



Cheshire
Wildlife Trust

Delamere's Lost Mosses

Final Report



November 2013 – January 2018



Cheshire West
and Chester



Forestry Commission



Executive Summary

The Delamere's Lost Mosses Project ran from November 2013 till January 2018 and within that time achieved a number of milestones. Below are detailed some of the highlights of the project;

- The Delamere Landscape project received a Best Practice award from the Chartered Institute of Ecological and Environmental Management
- Over 125ha of mossland habitat has been improved
- Over 40ha of mossland habitat managed with the help of volunteers
- Volunteer work on the mosslands was equivalent to £200,000 of contractor costs
- Over 100 volunteers engaged in the project
- Had over 2,000 volunteer days contributed
- Upskilled six part-time volunteer trainees, four of which have gone on to work in the conservation and ecology sectors, with the other two remaining in education and training
- Fourteen additional mossland sites have been added to the project since the start of the restoration work in order to increase connectivity throughout the forest
- Ten landowners were engaged in invasive species control
- Water quality was tested across 8 project sites, the results leading to mitigation actions being carried out which should help improve water quality in the area
- Through landowner engagement a parcel of land was gifted to the Cheshire Wildlife Trust which connects to its Hatchmere Nature Reserve and includes areas of wet woodland, flushes and wet grassland with species such as ragged robin, water mint and bittersweet. This addition will increase the size of the reserve by a third
- Recorded 12 species of sphagnum, two of which are rare within the Cheshire region
- Seen the return of the green hairstreak butterfly to two restoration areas within Delamere Forest (Black Lake and Norley moss)
- Confirmed that *Scitticus floricola* (the Delamere Jumping Spider) is still present on Black Lake and Abbots moss, as well as finding two previously unknown populations within the Delamere landscape, bringing known UK sites up to thirteen
- Nationally rare money spider *Glyphesis cottonae* was found on four new sites within the Delamere landscape, almost doubling the number of sites it has been found on in Cheshire
- Rare mossland hoverfly *Orthonevra intermedia* was confirmed to be using five mossland sites within the Delamere area, currently the only known sites for this species in the UK
- Surveys were carried out for the bog bush cricket, currently known from only two locations in Cheshire. The historic population on Abbots moss SSSI was confirmed to be thriving
- Flaxmere SSSI was reclassified as Unfavourable – recovering from Unfavourable – declining due to the work carried out by the project. Natural England currently think the site should be considered to be in Favourable condition in the near future
- Sphagnum surveys have confirmed that area of sphagnum has increased across the Delamere mossland sites since the start of the DLM project
- Raised £700 through the sale of charcoal made from wood taken from the restoration sites
- Fifteen guided walks, ten talks and ten training days were given throughout the project
- Visited by the Secretary of State for the Environment, Rural affairs and Agriculture, local MPS (such as Graham Evans) and the Society for Ecological Restoration

Contents	Page
1. Project overview	3
2. Project program	4
2.1. Practical management on core and restoration sites	4
2.1.1. Core sites	4
2.1.2. Restoration sites	14
2.1.3 New project sites	28
2.2. Landowner and public engagement	33
2.2.1. Landowner engagement	33
2.2.1.1 Invasive species	36
2.2.1.2 Water quality	41
2.2.2. Public engagement	45
2.3. Surveying and monitoring	51
Acknowledgements	76

1. Project Overview

Delamere's meres and mosses have existed since the end of the last Ice Age over 10,000 years ago. Just like the more than 200 other meres and mosses scattered across Cheshire and Shropshire they are internationally important for the species they support and the ecosystem services they provide. Once known as the 'Forest of the meres' Delamere has lost many of its meres and mosses since 1812 when the area was first drained and forested.

The restoration efforts carried out by the Forestry Commission and Natural England in the 1990's have seen startling changes occur, with rare species such as the royal fern and the round-leaved sundew returning to the area. The Delamere's Lost Mosses project, run in partnership with the Cheshire Wildlife Trust, the Forestry Commission, WREN, Natural England and Cheshire West and Chester Council, has continued this restoration effort, restoring over 125ha of core and relict mossland sites in and around the forest.

As well as restoring core areas (Maps 1 and 2) the project has tried to better link sites, to ensure that habitats are not isolated within the landscape. In order to accomplish this local landowners and communities have been encouraged to participate, in order to manage land sustainably and help care for these unusual habitats. Engagement has been an important tool within the project, in order to inspire the local community, as well as the wider scientific community, to take ownership of these wild areas. In doing so we hope to have given people an understanding and an appreciation for these mosslands and the species they support.

The Delamere's Lost Mosses began in November 2013 and finished in January 2018. In this report the last four years of work are laid out against the aims of the project to demonstrate what has been achieved, and how this will influence future work within the Delamere area.

Project aims:

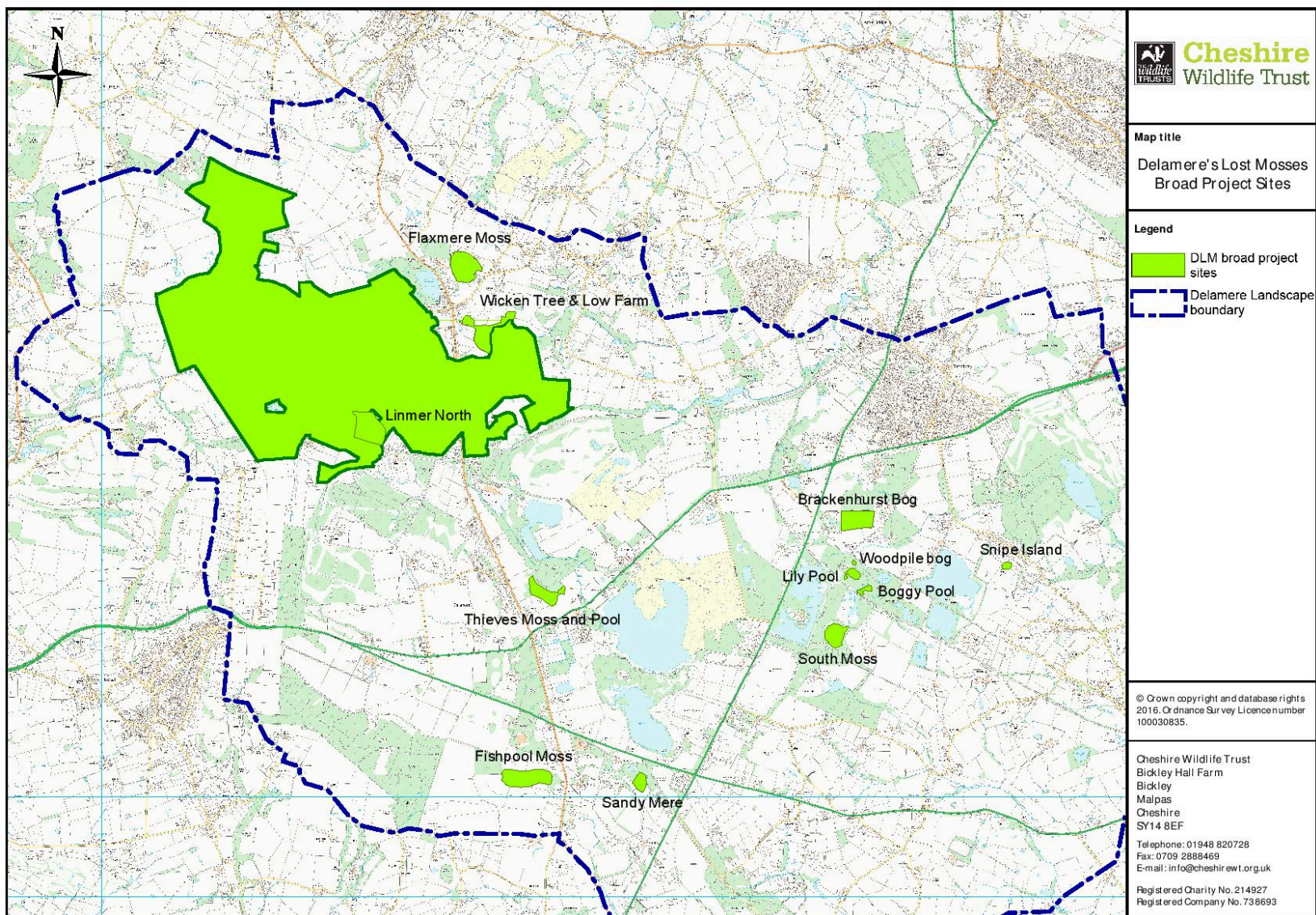
Aim 1: Bring in to positive management core areas of BAP habitat to maintain, and where possible, enhance their value for wildlife.

Aim 2: Deliver restoration of BAP habitat at relict mossland sites to create stepping stones within the wetland complex. Restoration sites will expand or link existing core areas and in time will be of high nature value in their own right.

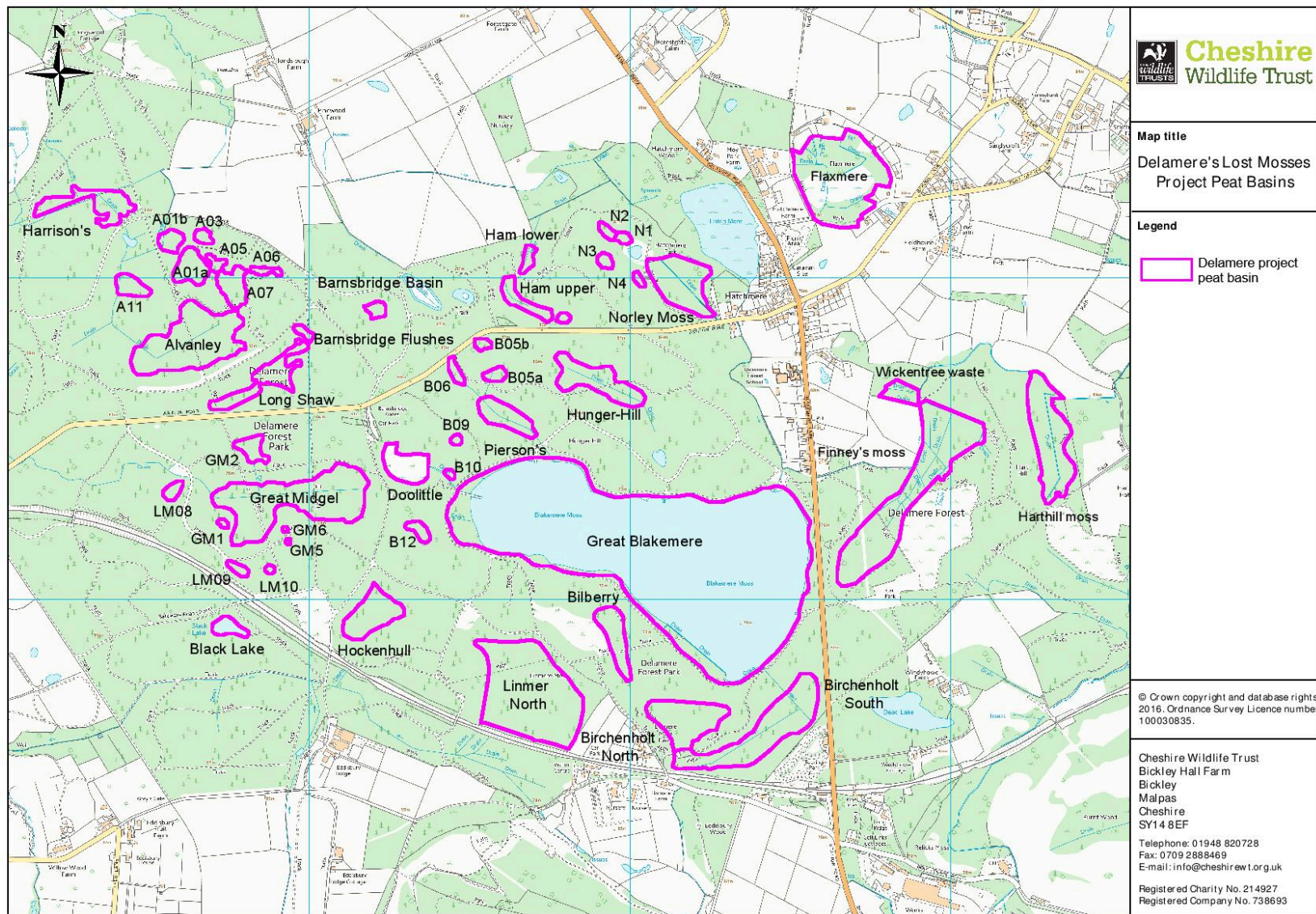
Aim 3: Influence wider environmental management to reduce the impact of surrounding land on the BAP habitat within the core and stepping stone sites.

Aim 4: Ensure that the Delamere's Lost Mosses project creates a lasting legacy whereby the nature conservation value of the Delamere landscape is valued, protected and maintained.

Aim 5: Provide evidence to support and analyse the ecological functionality of the site network throughout the project life to inform land management activities and evidence the success of the landscape scale approach.



Map 1. The Delamere's Lost Mosses project concentrated on ten broad project sites. Delamere Forest and Abbots moss were further divided into individual peat basins within their complexes (south moss, woodpile bog, lily pool and boggy pool are all part of the Abbots moss SSSI).



Map 2. Delamere's Lost Mosses project sites within Delamere Forest.

2. Project Programme

2.1. Practical management on core and restoration sites

2.1.1. Core sites

A06



Photo 1 and 2: From left, A06 2015 and 2017.

Already one of the most pristine sites within Delamere at the start of the project, a metal sluice with wooden boards was installed on the main outflow of A06 to raise the water levels by 10cm. This has resulted in slightly more open water on the site, some loss of heather and bilberry and a slight shift in the sphagnum community with the amount of *S.pulustre* decreasing and *S.fallax* increasing. As *S.pulustre* prefers drier and wooded sites this can be seen as a positive shift.

Barnsbridge basin



Photo 3 and 4: From left, Barnsbridge basin 2015 and 2017.

One of the best developed mosses in the forest Barnsbridge basin benefitted from the clearance of conifers around its edge, which had fallen during high winds. Volunteers cleared the small amounts of internal scrub and cut and treated the large area of rhododendron which had established itself within the site, and within the surrounding

woodland. Additionally work was carried out over the following years to re-treat both scrub and rhododendron.



Photo 5 and 6: From left, rhododendron in 2015 and 2017.

Birchenholt North



Photo 7 and 8: From left, Birchenholt North 2015 and 2017. Damming significantly raised water levels, particularly in the centre of the site.

Birchenholt North is made up of a small area of heathland surrounded by dense bracken, with the northern edge being dominated by scrub and a few areas of bulrush. Water quality testing revealed high phosphate levels in water washing onto the north of the site from a drain from the residential houses opposite. An attenuation pond was therefore installed to stop this water from directly entering the site, with reeds to filter out the phosphates. Scrub was cleared with volunteers and some attempts were made at pulling the bracken to stop it from encroaching on the heathland. However the most effective management of the bracken and scrub would be to raise the water levels. A new plastic piling and peat dam was installed on the outflow, as well as several internal plastic piling dams being placed along the main drain. Due to the presence of a GoApe zipline platform on the site it is not possible to raise the water levels to their optimum levels however the current dams have significantly raised the water levels in the winter,



by roughly half a foot, and has also kept summer levels higher than previously. Many new pools have formed and the centre of the site is now mostly underwater. Lower areas across the north of the site, currently bracken infected, are also mostly underwater or boggy. Already new areas of sphagnum have appeared, even in

previously dry areas. It is hoped that the higher water levels will kill off some of the bracken.

Photo 9: Birchenholt north centre in 2017. Previously only the ditches on Birchenholt north contained any water. Winter water levels have now risen significantly and sphagnum has covered most of the core of the site, which keeps it damp even in summer.

Birchenholt South

Birchenholt South was a fairly dry with a stream running through its centre. Water quality testing found that the water within this stream was very high in nitrates, which were running off Old Pale, although the exact source could not be ascertained. This long thin site graded from mixed young birch and willow in the west into an area of fallen conifer trees in the centre to an area of dry conifer plantation in the east. Forestry Commission contractors removed the accessible conifers and project contractors cleared and burnt the brash before installing a large peat and plastic piling dam on the main outflow, with an overflow pipe. This dam was very successful, raising the water levels by approximately two foot and rewetting the majority of the site.

The result has been that whilst the water entering the site is very high in nitrates the water flowing on into Great Blakemere is low in nitrates, meaning the site is acting as a filtration system. The hope is that in time a wet woodland complex will be created. Already the silver birch within the site is dying whilst the willow is thriving. Some bulrushes are already present and it is hoped that reed may establish itself in the future. Some small patches of sphagnum were present on the site prior to water levels being raised, in pools disconnected from the main stream. All sphagnum has now disappeared from the site due to the water level change and poor water quality, however it is hoped that in time sphagnum may re-establish in the eastern end of the site, where water is clean and more suitable for sphagnum growth.

One unfortunate side effect of the raising of the water levels has been that New Zealand pygmyweed has appeared (*Crassula helmsii*) and rapidly spread throughout the basin. This is likely due to the movement of dogs and ducks between nearby Great Blakemere, where the New Zealand pygmyweed is already widespread, and this newly formed pool. If sphagnum can be established then in time it will likely outcompete this invasive species, however the poor water quality may hamper its growth. If an attenuation pond could be created to clean up the water before it enters this site there might be a better chance of the New Zealand pygmyweed being outcompeted. Water mint, gypsywort and bulrush are currently found growing through the New Zealand pygmyweed, hopefully if these are able to grow alongside the invasive species there may still be some botanical interest on the site in the future.



Photo 10 and 11: From left, Birchenholt South eastern end post-felling in 2016 and after flooding later in 2016.

Boggy pool and Lily pool

Lying within the Abbots moss SSSI, Ramsar and SAC Boggy Pool and Lily pool both suffer with surrounding trees causing large amounts of saplings to grow on the bogs surface. On both sites volunteers were able to hand pull the majority of the sapling, however on Lily pool safety considerations meant some saplings had to be left. This issue will be ongoing and would benefit from some of the trees being cleared from the edge of the sites. Another significant issue is the rampant rhododendron surrounding the bogs and present throughout the woodland. Saplings are already establishing themselves on the surface of the bogs. Though they were cleared and treated it is likely more rhododendron will establish itself in the future.



Photos 12 and 13: From left, Lily pool in 2015 and 2017.



Photo 14 and 15: From left, Boggy pool boardwalk pre and post clearance in 2017.

Brackenhurst bog

Internal scrub was cleared from Brackenhurst bog through hand pulling, a labour intensive process. Birch scrub was also removed from the edge of the site through pulling and cutting and treating where needed, with brash being moved into the surrounding woodland. For most of the site scrub levels were relatively low, as should be expected with a good conditioned mossland, however on the western boundary scrub was unusually dense and tall. A small seasonal drain on this edge was tested and found to have high phosphate levels, suggesting this was the reason for the prolific scrub growth on this edge. An excellent grass snake population was found to be using this site, with both mature and juvenile snakes spotted. Additionally a good population of green hairstreaks was also noted. Rhododendron has infested a woodland north of the site and small saplings were found on the site itself, suggesting this could be a future threat to this pristine mossland.



Photo 16 and 17: From left, Brackenhurst bog from 2015 and 2017. Large amounts of small saplings were cleared from the centre of the site whilst larger saplings were cleared from under the edges of the trees.

Doolittle moss

The installation of a new plastic piling and peat dam on the main outflow of Doolittle moss, after the existing dam failed, raised the water levels by two inches across the site. Whilst this had little effect on the main pool, which was already in good condition, it did mean more of the peat basin was rewet within the north of the site, where bramble and birch had been establishing. Due to this work the sphagnum lawn has extended into these areas as well as species of sphagnum beginning to grow beneath the woodland north of the site.



Photo 18 and 19: From left, Doolittle moss 2015 and 2017.

Finney's moss

One of the most difficult sites in the forest to rewet, Finney's is a valley mire with a wide and flat base. Various attempts had been made in the past to raise water levels through ditch blocking but these were generally unsuccessful as the water was able to find a way round. It was therefore decided to install a series of peat bunds across the site. These proved to be particularly effective in the north of the site, where water levels rose significantly and remained above ground level throughout the year. Clearing of scrub around the northern end of the site also benefitted this area. Through the centre of the site bunds have been very effective throughout the winter, however levels fell significantly in summer in these areas, although the peat remained largely damp. As the sphagnum expands this should help keep the area wet all year. The top third of the site remains unbunded simply due to the additional cost of carrying out work on this area. The site could also benefit from tree clearance in areas which the bunds have rewet, and cell bunding in the south of the site.



Photo 20 and 21: From left, Finney's 2015 and 2017.

