

Developing a matrix to assess the biodiversity value of amenity grasslands in Wales.



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Author's Declaration

I declare that the work in this dissertation was carried out in accordance with the regulations of UWTSD. The work is original except where indicated by special references in the text and no part of the dissertation has been submitted for any other degree.

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I. Acknowledgements

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II. Abstract

The loss of the world's species rich grasslands is considered part of the global nature emergency. Restoring, creating, and enhancing the UK's semi-natural grasslands is considered an effective strategy in the fight against biodiversity loss. Creating lowland meadows on existing amenity grasslands could support the UK's struggling pollinators, supporting ecosystem services vital for food production and supporting other flora and fauna. Many local authorities and land managers have been encouraged to adopt 'No-mow' strategies, with Welsh Government legislation and funding supporting this drive. Being able to effectively measure the biodiversity value of amenity grasslands could prove invaluable data for decision makers and stakeholders. By assessing the data from both a typical species rich grassland and from recovering improved grasslands, it has been possible to assess the most frequently occurring flowering species found. Combining this data with published data on plant communities (NVC), nectar values, and peer reviewed research, this study provides a desirable plant species list that land managers can aim to replicate. The development of a 'Top 20' plant list and scoring system allows land managers to simply assess the biodiversity value of amenity grassland and take informed management decisions. The remaining species on the list contribute to an overall score that also includes negative scores (negative indicator species) to encourage more active management. The use of this simple scoring system could increase engagement with stakeholders and be used as a public communication tool measuring the development in species diversity following changes in mowing methods.

Key Terms

Biodiversity

Amenity grasslands

Pollinators

Meadow creation

Cut and Collect

III. Glossary of terms and abbreviations

CCW	Countryside Council for Wales
DEFRA	Department for Environment, Food and Rural Affairs
EU	European Union
Forbs	Herbaceous flowering plants that are not grasses, sedges and rush.
IPBES	Intergovernmental science-policy Platform on Biodiversity and Ecosystem Services
Mesotrophic	Neutral soil habitats
NRW	Natural Resources Wales
NVC	National Vegetation Classification
Rank grassland	Grassland, or marsh vegetation that has grown abundantly without being cut or grazed for some time, and as a result has become tall, tussocky, and dominated by coarse species of grass.
Rhôs pastures	A marshy grassland comprising of Purple moor grass and rushes.
SDGs	Sustainable Developmental Goals (United Nations)
Section 6	A legislative duty of all public bodies in Wales to embed Biodiversity into their decision making and processes.
Thatching	Dead and decaying vegetation that smothers new growth cause by leaving the cuttings in situ after mowing.
UN	United Nations

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1.0 Introduction

There are many different pressures on land managers at public authorities to manage their amenity grasslands differently, and these are summarised by the diagram in Figure 1.1.

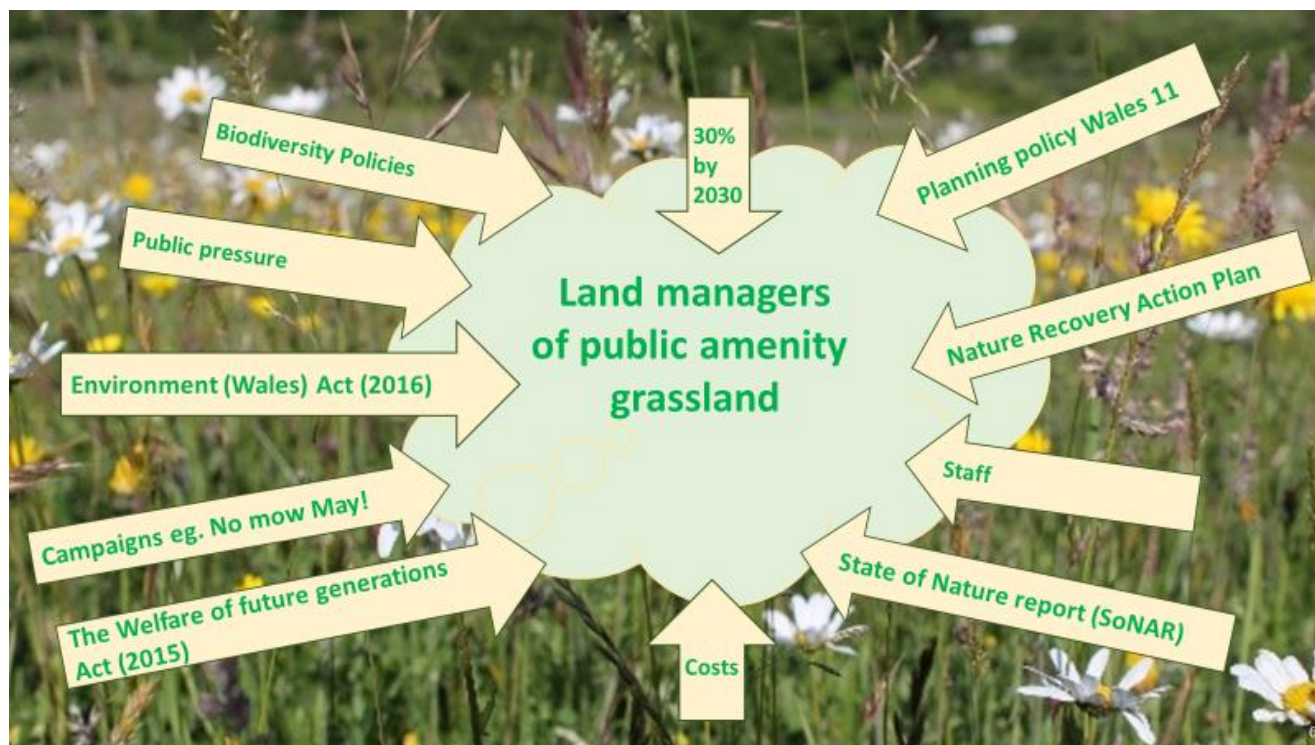


Figure 1.1 - An infographic showing the pressure on amenity grassland managers.

Welsh Government legislation arising from both the UN SDGs and EU directives mean that local authorities (LAs) have a legislative duty to embed biodiversity in all decision making, and report on efforts to increase ecosystem resilience (*Environment (Wales) Act 2016*).

This research will support the aims of some key legislation in Wales which is mirrored across the UK and internationally. The increase in botanical diversity created by no mow methods could meet the objectives of UN SDG 14, Section 6 of *The Environment Act (Wales) 2016*, *The Welfare of Future Generations Act 2015* and the Nature Recovery Action plan (NRAP) objectives. In particular, LAs managing amenity grassland are required to meet the Section 6 duty of the Environment Act, aligned with the DECCA framework (Diversity, Extent, Condition, Connectivity, and Adaptability of ecosystem resilience). No-Mow methods could offer a simple cost-effective method of meeting these duties.

The population of vital pollinator species are declining across the world. These pollinators provide essential ecosystem services to agriculture. In Wales alone this could be worth as much as £1.8billion if hand pollination had to replace natural pollination (Welsh Government, 2013). This recorded decline has been attributed to many causes including the decline in forage and pollinator resource such as pollen and nectar (Powney *et al.*, 2019). It has been estimated that 97% of species rich meadows were lost between 1930 and 1984 in England and Wales (Fuller, 1987). These diverse grasslands are of high conservation importance due to the diversity of floral and fauna present (Duffey *et al.*, 1974) and were once widespread over much of western Europe (Van Dijk, 1991). Their loss has been partly attributed to an increase in high intensity farming practices and use of herbicides (Pywell, 2003). There has been a great deal of research into the restoration of meadows on depleted grasslands, arable land, and improved agricultural land across the world but at a local level there is less data available on the efficacy and benefits of creating species rich meadows on our urban amenity grasslands.

Recent UK biodiversity action plans and legislation have reflected the need to restore these important habitats, and in Wales, emphasis has been placed on increasing plant diversity on amenity grasslands and road verges where possible. The 'No Mow' movement, started by Plantlife UK in 2018 mainly in domestic gardens, has been shown to increase pollinator habitat as well as increase structural diversity by introducing variety in sward height (Garbuzov *et al.*, 2015).

These popular campaigns have been shown to increase early-season forage resource for pollinators in urban green spaces. However, land managers must balance the benefits to biodiversity with economic pressures and providing accessible amenity spaces for recreation (Hemmings *et al.*, 2022). A study by Hemmings *et al.*, (2022) showed the importance of extending 'No-Mow' schemes into June to protect the highest pollen and nectar resources. This method has also been proven to increase early season floral diversity, and abundance in domestic lawns which when expanded to amenity spaces could support a greater population of bees (Hemmings *et al.*, 2022).

The introduction of a cut and collect method of land management across amenity grassland is therefore an attractive option for many public authorities. The comparison of the traditional cut and collect methods is shown below in Figure 1.2.

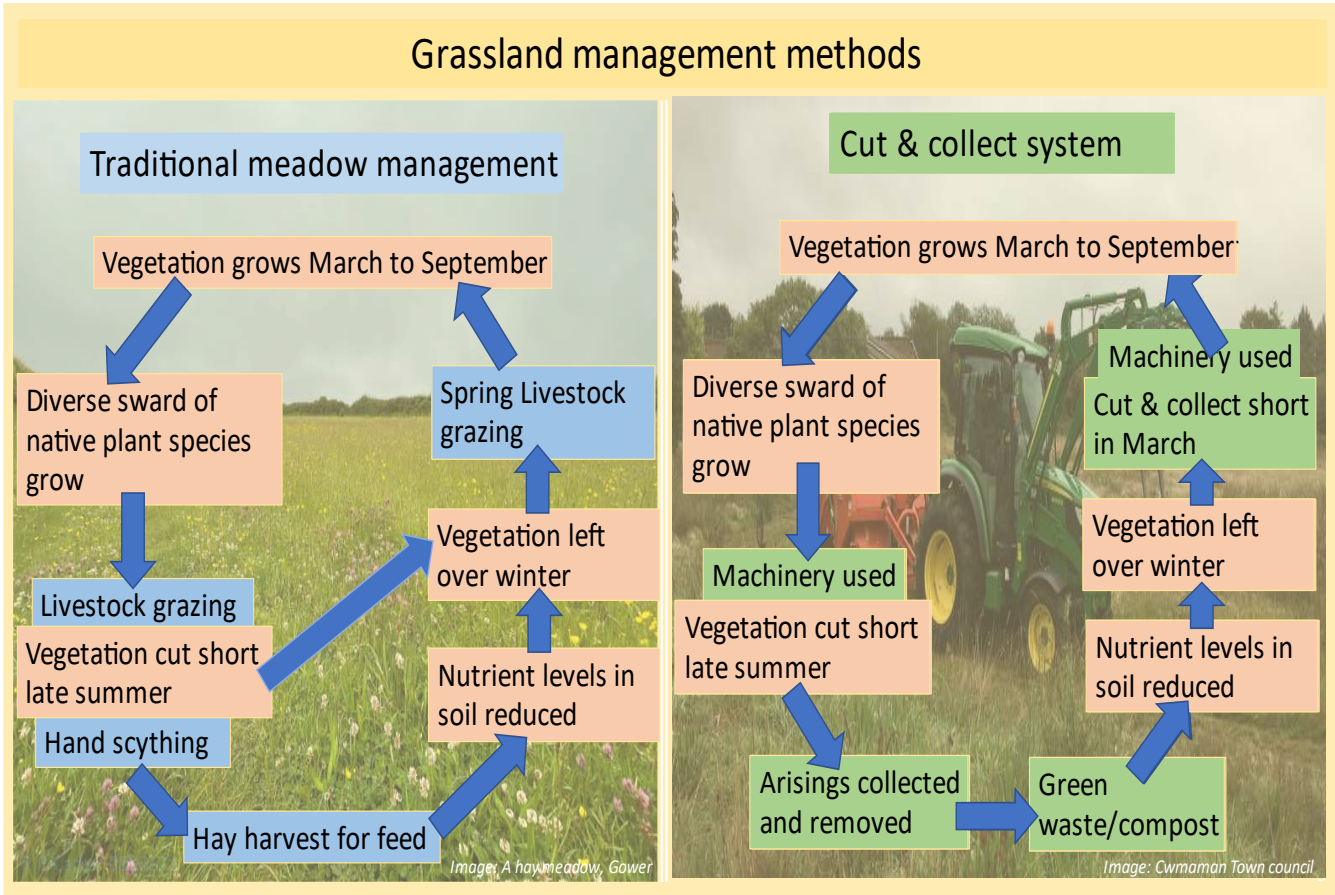


Figure 1.2- Comparisons between traditional hay meadow management and the cut and collect mowing method.

By replicating the grazing impact of ungulates, a species rich meadow can be created at amenity grassland sites and road verges by reducing dominant grasses and scrub and exposing soil (poaching) by trampling and grazing. LAs leaving vegetation to grow throughout the summer can cause conflict with residents and other stakeholders. This can lead to complaints and the increased risk of LAs cutting too early as a result. It may be beneficial if LAs and their residents could understand and measure the biodiversity value of changing mowing methods and use this to monitor any improvements and enhancements that need implementing in the future. This idea has led to the development of the research aim described in the following section.

1.1 Aims and Objectives

Research aim.

Develop a matrix to measure the biodiversity value of amenity grasslands to inform future management.

Collecting data on floral species abundance from restored meadows and amenity grasslands across Welsh Local authorities engaged in changes to mowing, will help construct a model for species-rich grassland recovery. Understanding the value of their public green spaces could aid management decision making by land managers and ensure prioritisation of grassland restorations. This in turn will likely increase botanical diversity, highlight the importance of different species and build ecosystem resilience. The biodiversity value will be a measure of its value to pollinators. Research into the actual value of these changes in plant diversity and abundance on Welsh amenity grassland has not been fully explored, and this research aims to provide reliable data that could be used for future management guidance. While research parameters will be based on Welsh policies and procedures, the research and rationale will be informed from a broad scope of UK and international research into grassland restoration. To fulfil the research aim, the following three objectives will need to be met:

Objectives

1. To identify the common forbs found growing on mesotrophic grassland in Wales and their value to pollinators.
2. To establish a list of the most common, key species that exemplify species rich grasslands of value to pollinators.
3. To design a method to assess biodiversity value of amenity grassland by recording the species present that can be used to inform future management.

The methodology to meet these objectives will be detailed in Section 4, but Section 1.2 aims to contextualise the research within current policy and practice in Wales.

1.2 Current practice in Wales

Current biodiversity policy in Wales is centred around 2 key pieces of legislation as mentioned in Chapter 1.0 based on taking an ‘ecosystem approach’ to reverse biodiversity decline. Public bodies must publish a NRAP with clear objectives aligned to the NRW area statements for each region of Wales. The priorities of this policy include ‘delivering nature based solutions’ and ‘taking a place based approach’ (Welsh Government, 2020). Plantlife’s ‘Good practice guide’ published in 2019 was adopted by the Welsh government as a method of best practice for managing amenity grassland for increased biodiversity value. The guide highlighted the importance for cyclical or annual mowing of amenity grassland to allow wildflowers to complete their life cycles and ensure continued forage and habitat for Wales’s essential pollinators (Plantlife, 2019). The best practice model is highlighted in Table 1.1

Table 1.1 Management options to the 2 cut approach to amenity grassland management to maximise flowering plants and availability of pollen resources. (Plantlife, 2019)

Management option		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
One cut									full cut				
Two cuts	Summer and autumn cutting								partial cut		full cut		
	Late winter and autumn cutting		full cut							full cut			
	Dry verges (short vegetation)	regular cuts								regular cuts			
	Species-rich verges with mown edge		1m strip							full cut			

The guide recognised that different approaches may need to be taken due to staff and machinery resources at individual authorities. An alternative 1 cut approach is advocated where necessary. This is adopted when there are limited resources, specifying a late summer cut and creation of bare patches to encourage pioneer species and establishment of seed. The guide also recognises importance of low soil fertility and the use of cut & collect methods to achieve this, emulating historical grazing patterns and reducing growth of species such as *Urtica dioica* (Common nettle) and reducing thatching from grass cuttings (Plantlife, 2019). Although this guide set out to advise on mainly roadside verges this strategy has been extended to amenity grassland and recreational spaces in the same way. Combined with guidance of meadow restoration, amenity grassland could offer a good location for public bodies to restore, create and enhance biodiversity and ecosystems resilience and meet the mandatory requirements of Section 6 of *The Environment Act (Wales) 2016*.

Amenity grassland: defined as frequently mown short-sward grassland managed for recreation (Norton *et al.*, 2019) includes public lawns, parks, and sports grounds. Covering an estimated 25% of U.K. urban land area (Evans *et al.*, 2009) it offers a viable nature based solution to the problems identified.

In 2019 Monmouthshire County Council piloted a programme of cut and collect management of amenity grassland as part of its 'Nature isn't neat' campaign. The result of this programme of funding led to the production of a management manual and guide and has been adapted for use by all local Authorities in Wales. In 2020, Welsh Government launched a new programme of funding to encourage cut & collect management of amenity grasslands and increase pollinator habitat. Local nature partnerships developed this strategy further with purchase of machinery and increase used of cut & collect on verges and amenity grassland by all public authorities, including the National Parks, Trunk Road agencies, health boards and other public services.

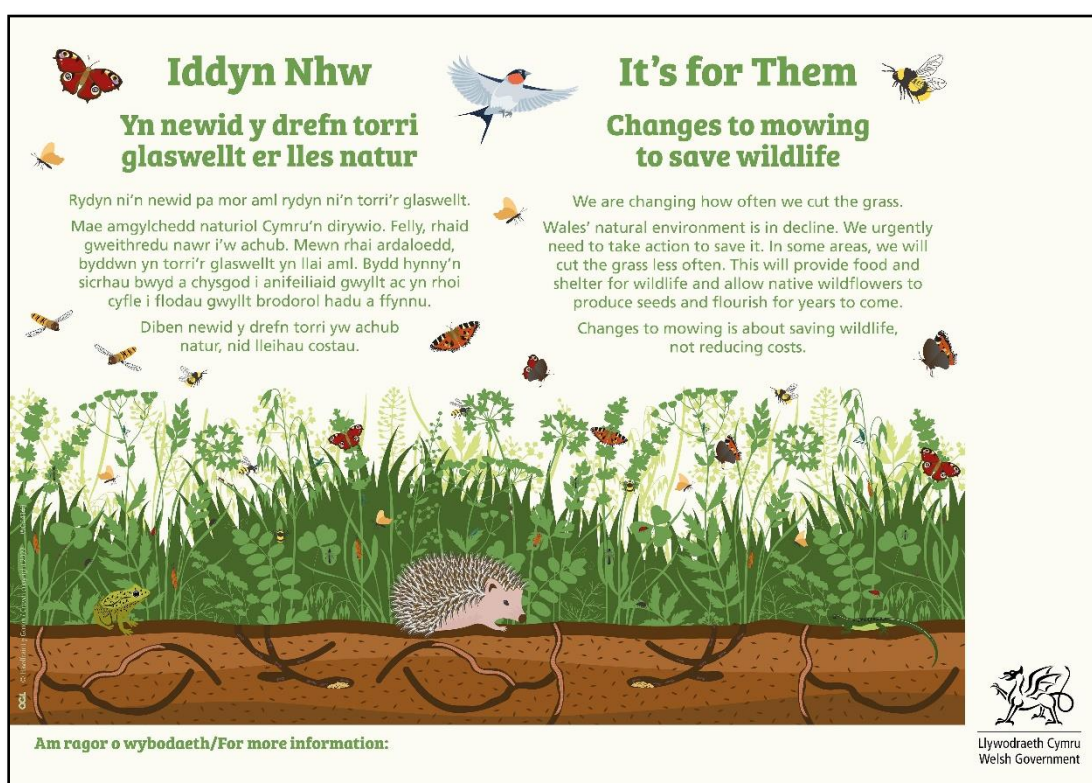


Figure 1.3 An example of an 'It's for Them' sign provided by Welsh Government. (Welsh Government website, 2024)

In 2022, a Wales wide campaign – It's for Them – was launched to increase communication between policy makers and stakeholders as set out in the Plantlife guide (Plantlife, 2019). As shown in Figure 1.3 above the campaign aims to communicate the importance of reduced mowing and wildflowers to pollinators and wider biodiversity and soil health.

It is against the backdrop of this continued legislation, policy, and funding that this study aims to assess and measure the biodiversity value of amenity grassland in Wales, enabling simple monitoring, data collection and evidence gathering by public authorities.

2.0 Literature review

The aim of this literature review is to conduct a thorough assessment of the current research and understanding of the impact of biodiversity loss of lowland grassland ecosystems. An understanding of the causes of biodiversity loss and the methodological approaches of grassland restoration is essential to build a picture of the value of grassland ecosystems. The review is split into three sections starting with a wide scope on the international picture of biodiversity loss and international policy on grassland ecosystems. Understanding the international directives on halting biodiversity loss will lead into a review of literature on the causes of species rich grassland loss, both internationally and specific to the British Isles. Finally, the review will focus on methods and theories of restoring grasslands in the UK and in Wales, and the methodologies that have been tested and trialled. This research will contribute to an understanding of the policy of *cut and collect* mowing methods that seek to restore plant diversity on amenity grasslands and support the resulting matrix to measure biodiversity value. The overall result of this review will validate both the aim of the research and the methodological approach taken in this study.

2.1 The decline of Biodiversity from an international perspective

To fully contextualise the current research into biodiversity loss at a national level it is important to understand the international strategies and priorities that have been realised over the last 20-30 years. In this section literature will be reviewed on both international policy on biodiversity loss and how this has influenced government policy and priorities in the UK and Wales.

2.1.1 International strategic policy on biodiversity

One of the major drivers for biodiversity protection and policy was the establishment of the Convention on Biological Diversity (CBD), 1993. It was originally commissioned in response to the United Nations Environmental Programme (UNEP) working group in 1988. The convention was signed by 168 world leaders at the 1992 Rio 'Earth summit', and finalised in 1993 (CBD Secretariat, 2023). The convention is a comprehensive international treaty addressing 3 main targets:

- The conservation of biological diversity
- The sustainable use of the components of biological diversity

- The fair and equitable sharing of the benefits arising out of the utilization of genetic resources.

Enacted and signed at the first Conference of the Parties (COP) 1994, it led to a global agreement to develop National Biological Strategies and Action Plans (NBSAPs) which must be reported on periodically (CBD Secretariat, 2023). Countries agreed to create plans to address conservation and sustainable use of biodiversity within their respective territories and NBSAPs played a crucial role in achieving these goals. Their aim was to foster a coordinated and comprehensive approach to protecting and utilizing biodiversity at the national level, contributing to the global efforts aimed at safeguarding the world's natural heritage. Adjustments and updates were made to the reporting requirements based on decisions made during subsequent CBD COP meetings. For instance, during the CBD COP 10 in Nagoya, Japan, (2010), the Strategic Plan for Biodiversity 2011-2020 was adopted, along with the Aichi Biodiversity Targets. As part of this Strategic Plan, countries agreed to accelerate actions and monitor progress toward achieving the Aichi Targets.

The Aichi Biodiversity Targets

A set of 20 specific, measurable targets adopted in 2010, these targets aimed to address global biodiversity decline setting out an action framework to conserve and sustainably use biodiversity. A summary of the targets can be found in Appendix 1. An analysis of the global progress towards the Aichi Targets in 2021 by Carrasco *et al.*, looked at the success of identifying and adding new conservation areas. The study found that in 2010, countries committed to expanding global Protected Area (PAs) to 17% by 2020 under Target 11. An evaluation of the contribution of PA expansion to three key approaches for maintaining biodiversity amid climate change were: safeguarding climate refuges, preserving abiotic diversity, and enhancing connectivity (Carrasco, 2021). These approaches mitigated uncertainties in predicting biodiversity changes due to climate shifts and accounted for undiscovered species. Results showed that over half of countries established new PAs. However, connectivity between PAs decreased in more than half of the countries, suggesting that many new PAs were distant from existing ones. Connectivity was assessed by recording species dispersal and was identified as a key metric in mitigating against climate change, as improved habitat quality and biodiversity corridors has been shown to improve PA connectivity for biodiversity (Driscoll et al., 2013). Almost all countries were shown to have the potential to improve in at least one approach to biodiversity conservation, emphasising a need for integrated strategies, targeting various land protection methods. Carrasco *et al.*, (2019) concluded that there was a need for a comprehensive approach to land protection that integrated multiple conservation

strategies, and the study offered countries a framework to prioritize land protection for climate adaptation.

In 2019, a UN report by IPBES carried out a global assessment of biodiversity actions and knowledge at global, regional and local level. It found that overall, whilst the Aichi biodiversity targets stimulated action and awareness, challenges in achieving all the goals highlighted the complexity of conserving biodiversity and the need for more coordinated, transformative, and sustained efforts at the global, national, and local levels (IPBES, 2019). The report concluded that only five of the targets were assessed as having made 'Good' progress, amongst these were:

- Invasive species were prioritised.
- 10% of marine areas are conserved.
- 17% of terrestrial areas are conserved.

The Aichi Biodiversity Targets expired in 2020 without being met (IPBES, 2019) and the global community discussed new targets and strategies as part of the process at the COP 15 - Kunming, China, in 2021.

The IPBES report (2019) recognised that the environment can be safeguarded but is reliant on cooperation on locally relevant measures which needs definitive actions and funding from governments.

Kunming Protocol 2021

The Kunming Declaration was devised at the CBD in October 2021, during COP 15 held in Kunming, China, to discuss another new global framework. The goal was to set new targets and strategies to protect biodiversity and ecosystems building on and expand the objectives of the Aichi Biodiversity Targets. These new targets aim to be SMART (Specific, Measurable, Achievable, Relevant, Time-bound) and cover areas such as habitat protection, species conservation, sustainable resource management, and engagement of multiple stakeholders. These targets were designed to align with Sustainable Development Goals (SDGs) and aimed to recognise the interconnectivity between biodiversity, conservation, and the broader UN societal and development goals. The framework focussed on robust monitoring, reporting, and review mechanisms to track progress, assessing the effectiveness of actions, and promoting transparency and accountability among parties. The new element to this agreement was the introduction of engagement and collaboration, highlighting the importance of engaging with a wide range of stakeholders including indigenous and local communities to work together to achieve the goals.

Also, at this convention, the international agreement to protect 30% of land and oceans by 2030 (30 by 30) was adopted.

As with all agreements, protocols and conventions, this framework can only be successful if there is strong political will, international cooperation, equality of actions and investment in resources. The CBD itself does not have punitive measures for non-compliance, the international community often uses diplomatic channels and public scrutiny to encourage adherence to commitments made under international agreements like the Kunming framework. Non-compliance or lack of progress toward meeting biodiversity targets might lead to reputational and political consequences rather than direct sanctions. As discussed previously, the failure of countries to achieve the Aichi targets does not set a positive environment in which to achieve a new set of targets. Without robust sanctions and 100% cooperation this agreement runs the risk of just being replaced without having been achieved with a brand new set of targets with the background of ever decreasing biodiversity.

A summary of the key international protocols, policies and agreements is shown in Figure 2.1. The timeline of conventions and agreements are shown parallel to each other with the key documents that fed from those targets to published reports in 2005 and 2022.

