominated by grasses and herbs on shallow soils rich in bases (calcium carbonate), pH 5-6. Calcareous Grassland is a relatively uncommon habitat in Wales (and in Britain as a whole). Because the habitat type is so scarce and unevenly distributed, it is not well sampled by this survey. Hence, we do not have sufficient vegetation data to analyse Calcareous Grasslands. Results based on limited pollinator data are, however, presented.

Calcareous Grassland represented < 0.1% of Wales land use in 2021. Change data are not reported due to small areas involved.

1.3.2.1 National Trends

Positive Outcomes

- The indicators for functional group richness and the generality (range) of ecological functions pollinators deliver are stable.

Areas for Concern / Need for Further Action

- Pollinator abundance, mean butterfly abundance, and butterfly species richness have all shown declines.

Table 3.43 National Trend analysis for pollinator indicators in Calcareous grassland. Mean estimate, change and p-values were extracted from models for periods 2013-16 and 2021-23.

Asset Class	Habitat	Indicator	Long term analysis using CS data 1978/1990 - 2007	Mean 2013-16	Mean 2021-23	Short term analysis using GMEP 2013-16 to 2021-23
Semi-Natural Grassland	Calcareous grassland	Pollinator abundance per site		105.64	55.14	--
		Mean number of individuals per butterfly species per site		1.26	0.31	--
		Species richness of butterflies		10.2	4.72	-
		Functional group richness of pollinators		9.24	8.01	=
		Generality of pollinators		2.37	1.62	=

1.3.2.2 Glastir Impact

There were insufficient data to analyse.

1.3.3 Acid Grassland

Vegetation is dominated by grasses and forbs within a range of soils, derived from acidic bedrock, sands and gravels or shallow peat. It can consist of fine grasses in generally dry situations e.g. *Agrostis curtisii, Festuca ovina* and *Anthoxanthum odoratum* on brown podzolic soils. This Broad Habitat also includes Moorland grass dominated by coarser grass species (*Nardus* or *Molinia*), usually occurring in a moorland setting but also present within lowland heath landscapes. Dwarf shrubs and peatland species may be frequent but are usually less than 25% cover and are never dominant. The results for vegetation are split into the priority habitat Lowland Dry Acid Grassland and Upland Acid Grassland as underlying conditions are so different. Results presented are for both unless otherwise stated.

Acid Grassland represented 21% of land use cover of Wales in 2021 according to the UKCEH Land Cover Map. This was a decrease in cover of 2% relative to 2010.

Vegetation indicators

This habitat is sensitive to grazing pressure which will be linked to a decrease in plant Commons Standard Monitoring species and an increase in Grass:Forb ratio (a negative indicator). Grass:Forb ratio describes the relationship between grasses and forbs, a higher score indicates that there is more grass cover which is undesirable, and the aim is to increase forb richness of these grasslands. A high cover of grass in relation to the abundance of forbs can indicate intensive management impacts, e.g., high grazing intensity, nutrient enrichment.

The habitat is also particularly sensitive to acidic deposition due to its limited soil buffering capacity. It is also naturally nutrient limited so changes due to atmospheric nitrogen deposition could increase grass competitiveness relative to forb species.

Pollinator indicators

Pollinator metrics considered here matched those used for Broadleaf Mixed and Yew Woodland; see section 1.1.1. Pollinators largely depend on plant diversity and vegetation quality, so the pressures on them will follow those described for vegetation, although upland grassland is always likely to be species-poor, relative to lowland habitats.

Soil indicators

Soil was sampled from 0-15 cm; this is considered to be the most dynamic component of the soil profile, responding to land use, climate and management change. As such, topsoil indicators such as for carbon density do not capture the complete soil profile but serve to indicate the direction of change. Care must be taken when interpreting measurements of topsoil carbon density as it is partially determined by bulk density, which changes with soil wetness (wet and dry years) and with compaction. Changes in bulk density can cause an apparent change in carbon density that does not reflect additional carbon storage. The best evidence for an increase in topsoil carbon density occurs when an increase in both carbon concentration and carbon density has occurred, with stable or decreasing bulk density. Topsoil pH and nitrogen concentration reflect soil properties needed for healthy soil function and ecosystem health, and grassland productivity. Changes in these indicators can be indicative of changes to vegetation, climate, nutrient deposition rates and management change, including the extent of soil improvement and inputs. This habitat is particularly sensitive to acidic deposition due to its limited soil buffering capacity. It is also naturally nutrient limited so indicators of changes in nitrogen content are important.

1.3.3.1 National Trends

There are early signs of a decline in Acid Grassland condition after a longer-term period of stability with an increase in the Grass:Forb ratio (a negative indicator), a decline in some pollinator indicators and an increase in topsoil acidity although there has been a slight reduction in Ellenberg fertility.

Positive Outcomes

- Plant positive indicators are stable.
- There has been a slight reduction in Ellenberg fertility in upland Acid Grassland.
- Functional group richness and generality of pollinators are stable.
- Topsoil carbon and nitrogen concentrations and compaction remained stable in Acid Grasslands.

Areas for Concern / Need for Further Action

- The Grass:Forb ratio has increased which indicates a decline in condition in both Lowland Dry Acid Grassland and Upland Acid Grassland.
- There has been a slight reduction in Ellenberg moisture.
- Mean butterfly abundance has declined. Pollinator abundance and butterfly species richness also tended towards decline but were marginally non-significant.
- Topsoil pH has significantly decreased in Acid Grasslands, which is in line with wider trends for Great Britain.

Table 1-49 Long-term and short-term trends in vegetation indicators for Acid Grassland. "=": no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01.

Asset Class	Habitat	Indicator	Long term analysis using CS data 1978/1990 - 2007	Mean 2013-16	Mean 2021-23	Short term analysis using GMEP
Semi-Natural Grassland	Lowland Dry Acid Grassland	Grass: Forb ratio*	=	0.48	1.66	++
		CSM positive	=	1.67	0.89	=
		Ellenberg fertility*	=	3.7	3.23	=
		Ellenberg moisture	=	5.19	5.61	=
	Upland Acid Grassland	Grass: Forb ratio*	=	2.1	2.4	++
		CSM positive	=	0.86	0.9	=
		Negative indicators*	=	1.4	1.22	=
		Dwarf Shrub Heath cover (rescaled)	=	0.07	0.08	=
		Ellenberg fertility*	=	3.13	3.05	-
		Ellenberg moisture	=	6.04	5.99	-

*These are negative indicators so a '+' indicates a decrease in condition.

Table 1-50 Long-term and short-term trends in topsoil indicators for Acid Grassland. Long-term trends in indicators for Wales were extracted from (Smart, et al., 2009). "=": no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01. No data are shown as grey boxes. Note: Countryside Survey sample population was sampled from, on average, a higher latitude than the sample population in 2013-16 and the re-survey in 2021-23.

Asset Class	Habitat	Indicator	Long term analysis using CS data 1978/1990 - 2007	Mean 2013-16	Mean 2021-23	Short term analysis using GMEP 2013-16 to 2021-23
Semi-Natural Grassland	Acid Grassland	Carbon (g/kg, from Organic matter)	=	135.4	129.3	=
		pH	=	4.79	4.56	--
		N (g/100g dry soil) *		0.80	0.77	=
		C density (tC/ha)[1]	=	69.5	76.8	+
		Bulk density (g/cm^3) *		0.40	0.45	=

*An increase in this indicator is interpreted as a decline in condition for this habitat.

[1]As carbon concentrations have not increased this is driven by the increase in bulk density and does not reflect an increase in soil carbon storage.

Table 1-51 Long-term and short-term trends in pollinator indicators for Acid Grassland. "=": no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01. No data are shown as grey boxes.

Asset Class	Habitat	Indicator	Long term analysis using CS data 1978/1990 - 2007	Mean 2013-16	Mean 2021-23	Short term analysis using GMEP 2013-16 to 2021-23
Semi-Natural Grassland	Acid Grassland	Pollinator abundance		20.41	21.39	=
		Mean butterfly abundance		0.15	0.08	-
		Butterfly species richness		2.18	1.48	=
		Functional group richness		3.58	2.9	=
		Generality of pollinators		1.26	1.33	=

1.3.3.2 Glastir Impact

As for many other habitats, Acid Grassland entering Glastir was generally in better condition than land outside of Glastir possibly linked to the fact most sites had been in previous AES schemes.

There was evidence that Habitat Management has had a positive effect on vegetation condition in Acid Grassland with a decrease in the negative indicator Grass: Forb ratio. No effect on topsoil or pollinator indicators was observed. No effect of Grazing Lo/No Input management was observed for any indicator.

As the national trend is for a recent onset of decline in vegetation condition, it is clear that whilst Glastir can help to reverse this decline for some indicators, the uptake of Glastir is insufficient to shift the national trend.

For vegetation Glastir impacts were assessed using the Habitat Management bundle (included reduction in stocking level and management of upland grassland, grazing management of open country (41) and other habitat specific measures. The Grazing Lo/No Inputs management and Commons bundles were also assessed. The sample size was too low for Lowland Acid Grassland for analysis.

For soils, Glastir impacts on Acid Grassland was assessed using the Habitat Management bundle, the Grazing Lo/No Inputs Management bundle, and the Organics and Commons bundles. The presence in historic AES schemes was assessed too. The Habitat Management bundle was the largest bundle and associated with a total of eight actions, the two dominating actions being: reduced stocking and grazing management of open country. The Grazing Lo/No Inputs management bundle was mainly associated with the option of grazed permanent pasture with no inputs. The Organics bundle was represented by the action on “Glastir Organic Interventions”, and the Commons bundle was represented by the action “Commons management of options combined”.

Positive Outcomes

- Grass: Forb ratio (a negative indicator) decreased with Habitat Management.
- Glastir options had no significant effect on topsoil condition in Acid Grassland however the majority (79.2%) of sites applying Glastir options were also members of historic agri-environment schemes. These Glastir managements may then be serving to “hold the line” and preserve past improvements.

Outcomes not as intended, trade-offs and contextual dependencies

- There was no effect of Habitat Management (General) on topsoil carbon concentrations in Acid Grasslands as seen in Semi-Improved Grassland and Broadleaved Mixed and Yew Woodland, despite a high uptake of “reduce stocking density” options.
- There were no significant effects of Glastir management on most vegetation indicators.
- There were no significant positive individual bundle effects on pollinators.
- There was no effect of Glastir on pollinator indicators. Pollinator abundance and mean butterfly abundance had lower baselines where Glastir Commons Management was applied.

Status of land coming into scheme and status of land where bundles / options are present

- Land under Grazing Lo/No Input options tends to have lower positive plant indicator species and higher negative indicators suggesting payments have been targeted at habitat with poorer vegetation condition.

Table 1-52 Glastir analysis for vegetation indicators for Acid Grassland. Glastir management bundles assessed for effects on indictors are shown. Context effect was tested using information related to participation in historic agri-environment schemes. + significant increase, - significant decrease, ++/-- strong response, = indicator remained stable over time.

Asset Class	Habitat	Indicator	Habitat Management	Commons	Grazing Lo/No Input Management	Context: Historic AES
Semi-Natural Grassland	Upland Acid Grassland	Ellenberg fertility*	=	=	=	=
		Ellenberg moisture	=	=	=	=
		DSH cover	=	=	=	+
		Grass: Forb ratio*	-	=	=	=
		Positive indicator richness	=	=	=	=
		Negative indicator richness*	=	=	=	=

*These are negative indicators so a '+' indicates a decrease in condition.

Table 1-53 Glastir analysis for topsoil indicators for Acid Grassland. Glastir management bundles assessed for effects on topsoil indictors are shown. Context effect was tested using information related to participation in historic agri-environment schemes. + significant increase, - significant decrease, ++/-- strong response, = indicator remained stable over time. No data are shown as grey boxes.

Asset Class	Habitat	Indicator	Habitat Management	Grazing Lo/No Input Management	Organic	Commons	Context: Historic AES
Semi-Natural Grassland	Acid Grassland	Carbon (g kg-1, from Organic matter)	=	=	=	=	
		pH in water	=	=	=	=	=
		N (g 100-1 g dry soil)*	=	=	=	=	=
		Carbon density (t carbon ha-1)	=	=	=	=	=
		Bulk density (g cm-3)*	=	=	=	=	=

* An increase in this indicator is interpreted as a decline in condition for this habitat.

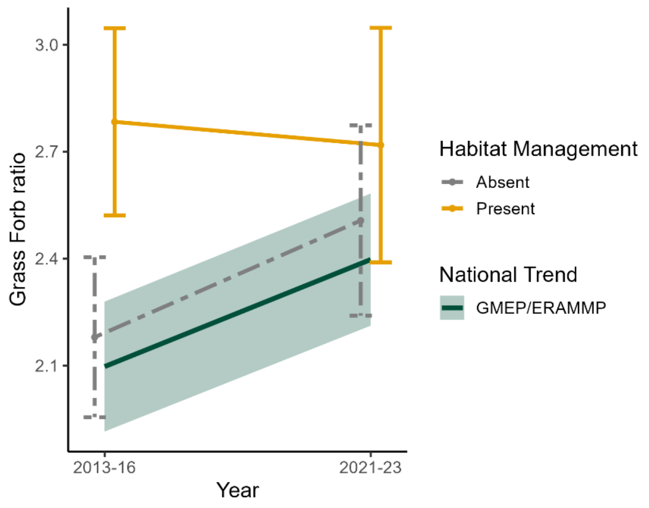

Figure 1-25 Trend in Grass: Forb ratio between 2013-16 and 2021-23 in Acid Grassland showing both national trends and effect of Habitat Management.

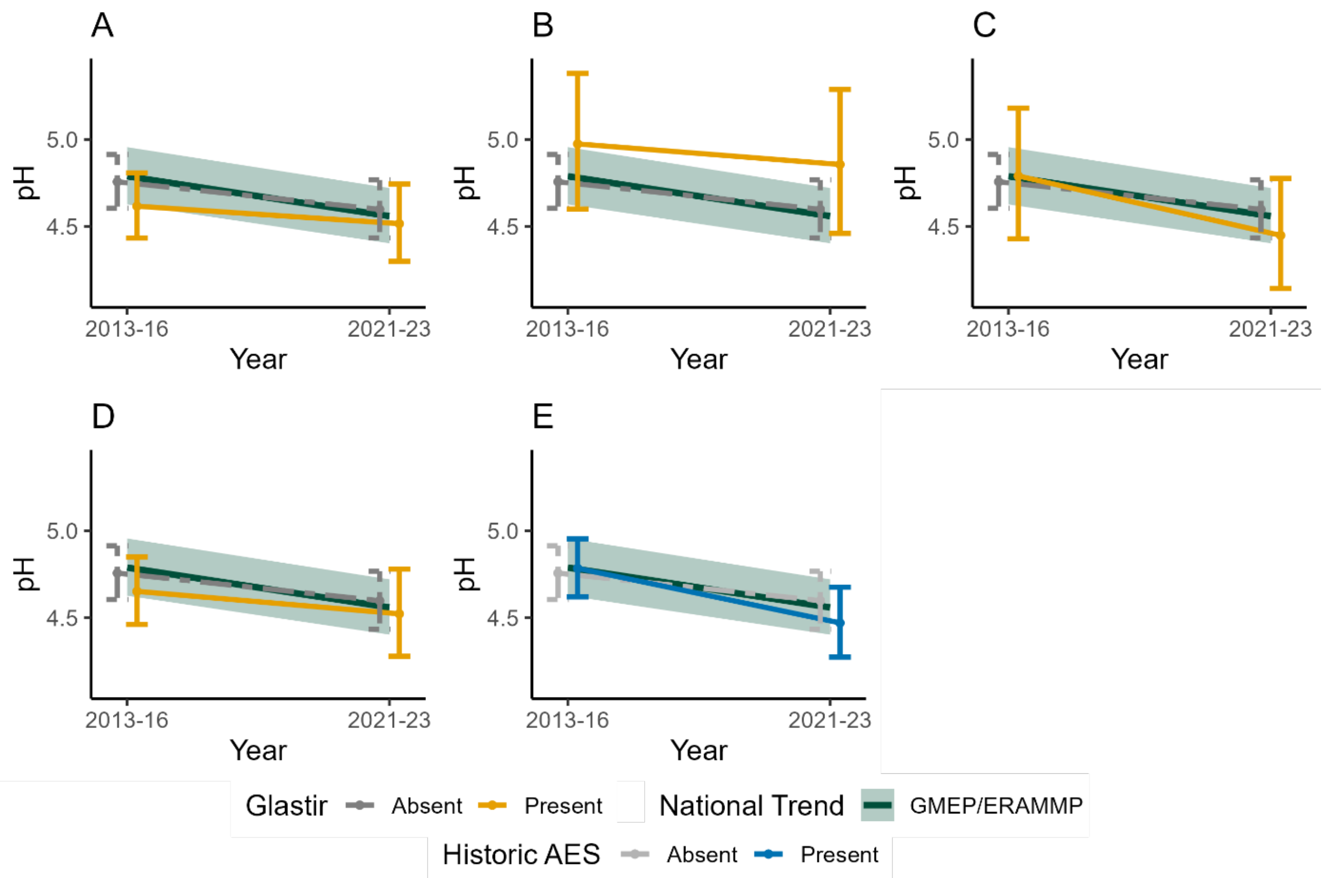

Figure 1-26 Trend in topsoil pH between 2013-16 and 2021-23 in Acid Grassland showing both national trends and A) Glastir Habitat Management, B) Glastir Grazing Lo/No Inputs Management, C) Glastir Organics, D) Glastir Commons and E) where historic AES is present or absent.

Table 1-54 Glastir analysis for pollinator indicators for Acid Grassland. Glastir management bundles assessed for effects on indictors are shown, but greyed out where data did not allow for analysis. Context effect was tested using information related to participation in historic agri-environment schemes. + significant increase, - significant decrease, ++/-- strong response, = indicator remained stable over time.

Asset Class	Habitat	Indicator	Grazing Lo/No Inputs	Habitat Management	Hedge Management	Habitat management peat/heath	Organic	Commons
Semi-Natural Grassland	Acid Grassland	Pollinator abundance	=	=	=	=	=	=
		Mean butterfly abundance	=	=	=	=	=	=
		Butterfly species richness	=	=	=	=	=	=
		Functional group richness	=	=	=	=	=	=
		Generality of pollinators	=	=		=	=	

1.3.4 Birds

1.3.4.1 Birds – Semi-Natural Grassland (except Acid Grassland)

The following analysis is relevant to all broad habitats within the Semi-Natural Grassland asset class, with the exception of Acid Grassland and Upland Birds, for which a different set of indicators have been used (Section 1.2.9. Due to the known resolution of habitat preferences of the species in the relevant indicators and the similarity of management measures for different grassland types, all Semi-Natural Grassland habitats analyses are combined together for each of lowland and upland contexts. Tests considering the bird indicators that are not specific to habitats are reported here but can be considered to be relevant to all semi-natural grassland, i.e. including acid grassland, as the Glastir bundles apply across both upland and lowland grass.

Semi-Natural Grassland is typically a patchy habitat in the lowlands, forming part of bird habitat, as opposed to supporting populations alone. However, its value has been affected and is threatened by the same factors that are relevant to vegetation.

