Invertebrate conservation value of colliery spoil habitats in South Wales

Written by Liam Olds

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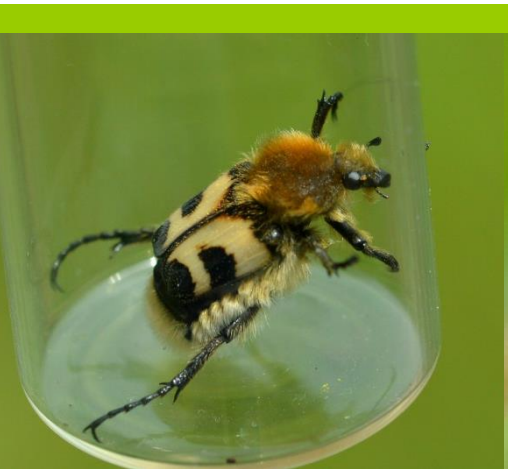

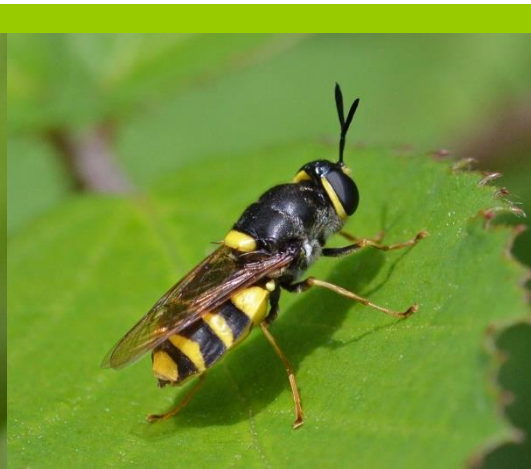

Contents

Executive Summary

The pivotal role of coal mining in shaping the British way of life cannot be underestimated. For centuries coal mining has been an essential part of British industry and many regions were dependent on it, particularly South Wales. Coal was dug from the ground by generations of miners, and the spoil hauled and tipped on the surrounding valley sides. While many signs of this once thriving industry have now gone, with colliery buildings demolished and shafts capped, the colliery spoil tips have remained. Once considered eye-sores in the landscape, they have undergone a truly remarkable transformation.

In the decades that have followed the demise of deep coal mining in Wales, nature has acted. The colliery spoil tips, once symbols of an ecologically destructive industry, have been colonised by a wide variety of species and habitats. Diverse and intricate mosaics of heathland, flower-rich grassland, species-rich lichen and moss communities, scrub, woodland and wetlands now clothe the once bare ground. Today, they form an important and unique part of the social, cultural, historical, visual, geological and biological landscape of Wales: an importance which we have only just recognised. However, colliery spoil habitats are under threat. In part, this threat comes from industrial and recreational use and an aesthetic drive to 'green' an already green landscape, re-using these sites for the perceived 'better' land uses of forestry and bio-fuels, and also partly through the dynamics of natural succession. The pressures are intense and a strategy for the conservation of colliery spoil is urgently needed, but that needs both thought and discussion and a new multi-disciplinary approach.

All strategies need to start somewhere and this document uses the findings and results of invertebrate surveys conducted across fifteen colliery spoil sites in South Wales between 2015 and 2018 to focus attention on a key nature conservation feature of colliery spoil. It updates our current scientific understanding of colliery spoil invertebrates and attempts to evaluate the importance of these sites to invertebrate conservation in Wales. It also provides guidance for how to consider and deliver habitat management on colliery spoil sites.

A total of 901 invertebrate species were positively identified from the surveys, with Coleoptera (173 species), Diptera (176), Hemiptera (204) and Hymenoptera (129) being particularly well represented. Of the 901 invertebrate species recorded, 195 (~22% of the total) are deemed to be of 'conservation priority' (i.e. species considered to be Nationally Local, Scarce or Rare in Britain, and/or are listed under Section 7 of the Environment (Wales) Act 2016 as Species of Principal Importance in Wales). In some instances, colliery spoil sites were found to support the only known population of a given species in Wales, Britain or even the World.

Though further research is needed, colliery spoil sites are evidently important areas for invertebrate conservation in Wales. Given the significant number of colliery spoil sites under public ownership, an excellent opportunity exists to promote, manage and conserve these sites as de facto nature reserves for the benefit of biodiversity and local communities. These sites deserve to be appreciated, managed, protected and appropriately, holistically and sustainably used for the benefit of people and wildlife.

Introduction

The South Wales Coalfield boldly stands out on geological maps, stretching from Torfaen in the east, through the Glamorgan heartlands to the Welsh speaking coal towns of eastern Carmarthenshire in the west. In the nineteenth century, the coalfield's high quality coal powered the industrial revolution and Britain's burgeoning empire. In a few short decades the exploitation of this black gold transformed these Valleys from quiet, rural backwaters to World leading industrial centres, populated by a new industrial class and generating wealth for the lucky few – a wealth that spilled out to Cardiff, Swansea, Barry and way beyond. At its peak over 200,000 were employed in the industry and over 600 mines were sunk (Ashbourn, 2011), but eventually the economic booms and busts of the twentieth century was marked by one final sharp decline and the loss of an industry which had changed lives, society and the landscape of the Valleys.

A century or more of deep coal mining generated vast quantities of colliery shale and other waste rock, which was hauled from the ground by generations of miners and tipped onto the Valleys sides. Brooding ominously over the Valleys, these tips coloured the public's perception (Figure 1). It was not until the Aberfan disaster that the scandal of dangerous tips was finally brought to national attention and remediation began. From the late 1960s until the early 1990s, a series of environmental-improvement schemes further transformed the landscape. Spoil tips were remodelled and seeded, leaving relatively few old tips. Today, coal mining has a legacy in the unique sense of place and pride of Valley's communities, the grand and humble architecture of Valley's towns and, despite the passage of time, the tell-tale signs of coal workings that still characterise the landscape. Land reclamation has now largely been completed and the colliery spoil sites, both old and new, have been claimed by nature. Quietly these sites have become habitats rich in biodiversity with a characteristic flora and fauna that boasts many scarce and rare species. The powers of nature have transformed the colliery spoil sites of South Wales into visually-spectacular wildlife havens (Figure 2).

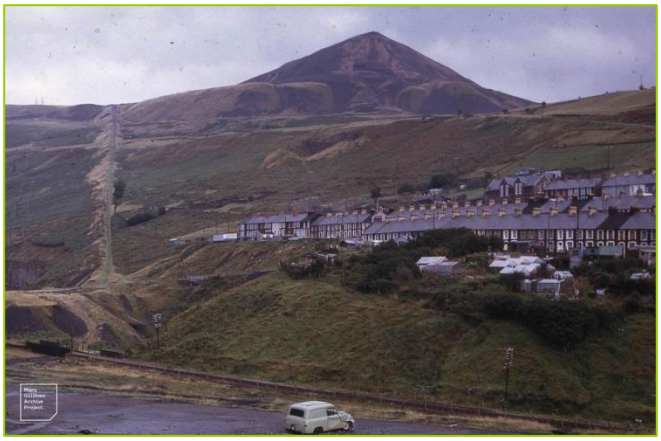

Figure 1. Tylorstown Tip (Old Smokey) in 1971, viewed from Wattstown, Rhondda © Mary Gillham Archive Project.

Figure 2. Heath-covered slopes of Gelli Tips – one of the best preserved coal tip systems in the Rhondda Valleys.

What makes colliery spoil biologically interesting?

In reality, the reasoning behind the biological richness of colliery spoil shouldn't surprise us. Composed of nothing more than waste rock, the spoil itself is extremely nutrient poor. This creates stressed conditions that prevent dominant plant species form taking over, slowing vegetation succession and allowing complex habitat mosaics to persist. As one would expect, the greater the diversity of habitats, the more niches there are available to support a greater diversity of species. Such habitat mosaics are therefore important in creating and maintaining biodiversity.

The constituent materials of colliery spoil also vary enormously, which further drives diversity. Contrary to expectation, colliery spoil is not necessarily

fiercely acidic, and is perhaps best described as oligotrophic in nature. The pH can vary considerably within and between sites and a very characteristic (and rather unique) feature of colliery spoil is the complex juxtaposition of acidic, neutral and calcareous species within open grass swards - something rarely seen on natural grassland sites. Genuine inputs of base-richness are obvious in places – a reaction to lime-rich colliery waste or complex chemical processes.

Colliery spoil is often friable and easily eroded. This encourages bare ground to form – an easily overlooked but essential habitat type. Lichens and bryophytes take advantage of the open conditions, which can persist on steeper slopes and paths where erosion processes are more pronounced. *Cladonia* lichen-heath communities (Figure 3) are a particularly distinctive feature of colliery spoil, owing to the open conditions and lack of competition. While colliery spoil is often free-draining and parched in dry weather, on flatter ground (and when compacted) it can hold water, encouraging wetland habitats to develop. These attributes all encourage biological diversity.

Figure 3. Cladonia lichen-heath at Maerdy Colliery, Rhondda.

Then we come to the structures into which the spoil is formed – one of the wonders of old spoil tips are their complex topographies, with each tip type indicative of the coal extraction, processing and deposition techniques used at that time. Varied topography offers different multiple aspects; shady and damp, sunny and dry, free draining and compacted. Part of the shear complexity of habitat mixes on old colliery spoil sites is down to the intricate patterns and forms with which they were carelessly created. More recently reclaimed sites have had such variation 'engineered out' and, as a result, habitat mosaics of more recently modified sites (although often rich) are generally less complex.

Threats to colliery spoil

The ecological significance of colliery spoil has only very recently started to gain recognition. Given its history, it is perhaps not surprising that a major shift in attitude will be required before colliery spoil can be universally seen as a valuable resource. The perception of dereliction and problematic land still predominates and pressures for other uses are high. These include:

- Development (residential and commercial);
- Inappropriate restoration or reclamation (e.g. tree planting on colliery spoil);
- Re-working of tips to extract useable coal; and
- Opencast coal mining.