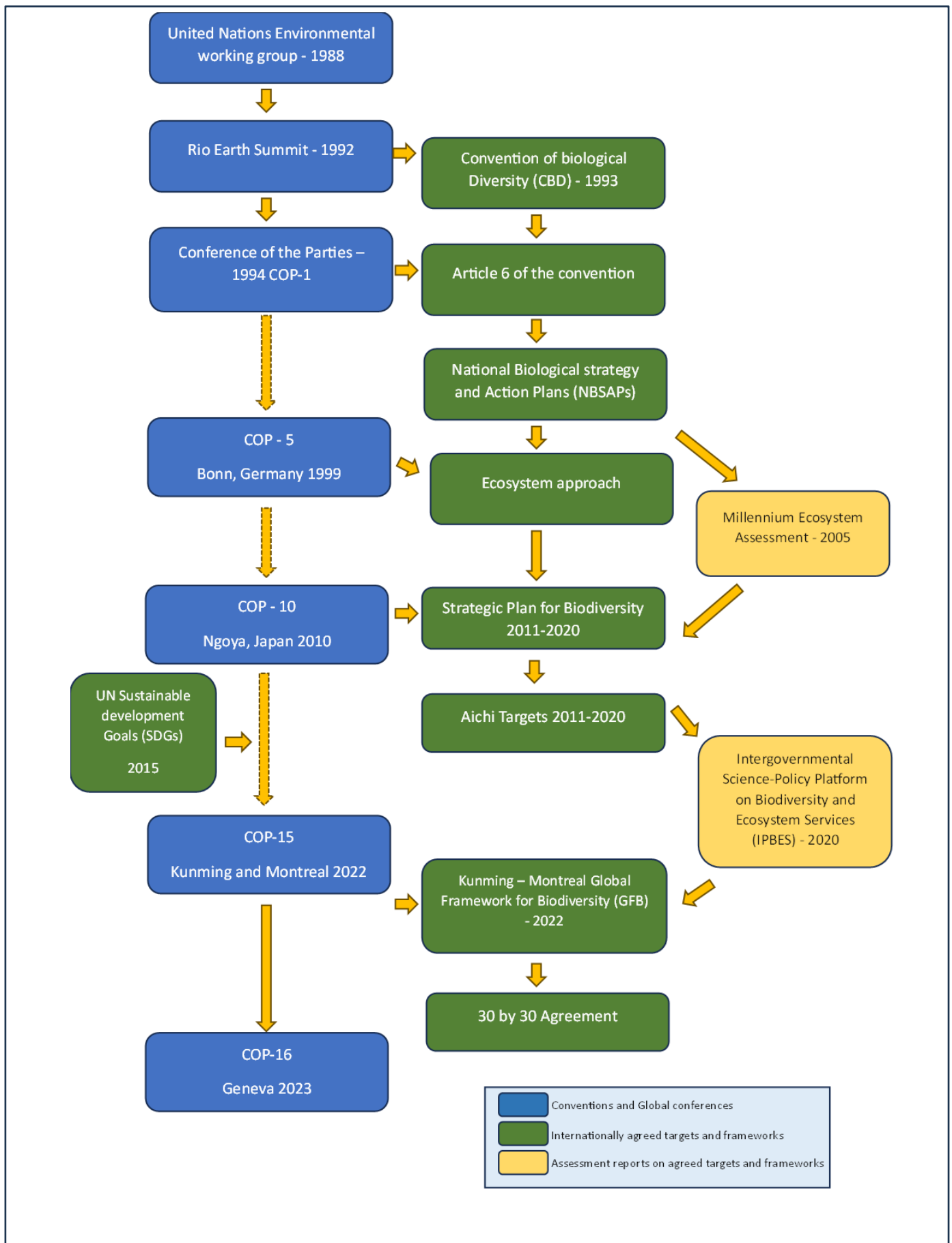


Figure 2.1 Flowchart of key international policy, protocols, and agreements on biodiversity protection, 1988 - 2023.

2.1.2 UK and Wales strategic policy on biodiversity

A key feature of increasing connectivity and ecosystem resilience to improve biodiversity mentioned in the previous section was the importance of local government and use of connected strategies (IPBES, 2019). The UK National Ecosystem Assessment was published in 2011 with a follow up report in 2014. It was written in partnership with key stakeholders from the 4 constituent governments of the UK and public bodies such as DEFRA, CCW and Natural Environment Research Council (NERC). The aim of the report was to provide a comprehensive overview of the state of the natural environment and estimate 'Natural wealth' (UKNEA, 2011). The findings showed that about 30% of ecosystem services in the UK were in a reduced or degraded state with soil degradation being a major factor.

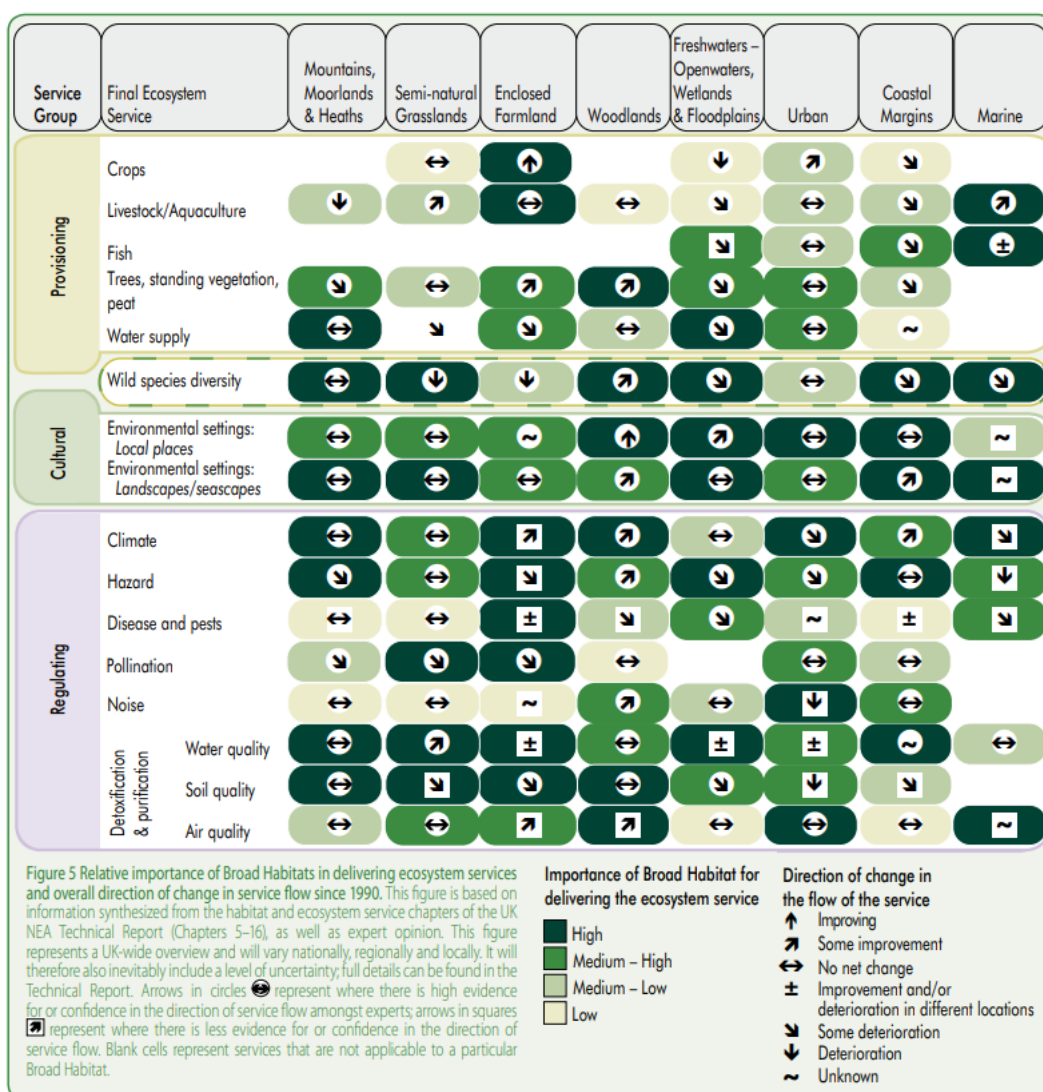


Figure 2.2 Relative importance of Broad Habitats in delivering ecosystem services and overall direction of change in service flow since 1990. (UKNEA, 2011)

Increasing population and the consequences of increase demand of food and housing was identified as a driver for land use change at the detriment to biodiversity. The assessed state of different ecosystem services is summarised in Figure 2.2 above.

The data used to construct the table shown in Figure 2.2 represents a level of uncertainty and was synthesised from expert opinion as well as data and surveys. Whilst it presents a useful overview, the authors accept that the state of ecosystem services in different areas of the UK may vary. This is useful to understand the overall trend and pressure on different ecosystems and shows the state of semi-natural grassland as an ecosystem service. Across all service areas bar one, they are identified as either declining or no net change with high confidence and assessed as being of high or medium importance as a habitat. Most significantly for the research aims of this study, it shows the declining species diversity and high importance value of the ecosystem service. This report and the follow on report in 2014 informed governmental legislation across the UK consolidated by the international policies and actions outlined in Figure 2.1. The report emphasises the urgent need to develop more resilient ways of managing ecosystems due to the decline and degradation of these identified ecosystem services. Actions taken now could significantly impact ecosystems and their services into the future, considering the slow recovery rates of certain services like soils.

The report explains that understanding the consequences of current decisions is crucial for making informed choices benefiting both present society and future generations. To achieve this, it states that there will be a necessity to comprehend the diverse values associated with ecosystem services, including cultural and non-market values often overlooked in economic frameworks and local decision-making processes. It warns that ignoring these values in decision making could result in inefficient resource allocation. Implementing such an approach involves a blend of regulations, technology, and financial investment. It recognises that an integrated approach in ecosystem management is needed. Decision makers should recognise their multifunctional nature and adaptable operation across various spatial and temporal scales, and that this approach should transcend national borders and encompass regional and global processes. In conclusion, the report recommends that any Governmental legislation should be developed in line with international frameworks and targets and work together across the UK.

The map shown in Figure 2.3 below shows the extent and importance of semi-natural grassland in The UK, and in particular Wales.

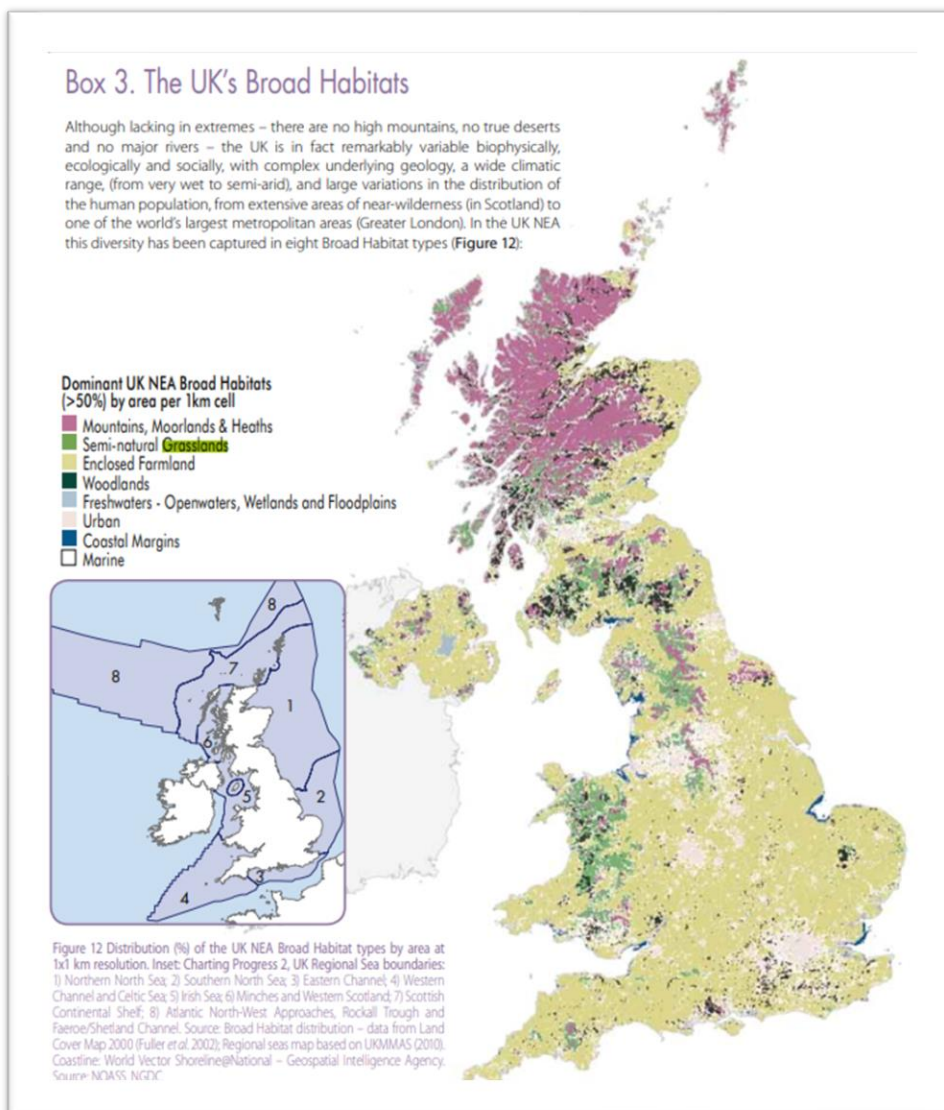


Figure 2.3 A map showing the distribution of the UK NEA broad habitat types by area (UK NEA, 2011).

The dominance of enclosed farmland is demonstrated here and has been identified as a driver in the loss of these important habitats across Wales (Fuller, 1984). These semi-natural grasslands are identified as now 'extremely reduced' comprising only 2% of UK grasslands. These grasslands are noted as being culturally important and of a high value to the tourism economy. Agri-environment schemes could be critical in restoring these lost grasslands and increasing biodiversity and could present valuable opportunities to deliver multiple services with low energy inputs (UK NEA, 2011). The key driver of the decline of semi-natural grasslands is identified as overexploitation and climate change, with nutrient enrichment and land use change being given as historical factors in the decline. An important element

of this report is recognising the value and impact of ecosystem services on human health and welfare, not only on mental health but by facilitating nature based activities and social engagement which could impact on physical health. Changes in the composition of the UK's habitats such as forestry were cited as being at the expense of semi-natural grasslands in wetter areas like the western areas of the UK. Semi-natural grasslands make up 22.8% of Wales's broad habitat type, the largest in the UK, and is estimated at 474 hectares. The UK NEA report provides country specific analysis and identifies the biodiversity of Wales's lakes as exceptional for biodiversity. However, it states that the degradation of Wales's lowland grassland habitat represents the most rapid and widespread vegetation changes over the 20th century with 90% of former unimproved and semi-improved grasslands being transformed by agricultural management to improved grassland (UK NEA, 2011).

The key findings of the UK NEAFO, 2011 showed that in Wales 89% of lowland Semi-natural grasslands have been lost between 1930-1990s. It recognises the importance of agricultural improvements as a main driver for the loss, but that this is now less important as much of the grasslands are protected with 52% being within national parks. Nitrogen deposition, inadequate management and habitat fragmentation are poorly quantified but are widely stated as the recognised causes of the ongoing loss (UK NEA, 2011). The importance and value of the higher plant richness in semi-natural grasslands is noted, as is the carbon sequestration ability of the topsoil (top 15cm) especially in acid grasslands with acid and neutral grasslands storing 293 teragrams of the UK's carbon store. These grasslands contain a high abundance of invertebrates and diversity, including essential pollinators and this this can provide an ecosystem service to neighbouring arable farmland as pest control and pollination. However, the decline in bumblebees since the 1960s have been linked to a decline in associated grassland species (UK NEA, 2011). Semi-natural grasslands when compared to improved grasslands and arable/horticultural land can exhibit multiple benefits:

- Carbon Storage and Emissions: They generally store higher carbon densities and emit less nitrous oxide. Moreover, their lower stocking densities result in decreased methane production.
- Water Management: Semi-natural grasslands allow greater water infiltration rates, aiding in flood prevention, and experience reduced pollution due to minimal fertilizer input.
- Nutrient Cycling Efficiency: Nutrient cycling appears more efficient in unimproved grasslands, contributing to the ecosystem's overall health.

- **Enhanced Biodiversity Benefits:** Increasing plant richness within these grasslands can heighten production without fertilizer use, as seen in an experiment showing a 40% difference in hay yield between species-rich and species-poor plots.

Therefore, these low-input, service-rich semi-natural grasslands could present an alternative land-use model compared to high-input agriculture whilst providing numerous environmental services and benefits.

The follow on report published in 2014 referenced the key principles of the Ecosystem Approach (EA) adopted by the CBD at COP – 5 in 1999 as shown in Figure 2.1. The 12 principles of the EA are shown in Figure 2.4 and the report suggested this should be incorporated into programmes and policies but recognised that there is no single way to integrate this fully but could present a model of integration for decision makers. (UK NEA, 2014).

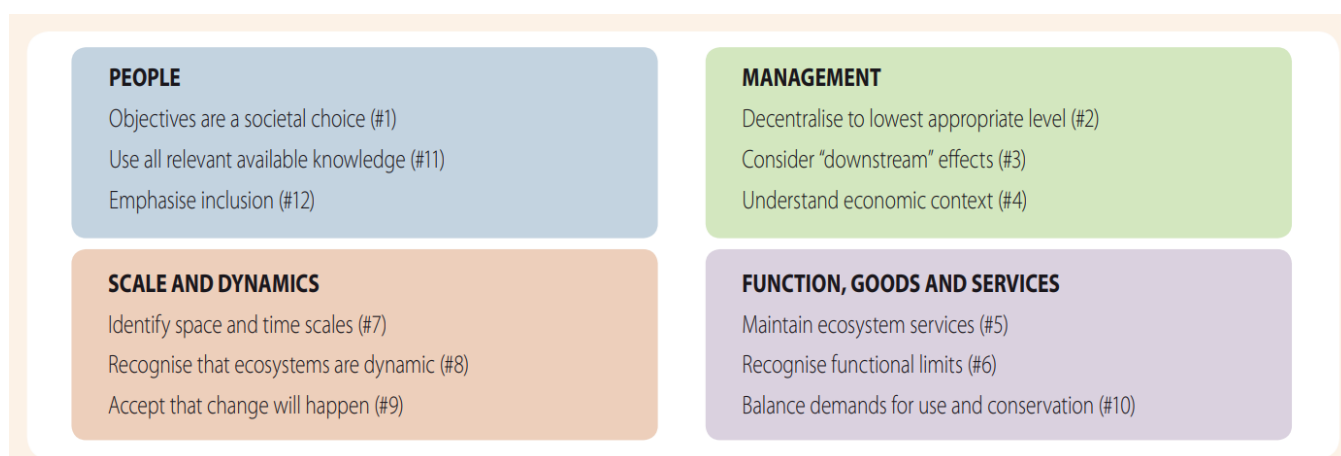


Figure 2.4 - The 12 principles of the Convention of Biological Diversity and how they relate to the four overarching themes of the approach: people; management; scales and dynamics; and function, goods, and services. (UK NEAFO, 2014).

The importance of people and decentralisation is a part of this model for policy. It is identified as a potential way to achieve increased biodiversity. This could form part of legislation and policies by central governments to effect change downstream, whilst appreciating that a balance may be required between conservation, land use, economics, and the pressures of dynamic ecosystems.

2.2 The causes of biodiversity loss in grasslands.

To understand the importance of grassland recovery in the context of this study it is necessary to assess the most common causes of biodiversity loss globally and those specific to the UK.

2.2.1 Global scale causes of biodiversity loss

Grasslands are estimated to cover 40% of the earth's surface and 69% of agricultural land (Bardgett *et al.*, 2021). Human impact and anthropogenic changes can have significant impacts on the biodiversity of grasslands on a global scale.

Grassland degradation is a major global challenge and is recognised as a key global target to fight the nature emergency (Bardgett *et al.*, 2021). There are many drivers of grassland ecosystem loss including overgrazing, land use changes, agricultural changes and climate extremes including fire (Bardgett *et al.*, 2021). To be able to develop effective policies to combat this, decision makers need to understand the main drivers of biodiversity loss (Jaureguiberry *et al.*, 2022).

Land use and change by rapid expansion due to building developments and agricultural practices and direct exploitation are the 2 most dominant drivers of biodiversity globally (Jaureguiberry *et al.*, 2022). Research by Jaureguiberry *et al.*, (2022) also recognised the growing threat of climate change with increase wildfires and drought condition on biodiversity loss worldwide. Conversely in the race to reach net zero and tackle the climate emergency afforestation could be a threat to grassland biodiversity. Government tree planting schemes, carbon offsetting and UN directed targets could drive the tree planting agenda at the expense of the worlds natural and semi natural grassland ecosystems (Buscardo *et al.*, 2008).

This global picture is reflected in the current issues in the UK and Wales where pressures for redevelopment, agricultural improvements along with historical deforestation and overgrazing have led to degraded grassland systems.

2.2.2 Specific issues in the UK

Although published in 1987 the paper published by Fuller is still the key piece of literature of research on grassland management and restoration of wildflower meadows. The survey of the grasslands of

England and Wales showed a decline from 7.8 MHa in 1937 to 4.8 MHa in 1987. Fuller cites the main causes of loss as drainage and the mechanisation of farming (Fuller, 1987).

Blackstock *et al.*, (1999) carried out a review on behalf of the former Countryside council for Wales of the extent of semi-natural grassland across England and Wales based on previous surveys between 1978 and 1996. The study found that there was a continuing decline as identified by Fuller (1987) and that the advent of the NVC classification has enabled identifying this decline easier to record. The overall conclusion was that ancient grasslands have declined, the characteristic grasslands M22-26 marshy grasslands in Wales have showed considerable decline. These findings echo the research by Fuller (1987) that drainage and farming practices may have contributed to reduced grassland coverage.

The State of Nature Report (SONAR) published in 2023 found that 42% of flowering plants have declined across Wales mostly in upland habitats with vascular plants showing a lower decline than the rest of the UK. An overall species abundance decline of 20% was estimated in the report however a 14% increase in pollinator distribution since 1970 appears to show some recovery, potentially linked to grassland management.

2.3 UK based research and case studies on strategies and methods to increase biodiversity.

The issues with biodiversity loss in the UK and Wales discussed in the previous section have led to some significant research into British habitat grassland restoration and management. the most important research in the context of this piece of work are discussed in this section.

2.3.1 Grassland management as a method to increase biodiversity.

Comba et al. (1999) looked at 24 native species to evaluate potential nectar resource. Although his study was conducted in 1999, it remains relevant to the aims of this research project as it provides valuable information of the nectar resources of common grassland species. The study was carried out in a botanical garden setting and recognises that other pollen and nectar resources may have been available and affected frequency of pollinators visits to the test species. It also recognises that their results reflect the population present in that area. However, the study is valuable as it provides dawn to dusk data on nectar levels of common species in grasslands that will contribute to this research project. It is also

important to note that the availability of nectar is relevant to the species of bees in the area and the length of proboscis. Many of the floral nectaries may be unavailable to honey bees and so have a positive effect on native species of bees and therefore biodiversity. The temporal difference in nectar resource between plant species is also important in informing a definitive list of the most beneficial plants that a land manager should aim to have on a green space.

2.3.2 Changes to grassland management to benefit pollinators.

UK wildflower meadows declined by 97% between 1930 and 1984 (Fuller *et al.*, 1987), impacting the diversity of pollinating insects who require pollen and nectar to be available throughout summer months. Semi natural hay meadows provide an important source of forage for pollinators (Johansen, 2019). Increased soil fertility from agricultural inputs (fertilisers or manure) additionally reduce biodiversity. Higher soil fertility favours fast growing species which crowd and out-compete native wildflowers such as dipsacaceae, orchidaceae, and centaurea (Critchley *et al.*, 2002; Janssens *et al.*, 1998). Consequently, tough grass species dominate swards and inhibit the growth of nectar-rich species vital for pollinators.

Land Ownership and Agri-Environmental Schemes

A 3 year study carried out by Rothero *et al.*, (2020) investigated the effectiveness of restoring wet grasslands across 163 sites in England and Wales. Results showed that many factors contribute to the success of restoration. Land ownership and a commitment to agri-environmental schemes were key contributors, with most success being reported on pasture and arable land. Application of green hay and a change of management resulted in significant success; however, it was noted that ongoing management and sufficiency of treatments was vital. It was also remarked that wetland grasslands can take 5-10 years to reach successful levels of restoration but in reality, a longer timeframe would be needed to fully assess outcomes (Poptcheva *et al.*, 2009).

Land management: method of meadow creation.

A study by Hicks *et al.*, in 2016 looked at the difference between nectar and pollen values of flowers grown from commercial seed mixes. This was the first study looking at this element of meadow creation (Hicks *et al.*, 2016) and generated data on pollen and nectar resource for many native species. The results of the study showed that nectar resource varied greatly between annual and perennial species. These annual plants common in commercial seed mixes for their vibrant colour displays yielded relatively low levels of pollen and nectar. Perennial species fared slightly better, and this included some key species like *Centaurea nigra* (Common knapweed). Significantly the nectar and pollen values for the naturally occurring 'weeds' that grew alongside the seeded species yielded considerably more nectar and pollen resource per flower than the others. The results are shown in Figure 2.5 below, and shows that the

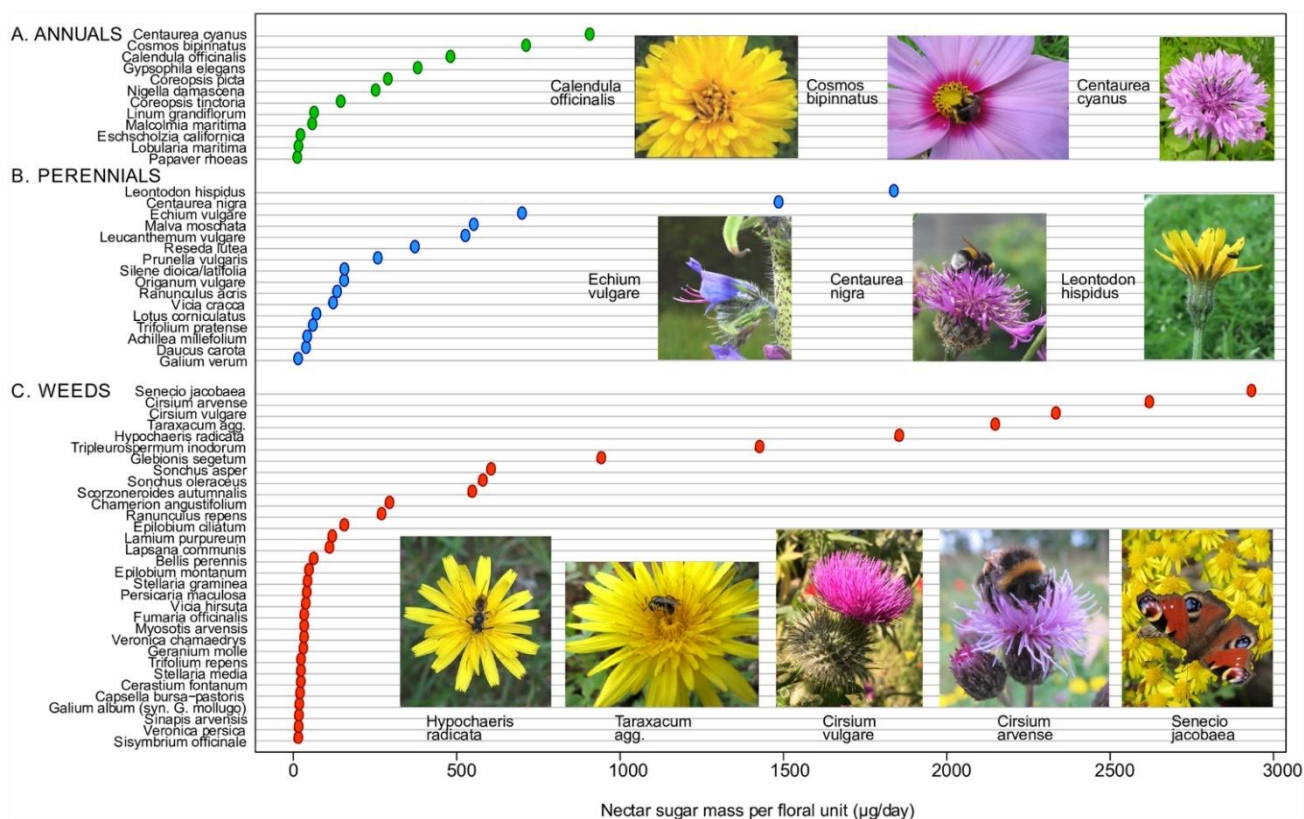


Figure 2.5 - A comparison of nectar values for different plant species grown from commercial seed mixes versus native weed species. (Hicks *et al.*, 2016)

values for *Senecio jacobaea* (Common ragwort) and *Cirsium arvense* (Creeping thistle) were measured at two and a half times higher than *Centaurea cyanus* (Cornflower). The native weeds provided almost all of the resource for pollinators in the early season, and their recommendations were that seed mixes

should include more native species across the season to have maximum value to pollinators (Hicks *et al.*, 2016).