1.3.4.2 National Trends

Positive Outcomes

- The abundance of Lowland Farmland bird (indicator) showed no significant decline between GMEP and ERAMMP, unlike the national BBS.

Areas for Concern / Need for Further Action

- A decline in the abundance of grassland bird species (guild) was observed. It is important to understand which specific grassland bird species are driving the negative guild-trend, nationally.

Table 1-55 National Trends for all bird indicators linked to Unimproved Neutral Grasslands. =: no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01. Priority birds and Dietary indicators can be found in Table 1-12 to avoid repetition. No data are shown as grey boxes.

Asset Class	Habitat	Indicator	Long term trend from BBS (1994-2013)	Mean 2013-16	Mean 2021-23	Short term analysis using GMEP 2013-16 to 2021-23
Semi-Natural Grassland	**Unimproved Neutral Grassland**	Abundance of lowland farmland bird species (indicator)	-	81.4	70.5	=
		Abundance of grassland bird species (guild)				--

1.3.4.3 Glastir impact

Positive Outcomes

- Grazing Lo/No Input management showed small, but positive impacts on population change for lowland farmland bird species, grassland guild species, and invertebrate- and vertebrate-eating species.

Outcomes not as intended, trade-offs and contextual dependencies

- The negative associations with Grassland Management for priority, granivorous and invertebrate-eating species may be driven by specific bird species, for which additional work would aid in understanding whether these patterns are likely to reflect real negative effects of Glastir, or chance associations with other, unforeseen, background associations. However, the effects involved were small in magnitude, so are unlikely to have an important effect on national populations. Note also that these effectively consider all types of grassland, i.e. including Acid Grassland as well.

Table 1-56 Glastir analysis for Bird indicators for Semi-Natural Grassland (excluding Acid Grassland). Glastir management bundles assessed for effects on indicators are shown. + significant increase, - significant decrease, ++/-- strong response, = indicator remained stable over time. No data are shown as grey boxes.

Asset Class	Habitat	Indicator	Grassland Grazing Lo/No Input Management	Habitat Management (General Grassland)
Semi-Natural Grassland	Semi-natural grassland (excluding acid grassland)	Abundance of lowland farmland bird species (indicator)	++	
		Abundance of grassland bird species (guild)	++	=
		Priority Bird Abundance	=	--
		Granivorous eating bird species abundance	=	--
		Invertebrate-eating bird species abundance	++	--
		Vertebrate-eating bird species abundance	+	=

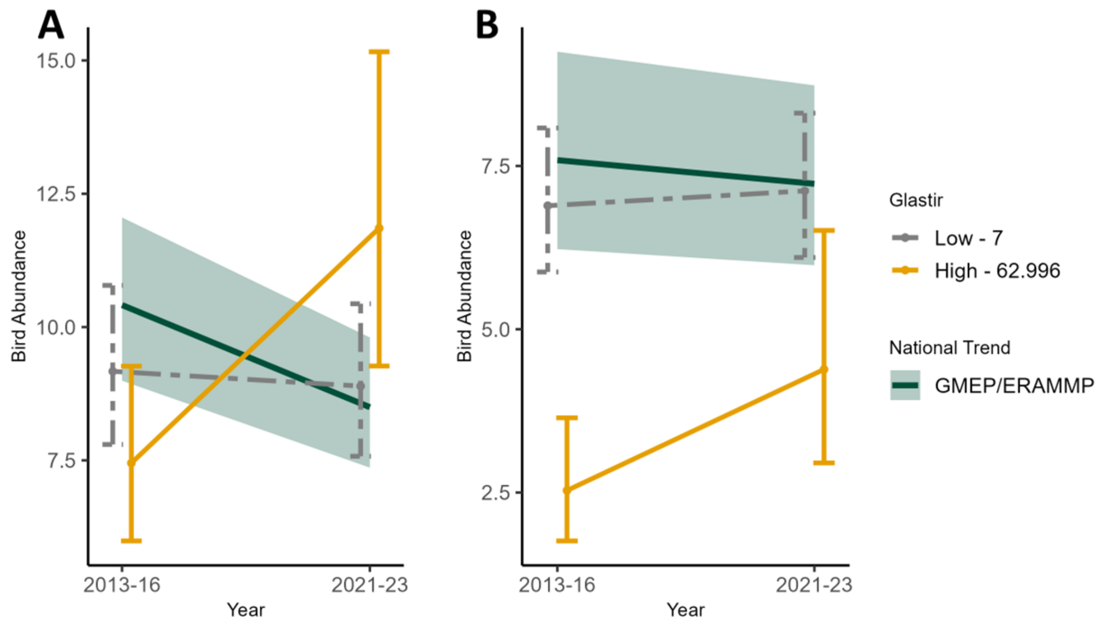

Figure 1-27 Trend in A) Grassland guild bird abundance and B) Lowland farmland bird indicator species between 2013-16 and 2021-23 in Semi Natural Grassland showing both national trends and effect of uptake of Grassland Lo/No Grazing Input management is low or high in proportion to specific bundle coverage maximums. Other effects not shown were small or non-significant and their plots can be found in the ERAMMP Technical Annex-105TA1S6: Wales National Trends and Glastir Evaluation. Supplement-6: Birds.

1.3.4.4 Birds – Acid Grassland

The majority of Acid Grassland surveyed will have been in upland areas and grassland types could not be distinguished in respect of bird habitat preferences, so Acid Grassland was considered in respect of the two bird indicators that are relevant for upland: Abundance of upland farmland bird species (indicator) and Abundance of upland bird species (guild). The tests for the four general indicators for Priority bird species and the three dietary guilds (Granivorous, Invertebrate-eating and Vertebrate-eating bird species) against grassland management in Glastir reported in Section 1.1.3 can also be considered relevant to acid grassland. The indicator follows a policy-led standard list of species from (Burns, et al., 2023) and considers a species set nominally associated with farmed areas in the uplands.

1.3.4.5 National Trends

Positive Outcomes

- No change was detected in Upland farmland bird indicator species or Upland bird (guilds) in abundance between the survey periods of GMEP and ERAMMP, but this contrasts with a contemporaneous decline in the analogous national BBS indicator.

Areas of Concern / Need for Further Action

- A decline in the Breeding Bird Survey Upland farmland bird indicator in more recent analyses post 1994.

Table 160 National Trends for all bird indicators linked to Acid Grassland. =: no significant effect, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01. Priority birds and Dietary indicators can be found in Table 1-12 to avoid repetition. No data are shown as grey boxes.

Asset Class	Habitat	Indicator	Long term trend from BBS (1994-2013)	Mean 2013-16	Mean 2021-23	Short term analysis using GMEP 2013-16 to 2021-23
Semi-Natural Grassland	Acid Grassland	Abundance of upland farmland bird species (indicator)	=	103.0	89.2	=
		Abundance of upland bird species (guild)				=

1.3.4.6 Glastir outcomes

Positive Outcomes

- None.

Outcomes not as intended, trade-offs and contextual dependencies

- There were no significant effects of Glastir on the indicators.

Table 1-57 Glastir analysis for Bird indicators for Acid Grassland. Glastir management bundles assessed for effects on indicators are shown. + significant increase, - significant decrease, ++/-- strong response, = indicator remained stable over time. No data are shown as grey boxes.

Asset Class	Habitat	Indicator	Grassland Grazing Lo/No Input Management	Habitat Management (General Grassland)
Semi-Natural Grassland	Acid Grassland	Abundance of upland farmland bird species (indicator)	=	
		Abundance of upland bird species (guild)	=	=

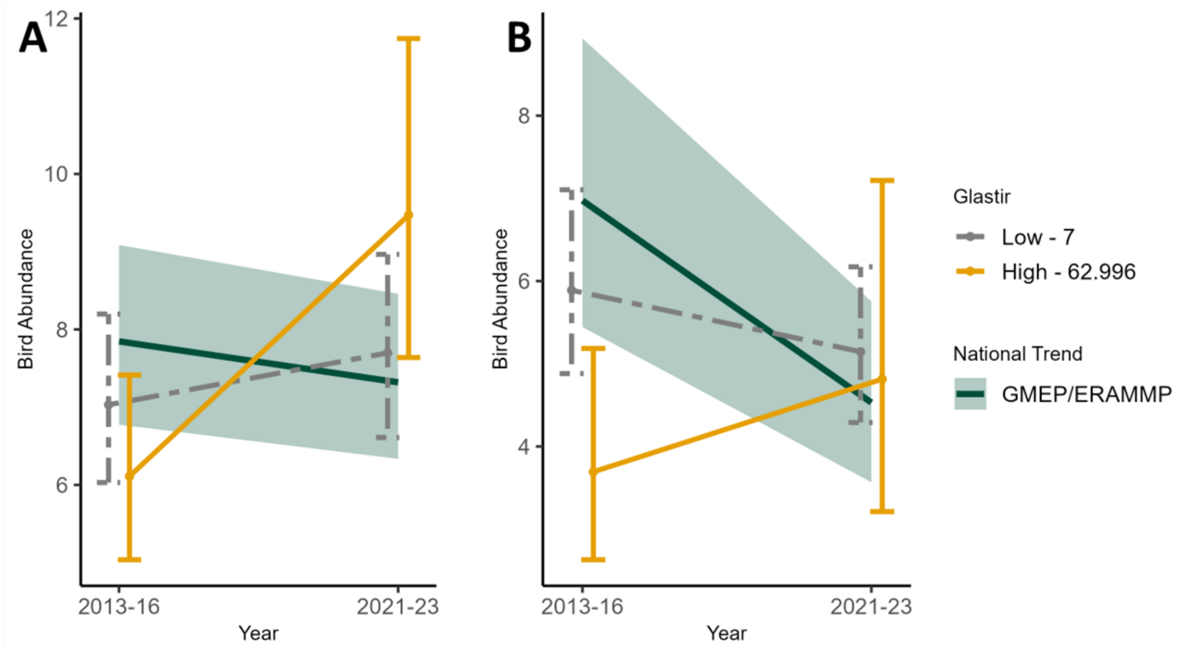

Figure 1-28 Trend in A) Invertebrate-eating bird abundance and B) Vertebrate-eating bird species between 2013-16 and 2021-23 in Acid Grassland showing both national trends and effect of uptake of grassland grazing/input management is low or high in proportion to specific bundle coverage maximums. Other effects not shown were small or non-significant and their plots can be found in the ERAMMP Technical Annex-105TA1S6: Wales National Trends and Glastir Evaluation. Supplement-6: Birds (Siriwardena & Bowgen, 2025).

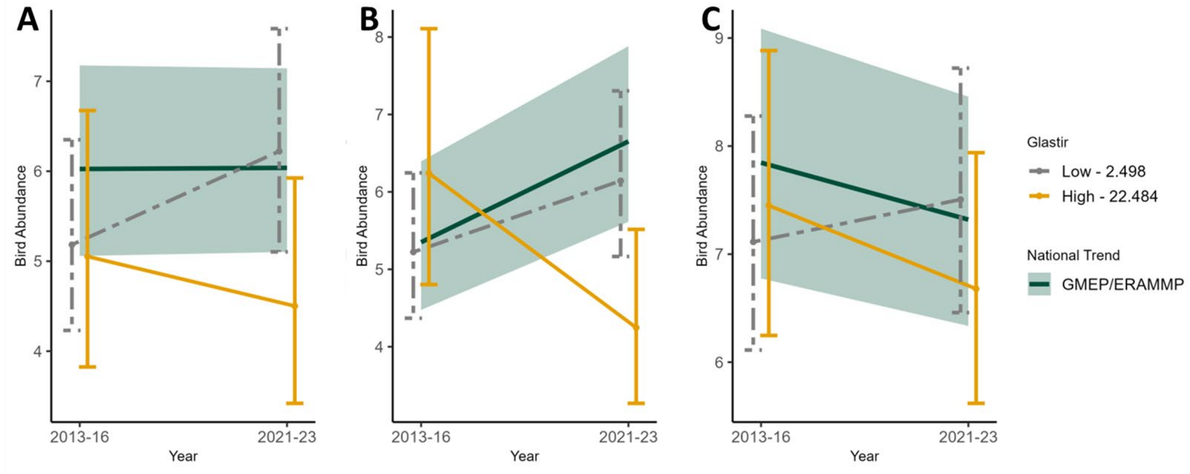

Figure 1-29 Trend in A) Priority bird species abundance, B) Granivorous eating bird abundance and C) Invertebrate-eating bird abundance between 2013-16 and 2021-23 in Acid Grassland showing both national trends and effect of uptake of general habitat management for grassland is low or high in proportion to specific bundle coverage maximums.

1.4 Enclosed Farmland

Enclosed Farmland comprises a wide mix of different habitats where the majority of land is managed primarily for food production. The soils are naturally the most productive in Wales. Whilst the management aims to maximise production, a number of important refugia provide space for native wildlife and some traditional management approaches, such as using a wall or Hedgerows as field boundaries, also provide important landscape and cultural values. Increasingly the potential of linear features, such as field margins, riparian strips as well as the greater use of trees within the intensive agricultural landscape to support native species, increase connectivity in the landscape, and capture carbon is being realised and encouraged as part of schemes such as Glastir. Their value in improving resilience for crops with respect to heat stress for animals, control of pests and disease is being tested as is the potential for so called ‘regenerative’ agricultural practices which include reduced tillage and reduced use of synthetic fertilisers to improve resilience and overall sustainability of the farm system. The Organic method of production also has greatest relevance for this Asset Class, and transfer into that approach has been supported by the Glastir scheme. Note that Bird results are provided for some individual Broad Habitats rather than combined for the whole Asset Class but are not available for all.

1.4.1 Arable and Horticultural

Arable and Horticultural habitats include ploughed land, land planted with crops and also Annual/early successional with open ground habitats. It may also be used to define some types of field margin, Uncropped strips, usually cultivated each year; Wild bird seed cover e.g. kale, quinoa and Pollen and nectar mixes, usually with a high proportion of legumes.

Arable and Horticultural represented 4% of land cover of Wales in 2021. This was a decrease of 24% compared to 2010.

Vegetation indicators

Vegetation indicators for Arable habitats include annual forbs, positive and negative arable indicators which could be characteristic of species-rich arable plant communities. Total species richness was also included as was Ellenberg fertility which is likely to be high in these habitats.

Pollinator indicators

Pollinator metrics considered here matched those used for Broadleaf Mixed and Yew Woodland; see section 1.1.1. Pollinators largely depend on plant diversity and vegetation quality, so are largely dependent on the semi-natural habitats that are peripheral to production arable, such as Hedgerows, and their condition, although mass-flowering crops (in particular) can provide flushes of resources. Non-crop arable plants are particularly important as food plants and nectar sources, so agricultural practices that restrict their availability constitute particular pressures.

Soil indicators

Soil was sampled from 0-15 cm; this is the most dynamic component of the soil profile, responding to land use, climate and management change. There is good evidence that changes in topsoil properties are indicative of changes to depth in Arable and Horticultural land, although the magnitudes of change will differ across the soil profile. Care must be taken when interpreting measurements of topsoil carbon density as it is partially determined by topsoil bulk density, which can change with soil wetness and with compaction. As such, changes in bulk density can cause an apparent change in carbon density that does not reflect additional carbon storage. The best evidence for an increase in topsoil carbon density is when an increase in both carbon concentration and carbon density has occurred, with stable or decreasing bulk density. Topsoil pH, Olsen P and nitrogen concentration are expected to be within specific thresholds for optimal productivity in an arable context and for wider ecosystem health. All of these indicators are strongly influenced by inputs and management but may also be affected by more general processes such as climate change or atmospheric nitrogen deposition.

Bird indicators

Six indicators were investigated in these analyses - Abundance of lowland farmland bird species (indicator) and Abundance of Arable species (guild) plus four general indicators for Priority bird species and the three dietary guilds (Granivorous, and Invertebrate- and Vertebrate-eating bird species). The indicator follows the policy-led standard list of species from (Burns, et al., 2023), whilst the Arable guild indicator represents a list of species selected for an ecological association with this habitat (derived from (Siriwardena, Henderson, Noble, & Fuller, 2019). Siriwardena also provides the species lists for the key dietary guilds. The priority bird species list consists of all section 7 species from the Environment (Wales) Act 2016.

Arable habitats are localised in Wales but support a distinct bird community that is not found elsewhere. They are threatened by long-term trends in agriculture towards simplification (loss of arable to grass in the Welsh context), greater cropping efficiency reducing the availability of seed and invertebrate food resources associated with non-crop plants and declining condition of peripheral habitats like Hedgerows.

1.4.1.1 National Trends

There is no change in indicators of vegetation condition in Arable and Horticultural Broad Habitat. However, several topsoil indicators indicate a decline in soil condition with a decrease in topsoil carbon concentration, an increase in bulk density (i.e. compaction), and sites with phosphorus concentrations which risk leaching to water courses. These all indicate potential risks for soil health, associated risks for water quality and reduced carbon sequestration. Abundance of arable bird species (guild) showed a significant decline between 2013-16 and 2021-23.

Positive Outcomes

- There were no significant trends in the Arable plant indicators including those for; Ellenberg fertility, total plant species richness, Arable forbs, positive and negative Arable indicator richness.
- All pollinator indicators were stable.
- Typical Olsen-P levels have remained stable and within the range suggested for biomass production in Arable and Horticultural land.
- Potential point sources of phosphorus leaching (i.e. where Olsen-P > 60 mg P kg^{-1}) increased from 4% of Arable sites in 2013-16 to 16% of Arable sites in 2021-23, although 8% of the new sites identified in 2021-23 were under grassland management in 2013-16.
- 14% of sites shifted between Arable and Improved Grassland between surveys i.e. were leys. This is likely to be an underestimate of the number of leys in Wales as fields may have switched between visits but have returned to the original state at the time of the survey. Satellite image analysis will enable leys to be separately reported going forward. This is important as they are likely to have intermediate trends compared to Arable or Improved Grassland and are therefore currently increasing variability and thus reducing detection limits in both Arable and Improved Grassland. Welsh Government does not currently capture this information through the Farm Business Survey.
- Topsoil nitrogen levels have decreased significantly by 10.6% on Arable and Horticultural land. In combination with the decrease in topsoil carbon concentration, the topsoil C:N ratio remains stable.

Areas for Concern / Need for Further Action

- Arable topsoil carbon concentration has significantly decreased by 8% (3 g kg^{-1}) which is in line with the magnitude of change observed in the long-term trend in Arable and Horticultural land in Wales from 1978 to 2007 (Emmett, et al., 2010). However, topsoil carbon density remains stable as there is a significant increase in topsoil bulk density of almost 10%. The decrease in soil carbon concentration suggests a potential overall loss of topsoil carbon stock from Arable soils.
- 18% of Arable soils exceed the threshold of bulk density (i.e. compaction) for well-functioning mineral soils in 2021-23 (>1.3 g cm^{-3}).
- The abundance of arable bird species (guild) declined. It is important to understand which arable bird species are driving the guild-level decline in the national trend, but this is likely to reflect an ongoing, well-known trend at UK level in this bird community, as is shown by the analogous indicator from the national BBS for lowland farmland birds. The declines among both upland and lowland farmland birds seem to have halted in the 2021-23 sample, unlike the national BBS sample.