While pressure from opencast coal mining is likely to decline in coming years following Welsh Government's effective ban on new coal mines stating "*Applications for opencast and deep-mine coal mining will only be allowed under "exceptional circumstances*", additional new threats are arising. These include the potential use of colliery spoil:

- As a source of aggregate in the construction industry (as a substitute for new minerals), as proposed in the latest *Planning Policy Wales* document (Welsh Government, 2018a);
- As sites for woodland planting, to meet Welsh Government *Woodlands for Wales* tree-planting targets (Welsh Government, 2018b) and *Low Carbon Pathway to 2030* emission reduction targets (Welsh Government, 2018c); and
- As sites for growing plant biofuels.

Another threat which is becoming increasingly problematic is natural succession - *the natural process through which communities of vegetation*

develop and change over time. Despite the initial nutrient-poor conditions of colliery spoil, inevitably, over time, conditions improve for plant growth (i.e. a soil layer establishes and nutrient content builds) and the communities present move from pioneer communities (lichens and bryophytes) towards climax communities (woodland).

After decades (and, in some cases, centuries) of natural colonisation and succession, some colliery spoil sites are now reaching (or surpassing) their peak value for biodiversity. Management intervention is now needed on these sites to retain that wildlife value. Without management, these sites will eventually revert to dense scrub and secondary woodland with the loss of open habitats and the unique species they support. Management of colliery spoil habitats is discussed later in this document.

Study sites

This document presents the results of invertebrate surveys conducted across fifteen colliery spoil sites located in the South Wales Coalfield between 2015 and 2018. Seven of these sites are located in the county borough of Neath Port Talbot, with the remaining eight being found in Rhondda Cynon Taf (Figure 4).

All study sites were open-access and represent a mix of 'technically reclaimed' tips (i.e. where land reclamation schemes have been implemented) and those left to naturally-revegetate (i.e. undergo spontaneous succession without human intervention). While the reclaimed tips were of similar age and structure, having been regraded to specified contours in the 1970s-80s or sometimes later, the naturally revegetated tips varied considerably in terms of their age, design and structure. Further information on each study site can be found in Appendix 1.

Invertebrate sampling methodology

Terrestrial invertebrates were sampled once per month (April to September) at each study site using several different active sampling techniques including:

- **Aerial netting** - a lightweight 40cm diameter net mounted on a meter long pole was used to catch flying insects as and when encountered.
- **Beating trees and bushes** - a beating tray, consisting of a white cloth sheet supported by a frame, was positioned below branches of trees and bushes which were subsequently tapped with a stick to dislodge insects within the foliage. Target taxa were then selectively removed using an aspirator (or pooter).

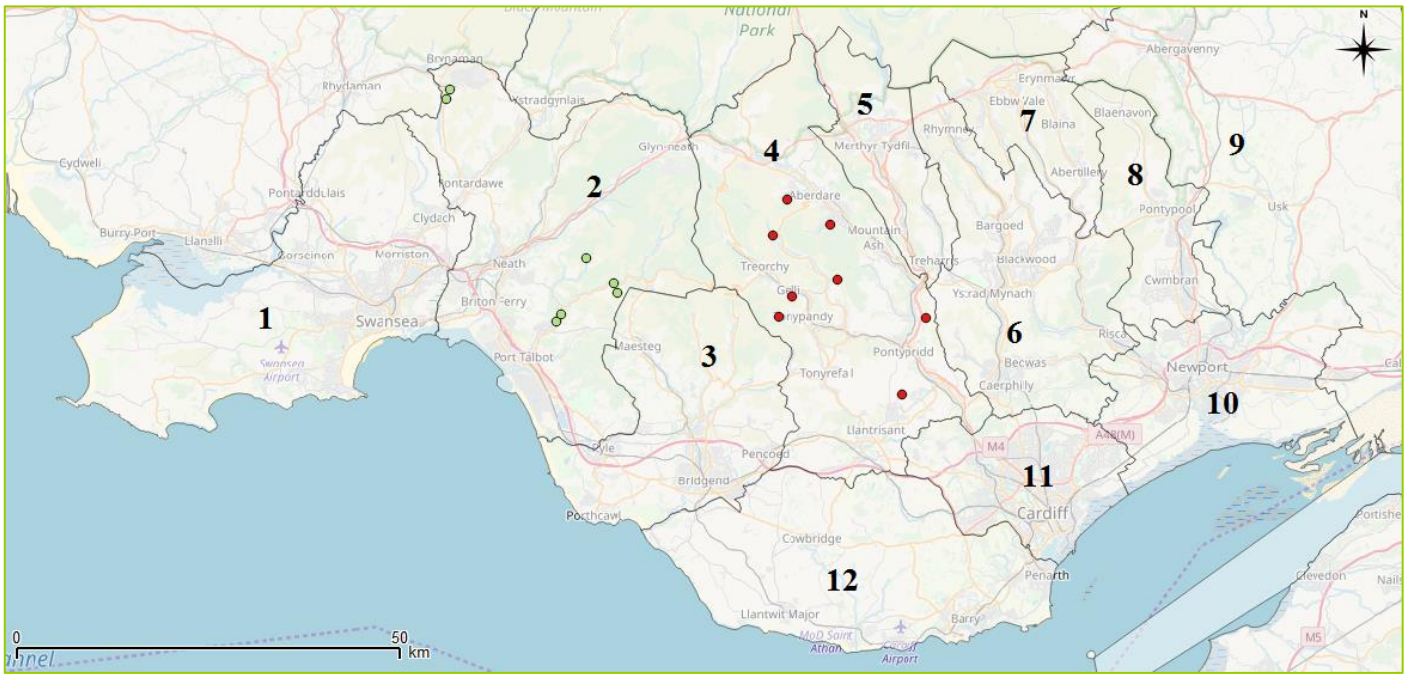

Figure 4. Map of south-east Wales showing the location of the fifteen study sites across Neath Port Talbot (green circles) and Rhondda Cynon Taf (red circles) © Crown copyright.

1 = Swansea; 2 = Neath Port Talbot; 3 = Bridgend; 4 = Rhondda Cynon Taf; 5 = Merthyr Tydfil; 6 = Caerphilly; 7 = Blaenau Gwent; 8 = Torfaen; 9 = Monmouthshire; 10 = Newport; 11 = Cardiff; 12 = Vale of Glamorgan.

- **Hand searching** - this involved sieving leaf litter, bark peeling, looking under/inside rotting logs, and looking under stones/boulders for invertebrates that may be feeding, resting or sheltering.

- **Suction-sampling** (i.e. vacuum sampling) - a modified leaf-blower was used to collect invertebrates from habitats that would otherwise be difficult to sample from using a sweep net (e.g. very short or very long vegetation) – see Figure 5. This method is particularly effective at catching species which do not fly readily or which live in deep vegetation. Samples were emptied into a sturdy sweep net and target taxa selectively removed using an aspirator.

- **Sweep netting** - a sturdy 40cm diameter net mounted on a meter long pole was moved vigorously through long vegetation and over bushes and tree foliage to dislodge invertebrates. Target invertebrates were then selectively removed from the sweep net using an aspirator.

Sampling was undertaken between the hours of 10am and 3pm in suitable weather conditions (dry and ideally sunny) – it is during this period that diurnal invertebrates are most active. On a small number of study sites, additional ad-hoc sampling was undertaken during the winter months (Oct-Feb). Such sampling targeted non-insect invertebrates that are active during winter, such as representatives of the taxa Myriapoda (centipedes and millipedes) and Isopoda (woodlice).

Passive sampling, in the form of pitfall trapping, was also undertaken on a small number of the study sites for a short period in 2015. This involved the placing of plastic cups (approximately 5cm in diameter) in the ground with the rim flush with, or slightly below, the surface. These were placed in grassland and other open areas. A salt solution was placed at the bottom of each cup as a killing agent, with a little detergent added to reduce surface tension. These traps were left for several weeks and emptied at weekly intervals. Due to time constraints, issues with trap flooding and low

Figure 5. Dr Michael Wilson of National Museum Cardiff assisting with suction-sampling for Auchenorrhyncha (leafhoppers and planthoppers) at Albion Tip, Cilfynydd.

catches, pitfall trapping was terminated after just a few weeks. Where practical, invertebrates were identified in the field using a hand lens. Where necessary, specimens were collected and later identified using a x20/x40 stereo microscope. All insect taxa were stored dry and later pinned to aid identification. Non-insect taxa was stored in 70% IMS (industrial methylated spirit). Invertebrate identification was to species level wherever possible. The majority of species identifications were made by the author using the appropriate identification keys and verified using voucher material from the reference collections at Amgueddfa Genedlaethol Caerdydd - National Museum Cardiff. Verification was also sought by the appropriate national experts where applicable.

Why study invertebrates?

Colliery spoil sites have gained increasing recognition in recent decades owing to their important and unique role in the social, cultural, historical, visual, geological and biological landscape of Wales. The recent establishment of the *Coal and Mineral Spoil Working Group* has helped raise the profile of colliery spoil (and other mineral sites) in South Wales. However, the conservation value of colliery spoil remains underappreciated. A strategy for the conservation of colliery spoil is therefore urgently needed, but this will require a greater understanding of its ecology. Understanding why certain colliery spoil sites are of 'higher quality' than others will be essential if we are to successfully recognise and conserve colliery spoil biodiversity within a context of pressures for future change and alternative use.

Until recently, relatively little was known about the invertebrate fauna of colliery spoil sites beyond a few more 'charismatic' groups such as butterflies and dragonflies. In response to this evidence gap, National Museum Cardiff hosted the author of this document (Liam Olds) to study the invertebrates of colliery spoil habitats as part of The Conservation Volunteers (TCV) *Natural Talent Traineeship Scheme*. Sampling took place at a small number of study sites within Rhondda Cynon Taf in 2015 and quickly revealed the importance of colliery spoil for invertebrates. In the years that have followed, investment from two local authorities has allowed this work to continue. To date, 15 sites have been surveyed across Rhondda Cynon Taf and Neath Port Talbot county boroughs. This document summarises the results of those surveys and presents current scientific understanding on the invertebrate fauna of colliery spoil sites in South Wales.