Land Management: Timing of cuts

Conversely, Starr-Keddle (2022) looked at the success of restoration using green hay across 89 upland meadows, (NVC MG3b). Monitoring 3-5 years post application, success was observed in 77 meadows. However, there remained an absence of indicator species for NVC MG3b. The study further highlighted the importance of quality donation meadows being essential in the success of restoration and that indicator species may need additional management such as transplantation. Consistency of approach was recognised as being important but controlling this can be an issue with mixed ownership.

Studies into the importance of species richness and flowering periods on restored meadows was highlighted by Johansen (2019) studying low intensity agricultural sites in Romania. Changing the times of mowing was shown to affect floral diversity and availability of pollen and nectar resource. Meadows cut in midsummer did not show the expected decrease in diversity and abundance, due to a post mow bloom. Use of heterogeneous mowing schedules across sites may result in higher species diversity across the summer in particular pollen availability in late summer when traditional cutting is carried out. This would indicate that the cut and collect methods employed currently across Wales with a cut at the end of August as described in section 1.2 may be contributing to a loss of pollinator resource in late summer.

The heterogeneous method of mowing and the time of cutting in summer months was further highlighted in a study by Hemmings *et al.*, (2022). This study looked at the well accepted practice of 'No mow May'. The data showed increased plant diversity where amenity grassland was left unmown until late June. Findings showed that 'no-mow' plots were significantly higher in diversity, nectar, and pollen resource particularly in early summer. Interestingly this study also showed that one of the most important species for nectar and pollen production was *S. Jacobea* however as this is defined as a 'controlled weed', careful management of sites must be applied to align with local legislation.

Current research into grassland restoration indicates that management plans need to consider site condition, land ownership and ongoing management pressures when devising a restoration plan, (Rothero *et al.*, 2020). Although green hay and seeding has shown to be effective (Starr-Keddle, 2022) it has limitations related to the availability of quality seed and the application methods required. Use of

heterogeneous mowing regimes that can be adapted to current climate and visible indicators such as late flowering species being present (*Centaurea nigra/Succisa pratensis*) have been shown to work well in the above studies (Johansen, 2019; Hemmings *et al.*, 2022). On amenity grassland where the status quo is to mow every 2-4 weeks, any reduction in mowing intervals will result in floral and plant diversity increases (Hemmings *et al.*, 2022). It may be beneficial to employ a midsummer cut at the end of June to encourage further flowering and avoid the late August cut which has shown to be detrimental to some species (Johansen, 2019).

2.3.3 The human benefits of grassland restoration

Positive effects of urban greenspace

A study conducted in 2007 by Fuller *et al.*, revealed positive connections between urban greenspace species richness and the well-being of visitors. Psychological benefits were linked to plant and bird richness, with stronger relationships observed for plant species. While greenspace areas positively impacted well-being, plant diversity exhibited more robust associations. The study suggests that people in urban settings aren't entirely detached from biodiversity experiences, and accurately perceived higher species diversity and linked this to a feeling of well-being. Interestingly the correlation was less pronounced for the birds and butterflies observed and this could be due to the visually aesthetic nature of plant diversity. The study does note that causality is difficult to determine due to the non-random distribution among parks and individual preferences and that there may be cultural differences that were not explored. Overall, the findings emphasise the importance of greenspace quality for both human health and biodiversity promotion.

People's attitudes to biodiversity

Garbuzov *et al.*, (2015) carried out a trial of reduced mowing in the Saltdean Oval public park. Plots were managed under different mowing regimes over 1 year. Public opinion was surveyed, and the results showed strong support for the no mow and reduced mowing plots versus the control plot (mowed every 2 weeks). Interestingly the results didn't show the expected variation in species diversity between the plots with the plots mown in June and July showing similar levels of plant diversity as the no mow plot. The no mow plot did show larger numbers of insect visitation, however. The public opinion survey was not extensive with only 36 responses and carried out in one Spring/Summer season, but the results did

show that the reduced mowing was beneficial for both biodiversity conservation and public opinion. It was also noted that cost savings from reduced mowing are often offset by green waste disposal costs, regular mowing incurs no such costs as cuttings decompose in place. In the context of the UK where human land use has been prioritised over biodiversity conservation, the study highlights a win-win scenario where land management changes can align with both human and wildlife interests. This study demonstrates the feasibility of achieving conservation goals while considering the needs of both humans and wildlife, promoting sustainability in land management practices.

2.4 Summary of Literature Review

This section has outlined the main global strategic policies and driving factors related to biodiversity loss and the pressures on grassland habitats. The UK based research, reviewed here, highlighted the importance of grassland restoration and the techniques and management options available to land managers in the UK. From this research a methodology for meeting the aims of this study outlined in section 1.1 were developed and are detailed in section 4.

3.0 Physical background

For the purposes of the aims of this study it was necessary to obtain primary data for a restored species rich grassland. This section will detail the site chosen and the main reason for its suitability as a model for grassland recovery in lowland Wales.

3.1 Site context and history

The Waun las nature reserve (51.845011, -4.145753) is located at the National Botanic Gardens of Wales (NBGW) in Carmarthenshire. The site is to the north of the glass house of the NBGW as shown in figure 3.1 and formed part of the farmland attached to the Middleton Hall estate (*Figure 3.2*).



Figure 3.1 Satellite image showing location of survey site within the Waun las nature reserve at NBGW, Carmarthenshire (Bing maps © 2024 Microsoft)

During the 19th century it was historically used for sheep grazing, hay meadows and a deer park. The site under survey for this research was one of a small number of fields that were historically fenced off to the deer (Bosenquet, 2008). From the 1990s the site was then used as an organic farm and one of the first farms in Wales to join the Welsh Assembly Government (WAG) Tir gofal Agri-environment scheme.

For the last 22 years the site has been actively restored to wildflower meadow by the NBGW team using machinery cutting, seed harvesting and periodic grazing. The Trawscoed meadow is used a donation site for green hay application to restore other fields on the nature reserve.

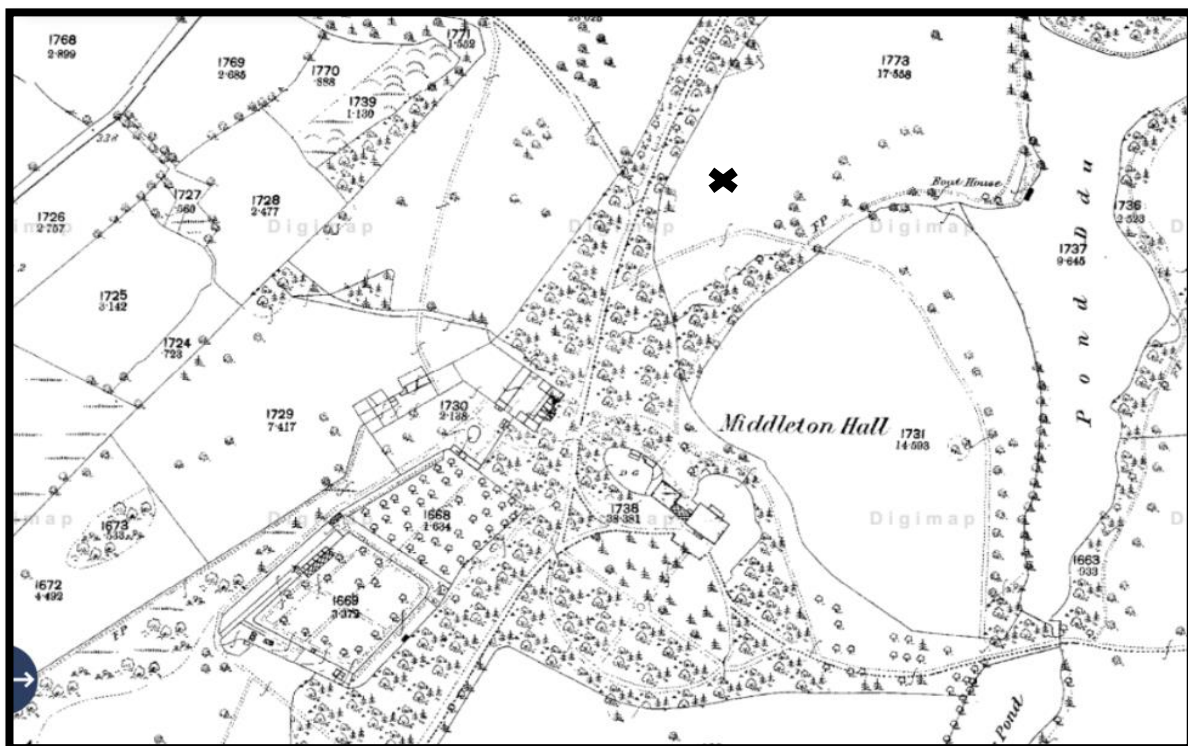


Figure 3.2 Map showing the site within the Middleton estate in 1880s. (Data map Wales)

3.2 Climate and weather

The site is exposed to median levels of rainfall for Wales as shown in Figure 3.3 below. Species present on the site are indicative of some marshy conditions and wet soils. The site is southward facing and exposed to the prevailing south-westerly wind although there may be some protection offered from the adjoining broadleaf woodland.

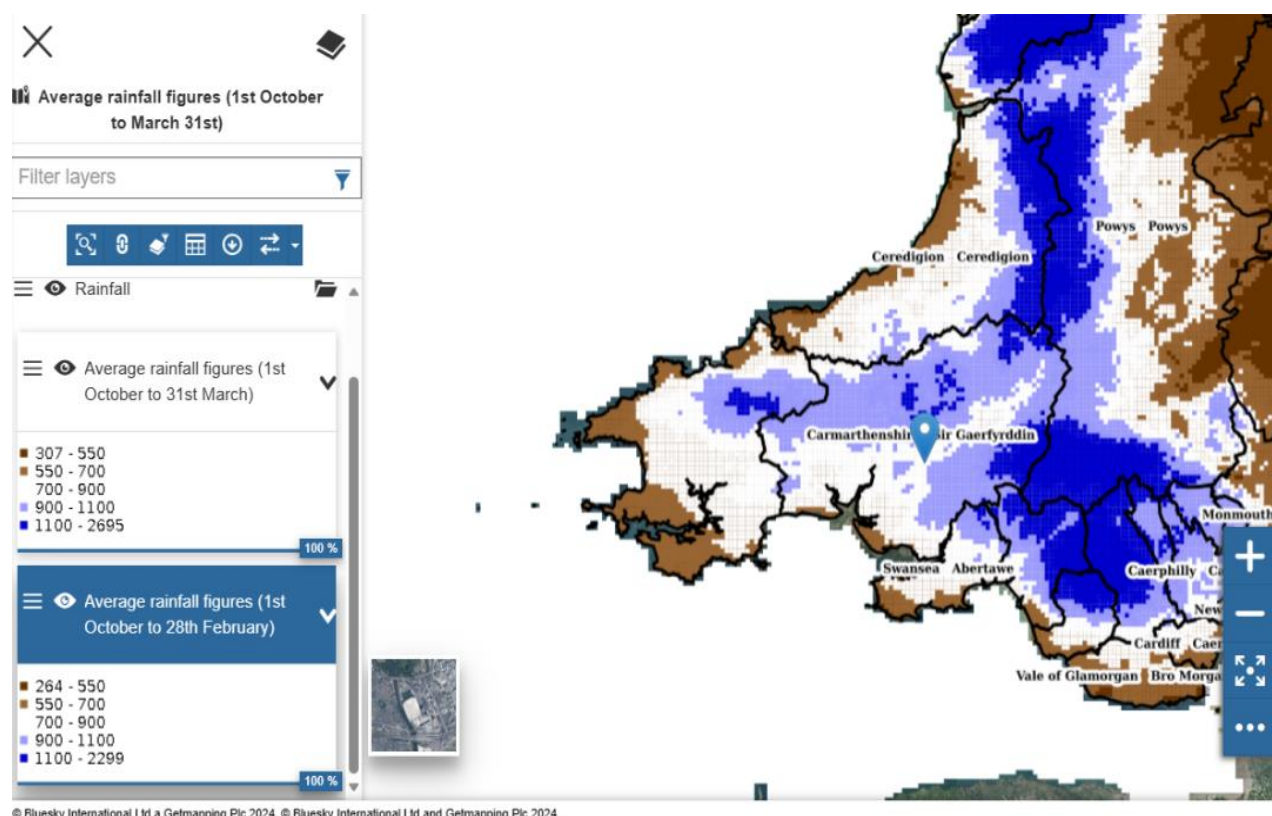


Figure 3.3 Map showing the annual rainfall at Waun las nature reserve. (Data map Wales, 2024)

The site is within the watershed of the Afon Gwynon which feeds into the Towy basin and minor tributaries of the Afon gwendraeth fach. The nature reserve contains a number of springs which feed areas of marshy grassland and is adjacent to a large lake, Llyn mawr/Pond ddu.

3.3 Geology of the site

The site lies on a band of siltstone and limestone as shown in Figure 3.4 with no significant faults or ground movement. pH readings recorded as part of primary data collection showed neutral mesotrophic soils with 1 slightly alkaline reading in the area marked 'C' on Figure 3.4 below, which could be due to its position on the edge of the band of embedded limestone.

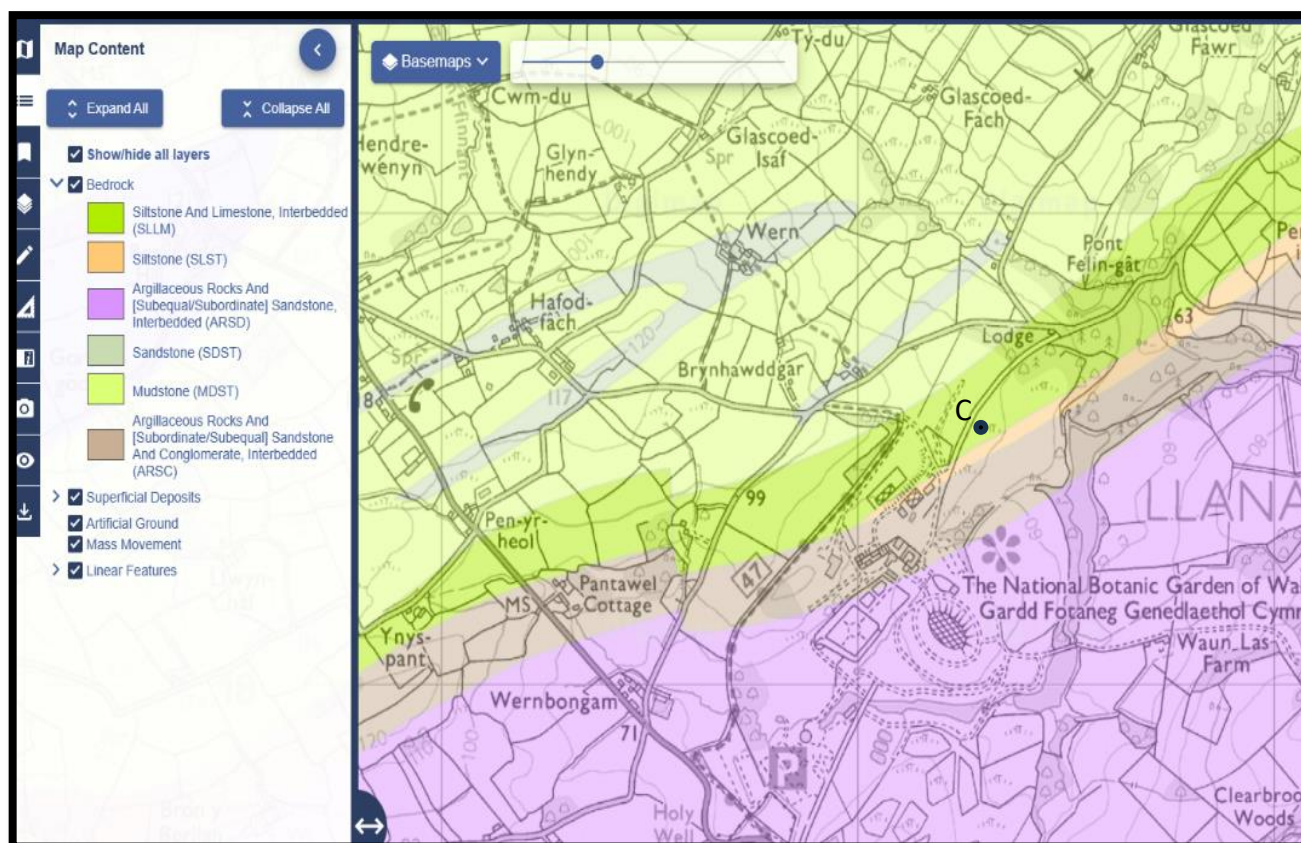


Figure 3.4 Map showing the rock types at the Waun las nature reserve (Data map Wales, 2024)

3.4 The ecology of the site

It is currently classified as largely species rich MG5 (Bosenquet, 2008; Pryce, 2016). In the 1990 Phase 1 habitat survey shown in Figure 3.5 the site was classified as 'Improved grassland' and later classified in 2016 as having regained species diversity due to conservation management (Pryce, 2016).

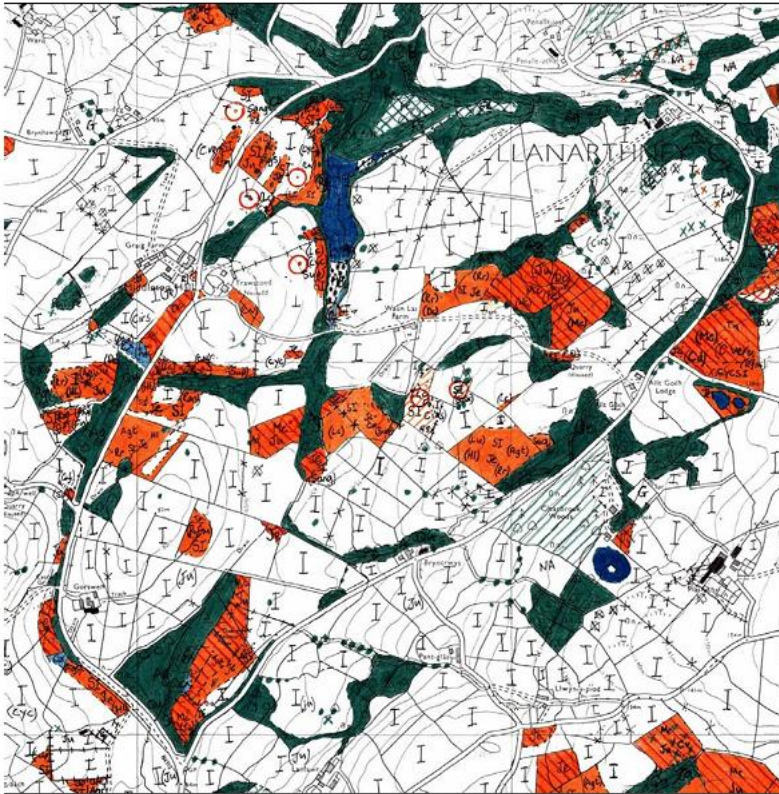


Figure 3.5 Phase 1 habitat survey carried out by the Countryside Council for Wales (CCW) in 1990 showing the site as I for Improved grassland (Pryce, 2016).

Following the establishment of the NBGW and the proposal for a Regency landscape restoration project a full ecological survey was commissioned, and the site was surveyed under the original compartment mapping done by Bosenquet in 2008. Bosenquet commented that Cae Trawscoed (compartment 30) supported the most diverse MG5a community with *Centaurea nigra* (Common knapweed) a constant feature with high cover of *Lotus pedunculatus* (Greater bird's foot trefoil) over the expected *Lotus corniculatus* (Lesser bird's foot trefoil). The abundance of *Lotus pedunculatus* is a feature of damper ground and an indicator of MG4 grassland alongside the presence of *Sanguisorba officinalis* (Greater burnet). Despite the similarities to MG4 the designation in 2008 was MG5a. Similar findings were noted in the survey carried in 2016 by Richard Pryce.

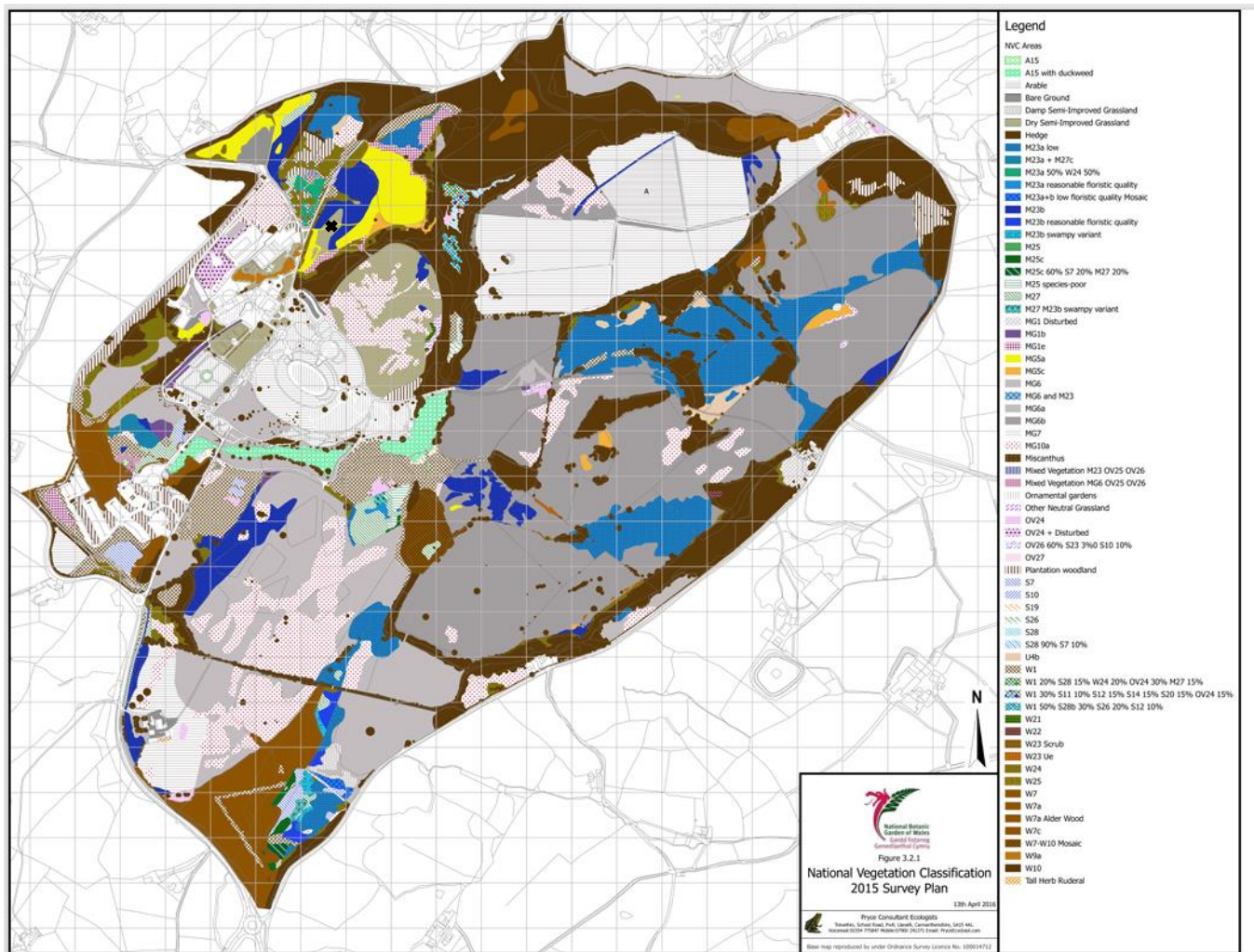


Figure 3.6 – A map showing the NVC habitat classification survey carried out in 2016 (Pryce, 2016)

In 2016 the site was recorded as a prominent MG5 community under hay meadow management, this was noted as a key cause of the species richness observed and an enlargement of the field now classified as MG5. Although it is noted, that the frequent recording of species such as *Succisa pratensis* (Devil's bit scabious) and *Potentilla erecta* (Tormentil) could indicate areas of MG5c. Pryce (2016) concluded that the frequency of these species was insufficient to class the whole area as MG5c. Pryce also noted that the recent hay meadow management had increase species diversity with the appearance of *Hypochaeris radicata* (Catsear), *Rhinanthus minor* (Yellow rattle), the rare *Platanthera chlorantha* (*G. butterfly orchid*), and *Sanguisorba officinalis*, however this was not sufficient to change the NVC classification and the field remained of moderate floristic quality. The site as seen in Figure 3.6 was noted as being a mosaic of MG5 with M23 rush pasture and species characteristic of an MG4 community but overall, a classification of MG5c was retained (Pryce, 2016).

3.5 The survey site.

Cae Trawscoed is part of the North Trawscoed meadow in the Waun las nature reserve within the grounds of the NBGW. The area for survey was chosen following recommendation by Bruce Langridge – site manager for NBGW and covered the range of different conditions on site, i.e. tree cover, pathways, and wetter areas of the meadow. When compared to the NVC survey map in Figure 3.6 you can visibly see the darker green area of rush pasture area characteristic of M23 due to the growth of *Juncus effusus* (Soft rush) and *Juncus articulatus* (Jointed rush). Also visible in Figure 3.7 are the tracks from the mowing machinery used to manage the hay meadow as part of the meadow restoration programme.



Figure 3.7 Satellite image showing the location of the Cae Trawscoed meadow. (Google maps, 2024)

There is only 1 designated site within 2 km of the survey area, which is a SSSI: Wernbongam Stream Section and Quarry, noted for its geological characteristics (NRW, 2024).

As a point of interest, the Waun las nature reserve and the Trawscoed meadow have been classified with a ‘High’ score for woodland creation on the Wales ‘Woodland opportunity’ map (Datamap Wales, 2024) shown in Figure 3.8. According to the Welsh Government guidance (Welsh Government, 2021) this values the site as a high priority for tree planting and tree suitability which could form a basis of funding applications to tree planting schemes such as Glastir woodland creation.

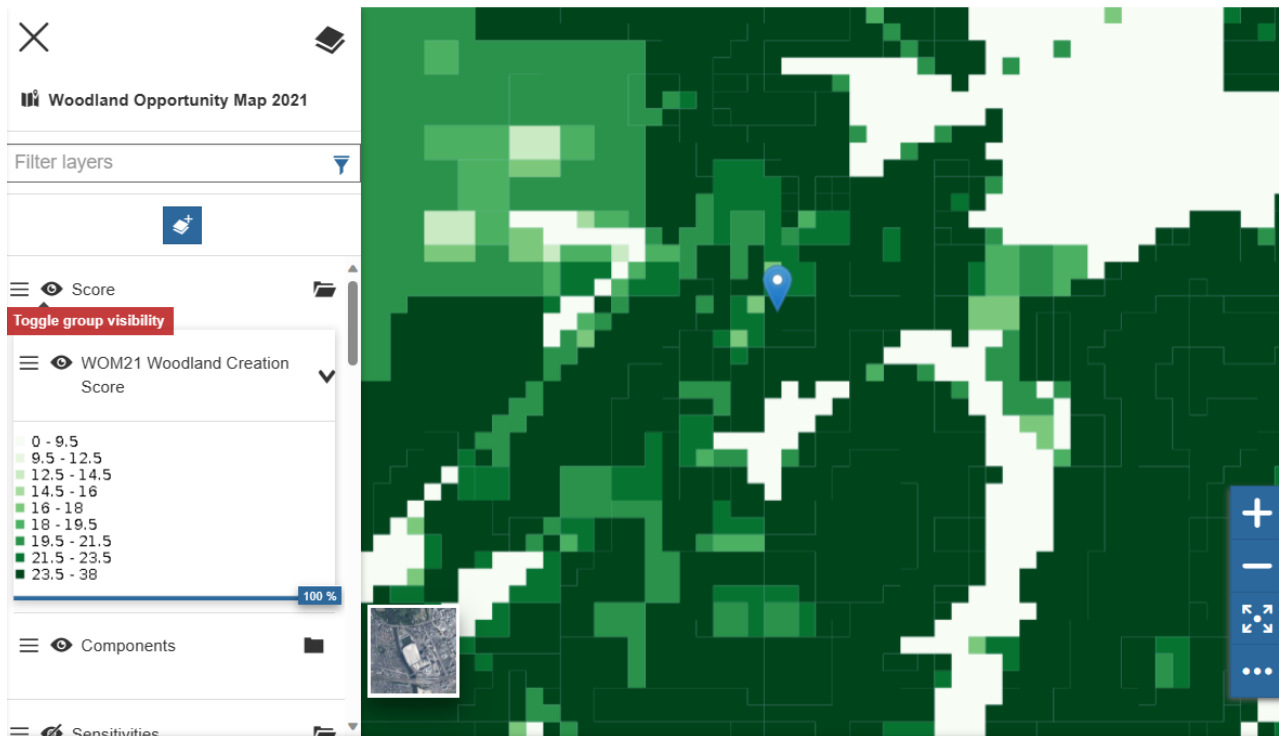


Figure 3.8 Map of site showing the 'Woodland creation score (Data map Wales, 2024)

The woodland opportunity map does not list any restrictions for this site. Afforestation of grassland ecosystem such as Cae Trawscoed can significantly reduce species richness and diversity and loss of plant communities (Buscardo *et al.*, 2008). For future security this could be an existential threat to valuable plant communities and grasslands. The aim of this research is to allow land managers and decision makers to quantify the value of such grassland and contribute to arguments for its protection.