Table 1-58 Long-term and short-term trends in vegetation indicators for Arable and Horticultural. "=": no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01.

Asset Class	Habitat	Indicator	Long term analysis using CS data 1978/1990 - 2007	Mean 2013-16	Mean 2021-23	Short term analysis using GMEP 2013-16 to 2021-23
Enclosed Farmland	Arable and Horticultural	Ellenberg fertility*	=	6.3	6.39	=
		Total species richness	=	9.49	8.66	=
		Arable forbs	=	1.87	1.79	=
		Arable positive indicators	=	0.12	0.09	=
		Arable negative indicators*	=	1.87	1.75	=

*These are negative indicators so a '+' indicates a decrease in condition.

Table 1-59 Long-term and short-term trends in pollinator indicators for Arable and Horticultural. "=": no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01. No data are shown as grey boxes.

Asset Class	Habitat	Indicator	Long term analysis using CS data 1978/1990 - 2007	Mean 2013-16	Mean 2021-23	Short term analysis using GMEP 2013-16 to 2021-23
Enclosed Grassland	Arable and Horticultural	Pollinator abundance		36.12	39.65	=
		Mean butterfly abundance		0.39	0.2	=
		Butterfly species richness		3.71	3.35	=
		Functional group richness		5.36	5.67	=
		Generality of pollinators		1.54	1.73	=

Table 1-60 National Trends for all bird indicators linked to Arable and Horticultural habitats. =: no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01. Priority birds and Dietary indicators can be found in Section 1.1.3 to avoid repetition. No data are shown as grey boxes.

Asset Class	Habitat	Indicator	Long term trend from BBS (1994-2013)	Mean 2013-16	Mean 2021-23	Short term analysis using GMEP 2013-16 to 2021-23
Enclosed Farmland	Arable and Horticultural	Abundance of lowland farmland bird species (indicator)	-	81.4	70.5	=
		Abundance of arable bird species (guild)		9.895	8.626	--

Table 1-61 Long-term and short-term trends in topsoil indicators for Arable and Horticultural. Long-term trends in indicators for Wales were extracted from (Smart, et al., 2009). "=": no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01. No data are shown as grey boxes. Note: Countryside Survey sample population was sampled from, on average, a higher latitude than the sample population in 2013-16 and the re-survey in 2021-23.

Asset Class	Habitat	Indicator	Long term analysis using CS data 1978/1990 - 2007	Mean 2013-16	Mean 2021-23	Short term analysis using GMEP 2013-16 to 2021-23
Enclosed Farmland	Arable and Horticultural	Carbon (g/kg, from Organic matter)	=	38.9	35.9	--
		pH	=	6.17	6.29	=
		N (g/100g dry soil)*		0.33	0.30	--
		Phosphorus (Olsen P mg/kg)*		23.9	28.2	=
		C density (tC/ha)	=	55.7	58.2	=
		Bulk density (g/cm^3)*		0.99	1.09	++

* An increase in this indicator is interpreted as a decline in condition for this habitat.

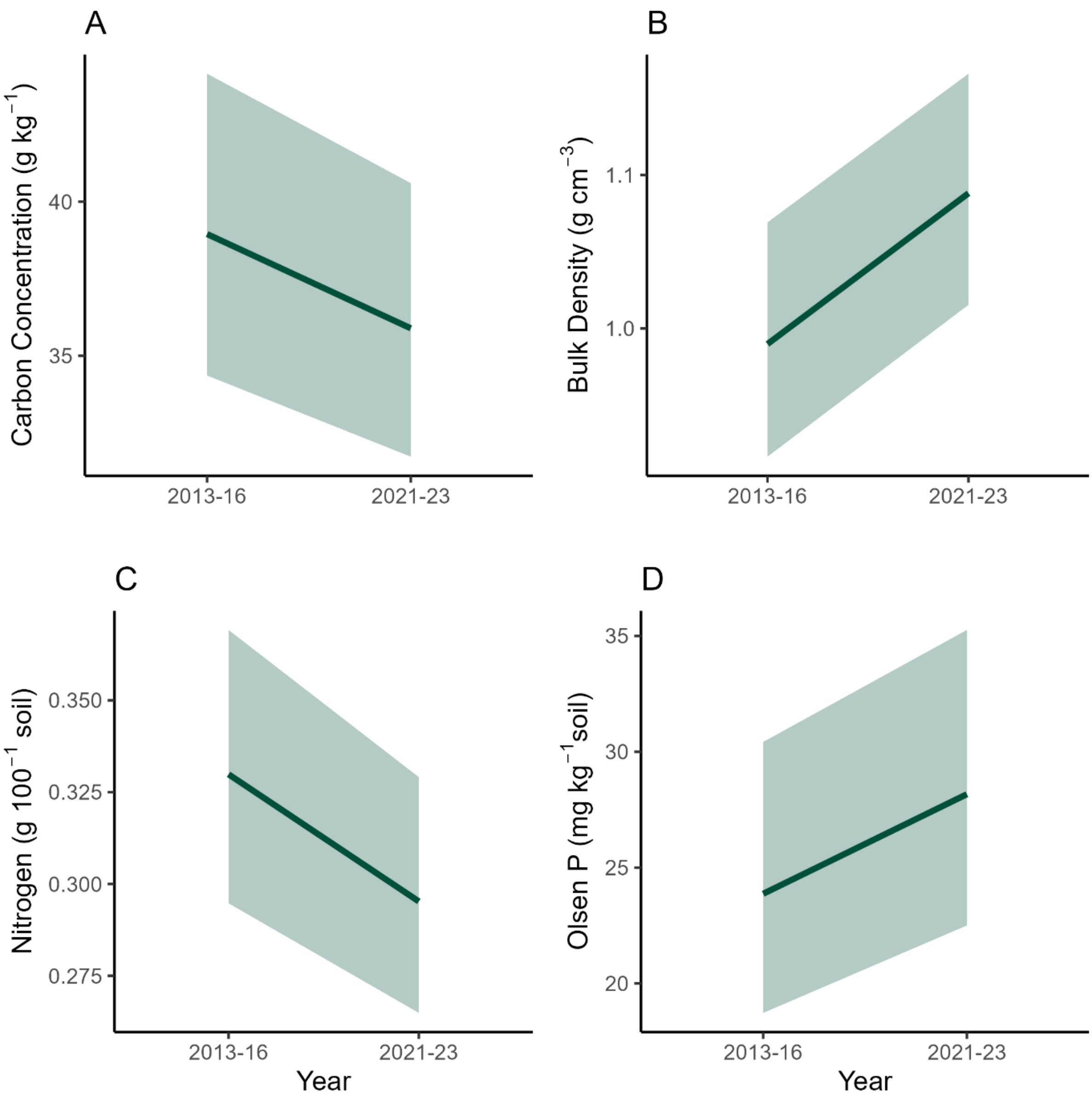

Figure 1-30 Trend in Arable and Horticultural topsoils for A) carbon concentration, B) bulk density, C) nitrogen concentration, and D) Olsen-phosphorus concentration between 2013-16 and 2021-23 from nationally representative survey squares.

1.4.1.2 Glastir Impact

For vegetation, Glastir options on Arable habitats included Arable Management options (such as cover crops, margins, unsprayed root crops, retaining winter stubbles) and Glastir Organics management. There was no impact of these Glastir options on indicators of vegetation condition.

There was an improvement in pollinator abundance where Glastir Organics was applied and Butterfly species richness where Arable Management options were applied. For soils, Glastir impacts on Arable and Horticultural soils was not assessed due to very low Glastir action uptake on Arable and Horticultural land.

Arable-associated bird species, priority bird species, and invertebrate- and vertebrate-eating species all responded positively to Arable Management options.

Positive Outcomes

- Pollinator abundance has increased where Glastir Organics was applied.
- Butterfly species richness has increased where Arable Management options were applied.
- All bird indicators tested but one (granivorous bird guild) showed positive population change responses to Glastir Arable Management. Note, however, that low-Glastir areas had higher initial bird densities that high-Glastir areas for two of the indicators. The arable Glastir options in survey squares were dominated by unsprayed crop options; these are most likely to benefit insectivorous birds.

Outcomes not as intended, trade-offs and contextual dependencies

- There were no effects of Glastir on vegetation indicators.
- Granivorous bird species showed no effect of Glastir Arable Management options, despite the latter being the principal element of Glastir that should nominally benefit this group.
- Under historic AES total species richness decreased, however, there was no change in positive indicators and annual forb species.

Table 1-62 Glastir analysis for vegetation indicators in Arable and Horticultural land. Glastir management bundles assessed for effects on indicators are shown. Context effect was tested using information related to participation in historic agri-environment schemes. =: no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01. Model wouldn't converge for positive indicators.

Asset Class	Habitat	Indicator	Arable Management	Organic	Context: Historic AES
Enclosed Farmland	Arable and Horticultural	Ellenberg fertility*	=	=	=
		Total species richness	=	=	--
		Arable forb count	=	=	--
		Arable positive indicators			
		Arable negative indicators*	=	=	=

*These are negative indicators so a '+' indicates a decrease in condition.

Table 1-63 Glastir analysis for pollinator indicators in Arable and Horticultural land. Glastir management bundles assessed for effects on indicators are shown. =: no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01.

Asset Class	Habitat	Indicator	Arable Management	Wildlife corridors	Organic
Enclosed Farmland	Arable and Horticultural	Pollinator abundance	=	=	+
		Mean butterfly abundance	=	=	=
		Butterfly species richness	++	=	=
		Functional group richness	=	=	=
		Generality of pollinators	=	=	=

Table 1-64 Glastir analysis for bird indicators in Arable and Horticultural land. Glastir management bundles assessed for effects on indicators are shown. =: no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01.

Asset Class	Habitat	Indicator	Arable Management
Enclosed Farmland	Arable and Horticultural	Abundance of lowland farmland bird species (indicator)	=
		Abundance of arable species (guild)	++
		Priority Bird Abundance	++
		Granivorous eating bird species abundance	=
		Invertebrate-eating bird species abundance	++
		Vertebrate-eating bird species abundance	++

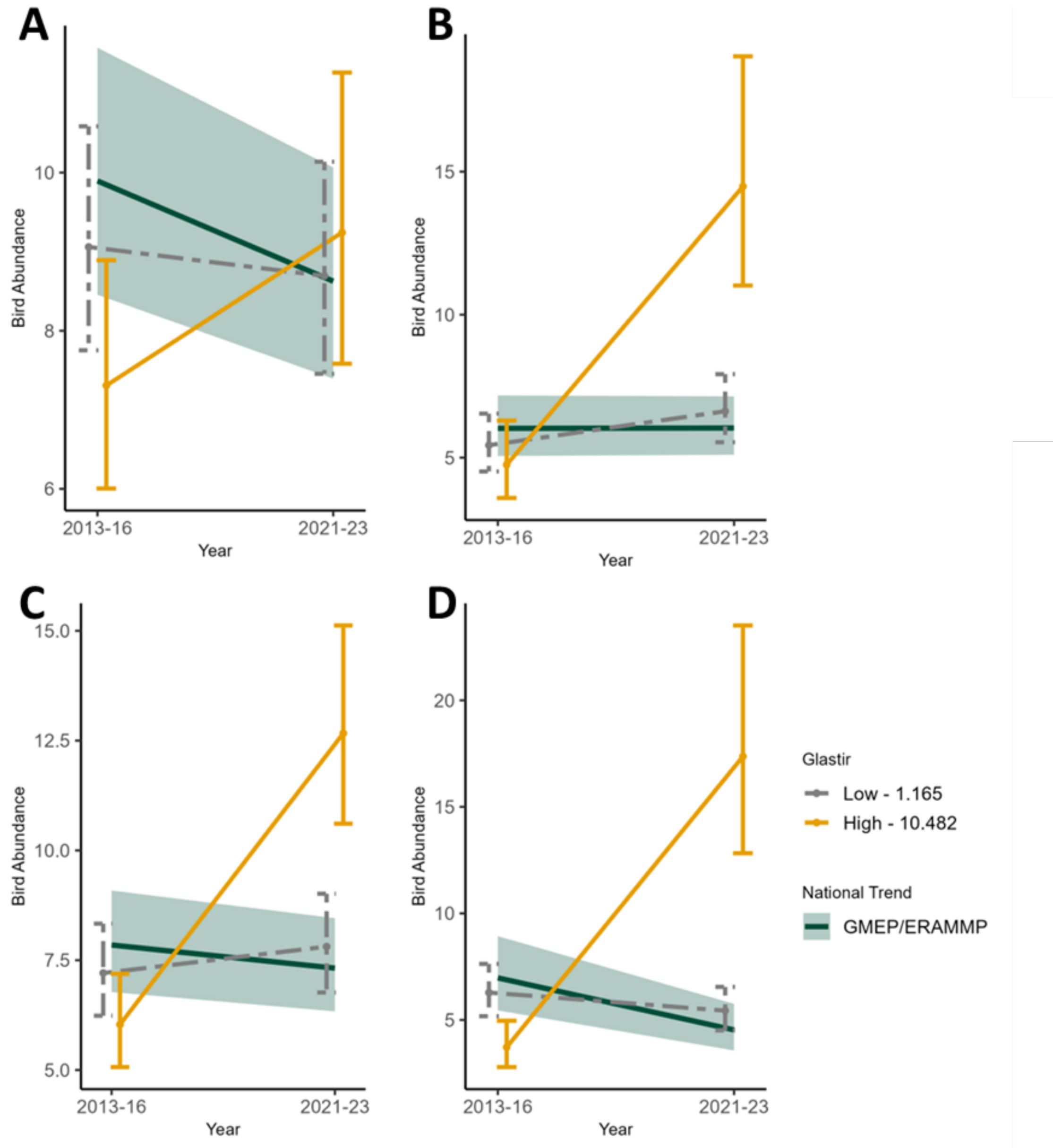

Figure 1-31 Trend in in A) Arable bird guild, B) Priority bird species, C) Invertebrate-eating bird guild and D) vertebrate-eating bird guild abundances between 2013-16 and 2021-23 in Arable and Horticultural showing both national trends and effect of uptake of Arable Management is low or high in proportion to specific bundle coverage maximums. Other effects not shown were small or non-significant and their plots can be found in the ERAMMP Technical Annex-105TA1S6: Wales National Trends and Glastir Evaluation. Supplement-6: Birds (Siriwardena & Bowgen, 2025).

1.4.2 Improved Grassland

This is an extensive Broad Habitat comprising low botanical quality grassland with high grazing value used as pasture, silage or occasionally hay. Intensively managed agricultural grasslands include ecologically impoverished swards usually dominated by rye grass (*Lolium perenne)*, often with varying amounts of *Cynosurus cristatus, Holcus lanatus* and *Poa trivialis*. The diversity of flowering plants is characteristically low, consisting of white clover (T*rifolium repens), dandelions (Taraxacum officinale* agg.)*, creeping buttercup (Ranunculus repens*.), docks, thistles and nettles. Separation of improved from Semi-Improved Grassland has been done by separating habitats with greater than 25% cover of *Lolium perenne* and clover and assigning them to Improved Grassland.

Improved Grassland represented 40% of land use in Wales in 2021 according to the UKCEH Land Cover Map. This was a 3% decrease in cover from 2010.

Vegetation Indicators

Improved Grassland tends to be of low botanical quality, increasing the species richness of the sward is an aim to increase biodiversity, so we have included total plant species richness as an indicator. We have also used positive and negative plant species richness, as Improved Grassland is not a habitat of conservation importance the indicators came from discussions with NRW and it is the same list as used for Semi-Improved Grassland. Grass: Forb ratio describes the relationship between grasses and forbs, a higher score indicates that there is more grass cover which is undesirable and the aim is to increase forb richness of these grasslands. A high cover of grass in relation to the abundance of forbs can indicate intensive management impacts, e.g., high grazing intensity, nutrient enrichment. High fertility and low sward diversity are characteristics of these habitats so improvement will likely also require reduction in fertility as indicated by Ellenberg fertility scores.

Pollinator indicators

Pollinator metrics considered here matched those used for Broadleaf Mixed and Yew Woodland; see section 1.1.1. Pollinators largely depend on plant diversity and vegetation quality, so the pressures on them will follow those described for vegetation, as well as a need for access to bare ground for various species. Dense, homogeneous swards provide few resources, although species like clovers will support some pollinators.

Bird indicators

Six bird indicators were investigated in these analyses - Abundance of lowland farmland bird species (indicator) and Abundance of grassland bird species (guild) plus four general indicators for Priority bird species and the three dietary guilds (Granivorous, and Invertebrate- and Vertebrate-eating bird species). The indicator follows the policy-led standard list of species from (Burns, et al., 2023), whilst the guild is based on specific ecological associations, derived from (Siriwardena, Henderson, Noble, & Fuller, 2019). Siriwardena also provides the species lists for the key dietary guilds. The priority bird species list consists of all section 7 species from the Environment (Wales) Act 2016. Semi-Improved Grassland could not be separated from improved grass in terms of bird habitat preferences, so results for this habitat should be considered to be covered here.

Soil indicators

Soil was sampled from 0-15 cm; this is the most dynamic component of the soil profile, responding to land use, climate and management change. There is good evidence that changes in topsoil properties are indicative of changes to depth on managed land, although the magnitudes of change will differ across the soil profile.

Care must be taken when interpreting measurements of topsoil carbon density as it is partially determined by topsoil bulk density, which can change with soil wetness and with compaction. As such, changes in bulk density can cause an apparent change in carbon density that does not reflect additional carbon storage. The best evidence for an increase in topsoil carbon density is when an increase in both carbon concentration and carbon density has occurred, with stable or decreasing bulk density. Topsoil pH, Olsen P and nitrogen concentration are expected to be within specific thresholds for optimal grassland productivity and for wider ecosystem health. All of these indicators are strongly influenced by inputs and management but may also be affected by more general processes such as climate change or atmospheric nitrogen deposition.

1.4.2.1 National Trends

Whilst there are some signs of positive improvement in Improved Grassland such as an increase in positive plant indicator richness, reduction in Ellenberg fertility and stability of pollinator indicators a decline in several soil health indicators is of major concern. Topsoil pH is below that suitable for production in 72% of all sites. There has been a three-fold increase in sites where Olsen-phosphorus concentrations risk soils being a point source of pollution to water courses and topsoil bulk density has increased. Going forward, with support from satellite information, a separate category of leys should be included to capture land moving between arable and pasture systems. Currently this is known to affect a minimum of 14% of all Arable and Improved Grassland sites but this will have missed more sites where a switch was not apparent at the specific time of the two surveys. Abundance of grassland birds (guild) showed a decline between 2013-16 to 2021-23.

