REPORT OF THE BIODIVERSITY OFFICER

SUBJECT: PENLAN HABITAT RECREATION PROJECT: EXTENDED PHASE 1 SURVEY, CONDITION ASSESSMENT AND RECOMMENDATIONS FOR FUTURE MANAGEMENT

1. In 2001 the National Park Authority undertook a 5 year experimental project to re-create heathland and native woodland on a 70ha Sitka Spruce woodland woodland overlooking the Gwaun Valley.

2. In 2015, ten years since the completion of the project the Biodiversity Officer commissioned an external consultant to conduct a vegetation survey and biodiversity assessment of the newly created habitats within the project area. In addition the consultant was requested to provide a discussion on options for the future management of Penlan.

3. The attached report concludes the project successfully met its original habitat creation objectives. The majority of the site is now mapped as a mosaic of heathland (39ha), grassland and scrub – incipient woodland (21 ha) using standard national vegetation classification techniques.

4. The site is noted as having potential for colonisation by several scarce higher plants present on adjacent Carningli, and in particular has the potential for the colonisation by uncommon invertebrates, in particular moths and two uncommon damselflies, the southern damselfly and the scarce blue-tailed damselfly. Highly mobile bird species associated with heathland such as linnet, reed bunting and skylark are likely to be present and grasshopper warbler, kestrel and cuckoo are already known to be present.

5. The report discusses two main scenarios for future management for consideration by the National Park Authority 1. Non-intervention, 2. Livestock grazing management. The relative merits of the two are discussed from a wildlife conservation perspective. Other considerations such as access and landscape were outside the scope of this report.

6. The report also considers mechanisms for greater community utilisation of the ecosystem ‘goods and services’ of the area. Realisation of these goods and services mostly require a continuation of cultural management under Option 2 - Livestock management.

7. This report will be used as part of the evidence for the production of a new management plan for Penlan.

RECOMMENDATION:

Members are requested to note the Report.

(For further information contact Sarah Mellor on extension 4829)

Penlan Habitat Recreation Project

Extended Phase I Survey, Provisional NVC and Condition Assessment & Recommendations for Future Management

Client: **PCNPA**

Survey Date: **September 2015**

Report Reference: **MSE/PCNPA/0915**

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Executive Summary

Matt Sutton Ecology was contracted to carry out an extended Phase I survey and review of the PCNPA-owned land at Penlan. This former conifer plantation has been subject to experimental heathland and native woodland re-creation. A phased approach to this work began in 2002.

The site has successfully met its original objectives, and currently holds a mosaic of heathland, grassland and scrub. These habitats are mapped and described, and a provisional assessment according to the National Vegetation Classification is included. Uncommon species are highlighted, as are potentially invasive non-native species.

The current management regime comprises mixed grazing, together with a limited amount of strimming or mowing alongside footpaths.

Traditional livestock management here faces economic and logistical constraints, but will be necessary in some form if successional processes are to be slowed, and at least some of the newly created heathland maintained into the future.

Without management interventions, successional processes will lead to tree growth across the whole site. This would create a woodland habitat which would ultimately develop some of the wildlife value of the adjoining woodland SAC. The concept of non-intervention management may prove less politically attractive than continued management, but would require less resource-input.

Several additional activities are suggested which would enhance local community utilisation of the site, whilst maintaining or enhancing the ecological diversity. These include beekeeping, foraging, bushcraft and biomass.

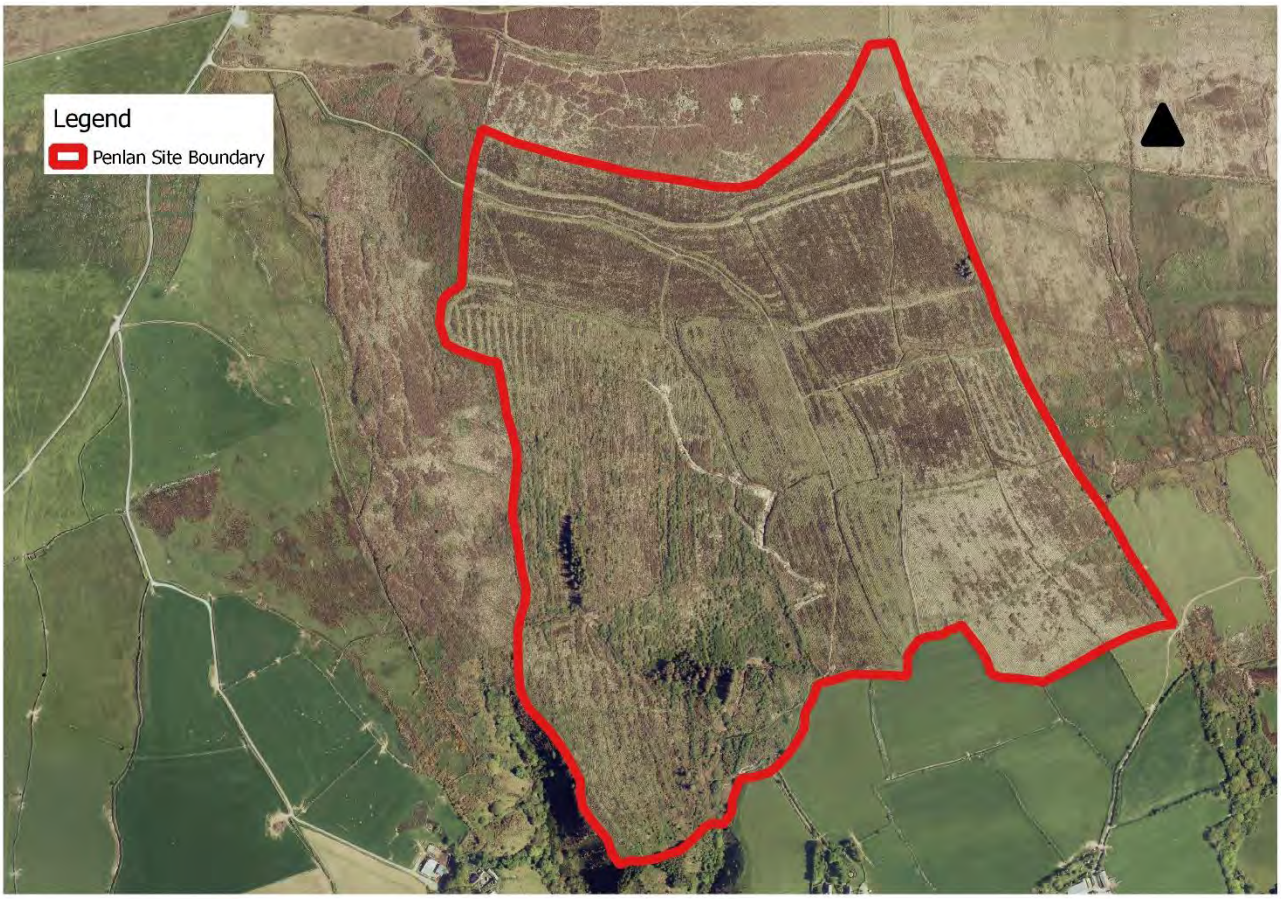
1. Introduction

Matt Sutton Ecology was contracted to carry out an extended Phase I survey and review of the PCNPA-owned land at Penlan.

Penlan is located on the south-facing slope of the Carningli – Dinas ridge. It lies between 200-300m, with the open moorland landscape of the Carningli commons above, and the steep oak-clad valley sides of the Gwaun below. It is flanked by rough grazing land to the west and north-east, and by more agriculturally-improved pasture to the south-east.

The underlying rocks are Ordovician volcanic rocks and slates, with periglacial surface features from the Pleistocene. These include the clay soils which were deposited as Irish sea ice swept across the area during a glacial episode. These lead locally to impeded drainage, where springs or seepages issue from the slope.

