Environment and Rural Affairs Monitoring & Modelling Programme

ERAMMP Year 1 Report 20:
GMEP Outstanding Analysis Part 1 - Re-analysis of data for SoNaRR

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Version History

Version	Updated By	Date	Changes
0.1	PMO	30/4/19	Initial draft.
0.11	PMO	8/5/19	Mainly formatting edits – draft for SG
0.12-0.13	PMO	12/9/19	Minor formatting edits
0.14	PMO	27/9/19	Approved for publication
1.0	PMO	30/9/2019	As published

Contents

Abbreviations and some of the technical terms used in this report are expanded in the project glossary: https://erammp.wales/en/glossary (English) and https://erammp.cymru/geirfa (Welsh)

1 Introduction

The State of Natural Resources Report (SoNaRR) assesses the extent, condition and trends of natural resources and ecosystems in Wales. In it trends which affect the state of natural resources are identified as well as gaps in evidence. SoNaRR is the evidence base for preparing or revising the National Natural Resources Policy, and for Natural Resources Wales (NRW) when preparing Area Statements, which facilitate the implementation of the National Natural Resources Policy.

GMEP[1] data contributed to SoNaRR 2016 reporting, however, that report was compiled during the 2016 field season, so data from the 2016 field survey were not included. Previous GMEP reporting for Biodiversity and Soil outcomes (Emmett et al. 2017) was carried out using the Whole Farm Code habitat groups as requested by the GMEP Stakeholder Group; Arable, Improved land, Habitat land (excluding Improved land, Arable, Woodland, Freshwater) and Woodland.

To better support the next SoNaRR report due in 2020, it was agreed with NRW that data would be re-analysed using the likely reporting structure for ecosystems in SoNaRR; Mountain Moor and Heath, Semi-natural grasslands, Enclosed farmland and Woodland and to include the final year 2016 results which were not all ready in time for the final GMEP report.

[1] Glastir Monitoring and Evaluation Programme (GMEP): https://gmep.wales/

2 Approach

These results are based on the 'Wider Wales' survey of 150 1km squares sampled over a 4 year period between 2012 and 2016. The squares were chosen by randomly sampling within assigned land classes to provide a good representation of widespread broad habitats and the wider countryside. Habitat type was recorded by field surveyors for each land parcel and vegetation plot. Previous analyses of outcome indicators (GMEP report) used habitat groups taken from the Whole Farm Code. This re-analysis uses ecosystems from SoNaRR reporting;

- Mountain, moor and heath (MMH); comprising Fen, Marsh & Swamp, Dwarf Shrub Heath, Montane, Inland Rock, Bog and Bracken
- Enclosed farmland; consists of
    i. Improved grassland; includes vegetation mapped as Improved grassland, as well as Neutral grassland with >25% improved grassland indicators (*Lolium perenne*, *L. multiflorum* and *Trifolium repens*).
    ii. Arable; vegetation mapped as arable & horticulture.
    iii. The category Improved land has also been used which combines improved grassland and arable habitats.
- Semi-natural grassland; Acid grassland, Neutral grassland (where improved grassland indicators are <25% cover) and Calcareous grassland.
- Woodland; Broadleaved, mixed and yew woodland, with Coniferous woodland included for soils analyses.

Broad Habitat	**GMEP Final Report**	**SoNaRR**
Arable & Horticultural	Improved land	Enclosed farmland
Improved Grassland	Improved land	Enclosed farmland
Neutral grassland (>25% *Lolium + Trifolium repens* cover)	Improved land	Enclosed farmland
Neutral grassland (<25% *Lolium + Trifolium repens* cover)	Habitat	Semi-natural grassland
Calcareous grassland	Habitat	Semi-natural grassland
Acid grassland	Habitat	Semi-natural grassland
Dwarf shrub heath	Habitat	Mountain, moor & heath
Bog	Habitat	Mountain, moor & heath
Bracken	Habitat	Mountain, moor & heath
Fen, marsh & swamp	Habitat	Mountain, moor & heath
Montane	Habitat	Mountain, moor & heath
Inland rock	Habitat	Mountain, moor & heath
Broadleaved, mixed & yew woodland	Woodland	Woodland
Coniferous woodland	Woodland (excluding biodiversity analysis)	Woodland (excluding biodiversity analysis)