Positive Outcomes

- There has been an increase in positive plant indicator richness reversing a long-term decline.
- There has been a decrease in Ellenberg fertility score.
- Although there has been no increase in total species richness, a previously reported decline (1990-07) has been stabilised at a higher level. (NB the total species richness reported here is higher than in ERAMMP Report 30 (Alison J. , et al., 2020) but here negative indicators haven't been excluded).
- Pollinator abundance, mean butterfly abundance and generality of pollinators are stable.
- There was no change in lowland farmland bird indicator (species).
- Topsoil carbon concentrations, nitrogen and C:N in Improved Grassland remain stable.
- Topsoil acidity (pH) is now stable in Improved Grassland after a long-term increase. Topsoil acidity remains within the optimal range of pH for *mesotropic grassland (pH 5 to 7) (ERAMMP Technical Annex-105TA1: Wales National Trends and Glastir Evaluation Section 5* (Emmett & the ERAMMP Team, 2025)*).*
- 14% of sites shifted between Arable and Improved Grassland between surveys i.e. were leys. This is likely to be an underestimate of the number of leys in Wales as fields may have switched between visits but have returned to the original state at the time of the survey. Satellites information will enable leys to be separately reported going forward as they are likely to have very different trends compared to either Arable or Improved Grassland. Welsh Government does not currently capture this information.

Areas for Concern / Need for Further Action

- 72% of Improved Grassland had a topsoil pH below 6 in 2021-23, identified as a trigger point to grassland productivity on mineral soils (down from 75% in 2013-16).
- Topsoil Olsen-Phosphorus increased by 15.6% to an average of 24.7 mg P kg^{-1} in Improved Grassland. However, this is well below the critical threshold of 60 mg P kg^{-1} associated with leaching. It is also within the range of 16-25 mg P kg^{-1} suggested for biomass production in Improved Grassland.
- Potential point sources of phosphorus leaching in Improved Grassland (i.e. where Olsen-P > 60 mg P kg^{-1}) has approximately tripled from 5.4% of sites in 2013-16 to 17.1% of sites in 2021-23, within the resurveyed population.

- Topsoil bulk density (i.e. compaction) has significantly increased in Improved Grassland by 6% from 2013-16 to 2021-23. This has caused national topsoil carbon density to increase for the same period.
- A decline in grassland bird abundance (guild). This reflects an established pattern of change among lowland farmland bird species at the UK level, although the analogous index for 2021-23 data showed no change, while the BBS indicator declined.

Table 1-65 Long-term and short-term trends in vegetation indicators for Improved Grassland. "=": no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01.

Asset Class	Habitat	Indicator	Long term analysis using CS data 1978/1990 - 2007	Mean 2013-16	Mean 2021-23	Short term analysis using GMEP 2013-16 to 2021-23
Enclosed Farmland	Improved Grassland	Total species richness	-	10.06	10.26	=
		Grass: Forb ratio*	=	1.52	1.63	=
		CSM positive	--	0.83	1.99	++
		Negative indicators*	=	3.06	3.24	=
		Ellenberg fertility*	=	5.48	5.39	-

*These are negative indicators so a '+' indicates a decrease in condition.

Table 1-66 Long-term and short-term trends in pollinator indicators for Improved Grassland. "=": no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01. No data are shown as grey boxes.

Asset Class	Habitat	Indicator	Long term analysis	Mean 2013-16	Mean 2021-23	Short term analysis using GMEP 2013-16 to 2021-23
Enclosed Grassland	Improved Grassland	Pollinator abundance		20.41	21.39	=
		Mean butterfly abundance		0.19	0.16	=
		Butterfly species richness		2.82	2.44	=
		Functional group richness		4.47	4.75	=
		Generality of pollinators		1.68	1.6	=

Table 1-67 National Trends for all bird indicators linked to Improved Grasslands. =: no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01. Priority birds and Dietary indicators can be found in Section 1.1.3 to avoid repetition. No data are shown as grey boxes.

Asset Class	Habitat	Indicator	Long term trend from BBS	Mean 2013-16	Mean 2021-23	Short term analysis using GMEP 2013-16 to 2021-23
Enclosed Grassland	Improved Grassland	Abundance of lowland farmland bird species (indicator)	-	81.4	70.5	=
		Abundance of grassland bird species (guild)		10.413	4.987	--

Table 1-68 Long-term and short-term trends in topsoil indicators for Improved Grassland. Long-term trends in indicators for Wales were extracted from (Smart, et al., 2009). "=": no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01. No data are shown as grey boxes. Note: Countryside Survey sample population was sampled from, on average, a higher latitude than the sample population in 2013-16 and the re-survey in 2021-23.

Asset Class	Habitat	Indicator	Long term analysis using CS data 1978/1990 - 2007	Mean 2013-16	Mean 2021-23	Short term analysis using GMEP 2013-16 to 2021-23
Enclosed Farmland	Improved Grassland	Carbon (g/kg, from Organic matter)	=	54.9	54.7	=
		pH	+	5.75	5.78	=
		N (g/100g dry soil)*		0.46	0.46	=
		Phosphorus (Olsen P mg/kg)*		21.4	24.7	++
		C density (tC/ha)[1]	=	66.9	71.9	++
		Bulk density (g/cm^3)[1]*		0.82	0.87	++

* An increase in this indicator is interpreted as a decline in condition for this habitat.

[1]As carbon concentrations have not increased this is driven by the increase in bulk density and does not reflect an increase in soil carbon storage.

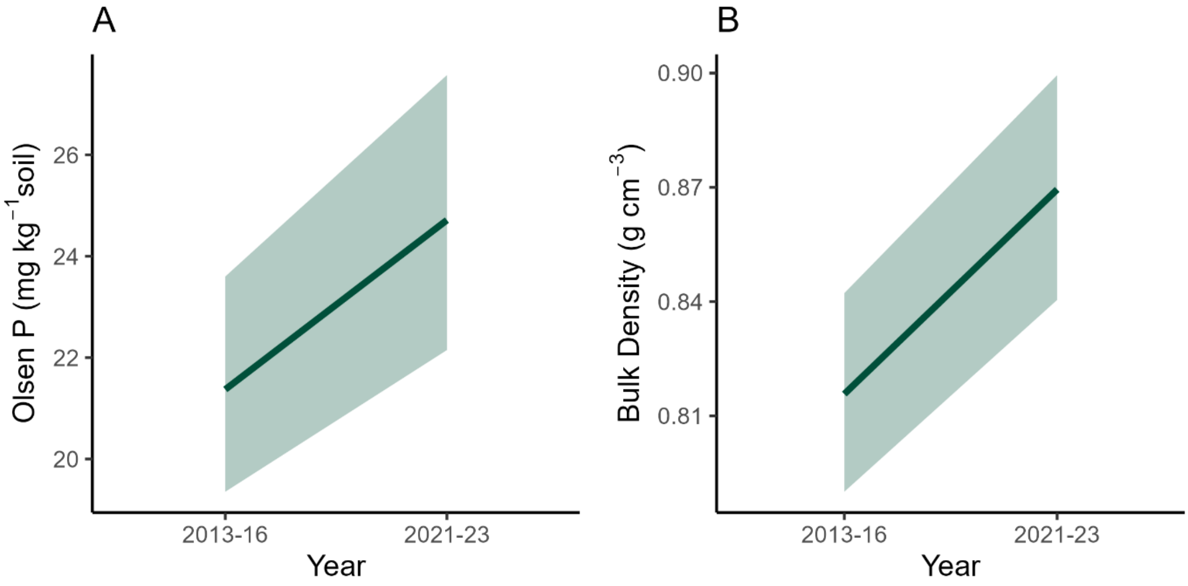

Figure 1-32 Trend in Improved Grassland topsoil for A) Olsen phosphorus concentration, and B) bulk density between 2013-16 and 2021-23 from nationally representative survey squares.

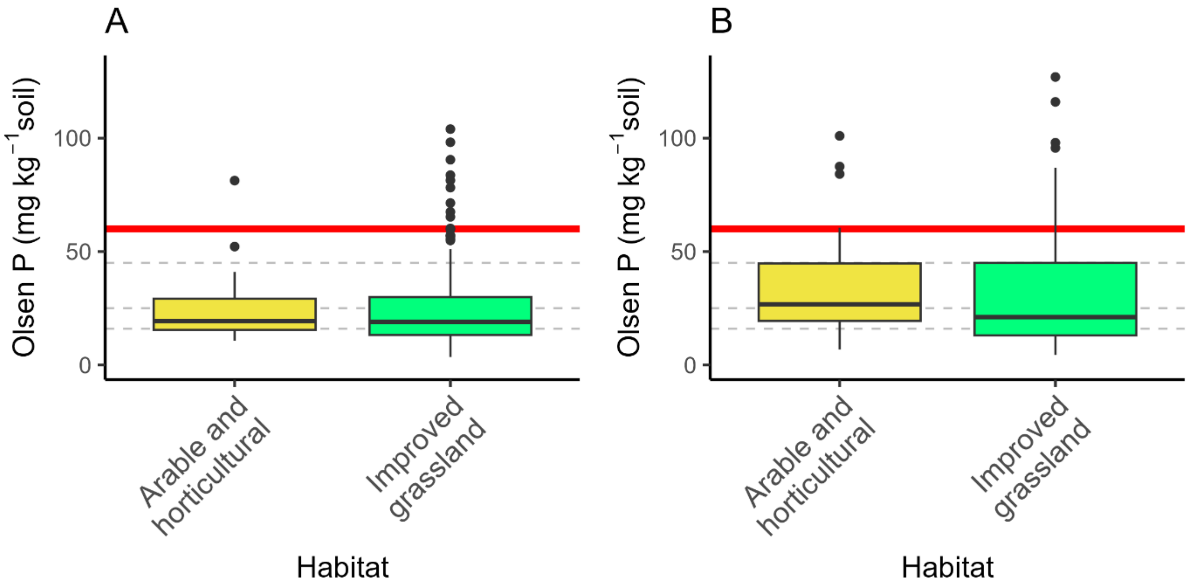

Figure 1-33 The difference in topsoil Olsen phosphorus concentration across Arable and Horticultural and Improved Grassland. A) 2013-16 and B) 2021-23. The red line indicates the 60 mg kg-1 threshold at which leaching occurs. The grey dashed lines indicate upper and lower thresholds for productivity in Arable and Horticultural systems (16-45 g kg-1) and improved grassland systems (16-25 g kg-1). The black horizontal lines in the boxes indicate the midpoint, the boxes indicate where the mid 50% of all values sit and the vertical lines represent the full range of values observed.

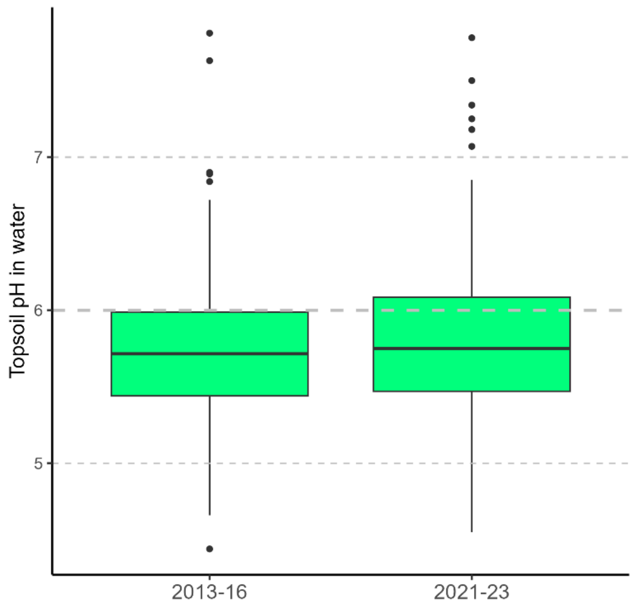

Figure 1-34 The difference in topsoil pH in Improved Grassland in 2013-16 and 2021-23 with critical pH thresholds for productivity surpassed at pH <6, and optimal pH for habitat support at pH 5-7.The horizontal lines indicate the midpoint, the boxes indicate where the mid 50% of all values sit and the vertical lines represent the full range of values observed.

1.4.2.2 Glastir Impact

For vegetation the bundles analysed included Habitat Management with a small number of plots with habitat specific options- lowland marshy grassland and some bracken control, Grazing Lo/No Inputs, as with soils the main options were grazed permanent pasture with no, and with low inputs, and grazed permanent pasture with low inputs and mixed grazing. There were also some plots subject to Organic management.

For soils, Glastir impacts on Improved Grassland were assessed using the Arable Management bundle, the Grazing Lo/No Input management bundle, and the Organics bundle. The effect of presence in historic AES schemes was assessed too. The Grazing Lo/No Inputs management bundle had the largest uptake and was represented by five actions with the top three actions being grazed permanent pasture with no, and with low inputs, and grazed permanent pasture with low inputs and mixed grazing. The Arable Management bundle contained two actions, with the main action being “Unsprayed spring sown cereals or legumes”. The Organics bundle was represented by the action on “Glastir Organic Interventions”.

Glastir has not resulted in any detectable improvements in soil or vegetation condition in Improved Grassland. The single example of a benefit of Glastir was observed for Organics which was positive for butterfly abundance and butterfly species richness. Surprisingly, Grazing Lo/No Inputs (primarily “Grazed permanent pasture with no/low inputs” which reduced nutrient and pesticide inputs) had no effect on soil nutrient concentrations.

In general, in-scheme land was of better quality e.g. has higher total species richness and lower number of plants which require high nutrient status (i.e. Ellenberg fertility score). This suggests targeting of land in better condition and may also mean that limited response is expected over time if quality on scheme entry is already high and/or options are not sufficiently transformative. The presence of historic AES and landscape context i.e. the presence/absence of HNV land 1 and 2 in the surrounding 1km square were not found to have any significant influence on vegetation. (Note the contrast to Semi-Improved Grassland and Acid Grassland where benefits were observed).

It is worth noting, uptake of Glastir in Improved Grassland has been low compared to membership of historic agri-environment schemes. Of the 131 sites sampled for soil that were members of historic agri-environment schemes only 19 (15%) had Glastir options between 2013-16 and 2021-23. Note that Glastir options were also implemented on sites that had no membership of prior schemes. For soils, land which was part of historic AES schemes have seen significant faster declines in soil carbon concentrations than sites that were not part of schemes. This suggests that the benefits of historic management have been short-lived and were not maintained by subsequent schemes. This illustrates the lack of permanence of soil carbon which should be considered as part of future Net Zero plans.

A positive impact of Grazing Lo/No Input and management is seen for the lowland farmland bird species indicator, grassland bird species (guild) and invertebrate- and vertebrate-eating bird species.

Positive Outcomes

- Mean butterfly abundance and butterfly species richness increased where Glastir Organics management was applied.
- Bird abundances showed increases for four indicators with Grazing Lo/No Input management – lowland farmland bird species, grassland bird species (guild) and invertebrate- and vertebrate-eating bird species.

Outcomes not as intended, trade-offs and contextual dependencies

- No impact of Glastir was detected for indicators of vegetation condition. However, the land under the grazing input bundle appears to have lower starting values of Ellenberg fertility, lower Grass: Forb ratio and higher total species richness suggesting that land coming into the scheme is of higher quality than land outside of scheme.
- The Glastir Grazing Lo/No Inputs management bundle is associated with a decrease in topsoil carbon concentrations. These sites had higher topsoil carbon concentrations in 2013-16 and have now converged with the national average. This is not expected, and further analysis is required to understand underlying causes.
- The Glastir Grazing Lo/No Inputs management bundle (primarily "Grazed permanent pasture with no/low inputs" which reduced nutrient and pesticide inputs) did not affect topsoil nitrogen or Olsen phosphorus concentrations in Improved Grasslands. This may be explained by the results of the Farmer Practice Survey which show no difference in fertiliser application levels between Glastir and non-Glastir land.
- Land that was part of historic agri-environment schemes have seen significantly faster declines in carbon concentration and topsoil carbon density than sites that were not part of historic agri-environment schemes.
- Land with Glastir options in the Arable Management bundle were below average soil condition for Improved Grassland (e.g.likely reflecting the effect of rotation into Arable Management on topsoil carbon concentrations.

Table 1-69 Glastir analysis for vegetation indicators for Improved Grassland. Glastir management bundles assessed for effects on indicators are shown. Context effect was tested using information related to participation in historic agri-environment schemes. + significant increase, - significant decrease, ++/-- strong response, = indicator remained stable over time.

Asset Class	Habitat	Indicator	Habitat management	Grazing Lo/No Input Management	Organic	Context: Historic AES	Context HNV
Enclosed Farmland	Improved Grassland	Ellenberg moisture	=	=	=	=	=
		Total species richness	=	=	=	=	=
		Positive indicators	=	=	=	=	=
		Negative indicators*	=	=	=	=	=
		Grass: Forb ratio*	=	=	=	=	=

*These are negative indicators so a '+' indicates a decrease in condition.

Table 1-70 Glastir analysis for pollinator indicators for Improved Grassland. Glastir management bundles assessed for effects on indictors are shown. + significant increase, - significant decrease, ++/-- strong response, = indicator remained stable over time. No data are shown as grey boxes.

Asset Class	Habitat	Indicator	Grazing Lo/No Inputs	Habitat Management (General)	Hedge Management	Habitat management advanced	Wildlife corridors	Wood creation	Organic	Commons
Enclosed Farmland	Improved Grassland	Pollinator abundance	=	=	=	=	=	=	=	=
		Mean butterfly abundance	=	=	=	=	=	=	+	=
		Butterfly species richness	=	=	=	=	=	=	++	=
		Functional group richness	=	=	=	=	=	=	=	=
		Generality of pollinators	=	=	=		=		=	

Table 1-71 Glastir analysis for bird indicators in Improved Grassland. Glastir management bundles assessed for effects on indicators are shown.

Asset Class	Habitat	Indicator	Grassland Grazing Low/No Input Management
Enclosed Farmland	Improved Grassland	Abundance of lowland farmland bird species (indicator)	++
		Abundance of grassland species (guild)	++
		Priority Bird Abundance	=
		Granivorous eating bird species abundance	=
		Invertebrate-eating bird species abundance	++
		Vertebrate-eating bird species abundance	+

Table 1-72 Glastir analysis for topsoil indicators for Improved Grassland. Glastir management bundles assessed for effects on topsoil indicators are shown. Context effect was tested using information related to participation in historic agri-environment schemes. + significant increase, - significant decrease, ++/-- strong response, = indicator remained stable over time.

Asset Class	Habitat	Indicator	Arable Management	Grazing Low/No Input Management	Organic	Context: Historic AES
Enclosed Farmland	Improved Grassland	Carbon (g kg-1, from Organic matter)	=	--	=	--
		pH in water	=	=	=	=
		N (g 100-1 g dry soil)*	=	=	=	=
		Phosphorus (Olsen P mg kg-1)*	=	=	=	=
		Carbon density (t carbon ha-1)	=	=	=	-
		Bulk density (g cm-3)*	=	=	=	=

* An increase in this indicator is interpreted as a decline in condition for this habitat.