4.0 Methodology

In choosing the methodological approaches to collecting the primary data, the literature reviewed in section 2.3 and the methodology of the secondary data collected were compared and a common approach found. This is outlined in section 4.1. The data from both primary and secondary data sets will be streamlined and codified to allow comparison of the species found at each of the sites surveyed. It is recognised that as different surveyors, methods, and time of the year are used that there is potential for errors in recoding, identifying and assessment of abundance. To reduce this element only the species recorded is analysed and its abundance disregarded in the secondary data. This is discussed more fully in section 4.2. In section 4.3 the method of creating a hierarchy of plant species value for amenity grassland is outlined.

4.1 Primary data

The Cae Trawscoed site is the gently sloping western section of the North Trawscoed meadow as described in section 3. The methodology for survey was chosen to effectively capture as many of the species present as seen in Figure 4.1 below.



Figure 4.1 - Cae Trawscoed meadow looking North showing some of the abundant species found during the survey.

4.1.1 Surveying techniques

Following a review of relevant literature in section 2.3 and reviewing the most common techniques in use by county ecology teams in Wales, the W-shape quadrat method was chosen for this site. This allowed the different areas and topographies of the site to be included (Starr-Keddle, 2022). As the site is diverse and many species have been found in different areas such as *Ophrys apifera* (Bee orchid) and *Carum verticillatum* (Whorled caraway), a 20 quadrat survey was chosen at intervals of 10 metres. The area surveyed is shown below in Figure 4.2 and the footpaths and tracks are clearly shown which could impact species found in quadrats 3, 6 and 12.

This allowed a large section of the Trawscoed meadow to be surveyed which had been previously described as in better condition and of higher conservation value than the rest of the meadow (Bosenquet, 2008; Pryce, 2016). Data was collected on a warm sunny day in late July 2023 after a prolonged period of heavy rain.



Figure 4.2 - An aerial view of Cae Trawscoed showing the locations of each of the 20 quadrats used in the botanical survey.

The meadow is extensive in size and a walkover survey recording all species was discounted as not appropriate. To record relevant abundance of each species, the DAFOR scale was chosen as the most common method as shown in Table 4.1 and is also outlined in the Plantlife UK Rapid grassland assessment toolkit (Plantlife UK, 2021).

Table 4.1 - Table showing how to assess relative abundance of each plant species using the DAFOR scale.

The DAFOR Scale		
Relative abundance	Description	Letter code
51% - 100%	Dominant in the sward	D
31% - 50%	Abundant in the sward	A
16% - 30%	Frequently present in the sward	F
6% - 15%	Occasionally found in the sward	O
1% - 5%	Rarely found in the sward.	R

An adapted version of this toolkit is currently used by many County ecology teams as advised by Brannovic and Revera (2023). Assigning a DAFOR scale within quadrats allows for easy assessment of relative abundance, the presence of the species being the most important data as this will allow comparison to the NVC plant communities lists to assign an NVC classification in section 5.0. It is the presence of the species that is important for the research aim. It was important that any method chosen would be simple and easily repeated by citizen scientists and inexperienced surveyors. This will allow the resultant matrix to be used by volunteers in the field.

The primary data will be analysed for statistically significant relationships using linear regression lines and calculating the Coefficient of Determination(R^2) and a Pearson coefficient value (r). This will measure any commonalities between the Quadrat location, species diversity and soil pH. The values calculated will be compared to published confidence tables (Martin and Bateson, 1994).

4.1.2 Plant identification.

Plants were identified to species level where appropriate, such as members of the Ranunculaceae family (buttercups) with others being recorded as an aggregate species such as Euphrasia agg. (Eyebrights) and Agrostis (Bents). This methodology was guided by the NVC plant communities and also the importance of the individual species such as Ranunculus acris (meadow buttercup) being an indicator species for good quality meadow, and Ranunculus repens (creeping buttercup) being present in lower quality meadows. This removed the need for specialist botanical skills and aimed to reduce identification errors. Figure 4.3 shows the positioning of a quadrat using red flags to mark out the intervals and the identification of Common bird's foot trefoil.



Figure 4.3 – (Image on left) Shows the positioning of a quadrat during the Cae Trawscoed survey. (Image on right) The Identification of Common bird's foot trefoil during the survey. (Carter,2023)

4.2 Secondary data

Survey data from recent ecological surveys were obtained from County Ecologists in the following counties: Gwynedd, Blaenau Gwent and Torfaen. The 15 sites were a mix of grasslands and road verges either under intensive management with regular mowing or after 1 year of a cut and collect regime. All sites were chosen as they were typical of mesotrophic amenity grassland found at lower altitudes.

4.2.1 Gwynedd sites

Data was collected by walkover survey recording plant species including forbs, grasses, sedges and woodland species of 5 sites on the Llŷn peninsula. Relative abundance was estimated using the ACFOR scale. This system differs slightly from the DAFOR used in the primary data (see Table 4.2). Data was collected in April 2022.

Table 4.2 - Table showing how the Gwynedd data was assessed using the ACFOR scale.

The ACFOR Scale		
Relative abundance	Description	Letter code
30% +	Abundant in the sward	A
20% - 29%	Common in the sward	C
10% - 19%	Frequently present in the sward	F
5% - 9%	Occasionally found in the sward	O
1% - 4%	Rarely found in the sward.	R

4.2.2 Torfaen and Blaenau Gwent sites

Data was collected by walkover survey recording plant species including forbs, grasses, sedges and woodland species of 10 sites across the area. Sites surveyed ranged from cemeteries, road verges and recreational fields. The area has many post-industrial landscapes with high levels of urbanisation. Whereas the Gwynedd sites outlined in the previous section were mainly coastal at low altitudes these

sites were in the South Wales valleys and at slightly higher altitudes. Relative abundance was recorded using the DAFOR scale with notes made of whether species were local and 'very'.

4.2.3 Nectar and pollen data

Two distinct data sets were used for this secondary data source. A study carried out in 2016 by Baud, Kunin and Memmott at the University of Bristol. Supplementary values were obtained by a study in 2022 on 'No mow' versus 'Mow' plots in Cirencester previously discussed in section 2.3.3 (Hemmings *et al.*, 2022). The 2016 dataset consists of nectar sugar values of common UK plant species recorded during field surveys from February to October in 2011 and 2012. The sites were centred around Bristol and the South of England. The full methodology of nectar collection and analysis is detailed in Appendix 2. The 2022 study by Hemmings *et al.*, was based on the Plantlife UK 'Every flower counts' method whereby the observer counted all open flowers in a set plot every week between 27.4.21 and 15.7.21. To quantify the nectar data for each species recorded the 'Total nectar sugar value' per flower per day (Baud *et al.*, 2016) was multiplied by the number of open flowers recorded each week to obtain an average value per species per week. Additional data on species of the Asteraceae family (Daisys) were obtained from Hicks *et al.*, (2016). Where no data was available for some species data from similar species was used, based on work by Hardman, C.J. (2016). Hicks *et al.*, (2016) used similar methods to the Baud methodology outlined in Appendix 2 using fine netting to exclude pollinators for extracting nectar before sampling.

Nectar extraction using the outlined methodologies has many limitations due to the small volumes of nectar found in certain plants. The nectar can be difficult to extract and there are many variables that can affect nectar production in flowers. The data available should be considered estimates and could vary due to weather location and insect activity (Hicks *et al.*, 2016) For the purposes of this study it provides a relative reference for the most valuable floral species to pollinators that may be present in amenity grasslands.

5.0 Results and discussion

The following section will analyse and discuss primary data from Cae Trawscoed. This data will provide information on the species composition of High Conservation Value (HCV) grassland that has transitioned from improved grassland (Bosenquet, 2007). Using this as a model, data from 15 secondary sources will be collated and compared to primary data set. This will create a desired plant species list for recovering meadows that should be applicable to most amenity grasslands across Wales. The analysis of the published data from nectar resource studies (Baude *et al.*, 2016; Hemmings *et al.*, 2022) will contribute to the final list of wildflower species based on recorded frequency, most likely plant communities, and known nectar resource values.

5.1 Primary data – Cae Trawscoed, Waun las nature reserve

The quadrat survey recorded plant species and their relative abundance according to the DAFOR scale as set out in section 4.1.1. Significant locations were recorded in Figure 5.1 and any specific conditions noted. The soil pH was recorded and maintained a continuous neutral value across the profile with only a mildly alkaline value for Q1. Some species of NVC classification MG5 and its sub communities may not have been captured in this survey due to the lateness in the season.

Quadrat no.	Site:				Cae trawscoed																														
	Notes on quadrat station	pH	Is sward height <15cm	Is the cover of herbs and sedges >50%	<5% bareground?	Agrostis SP./Bent	Ranunculus bulbosus/Bulbous Buttercup	Centaurea nigra agg./Common Knapweed	Rumex acetosa/Common Sorrel	Ranunculus repens/Creeping Buttercup	Cynosurus cristatus/Crested Dog's Tail	Euphrasia spp/Eyebright	Lotus corniculatus/Common Birds Foot	Sanguisorba Officialnalis/Greater Burnet	Leontodon spp/Hawkbits	Ranunculus flammula/Lesser Spearwort	Dactylorhiza praetermissa/Marsh Orchid	Ranunculus acris/Meadow Buttercup	Pulicaria dysenterica/Meadow Fleabane	Filipendula ulmaria/Meadow Sweet	Cerastium fontanum/Common Mouse-ear	Odonites vernus/Red Bartsia	Trifolium pratense/Red Clover	Plantago lanceolata/Ribwort Plantain	Prunella vulgaris/Selfheal	Juncus articulatus/Sharp Flower Rush	Festuca sp/Sheeps/Red Fescue	Potentilla Anserina/Silverweeds	Achillea ptarmica/Sneezewort	Juncus effusus/Soft Rush	Anthoxanthum odoratum/Sweet Vernal	Trifolium repens/White Clover	Carum verticillatum/Whorled Caraway	Geum urbanum/Wood Avens	Rhinanthus minor agg./Yellow Rattle
1 highest pt	8.7	0	1	1	R		F		O			O	O				O						F				F								O
2	7.5	0	1	1			F					O					F						A	R		F									
3 tracks	7.2	0	1	1			O					R					R		F				F		R		F		O						
4 near tree	6.6	1	1	1			A		O			F	F			R	O			F		O	A	O		F		R	O						
5	7.2	0	1	1			D		R			O	O	R			R						R		O		F		R				R		
6 edge of path	6.9	0	1	1			O	O				O		R			R				R		R	O			F	O				O		R	
7	6.7	0	1	1			F					F	R				O		A			R	O				F	O			F	R			
8	6.5	0	1	1			F					R	D	R			R		O							F		F							
9	6.0	0	1	1			O		R				O	F					O				O			F		F							
10	6.0	0	1	1			O		O		R	O	O				R		O				F		F		F	O							A
11	6.0	0	1	1			A		O		R	R											D		A		O		O						A
12	7.0	1	1	1			R	F	O		R		O			R										O	A	O						O	
13	7.0	0	1	1		O	A		O		F		O									R		A		O	A	O							O
14	6.0	0	1	1	O		D		O			O	F	O									F	O											
15	7.0	0	1	1	A		F						F										O											O	
16	6.5	0	1	1			R								R											D								R	
17	7.0	0	1	1							R		O					O								A				A				R	
18	7.0	0	1	1			O					O	O													F		F							
19	7.0	0	1	1			O					R						O							A										
20	7.0	0	1	1		R	F					R												O		F		F						O	

Figure 5.1 - Spreadsheet showing the raw survey data from primary data survey of Cae Trawscoed.

The DAFOR survey data was codified according to the following rule (D=5, A=4, F=3, O=2, R=1) to allow data analysis and comparison to other data. A total score was calculated for all 20 quadrats representing the frequency each species was found with the calculated median, shown in Figure 5.2 below.

Species Name	Frequency
Cynosurus cristatus/Crested Dog's Tail	1
Ranunculus flammula/Lesser Spearwort	1
Dactylorhiza praetermissa/Marsh Orchid	1
Cerastium fontanum/Common Mouse Ear Chick We	1
Odontites vernus/Red Bartsia	1
Anthoxanthum odoratum/Sweet Vernal Grass	1
Geum urbanum/Wood Avens	1
Trifolium repens/White Clover	2
Ranunculus bulbosus/Bulbous Buttercup	3
Prunella vulgaris/Selfheal	3
Juncus effusus/Soft Rush	3
Pulicaria dysenterica/Meadow Fleabane	4
Achillea ptarmica/Sneezewort	4
Rumex acetosa/Common Sorrel	5
Trifolium pratense/Red Clover	6
Agrostis SP./Bent	7
Euphrasia spp/Eyebright	8
Leontodon spp/Hawkbits	8
Rhinanthus minor agg./Yellow Rattle	8
Carum verticillatum/Whorled Caraway	9
Filipendula ulmaria/Meadow Sweet	13
Ranunculus acris/Meadow Buttercup	14
Ranunculus repens/Creepng Buttercup	16
Festuca sp/Sheeps/Red Fescue	18
Lotus corniculatus/Common Birds Foot Trefoil	25
Potentilla Anserina/Silverweeds	25
Sanguisorba Officianalis/Greater Burnet	32
Plantago lanceolata/Ribwort Plantain	37
Juncus articulatus/Sharp Flower Rush	44
Centaurea nigra agg./Common Knapweed	54
Median	6.5

Figure 5.2 - List of the recorded species at Cae Trawscoed with their frequencies and calculated median value.

This allowed the less common species to be discounted in graphical interpretation, therefore only the most abundant species are shown in Figure 5.3.

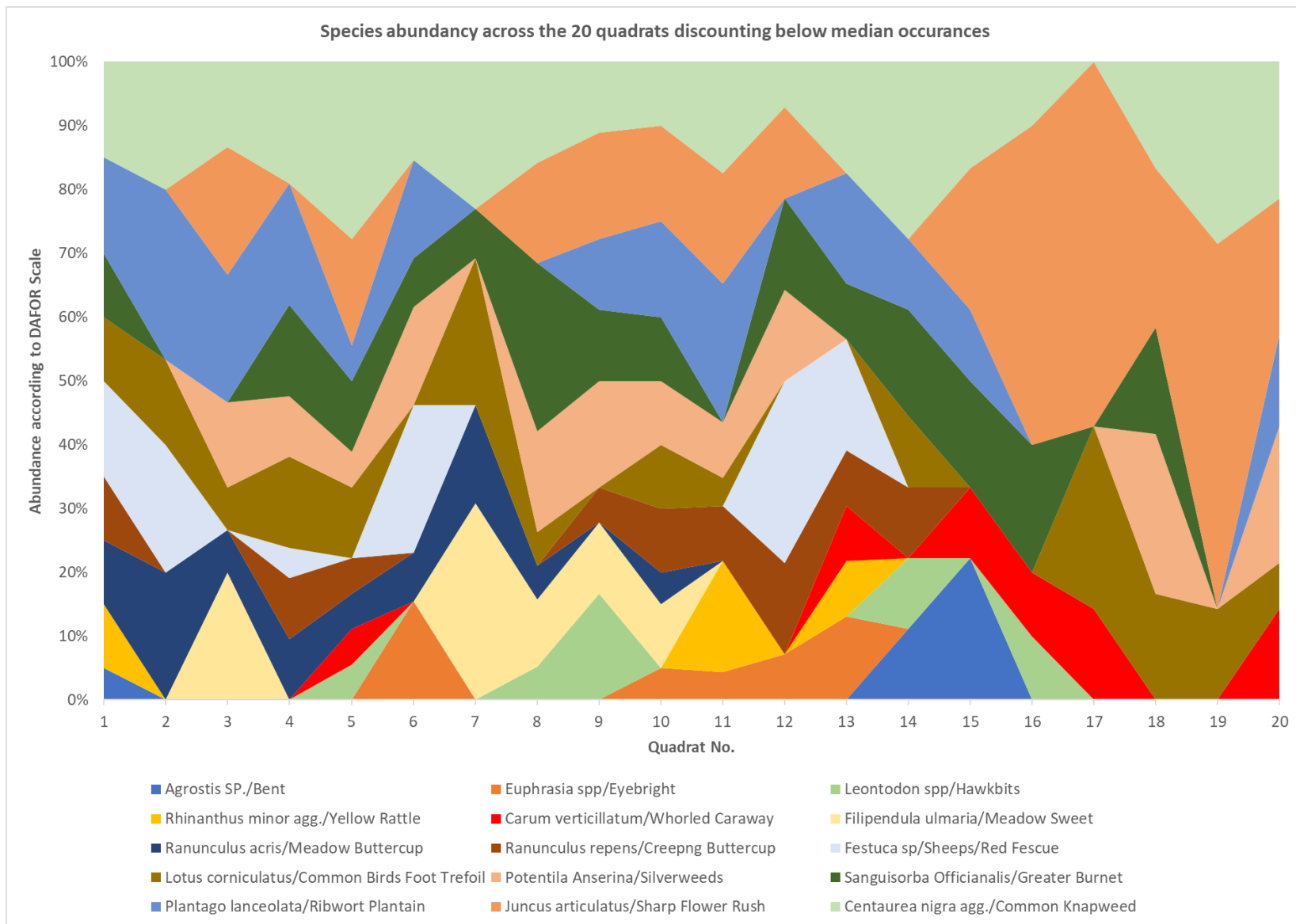


Figure 5.3 – Graph showing the abundance across the 20 quadrats of all species occurring above the median of 6.5.

The colours show how the abundancy varies across the quadrats. in particular species such as Eyebright appear at quadrats 6, 12 and 13 in great numbers as these quadrats were on or near the path/machinery tracks. It can also be seen that Common knapweed is consistently present across all 20 quadrats. This species is classed as a constant species - necessary to assign a site as a MG5 plant community (Rodwell, 2012, pp43-46). Another species that occurs at certain locations is Whorled caraway which is locally frequent to Rhôs pastures of SW Wales and was designated the county flower of Carmarthenshire in 2002 (Plantlife UK, 2002). The importance of concepts such as ‘County flowers’ with regards human engagement will be discussed further in section 5.1.6.

Soil pH was recorded to assess the soil type and expected plant species aligning with the NVC plant list for Mesotrophic Grassland (MG5). A relationship between soil pH and location was not expected as soil pH dictates the species present and not the diversity, unless at the extremes (Ellenberg, 1988; Barr *et al.*, 1993). The graph showing the relationship between the 3 variables is shown in Figure 5.4. A Pearson correlation coefficient $P = -0.06$ was calculated for the relationship between soil pH and species diversity, showing a statistically insignificant negative correlation, and the R^2 Value (0.0036) also confirmed no

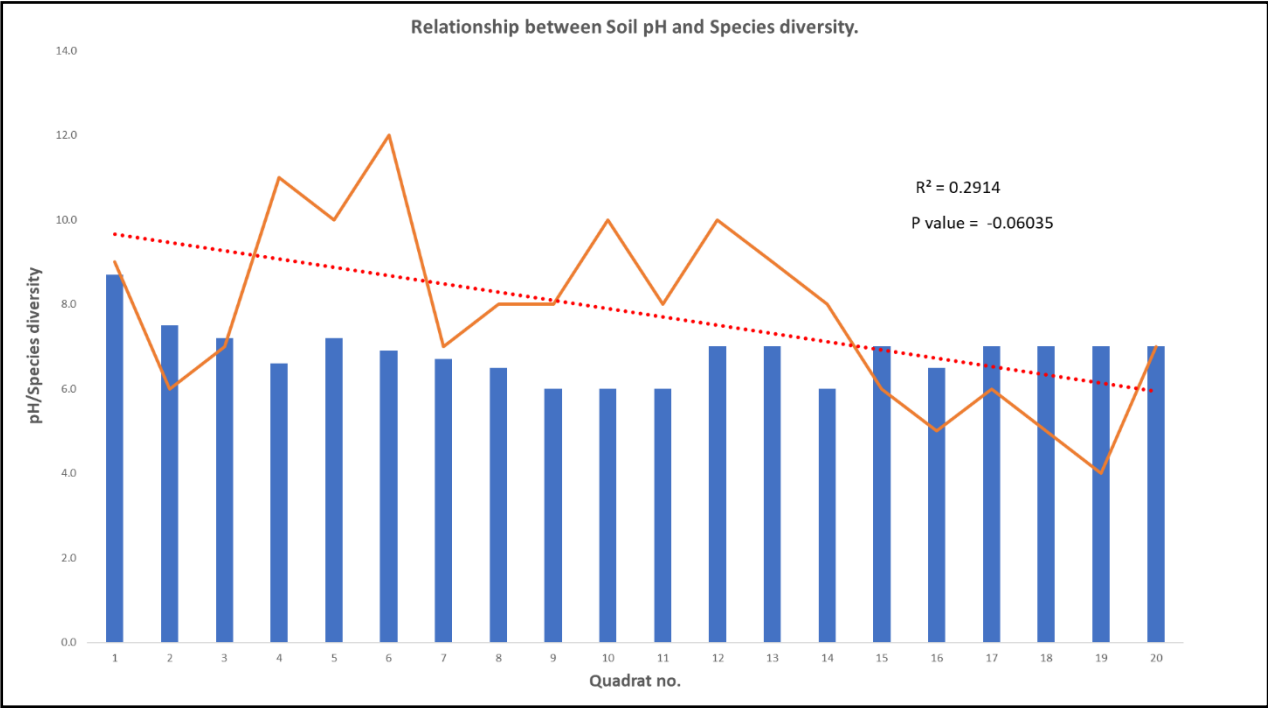


Figure 5.4 – Graph showing the recorded soil pH values and species diversity across the 20 quadrats of the Cae Trawscoed meadow.

statistical relationship. Conversely an R^2 Value of $R^2=0.2914$ was calculated for species diversity versus quadrat number, showing a low correlation with a definite but small relationship. This was expected as

the site is diverse and there are multiple variables affecting plant diversity on the site such as topography, moisture, and soil type. The small relationship indicated by this value could be accounted for by the small sample size, which can lead to patterns occurring by chance (Martin and Bateson, 1994). Using the Critical values table (Appendix 3), the relationship between soil pH and species diversity ($r(18) = 0.06$, $p > .05$) shows that the correlation coefficient was less than the critical value needed to be 95% confident that any relationship exists between the two variables.

Finally, a comparison test was carried out to compare the species present in the site against the species list characteristics of NVC classifications and MG5 plant communities list (Rodwell, 2006). The similarity scores for the primary data are shown in table 5.1 and confirm the highest similarity to an MG5 classification. This is further confirmed by the Jaccard similarity scores, and dissimilarity scores shown in Table 5.2. The Jaccard similarity showed closest correlation to the MG5c sub community which is characterised by the presence of *Gallium verum* (Lady's bedstraw) and other acid loving plants. This deviation may be due to the small sample taken and the timing of the survey in late July, which is sub optimal for some key species of MG5 grasslands.

Table 5.1- Shared similarity scores for the species list recorded at Cae Trawscoed against the NVC plant communities list for all communities (Rodwell, 2006)

NVC Class	Shared Similarity
MG5	21
MG8	21

Table 5.2 - The Jaccard similarity score and dissimilarity score for the species list recorded at Cae Trawscoed against the NVC plant communities list for all communities (Rodwell, 2006)

NVC Class	Jaccard Similarity	Dissimilarity
MG5c	0.28	0.72
MG6b	0.28	0.72

The primary data shows that the meadow surveyed is characteristic of Mesotrophic grassland in transition closest to the MG5 classification of *Cynosurus cristatus* - *Centaurea nigra* grassland. This was expected by referencing the previous data and a result of over 20 years of restoration management from semi improved grassland. The site represents the result of the recovery achieved through change in management using the cut and collect mowing method without requirements for seed mixes or soil preparation. MG5 is a typical grassland type of lowland UK, so as such the species found here can confidently be used a reference point to compare recovering grasslands.

5.2 Secondary data

To assess the most common species occurring in recovering grasslands and meet objective 1 of this study, data was obtained from 2 different regions of Wales. The Torfaen and Blaenau Gwent sites are inland areas with some sites surveyed on or around 300m altitude, 300 metres being the boundary between Upland and Lowland meadows. The second dataset is from Gwynedd, sites are lowland areas below 100 metres, close to the coast at various locations on the Llŷn peninsula. Secondary data was collected by external ecological consultants on behalf of the local authority.

5.2.1 Torfaen and Blaenau Gwent Sites

There were 31 sites in the original data set, 10 sites chosen for this data set to include varied locations from cemeteries and road verges to managed meadow sites. All sites were owned and managed by the local authorities of Torfaen and Blaenau Gwent. To simplify the data and to allow comparisons to meet the aims and objectives of this research, all wood species records were discounted along with garden escapes and non-natives. A description of each site 1T-10T can be found in Appendix 4.

The data was converted from the adapted DAFOR scale and codified to a binary system to create a list of all species recorded over the ten sites. The data was ranked and a median calculated. The median value of 2 allowed all species that were recorded once only across the sites to be discounted for ease of analysis. The data is shown in Table 5.3 below.

Table 5.3 - Table showing the species recorded ranked according to frequency with all species below the median of 2 discounted for ten locations across the Torfaen and Blaenau Gwent sites.

