Radnorshire Wildlife Trust

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WSP

1 Capital Quarter
Tyndall Street
Cardiff
CF10 4BZ

Phone: +44 2920 769200

WSP.com

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Signature		Holder, Kristy (UKKLH002) DN: cn=Holder, Kristy (UKKLH002), ou=Active, email=Kristy.Holder@wsp.com Date: 2022.05.12 12:59:13 +01'00'	Holder, Kristy (UKKLH002) Digitally signed by Holder, Kristy (UKKLH002) DN: cn=Holder, Kristy (UKKLH002), ou=Active, email=Kristy.Holder@wsp.com Date: 2022.08.03 15:41:28 +01'00'
Checked by	Lucy Gilbert Digitally signed by Gilbert, Lucy (UKLJG003)	Lucy Gilbert	
Signature	Gilbert, Lucy (UKLJG003) DN: cn=Gilbert, Lucy (UKLJG003), ou=Active, email=Lucy.Gilbert2@wsp.com Date: 2022.03.30 16:18:07 +01'00'	Gilbert, Lucy (UKLJG003) Digitally signed by Gilbert, Lucy (UKLJG003) DN: cn=Gilbert, Lucy (UKLJG003), ou=Active, email=Lucy.Gilbert2@wsp.com Date: 2022.05.12 14:40:16 +01'00'	
Authorised by	Jenny Merriman	Jenny Merriman	Jenny Merriman
Signature	 Digitally signed by Merriman, Jenny (UKJCM005) DN: cn=Merriman, Jenny (UKJCM005), ou=Active, email=Jenny.Merriman@wsp.com Reason: I am approving this document	Merriman, Jenny (UKJCM005) Digitally signed by Merriman, Jenny (UKJCM005) DN: cn=Merriman, Jenny (UKJCM005), ou=Active, email=Jenny.Merriman@wsp.com Reason: I am approving this document	Merriman, Jenny (UKJCM005) Digitally signed by Merriman, Jenny (UKJCM005) DN: cn=Merriman, Jenny (UKJCM005), ou=Active, email=Jenny.Merriman@wsp.com Date: 2022.08.04 13:36:22 +01'00'
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CONTENTS

EXECUTIVE SUMMARY

1 INTRODUCTION 1

2 METHOD 2

2.1 SOURCES OF INFORMATION 2

LITERATURE 2

HYDROLOGICAL DATA 2

STAKEHOLDER ENGAGEMENT 2

LANDOWNER ENGAGEMENT 2

3 FINDINGS 3

3.1 RHOS PASTURE ECOSYSTEM SERVICES 3

CARBON ECOSYSTEM SERVICES 4

SOIL ECOSYSTEM SERVICES 5

WATER ECOSYSTEM SERVICES 5

3.2 HYDROLOGICAL DATA REVIEW 7

EXISTING FLOOD RISK IN THE WYE RIVER CATCHMENT 7

WATER FRAMEWORK DIRECTIVE 7

NATURE-BASED SOLUTIONS / NATURAL FLOOD MANAGEMENT FOR WATER ENVIRONMENT 7

4 REVIEW OF SPECIFIC SITES WITHIN RHOS PASTURES PROJECT 9

4.1 SITE 1 (LANDOWNER NOT CONTACTED) - SLIGHTLY DEGRADED CONDITION / GOOD CONDITION 9

RECOMMENDATIONS 10

4.2 SITE 2 (LANDOWNER 7) - DEGRADED CONDITION 10

RECOMMENDATIONS 10

4.3 SITE 3 (LANDOWNER 2) - VERY GOOD CONDITION (ASSUMED) 10
RECOMMENDATIONS 11
4.4 SITE 4 (LANDOWNER 4 & 5) - GOOD CONDITION 11
RECOMMENDATIONS 12
5 OPPORTUNITIES TO 'SLOW-THE-FLOW' AT RHOS PASTURES 13
6 ECONOMIC ANALYSIS OF RHOS PASTURE VALUE 15
7 FINANCING PAYMENTS FOR RHOS PASTURE ECOSYSTEM SERVICES 17
7.1 SUSTAINABLE FARMING SCHEME 17
7.2 CHARITABLE SOURCES OF FUNDING 17
7.3 UK FARM SOIL CARBON CODE (UKFSCC) 18
7.4 PRODUCT DIVERSIFICATION 18
7.5 WILDER CARBON 18
7.6 LENS (LANDSCAPE ENTERPRISE NETWORKS) 19
7.7 NATIONAL PEATLAND ACTION PROGRAMME (NPAP) 19
7.8 THE PEATLAND CODE 19
7.9 COOPERATION WITH WELSH WATER 20
8 LANDOWNER PERSPECTIVES 21
8.1 UNDERSTANDING OF RHOS PASTURE ECOSYSTEM SERVICES 21
8.2 PAYMENTS FOR ECOSYSTEM SERVICES 21
9 RECOMMENDATIONS 23
9.1 LANDOWNERS 23
9.2 SITE SURVEYING 23
9.3 NATURAL FLOOD MANAGEMENT 23
9.4 ECOSYSTEM SERVICES 24
10 REFERENCE LIST 26

TABLES

Table 1 - Ecosystem service categories as classified by the Millennium Ecosystem Assessment (2005) 3

Table 2 - Summary of Nature-based Solutions for the Water Environment 7

Table 3 - Example Ecosystem Service Economic Valuations 15

APPENDICES

APPENDIX A: RELEVANT CASE STUDIES

APPENDIX B: STAKEHOLDER LIST

APPENDIX C: SOIL SUMMARY FOR RHOS PASTURE IN RADNORSHIRE

EXECUTIVE SUMMARY

Radnorshire Wildlife Trust (RWT) developed the 'Rhos Pasture Restoration Project' which is focused on several selected rhos pasture sites in Radnorshire, Wales, UK. The aim is to restore rhos pasture habitat in the area.

As part of this project WSP was commissioned to conduct a desktop feasibility study to research the ecosystem services that rhos pasture can deliver, explore ways to measure them economically, and how to receive payments for ecosystem services. RWT are particularly interested in water, soil and carbon ecosystem services. This report summarises the findings of the feasibility study.

To conduct the study, several different approaches were used: a high-level review of relevant literature and case studies was conducted to assess the feasibility of rhos pasture to deliver ecosystem services (with specific reference to soil, carbon and water); a desktop assessment of local hydrological features to identify potential techniques to enhance nature-based solutions for natural flood management, and other water benefits in the catchment; stakeholder meetings to obtain recommendations for establishing payments for rhos pasture ecosystem services; and landowners were engaged with to provide an understanding of their enthusiasm for various land management techniques, to improve/maintain ecosystem services and their willingness to help establish payments for ecosystem services.

The literature and case studies reviewed suggest that rhos pastures do/could provide water, carbon and soil ecosystem services. However, this potential needs to be validated by site surveys and investigations of the rhos pasture in the Radnorshire area. Nonetheless, a core message that came out of the literature is that it is better (in terms of ecosystem service provision) to have semi-natural grasslands than intensively managed grasslands for agriculture. Assessment of the case studies also revealed that projects with strong landowner engagement are typical and that ecosystem service enhancements need to be tailored to local needs.

The review of hydrological features found that rhos pastures might provide water benefits within the catchment. It identified sediment loading as a specific issue that rhos pasture could mitigate against. Suggestions are provided for how water ecosystem services may be enhanced at five rhos pasture sites. These recommendations include land management techniques to increase infiltration and reduce overland flow and disconnection or removal of any existing field drains.

Stakeholder guidance stipulated that rhos pasture ecosystem services can be valued through an economic analysis assessment, that should be conducted by a qualified environmental economist. In addition to this, stakeholders provided guidance on public and private financing options for payments for ecosystem services that can be investigated further by RWT.

Landowners were knowledgeable about rhos pasture ecosystem services and the potential for future payments. Many of the landowners are already working to preserve or conserve their rhos pasture areas for the Rhos Pasture Restoration project and would be happy to continue to do so. Furthermore,

it seems likely that landowners would collaborate on future projects, making the viability of establishing payments for ecosystem services greater.

The report concludes with a list of recommendations that have been sourced from landowners, stakeholders, WSP experts and the literature reviewed. Overall, we recommend that RWT conduct site surveys and investigations at the rhos pasture sites to validate their ecosystem services and provide a database to underpin policy implementations and investment. After this, an economic analysis could indicate the value of the sites and landowners could choose to tap into the value if they wish. The information in this report and the supplementary documents can be used by RWT to undertake the recommendations. However, the recommendations made in this report are subject to landowner permission and individual situations. RWT can only implement these recommendations in cooperation with the relevant landowner.

Contact name Kristy Holder

Contact details 07825723445 | Kristy.Holder@wsp.com

1 INTRODUCTION

Rhos pasture vastly comprises species-rich purple moor grass and rush. It is found at various altitudes, mostly on hillsides and undulating plateaux. It is also found in river and stream valleys or floodplains (low-lying coastal or inland). Rhos pasture is often found in conjunction with other wetlands, wet heath, dry grassland and scrub (Elliot, 2004). In the more acidic areas species such as cross leaved heath *Erica tetralix*, devil's-bit scabious, *Succisa pratensis* and star sedge *Carex echinate* are present. Alkaline soils tend to support communities of rushes in conjunction with species such as sneezewort *Achillea ptarmica*, marsh-marigold *Caltha palustris* and greater bird's-foot-trefoil *Lotus uliginosus* (Countryside Council for Wales., 1989).