There is a long-history of human occupation here, with archaeological features dating back to the iron-age. Prior to afforestation in the 1970s, the area was enclosed land, with heathland and unimproved grassland used at times for livestock grazing.



View across top of Gwaun valley from upper part of site (top) and lower part of site (bottom)

2. Extended Phase I Survey

A thorough site inspection was made on 19th and 25th September 2015; a brief additional visit was made on 7th December. The survey followed the methodology set out by the Handbook for Phase 1 Habitat Survey (JNCC, 1993) and then subsequently by the Institute of Environmental Assessment (1995). The methods provide quick and accurate classification of habitats.

Communities were also assessed according to the National Vegetation Classification (NVC). Detailed floristic data in the form of quadrats or DAFOR lists was not collected, but placement was made according to an assessment of key species. NVC affinities are described under each habitat type; no NVC map has been produced.

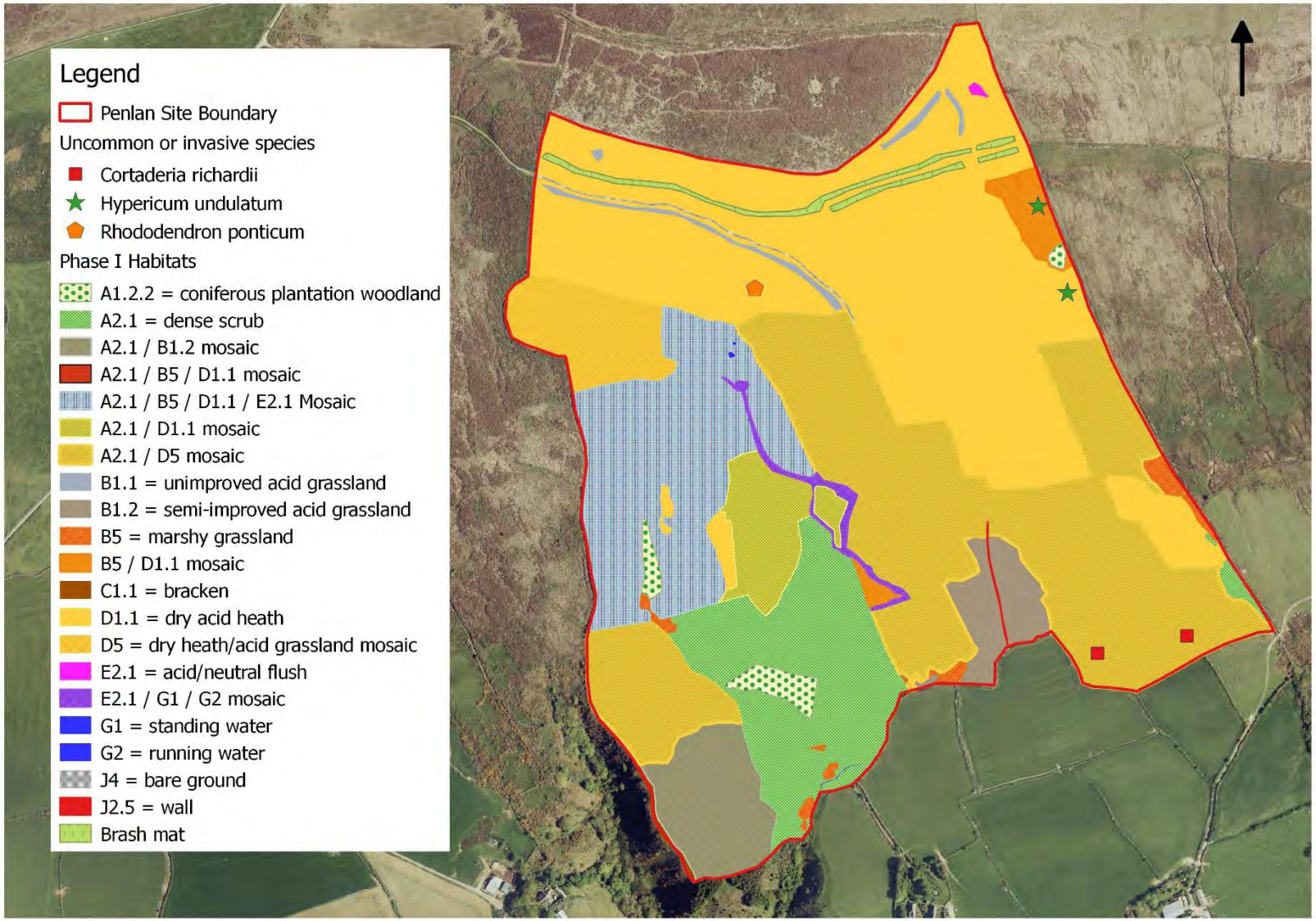
In addition the survey looked for uncommon and invasive plant species, and recorded birds, dragonflies and other wildlife.

2.1 Phase I Habitat Survey

The site holds a variety of habitat types. The survey recorded:

26.82ha	Dry Acid Heath
11.77ha	Dry Heath / Acid Grassland Mosaic
3.24ha	Semi-improved Acid Grassland
0.44ha	Unimproved Acid Grassland
0.67ha	Brash Mats
3.06ha	Marshy Grassland
2.22ha	Acid / Neutral Flush
0.01ha	Running Water
0.01ha	Standing Water
20.77ha	Scrub
0.69ha	Coniferous Plantation Woodland
0.19ha	Bracken
0.11ha	Bare Ground
<0.01ha	Wall

Each of these is described in turn below.



Phase I habitat map

Dry Acid Heath (D1.1)

Much of the drier heath in the upper part of the site comprises a closed canopy of heather (*Calluna vulgaris*), bell heather (*Erica cinerea*) and western gorse (*Ulex gallii*). These three constants are characteristic of the *Calluna vulgaris – Ulex gallii* heath, H8. The canopy of these sub-shrubs is so dense here that it excludes all but a very sparse associated flora. The presence of bilberry (*Vaccinium myrtillus*), locally-frequent in places, brings the stands towards the *Vaccinium myrtillus* sub-community, H8e. However, the general absence of other sub-community preferentials such as mat grass (*Nardus stricta*) and wavy hair-grass (*Deschampsia flexuosa*), suggests that all stands would be better referred to the species-poor sub-community H8a. Emerging through the canopy, particularly on the eastern side, there are saplings of various tree species, including holly (*Ilex aquifolium*), downy birch (*Betula pubescens*) and sessile oak (*Quercus petraea*). A scattering of self-set sitka spruce trees (*Picea sitchensis*) provide a link to the former use of the site.

One small area in the north-east corner of the site has low cushions of heather dominating in a grassy matrix with frequent bilberry, and this is best referred to the *Calluna vulgaris – Vaccinium myrtillus* heath, H12. Green-ribbed sedge (*Carex binervis*), lousewort (*Pedicularis sylvatica*), tormentil (*Potentilla erecta*), soft rush (*Juncus effusus*) and *Hypnum jutlandicum* are amongst the species in the grassy runnels here. Bell heather and western gorse are no more than locally frequent.

A small stand of a third heathland type occurs on damper ground along the eastern boundary. This is referable to the *Ulex gallii – Agrostis curtisii* heath, H4, although in common with all Pembrokeshire examples, *Agrostis curtisii* itself is lacking. Characterisation instead is provided by the abundance of *Molinia* in a species-poor heathy sward.

There are a few micro-habitat features within the dry heath, and it is these which tend to provide a locus for a few smaller plants otherwise excluded from the sward, such as heath bedstraw (*Galium saxatile*). They also provide niches for lichens, invertebrates, fungi, birds and perhaps reptiles. The retained conifer stumps are perhaps the most distinctive feature, and these often support a variety of *Cladonia* species and other lichens, mosses such as *Dicranum scoparium* and *Camplylopus introflexus*, and fungi such as plums and custard (*Tricholomopsis rutilans*) and sulphur tuft (*Hypholoma fasciculare*). There are a few small boulders, with saxicolous mosses and lichens, but no significant rock exposures. Bare-ground is generally limited to path-sides, where some solitary wasp burrows were noted.

