Specialist site visit – Forest of Dean, Tuesday 3 – Thursday 5 May 2016

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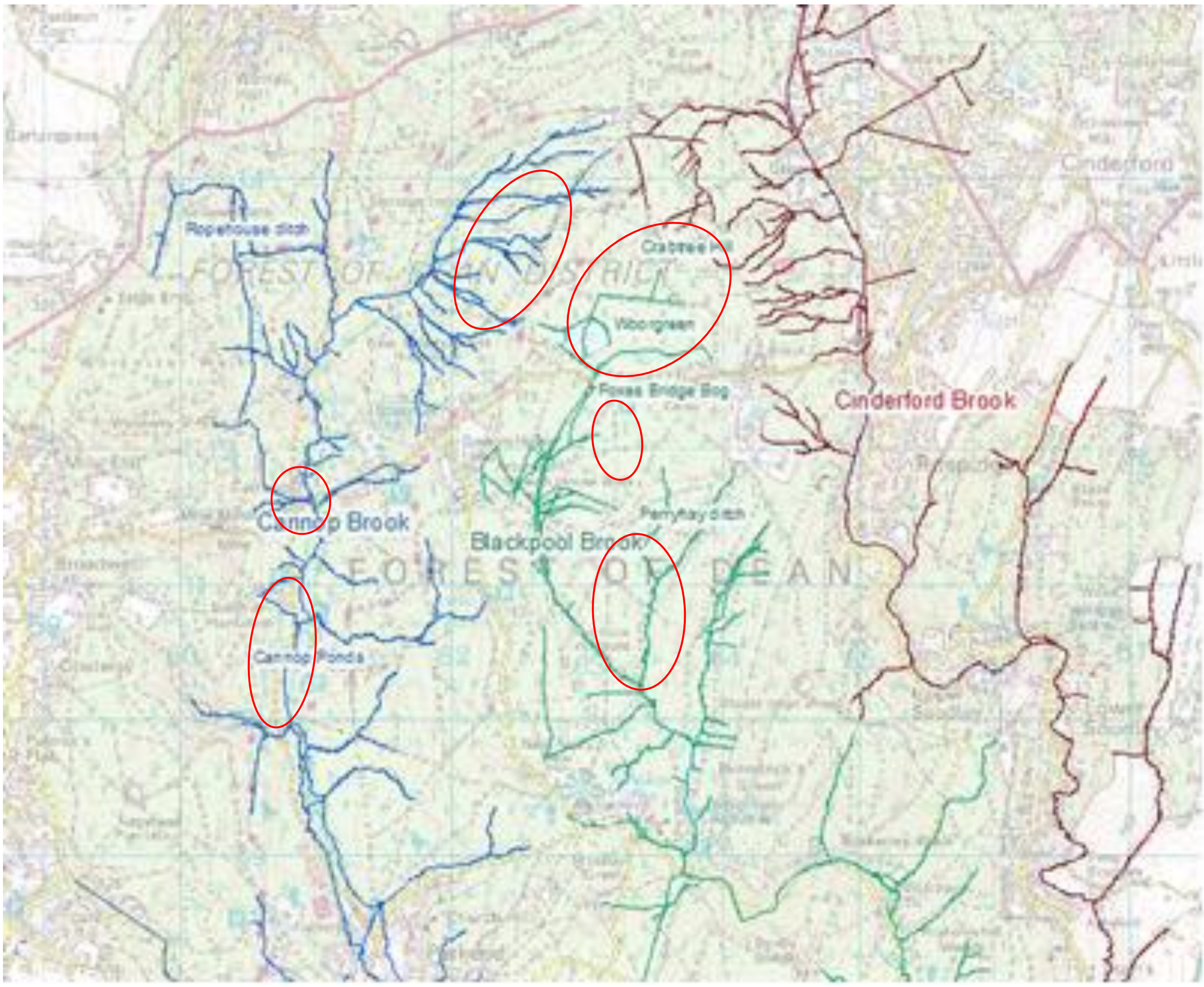
In attendance at various points: Chris Mainstone (running waters), Iain Diack (wetlands), Ruth Hall (standing waters), Isabel Alonso (heathland), Alisa Swanson, Emma Heald, Lis Harris, Sue Buckingham, Rebecca Wilson (Forestry Commission), Peter Kelsall (Forest Enterprise), Gill Walters (EA Biodiversity), Libby Capps (EA monitoring)

We visited a range of sites across the Forest (see map below) to get a good feel for the quality of running/standing water, wetland and other habitats in different catchments. We also inspected some streams running into the River Wye that have their headwater catchments within the western parts of the Forest (see the map later in this document).



Map of Forest of Dean showing main areas visited circled in red (map produced by Alisa Swanson).

1. Tuesday 3 May

1.1 Woorgreens and Crabtree Hill

Woorgreens/Crabtree Hill is the main watershed within the Forest of Dean supplying water to Blackpool Brook in the south, Cannop Brook in the west, Greathaugh Brook in the north and Cinderford Brook to the east.

The **Woorgreens marsh area** on the southern and western slopes was an opencast coal quarry decommissioned and re-landscaped some years ago. The nature of the area prior to quarrying was not clear from the site visit but would presumably have been sloping land of moderate gradient, with heavy soils generating flushes, runnels and pools and a range of wetland types. Landscaping has involved the creation of a large shallow lake (Woorgreens Lake, Figure 1.1) as well as land-forming of the surrounding area to generate a large-scale undulating linear landscape of troughs and ridges (Figure 1.2). The land-forming was designed to create sufficiently well-drained land for forestry, with some of the troughs planted up with alder.

Figure 1.1 Woorgreens Lake.

Figure 1.2 Land-forming to the east of the lake. The line of rushes running top left to bottom right indicates a trough, showing the orientation of the large-scale undulation.

There are few aquatic plant species recorded from the lake, and none particularly notable. Brief inspection by grapnel revealed a previously unrecorded charophyte (*Nitella* sp.), *Elodea* sp and *Potamogeton pectinatus* suggesting that current volunteer recording might be enhanced by the use of a grapnel. Notwithstanding the lack of detailed survey, the lake appeared to support limited interest; this may well in part be due to the recent management of the lake and a lack of propagules in the post-quarry landscape. The lake has been drained 2 or 3 times in an attempt to eliminate carp that have been introduced without permission. Carp persist however, either by surviving the drainage or by further unpermitted introduction. There are no angling rights on the lake and it is not fished.

The composition of the fringing transitional mire (Figure 1.3 and Figure 1.4) is of much greater conservation interest, probably reflecting the nature of the seedbank from the pre-impact wetland landscape (which is unlikely to have contained large open standing water areas). The mire contains a range of *Sphagnum* mosses (*S. denticulatum* the most abundant) in amongst soft rush and sharp-flowered rush, as well as abundant marsh St John's wort and marsh speedwell. The transition between clear open water and mire supports bog pondweed and floating club-rush, alongside the moss *Calliergon cordifolium*. It is actively encroaching into the shallow lake, creating ever larger expanses of priority mire habitat which is probably referable to the EU Habitats Directive Annex 1 habitat Transition mire and quaking bog.

Figure 1.3. Transition mire around the lake.