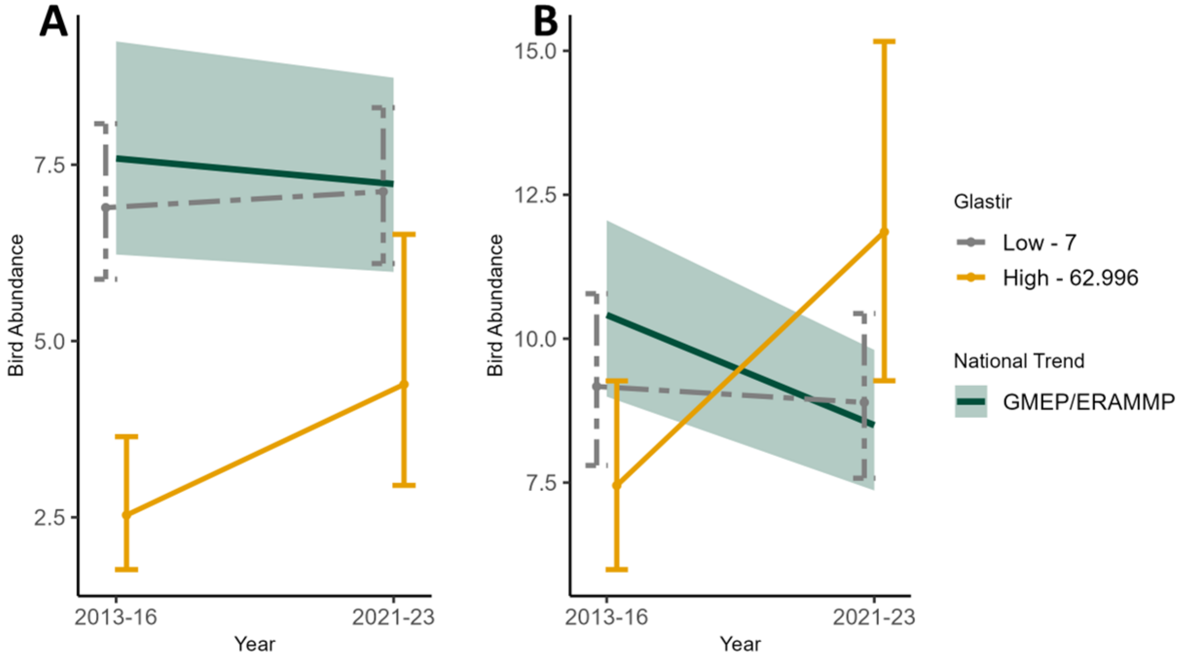

Figure 1-35 Trend in A) Lowland farmland bird indicator and B) Grassland bird guild abundance between 2013-16 and 2021-23 in Improved Grassland showing both national trends and effect of uptake of Grazing Lo/No Inputs bundle is low or high in proportion to specific bundle coverage maximums.

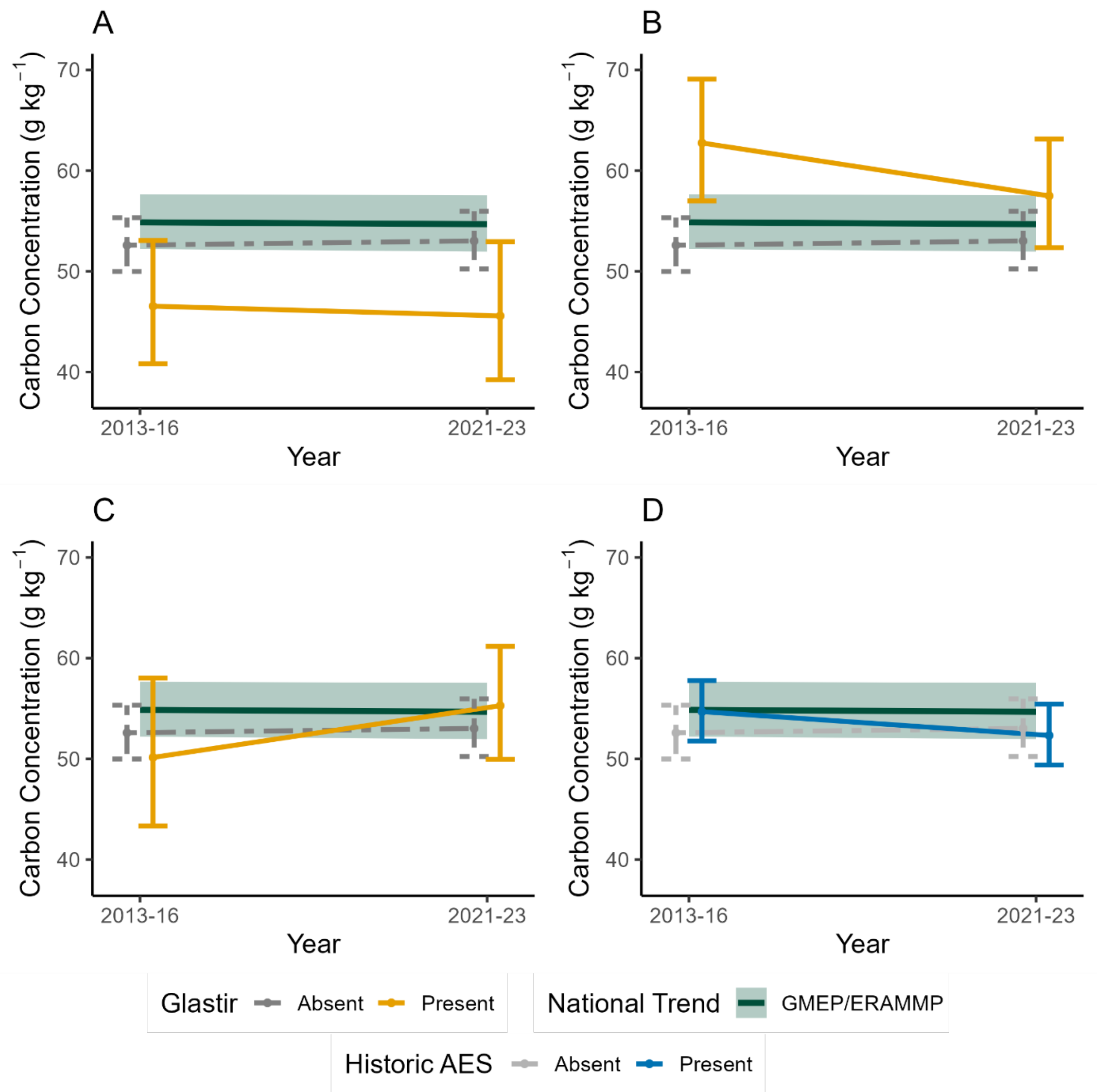

Figure 1-36 Trend in topsoil carbon concentration between 2013-16 and 2021-23 in Improved Grassland showing both national trends and effect of A) Glastir Arable Management, B) Glastir Grazing Lo/No Inputs Management ,C) Organics, and D) where historic AES is present or absent.

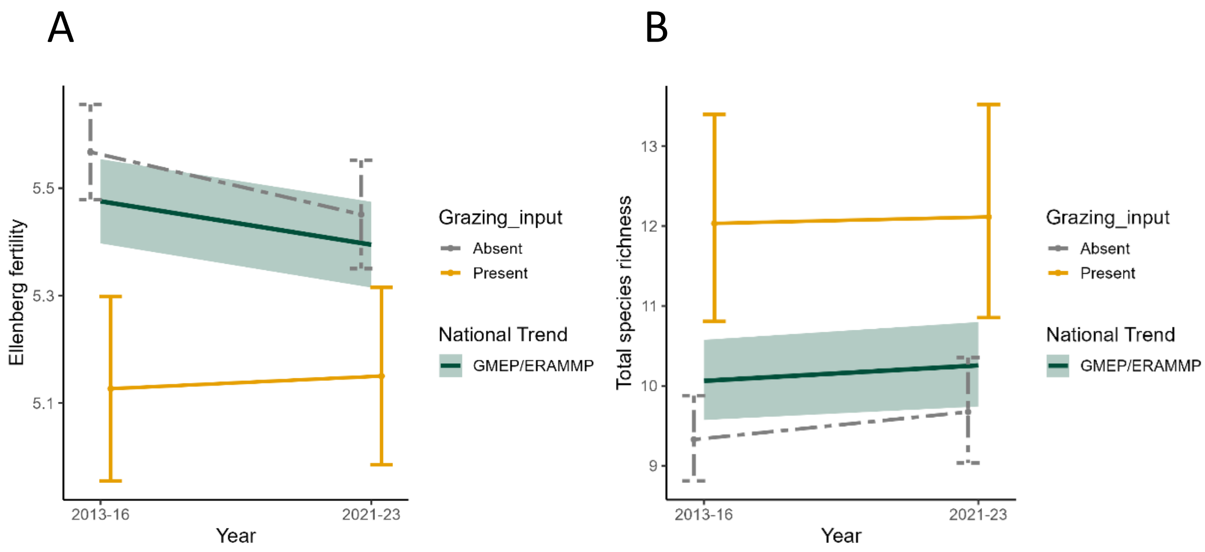

Figure 1-37 Trend in A) Ellenberg fertility and B) total species richness between 2013-16 and 2021-23 in Improved Grassland showing both national trends and effect of uptake of Grazing Lo/No Inputs.

1.4.3 Semi-Improved Grassland

This includes all Semi-Improved Grassland occurring on circum-neutral soils. It includes enclosed and managed grassland such as pastures, a range of grasslands which are inundated with water periodically, permanently moist, or even waterlogged grassland, where the vegetation is dominated by grasses, and tall and unmanaged grassland. It has been distinguished from the Improved Grassland above by a lower percentage of rye grass (*Lolium perenne* and *L. multiflorum*) and white clover (<25%). It also does not include high quality neutral grassland such as upland and lowland hay meadows.

It was not possible to separate bird data for Semi-Improved Grassland from those for Improved Grassland, so the results for the latter should be considered to represent both habitats.

There is no satellite data available from UKCEH Land cover Map (LCM) to indicate change or current cover of this Broad Habitat.

Vegetation indicators

Semi-Improved Grassland is of slightly higher botanical quality than Improved Grassland, with less domination by *Lolium perenne* and white clover. Increasing species richness of the sward is still desirable, we have included total plant species richness as an indicator, this is more comparable across habitats than indicators, although we have also used the positive and negative plant species richness from a list created by discussions with NRW. Grass: Forb ratio describes the relationship between grasses and forbs, a higher score indicates that there is more grass cover which is undesirable, and the aim is to increase forb richness of these grasslands. A high cover of grass in relation to the abundance of forbs can indicate intensive management impacts, e.g., high grazing intensity, nutrient enrichment. High fertility and low sward diversity are characteristics of these habitats so improvement will likely also require reduction in fertility as indicated by Ellenberg fertility scores.

Pollinator indicators

Pollinator indicators and pressures follow Improved Grassland.

Soil indicators

Soil was sampled from 0-15 cm; this is the most dynamic component of the soil profile, responding to land use, climate and management change. There is good evidence that changes in topsoil properties are indicative of changes to depth in managed land, although the magnitudes of change will differ across the soil profile.

Care must be taken when interpreting measurements of topsoil carbon density as it is partially determined by topsoil bulk density, which can change with soil wetness and with compaction. As such, changes in bulk density can cause an apparent change in carbon density that does not reflect additional carbon storage. The best evidence for an increase in topsoil carbon density is when an increase in both carbon concentration and carbon density has occurred, with stable or decreasing bulk density. Topsoil pH, Olsen P and nitrogen concentration are expected to be within specific thresholds for optimal grassland productivity and for wider ecosystem health. All of these indicators are strongly influenced by inputs and management but may also be affected by more general processes such as vegetation shifts, climate change or atmospheric nitrogen deposition.

1.4.3.1 National Trends

There are some early indicators of a decline in the condition of Semi-Improved Grassland after a period of stability. Whilst the number of negative plant indicators is decreasing, and pollinator indicators were stable, total plant species richness has declined together with an increase in Grass: Forb ratio (a negative indicator). Topsoil bulk density (an indicator of soil compaction) has also increased.

Positive Outcomes

- There has been a decrease in negative plant indicators.
- Positive plant indicators have remained stable.
- Pollinator functional group richness increased. All other pollinator indicators remained stable.
- Topsoil carbon and nitrogen concentrations in Semi-Improved Grassland remained stable across Wales.
- The national average topsoil pH is now stable in Semi-Improved Grasslands after a period of recovery from acidification but remains within the optimum pH for mesotropic grasslands (pH 5 to 7).

Areas for Concern / Need for Further Action

- Grass: Forb ratio increased which is a negative plant indicator.
- There was a decline in total plant species richness. This trend is reversed where there was High Nature Value Farmland Type II within the 1km survey square. This suggests decline in this habitat is more likely where land is isolated e.g. from potential seed sources.
- Topsoil bulk density, which is an indicator of compaction, has significantly increased in Semi-Improved Grassland by 13%. This increase in topsoil bulk density has led to an increase in topsoil carbon density that does not reflect additional carbon storage as carbon concentration did not change.

Table 1-73 Long-term and short-term trends in vegetation indicators for Semi-Improved Grassland. "=": no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01. No data are shown as grey boxes.

Asset Class	Habitat	Indicator	Long term analysis using CS data 1978/1990 - 2007	Mean 2013-16	Mean 2021-23	Short term analysis using GMEP 2013-16 to 2021-23
Enclosed Grassland	Semi-Improved Grassland	Grass: Forb ratio*	=	0.94	1.44	++
		CSM positive	=	3.21	3.13	=
		Negative indicators*	=	2.8	2.33	--
		Ellenberg fertility*	=	4.74	4.68	=
		Total species richness	=	14.93	14.07	

*These are negative indicators so a '+' indicates a decrease in condition.

Table 1-74 Long-term and short-term trends in pollinator indicators for Semi-Improved Grassland. "=": no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01. No data are shown as grey boxes.

Asset Class	Habitat	Indicator	Long term analysis using CS data 1978/1990 - 2007	Mean 2013-16	Mean 2021-23	Short term analysis using GMEP 2013-16 to 2021-23
Enclosed Grassland	Semi-Improved Grassland	Pollinator abundance		21.81	24.51	=
		Mean butterfly abundance		0.24	0.19	=
		Butterfly species richness		2.95	2.6	=
		Functional group richness		4.47	4.93	=
		Generality of pollinators		1.6	1.52	=

Table 1-75 Long-term and short-term trends in topsoil indicators for Semi-Improved Grassland. Long-term trends in indicators for Wales were extracted from (Smart, et al., 2009). "=": no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01. No data are shown as grey boxes.

Asset Class	Habitat	Indicator	Long term analysis using CS data 1978/1990 - 2007	Mean 2013-16	Mean 2021-23	Short term analysis using GMEP 2013-16 to 2021-23
Enclosed Grassland	Semi-Improved Grassland	Carbon (g/kg, from Organic matter)	=	59.8	57.6	=
		pH	+	5.61	5.51	=
		N (g/100g dry soil)*		0.46	0.46	=
		C density (tC/ha)[1]	=	64.7	70.6	++
		Bulk density (g/cm^3)[1] *		0.72	0.81	++

* An increase in this indicator is interpreted as a decline in condition for this habitat.

[1]This does not represent an increase in carbon stock as carbon concentration has not increased. It is driven by an increase in bulk density (i.e. compaction).

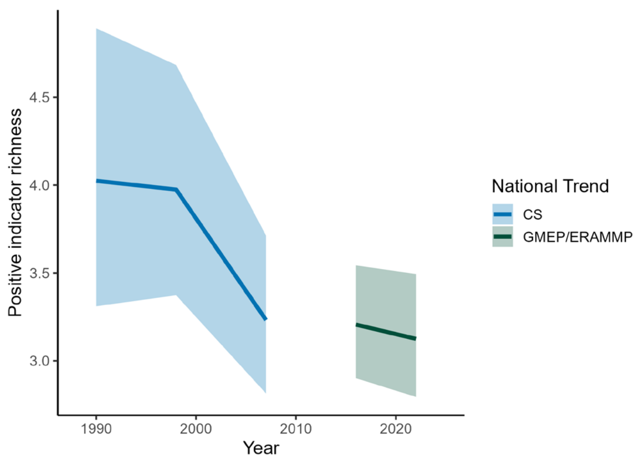

Figure 1-38 Long-term national trends in plant positive indicators (Common Standard Indicators) in Semi-Improved Grassland from Countryside Survey squares in Wales (1990 to 2007) and GMEP/ERAMMP (2013 – 16 to 2021 – 2023) from nationally representative survey squares.

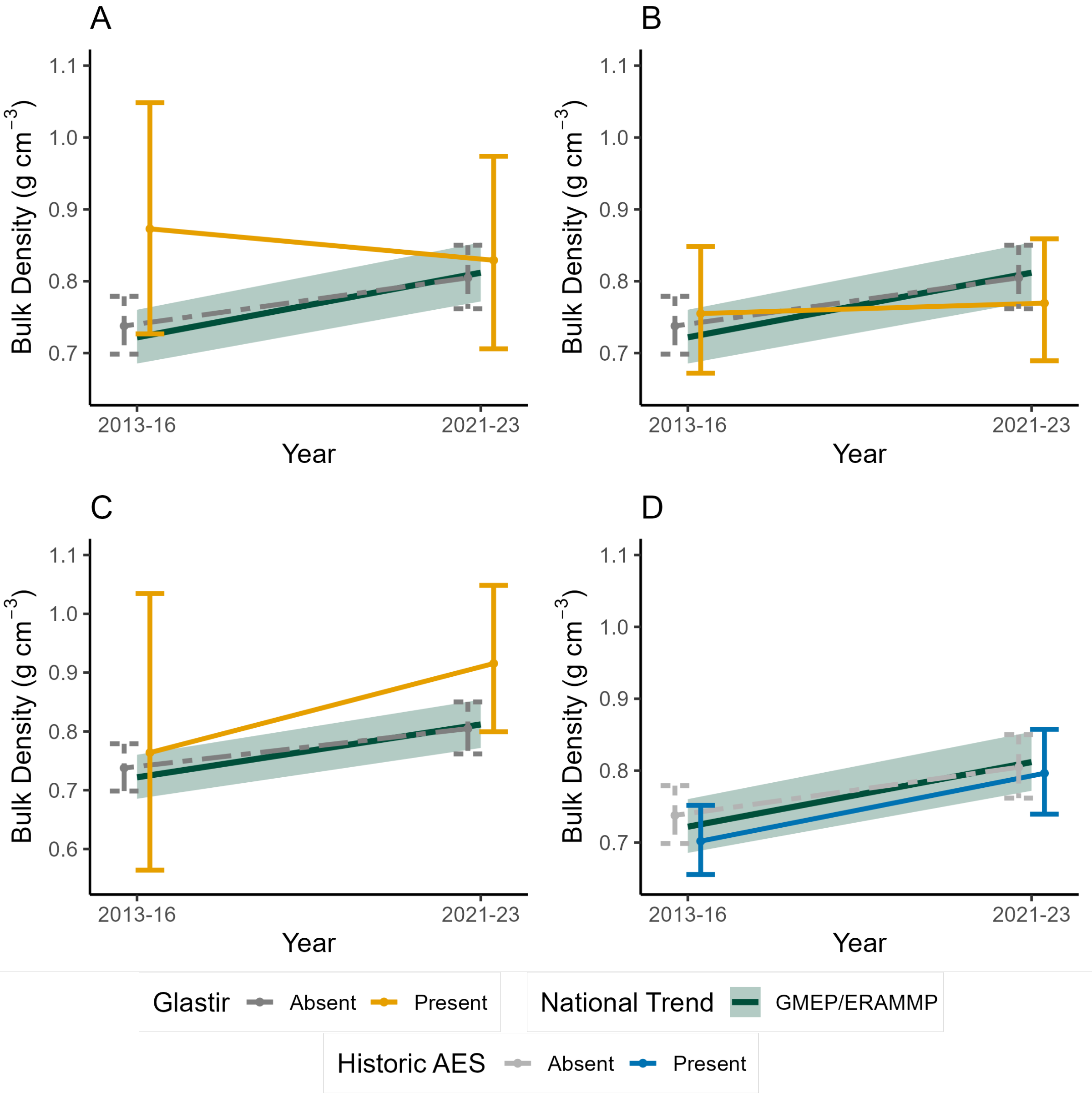

Figure 1-39 Trend in topsoil bulk density between 2013-16 and 2021-23 in Semi-Improved Grassland showing both national trends and effect of A) Glastir Habitat Management, B) Glastir Grazing Lo/No Inputs Management, C) Organics, and D) where historic AES is present or absent.