Clockwise from top left – self-set spruces in mature H8 heath below access track; Hypholoma sp. on old stump; solitary bee or wasp burrows in earth bank; H12 heath

Acid Grassland (Semi-improved B1.2 / Unimproved B1.1)

Grassland areas occur along footpaths or other mown areas, and within some heathland areas towards the centre and south of the site. These are all acidic, with two calcifugous grasses - common bent (*Agrostis capillaris*) and brown bent (*Agrostis vinealis*) – generally dominating. Heath bedstraw (*Galium saxatile*), a good marker for acid grassland, is sometimes frequent, whilst sheep's fescue (*Festuca ovina*) is prominent in the better characterised unimproved stands. Conversely, sweet vernal grass (*Anthoxanthum odoratum*) and Yorkshire fog (*Holcus lanatus*) are more typical of the semi-improved stands which were noted in the south-eastern part of the site where stock appear to congregate. All grassland is best placed within the *Festuca ovina – Agrostis capillaris – Galium saxatile* grassland, U4. The unimproved stands represent the Typical sub-community, U4a, whilst the semi-improved swards are a reasonable fit for the *Holcus lanatus – Trifolium repens* sub-community (although the latter eponymous species is somewhat scarce).

Brash mats have been mapped separately, but could generally be referred to a form of unimproved acid grassland. They often have a high cover of mosses such as *Hypnum jutandicum*, *Polytrichum juniperinum* and *Campylopus introflexus*, together with heath bedstraw and sheep's sorrel (*Rumex acestosella*). Pill sedge (*Carex pilulifera*) is occasional in these areas, whilst bilberry and heather are frequent in others, and some have a coarser growth of male fern (*Dryopteris filix-mas*), rosebay willowherb (*Chamerion angustifolium*) or bramble (*Rubus fruticosus*).

Well grazed acid grassland in south-east part of site

Dry Heath / Acid Grassland Mosaic (D5)

This category was used where the two previously described communities occur in intricate mosaics. The pattern of heathy ridges and grassy runnels produces distinctive stripes within the central and south-eastern parts of the site, the ridges presumably picking out the brash mats created when the felling operation took place.

These areas perhaps come closer to ‘favourable condition’ heath (as defined by JNCC ‘Common Standards Monitoring’) than the pure dry heath stands.

Marshy Grassland (B5)

Tall M23 (above), flushed M23a (bottom left), and M25c (bottom right)

Small areas of marshy grassland are dominated by purple moor-grass (*Molinia caerulea*). These are referable to the *Molinia caerulea – Potentilla erecta* mire, M25. A small area of the *Angelica sylvestris* sub-community, M25c, lies next to the stream running south from one of the retained conifer blocks. The *Angelica* is occasional here in a strongly tussocky, species-poor example of the vegetation. Similarly species-poor examples lie near the head of the re-created flush channel, and alongside scrub near the eastern boundary. Another small area,

less tussocky and with a more diverse range of associates was noted further up this boundary. Common valerian (*Valeriana officinalis*), marsh thistle (*Cirsium palustre*), devil's-bit scabious (*Succisa pratensis*), lesser skullcap (*Scutellaria minor*) and a couple of plants of wavy St. John's-wort (*Hypericum undulatum*) were among the associates here. A small, rather mundane, area of the *Anthoxanthum odoratum* sub-community, M25b, was found on the eastern side as well. This grazed, grassier vegetation lacks the *Angelica* and other tall fen herbs. Further south along this edge is a heathy rank *Molinia* sward, which would perhaps be best referred to the *Erica tetralix* sub-community, M25a.

Small patches of un-grazed meadowsweet (*Filipendula ulmaria*) were noted within the scrub near the southern edge of the site. These represent the *Filipendula ulmaria* mire, M27.

Much of the remaining marshy grassland, such as that in the central mosaic, is dominated by soft rush and fits the *Juncus effusus* / *acutiflorus* – *Galium palustre* rush-pasture, M23. These examples are mostly rather scruffy, with a limited poor-fen flora. The *Juncus effusus* sub-community, M23b, generally provides the best fit here - Yorkshire fog (*Holcus lanatus*), velvet bent (*Agrostis canina*) and broad-buckler fern (*Dryopteris dilatata*) are typical associates, whilst purple moor-grass and sharp-flowered rush (*Juncus acutiflorus*) are only occasional. Where the latter becomes frequent, stands fit the *Juncus acutiflorus* sub-community, M23a. Better examples occur in a few places, for example alongside the retained conifer block. The sharp-flowered rush dominates here, and water horsetail (*Equisetum fluviatile*) is frequent; the reasonably diverse range of herbs includes marsh bedstraw (*Galium palustre*), water mint (*Mentha aquatica*), lesser skullcap (*Scutellaria minor*), bog pimpernel (*Anagallis tenella*), devil's-bit scabious (*Succisa pratensis*) and greater bird's-foot trefoil (*Lotus uliginosus*). Bristle club-rush (*Isolepis setacea*) and a single clump of smooth-stalked sedge (*Carex laevigata*) were also found. The eastern boundary also has a relatively diverse example, with star sedge (*Carex echinata*), marsh willowherb (*Epilobium palustre*) and marsh pennywort (*Hydrocotyle vulgaris*) amongst the species underneath the rush.

Acid / Neutral Flush E2.1

Seepages, wet runnels and pond edges hold flush vegetation, where the cover of rushes or purple moor-grass becomes more patchy, and a variety of sedges and mosses become prominent. The typical acidic flush community here is the *Carex echinata – Sphagnum recurvum* / *auriculatum* mire, M6. All examples noted fit the *Juncus acutiflorus* sub-community, M6d. towards the north-east corner, for example, star sedge (*Carex echinata*) is joined by common yellow sedge (*Carex viridula* ssp. *oedocarpa*) and carnation sedge (*Carex panicea*). The Sphagna include *Sphagnum subnitens* and *S. palustre*, and among the other typical flush species are bog pimpernel (*Anagallis tenella*), lesser spearwort (*Ranunuclus flammula*), marsh violet (*Viola palustris*) and lesser skullcap (*Scutellaria minor*).

A less acidic flush community occurs in the north-east corner itself, where Sphagna are almost lacking and the bryophyte flora is largely restricted to *Calliergon cuspidatum* and some *Racomitrium aciculare* on wet rocks. This neutral or 'other short-sedge' flush has jointed rush (*Juncus articulatus*), toad rush (*Juncus bufonius*), bulbous rush (*Juncus bulbosus*), bristle club-rush (*Isolepis setacea*), common yellow, star and carnation sedges, and lesser spearwort as the most prominent species.

Flush vegetation also occurs in and alongside the recreated channel, described below.

Running water (G2)

A wet ditch / flush system has been created, which collects spring inputs and surface drainage water from the upper central part of the site. Through shallow profiling and partially excavating along contour lines rather than down them, the flow is slowed and a drawdown zone with bare clay and developing flush vegetation has been created.

Plants within the main channel include many-flowered spike rush (*Eleocharis multicaulis*), bog pondweed (*Potamogeton polygonifolius*) and lesser spearwort (*Ranunculus flammula*). Marsh St. John's wort (*Hypericum elodes*) and water-cress (*Rorippa nasturtium-aquaticum*) were also found in small quantity. The fringe of wet or seasonally-inundated vegetation on the exposed clay edges includes jointed rush (*Juncus articulatus*), soft rush (*Juncus effusus*), common yellow sedge (*Carex viridula* ssp. *oedocarpa*), bristle club-rush (*Isolepis setacea*), bog pimpernel (*Anagallis tenella*), cuckoo-flower (*Cardamine pratensis*) and mosses such as *Philonotis fontana* and *Sphagnum subnitens*. A secondary or overflow channel cuts a corner before re-joining the main channel lower down. This has a combination of peat and clay margins and a stepped channel. Bryophytes on and above the side of the channel here include *Didymodon tophaceus*, *Campylopus atrovirens* and *Dichodontium palustre*. The latter two species are, within Pembrokeshire, almost confined to Mynydd Preseli and surrounds (Bosanquet, 2010).