Species	Common name	Frequency
Ranunculus acris	Meadow buttercup	10
Ranunculus repens	Creeping buttercup	10
Trifolium pratense	Red clover	10
Agrostis capillaris	Common bent	9
Centaurea nigra	Common knapweed	9
Dactylis glomerata	Cocksfoot	9
Holcus lanatus	Yorkshire fog	9
Plantago lanceolata	Ribwort plantain	9
Rubus fruticosus agg.	Brambles	9
Rumex obtusifolius	Broad-leaved dock	9
Trifolium repens	White clover	9
Anthoxanthum odoratum	Sweet vernal grass	8

<i>Arrhenatherum elatius</i>	False oat-grass	8
<i>Heracleum sphondylium</i>	Hogweed	8
<i>Lotus corniculatus</i>	Common bird's foot trefoil	8
<i>Potentilla reptans</i>	Creeping cinquefoil	8
<i>Senecio jacobaea</i>	Common Ragwort	8
<i>Taraxacum officinale</i> agg.	Dandelions	8
<i>Urtica dioica</i>	Common nettle	8
<i>Cerastium fontanum</i>	Common mouse-ear	7
<i>Epilobium hirsutum</i>	Hairy willowherb	7
<i>Festuca rubra</i>	Red fescue	7
<i>Hypochaeris radicata</i>	Catsear	7
<i>Lotus pedunculatus</i>	Greater bird's foot trefoil	7
<i>Prunella vulgaris</i>	Primrose	7
<i>Achillea millefolium</i>	Yarrow	6
<i>Agrostis stolonifera</i>	Creeping bent	6
<i>Bellis perennis</i>	Daisy	6
<i>Chamerion angustifolium</i>	Great willowherb	6
<i>Cirsium arvense</i>	Creeping thistle	6
<i>Cynosurus cristatus</i>	Crested dog's-tail	6
<i>Epilobium</i> spp.	Willowherbs	6
<i>Galium aparine</i>	Cleavers	6
<i>Lathyrus pratensis</i>	Meadow vetchling	6
<i>Phleum pratense</i>	Timothy grass	6
<i>Rumex acetosa</i>	Sorrel	6
<i>Carex flacca</i>	Glaucous sedge	5
<i>Carex hirsute</i>	Hairy sedge	5
<i>Carex spicata</i>	Spiked sedge	5
<i>Cirsium palustre</i>	Marsh thistle	5
<i>Geranium molle</i>	Dove's foot crane's-bill	5
<i>Lolium perenne</i>	Perennial rye grass	5
<i>Plantago major</i>	Greater plantain	5
<i>Veronica chamaedrys</i>	Germander speedwell	5
<i>Alopecurus pratensis</i>	Meadow foxtail	4
<i>Juncus effusus</i>	Soft rush	4
<i>Luzula campestris</i>	Field wood rush	4
<i>Poa trivialis</i>	Rough meadow grass	4
<i>Trifolium dubium</i>	Lesser trefoil	4
<i>Cardamine pratensis</i>	Cuckoo flower	3
<i>Cirsium vulgare</i>	Spear thistle	3
<i>Elymus repens</i>	Couch grass	3
<i>Equisetum arvense</i>	Field horsetail	3
<i>Geranium robertianum</i>	Herb Robert	3
<i>Geum urbanum</i>	Wood avens	3
<i>Hypericum maculatum</i>	Imperforate St John's wart	3
<i>Leucanthemum vulgare</i>	Oxeye daisy	3

<i>Medicago lupulina</i>	Black medic	3
<i>Nardus stricta</i>	Mat grass	3
<i>Pilosella officinarum</i>	Mouse ear hawkweed	3
<i>Potentilla erecta</i>	Tormentil	3
<i>Pteridium aquilinum</i>	Bracken	3
<i>Rumex crispus</i>	Curly dock	3
<i>Sonchus asper</i>	Spiny Sow thistle	3
<i>Torilis japonica</i>	Upright hedge parsley	3
<i>Vicia sativa</i>	Common vetch	3
<i>Viola riviniana</i>	Dog violet	3
<i>Aegopodium podagraria</i>	Ground elder	2
<i>Calystegia sepium</i>	Hedge bindweed	2
<i>Carex ovalis</i>	Oval sedge	2
<i>Daucus carota</i>	Wild carrot	2
<i>Deschampsia caespitosa</i>	Tufted hair grass	2
<i>Epilobium parviflorum</i>	Hoary willowherb	2
<i>Epipactis helleborine</i>	Broad-leaved helleborine	2
<i>Eupatorium cannabinum</i>	Hemp agrimony	2
<i>Galium saxatile</i>	Heath bedstraw	2
<i>Geranium dissectum</i>	Cut leaved Cranesbill	2
<i>Hedera helix</i>	Common ivy	2
<i>Juncus conglomeratus</i>	Compact rush	2
<i>Juncus inflexus</i>	Hard rush	2
<i>Juncus tenuis</i>	Slender rush	2
<i>Lapsana communis</i>	Nipplewort	2
<i>Leontodon hispidus</i>	Rough hawkbit	2
<i>Odontites vernus</i>	Red bartsia	2
<i>Pilosella auriantica</i>	Fox & Cubs	2
<i>Poa annua</i>	Annual meadow grass	2
<i>Polygonum aviculare</i>	Common knotgrass	2
<i>Potentilla anserina</i>	Silverweed	2
<i>Ranunculus bulbosus</i>	Bulbous buttercup	2
<i>Ranunculus flammula</i>	Lesser spearwort	2
<i>Rhinanthus minor</i>	Yellow rattle	2
<i>Rosa canina</i>	Dog rose	2
<i>Rumex acetosella</i>	Sheep's sorrel	2
<i>Rumex sanguineus</i>	Wood dock	2
<i>Stellaria graminea</i>	Lesser stitchwort	2
<i>Trifolium medium</i>	Zig zag clover	2
	Total species recorded	512
	Median	2

The survey data was collected by more than one surveyor and some discrepancies in botanical identification are possible. Where unusual or possible misidentification may have occurred, this can be compensated by the more frequent species. The species recorded are representative of the habitats in this locality being more upland meadows and with some sites being wetter, characterised by species such as *Cardamine pratensis* (Cuckoo flower) and *Cirsium palustre* (March thistle) which prefer wetter soils. Some negative indicator species such as *Urtica dioica* (Common nettle), *Senecio jacobaea* (common ragwort) and *Rumex obtusifolius* (Docks) were found across the sites. This could be indicative of an early stage in restoration or a lack of management leading to some rank grasslands being noted.

The most common species recorded were indicative of mesotrophic grassland habitats and further analysis showed that MG1 and MG5 were the most common matches for the species found. The sites are characteristics of transitioning sites, where species from more than one NVC plant community are found as the habitat changes from improved or rank grasslands such as MG1 sub-communities, MG7 and MG9. These communities are considered of low conservation value (Rodwell, 2006).

The large amount of data allows a comprehensive species list for recovering grasslands to be composed which includes the expected vascular plant species that could be found on wetter more upland sites.

5.2.2 Gwynedd sites

The five Gwynedd sites surveyed were carried out as part of a baseline assessment on road verges in one part of the county. The sites were all managed with cut and drop with cuts once per year. All five datasets provided were include in this study. As in the previous data the list of all species recorded was collated for all five sites and ranked according to their frequency. The median value was calculated and anything below that discounted. Only native grasses, sedges, rushes and forbs were recorded in this data, so no species were discounted at this stage. The ranked data showing species found above the median frequency of 2 is shown in Table 5.4 below.

Table 5.4 - Table showing the species recorded ranked according to frequency with all species below the median of 2 discounted for five locations across Gwynedd.

Species	Common name	Frequency
Plantago lanceolata	Ribwort plantain	5
Ranunculus acris	Meadow buttercup	5
Rumex acetosa	Common sorrel	5
Taraxacum officinalis agg.	Dandelions	5
Agrostis capillaris	Common bent	4
Anthoxanthum odoratum	Sweet vernal grass	4
Arrhenatherum elatius	False oat-grass	4
Centaurea nigra agg.	Comon knapweed	4
Dactylis glomerata	Cock's foot	4
Festuca rubra agg.	Red fescue	4
Holcus lanatus	Yorkshire fog	4
Juncus effusus	Soft rush	4
Lotus pedunculatus	Greater bird's foot trefoil	4
Achillea millefolium	Yarrow	3
Anthriscus sylvestris	Cow parsley	3
Ficaria verna	Lesser celandine	3
Juncus articulatus	Jointed rush	3
Lathyrus pratensis	Meadow vetchling	3
Lotus corniculatus	Common bird's foot trefoil	3
Ranunculus repens	Creeping buttercup	3
Rumex obtusifolius	Broad-leaved dock	3
Trifolium pratense	Red clover	3
Trifolium repens	White clover	3
Vicia cracca	Tufted vetch	3
Vicia sativa	common vetch	3
Agrostis stolonifera	Creeping bent	2
Bellis perennis	Daisy	2
Cardamine pratensis	Cuckoo flower	2
Cerastium fontanum	Common mouse ear	2
Cerastium glomeratum	Sticky mouse ear	2
Geranium dissectum	Cut-leaved cranesbill	2
Heracleum sphondylium	Hogweed	2
Hyacinthoides non-scriptus	Bluebell	2
Hypericum tetapterum	Square stalked St John's wort	2
Leucanthemum vulgare	Oxeye daisy	2
Rumex crispus	Curly dock	2
Senecio Jacobea	Common ragwort	2
	Total species	138
	Median	2

Ranking the species in this way allows you to analyse the most frequent species on amenity grassland. Table 5.4 shows that the most common species found were *Plantago lanceolata* (Ribwort plantain) and *Ranunculus acris* (Meadow buttercup), both positive indicators for grassland restoration to MG5. *Rumex acetosa* (Common sorrel) and *Taraxacum* species, whilst not important meadow species are vital pollen and nectar resource to support pollinators. The high frequency of Common bent is a positive indicator to the development of the grasslands as this species can be scarce particularly on roadside verges. This will be discussed further in section 5.3.

The sites show variation in their species diversity with 3 of the 5 sites - Clynog verge (CV), Hafan y mor (HYM), and Afon Wen (AW) - showing a closest correlation with low conservation value habitat of MG7 and MG9. For the sites at Trefor (TJ) and TanYGraig (TYG), the species recorded are indication of lower nutrients and lower levels of dominance from fine grasses such as *Lolium perenne* (Perennial rye grass) species found include red clover, *Agrostis capillaris* (Common bent) and Common knapweed.

5.2.3 Nectar and Pollen data

Published nectar and pollen data will be used to support objective 3 of this study and are sourced from work carried out by Baude *et al.*, (2016) measuring floral resources of 240 common species. The methodology for this study is outlined in section 4. The species selected were based on work done by Carey *et al.*, (2008) and aimed to cover 99% of the UK species present on the landscape, plus a further 50 less common species which were chosen due to their important floral resource to pollinators (Baude *et al.*, 2016). The data was collected from February to October in 2011 and 2012 to capture the broadest range of flowering species and the range available to pollinators across the season. Further data from studies by Hemmings *et al.*, (2022) provide more data on common 'No mow' species found on amenity grassland.

Baude *et al.*, data

For the purposes of this study, the following species were discounted from the data: Tree species, Non-native and Invasive non-natives, and horticultural species. Habitat specialists such as saltmarsh specialists; *Armeria maritima*, (Sea thrift) and *Tripolium pannonicum*, (Sea Aster) were also discounted. Ranking the data allowed the creation of a top 50 highest nectar sources shown in Figure 5.5 below.

Table 5.5 - Table showing the modified Baude data listing the top 50 native species common in the UK by Nectar resource. (Baude et al., 2016)

Rank	Species	Common name	Nectar value (µg/flower/day)
1	<i>Symphytum officinale</i>	Comfrey	1969.46
2	<i>Rubus fruticosus</i> agg.	Bramble	1892.83
3	<i>Calystegia sepium</i>	Hedge bindweed	1800.78
4	<i>Lonicera periclymenum</i>	Common honeysuckle	1726.84
5	<i>Digitalis purpurea</i>	Foxglove	1273.88
6	<i>Lamium album</i>	White dead nettle	1043.99
7	<i>Lathyrus pratensis</i>	meadow vetchling	952.69
8	<i>Chamerion angustifolium</i>	Rosebay willowherb	941.59
9	<i>Linaria vulgaris</i>	Yellow toadflax	543.89
10	<i>Vicia cracca</i>	Tufted vetch	484.4
11	<i>Silene dioica</i>	Red campion	450.65
12	<i>Saponaria officinalis</i>	Wild sweet William	445.64
13	<i>Lamium galeobdolon</i>	Yellow archangel	440.16
14	<i>Convolvulus arvensis</i>	Field bindweed	351.82
15	<i>Epilobium hirsutum</i>	Hairy willowherb	323.52
16	<i>Stachys sylvatica</i>	Hedge woundwort	311.11
17	<i>Vicia sativa</i>	Common vetch	300.34
18	<i>Campanula rotundifolia</i>	Harebell	290.18
19	<i>Silene vulgaris</i>	Bladder campion	251.47
20	<i>Cirsium palustre</i>	Marsh thistle	216.18
21	<i>Ranunculus lingua</i>	Spearwort	205.77
22	<i>Centaurea nigra</i>	Common knapweed	198.99
23	<i>Teucrium scorodonia</i>	Germander/wood sage	173.61
24	<i>Viola riviniana/reichenbiana</i>	Dog violet	173.41
25	<i>Primula vulgaris</i>	Primrose	171.91
26	<i>Brassica rapa</i>	Field mustard	165.4
27	<i>Ajuga reptans</i>	Bugle	155.06
28	<i>Knautia arvensis</i>	Field scabious	146.31
29	<i>Prunella vulgaris</i>	Self-heal	138.62
30	<i>Lythrum salicaria</i>	Purple loosestrife	136.72
31	<i>Vicia sepium</i>	Bush vetch	117.07
32	<i>Trifolium pratense</i>	red clover	116.86
33	<i>Raphanus raphanistrum</i>	Wild radish	115.08
34	<i>Hyacinthoides non-scripta</i>	Bluebell	113.44
35	<i>Rhinanthus minor</i>	yellow rattle	108.9
36	<i>Ranunculus repens</i>	Creeping buttercup	104.51
37	<i>Heracleum sphondylium</i>	Hogweed	98.17
38	<i>Geranium robertianum</i>	Herb Robert	97.79
39	<i>Glechoma hederacea</i>	Ground ivy	94.37
40	<i>Erica cinerea</i>	Bell heather	80.63
41	<i>Ranunculus acris</i>	Meadow buttercup	78.83

42	Cirsium vulgare	Spear thistle	76.51
43	Cirsium arvense	Creeping thistle	76.22
44	Arctium agg.	Burdocks	71.76
45	Erica tetralix	Cross leaved heath	70.3
46	Cornus sanguinea	Common dogwood	68.79
47	Epilobium montanum	Broad-leaved willowherb	66.96
48	Cirsium acaule	Dwarf thistle	66.45
49	Fallopia convolvulus	Black bindweed	65.08
50	Lotus corniculatus	lesser birds foot trefoil	61.82

The list contains many of the species recorded in both primary and secondary data, with some notable additions such as Comfrey and Hedge bindweed scoring high for nectar resources but not commonly found on grasslands. Bindweed species are often found on hedges and edges so could feature at the perimeter of grassland sites. Bindweeds are not generally considered favourable as they can dominate and outcompete less vigorous plants. There are also some negative indicator species present on the list such as *Rubus fruticosus* (Brambles), *Cirsium spp.* (Thistles) and *Ranunculus repens* (Creeping buttercup). In constructing the final list the nectar resource values, prevalence in the desired habitat and status of the plant as an indicator will be taken into consideration.

Hemmings *et al.*, (2022) data

The data from the Hemmings *et al.*, study in 2022 looked at the difference in nectar resources between 'mow' and 'no mow' plots as discussed in section 2.3. The nectar values were obtained by sampling from April to July for the most common species found on the plots involved in that study. The mean values for each of these species are shown in Figure 5.6 below.

Table 5.6 - Table showing the nectar values for common amenity grassland species after a no mow period (Hemmings *et al.*, 2022)

Rank	Species	Common name	Average Species nectar levels (ug ⁻¹ m ² 24hr)
1	Senecio jacobaea	Common Ragwort	15193.00
2	Crepis vesicaria	Beaked Hawksbeard	3495.73
3	Taraxacum agg.	Dandelions	2435.00
4	Bellis perennis	Daisy	1894.18
5	Achillea millefolium	Yarrow	1486.82
6	Medicago lupulina	Black medick	1380.36
7	Prunella vulgaris	Primrose	1233.36
8	Cerastium fontanum	Common mouse ear	507.73
9	Torilis nodosa	Knotted hedge parsley	470.45

10	Geranium molle	Doves foot cranesbill	463.64
11	Ranunculus repens	Creeping buttercup	420.00
12	Leucanthemum vulgare	Oxeye daisy	334.09
13	Trifolium repens	Lesser birds foot trefoil	228.55
14	Convolvulus arvensis	Field bindweed	213.18
15	Sherardia arvensis	Field madder	190.82
16	Ranunculus acris	Meadow buttercup	182.36
17	Cirsium vulgare	Spear thistle	84.55
18	Geranium dissectum	cut-leaved cranesbill	27.09
19	Veronica arvensis	Wall speedwell	18.00
20	Silene latifolia	White campion	3.09
21	Veronica persica	Common field speedwell	0.55
22	Ophrys apifera	Bee orchid	0.00

The highest nectar levels were obtained from Common ragwort, *Crepis vesicaria* (Beaked hawksbeard), and Dandelions, all common species found on roadside verges and amenity grassland (Hemmings *et al.*, 2022). These values vary significantly from the Baude data shown in Figure 5.5 - this could be due to several variables such as differing techniques of extracting nectar, the time of year, and recent visitation before addition of nets and collection. The data is still significant enough to be used to meet the objective of assessing the most nectar rich species present on amenity grassland, as it does show relative difference between the species.

5.3 Discussion of data

To meet the objectives of this study, the data presented in section 5.1 and 5.2 will be discussed and evaluated to identify the common flowering plants recorded on grasslands in the UK, and particularly the mesotrophic grasslands of lowland Wales. This data can then be integrated with data on nectar resource allowing the development of a matrix to assess the biodiversity value of amenity grassland.

5.3.1 Primary data

The primary data presented a profile of a species rich meadow containing the typical species of an MG5 plant community classed as being of 'high botanical conservation value' (Rodwell, 2016). The results of the survey showed improvement in species richness from previous surveys carried out in 2008 and 2016 with increased indicator species such as Common knapweed and Crested dog's tail. The methodology of this study's survey and previous ecological surveys varied in this approach, which may have led to different species being recorded. The time of year, although still within optimal period (Rodwell, 2006) was late and followed a very dry spring, it was evident that some species had already seeded and gone over before the survey took place. This may have led to misidentification or omission of some species. The survey data from Cae Trawscoed is valuable as an example of the plant community that can be achieved from meadow management, with twice per year cut and collect mowing methods.

This data supports the literature reviewed in section 2.3 - that reduced grazing/mowing of grasslands to twice per year and removing all arisings can encourage development with lower soil nutrient levels. Although analysing soil nutrients was not a part of this study, nutrient levels can be assessed by the species present, e.g. Common knapweed and Greater burnet grow in lower nutrient soils, both species were abundant throughout the site as shown in Figures 5.2 and 5.3. One species that was less abundant was *Trifolium pratense* (Red clover) - this is generally a good indicator of low nutrients, reduced grazing and species rich meadow. One reason for this could be the timing of the survey, the more vigorous forbs and grasses had grown tall and smaller species such as red clover were out competed or had completed their life cycle. The species recorded on this survey provides valuable data partly meeting objective 1 of this study.

5.3.2 Secondary data

This data was used to help meet objective 1 and 3 of this study by identifying the most common plant species being found on amenity grassland under different management methodologies. The data aimed to cover different grassland types and locations. To meet objective 2 and 3 it was necessary to analyse data on nectar resources from secondary sources and previous studies.

Torfaen and Blaenau Gwent sites

The 10 sites chosen from 31 sites provided showed a range of location types, soil hydrology and management methods. The results showed amenity grasslands in transition between species poor MG7 and MG9 communities, dominated by nutrient loving species such as *Arrhenatherum elatius* (False oatgrass), *Lolium perenne* (Perennial rye grass), and *Dactylis glomerata* (Cocksfoot) to a more species diverse community of Red clover, Meadow buttercup, and Common knapweed and also finer grasses like Crested dog's tail and *Agrostis* (Bents). The site labelled 3T (Appendix 4) is a site being 'managed as meadow' but not employing cut and collect methods. Areas of rank grassland were prevalent which is shown by the species False oatgrass and Cocksfoot, which smother smaller vascular plants and fine grasses. In some areas positive indicator species such as Meadow buttercup, *Epilobium spp.* (Willowherbs), Devil's bit scabious and Tormentil were present. A site like 3T, if managed with cut & collect, could reduce those ranker grasses and allow the positive indicator species to thrive, thus changing the grassland to a more MG5 or marshy grassland characteristic.

Gwynedd sites

The data from Gwynedd was mainly from road verges and small patches of amenity grassland, currently managed for visibility using cut and drop by the local authority. Surveys were carried out within the optimal time range for forbs but were early in the season, some species may have been missed due to the difficulty of identifying some species vegetatively. The species recorded was varied, with all sites having positive indicator species such Meadow buttercup and *Plantago lanceolata* (Ribwort plantain). However, the presence of negative indicators such as Cocksfoot, *Holcus lanatus* (Yorkshire fog) and False oat-grass could be inhibiting further development of a species rich community. The ranker grass species like this have been left after mowing and caused thatching (Ecoscope, 2022), smothering finer grasses like red fescue and less vigorous forbs. The data provides a good indication of the species that can be

found on recovering grasslands on coastal lowland areas. The ranked data showed a close correlation with the previous data, with common species becoming apparent supporting the objectives of this study. All sites from the secondary data had 24 species in common with the primary site MG5 grassland as shown in Table 5.7. The species not found in the secondary data sites (bold type) are species indicative of high conservation value habitat e.g. *Sanguisorba officianalis* and *Cynosurus cristatus*, with specialist species like *Carum verticillatum* and *Filipendula ulmaria*, characteristic of the locality and the primary site's wetter soils respectively.

Table 5.7 - Species list for Cae Trawscoed and Gwynedd sites, species only recorded at Cae Trawscoed are shown in bold type.

Cae Trawscoed and Gwynedd Sites	
Species	Common Name
Achillea ptarmica	Sneezewort
Agrostis capillaris	Common bent
Anthoxanthum odoratum	Sweet Vernal Grass
Carum verticillatum	Whorled Caraway
Centaurea nigra	Common Knapweed
Cerastium fontanum	Common mouse ear
Cynosurus cristatus	Crested Dog's Tail
Dactylorhiza praetermissa	Marsh Orchid
Euphrasia spp.	Eyebrights
Festuca ovina	Sheeps Fescue
Festuca rubra	Red Fescue
Filipendula ulmaria	Meadowsweet
Geum urbanum	Wood Avens
Juncus articulatus	Jointed Rush
Juncus effusus	Soft Rush
Leontodon spp.	Hawkbits
Lotus corniculatus	Common Birds Foot Trefoil
Odontites vernus	Red Bartsia
Plantago lanceolata	Ribwort Plantain
Potentilla anserina	Silverweed
Prunella vulgaris	Self-heal
Pulicaria dysenterica	Meadow Fleabane
Ranunculus acris	Meadow Buttercup
Ranunculus bulbosus	Bulbous Buttercup
Ranunculus flammula	Lesser Spearwort
Ranunculus repens	Creeping Buttercup
Rhinanthus minor	Yellow Rattle
Rumex acetosa	Common Sorrel
Sanguisorba officianalis	Greater Burnet
Trifolium pratense	Red clover
Trifolium repens	White Clover

Comparing all the data, it is possible to identify any negative indicator species (Plantlife, 2019), these are shown in orange in Table 5.8

Table 5.8 - Table showing the presence of negative indicators for recovering grasslands including rank grasses.

Gwynedd			Torfaen			Cae trawscoed		
Species	Common name	Frequency	Species	Common name	Frequency	Species	Common name	Frequency
Rumex acetosa	Common sorrel	5	Ranunculus repens	Creeping buttercup	10	Centaurea nigra	Common Knapweed	54
Taraxacum officinalis agg.	Dandelions	5	Ranunculus acris	Meadow buttercup	10	Juncus articulatus	Jointed Rush	44
Ranunculus acris	Meadow buttercup	5	Trifolium pratense	Red clover	10	Plantago lanceolata	Ribwort Plantain	37
Plantago lanceolata	Ribwort plantain	5	Rubus fruticosus agg.	Brambles	9	Sanguisorba officinalis	Greater Burnet	32
Dactylis glomerata	Cock's foot	4	Rumex obtusifolius	Broad-leaved dock	9	Lotus corniculatus	Common Birds Foot Trefoil	25
Agrostis capillaris	Common bent	4	Dactylis glomerata	Cocksfoot	9	Potentilla anserina	Silverweeds	25
Centaurea nigra agg.	Common knapweed	4	Agrostis capillaris	Common bent	9	Festuca sp	Red and Sheeps Fescue	18
Arrhenatherum elatius	False oat-grass	4	Centaurea nigra	Common knapweed	9	Ranunculus repens	Creeping Buttercup	16
Lotus pendunculatus	Greater bird's foot trefoil	4	Plantago lanceolata	Ribwort plantain	9	Ranunculus acris	Meadow Buttercup	14
Festuca rubra agg.	Red fescue	4	Trifolium repens	White clover	9	Filipendula ulmaria	Meadow Sweet	13
Juncus effusus	Soft rush	4	Holcus lanatus	Yorkshire fog	9	Carum verticillatum	Whorled Caraway	9
Anthoxanthum odoratum	Sweet vernal grass	4	Lotus corniculatus	Common bird's foot trefoil	8	Euphrasia spp.	Eyebright	8
Holcus lanatus	Yorkshire fog	4	Urtica dioica	Common nettle	8	Leontodon spp.	Hawkbits	8
Rumex obtusifolius	Broad-leaved dock	3	Senecio jacobaea	Common Ragwort	8	Rhinanthus minor	Yellow Rattle	8
Lotus corniculatus	Common bird's foot trefoil	3	Potentilla reptans	Creeping cinquefoil	8	Agrostis spp.	Bent	7
Vicia sativa	common vetch	3	Taraxacum officinale agg.	Dandelions	8	Trifolium pratense	Red Clover	6
Anthriscus sylvestris	Cow parsley	3	Arrhenatherum elatius	False oat-grass	8	Rumex acetosa	Common Sorrel	5
Ranunculus repens	Creeping buttercup	3	Heracleum sphondylium	Hogweed	8	Pulicaria dysenterica	Meadow Fleabane	4
Juncus articulatus	Jointed rush	3	Anthoxanthum odoratum	Sweet vernal grass	8	Achillea ptarmica	Sneezewort	4
Ficaria verna	Lesser celandine	3	Hypochaeris radicata	Catsear	7	Ranunculus bulbosus	Bulbous Buttercup	3
Lathyrus pratensis	Meadow vetchling	3	Cerastium holsteoides	Common mouse ear chickweed	7	Prunella vulgaris	Selfheal	3
Trifolium pratense	Red clover	3	Lotus pedunculatus	Greater bird's foot trefoil	7	Juncus effusus	Soft Rush	3
Vicia cracca	Tufted vetch	3	Epilobium hirsutum	Hairy willowherb	7	Trifolium repens	White Clover	2
Trifolium repens	White clover	3	Prunella vulgaris	Primrose	7	Cerastium fontanum	Common Mouse Ear	1
Achillea millefolium	Yarrow	3	Festuca rubra	Red fescue	7	Cynosurus cristatus	Crested Dog's Tail	1
Hyacinthoides non-scriptus	Bluebell	2	Galium aparine	Cleavers	6	Ranunculus flammula	Lesser Spearwort	1
Cerastium fontanum	Common mouse ear	2	Agrostis stolonifera	Creeping bent	6	Dactylorhiza praetermissa	Marsh Orchid	1
Senecio Jacobaea	Common ragwort	2	Cirsium arvense	Creeping thistle	6	Odontites vernus	Red Bartsia	1
Agrostis stolonifera	Creeping bent	2	Cynosurus cristatus	Crested dogtail	6	Anthoxanthum odoratum	Sweet Vernal Grass	1
Cardamine pratensis	Cuckoo flower	2	Bellis perennis	Daisy	6	Geum urbanum	Wood Avens	1

In Cae Trawscoed only one negative indicator species was recorded (white clover), whilst in the other less managed sites, negative indicators made up some of the most frequent species recorded. It is worth noting here that the White clover species is only negative as an indicator of more fertile soils, and was only found on quadrats of disturbed soil such as mower tracks. The sites at Torfaen and Gwynedd had frequent stands of rank grasses and high nutrient species, indicative of a less managed grassland where grass cuttings are left on site to rot and nutrify the soils.

Across all 16 sites the most frequently recorded species can be seen in Figure 5.5 below. This includes negative indicator species such as Common nettle, *Rumex spp.* (Docks), and False oat grass. The only species found across all sites was meadow buttercup, an indicator of lower nutrient soils and recovering grasslands.