Flaxmere moss SSSI



Photo 22 and 23: From left, Flaxmere interior 2016 and 2017.

Flaxmere SSSI has improved since the start of the project, the dams installed on the central drain helping to raise water levels internally and encourage sphagnum growth. Regular scrub clearance, carried out by local group the Norley Wildlife Group, and spraying of regrowth has helped to knock it back to acceptable levels. A large stand of Himalayan balsam on the edge of the site has been hand pulled over several years so that only a few individual plants are now returning. A stand of Japanese knotweed on the site has also been sprayed for several years, so it is now close to being eradicated. Water testing demonstrated that an external ditch held high levels of nitrates, which was then mingling with the water on the edge of Flaxmere. Construction of a bund, to re-establish the edge of this drain, has both stopped this water from entering the site but also stopped water from being drawn off the site by this drain. The area opened up for this work is now establishing with some interesting species such as cuckoo flower. Due to the work carried out by the project the central mossland area of the site has been reclassified from 'Unfavourable – declining' to 'Unfavourable – recovering'.



Photo 24 and 25: From left, immediately after bund installation in 2016 and several month later as vegetation began to establish.

Great Blakemere

The largest restoration site within Delamere Forest the internal scrub on Great Blakemere was cleared of through volunteer effort alone. Contractors also cleared an area in the north of the site, where understorey species were particularly good, with volunteers clearing the regrowth. As the internal drains were never blocked on this site scrub regrowth is caused in part because of the seasonal draw down as the lake levels drop. In order to prevent this from happening largescale drain blocking was carried out across the site with peat dams being installed on small drains and plastic piling and peat dams on the larger drains. This work should help to keep water on the peat basin and hopefully reduce the amount of maintenance required in the future to remove the regrowth of birch scrub.



Photo 26 and 27: From left, interior of Great Blakemere before and after dam installation in 2015 and 2017.

Great Midgel

At the start of the project Great Midgel had been maintained for several years by a Butterfly Conservation Trust group of volunteers who had opened small glades within the birch trees across the site. This had encouraged heathland establishment and maintained the site's green hairstreak population. Through use of contractor and volunteer power it was possible to expand these glades and clear larger areas across the site. This work should allow the

existing heathland and areas of bilberry to expand and become denser. Some birch was kept on the site as wind breaks to create shelter for butterflies, and as a food plant for the orange underwing moth which is known to use the site. Regrowth was treated in the following years. A new dam was installed on the main outflow of the site to raise water levels across the western third of the site. This will encourage sphagnum growth across this area and hopefully reduce the need for maintenance. A green hairstreak population has persisted on the site in small number and it is hoped it will expand as the bilberry recovers from the clearance work.



Photo 28 and 29: From left, middle section of site pre-clearance in 2015 and post clearance in 2017.



Photo 30 and 31: From left, eastern end of site pre and post clearance in 2015 and 2017.

Hockenhull

Whilst the southern portion of this site was seasonally wet, water was quickly lost in the summer and the northern half remained dry all year. The installation of a sluice on the outflow raised the water level by roughly a foot. This helped to rewet roughly three quarters of the site. Even areas which were not flooded have benefitted by becoming saturated, which has encouraged sphagnum, heather and bilberry growth. Round-leaved sundews have begun to grow on areas which were previously too dry for them to establish. Within the wetter areas of the site more stable levels have led to the spread of common and hare's tail cotton grass as well as white-sedge. Due to the good quality and depth of peat on this site it was decided to bund the areas which were too high to be rewet by the sluice. Cell bunds

were built, which has raised the water levels on these higher peat areas. This should help to reduce the maintenance need on these areas.



Photo 32 and 33: From left, Hockenhull centre in 2015 and 2017.



Photo 34 and 35: From left, south-western end of site before installation of sluice in 2015 and post installation in 2017.

Linmere moss SSSI

Linmere moss was one of the most challenging sites to bring into condition due to the large areas of scrub which had established across the site and the size of the ditches. Internal scrub was cleared by contractors and ditches blocked with twenty four plastic piling and peat dams. As dams were installed in the last months of the project changes in water levels had not risen significantly by its end, however it is hoped this work will allow winter water levels to be maintained across the site for more, if not all, of the year.



Photo 36 and 37: From left, Linnere moss 2015 and 2017.

LM09/LM10

At the start of the project these two sites were separated by a line of conifer trees and only connected by a drain. The conifers separating the two sites, as well as several others surrounding LM10, were toppled during a storm and later removed. This greatly improved connectivity between the two sites. A plastic piling dam was installed across the drain to prevent LM10 from emptying into LM09 during drought periods. This had increased stability in this site, allowing sphagnum to spread and levels to remain higher throughout the year.



Photo 38 and 39: From left, LM09 in 2015 and 2017.



Photo 40, 41 and 42: From left, connecting corridor between LM09 and LM10 in 2015, 2016 and 2017.

Norley moss

Norley moss is a fairly dry site with a large area of heathland established across its centre. The northern portion of the site was thick with bracken, bramble and scrub at the start of the project. Volunteers have cleared the scrub and over the following years the regrowth was sprayed and the bracken was hand pulled. This method has proved very successful with this area now having a large amount of young bilberry, common heather and wavy hairgrass growing across it. Although bracken does still return it is much thinner and smaller than surrounding stands and grows mostly in small patches rather than blanketing the area. Volunteers installed a series of dams into the drain surrounding the area to reroute water onto the site which had previously simply travelled round it. This has created areas of sphagnum where the water enters. Additionally a contractor covered existing dams across the site from a previous project to stop them from becoming sun damaged. With the digger the contractor pressed the piling further into the ground and this has resulted in water levels rising significantly across the site, up to a half a foot. Although the levels still drop in the summer the ground remains much damper than in previous years and sphagnum is beginning to grow on areas which were previously too dry.



Photo 43 and 44: From left, northern end of Norley moss post-clearance 2014 and post-installation of dams 2016.



Photo 45 and 46: From left, centre of northern end of Norley moss post clearance 2014 and 2016.

Pierson's

An important site for dragonfly species and a potential site for a future white-faced darter population, if they naturally spread, Pierson's pool was in good condition at the start of the project. The southern bank was covered in scrub and bramble. Having cleared this bramble continued to spread and take over the newly cleared areas. Several years of cutting, spraying and pulling both bramble and bracken, has resulted in common heather spreading across this bank, with bilberry, wavy hairgrass, gorse and heath bedstraw also becoming well established. The site will need maintenance to keep it open but the establishment of a heathland bank here would be highly beneficial to the species using it. Already large numbers of dragonflies and damselflies have been observed using the newly established cover on this area.



Photo 47, 48 and 49: From left, Pierson's moss 2014, 2015 and 2016.

Sandy mere

Due to the significantly lowered water levels on Sandy mere, due to a proportion of the site having been dug out to create an ornamental pond, scrub regrowth has been a serious problem for this site. The open areas of the site have been cleared twice and sprayed several times to remove scrub, however tree saplings continue to grow quickly across the whole area. However sphagnum is slowly spreading across the surface of the site, and this will

hopefully result in the area becoming much wetter in the long-term. In the meantime the site will need to be continuously cleared to keep it open and encourage mossland species to spread. Contractors removed the majority of the mature trees from the site, which will decrease the amount of seed rain and should help to encourage the spread of sphagnum. Unfortunately several garden plants have established themselves on the site, and several attempts to clear them have proved unsuccessful. These will need to be cleared annually until they fail to return.



Photo 50 and 51: From left, Sandy mere in 2015 and 2016. Scrub has regrown due to dry conditions on site.

Snipe Island

Similar to Sandy mere Snipe Island suffers from continual scrub regrowth, most probably because the water levels drop significantly for the summer months. The site has been cleared three times over the four year project, re-growing each time at a rapid rate. Bunding may help to maintain levels for longer however regular clearance will be required if this cannot be carried out.





Photo 52, 53, 54 and 55: From top left, Snipe Island 2014, top right, 2015, bottom left, post clearance 2016, bottom right, 2017.

2.1.2 Restoration sites

Abbots moss, South Bog SSSI/Ramsar/SAC

An excellent example of a healthy mossland South bog contains a number of rare species. Through the project we were able to confirm the continued presence of the nationally rare spider *Sitticus floricola*, which hadn't been surveyed for since the 1980s and the Bog bush Cricket which hadn't been recorded for a similar amount of time. The main issue for South bog was the constant seed rain which resulted in large amounts of saplings growing across the site. To combat this the deciduous woodland on the edge of the site was cleared, with only a few trees being left, due to their containing potential roosting cavities for bat species. These trees were ring barked. A sump was also created on the north-western edge of the site, where a drain carried water washed from the forestry track onto the site, polluting the surrounding mossland and causing bulrush and other undesirable species to thrive. Volunteers also spent some time on the surface of the mossland itself to hand pull the saplings. Several stands of rhododendron exist on the site, both on the edge and on the mossland. Controlling this rhododendron will be an ongoing issue into the future as woodlands both to the north and south of the site harbour large amounts of this invasive species.



Photo 56 and 57: From left, South bog in 2015 and post clearance of surrounding trees 2016.

Alvanley

One of the largest sites within the project Alvanley had very deep water levels when the project started, which can impede the sphagnum colonisation. In order to be able to control these levels a metal sluice was installed on the main outflow. Once installed water levels were slowly lowered by two foot. This was done in order to encourage sphagnum growth, as during the first two years of the project no sphagnum was recorded on the site. Within six months of the water levels being lowered several large patches of sphagnum were recorded along the edge of the site, as well as many smaller clumps. The water will now be kept at its current level for several years to see if the sphagnum now spreads, however if it failed to do so it may be worth further lowering the levels. The decision was made not to clear the dead trees across the site, however areas of the pool are beginning to open up as more and more of the dead scrub and trees fall down in heavy winds or due to rotten trunks.



Photo 58 and 59: From left, Alvanley 2015 and 2017.

A01a, A01b, A03, A05 and A07

Interlinking sites in similar condition the A01a, A01b, A03, A05 and A07 can largely be treated as one site. The majority of the A0 series has been untouched during the project. It was decided to install an adjustable pipe at the main outflow on A01b to better control the outflow of all these sites, however water levels were not lowered due to concerns that it would make the sites less suitable for dragonfly species. Due to the depth of the water it was not possible to access the sites for future scrub clearance, however like Alvanley the trees are slowly falling due to rot and high winds, meaning the basins are slowly self-clearing. Some patches of sphagnum were spotted on the edges of the sites, though largely on areas of damp ground on the edge of the sites.



Photo 60 and 61: From left, A01a in 2014 and 2017.



Photo 62 and 63: From left, A01b in 2014 and 2017.



Photo 64 and 65: From left, A03 in 2014 and 2017.



Photo 66 and 67: From left, A05 in 2014 and 2017.



Photo 68 and 69: From left, A07 in 2014 and 2017.

A11

A new dam was installed on the outflow to this site to better control the water levels and secure the site before the Alvanley sluice was lowered. Scrub was also removed from the edges of the site. Although largely dead this has helped to open up the area allowing in more light for mossland species.



Photo 70 and 71: From left, A11 in 2014 and 2017.

Bilberry

Has been one of the driest sites within the project since the start, with little obvious potential to be rewet. However it was decided for volunteers to install a series of dams down the main drain of the site to try and slow loss of water from the area. Whilst all of the dams held water this was only to approximately a foot in depth which, though a significant improvement from the previously dry ditches, was nowhere near the three to four feet required to reach the top of the drains. However two dams raised the water levels of the lowest end of the site significantly more and have forced water out and into the surrounding area. This has resulted in the creation of several new pools which will hopefully in time hold sphagnum. A pipe was installed into the dam to carry away excess water. The young birch was left standing due to time constraints on the project and to create a slightly different habitat niche compared to the cleared pools nearby.



Photo 72 and 73: From left, Bilberry centre pre and post dam.

B09

A relatively small site at the start of the project B09 seemed to have little potential aside from acting as a stepping stone site between Doolittle moss and Piersons. However, after trees were cleared along its banks and the main outflow was blocked with a plastic piling and peat dam the site flourished. Previously too dark to attract many dragonflies it now regularly hosts the same species as its neighbour Doolittle. Additionally water birds such as teal are regularly found to be using the site. White sedge has spread across the waterbody and the sphagnum raft has significantly spread. The banks have not developed heathland vegetation as quickly as Piersons, however some bilberry, common heather, gorse and wavy hairgrass has begun to spread, indicating that future management could encourage heathland to thrive here. The presence of a white-faced darter on the site in the second year of the project also confirmed it be to a suitable stepping stone site, and that it may even one day be a suitable breeding pool for this species.



Photo 74 and 75: From left, B09 post clearance in 2015 and post flooding in 2016.

B12

B12 has grown significantly since the first year of the project. Clearing of the trees surrounding the site and the blocking of the outflow with a plastic piling and peat dam has allowed the site to expand and for mossland species to become better established. A good dragonfly population can now be observed to be using the area and a young schwingmoor has begun develop. White sedge has spread within the water, whilst bilberry plants are flourishing on the banks, where trees have been cleared. The north-eastern corner of the site is dominated by pondweed and bulrush due to the inflow of water from a drain with different water quality, however this patch does not appear to be spreading throughout the rest of the site. The trees drowned within the centre of the site are beginning to fall down which is further opening up this area.



Photo 76 and 77: From left, B12 in 2015 and 2017.

Fishpool moss

Whilst water levels were always high in the winter on Fishpool moss, the water inevitably disappeared each spring, resulting in this site becoming overgrown with willow. In order to encourage mossland species to develop it was decided to clear a hectare of the dense willow on this site. Once cleared work was carried out to ascertain whether any underground water flow existed. Excavation revealed a steady stream of water leaving the site on the north western tip. A bund was created in attempt to keep this water on the site for longer. Whilst the bund has been successful in rewetting the site for part of the year an additional consideration was the water quality on this site. Whilst testing the winter water on the site suggested the water to be clean discussions with the landowners revealed that an ornamental pool further up the catchment sometimes overflowed during high winter rains. Testing this pool revealed high nutrient levels. Investigations within the catchment revealed the source to be a waste water treatment plant. It is hoped this issue can be resolved by United Utilities in the long term, however in the short-term it is unlikely mossland species will thrive in the pool, though it may benefit local wildlife by developing as a wet woodland and reedbed in time.



Photo 78 and 79: From left, Fishpool moss post clearance in 2016 and 2017.

Harthill moss

One of the valley mire sites within Delamere, Harthill moss contains a slightly different species composition to the other mosslands, with large amounts of bog pondweed, bulrush and flag iris existing across the site. Due to the flat nature of the basin a bund was installed across the narrowest part of the site. This raised water levels by a foot across the site. The rise in water levels has encouraged the spread of aquatic species across the basin and rewet the large majority of the peat. It has also helped to kill most of the scrub which had begun to establish itself across the area, aside from the willow and alder which continues to grow. It is expected that the site will develop into a wet woodland and fenn complex. Some sphagnum still exists across the site, including the largest population of *Subsecunda* species in the forest. The only negative of the raise in water levels is that it has also spread the population of invasive water fern (*Azolla filiculoides*), which has already established itself on the site. However this invasive species does not seem to be able to outcompete the other aquatic species on the site, meaning it will hopefully remain within its current area.



Photo 80 and 81: From left, Harthill moss in 2014 pre-bund installation and post bund installation in 2016.

Harrisons

Harrisons was completely overgrown at the start of the project, with some small sphagnum lawns persisting in the centre of the site. The area was cleared by volunteers, with larger trees being removed by Forestry Commission staff. The water source for the site had been diverted into a drain between two high banks, this water was rerouted onto the site and several small dams installed to encourage the water to spread out across the area. Later a line of dams was installed towards the top of the site to create pools within the driest area of the site. Leaky dams were also created to slow water and encourage sphagnum growth. All this work has been highly successful, with sphagnum spreading quickly across the site and mossland species establishing themselves within the water and on the banks. Although water levels still fluctuate between the seasons the increased sphagnum cover means the areas stays damp throughout the year. An area of rhododendron was cleared next to the site to stop its spread. This area now floods for much of the year, meaning hopefully that any regrowth will be drowned. Higher ridges on the site suffer from regrowth of saplings and bramble, however bilberry and wavy hairgrass are also establishing themselves here.



Photo 82, 83 and 84: From left, Harrisons in 2014, 2015 and 2016.

Hungerhill

The least developed site within the project Hungerhill had the longest way to go to being a healthy mossland. Since the hemlock plantation was cleared and the main outflow was

blocked the site has come on in leaps and bounds with over half the area having been flooded and the drier half being covered in pools and wet drains. No mossland or heathland species were found across the site pre-restoration work, however within a year of being flooded three species of sphagnum were discovered, scattered across several pools. Additionally common heather and bilberry species have starting to grow across the drier areas. No dragonfly species were observed using the site before clearance, however already high numbers of four spotted chaser, southern hawker, black darter, common darter and damselfly species have been observed on the pools. A pair of yellow wagtails was also noted on the site during nesting season and oystercatchers bred on the site for the first time in the last summer of the project. To reduce the maintenance required on the site four bunds were installed across the drier end to raise water levels here. This has been successful though due to the hummocky nature of the site some ongoing management of the scrub, bramble and bracken will be required, however if managed correctly it is likely heathland will establish across these higher areas.



Photo 85 and 86: From left, Hungerhill pre-clearance in 2014 and post-clearance and flooding in 2016.

Longshaw

Longshaw was one of the last sites to be cleared within the forest. Having been cleared of conifers by Forestry Commission contractors three peat and plastic piling dams were installed on the main drain running through the site. This significantly raised the water levels allowing much of the peat basin to be rewet, however due to the sloping nature of the site, and the hummocky ground, much of the site will still be prone to invasion by bramble and scrub, meaning that ongoing management will be required.



Photo 87 and 88: From left, Longshore moss pre-clearance in 2015 and post-clearance in 2017.

N1

A relatively small site on the edge of the forest N1 seemed to have very little potential initially, however once the trees were cleared with the help of the Forestry Commission and the main outflow dammed the site expanded significantly. It is hoped that this site will act as a stepping stone for species from the surrounding landscape sites into the forest. Although no dragonflies were observed at the site previous to water levels being raised six species were observed within a few months of the work being carried out. Although an overflow pipe was initially installed into the dam the water has now begun to find an alternative way through to the next site when the pool is particularly high. This is a much more natural system, meaning the pipe can be removed.



Photo 89 and 90: From left, N1 pre-clearance in 2014, post-clearance in 2016 and post-flooding in 2017.

N2

A relatively well developed site N2 already supported a large sphagnum lawn at the start of the project. A drain was installed on the main outflow, however the water levels did not rise significantly. Trees were cleared from the surfaced of the site, and in a buffer area surrounding it. Scrub was also cleared by volunteers.



Photo 91 and 92: From left, N2 pre-clearance in 2015 and post-clearance 2016.

N3

A good quality mossland containing bog cranberry, cross-leaved heath and common cottongrass N3 needed scrub removal work to be carried out to open up the site and stop the trees from drying up the site. Rhododendron was also present on the edge of this site and needed to be cleared and treated. A line of trees was left next to the path to dissuade walkers from wandering onto the mossland surface. Trees were cleared along the drain running from this site to the next and small stepped dams installed, in order to create better linkage between the N series.



Photo 93 and 94: From left, N3 pre and post clearance in 2015.

N4

Conifer trees were still present on this site at the start of the project, and were cleared in the last year. Although some ditches existed within the basin with good amounts of sphagnum present, raising the water levels will to allow these species to spread out across the site.



Photo 95 and 96: From left, N4 pre-flooding 2017 and installation of dam in 2018.

Thieves' moss

Thieves' moss is owned and managed by the Forestry Commission but used by an archery club for field archery. Initial plans had been to remove fallen trees from the mossland area of the site and install several step dams into the main drain. However practical considerations meant that this plan could not be carried out and, without the trees being cleared, the main drain was not accessible for the installation of dams. An alternative plan of action for the site was to raise the water levels of the pool, which has been lowered through the installation of a drain. A sluice was installed on the main outflow and levels were then raised by the installation of sluice boards to ensure a gradual rise. Due to the site being home to grass snakes and great crested newts, as well as historically being home to adders, additional areas were cleared within the scrub to create new basking spots, due to the loss of basking spots by the flooding of banks. This help to rewet some of the mossland areas. Large areas of Himalayan balsam were also discovered on the site, having spread from neighbouring farmland. As well as hand pulling this invasive species with volunteers training was given to the Thieves moss archers, who carried out large amounts of pulling themselves.



Photo 97 and 98: From left, Thieves' moss pool 2016 and 2017.

