Environment and Rural Affairs Monitoring & Modelling Programme

ERAMMP Year 1 Report 11: Year 1 Summary

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Version	Updated By	Date	Changes
1.0	PMO	30/9/2019	As published
1.1	CB	23/10/2019	Corrected 2 author names/initials
1.2	BJC	24/04/2020	2.1 Quick Start a. Figures were reformatted where necessary to improve legibility of labels and legends, and font size of figure legends was increased and standardised. Information content was not changed. b. Tables were reformatted where necessary for uniformity of font size, bolding and shading, and font size of table legends was standardised. Information content was not changed.

Contents

1 Introduction

The Welsh environment underpins the agriculture, fisheries, tourism and forestry sectors, and is of importance to other policy areas including health and well-being, energy and infrastructure. In order to develop policies that build social, economic and environmental resilience and to evaluate programme implementation Welsh Government are investing £3.6 million over 3 years in the Environment & Rural Affairs Monitoring and Modelling Programme (ERAMMP). The programme benefits from significant aligned funding, £1.3million from the lead organisation the Centre for Ecology & Hydrology.

ERAMMP is delivering a programme of environmental monitoring and modelling; it collects and assimilates data, undertakes analysis and modelling and supplies policy teams, NRW and stakeholders with targeted evidence. It also delivers a strategic function, helping Welsh Government to understand long term drivers, climate change for example, and impacts of change on the resilience of the environment, the benefits and public goods provided by our environment and broader social and economic impacts.

ERAMMP is a collaborative venture and involves a large consortium of partners (Figure 1.1). It draws upon and makes best use of existing and ongoing data, monitoring and modelling from across Wales and wider UK.

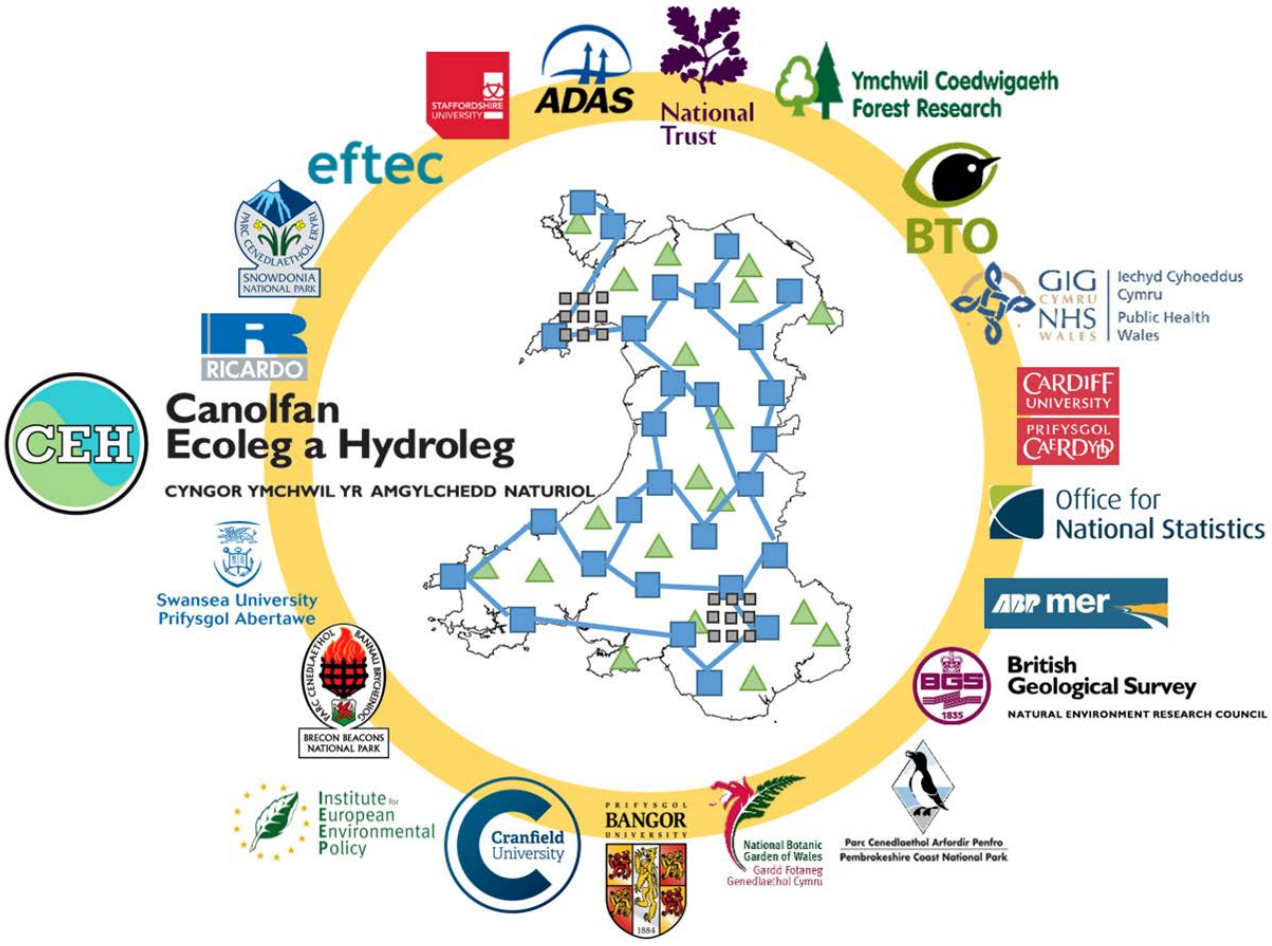

Figure 1.1 The ERAMMP Consortium

The strategic nature of ERAMMP enables it to provide valuable evidence across a number of policy portfolios. The immediate priorities for ERAMMP are to; inform Brexit planning and the design of the CAP replacement programmes and contribute to the second iteration of NRW's State of Natural Resources Report.

This overview report brings together the highlights from a number of activities required as part of Year 1 within the original contract and some additional work commissioned as opportunities and priorities emerged during the year. A series of sub-reports are available with the details of the individual activities. Many of these activities have been collaborative between a number of ERAMMP partners, Welsh Government and NRW.

In brief, the ERAMMP Year 1 activities and sub-reports fall under three categories of activities: Modelling; Monitoring and Analysis. Specific tasks in each are:

Modelling

1. Quick Start: Undertake early sight (Quick Start - QS) modelling activities to explore the environmental and socio economic impact of the EU exit process, futures based on broad scenarios. Undertake ad hoc simulations to inform policy response and design in the context of the Natural Resources Policy.

2. Integrated Modelling Platform: Develop a modular based integrated modelling platform (IMP) for longer term needs for use internally within Welsh Government and by wider stakeholders.

Monitoring

3. ERAMMP national monitoring programme: Develop a responsive component and test and new approaches which makes best use of and integrated current methods with new technologies and innovations.

4. NRW Monitoring Review: Assess the potential for greater joint working between ERAMMP and NRW to avoid duplication and identify new opportunities.

5. Woodland Monitoring Review: Work with the wider community to understand current activities and identify the priorities for woodland monitoring in the ERAMMP Field Survey to avoid duplication and ensure evidence needs are captured.

6. Soil erosion monitoring methods: Explore opportunities for new technologies which could be used for capturing evidence on the extent of soil erosion.

7. Land–sea interface monitoring review: Working with NRW, WG marine policy and stakeholders review monitoring activity at the land - sea interface identifying opportunities to better align monitoring activities and improve understanding of pathways and impact.

Data and Analysis

8. Outstanding analysis of GMEP data: Agree with the ERAMMP steering group a series of outstanding analysis of the GMEP data. A key component of this is to ensure data is in a format useful for the next SoNaRR report due 2021.

9. Local Records Centre potential (*Additional activity*): Review the contribution of species records held by the Local Environmental Record Centres to support evidence needs.

10. Well Being of Future Generations; Biodiversity Indicator No. 44 (*Additional activity*): Explore the potential use of unstructured biodiversity data of both threatened and more widespread species which may be more widely experienced by people and which play an important role in delivery of ecosystem services.

11. Develop Natural Capital Accounts for Welsh Woodland, Farmland and Freshwater Habitats *(Additional activity)*: Explore new opportunities for using specific Wales data.

Two activities were put on hold at the request of WG:

12. Farm Practice Survey: A repeat of the survey to inform the design and evaluation of RDP programmes including Glastir and Farming Connect, inform the EU exit process analysis and the agricultural sector climate change mitigation action plan.

13. Pilot for carbon foot printing: Build upon the recommendations of the Climate Smart Agriculture project and, learning lessons from elsewhere, undertake a pilot for carbon foot printing.

2 Modelling

Cosby, B.J.[1], Thomas, A.[1], Emmett, B.A.[1], Anthony, S.[2], Bell, C.[1], Carnell, E.[1], Dickie, I.[3], Fitch, A.[1], Gooday, R.[2], Kettel, E.[6], Jones, M.L.[1], Matthews, R.[4], Petr, M.[4], Siriwardena, G.[6], Steadman, C.[1], Thomas, D.[5], Williams, B.[1] and Vieno, M.[1]

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2.1 Quick Start

The Quick Start modelling work has been a challenging piece of work, which had an extremely tight deadline for delivery, and relied on close collaboration both within the ERAMMP modelling team, and between the ERAMMP team, WG staff and the Evidence and Scenarios Roundtable Sub-Working Group of the Brexit Roundtable. We would like to express our thanks to WG staff and Sub-working group for their contribution without which this report would not have been possible.

2.1.1 Brexit scenarios

With respect to the Brexit scenarios work, the outputs highlight the highly variable magnitude of the potential risks and benefits which may arise from the different Brexit trade scenarios with respect to environmental outcomes. The application of the models, albeit with many brave assumptions, also highlight the spatially variable nature of these potential outcomes. This information may be used to both indicate where the regulatory floor may need enhancing and / or transition schemes put in place to support communities heavily reliant on the agricultural livestock sector.