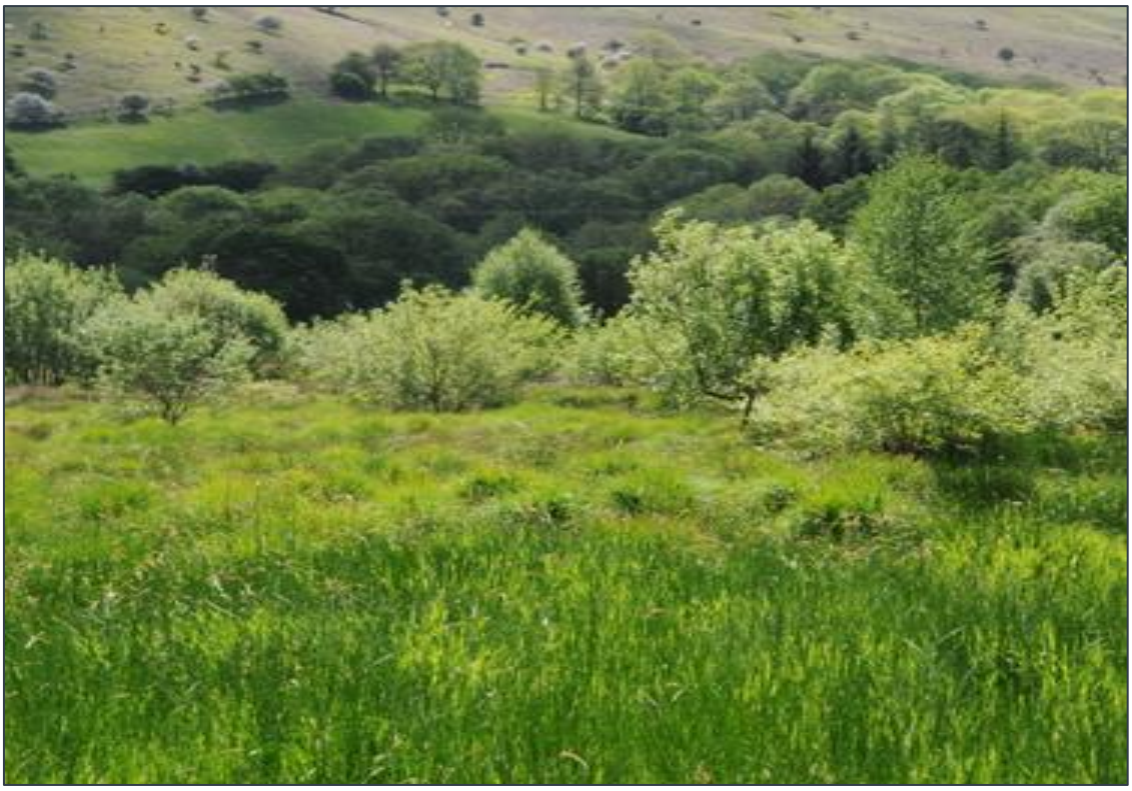

Figure 1 – Rhos pasture (Radnorshire Wildlife Trust, 2022)

2 METHOD

2.1 SOURCES OF INFORMATION

LITERATURE

Scientific studies, case studies, government and non-government reports were reviewed. All literature reviewed is provided in the reference list and a summary of case studies is provided in Appendix A. Research specifically on rhos pasture was limited, so studies on Culm grassland (the English term for rhos pasture habitat) and semi-natural/natural grassland ecosystem services were also assessed. In addition to this, reports exploring how to measure ecosystem services economically and establish payments for ecosystem services (PES) are considered for grassland habitats and other comparable habitats in the UK.

HYDROLOGICAL DATA

An area specific review of local hydrological features was carried out, plus identification of potential techniques to enhance nature-based solutions for natural flood management (NFM) and other water benefits in the catchment. The following sources were used:

- Water Framework Directive (WFD) mapping dataset (Water Watch Wales, 2018)
- Flood Risk Assessment Wales Map (Natural Resources Wales, 2022).
- Maps for NFM (suggesting areas with potential for measures and also related projects and plans in England and Wales) (Natural Resources Wales, 2021).
- Google Earth software for identifying relevant features visible on aerial imagery for five representative sites identified for comment by Radnorshire Wildlife Trust (RWT).

STAKEHOLDER ENGAGEMENT

To inform this research WSP met with representatives from Welsh Government, Welsh Water, Devon Wildlife Trust, University of Exeter, Scottish Environmental Protection Agency (SEPA), Ecosystems Knowledge Network, The Wildlife Trusts and RWT. The representatives are anonymised within this report and are referred to as ‘SH, organisation’ e.g., ‘(SH, Welsh Water, 2022)’ within the text and reference list. The name of each representative has been given to RWT in a separate confidential document and where permission has been granted their contact details are included for further discussion with RWT. A full list of stakeholders is provided in Appendix B.

LANDOWNER ENGAGEMENT

WSP spoke with seven landowners of rhos pasture in the Radnorshire area to understand local landowners’ perspectives. As with the other stakeholders, landowners are anonymised in this report and referred to as ‘Landowner 7, 2022’, for example. RWT will be provided with the names of landowners in a separate document. Landowners were made aware that this information would be passed on.

3 FINDINGS

3.1 RHOS PASTURE ECOSYSTEM SERVICES

Ecosystem services are "*the benefits that people obtain from ecosystems*" (Natural Resources Wales, 2015). The types of ecosystem services are summarised in the Table 1 below. In this research the following ecosystem services have been identified for rhos pasture, based on research of relevant services (Cowap *et al*., 2015; DWT, 2022).

- water storage
- soil erosion reduction
- carbon storage and capture
- reduced phosphate and nitrogen load in water
- reduction in suspended sediment load in water
- flood mitigation
- biodiversity
- research and education
- climate regulation
- food and fibre provision

Similar ecosystem services are reported for semi-natural grasslands of which rhos pasture is comparable (e.g., ONS, 2018; Richter *et al*., 2018). This study focused on soil, carbon and water-based ecosystem services, as requested by RWT.

Table 1 - Ecosystem service categories as classified by the Millennium Ecosystem Assessment (2005)

Ecosystem service category	Description
Provisioning services	Products obtained from ecosystems e.g., fuel, fresh water, food, fibre.
Regulating services	Benefits obtained from ecosystem regulation e.g., erosion reduction, climate regulation (i.e., carbon ecosystem services), water purification.
Cultural services	Non-material benefits acquired from ecosystems e.g., recreation, cognitive development, spiritual enrichment.
Supporting functions	Services needed to support all other ecosystem services e.g., soil formation, oxygen production, primary production.

CARBON ECOSYSTEM SERVICES

Estimates for carbon storage in different grassland types are available in an extensive synthesis of data from England and other regions (including Wales) (Natural England, 2021). Within the grassland categories identified, rhos pasture falls within the semi-natural grassland type (ONS, 2018). The values for below ground carbon storage reported for semi-natural grassland vary from 60 t C ha^{-1} to 87 t C ha^{-1} (Emmet *et al*., 2007). The report found that semi-natural grasslands store and sequester more soil carbon than intensively managed grasslands (IMG), but less than woodlands, peatlands and saltmarshes. However, the estimate for semi-natural grassland carbon storage is stated to be an underestimation. This is because the studies quoted only consider topsoil, but subsoil carbon storage in grassland habitats can also be substantial (Natural England, 2021; SH Devon Wildlife Trust, 2022). Overall, the Natural England (2021) report identifies the preservation of semi-natural grasslands, like rhos pasture, as a climate mitigation approach because they store '*appreciable*' quantities of carbon. This carbon is rapidly released if grasslands are improved for agricultural purposes (Bengtsson *et al*., 2019).

Two studies provide estimates of carbon stored specifically in rhos pasture / culm grassland in Devon, UK (Puttock & Brazier, 2014; Ellis, 2021). Both studies monitored three areas over at least two years. These areas included fields of rhos pasture (rush and *Molinia* dominated), IMG and woodland. The most recent study reported that species-rich rush pasture, and *Molinia* dominated culm grassland had 2.6 and 3.8 times more organic carbon (respectively) than IMG (Ellis, 2021). The higher carbon content in the *Molinia* dominated areas was theorised to be because these sites had been left undisturbed for longer (Ellis *et al*., 2021; Ellis, 2022). Puttock & Brazier (2014) reported that rhos pasture topsoil holds more carbon for a given surface area than IMG (with ~1.8 mg/cm^2 and ~1.5 mg/cm^2 respectively). Furthermore, carbon storage in rhos soils was found to be equal to that of woodland soils (Puttock & Brazier, 2014).

In addition to the findings from the literature, RWT report that many of the rhos pasture sites in Radnorshire are old turbaries with underlying peat. Furthermore, preliminary peat probing at one site found peat depths of 0.5-1.8m (Landowner 5, 2022). Therefore, carbon storage at these sites might exceed grassland estimates and potentially be comparable to peatlands, that are the most effective carbon store and sink (Natural England, 2021).

The carbon storage figures reported for grasslands and Culm grasslands, and the likely presence of peat deposits, implies that the rhos pasture sites in Radnorshire can provide the ecosystem services of carbon storage and sequestration. The Culm Grassland case study, found in Appendix A, is a useful case study to draw upon for the enhancement / establishment of carbon ecosystem services at rhos pasture environments.

RWT expressed concerns that rhos pasture areas might be seen as sites to convert into woodland due to the attention being given to tree planting for delivering carbon offsetting. The stakeholder from Devon Wildlife Trust stated that this is inappropriate in most cases. This is because the planting will lead to a loss of carbon stored in rhos, through oxidisation, that may take decades for the trees to make up for (SH Devon Wildlife Trust, 2022). In addition, research shows that carbon storage in rhos soils was found to be equal to that of woodland soils (Puttock & Brazier, 2014). Moreover, there will be a loss of the cultural and historic heritage associated with rhos pasture, even though these haven't been explored as part of this study (SH Devon Wildlife Trust, 2022).

The Welsh Government representative explained that if rhos pasture was to be converted to woodland it would need to go through the EIA process (Environmental Impact Assessment (Agriculture) (Wales) (2017) and Environmental Impact Assessment (Forestry) (England and Wales) (1999)) and the conversion is unlikely to be approved unless the species richness of the current habitat is poor (SH Welsh Government, 2022). More guidance can be found in the legislation noted above.

SOIL ECOSYSTEM SERVICES

Rhos pasture falls within the grassland category of semi-natural grassland (ONS, 2018). Reports for the soil ecosystem services of semi-natural grasslands were less available, in a UK context, when compared to the research for carbon ecosystem services.

A large database for Europe (that includes some British studies) states that soil erosion is significantly lower in natural grasslands, woodlands and shrublands when compared to arable crop fields (Cerdan *et al*., 2015). This erosion reduction is likely a factor of these environments having higher vegetation cover, more developed undisturbed soil profiles and complex microtopographical features (e.g., hollows, that impede surface run-off and subsequent erosion). Other studies support the findings above and report that natural grasslands, if positioned carefully, can contribute to area wide erosion reductions, lessening soil losses in adjacent agricultural fields (Souchere *et al*., 2003; Cerdan *et al*., 2010; Bengtsson *et al*., 2019).