Wickentree waste

Once home to a number of rare species, including the marsh violet and the small pearl bordered fritillary Wickentree Waste and Fen became too dry due to the dredging of surrounding drains and became overgrown with scrub. Volunteers cleared trees from the site and the local group the Norley wildlife group have pulled bracken, bramble and saplings from the site for several years. The site is still dry during the summer, despite the installation of several dams, however it is significantly wetter in the winter months, meaning sphagnum has expanded in the damper areas, and particularly within the drain. Purple moorgrass and wavy hairgrass have spread across the drier areas due to the bracken being kept in check and bottle sedges have expanded within the drain. Whilst it is unlikely the site will rewet enough to become as biologically interesting as it once was, continued management of undesirable species should allow the mossland species to expand and establish an acid grassland in the surrounding areas.



Photo 99 and 100: From left, Wickentree waste centre post-clearance 2015, and once vegetation had begun to grow in 2016, rushes and sphagnum had expanded significantly.



Photo 101 and 102: From left, centre of site in 2016 and 2017. Grasses, sedges and sphagnum have all expanded due to increased light and water levels and the control of the bracken on site.

Corridors

Several wildlife corridors have been created across the forest to try and encourage the dispersal of mossland species. These have largely been cleared along existing drains by small step dams being created with plastic piling to help the ditch better retain water levels. In

some places small pools have also been created through this damming. Corridors now link Doolittle, B10, B09, Piersons and Great Blakemere, Norley, N1, N2 and N3, Doolittle, Great Midgel, LM09/LM10 and Black lake, and Great Blakemere, Bilberry and Birchenholt North. These corridors are the most maintenance heavy areas within the project and will need annual control to keep back bramble, bracken and scrub regrowth. However already dragonflies and birds have been seen using these areas as flight lines, moving between the various pools. Additionally mossland species have begun to establish within the water features, such as sphagnum and white sedge, and heathland species on the banks such as pill sedges, bilberry and common heather. Whilst the maintenance of these areas will be very high the additional species movement they will encourage in a large plantation forest will be highly beneficial for the future of the mossland species.



Photo 103 and 104: From left, corridor between Great Blakemere and Doolittle post-clearance in 2015 and in 2016. Stepped dams have helped keep winter water levels high allowing sphagnum, rushes and bilberry and heather to expand along the corridor.



Photo 105 and 106: From left, pool in Doolittle to Pierson's corridor pre-damming in 2015 and post-damming in 2016.



Photo 107 and 108: From left, Doolittle and Pierson's corridor 2015 and 2016.

2.1.3 New sites

Throughout the project a number of new projects were taken on for management either due to their suitability as stepping stone sites or due to their individual ecological value.

Barnsbridge flushes

Barnsbridge flushes was taken on by the project due to its ability to provide a link between Longshaw and the A0 series. Running up from the top of Longshaw to the forest road the site already had a good sphagnum lawn before tree clearance began and relatively deep water within a series of drains. Trees were removed by volunteers and the main drain blocked several times along its course to force the water out into drier areas. Unfortunately water levels have not risen significantly. Bunding would be recommended to raise levels in the future.



Photo 109 and 120: From left, Barnsbridge basin post-clearance 2017 and post-flooding 2017.

B05a, B05b, B06

The B series was selected for restoration due to work carried out by Manchester Metropolitan University to test water quality throughout the forest. This work highlighted that runoff from the road was finding its way into Piersons, such as road salts during the

winter. As a potential future breeding site for the white-faced darter it was important to ensure Piersons water quality remained high. The B sites, which were already fairly wet, were dammed to act as sumps for Piersons. These sites should also benefit from increased stability in their water levels and be valuable stepping stone to site north of the road.



Photo 121 and 122: From left, B05a 2017 pre-flooding and post-flooding.



Photo 123 and 124: From left, B05b pre-flooding and post-flooding.



Photo 125 and 126: From left, B06 pre-flooding and post-flooding.

B10

This site sits between Doolittle moss and Great Blakemere. Some sphagnum already exists within this area and it acts as a good stepping stone between these two important mosslands. When the dam across the mouth of the site began to leak it was decided to install plastic piling as well as an overflow pipe to stabilise the levels.



Photo 127: B10 post-flooding.

GM1

This small site sits on the edge of Great Midgel. Prior to clearance it already contained a large amount of sphagnum. It was decided to clear trees from the basin and install a plastic piling and peat dam to create better connectivity between Great Midgel and Black lake. Water levels rose quickly once the dam has been installed, flooding the area. Within a few weeks of clearance several teal were observed using the site and soon afterwards several species of dragonflies were observed using the pool.



Photo 128 and 129: From left, GM01 post-clearance in 2016 and post-flooding in 2016.

GM2

A large, very wet, site on the northern edge of Great Midgel GM2 was added to the project to encourage better connectivity between the sites either side of the main road. Access to the site was difficult due to the high water levels, however volunteers cleared scrub from the site wherever possible to open up the pool a little better.



Photo 130 and 131: From left, GM2 pre-clearance 2016 and post-clearance 2017.

GM5

A small site on the edge of Great Midgel GM05 was selected both to improve connectivity and due to its location on the edge of a forestry track, meaning visitors would be able to view this small mossland. The area was cleared of scrub by volunteers and a dam installed on the outflow. The dam raised water levels by roughly 1 foot, however due to the presence of a sand embankment the water leached out slowly when rainfall was low.



Photo 132 and 133: From left, GM5 pre-clearance and post-clearance 2017.

GM6

Situated opposite GM5 on a main path GM6 contained little water and many large conifers prior to restoration. The conifers were cleared with the help of Forestry Commission personnel and a dam installed in the main outflow. This raised water levels significantly and a pool was created. This area will hopefully be frequented by dragonfly species in the summer, which passers-by will be able to enjoy.



Photo 134 and 135: From left, GM6 pre-clearance and post-clearance 2017.

Ham upper and Ham lower

The Ham series was chosen to be added into the project due to their location between Hungerhill moss and the Hatchmere peat basin, and the N series and the Barnsbridge series, meaning they provide excellent stepping stones between the north, south, east and west sites. Ham upper was already flooded when taken into the project. With a good amount of sphagnum present, the site was dammed and cleared of accessible trees to stabilise water levels and increase the amount of light reaching this site. Ham lower was much drier with little sphagnum or water, and a large amount of young birch across the basin. This birch was cleared and burnt, and a dam placed across the main outflow, raising water levels.



Photo 136 and 137: From left, Ham upper pre-clearance and post-clearance and flooding 2017.



Photo 138 and 139: From left, Ham lower pre-clearance and post-clearance and flooding 2017.

M08

Around half of the LM08 peat basin was already in good condition, with large amounts of sphagnum across this area, however half of the site was still covered in large conifers. These were cleared by Forestry Commission staff, whilst the smaller scrub on the more open area was cleared by volunteers. Wood was removed by contractors and the outflow was then dammed to increase water levels to prevent scrub regrowing across the site.



Photo 140 and 141: From left, LM08 pre and post-felling in 2017.

2.2 Landowner and public engagement

2.2.1 Landowner engagement

Project site landowners

Eight landowners existed within the project, including private landowners, the Forestry Commission, the Norley Parish Council and the Cheshire West and Chester Council. Throughout the project landowners were engaged with to ensure the work being carried out did not negatively affect their requirements. Additionally landowners were offered advice on how to improve surrounding land to create wider wildlife benefits.

In Delamere Forest the project inputted into the ten year forest plan, which included highlighting the meres and mosses as areas for wildlife not to be replanted and wildlife corridors between key sites being maintained to encourage movement of wildlife. Good communication between partners also meant that when thinning was being carried out of plantation forest near restored mosses, trees on the edge of some of the sites were cleared to let in more light. Coordination with forestry contractors has also meant that wood felled by hand could be picked up by contractors, avoiding the need to burn. Work with the Forestry Commission civil engineers has also meant that in two places forestry tracks were raised where water levels were damaging these paths, meaning that levels could be maintained without impacting the surrounding land use.

On two sites reptile surveys proved particularly useful in terms of informing surrounding land use. On Thieves moss surveys were carried out on the edge of Thieves moss pool to assess whether reptiles were using this area for basking. After a high number of grass snakes were found in these areas it was decided that the Forestry Commission would open up other basking areas within the plantation next to the pool, in order to mitigate for the potential loss of basking sites once the water levels were raised on the pool, in order to rewet the surrounding mossland. On Brackenhurst bog, a privately own site, reptile surveys also showed an excellent population of grass snakes to be using the site. The land surrounding the site was at the time being converted from rough pasture, scrub and young woodland back into commercial pasture, meaning there was a potential risk that the grass snakes would become isolated, particularly from the nearby woodlands. It was therefore agreed with the landowner that a strip of land would be left untouched, in order to act as a corridor for the grass snakes.



Photo 142: Grass snake found during surveys on Brackenhurst bog 2017.

External landowners

Management changes

As well as working with landowners within the project, landowners surrounding the project sites were targeted. In particular those landowners who managed peat basins around the Delamere area were targeted to ascertain if the changes in the management of the land could be beneficial for nature. Several of the peat basins south of Small Brook had extensions which reached beyond the project areas. At Wickentree waste an area of wet grassland which holds a number of wet meadow species including ragged robin had previously been managed as a hay meadow by the owner. Since land ownership had changed three years ago the cutting of hay on the site had stopped, and as no grazing was taking place on the area aside from the occasional introduction of horses there was some risk that the meadow would scrub over. The current landowners were contacted and information shared with them about the site and how best to manage it to encourage the current suite of species to thrive. The landowners agreed that they would consider their options and were keen to ensure the site remained in good condition. No management changes have been made to date, though there is potential they will be changed in the future.



Photo 143: Ragged robin and other meadow flowers in full bloom at the Wickentree waste meadow.

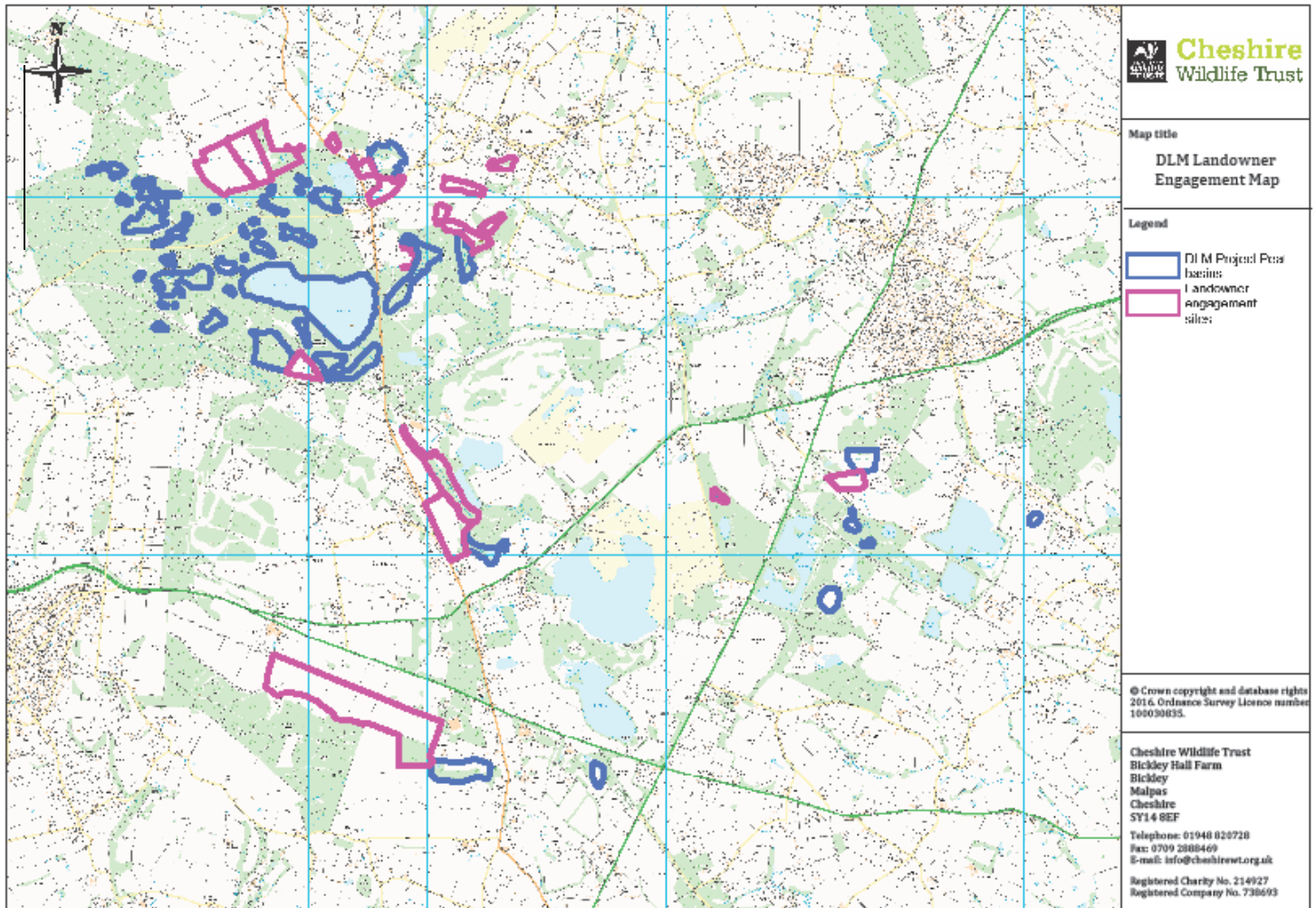
Further along Small Brook another landowner was contacted regarding a second area of wet grassland, which had already scrubbed over, as well as about a drained area of peatland within their farmland. It was agreed to remove some of the scrub from the grassland to encourage the growth of meadow species. Unfortunately the area of peatland could not be rewet due to conflicts with existing land use.

The final area of wet grassland along the Small Brook, belonging to another landowner, was visited to ascertain if changes in management could be put into place. As the wet grassland was grazed at the recommended density each year, and the rush topped during the autumn it was felt management was already appropriate. A good number of meadow species were observed here. It was noted that management had changed from a more intensive system in the last decade, which was potentially why meadow species were less numerous than at Wickentree waste.



Photo 144: Wet grassland and meadow flowers opposite Harthill moss.

Landowners for a wet woodland along the brook were also contacted, however they were not keen to make any changes to the management of this site.



Map 3. Landowners engaged throughout the Delamere's Lost Mosses project.

2.2.1.1 Invasive species control

Throughout the project several areas were highlighted where invasive species were either causing damage to sites directly, were likely to spread onto sites or were damaging potential stepping stone sites. Work was then carried out to control invasives with volunteers or to give landowners the tools to manage these invasive species themselves.

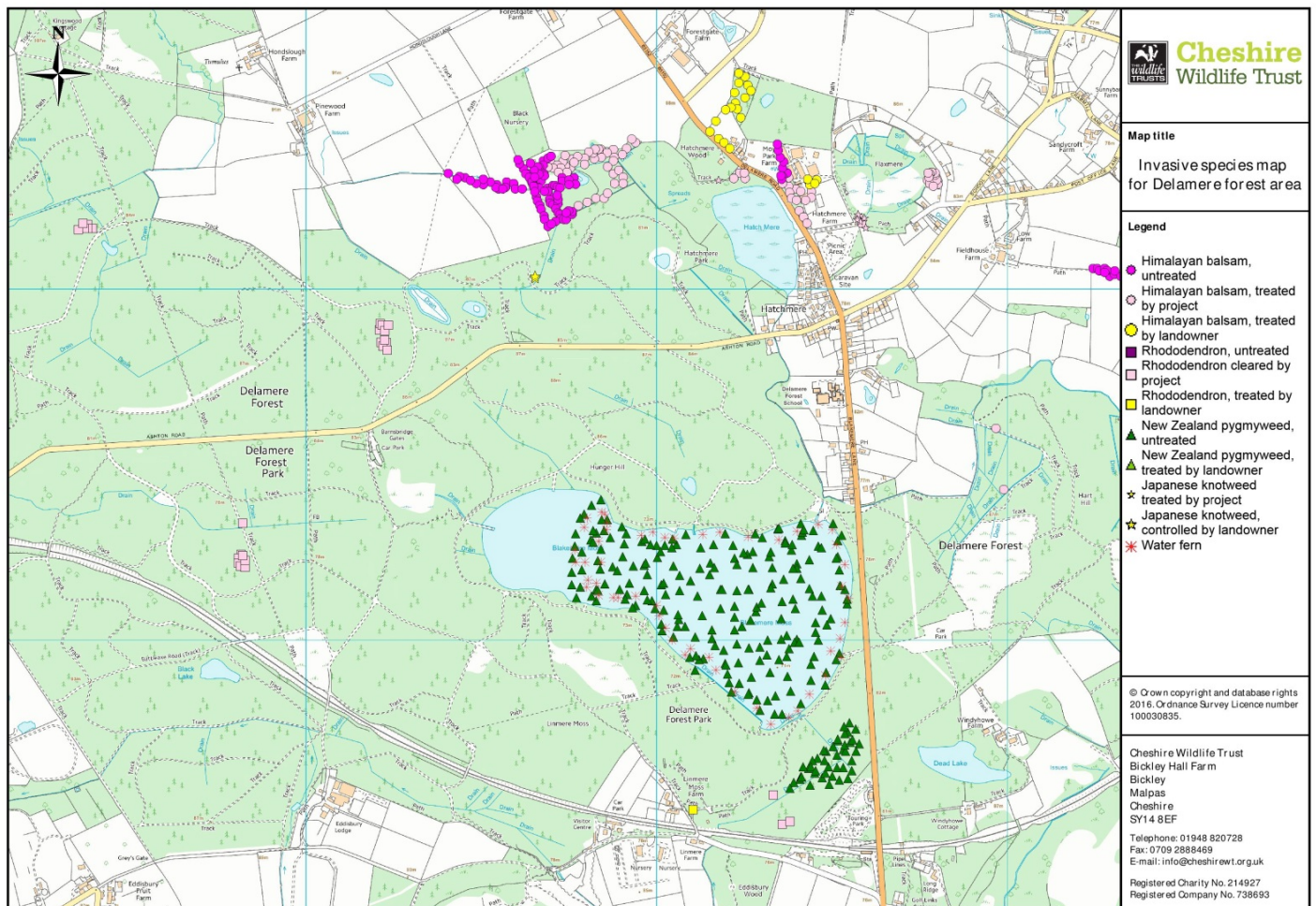
Flaxmere

A stand of Japanese knotweed was discovered on the edge of the site, which if left unchecked could easily have spread onto the surface of the moss. This area was fenced off using volunteers and treated by the CWAC ranger and the project officer, using both stem injection and spraying for several years.

Himalayan balsam was discovered in a large patch on the edge of the moss. This was controlled by hand pulling by the Norley Wildlife Group with the help and guidance of the project officer. Several years of pulling by the group have now eradicated this patch.

More Himalayan balsam was discovered across several privately owned areas on the south of the site. Volunteers assisted to hand pull most of the area in the first year in

order to bring it down to a level where the landowners could control it independently. Three landowners are now controlling the balsam on their land themselves. Unfortunately one landowner still has not engaged with the project, and is not controlling the Himalayan balsam on their land, however the areas being controlled have created a buffer between the area of Himalayan balsam and Flaxmere and Hatchmere SSSIs.



Map 4. Invasive species found around the Delamere, Hatchmere and Flaxmere peat basins.

Hatchmere

On Hatchmere Himalayan balsam was found to be entering the mossland along the main inflow. Tracking the balsam along this inflow large amounts were found throughout the rest of the peat basins, owned privately, and along the ditch in the farmland beyond. The farmer was contacted and agreed to control the balsam on his land, however failed to do so prior to it seeding. It is hoped that another attempt may be made to do so next year. The owner of the peat basin agreed to attempt control but agreed that the area was too large and difficult to access for them to clear the balsam independently. Therefore volunteers were used to clear the balsam throughout the difficult to access areas on this site, in particularly the wet woodland which comprised most of this area. Volunteers helped to clear the balsam up until

the more open grassland areas of the site, meaning management is much simpler and more achievable for the landowner from this point forward.

Fishpool

A landowner north of Fishpool moss was contacted about a small area of Himalayan balsam on their land, which they agreed to spray in order to control.