Some key findings include:

- Potential change in animal numbers are between -36% (sheep sector; No Deal and MFTA) and +54% (Dairy; No Deal). The sheep sector is more negatively affected due to reliance on exports relative to the dairy and beef sectors.
- Total area potentially affected by the Brexit trade scenarios is 3 to 17% of current farmland depending on the scenario.
- Total area potentially changing to non-agricultural uses is 2 to 15% of current farmland depending on the trade scenario (with the sheep sector comprising 65 to 100% of this land). For the MFTA scenario, potential changes for all three livestock sectors is to non-agricultural use.
- The distribution of land area changed is highly spatially variable depending on current distribution of farming sectors, quality of land selected (depending on change either best or worst land selected first) and also proximity to farms within the new sector (Figure 2.1.1.1). The results have been disaggregated by region to further illustrate this spatial variability.
- The area with potential to change to non-agricultural use may not all be available for new woodland planting due to current constraints and sensitivities included in the Glastir Woodland Creation Rules (GWC-Wales, 2018).
- Environmental outcomes of the trade scenarios have been explored in terms of magnitude (e.g. Figure 2.1.1.2) and spatial distribution (e.g. Figure 2.1.1.3) across Wales for greenhouse gas (GHG) emissions, water quality, air quality, bird abundance and diversity. The results emphasis the improvement in environmental outcomes for some regions but a risk of degradation in others.
- Potential change in farm jobs was also explored (e.g. Figure 2.1.1.4).

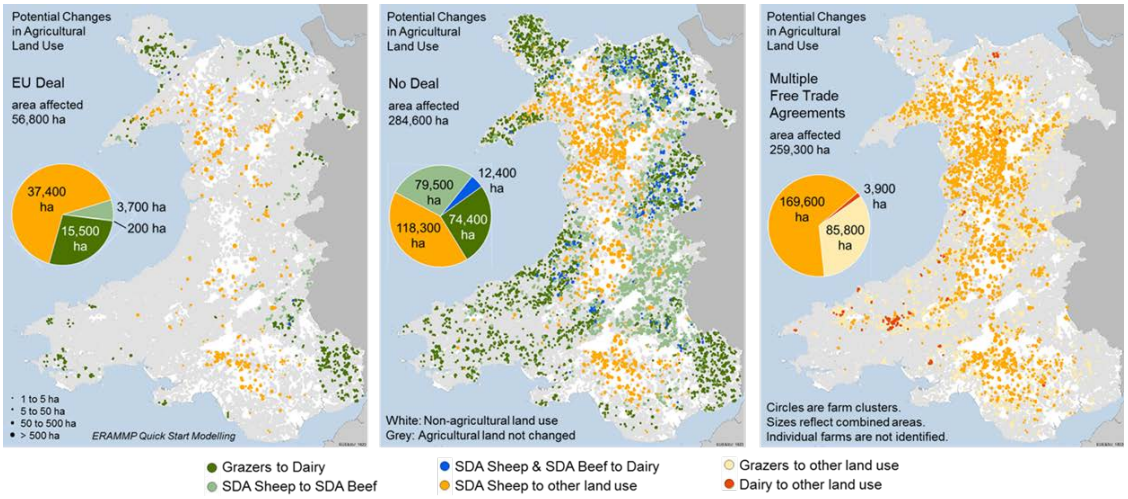

Figure 2.1.1.1. Potential agricultural land use change for the three Brexit trade scenarios. Farms that have potential for land conversion and are geographically close to each other have been combined into circles proportional to their combined area, such that individual farms cannot be identified. Grey areas are included in the simulation.

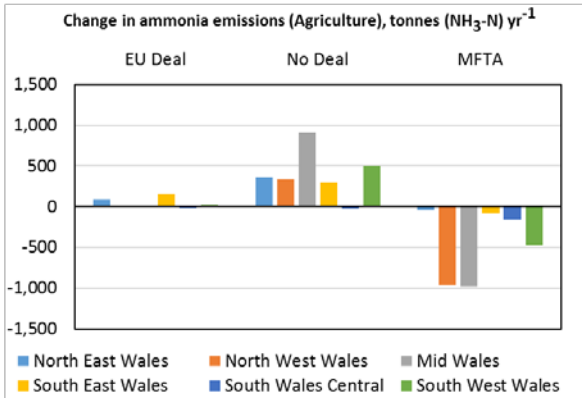

Figure 2.1.1.2. Potential change in ammonia emissions at a regional scale for the three Brexit trade scenarios

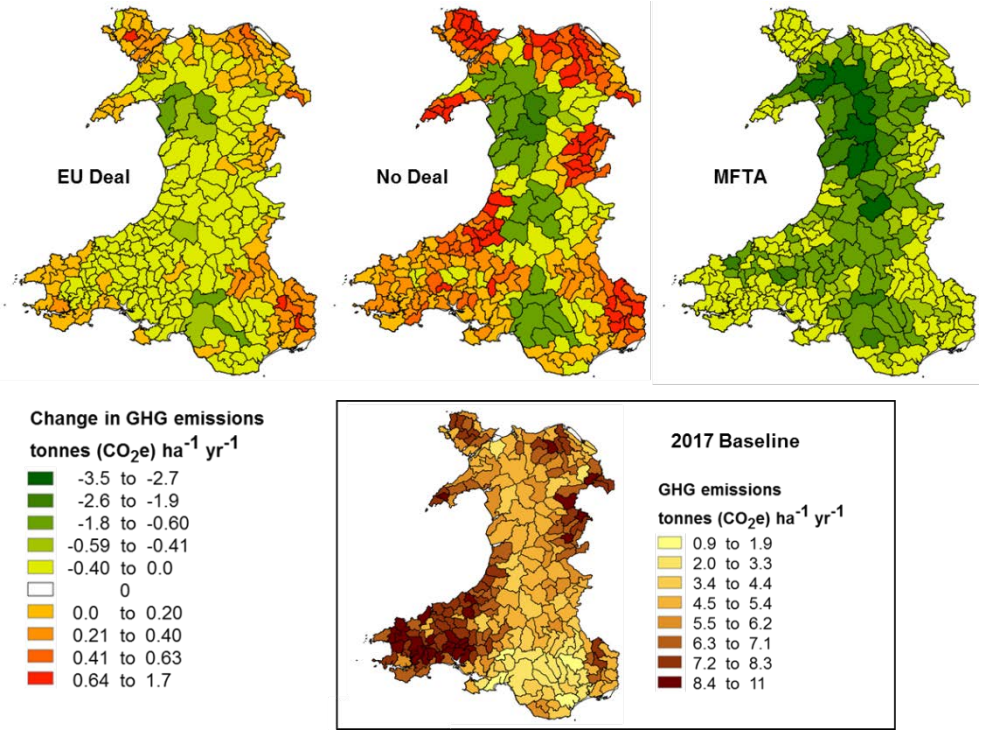

Figure 2.1.1.3 Spatial patterns of potential changes in agricultural GHG emissions across Wales for the Brexit trade scenarios. Changes are relative to 2017 baseline values (inset). Maps are based on Welsh Agricultural Small Areas containing 100 to 200 farms.

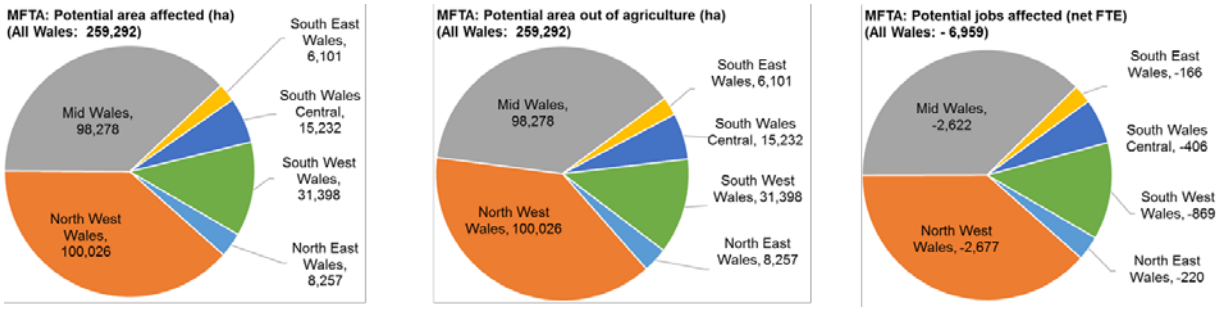

Figure 2.1.1.4 Potential area affected, potential are out of agriculture and number of farm jobs affected by region for the MFTA Brexit trade scenario.

2.1.2 Land management scenarios

For the land management scenario work, the outputs highlight a range of issues when applying monetary valuation of public goods. In summary, the work emphasises that the approach does not provide a 'solution' due to the partial nature of any valuation as methods are not available for all public goods. There are also many uncertainties and caveats which are described in the report relating to metrics, maps and assumptions which mean results can be mis-interpreted. Our advice is the approach can be used as a valuable contribution but should not limit the political and public debate. Furthermore, the variability in monetary values depend on location as illustrated by the contrasting results from the three test areas selected. These test areas were; the Conwy; Vale of Clwyd; and a set of South Wales valleys including the Heads of the Valleys (referred to as Heads of Valleys for brevity here and throughout Cosby et al. (2019) - ERAMMP Year 1 Report 12) (Figure 2.1.2.1).

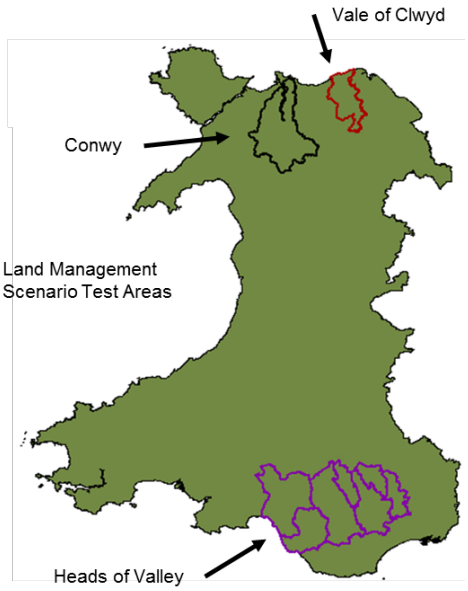

Figure 2.1.2.1. Location of test area for the land management scenarios

Between 1 and 87% of current farmland in the landscape study areas is potentially affected by the land management options depending on scenario and landscape study area. Key findings for each management option include:

- New woodland creation:
  - Climate mitigation benefits of new woodland are dominated by the reduction of GHG emissions due to removal of agriculture for planting trees (66 to 92% of total mitigation). Carbon sequestration in new woodland contributes the remaining mitigation benefit (8 to 34%).
  - Differences in woodland type and management affect carbon sequestration rates by a factor of 3.
  - Transfers of pollutants to water bodies are reduced by 7 to 50% depending on woodland scenario and landscape area. Similar reductions are estimated for agricultural ammonia emissions.
  - Additional peri-urban recreation land and GHG emissions reductions from agriculture are largest contributors to monetary value of new woodlands.