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The flower-rich grasslands of Cwm Tips, Beddau (below) – one of fifteen colliery spoil sites surveyed for invertebrates as part of this research.

Results

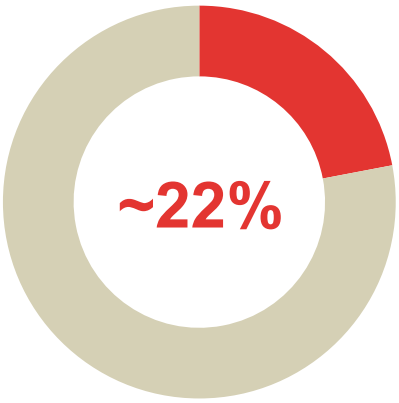
SURVEY DATA SUMMARY

901 invertebrate species recorded

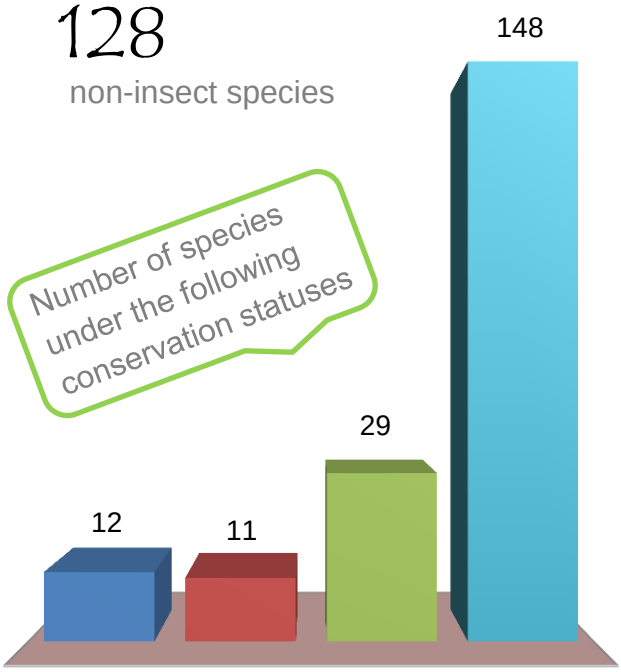
773 insect species

128 non-insect species

~22% of all species are of conservation priority

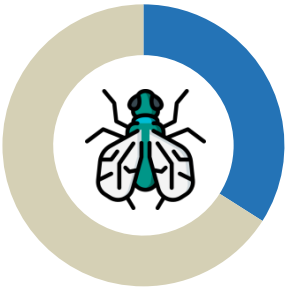


Number of species under the following conservation statuses



28 butterfly species

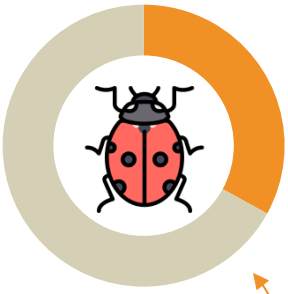
1 'New to Science'



34% of fly species are of conservation priority

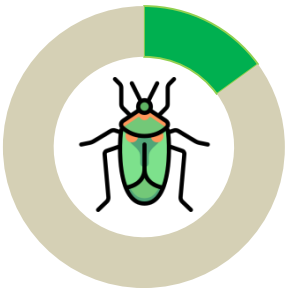
164 invertebrate families recorded

13 dragonfly species



33% of beetle species are of conservation priority

90 bee species



15% of true bug (Hemipteran) species are of conservation priority

1 'New to Britain'

4 'New to Glamorgan'

ICONIC SPECIES

– distinctive species of colliery spoil habitats

Dingy skipper (*Erynnis tages*) – a declining butterfly characteristic of early successional conditions on old and reclaimed sites.

Green tiger beetle (*Cicindela campestris*) – this fast and agile hunter is commonly found on sparsely vegetated, sunny banks where they can be seen hunting other invertebrates.

© Steven Falk

Red-backed mining bee (*Andrena similis*) – this scarce bee is commonly associated with the gorse-clad slopes of old, revegetated sites.

Grayling (*Hipparchia semele*) – this declining butterfly is characteristic of sunny, dry sites with sparse vegetation and bare ground, and is perhaps the most iconic invertebrate species of colliery spoil habitats.

© Tristan Bantock

Hoplomachus thunbergii – associated with Mouse-ear hawkweed (*Pilosella officinarum*), this scarce bug can be encountered on old and reclaimed sites that support its host plant.

Small pearl-bordered fritillary (*Boloria selene*) – this declining butterfly is associated with marshy conditions on old and reclaimed sites where violets, the larval foodplants, grow.

NOTABLE SPECIES

– a selection of the most notable discoveries

© Paul Richards: Flickr.com/invertimages

Maerdy Monster (*Turdulisoma cf helenreadae*) – a millipede found '**New to Science**' by Christian Owen at Maerdy Colliery, Rhondda.

Larinus carlinae – a weevil associated with thistles (*Cirsium* and *Carduus*) in grasslands and found '**New to Glamorgan**' (VC41).

© Chris Lawrence

Beddau Beast (*Cranogona dalensi*) – a millipede found '**New to Britain**' by Christian Owen at Cwm Tips, Beddau.

© Stephen Paul Plant

Acompus rufipes – a ground bug found '**New to Glamorgan**' (VC41); previously known from just a single site in Wales.

© Tristan Bantock

Himacerus boops – a damsel bug found '**New to Glamorgan**' (VC41) and the '**New to mainland Wales**' (previous records only from Anglesey).

© Tristan Bantock

Drymus pumilo – a ground bug found '**New to Glamorgan**' (VC41); previously known from just two sites in Wales.

A total of **901** invertebrate species from **164** families were positively identified from the surveys. This included **773** species of insect and **128** species of other invertebrate (i.e. non-insects). A breakdown of these species into their retrospective taxa can be found in Table 1 and in the chart below. It is important to note that this species total is by no means exhaustive and further survey effort will certainly reveal additional species. Nonetheless, it is clear that colliery spoil sites support a **diverse invertebrate fauna**.

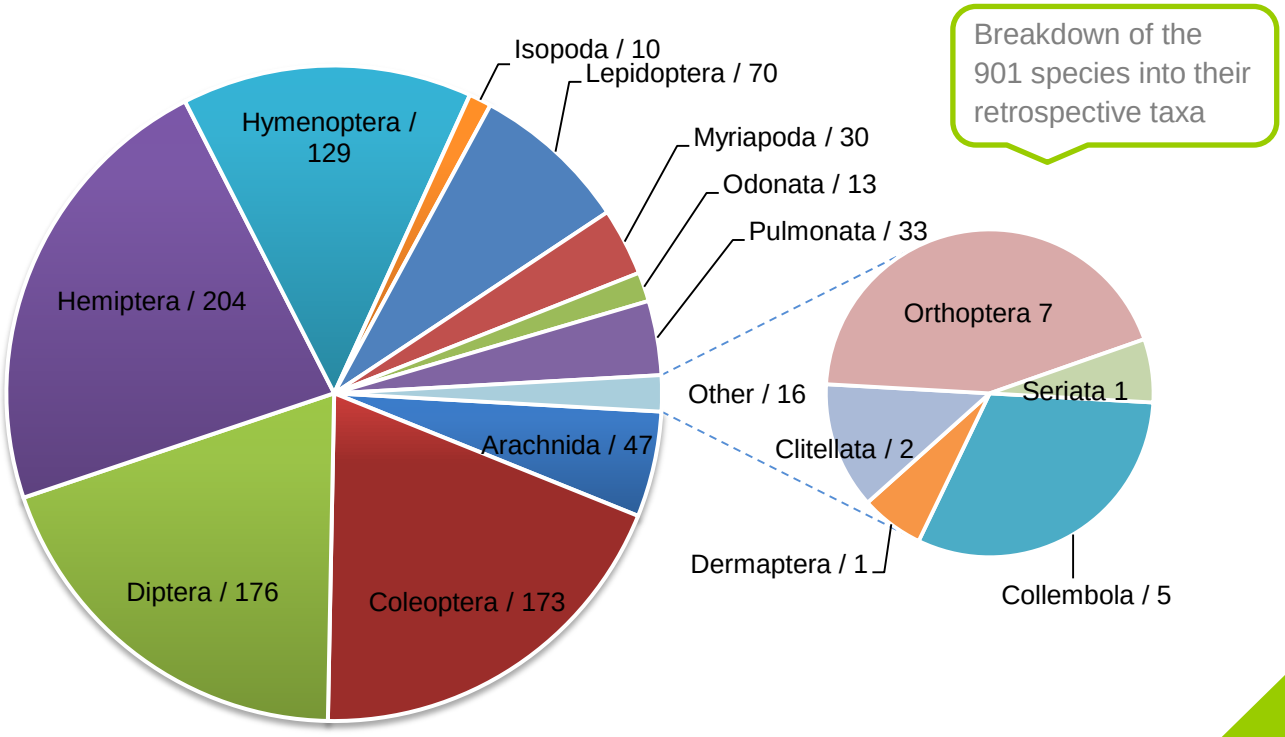
Of the 901 invertebrate species recorded, **195 (~22%)** are deemed to be of 'conservation priority' in the UK (i.e. species considered to be Nationally Local, Scarce or Rare, and/or are listed under Section 7 of the Environment (Wales) Act 2016 as Species of Principal Importance in Wales). This included:

- **148** Nationally Local species;
- **29** Nationally Scarce species (NS, Na or Nb listed species);
- **11** Nationally Rare species (NR, NT or VU listed species); and
- **12** Section 7 listed species (5 of which were also Nationally Rare).

Approximately **one third** of all beetles (Coleoptera) and flies (Diptera) were deemed to be of 'conservation priority', along with **15%** of true bugs (Hemiptera) and **13%** of bee, wasp and ant (Hymenoptera) species.