Two studies provide information of soil characteristics specifically in rhos pasture / culm grassland (Puttock & Brazier, 2014; Ellis, 2021). Both studies monitored three areas over at least two years and these areas included fields of rhos pasture (rush and *Molinia* dominated), IMG, and woodland. Rhos pasture topsoil was found to be 20cm deeper than IMG, and the organic soil layer was 4.7 cm (whilst IMG sites tended to not have an organic layer) (Puttock & Brazier, 2014; Ellis, 2021). It also stored more nitrogen and less phosphate in its soils meaning that its presence could reduce nutrient pollution in water ways (Puttock & Brazier, 2014).

A review of the Soil Survey of England and Wales mapping for the area was undertaken and has been summarised in Appendix C.

The literature reviewed suggests that rhos pasture could provide soil ecosystem services of reduced soil losses through erosion (at rhos pasture sites, adjacent IMG, and the surrounding area), higher nitrogen storage and lower phosphate content when compared to IMG.

WATER ECOSYSTEM SERVICES

The higher capacity of rhos pasture (when compared to arable land) to store nutrients in its soils and reduce soil losses through erosion can lead to reduced phosphate and nitrogen in freshwater resources (Cowap *et al*., 2015). This service can be enhanced by further conversion of IMG to rhos pasture, or other semi-natural grasslands, in an area. Furthermore, any conversion can reduce the need for artificial fertilizers that contribute to nitrogen and phosphate pollution. These ecosystem services can help a catchment achieve nutrient neutrality, where nutrient inputs into a system are counteracted by nutrient reduction measures.

In addition to reductions in nutrient pollution, rhos pasture's ability to reduce soil erosion means that it's presence can lead to reduced sediment run-off and subsequent sediment loads in water resources (Cowap *et al*., 2015). Puttock & Brazier (2014) report a likely sediment runoff reduction of 0.5 tonnes per ha of rhos pasture restored.

UK evidence suggests that nature-based solutions, like semi-natural grassland presence can contribute to approximately a 5% reduction in peak flows. Furthermore, a multi-site study reported that water levels were higher at Culm grassland sites, ~0.07m below surface, compared to ~0.16m below the surface at IMG and they stored a mean 216 litres more per metre squared than IMG (Puttock & Brazier, 2014). In addition to this, modelling analysis showed that a 30% increase in culm grassland could lead to a 7% reduction of a flood peak (Ellis, 2021). An analogy referred to by Devon Wildlife Trust (2022) is that "*Culm grassland acts a little like a leaky bucket, holding and releasing water more slowly than more intensive land uses.*

The literature reviewed implies that rhos pasture could provide three water ecosystem services, including a reduction in water pollution, water sediment loads and flood risk mitigation. The latter is explored further in the hydrological data review. These services might be of interest to others in the region such as Welsh Water. This is discussed in the financing section of the report. The Solent and Carmarthenshire nutrient mitigation case studies in Appendix A are also useful to draw upon as examples of nutrient mitigation through ecosystem services.

3.2 HYDROLOGICAL DATA REVIEW

The following review of hydrological features identifies potential techniques for nature-based solutions and natural flood management. These measures may reduce surface water runoff and provide associated water benefits in this catchment.

EXISTING FLOOD RISK IN THE WYE RIVER CATCHMENT

The River Wye is part of the Severn River Basin District, with the Wye entering the Severn Estuary south of Chepstow. Extensive flood risk is identified adjacent to the main channel of the Wye, particularly where confluences with tributary watercourses coincide. The downstream settlements close to the River Wye, such as Newbridge-on-Wye, are particularly sensitive receptors.

WATER FRAMEWORK DIRECTIVE

The Water Framework Directive (WFD) classification is used to identify water risks. The WFD requires characterisation of water bodies, across several measures. A key objective is to seek to achieve (at least) 'good' overall status, identifying and seeking to address negative pressures that prevent attainment of this target status. The WFD uses a system developed by the Environment agency for different water body locations. Using this system, the water bodies within the area of interest (as stipulated by RWT) include the River Wye (confluence Afon Elan to confluence R. Ithon) (GB109055042250) and the Afon Dulas. The WFD classification for these river water bodies is '*Moderate overall status'* and the catchment risks have been identified as following:

- Sediment levels
- Polycyclic aromatic hydrocarbons
- Invasive Species – Himalayan Balsam, Floating Pennywort, Red Swamp Crayfish (and overall invasive species)

The risks are common to all sites within the rhos pastures project.

NATURE-BASED SOLUTIONS / NATURAL FLOOD MANAGEMENT FOR WATER ENVIRONMENT

Nature-based solutions such as NFM seek to enhance natural processes and to provide local benefits to the water environment and the wider catchment, if scaled-up regionally. Table 2 summarises potential water benefits from nature-based solutions. Rhos pasture restoration/ preservation ties in with the land management category of Table 2.

Table 2 - Summary of Nature-based Solutions for the Water Environment

Measure Group	Specific Measure	Water Environment Benefits
Woodland creation	Catchment woodlands	▪ Runoff attenuation ▪ Improved infiltration
	Floodplain woodlands	▪ Runoff attenuation ▪ Improved infiltration
	Riparian woodlands	▪ Runoff attenuation ▪ Improved infiltration

Land management	Land and soil management practices	▪ Runoff attenuation ▪ Reduced sediment load ▪ Improved infiltration
	Agricultural and upland drainage modifications	▪ Runoff attenuation ▪ Reduced sediment load
	Non-floodplain wetlands	▪ Runoff attenuation ▪ Reduced sediment load ▪ Improved infiltration ▪ Water quality improvements
	Overland sediment traps	▪ Runoff attenuation ▪ Reduced sediment load
River and floodplain restoration	Riverbank restoration	▪ Reduced sediment load
	River morphology and floodplain restoration	▪ Increased floodplain storage ▪ Reduced sediment load
	In-stream structures	▪ Runoff attenuation ▪ Increased storage
	Offline storage ponds and washlands	▪ Increased storage ▪ Reduced sediment load ▪ Improved infiltration ▪ Water quality improvements
	Online storage	▪ Runoff attenuation ▪ Reduced sediment load ▪ Water quality improvements

Wet pasture/grassland/heathland such as rhos pastures are likely to offer existing water ecosystem services, this land use typically features minimal drainage and low intensity/stocking levels of livestock. For those locations in current good condition, water retention on low-gradient slopes will be relatively high due to inefficient drainage pathways, potential ponding of overland flow, vegetation providing higher surface roughness values and less compacted soil enabling better water infiltration. These factors combine to 'slow the flow' (i.e., lessening and slowing down surface water runoff) and reduce sediment and contaminant transport from such sites to local watercourses. Where pasture habitats are degraded, such as areas that are more effectively drained or more intensively grazed, it would be expected that there will be less valuable ecosystem services to the water environment.

4 REVIEW OF SPECIFIC SITES WITHIN RHOS PASTURES PROJECT

RWT provided WSP with a representative group of five sites, with varying condition status, to enable feasible opportunities to be considered for local hydrological measures at this early stage of the project. Each of these has been discussed in the subsections below.

The recommendations made in this section are subject to landowner permission and individual situations. RWT can only implement these recommendations in cooperation with the relevant landowner.

4.1 SITE 1 (LANDOWNER NOT CONTACTED) - SLIGHTLY DEGRADED CONDITION / GOOD CONDITION

The Flood Risk Assessment Wales Map (Natural Resources Wales, 2022) identifies:

- Flood Risk from Rivers – High, adjacent to Nant Treflyn channel (North / South) and extensive areas downstream of Argoed Bridge at confluence with River Wye, extending downstream on River Wye
- Flood Risk from Surface Water and Small Watercourses – Low on tributary channel on site (North). High on tributary channel and ponds (South)

The flood risk indicated would suggest that opportunities to reduce local runoff and increase lag time for peak flows would be beneficial to downstream receptors.

The Maps for NFM (Natural Resources Wales, 2021) suggests Areas of Potential for:

- Additional floodplain woodland - at western extent, adjacent to Nant Treflyn channel
- Additional riparian woodland - extending further east from Nant Treflyn channel
- Additional catchment woodland – across site
- Runoff attenuation features to reduce 1/30 annual probability flows – centre of south site
- Runoff attenuation features to reduce 1/100 annual probability flows – centre of south site

However, it is understood that the RWT does not plan to increase tree coverage in the rhos pasture sites. The runoff attenuation zone identified covers a relatively small area in the centre of the southern site.

From review of GoogleEarth imagery, artificial drainage features are more apparent in the northern site (identified by RWT as a slightly degraded), compared to the southern site (good). These channels are likely to more efficiently drain the local pasture, thereby transferring water to Nant Treflyn more effectively and reducing groundwater level.

Surface water flow is likely to travel from east to west, from GoogleEarth review. The northern site appears to have more modified land use on the eastern boundary, potentially improved grassland, which may include drainage channels that are reducing water input to the site. By contrast the sloped area to the east of the southern site appears to be a combination of woodland and rough grazing, where there could be potential to further improve water retention.

RECOMMENDATIONS

The small watercourse flood risk identified in South area (tributary to Nant Treflyn) may be a more feasible feature to address within the site than the issues relating to the larger Nant Treflyn channel. RWT should seek to understand potential for more water retention within South area, possibly increasing capacity of existing online ponds, creation of additional offline storage as well as runoff attenuation on the tributary of the Nant Treflyn. Land management techniques to increase infiltration and reduce overland flow should be considered.

4.2 SITE 2 (LANDOWNER 7) - DEGRADED CONDITION

The Flood Risk Assessment Wales Map (Natural Resources Wales, 2022) identifies:

- Flood Risk from Rivers – High for extensive areas downstream on River Wye
- Flood Risk from Surface Water and Small Watercourses – High/Medium on tributary channel on site

The flood risk indicated would suggest that opportunities to reduce local runoff and increase lag time for peak flows would be beneficial to downstream receptors.