2.1 Biodiversity

The high level Outcome Indicators for Biodiversity analysed here are:

- Species richness for plants in the wider countryside (calculated as vascular plant species richness per 4m^2 plot)
- Habitat condition; as indicated by Common Standards Monitoring plant indicators for any of the habitats listed in the JNCC guidance notes[2] in improved grassland, semi-natural grassland, and mountain, moor and heath. For arable habitats the number of annual forbs has been used and for woodlands the number of Ancient Woodland Indicators per 4m^2 plot. Estimates are derived from random plots ("X plots") as well as stratified random plots from unenclosed habitats ("U plots") and plots targeted to priority habitats ("Y plots").

2.2 Soils

Soil properties measured are related to soil and ecosystem function and are important for determining the soil resilience and the impact any environmental or Glastir changes may have on broad habitats and biodiversity. All soil properties selected are indicators which were proposed and tested by the UK Soil Indicators Consortium for specific functions, including environmental interactions which include hydrological filtering by soils, habitat support and carbon gas exchanges with the atmosphere.

Soil indicators are;

- Carbon (g/kg, from LOI): topsoil condition for carbon
- pH: acidity
- N (g/100g dry soil): nutrient levels -nitrogen
- Phosphorus (Olsen P mg/ kg): nutrient levels - available phosphorus
- Soil biota (Total invert catch): soil mesofauna numbers

[2] http://jncc.defra.gov.uk/page-2199

3 Results

3.1 Biodiversity

The results of the re-analysis can be seen in the Table GMEP-BD-Outcome-A4 and Figures GMEP-BD-Outcome-A4 and GMEP-BD-Outcome-B4.

3.1.1 Positive outcomes

- Condition of land (as measured by plant indicators indicative of good condition) has improved in the latest period for mountain, moor and heath and woodland after having remained stable over the long term.
- Condition of semi-natural grassland has improved recently and longer term.
- No change in the condition of arable habitats or improved grassland.
- Plant species richness has increased in improved grassland, semi-natural grassland and MMH in the recent period and remained stable in woodland.
- For semi-natural grassland the recent increase in plant species richness has built on a longer term trend.
- There has been no change in species richness of arable habitats.

Table GMEP-BD-Outcome-A4: Trends for Habitat condition and species richness. Habitat quality is calculated from the presence of high quality habitat indicators.

Significant differences over the data series and the latest period are indicated by: + significant increases; - significant decreases; = no change;

Habitat Groups	Indicator	Countryside Survey[1]			GMEP	Significant differences	
		1990	1998	2007	2013-16	Overall	Latest period
Arable	Habitat condition[2]	2	2.7	1.7	2.1	=	=
	Plant species richness[3]	6.85	8.75	4.95	7.61	=	=
Improved[4] Grassland	Habitat condition[5]	1.97	1.95	1.76	2.55	=	+
	Plant species richness[3]	9.8	10.8	9.3	11.97	+	+
Improved Land (combined Improved Grass and Arable)	Habitat condition[5]	2.16	2.19	1.88	2.04	=	=
	Plant species richness[3]	9.91	10.83	9.10	10.69	=	+
Semi-natural Grassland[6]	Habitat condition[5]	4.12	4.91	4.61	5.35	+	+

Habitat Groups	Indicator	Countryside Survey[1]			GMEP	Significant differences	
		1990	1998	2007	2013-16	Overall	Latest period
	Plant species richness[3]	10.10	10.92	10.36	11.52	+	+
Mountain, Moor & Heath[7]	Habitat condition[5]	5.01	4.90	4.56	5.20	=	+
	Plant species richness[3]	10.02	8.69	8.26	10.20	=	+
Woodland[8]	Habitat condition[9]	1.74	1.72	1.59	2.16	=	+
	Plant species richness[3]	9.92	9.91	9.07	9.67	=	+

[1] As estimates are obtained via a model-based approach with a correlation structure to account for repeated measures, there is the possibility that estimates change at each reporting occasion as the correlation structure is re-estimated. The change in estimated correlation structure affects the estimated parameters in the model and hence yearly estimates. See Scott, W. A. 2008 for further details.