- Removal of agriculture from low quality land resulted in:
  - 45 to 83% increase in climate mitigation.
  - 44 to 88% reduction in pollutant loadings to water bodies.
  - 40 to 77% reduction in ammonia emissions.
- Removal of agriculture form peatlands resulted in:
  - 1 to 50% increase in climate mitigation.
  - 1 to 53% reduction in pollutant loadings to water bodies.
  - 1 to 46% reduction in ammonia emissions.

In terms of partial monetary value per hectare of land changed (partial because not all public goods were valued), the management scenarios had a range of outcomes depending on the test area. The ranges across the three study areas of additional partial annual values of public goods per hectare of land changed per year for each management scenario were:

- Removal of agriculture from peatland: £345 to £526.
- New woodland creation: £651 to £2,704.
- Removal of agriculture from low quality land: £384 to £5,150.

A combined scenario was developed which brought together all three management scenarios in a stepwise approach to allow monetary values to be added within each test area. The stepwise approach prevented double uses of changed land within individual management scenarios. The results again indicate there was a large range in the additional partial annual value of public goods delivered between the three test areas (Table 2.1.2.1) and in the relative contribution of different individual public goods to the total values in each test area (Figure 2.1.2.2).

Table 2.1.2.1 Additional partial annual monetary value of new public goods explored for each test area for the combined scenario; expressed as total value and total value as a rate of return per hectare of land changed.

Monetary value units	Conwy	Vale of Clwyd	Heads of Valley
Total annual value (£m yr^{-1})	17	5.5	47
Total annual value corrected for area changed (£ (ha changed)$^{-1}yr^{-1}$)	418	2,257	918

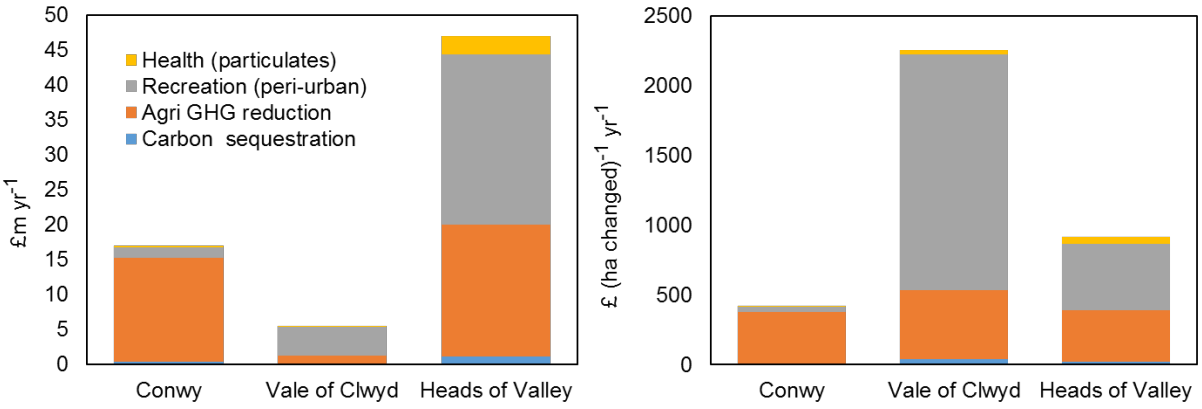

Figure 2.1.2.2 Additional partial annual monetary value of the combined scenario in each test area partitioned by individual public good valued. Left: total value (£m yr^{-1}). Right: standardised for area changed (£ (ha changed)$^{-1}$ yr^{-1}).

2.1.3 Assumptions and limitations

The large number of assumptions, limitations and uncertainties have been described in detail for transparency purposes and a language used throughout the report to emphasise the highly speculative nature of the work. Predicting the behaviour and decision making of any sector has many pitfalls, not least when no comparable situation has been experienced before.

2.1.4 Future plans and recommendations

Overall, despite these limitations the results provide a significant contribution to the debate concerning the trade-offs / risks and benefits we can all derive from either intended (management scenarios) or unintended (Brexit scenarios) changes in the way our land is managed. Some past perceptions of the contribution of different sectors and the spatial configuration of public goods in the Welsh landscape have perhaps been challenged through the work. We hope this report will contribute to an informed, collective discussion about how Wales can secure a more sustainable future for our primary production industries and natural resources going forward.

Recommendations include:

- Ensuring the limitations and assumptions for the work are always included in any presentations and future uses of the work;
- For WG to discuss with the ERAMMP team on the best use of the Quick Start approach versus the Integrated Modelling Platform (IMP) for any future scenario work required;
- To select from a list of possible options proposed as to additional environmental impacts and public goods which should be considered in any Quick Start work going forward.
- WG to ensure future work regarding the potential impact of new woodland defines the type of agriculture land it is replacing, location, woodland and management type as the environmental outcomes are as variable as when considering the impact of different agricultural livestock sectors. Quick Start work on substitution effects and the effect of improved management of current woodland should also be completed.
- Displacement or leakage of environmental impacts within Wales, UK and globally needs to be taken into account to ensure the Well Being of Future Generation Goals of e.g. ‘A Globally Responsible Wales’ in future work.

These recommendations will be reviewed by the Steering Group and other Stakeholders before a decision is made.

2.2 Integrated Modelling Platform

Dunford, R.[1], Harrison, P.[1], Alison, J.[1], Anthony, S.[2], Beauchamp, K.[5], Bell, C.[1], Brown, M.[1], Cooper, J.[1], Cosby, B.[1], Dickie, I.[4], Emmett, B.A.[1], Gooday, R.[2], Hollaway, M.[1], Holman, I.[3], Matthews, R.[5], Norris, D.[1], Petr, M.[5], Smart, S.M.[1], Sandars, D.[3], Thomas, A.[1], Trembath, P.[1], Van Oijen, M.[1], Vieno, M.[1], Watkins, J.[1], West, B.[1] & Williams, A.[3]

[1] CEH, [2] ADAS, [3] Cranfield University, [4] eftec, [5] Forest Research

The Integrated Modelling Platform (IMP) is a tool designed to explore and stress-test policy and management interventions for the land use and environment of Wales under a range of future Welsh economic and climatic futures. It comprises a chain of specialised, state-of-the-art models covering agriculture, forestry, land use allocation decisions, water, air, soils, biodiversity, ecosystem services and valuation. The platform takes an integrated approach, recognising that policy effects in one sector have indirect effects in other sectors. Thus, the platform explicitly accounts for biophysical and socio-economic interactions and feedbacks between sectors. Importantly, the platform has a modular structure such that individual models can be updated, changed and replaced if needed while maintaining overall function.

The primary aim of the IMP is to enable rapid assessment of natural resource policy options. User specified interventions (such as changes in agricultural subsidies) serve as inputs for the IMP, alongside various other environmental and socio-economic variables. Outputs from the platform can be used to assess environmental, agricultural and socio-economic impacts of policy options. The output variables selected will be aligned where possible to the WG public goods and sustainable land management outcomes of interest to the Welsh Government including:

- Air quality
- Public health
- Greenhouse gas balance
- Biodiversity
- High water quality
- Productivity
- Conservation of heritage
- Improvement of the natural landscape
- Social outcomes (e.g. public access, outdoor recreation).

Progress in Year 1 of ERAMMP has included the following:

Eight compatible, well-tested and policy-relevant models have been selected for inclusion in the IMP (Figure 2.2.1). Furthermore, the linkages between these models have been established Decisions have been reached about relevant spatial and temporal scales at which the IMP will provide outputs which provides both the transparency and fine scale required by Welsh Government and a coarser scale to ensure data protection for the public-facing interface.

Progress has also been made with regard to the user interface, which will allow the user to manipulate inputs and visualise outputs to prioritise and spatially target policy interventions. Initial “baseline” runs for current conditions have been completed by the core models and “data cubes” have been created from these outputs.

The modellers are in the process of running economic and climate change scenarios, and these outputs will be added to the data cubes. Work is underway to automate data passes between these data cubes to develop a prototype for internal testing by the modelling team.

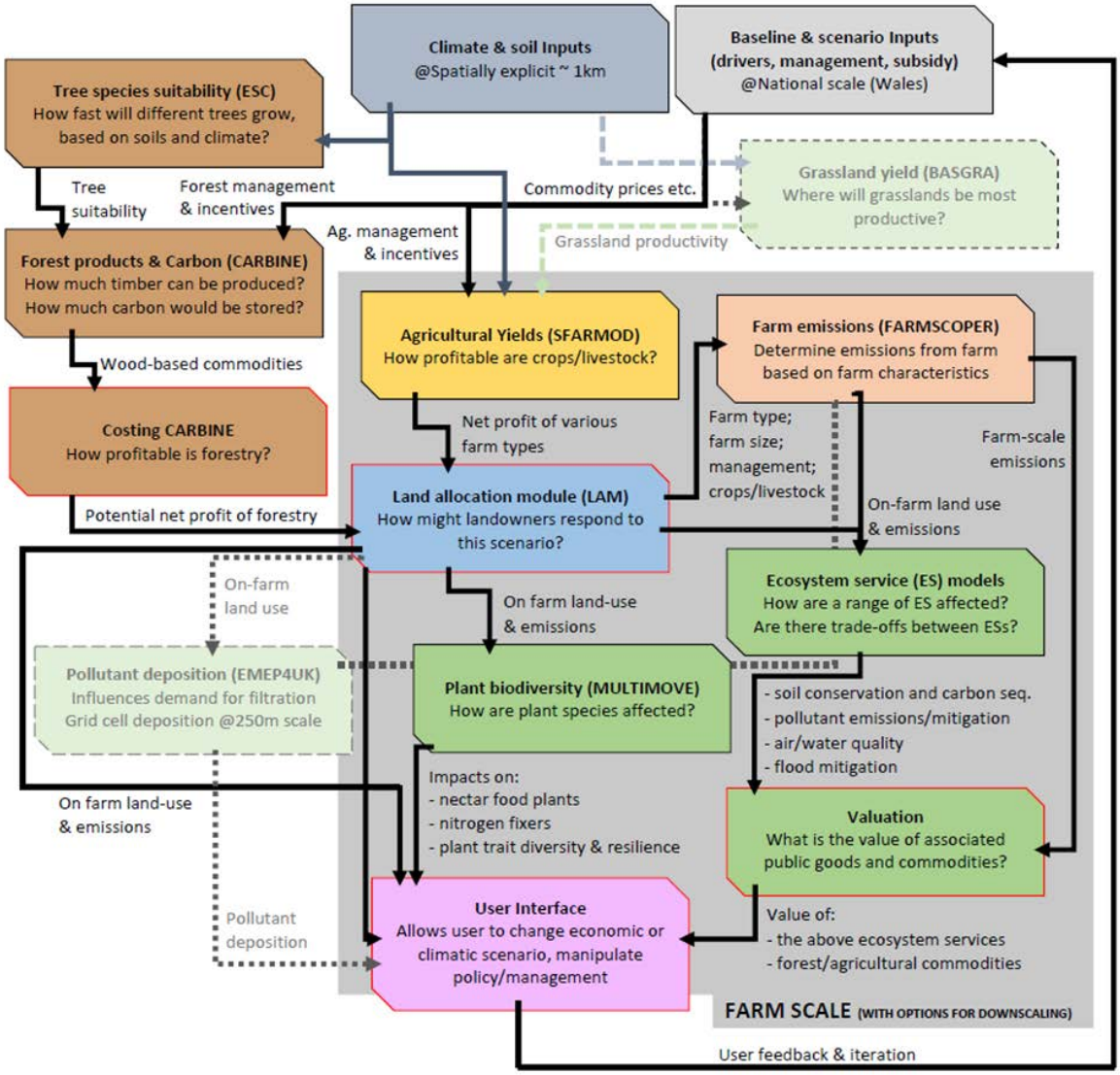

Figure 2.2.1. Simplified schematic displaying the component models of the Integrated Modelling Platform (IMP) and the links between them. Black-bordered boxes represent either inputs or component models (name shown in brackets where applicable). Red-bordered boxes represent intermediate stages in the IMP chain. Black arrows represent the flow of data, with floating text representing the types of data being passed between models. Faded boxes may not be included in the IMP's first year.