1.4.3.2 Glastir Impact

For vegetation, the impact of Glastir was assessed using the bundles Habitat Management which included grazing management of open country, reduced stocking additional payments, some options targeted at specific habitat types; Unimproved Neutral Grassland (pasture and hay meadows), marshy grassland. There were also some Organic interventions.

For soils, the impact of Glastir on Semi-Improved Grassland was assessed using the Habitat Management bundle, Grazing Low/No Inputs management bundle, and the Organics bundle. The impact of the presence in historic AES schemes was assessed too. The Grazing Lo/No Inputs management bundle was the largest bundle with actions covering grazed permanent pasture with no, and with low inputs. The Habitat Management bundle was mainly represented by the actions on existing hay meadows. The Organics bundle was represented by the action on “Glastir Organic Interventions”.

There were few impacts of Glastir options on soil with the exception of increased topsoil carbon concentration with the Habitat Management bundle. Evidence of continued benefits from historic AES schemes are detected with declines in Grass: Forb ratio (a negative indicator) and topsoil nitrogen concentrations.

Positive Outcomes

- The Habitat management bundle (primarily reduced stocking density) increased topsoil carbon concentration, counter to the stable national trend for Semi-Improved Grasslands. These options were applied on land that had below average topsoil carbon concentration and has brought it up to the national average.

Outcomes not as intended, trade-offs and contextual dependencies

- There were no significant impacts for indicators of vegetation condition.
- There were no significant positive individual bundle effects on pollinator indicators.

Historic AES

- Grass: Forb ratio (a negative indicator) was reduced with historic AES suggesting a possible lag time in benefits realised from previous schemes.
- Land that was in historic AES schemes shows a greater decrease in topsoil nitrogen concentration compared to land not in historic argi environment schemes and contrasts the stable national trend for Semi-Improved Grasslands. Land associated with historic agri-environment schemes had above average topsoil nitrogen in 2013-16 and has now fallen below the national average.

Table 1-76 Glastir analysis for vegetation indicators for Semi-Improved Grassland. Glastir management bundles assessed for effects on indicators are shown. Context effect was tested using information related to participation in historic agri-environment schemes. + significant increase, - significant decrease, ++/-- strong response, = indicator remained stable over time.

Asset Class	Habitat	Indicator	Habitat Management	Commons	Grazing Lo/No Input Management	Organic	Context: Historic AES	Context HNV
Enclosed Farmland	Semi-Improved Grassland	Ellenberg fertility*	=	=	=	=	=	=
		Grass: Forb ratio*	=	=	=	=	--	=
		Positive indicators	=	=	=	=	=	=
		Negative indicators*	=	=	=	=	=	=
		Total species richness	=	=	=	=	=	+

*These are negative indicators so a ‘+’ indicates a decrease in condition.

Table 1-77 Glastir analysis for pollinator indicators for Semi-Improved Grassland. Glastir management bundles assessed for effects on indictors are shown, but greyed out where data did not allow for analysis. + significant increase, - significant decrease, ++/-- strong response, = indicator remained stable over time.

Asset Class	Habitat	Indicator	Grazing Lo/No Inputs	Habitat Management (General)	Hedge Management	Habitat Management Advanced Reversions	Wildlife corridors	Woodland Creation	Organic	Commons
Enclosed Farmland	Semi-Improved Grassland	Pollinator abundance	=	=	=	=	=	=	=	=
		Mean butterfly abundance	=	=	=	=	=	=	=	=
		Butterfly species richness	=	=	=	=	=	=	=	=
		Functional group richness	=	=	=	=	=	=	=	=
		Generality of pollinators	=	=	=		=		=	

Table 1-78 Glastir analysis for topsoil indicators for Semi-Improved Grassland. Glastir management bundles assessed for effects on topsoil indictors are shown, but greyed out where data did not allow for analysis. Context effect was tested using information related to participation in historic agri-environment schemes. + significant increase, - significant decrease, ++/-- strong response, = indicator remained stable over time.

Asset Class	Habitat	Indicator	Habitat Management	Grazing Lo/No Input Management	Organic	Context: Historic AES
Enclosed Farmland	Semi-Improved Grassland	Carbon (g kg-1, from Organic matter)	+	=	=	=
		pH in water	=	=	=	=
		N (g 100-1 g dry soil) *	=	=	=	--
		Carbon density (t carbon ha-1)	=	=	=	=
		Bulk density (g cm-3)*	=	=	=	=

*An increase in this indicator is interpreted as a decline in condition for this habitat.

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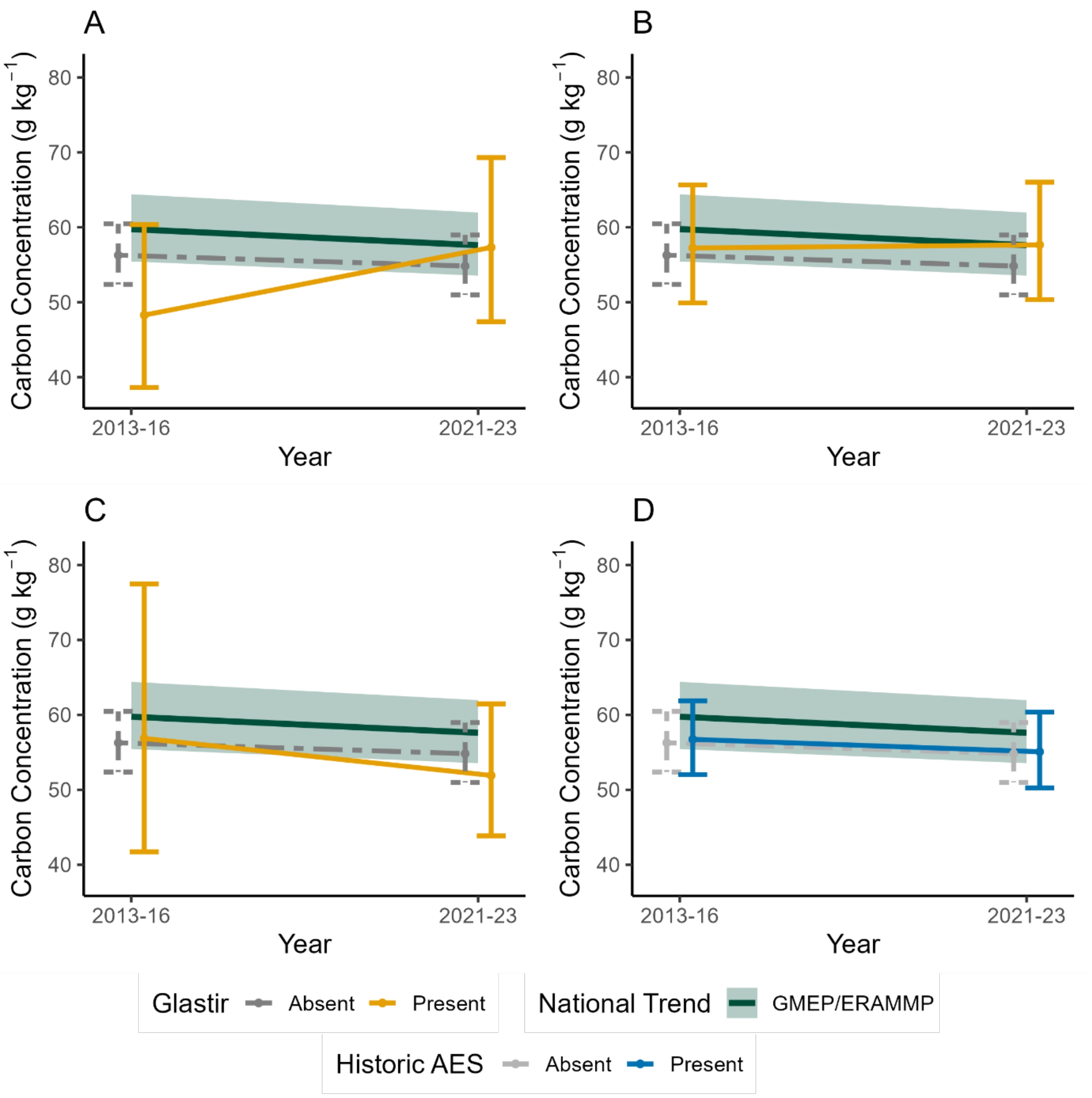

Figure 1-40 Trend in topsoil carbon concentration between 2013-16 and 2021-23 in Semi-Improved Grassland showing both national trends and effect of A) Glastir Habitat Management, B) Glastir Grazing Lo/No Inputs Management, C) Organics, and D) where historic AES is present or absent.

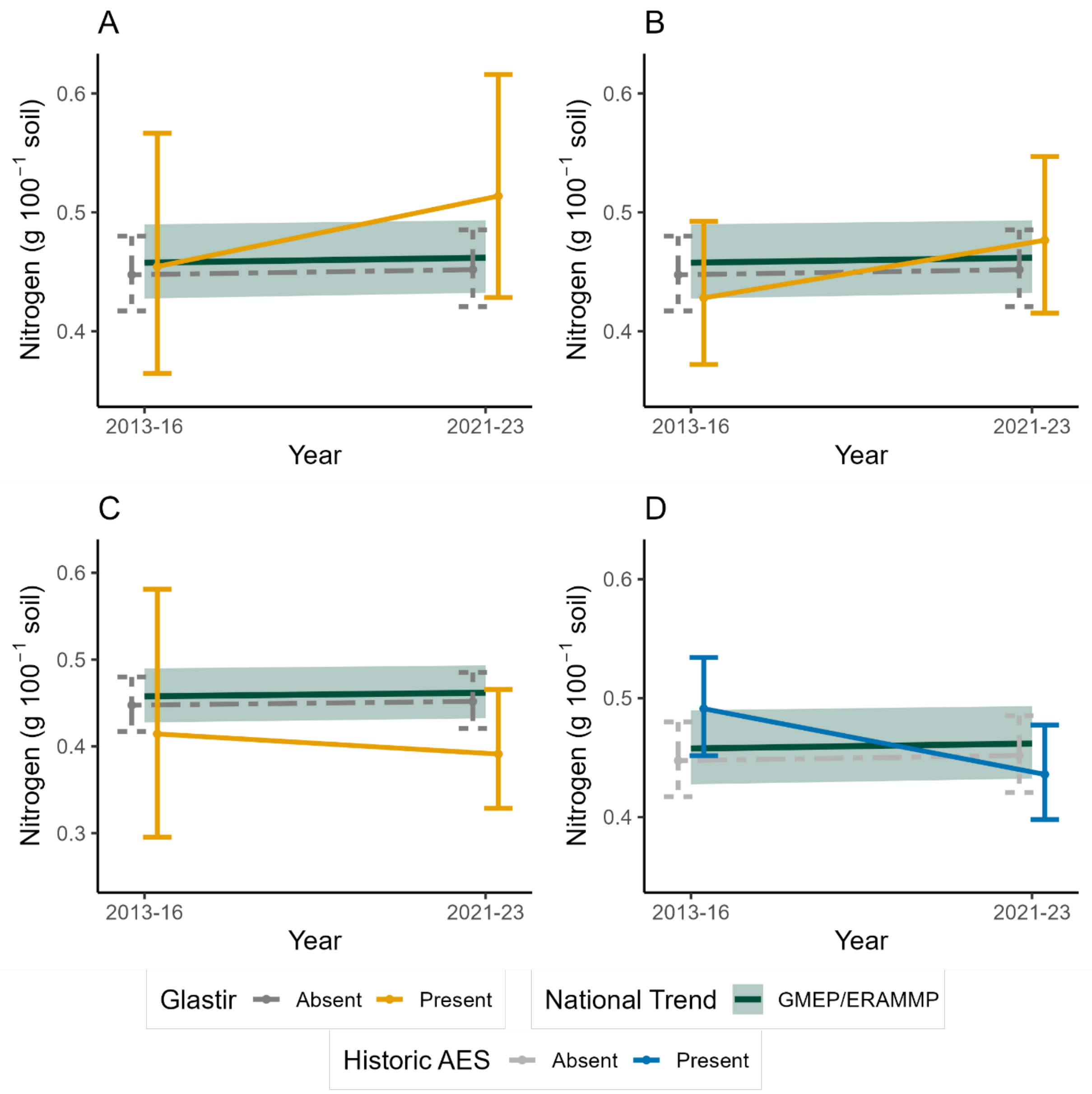

Figure 1-41 Trend in topsoil nitrogen concentration between 2013-16 and 2021-23 in Semi-Improved Grassland showing both national trends and effect of A) Glastir Habitat Management, B) Glastir Grazing Lo/No Inputs Management, C) Organics, and D) where historic AES is present or absent.

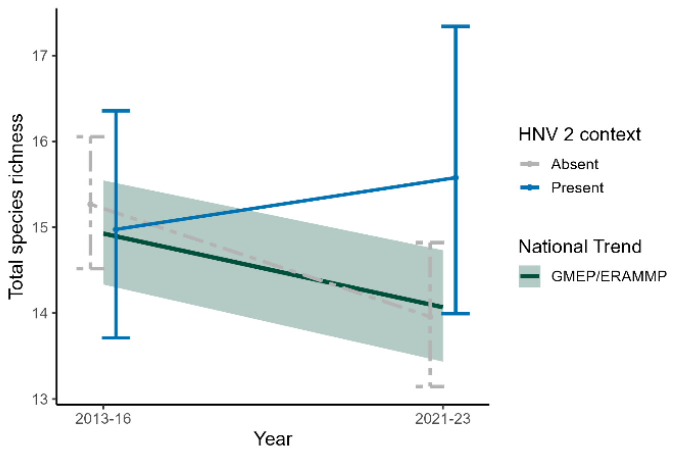

Figure 1-42 Trend in total plant species richness between 2013-16 and 2021-23 in Semi-Improved Grassland showing both national trend and where HNV2 (heterogeneous land) as context is present or absent.

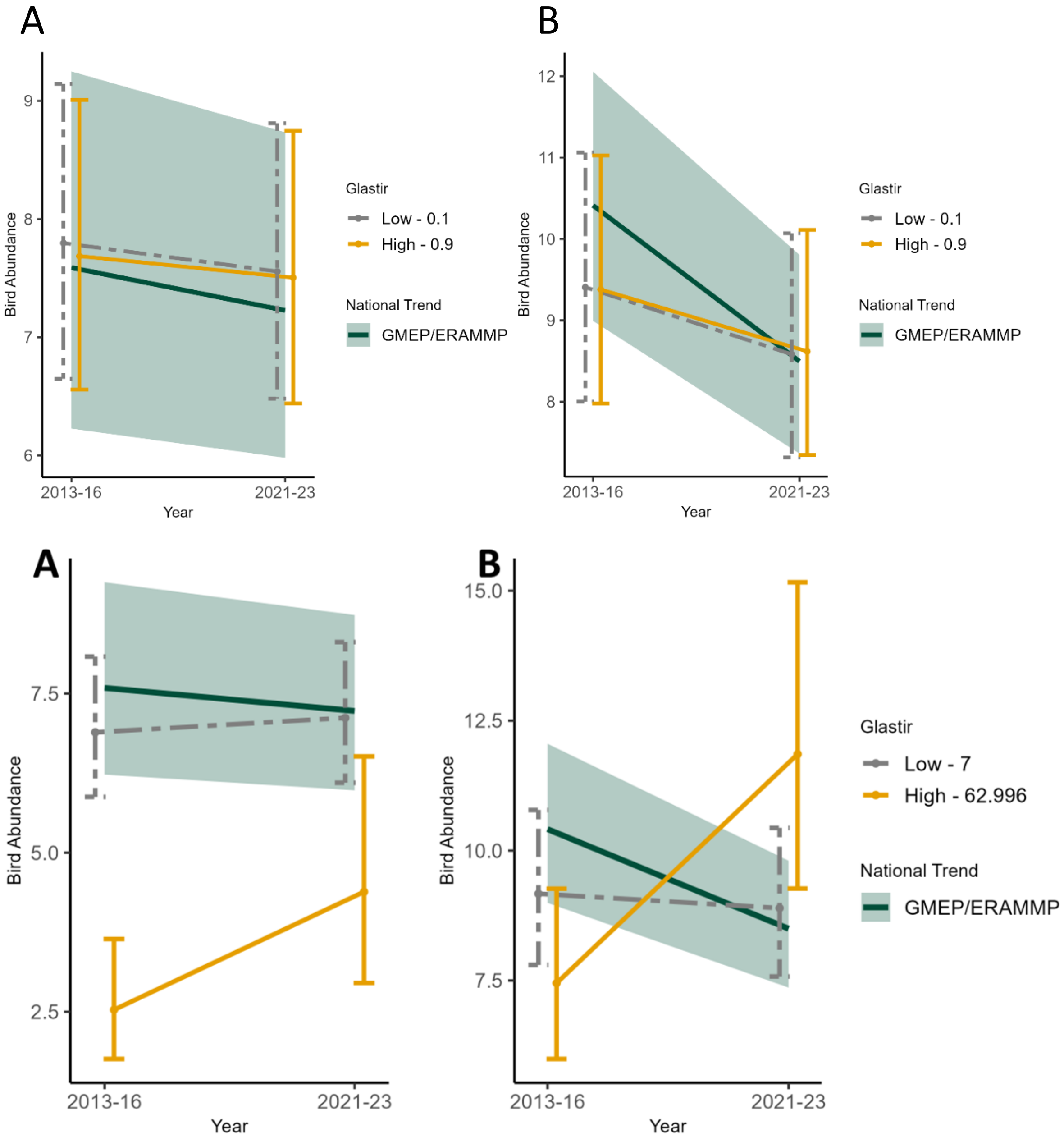

Figure 1-43 Trend in A) Lowland farmland bird indicator and B) Grassland bird guild abundance between 2013-16 and 2021-23 in Semi-Improved Grassland showing both national trends and effect of uptake of Grazing Lo/No Inputs bundle is low or high in proportion to specific bundle coverage maximums.