[2] Number of annual forbs per $4m^2$ in arable fields.

[3] Vascular plant species richness per $4m^2$ plot.

[4] Improved grassland includes vegetation mapped as Improved grassland and vegetation mapped as Neutral grassland with >=25% summed cover of *Lolium perenne*, *L. multiflorum* and *Trifolium repens*.

[5] Number of Common Standards Monitoring (CSM) indicators per $4m^2$ plot for any of the habitats listed in the JNCC guidance notes (REF). Estimates are derived from random plots ("X plots") as well as stratified random plots from unenclosed habitats ("U plots").

[6] Semi-natural grassland is defined as all remaining Neutral grassland as well as vegetation mapped as Acid grassland.

[7]Mountain, moor & heath is defined as vegetation mapped as Fen, Marsh & Swamp, Dwarf Shrub Heath, Montane, Inland Rock, Bog or Bracken.

[8]Woodland is defined as vegetation mapped as Broadleaved, mixed and yew woodland or Coniferous woodland.

[9] Number of Ancient Woodland Indicators per $4m^2$ plot. Estimates are derived from random plots ("X plots") as well as plots targeted to priority habitats ("Y plots").

Figure GMEP-BD-Outcome-A4: Trends in high quality plant habitat indicators (positive Common Standards Monitoring (CSM) species) in semi-natural grassland, mountain, moor and heath, improved land (arable and Improved grassland combined) and woodland. Indicators were compiled by the Botanical Society of Britain and Ireland in 2013 based on published CSM guidance notes.

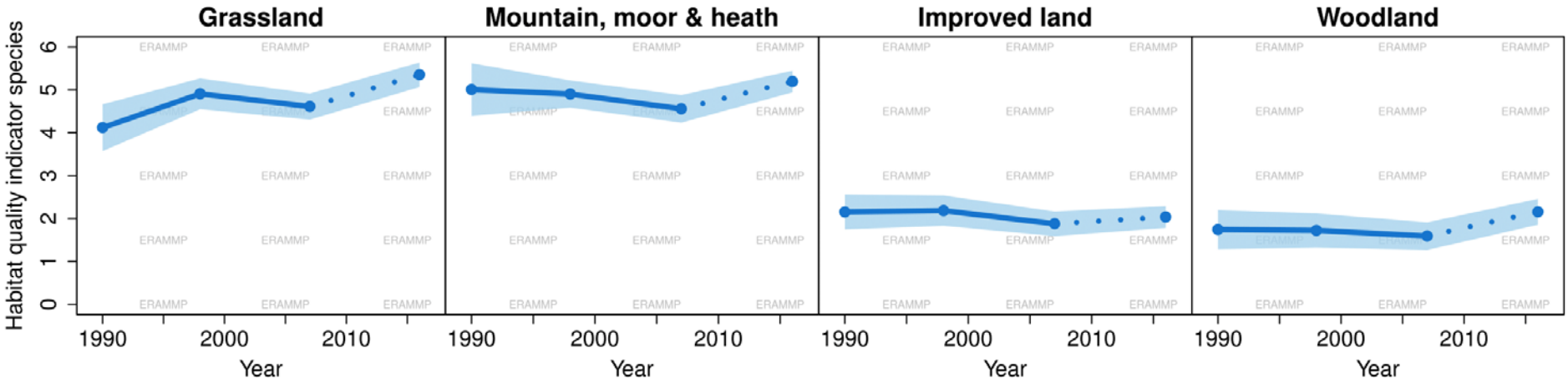
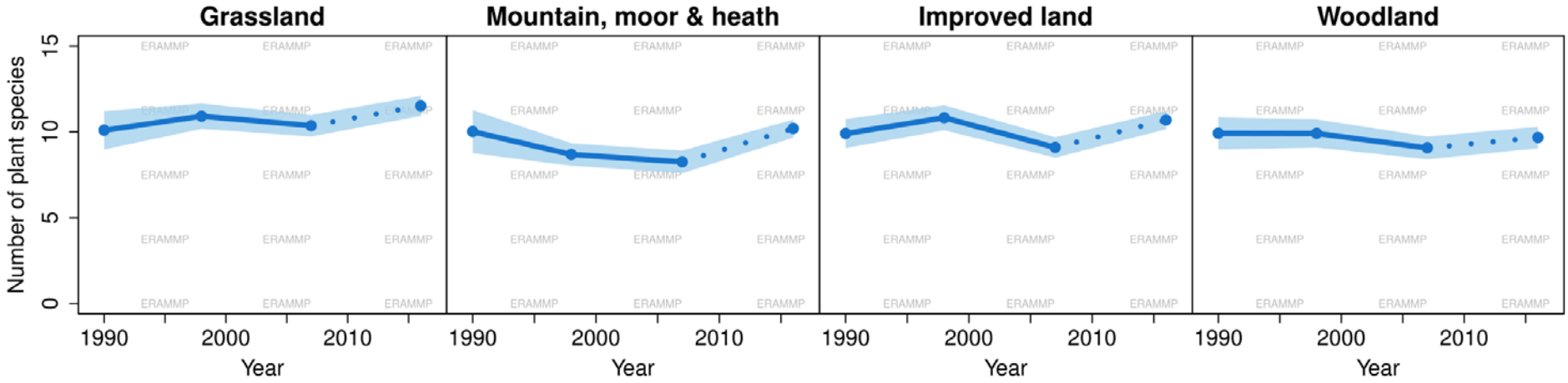