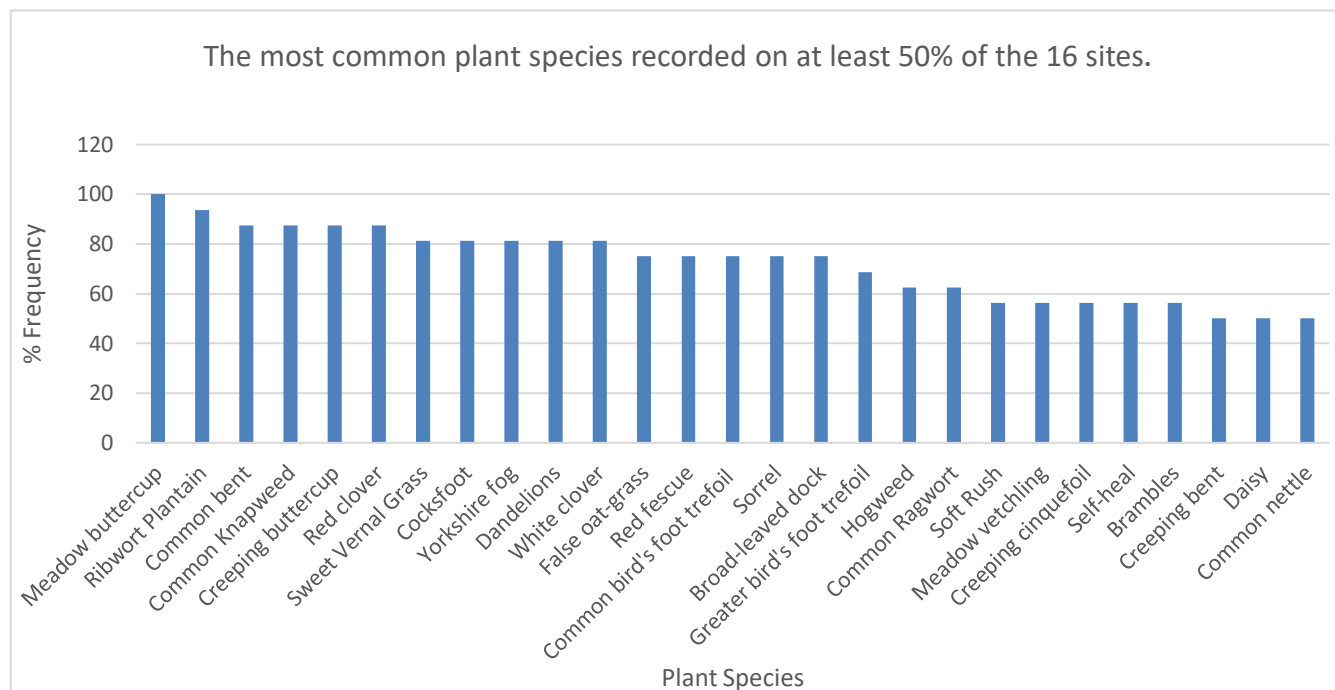


Figure 5.5 - Graph showing the most frequently recorded plant species across all 16 sites.

By removing all grasses, sedges, rushes and negative indicators, the most common meadow-like species can be seen in Figure 5.6. Each species was cross-referenced with Harrap's wildflowers (2013). Wildflower species provide important nectar source to pollinators and can be easier to identify for non-

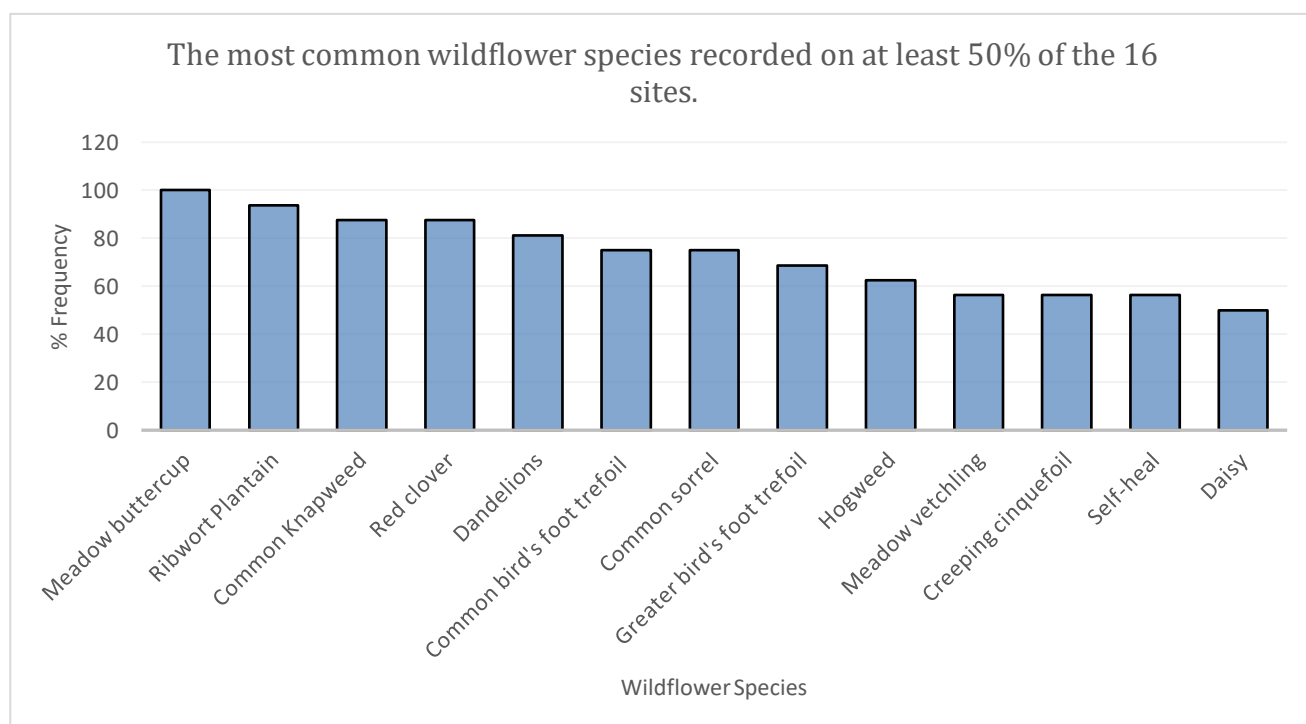


Figure 5.6 - Graph showing the most frequently recorded species across all 16 sites.

specialists, and citizen scientists than positive indicator species of grasses such as fescues and bents. Removal of the less desirable species allows a focus on the most important species to be found on recovering grasslands. However, removing these species did not lead to inclusion of any new positive species due to the low number that were recorded overall. This was due in part to the type of grasslands surveyed in the secondary data. The data is useful to show the most commonly found species on amenity grassland, with the complete list in Appendix 5 showing the more desirable species that could be found after improved management and reduced soil nutrients over time.

Looking at all the data together and comparing frequencies and the species recorded, it is possible to construct a list of the most common grassland species likely to be recorded on recovering grasslands when adopting a cut & collect mowing management. This list can then be cross referenced with the list of plant species produced by Plantlife UK in their 'Magnificent meadows' handbook for Rapid grassland assessment 2020 (Plantlife, 2020). Adding these species for habitats such as Lowland meadows, Rush pastures and Calcareous grassland, creates a comprehensive list to meet objective 1 of this study. In constructing the final list, the following species were discounted:

- Rushes
- Sedges
- Dominant species such as *Ulex Europea* (Common gorse) and Purple Moor grass
- Invasive non-native species and negative indicators
- Rank grasses as previously discussed in this section.

The full list can be seen in Appendix 6

Baude *et al.*, data

In meeting objective 3 of this study, it was necessary to compile the data discussed in Section 5.2.3 into a list of nectar rich plants that correlated with species found in the primary and secondary data, and therefore more typical of the species likely to be found on amenity grasslands in lowland Wales.

If the highest data is retained from both data sets, (Baude, *et al.*, 2016; Hemmings *et al.*, 2022) the list of most nectar rich species can be constructed, shown in Table 5.9 below.

Table 5.9 - Table showing the combined mean nectar values for flowering species (Baude *et al.*, 2016; Hemmings *et al.*, 2022)

Rank	Species	Common name	Average of the Species average nectar($\mu\text{g}^{-1}\text{m}^2$ 24hr)
1	Senecio jacobaea	Common Ragwort	15193.00
2	Crepis vesicaria	Beaked Hawksbeard	3495.73
3	Taraxacum agg.	Dandelions	2435.00
4	Symphytum officinale	Comfrey	1969.46
5	Bellis perennis	Daisy	1894.18
6	Rubus fruticosus agg.	Bramble	1892.83
7	Calystegia sepium	Hedge bindweed/bell bind	1800.78
8	Lonicera periclymenum	Common honeysuckle	1726.84
9	Achillea millefolium	Yarrow	1486.82
10	Medicago lupulina	Black medick	1380.36
11	Digitalis purpurea	Foxglove	1273.88
12	Prunella vulgaris	Self-heal	1233.36
13	Lamium album	White dead nettle	1043.99
14	Lathyrus pratensis	Meadow vetchling	952.69
15	Chamerion angustifolium	Rosebay willowherb	941.59
16	Linaria vulgaris	Yellow toadflax	543.89
17	Cerastium fontanum	Common mouse-ear	507.73
18	Vicia cracca	Tufted vetch	484.4
19	Torilis nodosa	Knotted hedge parsley	470.45
20	Geranium molle	Doves foot cranesbill	463.64
21	Silene dioica	Red campion	450.65
22	Saponaria officinalis	Wild sweet William	445.64
23	Lamium galeobdolon	yellow archangel	440.16
24	Ranunculus repens	Creeping buttercup	420.00
25	Leucanthemum vulgare	Oxeye daisy	334.09

26	<i>Epilobium hirsutum</i>	Hairy willowherb	323.52
27	<i>Stachys sylvatica</i>	Hedge woundwort	311.11
28	<i>Vicia sativa</i>	Common vetch	300.34
29	<i>Campanula rotundifolia</i>	Harebell	290.18
30	<i>Silene vulgaris</i>	Bladder campion	251.47
31	<i>Trifolium repens</i>	Common bird's foot trefoil	228.55
32	<i>Cirsium palustre</i>	Marsh thistle	216.18
33	<i>Convolvulus arvensis</i>	Field bindweed	213.18
34	<i>Ranunculus lingua</i>	Spearwort	205.77
35	<i>Centaurea nigra</i>	Common knapweed	198.99
36	<i>Sherardia arvensis</i>	Field madder	190.82
37	<i>Ranunculus acris</i>	Meadow buttercup	182.36
38	<i>Teucrium scorodonia</i>	Germander/wood sage	173.61
39	<i>Viola riviniana</i>	Dog violet	173.41
40	<i>Primula vulgaris</i>	Primrose	171.91
41	<i>Brassica rapa</i>	Field mustard	165.4
42	<i>Ajuga reptans</i>	Bugle	155.06
43	<i>Knautia arvensis</i>	Field scabious	146.31
44	<i>Lythrum salicaria</i>	purple loosestrife	136.72
45	<i>Vicia sepium</i>	bush vetch	117.07
46	<i>Trifolium pratense</i>	red clover	116.86
47	<i>Raphanus raphanistrum</i>	wild radish	115.08
48	<i>Hyacinthoides non-scripta</i>	Bluebell	113.44
49	<i>Rhinanthus minor</i>	yellow rattle	108.9
50	<i>Heracleum sphondylium</i>	Hogweed	98.17
51	<i>Geranium robertianum</i>	Herb Robert	97.79
52	<i>Glechoma hederacea</i>	Ground ivy	94.37
53	<i>Cirsium vulgare</i>	Spear thistle	84.55
54	<i>Erica cinerea</i>	Bell heather	80.63
55	<i>Cirsium arvense</i>	Creeping thistle	76.22
56	<i>Arctium agg.</i>	Burdocks	71.76
57	<i>Erica tetralix</i>	Cross leaved heath	70.3
58	<i>Cornus sanguinea</i>	Common dogwood	68.79
59	<i>Epilobium montanum</i>	Broad-leaved willowherb	66.96
60	<i>Cirsium acaule</i>	Dwarf thistle	66.45
61	<i>Fallopia convolvulus</i>	Black bindweed	65.08

62	<i>Lotus corniculatus</i>	Lesser birds foot trefoil	61.82
63	<i>Geranium dissectum</i>	Cut-leaved cranesbill	27.09
64	<i>Veronica arvensis</i>	Wall speedwell	18.00
65	<i>Silene latifolia</i>	White campion	3.09
66	<i>Veronica persica</i>	Common field speedwell	0.55

The resulting list contains 66 species, with any previously discounted species shown in bold. It is notable that the highest nectar values were obtained for Common ragwort, a plant included in *The Weeds Act, 1959* alongside the Spear and Creeping thistle. The 1959 act classes these as ‘injurious weeds’ and landowners can be served notice to take action to prevent spreading of these ‘weeds’. Common ragwort contains a toxic compound (pyrrolizidine alkaloids) and some studies have shown that this toxin can be passed onto humans through meat and milk from grazing cattle, (Leiss, 2011). For this reason, it is



Figure 5.8 - Image of a Cinnabar moth caterpillar feeding on *Senecio jacobaea* (Common ragwort) (Carter,2023)

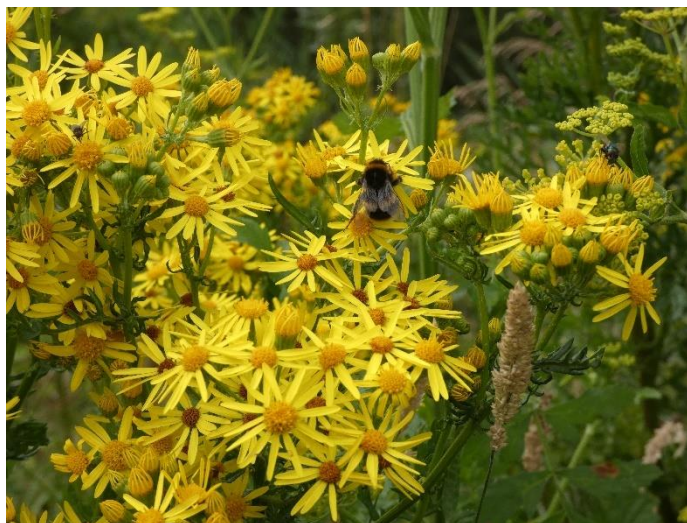


Figure 5.7 - Image of a *Bombus* spp. (bumblebee) feeding on *Senecio jacobaea* (Common ragwort) (Carter,2023)

classed as a notifiable weed in Wales and the UK. Ragwort is a vital plant for the life cycle of the Cinnabar moth by providing larval food for the caterpillar. The ingestion of the plant by large numbers of this caterpillar can act as biological control, reducing the population and chance of seed dispersal. Ragwort is larval food plant to at least 77 species, including 8 nationally scarce and at least 30 obligate species. Welsh Government recognised the importance of this ‘weed’ in its Code of Practice, (2011) and advises that control was only necessary when it posed an imminent risk to grazing animals or forage production, (Welsh Government, 2011). Literature reviewed as a part of this study showed some of the highest nectar resource has been found in ‘weeds’ such Common ragwort, Spear thistle, Creeping thistle and

Dandelions (Hicks *et al.*, 2016). These species have been recorded as providing 2-3 times the nectar resource as 'desirable' species such as Meadow buttercup, *Geraniums spp.* (Crane's bills) and Common knapweed, and possibly 2000 times higher than Red clover. It is also worth noting that availability of nectar to different pollinators may affect the value of a wildflower species due to length of proboscis, depth of nectaries and structure of flowers (Comba *et al.*, 2009; Ollerton *et al.*, (2009); Szigeti *et al.*, 2020). Flower specificity, where some species of pollinators show a preference to certain families of flowers and the pollinator syndrome hypothesis, could imply that not all flowers are equally valuable to all pollinators, which supports the need to have the greatest diversity possible. Some Bumblebee species can out-compete other pollinators such as the longer tongued *Bombus Pascuorum* (Carder bee) which can feed on *Stachys* species such as *Stachys sylvatica*, (Hedge woundwort) and have been shown to represent the majority of flower visits to this species (Comba *et al.*, 1999). Further studies on butterflies showed variation in proboscis length determined the flowers visited and the ability to collect nectar resources (Szigeti *et al.*, 2020).

For the purposes of this study, common ragwort and the 3 thistle species will be excluded from the list. Although amenity grassland sites are largely in urban areas and according to the Welsh Government guidelines the risk posed should be low, they are widely recognised as a negative indicator species for grassland recovery and high soil nutrients, which are unfavourable to the aims of the study. To meet objective 3 of this study it is necessary then to combine the data discussed previously into a final list of plant species important to both species rich grassland recovery and pollinators. This final list can be seen in full in Appendix 7 and its applications will be discussed in the next section.

5.3.3 Development of the matrix

The research carried out as part of this study has allowed the creation of a scoring matrix which can be used easily by non-specialist land managers. The species chosen have key identification features, and where identification could be problematic to species level they have been aggregated. The full score sheet is shown in Appendix 8. Land managers can carry out a simple walkover survey listing all flowering species, and by imputing this data into the matrix a score will be generated. The matrix has been designed to be also used by volunteers as part of citizen science activities. The intention is that it could be used as part of rapid baseline assessment before instigating a change in management, as well as a

monitoring tool. Repeated assessments using the matrix would aim to show an increased score as negative indicators reduce, and positive indicators increase. These desired species would indicate lower soil nutrients and reduced competition from vigorous grasses. The presence of nectar rich species according to the data discussed in section 5.3.2 are given higher value. This allows the creation of the 'Top 20' species shown in Table 5.10.

Table 5.10 The Top 20 desirable species for recovering amenity grasslands. Including bonus species to aid community engagement and showing the aggregated Willowherb species to aid identification with the scores assigned to each.

Rank	Common name	Score	Nectar score	Total score	Reasoning
0	County flower	2	0	2	Regional importance
0	Orchids (all families)	2	0	2	Public popularity
1	Yarrow	3	2	5	Known High nectar resource
2	Daisy	3	2	5	Known High nectar resource
3	Common Knapweed	3	2	5	Known High nectar resource
4	Common mouse ear	3	2	5	Known High nectar resource
5	Great willowherb	3	2	5	Known High nectar resource
6	Foxglove	3	2	5	Known High nectar resource
7	Willowherbs	3	2	5	Known High nectar resource
8	Catsear	3	2	5	Known High nectar resource
9	Meadow vetchling	3	2	5	Known High nectar resource
10	Rough hawkbit	3	2	5	Known High nectar resource
11	Hawkbits	3	2	5	Known High nectar resource
12	Oxeye daisy	3	2	5	Known High nectar resource
13	Self-heal	3	2	5	Known High nectar resource
14	Hedge woundwort	3	2	5	Known High nectar resource
15	Dandelions	3	2	5	Known High nectar resource
16	Common vetch	3	2	5	Known High nectar resource
17	Common bird's foot trefoil	3	1	4	Good meadow indicator
18	Devil's bit scabious	3	1	4	Important larval food plant for Marsh fritillary butterfly
19	Red clover	3	1	4	Good meadow indicator
20	Meadow buttercup	3	1	4	Good meadow indicator

In constructing the matrix, data from Hicks *et al.*, (2016) was considered for the species shown in Appendix 7. All species that were found to have higher than average nectar values (ug/flower/24hr)

were added to the previous list (Table 5.9) to create the final list. Some adjustments were made to group some species, such as the Willowherb family (*Epilobiums*), as they can be hard to identify to species level. The Southern marsh orchid was replaced with all Orchids. Orchids have the public perception of being very desirable and valuable to pollinators (Sarasan, 2023). It was decided to add these as a ‘bonus’ species to aid stakeholder engagement. Bonus points are given for the relevant County flower. This is a list created following a UK wide survey by Plantlife in 2002 and added to create a regional link and ownership of any developing grasslands (Appendix 9). This addition, although less evidence based, could increase engagement with stakeholders and reduce complaints and negative feelings toward reduced mowing. People are more likely to respond positively to change if the reasons are clearly explained to them and they have agency in the decisions taken (Altman *et al.*, 2022). This could mean that more engaged communities will have benefits for the environment (Ross *et al.*, 2016). In assigning a points system based on the aforementioned characteristics and data, each species was assessed for probability of occurrence on amenity grassland in lowland Wales by cross referencing with habitat information (Harrap, 2013; Rose, 2006). The score generated will give a rating and recommend any management changes needed to improve the score and species richness whilst reducing negative species. The methodology for generating the final score is shown in Figure 5.9 below.

Scoring Tables	
91 single scoring species	91
2 double scoring species	4
4 x 4 score species	16
16 x 5 score species	80
17 Negative scoring species	-17
Max possible score	174
All Top 20 Species	92

How the matrix determines the final score	
Raw Score	Total score for all plants recorded
Maximum score	Total possible score (174)
Top 20 score	Score from all the Top 20 plants recorded
Relative score 1	(Raw Score / Maximum score) x 100
Relative score 2	(Top 20 score / Maximum Top 20) x 100
Negative indicator Score	8 or more negative indicators recorded adds a penalty score of -10
Final score	Relative score 1 + Relative score 2 + (any negative indicator penalty)

Grading System		
Final Score	Grade awarded	Reccomendations
>100	Species rich meadow	Continue with current management and consider a ecological survey.
>75	Excellent	Continue with current management
>50	Good	Continue with current management, consider plug planting Top 20 species or addition of Yellow Rattle
>25	Improving	Ensure cut & collect is enforced with 2/3 cuts per year. Yellow rattle seeds could be considered.
<25	Poor	Introduce cut and collect mowing twice per year, with addition of yellow rattle seeds.

Figure 5.9 - The matrix scoring system that has been developed as a result of this research project. The score generated provides the user with a grade and recommended actions.

The calculations ensure that sites with many desirable species but with negative indicators are penalised, and that sites closest to an MG5 community i.e. containing all top 20 species, generate the highest score. One of the main assumptions made was that no site will record all of the desirable species, as they are growing in different habitat and soil types. The scoring was adjusted so that MG5 sites such as Cae Trawscoed would generate in the high scoring range (it scored 84). To assess the viability of the matrix in practice, two case studies were carried out.

Case study 1

Pontypool park, Torfaen - The species recorded here were inputted into the pilot matrix and a score generated according to the rules shown in Figure 5.9. Information provided in the site description in Appendix 10 describes this area as varied, with many positive indicators in one section, but with 8 negative indicator species lowering the total score.

Survey Site				
Pontypool Park				
Date				
10.7.20				
		Species recorded	Present	Score
		Brambles	1	-1
		Broad-leaved dock	1	-1
Raw Score	44	Common Ragwort	1	-1
Top 20 Score	38	Creeping buttercup	1	-1
		False oat-grass	1	-1
Relative score 1	25	Perennial rye grass	1	-1
Relative score 2	42	White clover	1	-1
negative ind. score	-10	Yorkshire fog	1	-1
		Common sorrel	1	1
Final Score	57	Creeping cinquefoil	1	1
		Germander speedwell	1	1
GRADE SCORE	Good	Greater plantain	1	1
		Hawkweeds	1	1
		Hedge bindweed	1	1
		Hogweed	1	1
		lesser stitchwort	1	1
		Meadowsweet	1	1
		Pignut	1	1
		Raspberry	1	1
		Ribwort Plantain	1	1
		Sheep's sorrel	1	1
		Tormentil	1	1
		Common bird's foot trefoil	1	4
		Meadow buttercup	1	4
		Catsear	1	5
		Common Knapweed	1	5
		Common mouse ear	1	5
		Daisy	1	5
		Dandelions	1	5
		Self-heal	1	5
		Total		44

Figure 5.10 - The draft matrix being applied to the data collected from Pontypool park, Torfaen in July 2020.

The Grade awarded to this site is 'Good', with the recommendation to consider plug planting or seeding with some 'Top 20' species. This is similar to recommendations in the original ecological survey (Gwent Ecology, 2020).

Case study 2.

Canalside, Torfaen - In contrast, this site generates a much lower score of 23. This area was described as rank grassland (Appendix 11). Recommendations for this area would be to introduce cut & collect twice per year to reduce soil nutrients and consider seeding with Yellow rattle to reduce dominant grasses such as P. Rye grass, again similar to the recommendations of the survey (Gwent Ecology, 2020).

Survey Site					
Canalside					
Date					
10.7.20					
		Species recorded	Present	Score	
		Brambles	1	-1	
		Broad-leaved dock	1	-1	
		Bush vetch	1	1	
Raw Score	21	Common Knapweed	1	5	
Top 20 Score	19	Creeping buttercup	1	-1	
Relative score 1	12	Creeping thistle	1	-1	
Relative score 2	21	Dandelions	1	5	
negative ind. score	-10	False oat-grass	1	-1	
Final Score	23	Greater bird's foot trefoil	1	1	
		Hedge bindweed	1	1	
		Hogweed	1	1	
		lesser stitchwort	1	1	
GRADE SCORE	Poor	Meadow buttercup	1	4	
		Meadow vetchling	1	5	
		Perennial rye grass	1	-1	
		Red clover	1	4	
		Ribwort Plantain	1	1	
		Silverweed	1	1	
		Timothy grass	1	-1	
		White clover	1	-1	
		Yorkshire fog	1	-1	
		Total		21	

Figure 5.11 -- The draft matrix being applied to the data collected from Canalside, Torfaen in July 2020

Use of the matrix

The formation of a toolkit as discussed could have issues, considering the complexities of habitats, individual soil types, microclimates, scrub and tree occurrence. In compiling this list, a balance was sought between ease of identification and use by non-specialists whilst providing a valuable indicator to

grassland recovery. The rationale being if any of the species listed are recorded, then that would be a positive indication of improving conservation value, and the more of these species that are found (higher points score) the closer that site is to high conservation value grassland, e.g. MG5. Negative indicators recorded would also lower the final score and encourage better management, as their presence typifies high soil nutrients. Dominance by Common knapweed or other late flowering species could suggest a mid-July cut is required (Hemmings *et al.*, 2020; Starr-Kedde, 2022). By encouraging recording of flowers only, this would exclude areas where mowing is less frequent at higher heights, although the recording of some species would give a satisfactory score.

6.0 Conclusion

This study set out to ascertain the best method to assess amenity grasslands and create a matrix to calculate an arbitrary score of biodiversity value by land managers and decision makers. The objectives of the study have been met and the resulting list of desirable species include the most frequent species found on amenity grasslands in lowland Wales integrated with the most nectar rich species according to current research. This list has then been used to create a matrix, which generates an overall score for each piece of land which both assesses current management and informs future management. The resulting methodology for the matrix allows its use by non-specialists by limiting any identification errors.

The species recorded on the 16 sites were close to expected for this type of amenity grassland and closely correlated with MG5 NVC plant communities. Even for the 'poor' species sites, there was evidence of transition from lower value habitat to the more desired MG5 type. When assessing the nectar values there were some unexpected results that shaped the final Top 20 species. Specifically, this was due to the high nectar value of negative indicator species and 'injurious' weeds controlled by legislation, which were removed from the final list. Data on nectar resource was also limited, and this impacted the final list created and potentially its use going forward. This will be discussed further in recommendations.

7.0 Recommendations

Further work to develop the findings of this study could include the collection of nectar values for a wider range of typical species. Valuable additions could also be the following:

- Consideration of regional variations.
- Adjustments for different habitats.
- Importance to obligates.
- Role in invertebrate life cycles.

A full toolkit, and ID charts could be further developed and trialled at pilot sites. This could allow for standardisation of the scoring system to improve accuracy. For the toolkit to be successful some assumptions about the land managers would need to be made.

- There is a desire and motivation to change management.
- An understanding of the need to use cut and collect methods.
- An understanding of the importance of meadows to pollinators.
- The need for clear communication to stakeholders.

A key benefit of wildflower meadows, in contrast to other types of habitat enhancements, could be their carbon sequestration properties. Further research could investigate a method to measure this contribution and integrate it into the matrix presented in this study. In this way, wildflower meadows could play a valuable part in local authority strategies to meet 'Net Zero' targets.

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9.0 Appendices

Appendix 1

Strategic Goal A: Address the underlying causes of biodiversity loss by mainstreaming biodiversity across government and society



Target

1

By 2020, at the latest, people are aware of the values of biodiversity and the steps they can take to conserve and use it sustainably.