Figure 1.4 Sphagnum with standing pools on the transition mire habitat

The large-scale land-forming to the east of the lake has generated a highly unnatural landscape, with poor-quality dry habitat on the ridges and troughs running downslope into a deep ditch where erosion is evident (Figure 1.5). The drainage efficiency this landscape is creating precludes the restoration of a natural mire/flush/pool/runnel habitat mosaic that might have been expected in this area. Of interest was the presence of wetland bryophytes indicative of both acid (*Sphagna* and *Aulacomnium palustre*) and base-rich (*Bryum pseudotriquetrum*, *Pellia endiviifolia* and *Riccardia multifida* (?)) conditions in the bottom of some of the troughs, suggesting that restoration of these areas could result in a highly diverse wetland.

Figure 1.5. Deep ditch into which the troughs of the land-forming drain (an entry point can be seen in the centre of the photo). Note the heavy poaching, presumably by wild boar.

We walked uphill through Woorgreens Marsh into Crabtree Hill, which is outside of the old opencast site but still impacted by forestry drainage of similar design to Woorgreens. This area was cleared from conifers by the FC some years ago. Observations from a previous site visit by Isabel Alonso (Heathland specialist) are incorporated into the account below.

The south-facing slope of Woorgreens Marsh exhibits a wetness gradient, with the wettest area at the base of the slope in the south and drier soils higher up. There are seepages emerging from the slope at various points giving rise to wetland vegetation and shallow peat. These seepages drain in a southward direction towards the valley bottom where the lake is located. There is a dense network of artifical drains, presumably associated with past forestry operations, which drain the entire slope into larger arterial drains (see Figures 1.6 and 1.7). Their impact is to significantly reduce the wetness of the valley slopes, which in a natural undrained state are likely to have supported vegetation of wet heath, mire and runnels and soakaways/flowtracks, of which vestiges (indicated by *Molinia*, *Juncus acutiflorus*, *Carex binervis*, *Sphagnum denticulatum*) remain close to the drains and in hollows. Above the seepages dry heath is likely to have occurred in a 'classic' heathland/valley mire zonation.

Figure 1.6 The northern (upper) part of Woorgreens Marsh showing drainage pattern (from Bing maps).

Figure 1.7. The southern (lower) part of Woorgreens Marsh (the valley bottom), showing drainage pattern (Bing maps).

The lower parts of the slope are dominated by dense Purple moor-grass *Molinia caerulea*, *Polytrichum commune* (Figure 1.8) and several *Sphagnum* species, including *S. denticulatum*, which is the commonest and most abundant species, *S. inundatum*, *S. papillosum*, *S. capillifolium*, *S. cuspidatum*, *S. fallax*, *S. palustre* and *S. fimbriatum*. In addition a small patch of *Sphagnum russowii* was found, a new record for Gloucestershire (conf. T. Blockeel). Although degraded and, in terms of vascular plants, species-poor (few mire plants remain, with the exception of *Carex demissa, C. echinata*, *C panicea* and maybe others given more time on site), in a Gloucestershire context this is a very important remnant of habitat. Pioneer heather appears in the few bare ground spots (Figure 1.8), so there seems to be some seed bank.

Figure 1.8 Woorgreens, southern slope, showing dense purple moor grass (left) and pioneer heather on bare ground (right).

There is some dry heath in the drier substrates (Figure 1.9), most of it in mature/degenerate stage. There have been heather beetle outbreaks recently which may have killed some of the mature heather plants (Figure 1.10). Gorse *Ulex europaeus* and *U. gallii* are both present on site, as well as bilberry *Vaccinium myrtillus*. There are areas with dense bracken *Pteridium aquilinum* litter with high frond cover in summer (Figure 1.10), but the GWT is controlling it by spraying and flailing. There are also areas of arisings left after tree-felling (evident in Figure 1.9) which may complicate future management interventions, particularly mechanically. Gorse is regenerating in many areas and may pose future management problems.

Figure 1.9 Dry heath on the upper slopes of Woorsgreen.

Figure 1 10 Woorgreens - outbreak of heather beetle (left) and a patch dense bracken (left).

Several pools have been dug on the slopes; whilst this may increase the area of wetland while the site remains in a drained state, the optimal condition for this site from a nature conservation perspective is one of restored hydrological integrity through the blocking and in-filling of all drains. This would allow the re-development of natural patterns of wet and dry heath, mire and soakaways, without the need for interventions such as pool creation which leads to piles of spoil etc on potential high-value naturally functioning habitat.

The ditch shown in Figure 1.7, which runs alongside the road adjacent to Woorsgreen Lake, reflects the influence of base-richness by the presence of bog pimpernel and tawny sedge (tentative id), both species now very uncommon in Gloucestershire. This again indicates both diversity in water chemistry and geology and the low nutrient status of this area, which would appear to lend itself to the restoration of a high quality wetland system.

At the top of the slope in Crabtree, some restoration work has already been undertaken to push soil from parts of the ridges into the troughs to create linear ponds (Figure 1.11), which host species such as the scarce blue-tailed damselfly *Ischnura pumilio*. Although these ponds are being used by *I. pumilio,* it is a species characteristic of natural wetland habitat mosaics where pools and runnels are interspersed in mire and other wetland habitats. These ponds also supported a charophyte (unidentified) as well as *Potamogeton natans* and *Potamogeton polygonifolius.*

Figure 1.11 One of the linear series of ponds created by partial restoration of the Crabtree area.

Reflections on Woorgreens and Crabtree Hill

- **Woorgreens Lake** - Overall, and considering the likely natural habitat mosaic that was lost by quarrying, the best course of action is likely to be to allow the mire to continue to encroach into the open water, creating more high-value mire at the expense of a large expanse of open water which currently has low conservation value. A more complete hydrosere would then develop, from drier willow scrub at the periphery through transition mire to open water. The fragmentation of the open water into smaller areas is likely to help reduce and restrict the carp population, and will create open water habitat that is more characteristic of the pre-quarrying landscape. Some larger open water areas could be kept open near the existing lake margin to maintain existing public enjoyment of the area.

- **Woorgreens to the east of the lake** - Given this area is of limited forestry interest, the best course of action would be to shift the surface soils from the ridges and deposit them into the troughs, in an irregular fashion to create a poorly drained landscape with substantial and random microtopography. This would allow the area to be rewetted to provide a high quality mosaic of running, standing and wetland habitats without needing to direct water to these habitats via ditches. See also the discussion and recommendations section which refers to similar work undertaken elsewhere.

- **Woorgreens Marsh south-facing slope** - As described above, the blocking and infilling of the entire drainage network would start to re-create the conditions necessary to restore the valley mire system including fringing wet and dry heath. The presence of the *Sphagna* and the clean catchment suggest that such an approach would bring rapid positive results, restoring a habitat type now almost lost from the county. As the mire/heath system develops it may be necessary to re-introduce components of the mire vegetation that have been lost from the area. The Flora of Gloucestershire lists many heath/mire species now apparently extinct from the county that once occurred in the Forest of Dean, including all three native sundew species.

- **Crabtree Hill** - Further soil movement from the ridges in the same manner as suggested for Woorgreens would provide a closer approximation to the habitat conditions naturally supported by the area, generating excellent conditions for characteristic species of both wet and dry heathland and mire habitats (such as *I. pumilio)*. AS has highlighted that a Countryside Stewardship application focused around Crabtree Hill has been submitted to Natural England in 2016, based on re-introduction of grazing for the restoration of heathland. The applicant has funding to carry out an Implementation Plan which will determine the best options and capital work they need to deliver heathland and other habitats. They will need to look at the likely impact of grazing on mire restoration. The start of the CS agreement may need to be delayed for a few years to allow hydrological monitoring to take place.