1.4.4 Hedgerows, Boundaries and Streamsides

The term ‘woody linear features’ (WLFs) has been used to account for the tremendous diversity of WLFs to be found in the countryside including everything from a traditionally managed hedge to a planted avenue of trees or a line of old scrub which may at one time have been a managed hedge. WLFs fall into two broad categories based on the extent to which the trees within them take their natural shape.

- 'Natural shape' means unhindered/unmanaged growth for at least a decade. Where trees take their natural shape, the feature will essentially be a line of trees or scrub.
- Where trees/scrub has been managed relatively recently the WLF will fall into the hedgerow category.

Most of the analyses presented are on Hedgerows as the managed component for which specific Glastir options have been created- these have been put into two bundles for hedgerow management and restoration.

Boundary plots are also analysed as a group; these are linear features including fences, walls, hedges, and grass strips. Understanding the condition of these features is important as they can play an important role as a refuge for species lost from the wider countryside, they may also improve connectivity for some species and have been used as buffers.

For birds, relevant bird indicators are analysed with respect to the Glastir bundles for hedgerow management and Streamsides (which dominated the options considered for 'wildlife corridors'). Some Glastir bundles focus on these features e.g. wildlife corridors, others that reduce inputs or grazing density may have indirect effects on them via impacts on adjacent land.

Vegetation indicators

Hedgerow condition assessment depends on recording hedgerow 'attributes', based on thresholds from the UKHAP Steering Group to indicate whether a particular hedgerow is in 'favourable condition'. These attributes include:

- Structural only; height >1m, width of the woody component >1.5m, Cross-sectional area (height x width) >3m, the degree of intactness of the hedgerow canopy, Vertical gappiness 5m wide, the height above ground at which the canopy starts 1m),
- Structural and undisturbed ground >2m adjacent to the hedgerow (all land)
- Structural and margins (width of perennial herbaceous vegetation >1m)
- Undisturbed ground >2m adjacent to the hedgerow (on arable land only)

The % of plots meeting these condition thresholds is then calculated.

Individual elements of structural condition; hedge height and width have also been analysed along width changes in management type (% of length).

For all linear plots, hedgerow, Boundary and Streamsides the total species richness of the understorey has been analysed, along with the number of ancient woodland indicators and nectar plant species. This enables tracking of changes in plant diversity. By also analysing Ellenberg fertility and light score we hope to understand why changes are happening i.e. is it due to increased fertility or changes in successional processes resulting in shading (and lower light scores) changing the type of species that might succeed?

Pollinator indicators

Pollinator metrics considered here matched those used for Broadleaf Mixed and Yew Woodland; see section 1.1.1. Pollinators largely depend on plant diversity and vegetation quality, so the pressures on them will follow those described for vegetation, particularly the (lack of) management or maintenance of Hedgerows. Rich and diverse peripheral habitats within enclosed farm landscapes will support larger and more diverse pollinator communities.

Bird indicators

Six bird indicators were investigated in these analyses, which considered Hedgerows and Wildlife Corridors (in practice, Streamsides) - Abundance of lowland farmland bird species (indicator) and Abundance of arable bird species (guild) plus four general indicators for Priority bird species and the three dietary guilds (Granivorous, and Invertebrate- and Vertebrate-eating bird species). The indicator follows the policy-led standard list of species from (Burns, et al., 2023), whilst the guild is based on specific ecological associations, derived from (Siriwardena, Henderson, Noble, & Fuller, 2019). Siriwardena et al. also provides the species lists for the key dietary guilds. The priority bird species list consists of all section 7 species from the Environment (Wales) Act 2016.

Key pressures for birds on Hedgerows and other peripheral habitats in Enclosed Farmland are those associated with more intensive farming, such as loss and neglect of non-production areas, and spray drift reducing vegetation diversity and invertebrate numbers. A range of management measures, as implemented under Glastir options, are well-established, with the aim of restoring the value of these habitats for food, nest sites, cover and connectivity.

Soil indicators

No data is available for these habitats.

1.4.4.1 National Trends

Overall, there is a marginal signal of improvement of hedges with an increase in length, height, width, woody species richness and an overall improvement in condition. Although aesthetically hedges may look different from being taller and wider, both hedge height and hedge width are important for hedge condition, ensuring a greater area of habitat for wildlife as well as storing higher amounts of carbon so taller, wider hedges have many benefits. Changes in woody species richness are most likely to occur if there is a significant increase in hedge extent or restoration resulting from the planting of multi-species hedges, although we did not find evidence of a large uptake of Glastir restoration options, these could be implemented outside of Glastir.

A higher percentage of Hedgerow woody diversity plots were in good condition according to UKHAB criteria in 2021-23 compared to 2013-16. This is due mostly to improvements in structural condition with increased height. There is no evidence that this is related to Glastir although the survey overlap with Glastir options was not high particularly for restoration actions. Although hedgerow condition had improved, over half of hedges surveyed still failed to reach both good structural and margin condition criteria.

Ground flora species richness and nectar plant richness have declined in hedges. A decrease in species richness is likely to reflect the increasing dominance of species that can tolerate shady/eutrophic conditions as indicated by the decreasing Ellenberg light score.

When analysing all boundary plots together the trend previously observed of succession along linear features appears to have been stabilised in these habitats. At the same time there has been a decline in species richness, although not the positive indicators, this does include nectar plants.

Unlike Boundaries where the successional trend may have been stabilised, results from Streamsides suggest a shift to more shade tolerant species as the canopy closes, favouring a gradual colonisation of slow dispersing AWI species but not yet at a rate to offset loss of more light demanding species. Note that this was less the case in adjacent P plots (which may be undergoing less succession further into the habitat).

Lowland farmland bird indicator species showed no significant difference in abundance between the survey periods of GMEP and ERAMMP. The abundance of grassland and arable bird species (guilds) showed significant declines between GMEP and ERAMMP.

Positive Outcomes

Hedgerows

- There is an improvement in Hedgerow condition overall (based on UKHAB condition measures)
- There is increased Hedgerow height (+4%) and width (+20%).
- There is increased woody species richness in Hedgerows.
- The length of Hedgerows as calculated by the national estimate method has increased by 4% of 2010 values however, there is high uncertainty around these estimates.
- Analysis of mean length per square suggests no change in hedgerow length.
- Hedgerow management has remained stable in the short term.
- No significant change in Ancient Woodland Indicators in Hedgerows.

Individual Trees

- The age structure of individual trees is progressing- there are more older trees for some species e.g. ash and oak.
- There has been no change in the total number of trees per square.
- Veteran trees: there have been some condition changes, more epiphytes, slightly less of the canopy live, more hollow trunks, more trees pollarded.

Boundaries

- In Boundary plots declines in plants that favour high light conditions has stabilised after a decline in the longer-term data. Canopy height has also stabilised after a long-term increase in Boundary plots.
- Positive indicators have stabilised from a long-term decline in Boundaries.
- Increasing trends for Ellenberg fertility and Reaction through CS seem to have stabilised more recently in Boundary plots.

Streamsides

- Positive indicators have stabilised from a long-term decline in Streamsides.
- Increasing trends for Ellenberg fertility and Reaction seem to have stabilised more recently in Streamside plots.

Areas for Concern / Need for Further Action

- There has been a decline in nectar rich plants since 2016 in Hedgerows, Boundary plots and Streamsides.
- There is an ongoing significant reduction in total species richness in Streamsides and Boundary plots and short-term decline in hedgerow ground flora.
- Increased canopy height and a trend towards lower mean Ellenberg light score in short and long-term trends, indicate greater shading in Streamsides and hedgerows.

Table 1-79 Long-term and short-term trends in vegetation indicators for Hedgerows, Boundaries and Streamsides "=": no significant change, +/-: significant at p =< 0.05, ++/--: significant at p =< 0.01. No data are shown as grey boxes. Note: Countryside Survey sample population was sampled from, on average, a higher latitude than the sample population in 2013-16 and the re-survey in 2021-23.

Asset Class	Habitat	Indicator	Long term analysis using CS data 1978/1990 - 2007	Mean Trend 2013-16	Mean Trend 2021-2013	Short term analysis using GMEP 2013-16 to 2021-23
Enclosed Farmland	Hedgerows	Ellenberg fertility*	=	5.8	5.8	=
		Ellenberg light	=	6.12	6.05	--
		Ground Flora species richness	=	19.49	17.8	-
		AWI richness	=	2.18	2.04	=
		Nectar plant richness	=	12.87	11.98	-
		Woody diversity	=	5.52	5.83	+
		National estimates of Hedgerow length ('000s km)	-	50.5	52.7	=
		Mean length per square (m)	=	3337.87	3067.07	=
		Hedgerow width (m)	=	2.1	2.29	+
		Hedgerow height (m)	=	1.87	2.03	+
		Hedgerow management: laying and coppicing, newly planted, cutting				=
		% favourable condition HAP		47.8	50.1	+
	Individual trees	Total number of trees (mean per square)		28.14	26.74	=
	Boundaries	Ellenberg fertility*	++	5.15	5.15	=
		Ellenberg Reaction	++	5.58	5.57	=
		Ellenberg Light	--	6.51	6.51	=
		Ground Flora species richness	-	16.57	15.84	--
		Nectar species	=	8.15	7.7	--
		AWI species	=	0.95	0.96	=
		CSM Positive indicator richness	-	8.64	8.53	=
		Negative indicators*	=	11.5	11.13	=
		Canopy height	++	2.57	2.58	=
		NNS cover	=	0.27	0.27	=
		NNS rich		0.14	0.15	=
	Streamsides	Ellenberg fertility*	+	4.97	5	=

		Ellenberg Reaction	+	5.42	5.4	=
		EBERGL	--	6.33	6.23	-
		Total species richness	--	20.48	19.41	--
		Nectar species	-	10.15	9.22	--
		AWI species	=	2.26	2.43	=
		CSM positive indicator richness	--	11.62	11.26	=
		Negative indicators*	-	10.89	10.44	=
		Canopy height	++	2.64	2.79	++
		NN cover rescaled 0 to 1	=	0.14	0.14	=
		NN richness*	+	0.21	0.29	+

*These are negative indicators so a '+' indicates a decrease in condition.

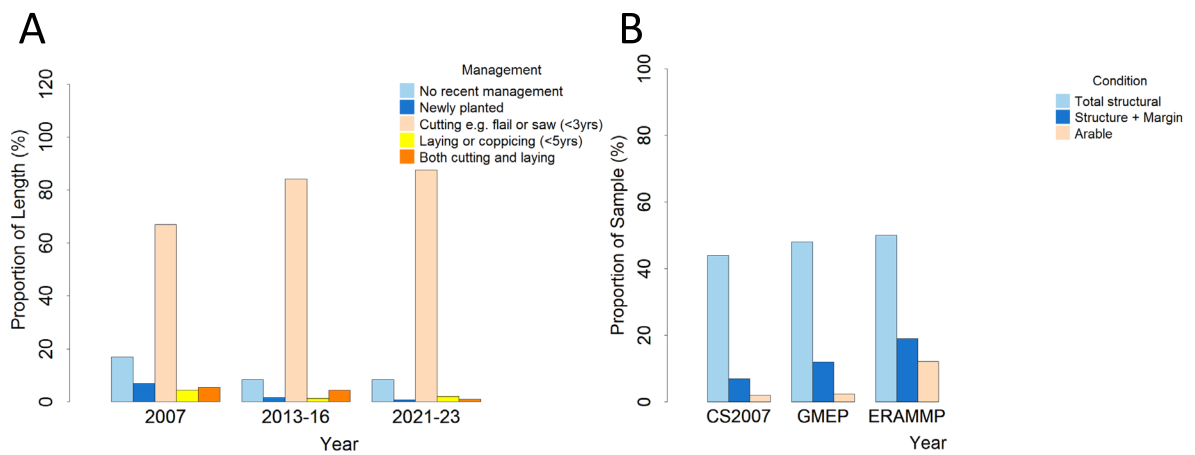

Figure 1-44 Long term national trends in A) Management B.) % of plots meeting UKHAB condition standards from Countryside Survey squares in Wales 1990 to 2007 and GMEP/ERAMMP (2013 – 16 to 2021 – 2023) from nationally representative survey squares.

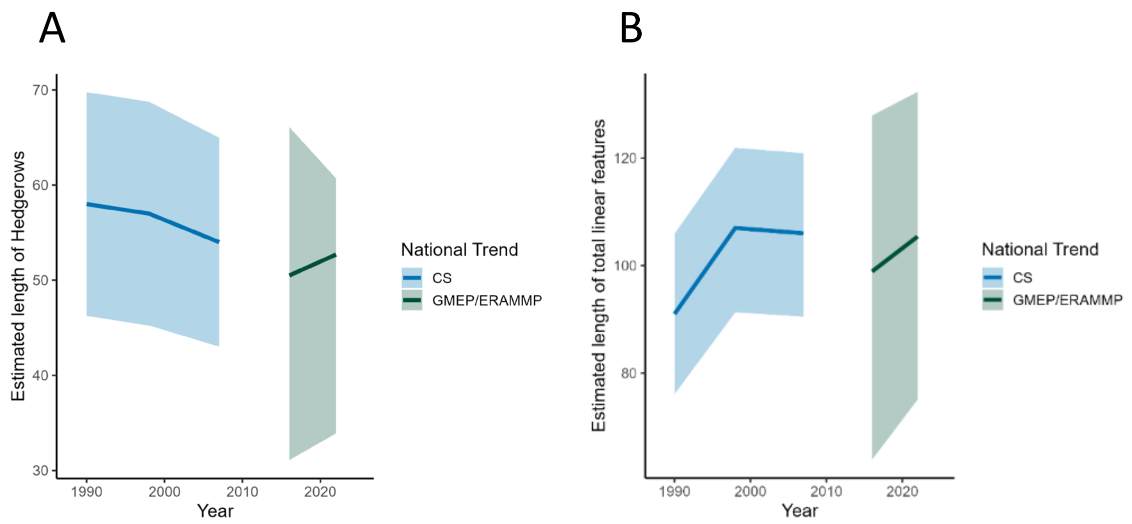

Figure 1-45 Long term national trends in Length of Hedgerows from Countryside Survey squares in Wales (1990 to 2007) and GMEP/ERAMMP (2013 – 16 to 2021 – 2023) from nationally representative survey squares A Total Linear features B WUS- Woody Unnatural Shape C WNS Woody natural Shape.

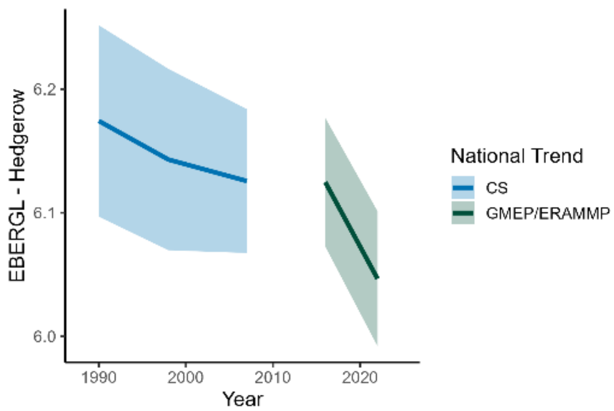

Figure 1-46 Long term national trends in Ellenberg light in Hedgerows from Countryside Survey squares in Wales (1990 to 2007) and GMEP/ERAMMP (2013 – 16 to 2021 – 2023) from nationally representative survey squares.

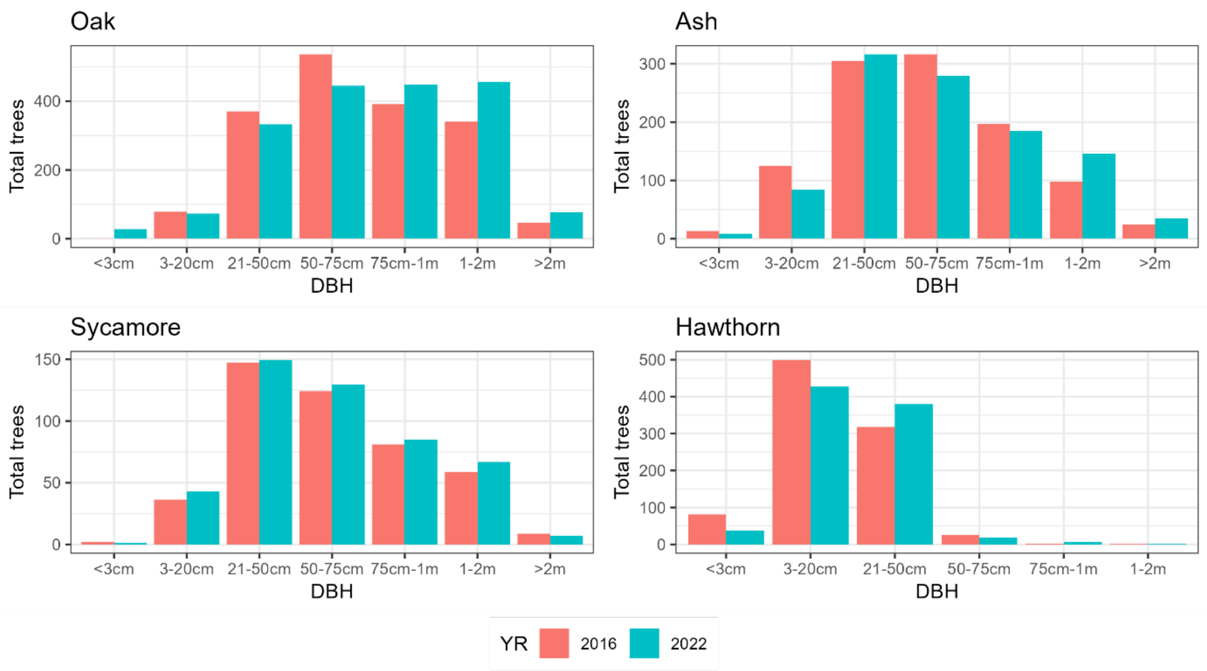

Figure 1-47 Distribution in the diameters (size) of four different species present as individual trees in the landscape.

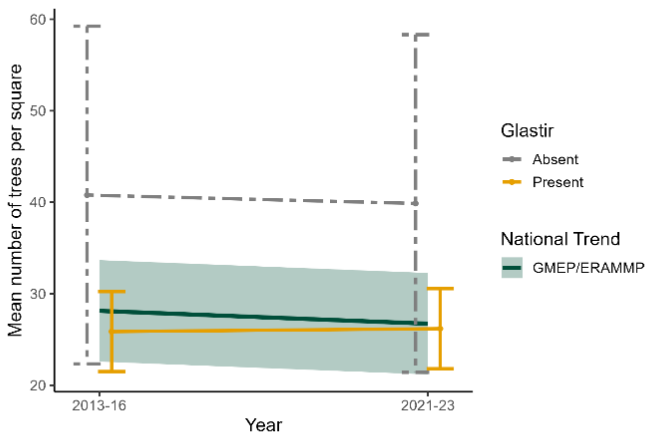

Figure 1-48 Long term national trends mean number of individual trees per square GMEP/ERAMMP (2013 – 16 to 2021 – 2023) from nationally representative survey squares with presence/absence of Glastir within a 1km square.

Table 1-80 Table showing the percentage of veteran trees in different condition categories.