Invertebrate group	Total number of species recorded	Number of conservation priority
Arachnida (spiders, harvestmen & pseudoscorpions)	47	9
Coleoptera (beetles)	173	57
Diptera (flies)	176	59
Hemiptera (true bugs)	204	30
Hymenoptera (bees, wasps & ants)	129	17
Isopoda (woodlice)	10	
Lepidoptera (butterflies & moths)	70	12
Myriapoda (centipedes & millipedes)	30	9
Odonata (dragonflies)	13	2
Orthoptera (grasshoppers & crickets)	7	
Pulmonata (slugs & snails)	33	
Collembola (springtails)	5	
Oligochaeta (earthworms)	2	
Dermaptera (earwigs)	1	
Seriata (flatworms)	1	
Total	901	195 (~22%)

Table 1. Total number of species recorded in each taxon group, along with the number of those species of 'conservation priority'.

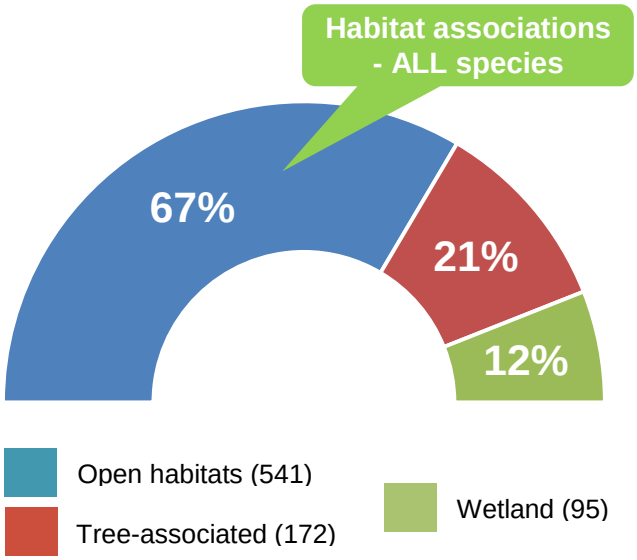


In addition to supporting a diverse invertebrate fauna, colliery spoil sites evidently support a high proportion of 'priority species' and are therefore likely **important habitats for invertebrate conservation** in Wales. In some instances, colliery spoil sites were found to support the only known population of a given species in Britain (e.g. the millipede *Cranogona dalensi*) or even the World (i.e. the millipede *Turdulisoma cf helenreadae*), with many more species seemingly restricted to colliery spoil sites within Wales or the South Wales region.

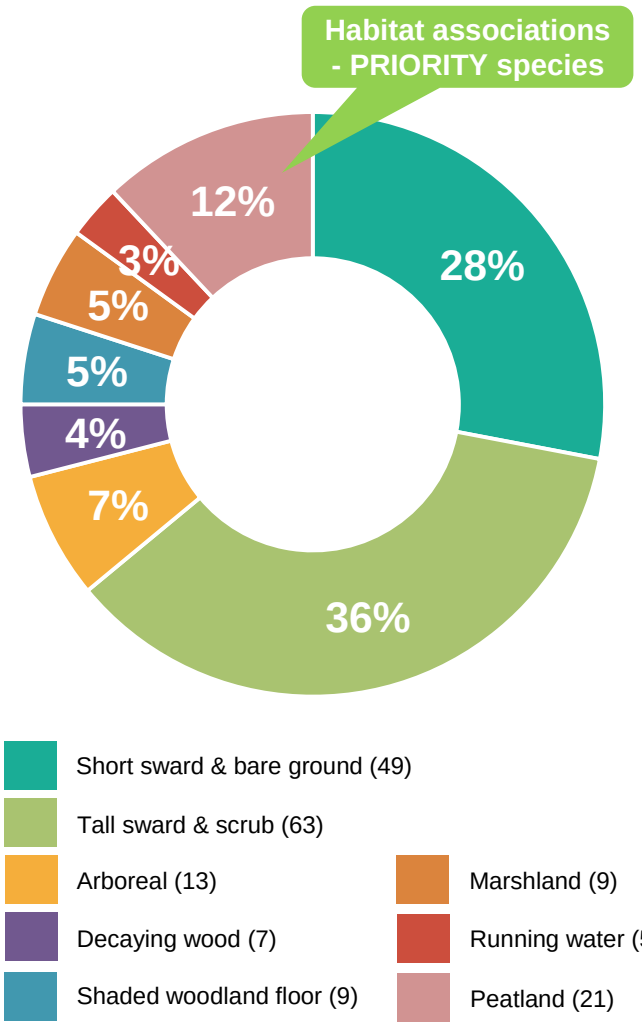
Analysis of the 901 invertebrate species using the invertebrate assemblage analysis online tool *Pantheon* revealed that **67%** of species are associated with open habitats – defined as "open vegetative grassland swards, dwarf herb communities and open, bare ground not associated with woodland closed canopies". Though some caution needs to be taken when interpreting this statistic (which is somewhat reflective of the invertebrate groups targeted), it does highlight the importance of the open conditions that are so typical of colliery spoil habitats; management should seek to maintain such open conditions. Analysis also revealed that **21%** of species are tree-associated and **12%** wetland-associated.

Pantheon was also used to determine the habitat associations of priority species. Collectively, open habitats support **64%** of priority invertebrate species on colliery spoil sites, with **36%** associated with 'tall sward and scrub' habitat (e.g. tall sward grassland, heath, moorland, scattered scrub and woodland edge) and **28%** with 'short sward and bare ground' (i.e. areas of bare or sparsely vegetated ground). A further **20%** of priority species are associated with wetland habitats, with **12%** associated with peatland, **5%** marshland and **3%** running water. The remaining **16%** of priority species are tree-associated, with **7%** arboreal, **5%** shaded woodland floor (i.e. found in closed canopy woodland and scrub) and **4%** decaying wood. **Conserving and promoting open habitat mosaics** is evidently important to invertebrate conservation on colliery spoil sites.

Although a mere baseline, the results presented here highlight the collective importance of our colliery spoil resource to invertebrate conservation in Wales and the UK.



*Results generated using *Pantheon* following analysis of 808 invertebrate species with known broad biotype associations, of 901 species in total.



*Results generated using *Pantheon* following analysis of 168 invertebrate species of conservation priority with known habitat associations, of 195 species in total. Please note that 10 species are associated with more than one habitat.

Management

The edaphic conditions typical of most colliery spoil sites (nutrient-poor, free-draining, sometimes acidic) are extremely limiting to plant growth. This subsequently slows vegetation succession, meaning that sites that have received no fertiliser input (which was typical of land reclamation schemes) can often persist (remaining relatively stable) for decades without active management. However, inevitably over time, conditions improve for plant growth (i.e. a soil layer establishes and nutrient content builds) and the communities present move from pioneer communities of early succession, towards more mature 'climax' communities.

The powers of natural succession raise the question of whether we should leave colliery spoil to naturally succeed to woodland, or intervene in order to retain the rich mosaics of open habitat. Although an absence of management on colliery spoil sites (and other brownfields) is often a key factor in promoting high biodiversity, management will eventually be necessary if we want to retain the unique biodiversity of these sites.

When is it best to intervene?

It is important to gauge an understanding of when best to implement habitat management on colliery spoil sites, and when stepping back to allow nature to run its course may be more appropriate. Though this decision should be considered on a site by site basis, taking into account site-specific species and habitats, general assumptions can be made.

Sites in the **early stages** of natural succession generally require **little to no habitat management**. Such conditions are typified by a mosaic of early successional (pioneer) communities, with often extensive areas of exposed bare ground and little scrub (Figure 6). Here, vegetation succession is often slow (owing to the lack of soil structure and low nutrients) meaning conditions remain relatively stable for long periods of time. Monitoring the rate of succession is important at this stage.

Figure 6. Early successional communities on colliery spoil tips on Craig-Evan-Leyshon Common, Cilfynydd.

Sites in the **mid to latter stages** of natural succession typically **require habitat management** to retain open conditions. Here, scrub (which typically forms an intermediate community between bare ground and woodland) begins to dominate and threaten priority habitats such as bare ground, semi-natural grassland and heath/moorland (Figure 7). Though in some instances it may be desirable for sites to succeed to woodland, this is likely to lead to long-term losses in habitat and species diversity, and the exclusion of many of the most distinctive features of colliery spoil biodiversity.

Figure 7. Gorse scrub encroachment threatening open bare ground and heath on Twin Tips, Dare Valley Country Park.

On sites that have already succeeded to native broadleaf woodland (i.e. reached their climax community), two options typically exist:

(1) **Attempt to restore open conditions via woodland clearance*** (i.e. tree felling). This may be best directed towards sites that have been planted with woodland, as opposed to those more 'interesting' woodlands that have naturally-regenerated from the local seedbank (and which tend to develop more open scrub woodland). Woodland should not be totally eradicated on any one site, however, and should form part of the intricate mosaic of habitats on colliery spoil sites (a small piece in a larger puzzle). This is particularly important with regard to wet woodland or 'carr' habitat, which has experienced considerable losses across Britain in the last century and is considered a priority habitat for conservation.

(2) **Manage the current woodland habitats to diversify conditions**. This could involve: creating a network of clearings, rides and scallops, and maintaining these via rotational coppicing and periodic scrub removal; thinning of woodland where dense shading has reduced the growth of wildflowers and shrubs; control of non-native invasive species such as Japanese Knotweed *Fallopia japonica* and Himalayan Balsam *Impatiens glandulifera*; encouraging a diverse understory structure; retaining wet features such as springs, seepages, pools and seasonally inundated areas; and leaving dead branches and stumps *in situ* where possible (unless there are public safety concerns).

Key habitats

A characteristic feature of colliery spoil (and other brownfields) is the presence of multiple habitat types within a single site. Often, these habitats form a complex mosaic encompassing **bare ground** with:

- **early pioneer communities** (of mosses, lichens, annuals and ruderals);
- **semi-natural grasslands** (comprising short, tall or open sward vegetation);
- **scrub** (typically gorse in free-draining areas and willow in wet areas); and
- patches of other habitats such as **heath and moorland**, **marshland**, **ephemeral pools** and other wetlands.