Poached clay edge on main flush channel (left) and peaty bank of overflow channel (right)

Standing Water (G1)

Two small pools lie near the top end of the re-created flush channel, and a series of stepped pools lie along the channel at the bottom end of it. There is also a shallow, oval-shaped pool towards the north-east of the site, and some partially-flooded linear scrapes alongside the path nearby.

The permanently inundated pool vegetation contains bog pondweed and many-flowered spike rush, together with some floating club-rush (*Scirpus fluitans*) and common duckweed (*Lemnna minor*). Water purslane (*Peplis portula*), lesser spearwort and round-leaved water-crowfoot (*Ranunculus omiophyllus*) grow in the shallows, and the fringes have a good selection of bryophytes including *Sphagnum palustre*, *Aulcacomnium palustre, Thuidium delicatulum, Straminergon stramineum, Pellia neesiana, Dichodontium palustre,* and *Calypogeia muelleriana* growing through *Philonotis fontana*. The *Campylopus pyriformis* here appears to be the scarce var *azoricus*, not previously recorded in the county.

Linear scrapes (top left); pond (top right) and Philonotis fontana on pool edge (bottom)

Scrub (A2.1)

Understorey of willow scrub in central part of site

Scattered patches of bramble (*Rubus fruticosus*) and European gorse (*Ulex europaeus*) scrub are scattered through much of the heathland in the upper part of the site.

Grey willow (*Salix cinerea*) becomes prominent in the wetter areas in the mid-section, and lines the wetter furrows between heathy ridges. Some eared willow (*Salix aurita*) accompanies it, and saplings of rowan (*Sorbus aucuparia*) are present under the canopy. The impoverished ground flora includes small tussocks of purple moor-grass (*Molinia caerulea*), together with male fern (*Dryopteris filix-mas*), rosebay willowherb (*Chamaerion angustifolium*) and common pleurocarpous mosses. In NVC terms, this willow scrub is perhaps best accommodated within the *Salix cinerea – Galium palustre* woodland (W1), although it shows affinities to the *Betula pubescens – Molinia caerulea* woodland (W4), particularly where *Molinia* and *Polytrichum commune* are prominent in the ground flora.

A taller, thicker scrub then dominates the lower eastern part of the site, with downy birch (*Betula pubescens*) accompanying the grey willow. Areas of dense bracken, western gorse and bramble, together with patches of rosebay willowherb and meadowsweet (*Filipendula ulmaria*), form overgrown glades here. The drier south-western part of the site has patches of bramble, European and western gorse, and downy birch scattered through the rank grassland. There is also a fringe of **dense bracken** (**C1.1**) along the boundary with the valley below.

Coniferous Plantation Woodland (A1.2.1)

Small areas of conifers have been retained in two areas. A narrow strip around the headwaters of a small stream comprises sitka spruce (*Picea sitchensis*), with wind-blow starting to topple trees around the edges. The needle mat suppresses almost all growth underneath. The slightly larger stand to the south is more open, with grey willow (*Salix cinerea*) between the trees.

Stone Wall (J5)

There is a short remnant length of wall near the southern edge of the site. This, and the few other stone features such as gateposts and boulders, have a few saxicolous bryophytes and lichens, such as *Racomitrium heterostichum*/*affine* and *Dicranoweisia cirrata*.

2.2 Uncommon Plants

Wavy St. John's-wort (*Hypericum undulatum*), pictured below, is a lowland plant with an 'Oceanic Southern-temperate' distribution, and in the UK is entirely restricted to south-west England and Wales. It is still relatively widespread in Pembrokeshire, but apparently absent from Mynydd Preseli – this record (at 285m) may represent the known altitudinal limit in the county. It shows a preference for waterlogged areas subject to lateral water movement, often slightly base-enriched. It can form a persistent seed-bank, so the four plants noted in marshy grassland on the eastern boundary could potentially have re-appeared following disturbance.

2.3 Other Wildlife

Blue-tailed Damselfly

The late and brief survey did not allow for many additional sightings to be made.

No breeding birds could be recorded, and meadow pipit, reed bunting, wheatear and red kite were among the few species seen.

No reptiles were seen, and common frog was the only amphibian recorded – tadpoles were noted in the linear path-side scrapes in the north-east part of the site.

Blue-tailed damselfly, southern hawker and common darter were the only odonata noted.

Sulphur tuft (*Hypholoma fasciculare*), deceiver (*Laccaria laccata*), dung roundhead (*Stropharia semiglobata*) and ergot (*Claviceps purpurea*) on sweet vernal grass were among the few fungi noted.

2.4 Non-native / Invasive Species

A single bush of rhododendron (*Rhododendron ponticum*) (see target note on map) was noted in the dry heath. Two large clumps of early pampas grass (*Cortaderia richardii*) are well established in acid grassland near the southern edge of the site. This native of New Zealand

has recently become invasive in Tasmania and Australia, and is established in a few places in west Wales, including on a gorse-dominated hillside in Ceredigion. It is frost-hardy, wind-tolerant and – thanks to the tough, sharp-edged leaves – resistant to grazing. Prompt removal of both species would be advisable. Young self-set trees of sitka spruce (*Picea sitchenis*) are scattered across the site – these might be expected to succumb to wind-throw before reaching maturity, but it would be prudent to remove them – and the retained mature trees which act as a seed source – to prevent the possible return of the land to conifers once more.

Rhododendron ponticum (left) and Cortaderia richardii (right)

3. Discussion

3.1 Current Management

A description of the recreation project is provided in Mellor, in prep. Post-project observations for one experimental plot are given in Anderson, 2012.

The current management regime comprises mixed grazing, together with a limited amount of strimming or mowing alongside footpaths. The grazing is limited to the north-western part; the lower third is fenced and stock are excluded. An eastern section which includes the former restoration trial site, is also fenced separately; stock appear to have been excluded from this at least during 2015.

8 Welsh mountain ponies are grazed here for 11 months of the year; occasional trespass of ponies from adjoining heathlands may increase this number at times. Cattle grazing has also been in place, with up to 15 longhorn cattle from a local grazier on the land from May to September. No cattle grazing took place in 2015, as the removal of ‘sole occupancy rights’ in 2014 means that TB testing is now required before cattle can be moved on to and off the site. The grazier had previously reported that his animals were not maintaining the expected condition and growth rates, and trace element deficiencies (notably selenium) required supplements. Removal of ponies before spring to allow a spring flush of grasses for cattle has been contemplated.

Old conifer stumps have been left in situ – they provide a good niche for lichens, fungi and invertebrates but create logistical difficulties when contemplating mechanical management

3.2 Recommendations for Future Management

This section will attempt to outline the potential trends in the habitats under three different scenarios – non-intervention, livestock grazing and an 'ecosystems goods and services' or local community utilisation scenario. Although some suggestions can be made as to the relative merits of each approach, the range of political and financial factors also requiring consideration are outside the scope of this report.

Scenario 1: 'Re-wilding' or Non-intervention

Holly, downy birch and sitka spruce emerging through heather on the eastern side

The site is currently a mosaic of heathland, grassland and scrub. Without management interventions, successional processes will lead to tree growth across the whole site. This could be expected to comprise willow and birch in the short term, with a longer-term progression towards sessile oak, with rowan, holly, birch and perhaps rhododendron prominent in the understorey. However, the impacts of disease could be expected to affect this longer-term trend – oak, for example, could be removed by acute oak decline, sudden oak death (*Phytophthora ramorum*) or other emerging diseases. The impacts of climate change will also play a role in shaping the climax vegetation – extreme winds could periodically remove self-set sitka spruce or other mature trees, whilst drought or fire could also maintain stunted or shrubby growth. Such extreme events would perhaps counter any trend towards enhanced growth under conditions of increased mean temperature and elevated carbon dioxide levels.