Category	2007	2016	2022
Tree dead	1.7	1.1	1.8
Missing limbs	77.9	79.8	77.1
Dead wood	84.2	75	74.3
Lightning strike	50.8	55.9	47.3
Hollow trunk	16.7	25	31.6
Epiphytes - Rare	45.8	70.7	46.3
Epiphytes - Present	33.3	24.5	41.1
Epiphytes - Abundant	20.8	4.8	10.4
Canopy live 90-100%	55.8	77.7	71.5
Canopy live 50-89%	39.2	17.6	20.1
Canopy live 25-49%	2.9	3.2	5.6
Canopy live <25%	2.1	1.6	2.5
Standard	66.25	85.1	75.1
Lay	6.3	3.7	5.3
Pollard	27.5	11.2	19.3

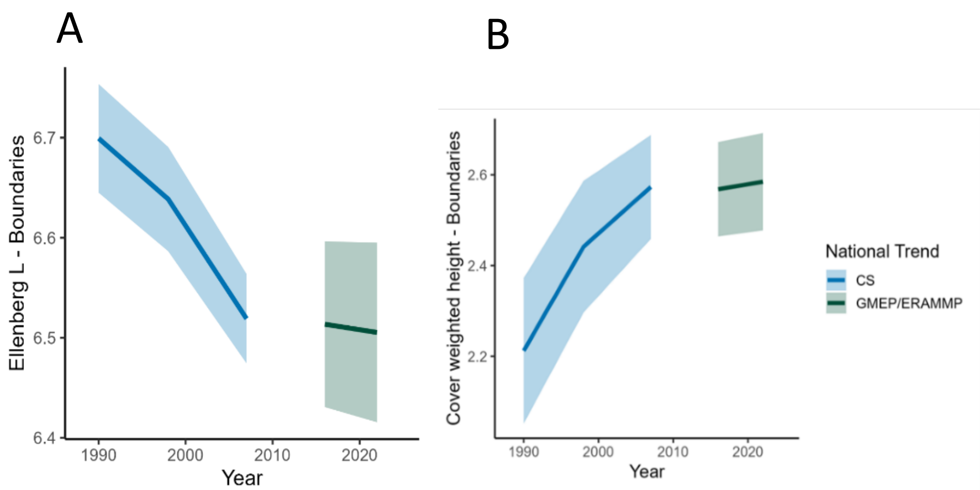

Figure 1-49 *Long term national trends in A) Ellenberg light on boundaries B) Cover weighted canopy height on boundaries from Countryside Survey squares in Wales (1990 to 2007) and GMEP/ERAMMP (2013 – 16 to 2021 – 2023) from nationally representative survey squares.*

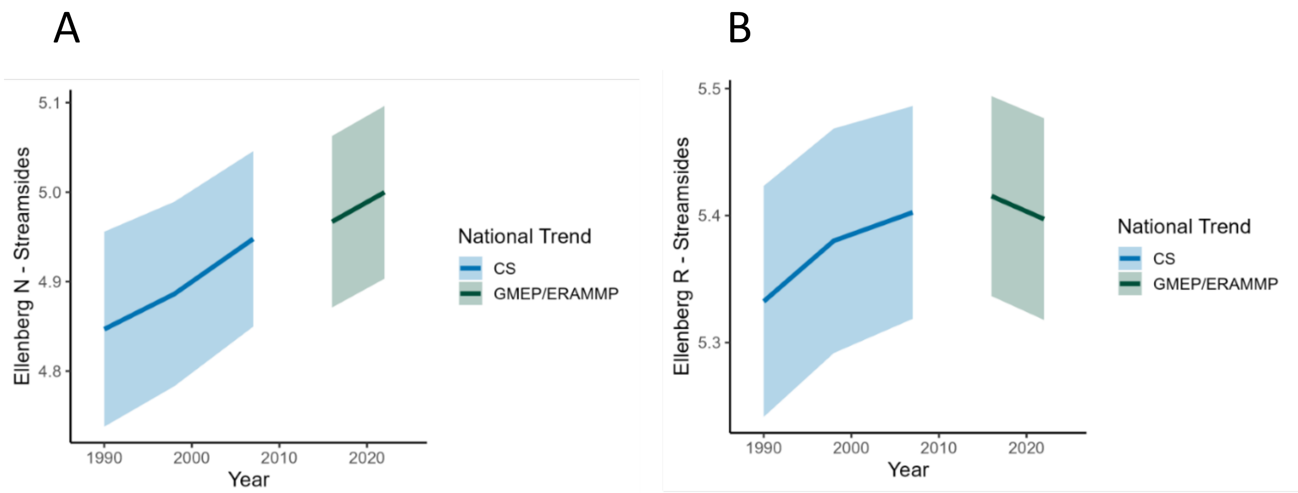

Figure 1-50 *Long term national trends in A) Ellenberg fertility on Streamsides B) Ellenberg Reaction on Streamsides from Countryside Survey squares in Wales (1990 to 2007) and GMEP/ERAMMP (2013 – 16 to 2021 – 2023) from nationally representative survey squares.*

1.4.4.2 Glastir Impact

Glastir effects have been analysed using a number of different bundles. On hedgerows hedgerow management includes enhanced hedgerow management, double fencing gappy Hedgerows, restoration includes hedge laying, coppicing, planting and gapping up. On Boundaries, in addition to Hedgerow Management the Grazing Lo/No Inputs bundle and Wildlife Corridors were also included. This was similar for Streamsides with Habitat Management rather than Hedgerow Management in addition to Wildlife Corridors. There were few notable improvements in vegetation condition in response to Glastir bundles in Hedgerows, Boundaries and Streamsides.

Overall Hedgerow condition may have improved with Hedgerow Management, but it is not statistically testable. We did test hedgerow height, width and length with Glastir and these were not significant.

The Wildlife Corridor Management bundle resulted in a reduction in plant negative indicators on Streamsides. The Grazing Lo/No Input bundle had a positive effect on species richness of Boundary features. All bird indicators considered here, except for priority bird species, showed positive relationships to Hedge Management. Wildlife Corridor Management was a positive influence on priority bird species, and invertebrate- and vertebrate-eating bird species.

Positive Outcomes

- Grazing Lo/No Inputs bundle had a positive effect on total ground flora species richness on Boundary features.
- Hedgerow condition positively increased with Hedgerow Management (this is based on % of plots meeting condition criteria so not statistically confirmed).
- There was a reduction in plant negative indicators on Streamsides with the Wildlife Corridor Management bundle.
- Positive responses from most bird indicators to Hedge Management, as well as to Wildlife Corridor Management. Actual option coverage indicates that the latter pattern involved responses to Streamside Management.

Outcomes not as intended, trade-offs and contextual dependencies

- There were no significant effects of Glastir on height, length, woody species richness or ground flora species richness of Hedgerows.
- There was no effect of Glastir on the number of individual trees.

Historic AES context

- Ellenberg fertility and reaction (pH) seem to be levelling off more in Boundary plots which were in historic AES schemes.
- Total species richness and nectar species are declining more in historic AES plots on Hedgerows and Boundaries (possibly a legacy of canopy height increases/Ellenberg light related declines to richness as time lags are resolved)

Table 1-81 Glastir analysis for Biodiversity indicators in Hedgerows. Glastir Management bundles assessed for effects on Biodiversity indicators are shown, but greyed out where sample size was too small for analysis. Context effect was tested using information related to participation in historic agri-environment schemes. + significant increase, - significant decrease, ++/-- strong response, = indicator remained stable over time.

Asset Class	Habitat	Indicator	Hedge Management	Hedge Restoration	Wildlife corridors	Woodland creation	Context: Historic AES
Enclosed Farmland	Hedgerows	Height	=	=			=
		Length (mean per square)	=	=	=	=	
		Width	=	=	=	=	
		Ground flora species richness	=				=
		Woody species richness	=				=
		AWI	=				=
		Nectar plant richness	=				-
		Structural condition	+				

*This is the % of plots in condition i.e. not quantitatively analysed.

Table 1-82 Glastir analysis for Biodiversity indicators for Boundary plots. Glastir management bundles assessed for effects on Biodiversity indicators are shown. Context effect was tested using information related to participation in historic agri-environment schemes. + significant increase, - significant decrease, ++/-- strong response, = indicator remained stable over time.

Asset Class	Habitat	Indicator	Hedge Management	Grazing Lo/No Input Management	Wildlife Corridors	Context: Historic AES
Enclosed Farmland	Boundaries	EBERGN*	=	=	=	--
		EBERGR	=	=	=	--
		EBERGL	=	=	=	-
		Totall species richness	=	+	=	-
		AWI species richness	=	=	=	=
		Nectar species	=	=	=	-
		CSM positive species	=	=	=	=
		Negative indicators*	=	=	=	-
		Canopy height	=	=	=	=

*These are negative indicators so a ‘+’ indicates a decrease in condition.

Table 1-83 Glastir analysis for Biodiversity indicators for Streamside plots. Glastir management bundles assessed for effects on Biodiversity indicators are shown. Context effect was tested using information related to participation in historic agri-environment schemes. + significant increase, - significant decrease, ++/-- strong response, = indicator remained stable over time.

Asset Class	Habitat	Indicator	Habitat management	Grazing Lo/No Input Management	Wildlife Corridors	Context: Historic AES
Enclosed Farmland	Streamside	Ellenberg fertility*	=	=	=	=
		Ellenberg reaction	=	=	=	=
		Ellenberg Light	=	=	=	=
		Total species richness	=	=	=	=
		Nectar plant species richness	=	=	=	=
		AWI species	=	=	=	=
		CSM positive indicator species	=	=	=	=
		Negative indicators*	=	=	--	=
		Canopy height	=	=	=	=

*These are negative indicators so a ‘+’ indicates a decrease in condition.

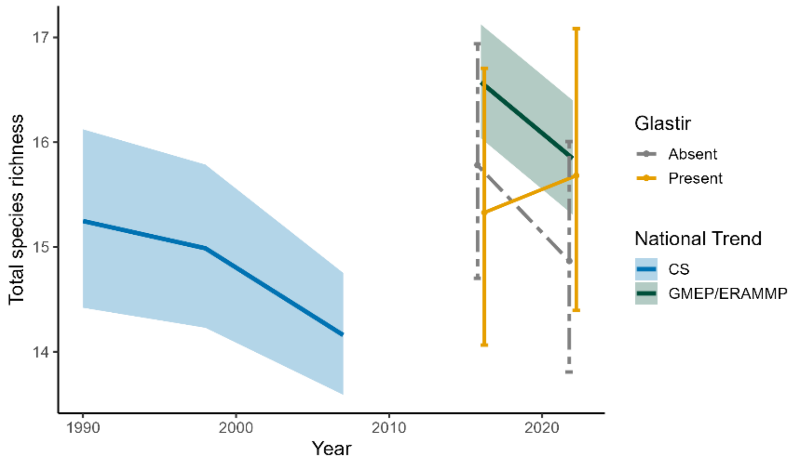

Figure 1-51 Trend in total plant species richness between 2013-16 and 2021-23 in boundary plots showing both national trends and effect of Grazing Lo/No Inputs bundle.

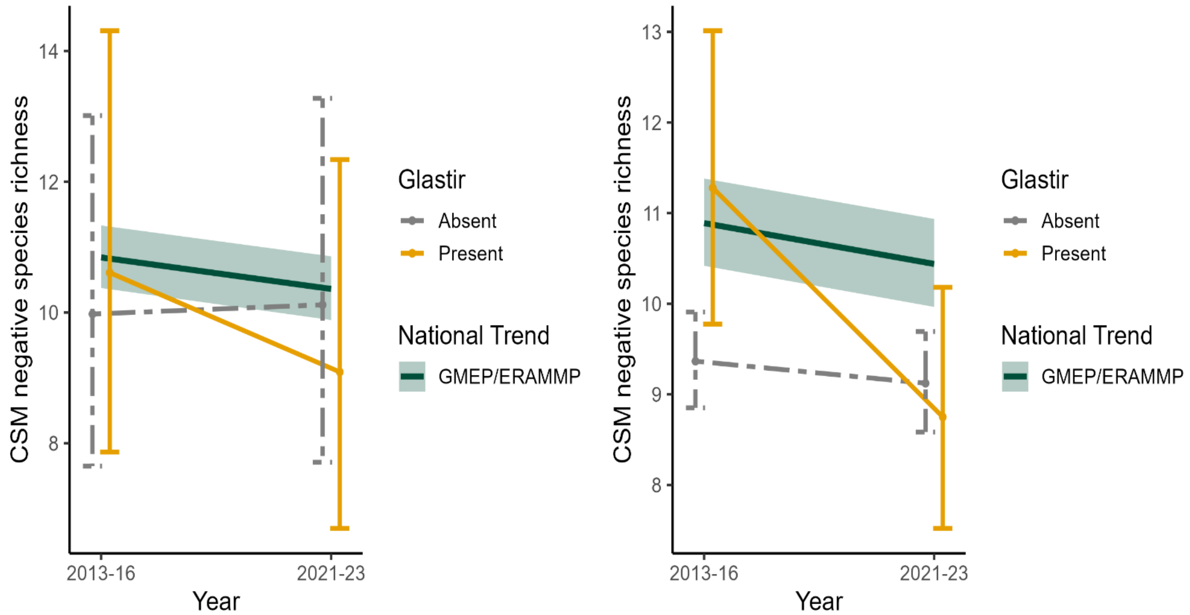

Figure 1-52 Trend in CSM negative species between 2013-16 and 2021-23 in A) P plots and B) SW plots showing both national trends and effect of Wildlife Corridors bundle. P plots are placed at right angles to the stream to sample the landuse and context of the streamside. SW plots are linear plots that lie adjacent to the stream.

Table 1-84 Glastir analysis for bird indicators in relation to Hedgerows and Boundaries. Glastir management bundles assessed for effects on indicators are shown. Context effect was tested using information related to participation in historic agri-environment schemes. + significant increase, - significant decrease, ++/-- strong response, = indicator remained stable over time. No data are shown as grey boxes.

Asset Class	Broad Habitat	Indicator	Hedge Management	Wildlife Corridors
Enclosed Farmland	Hedgerows & Boundaries	Abundance of lowland farmland bird species (indicator)	++	
		Abundance of Arable species (guild)	++	
		Priority Bird Abundance	=	++
		Granivorous eating bird species abundance	+	=
		Invertebrate-eating bird species abundance	++	++
		Vertebrate-eating bird species abundance	++	++

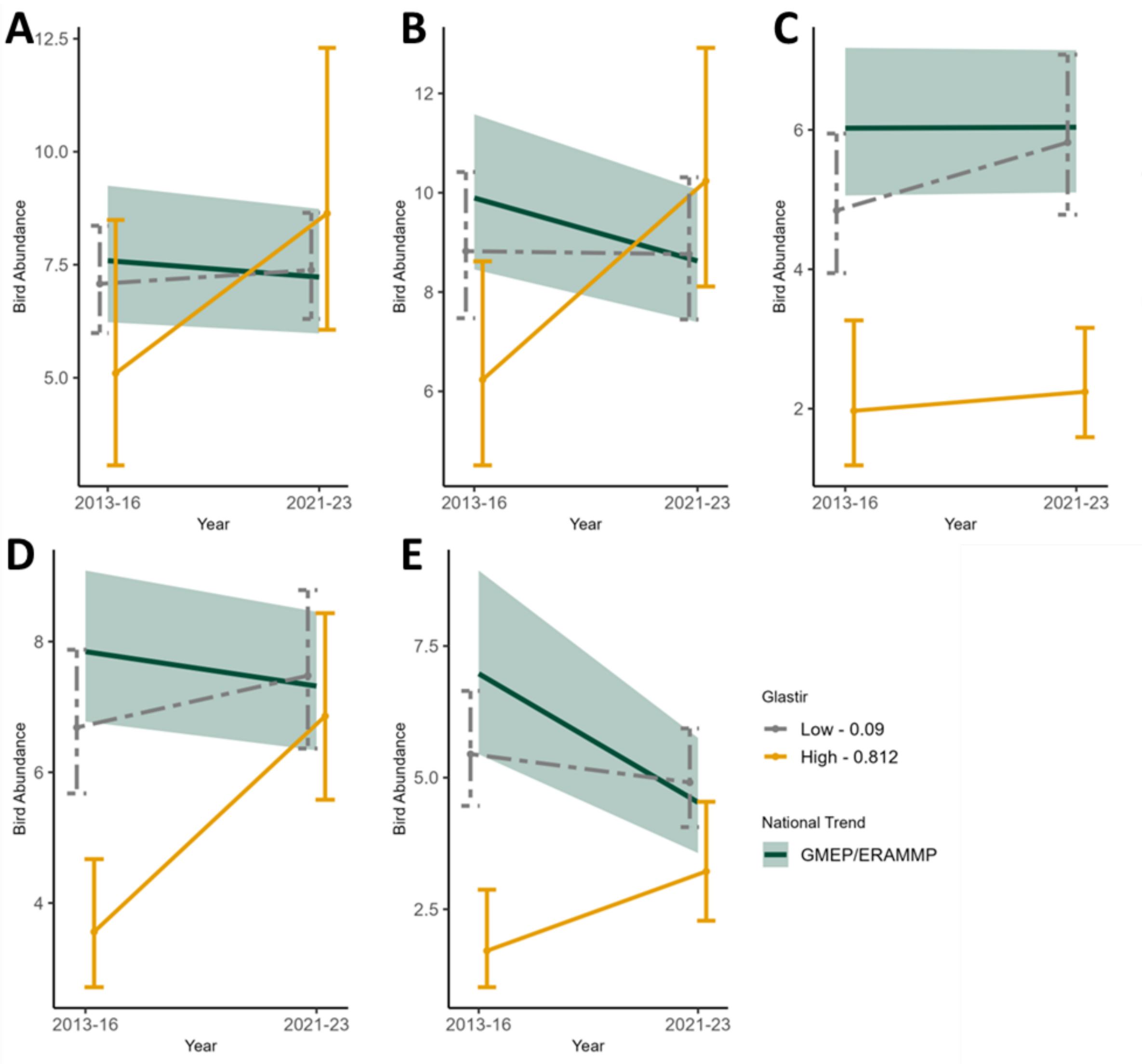

Figure 1-53 Trend in A) Lowland farmland bird indicator and B) Arable bird guild abundance species between 2013-16 and 2021-23 in Hedgerows and Boundaries showing both national trends and effect of uptake of Hedge Management is low (0.1) or high (0.9). Trend in C) Priority bird species, D) Insect-eating guilds and E) vertebrate-eating guild species between 2013-16 and 2021-23 in Hedgerows and Boundaries showing both national trends and effect of uptake of corridors and buffers is low or high in proportion to specific bundle coverage maximums. Other effects not shown were small or non-significant and their plots can be found in the ERAMMP Technical Annex-105TA1S6: Wales National Trends and Glastir Evaluation. Supplement-6: Birds.

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ERAMMP Programme Office
UKCEH Bangor
Environment Centre Wales
Deiniol Road
Bangor, Gwynedd
LL57 2UW
+ 44 (0)1248 374500
erammp@ceh.ac.uk

www.erammp.cymru

www.erammp.wales