It is important to recognise that any such restoration of natural hydrological pathways and conditions will result in changes to the spatial distribution and extent of existing degraded dry heath. In locations where dry heath has been created by the major drainage infrastructure across the site, mire or wet heath will return. It may be that some of the vegetation management problems described above will be alleviated by the restoration of natural hydrological function.

1.2 Foxes Bridge Bog

Although this area contains what appears to be a stream running into it, originating from the Woorgreens area and culverted under the B4226, this is unlikely to be a natural stream at this point given the landscape in which it sits. This area is a relatively intact valley mire (Figure 1.12), although it has been affected by some drainage activity. The ‘stream’ channel at the upstream end of the mire is likely to have been formed by the road culverting, and is possibly maintained by the hydraulic energy generated by the upstream drainage and culvert. The channel soon disappears into the body of the valley mire (Figure 1.13). Drainage features are evident at the bottom of each valley side, acting to dewater the valley slopes for forestry purposes (Figure 1.14).

Figure 1.12 The valley mire at Foxes Bridge Bog.

Figure 1.13 Channel petering out from left to right at the top of the valley mire.

Figure 1.14 Ditch draining the left hand valley side.

Further down the mire, drains have been formed (Figure 1.15) to channel water into a culvert passing through an inclosure wall, both of which appear to be historic features. Immediately upstream of the inclosure wall a ‘stream’ channel becomes distinct once more (Figure 1.16), running out of the mire and through the culvert, picking up significant energy from the gradient downstream – sufficient to start to exhibit some stream behaviour (erosion features, coarse gravel and cobble substrates etc. – Figure 1.17). As a result of this energy the channel appears to have incised into the bed. However, as is the case at the upstream end of the mire, a stream is unlikely to have existed here naturally in this landscape – the channel is a result of the drainage works associated with the inclosure wall, and persists with the help of further lateral drainage in the valley mire that continues downstream of the wall.

Figure 1.15 Ditch draining the central part of the mire, looking up the valley from the inclosure wall.

Figure 1.16 The main channel as it enters the culvert in the inclosure wall.

Figure 1.17 The main channel after exiting the culvert in the inclosure wall, running into the mire downstream.

Reflections on Foxes Bridge Bog

Restoration of this area needs to consider how the valley mire system would have functioned naturally. It seems unlikely that there is sufficient natural hydraulic energy in the hydrological pathways upstream of the mire to overcome mire formation and generate a natural stream channel. It is possible that the landslope upstream of the mire may be sufficient, but the hydraulic energy has been enhanced by the culverting under the road, and in any case soon dissipates in the body of the mire. A stream channel will naturally be generated at some point down the valley, where hydraulic forces become large enough. As the gradient of the valley changes, mire and stream may well alternate naturally, influenced by bedrock and the presence of trees (both of which can stabilise mire and reduce the erosive force of the hydrological pathway). However, at the point of the inclosure wall running across the mire, the stream channel appears to be an entirely artificial construction associated with mire drainage.

In the light of this, the best course of action for restoration would be to block the central and lateral drains upstream and downstream of the inclosure wall to restore the integrity of the mire. This would involve blocking the culvert through the inclosure wall, but would not necessarily require the removal of the wall itself if this is considered to be a heritage feature. Holes could be created in the wall to allow a more natural seepage of water through the mire system. Restoration works should not aim to create a flat surface across the mire, but rather should provide a varied microtopography that would develop naturally in such systems. This allows for the creation of natural pools for standing water interest within the mire without having to dig out ponds which are often created with artificially steep edges, are often deeper than would naturally be expected, and are associated with piles of spoil from their excavation.

2. Wednesday 4 May

2.1 Blackpool Brook and Perryhay Ditch

Blackpool Brook proper is the stream that drains the Woorgreens and Fox Bridge Bog area. We visited it at a location where hydrological pathways are sufficiently energetic and focused to form a natural stream channel. We walked eastwards from New Fancy View car park to meet the tributary Perryhay Ditch at NGR SO 631 104, following it up towards the natural mire/stream transition before walking downstream to the confluence with Blackpool Brook.

Perryhay ditch exhibits varied natural morphology within an incised 'ghyll' (Figure 2.1) formed by the hydraulic energy of the brook itself. This is similar in appearance to the ghyll streams running off the High Weald in Kent, but the ghyll sides and atmosphere generated are far less humid than the Wealden streams. This may be partly due to differences in solid and drift geologies and the specific aspect and canopy cover of the ghyll visited, but it is likely to be strongly influenced by the intensive drainage of the land above the ghyll, which is diverting water that would have seeped through the ghyll sides and helped to create a moist microclimate for ferns, bryophytes and flush vegetation. Much of the land above the 'ghyll' has been planted with oak, which in general appears to be in very poor condition with many trees dead and dying, largely as a result of squirrel and deer damage. The character of this higher ground is heavily influenced by drainage, but retains elements of heathland and mire and other semi-natural vegetation (various *Sphagna* present in drains), and would probably respond rapidly to restoration action, particularly drain blocking.

The extent of influence of footfall, either by animals or humans, in the lack of riparian vegetation is not clear but may be a factor. It is also worth noting that there is a reasonable amount of plantation beech, which generates heavy leaf litter and suppresses ground vegetation.

Figure 2.1 Channel habitat mosaic created by riparian trees. A fallen tree has created a pool, whilst the rootplate of a standing riparian tree has held up the stream bed level, creating a small cascade and scour pool below.

Within the channel, the importance of riparian trees to the creation of the natural habitat mosaic is immediately apparent. Tree root systems generate points of resistance to streamflow, creating a characteristic sequence of debris dam, scour pool, riffle and exposed sediment bar downstream (Figure 2.2). They also generate lateral movement as the stream cuts through areas of least resistance, creating meander bends with characteristic patterns of erosion and deposition across the channel. All of this activity creates the habitat mosaic of shallow and deepwater, high and low current velocities, fine and coarse substrates, and retained woody material and leaf litter which the characteristic flora and fauna are adapted to exploit. Each species and life stage uses different parts of the mosaic under different flow conditions, and loss of any one part of the mosaic has ecological consequences.

Figure 2.2 Sequencing of habitats formed by natural riverine processes.

A brief kick-sample was taken of the benthic macroinvertebrate assemblage of Perryhay Ditch at this point. The stoneflies *Leuctra nigra* and *Amphinemura sulcicollus* reflect the presence of silty substrates and leaf litter within the habitat mosaic, whilst *Isoperla grammatica* reflects the presence of coarse substrates, (located within small riffles). The mayfly *Habrophlebia fusca* is a specialist of slow-flowing water and leaf litter, whilst Polycentropid, Limnephilid and Plectronemid caddis-fly larvae reflect the range of current velocities within the habitat mosaic. *Plectrocnemia* species are net-spinning caseless caddis-flies that specialise in small headwater streams, giving way to other caseless caddis-flies further downstream.in a recognisable pattern of longitudinal species change. Freshwater shrimps were prominent in the sample taken – these are leaf-shredders like some of the stone-flies above and will be taking advantage of the retention of some of the heavy leaf-fall to the stream within the complex river habitat mosaic. Scirtid beetle larvae were also found, which are associated with active wetland vegetation in stream margins. Such vegetation was not prominent in most of the stream reach inspected - presumably they are dispersing downstream from the more vegetated mire/stream transition (see below).