Marshy grassland, flush areas and ponds would succeed to willow scrub or wet woodland. Left unmanaged, the top parts of the site could perhaps retain some heathland areas through the actions of periodic extreme events. Although these would temporarily create areas of early successional heathland, mature, closed heathland would dominate and gorse and broom growth would perhaps be favoured over ericoid growth. Plant diseases would potentially impact on these heathland areas too – bilberry is a known host of *Phytophthora ramorum* and could disappear alongside the oak.

Interacting with successional processes would be the impact of herbivory. No large wild herbivores are currently present, but there is some potential for the natural colonisation of deer species. The two species currently expanding their ranges westwards – muntjac and roe deer – are more characteristically associated with lowland broad-leaf woodland. The few sightings within Pembrokeshire are focussed on the woodlands around the Cleddau estuary, but there are records of both species from in or near the Gwaun valley. Wild fallow deer are also spreading in south Pembrokeshire; they are also farmed on the eastern side of Mynydd Preseli near Mynachlog-ddu and could conceivably escape. Red deer have also been farmed in the north of the county, and this enterprise could be the source of the two recent sightings in the Preseli area. Although an established, wild red deer population could create a varied, dynamic structure within the heathland and woodland at Penlan, in the absence of natural predators (such as reintroduced lynx), their browsing impacts could ultimately prove undesirable, as it has done in parts of Scotland.

Management Actions required under this scenario

Few or none. Maintenance of boundary fencing to prevent ingress of stock would technically be the responsibility of the neighbouring landownwer, but if considered undesirable may require occasional financial input. Maintenance of access routes may involve more significant vegetation clearance.

Wildlife Value under this scenario

The principal wildlife value of the site under a scenario of no active management would presumably become associated with mature tree growth. Such newly created or secondary woodland would take a significant time – perhaps centuries rather than decades – to achieve the richness of the current ancient woodland resource in the neighbouring Gwaun valley. However, the addition of a large block of young woodland and scrub to that resource will buffer and enhance it. Some mobile species would benefit from having younger growth alongside the mature woodland, as it provides a wider foraging network and increased range of opportunities. Examples could include birds such as willow tit, invertebrates such as silver washed fritillary and mammals such as dormouse. Other woodland species which require large home-ranges, such as honey buzzard, could conceivably colonise. The eventual value of the site to woodland invertebrates, fungi, lichens and other wildlife may justify the decision to pursue this scenario. It is hard, however, to visualise the site providing enhanced ‘connectivity’ for woodland species, as it effectively forms a ‘cul-de-sac’ rather than a new ‘through route’.

Wider Environmental ‘Services’ under this scenario

In addition to direct wildlife benefits, non-intervention management would provide carbon sequestration and flood amelioration benefits. Landscape benefits are more subjective to assess, but some authors (eg. Rotherham, 2009) would argue that ‘cultural severance’ would lead to a lowering of these benefits, and the resulting ‘derelict’ landscape would hold ‘little appeal for tourists or leisure visitors’.

Scenario 2: Livestock Grazing Management

As recent experiences with cattle management on site indicate, Penlan is a marginal site from an agricultural perspective. The site had reportedly been abandoned prior to afforestation in the 1970s, and attempts to integrate the post-restoration heathland and grassland with the local agronomy will face numerous challenges.

PCNPA appear to hold no records of the grazing regime prior to afforestation. Mixed stocking with sheep, ponies and / or cattle seems likely.

Cattle

Cattle are generally considered the optimum grazing stock for lowland heathlands (eg. Gimingham, 1992), and hardy native breeds are better suited to the poorer forage quality and exposure on sites such as Penlan.

Carn Edward Farms have been using rare breed Longhorn cattle on their hill farm in the Gwaun valley for over ten years. They have a spring-calving suckler herd, with animals housed during the worst part of the winter and finished on home-grown barley and oats. They held a grazing licence and supplied animals to the Penlan project during the summer months for a 5 year period.

Longhorns have a docile temperament, their thrifty nature makes them able to maintain condition on rough pasture, and their thick, silky hide means they cope well with exposure to cold, wet weather. They are noted as good browsers, able to push through and open out dense scrub, for example in hot weather and when trying to avoid flies (GAP, 2008). Along with Welsh Black, they are among the cattle breeds best suited to extensive grazing on heathlands and other semi-natural habitats.

Carn Edwards sell their beef through direct-marketing. The environment of the Gwaun is a key part of their marketing strategy, although grazing at Penlan itself is not directly mentioned on their website. Their beef enterprise does not come under the 'umbrella' of the National Trust's 'Heathland Beef Scheme', now run in conjunction with Gwaun Valley Meats, but shares a similar 'eat-the-view' philosophy.

Recent changes to pre-movement TB testing mean that it is no longer possible for a grazier to claim sole occupancy of land outside of their own holding. TB tests will now be required for all movements on to and off the land at Penlan. As a result, handling facilities to enable on-site testing would need to be established.

The cattle grazing regime as it has been implemented appears not to be viable without support. If it is to be continued in its current form, without associated burning or supplementary feeding, it may require incentivising through a S39 Management Agreement or similar payment to the grazier. (it is presumed that the land has, and will have, no registered entitlements that could be activated under BPS). Although the Carn Edwards herd stands at 200 and growing, the potential for a dilution effect of grazing at Penlan pulling stock away from Carn Ingli or other high profile sites should be considered.

Should annual payments not prove possible, an alternative approach would be to compromise on supplementary feeding and perhaps burning management – activities which are currently restricted.

Supplementary feeding would result in at least local zones of enrichment, but if the conserved fodder was hay from semi-natural grasslands, this could lead to the development of a more species-rich grass-heath mosaic near feed areas. An example of this effect can be seen on parts of Plumstone Mountain. Moving feed sites across a defined area would perhaps be preferable to sacrificing one spot. Intensively produced silage should not be fed, as this would perhaps result in a greater degree of enrichment and the introduction of rye-grass and associated agriculturally-favoured species.

Burning has traditionally been used to support agricultural usage of heathlands, as it promotes an early flush of more palatable growth the following season. It clearly has environmental implications, particularly in terms of release to the atmosphere of particulates and carbon dioxide, and should increasingly be scrutinised to ensure that the intended benefits can justify this pollution. Incorrectly applied, burning regimes can be counter-productive and result in the promotion of the more fire-resistant plants – often the less desirable species such as bracken, purple moor-grass and European gorse. A sufficiently large herd should always be ready to graze back the additional forage.

Burning management would require the establishment of a firebreak network. Both this and the aftermath of a burn would have some impacts on landscape and scenic appreciation, so would require careful consideration to ensure that lines were curved to follow contours rather than applied in a rigid grid fashion. It would be preferable to use and link existing natural fire-break features, such as seepage lines, old brash-mats and pathways. Even if controlled burning management is not to be applied, it would be prudent to consider establishing a firebreak network in this way. The apparent lack of prescribed burning on adjoining land may buffer the site from uncontrolled burns to a degree. However, mature heath carries a high fuel load and, although the potential for arson attack or accidental burns would appear to be low it cannot be ruled out.

Firebreak creation would be most effectively carried out by a tractor-mounted flail. The site is accessible to tractors – the slope is not too steep, and the rocks here present a relatively minor hurdle. However, the old conifer stumps make much of the site impossible to mow using conventional attachments, and a mulcher-grinder would be required to remove stumps from any areas where mechanical maintenance was to be carried out.