Colliery spoil sites of greatest nature conservation value are generally those supporting an **open mosaic** of different habitats. The habitats that develop on a given colliery spoil site are the consequence of a variety of integrating factors including topography; hydrology; pH; elevation; composition of the spoil material; the underlying geology; the surrounding habitats (which provide the seed sources and species for colonisation); age of the site; and its industrial history (e.g. how it was formed – the deposition techniques used). Since these factors are unique to each individual site, no two colliery spoil sites are ever the same with each supporting a unique community of species and suite of habitats (of varying extent), further adding to their nature conservation value.

Management recommendations

Given the unpredictable nature of colliery spoil, management recommendations should be decided on a **site-by-site basis** and only after a full site assessment (to take account of 'key' species) has been made. This should ensure that no management intervention causes significant harm to species of 'conservation priority'. As a general rule, however, management should seek to **maintain open conditions**. Colliery spoil sites are most valuable when kept as open habitat. Such open habitats are particularly valuable to vascular plants, bryophytes, lichens, invertebrates and grassland fungi – it is these groups that are particularly important on colliery spoil sites. Site assessments should ideally take into account these groups, while also including amphibians, reptiles, birds and mammals.

Methods to enhance biodiversity on colliery spoil sites (particularly for invertebrates) include:

- **Rotational scrub and bracken clearance** – this can help restore open habitats on sites that are scrubbing over due to an absence of management. Some areas of scrub and bracken should always be retained, however, as these are valuable habitats in their own right. Therefore allow some self-seeded scrub and scattered trees to establish, but manage these carefully to prevent them encroaching on other habitats. Ideally remove, rather than coppice, unwanted scrub and trees, then allow new establishment elsewhere. Stumps may be treated after

cutting and any humic layer or leaf litter scraped off to create bare conditions for ruderal plants to colonise. In wetlands, willow encroachment can be persistent and is best controlled on cycles of 5 to 10 years to diversify carr conditions, whilst maintaining some open wetland. Previously scrub-cleared areas can be managed by regularly pulling young saplings to slow vegetation succession.

- **Diversifying the micro-topography.** This could involve the use of machinery to create a network of scrapes, and using the arisings to create mounds. This will vary the topography, soil conditions and hydrology, creating a diversity of microclimates. Topography can be managed in a piecemeal manner by creating new mounds and hollows on a cycle of 10 to 20 years. This can be linked to the maintenance of early successional stages and stripping of any over-fertile soils. Where a site shows a natural tendency to become waterlogged, large scrapes and hollows can be created to encourage ephemeral or permanent pools to develop.
- **Rotational disturbance to restore bare, low-nutrient substrate** – over time, this will encourage a mosaic of successional stages to develop. Be aware, however, of the need to carefully consider topography and drainage so that erosion is avoided. While disturbance can be implemented manually, it can be labour intensive and the use of machinery (such as an excavator) to scrape off larger areas of material and vegetation can achieve this more effectively, as can conservation grazing. Disturbance in low nutrient areas will often produce better results than in higher nutrient areas. Recreational use such as walking and cycling should be encouraged as this creates localised areas of disturbance which can prove beneficial (e.g. some invertebrates such as mining bees and ground beetles benefit from a small amount of localised disturbance as this creates patches of bare soil for nesting or hunting prey). Off-road motorcycling and 4x4 driving should be minimised, however, as this can cause excessive erosion and vegetation loss - high altitude sites are particularly fragile and can take a long time to recover. Within moderation, however, off-road motorcycling can help maintain open bare ground and early successional communities and thus prove beneficial.
- **Control of non-native species** such as Japanese Knotweed, Himalayan Balsam, Rhododendrons and conifers. These non-natives should be removed, and stumps/stems treated where applicable. The self-establishment of non-native conifers can be particularly problematic on sites adjacent to conifer plantations, resulting in the loss of open habitats (Figure 8).

Figure 8. Conifer establishment on Tylorstown Tip (Old Smokey), Rhondda.

- **Retaining deadwood of all ages.** Standing and lying deadwood should be left *in situ* wherever possible, unless there are public safety concerns. If fallen wood is to be moved to log or brash piles (also known as habitat piles), situating them in a variety of conditions from direct sunlight to deep shade will create greater opportunities for wildlife.
- **Coppicing of established woodland** to diversify conditions. Coppicing increases the structural diversity, and therefore biodiversity, of woodland by increasing the levels of light, subsequently rejuvenating individual trees and shrubs and encouraging the growth of woodland flowers. As discussed above, arisings can be retained in log or brash piles as an additional habitat feature which provides shelter, overwintering areas and developmental sites for saproxylic (deadwood feeding) species.
- **Grassland management** – if left unmanaged, grasslands will eventually become rank and lose floral and

invertebrate diversity. Management should seek to create structural variation of the sward, with a succession of different types from sun-baked bare ground to patchy scrub, including short open turf, tall grass and tussocks. Mowing is generally best avoided as this can contribute to high mortality of grassland invertebrates (especially where a conditioner is used). Scything (Figure 9) is recommended wherever possible as this contributes to lower mortality of grassland invertebrates and, unlike mechanical mowers, a scythe is also perfectly happy cutting wet vegetation. Mechanical mowers (such as power scythes) may be needed in some situations, however, especially on difficult terrain where scything is not possible.

Figure 9. Afan Environment Volunteers scything meadows at Duffryn Rhondda Colliery © Deborah Thornton

Grasslands should be cut on rotation (a minimum 2 to 3 year rotation but preferably 3 to 5 years). Avoid cutting all of the grasslands in any given year as this will create a uniform vegetation structure, while also eliminating foodplants for invertebrates. Instead, leave some areas uncut on cycles of several years to allow tall herbs, scrub and bramble to grow and diversify the vegetation structure. Always ensure cuttings are removed. Low intensity /sensitive grazing that manages the invasion of scrub and ranker vegetation may be an important tool in maintaining open swards. Should such 'conservation grazing' be desirable, ensure stocking densities are low as to avoid overgrazing. Due to the nature of colliery spoil, there is a need to develop best practice examples for how to successfully conservation graze colliery spoil sites.

- **Heath/moorland management**. Many heath and moorland invertebrates need a combination of habitat features to complete their life-cycles. As such, the most important management aim should be to maintain a diverse vegetation structure to provide a wide range of habitat niches for invertebrates. This should include: bare ground (particularly on slopes of a southerly aspect which are important for nesting, hunting and basking); semi-natural grassland (which provides plant and floral resources before and after the heathers flower); dwarf scrub (i.e. heathers – which are among the best sources of pollen and nectar between June and September); scattered shrubs and trees such as broom, gorse and birch (which provide shelter, structural diversity, floral resources and deadwood); and other habitats such as pools, and ditches. Use 'conservation grazing' or cutting to develop variable age and structure within the heathers. Avoid creating structural monocultures that lack patches of other habitats (such as bare ground). Scrub control is particularly important; if left unmanaged, it will spread leading to a loss of valuable heath/moorland communities. Bracken, which is a natural component of many heathlands, should be managed to maintain core areas, while preventing it from smothering more valuable habitats.

The lack of deliberate management on colliery spoil sites, in particular the lack of any form of regular cutting, is crucial to their ecological importance since it provides a continuity of forage and vegetative resources. **Management should always be rotational**, with only a small proportion of a site worked in any one year - this is essential in order to retain a habitat mosaic and prevent homogenisation of a site.

Conservation

Colliery spoil tips (and their associated colliery sites) are an iconic feature in the landscape of the South Wales Valleys, yet they are readily overlooked and underappreciated. Many have now been lost, and those that remain face various threats. Colliery spoil should be recognised as unique landscape features of high biodiversity significance, but instead remain a largely unrecognised resource for nature conservation in South Wales.

There is a need to fully map the distribution of colliery spoil sites across the whole of the South Wales Coalfield. The assumption is that the great majority of colliery spoil now exist as secondary remodelled/reclaimed tips, with only a small proportion being original older tips, however we need to confirm and better understand that baseline. Having a proper grasp of the total resource is clearly essential. Having established that baseline, there will then be a need to ecologically assess sites against agreed habitat and species criteria. Developing an ecological audit of colliery spoil is necessary if an effective conservation strategy is going to be developed – a strategy which can provide the robust evidence to protect and conserve the most important sites and to develop effective restoration, mitigation and compensation measures if colliery spoil habitats are affected by development or remediation.

Assessing nature conservation value

In order to properly assess colliery spoil sites, we need to identify the habitat features or characteristics generally attributable to sites of high nature conservation value. These are as follows:

Open mosaic of habitats – this means that a site supports multiple habitat types arranged in a complex pattern. Typically this mosaic encompasses bare ground with: early pioneer communities; more established open grasslands; scrub; and patches of other habitats such as heathland, marshland and ephemeral pools. In other words, a variety of successional stages are evident. Habitat mosaics are the consequence of a variety of integrating factors including topography, aspect, substrate composition, hydrology, pH and disturbance, and are important in creating and maintaining biodiversity.

Complex and structurally diverse habitats – this refers to the structural diversity within and between habitats and includes variations in habitat density, age, height, spatial arrangement, and species assemblages or communities. For example, structurally diverse grassland comprises varied sward height from short open turf to tall grass, tussocks and patchy scrub. The greater the structural diversity, the more complex and numerous the micro-habitats.

Varied topography – topographic aspect, slope position, inclination and elevation strongly influence variables such as air and ground temperature, light availability, disturbance, soil depth and composition, soil drainage and water availability. Complex topography creates a diversity of conditions and is usually the principal causal factor for the formation of habitat mosaics.

Areas of open bare ground (i.e. exposed colliery spoil substrate) – these areas warm up rapidly in sunny weather to create warm microclimates in which thermophilic (warmth-loving) invertebrates can bask. It also provides burrowing and ground nesting opportunities (e.g. for solitary bees and wasps), foraging areas for visual predators (such as spiders and ground beetles), and helps to incubate eggs which are laid nearby. Bare ground is an important component of sites of high ecological value. The warm microclimates they induce enable colliery spoil sites to support invertebrate species normally restricted to warmer, coastal environments. As such, these sites sometimes support the only inland populations of otherwise coastally-restricted species in Wales.