Figure GMEP-BD-OUTCOME-B4: Trends in Biodiversity. The total number of plant species observed in 4m^2 plots located in semi-natural grassland, mountain, moor and heath, improved land (arable and improved grassland combined) and woodland.



3.2 Soils

The results of the re-analysis can be seen in the Table GMEP-S-Outcome-A4 and Figure GMEP-S-Outcome-A4.

3.2.1 Positive outcomes

- Acidity of topsoil has improved (i.e. decreased) in all soils over the last three decades with the most likely reason being the large reductions since their peak in the 1970's of acidifying pollutants which have been emitted and deposited all across the UK.
- Topsoil carbon in woodland has increased (NB although this trend could be seen in the previous GMEP analysis it was not statistically significant. The change here could be because misallocations of a small number of plots to woodland were corrected, but this has not been tested).
- Topsoil carbon has remained stable in improved land and semi-natural grasslands for 30 years.
- After recent declines in soil phosphorus, levels in improved land are stable and within the zone appropriate for sustainable production whilst presenting a lower risk to waters.
- Nitrogen levels have decreased in Mountain, Moor and Heath which should benefit native plant species. Reasons for the decline are unclear but could relate to a decline in nitrogen deposition.
- There is no consistent pattern in soil mesofauna numbers. Values are now back to those observed in 1998 (for most habitats MMH values are lower). Further work is needed to understand inter-annual variation together with an analysis of the species present.

3.2.2 Areas of concern or a need for further action

- A recent increase in the acidity of topsoil in improved land has been observed. This may be due to the long standing decline in lime use combined with continued fertiliser use. However, on average soil pH remains above recommended levels for sustained production in improved land.
- A recent increase in acidity has been observed in woodland after years of declining acidity despite continued lower levels of acidic deposition. More active management and harvesting could be accelerating base cation removal from the soil which contributes to soil acidification.
- There has been significant decline in soil carbon in MMH over the last 10 years (see ERAMPP report on soil Carbon). This could be related to a reduction in *Ericoidaceae* (mostly heather).