Store cattle browsing western gorse on adjoining Carningli common, December 2015.

Ponies

Pony grazing has been used in conjunction with cattle grazing at Penlan. As on other conservation sites, the use of Welsh Mountain ponies has become a fall-back option when cattle have not been available.

Although a dedicated herd grazes Penlan for most of the year, numbers are low. The ponies appear to be maintaining an open structure here in some of the grassland and flush areas here. However, they have failed to create a diverse age structure within the heath. The experiences of other heathland grazing schemes in the county suggests that ponies are rarely capable of restoring or maintaining mature or neglected heathland alone, without a significant amount of additional mowing, burning and scrub-clearance. Heather itself is generally avoided, and gorse primarily taken in hard weather when grass is not available. At these times, ponies may use their hooves to break bushes so that they can get to the nutritious bark on the lower parts of the stems (pers. obs.).

Registered pedigree Welsh Mountain ponies can still command reasonable prices if exported, but few pony graziers are currently able to derive an income from raising ponies. Most, if not all, of the hill farms around Preseli have stopped keeping ponies, or now largely do so for sentimental reasons.

Sheep

Although often the only economical and practical grazing solution currently available on hill-land, the close-grazed grasslands created by a combination of frequent burning and intensive sheep-grazing have become associated with much of the dull, wildlife-poor hill country of Wales. Alone, they are unable to tackle tall growth of purple moor-grass and other dominant plants.

Although not a first-choice grazing animal for conservation purposes, an element of grazing with hardy sheep in late summer / autumn could, in the absence of cattle, help retain a link with the local agronomy should this be considered desirable.

Other Livestock

Although animals such as deer could have positive impacts through their browsing, no other livestock are likely to be a practical option for various reasons, such as public access considerations or the high perimeter fencing required to enclose the site.

Management Actions potentially required under this scenario:

Provision of mobile or permanent cattle holding pen and crush facilities
Payments to grazier, at least to cover costs of cattle pre-movement TB tests
Some periodic rejuvenation of mature scrub and heathland vegetation
Removal of rhododendron and pampas grass.
Establishment of firebreaks

Wildlife Value under this scenario

The principal wildlife value of the site under a scenario of livestock management would presumably be associated with a continued mosaic of the current habitats. However, over significant areas of the site, the succession from grassland through heathland and scrub to woodland is likely to be slowed rather than halted, as the less palatable woody species will generally be avoided under extensive grazing regimes.

The concept of connectivity for wildlife is perhaps easier to apply here to heathland species than to woodland species. Penlan forms part of a relatively short potential link between the more extensive heathlands of Carn Ingli and Mynydd Preseli. However, habitat conservation and re-creation would perhaps be required around Penralltddu or Tregynon on the south side of the Gwaun to shorten this link, and the wooded valley sides could still effectively sever the two areas. Mobile species which could cross the valley would perhaps be capable of the longer distance dispersal required without the 'stepping-stone' effect of Penlan.

The adjoining Carn Ingli heathlands provide the most obvious source of colonising species. From a botanical perspective, the dry heaths at Penlan already have a similarly restricted range of common species, and even periodic rejuvenation through cutting, grazing or burning management seems unlikely to introduce less common species. The flush areas and ponds, however, seem likely to stay receptive to colonists under grazing management, as the actions of stock congregating around water will ensure that short, open vegetation and bare clay patches are maintained. Several scarce higher plants on Carn Ingli are associated with similar habitat, the most notable of which is pale butterwort (*PInguicula lusitanica*). Seeds of this species can be wind dispersed, but it is perhaps noting that Penlan is on the wrong side of Carn Ingli to receive seeds – or spores - dispersed by the prevailing winds. Animal transfer is another potentially significant transfer mechanism for seeds, but - due to their smoother coats - cattle are less effective at seed dispersal than sheep, and no direct interchange of stock between these sites is envisaged. Birds, notably snipe, then become perhaps the most likely agent of seed transfer between sites.

Overall, the site could be expected to be a significant resource for invertebrates, and their conservation should perhaps be considered a more important driver for management than plants or birds. Many invertebrates are capable of dispersal between nearby sites, and suitable micro-habitats are likely to become readily colonised by a variety of, for example, hymenoptera, coleoptera, diptera, odonata and lepidoptera. The current varied structure will be attractive to numerous spiders. Bumblebees (such as *Bombus jonellus* and *B. sorooensis*) and a large numer of other hymenoptera will benefit from the extensive nectar and pollen sources provided by heather, willow and other plants.

There are a number of uncommon moths recorded from the county which require mature heath with scrub, or transitions to woodland. These include heath rivulet (*Perizoma minulata*), dotted border wave (*Idaea sylvestraria*), small chocolate-tip (*Clostera pigra*) and dingy mocha (*Cyclophora pendularia*). The latter, a RDB3 species, requires young willow bushes in open situations, and is thought to have been impacted by conservation grazing and scrub clearance in south-west England. The sole Pembrokeshire record is from 1875. Targeted moth surveys would be worth supporting.

A limited range of common odonata was recorded during the current survey. The key species for which management of wet areas is already being targeted is the southern damselfly

(*Coenagrion mercuriale*). Present in small populations on the north side of Carn Ingli, Penlan lies within its maximum observed dispersal range (between 1 – 1.5km), and well within the 3km range suspected by recorded colonisation events (Purse, 2002; McHattie, 2003). Colonisation from the stronger populations on Mynydd Preseli would appear less feasible. If this species is to be attracted, efforts should be made to extend the area of suitable breeding habitat. Relatively minor adjustments to the constructed flush / ditch system could result in greater areas of the sluggish-flow flush vegetation which the southern damselfly requires. Flow in the initial section is a little strong, and encouragement of lateral flow along the contours of the slope rather than down it would be preferable. Elsewhere, creating shallower profiles to the ditch sides could be contemplated. The scarce blue-tailed damselfy (*Ischnura pumilio*) is another potentially uncommon colonist, usually associated with freshly dug pools. Populations can persist with sufficient levels of livestock trampling.

Numerous specialist bird species are associated with mature heathland of the kind currently found at Penlan. Many of these have very restricted distributions in the UK, but several could potentially breed at the site in the near future. Three widespread S42 species – linnet, reed bunting and skylark - are obvious candidates, and may well already be breeding. Kestrel, grasshopper warbler and cuckoo, the latter two newly red-listed (Eaton et al, 2015), are also known to be present. Two less common species are already present locally. Whinchat – also a red-listed species - is found on Carn Ingli, often in association with tall bracken and gorse areas. It could perhaps be expected to colonise. Dartford warblers breed in similar, albeit more lowland, mature heathland to the south and west - they could well nest if climatic conditons permit. Less likely colonists are the heathland raptors and owls. Hen harriers may forage here in winter, and could adopt the site for roosting. Breeding here though would be an exceptional event. The even rarer Montague's harrier once bred on Pembrokeshire heathlands, but unless the fortunes of the UK population dramatically improve, it remains an unlikely colonist. Short-eared owls are more-or-less restricted to the Pembrokeshire islands as a breeding bird in the county, but may well winter here and could conceivably breed. Merlins likewise would be an expected winter visitor, but one currently unlikely to breed. The hobby is enjoying a range expansion across Wales, and may find the mosaic of woodland and heathland to its liking. Woodlark and nightjar are currently thought to be absent from the county as breeding birds, although the latter was still recorded as a probable breeder in the area into the 1980s. One was reportedly recorded displaying in suitable habitat at nearby Brithdir Mawr a few years ago (Paul French, pers. comm.). However, they are semi-colonial breeders requiring a large area of suitable habitat, and the short dispersal distances undertaken by returning young birds further limits their colonisation abilities. It would seem preferable to consider the site primarily as valuable habitat for good numbers of scrub and rough grassland species, rather than heathland specialists.