The prototype will contain a limited set of economic and climate scenarios and policy interventions, which demonstrate the functionality of the platform. Following this testing phase the prototype of the linked system will be demonstrated to the Welsh Government Strategic Evidence Group (SEG) on 17th July 2019.

Options for further elaboration of the model runs contained within the platform (i.e. the number of economic and climate scenarios and policy interventions represented) and functionality of platform will be presented at the SEG meeting to inform further development from the prototype to the full working version of the IMP.

Recommendations are that WG needs to fully engage during this design process to ensure the IMP is fit-for-purpose, expectations are managed and its potential fully realised.

3 Monitoring

3.1 ERAMMP responsive monitoring

3.1.1 Square selection

Alison, J.[1], Henrys, P.[1], Smart, S.M.[1], Siriwardena, G.[2] & Emmett, B.A.[1]
[1] CEH, [2] BTO

A reduction in the number of GMEP squares to be revisited in the ERAMMP field survey is required to meet budgetary constraints whilst ensuring the survey will deliver the most robust evidence base which is responsive to such issues as the actual uptake of different Glastir interventions by land owners and the capture of those within the baseline GMEP survey.

An approach was needed which would maximise outputs matched to policy priorities for assessing national trends, provide evidence for the outcomes of Glastir interventions and support policy priorities such as restoration of peatlands.

The target is to reduce survey squares from 300 to 240 1km squares.

Square selection took four main stages, reflecting four key selection criteria established in various meetings about ERAMMP field survey priorities. Note that some of discussed criteria could not be considered due to time and data restrictions. Key criteria were:

1. Capacity to represent stock and change across Wales (e.g. prioritizing Wide Wales GMEP survey squares which deliver a balanced structured design of the Welsh countryside)
2. Quantity of baseline data
3. Presence of peatland, including lowland peat
4. Presence of Glastir interventions, especially those affecting inputs/stocking on grazed land, but also streamside corridors, hedgerows, cover crops and habitat creation

Only 1km squares which were previously surveyed under the Glastir Monitoring and Evaluation Programme (GMEP) were considered. The aim is that 120 squares surveyed in 2013/2014 will be revisited in 2019, while 120 squares initially surveyed in 2015/2016 will be revisited in 2020. 10 of 60 unselected GMEP squares were also required marked as ‘reserves’ in case access is refused to any of the 240 selected squares.

Application of the criteria in a step-wise approach resulted in selection of:

- All Wider Wales survey squares which are the representative sites which provide national trends (150 squares selected).
- All squares with >50% overlap with the unified peat map (an additional 17 squares selected).
- All squares in which soil and vegetation samples had been taken within one of a prioritised list of Glastir interventions (another 56 squares added).
- Finally, we prioritised squares with larger numbers of vegetation samples only which intersect a broader list of Glastir interventions until the maximum number of 240 squares had been selected plus reserves in case of refusals (17 squares added with another 10 reserves).

A check of included and excluded squares identified that there was a slight bias for improved and neutral grassland being excluded whilst acid grassland and bog show a slight bias towards being selected (Figure 3.1.1.1). However, a Chi-squared test of homogeneity suggests that the distribution of habitats did not differ significantly between selected and excluded squares (P > 0.05).

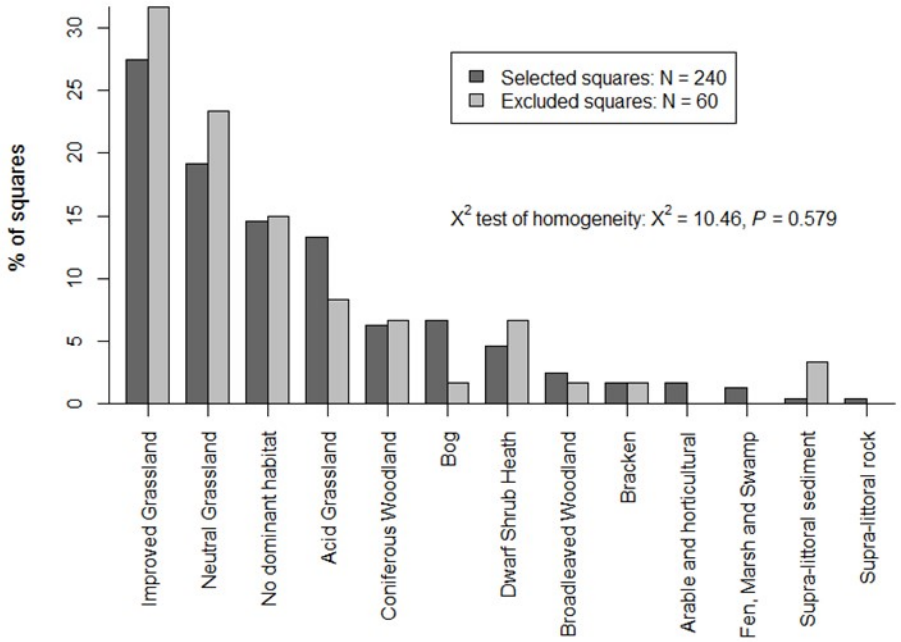

Figure 3.1.1.1 Percentage of selected squares (dark grey) and excluded squares (grey) falling into various broad habitat categories based on the allocation of the majority of X plots within that. Improved and neutral grassland show a slight bias towards being excluded whilst acid grassland and bog show a slight bias towards being selected. However, a Chi-squared test of homogeneity suggests that the distribution of habitats did not differ significantly between selected and excluded squares (*P* > 0.05).

The recommendation is that this new subset of 1km survey squares is used for the ERAMMP survey. This will be reviewed by the Steering Group and other Stakeholders before a decision is made.

3.1.2 New approaches to habitat mapping

Smart, S.M. & Freeman, S.
Centre for Ecology & Hydrology

Repeat survey of GMEP baseline 1km squares is scheduled to start in 2019. In order to meet the requirements of a reduced budget an 80% reduction in survey effort is required. If reporting is required in the future that maintains a connection with the past time-series then new methods have to be developed that ensure that the major reduction in field survey effort and methodology either does not impact reported quantities or that the unique effect of an abrupt change in methods can be estimated and isolated from real change. Thus innovative new approaches are required focussing on a synthesis of limited ground-truthing with Earth Observation products.

Work on developing the new models which links EO and field data has started which compares the level of disagreement between EO and field survey from past Landcover Maps and field surveys. The next stage is to introduce additional information into each model that explains the variation in both the EO classification accuracy and field survey accuracy. Once these predictor variables are introduced into the models we will be able to determine how new joint estimates of habitat extent compare with full mapping approaches as part of the traditional mapping approach within the field survey and the Land Cover map alone. The logic behind this approach is that each independent mapping method validates the other. If LCM and CS generally agree then we can be more certain of the true habitat type whereas if they tend to disagree there is more uncertainty. By bringing in explanatory variables that help understand how these levels of agreement, or disagreement, vary in space we can also make the joint habitat assignment more geographically sensitive. The method will guard against declaring change over time when none has occurred. Because the approach is based on much more limited mapping effort within each GMEP square much less detail will be recorded within each square going forward although this will significantly reduce the cost of the field survey.

One positive potential benefit of the new approach is that the results for habitat extent and change will be more repeatable due to reduction in unquantified surveyor impact but because fewer points are surveyed in each square uncertainty will inevitably increase. A move to a model-based approach, as already implemented in the ECOMAPS platform, would also enable flexible interpolation of the modelled relationships between attributes and habitat outside of the 1km square sample and across regions of varying size. The caveat as ever is that even if such models can be produced they may have high uncertainty. The likely outcome is that models will work well for some variables and not so well for others.

However a series of limitations also need to be highlighted. We know that EO and LiDAR do not record many structural attributes nor many priority habitats. So we can say with certainty that the time-series that can be reconstructed based on the best modelled synthesis of EO and point-based survey will not be able to report at the level of detail available up until GMEP 2016. Early conclusions from a review of past LiDAR coverage has also indicated that coverage in Wales is very patchy and does not reproduce the coverage or detail available from field survey. Going forward, a new LiDAR campaign is planned for Wales. Once details are known then it will be possible to estimate the extent to which the new LiDAR data can reproduce the detail recorded in the field from the initial start-up year. However, it is extremely unlikely that any new product will be able to discriminate useful attributes such as plant species composition, presence of fences, streams and ditches beneath hedges. To mitigate this risk for small woodlands and linear features – the field mapping of these elements has been re-introduced back into the planned field survey (see Section 3.3 Woodland Monitoring Review).

The recommendation is that this work is continued to a final proof-of-concept stage. The findings then be exposed to a robust review to identify the risks, costs and benefits of this new approach cross-checked to policy needs from WG and NRW. This to be overseen by the Steering Group and other Stakeholders before a decision is made.

3.2 NRW & ERAMMP Monitoring Activities Review

Emmett, B.A., Maskell, L., Read, D., Robinson, D.A., Smart, S.M., Garbutt, R.A. & Williams, B.