Walking upstream the ghyll becomes less incised as we near the area of natural transition between mire and stream. Trees begin to invade the nascent channel as hydraulic energy declines, forming an obstacle to the transport of sediment, leaf litter and woody material behind which mire vegetation can stabilise (Figure 2.3). This area of transition should not be seen as a single fixed point on the map. In some stream systems sub-surface hydrological pathways create a single strong-flowing spring which is defined as a ‘perennial head’ to the stream, but even in such cases there is seasonal stream flow above this point. In many streams the ‘source’ moves up and down the hydrological pathway along which the stream forms, depending on natural constraints to erosion of the channel, which are either formed by living or fallen trees or bedrock controls on the stream bed. Within this transition zone the mire and stream often alternate down the course of the hydrological pathway, just as fast and quiescent zones of a river alternate depending on stream gradient.

Figure 2.3 A tree in the channel near the top of the ghyll, encouraging sediment retention and invasion of the channel by mire vegetation. Note heavy poaching, presumably by wild boar.

We came across a culvert near the top of the ghyll (Figure 2.4). This seems to have no significant use and generates an unnecessary impact on natural stream function, eliminating stream habitat for some metres.

Figure 2.4 A culvert near the top of the ghyll.

We did not walk as far as the top of the ghyll, but we walked far enough to observe the extensive drainage near the top, similar to the drainage observed at the top of the ghyll sides further downstream.

Below the confluence with Perryhay Ditch, Blackpool brook becomes a significant size and continues to exhibit a good range of natural morphological behaviour (Figure 2.5). The habitat mosaic provided by the stream along this section is very good, although there is a distinct absence of large woody material (fallen large boughs or trunks) lying across the channel. This material is highly important to the creation of partial blockages to flow, and the kind of habitat patterns described above. There are some suggestions that large material may be being relocated outside of the channel for some reason, although there is no known formal management practice of that kind operating within Forest Enterprise.

Figure 2.5 The Blackpool Brook below the confluence with Perryhay Ditch.

A brief kick-sample was taken of the benthic macroinvertebrate assemblage of the stream at this point. The stonefly *Amphinemura sulcicollus* was again prominent, reflecting the presence of silty substrates and leaf litter. However, good numbers of the predatory stoneflies *Isoperla grammatica* and *Chloroperla torrentium* indicate larger stream size and more prevalent riffle habitat, as does the presence of the caseless caddis-flies *Hydropsyche siltalai* and *Rhyacophila* spp., Ecdyonurid and Rithrogenid mayflies, and riffle beetles (Elmidae). This said, Plectronemid caddis-flies are also present at this location, reflecting the headwater nature of the stream, and the burrowing mayfly *Ephemera danica* indicates the presence of finer substrate patches within the habitat mosaic. Again freshwater shrimps were prominent in the sample taken.

Reflections on Blackpool Brook and Perryhay ditch

In restoration terms, there is little wrong with the stream channel – it is generally left to behave naturally although any temptation to remove fallen trees from the channel should be resisted. The biggest issue to address is the drainage at the top and to the sides of the ghyll. It would be best to block drains in at least the immediate vicinity of the ghyll top and sides, to help restore natural stream flows (which are likely to be diminished in the summer months due to poor water retention in the catchment) and hopefully restore more humid conditions to the ghyll for the benefit of the lower plant flora, flush vegetation and associated fauna (e.g. Scirtid beetles, Taeniopterygid stoneflies). Selective felling of plantation trees and planting of more characteristic riparian trees (alder, willow) to generate patchy shade and stronger interactions with channel form would also be beneficial. The culvert could be removed and if necessary replaced with a fording point using local coarse substrates.

2.2 Cannop Ponds

Cannop Ponds are located in an adjacent catchment within the forest, being formed by a series of on-line artificial impoundments of Cannop Stream. We visited the two upstream ponds – the third appears to be quite similar to the middle pond.

The impoundment creating the middle pond is a substantial rock structure extending across the narrow incised valley. The overflow is a rock spillway that would appear to be passable by eels (Figure 2.6). From a brief inspection by grapnel the submerged plant assemblage of the middle pond (Figure 2.7) is dominated by non-native *Elodea.* This appears to grow in a relatively large bed in the centre of the pond, suggesting it is not very deep. No other aquatic plants were found by brief grapnel sampling from the shore. There also appears to be a reasonable flushing rate through the pond, with *Elodea* fragments accumulating towards the outflow. There was limited emergent vegetation around the lake possibly due to shading and recreational pressures as well as unsuitable substrates where artificial structures/shorelines are present.

Figure 2.6 Rock spillway at the impoundment for the middle pond.

Figure 2.7 The middle Cannop Pond.

The most upstream pond is no longer impounded at a level above the middle pond. It is separated from the middle pond by a short interconnecting channel running through what appears to be an old retaining structure, but the hydrological connection is free. The upper pond has succeeded to swamp vegetation and exhibits a good wetland hydrosere from water horsetail swamp (in the lowest part of the old pond), through reedswamp and willow carr, to alder carr in the most upstream area (Figures 2.8 and 2.9). Upstream of this the stream channel displays natural morphological function (see description under Thursday 5 May).

Figure 2.8 The hydrosere that has developed in the upper Cannop pond, viewed from the overflow to the middle pond. Water horsetail swamp (in the foreground), through reedswamp to willow carr (alder carr is beyond the willow).

Figure 2.9 Alder woodland at the upstream end of the hydrosere in the upper pond. Note heavy poaching in the foreground.

Walking up into the alder carr, specimens of the invasive non-native skunk cabbage were found scattered within the carr vegetation. Given the dispersed nature of the plants this does not appear to be *ad hoc* dumping by an individual who has cleaned out their pond. AS believes the plants are likely to originate from a small nursery immediately upstream of the site. Urgent action is needed to remove plants from the carr and to address the invasion pathway from the nursery.

Reflections on Cannop Ponds

In terms of habitat restoration, ideally the impoundments would be removed to restore natural stream and riparian habitat and reinstate the natural connectivity of the stream system for stream biota. However, the ponds are a key recreational amenity for the local community and are an important tourist attraction. In some cases in the river SSSI system the effect of on-line artificial impoundments has been circumvented by 'dragging the river' out of the lake/pond, i.e. creating a new channel beside the lake/pond and taking the standing water habitat off-line. The scope for doing this varies from site to site and it would not be easy at Cannop Ponds given the incised nature of the valley and road/car park infrastructure adjacent to the ponds.

Given the high recreational profile of the ponds and the many other opportunities to restore natural water and wetland habitat mosaics within the forest, restoration of natural stream habitat at this location should not be considered a priority. There are plenty of places in the forest where stream restoration can occur without raising tensions between different management objectives. This includes acting on some of the more minor impoundments that are causing stream habitat loss and connectivity issues. In addition, the hydrosere at the upstream end of Cannop Ponds has significant conservation interest, even though it has been created artificially and exists at the expense of natural stream and riparian habitat.

It is likely to be best to accept the impounding structures at Cannop Ponds, at least in the short-medium term, and focus on protecting and enhancing the existing habitats there whilst addressing problems arising from the impounding structures. This includes dealing with skunk cabbage as quickly as possible, ensuring the impoundments are passable by eel (e.g. perhaps by increasing surface roughness on the rock spillway draining the second pond), and considering pond management measures that would enhance submerged and marginal vegetation and their associated fauna. It is assumed that water quality is not an overriding issue at this site, as water comes from the forest, but this should be confirmed. Consequently, pond conservation measures for consideration include: 1) ensuring that the fish community represents a locally native balanced mixed fish assemblage, 2) managing recreational activities on the site so that they do not impact upon the pond habitat (including its fringing vegetation), and 3) active creation of areas of fringing vegetation with appropriate management to enable its establishment.