Early successional communities of mosses, lichens, annuals and ruderals – their presence is indicative of an area or site in the early stages of natural succession (i.e. the first stage in a habitat's journey towards becoming woodland). These early successional communities form

a key component of open mosaic habitat and are of high conservation value owing to their increasing rarity within the British landscape.

Flower-rich grassland – like bare ground and early successional communities, flower-rich grassland is an important component of sites of high ecological value. It is a good indicator of the nutrient-poor status of colliery spoil, which creates stressed conditions that prevent dominant plant species (i.e. coarse grasses) from taking over. This allows less competitive wildflowers to grow, resulting in the formation of open grasslands rich in wildflowers. Such wildflower-rich grasslands provide foodplants for invertebrate larvae and adults, including diverse pollen and nectar resources for adult insects during their flight period.

The most biodiverse colliery spoil sites are usually those where habitats are a complex mosaic, structurally diverse and include flower-rich grasslands as well as bare ground, sparsely vegetated areas, lichen heath and ruderal vegetation.

Spontaneous succession tips

Prior to the 1960s, many colliery spoil tips were simply left to nature, left alone to spontaneously (or naturally) revegetate without any human intervention (such as the application of fertilisers, seed sowing and tree planting typical of some reclamation schemes). Though entirely unintentional, this method of 'natural reclamation' has proved highly successful for biodiversity and these old spoil tips are now among the most biodiverse habitats in the South Wales Coalfield.

Their high ecological value is largely attributable to their often complex topography (Figure 10) – a product of the deposition technique from which they were formed. Colliery waste was often discarded indiscriminately and heaped into hummocks of every size and shape, resulting in complex topographical variation. This strongly influences aspect, slope position, inclination and elevation, in-turn influencing factors such as temperature and water availability. As mentioned previously, these diverse factors result in the formation of complex habitat mosaics in close proximity. Though such habitat mosaics are also present on technically reclaimed (i.e. landscaped) sites, here they are often less complex owing to the more uniform, highly-engineered topography.

The positioning of old spoil tips on 'mountain tops' at high elevation has also contributed to their high nature conservation value. In these highly exposed, inhospitable environments, rates of natural succession are slow and sites often persist (remaining relatively stable) for decades without active management. This means that they retain their open habitat mosaic, and thus their high ecological value. Wind and water erosion, natural slippage of the spoil substrate (owing to the steep gradients), and disturbance by off-road motorcyclists (their remote location and varied topography being particularly attractive to such sports) contributes to this by maintaining a continuity of bare ground and early successional conditions.

The following habitats are typically associated with spontaneous succession sites:

- **Bare ground;**
- **Early successional communities;**
- **Semi-natural grassland** (a mixture of acid, neutral and calcareous flora is particularly characteristic of colliery spoil grasslands)**;**
- **Heath and moorland;**
- **Scrub** (typically gorse but also bramble);
- **Reedbed** (this typically develops around the base of more conical spoil tips);
- **Ephemeral pools**; and
- **Calcareous seepages** (with calcareous tufa).

Figure 10. Gelli Tips, Rhondda, showing the varied topography and mosaic of heath, semi-natural grassland and scrub vegetation.

Technically reclaimed tips

As the complex topography (i.e. randomness) was engineered out of more recently reclaimed tips, they evidently lack the heterogeneity of spontaneous succession tips (Figure 11). Despite this, reclaimed tips are still of nature conservation value. As the applied fertiliser leaches away and the sown grass mix declines, even tips that were reclaimed in recent decades are able to experience biodiversity 'renaissances'.

Due to their nutrient-poor soils and slow rates of succession, a mosaic of habitats develops (despite the more uniform topography). Their often large size (often incorporating both spoil tips and the former colliery sites themselves) makes them particularly valuable, increasing the likelihood of more habitats, and thus niches, to support a great variety of species. Often situated on the valley floor close to settlements, they are also an integral component of urban ecology.

The following habitats are typically associated with technically reclaimed sites:

- **Bare ground** (though substantially less abundant than on spontaneous succession sites) – this is often maintained through disturbance from recreational activities;
- **Semi-natural grassland** – this is typically among the most dominant habitat types on reclaimed sites. Such grasslands tend to be rich in Fabaceae (legumes) such as clovers, vetches and bird's-foot-trefoils and Asteraceae (composites).
- **Wetlands** including marshland, wet grassland, ephemeral pools, carr woodland, and formal ponds and lakes – as the ground is rather level and the spoil often compacted, there is a tendency of reclaimed sites to hold water. As such, wetland habitats are typically far more frequent on reclaimed sites in comparison to spontaneous succession tips (which are largely dry and free-draining);
- **Scrub and secondary woodland** – the more level ground conditions, greater water availability, higher soil nutrient content, and generally less inhospitable conditions in comparison to spontaneous succession tips, favours woodland establishment on reclaimed sites. Gorse, birch and willow scrub are particularly prevalent on such sites, though other scrub species may also be present. Generally, most established woodlands on reclaimed sites are attributable to woodland planting schemes.

Figure 11. Reclaimed colliery spoil grassland at Dare Valley Country Park, Aberdare.

Importance beyond biodiversity

Biodiversity is just one the important features of colliery spoil and many sites also have cultural, visual, historical, archaeological, social, and/or geological interest and value. Indeed, if we can successfully draw together these different aspects we are likely to realise a much deeper understanding of the 'unique' importance of colliery spoil. There is the exciting prospect that we might be able to tell a much richer story of colliery spoil and, in doing so, sites may start to realise value and relevance for local communities. Local recognition will inevitably be the best and most effective conservation outcome. So, what are these other features?

- They are **part of our cultural identify** as South Walians, relics of a bygone era where coal mining dominated the landscape and lives of our ancestors;
- They are among the **few remaining tangible links to our past** - sites created by our ancestors that we can continue to visit long after they and their industry has gone;
- **Each is unique** - a product of the coal extraction, processing and deposition techniques of that time period;
- They are **tools for local and regional interpretation** (i.e. they tell a landscape story and form family-landscape links);

- They **provide access to fossils and minerals**, and are thus important in the fields of Palaeogeography and Palaeobotany;
- They **teach us about our past** by revealing evidence of historic structures and remains, and highlighting technological advancements in coal mining;
- They are **valuable components of industrial heritage tourism** in South Wales, enhancing visitor experience;
- They are **tools for education** - they contribute specimens to new and historic collections; are sites for field trips and excursions; sites for scientific research and publication; and they integrate into the National Curriculum for Science, Geography, History and Welsh. They also provide windows that enable the study of South Wales geological succession (stratigraphy); and
- They **provide opportunities and benefits for community involvement and enjoyment**. Often situated close to settlements, and often being 'open access' land, they are perceived as 'un-used' and therefore available for informal use. They provide recreation and adventure play opportunities, bringing physical and mental health benefits to local communities.

Land use planning context

Though colliery spoil sites are evidently of high nature conservation value, there will inevitably be pressure for other uses. Industry, employment and housing are obvious alternative land uses, but increasingly a home for woodland planting and biofuel production are being considered for South Wales' 'derelict' colliery spoil sites. Under such pressures, colliery spoil biodiversity needs to be properly considered during land-use and planning proposals and the burden of 'dereliction' needs to be lifted. The following policies and legislation are applicable when considering land-use and planning proposals on colliery spoil sites.

Environment (Wales) Act 2016

The biodiversity and resilience of ecosystems duty under Section 6 of the Environment (Wales) Act 2016 requires public authorities in Wales to "*maintain and enhance biodiversity…and promote the resilience of ecosystems*". This means that public bodies must make biodiversity an integral part of policy and decision making. Since colliery spoil sites are seemingly biodiversity hotspots within the South Wales Coalfield, their biodiversity value needs to be properly considered.

Section 7 of the Act also makes provision for a list of habitats and species "*of principal importance to maintaining and enhancing biodiversity in relation to Wales*" (formerly Section 42 under the NERC Biodiversity Duty) and outlines a duty on Welsh ministers to take steps to **maintain and enhance the habitats and species on the list**. The following habitats and species can be found on colliery spoil sites in South Wales and thus any potential impact on these needs consideration.

Priority habitats

Open Mosaic Habitats on Previously Developed Land (OMHPDL) – this habitat was identified as a UK Biodiversity Action Plan Priority Habitat in 2007 due to its high biodiversity value, particularly for plants and invertebrates, and was subsequently incorporated into Section 7 of the Environment (Wales) Act 2016. Though not all colliery spoil sites will likely match the criteria of OMHPDL – perhaps especially mature sites that have lost their open mosaic or highly engineered sites that lack structural and habitat heterogeneity – a significant proportion of sites will.

Colliery spoil sites also include elements of other Section 7 priority habitats including:

- wet woodland;
- lowland mixed deciduous woodland;
- lowland meadows;
- lowland dry acid grassland;
- lowland heathland;
- upland heathland;
- upland flushes, fens and swamps;
- reedbeds; and
- ponds.

Priority species

The following Section 7 priority invertebrate species have been recorded on colliery spoil sites in South Wales as part of this research:

Tormentil mining bee (*Andrena tarsata*)
Brown-banded carder (*Bombus humilis*)
Small pearl-bordered fritillary (*Boloria selene*)
Small blue (*Cupido minimus*)
Dingy skipper (*Erynnis tages*)
Marsh fritillary (*Euphydryas aurinia*)
Grayling (*Hipparchia semele*)
Wall brown (*Lasiommata megera*)
Garden tiger (*Arctia caja*) (*R*)
Broom moth (*Ceramica pisi*) (*R*)
Latticed heath (*Chiasmia clathrata*) (*R*)
Small heath (*Coenonympha pamphilus*) (*R*)
Shaded broad-bar (*Scotopteryx chenopodiata*) (*R*)
Cinnabar (*Tyria jacobaeae*) (*R*)

R = research only

The above list is by no means exhaustive and further Section 7 invertebrate species are likely to be present on colliery spoil sites in the South Wales Coalfield – further research is evidently needed to explore this further. It is also important to note that other non-invertebrate priority species exist on colliery spoil sites including amphibian, reptile, bird, mammal and vascular plant species. Site assessments should ideally take into account these groups, while also considering bryophytes, lichens, grassland fungi and invertebrates, to ensure that priority species are appropriately identified in ecological surveys informing such land-use and planning proposals.