Thieves' moss

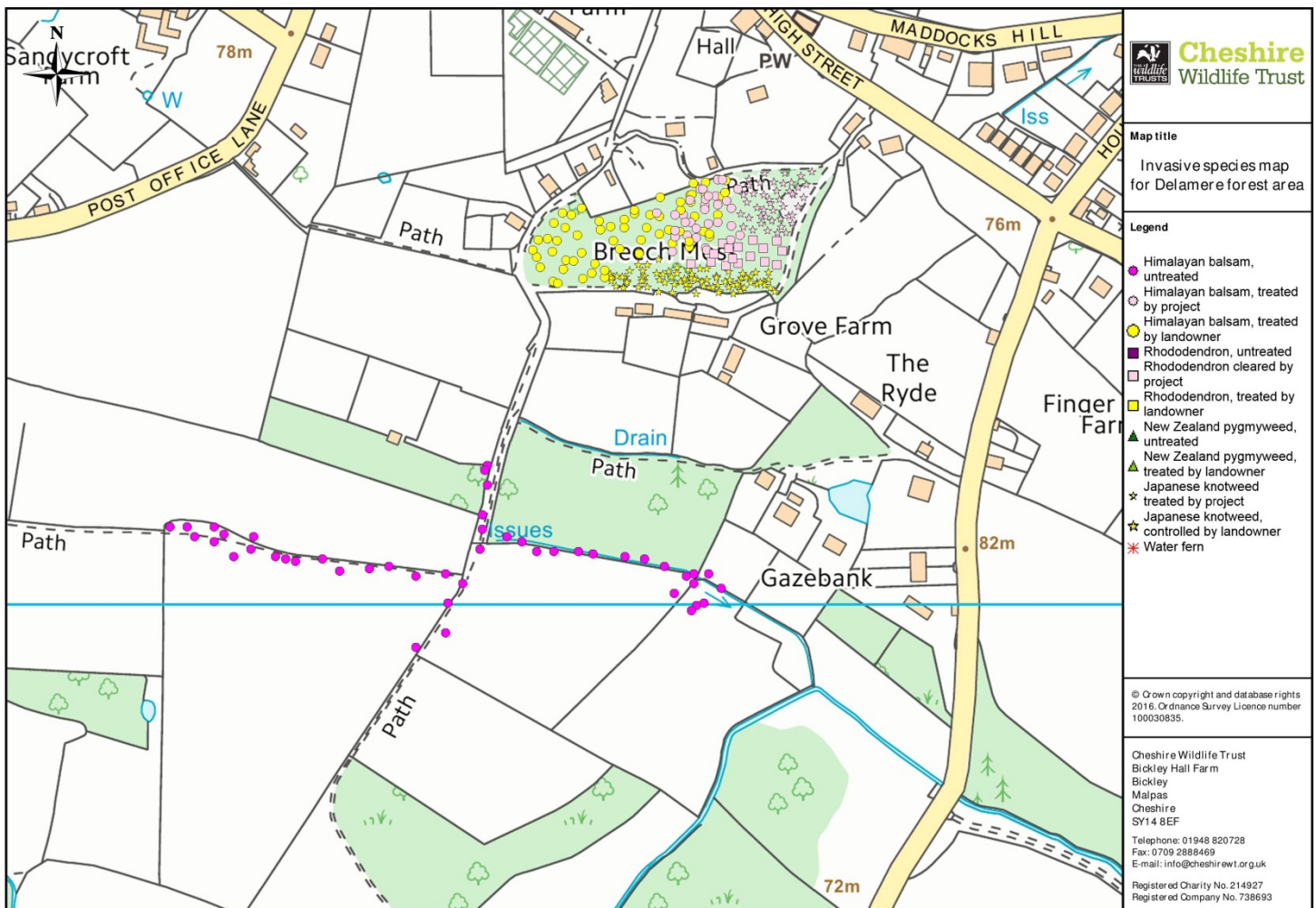
At Thieves moss Himalayan balsam was introduced by accident with wood chippings used to service a farm track. When first discovered it had spread through some of the Thieves moss woodland, a large area of the neighbouring land at Relick's moss and along the edge of a privately owned field. In the first year of control volunteer's cleared areas in both Thieves moss and Relick's moss but many stands went to seed before too long. In the second year the Thieves moss archery club, with guidance from the project officer, cleared the patches on Thieves moss whilst volunteers tackled the areas on Relick's moss. The landowner of the fields was also engaged to control his patch, which he intended to spray later in the year, but unfortunately the patch went to seed before spraying was possible. The landowner of Relick's moss was also engaged and agreed to begin control of the balsam in 2018. It is hoped that next year landowners will be able to control the reduced patches independently and this area of balsam can be eradicated before it spreads throughout more of these important wildlife sites.

Breech moss

Although not within the project Breech moss was highlighted as a potential stepping stone site by the Norley Wildlife Group. Infested with large amounts of Japanese knotweed, Himalayan balsam, rhododendron and other garden escapees the site was in poor condition. The project officer treated areas of the knotweed and communicated with the Norley Parish Council to ensure the rest of the stand was similarly treated. The Norley Wildlife Group hand pulled the Himalayan balsam and cut and burned the rhododendron. Training made available to the group by the Cheshire Wildlife Trust allowed members to be trained in pesticides usage so they could treat stumps and regrowth where needed. The site was also cleared of rubbish by the group and surrounding landowners engaged in control of the invasives on their land. The site would benefit from work to clean up pollution sources entering the peat basin, and blocking of drains across the area, as well as thinning of the canopy in the future, but the invasive management so far has already offered significant improvements to this largely forgotten peat basin.



Photo 145: Treated Japanese knotweed at Breech moss Local Wildlife Site.



Map 5. Location of invasive species around Breech moss.

Petty pool

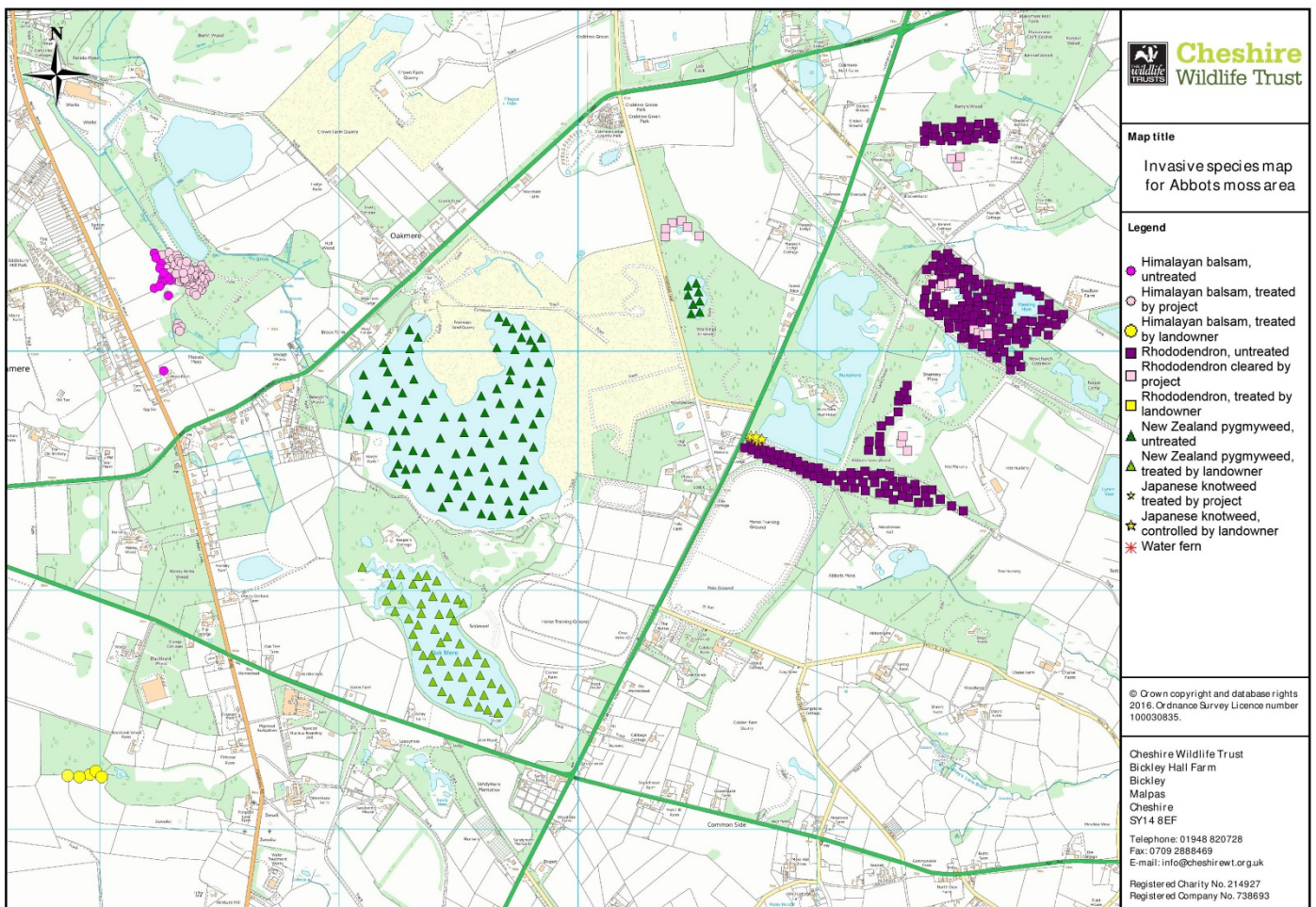
The Petty Pool Trust has worked with the project on a number of peat basins within the forest with their students. A site visit was made to the area of woodland, adjacent to Petty Pool SSSI, owned by the Trust and several volunteer days were held thereafter to help clear several patches of rhododendron across this area with the help of students and project volunteers.



Photos 146 and 147: Burning Rhododendron at the Petty Pool Trust woodland, adjacent to the Petty Pool SSSI, with students at the school.

Hogshead moss

An excellent condition mossland, Hogshead moss is a good stepping stone site between areas such as Abbots moss and Delamere Forest. However rhododendron had become an issue on the site so the landowner was contacted and access was granted for a volunteer party to clear the land of this invasive species.

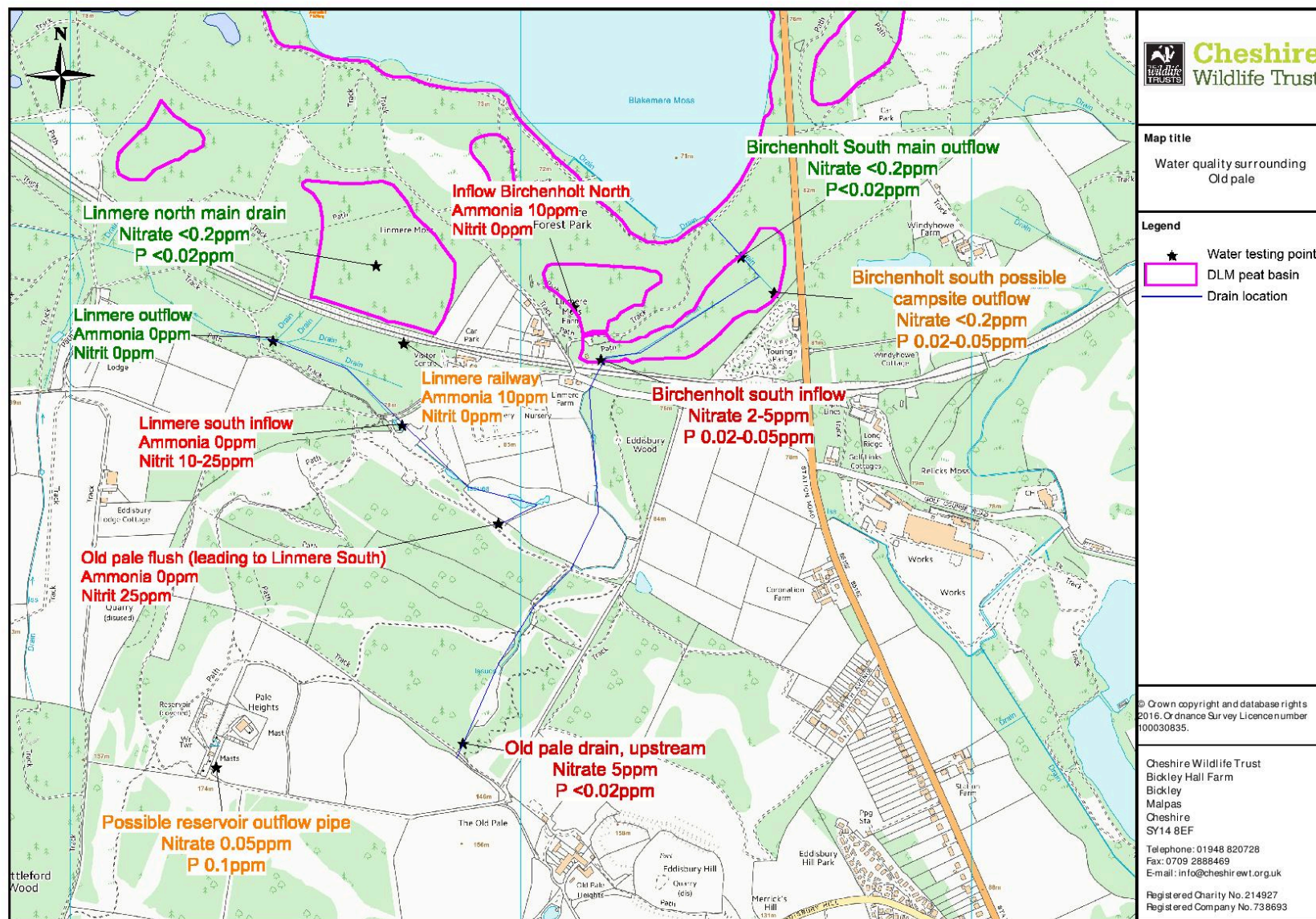


Map 6. Location of invasive species around the Abbots moss area.

2.2.1.2 Water quality testing

Water quality was tested across several sites within the project to ascertain where issues may exist which could be resolved. Initial testing took place within Delamere around sites located close to Old Pale. This testing showed high nitrate and nitrite levels to be coming from Old Pale and entering Linmere South and Birchenholt South. No clear source could be found for these issues however several options were considered to mitigate the problem including attenuation ponds and reedbeds. However due to existing constraints no solution was found at this time, though there may be scope to implement these solutions in the future. For now both Birchenholt south and Linmere south are themselves acting as cleaning systems for the water, with water coming in with high levels and leaving with levels too low to be detected. Additional pollution issues were found on Linmere south close to the railway, where high ammonia levels were detected, presumably washing off from the railway itself.

At Birchenholt north a separate issue was found with a pipe entering the site on the western edge of the peat basin. This was found to be carrying high ammonia and phosphate levels onto the area. This is an old drain which takes water from the roofs of the neighbouring houses. After discussions with the landowners no clear source for the high levels could be found and it was decided to create an attenuation pond on the outflow of the pipe to clean the water before it entered the site.



Map 7. Water quality around Old Pale in Delamere Forest.

Flaxmere Moss

The source of the high nitrate levels in the water entering the Flaxmere external drain through a pipe was investigated, however it was concluded this was due to runoff from the road. Although no clear options presented themselves for stopping this runoff it was found the pool created by the bunding on the edge of the moss acted as an attenuation pond, cleaning up the water before it continued to Hatchmere.

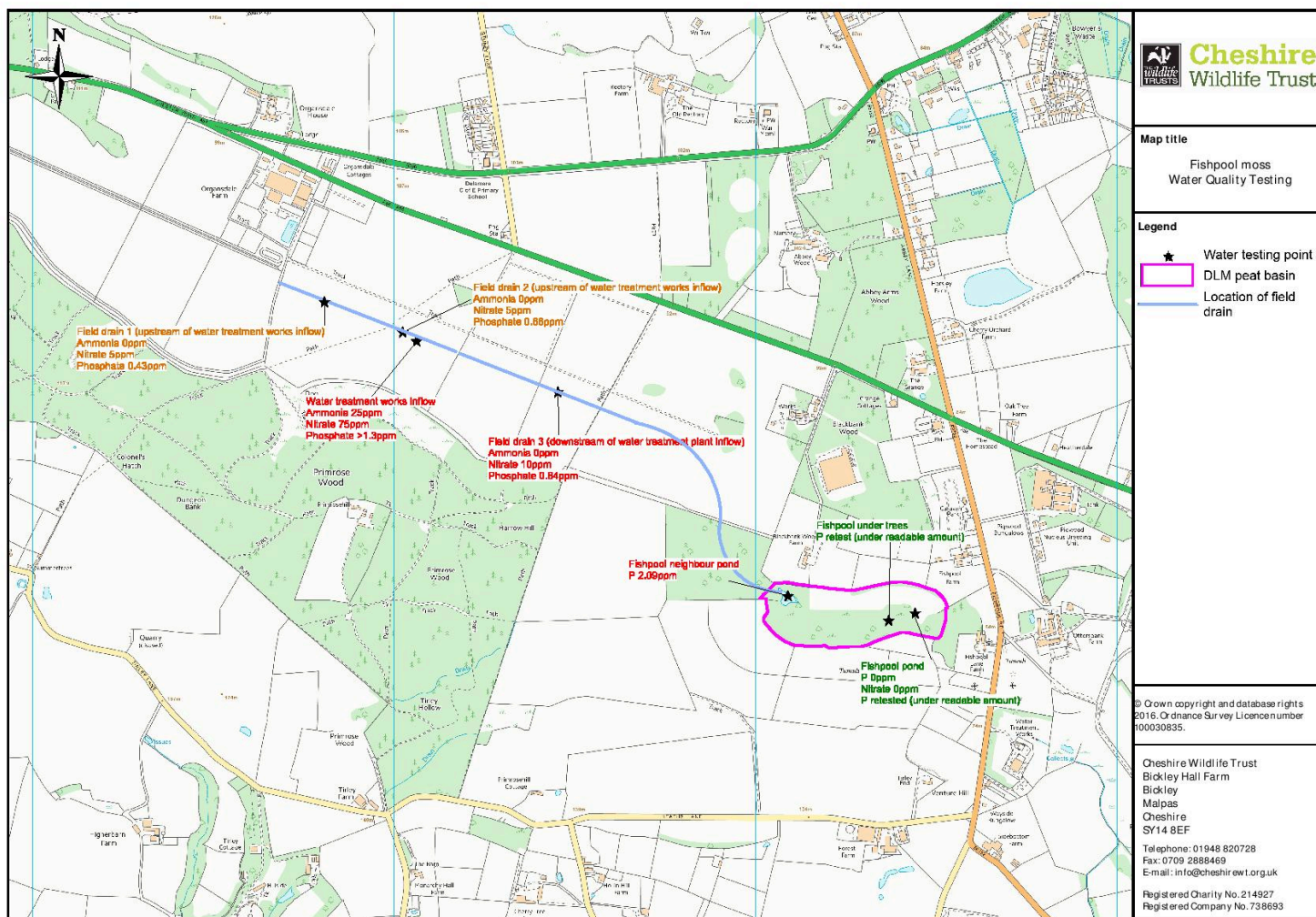


Photo 148: Delamere's Lost Mosses trainee taking water samples from ditch surrounding Flaxmere.

Fishpool Moss

On Fishpool there were clear indication of raised nutrient levels such as the presence of large amounts of nettles on the site, however water testing within the pool during winter showed no elevated levels. However discussions with the landowner indicated that a pool upstream occasionally overflowed into this site. Testing this pool, and the inflow into it, showed very high phosphate levels.

Discussions with the landowner north of Fishpool resulted in the testing of a land drain which emptied into the Fishpool pool. Water from a water treatment works was known to enter this pipe and testing before and after this additional inflow resulted in the conclusion that most of the high nutrient levels were coming from the water treatment works. The owners of the works were contacted and it is hoped a solution can be found.



Map 8. Water quality on land surrounding Fishpool moss.

Brackenhurst Bog

Although most of Brackenhurst Bog appears to be in excellent condition the western edge of the site had become very overgrown with scrub at the start of the project, despite being very boggy. A seasonal stream was found on this edge and testing it revealed very high phosphate levels. No clear source was found for the issue but discussions were had with surrounding landowner to try and find the source. For now no solution has been found but with this information it is clear that management of scrub on the western edge of the site will need to be more regular than across the rest of the area.

Land acquisition

Through the work carried out with landowners in the Delamere area several sites were highlighted for land acquisition by the Cheshire Wildlife Trust in order to improve them for wildlife. The area of wet woodland north of Hatchmere SSSI was offered to the Trust by the landowners during discussions over the Himalayan balsam on this site. The site has now been added to the Hatchmere Nature Reserve increasing the reserve by a third. As well as allowing better control of the inflow, and almost giving management of the whole peat basin to the Cheshire Wildlife Trust

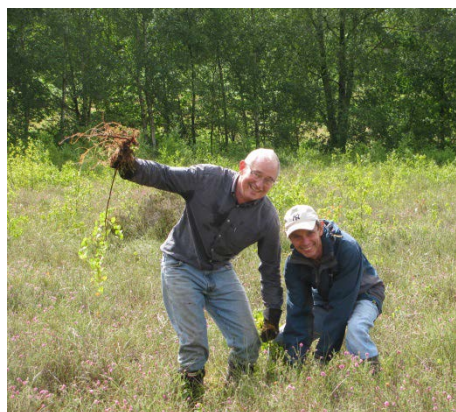
there is also a possibility to create new areas of wet grassland, wet woodland and fen habitats within areas of the site currently covering in conifer plantation.