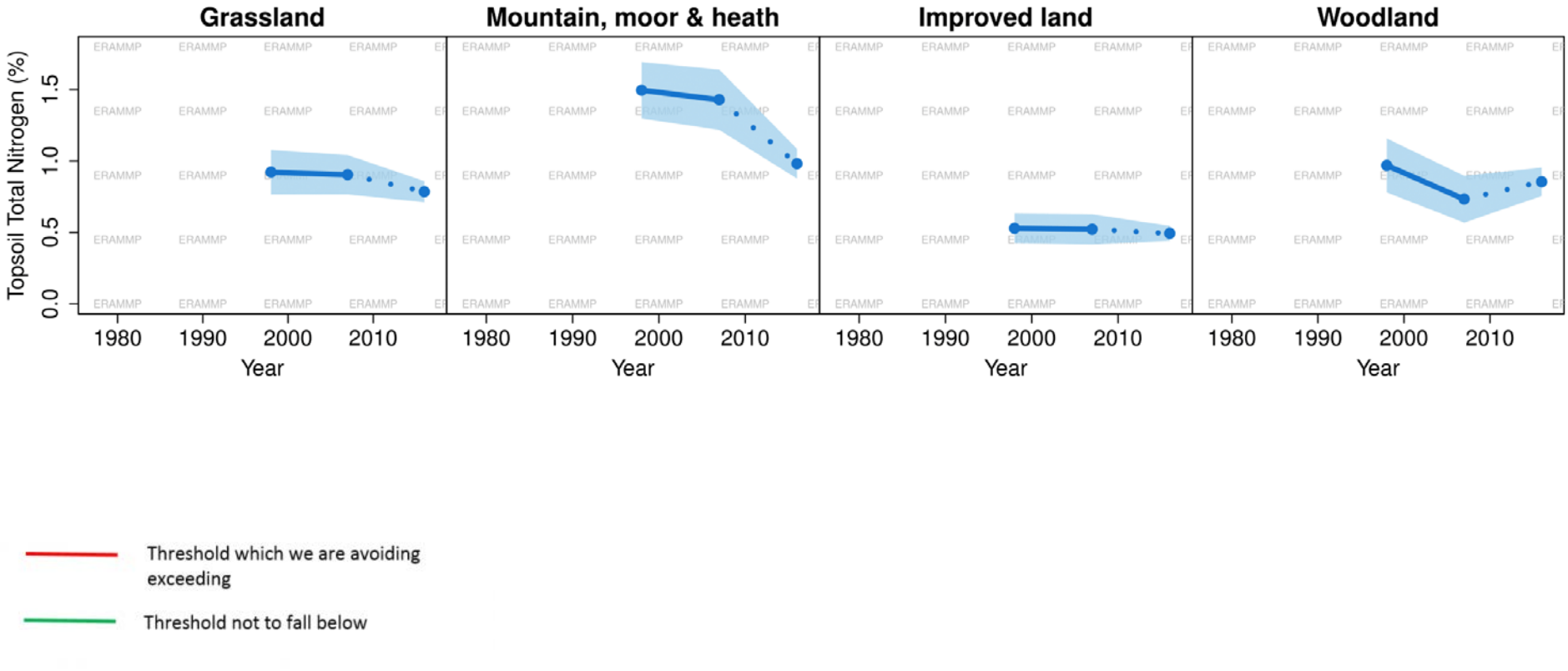
Table-GMEP-S-OUTCOME-A-4: Long term trends in topsoil (0-15cm)

Habitat Groups	Indicator	Countryside Survey[1]			GMEP	Significant differences	
		1978	1998	2007	2013-16	Overall	Latest period
Improved Land (Improved grassland and arable)	Carbon (g/kg, from LOI)	65.54	62.44	54.83	61.28	=	=
	pH	5.35	5.74	5.99	5.77	+	-
	N (g/100g dry soil)		0.53	0.52	0.49	=	=
	Phosphorus (Olsen P mg/ kg)		41.49	23.54	23.47	-	=
	Soil biota (Total invert catch)		38.09	50.92	35.24	=	-
Semi-natural grassland	Carbon (g/kg, from LOI)	134.67	131.63	140.99	124.29	=	=
	pH	4.68	5.23	5.20	5.22	+	=
	N (g/100g dry soil)		0.92	0.90	0.79	=	=
	Phosphorus (Olsen P mg/ kg)		17.38	23.73	15.86	=	=
	Soil biota (Total invert catch)		40.57	74.18	48.22	=	-
Mountain, moor & heath	Carbon (g/kg, from LOI)	215.10	227.70	238.74	203.69	=	-
	pH	4.14	4.81	4.65	4.82	+	=
	N (g/100g dry soil)		1.50	1.43	0.98	-	-
	Phosphorus (Olsen P mg/ kg)		10.37	11.70	17.66	=	=