2.3 Headwaters of Cannop Brook

We drove upstream to the plantation area where the headwaters of the Cannop Brook form. We parked at NGR SO 623 125 and walked up a forest track to cut across a number of headwater streams (marked on the 1:25k OS map) draining the western side of Woorgreens.

A pond (Figure 2.10) has been created to the west of Woorgreens Lake which seems to receive an overflow from the lake through a drainage ditch before discharging into the headwaters of the Cannop Brook. It has a concrete overspill and has the appearance of a settlement pond. Like many created ponds of this type it has filled with a monoculture of reedmace. Downstream of the pond there is a distinct channel which has sufficient energy on a relatively steep gradient to influence its own morphology (Figure 2.11). However, it is unclear if it was a stream channel prior to the upstream drainage works, and may have originally been flush habitat.

Figure 2.10 Artificial pond to the west of Woorgreens Lake, showing overspill.

Figure 2.11 The channel downstream of the artificial pond.

Upslope of the track the land is of higher gradient and planted with conifers, whilst downslope the gradient is gentler and the land is planted with broadleaves. This whole area has been intensively drained for forestry purposes. The ‘streams’ on the OS map are actually drains (e.g. Figures 2.12 and 2.13). Prior to drainage it is likely that the location of these drains was occupied by flushes and springs that would have constituted the start of the surface hydrological pathways leading to stream channels further downstream. Given the time of year, the landscape seemed exceedingly dry, with very few signs of any surface dampness. We found only a handful of areas supporting any vegetation with wetland character, where the drainage system had failed to dry it out completely, and where seepages emerged above the track. In contrast to the Woorgreens area, the water chemistry in this area appeared to be more base-rich, reflected in the presence of basicolous vascular plants, e.g. *Carex flacca*, and bryophytes, including *Fissidens adianthoides*,

The main track leading down the slope had a side drain with a healthy flow of water being channelled away from the upper slopes. It indicates there could be sufficient water to resupply the largely defunct flushes and springs across the western slope draining into the Cannop brook.

Figure 2.12 Forest drains cut through the broadleaf plantation area.

Figure 2.13 Another drain through the broadleaf plantation.

Reflections on Cannop headwaters

In restoration terms, ditch blocking is again the main requirement in the area inspected. If the ditches are blocked, natural hydrological pathways will be restored and the flow and retention of water within the landscape will dictate the level of wetness and the location of the transition between mire, flush and stream. Given the gradient of the land it may well be that mire (i.e. peat-forming) habitat would not be naturally present in this headwater area other than within discrete flushes. However, other forms of wet vegetation would certainly redevelop between flushes following ditch-blocking.

3. Thursday 5 May

3.1 Cannop Brook and Ropehouse Ditch

Brief inspections were made (by Chris Mainstone only) of the middle and lower reaches of the Cannop Stream, above and below Cannop Ponds. Above Cannop Ponds at NGR SO 611 127, the stream channel functions very naturally, meandering through a narrow valley floor (Figure 3.1). A brief kick-sample was taken of the benthic macroinvertebrate assemblage of the stream at this point. A good range of stoneflies was again recorded: the predators *Isoperla grammatica* and *Chloroperla torrentium*, the shredder/detritivore *Amphinemura sulcicollis*, and the Taeniopterygid species *Brachyptera risi.* An abundant mayfly assemblage was evident, dominated by riffle-dwelling species *Rithrogena semi-colorata* and *Ecdyonurus* sp. and *Ephemera danica* in areas with somewhat finer substrates. Other riffle dwellers recorded are the caseless caddis-fly *Rhyacophila* sp. and riffle beetles (Elmidae). Freshwater shrimps (Gammaridae) were abundant as in other Forest streams.

Below the ponds towards Lydney, the stream is more constrained by development, with reinforced banks and occasional weirs. The habitat provided through this section is consequently more limited.

Figure 3.1 The Cannop Brook above Cannop Ponds.

Ropehouse Ditch was inspected at NGR SO 611 134, immediately above its confluence with the Cannop Brook. Although given the epithet of ‘ditch’, the channel appears to be functioning very naturally, showing quite extreme meandering behaviour with good interaction with riparian trees (Figures 3.2 and 3.3). The resulting habitat mosaic is of reasonable quality, although coarser substrates are in short supply (possibly due to the stream gradient at this point, or historical ditching operations). The channel was presumably ditched at some point in the past (the stream bed is a considerable way below the bank top) but it seems likely that there was a pre-existing stream. A brief kick-sample was taken of the benthic macroinvertebrate assemblage of the stream at this point. The stoneflies *Isoperla grammatica* and *Brachyptera risi* (?), and Ecdyonurid and Rithrogenid (*R. semi-colorata*) mayflies, indicate swift-flowing gravelly biotopes within the habitat mosaic. The presence of Scirtid beetles and alder-fly larvae (Sialidae) reflect more quiescent zones and vegetated margins. Freshwater shrimps (*Gammarus* sp.) were again abundant. Overall invertebrate diversity was lower than in other streams visited, presumably in part due to the predominance of relatively fine substrates.

Figure 3.2 Ropehouse Ditch above the confluence with Cannop Brook.

Figure 3.3 Ropehouse Ditch above the confluence with Cannop Brook.

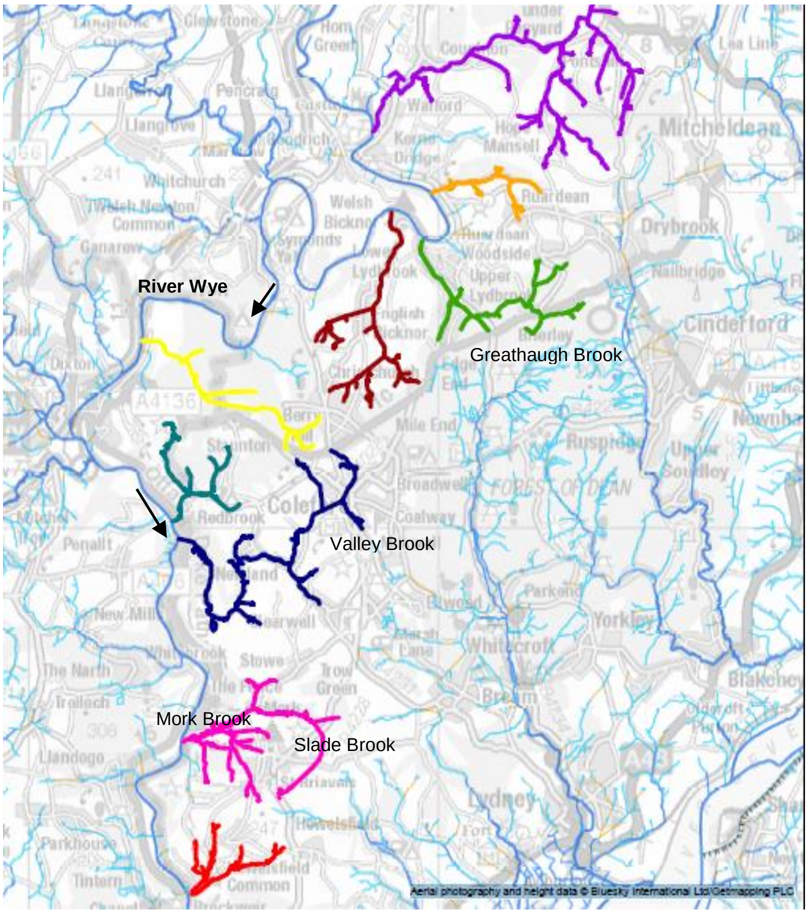
Reflections on Cannop Brook and Ropehouse Ditch

The middle reaches of the Cannop Brook above Cannop Ponds (at least where inspected) appear to be functioning naturally and require little by way of physical intervention. Below Cannop Ponds there are opportunities for restoring natural function, but development constrains what can realistically be achieved. Weirs should be removed where possible and (if practicable) large woody material should be allowed to fall and be retained in the stream to help restore the habitat mosaic.