Well-being of Future Generations (Wales) Act 2015

The Well-being of Future Generations (Wales) Act 2015 places a duty on public bodies to deliver against 7 well-being goals. The conservation of colliery spoil sites directly contributes towards the following three well-being goals:

A Resilient Wales

"A nation which maintains and enhances a biodiverse natural environment with healthy functioning ecosystems that support social, economic and ecological resilience and the capacity to adapt to change".

In light of ongoing biodiversity loss, colliery spoil sites hold great potential for preserving biodiversity and protecting rare species in the South Wales Coalfield. They are integral to the functioning of healthy ecosystems and by offering stepping stones of suitable habitat in the landscape, these sites aid species movement and could offer new opportunities for wildlife when their distributions shift in response to climate change.

A Healthier Wales

"A society in which people's physical and mental well-being is maximised and in which choices and behaviours that benefit future health are understood".

Colliery spoil sites provide readily accessible green space for local communities in the South Wales Valleys. In light of increasing evidence showing a lasting positive effect of green spaces on physical health and well-being, the potential importance of colliery spoil sites to the health and well-being of Valleys communities cannot be underestimated.

A Wales of Vibrant Culture & Welsh Language

"A society that promotes and protects culture, heritage and the Welsh language, and which encourages people to participate in the arts, sports and recreation".

Colliery spoil sites are an integral component of Wales' rich culture and industrial heritage. They are part of our cultural identify as South Walians and are often the few remaining tangible links to our past. Their conservation is therefore paramount to the conservation of Welsh culture and heritage. As mentioned previously, by providing readily accessible green space for local communities, they also provide opportunities for sports and recreation including walking, cycling and running.

Sites of Importance for Nature Conservation (SINCs)

Many colliery spoil sites in the South Wales Coalfield have been identified as Sites of Importance for Nature Conservation (SINCs), and work to complete the series across the coalfield is a priority recommendation. SINCs are non-statutory planning designations linked to ecological policies of Welsh Government Planning Policy and Local Development Plan biodiversity policy protection. SINC designation ensures that the biodiversity importance of a

site is properly considered and weighed when planning applications affecting sites are considered and determined. This designation protection can lead to planning permissions being refused, or if not, it then provides weight to ensure effective mitigation is provided to off-set impacts. Success in protecting colliery spoil through the planning process varies, as does the quality and effectiveness of mitigation. Sharing experience and case studies (good and bad) between local authority ecologists is therefore another recommendation.

Lessons learnt

In recent years, the following lessons have been learnt by studying and observing colliery spoil in South Wales.

- Colliery spoil sites **provide much-needed landscape-scale refuges** for unique habitat mixes and a plethora of rare and scarce species. Modern British landscapes rarely find space for such a habitat resource.
- Colliery spoil sites often **grade into adjacent natural habitats**, enriching these habitats and being enriched in return, and **providing vital habitat connectivity**. The strong habitat connectivity that exists in the Valleys, for which colliery spoil is a component, may explain why many declining species are still common in the Valleys and why many scarce and rare species find a home here. As distributions shift in response to climate change, such connectivity to potential future habitats will be essential for adaptation.
- Colliery spoil sites **offer wild environments in an urban context** – environments that cannot be found in formal gardens and parks where ecological processes like succession and erosion are controlled.
- Colliery spoil sites are **most valuable when kept as open habitat**. As such, tree planting should be avoided on these sites and management implemented to retain open conditions. Management should seek to encourage a successional mosaic, and control scrub and woodland colonisation. Localised disturbance, such as the introduction of 'conservation grazing', may help to achieve this. Developing case studies for colliery spoil management (including grazing) is recommended.
- Colliery spoil **restoration strategies should incorporate natural regeneration at their core**, embracing what is now known of the ecology of colliery spoil. Nature can recover these sites far more successfully than we can – and for free!
- Colliery spoil sites **contribute greatly to biodiversity in the South Wales Coalfield**, whilst at the same time providing similar functions as traditional public green spaces such as parks or gardens. Furthermore, they often offer recreational services which aren't always met by more conventional public green spaces.

Conclusion

Though further research is evidently needed, the results presented here emphasise the importance of colliery spoil sites to invertebrate conservation in South Wales. While the species total is by no means exhaustive and significant scope exists to find additional species, it is clear that colliery spoil sites in South Wales support a rich fauna that includes many species of 'conservation priority' in the UK. Should one reflect on the status' of such species at a national (Wales), regional or local level, the importance of colliery spoil sites is likely to be further heightened. In light of growing evidence of alarming declines in invertebrate populations, colliery spoil sites are becoming an increasingly important refuge for species declining in the wider countryside. Not only are they important in preserving biodiversity and protecting rare species, they also offer stepping stones of suitable habitat in the landscape, aiding species movement. In a changing climate, such connectivity to potential future habitats will be essential for adaptation, offering new opportunities for wildlife when their distributions shift. The ecological value of colliery spoil sites is therefore anticipated to grow in future years and has not yet been fully realised.

Given the significant number of colliery spoil sites under public ownership, an excellent opportunity exists to promote, manage and conserve these sites as de facto nature reserves for the benefit of biodiversity and local communities. Although an absence of management is often a key factor in promoting high biodiversity on these sites, management will eventually be necessary if we want to retain that wildlife value. Management should seek to maintain and encourage an open mosaic of different habitats. The most biodiverse sites are usually those where habitats are a complex mosaic, structurally diverse and include flower-rich grasslands as well as bare ground, sparsely vegetated areas, lichen heath and ruderal vegetation.

Despite increasing recognition of the unique role of colliery spoil sites in the social, cultural, historical, visual, geological and biological landscape of Wales, perceptions of dereliction and problematic land still predominate. Pressures for other uses are high and under such pressures, colliery spoil biodiversity needs to be properly considered. The burden of 'dereliction' needs to be lifted and these sites considered as ecological assets. Instead, they are often viewed as problems in need of 'fixing' - an issue not unique to colliery spoil but instead a constraint to the conservation of all brownfield sites. A major shift in attitudes towards brownfield land is urgently needed – after all, brownfield sites now support some of our rarest and most endangered species. Developing public support and interest in brownfields is key to overcoming this, and colliery spoil is perhaps particularly well placed in this respect, owing to the strong sense of place and pride that exists in Valley communities.

Many signs of the once thriving Welsh coal industry have now gone but its legacy lives on in the unique sense of place, the tell-tale patterns of settlement and as a dwindling resource of old revegetated spoil tips. If we are to fully understand and protect our colliery spoil resource, we need to map the distribution of colliery spoil sites across the whole of the South Wales Coalfield. As a uniquely rich South Walian habitat, rooted in the history of the Valley communities that created them, we should work to ensure that colliery spoil is recognised as something to be proud of. Colliery spoil deserves to be appropriately managed, protected, appreciated and sustainably used for the benefit of people and wildlife. It is hoped that one day soon, the future of colliery spoil sites will be secured for future generations to appreciate and enjoy.

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Appendix 1. Characterisation of individual study sites.

Site Name	Restoration method	National Grid Reference	Age (years)*	Description
Cwm Tips (Beddau)	Reclamation	ST070862	32	Cwm Tips is a 1980's colliery spoil tip associated with the nearby Cwm Colliery (1909-1986), which has seemingly been left to naturally revegetate following its initial reclamation (presumably in the 1990s). This tip now comprises a diverse mix of habitats that includes bare ground, flower-rich grassland, secondary woodland, scrub, flushes, ponds, a lake and a large reedbed. Cwm Tips is believed to be among the most biodiverse and important colliery spoil sites in South Wales.
Albion Tip (Cilfynydd)	Reclamation	ST090924	44	The Albion Tip is a colliery spoil tip associated with the former Albion Colliery (1884-1966). The tip was reclaimed in 1975 – it is unclear what this involved beyond reprofiling of the tips, but likely involved the addition of fertiliser (i.e. manure) and grass seeding typical of land reclamation schemes of this period. The tip has since developed into a mosaic of semi-natural habitats that includes bare ground, dry heath, dry grassland, scrub and secondary woodland.
Clydach Vale Country Park	Succession Reclamation	SS960923 SS971927	53 32	Formally the location of the Cambrian Colliery (1872-1966) and its associated railways, Clydach Vale Country Park was formed following a land reclamation scheme conducted between 1985 and 1987 – it is unclear what this involved beyond reprofiling of the tips and the creation of two large lakes, but likely involved the addition of fertiliser (i.e. manure) and grass seeding typical of land reclamation schemes of this period, plus potential tree planting. This 1980's land reclamation site now supports dry and marshy grasslands, several wetlands, scrub and secondary woodland. The park also incorporates a 1960's spoil tip (SS960922) which has been left to natural revegetate and comprises predominately dry heath/moorland habitat - the establishment of non-native conifers is proving problematic here.
Dare Valley Country Park (Aberdare)	Succession Reclamation	SN980021 SN980023	83 46	Formally the location of four working collieries, work began in 1971 to reclaim the derelict land left behind by heavy industry – it is unclear what this involved beyond reprofiling of the tips, creation of two large lakes and re-routing of the River Dare, but likely involved the addition of fertiliser (i.e. manure) and grass seeding typical of land reclamation schemes of this period, plus potential tree planting. Dare Valley Country Park was officially opened in December 1973, becoming the first country park in England and Wales to be created almost entirely from post-industrial land. This 1970's land reclamation site now supports dry and marshy grasslands, scrub, secondary woodland and several wetlands. The site also includes the Twin Tips (SN980022), two original 'fan-ridge' spoil tips associated with the former Powell's Pit or Bwllfa No. 3 (1851-c.1900 and 1907-1936) and which have been seemingly left to naturally revegetate since the late 1930's. The Twin Tips are predominately composed of dry heath, acid grassland and scrub.
Gelli Tips	Succession	SS982943	57	Gelli Tips are a series of multiple 'fan-ridge' spoil tips associated with the former Gelli Colliery (1870-1962), which have been left to naturally revegetate since the 1960s. Gelli Tips is one of the best preserved coal tip systems in the Rhondda and the site supports a highly complex mosaic of habitats including bare ground, acid grassland and dry heath.
Maerdy Colliery	Succession	SS967993	34-70+	Maerdy Colliery (1875-1990) was the last deep coal mine to close in the Rhondda Valleys . Following its closure, the colliery buildings and associated infrastructure were demolished and cleared, and the site seemingly left to naturally revegetate. The site now supports a highly complex mosaic of habitats that includes bare ground, flower-rich grassland, scrub, secondary woodland, ephemeral ponds, marshland and other wetlands. Given the long history of Maerdy Colliery, the age of its spoil likely varies - the most recent of which was likely deposited no later than 1985, after which time all coal from the mine was raised at Tower Colliery. Maerdy Colliery is believed to be the most biodiverse and important colliery spoil sites within the Rhondda Valleys.