With input from NRW

The aim of the Natural Resources Wales (NRW) and other monitoring activities review is to recommend where the key opportunities exist to address evidence gaps, better align activities and reduce duplication. A framework to steer the review was provided by NRW based on the likely structure of the next State of Natural Resources Report (SoNaRR) report. This framework was supplied in the format of a table with headings focussed on likely SoNaRR chapters. Completing the table was a collaborative effort by both NRW and CEH staff to capture monitoring activities likely to meet national reporting requirements by their own organisations, and also other key sources. A workshop then reviewed the table to identify gaps and identify priorities going forward.

A series of reviews on specific topics were also commissioned by the ERAMMP team for Woodland, Soil erosion and the Land Sea Interface. NRW also separately commissioned a review on freshwater monitoring.

Other sources of information concerning monitoring gaps and new opportunities include bilateral meetings between ERAMMP and different departments within NRW and the Welsh Government (WG) were also used.

At the workshop the following current priorities of ongoing activities were clarified:

- NRW monitoring focus is on site level monitoring to improve management with the addition of monitoring to report on the wider national picture for: freshwaters, fish stocks and distribution and extent of habitats
- The scope for ERAMMP is for fundamental evidence which can be used to inform national policy

It was also noted by NRW that SoNaRR does not cover all monitoring for example it missed site level monitoring. Marine was excluded from the review as it was not the specialism of the NRW-ERAMMP group convened and was not within scope for ERAMMP with the exception of the land-sea interface for which a separate review has been commissioned by WG as part of ERAMMP. WG also confirmed freshwater should not be considered beyond the scope of ERAMMP (i.e. headwaters and ponds) as NRW had commissioned a separate review.

A list of 27 potential future collaborative activities were identified but this was beyond the capacity and resources of both NRW and ERAMMP, the ERAMMP Steering Group was asked to prioritise which should be followed up with a timeline for completion within Year 2 of the ERAMMP contract. These three categories were identified as the priority:

1. Habitat extent and condition data
   The top priority was identified as more joint analysis of data particularly with respect to extent and condition data of habitats to support SMNR. Other priorities were for linking to ongoing NRW Phase II survey work on peatlands and ensuring more joint working on priorities for soil monitoring.

2. EO and LIDAR

NRW were keen to work together and learn more about the ERAMMP proposed combined EO x field survey approach for assessing change in habitat extent. The extensive and well-audited datasets of habitat of NRW (and legacy bodies) could be valuable for ground-truthing of EO assessments alongside the ERAMMP field survey data. Collective working between ERAMMP, NRW, Living Wales and the wider community e.g. Defra with respect to remote sensing in general was prioritised and it was noted this was already in progress. The potential role of the new national programme of LIDAR to be commissioned by NRW was also highlighted as a potential opportunity for partnership working for connectivity and extent metrics.

3. Resilience

   Joint working to develop an operational approach to reporting on resilience was highlighted. This also informed NRW priorities for elements to be included in the ERAMMP field survey to ensure an appropriate balance to diversity, connectivity, extent and condition combining field and EO approaches.

The recommendation is for small working groups to be formed to take forward these three priority areas for joint working. The Steering Group to review this recommendation before a final decision is made.

3.3 Woodland Monitoring Review

Emmett, B.A.[1], Ditchburn, B.[2], Jenkins, T.[2], Maskell, L.[1], Smart, S.M.[1] & Williams, B.[1]

[1] CEH, [2] Forest Research
With input from WG and NRW

To aim was to review the ongoing monitoring of woodlands and propose a set of recommendations to inform the commissioning of the ERAMMP field survey due in 2020-2021 to ensure the policy requirements of priorities of Welsh Government Forest Policy and NRW were met. The purpose was to identify where the ERAMMP could best contribute and add value to the wider woodland monitoring landscape.

A review table for 6 major national current monitoring activities was co-developed by CEH and Forest Research. Categories reported on for each scheme were:

- Sampling approach
- Extent
- Diversity
- Woodland structure
- Management / Impact
- Condition and pressures
- Landscape context, cultural features, connectivity and resilience

This table provides a good oversight of nationally relevant ongoing woodland monitoring activities across Wales for future reference.

A series of options with rationale and costs were proposed for consideration by a joint NRW / WG working group for inclusion in the ERAMMP field survey. After reviewing the advice / recommendations from this working group the following

recommendations were approved by the ERAMMP Steering Group and WG for the ERAMMP field survey as follows:

- To include extent and condition of small woodlands and linear features
- To include assessment presence of veteran / ancient / individual trees
- To exclude assessment of disease

3.4 Soil Erosion Review

Tye, A.[1] & Robinson, D.A.[2]

[1] BGS, [2] CEH

Soil erosion is considered one of the greatest threats to food supply across the globe as outlined in the FAO report 'Status of the World's Soil Resources' (FAO, 2015). Issues regarding soil erosion have been compounded because whilst erosion effects are evident, little is known about the soil formation rates. However, it is generally accepted that the rate of soil erosion under conventional cultivation tends to be at least one to two orders of magnitude greater than soil formation. Thus it is apparent that within any monitoring and land use planning programme, soil erosion is a key parameter that needs to be considered. The effects of soil erosion often extend beyond the field and can contribute to the eutrophication of waters, poor water quality leading to poor ecosystem function and sedimentation of water courses.

When considering soil erosion and its monitoring, it is not only important to understand the principal processes through which water (sheet, rill and gully erosion) and wind (saltation) erode soil, but also the many additional factors which influence the rates of soil erosion. These include properties such as soil texture, slope angle and slope length that can be measured and remain for all purposes static variables, along with those factors that which are largely unpredictable, such as the timing and intensity of storms in relation to vegetation coverage.

A further consideration when choosing techniques is how to account for eroded soil stored within the landscape. This again is a question of methodology and how erosion rates are measured and averaged. Thus, in many cases erosion only occurs in a small part of the landscape, and often the soil is stored within that landscape (i.e. it doesn't reach a water course because there is no hydraulic connectivity). Therefore catchment scale measurements using turbidity sensors, only provide an estimate of net erosion that has made its way to the hydrological system. It is common that as the catchment size increases, net erosion per unit area decreases because of the reduction in hydrological connectivity to water courses.

As a result of the variables contributing to soil erosion, a large numbers of techniques have been developed to quantify soil loss and act as a basis for developing mitigation techniques. These techniques operate over a range of different spatial scales, extending from plot to field to catchment to national scale and over a range of temporal scales from single event to decadal. This is in part a reflection on the different erosion processes and their potential magnitude. A range of issues which need to be considered before designing a bespoke monitoring programme. A table and review of current methodologies used in soil erosion studies is provided.

When selecting the most appropriate methods for Wales, the techniques should be ideally suitable for both grassland and arable agriculture. Riverbank erosion is also

another important erosional feature which often is overlooked. The temporal scale is important. For example, the use of ^{137}Cs provides a measure of erosion that is an average over ~50 years (since bomb and Chernobyl deposition), and therefore avoids major events that happen very occasionally and those years when erosion may not take place (or is minimal). It also, when used on arable land includes the contribution of tillage erosion, which could be the dominant process. However it is extremely costly with an estimate using this approach with sufficient sites to detect 80 % confident that the survey would be able to detect a 50 % increase in erosion rate (two date comparison) was > £2m.

Past reviews of soil erosion in Wales indicate that soil erosion in Wales is mainly attributable to upland erosion processes, e.g. peat, landslips and stream bank erosion, and water erosion along the border with England. Identifying the occurrence of hotspots for landslips and bank erosion, and erosion in peatlands would offer perhaps the most cost effective assessment of dominant erosion processes. The ERAMMP review suggests multi-layered approach would be the most appropriate to take forward:

- modelling for assessing direction of travel (e.g. Figure 3.4.1);
- aerial and satellite imagery which are highly appropriate to assessing bank erosion and landslides, over different spatial and temporal scales;
- ground-truthing through the ERAMMP field survey as all remote methods need validation;
- Citizen science to increase spatial coverage and low coast future evidence.

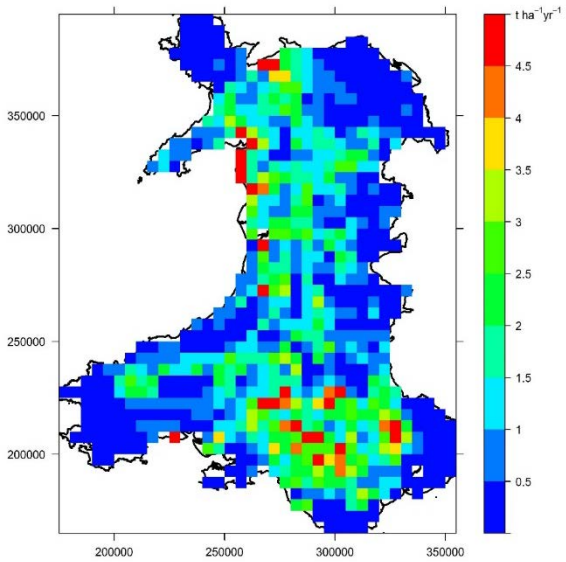

Figure 3.4.1: Predicted water erosion using the PESARA model for Wales.

Recommendations:

1) A review is carried out of landslip occurrence in Wales and identify locations and hotspots using an air survey, based on satellite data to identify bank erosion hotspots. This could be ground-truthed in the uplands using the head water streams survey as part of the ERAMMP survey.
2) Undertake an air survey, based on satellite data to identify erosion hotspots in peat areas. This could be ground truthed in the uplands using surveyors to identify locations and confirm during the ERAMMP survey.

3) Consider the potential for citizen science to report bank erosion or landslips using a new app under development at CEH for recording land cover and soil threats. The app will be free and work off line with data available to WG approved researchers.
4) Organise a scoping meeting to explore options for developing a modelling framework for assessing soil erosion in Wales.

The above would provide a comprehensive assessment of the state and potential change of targeted erosion processes in the uplands and along rivers across Wales and would have a cost of ca. £84k. It would link with both the head water stream survey and the assessment of peat condition from surveyor data.

These recommendations will be reviewed by the Steering Group and other Stakeholders before a decision is made.

3.5 Land – Sea Interface

Garbutt, R.A.[1], Alexander, M. [2], Ballinger, R.[2], Bowgen, K.[3], Cooper, D.[1], Frost, N.[4], Hull, S.[4]; Jones, L.[1] & Mant, J.[5]
[1] CEH, [2] Cardiff University, [3] BTO, [4] ABPMarine, [5] Ricardo
With input from NRW and WG

This report was commissioned under ERAMMP to review monitoring activity at the Land-Sea interface identifying opportunities to better align monitoring activities and improve understanding of pathways and impact, working with NRW and WG marine policy.