On Ropehouse Ditch, management that supplies coarse woody debris to the channel (preferably through natural fall of riparian trees across the channel) would provide partial obstructions that should raise the bed of the stream over time, shallowing the profile to provide better hydrological connectivity with the riparian zone.

3.2 Wye Valley streams

The River Wye in its lower reaches intersects the Welsh and English borders and has many headwater tributaries feeding into it. Some of these have part of their gathering grounds in the Forest of Dean (see map below) and we visited a selection of them. Of these only Greathaugh Brook can be considered to lie within the Forest itself.



Map of streams originating in the Forest of Dean and discharging to the River Wye - named streams are those inspected.

Slade Brook (part of Mork Brook system)

A brief inspection (by Chris Mainstone only) was made walking upstream from Mork. The brook is extremely natural with excellent in-channel habitat mosaics and woodland riparian zone (Figures 3.4 and 3.5). It is heavily tufa-forming, creating characteristic tufa steps (Figure 3.6). A brief kick-sample was taken of the benthic macroinvertebrate assemblage of the stream. This revealed a wide range of caseless (Psychomyiidae, *Hydropsyche* sp. and *Rhyacophila* spp.) and cased caddis-fly larvae (Odontoceridae and Limnephilidae), a diverse mayfly assemblage (*Seratella ignita*, *Rithrogena semi-colorata, Ephemera danica*, and baetids), abundant freshwater shrimps (*Gammarus* sp.) and Scirtid and Elmid beetles. No stoneflies were found but this is likely to be a natural water chemistry issue. Overall, the invertebrate assemblage reflects a diverse range of habitat opportunities (substrate types, current velocities) provided by the natural habitat mosaic.

Figure 3.4 Slade Brook immediately upstream of Mork.

Figure 3.5 Slade Brook immediately upstream of Mork.

Figure 3.6 Tufa steps in Slade Brook.

Later in the day a larger group walked downstream from the top end of the southern headwater of the brook. Although the top end of the headwater catchment has been drained and developed (scattered housing and gardens), there is a small field at the top of the stream channel where there is still a natural transition between flushes and the stream proper (Figure 3.7). This field is fenced off and covered by golden saxifrage. The top end of the stream channel is defined by bedrock controls (Figure 3.8), which support the large area of flush vegetation above it. There was no flow at the stream head at the time of inspection (probably naturally ephemeral). At the confluence of the northern and southern arms, it was clear that the northern arm (Figure 3.9) contributes much greater flow than the southern arm.

Figure 3.7 Head of the stream channel on the southern headwater of Slade Brook.

Figure 3.8 The perennial section of the southern headwater of Slade Brook.

Figure 3.9 The northern headwater of Slade Brook immediately upstream of the confluence with the southern headwater.

Immediately below the confluence of the headwater arms the stream runs through a culvert underneath a farm track. This has created an artificial tufa mound and a scour pool underneath the discharge point of the culvert (Figure 3.10).

Figure 3.10 The culvert, tufa mound and scour pool on Slade Brook.

Reflections on Slade Brook

Slade Brook is notified as a geological SSSI for its tufa formations. Under the existing guidelines for biological SSSIs the site does not fit the criteria for river/stream habitat, since they are heavily focused on instream vegetation communities. However, revisions being made to the freshwater chapter of the guidelines will allow river/stream habitat to be included in the notification, based on naturalness considerations.

The culvert is creating a loss of naturalness, causing complete loss of stream habitat for a short distance, interfering with natural morphological processes that create the natural habitat mosaic, and interrupting biological movements. It is recommended that the culvert be replaced by a wide span bridge. There was also a section of the brook which overlapped with the footpath and could be looked at whether a separate footpath route can be devised slightly upslope of the brook.

Mork Brook

This is located downstream of Slade Brook, discharging directly into the main River Wye at Bigweir Bridge. The downstream end of the brook is heavily incised to meet the bed level of the main Wye (Figure 3.11), and shows considerable tidal influence from the main river. However, the bed level shallows considerably only a short distance upstream, due to the stabilising influence of tree root systems (Figure 3.12).

Figure 3.11 The heavily incised Mork Brook at the confluence with the tidal River Wye,

Figure 3.12 The bed level of Mork Brook being protected from incision by extensive riparian tree root systems.

Walking upstream, the brook exhibits a reasonable habitat mosaic (Figure 3.13). A brief macroinvertebrate sample as taken at this point. This revealed a relatively diverse assemblage including stoneflies (*Isoperla grammatica* and *Brachyptera risi*), caseless (*Rhyacophila* sp.) and cased caddis-flies (*Sericostoma personatum*, Odontoceridae, Limnephilidae), mayflies (*Rithrogena semi-colorata*, *Seratella ignita*, *Baetis* sp.), Elmid and Gyrinid beetle larvae, and Simuliid and Chironomid dipteran larvae,

Figure 3.13 The habitat mosaic in Mork Brook.

Further upstream, and prior to the confluence with Slade Brook, the channel is heavily affected by landscape engineering associated with an old country house (Figures 3.14 and 3.15).

Figure 3.14 Weir below Mork Farm and confluence with Slade Brook.

Figure 3.15 Weir on Mork Brook in the grounds of an old Country House.

Valley Brook

This brook discharges into the Wye upstream of Mork Brook. It is more affected by development than the Mork Brook system, but has some stretches with reasonable remaining physical habitat. We walked along a short section of the middle reaches. The section was heavily impacted by an impounding structure which seems to serve no on-going function – the resulting pond is heavily silted and devoid of submerged plants. Downstream the brook runs through sheep pasture (Figure 3.16), with some impressive riparian alders (Figure 3.17). The channel behaves naturally through this stretch, creating a good in-channel habitat mosaic (Figure 3.18). However, the heavy bankside grazing provides no opportunity for a diverse riparian zone – the effect of eliminating grazing pressure can be seen further downstream, (Figure 3.19), where the vegetation (albeit mainly hemlock water dropwort) has spring up behind riparian fencing.

Figure 3.16 Middle reaches of the Valley Brook.

Figure 3.17 Old riparian alders on Valley Brook.

Figure 3.18 Strong dynamic habitat mosaic in Valley Brook.

Figure 3.19 The effect of fencing on Valley Brook.

The incised valley does show evidence of flushes that would have come off the valley sides before land drainage activity (Figure 3.20).

Figure 3.20 A flush running into the middle reaches of Valley Brook.

We briefly visited a stretch further downstream above Redbrook, which turned out to be heavily impacted by an impoundment (Figure 3.21), seemingly for fishery purposes.

Figure 3.21 Impoundment on Valley Brook.