The Maps for NFM (Natural Resources Wales, 2021) suggests Areas of Potential for:

- Additional catchment woodland – across the site
- Runoff attenuation features to reduce 1/30 annual probability flows – on site and downstream
- Runoff attenuation features to reduce 1/100 annual probability flows – on site and downstream

As discussed previously, it is understood that RWT does not plan to increase tree coverage in the rhos pasture sites. Runoff attenuation within this catchment is suggested as having potential for NFM, with zone of interest extending downstream of the site.

Based on GoogleEarth review, the area to the east of the stream appears to be improved grassland, with the western area appearing less modified. It is likely that artificial drainage is present in the area to the east, perhaps including a subsurface network of field drains.

RECOMMENDATIONS

The small watercourse flood risk may be feasible to address within the site. RWT should seek to understand potential for more water retention within this area, possibly involving the creation of offline storage as well as runoff attenuation on this tributary of the River Wye. Land management techniques to increase infiltration and reduce overland flow should be considered, as well as disconnection or removal of any existing field drains.

4.3 SITE 3 (LANDOWNER 2) - VERY GOOD CONDITION (ASSUMED)

This location is assumed to be in very good condition, given SSSI status and SSSI citation that it is “considered one of the finest and botanically rich damp-wet heathy pasture in Radnor” (Countryside Council for Wales., 1989). It includes acidic and base-rich vegetation communities, with a series of wet ditches and hollows at the northern extent.

The Flood Risk Assessment Wales Map (Natural Resources Wales, 2022) identifies:

- Flood Risk from Rivers – High, downstream of site at confluence with River Wye

- Flood Risk from Surface Water and Small Watercourses – High on Rhyd-y-ceir Brook on site, particularly at confluence of main channels. Overland flow entering the brook from the north

The flood risk indicated would suggest that opportunities to reduce local runoff and increase lag time for peak flows would be beneficial to downstream receptors.

The Maps for NFM (Natural Resources Wales, 2021) suggests Areas of Potential for:

- Additional riparian woodland - both banks of the Rhyd-y-ceir Brook
- Additional catchment woodland – across the site
- Runoff attenuation features to reduce 1/30 annual probability flows - upstream
- Runoff attenuation features to reduce 1/100 annual probability flows - upstream

As discussed previously, it is understood that RWT does not plan to increase tree coverage in the rhos pasture sites. Runoff attenuation measures may be more beneficial upstream of the site.

Following review of GoogleEarth, runoff attenuation suggested upstream may coincide with plantation forestry, with extensive artificial drainage networks often created at time of planting, ploughed slopes and furrows also act as an effective pathway for runoff in commercial forestry plantations. No areas of bare peat were noted during review of GoogleEarth data, indicating good vegetation coverage and limited opportunity for peatland erosion and degradation. Commercial forestry on the margins of the site may be drawing down the local water table.

RECOMMENDATIONS

The small watercourse flood risk may be feasible to address within the site. RWT should seek to understand potential for more water retention within this area. Runoff attenuation and drain blocking within and upstream of the SSSI could be used to increase groundwater levels and moisture content of soils, if this was aligned with the site management objectives for this SSSI. There is also potential for creation of offline storage as well as techniques to reduce overland flow prior to reaching defined channels.

4.4 SITE 4 (LANDOWNER 4 & 5) - GOOD CONDITION

The Flood Risk Assessment Wales Map (Natural Resources Wales, 2022) identifies:

- Flood Risk from Rivers – High, adjacent to Afon Dulas confluence, with an extensive area downstream and at confluence with River Wye
- Flood Risk from Surface Water and Small Watercourses – High on tributary channel on site, with this zone extending into upper reaches of catchment

The flood risk indicated would suggest that opportunities to reduce local runoff and increase lag time for peak flows would be beneficial to downstream receptors.

The Maps for NFM (Natural Resources Wales, 2021) suggests Areas of Potential for:

- Additional floodplain woodland - adjacent to Afon Dulas channel
- Additional riparian woodland - adjacent to Afon Dulas channel
- Additional catchment woodland – across the site
- Runoff attenuation features to reduce 1/30 annual probability flows – on site and upstream
- Runoff attenuation features to reduce 1/100 annual probability flows – on site and upstream

As discussed previously, it is understood that RWT does not plan to increase tree coverage in the rhos pasture sites. Runoff attenuation measures may be more beneficial upstream of the site, with more limited opportunities on the lower part of the watercourse pre-confluence with Afon Dulas.

This pasture is at the base of a slope, adjacent to the Afon Dulas. From review of GoogleEarth, this pasture appears less improved than adjacent farmland. The tributary channel to the Afon Dulas that flows through this site has been identified as having potential for runoff attenuation.

RECOMMENDATIONS

The small watercourse flood risk may be feasible to address within the site. RWT should seek to understand potential for more water retention within this area. Runoff attenuation and drain blocking could be used to increase groundwater levels and moisture content of soils. There is also potential for creation of offline storage as well as techniques to reduce overland flow prior to reaching defined channels and the Afon Dulas.

5 OPPORTUNITIES TO ‘SLOW-THE-FLOW’ AT RHOS PASTURES

These measures are probably most applicable to locations in a more degraded condition but could boost the existing ecosystem services provided at any of the grassland locations.

- Runoff Attenuation:
  - drain-blocking of artificial channels
  - installation of leaky dams, on natural or artificial channels using woody debris or wooden structures to restrict peak flows (out of bank conditions) and temporary ponding behind barriers (online storage)
  - increasing surface roughness of overland flow, for example by varying vegetation cover, introducing filter strips, sustainable land management, or retaining woody debris on flow paths
- Increased Storage of Water:
  - encouraging offline storage adjacent to existing channels, diverting peak flows into detention zones
  - excavating existing hollows or creating depressions on overland flow pathways
  - naturalising channels to reintroduce meanders in modified/straightened reaches, reducing flow rate and increasing watercourse channel capacity, including excavating online storage ponds on channel pathway
- Improved Infiltration:
  - encouraging infiltration pathway for overland flow and waterlogged areas to reach groundwater

The flow attenuation benefits of such techniques are difficult to accurately quantify (see estimates quoted in the water literature section above). Peak flow mitigation may be more likely to be realised for higher frequency/lower intensity storm events, as saturated ground conditions are likely to limit the benefit during more extreme events. However, pre-installation, care should be taken to review the potential of synchronising peak flows from various channels, prior to implementation of new measures.

Further benefits are likely to be obtained from ‘slowing the flow’ with sub-catchments, these are achieved by a combination of features including:

- Reducing potential erosion/scour, with lower flow rates having less energy to erode channel banks/bed
- Less sediment loss from agricultural land due to reduced erosion and also encouraging sediment drop-out in detention basins, reducing requirement to import material or fertiliser
- Infiltration of runoff via soil will act as a filter to remove/retain sediment and reduce fertiliser wash-off, with nutrients retained.
- Recharge of groundwater resource
- Less sediment deposition downstream in catchment, where it may exacerbate existing flood risk conditions and possible requirement for dredging
- Natural processes in constructed wetland zones will reduce nutrient load to receiving channels
- Improvement to water quality and habitat management due to reduced sediment transport/deposition

In addition to the above. The risk of increased sediment load in this area, identified in the WFD classification for the River Wye, is a matter that can be attenuated by application of nature-based solutions/natural flood management techniques.

6 ECONOMIC ANALYSIS OF RHOS PASTURE VALUE

The economic value of rhos pasture could be assessed through a robust economic analysis that exposes the value of the habitat's ecosystem services for society, people, and markets (SH Ecosystems Knowledge Network, 2022). This value could be determined by procuring the services of a qualified environmental economist to calculate the monetary value (Natural Resources Wales, 2015). Non-monetary values can also be assessed using established tools, such as the NATURE tool that takes set habitat types and gives scores for the different services they provide. Two relevant economic valuations of ecosystem services are provided in Table 3.

Table 3 - Example Ecosystem Service Economic Valuations

Example 1: Estimated economic value of purple moor grass and rush pasture SSSIs with current conservation funding (~22500 ha) ecosystem services in Wales and England. (Christie & Rayment, 2012).

Ecosystem service	Estimated value (£/yr)	Estimated value (£/ha/yr)
Research and Education	830,000	37.89
Climate Regulation	650,000	28.89
Water Regulation	580,000	25.78
Sense of Experience	1,370,000	60.89
Charismatic Species	3,030,000	134.67
Non-charismatic Species	600,000	26.67

Example 2: Estimated economic value of Devon's Culm grassland (~6420 ha) water and carbon ecosystem services. (Cowap et al., 2015).

Ecosystem service	Estimated value total (£)	Estimated total value (£/ha)
Value in 2015	14,723,000	2,293.30
Additional value that can be added with further restoration works	9,139,000	1,423.05

Once the value has been demonstrated RWT can determine how that value can be tapped into through finance i.e., new revenue and new investment (SH Ecosystems Knowledge Network, 2022). This should be a process that is done with landowners where discussions where the calculated value of the rhos pasture services are and they can decide whether to dip into this value as a source of income diversification. If they choose to; the market can be assessed and new sources of payments for rhos pasture ecosystem services can be investigated together.

7 FINANCING PAYMENTS FOR RHOS PASTURE ECOSYSTEM SERVICES

7.1 SUSTAINABLE FARMING SCHEME

The Sustainable Farming Scheme (SFS) is a government run scheme, that comes into effect in 2025, has been advised as the "*most practical, and viable, way for farmers to financially benefit from rhos pasture conservation/preservation in the long-term*" (SH Welsh Government, 2022). An outline of the SFS is due to be published in June 2022, but how much detail it will contain is uncertain. The Welsh Government stakeholder stated that under the scheme there will likely be financial incentives for carbon capture and management of priority habitats. Rhos pasture preservation, with its carbon rich soils, would be suitable for the carbon capture aspect of this. However, it is worth noting that any payments are likely to be for something that is 'additional' i.e., not carbon stocks already present but for sequestering additional carbon. So, it's likely that landowners will need to demonstrate some enhancement and/or avoided change of use (to IMG).

In addition to carbon storage, rhos pasture might be eligible for the incentive for managing priority habitats depending on its biodiversity status. Suggesting that the more restored or sensitively managed, the better the chance of receiving financial top ups for its preservation. Financial incentives will be paid on a per hectare basis and there will be financial rewards for things that go above and beyond the minimum (SH Welsh Government, 2022). RWT are advised to review the SFS second consultation document (Welsh Government, 2020) that gives an insight into the aims of the scheme and to read through the details of policy's found in at the Welsh Government's 'Farming and Countryside Planning Strategy (Welsh Government, 2022).