Scenario 3: Community Utilisation – 'Ecosystem Goods'

The south facing slope here could lend itself to an apiary

The following are a few suggested ways in which people could be enabled to use the land in a manner which respects or enhances its wildlife interest. These could be accommodated alongside either scenario outlined above.

Beekeeping

The site currently looks to have good potential for the production of heather honey. As a minimum requirement, vehicle access would need to be established to a suitable level area of ground, temporarily or permanently fenced from livestock and people. The most suitable area lies on the slope just underneath the main access route in from the north-west, but would require some minor vegetation clearance and levelling. A more elaborate proposal could involve the creation of a bespoke 'bee shelter' fashioned into the bank. Such shelters for the old beehives or 'skeps' used to be commonly built out of stone, and are now considered of archaeological importance. Willow, clay and turf could be used as building material in the absence of clean loose stone here. A newly exposed bank would simultaneously create habitat for solitary bees and wasps.

Foraging

Heather flowers, bilberry leaves and other heathland plants can be used in various products such as teas, wines, ales and soaps. Hand-harvesting would clearly be sustainable here, and a small business could wish to trial the supply of such products through PCNPA retail outlets. The concept of heather ales seems ripe for exploration with two micro-breweries present nearby. Heather is more widely used in Scotland – for example in products such as floor-tiles and jewellery http://www.heathergems.com/about.php.

Bushcraft

The site may lend itself to bushcraft courses or events (provided they are fire free). The small-scale disturbance associated, for example, with cutting willow for benders or making walls out of heather and daub (clay and cow pats) for temporary human (or bee) shelters, could have ecological benefits.

Natural History

The site is accessible to and used by birdwatchers, botanists, dragonfly enthusiasts and other naturalists. More could be done to harness the knowledge and enthusiasm of the wildlife recording community, for example by allowing vehicle access to moth recorders (via the North Pembrokeshire Moth Group), organising recording days in conjunction with WWBIC, or enticing specialists through groups such as the Dipterists Forum or FSC courses. Observations made by such visits will help build a picture of the site to inform management decisions.

Biomass

As demand for firewood rises and the site becomes dominated by more substantial willow and birch, there may be some interest from the local community for coppicing or clearing areas. Firewood work parties could be organised, following a ‘cut-your-own’ approach. Assistance with extraction could be provided by PCNPA. This would help to link people to their fuel supply and local environment, and provide a cost effective solution to the periodic glade creation needed to diversify the habitats and structure on the site.

Opportunities for more significant biomass harvesting are currently limited by the old conifer stumps, which make much of the site too difficult to take harvesting machinery across. If these were removed with a mulcher-grinder, there would be some potential to periodically harvest mature heather and gorse. 25 year rotations are favoured, with cutting between October and mid-December optimal. Studies have been done (see for example Worrall and Clay, 2014) which demonstrate that the cut material is suitable for fuel use. Yields have been quoted for English sites at 21-32 tonnes / ha (equating to 3,500kwh / tonne at 40% moisture).

The RSPB have been pioneering the use of cut heathland vegetation from their reserves, and employ a Reserves Bioenergy Project Manager, Sally Mills. They use a modified forage harvester with collection facility to remove the material, which is then stored and dried before being used to make either biochar or briquettes. The latter are produced using a mobile briquette press.

An alternative technique for biomass harvesting would utilise a brash-baler. The Anderson 'Biobaler' is an example of a machine which cuts, collects and bales biomass in one pass, although it is expensive and heavy, requiring a 200hp tractor. Such bales can be burnt in more robust biomass boilers, such as the Farm 2000, or potentially processed into a more refined form such as pellets.

There is currently a disconnect between the biomass boilers being installed in the county and the sourcing of fuel to supply them. Large facilities, such as the one in development at Trecwn, intend to source wood from other countries as their primary fuel. Smaller boilers, such as those installed by the local authority in some schools, have opted for the convenience of pellets which are not currently manufactured in the country. Pembrokeshire Bioenergy Ltd have investigated the possibility of producing pellets locally, but economies of scale make this a difficult market to compete in. The supply of biomass from Penlan is thus perhaps not a viable option at present, but future developments may change this.

4. Summary and Conclusions

The site has successfully met its original objectives, and currently holds a mosaic of heathland, grassland and scrub. Without management interventions, successional processes will lead to tree growth across the whole site. This would create a woodland habitat which would ultimately develop some of the wildlife value of the adjoining woodland SAC. The concept of non-intervention management may be less politically attractive than continued management, but would require less resource-input. Traditional livestock management here faces economic and logistical constraints, but will be necessary in some form if these successional processes are to be slowed, and at least some of the newly created heathland maintained into the future. Parts of the site will be receptive to colonisation by uncommon species, most notably the re-created flush and pool systems. Some minor additional works could enhance these. Several additional activities are suggested which would enhance local community utilisation of the site, whilst maintaining or enhancing the ecological diversity.

5. References

Anderson, R (2012). *Penlan heathland restoration experiment - Summary of observations*. Unpublished, PCNPA files.

Bosanquet, SDS (2010). *The Mosses and Liverworts of Pembrokeshire*. Privately published.

Eaton et al (2015). *Birds of Conservation Concern 4*. British Birds 108, 708-746.

GAP (2001). *The Breed Profiles Handbook: A Guide to the Selection of Livestock Breeds for Grazing Wildlife Sites*. Grazing Animals Project.

Gimingham, CH (1992). *The Lowland Heathland Management Handbook*. English Nature.

Anon (1990). *Handbook for Phase I habitat survey*. Nature Conservancy Council, Peterborough.

McHattie (2003). *Analysis of data on dispersal in southern damselflies*. BSc Zoology Honours project University of Liverpool

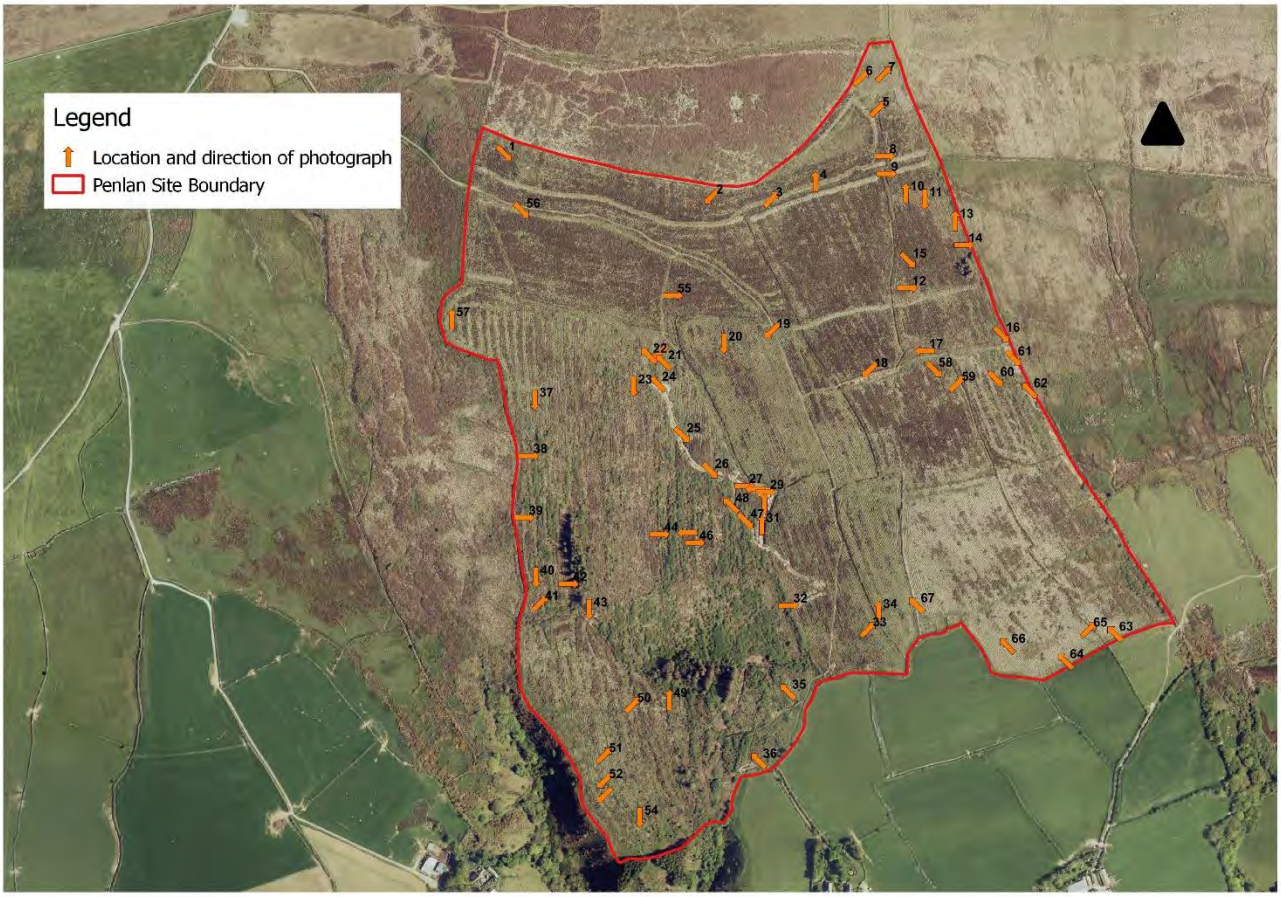
Mellor, S (in prep, 2015). *Penlan – Restoring habitats at scale for wildlife and people*. PCNPA.