Reflections on Valley Brook

Valley Brook has considerable potential for restoration, with some stretches showing good physical habitat amongst heavily impacted stretches. The water quality and hydrological effects of development in the catchment are not immediately apparent and may require attention. No invertebrate samples were taken from Valley Brook, but the EA has a monitoring site at the downstream end of the brook which would provide valuable information.

Greathaugh Brook

This is the proposed site of a beaver enclosure, in the northern part of the forest draining the northern slopes of Woorgreens/Crabtree Hill. We walked downstream from the forest track at NGR SO 622 154. The channel has been ditched historically but is beginning to show signs of natural recovery (Figure 3.22). There are still strong flushes entering the channel from the right hand bank (e.g. Figure 3.23), from seepages along the steep valley side – these are probably the strongest flushes we have seen during this visit to the forest, supporting abundant golden-leaved saxifrage and valerian.

Figure 3.22 Greathaugh Brook.

A brief kick-sample was taken of the benthic macroinvertebrate assemblage of the stream. Diversity is relatively low because of the historical impacts on the physical habitat mosaic, but despite this a number of stonefly species were present – *Nemoura cinerea*, *Leuctra nigra* and *Amphinemura sulcicollis* all prefer siltier and slow-flowing components of the stream habitat mosaic so it was not surprising to find them here. The first two of these were only recorded at this site during our visit to the Forest, which is partly due to the small size of the stream but also to the water chemistry (this is the only site where chalybeate springs were observed). The predatory stonefly *Isoperla grammatica* was also recorded, reflecting small patches of riffle habitat. This site was also the only one sampled to yield nymphs of the golden-ringed dragonfly (*Cordulegaster boltonii*). The larvae of this species inhabit slow-flowing ‘pool’ habitat in small heathland and moorland streams (as well as bogpools), burying themselves in silt or mud to ambush prey. Other invertebrates present include *Gammarus* sp., baetid mayflies and caseless (*Hydropsyche* sp.) and cased (Goeridae) caddis-flies.

Figure 3.23 Chalybeate (ferruginous) spring entering Greathaugh Brook.

Reflections on Greathaugh Brook

Greater occurrence of large woody material (from riparian trees), riparian tree root systems, and debris dams would help to restore the bed level of brook, improve hydrological connectivity with the riparian zone and help to initiate the lateral movement of the channel that is needed to restore the stream habitat mosaic. Since the stream has been so adversely affected by drainage and channelization the impact of a beaver release at this site on existing stream habitat would be lower than on more natural stream sections in the Forest (e.g. the middle reaches of the Cannop Brook).

4. Discussion and recommendations

General

Overall, although the Forest has lost much of its wetland interest, it retains a significant amount of natural stream habitat and presents an excellent opportunity for landscape-scale restoration of naturally functioning mire/stream/standing water habitat mosaics, within a wider mosaic of wet and dry habitats catering for all of its characteristic flora and fauna. An explanation of these mosaics and their conservation is provided in Mainstone *et al.* (2016). The Forest is a working landscape with little in the way of existing SSSI notification, which also has considerable amounts of built heritage, and so a sensible balance needs to be struck between wildlife restoration, activities on which the local economy depends, and other interests. If this balance can be achieved, the benefits to the local community through wildlife tourism could be substantial, contributing to restoring the local economy.

Strategic planning

In some areas, such as Woorgreens and Foxes Bridge Bog, the restoration action needed is fairly straightforward and should not require a great deal of investigation. More generally, however, strategic planning of habitat restoration measures across the forest is urgently needed. Forest Enterprise seems amenable to a greater focus on wildlife conservation in parts of the forest that are most problematic in forestry terms. These are generally those areas that are most difficult to drain for commercial tree production, and so should fit well with a restoration strategy built on restoring natural hydrological function to key parts of the forest. A long-term view is required – this enables greater aspiration over what can be achieved and generates less stakeholder conflict because there is more time for stakeholders to accommodate change.

Better understanding of natural hydrological pathways and their consequences for the natural distribution of mire, flush, running and standing water habitats is required. This knowledge provides the basis for dialogue with local partners and stakeholders over where to prioritise restoration action and what specific measures to take. A key part of this dialogue concerns dovetailing into Forest Enterprise plans, about where their least favoured areas are for commercial production and where these coincide with highest priority areas for restoring naturally functioning habitat mosaics.

A strong local partnership is essential to generate strategic plans that have good levels of support with momentum for implementation. Given the lack of SSSI or SAC driver it may be useful to establish a partnership that plugs into other high-level drivers or delivery programmes. NE's conservation strategy is one possible route, through the Focus Areas initiative, The Catchment-Based (CaBa) initiative set up to help implement the Water Framework Directive would also provide additional profile, mechanisms and funding opportunities. However, the restoration work required goes well beyond what would be expected to deliver WFD objectives for the area, and it would be important to ensure that the objectives of any local partnership are comprehensive.

Generating a long-term vision

Generating a vision that can be shared by all interested parties is critical to strategic planning, since it heads off conflicts and allows people to invest in restoration with confidence. This necessarily involves spending up-front resources on evaluation and planning, but this is repaid manifold by reducing time spent on reactive conflict resolution and securing better access to funding opportunities, most of which require worked-up restoration plans before funds will be committed. River SSSI restoration plans provide a good demonstration of how successful strategic planning can be at pulling stakeholders together around a common vision and attracting resources (see this website). However, a broader technical approach to naturally functioning habitat mosaics is required for the Forest of Dean, more centred on headwater mire, flush and pool restoration through which stream restoration can be achieved and around which landscape-scale heathland and woodland restoration can be framed.

In terms of what the vision might look like, a better understanding of the natural hydrological functioning of the forest is required. Other large sites give indications of what the habitat mosaic might look like under natural function. The characteristic New Forest mosaic of flushes, runnels, pools and mires, created by natural hydrological pathways through the landscape, might provide a useful analogy (Figure 4.1 - see also the specialist site visit reports on the Lymington River and New Forest ponds in this folder). The drift and solid geology is very different (the Forest of

Dean seems to have much more heavy clay drift) but there are inescapable similarities in the way hydrological pathways gather momentum downslope within catchments.

Figure 4.1 Seepages and runnels running into Oberwater at Aldridgehill Inclosure, New Forest.

On a separate visit Suzanne Perry (Woodland specialist) has observed considerable natural regrowth of characteristic broadleaf trees in the forest, suggesting that natural recovery could play an important role in the restoration of characteristic woodland in the forest. However, it is important to frame natural woodland regeneration within a restored hydrological landscape so that the regeneration works towards the restoration of the desired landscape-scale habitat mosaic. Regeneration on hydrologically unrestored land is likely to create woodland types that are not compatible with a restored naturally functioning landscape, and the future removal or demise of these trees through rewetting parts of the landscape may create unnecessary stakeholder tensions.

Networking

Local staff working on other sites face similar strategic issues and are at various stages of resolving them. Forest Enterprise and Natural England staff working in the New Forest have extensive experience of designing and implementing mire/stream restoration measures. Ashdown Forest in East Sussex provides a relatively unimpacted example of mire/stream habitat mosaics in a forest environment, having escaped significant forestry operations (e.g. Figures 4.2 and 4.3 - see also this specialist site visit report). More widely in the High Weald, fragments of ancient broadleaved woodland provide excellent examples of natural stream habitat function (e.g. Figure 4.4 - see also this folder). Both the New Forest and High Weald are also important for their lowland heathland habitats, which can be a distinctive if locally restricted feature in the Forest of Dean. It would be highly beneficial for all sites if there were some knowledge exchange between local staff, including site visits to get first-hand experience of habitats, issues and their resolution.