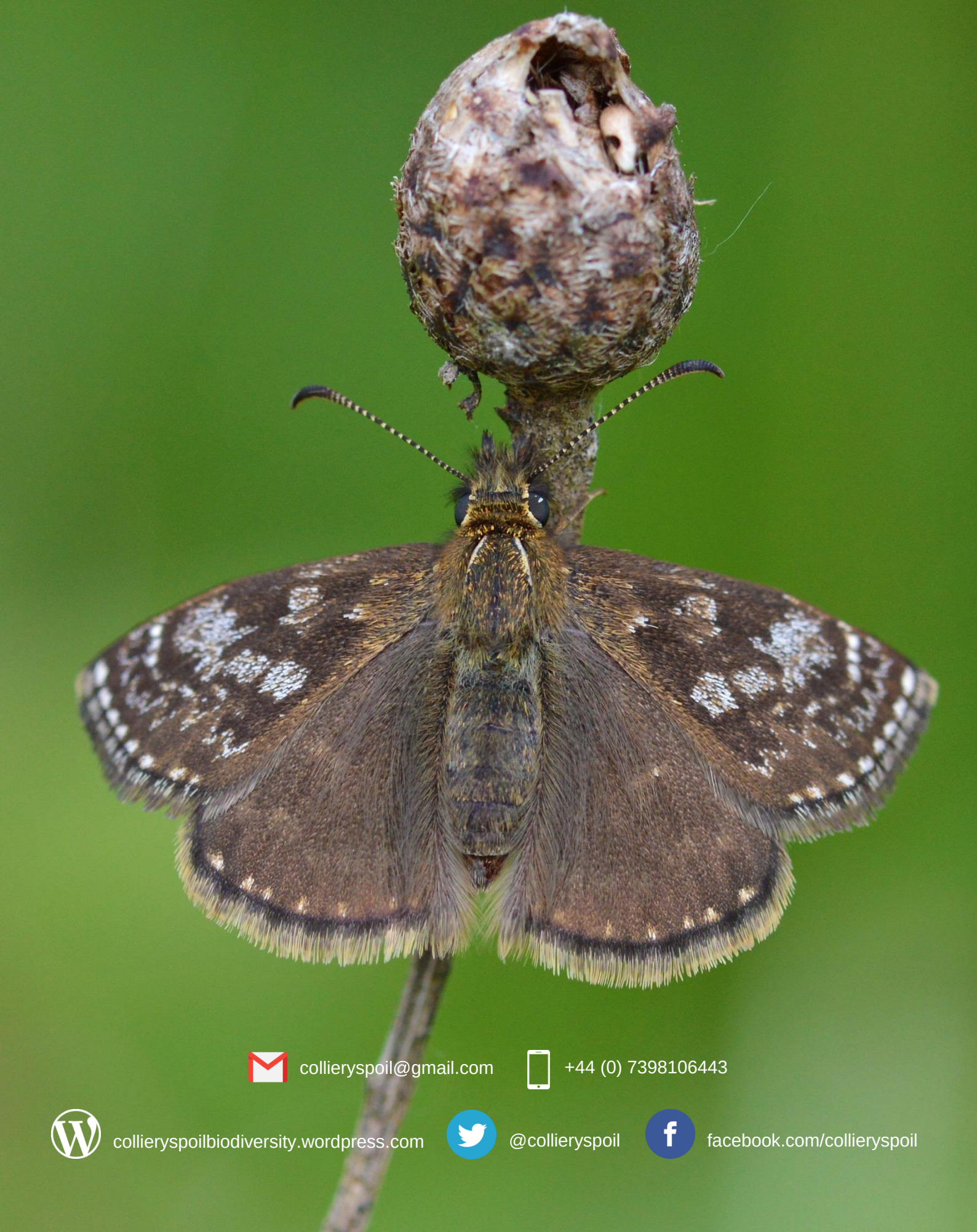
Tylorstown Tip	Reclamation	ST019956	c.44	Tylorstown Tip (also known as Old Smokey) is a large, conical spoil tip associated with the former Tylorstown No. 8 Colliery or Cynllwyn-du Colliery (1858-1936) and Ferndale Colliery (1857-1959). Formerly two conical tips, these were reclaimed in the early 1970s – this involved the removal of the smaller tip and the decapitation, reprofiling and grass seeding of the larger tip. Tylorstown Tip now supports a mosaic of wetlands, bare ground, acid grassland and dry heath/moorland habitat. The self-establishment of non-native conifers from the nearby Welsh Government Woodland Estate of Llanwonno / Llanwynno Forest (St Gwynno Forest) is proving problematic and many priority habitats have already been lost.
Aberaman Colliery Reclamation Site (Cwmaman)	Reclamation	SO014001	?	Once the location of the Aberaman Colliery (1840-1962) and its associated railways, the site was cleared shortly after closure and reclaimed (probably in the 1970s/80s). It is unclear what this involved beyond reprofiling of the tips, but likely involved the addition of fertiliser (i.e. manure) and grass seeding typical of land reclamation schemes of this period. The site now supports a diversity of habitats including grasslands, heath, scrub, secondary woodland and several man-made ponds.
Salem Road (Cwmafan)	Reclamation	SS790927	?	The history of this site is unclear but examination of historic Ordnance Survey (OS) maps suggests that it once supported Oakwood Iron Works, and a series of tramways and railway lines including the Rhondda and Swansea Bay Railway. Land reclamation has evidently been undertaken to remove railway lines, tramways and former industrial buildings, and level any associated spoil material - this likely occurred in the 1970s/80s. National Cycle Route 887 now transects both sites, presumably following the former Rhondda and Swansea Bay Railway. The site is now largely dominated by scrub and wet woodland, but small areas of open grassland are evident.
Cwm Nanto (Cwmafan)	Reclamation	SS794933	?	The history of this site is unclear but examination of historic Ordnance Survey (OS) maps suggests that it once supported a coal pit (No. 43), The Eagle Brick Works (1907-1967) and Tymaen railway sidings; the Rhondda and Swansea Bay Railway also transected the site north to south. Land reclamation has evidently been undertaken to remove railway lines, tramways and former industrial buildings, and level any associated spoil material - this likely occurred in the 1970s/80s. National Cycle Route 887 now transects both sites, presumably following the former Rhondda and Swansea Bay Railway. The site is now largely dominated by scrub and secondary woodland, but small areas of open grassland and heathland are evident in places.
Cwm Blaenpellana (Tonmawr)	Succession	SS816978	55+	Over a century of mining in this small river valley left behind numerous spoil tips. Several working collieries existed in the valley, the last of which - Garth Colliery - closed in 1964. The site, which incorporates colliery spoil tips of several former collieries, has seemingly been left to naturally revegetate. A diversity of habitats is now evident including bare ground, dry heathland, semi-natural grassland, scrub and some wetlands. The establishment of non-native conifers from nearby Welsh Government Woodland Estate is proving problematic and many priority habitats have already been lost.
Duffryn Rhondda Spoil Tips	Succession	SS840949	52	Duffryn Rhondda Spoil Tips are a series of colliery spoil tips situated on the northern slopes of Foel Trawsnant, south of the village of Duffryn Rhondda in the Afan Valley. An aerial ropeway connected the tips to Duffryn Rhondda Colliery (<1880-1966/7), after which they are named. The spoil tips have seemingly been decapitated but otherwise appear to have been left to naturally revegetate. Unfortunately the tips are heavily sheep grazed and largely dominated by short-cropped, species-poor grassland.
Duffryn Rhondda Colliery	Reclamation	SS838957	?	The former site of the Duffryn Rhondda Colliery (<1880-1966/7), it has since been the subject of land reclamation (which probably occurred in the 1980s/90s and involved the addition of fertilisers and grass seeding). The site comprises a flat plateau supporting an open mosaic of habitats typical of colliery spoil sites such as flower-rich grassland, bare ground, scrub and wetlands. The Rheilffordd Trail passes through the site making it popular with cyclists, runners and walkers.

Maerdy Playing Fields (Gwaun-Cae-Gurwen)	Reclamation	SN709117	?	Maerdy Playing Fields is an area of reclaimed colliery spoil associated with the former Gwaun-Cae-Gurwen Colliery (1837-1962). Following the closure of the colliery, the site was cleared of buildings and the spoil tips reprofiled – this likely occurred sometime in the 1980s and involved the addition of fertilisers (i.e. manure) and grass seeding. The site now comprises a mosaic of semi-natural grassland, scrub, secondary woodland and wetlands.
Llwyn-rhydiau (Cwmgors)	Reclamation	SN706109	?	Llwyn-rhydiau is an area of reclaimed colliery spoil associated with the former New Cwmgorse Colliery (c.1880-1964), located in the village of Cwmgors, Gwaun-cae-Gurwen. Following the colliery's closure, the site was cleared of buildings and reclaimed – this likely occurred sometime in the 1980s and involved the addition of fertilisers (i.e. manure) and grass seeding. Much of the site now consists of amenity grassland, however an area of dry grassland, heath, marshland and scattered scrub also exists.

* Age refers to the cessation of dumping

Colliery Spoil Biodiversity Initiative

“Raising awareness of the biodiversity value of colliery spoil tips”



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