It is also possible that SFS will have water-related objectives of clean water, reduced risk of harm from flooding and mitigating and adapting to climate change (like the English equivalent – the Sustainable Farming Initiative (SFI). The early stages of SFI includes pilot studies to aid establishment of standards, including potential payments for low input grassland, hedgerow and waterbody buffering outcomes. Rhos pasture preservation could align with these targets if similar ones are included in the Welsh SFS.

The Culm Grassland Natural Flood Management project is a useful example for RWT to draw upon as a large amount of the restoration work was funded from payments to farmers through the Government's Countryside Stewardship grants (SH Devon Wildlife Trust, 2022). Devon Wildlife Trust established buy ins through the scheme for the biodiversity of Culm grasslands. Richer plant habitats added to the economic value and helped pushed them from mid-tier to a higher tier (SH Devon Wildlife Trust, 2022).

7.2 CHARITABLE SOURCES OF FUNDING

Charitable funding could be secured to help the long-term establishment of payments for ecosystem services at the rhos pasture sites. Two viable options are to apply for a grant from the Heritage Lottery Fund or the Esmee Fairbairn Foundation (SH Ecosystems Knowledge Network, 2022). Both organisations are interested in nature preservation and novel finance. They are likely to want to support a project that is rooted in Welsh heritage, helping to meet economic needs and is part of a long-term strategy for developing sustainable ecosystem services. Key themes of carbon, nature and livelihoods should be drawn upon for the application (SH Ecosystems Knowledge Network, 2022).

These organisations would also be interested in projects that promote public awareness of natural cultural heritage (SH Ecosystems Knowledge Network, 2022). Grants through charitable sources could be part of slower longer-term approach to rhos restoration, stakeholder appreciation and the development of payments for ecosystem services. See the Carmarthenshire Bogs Project and Pont Pren in Appendix A.

7.3 UK FARM SOIL CARBON CODE (UKFSCC)

The UK Farm Soil Carbon Code (UKFSCC) could be a possible source of future payments for carbon capture or regenerative farming at the rhos pasture sites. The code will set out ways for farmers to quantity and validate reductions in greenhouse gas emissions and soil carbon sequestration through the adoption of regenerative farming (Sustainable Soils Alliance, 2022). The code is currently being trialled and a date of inception has not been announced but it is estimated that it could lead to an additional £500 m of annual revenue for farmers by 2030 (Farming & Wildlife Group South West, 2021). The organisers of the UKFSCC were not able to engage with WSP during the time of the feasibility study but RWT are advised to contact them to discuss the future edibility of rhos pasture restoration/preservation and what steps would be needed to qualify for the code.

7.4 PRODUCT DIVERSIFICATION

Rhos pastures rich biodiversity can provide novel produce for farmers and although not explored in this study, nature-based tourism is also an option. The existing land use practices in the rhos pastures sites are likely to provide benefits due to the less intensive farming practices on these wet pasture/grasslands, as baseline conditions. Less degraded sites would be expected to provide greater benefits.

High quality beef can be produced from controlled cattle grazing (i.e. lower stocking densities) on the sites. This beef is higher quality because of the cattle's varied diet (SH Devon Wildlife Trust, 2022). Farmers who do well in the high-quality beef market tend to sell directly to high-end restaurants or to customers through beef boxes (SH Devon Wildlife Trust, 2022). This could provide an additional income for farmers and encourage them to implement controlled cattle grazing which also has benefits for biodiversity. RWT are advised to contact '*Farm Wilder*' (an organisation that market premium beef and lamb only from farms who practice conservation grazing) as they could offer advice and possibly collaborate with RWT on this (Farm Wilder, 2019).

Another suggested income source from the rhos pasture is to mow it for hay. This will depend on the status of the rhos pasture, and it cannot be done where the *Marsh Fritillary* butterfly might be present, but some sites will be suitable (RWT are advised to discuss more with Devon Wildlife Trust). Rhos pasture can provide good quality hay, for example - small bales of high-quality hay to sell to local horse owners for bedding or feeding, depending on the status of the rhos. The economic value of grass cut down and cured for livestock feed e.g., straw, hay, or silage can be assessed using Defra's relative feed values (Defra, 2022).

7.5 WILDER CARBON

Wilder carbon is a carbon standard that has been developed to sell carbon credits to approved buyers through restoration of native UK habitats (Wilder Carbon, 2022). The types of projects that are eligible include conversion of farmland to species rich grassland and rewetting of drained peatlands. Some of the rhos pasture areas or the re-establishment of rhos pasture where it is degraded might be eligible

under wilder. The minimum project term is 50 years, and the guidance suggests that a group of landowners would need to be involved. This is a possible option for RWT to explore further and interest in developing a project could be expressed to Wilder Carbon.

7.6 LENS (LANDSCAPE ENTERPRISE NETWORKS)

Landscape Enterprise Networks (LENs) is an approach used to connect suppliers of multifunctional landscape services (i.e., owners of landscapes with ecosystem services), and the demand-side entities which seek to benefit from them (i.e., potential markets for the ecosystem services) (LENs, 2022). The LENs approach identifies new examples of valuable landscapes and credible suppliers through appropriate third-party assurances, auditing, and accreditation (LENs, 2022). LENs can also bring together demand-side entities with shared interests, whose procurement of landscape assets may be bolstered in a partnership (LENs, 2022).

7.7 NATIONAL PEATLAND ACTION PROGRAMME (NPAP)

It was suggested that funding for restoration could be acquired through Natural Resources National Peatland Action Plan (NPAP). However, the plan is concerned with predominantly peat areas. Nonetheless, the Welsh Government stakeholder advised that it is worth RWT contacting the project coordinators and explaining their plan for the rhos pasture. With its peat resources being explored, the sites might be a viable candidate under the plan (SH Welsh Government, 2022). Contacts suggested for the NPAP have been passed on to RWT in a separate document.

7.8 THE PEATLAND CODE

The stakeholder from the Welsh Government's Natural Resources department stated that because rhos pasture tends to be over a layer of peat, and have various qualities of a peat habitat, it may have appreciable carbon stores and be eligible for financing through the Peatland Code. However, the Peatland Code needs to be broadened to better accommodate transitional environments like rhos pasture (SH The Wildlife Trusts, 2022). It is currently more suited to blanket bogs and raised bogs as vegetation proxies from these habitats inform the carbon sequestration estimations used (SH The Wildlife Trusts, 2022). In addition to this, the Peatland Code application process was described as 'long and tricky' and made problematic by the length of agreement and site-specific qualities required (SH Welsh Government, 2022). The code requires landowners to sign up for 30 years and they can be resilient to this length of agreement because of the emergence of new schemes in current climate (SH Welsh Government, 2022). Considering these complexities this seems to be a less viable opportunity to access funds in the short-term and may be something to consider for the future. Further advice is therefore included for future use.

Before applying for the Peatland Code, site assessments would need to be carried out (SH Welsh Government, 2022). The site assessments would identify the peat resource present and if large amounts of underlying peat are found it might be reclassified as a groundwater fed fen (SH The Wildlife Trusts, 2022). Such information would inform a possible agreement under the peatland code. In addition to the site assessments, it is advised that a group of landowners should come together to apply and benefit from economies of scale, as it is not cost-effective to apply for individual sites (SH Welsh Government, 2022).

7.9 COOPERATION WITH WELSH WATER

There are several examples of water companies providing payments for ecosystem services including culm grassland restoration and grassland creation. See the Culm Grassland Natural Flood Management Project, the Solent nutrient issue, the Carmarthenshire phosphate issue and the River Wyre case studies in Appendix A. These payments are for the provision of clean water, where grassland preservation or expansion is used as a nature-based solution to reduce nutrient and sediment loading.

Welsh Water is currently not providing payments for ecosystem services, except in a few instances where they have match funded large-scale projects, such as the Brecon Beacons Mega-Catchment project (see Appendix A) (Welsh Water, 2022). However, they are open to contribute funds to learning opportunities between themselves and landowners/farmers. These learning opportunities will assist famers in becoming more sustainable and economically efficient and benefit Welsh Water too (SH Welsh Water, 2022). They benefit Welsh Water because it means they can reduce the levels of water treatment downstream.

Welsh Water are predominantly interested in nature-based solutions to reduce sediment loads and pollution into rivers. As a result, they will work with farmers to learn ways to mitigate these factors. This might include the following:

- Financing soil analysis, so that the level of fertilizer application is appropriate.
- Working with farmers to reduce sediment run off from soils in flash floods (rhos pasture preservation / restoration fits in with this).
- Financing animal testing for cryptosporidium, to prevent sheep and cattle losses and reduce its presence in water bodies.
- Working with local authority to implement nature-based solutions to chemical loading in water.

(SH Welsh Water, 2022)

Welsh Water are still learning and trying to understand how these natural interventions work. Until they have a database of proven costs and benefits for capital investment in restoration, they will remain hesitant to make payments for ecosystem services (SH, Welsh Water, 2022). However, it is feasible that as that database strengthens Welsh Water might become involved more with funding projects that mitigate their water issues. As it stands, they are keen to be involved in the learning process and this represents an opportunity for RWT to gain funds/assistance in using rhos pastures for some of the mitigation measures discussed above.

8 LANDOWNER PERSPECTIVES

8.1 UNDERSTANDING OF RHOS PASTURE ECOSYSTEM SERVICES

WSP held telephone calls with seven landowners of rhos pasture in the Radnorshire area to understand local landowners' perspectives. The landowners were identified by RWT. Most of the landowners were unfamiliar with the term 'ecosystem service' but they were aware that rhos pasture provides benefits for the environment and society, and that these can be enhanced through land management practices. Such benefits include carbon storage, biodiversity, recreation, water retention and flood mitigation.

Some examples include, landowners being aware that the rhos pasture held high carbon content and organic matter and that this could lead to payments for carbon credits in the future. Landowner 5 also remarked on the peat storage on their land. Natural Resources Wales are presently undertaking surveys of this peat resource and initial findings report depths up to 1.8 m. One landowner had also observed that rhos pastures, with their rough vegetation, had a higher water retention capacity compared to areas with smoother vegetation (Landowner 4); this feature is corroborated by scientific findings e.g., Ellis (2021). Moreover, Landowners 4 and 5 are already tapping into some of the educational and tourism value of rhos pasture ecosystem services. They manage their pastures as a nature reserve and make a second income through a self-catering cottage where wildlife enthusiasts can stay.