Hogshead moss and wood is an area of conifer plantation and a few wetland areas, which has decreased in wildlife value over the years. Large areas of heathland have been lost from this site, but could easily be re-established through the clearing of the conifer plantation. Through discussions with the landowner an opportunity arose to buy this parcel of land, which the Cheshire Wildlife Trust decided to pursue. Discussions are still taking place but there could be excellent wildlife and connectivity benefits gained through the restoration of this site.

2.2.2 Public engagement

Volunteers

Throughout the course of the project over 1,500 volunteer days have been worked across the sites by volunteers carrying out a range of activities; from clearing scrub, to pulling balsam, to surveying for species. Around 150 volunteers signed up to the project mailing list, with approximately half of these engaging directly with the project at some over the course of the four years. Many on the mailing list who never became physically involved in the activities advertised continued to follow the work being carried out through the regular emails and occasionally gave feedback of their personal experiences on project sites. Approximately forty individuals took part in activities on a regular or semi-regular basis at various stages throughout the project, whilst approximately a dozen continued to volunteer on a regular basis throughout the whole of the project. Four volunteers in particular attended almost every volunteer day from the first to the last.



Photos 149, 150 and 151: Four volunteers attended most of the volunteer days throughout the project, contributing significantly to the work on the mosses.

Women were well represented within the project volunteers, composing exactly half of the mailing list. Whilst volunteer days themselves generally held higher numbers of men roughly a third of the semi-regular volunteers and a similar percent of the regular volunteers were female.



Photos 152, 153, 154, 155 and 156: Female volunteers taking part in practical volunteer days.

Younger generations were also comparatively well represented. Although the majority of the volunteers were retired or semi-retired several working adults also attended weekend sessions. Particularly encouraging was the number of 14-21 year olds who attended throughout the project. Eight 14-18 year olds attended, accompanied by their parents, using the hours accumulated to gain Duke of Edinburgh awards. Two of these young adults attended for a number of years and gained more than one DoE for over the course of their volunteering. One parent accompanied at first his daughter through gaining her certification with the project and then his son for the same purpose.



Photos 157, 158 and 159: Young volunteers carrying out practical work throughout the project.

The majority of volunteers came from villages surrounding Delamere Forest and nearby towns such as Chester, Northwich and Winsford, and were familiar with the area prior to volunteering. A handful came from further afield, particularly from suburbs of Liverpool and Manchester. Some were signposted to the project through the Forestry Commission. Even for those who lived locally, and visited the forest regularly, were unfamiliar with the meres and mosses of the area and very few had visited, or been aware of, the project sites previously.

Over the course of the project, based on contractor costs for similar work, the volunteers have been estimated to have saved the project over £200,000 through carrying out scrub clearance, damming and invasive species control.

Trainees and work experience

Ten work experience students took part in the project, working for a one to four weeks depending on preferences. Two of these students are known to have gone on to work in conservation whilst others expressed an interest in doing after the work experience was completed.



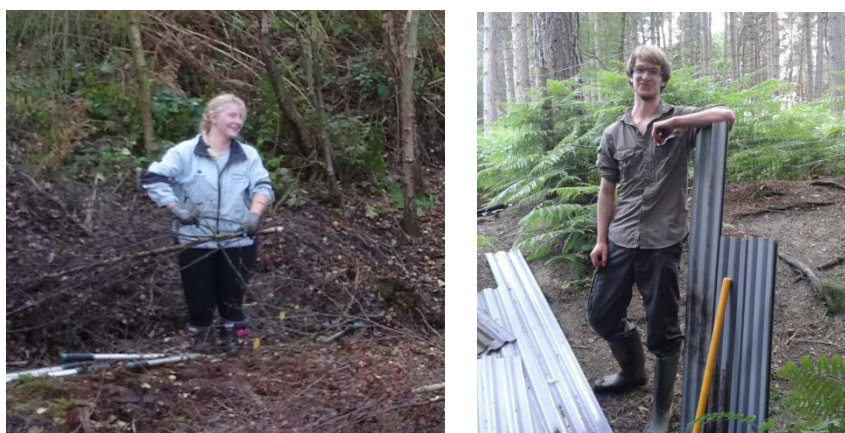
Photos 160, 161, 162 and 163: Work experience students assisting on the work within the project.

Four trainees carried out year-long placements with the project, and two shorter placements with a six month summer placement and a three month winter placement. Five of these stayed for the full term of the placement. Three of the trainees were existing volunteers, known to the project, and one was a volunteer for the Delamere's Dragons project. Of these trainees one had initially started in Cheshire Wildlife Trust's Access programme, which aims at giving young people not in employment, training or education conservation skills to improve their employability, before becoming a volunteer for the project and then a trainee. Two trainees took on roles at the Cheshire Wildlife Trust after their placements, whilst three more gained positions elsewhere in the environmental section. The remaining trainee remained in education whilst volunteer in other roles for the Cheshire Wildlife Trust.



Photos 164, 165, 166, 167, 168 and 169: Six trainees were taken on throughout the project, from a variety of backgrounds and ages.

Aside from volunteers taken on to be trainees within the project two other volunteers were given guidance to help make their way into conservation, one gaining a traineeship elsewhere in the Cheshire Wildlife Trust before going on to paid work within the trust and one gaining a traineeship with the National Trust.



Photos 170 and 171: Two project volunteers went on to gain employment within conservation.

Local groups

Two local wildlife conservation groups operated in the Delamere Landscape throughout the project. The Pale volunteers existed prior to the start of the project and assisted with aspects of practical management on Pierson's and carried out bird surveys for the project. Additionally they carried out work within Lobslack nursery on grassland, pond and woodland restoration.

The Norley Wildlife Group was formed at the start of the project and has worked closely together with the Delamere's Lost Mosses to help improve Norley for wildlife. The group has carried out regular scrub clearance on Flaxmere SSSI, as well as hand pulling the Himalayan balsam in this area. They have also taken on the management of Breech moss, a drained mossland near Flaxmere, removing Himalayan balsam and rhododendron. Additionally they have taken on the management of Wickentree waste, pulling bracken and bramble and clearing

rubbish from the site. The group has also carried out woodland management and wildflower planting in the area.



Photos 172 and 173: The Norley Wildlife Group carrying out scrub and invasive species control.

Corporate groups

Eight corporate volunteer days were given during the project to a variety of groups from Cheshire Wildlife Trust corporate members to the work colleges of regular volunteers.



Photos 174 and 175: Corporate groups carrying out practical habitat management.

Events

Throughout the life of the project 15 guided walks were held and 10 talks. These were to a varied range of groups, from members of the public to Women's Institute groups to members of the scientific community. The most notable walks were given to the Society for Ecological Restoration, the Chartered Institute of Environmental and Ecological Management and the Minister for the Agriculture and the Environment. Ten visits were made by university groups including Manchester Met, Bangor and Chester Universities. These trips included an introduction to the meres and mosses and gathering data from the sites. From these trips three Bachelors and three Masters projects were carried out in the forest.



Photos 176 and 177: University groups visiting project sites for fieldtrips.

As well as events training days were offered as part of the project. Ten training days were carried out throughout the life of the project, including training in reptile, butterfly and sphagnum identification, training in charcoal making and in carrying out rapid habitat assessments.



Photos 178 and 179: Training days engaged members of the public in the work taking place in the Delamere landscape area.

Publicity

Media, TV, newspapers

Ten articles were published in local newspapers about activities within the project. Regular updates were also sent out into the local parish newsletters updating the local community on the work being carried out within the project. The project was also fortunate enough to be featured on ITV's Countrywise in the third year. News of the project was shared on the Cheshire Wildlife Trust's Facebook page and in its membership magazine. Additionally a weekly Twitter campaign was set up in the final year of the project to engage a greater number of people in the mosslands and the work being carried out.



Photo 180: ITV's Countrywise filming a piece on the restoration of the mosses.

Awards

In the final year the project was awarded the CIEEM Best Practice award for a Largescale conservation project. This award demonstrates that the project was carried out a scientific and sustainable manor, achieving its goals and working to a high standard.

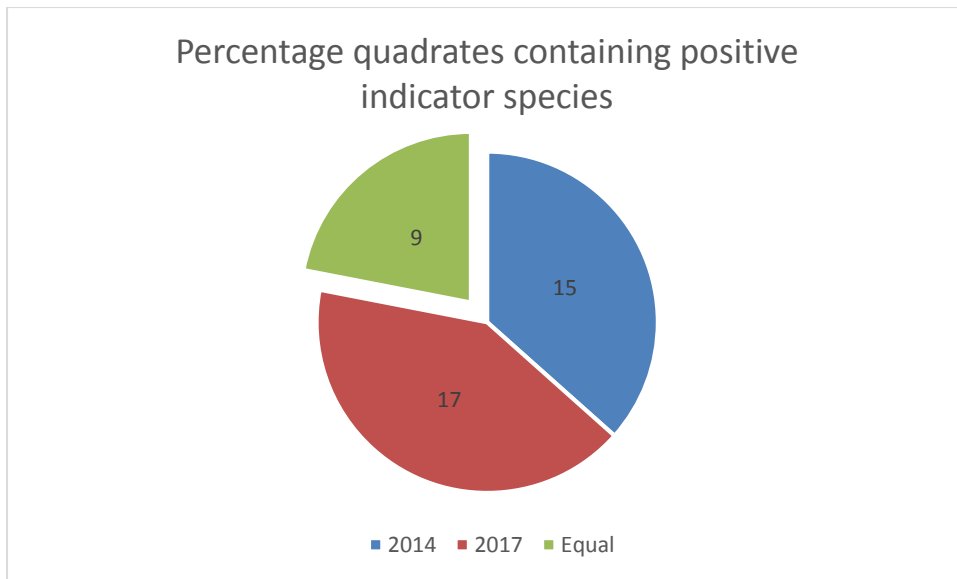


Photo 181: The Delamere Landscape Team collecting the award from the Chartered Institute of Ecology and Environmental Management.

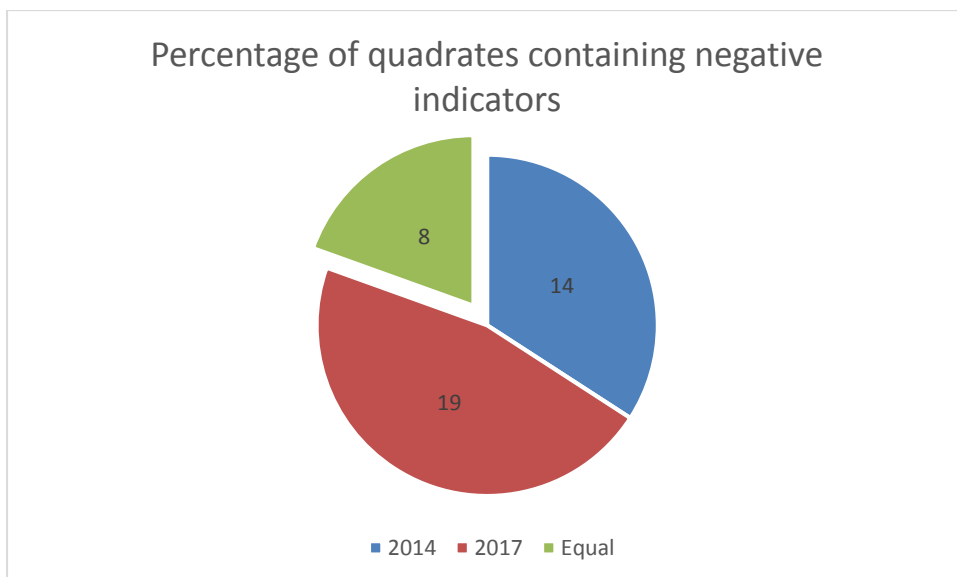
2.3 Surveying and monitoring

Rapid Habitat Assessments

Rapid Habitat Assessments were carried out across all sites from 2013 to 2017 with the exception of the new sites added towards the end of the project. As these sites were only surveyed once no comparison could be made of the data, but the survey results are available for comparison if future surveys are carried out. The rapid habitat assessments consisted of quadrature surveys of the positive and negative indicator species for mossland sites, each species being registered as present or absent within the quadrature. Quadrates were taken along transects through or around the site.



Graph 1. Percentage of quadrates containing positive mossland indicator species (sphagnum, common cottengrass, hare's tail cotton grass, bog rosemary, bog myrtle, bog asphodel, haircap moss, round-leaved sundew, cranberry, royal fern, bilberry, cross-leaved heath, common heather and gorse) on sites surveyed in 2014 and 2017.



Graph 2. Percentage of quadrates containing negative mossland indicator species (bracken, bramble, bramble, woody species, purple moor-grass, soft rush, reed canary grass, reed sweet canary grass, wavy hairgrass, common reed) on sites surveyed in 2014 and 2017.

The results of the rapid habitat surveys were highly mixed with some sites showing increases in species whilst others showed decreases, however comparison across all the sites showed that overall both negative and positive indicator species increased between 2014 and 2017. The increase in positive indicator species is largely due to the expansion of common cotton-grass, heather and sphagnum moss, which have spread quickly as conditions have become suitable. The reason that a higher increase in positive indicators was not seen is likely to be due to the short time which has elapsed since restoration work was carried out on the sites, with some sites only having been worked on in 2016 or 2017. For those worked on in the first year of the project changes can be seen however it is likely that the most significant changes won't happen for several years.

For many of the positive indicator species distance is also an obstacle. Bog rosemary, bog myrtle and bog asphodel are all confined to a few isolated sites and it may take a long time before they spread to other suitable areas. This is also true of round-leaved sundew and the royal fern however these have been shown to appear on restoration sites relatively quickly so they may be better adapted to spreading greater distances.

The increase in negative indicator species is largely due to the rise in bracken, bramble and saplings which naturally occurs as the sites are cleared of shading trees. These species are able to grow and expand much quicker than many of the mossland species. On many sites water levels have risen slowly due to the rewetting of the cracked peat taking several years, giving these species an advantage. As water levels stabilise and the peat becomes waterlogged these negative indicator species should dieback, as the conditions will become unsuitable.

For many of the sites where water levels have risen significantly surveying has become increasingly difficult and transects which passed through the centre of the site in the first year had to be moved to the edge, this has resulted in the quadrates sometimes showing sites becoming drier when the water levels have been known to have risen. This has also contributed to the increased recording of species like bracken and bramble which are often grow around the edge of the mosses, benefiting from increased light levels and the dry conditions away from the wet core of the sites.

Whilst the Rapid habitat data shows no great trends yet it will be useful data for comparison in a decade's time when the species are more likely to have had time to adapt and expand.

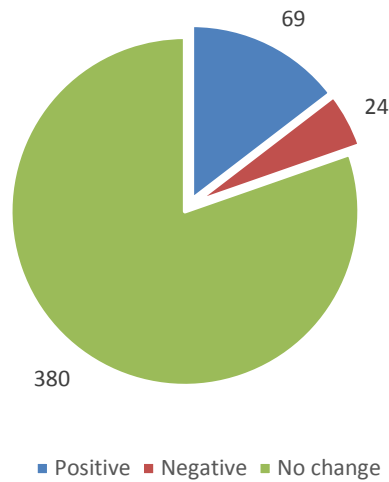
Sphagnum

Sphagnum surveys were carried out on all sites within the project in 2014 and then again in 2017. For sites which were brought into the project after 2014 a survey was carried out in 2017 but the data was excluded from any analysis. Surveys were carried out by walking sites and compiling a complete species list for sphagnum. The species found on each site were given a DAFOR rating (Dominant, Abundant, Frequent, Occasional or Rare). Overall coverage of the site by sphagnum was also estimated. Whilst these methods were objective they were the most effective way of surveying sphagnum on these sites as some sites had almost no sphagnum present on them at the start of the project, meaning transect or quadrate surveys would most likely have missed surveying them entirely.

Issues with surveying revolved largely around the difficulties in accessing the sites, particularly towards the end of the project. For sites with deeper water it was often only possible to survey sphagnum from the edges of the pool, meaning large areas were missed. However as only two sphagnum species general grow within the deeper waters this is unlikely to have affected the species lists for the sites. Additionally as some of the rarer sphagnums grow in very small patches it is possible that they could have been missed given the size of the sites.

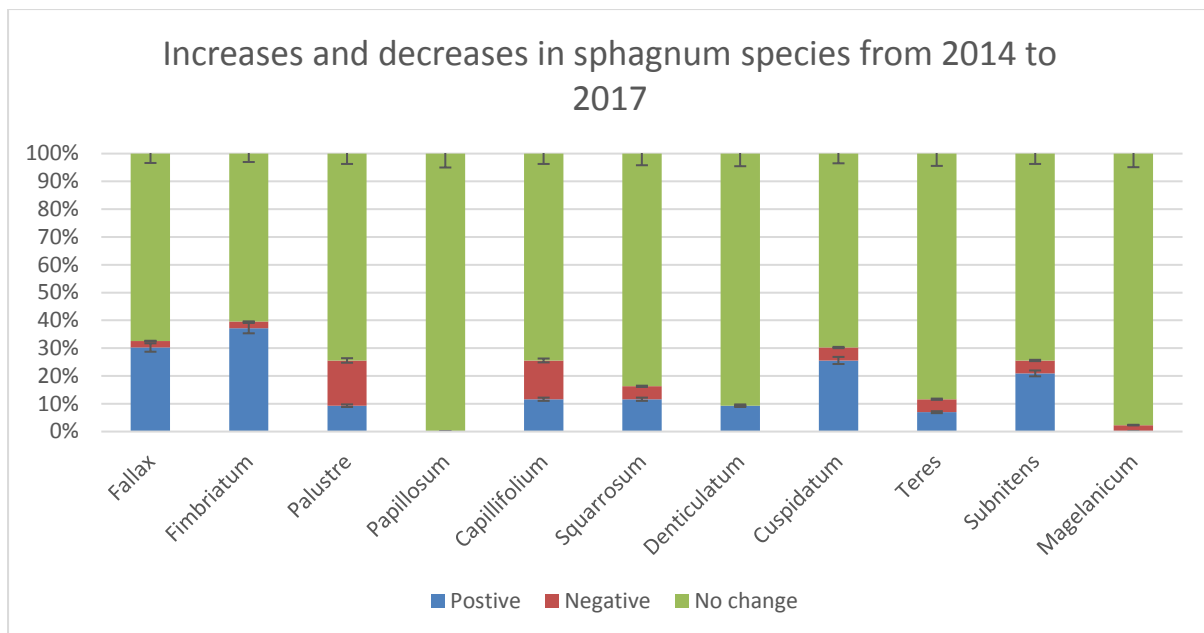
Whilst four years is a relatively short period of time in which to see a significant change in species or quantity of sphagnum comparison of the 2014 and 2017 data has shown positive changes across the sites (graph 3).