Target

2

By 2020, at the latest, biodiversity values have been integrated into national and local development and poverty reduction strategies and planning processes and are being incorporated into national accounting, as appropriate, and reporting systems.



Target

3

By 2020, at the latest, incentives, including subsidies, harmful to biodiversity are eliminated, phased out or reformed in order to minimize or avoid negative impacts, and positive incentives for the conservation and sustainable use of biodiversity are developed and applied, consistent and in harmony with the Convention and other relevant international obligations, taking into account national socio economic conditions.



Target

4

By 2020, at the latest, Governments, business and stakeholders at all levels have taken steps to achieve or have implemented plans for sustainable production and consumption and have kept the impacts of use of natural resources well within safe ecological limits.

Strategic Goal B: Reduce the direct pressures on biodiversity and promote sustainable use



Target

5

By 2020, the rate of loss of all natural habitats, including forests, is at least halved and where feasible brought close to zero, and degradation and fragmentation is significantly reduced.

-  **Target** **6**
By 2020 all fish and invertebrate stocks and aquatic plants are managed and harvested sustainably, legally and applying ecosystem based approaches, so that overfishing is avoided, recovery plans and measures are in place for all depleted species, fisheries have no significant adverse impacts on threatened species and vulnerable ecosystems and the impacts of fisheries on stocks, species and ecosystems are within safe ecological limits.
-  **Target** **7**
By 2020 areas under agriculture, aquaculture and forestry are managed sustainably, ensuring conservation of biodiversity.
-  **Target** **8**
By 2020, pollution, including from excess nutrients, has been brought to levels that are not detrimental to ecosystem function and biodiversity.
-  **Target** **9**
By 2020, invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment.
-  **Target** **10**
By 2015, the multiple anthropogenic pressures on coral reefs, and other vulnerable ecosystems impacted by climate change or ocean acidification are minimized, so as to maintain their integrity and functioning.

Strategic Goal C: To improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity

-  **Target** **11**
By 2020, at least 17 per cent of terrestrial and inland water, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes.
-  **Target** **12**
By 2020 the extinction of known threatened species has been prevented and their

conservation status, particularly of those most in decline, has been improved and sustained.



Target

13

By 2020, the genetic diversity of cultivated plants and farmed and domesticated animals and of wild relatives, including other socio-economically as well as culturally valuable species, is maintained, and strategies have been developed and implemented for minimizing genetic erosion and safeguarding their genetic diversity.

Strategic Goal D: Enhance the benefits to all from biodiversity and ecosystem services



Target

14

By 2020, ecosystems that provide essential services, including services related to water, and contribute to health, livelihoods and well-being, are restored and safeguarded, taking into account the needs of women, indigenous and local communities, and the poor and vulnerable.



Target

15

By 2020, ecosystem resilience and the contribution of biodiversity to carbon stocks has been enhanced, through conservation and restoration, including restoration of at least 15 per cent of degraded ecosystems, thereby contributing to climate change mitigation and adaptation and to combating desertification.



Target

16

By 2015, the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization is in force and operational, consistent with national legislation.

Strategic Goal E: Enhance implementation through participatory planning, knowledge management and capacity building



Target

17

By 2015 each Party has developed, adopted as a policy instrument, and has commenced implementing an effective, participatory and updated national biodiversity strategy and action plan.



Target

18

By 2020, the traditional knowledge, innovations and practices of indigenous and

local communities relevant for the conservation and sustainable use of biodiversity, and their customary use of biological resources, are respected, subject to national legislation and relevant international obligations, and fully integrated and reflected in the implementation of the Convention with the full and effective participation of indigenous and local communities, at all relevant levels.



Target

19

By 2020, knowledge, the science base and technologies relating to biodiversity, its values, functioning, status and trends, and the consequences of its loss, are improved, widely shared and transferred, and applied.



Target

20

By 2020, at the latest, the mobilization of financial resources for effectively implementing the Strategic Plan for Biodiversity 2011-2020 from all sources, and in accordance with the consolidated and agreed process in the Strategy for Resource Mobilization, should increase substantially from the current levels. This target will be subject to changes contingent to resource needs assessments to be developed and reported by Parties.

Methodology and supporting Documentation for AgriLand Nectar dataset (Baud *et al.*, 2016)

Experimental design/Sampling regime

Field survey

Field surveys took place during February through to October in 2011 and 2012 consecutively. The majority of field sites were situated in the south of England (Bristol, UK). For each species, one or two field populations in one or two distinct locations were monitored for the study. For three species (*Caltha palustris*, *Lamium purpureum* and *Sinapis arvensis*) half the nectar and for *Viola arvensis* all the nectar was collected from pot-grown plants because insufficient flowering field populations were found. See row data for precise locations and sample sizes.

Species list

The list of species to survey for floral resources was extracted from the UK Results of the Countryside Survey 2007 (Carey *et al.*, 2008) on the basis of species mean vegetative cover. Among the 454 species that cover 99% of the UK landscape surveyed, we selected 220 species potentially rewarding for pollinators (i.e. all insect-pollinated plants + some wind or self-pollinated plants showing flowers). 50 extra-species known as locally important to pollinators were also added to the list despite, they are less common. So, the initial list comprised 270 plant species to survey.

Sampling regime

10 bagged flowers (from at least 5 distinct individuals) per population on average.

2 populations per species when possible.

Total sampling per species: median= 20 flowers and range= 5-30 flowers collected per species

Sample size for each species is indicated in the dataset

Collection/Generation/Transformation methods

Nectar at the flower scale (in $\mu\text{g}/\text{flower}/\text{day}$)

In order to prevent insects depleting nectar, flowers were bagged with bridal mesh (1.4*1.7mm fabric mesh) twenty four hours prior to sampling to allow nectaries to replenish themselves with no hindrance to environmental surrounding conditions. For several species, nectar was also collected from unbagged flowers to get standing crops. Nectar sampling took place during 0900-1600 hours using glass microcapillaries (1, 5 and 10 μL Minicaps end to end, Hirshmann, Eberstadt, Germany). Microcapillaries were directly introduced to the flower to collect the nectar through capillary action from the nectaries. For each plant population, about ten flowers from at least five individual plants

were sampled. The volume of nectar per flower (μL) corresponds to the length of the microcapillaries occupied by the liquid. The sugar concentration of nectar (%; g sucrose/100 g solution) was measured by a handheld refractometer modified for small volumes (Eclipse, Bellingham and Stanley, Tunbridge Wells, UK). Nectar sugar content produced per flower in 24h (s ; μg in 24h) was calculated from the equation $s = 10dvC$, where v is the volume calculated above (μL), and d is the density of a sucrose solution at a concentration C (g sucrose/100 g solution) as read on the refractometer. The density was obtained as $d=0.0037921C+0.0000178C^2+0.9988603$ (Bolten et al., 1979; Prys-Jones and Corbet 1991; Corbet et al., 2001). Many plant species had very low nectar volume and required the flowers to be rinsed before collecting nectar. Flowers were rinsed twice with 1-5 μL of distilled water added with a pipette, each rinsing requiring the sampler to wait one minute before collecting the diluted nectar. In this case, nectar sugar content was estimated from the diluted volumes of nectar re-collected and the concentration of the two diluted samples.

Nectar at the vegetative scale (in kg/ha cover/year)

Empirical nectar sugar content per unit of vegetative cover (kg/ha cover/year) was scaled-up by multiplying nectar sugar content per flower in 24h, flower density at the peak of the flowering season and the number of flowering days/2. This assumes a triangular function of nectar productivity across the flowering period (see AgriLand flower density dataset and Supplementary Methods in Baude et al., 2015)

Modelled nectar productivity in kg/ha cover/year was predicted on the basis of fitted values from a linear model of annual nectar sugar productivity ($\log_{10}(x+1)$ transformed) as a function of plant traits. Plants traits were mainly collected from the BioFlor database and included: “flower shape”, “breeding system”, “life span”, the degree of “dicliny”, the maximum “height”, the “flowering length” and the “family”. The estimates from the most parsimonious based on AIC criterion statistical model were back-transformed to predict the annual nectar sugar productivity for the initial list of surveyed and unsurveyed species on the basis of their traits. See supplementary Methods in Baude et al., 2015

Analytical Methods

The amount of sugar produced per flower basis over 24h (s ; μg of sugars/flower/24h) was calculated using the formula $s=10dvC$

where v is the volume collected (μL), and d is the density of a sucrose solution at a concentration C (g sucrose/100 g solution) as read on the refractometer. The density of the sucrose solution was

calculated by the formula $d=0.0037921C+0.0000178C^2+0.9988603$ (Bolten et al. 1979; Prys-Jones and Corbet 1991; Corbet et al. 2001)

The amount of sugar produced per flower basis over 24h is derived from the sum of the subsequent samplings made from the same flower

The mean, variance and sample size of nectar sugar content per species ($\mu\text{g}/\text{flower}/24\text{h}$) were computed on nectar sugar content from flowers that belong to the same species

Quality Control

sugarmax. μg refers to potential maximum nectar sugar that can be collected considering that all the wader added can be recollected.

unbagged flowers are flowers that were not bagged 24h before nectar collection. These nectar values refer to nectar available at the time of sampling with permanent pollinator visitation (standing crop). These values were not used for calculating the average values of nectar per species.

Appendix 3

r Critical Value Table

Critical Values of the Pearson Product-Moment Correlation Coefficient				
How to use this table				
$df = n - 2$				
Level of Significance (p) for Two-Tailed Test	.10	.05	.02	.01
df				
1	.988	.997	.9995	.9999
2	.900	.950	.980	.990
3	.805	.878	.934	.959
4	.729	.811	.882	.917
5	.689	.754	.833	.874
6	.622	.707	.789	.834
7	.582	.666	.750	.798
8	.549	.632	.716	.765
9	.521	.602	.685	.735
10	.497	.578	.658	.708
11	.476	.553	.634	.684
12	.458	.532	.612	.661
13	.441	.514	.592	.641
14	.426	.497	.574	.623
15	.412	.482	.558	.606
16	.400	.468	.542	.590
17	.389	.456	.528	.575
18	.378	.444	.516	.561
19	.369	.433	.503	.549
20	.360	.423	.492	.537
21	.352	.413	.482	.526
22	.344	.404	.472	.515
23	.337	.396	.462	.505
24	.330	.388	.453	.496
25	.323	.381	.445	.487
26	.317	.374	.437	.479
27	.311	.367	.430	.471
28	.306	.361	.423	.463
29	.301	.355	.416	.456
30	.296	.349	.409	.449
35	.275	.325	.381	.418
40	.257	.304	.358	.393
45	.243	.288	.338	.372
50	.231	.273	.322	.354
60	.211	.250	.295	.325
70	.195	.232	.274	.303
80	.183	.217	.256	.283
90	.173	.205	.242	.267
100	.164	.195	.230	.254

Figure 9.1 - A table showing the r critical values for differing levels of confidence with 2 sets of data. The relevant position for the data discussed in Section 5.1 is circled in the table above (https://researchbasics.education.uconn.edu/r_critical_value_table/).

Appendix 4

Table 9.1 - Site descriptions of the 10 locations used in the secondary data set. Information is taken from the ecological survey report provided by Torfaen and Blaenau Gwent Ecologist (Gwent ecology, 2020).

Code: 1T	Site Name: An area of Cwmtillery woodland, below the football field.
Grid Reference: SO2171 0576	Local Authority: Blaenau Gwent
Survey Date: 4th August 2020	
Site Description: A roughly rectangular (together with a smaller triangle through the trees to the south), flat area of grassland (below/to the south) of Jim Owen Football Field. It was quite rough and grass heavy with some signs of becoming rank (Timothy, Couch and False Oat-grass), however there were still some finer grass species present within the sward. Bramble was encroaching to some extent on the east side, north-west corner and on the triangle to the south. Scrub was developing on the southern half of the rectangle, particularly a non-native Alder species. The grassland was not particularly species-rich, although a reasonable amount of indicator species could be found, although generally these were in small amounts with the exception of Meadow Vetchling which was abundant and Red Clover which was locally abundant. Occasional patches of tall-herb in the form of Greater Willowherb were present. The smaller triangle to the south was divided from the main field by a small stand of Grey Willow. The stand of Grey Willow is of note as it contained abundant sedges, frequent Zig zag Clover and 11 spikes of Broad-leaved Helleborine were counted.	

Code: 2T	Site Name: Silent Valley car park meadow.
Grid Reference: SO18680603	Local Authority: Blaenau Gwent
Survey Date: 9th July 2020	
Site Description: At the southern end is the carpark, then stretching north of this is a strip. vegetation transitions from low grassland to Taller herb and Brambles where it borders the trees. On the eastern side this strip comprises Brambles, Stinging Nettles, Cleavers and Hedge Bindweed and on the western side it is largely Bracken, Brambles, and Rosebay Willowherb. The main grassland area had generally ranker grass species such as Cocksfoot & False Oat-grass, although other finer species were present. Herbs were present but generally, not in great abundance although clovers, both Red and particularly White were frequent/abundant	

Code: 3T	Site Name: Area adjacent to land managed as wildflower meadow at Parc Nant-y-Waun.
Local Authority: Blaenau Gwent	Survey Date: 4th August 2020
Site Description: The area was largely False Oat-grass dominated rank grassland with limited herbs, with just occasional Tormentil and Common Knapweed being the only “indicator” species present, together with occasional thistles and locally frequent Broad-leaved Dock. Two areas just off the path (SO17917 11595) & (SO17903 11637) were however very species-rich with Devil's Bit Scabious being particularly abundant (possibly seeded). These species were spreading out onto the path (separate species list). A third species-rich area (SO17942 11566) was also found within the rank grassland away from the path, again a separate species list was undertaken. Brambles were spreading down from the northern end and there were patches of Rosebay Willowherb that could spread further.	

Code: 4T	Site Name: Cwm Recreation Ground.
Local Authority: Blaenau Gwent	Survey Date: 9th July 2020
Site Description: This site included a large area of flat, mown, species-poor sports fields that were flanked by trees (Sorbus and Limes) and a watercourse on the western side. The sports fields were very grassy with the only herbs in any abundance being White Clover, Dandelion and Common Mouse-ear. There was a very small un-cut bit by the fence in the north-west corner of the sports field, this provided most of the diversity in the sports fields despite its very small size. Also surveyed was a smaller area to the north of the play-ground in which there was an un-mown area on a bank, this was quite rank with Creeping Thistle, Bracken and Bramble threatening to take over various parts, it was however quite species rich with a definite calcareous element to it. Three separate species lists were compiled in relation to the playing fields, small un-mown area in NE corner of sports field and un-mown area in NE Corner.	

Code: 5T	Site Name: Old Cefn Golau Cemetery, Tredegar.
Local Authority: Blaenau Gwent	Survey Date: 9th July 2020
Site Description: A cemetery with a great mosaic of habitats present including elements of Acid, Neutral and Damp Grassland, scrub and individual trees. It is LWS/SINC quality. The southern part is older overgrown Graveyard with ranker and in places damper grassland, together with trees and scrub as well as areas of Japanese Knotweed, it represents good wildlife habitat but is in danger of becoming too overgrown. The remainder of the graveyard is grassland, much of which is quite species-rich, with some scattered trees. The eastern side being managed as a meadow and without graves, the western side generally being more acidic and in parts mown short and the areas left longer being more species rich. Japanese Knotweed was present at a number of points.	

Code: 6T	Site Name: Amos Field, Capel Newydd, Blaenafon.
Local Authority: Torfaen	Survey Date: 16th July 2020
Site Description: A nice flowery area on the sloping ground next to the wood. The un-cut part had abundant Red Clover together with much Common Knapweed, Birdsfoot Trefoil, and also Meadow Vetchling, Catsear and Fairy Flax amongst others. The rest was cut, however significant parts of the cut areas had a similar floral composition and if left uncut could form a similar flowery area, particularly the area immediately down slope of the cut area and that surrounding the car-parking area. There were a few “garden escapes” near the top of the slope.	

Code: 7T	Site Name: Festival Field, Talywaun.
Local Authority: Torfaen	Survey Date: 10th July 2020
Site Description: A flat area of grassland that slopes very gently to the south. It was mown around the perimeter and diagonally across the middle (the mown areas were generally less species-rich). It was very flowery with Red Clover, White Clover and Birdsfoot Trefoil abundant. There were some more localised damper patches with rushes and an acidic influence in places where Sheep’s Sorrel was frequent. The site is bordered by hedgerow and in places Bramble and some garden escapes.	

Code: 8T	Site Name: Riverside meadow, Pontypool.
Grid Reference: SO27800167	Local Authority: Torfaen
Survey Date: 10th July 2020	
Site Description: An area of rough grassland flanked by woodland. Throughout large parts the grassland was rank with Cocksfoot abundant and tall herbs such as Docks, Hogweed and Thistles prevalent. One area with a nicer sward of finer grass species (Common Bent & Red Fescue) was centred on SO27807 01679, this area wasn’t particularly species-rich but had abundant Yarrow and “indicator” species such as Bulbous Buttercup, Common Knapweed and Imperforate St. John’s Wort. Additionally, there was another smaller area at SO27813 01644 with a Red Fescue rich sward and more herbs (Red Clover (F), Creeping Cinquefoil (F), Imperforate St. John’s Wort (O), Rough Hawkbit (LA), Common Knapweed (O) as well as Spiked Sedge).	

Code: 9T	Site Name: Maendy Field, Upper Cwmbran.
Grid Reference: ST27879664	Local Authority: Torfaen
Survey Date: 16th July 2020	
Site Description: This was the corner of a much larger recreation field. It had a few large Oak and an Alder. Most of what was in the shade of the trees was very rough, heavy grass with False Oat-grass, Cocksfoot, Rough Meadow Grass and limited herbs, together with Bramble patches forming in some parts. In the open, the sward was much better with Sweet Vernal Grass and Yorkshire Fog being the main grasses. The very best part was on the northern edge, adjacent to where it is mown, here buttercups (Meadow, Creeping and Lesser Spearwort) were abundant together with much Greater Bird's Foot Trefoil, locally frequent Catsear and Red Clover, together with Common Knapweed and Birdsfoot Trefoil. The Schedule 9 species – Montbretia was noted close to the hedgerow, presumably coming through from gardens on the other side.	

Code: 10T	Site Name: Land adjacent to Llanyrafon social centre.
Grid Reference: ST30299465	Local Authority: Torfaen
Survey Date: 29th July 2020	
Site Description: A small area of unmown, north facing bank, below the road. Very heavy with grasses (Yorkshire Fog, Creeping Bent & False Oat-grass) over much with the consequence being there were very few herbs. In more limited areas grass such as Sweet Vernal Grass was more abundant and a few more herbs were present, particularly towards the western end where Yarrow & Knapweed were very locally frequent together with Catsear, Selfheal and some clover.	

Appendix 5

Table 9.2 - Table showing the Flowering species found across on 16 sites with their relative frequencies.

Species	Common name	Total Frequency	% Frequency
Ranunculus acris	Meadow buttercup	16	100
Plantago lanceolata	Ribwort Plantain	15	94
Centaurea nigra	Common Knapweed	14	88
Trifolium pratense	Red clover	14	88
Taraxacum officinalis agg.	Dandelions	13	81
Lotus corniculatus	Common bird's foot trefoil	12	75
Rumex acetosa	Common sorrel	12	75
Lotus pedunculatus	Greater bird's foot trefoil	11	69
Heracleum sphondylium	Hogweed	10	63
Lathyrus pratensis	Meadow vetchling	9	56
Potentilla reptans	Creeping cinquefoil	9	56
Prunella vulgaris	Self-heal	9	56
Bellis perennis	Daisy	8	50
Cerastium holosteoides	Common mouse ear chickweed	7	44
Epilobium hirsutum	Hairy willowherb	7	44
Hypochoeris radicata	Catsear	7	44
Chamerion angustifolium	Great willowherb	6	38
Epilobium spp.	Willowherbs	6	38
Galium aparine	Cleavers	6	38
Vicia sativa	Common vetch	6	38
Cardamine pratensis	Cuckoo flower	5	31
Geranium molle	Dove's foot crane's-bill	5	31
Leucanthemum vulgare	Oxeye daisy	5	31
Plantago major	Greater plantain	5	31
Veronica chamaedrys	Germander speedwell	5	31
Geranium dissectum	Cut-leaved cranesbill	4	25
Geum urbanum	Wood Avens	4	25
Potentilla anserina	Silverweed	4	25
Rhinanthus minor	Yellow Rattle	4	25
Vicia cracca	Tufted vetch	4	25
Viola riviniana	Dog violet	4	25
Achillea millefolium	Yarrow	3	19
Anthriscus sylvestris	Cow parsley	3	19
Cerastium fontanum	Common mouse ear	3	19
Ficaria verna	Lesser celandine	3	19
Geranium robertianum	Herb Robert	3	19
Hypericum maculatum	Imperforate St John's wart	3	19
Hypericum tetrapterum	Square stalked St John's wort	3	19
Medicago lupulina	Black medic	3	19

<i>Odontites vernus</i>	Red bartsia	3	19
<i>Pilosella officinarum</i>	mouse ear hawkweed	3	19
<i>Potentilla erecta</i>	Tormentil	3	19
<i>Ranunculus bulbosus</i>	Bulbous buttercup	3	19
<i>Ranunculus flammula</i>	Lesser Spearwort	3	19
<i>Rumex acetosella</i>	Sheep's sorrel	3	19
<i>Torilis japonica</i>	Upright hedge parsley	3	19
<i>Trifolium medium</i>	zig zag clover	3	19
<i>Achillea ptarmica</i>	Sneezewort	2	13
<i>Aegopodium podagraria</i>	Ground elder	2	13
<i>Calystegia sepium</i>	Hedge bindweed	2	13
<i>Cerastium glomeratum</i>	Sticky mouse ear	2	13
<i>Crepis capillaris</i>	Smooth hawksbeard	2	13
<i>Dactylorhiza praetermissa</i>	Southern marsh orchid	2	13
<i>Daucus carota</i>	Wild carrot	2	13
<i>Epilobium parviflorum</i>	Hoary willowherb	2	13
<i>Epipactis helleborine</i>	Broad-leaved helleborine	2	13
<i>Eupatorium cannabinum</i>	Hemp agrimony	2	13
<i>Euphrasia officinalis</i> agg.	Eyebrights	2	13
<i>Festuca ovina</i>	Sheeps fescue	2	13
<i>Galium saxatile</i>	Heath bedstraw	2	13
<i>Hyacinthoides non-scriptus</i>	Bluebell	2	13
<i>Lapsana communis</i>	Nipplewort	2	13
<i>Leontodon hispidus</i>	Rough hawkbit	2	13
<i>Pilosella auriantica</i>	Fox & Cubs	2	13
<i>Rosa canina</i>	Dog rose	2	13
<i>Stellaria graminea</i>	lesser stitchwort	2	13
<i>Ajuga reptans</i>	Bugle	1	6
<i>Alchemilla mollis</i>	Lady's mantle	1	6
<i>Alliaria petiolata</i>	Garlic mustard	1	6
<i>Arctium minus</i>	Common burdock	1	6
<i>Artemesia vulgaris</i>	Mugwort	1	6
<i>Calluna vulgaris</i>	Heather	1	6
<i>Capsella bursa-pastoris</i>	Shepherd's purse	1	6
<i>Cardamine hirsuta</i>	Hairy bittercress	1	6
<i>Carum verticillatum</i>	Whorled Caraway	1	6
<i>Circaea lutetiana</i>	Enchanter's nightshade	1	6
<i>Conopodium majus</i>	Pignut	1	6
<i>Coronopus</i> spp.	Swinecress	1	6
<i>Digitalis purpurea</i>	Foxglove	1	6
<i>Epilobium montanum</i>	Broad-leaved willowherb	1	6
<i>Ervilla hirsute</i>	Hairy Tare	1	6
<i>Ervum tetraspermum</i>	Smooth Tare	1	6
<i>Euphorbia peplus</i>	Petty spurge	1	6
<i>Filipendula ulmaria</i>	Meadowsweet	1	6

<i>Fragaria vesca</i>	Wild strawberry	1	6
<i>Galium palustre</i>	Marsh bedstraw	1	6
<i>Geranium pyrenaicum</i>	Hedgerow crane's-bill	1	6
<i>Glechoma hederacea</i>	Ground ivy	1	6
<i>Hieracium</i> spp.	Hawkweeds	1	6
<i>Hypericum androsaemum</i>	Tutsan	1	6
<i>Leontodon</i> spp.	Hawkbits	1	6
<i>Linum catharticum</i>	Fairy flax	1	6
<i>Lychnis flos-cuculi</i>	Ragged robin	1	6
<i>Lysimachia punctata</i>	Yellow loosestrife	1	6
<i>Matricaria discoidea</i>	Pineappleweed	1	6
<i>Mentha spicata</i>	Spear mint	1	6
<i>Myosotis</i> spp.	Forget me nots	1	6
<i>Oenanthe crocata</i>	Henlock water dropwort	1	6
<i>Oenothera</i> spp.	Evening primrose	1	6
<i>Origanum vulgare</i>	Oregano	1	6
<i>Potentilla sterilis</i>	Barren strawberry	1	6
<i>Pulicaria dysenterica</i>	Meadow Fleabane	1	6
<i>Rubus idaeus</i>	Raspberry	1	6
<i>Sagina procumbens</i>	Procumbent pearlwort	1	6
<i>Sanguisorba officinalis</i>	Greater Burnet	1	6
<i>Senecio erucifolius</i>	Hoary ragwort	1	6
<i>Senecio vulgaris</i>	Common groundsel	1	6
<i>Serratula tinctoria</i>	Saw-wort	1	6
<i>Sisymbrium officinale</i>	Hedge mustard	1	6
<i>Stachys palustris</i>	Marsh woundwort	1	6
<i>Stachys sylvatica</i>	Hedge woundwort	1	6
<i>Succisa pratensis</i>	Devil's bit scabious	1	6
<i>Trifolium media</i>	Zig zag clover	1	6
<i>Tussilago farfara</i>	Coltsfoot	1	6
<i>Ulex galii</i>	Western gorse	1	6
<i>Veronica serpyllifolia</i>	Thyme leaved speedwell	1	6
<i>Vicia sepium</i>	Bush vetch	1	6

Appendix 6

Table 9.3 - The complete list of species for a range of recovering and high conservation value grasslands.