The Welsh nation is closely connected to the sea with 60% of the population living on or near the coast, with the furthest settlement only 50 miles from the Irish Sea. The coastal economy makes up a significant percentage of national GDP through tourism, ports and shipping.

However, monitoring programmes have developed to address specific requirements of individual policy initiatives and specific statutory requirements (e.g. fulfilment of the Habitats Directive), rather than integrated monitoring programmes for monitoring terrestrial, freshwater and marine systems. More integrated approaches not only have the potential to improve resource efficiency, but are essential for improving our understanding of environment, society and economy linkages at the Land-Sea Interface, which in turn could help maximise and quantify benefits, as well as improving evidence and reporting for SoNaRR, Valuing Nature and the Well-Being agenda.

It was agreed the review would be limited to inshore waters (12 nautical miles) and that the landward extent should include monitoring downstream of headwaters to capture land use / catchment effects of land management impacting on the coastal and marine environment. Monitoring activities that report on pressures and drivers for change were included, but limited to those concerning the natural environment. Social and economic issues were not explicitly included in the review, but opportunities to link to social and economic and health data have been noted.

A monitoring table outlining a summary of current activities relevant to the LSI was jointly compiled. A total of 358 relevant activities were listed.

A workshop was convened for the NRW/WG Working Group to review the table and agree next steps. It was agreed to focus on three studies to better identify where better integration of monitoring across the Land-Sea Interface could be beneficial. The three case studies were:

1. Understanding the contribution of minor streams to water quality in Marine Protected Areas
2. Coastal squeeze and the coastal economy: better use and integration of existing data
3. Further investigation into sediment transport from land to sea and impacts

Some specific recommendations for each case study are:

The role of minor streams

Inputs from minor streams are usually unknown even though they can make a significant contribution to the waterbody loading and can generate significant local impacts (e.g. Figure 3.5.1). Having a better understanding of the relative inputs of nutrients from different catchments would help identify the key land areas contributing to marine impacts (particularly to MPAs) and would enable management action to be focussed when required, achieving maximum returns on efforts made. To achieve this, it is recommended that a costed proposal for water quality monitoring of smaller streams running directly into estuaries using the GMEP / ERAMMP methods for headwater streams is developed.

Recommendation 1: a costed proposal for water quality monitoring and water quality modelling of smaller streams running directly into estuaries using GMEP / ERAMMP methods for headwater streams is developed

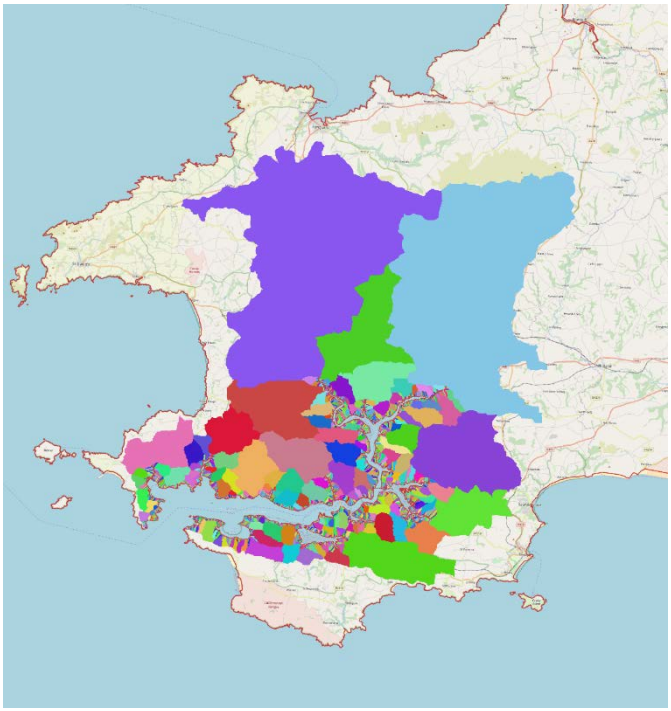

Figure 3.5.1 Land areas draining into Milford Haven

Coastal squeeze

There is a need to better understand to establish and test methodologies for using coastal change data to inform an assessment of change in coastal margin habitats on natural hazard protection ecosystem service benefits and the impact of coastal change (extent and quality) on benefits from tourism and recreation.

Recommendation 2: following an initial workshop a project plan is developed to establish and test methodologies for using coastal change data to inform:

- assessment of change in coastal margin habitats on natural hazard protection ecosystem service benefits and benefits from tourism and recreation
- Recommendations on how these assessments can be incorporated into SoNaRR.

Sediment transport from land to sea

Terrestrial runoff from land and riverine inputs can be a significant contributor to sediment in transitional and near coastal waters, particularly where coastal waters have low natural suspended sediment concentrations and thus there is limited marine sediment supply. Such inputs can change water clarity and levels of silt deposition. Levels of silt appear to have been increasing within some Welsh estuaries. Monitoring is limited, but appears to corroborate this in some instances

Recommendation 3: a workshop is held to bring together expertise in soil erosion, freshwater sediment and pathogen transport and marine sediments to scope the relative importance and impacts on changing land-use and erosion on marine ecosystems and coastal use and activities.

These recommendations will be reviewed by the ERAMMP Steering Group and other Stakeholders before a decision is made.

4 Data and analysis

4.1 Outstanding analysis of GMEP data

4.1.1 Soil Carbon change in Habitat land

Alison, J., Robinson, D.A., Smart, S.M., Thomas, A. & Emmett, B.A.
Centre for Ecology & Hydrology

New analysis was carried out to explore the reported loss of topsoil-C between 2007 and 2016 in the 'Habitat' category in the final GMEP report. This 'Habitat' category is defined as all habitats except woodlands, arable and improved grassland.

The GMEP survey squares were selected using Countryside Survey protocols stratified according to Land Classes. The final GMEP survey sample from 2012-2016 consists of 7% previously surveyed Countryside Survey squares. Further analysis was needed to explore, and account for, unintended shifts in environmental variables which could have contributed to the reported topsoil carbon decline.

The results indicate:

1. The reported change in the 'Habitat' category is driven by trends in upland habitats (median elevation of 400m).
2. In upland habitats, soil carbon is positively associated with dwarf shrub cover (particularly ericoid e.g. heather cover), *Sphagnum*, presence of peat, elevation and moisture conditions.
3. The coverage of dwarf shrubs was lower in GMEP than in Countryside Survey 2007, mostly due to lower cover of *ericoids* i.e. heather. This is consistent with decreasing soil carbon in upland habitats. Other variables (i.e. potential drivers) did not differ between surveys, or direction of change was inconsistent with reported C trends.
4. Re-analysis of Countryside Survey data (1978-2007) provides evidence that shifts over time from dwarf shrub to grass-dominated habitats are associated with a decline in topsoil carbon.
5. Overall, this suggest a potential role of ongoing vegetation change in upland habitats (i.e. conversion of dwarf shrub to grass-dominated) contributing to topsoil carbon loss.

Further work is needed to:

- Confirm recent vegetation change in upland habitats using independent data e.g. satellite data;
- Explore relationships between specific plant species and topsoil carbon in Countryside Survey where we have a high number of true repeat samples;

This work highlights the importance of the findings of the next ERAMMP survey, which will be more powerful than the combined CS-GMEP approach reported here.

4.1.2 Re-analysis of GMEP results to fit to SoNaRR reporting categories

Maskell, L., Alison, J. & Smart, S.M.
Centre for Ecology & Hydrology

The State of Natural resources report (SoNaRR) assesses the extent, condition and trends of natural resources and ecosystems in Wales. In it trends that 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 NRW when preparing Area Statements, which facilitate the implementation of the National Natural Resources Policy.

GMEP 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. These do not map completely onto the likely next SoNaRR reporting categories.

To better support the next SoNaRR report due in 2021, it was agreed with NRW that data would be re-analysed by CEH using the likely reporting structure for ecosystems in SoNaRR; Mountain Moor and Heath, Semi-natural grasslands, Enclosed farmland and Woodland. The main re-analysis is the split of the GMEP Whole Farm Code Habitat land into asset classes; Semi-natural grasslands and Mountain, Moor and Heath.

With respect to biodiversity, outcomes are either stable or positive (e.g. Table 4.1.2.1):

- 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.

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 ImprovedGrass 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	+	+
	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	=	+

Table 4.1.2.1 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

For soils, positive outcomes include:

- Acidity of topsoil has improved 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.
- There is a decline in soil nitrogen content in Mountain, Moor and Heath which is likely to benefit native plants. This may be linked 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.

Areas of concern are:

- On average topsoil acidity remains within recommended levels for sustained production in improved land however an area of concern is a recent increase in these acidity levels. This may be due to the long standing decline in lime use combined with continued fertiliser use and will potentially impact on production levels and resource use efficiency of fertiliser for some soils.
- A recent increase in topsoil acidity has been observed in woodland after years of declining acidity. Previous declines in acidity had been a result of the benefits of educed emissions and deposition of acidic pollutants since the 1980s in response to emission controls from power plans and transport. More active management and harvesting could be accelerating base cation removal from the soil which contributes to the recent increase again in soil acidification.
- There has been significant decline in soil carbon in MMH over the last 10 years (see Alison et al. (2019a) - ERAMPP year 1 report 21 on Soil Carbon) which suggests this trend is restricted to upland areas and could be related to a shift in vegetation composition (i.e. lower cover of shrubland / *Ericoidaceae* (mostly heather) (Figure 4.1.2.1; See also section 4.1.1).

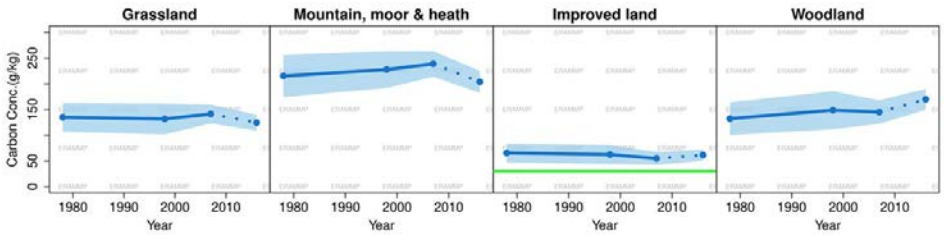

Figure 4.1.2.1 Long term trends in topsoil (0-15cm) condition for topsoil condition for carbon concentration.

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 and re-analysis were not required to map onto the future SoNaRR report.

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.