8.2 PAYMENTS FOR ECOSYSTEM SERVICES

Some of the landowners are already working with RWT to restore rhos pastures as part of the Rhos Pasture Restoration Project (Landowners 7, 5 and 4). This restoration includes re-wetting of habitats, pond creation, cattle grazing and species reintroduction. Landowners 4 and 5 have ambitions for scientific data to be collected at the sites to underpin management strategies and secure future funding, and they are prepared to work with RWT to establish this database. Furthermore, they are happy to continue this work into the future, in the hope that it remains eligible for ecosystem services payments. In addition, other residents have no intention of improving their rhos pastures for agriculture, so would be happy to preserve or restore it in exchange for payment (Landowner 3 and 6). Landowner 6 also knew of other rhos pasture areas, not included in the current project, that could be restored.

Landowner 4 has engaged with other landowners during the project and states that most are interested in restoration of their rhos pasture and have no interest in improving the land for agricultural production. They want to know what they can do in terms of management to make their sites more applicable for ecosystem service payments e.g., planting, cattle grazing, subtle diversification. However, they are hesitant to become further involved before they can see evidence that there is a payment system in place for improvement of rhos pasture ecosystem services (Landowner 7). Nonetheless, engagement / interest with the current project has been good and Landowner 7 does not foresee any issues in establishing collaborative projects in the future. Landowner 4 agrees and thinks many landowners would be willing to contribute to the scheme as a whole if they feel part of the masterplan (Landowner 4).

There are some potential barriers to setting up payments for ecosystem services. One landowner stated that many fear that some of their money will be lost to those facilitating ecosystem service

payments, like RWT. They would need to be assured that all of the money was being paid directly to them (Landowner 1). In addition, they need to know why any new initiatives would be of benefit to them. Landowner 1 stated that young farmers want to progress and want to push towards where the economy is i.e., grazing more sheep, not less. Farmers don't want their profitability or freedom restricted.

9 RECOMMENDATIONS

9.1 LANDOWNERS

- To take landowner opinions into consideration when it comes to sustainably managing their land, as some of them have done so for several generations (Landowner 2). This ties in with advice received from other stakeholders i.e., that the development of ecosystem services needs to be a conversation that starts with landowner views and needs (SH Ecosystems Knowledge Network, 2022).
- Ecosystem services will be favoured if they benefit local companies, not multi-national corporations (Landowner 1 and 2). This lends itself to the LENs approach.
- The farming community are more aware of available schemes than land managers who aren't farming. Farmers know that there are changes afoot, and that rhos pasture could be a market to tap into, but non-farming landowners might be less aware (Landowner 7).
- Project management should involve people on the ground as face-to-face contact is preferable (Landowner 4).
- Future ecosystem payments need to consider inflation over time. Capital costs have previously been set to a given time, but the costs rose considerably during the project.

9.2 SITE SURVEYING

- Site surveys and investigations of rhos pastures ecosystem services should be undertaken to foster a database that can be used to underpin policy action and boost access to funds available. Surveys and investigations suggested are:
  - Soil surveys that assess topsoil and subsoil, particularly to quantify the full carbon resource.
  - Up to date vegetation assessments.
  - Surveying and sampling a good example rhos pasture profile (i.e., not degraded or within proximity to intense agricultural land) to provide a benchmark of a good quality profile and identify carbon sequestration potential of the poorly maintained pastures.
  - Surveying and sampling the degraded areas to help in the assessment of how to improve soil health at these locations.
  - Additional peat resource surveys to better estimate carbon storage and sequestration potential.
  - A review of historical mapping to identify previous land uses at each site. This may be beneficial if current landowners do not have such information. Having fertiliser application history, along with details of artificial drainage, would be advantageous.
  - Conduct scientific experiments that assess factors like rates of erosion and infiltration (see Ellis, 2021 and Puttock & Brazier, 2014) to validate likely rhos pasture ecosystem services.

9.3 NATURAL FLOOD MANAGEMENT

- NFM could be enhanced, particularly on the degraded sites, by consideration of measures to attenuate runoff and introduce greater water storage, alongside land management practices to enhance surface roughness and encourage infiltration. Targeting small watercourses and overland flow patterns would be suggested as priorities for ongoing consideration. Such measures are most effective in headwater zones, where they can also seek to reduce sediment loss at source.

- The feasibility of NFM is likely to be enhanced when considered alongside secondary benefits relating to sustainable land management, fluvial geomorphology, water quality, habitat creation, peat restoration and carbon storage.
- Partnerships that target environmental improvements, alongside reduction of flood risk, are more likely to source funding and deliver NFM outcomes.
- NFM provide greatest benefits in more frequent storm events, rather than the more extreme higher intensity and/or prolonged rainfall events.
- The most demonstrable flood-related benefits of NFM are often in upland catchments, presenting more opportunity for runoff reduction and offline storage on less productive agricultural land.
- NFM measures are often longer-term solutions requiring several years to fully demonstrate anticipated benefits.
- Although not a priority to RWT, in order to enhance any improvements, consideration should be given to the benefits of scrub and hedge planting along margins of wet pasture land, particularly where these may intercept surface flows across sloping ground and adjacent to peripheral drains. Such planting introduces root structures that are likely to aid infiltration and containment/uptake of nutrients before these reach local surface water channels. There can be associated benefits to farmers from livestock shelter and harvesting of wood materials, as noted in the Pontbren Project (see Appendix A).

9.4 ECOSYSTEM SERVICES

- Rhos pasture should be preserved where possible. A core message that came out of the literature is that it is better to have semi-natural grasslands than intensively managed grasslands for agriculture. The conversion or loss of semi-natural grasslands leads to the rapid loss of many ecosystem services.
- Assess local needs for ecosystem services in the area with potential investors. The hydrological data review demonstrated that a reduction in sediment loads is a target in the Radnorshire area, so this may be an issue that rhos pasture could mitigate.
- Further investigate financing options presented in this report.
- Engage further with stakeholders involved in this study.
- Draw on the case studies provided in Appendix A.
- Contact Welsh Governments Agricultural Land Use & Soil Policy Advisor who was unable to engage with WSP during this feasibility study.
- Maximise ecosystem services by implementing appropriate management strategies. These include, controlled grazing, scrub management, discouraging pond creation, re-seeding and controlled burning (swaling) (SH Devon Wildlife Trust, 2022).
- Develop a GIS database to facilitate a quick appraisal of the possible ecosystem services for policy implementation development.
- Assess the economic value of rhos pasture ecosystem services through an economic analysis assessment.
- Discuss with landowners about ways to tap into the value identified by the economic analysis assessment.
- Strong landowner, farmer and community engagement will aid implementation of ecosystem service projects to achieve best outcomes.
- Multi-organisational projects should also be considered. For example, collaborating with utility companies, local universities, and museums.

- Seeking to achieve and maximise multi-benefits will enable access to wider funding sources, with objectives often complementary in terms of land management, habitat, water quality and flood risk.

10 REFERENCE LIST

Bardgett, R., (2022). Presentation at British Soil Society 'Zoom into soil' meeting. (February 2022).

Bengtsson, J., Bullock, J.M., Egoh, B., Everson, C., Everson, T., O'Connor, T., O'Farrell, P.J., Smith, H.G. and Lindborg, R., (2019). Grasslands—more important for ecosystem services than you might think. Ecosphere, 10(2), p.e02582.

Bengtsson, J., Bullock, J.M., Egoh, B., Everson, C., Everson, T., O'Connor, T., O'Farrell, P.J., Smith, H.G. and Lindborg, R., (2019). Grasslands—more important for ecosystem services than you might think. Ecosphere, 10(2), p.e02582.

Biggs, J., Stoate, C., Williams, P., Brown, C., Casey, A., Davies, S., Grijalvo Diego, I., Hawczak, A., Toshikazu, K., McGoff, E., and Szczur., J., (2014). Water Friendly Farming: Results and practical implications of the first three years of the programme. Available online at:> Link to reference (Accessed March 2022).

Carmarthenshire County Council (2022). Carmarthenshire Bogs Project. Available online at:> Link to reference (Accessed March, 2022).

Carmarthenshire County Council., (2021). How new phosphate targets may impact on your development. Available online at:> Link to reference (Accessed February, 2022).

Cerdan, O., Govers, G., Le Bissonnais, Y., Van Oost, K., Poesen, J., Saby, N., Gobin, A., Vacca, A., Quinton, J., Auerswald, K. and Klik, A., (2010). Rates and spatial variations of soil erosion in Europe: a study based on erosion plot data. Geomorphology, 122(1-2), pp.167-177.

Christie, M. and Rayment, M., (2012). An economic assessment of the ecosystem service benefits derived from the SSSI biodiversity conservation policy in England and Wales. Ecosystem Services, 1(1), pp.70-84.

Countryside Council for Wales., (1989). Powys – Rhos Rhyd-Y-Ceir. Site of Special Scientific Interest Citation.

Cowap, C., Warren, S., Puttock, A., Brazier, R., and Elliot, M., (2015). The Economic value of ecosystem services provided by Culm Grassland. Report available online at:> Link to reference (Accessed January 2022).

de Vere, N., (2020). Creating a biophilic Wales: increasing the health and wellbeing of people, biodiversity, and the environment. DOI 10.24823/Sibbaldia.2020.314.

Defra (2022). Animal Feed Prices. Available online at:> Link to reference (Accessed March 2022).

Devon Wildlife Trust., (2020). Culm Grassland Natural Flood Management Project. Available online at:> Link to reference (Accessed March 2022).

Elliot, D., (2004). Rhos Pasture. Available online at:> Link to reference (Accessed March 2022).

Ellis, N., (2021). How can Culm Grassland help with natural flood management? A summary of a Ph.D. study undertaken during 2016-21 by Nicola Ellis of Exeter University. Provided through personal communication with Ellis, N., (24/02/2022).