Change in the abundance of sphagnum species between 2014 and 2017



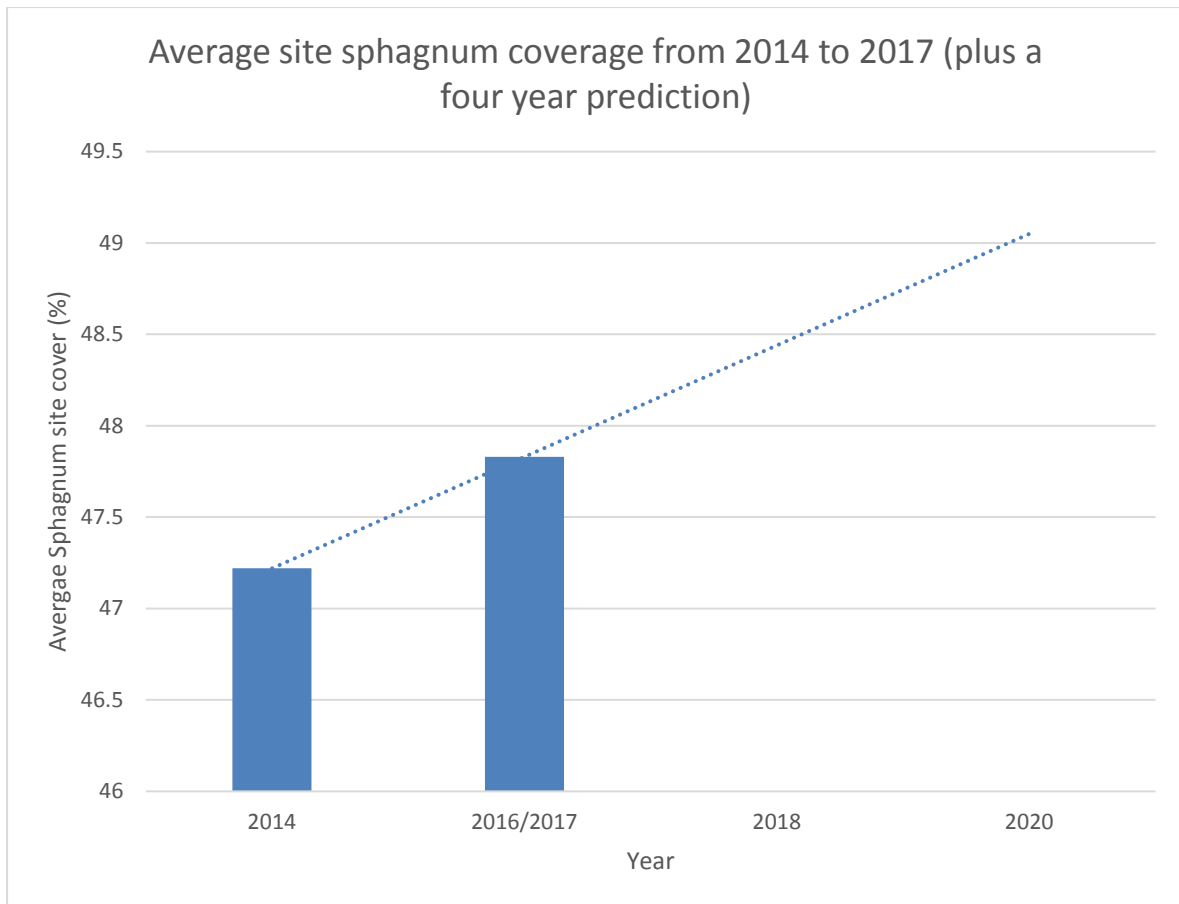
Graph 3. Across the sites surveyed in both years a positive change in abundance of sphagnum species was seen across 69 sites whilst a drop in abundance was only seen in 24.

Whilst increases in species is not always positive in sphagnum, as some species prefer damaged mossland sites to intact sites, the species which have been seen to increase are indicative of restoration work benefitting the mosslands. Increases in species such as *S.fallax* and *S.Cuspidatum* for example show that water levels have risen across the sites, as does a drop in *S.palustre*. The rise in *S.fimbriatum* is indicative of the work having been carried out in recent years, as this species thrives in disturbed, or recently rewet, peat. Drops in some of the sphagnum species known to indicate peat growth, *S.Magellanicum* and *S.capillifolium*, is likely due to raised water levels drowning out existing patches of these species. However these, and other, species should in time re-establish themselves on other suitable areas across the sites.



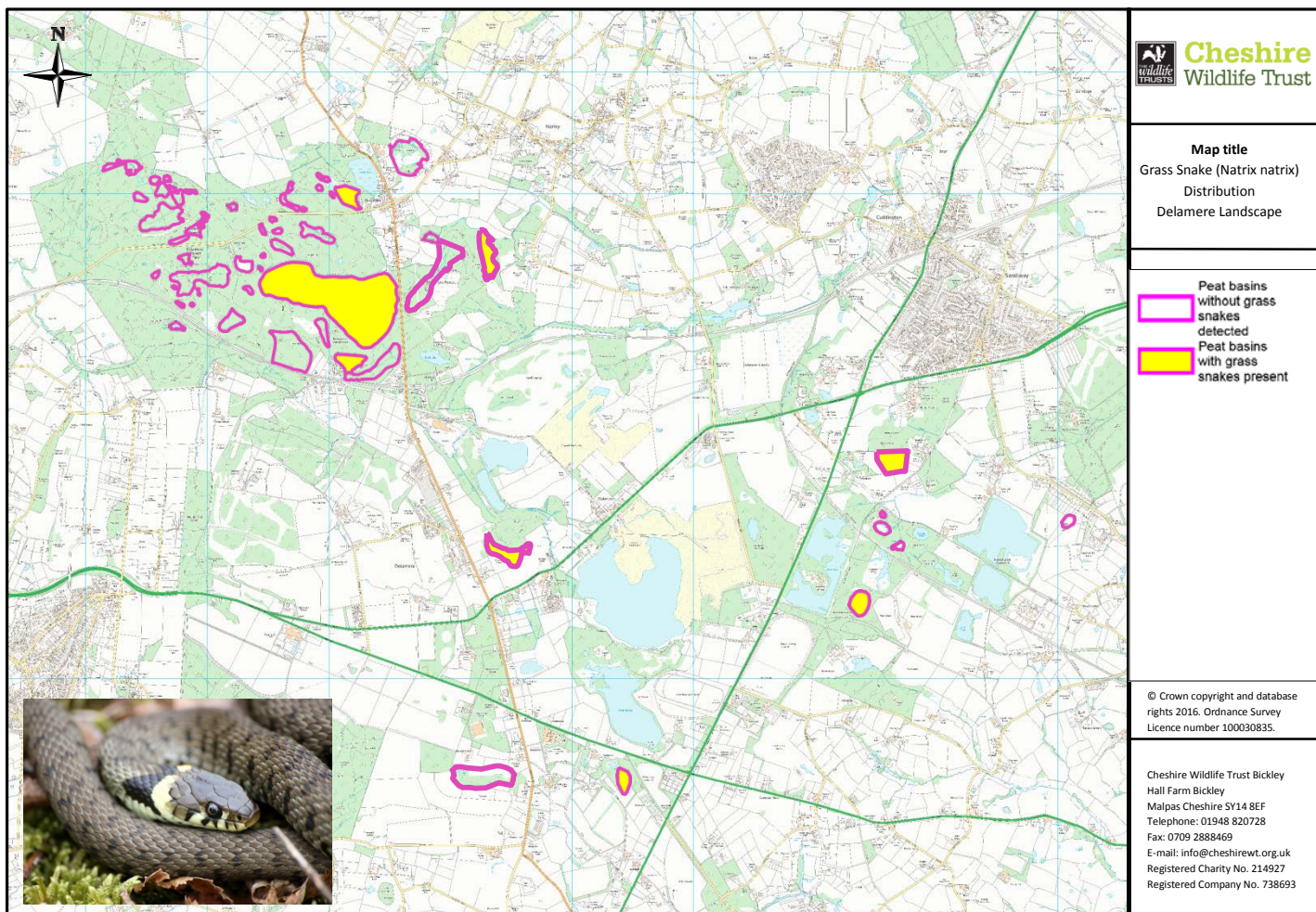
Graph 4. Increases and decreases in sphagnum species across sites surveyed in 2014 and 2017.

Overall the surveys have shown that sphagnum is increasing across the sites (graph 5). Although this increase is only small it is symptomatic of the unseen changes occurring within the mosslands, as higher and more stable water levels are encouraging the growth of mossland species. The real changes in the sphagnum species should take place over the next decade and into the future as pioneer species give way to species which indicate the mosslands are healthy, well-developed bogs.



Graph 5. Average site sphagnum coverage from 2014 and 2017.

Reptiles



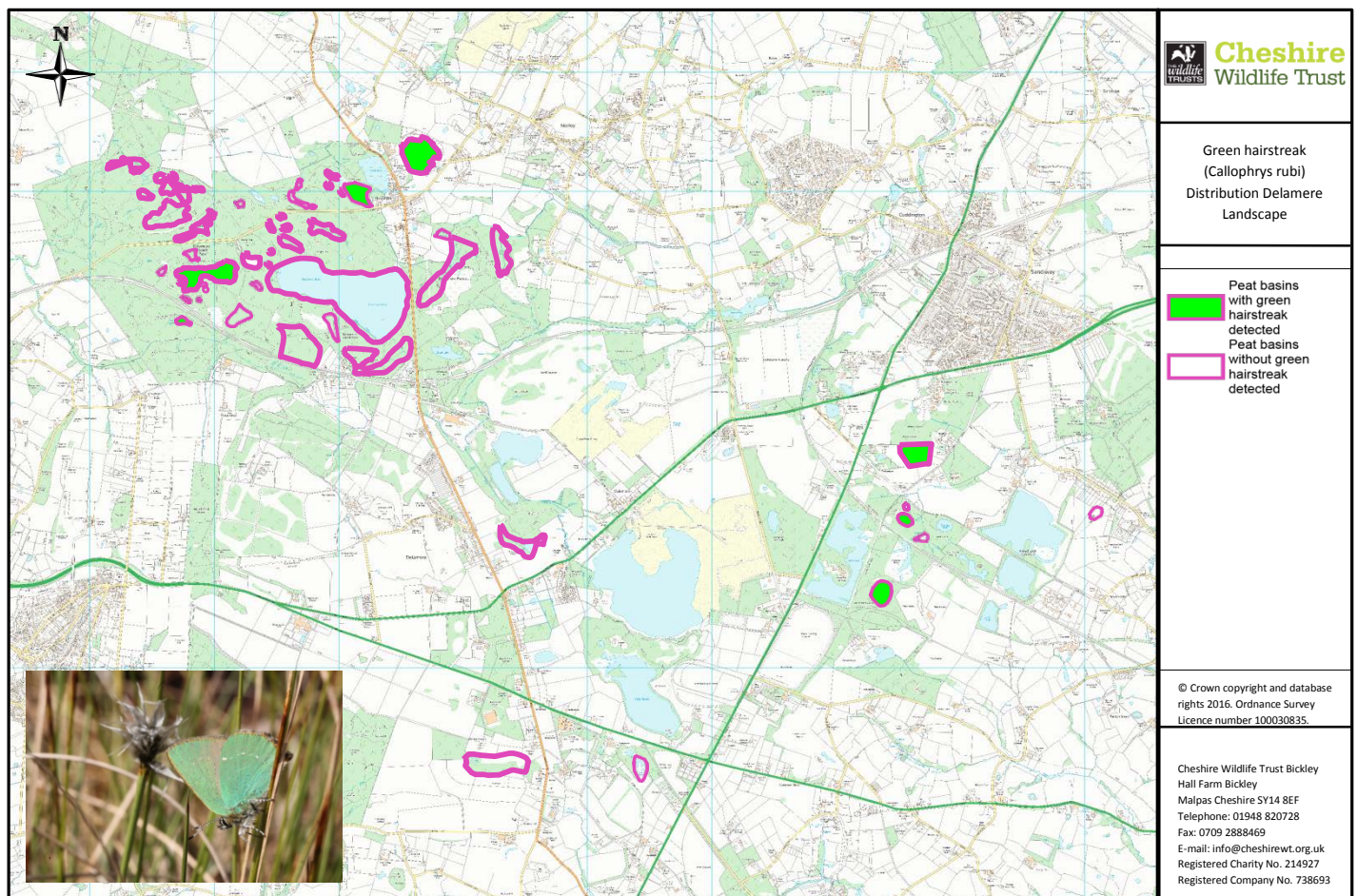
Map 9. Peat basins where signs of grass snakes were found during DLM surveys.

Reptile surveys took place across five of the project sites within Delamere forest from 2014 to 2017 to ascertain which reptiles were present across these sites. Sites for surveying were chosen based on their suitability for reptiles, with drier heathland sites being chosen over open water sites. In 2017 an additional three sites were surveyed due to extra staff time being made available.

Surveys showed good common lizard populations across all sites, with adults and juveniles regularly sighted during surveys. Grass snakes were found across eight sites across the landscape, with juveniles spotted on three sites and two sites in particular being highlighted by the surveys as supporting good grass snake populations, namely Brackenhurst bog and Thieves moss. Although refugia were used for surveys no slow worms were found, supporting the current belief that slow worm populations are low within Cheshire.

One of the reasons for surveying the Delamere area was to try and ascertain if adders were still to be found in this area, as historical records exist for many of the sites within the project. However no adders or signs of adders were recorded across the sites.

Butterflies



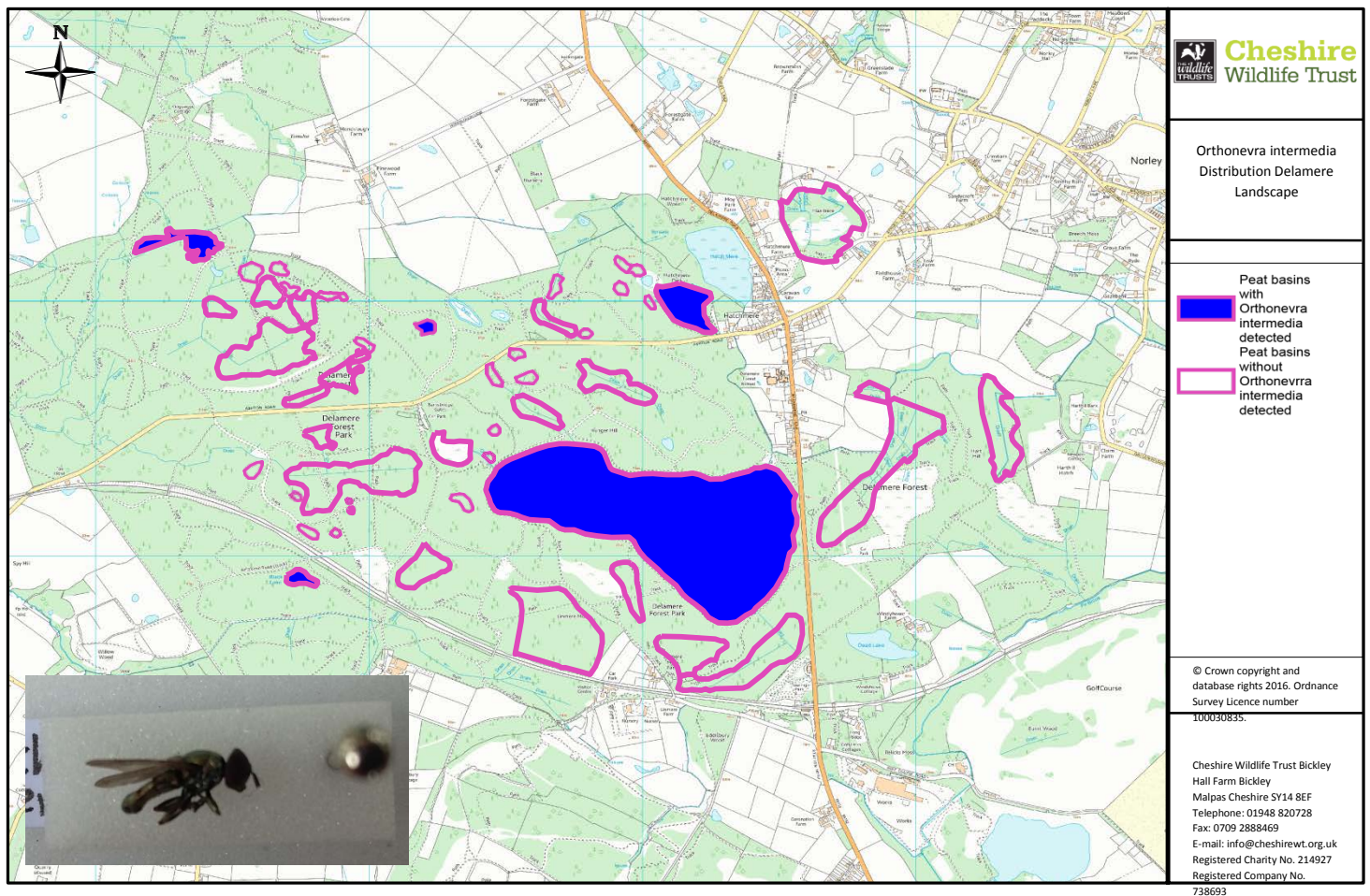
Map 10. Peat basins where green hairstreaks were found during DLM surveys.

Butterfly surveys were conducted across five sites within the landscape from 2014 to 2017. An additional four sites were added in 2017 due to extra staff capacity. Sites were chosen on the basis of their suitability for species of butterfly which thrived on mossland or heathland sites, such as the large heath, green hairstreak and small heath. Three existing populations of green hairstreak were known of in the landscape, one site with a single record of small heath and several sites with historic records of large heath butterfly.

Surveying brought to light three new sites which were being used by green hairstreak butterflies. Brackenhurst bog and Black lake both proved to have significant populations, which had not previously been recorded. On previously known sites populations remained fairly stable throughout the project, demonstrating that restoration work was not having a negative effect on the species. On several sites it is expected that populations will expand as food plants such as bilberry expand into newly cleared areas in the coming years.

Surveys also demonstrated the significance of Shemmy's moss for the species, as numbers of over 100 individuals were counted on several visits in 2017, much higher than on any other site across the landscape. No large heath or small heath were recorded from the butterfly surveys though a mix of generalist species was recorded. A strong population of brimstone butterflies was noted on Norley moss where alder buckthorn, its main food plant, can be found.

Diptera and Heteroptera



Map 11. Peat basins where *Orthonevra intermedia* has been found.

Diptera and Heteroptera surveys were carried out by Philip Brighton across Delamere Forest and Abbots moss, including on 21 peat basins and along forest rides and areas of woodland. These surveys were then analysed using PANTHEON, a piece of software designed by Natural England. Below is an extract from his report demonstrating his findings.

‘The species list from the current surveys has been run through the PANTHEON software which became available on the BRC website during 2017. This software is based on a database linking species to their larval and adult food “guilds”, to their characteristic habitats, and to other associated species such as the hosts of parasitic flies. It also flags up species with a conservation designation and for certain special habitats gives a score representing how specific the species is to that habitat. It should be noted however that it currently contains data for only 3047 fly species whereas the total number on the British list is over 7000.

The table lists those species from the present surveys which are flagged up in PANTHEON as having a national conservation designation and/or a score reflecting their fidelity to certain special habitats. The PANTHEON data for other species can be viewed on the BRC website. Various statistics can be generated and they combine to give an overall picture of the Delamere environment.

The Table below contains results from PANTHEON showing the number of species associated with each habitat represented in the data. As some species have multiple associations, some habitats

appearing on the Table are clearly irrelevant. The figure for representation is the number of species recorded as a proportion of the total number in the PANTHEON database for that habitat. The guidance states that 10-20% may indicate good quality while 21% or more certainly suggests a good proportion of characteristic species. These figures are reached for shaded woodland floor and wet woodland in our sample, but not for peatland.

Broad biotope	Habitat	No. of species	% representation	No. of designated species	SQI
tree-associated	shaded woodland floor	161	14	7	117
open habitats	tall sward & scrub	86	3		100
wetland	peatland	81	7	10	150
wetland	running water	60	6	7	137
wetland	wet woodland	55	20	5	130
tree-associated	wet woodland	54	21	5	130
wetland	marshland	43	5		100
tree-associated	decaying wood	22	2	3	145
tree-associated	arboreal	20	2		100
open habitats	short sward & bare ground	10	<1		100
open habitats	upland	3	2		100
coastal	saltmarsh	1	<1		100
coastal	brackish pools & ditches	1	<1		100

Table 1. Results from PANTHEON analysis.

Each species is assigned a species quality score (SQS) according to their conservation status. Non-designated species score 1 while the SQS increases from 4 to 32 as one progresses from the nationally scarce or notable to the rarest categories such as critically endangered. The SQI is 100 times the sum of the scores divided by the number of species, so that 100 indicates a lack of any designated species. On this measure the peatland habitat scores highest because of the high number of associated species with a designation. Decaying wood also shows up better on this measure: although the 22 species found are only 2% of the national total there are three species with a designation.'

Although PANTHEON is a relatively new piece of software the results of the analysis seem to reinforce the idea that the peatlands and associated wetland habitats in Delamere hold a high proportion of rarities in the area compared with the other habitats found here. It is however worth noting the high numbers of species supported by the shaded woodland floor habitat category, demonstrating the importance of Delamere as a more general woodland habitat in Cheshire, the least wooded county in England.'

The report also lists those species found in Delamere which are particularly rare or unusual to the area. The full list is given below.