4.2 Well-being of Future Generations; Biodiversity Indicator No. 44

Smart, S.M.
Centre for Ecology & Hydrology

This activity explores the possibility of developing a WFG indicator not based solely on priority species but recognises that there are, in addition to many threatened taxa, a wide range of common species more likely to be seen and heard by people and which, by virtue of being common and often being abundant where present, play a major role in the delivery of ecosystem services. This is not to question the value of the rarest species but to suggest merit in exploring an indicator that measures change in the wildlife people are more likely to experience across Wales.

At a UK level the focus on combined country lists of 'threatened' species to form the UK C4 indicators is partly driven by Aichi Target 12. Since the WFG indicator 44 is required by domestic Welsh legislation there would seem to be scope for considering a wider pool of schemes and species based on Welsh data only. A more inclusive and informative indicator could include trends in common species and a wider range of species groups. Data could be drawn from multiple structured schemes that have already proved capable of producing trends based on Wales-only data. At its most comprehensive indicator 44 could showcase the ability of multiple schemes to robustly cover a range of species groups comprising the rare and common in Wales.

Smart et al, (2019) - ERAMMP Year 1 Report 23 recommends for Wales that the results from different contributing schemes plus new analyses of section 7 species could be reduced to a usefully simple tally of increases, decreases and no detected change based on summarising modelled trends in a wide range of species although as with all high level reporting indices caution and transparency are required..

The report recommends a new multi-species Indicator 44 could be constructed using proven methods and available data (see Section 4.3 concerning the potential value of Local Environmental Record Centre (LERC) data).

These recommendations will be reviewed by the Steering Group and other Stakeholders before a decision is made.

4.3 Local Environmental Record Centre Potential

Smart, S.M., Maskell, L.C., Hatfield, J., Logie, M. & Powney, G.R.
Centre for Ecology & Hydrology

Better use of Local Environmental Record Centre (LERC) data in delivering biodiversity objectives is stated explicitly in the Nature Recovery Action Plan for Wales. Consistent with this aspiration we carried out two quantitative assessments of LERC data to determine the availability of species records at the resolution required

for ERAMMP and WFG (Indicator 44) evidence needs; <=1km. We gratefully acknowledge the following individuals for their input and advice to this work: From Natural Resources Wales; Liz Howe, Jon Rothwell, Dylan Lloyd, David Allen, Winter Dotto, Helen Wilkinson, Julie Boswell, Jim Latham and Barny Letheran. Colleagues at CEH; David Roy and Oli Pescott. We also thank Roy Tapping (Director, Cofnod) and Adam Rowe (Manager, South East Wales Biodiversity Records Centre (SEWBReC)) for their guidance and advice, and for providing the species records analysed in section 5 of the review.

A comparison of the availability of 1km square records for section 7 (i.e. priority) reptiles, amphibians and mammals between LERC and NBN Atlas showed that LERC data were more numerous in every case and sometimes markedly so (on average 17 times as many 1km square records in LERC data). For these species the NBN Atlas tends to have a greater number of records available at 10 rather than 1km square resolution.

An assessment of the contribution of LERC 1km square records to national trends modelling demonstrated that substantial benefits in increased species coverage and precision of modelled trends are likely to arise by including additional LERC data alongside surveillance scheme data already used for trends modelling (e.g. Figure 4.2.1). This figure indicates a rapid decline in the 1970s which appears to have halted in the 1990s with some evidence for improvement since 2000. By combining datasets the number of species that could be modelled increased by 267% on average across all the taxonomic groups previously modelled.

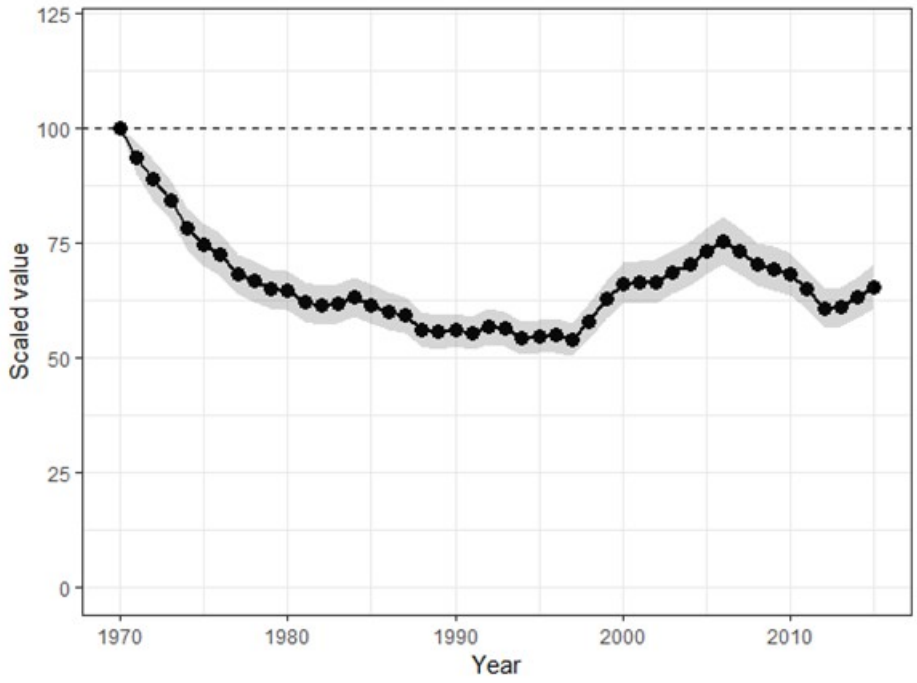

Figure 4.3.1 Trend lines show average occupancy of 1 km grid cells in Wales across all 1539 modelled species. Uncertainty is represented by the 95% credible intervals (delimited by the shaded region).

The design of the new Wales-only Indicator 44 “status of biological diversity” is currently under consultation. Our results show that species coverage for this indicator will benefit from combining multiple datasets with the current analytical state-of-the-art for trends modelling. While results are always dependent on sufficient data, there would seem to be scope for exploring how an ecologically more comprehensive Indicator 44 could be developed in partnership with Wales LERC and others.

This assessment also suggests that exploiting the more numerous 1km square records for section 7 (i.e. priority) species will increase the chances of detecting legacy and future effects of management scheme interventions for biodiversity and resilience objectives (Figure 4.3.2). A strategy for extracting the most biodiversity understanding for time spent would most likely involve applying state-of-the-art spatio-temporal modelling in collaboration with the Wales LERC and surveillance schemes.

A key benefit of working more closely with LERC is their ability to identify recording gaps and to mobilise new recording effort among the interested public as well as scholarly recording societies. This kind of reactive engagement activity could also contribute to efficient risk-based surveillance but with the proviso that voluntary effort typically exhibits strong spatial bias and variation in recording quality.

Further evidence needs driven by recent legislation and policy in Wales are likely to become clearer as indicators for SoNaRR and in particular the resilience objective of SMNR evolve in the near future.

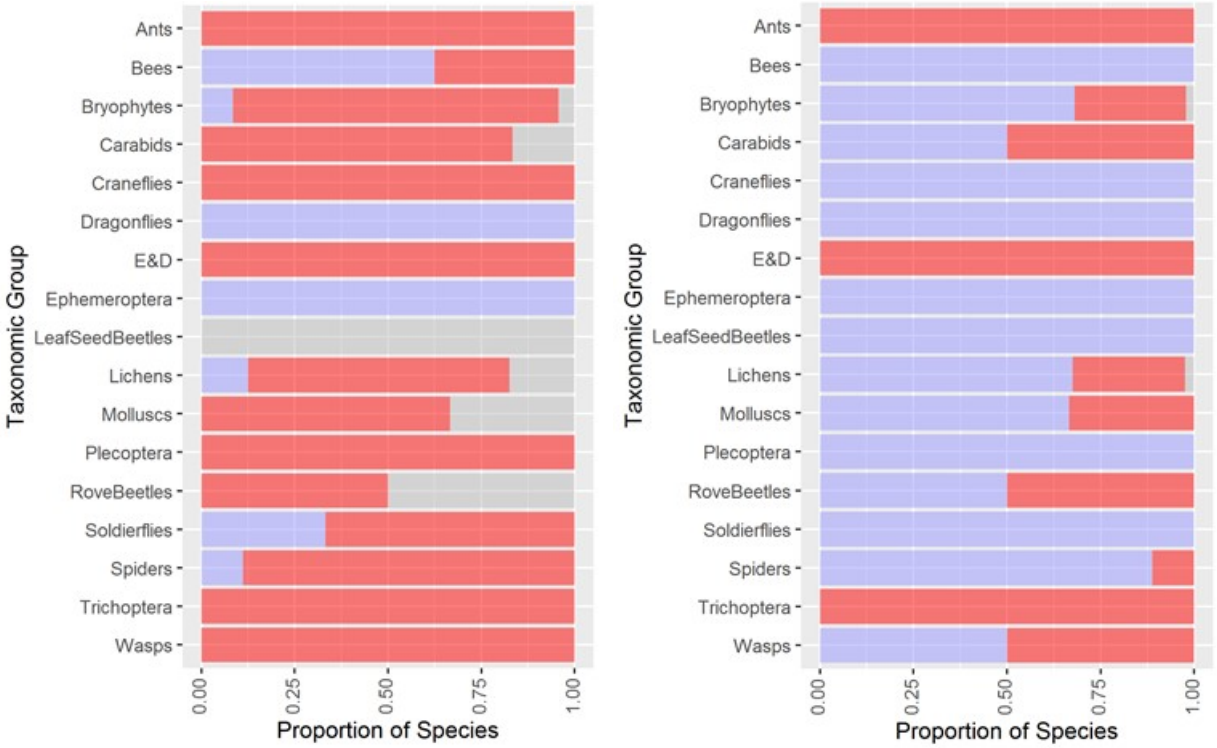

Figure 4.3.2 The proportion of section 7 (i.e. priority) species that meet (blue), and fail to meet (red and grey) the “rules of thumb” precision threshold for the species modelling approaches which can be used to detect trends: a) using previous data sources only and b) using previous data sources and Welsh LERC data combined.

The recommendation is that greater use and integration of LERC's data is developed going forward to improve the evidence base for biodiversity change together with more collaborative working. This recommendation will be reviewed by the Steering Group and other Stakeholders before a decision is made.

4.4 Develop Natural Capital Accounts for Welsh Woodland, Farmland and Freshwater Habitats

Engledew, M.[1], Maclean, K.[1], Thomas, T.1, Fitch, A.[2], Robinson, D.A.[2] & Jones, L[2]

[1] ONS, [2] CEH

This work was led by the Office of National Statistics (ONS) and thus ensures results are compliant with the broader UK approaches in methodology.