Ellis, N., Brazier, R. and Anderson, K., (2021). Comparing fine-scale structural and hydrologic connectivity within unimproved and improved grassland. Ecohydrology, 14(7), p.e2330.

Emmett, B.A., Reynolds, B., Chamberlain, P.M., Rowe, E., Spurgeon, D., Brittain, S.A., Frogbrook, Z., Hughes, S., Lawlor, A.J., Poskitt, J., Potter, E., Robinson, D.A., Scott, A., Wood, C., Woods, C., (2007). Soils Report from 2007: CS Technical Report No. 9/07. Available online at:> Link to reference (Accessed February 2022).

Environment Agency., (2010). Aire Catchment Flood Management Plan: Summary Report December 2010. Available online at:> Link to reference (Accessed March 2022).

Farm Wilder., (2019). Farm Wilder. Available online at:> Link to reference (Accessed January 2022).

Farming and Wildlife Advisory Group Southwest (FWAGSW)., (2021). [14.07.21] Press Release: Environment Agency grant kickstarts Soil Carbon Code Creation. Available online at :> Link to reference (Accessed March 2022).

Forest Research., (2022). Slowing the flow at Pickering. Available online at:> Link to reference (Accessed February 2022).

Hampshire & Isle of Wight Wildlife Trust (2020). Solent Nutrient Issue – Nature Based Mitigation Solution. Available online at:> Link to reference (Accessed February 2022).

Hodgson J.M., (1997). Soil Survey Field Handbook: describing and sampling soil profiles (3rd Edition). Rothamsted Experiment Station, Harpenden.

Hungate, B.A., Barbier, E.B., Ando, A.W., Marks, S.P., Reich, P.B., Van Gestel, N., Tilman, D., Knops, J.M., Hooper, D.U., Butterfield, B.J. and Cardinale, B.J., 2017. The economic value of grassland species for carbon storage. Science Advances, 3(4), p.e1601880.

International Union for Conservation of Nature., (2020). Integrating Natural Capital Schemes. Available online at at:> Link to reference (Accessed January 2022).

Landowner 1. Phone call with a rhos pasture landowner in Radnorshire, discussing rhos pasture Ecosystem services. (01/03/2022).

Landowner 2. Phone call with a rhos pasture landowner in Radnorshire, discussing rhos pasture Ecosystem services. (01/03/2022).

Landowner 3. Phone call with a rhos pasture landowner in Radnorshire, discussing rhos pasture Ecosystem services. (01/03/2022).

Landowner 4. Phone call with a rhos pasture landowner in Radnorshire, discussing rhos pasture Ecosystem services. (04/03/2022).

Landowner 5. Phone call with a rhos pasture landowner in Radnorshire, discussing rhos pasture Ecosystem services. (04/03/2022).

Landowner 6. Phone call with a rhos pasture landowner in Radnorshire, discussing rhos pasture Ecosystem services. (01/03/2022).

Landowner 7. Phone call with a rhos pasture landowner in Radnorshire, discussing rhos pasture Ecosystem services. (03/03/2022).

Landscape Enterprise Networks (LENs)., (2022). What is LENS? Available online at:> Link to reference (Accessed March 2022).

Millennium Ecosystem Assessment., (2005). Ecosystems and Human Well-being. Island Press, Washington.

Montgomeryshire Wildlife Trust., (2022). Pumlumon Project. Available online at:> Link to reference (Accessed 17/03/2022).

Moors for the Future., (2022). Making Space for Water in Detail. Available online at:> Link to reference (Accessed February 2022).

Natural England., (2021). Carbon storage and sequestration by habitat: a review of the evidence (second edition). Natural England Research Report NERR094. Available online at: > Link to reference (Accessed February 2022).

Natural Resources Wales., (2015). Calculating the economic values of the ecosystem services provided by Natura 2000 features and sites in Wales. Available online at:> Link to reference (Accessed March 2022).

Natural Resources Wales., (2021). Maps for Natural Flood management. Link to reference (Accessed February, 2022).

Natural Resources Wales., (2022). Check your flood risk on a map (Flood Risk Assessment Wales Map). Available online at:> Link to reference (Accessed February, 2022).

Nature Tool., (2022). Nature Tool. Available online at:> Link to reference (Accessed March 2022).

Office of National Statistics (ONS)., (2018). UK natural capital: developing semi-natural grassland ecosystem accounts. Available online at:> Link to reference (Accessed February 2022).

Puttock, A. and Brazier, R., (2014). Culm grasslands proof of concept phase 1: Developing an understanding of the hydrology, water quality and soil resources of unimproved grasslands. University of Exeter, Devon, UK.

Radnorshire Wildlife Trust, (2022). rhos Pasture Restoration Project | Radnorshire Wildlife Trust. [online] Available at:> Link to reference (Accessed March 2022).

Richter, F., Jan, P., El Benni, N., Lüscher, A., Buchmann, N. and Klaus, V.H., (2021). A guide to assess and value ecosystem services of grasslands. Ecosystem Services, 52, p.101376.

Sarukhan, J., Whyte, A., Hassan, R., Scholes, R., Ash, N., Carpenter, S.T., Pingali P.L., Bennett, E.M., Zurek, M.B., Chopra, K., Leemans, R., Kimar, P., Simons, H., Capistrano, D., Samper, CK., Lee, M.J., Raudsepp-Hearne, C., (Eds.) (2005). Millennium ecosystem assessment. Ecosystems and human well-being: Synthesis. Island Press, Washington, DC.

SH Devon Wildlife Trust (DWT)., (2022). Microsoft Teams meeting discussing rhos pasture Ecosystem services. (01/03/2022).

SH Ecosystem Services Knowledge Network., (2022). Microsoft Teams meeting discussing rhos pasture Ecosystem services (24/02/2022).

SH The Wildlife Trusts (2022). Microsoft Teams meeting discussing rhos pasture Ecosystem services. (04/03/2022).

SH University of Exeter / SEPA (Scottish Environment Protection Agency)., (2022). Microsoft Teams meeting discussing rhos pasture Ecosystem services. (24.02.2022).

SH Welsh Government (WG) (2022). Microsoft Teams meeting discussing rhos pasture Ecosystem services. (09/02/2022).

SH Welsh Water., (2022). Microsoft Teams meeting discussing rhos pasture Ecosystem services (24/02/2022).

Souchère, V., King, C., Dubreuil, N., Lecomte-Morel, V., Le Bissonnais, Y. and Chalat, M., 2003. Grassland and crop trends: role of the European Union Common Agricultural Policy and consequences for runoff and soil erosion. Environmental Science & Policy, 6(1), pp.7-16.

South West Water., (2022). Upstream Thinking. Available online at:> Link to reference (Accessed March 2022).

Sustainable Soils Alliance., (2022). Farm Soil Carbon Code. Available online at:> Link to reference (Accessed March 2022).

TEEB., (2010). The Economics of Ecosystems and Biodiversity: Mainstreaming the Economics of Nature: A Synthesis of the Approach, Conclusions and Recommendations of TEEB. TEEB.

The Environmental Impact Assessment (Agriculture) (Wales) Regulations 2017., (2017/No.565). HMSO. Available online at:> Link to reference (Accessed March 2022).

The Environmental Impact Assessment (Forestry) (England and Wales) Regulations 1999., (1999/No.2228). HSMO. Available online at:> Link to reference (Accessed March 2022)..

Villoslada, M., Vinogradovs, I., Ruskule, A., Veidemane, K., Nikodemus, O., Kasparinskis, R., Sepp, K. and Gulbinas, J., (2018). A multitiered approach for grassland ecosystem services mapping and assessment: The Viva Grass tool. One Ecosystem, 3, p.e25380.

Wakefield Council (2021). Project Verdant: Pre-feasibility study. Report not available to access on online.

Wales Rural Observatory., (2013). The Pontbren Project: The Farmers Experiences and Lessons Learnt. Available online at:> Link to reference (Accessed March, 2022).

Wang, L., Delgado-Baquerizo, M., Wang, D., Isbell, F., Liu, J., Feng, C., Liu, J., Zhong, Z., Zhu, H., Yuan, X. and Chang, Q., (2019). Diversifying livestock promotes multidiversity and multifunctionality in managed grasslands. Proceedings of the National Academy of Sciences, 116(13), pp.6187-6192.

Watch Water Wales., (2018). Water Watch Wales Map Gallery. Available online at:> Link to reference (Accessed February 2022).

Welsh Government., (2020). Sustainable Farming and Our Land: Proposals to continue and simplify Agricultural Support for Farmers and the Rural Economy. Consultation Report. Available online at:> Link to reference (Accessed January 2022).

Welsh Government., (2022). Farming and countryside planning and strategy. Available online at:> Link to reference (Accessed January 2022).

Welsh Water., (2022). Brecon Beacons Mega Catchment. Available online at:> Link to reference (Accessed February 2022).

Wilder Carbon., (2021). Version 1: Wilder Carbon Standards. Available online at:> Link to reference (Accessed February 2022).

Wilkinson, M.E., Quinn, P.F. and Welton, P., (2008). Belford Catchment Proactive Flood Solutions: Storing and Attenuating Run-off on Farms. Available online at:> Link to reference (Accessed March 2022).