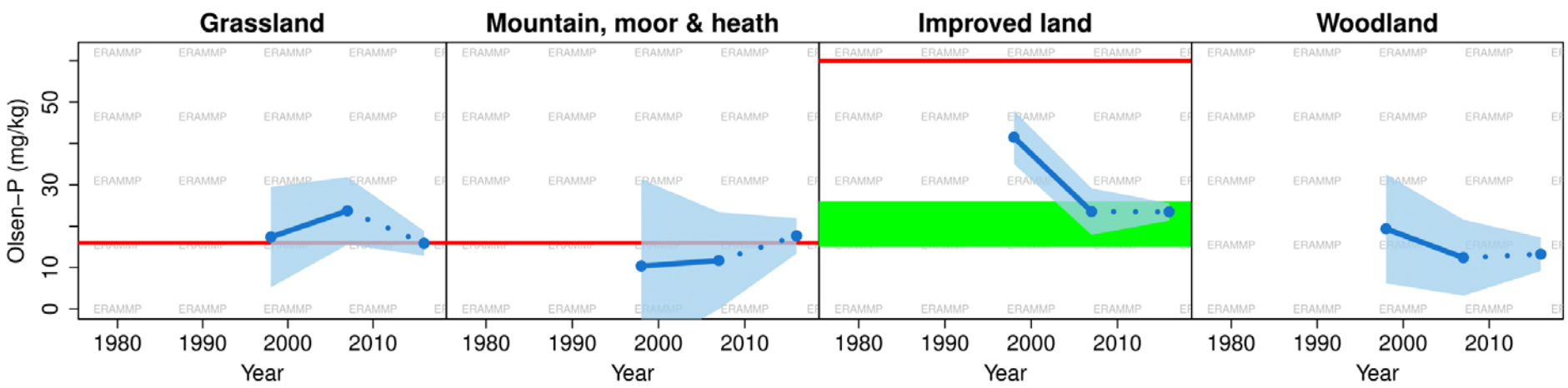
Habitat Groups	Indicator	Countryside Survey[1]			GMEP	Significant differences	
		1978	1998	2007	2013-16	Overall	Latest period
	Soil biota (Total invert catch)		83.64	136.09	42.73	+	-
Woodland	Carbon (g/kg, from LOI)	132.07	148.56	144.99	169.72	+	+
	pH	4.10	4.55	4.85	4.67	+	-
	N (g/100g dry soil)		0.97	0.73	0.85	=	=
	Phosphorus (Olsen P mg/ kg)		19.37	12.40	13.25	=	=
	Soil biota (Total invert catch)		87.24	117.81	64.38	=	-

FIGURE-GMEP-S-OUTCOME-A-4: Long term trends in topsoil (0-15cm) condition for a.) nutrient levels- nitrogen b.) nutrient levels- Phosphorus c.) acidity d.) topsoil condition for Carbon and e.) soil mesofauna numbers.