Species	Common name
<i>Achillea millefolium</i>	Yarrow
<i>Achillea ptarmica</i>	Sneezewort
<i>Aegopodium podagraria</i>	Ground elder
<i>Agrostis capillaris</i>	Common bent
<i>Agrostis stolonifera</i>	Creeping bent
<i>Ajuga reptans</i>	Bugle
<i>Alchemilla mollis</i>	Lady's mantle
<i>Alliaria petiolata</i>	Garlic mustard
<i>Alopecurus geniculatus</i>	Marsh foxtail
<i>Alopecurus pratensis</i>	Meadow foxtail
<i>Anacamptis pyramidalis</i>	Pyramidal orchid
<i>Anthoxanthum odoratum</i>	Sweet vernal grass
<i>Anthriscus sylvestris</i>	Cow parsley
<i>Anthyllis vulneraria</i>	Kidney vetch
<i>Arctium minus</i>	Common burdock
<i>Arrhenatherum elatius</i>	False oat-grass
<i>Artemisia vulgaris</i>	Mugwort
<i>Athyrium filix-femina</i>	Lady fern
<i>Bellis perennis</i>	Daisy
<i>Betonica officinalis</i>	Betony
<i>Blackstonia perfoliata</i>	Yellow-wort
<i>Briza media</i>	Quaking-grass
<i>Bromus erectus</i>	Upright brome
<i>Bromus hordeaceus</i>	Soft brome
<i>Bromus sterilis</i>	Barren brome
<i>Calluna vulgaris</i>	Heather
<i>Caltha palustris</i>	Marsh marigold
<i>Calystegia sepium</i>	Hedge bindweed
<i>Capsella bursa-pastoris</i>	Shepherd's purse
<i>Cardamine hirsuta</i>	Hairy bittercress
<i>Cardamine pratensis</i>	Cuckoo flower
<i>Carex caryophyllea</i>	Spring sedge
<i>Carex divulsa</i>	Grey sedge
<i>Carex flacca</i>	Glaucous sedge
<i>Carex hirsute</i>	Hairy sedge
<i>Carex nigra</i>	Common sedge
<i>Carex ovalis</i>	Oval sedge
<i>Carex panicea</i>	Carnation sedge
<i>Carex pendula</i>	Pendulous sedge
<i>Carex spicata</i>	Spiked sedge
<i>Carum verticillatum</i>	Whorled Caraway

<i>Centaurea nigra</i>	Common knapweed
<i>Centaurea scabiosa</i>	Greater knapweed
<i>Cerastium fontanum</i>	Common mouse ear
<i>Cerastium glomeratum</i>	Sticky mouse ear
<i>Cerastium holosteoides</i>	Common mouse ear chickweed
<i>Chamerion angustifolium</i>	Great willowherb
<i>Circaea lutetiana</i>	Enchanter's nightshade
<i>Cirsium palustre</i>	Marsh thistle
<i>Clinopodium vulgare</i>	Wild basil
<i>Conopodium majus</i>	Pignut
<i>Coronopus</i> spp.	Swinecress
<i>Crepis capillaris</i>	Smooth hawksbeard
<i>Cruciata laevipes</i>	Crosswort
<i>Cynosurus cristatus</i>	Crested Dog's Tail
<i>Dactylorhiza fuchsii</i>	Common-spotted orchid
<i>Dactylorhiza praetermissa</i>	Marsh Orchid
<i>Dactylorhiza praetermissa</i>	Southern marsh orchid
<i>Danthonia decumbens</i>	Heath grass
<i>Daucus carota</i>	Wild carrot
<i>Deschampsia caespitosa</i>	Tufted hair grass
<i>Digitalis purpurea</i>	Foxglove
<i>Elymus repens</i>	Couch grass
<i>Epilobium hirsutum</i>	Hairy willowherb
<i>Epilobium montanum</i>	Broad-leaved willowherb
<i>Epilobium parviflorum</i>	Hoary willowherb
<i>Epilobium</i> spp.	Willowherbs
<i>Epipactis helleborine</i>	Broad-leaved helleborine
<i>Equisetum arvense</i>	Field horsetail
<i>Erica tetralix</i>	Cross-leaved heath
<i>Ervilla hirsute</i>	Hairy Tare
<i>Ervum tetraspermum</i>	Smooth Tare
<i>Eupatorium cannabinum</i>	Hemp agrimony
<i>Euphorbia peplus</i>	Petty spurge
<i>Euphrasia</i> spp.	Eyebrights
<i>Festuca gigantea</i>	Giant fescue
<i>Festuca ovina</i>	Sheeps fescue
<i>Festuca rubra</i>	Red fescue
<i>Ficaria verna</i>	Lesser celandine
<i>Filipendula ulmaria</i>	Meadowsweet
<i>Filipendula vulgaris</i>	Dropwort
<i>Fragaria vesca</i>	Wild strawberry
<i>Galium aparine</i>	Cleavers
<i>Galium palustre</i>	Marsh bedstraw
<i>Galium saxatile</i>	Heath bedstraw
<i>Galium verum</i>	Lady's bedstraw

<i>Geranium dissectum</i>	Cut-leaved cranesbill
<i>Geranium molle</i>	Dove's foot crane's-bill
<i>Geranium pyrenaicum</i>	Hedgerow crane's-bill
<i>Geranium robertianum</i>	Herb Robert
<i>Geum urbanum</i>	Wood avens
<i>Glechoma hederacea</i>	Ground ivy
<i>Helianthemum nummularium</i>	Common rockrose
<i>Heracleum sphondylium</i>	Hogweed
<i>Hieracium</i> spp.	Hawkweeds
<i>Hippocrepis comosa</i>	Horseshoe vetch
<i>Holcus mollis</i>	Creeping soft grass
<i>Hyacinthoides non-scriptus</i>	Bluebell
<i>Hypericum androsaemum</i>	Tutsan
<i>Hypericum maculatum</i>	Imperforate St John's wart
<i>Hypericum tetrapterum</i>	Square stalked St John's wort
<i>Hypochoeris radicata</i>	Catsear
<i>Juncus acutiflorus</i>	Sharp-flowered rush
<i>Knautia arvensis</i>	Field scabious
<i>Knautia columbaria</i>	Small scabious
<i>Lapsana communis</i>	Nipplewort
<i>Lathyrus pratensis</i>	Meadow vetchling
<i>Leontodon hispidus</i>	Rough hawkbit
<i>Leontodon</i> spp.	Hawkbits
<i>Leucanthemum vulgare</i>	Oxeye daisy
<i>Linum catharticum</i>	Fairy flax
<i>Lotus corniculatus</i>	Common Birds Foot Trefoil
<i>Lotus pedunculatus</i>	Greater bird's foot trefoil
<i>Luzula campestris</i>	Field wood rush
<i>Luzula multiflora</i>	Heath wood rush
<i>Lychnis flos-cuculi</i>	Ragged-robin
<i>Lysimachia punctata</i>	Yellow loosestrife
<i>Medicago lupulina</i>	Black medic
<i>Mentha aquatic</i>	Water mint
<i>Mentha spicata</i>	Spear mint
<i>Myosotis</i> spp.	Forget me nots
<i>Odontites vernus</i>	Red bartsia
<i>Oenanthe crocata</i>	Hemlock water dropwort
<i>Onobrychis viciifolia</i>	Sainfoin
<i>Ononis repens</i>	Common restharrow
<i>Ophrys apifera</i>	Bee orchid
<i>Origanum vulgare</i>	Wild marjoram
<i>Pedicularis sylvatica</i>	Common lousewort
<i>Pilosella auriantica</i>	Fox & Cubs
<i>Pilosella officinarum</i>	mouse ear hawkweed
<i>Plantago lanceolata</i>	Ribwort plantain

<i>Plantago major</i>	Greater plantain
<i>Plantago media</i>	Hoary plantain
<i>Poa annua</i>	Annual meadow grass
<i>Poa nemoralis</i>	Wood meadow grass
<i>Poa trivialis</i>	Rough meadow grass
<i>Polygala vulgaris</i>	Common milkwort
<i>Polygonum aviculare</i>	Common knotgrass
<i>Potentilla anserina</i>	Silverweed
<i>Potentilla erecta</i>	Tormentil
<i>Potentilla reptans</i>	Creeping cinquefoil
<i>Potentilla sterilis</i>	Barren strawberry
<i>Poterium sanguisorba</i>	Salad burnet
<i>Prunella vulgaris</i>	Self-heal
<i>Pteridium aquilinum</i>	Bracken
<i>Pulicaria dysenterica</i>	Meadow Fleabane
<i>Ranunculus acris</i>	Meadow buttercup
<i>Ranunculus bulbosus</i>	Bulbous buttercup
<i>Ranunculus flammula</i>	Lesser spearwort
<i>Ranunculus repens</i>	Creeping Buttercup
<i>Rhinanthus minor</i>	Yellow rattle
<i>Rosa canina</i>	Dog rose
<i>Rubus idaeus</i>	Raspberry
<i>Rumex acetosa</i>	Common sorrel
<i>Rumex acetosella</i>	Sheeps sorrel
<i>Sagina procumbens</i>	Procumbent pearlwort
<i>Sanguisorba officinalis</i>	Greater Burnet
<i>Sanguisorba officinalis</i>	Great burnet
<i>Scutellaria minor</i>	Lesser skullcap
<i>Senecio erucifolius</i>	Hoary ragwort
<i>Senecio vulgaris</i>	Common groundsel
<i>Serratula tinctoria</i>	Saw-wort
<i>Silene silaus</i>	Pepper-saxifrage
<i>Sisymbrium officinale</i>	Hedge mustard
<i>Sonchus asper</i>	Spiny Sow thistle
<i>Stachys palustris</i>	Marsh woundwort
<i>Stachys sylvatica</i>	Hedge woundwort
<i>Stellaria graminea</i>	lesser stitchwort
<i>Succisa pratensis</i>	Devil's-bit scabious
<i>Taraxacum officinale</i> agg.	Dandelions
<i>Thymus praecox</i>	Wild thyme
<i>Torilis japonica</i>	Upright hedge parsley
<i>Trifolium dubium</i>	Lesser trefoil
<i>Trifolium medium</i>	Zig-zag clover
<i>Trifolium pratense</i>	Red clover
<i>Trifolium repens</i>	White clover

Trisetum flavescens	Yellow oat-grass
Tussilago farfara	Coltsfoot
Ulex gallii	Western gorse
Veronica chamaedrys	Germander speedwell
Veronica serpyllifolia	Thyme leaved speedwell
Vicia cracca	Tufted vetch
Vicia sativa	common vetch
Vicia sepium	Bush vetch
Viola riviniana	Dog violet
Vulpia bromoides	Squirrel tail fescue

Appendix 7

Table 9.4 - The final list of all desirable species for recovering grassland after discounting rushes, sedges, invasives, negative indicators and any non-natives.

Species name	Common name
<i>Achillea millefolium</i>	Yarrow
<i>Achillea ptarmica</i>	Sneezewort
<i>Aegopodium podagraria</i>	Ground elder
<i>Ajuga reptans</i>	Bugle
<i>Alchemilla mollis</i>	Lady's mantle
<i>Alliaria petiolata</i>	Garlic mustard
<i>Anthriscus sylvestris</i>	Cow parsley
<i>Arctium minus</i>	Common burdock
<i>Artemisia vulgaris</i>	Mugwort
<i>Bellis perennis</i>	Daisy
<i>Calluna vulgaris</i>	Heather
<i>Calystegia sepium</i>	Hedge bindweed
<i>Capsella bursa-pastoris</i>	Shepherd's purse
<i>Cardamine hirsuta</i>	Hairy bittercress
<i>Cardamine pratensis</i>	Cuckoo flower
<i>Carum verticillatum</i>	Whorled Caraway
<i>Centaurea nigra</i>	Common Knapweed
<i>Cerastium fontanum</i>	Common mouse ear
<i>Cerastium glomeratum</i>	Sticky mouse ear
<i>Cerastium holosteoides</i>	Common mouse ear chickweed
<i>Chamerion angustifolium</i>	Great willowherb
<i>Circaea lutetiana</i>	Enchanter's nightshade
<i>Conopodium majus</i>	Pignut
<i>Coronopus</i> spp.	Swinecress
<i>Crepis capillaris</i>	Smooth hawksbeard
<i>Dactylorhiza praetermissa</i>	Southern marsh orchid
<i>Daucus carota</i>	Wild carrot
<i>Digitalis purpurea</i>	Foxglove
<i>Epilobium hirsutum</i>	Hairy willowherb
<i>Epilobium montanum</i>	Broad-leaved willowherb
<i>Epilobium parviflorum</i>	Hoary willowherb
<i>Epilobium</i> spp.	Willowherbs

<i>Epipactis helleborine</i>	Broad-leaved helleborine
<i>Ervilla hirsute</i>	Hairy Tare
<i>Ervum tetraspermum</i>	Smooth Tare
<i>Eupatorium cannabinum</i>	Hemp agrimony
<i>Euphorbia peplus</i>	Petty spurge
<i>Euphrasia officinalis</i> agg.	Eyebrights
<i>Ficaria verna</i>	Lesser celandine
<i>Filipendula ulmaria</i>	Meadowsweet
<i>Fragaria vesca</i>	Wild strawberry
<i>Galium aparine</i>	Cleavers
<i>Galium palustre</i>	Marsh bedstraw
<i>Galium saxatile</i>	Heath bedstraw
<i>Geranium dissectum</i>	Cut-leaved cranesbill
<i>Geranium molle</i>	Dove's foot crane's-bill
<i>Geranium pyrenaicum</i>	Hedgerow crane's-bill
<i>Geranium robertianum</i>	Herb Robert
<i>Geum urbanum</i>	Wood Avens
<i>Glechoma hederacea</i>	Ground ivy
<i>Heracleum sphondylium</i>	Hogweed
<i>Hieracium</i> spp.	Hawkweeds
<i>Hyacinthoides non-scriptus</i>	Bluebell
<i>Hypericum androsaemum</i>	Tutsan
<i>Hypericum maculatum</i>	Imperforate St John's wart
<i>Hypericum tetrapterum</i>	Square stalked St John's wort
<i>Hypochoeris radicata</i>	Catsear
<i>Lapsana communis</i>	Nipplewort
<i>Lathyrus pratensis</i>	Meadow vetchling
<i>Leontodon hispidus</i>	Rough hawkbit
<i>Leontodon</i> spp.	Hawkbits
<i>Leucanthemum vulgare</i>	Oxeye daisy
<i>Linum catharticum</i>	Fairy flax
<i>Lotus corniculatus</i>	Common bird's foot trefoil
<i>Lotus pedunculatus</i>	Greater bird's foot trefoil
<i>Lychnis flos-cuculi</i>	Ragged robin
<i>Lysimachia punctata</i>	Yellow loosestrife
<i>Matricaria discoidea</i>	Pineappleweed

<i>Medicago lupulina</i>	Black medic
<i>Mentha spicata</i>	Spear mint
<i>Myosotis</i> spp.	Forget me nots
<i>Odontites vernus</i>	Red bartsia
<i>Oenanthe crocata</i>	Henlock water dropwort
<i>Oenothera</i> spp.	Evening primrose
<i>Origanum vulgare</i>	Wild Majoram
<i>Pilosella auriantica</i>	Fox & Cubs
<i>Pilosella officinarum</i>	Mouse ear hawkweed
<i>Plantago lanceolata</i>	Ribwort Plantain
<i>Plantago major</i>	Greater plantain
<i>Potentilla anserina</i>	Silverweed
<i>Potentilla erecta</i>	Tormentil
<i>Potentilla reptans</i>	Creeping cinquefoil
<i>Potentilla sterilis</i>	Barren strawberry
<i>Prunella vulgaris</i>	Self-heal
<i>Pulicaria dysenterica</i>	Meadow Fleabane
<i>Ranunculus acris</i>	Meadow buttercup
<i>Ranunculus bulbosus</i>	Bulbous buttercup
<i>Ranunculus flammula</i>	Lesser Spearwort
<i>Rhinanthus minor</i>	Yellow Rattle
<i>Rosa canina</i>	Dog rose
<i>Rubus idaeus</i>	Raspberry
<i>Rumex acetosa</i>	Common sorrel
<i>Rumex acetosella</i>	Sheep's sorrel
<i>Sagina procumbens</i>	Procumbent pearlwort
<i>Sanguisorba officinalis</i>	Greater Burnet
<i>Senecio erucifolius</i>	Hoary ragwort
<i>Senecio vulgaris</i>	Common groundsel
<i>Serratula tinctoria</i>	Saw-wort
<i>Sisymbrium officinale</i>	Hedge mustard
<i>Stachys palustris</i>	Marsh woundwort
<i>Stachys sylvatica</i>	Hedge woundwort
<i>Stellaria graminea</i>	lesser stitchwort
<i>Succisa pratensis</i>	Devil's bit scabious
<i>Taraxacum officinalis</i> agg.	Dandelions

Torilis japonica	Upright hedge parsley
Trifolium media	Zig zag clover
Trifolium pratense	Red clover
Tussilago farfara	Coltsfoot
Ulex galii	Western gorse
Veronica chamaedrys	Germander speedwell
Veronica serpyllifolia	Thyme leaved speedwell
Vicia cracca	Tufted vetch
Vicia sativa	Common vetch
Vicia sepium	Bush vetch
Viola riviniana	Dog violet

Appendix 8

Rank	Species	Common name	Score	Nectar score	Total score	Reasoning
0	County flower	County flower	2	0	2	Regional importance
0	Orchids (all families)	Orchids (all families)	2	0	2	Public popularity
1	Achillea millefolium	Yarrow	3	2	5	Known High nectar resource
2	Bellis perennis	Daisy	3	2	5	Known High nectar resource
3	Centaurea nigra	Common Knapweed	3	2	5	Known High nectar resource
4	Cerastium fontanum	Common mouse ear	3	2	5	Known High nectar resource
5	Chamerion angustifolium	Great willowherb	3	2	5	Known High nectar resource
6	Digitalis purpurea	Foxglove	3	2	5	Known High nectar resource
7	Epilobium spp.	Willowherbs	3	2	5	Known High nectar resource
8	Hypochaeris radicata	Catsear	3	2	5	Known High nectar resource
9	Lathyrus pratensis	Meadow vetchling	3	2	5	Known High nectar resource
10	Leontodon hispidus	Rough hawkbit	3	2	5	Known High nectar resource
11	Leontodon spp.	Hawkbits	3	2	5	Known High nectar resource
12	Leucanthemum vulgare	Oxeye daisy	3	2	5	Known High nectar resource
13	Prunella vulgaris	Self-heal	3	2	5	Known High nectar resource
14	Stachys sylvatica	Hedge woundwort	3	2	5	Known High nectar resource
15	Taraxacum officinalis agg.	Dandelions	3	2	5	Known High nectar resource
16	Vicia sativa	Common vetch	3	2	5	Known High nectar resource
17	Lotus corniculatus	Common bird's foot trefoil	3	1	4	Good meadow indicator

91 single scoring species	91
2 double scoring species	4
4 x 4 score species	16
16 x 5 score species	80
17 Negative scoring species	-17
Max possible score	174
All Top 20 Species	96

18	<i>Succisa pratensis</i>	Devil's bit scabious	3	1	4	Important larval food plant for Marsh fritillary butterfly
19	<i>Trifolium pratense</i>	Red clover	3	1	4	Good meadow indicator
20	<i>Ranunculus acris</i>	Meadow buttercup	3	1	4	Good meadow indicator
1	<i>Potentilla sterilis</i>	Barren strawberry	1		1	
2	<i>Medicago lupulina</i>	Black medic	1		1	
3	<i>Hyacinthoides non-scriptus</i>	Bluebell	1		1	
4	<i>Rubus fruticosus</i> agg.	Brambles	-1		-1	
5	<i>Rumex obtusifolius</i>	Broad-leaved dock	-1		-1	
6	<i>Epipactis helleborine</i>	Broad-leaved helleborine	1		1	
7	<i>Ajuga reptans</i>	Bugle	1		1	
8	<i>Ranunculus bulbosus</i>	Bulbous buttercup	1		1	
9	<i>Vicia sepium</i>	Bush vetch	1		1	
10	<i>Galium aparine</i>	Cleavers	1		1	
11	<i>Rumex conglomeratus</i>	Clustered dock	-1		-1	
12	<i>Dactylis glomerata</i>	Cocksfoot	-1		-1	
13	<i>Tussilago farfara</i>	Coltsfoot	1		1	
14	<i>Arctium minus</i>	Common burdock	1		1	
15	<i>Ulex europeus</i>	Common gorse	-1		-1	
16	<i>Senecio vulgaris</i>	Common groundsel	1		1	
17	<i>Cerastium holosteoides</i>	Common mouse ear chickweed	1		1	
18	<i>Urtica dioica</i>	Common nettle	-1		-1	
19	<i>Senecio jacobaea</i>	Common Ragwort	-1		-1	

20	<i>Rumex acetosa</i>	Common sorrel	1		1
21	<i>Anthriscus sylvestris</i>	Cow parsley	1		1
22	<i>Ranunculus repens</i>	Creeping buttercup	-1		-1
23	<i>Potentilla reptans</i>	Creeping cinquefoil	1		1
24	<i>Cirsium arvense</i>	Creeping thistle	-1		-1
25	<i>Cardamine pratensis</i>	Cuckoo flower	1		1
26	<i>Rumex crispus</i>	Curly dock	-1		-1
27	<i>Geranium dissectum</i>	Cut-leaved crane's bill	1		1
28	<i>Rosa canina</i>	Dog rose	1		1
29	<i>Viola riviniana</i>	Dog violet	1		1
30	<i>Geranium molle</i>	Dove's foot crane's-bill	1		1
31	<i>Circaea lutetiana</i>	Enchanter's nightshade	1		1
32	<i>Oenothera</i> spp.	Evening primrose	1		1
33	<i>Euphrasia officinalis</i> agg.	Eyebrights	1		1
34	<i>Linum catharticum</i>	Fairy flax	1		1
35	<i>Arrhenatherum elatius</i>	False oat-grass	-1		-1
36	<i>Myosotis</i> spp.	Forget me nots	1		1
37	<i>Pilosella auriantica</i>	Fox & Cubs	1		1
38	<i>Alliaria petiolata</i>	Garlic mustard	1		1
39	<i>Veronica chamaedrys</i>	Germander speedwell	1		1
40	<i>Lotus pedunculatus</i>	Greater bird's foot trefoil	1		1
41	<i>Sanguisorba officinalis</i>	Greater Burnet	1		1
42	<i>Plantago major</i>	Greater plantain	1		1

43	<i>Aegopodium podagraria</i>	Ground elder	1		1
44	<i>Glechoma hederacea</i>	Ground ivy	1		1
45	<i>Cardamine hirsuta</i>	Hairy bittercress	1		1
46	<i>Ervilla hirsute</i>	Hairy Tare	1		1
47	<i>Hieracium</i> spp.	Hawkweeds	1		1
48	<i>Galium saxatile</i>	Heath bedstraw	1		1
49	<i>Calluna vulgaris</i>	Heather	1		1
50	<i>Calystegia sepium</i>	Hedge bindweed	1		1
51	<i>Sisymbrium officinale</i>	Hedge mustard	1		1
52	<i>Geranium pyrenaicum</i>	Hedgerow crane's-bill	1		1
53	<i>Oenanthe crocata</i>	Hemlock water dropwort	1		1
54	<i>Eupatorium cannabinum</i>	Hemp agrimony	1		1
55	<i>Geranium robertianum</i>	Herb Robert	1		1
56	<i>Senecio erucifolius</i>	Hoary ragwort	1		1
57	<i>Heracleum sphondylium</i>	Hogweed	1		1
58	<i>Hypericum maculatum</i>	Imperforate St John's wart	1		1
59	<i>Alchemilla mollis</i>	Lady's mantle	1		1
60	<i>Ficaria verna</i>	Lesser celandine	1		1
61	<i>Ranunculus flammula</i>	Lesser Spearwort	1		1
62	<i>Stellaria graminea</i>	lesser stitchwort	1		1
63	<i>Galium palustre</i>	Marsh bedstraw	1		1
64	<i>Stachys palustris</i>	Marsh woundwort	1		1
65	<i>Pulicaria dysenterica</i>	Meadow Fleabane	1		1

66	Filipendula ulmaria	Meadowsweet	1		1
67	Pilosella officinarum	Mouse ear hawkweed	1		1
68	Artemesia vulgaris	Mugwort	1		1
69	Lapsana communis	Nipplewort	1		1
70	Origanum vulgare	Oregano	1		1
71	Lolium perenne	Perennial rye grass	-1		-1
72	Euphorbia peplus	Petty spurge	1		1
73	Conopodium majus	Pignut	1		1
74	Matricaria discoidea	Pineappleweed	1		1
75	Sagina procumbens	Procumbent pearlwort	1		1
76	Lychnis flos-cuculi	Ragged robin	1		1
77	Rubus idaeus	Raspberry	1		1
78	Odontites vernus	Red bartsia	1		1
79	Plantago lanceolata	Ribwort Plantain	1		1
80	Serratula tinctoria	Saw-wort	1		1
81	Rumex acetosella	Sheep's sorrel	1		1
82	Capsella bursa-pastoris	Shepherd's purse	1		1
83	Potentilla anserina	Silverweed	1		1
84	Crepis capillaris	Smooth hawksbeard	1		1
85	Ervum tetraspermum	Smooth Tare	1		1
86	Achillea ptarmica	Sneezewort	1		1
87	Mentha spicata	Spear mint	1		1
88	Cirsium vulgare	Spear thistle	-1		-1

89	Hypericum tetrapterum	Square stalked St John's wort	1		1
90	Cerastium glomeratum	Sticky mouse ear	1		1
91	Coronopus spp.	Swinecress	1		1
92	Veronica serpyllifolia	Thyme leaved speedwell	1		1
93	Phleum pratense	Timothy grass	-1		-1
94	Potentilla erecta	Tormentil	1		1
95	Vicia cracca	Tufted vetch	1		1
96	Hypericum androsaemum	Tutsan	1		1
97	Torilis japonica	Upright hedge parsley	1		1
98	Ulex galii	Western gorse	1		1
99	Trifolium repens	White clover	-1		-1
100	Carum verticillatum	Whorled Caraway	1		1
101	Daucus carota	Wild carrot	1		1
102	Fragaria vesca	Wild strawberry	1		1
103	Geum urbanum	Wood Avens	1		1
104	Rumex sanguineus	Wood dock	-1		-1
105	Lysimachia punctata	Yellow loosestrife	1		1
106	Rhinanthus minor	Yellow Rattle	1		1
107	Holcus lanatus	Yorkshire fog	-1		-1
108	Trifolium media	Zig zag clover	1		1

Appendix 9

Table 9.5 - The species assigned as County flowers in Wales following a UK wide survey by Plantlife UK in 2002.

County flowers (Plantlife UK, 2002)			
Species	Species	County	Habitat
<i>Tuberia guttata</i>	Spotted rock-rose	Ynys Môn	coastal dry grasslands
<i>Cardamine pratensis</i>	Cuckoo flower	Brecknockshire	damp grasslands
<i>Gagea serotina</i>	Snowdon lily	Caernarfonshire	rocky ledges and calcareous rocks
<i>Allium ampeloprasum</i>	Wild leek	Cardiff	Rocky coastal grasslands
<i>Carum verticillatum</i>	Whorled caraway	Carmarthenshire	Neutral grasslands
<i>Andromeda polifolia</i>	Bog rosemary	Ceredigion	lowland bogs
<i>Stachys alpina</i>	Limestone woundwort	Denbighshire	woodland glades calc. soils
<i>Erica cinerea</i>	Bell heather	Flintshire	Dry heathlands
<i>Draba aizoides</i>	Yellow whitlow grass	Glamorgan	limestone grasslands
<i>Papaver cambricum</i>	Welsh poppy	Merioneth	various low nutrient soils
<i>Digitalis purpurea</i>	Foxglove	Monmouthshire	road verges acid soils
<i>Veronica spicata</i>	Spike speedwell	Montgomeryshire	V. rare dry limestone grasslands
<i>Armeria maritima</i>	Sea thrift	Pembrokeshire	coastal grasslands
<i>Gagea bohemica</i>	Radnor lily	Radnorshire	calcareous rocky

Appendix 10

Case study 1 - Pontypool park adjacent to ski slope	
Grid Reference: SO28950113	Local Authority: Torfaen
Survey Date: 10 th July 2020	
Site Description: A long strip of grassland to the east of the path. The land slopes downwards to the east. The ecological quality of the grassland gets gradually better the further north you go, with docks, White Clover, Creeping Buttercup and the dominance of heavy Yorkshire Fog getting less and indicator species such as Catsear and Lesser Stitchwort and finer grass species becoming more prevalent as you travel north. This carries on until ultimately at the northern end there is quite nice quality grassland with fine grasses (bent and Red Fescue) and acidic influences where Field Woodrush (A), Mouse-eared Hawkweed (R), Pignut (O), Catsear (F), Lesser Stitchwort (F) and Sheep's Sorrel (LF) are all present.	

Figure 9.2 - Site description of Pontypool park used as a case study to test the matrix designed to measure biodiversity value (Gwent ecology, 2020)

Appendix 11

Case study 2 – Canalside, Sebastapol	
Grid Reference: ST29129809	Local Authority: Torfaen
Survey Date: 10 th July 2020	
Site Description: An area of rough grassland divided from the football field by metal rail, and from the canal by bank of Bramble & scattered trees. It was rough with bents and Yorkshire Fog dominating a 'heavyish' sward with localised areas of even ranker grass where Couch, Timothy, False Oat-grass, Tall Fescue & Cocksfoot were prevalent. Creeping Thistle was frequent in large parts with Silverweed and Field Horsetail noticeably abundant in certain parts. Creeping Buttercup was throughout; however "indicator" species were quite scarce and localised. Some thatch was forming beneath the grass.	

Figure 9.3 - Site description of Canalside, used as a case study to test the matrix designed to measure biodiversity value (Gwent ecology, 2020)