Family	Species	Status	Notes
Terrestrial Heteroptera	<i>Lamproplax picea</i>		Sphagnum specialist with few other Cheshire records.
	<i>Gastrodes abietum</i>		Is known as the spruce

			cone bug and this appears to be the first find in Cheshire, though it is more frequent in southern England.
Craneflies	<i>Idioptera linnei</i>	RDB 1	Confined to a few areas of North Wales and Northern England, where it is found in sphagnum pools.
	<i>Erioptera nielsenii</i>	Notable	Another scarce acid mire species was found in the Hockenhull basin: the scatter of previous records has been from the area around Abbots Moss.
	<i>Dicranomyia lucida</i>	Notable	The woodland seepage species is new to Delamere, found by a stream near the western edge of the Forest, and recorded in Cheshire only once before.
	<i>Tanyptera atrata</i>	Notable	The larvae develop in decaying wood, but the adults seem to be elusive, apparently appearing briefly around early June.
Hoverflies	<i>Orthonevra intermedia</i>	DD, NS	Delamere remains the only location for this species in Britain, found during Martin Drake's 2003 survey. The last two seasons have yielded further records in new areas of the Forest: one male at Harrison's on 6 th July 2016 and two males and two females at Black Lake on 7 th June 2017.
	<i>Xylota florum</i>		A particularly unusual find associated with coarse woody debris is with only a few previous Cheshire records, and apparently in decline

			nationally.
Empidoidea	<i>Leptopeza borealis</i>	NR and NT	Widespread in the Forest. Like <i>Orthonevra intermedia</i> it seems to be a relic from wide-spread boggy conditions following the end of the Ice Age. The NBN Atlas has only 4 records nationally, from Staffordshire and Yorkshire.
Calyptrates	<i>Lispocephala brachialis</i>	RDB 3	The nominally rare is a smallish grey and orange muscid, which were found at Blains and Blakemere Mosses. There are indications that it is not now as rare as previously thought.
Scathophagidae	<i>Cordilura rufimana</i>	Notable	Has clear associations with <i>Carex</i> species on acid mires.
Lauxaniidae	<i>Sapromyza albiceps</i>	Notable	Of the nationally scarce species was found at 9 locations in 2003.
Sepsidae	<i>Themira germanica</i>	Notable	The nationally scarce is an addition to the list for Delamere and for Cheshire. It rather resembles a small black ant.
Stratiomyidae	<i>Beris fuscipes</i>	Notable	

Table 2. Rare or notable species found during Diptera and Heteroptera surveys on DLM project site

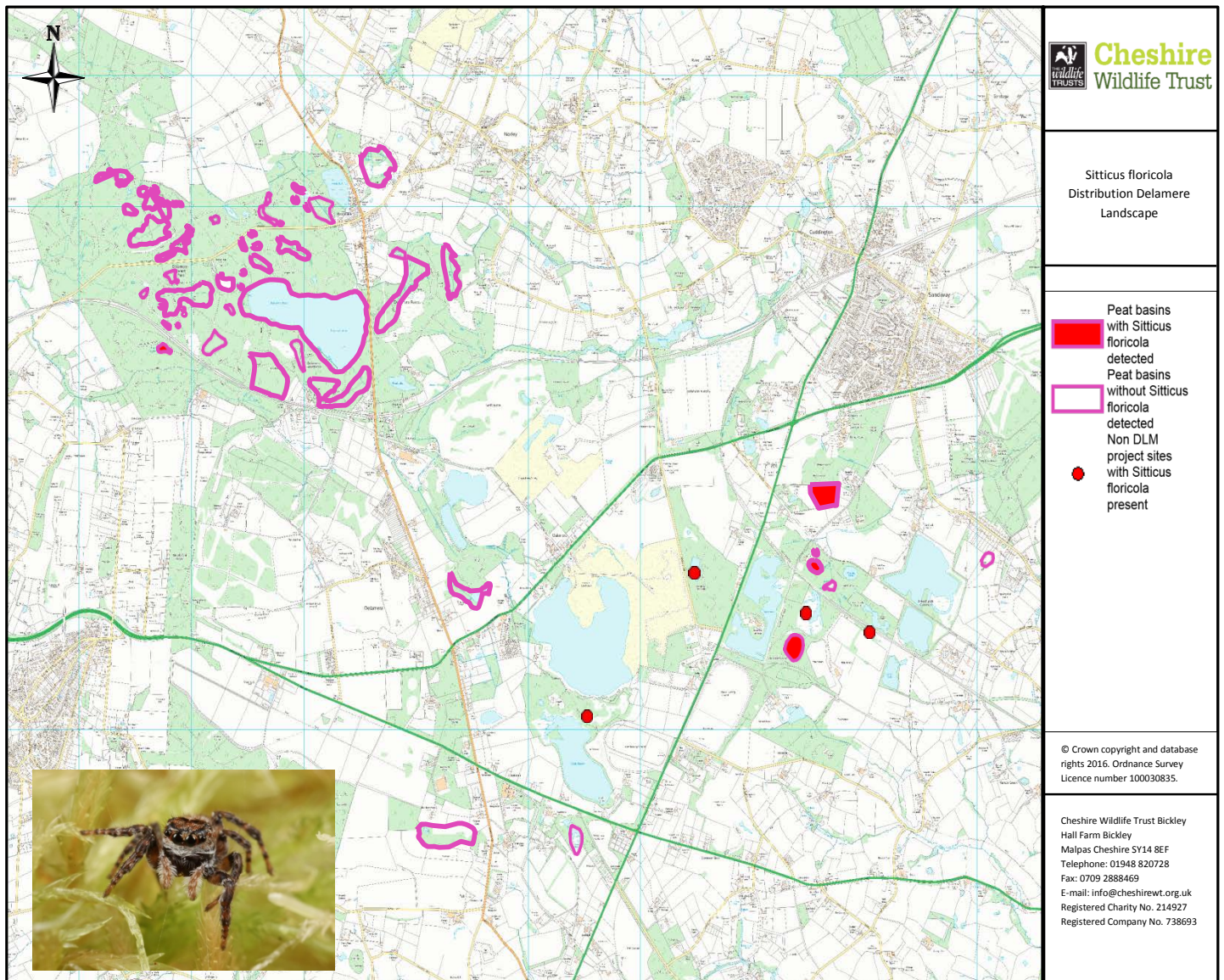
Moths

Moth surveys have been carried out in Delamere for many years by a local Butterfly Conservation volunteer group. Through these surveys many regionally and nationally rare species have been found, most associated with the deciduous woodland. However several species have been found which are dependent on the peat basins within the forest. Most of these species depend either on the heathland species, such as heather and bilberry or on general aquatic habitats. Few are specialised to mosslands, however the presence of wetland and heathland areas clearly benefits these species. Though few were nationally rare several were unusual in the Cheshire area. Species of note were;

- Dotted clay
 - A common moth of heathland and woodland habitats
- Beautiful snout
 - Moth of woodland and mossland habitats

- o Common food plants are bilberry, bell heather
- Small china mark
 - o Moth with an aquatic larval stage
- Brown china mark
 - o Moth with an aquatic larval stage
- Bilberry pug
 - o Feeds on bilberry
 - o Lives in woodlands with an understory of bilberry
- Northern Spinach
 - o A common moth of grasslands and moorlands
 - o Larvae foodplant bilberry
- Four Dotted Footman
 - o Moth of heathlands and open woodlands
 - o Foodplant algae on Heather
- Suspected
 - o Common moth of woodlands and heathlands
 - o Foodplant birches and willows
- Heath Rustic
 - o Uncommon species found on heathlands and moorlands
 - o Foodplant heather
- True Lover's Knot
 - o Common moth of heathlands and moorlands
 - o Larval foodplant Heather

Spider surveys



Map 12. Sites within the Delamere landscape where *Sitticus floricola* has been found.

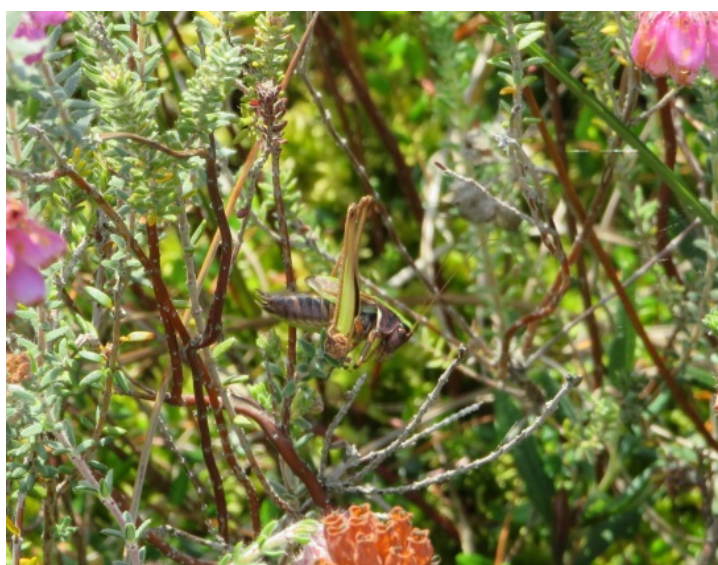
Surveys for the nationally rare spider *Sitticus floricola* were carried out in partnership with the Tanyptera project in the Delamere area due to historic data for the species across much of the landscape. All suitable sites were surveyed within the landscape and as well as reconfirming the spider's presence at several sites which had not been surveyed since the 1980s new records were made at Lily pool SSSI and Brackenhurst bog, site which had not been previously surveyed. Of historic sites only Flaxmere SSSI gave no current records, although it was visited three times. This may be due to the drying out of the site in recent years due to drainage.

Most records cluster around the area surrounding Abbots moss SSSI however a heavy population was found within Delamere Forest at Black lake Nature Reserve. Overall 10 sites are now known for this species in Cheshire and only an additional 3 across other areas of the UK. Other suitable sites were surveyed within the forest with A06, Barnsbridge basin and Hockenhull all being highlighted as meeting the spider's habitat requirements, however no individuals were found. This may highlight a limited dispersal ability for the spider, due to the dense canopy surrounding the sites. As more sites

become suitable in the future spread of the species should be monitored to see if translocations would be advisable.

Although not the target of the surveys a second nationally rare spider was recorded across many of the Delamere sites, namely *Glyphesis cottonae*. Recorded on historic sites at Hogshead moss and Black lake SSSI it was also found at Lily pool, Oakmere, Brackenhurst bog and Snipe Island. These are all new sites for the species and has almost doubled the number of sites where this spider is known to occur in Cheshire. It's preference for lowland bogs with sturdy sphagnum lawns means that like *Sitticus floricola* its range is very restricted throughout the landscape.

Bog bush cricket



Surveys for the bog bush cricket were carried out in partnership with the Tanyptera project due to historic data for Abbots moss SSSI. Surveys were carried out in the summer of 2017 with a bat detector to help locate the crickets. A large number (31 individuals) of both male and female crickets were located on Shemmy's moss, from the edge of the path right into the centre of the mossland. On South bog however numbers were significantly lower with only one small corner of the mossland harbouring any

Photo 182: Male bog bush cricket.

specimens (three individuals). The reason for such a marked difference is unclear but mirrors the difference found between the two sites with the green hairstreak population, with over 100 individuals located on Shemmy's and only a dozen being found on South bog.

Bird surveys

Bird surveys were carried out on five peat basins to assess what species might be benefitting from the mossland sites. Sites were selected to represent a variety of sizes and habitat types, though focus was given to sites in better condition rather than unrestored areas or areas recently cleared. Great Blakemere, Linnere moss, Harthill moss, Finney's moss, Pierson's moss and Doolittle moss were visited throughout 2014 to assess birds using the sites through Wetland Bird Survey and Breeding Bird Survey techniques.

Large numbers of birds were found to be using the sites regularly, with visits in May for example finding 240 species using Great Blakemere, 104 species on Linnere moss, 90 on Harthill moss and 82 on Finney's moss. Although smaller sites Pierson's and Doolittle moss still held 34 and 19 species respectively. Number of individuals was also found to be high with Great Blakemere holding 5,121 birds, 580 on Linnere moss, 330 on Harthill, 271 on Finney's moss, 102 on Pierson's and 50 on Doolittle moss.

Most species surveyed were generalists who were likely to be using the forest habitat more than the mosslands, though it is likely they benefitted from the increased access to water and insect species which the mosslands could offer. However large numbers of wetland birds were also observed, including rarities such as whooper swam, little grebe and garganey. These wetland species have been attracted to Delamere forest due to the increase in wetland areas and open water. Although most of these species keep to the larger peat basins they have been observed using some of the smaller pools as well. These surveys have therefore demonstrated the importance of the mosslands for bird species but also suggest that the combination of wetland and woodland habitats side by side that are helping to create a particularly diverse suite of species within this area.

University studies

Several BSc and MSc projects were carried out during the lifetime of the Delamere's Lost Mosses. Although many were useful to confirm the findings of the project officer the most significant in terms of dataset was an MSc carried out by a Manchester Metropolitan University student, Tracey Walker, on the 'Influence of water chemistry on Sphagnum mires in Delamere Forest'. In total 16 mires were sampled for NO₃, NO₂, PO₄, SO₄, NH₄, Ca, Cl, Na, K and Mg, as well as pH, conductivity, percentage vegetative cover, percentage shading and algal bloom. Sites were chosen based on previous water quality testing carried out by the project officer, with any sites suspected to have pollution issues being surveyed alongside several comparison sites thought to have relatively clean water. As well as confirming previous results the tests showed additional details due to the number of perimeters surveyed for, which indicate where the issues may be stemming from. Below is an extract from the discussion section of the MSc, outlining possible sources for pollution across the sites;

'Conductivity in Doolittle, Pierson's and Birchenholt South are higher than other sites. Both Pierson's and Doolittle are lower than, and adjacent to, Ashton Road, thus leading to the possibility of contamination from roadway run off. Birchenholt South is recorded by Duff 2017 in Table 6 and Bennett 2003, as having conductivity of over 420 $\mu\text{S}/\text{cm}$ which is consistent with this study results. Initial observation of high nutrient values in the different sites would suggest that Birchenholt South, Hunger Hill, Doolittle and Linmer have elevated nutrient levels.

Birchenholt South is clearly least acidic with 7 pH average. This is a known site to have a feed from the Old Pale area and farmland on Eddisbury Hill. This stream is known to be entering Birchenholt South at 7.5pH (Bennett, 2003) and due to the long formation of the basin, acts more like a stream than a mire as it has an outflow. The replicates in Appendix 3, 4, 5 and 6, indicate lowering pH and nutrient along the transect as it moves from West to East as the outflow feeds Blakemere. This is consistent with the theory that the mire is filtering nutrients as the water passes through the mire.

LM09 and LM10 (Fig 3 and Fig 4) both have higher than would be expected pH. This could be due to close proximity to forest rides known to be made up of limestone and both mires lying below the rides making run off highly likely (Irfanullah and Moss, 2005). Gorham 1957 indicates that Calcium carbonate, (CaCO₂) can be leached from glacial drift deposits in sand and gravel into the ground water. This would support spring water being alkaline. Calcium is known to suppress *Sphagnum* growth especially if combined with high water tables with capitula below the water surface ((Granath et al., 2010). Although *Sphagnum* is thought to be Ca intolerant, (Vicherova et al., 2016), it should also be noted that some *Sphagnum* species are more tolerant to higher levels of Calcium than others and can live in fen like conditions (Pleskova et al., 2016).'

Birchenholt South appears to have a greater number of elevated levels of nutrients than other mires followed by Doolittle, Pierson's and Hunger Hill. These latter three need to be examined in more detail to ascertain the contamination entry point and also determine whether it is a seasonal or

transient contamination. Pierson's and Doolittle sites are close to, and lower than, Ashton Road. This proximity could account for salt in run off, especially as sampling was carried out in late winter/early spring when gritting of roads had recently been carried out. From Irfanullah and Moss, 2005, it can be seen that nutrients fluctuate over the year and some quite significantly. It would therefore be relevant to carry this data collection over a year to give a clearer average picture. Some of the high nutrient levels could be attributed to seasonal activities being carried out within Forestry, agriculture or other Industries.

Magnesium is seen to be marginally higher in Hunger Hill and Birchenholt North. Magnesium within water can be due to agricultural contamination from fertiliser. This may be brought into these sites through drainage. High levels of Calcium are seen in Birchenholt South which corresponds with the high pH for this area and could be due to agricultural contamination although some local springs have high calcium content. Significant nutrient contamination is known to enter mires from run off and sub-surface percolation in forestry catchment areas (Kortelainen, & Saukkonen, 1998).

Potassium is seen in low levels across all sites except Birchenholt South. It is known that Potassium is variable throughout the season due to plant uptake, being highest in Spring and can easily be lost through leaching (Bragazza 1993; Proctor, 1994; Vitt *et al.*, 1995). Nitrite is seen to be varying across both Doolittle and Birchenholt South which suggests contamination from different points in each mire. Highest contamination is seen in Piersons, this would warrant further investigation to find the cause of contamination from possible drains. Nitrate is seen to be significantly high in Birchenholt South, possibly from agricultural contamination with water known to drain directly into the mire from The Old Pale area. Nitrite and Nitrate are both limiting factors in Sphagnum re-colonisation and therefore important to minimise in mire regeneration as mineralisation is known to suppress Sphagnum establishment especially if flooding the capitula (Vicherova *et al.*, 2015).

Phosphates are relatively low in all sites with some elevation seen in Hunger Hill. Sulphates are also relatively low across all sites except for raised levels in B09 and LM10, these will need investigation to find the source of contamination but could possibly be leaching from ride construction materials. The highest levels are seen again in Birchenholt South. Quite significant leaf litter was found in many mires which is known to mineralise and provide nutrients (Bragazza *et al.*, 1998). This, however, would be difficult to control or minimise in a forested area.

In the case of Birchenholt South from CCA analysis, it is evident that this mire is very different from all other mires in the study. It has raised pH level, high nutrient enrichment and shading from trees combined with the high water level could be responsible for the decline and current elimination of *Sphagnum* species and low vegetation diversity (Kollman and Rasmussen, 2012; Woziwoda and Kopek, 2014). The inflow of water from farmland on Eddisbury Hill could account for some of the contamination however it cannot be ruled out that this is also contributed to by other Industry localised to the site. Further investigation into inflows and ditch structure would be advantageous. It would further be useful to eliminate any inflow from natural springs that are known locally to be Calcium rich (Calcium from weathering of CaCO₂ in glacial drift deposits (Gorham, 1957).

Slightly higher levels in pH in other mires may be attributed to limestone contamination from roadways (Bennett, 2003). There is also ground water contamination possible from early road building in the 1950's when most of the rides were constructed. From discussion with K Walker, retired Forestry Commission Craftsman, these consisted of an initial layer of local gravel (extracted from Delamere area), followed in the 1950's with a layer of Red Shale from the Lancashire Coal mines, a further layer of Iron Ore from Shotton steel works and finally a layer of Limestone from Derbyshire. The ring road around Blakemere, Spiv Road and Battleaxe Road were the initial roadways of gravel prior to the 1950's, all other ride construction was carried out post the 1950's. It

is highly probable that these layers may still be releasing contaminants into the mires that are predominantly below the ride level and many rides run through or alongside the mire. This could possibly indicate inflow of contaminants and should be investigated further.

Flaxmere and Black Lake were used as comparison site with known recovery and *Sphagnum* regeneration. Flaxmere shows low pH, conductivity and good range of *Sphagnum* species indicating favourable conditions, as would be expected. Black Lake does seem to have a slightly high pH and the study found lesser diversity of *Sphagnum*. Irfanullah and Moss 2015 indicate that it may have an inflow from sub-surface percolation from the North East corner. It is suggested that this may be significantly high in forested areas without taking into account contamination from rides and roadways. Nutrients may well be different if the more central areas of Schwingmoor, however it is suspected that some leaching is occurring from roadways although conductivity is relatively low in comparison to other sites as discussed previously.

Wetness of the mire is important but deep water, especially above the *Sphagnum* capitula, is thought to be restrictive in *Sphagnum* regeneration (Bragg, 1995; Heathwaite, 1995). Careful monitoring and adjustment of water levels should be considered in developing the management plan.'