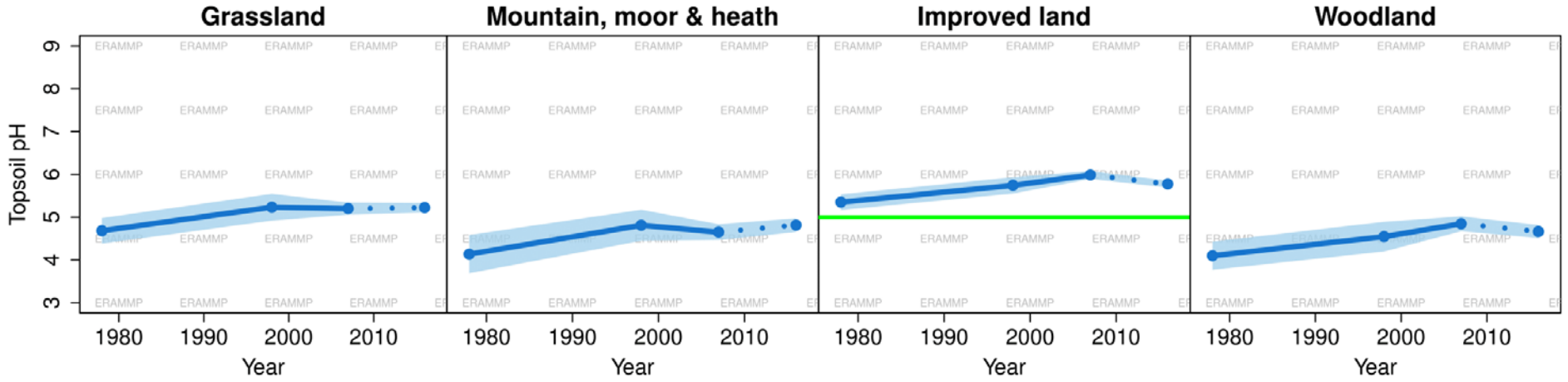
a.)



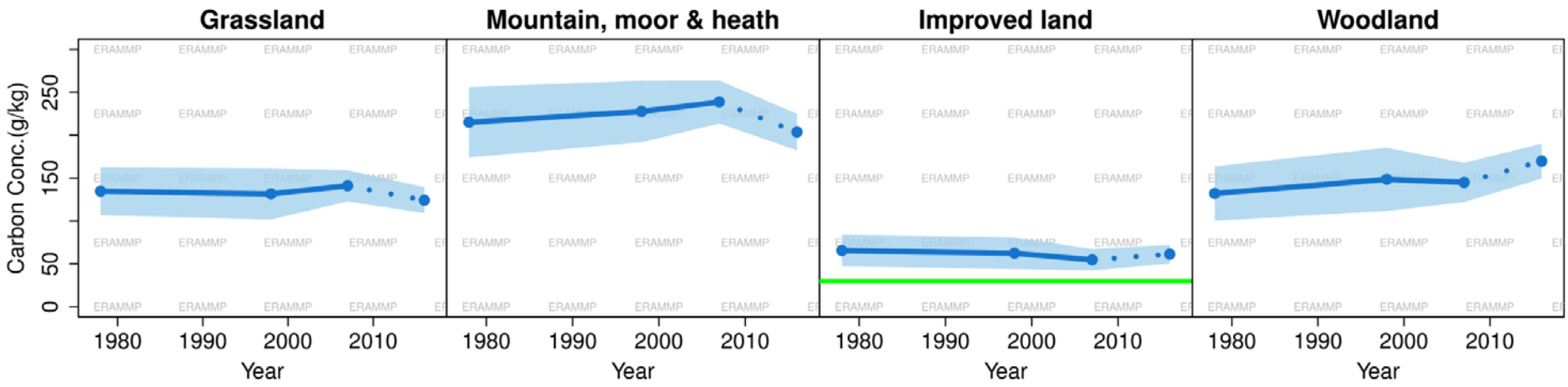
b.)


Grassland
Mountain, moor & heath
Improved land
Woodland
Olsen–P (mg/kg)
0
10
30
50
1980
1990
2000
2010
Year
ERAMMP