This baseline work is the fundamental foundation for any future work which could exploit the many condition, connectivity and diversity metrics collected as part of the GMEP / ERAMMP national monitoring programme. These are critical properties of ecosystems which influence the resilience to sudden shocks. They are important to include as they ensure the ongoing condition of the asset is not depleted even if its extent and delivery of services appear to be ongoing over time.

The value of the stock of Welsh natural capital in woodland, farmland, and freshwater was estimated to be approximately £30.5 billion in 2014 (Figure 4.4.1). This is a partial value and the true value is expected to be significantly higher than this figure as only seven of the benefits received from natural capital in Wales are currently measured.

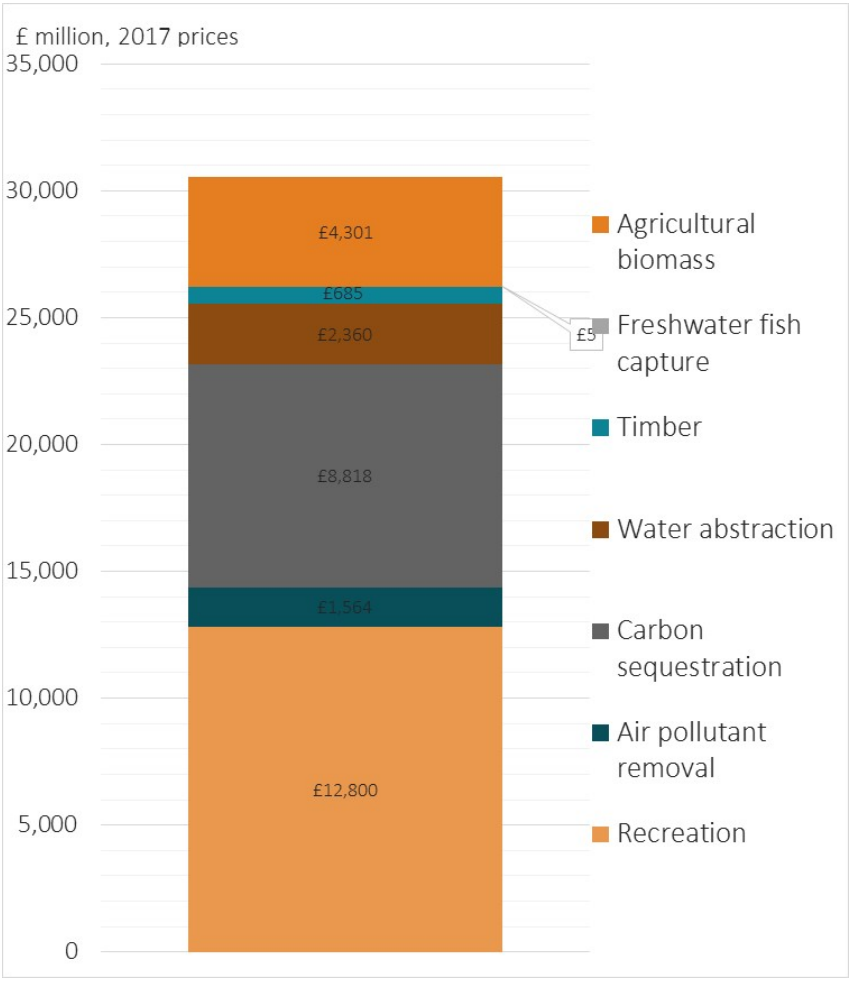

Figure 4.4.1 Partial Wales Natural Capital Asset value estimates

Some notable examples of ecosystem services which are not currently measured are flood protection, hydropower, and tourism. Of the services measured, 76% of this value was attributable to intangible services not traditionally captured in GDP (recreation, pollution removal and carbon sequestration).

In 2014 the sum of currently measured ecosystem service annual valuations for woodland is £309.7 million, £318.1 million for farmland, and £172.4 million for freshwater habitats. Incorporating these annual valuations, in 2014 the asset valuation of woodland is £13.0 billion, the valuation of farmland is £11.4 billion, and freshwater is £6.4 billion.

Specific novel work focussed on air pollutant removal by vegetation by the different habitats:

- Absolute pollution removal values reflect the extent of habitats as well as the habitat's effectiveness at removing pollution. For instance, despite removing the most pollution overall, farmland, on average, removed 52.0 kilograms of pollutant per hectare (kg/ha) over the time series, in comparison to 101.3 kg/ha for woodland. Freshwater averaged 45.9 kg/ha.
- Pollution removal annual valuation for woodland, farmland, and freshwater declined (46.8%) from £82.3 million in 2007 to £43.8 million. This trend is attributable to declining physical pollution removal, particularly those most harmful such as PM2.5, due to falling emissions (Figure 4.4.2). With woodland

removing the majority of the PM2.5 it represents an annual average of 84.6% of overall valuation. In 2017 woodland in Wales provided a pollution removal regulating service valuation of £36.9 million, or £137/ha.

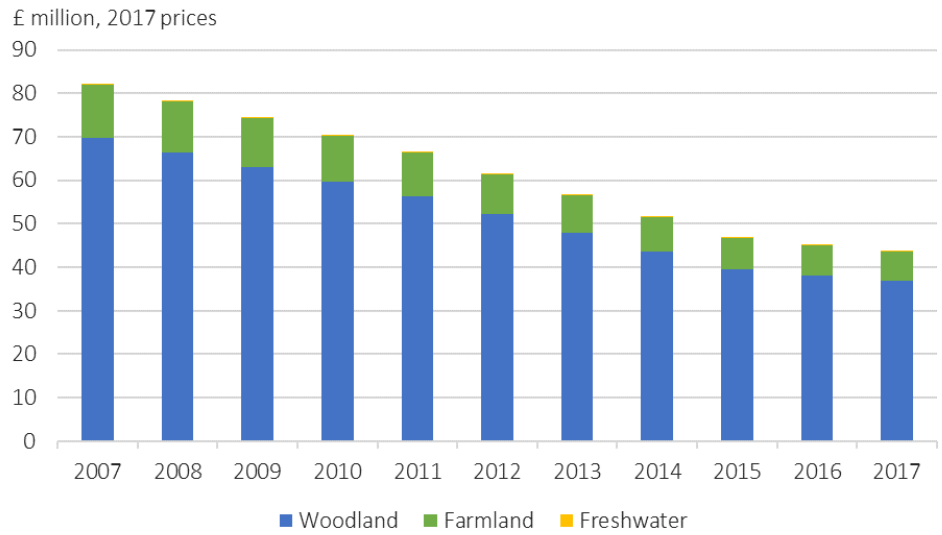

Figure 4.4.2 Pollution removal annual value by habitat, 2007 to 2017

A key recommendation is:

1. To now enhance these baseline accounts to include metrics from the ERAMMP and other data sources with respect to condition, diversity and connectivity of Welsh habitats to better link to the SMNR agenda and resilience ambitions of Welsh policy.

This recommendation will be reviewed by the Steering Group and other Stakeholders before a decision is made.

5 Conclusions, Future Plans & Recommendations

5.1 Year-1 Outcomes

All Year-1 tasks have been completed successfully where these were not deferred by WG. Three additional tasks have also been completed as requested by Welsh Government.

The large authorship reflects the collective approach of ERAMMP which benefits from the wide variety of expertise, dedication and flexibility of the many partners.

It should be noted that a large component of the modelling work was supported by aligned funding from CEH with additional support for underpinning work for the field survey and data science needs of the programme.

5.2 Modelling

The majority of ERAMMP resources was focussed on the modelling work which required significant time for interaction with Welsh Government to ensure collective understanding and agreement for the approach taken. The impact of the work appears to be significant in supporting inform policy going forward. Release of some of the detailed maps will require masking to protect personal data but this is in hand and should not delay release of this final report to the wider public beyond June/July 2019.

Future modelling work will focus on:

- Demonstration of the Integrated Modelling Platform prototype in July 2019
- Phase 2 of Quick Start to support policy priorities in Welsh Government – the precise nature of this is under current discussion.

5.3 Monitoring

Key decisions have been made regarding the planning of the ERAMMP field survey which it was agreed should be delayed by one year from 2019-2020 to 2020-2021. The rationale from Welsh Government for this delay was: “To mobilise more resource and capability to the modelling and analysis component of the ERAMMP, better serving Welsh Governments priority evidence needs associated with Brexit and to avoid any issues that may arise in undertaking a survey of Wales’ rural environment with ERAMMP field survey staff (external contractors) visiting many thousands of farms during a potentially turbulent period for the agricultural industry. Delaying the field survey will increase the capability of ERAMMP to inform policy, strengthen the ERAMMP evidence base and enhance opportunities for collaborative working.”

Key decisions arising from the series of Year 1 review include:

- An approach for survey square selection which provides a responsive approach to maintain capability for national trends; respond to uptake of Glastir options by farmers and fit within budget constraints.
- A move to an EO/field based modelling approach for non-woodland habitat extent assessment (again funded from aligned CEH work)
- Re-instatement of small woodland and linear feature extent and condition assessment but not disease.

A large number of planning activities are also in progress including redesign and update of field capture software. Permissions from land owners for access to survey squares will begin in autumn 2019 along with recruitment of surveyors to start training in March 2020 and deployment for the first full year of survey in April 2020.

Reviews on soil erosion methods and opportunities for better linking up the land-sea interface have been identified. Opportunities for joint data analysis with NRW has also been highlighted in the NRW monitoring review.

5.4 Data and analysis

Two key activities have been delivered involving re-analysis and exploration of GMEP data.

An additional task requested by Welsh Government has highlighted the significant potential for developing a new multi-taxa biodiversity index and improved priority species index by better exploiting the wealth of data within the Local Environment Record Centres previously not included in past biodiversity indices.

A first set of Natural Capital Accounts for Woodland, Farmland and Freshwater habitats provides the foundation for inclusion of more condition, connectivity and diversity metrics in the future which will better link them to SMNR and resilience issues.

Future work will focus on priorities as defined by Welsh Government but are likely to include; a) assessment of relative condition and rate of change within the designated landscapes (National Parks (NPs) and Areas of Outstanding Natural Beauty (AONBs)) relative to land in the same Land Classes outside of designated areas and b) a similar assessment for Area Statements. This work will be done in collaboration with the NPs / AONBs and NRW respectively and an initial workshop with NPs and AONBs has been completed to begin that process.

5.5 Recommendations

A series of recommendations have been made following the completion of each activity. These recommendations will be reviewed by the Steering Group and other Stakeholders before a decision is made.

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