Appendix A

RELEVANT CASE STUDIES

Case Study	Description	References
Culm Grassland Natural Flood Management Project (Devon, England)	Led by Devon Wildlife Trust. Enhancing Culm grassland ecosystem services through restoration, including natural flood management, water filtration, biodiversity, and carbon. Scientific research by University of Exeter into Culm grassland ecosystem services conducted. Economic Analysis of Culm grassland water and carbon ecosystem services. Landowner collaboration. Increasing public awareness of the habitat. Some funding received from South West Water as part of their 'Upstream Thinking Project' to improve water supply and quality in the catchment.	Cowap *et al*., (2015); Devon Wildlife Trust (2022); SH Devon Wildlife Trust (2022); South West Water (2022).
The Brecon Beacons Mega Catchment (Brecon Beacons, Wales)	Working towards sustainable environmental management on a landscape scale. Working with all stakeholders to meet the varying needs from the catchment. For example, Welsh Water's need for clean water. Initiatives include Welsh water funding weather stations for farmers so sludge spreading can be targeted. The project is match funded. Two of the known funders are Welsh Government (through Natural Resources Wales) and Welsh Water.	Welsh Water., (2022); SH Welsh Water (2022).
Biophillic Wales (Carmarthenshire, Wales).	Led by the National Botanic Garden of Wales and funded by Welsh Government. Large scale, multi-site project aiming to enhance biophilia. Grassland management approaches were tested at Waun Las, NNR (Llanarthne) Including rhos pasture translocation, controlled grazing, and seed harvesting.	de Vere (2020)
The Pontbren Project (Powys, Wales)	Led by Wales Rural Observatory. Farmer-led initiatives across several habitats, including woodland planting, wetland/pond creation, changes to sheep grazing practice. Overall aims included: sustainable farm management, business diversification, habitat creation and upland landscape enhancement. Good insight into landowners' perspective.	Rural Observatory Wales (2013)

	Match funded by Enfys Lottery grant and Welsh Government.	
Pumlumon Project (Powys, Wales)	Montgomeryshire Wildlife Trust led. Testing the scale of ecosystem services to benefit the local economy. Enhancing ecosystem services through peat regeneration, grip-blocking and facilitating flood storage areas. Local contractors and farmers paid to do the work.	Montgomeryshire Wildlife Trust (2022).
Carmarthenshire Bogs Project (Carmarthenshire, Wales)	Led by Carmarthenshire Country Council. Aiming to restore, preserve and educate the public about the six degraded peatland sites. Scientific research by Swansea University to quantify their environmental history and carbon storage. Public outreach events at sites and National Botanic Garden of Wales. Funded by Natural Lottery Heritage Fund.	Carmarthenshire County Council (2022)
Carmarthenshire phosphate loading issue (Carmarthenshire, Wales)	Carmarthenshire County Council are struggling to meet phosphate targets, so development inhibited Welsh Water also involved and are looking for nature-based solutions to reduce phosphorus loading. Natural grassland restoration is being considered.	Carmarthenshire County Council (2021)
Solent Nutrient Issue – Nature Based Mitigation (Solent Region, England)	Hampshire & Isle of Wight Wildlife Trust (HIWWT) led. High levels of nitrogen pollution are inhibiting new development in the Solent region. HIWWT mitigating against nitrogen pollution in the area by purchasing and rewilding farmland. The scheme will allow prospective developers to purchase nitrogen credits, which will fund ongoing conversions.	Hampshire & Isle of Wight Wildlife Trust (2020).
Belford Burn Proactive Flood Solutions (Northumberland, England)	Natural flood mitigation measures implemented, including bunds on surface flowpaths, online and offline storage features, buffer strip management and sediment retention and reuse by farmers. Plans incorporated stakeholder guidance. Led by Newcastle University and Environmental Agency.	Wilkinson *et al*., (2008)
Water Friendly Farming	Freshwater Habitats Trust and the Game and Wildlife Conservation Trust.	Biggs *et al*., (2014)

(Leicestershire, England)	Testing the landscape wide nature-based mitigation measures to reduce land use impacts of freshwater resources in three comparable catchments. Measures included creating additional water storage and slowing flow via series of permeable dams, interception ponds and bunded ditches. Farming community participation. Supported by a range of agency partners.	
Slowing the Flow (Pickering, England)	Forest research led. Enhancing natural water storage to reduce future flood risk. Creation of woodland, woody debris dams and moorland drain blocking and large offline storage bund, traditional flood alleviation was not economically feasible.	Forest Research (2022)
Aire Catchment Flood Management Plan (Yorkshire, England)	Tree planting, leaky barriers, wetland creation. Links with DNAire and Aire Rivers Trust to benefit habitats and fish.	Environment Agency (2010)
Making Space for Water (Peak District National Park, England)	Government led project. Restoration of moorland (blanket bog) for flood risk reduction and other ecosystem benefits. Other ecosystem services included health and wellbeing, wildlife recreation and tourism.	Moors for the Future (2022)
Rhos Pasture Habitat Action Plan (Gwynedd)	Led by Countryside Council for Wales supported by 14 key partners. Aims to maintain existing area of rhos pasture and secure appropriate long-term management and to increase rhos pasture total area by around 5% by restoring modified/neglected sites. Promote and support grant schemes to secure favourable management/restoration Provide integrated advice to landowners or managers on appropriate management including management of associated species. Identify all areas of rhos pasture and assess the quality. Assist with development of management and establishment techniques where practicable. Raise awareness of rhos pasture to the public and landowners.	Elliot (2004)
Wyre NFM Investment Readiness Project	The Wyre Catchment Natural Flood Management project led by the Rivers Trust is leveraging green finance from investors, which can be paid back over several years by a range of organisations which will	Wyre NFM Investment Readiness Project | The Rivers Trust

	benefit from reduced flood risk and other benefits from the project. Potential buyers of ecosystem services include utilities and water companies and local businesses that would benefit from enhancements to ecosystem services provided by NFM. This project is being delivered by The Rivers Trust, Wyre Rivers Trust, Environment Agency, United Utilities, Triodos Bank, Co-op Insurance and FloodRE with funding from Esme Fairbairn Foundation and is an exemplar for a new funding model for nature-based solutions.	

Appendix B

STAKEHOLDERS LIST

A list of names for each stakeholder has been sent separately to RWT. Stakeholders are anonymised in here for confidentiality.

Landowner 1. Phone call with a rhos pasture landowner in Radnorshire, discussing rhos pasture Ecosystem services. (01/03/2022).

Landowner 2. Phone call with a rhos pasture landowner in Radnorshire, discussing rhos pasture Ecosystem services. (01/03/2022).

Landowner 3. Phone call with a rhos pasture landowner in Radnorshire, discussing rhos pasture Ecosystem services. (01/03/2022).

Landowner 4. Phone call with a rhos pasture landowner in Radnorshire, discussing rhos pasture Ecosystem services. (04/03/2022).

Landowner 5. Phone call with a rhos pasture landowner in Radnorshire, discussing rhos pasture Ecosystem services. (04/03/2022).

Landowner 6. Phone call with a rhos pasture landowner in Radnorshire, discussing rhos pasture Ecosystem services. (01/03/2022).

Landowner 7. Phone call with a rhos pasture landowner in Radnorshire, discussing rhos pasture Ecosystem services. (03/03/2022).

SH Devon Wildlife Trust (DWT)., (2022). Microsoft Teams meeting discussing rhos pasture Ecosystem services. (01/03/2022).

SH Ecosystem Services Knowledge Network., (2022). Microsoft Teams meeting discussing rhos pasture Ecosystem services (24/02/2022).

SH The Wildlife Trusts (2022). Microsoft Teams meeting discussing rhos pasture Ecosystem services. (04/03/2022).

SH University of Exeter / SEPA (Scottish Environment Protection Agency)., (2022). Microsoft Teams meeting discussing rhos pasture Ecosystem services. (24.02.2022).

SH Welsh Government (WG) (2022). Microsoft Teams meeting discussing rhos pasture Ecosystem services. (09/02/2022).

SH Welsh Water., (2022). Microsoft Teams meeting discussing rhos pasture Ecosystem services (24/02/2022).

Appendix C

RHOS PASTURE SOIL SUMMARY

Soil summary for rhos Pasture in Radnorshire

Nant-glas and the surrounding land does not fall within an area which was mapped in detail by the Soil Survey of England and Wales, nor have there been any detailed Agricultural Land Classification surveys undertaken in the area from which soil data can suitably be extrapolated.

Sheet 2 of the 1:250 000 soil map (Soil Survey of England and Wales, 1983) shows a number of associations across the study area including the Denbigh 1 and Manod (which comprise similar Soil Series), Cegin and Harfen Associations[1]. These soils mapped in the study area are a wide range of lithomorphic soils, brown earths, podzols and surface-water gleys. Due to the available data being high-level from small scale mapping and the sporadic nature of the individual pasture sites, it is not possible to delineate with accuracy the soils anticipated on each of the plots. A description of the associations has been provided below.

The Denbigh and Manod Association comprise well drained fine loamy and fine silty soils over rock. Some similar soils are present with slowly permeable subsoils and there is slight seasonal waterlogging. There is localised shallow soils and bare rock. Steep slopes are common on the landscape. The main soils are permeable and naturally well-drained, but due to the climate they remain moist throughout most years. The soils accept most winter precipitation (except on the steep slopes), but temporary water storage capacity is limited by rock or locally by compact drift present within 80 cm of the surface, which causes some run-off. These are generally dominant in the southern extent of the study area (Dolcreiglyn, Gamrhiwisaf and Doldowlod) and to the west at Glaslyn and are acidic to slightly acidic in their natural form.

The Cegin Association are slowly permeable seasonally waterlogged, fine silty and clayey soils. Some fine silty and fine loamy soils are present with slowly permeably subsoils and there can be slight seasonal waterlogging on slopes present on the landscape. There are well drained fine loamy soils over rock in some places. These soils are intractable for much of the year unless they are artificially drained, and their slowly permeable subsoils are coarsely structured and often compact at depth. The soils generally absorb only a small portion of winter precipitation and generally are Wetness Class V (or improved to Wetness Class IV when drained) and can remain wet throughout the winter. This association is generally found on the flatter land around Nant-glas, stretching between the A470 in the south of the study area, to the north of the A44.

The Hafren Association are acidic, loamy permeable soils in the upland areas, developed on rock and generally not present below 500 m OD in the Radnorshire region. They have a wet peaty surface, underlain by a bleached subsurface horizon and often a thin iron pan is present. A diagnostic peat horizon is often present on the higher ground in this association. Repeated cultivation on this association can rupture the iron pan and reduce organic matter in the topsoil (and creating Manod or Cegin soils).

The water regime of these soils is complicated by the presence of the contrasting horizons. Water from precipitation is held in the surface horizons, the peat acting as a sponge so that they are seasonally waterlogged even though the subsoils drain freely (Wetness Class III or IV). Where a relatively robust iron pan is present, this will also impede water movement. Rainwater passes rapidly into streams and rivers when the upper horizons are already saturated, particularly during the winter[2].

[1] Soil Survey of England and Wales (1983). 1:250 000 soil map of Wales (Sheet 2)
[2] University of Cranfield (2022). LandIS Soils Guide. Accessed on 11th February 2022 from https://www.landis.org.uk/

1 Capital Quarter
Tyndall Street
Cardiff
CF10 4BZ

wsp.com