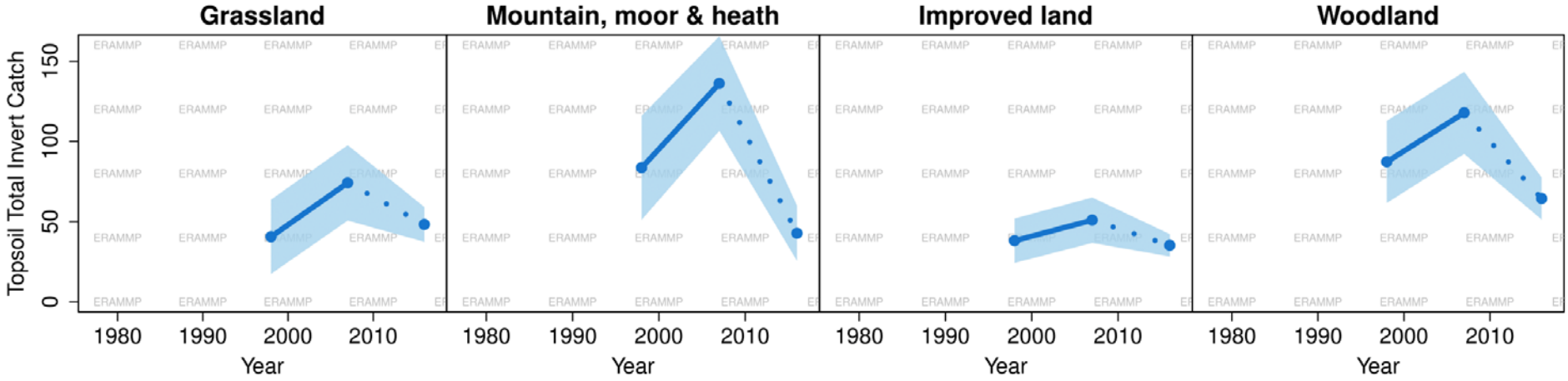
c.)


Grassland
Mountain, moor & heath
Improved land
Woodland
Topsoil pH
3
4
5
6
7
8
9
1980
1990
2000
2010
Year
ERAMMP

d.)


Grassland
Mountain, moor & heath
Improved land
Woodland
Carbon Conc.(g/kg)
0
50
150
250
1980
1990
2000
2010
Year

e.)


Grassland
Mountain, moor & heath
Improved land
Woodland
Topsoil Total Invert Catch
0
50
100
150
1980
1990
2000
2010
Year

4 Conclusions and recommendations

This report presents new results for biodiversity and soil outcomes for Mountain, Moor and Heath and Semi-natural grassland (which were previously reported as Habitat land) as well as results for improved land and woodland that were reported previously but have been re-analysed.

The results for biodiversity (plant species richness and habitat condition) have changed slightly, although MMH trends remain the same as Habitat land, positive trends in semi-natural grassland emerge in the long term trend. A positive response for recent change in woodland condition was not significant previously, although there was a non-significant trend. Some additional woodland Y plots that had been erroneously excluded were included in this re-analysis.

The soils results are also similar to the previous results. Acidity in most ecosystems has decreased over 30 years except for recent increases on improved land. The reduction in soil carbon observed previously in habitat land, and explored in more detail in Alison et al. (2019), can be observed here in MMH. This could be related to a reduction in *Ericoideae*, especially heather *Calluna vulgaris*. Soil carbon in semi-natural grassland has remained stable over the short and long term. When semi-natural grassland is disaggregated into acid and neutral grassland, there is a decline in soil carbon in acid grassland. Within the aggregated semi-natural grassland category, acid grassland declines may have been cancelled out by the stability of neutral grassland (see Alison et al., 2019).

The interpretation of these outcomes need to be further discussed with NRW and CEH scientists and other organisations to ensure a more collective assessment of the many sources of evidence is achieved in SoNaRR.

Many more results from GMEP, including figures and graphs for ecosystem extent, habitat diversity, hedgerows, birds, pollinators and freshwater can be found in Emmett et al. 2017. These were already well matched to the reporting categories likely for SoNaRR.

5 References

Alison, J., Emmett, B.A., Robinson, D.A., Smart, S.M. & Thomas, A. (2019) Environment and Rural Affairs Monitoring & Modelling Programme (ERAMMP) – *ERAMMP Year 1 Report 21: GMEP Outstanding Analysis Part 2 – Revisiting Trends in Topsoil Carbon from CS2007 to GMEP 2013-2016.* Report to Welsh Government (Contract C210/2016/2017). Centre for Ecology & Hydrology Project NEC06297.

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Scott, W. A. 2008 CS Technical Report No. *4*/07: Statistical Report. NERC/Centre for Ecology & Hydrology, (CEH Project Number: C03259).

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