Purse (2002). *The Ecology and Conservation of the Southern Damselfly (Coenagrion mercuriale – Charpentier) in Britain*. Environment Agency R&D Technical Report W1-021/TR

Rotherham, I (2009). *Cultural Severance in Landscapes and the Causes and Consequences for Lowland Heaths*. Journal of Practical Ecology and Conservation Special Series no. 5.

Worrall, F and Clay, G (2014). *The potential use of heather (Calluna vulgaris) as a bionergy crop*. Biomass and Bioenergy.

Appendix 1



Location of Site Photos

Photos 1 – 36 taken 19/9/15

Photos 27 – 57 taken 25/9/15

Photos 58 – 67 taken 7/12/15

Appendix 2

Plant species recorded at the site during the walkover visit 19 & 25/09/2015

Bilberry	*Vaccinium myrtillus*
Bog Pimpernel	*Anagallis tenella*
Bog Pondweed	*Potamogeton polygonifolius*
Bog Stitchwort	*Stellaria alsine*
Bracken	*Pteridium aquilinum*
Bramble	*Rubus fruticosus*
Bristle Club-rush	*Isolepis setacea*
Broad-buckler Fern	*Dryopteris dilatata*
Broom	*Cytisus scoparius*
Brown Bent	*Agrostis vinealis*
Bulbous Rush	*Juncus bulbosus*
Cock's-foot	*Dactylis glomerata*
Common Bent Grass	*Agrostis capillaris*
Common Duckweed	*Lemna minor*
Common Sorrel	*Rumex acetosa*
Common Spike-rush	*Eleocharis palustris*
Common Valerian	*Valeriana officinalis*
Common Water Starwort	*Callitriche stagnalis*
Common Yellow Sedge	*Carex viridula oedocarpa*
Compact Rush	*Juncus conglomeratus*
Creeping Bent	*Agrostis stolonifera*
Cross-leaved Heath	*Erica tetralix*
Cuckoo Flower	*Cardamine pratensis*
Devil’s-bit Scabious	*Succisa pratensis*
Downy Birch	*Betula pubescens*
Eared Willow	*Salix aurita*
Early Pampas Grass	*Cortaderia richardii*
Floating Club-rush	*Scirpus fluitans*
Floating Sweet-grass	*Glyceria fluitans*
Foxglove	*Digitalis purpurea*
Glaucous Sedge	*Carex panicea*
Gorse	*Ulex europaeus*
Green Ribbed Sedge	*Carex binervis*
Grey Willow	*Salix cinerea*
Hard Fern	*Blechnum spicant*
Hawthorn	*Crataegus monogyna*
Hazel	*Coryllus avellana*
Heath Bedstraw	*Galium saxatile*
Heath Rush	*Juncus squarrosus*
Heath Milkwort	*Polygala serpyllifolia*
Heath Woodrush	*Luzula multiflora*
Heather	*Calluna vulgaris*
Holly	*Ilex aquifolium*
Jointed Rush	*Juncus articulatus*
Lesser Skullcap	*Scutellaria minor*

Lesser Spearwort	*Ranunculus flammula*
Lousewort	*Pedicularis sylvatica*
Male Fern	*Dryopteris filix-mas*
Many-flowered Spike-rush	*Eleocharis multicaulis*
Marsh Lousewort	*Pedicularis palustris*
Marsh Pennywort	*Hydrocotyle vulgaris*
Marsh Ragwort	*Senecio aquaticus*
Marsh St. John's-wort	*Hypericum elodes*
Marsh Thistle	*Cirsium palustre*
Marsh Violet	*Viola palustris*
Marsh Willowherb	*Epilobium palustre*
Mat Grass	*Nardus stricta*
Meadowsweet	*Filipendula ulmaria*
Pill Sedge	*Carex pilulifera*
Purple Moor-grass	*Molinia caerulea*
Ragged Robin	*Lychnis flos-cuculi*
Rhododendron	*Rhododendron ponticum*
Rosebay Willowherb	*Chamaerion angustifolium*
Round-leaved Water Crowfoot	*Ranunculus omiophyllus*
Rowan	*Sorbus aucuparia*
Sessile Oak	*Quercus petraea*
Sharp-flowered Rush	*Juncus acutiflorus*
Sheep's Fescue	*Festuca ovina*
Sheep's Sorrel	*Rumex acetosella*
Sitka Spruce	*Picea sitchensis*
Smooth-stalked Sedge	*Carex laevigata*
Sneezewort	*Achillea ptarmica*
Soft Rush	*Juncus effusus*
Star Sedge	*Carex echinata*
Sweet Vernal Grass	*Anthoxanthum odoratum*
Toad Rush	*Juncus bufonius*
Tormentil	*Potentilla erecta*
Tufted Hair Grass	*Deschampsia cespitosa*
Velvet Bent	*Agrostis canina*
Watercress	*Rorippa nasturtium-aquaticum*
Water Horsetail	*Equisetum fluviatile*
Water Purslane	*Peplis portula*
Wavy St. John's-wort	*Hypericum undulatum*
Western Gorse	*Ulex gallii*
White Clover	*Trifolium repens*
Wild Angelica	*Angelica sylvestris*
Yorkshire-fog	*Holcus lanatus*

Bryophytes

Atrichum undulatum
Aulacomnium palustre
Brachythecium rutabulum
Bryum alpinum
Bryum pseudotriquetrum
Calliergonella cuspidata
Calypogeia fissa
Calypogeia muelleriana
Campylopus atrovirens
Campylopus introflexus
Campylopus pyriformis
Dichodontium palustre
Dicranoweisia cirrata
Didymodon tophaceus
Diplophyllum albicans
Ditrichum heteromallum
Hypnum jutlandicum
Lophocolea bidentata
Metzgeria conjugata
Pellia neesiana
Philonotis fontana
Pleuridium acuminatum
Pleurozium schreberi
Polytrichastrum formosum
Polytrichum commune
Racomitrium aciculare
Racomitrium cf. heterostichum
Rhytidiadelphus squarrosus
Sphagnum fallax
Sphagnum palustre
Sphagnum subnitens
Straminergon stramineum
Thuidium delicatulum