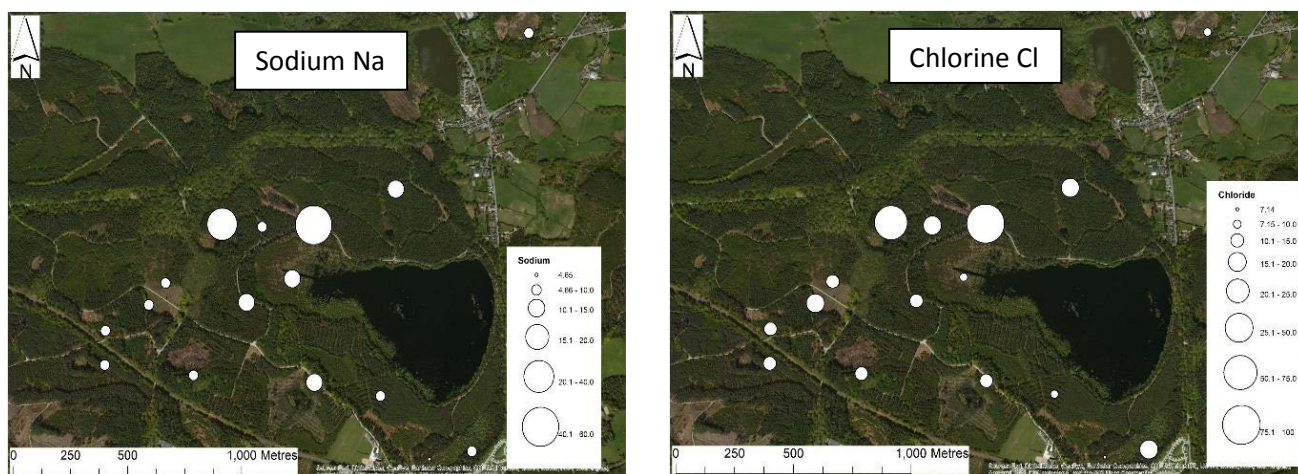


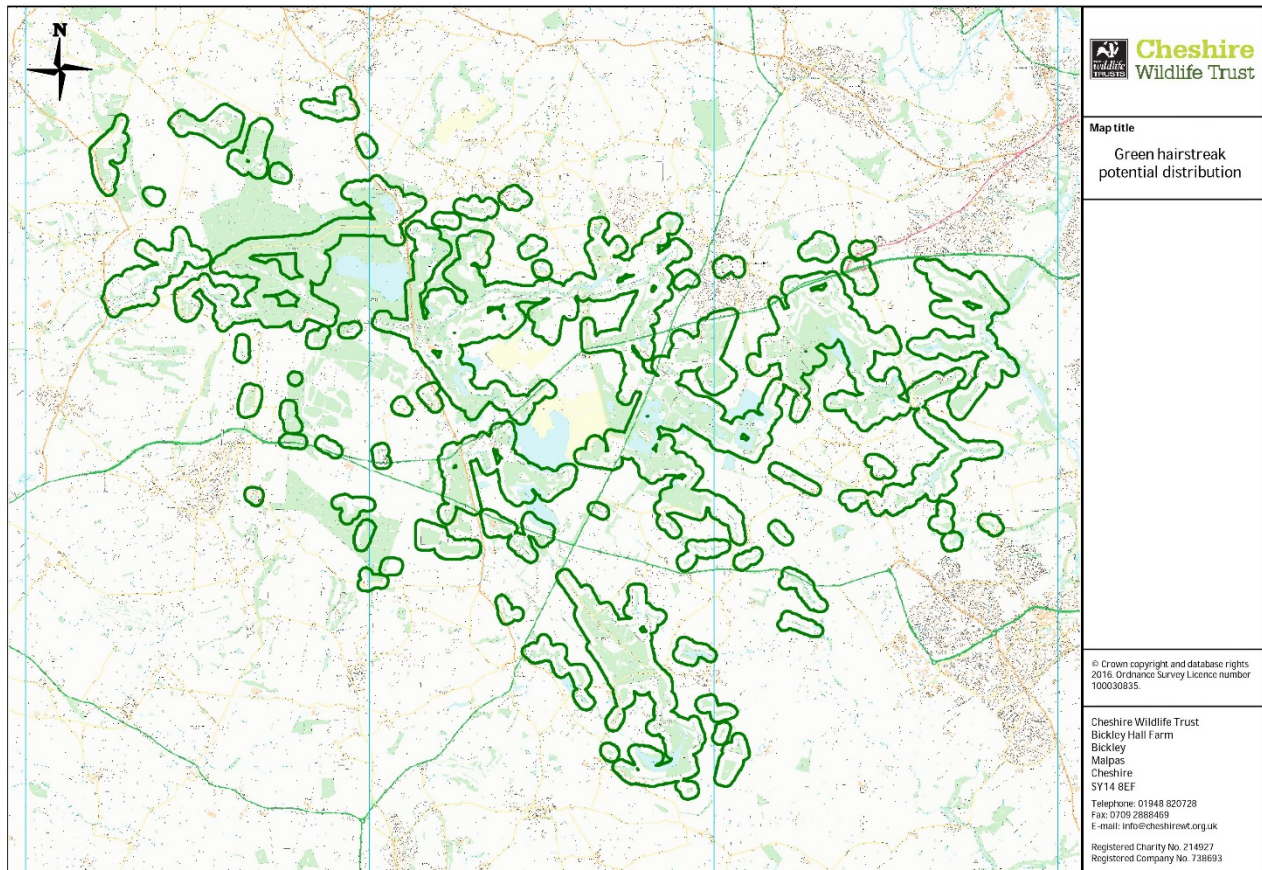
Fig. 1 An example of the findings within the MSc document. A visual representation of average Sodium and Chlorine levels on site. This clearly shows the sites close to Ashton Road (Doolittle and Pierson's) demonstrating the highest sodium and chlorine levels, presumably from salts spread on the road during the winter months.

In conclusion, the study showed that the main sources of contamination for the mosses of Delamere forest are likely to be the roadways running through the forest, both Ashton Road and the internal forestry roads. Aside from this outside influences, such as runoff from farmland, maybe affecting a number of sites. Birchenholt south is by far the most polluted site, due to runoff from Old pale. These findings support observations and surveying results collected over the lifetime of the project.

Connectivity mapping

In order to assess where gaps existed in the connectivity of the Delamere landscape fifteen mosslands species were selected and the habitats suitable for them mapped. A buffer was then added, using information gathered on how far these species could travel. The finished map showed the potential distribution and movement of the various species. Through this gaps in connectivity

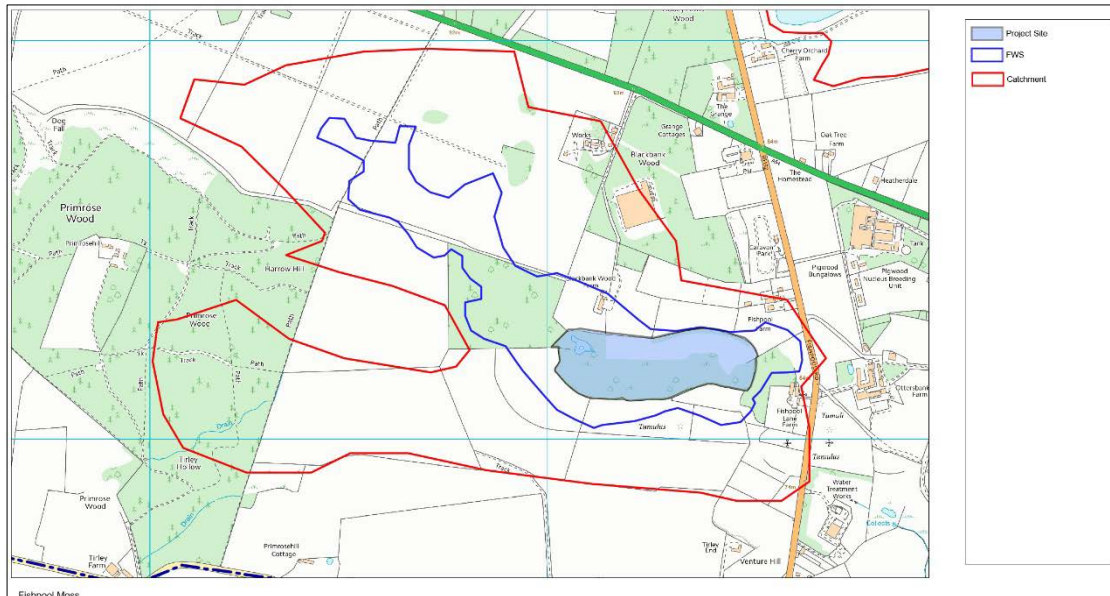
could be highlighted, and cross-referencing with data on current distributions allowed areas to be highlighted for further restoration work or reintroductions in the future. For some species, such as grass snake and nightjar, their ability to travel large distances means that if new habitat was created within the landscape they would be able to colonise it. However for species like bog rosemary and bog asphodel the mapping demonstrated that, whilst areas of habitat suitable for them already exist, their ability to move from one site to another is very limited meaning it is unlikely they will be able to recolonise restoration sites without translocation.



Map 13. Potential distribution of green hairstreak butterfly in the Delamere Landscape looking at suitability of habitats.

Catchment mapping

Using techniques pioneered by the Meres and Mosses Nature Improvement area soil types and topography were used to map the Functioning Wetland System and the catchment for each of the Delamere's Lost Mosses peat basins. The Functioning Wetland System represents the area which was once a part of the mossland habitat itself, whether it be as a lagg fenn area at the edge or seasonally wet grasslands. This is the area which ideally would be brought back into management as a wetland system in order to ensure the site had the best chance of maximising its potential for wildlife. The catchment is the wider area which effects the site in terms of water flow. This area is important as it is both a source of water for the site and a potential source of diffuse pollution to the sites. These maps were used to highlight areas of land within the wider landscape where restoration work, or work to decrease pollution levels, could have the biggest impact.



Map 14. Functioning Wetland System and Catchment of Fishpool moss.

1. Issues and mistakes within the project

Vandalism

Several incidents of vandalism occurred throughout the project from minor issues such as the removal of sluice boards to the smashing of a dam. Largely these issues have been dealt with through removing the opportunity, by introducing locks for moveable features such as pipes and sluices, and through covering dams in peat. Wild camping has also caused some damage, with burn marks on the ground and litter being left on site, however these incidents have not been too regular and largely only occur on the large sites.

Burst bunds

Bunds were used on several of the larger sites to rewet areas which were too flat for dams to function well. These bunds proved very successful. One issue has been the tendency of walkers to use bunds as footpaths, or venture onto them to get a better view. This has weakened the bunds in some areas but generally footfall has not been high enough to cause serious damage.

There were two bund bursts during the project, both on the weakest points of the bunds during fairly early stages before the bunds had completely settled. In both cases the leaks were easily fixed with plastic piling and recovered. The plastic piling headed to strengthen these weak points, and as the bunds settled further no more issues were found.

Side drains

Due to the historic nature of many of the drains on the mosslands, and particularly in Delamere Forest, it was not always possible to ascertain which drain was taking water from the site, particularly as some key drains remained dry on the surface, or

contained hidden culverts. On several occasions several attempts needed to be made to raise water levels as new outflows were discovered.

Perception

Negative perception of the restoration and mosslands has been an issue throughout the project. Newly rewetted areas were sometimes thought to be dangerous or ugly and many members of the public questioned the wildlife value of them compared to conifer plantations. However the concerted effort which has been made to engage with the public, and particularly the local people, in Delamere has paid off with more people being aware of the mosses in the area, and understanding at least some of the benefits of the restoration. A continued public engagement presence in this area would certainly benefit wider perceptions.

2. Recommendations for future work

Maintenance

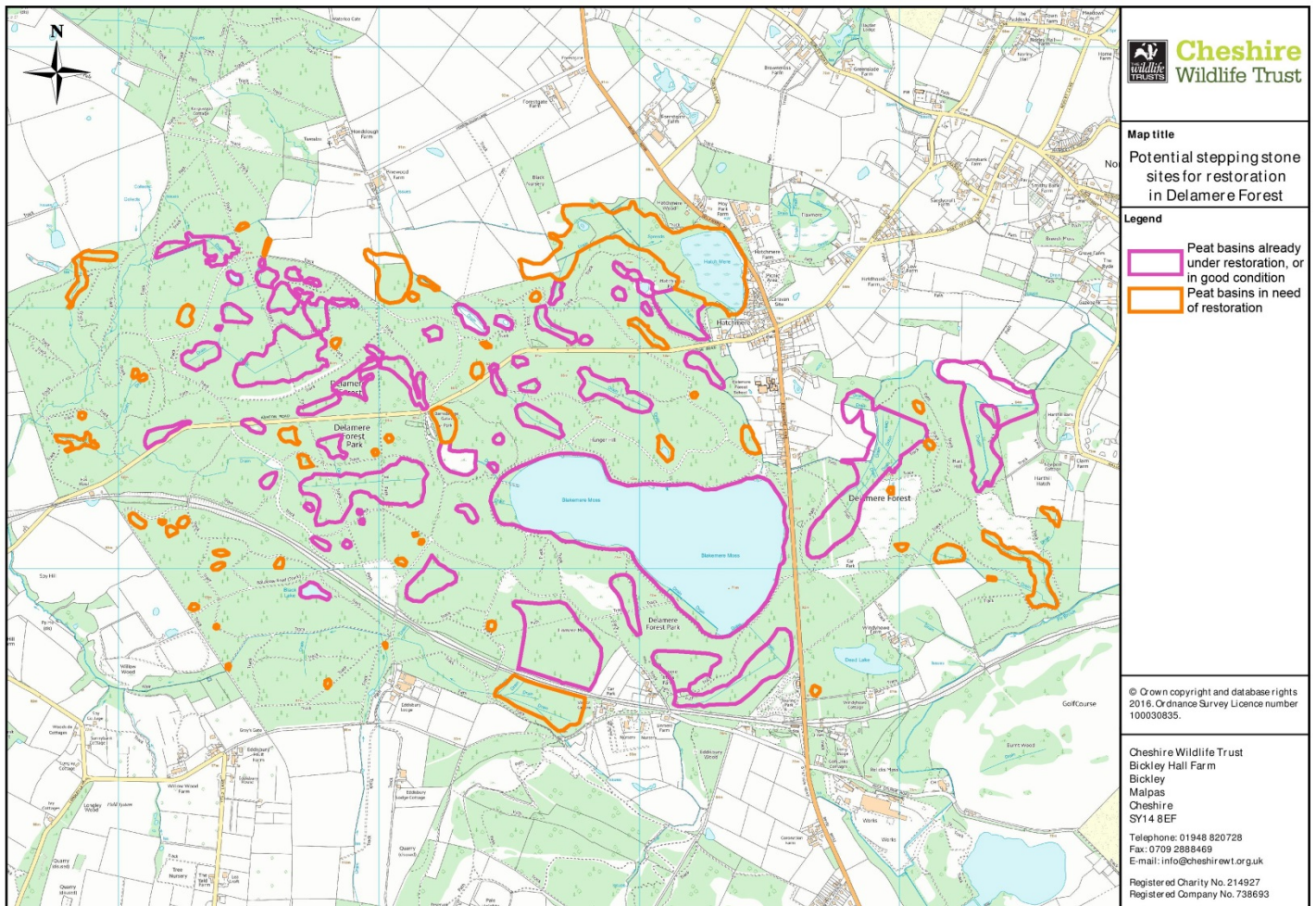
The work carried out by the project has taken most of the sites to a point where few capital works are required. For the site which remain wet all year little more is required other than to monitor progress. For drier areas such as areas of Norley moss, Pierson's, Hungerhill, Great Middel, Birchenholt north, Harrisons, Sandy mere, Snipe Island and the wildlife corridors ongoing management will be required to control scrub, bracken and bramble. This work should decrease as more desirable species spread in the next five years.

Some of this work could be decreased through additional bunding or damming to rewet higher areas of the sites. Great Middel and Birchenholt North could both benefit from additional damming to raise water levels across the site. Although current constraints mean this is not possible on Birchenholt North it should be considered in the future if the site is no longer used for recreational activities. Harrisons, Sandy mere and Snipe Island could all benefit from cell bunding to raise water levels across the drier areas of the site. Finney's moss could also benefit from additional cell bunding on the southern third of the site, or alternatively could be cleared and managed as a heathland area.

Linmere North and Great Blakemere are two large sites where extensive damming took place right at the end of the project. Both sites should be reassessed in two years' time to determine whether additional bunding or damming is required on higher areas of the sites.

Stepping stone sites

Throughout Delamere Forest and the wider landscape there are a number of very small mosses which could benefit from being cleared and their outflows dammed. Whilst they may hold little diversity themselves they will act as valuable stepping stone sites, or even simply act as attenuation ponds for run off from tracks and roads.



Map 15. Potential stepping stone sites for restoration in Delamere Forest. Hatchmere peat basin is included in this grouping, despite the main area being part of a nature reserve, due to several areas of the peat basins being on private land and in need of restoration.

Delamere Landscape sites

Several sites were identified during the project which should be considered for future restoration work. These are:

- Relick's moss
 - o Drained area of peatland currently wooded
 - o Would create good connectivity between Delamere sites and Thieve's moss
- Breech moss
 - o Drained area of peatland currently wooded
 - o Norley Wildlife Group are already moving to start restoration on this area
- Petty pool SSSI
 - o Several small bogs, areas of wet woodland and flushes within the woodland which would benefit from the clearance of rhododendron
 - o Work has already been begun by Natural England and some of the landowners

- Hogshead moss and woodlands
 - o Mossland is still in good condition but surrounding heathland has degraded as plantation woodland has established
 - o Restoration of heathland would create excellent connectivity between Abbots moss SSSI and Delamere forest
 - o Rhododendron control needed on the edge of the moss
- Leech mere
 - o Area of peatland which has been drained, currently wooded
 - o Potential to dam drains, creating a wetland immediately next to Thieve's moss

Species translocation and re-introductions

Large heath

The Large Heath butterfly is a species which has seen great declines in the last decade. In "The Butterflies and Moths of Cheshire, Flintshire, Denbighshire, Caernarvonshire, Anglesey and Merionethshire", a 1950 magnum opus by S.Gordon Smith, he notes that this butterfly "has not been recorded for many years from Delamere and must now be extinct in this locality". During the project the Butterfly Conservation Trust visited Delamere to assess the potential for carrying out a reintroduction for this species. Of the sites visited Flaxmere, Barnsbiridge basin, Great Blakemere and Hockenhull were those felt most suitable, however it was decided that all of these sites could do with a few more years to develop a better cover of cross-leaved heath and hare's tail cottongrass. The recommendation put forward was for a feasibility study to be carried out with the intention of reintroducing the species once the sites had become suitable.



Photo 183: Large heath butterfly.

Sitticus floricola

During the project surveys for the rare jumping spider *Sitticus floricola* were carried out by the Tanypetera Trust on every basin thought to be suitable for the species, within the Delamere landscape. Several of the Delamere basins were highlighted as meeting the requirements for the species, in particular A06 and Barnsbridge basin, however the spider was not found to be using these sites. As these particular sites

have been suitable for over a decade, and the population of *S.floricola* is doing well at Black Lake, this may indicate the spider is not able to successfully disperse throughout the forest. As spiders normally move through ballooning the size of the sites and the density of the conifer plantation may be impeding their ability to colonise new sites. Because of this a translocation may be worth considering, particularly as only one site currently exists within the forest.

As well as A06 and Barnsbridge basin, Hockenhull was highlighted by surveyors to have perfect conditions for this small spider. As this site is relatively large and close to Black Lake it may be worth monitoring over the coming years to see if the spiders make their way here naturally, and consider a reintroduction if they do not. More in depth spider surveys will be required before a translocation could take place. Additionally Flaxmere is currently the only site to have held a historic population where the spider has not been re-found, despite several searches. This may be due to the drying out caused by drainage. As the drain blocking, carried out during the project, rewets the site it may be worth reintroducing the species here as well if it is not re-found.



Photo 184: Female *Sitticus floricola* taken by Richard Gallon.

Floral rarities

Many of the rare floral species which once were common in Delamere Forest are now only found on a few marginal sites scattered across the landscape. Whilst some species may reappear naturally it is likely that many will not find their way back for many decades, if at all. The restoration of Great Blakemere, and other basins, has demonstrated that the royal fern and round-leaved sundews, along with many of the sphagnum species, can recolonise sites either through wind-borne dispersal or through revival of seeds and spores from within the peat. However species which may need translocating include bog rosemary, bog asphodel, lesser bladderwort and white-beaked sedge. It may take some time for sites to become suitable for these species to be re-introduced, therefore a feasibility analysis may be required to assess which sites are suitable.

Extinct bog species

Some evidence exists of species which have become completely extinct from the Delamere area in the last century such as greater sundew. The best records seem to

exist for Abbots moss, which had scattered records going back several centuries. Research should be undertaken to compile data on species no longer present, and to assess which can be reintroduced.

Records

The full datasets of the surveys carried out during this project can be obtained from RECORD. The full results have not been displayed in this report due to the volume of data collected during the project.

Acknowledgements

A great number of people helped to make the Delamere's Lost Mosses a success including the project partners at the Forestry Commission, Natural England and Cheshire West and Chester Council. Thank you to the volunteers who tirelessly carried out practical work and surveying throughout the project. Also thank you to the landowners who allowed the project to work on their land, or allowed access for surveys. Many thanks to the independent surveyors who worked with the project and shared their data, including Phil Brighton, Richard Gallon, John Roberts, Greg Osbourne, Mel Bellingham and Brian Bull. Thank you to the Tanypetra project for carrying out additional spider surveys and surveys for the bog bush cricket. Thank you to Tracey Walker for sharing her findings from her MSc project and to her supervisor Simon Caporn. Thank you to Jenny Joy from the Butterfly Conservation Trust for assessing the Delamere peat basins for a potential future reintroduction of the large heath butterfly. Thank you to the Norley Wildlife Group and the Old Pale volunteers for assisting in the management of some of the peat basins and their assistance with surveys. And thank you to the contractors who carried out much of the larger scale clearance, bunding and damming; BH Fletchers, Redwood Tree Specialists and Wildbanks.