Figure 4.2 Pool formation within the mire/stream transition of a ghyll stream in Ashdown Forest.

Figure 4.3 Chalybeate springs draining out of the Sphagnum beds to form the stream channel, Broadstone Warren in Ashdown Forest.

Figure 4.4 The mire/stream transition at the top of Nap Wood, High Weald, showing extensive *Sphagnum* cover and natural stream formation.

Mining damage

The impact of mining on the water quality and natural hydrology of the forest was not immediately apparent from this brief site visit. There are known to be some water quality issues associated with mine drainage in parts of the stream network. Mine addits are also known to divert natural hydrological pathways, which will have an effect on the wetness of the forest and the strength and sustainability of streamflows. These are issues that will require additional evaluation and planning. Water quality issues are recognised by the Environment Agency in river basin management planning, but the hydrological effects of the addits are less likely to be. If not already undertaken, investigations of the hydrological effects of the addits will be required as a basis for determining appropriate management measures. Similar investigations have been undertaken in Lathkill Dale NNR in the Peak District – this represents another worthwhile networking opportunitiy.

Biological connectivity issues

Access for long distance migratory fish has received some attention in the forest, but it should be remembered that many species are affected by artificial barriers to movement, including resident fish and non-flying invertebrate species that undertaken upstream spawning migrations to ensure that upstream stream sections remain colonised. A drought or pollution event can depopulate upstream areas, and free access is required to restore populations. In the case of long distance migrators, it is important to remember that species such as sea and river lamprey, sea trout and salmon have natural limits to their use of river and stream habitat – sea lamprey do not migrate up small streams to any great extent, whilst river lamprey arguably penetrate into smaller channels. In contrast, the smaller brook lamprey does not migrate to sea and favours small streams. This is worth remembering given the small size of the streams of the Forest of Dean.

Wild boar and beavers

Rooting by wild boar is surprisingly extensive in the forest. It is known that culling is not keeping pace with population growth and the population is set to increase, together with the soil disturbance it generates. This is likely to be a significant issue in terms of rewetting the forest, since the disturbance is likely to be magnified on soft wet soils (although it will depend on behavioural preferences). Whilst the reintroduction of large mammals to England is highly desirable ecologically, it is important to properly consider their natural position in the ecosystem to ensure they have the desired effect. Reintroduction without significant natural population controls and without an effective culling strategy will inevitably lead to an undesirable level of disturbance at some stage. It is therefore critical to put in place an effective control strategy to reflect natural controls (bearing in mind that humans would have been an important control mechanism in a more naturally functioning ecosystem) so that undesirable levels of disturbance can be avoided. There is a suggestion that the impact of wild boar at a local level may be disproportionate because of its preference for open space, which is highly limited in the forest – it is possible that addressing the limited open space may moderate wild boar impact.

As with wild boar, the effects of beavers on the status quo of habitats can be considerable, even though their ecosystem influence as part of a balanced food web is highly valued in conservation terms. Whilst current proposals within the forest are only for release into an enclosure, it is important to think through the control strategy needed to ensure that any future population is subject to natural levels of population regulation. See the appendix for general advice on managing the effects of beavers on river habitat.

Culverts

Many culverts have been built across the forest, largely for forestry purposes. Some of these culvert drains under forest tracks where there would have been no natural stream channel, just boggy areas with flush and seepage habitat. Where possible, these culverts should be removed as part of mire/stream restoration, to restore either mire or stream habitat depending on location. Where necessary for permanent access, they can be replaced by widespan bridges that do not interfere with natural mire/stream function. There are still however, significant number of culverts carrying the forest brooks under key highway routes that will be difficult to replace.

SSSI notification

The forest has little by way of existing SSSI notification. Owing to the widespread historical damage to the area there seems no case for a large area notification based on running or standing water or wetland habitat features. Some of the middle reaches of streams (Blackpool Brook and Cannop Brook) are functioning naturally, and Slade Brook is a highly natural stream. Once the revisions to the GB SSSI selection guidelines have been finalised, cases for notifying these specific streams will be possible (Slade Brook will definitely qualify for river/stream habitat). However, revisions being made to the guidelines strongly favour stream habitat notifications that include naturally functioning headwater mire/stream transitions – Slade Brook is the best candidate in this context based on current circumstances.

If, at some point in the future following strategic restoration works, a case were to be made to make the Forest a large area SSSI like the New Forest, it would be important to provide a habitat-based underpinning for it rather than restrict the notification to a small number of species. This would allow objectives to be set based on restoring naturally functioning habitat mosaics much more easily than with a species notification. There is scope for using the selection criterion of 'potential value' to do this, but it be best for any consideration of large area SSSI notification to follow restoration, and to focus on the use of priority habitat and species drivers for the time being. This does not preclude small-scale notification for individual features in the short-term where deemed to be necessary.

Priority habitat

There is considerable potential for adding naturally functioning stream sections to the priority river habitat map, and for degraded stream sections to be added to the restoration potential map (see Mainstone *et al.* 2015 for an explanation of these maps). This will help focus attention on the stream network of the forest, and on the protection and restoration of natural stream function including transitions with mire and flush habitat. An initiative has now been established with the Freshwater Biological Association to develop a stakeholder-based web portal for updating the priority river habitat inventory. This will allow stakeholders to evaluate and register the naturalness of streams and small lakes to help protect and restore them. The website should be operational sometime in the summer and would be available to any local partnership to raise the profile of the streams of the Forest.

Allied to priority river habitat, it would be worth considering a naming initiative for the streams of the forest. A lack of names, or the use of names signifying habitat degradation, is often a sign that streams are not valued for their wildlife. As part of the HLF project, it would be useful to review the names currently in use with local stakeholders, and consider whether any changes would be beneficial. Names of smaller streams could be added to help raise their profile, whilst names referring to habitat degradation (most notably names using the term 'ditch') could be replaced with something more positive. It is certainly the case that some streams that are currently named as ditches are likely to have been natural streams before any ditching operations, and they have since re-established much of their natural function.

Useful reading

Hall, R., Skinner, A., Phillips, G and Pitt, J. (2014) Priority lake habitat in England – mapping and targeting measures. Natural England joint publication JP008.

Macadam, C. (2015) A review of the stoneflies (Plecoptera) of Great Britain. Natural England Commissioned Report NECR174. Species Status Report No. 20.

Mainstone, C.P., Hall R., Diack, I. A narrative for conserving freshwater and wetland habitats in England. Natural England Research Reports, 2016, Number 064.

Mainstone, C.P., Skinner, A., Peters, S. and Rogers, M. (2015) Refining the priority river habitat map for England: a report on recent revisions and proposals for on-going refinement. Natural England joint publication JP012.

Mainstone, C.P., Laize, C., Webb, G. and Skinner, A. (2014) Priority river habitat in England – mapping and targeting measures. Natural England joint publication JP006.

Appendix – General advice on beaver reintroduction

As the freshwater and wetlands habitat narrative (Mainstone et al. 2016) explains, our general conservation aim for river ecosystems is for characteristic biological assemblages utilising river systems according to the habitat template provided by dynamic natural processes. Our management rationale is therefore about controlling impacts on natural function as far as possible. Within this framework, individual species are conserved as a balanced part of the characteristic community in accordance with natural habitat function.

With respect to beavers, the question then becomes are they a part of natural habitat function? As an extinct native species, the answer must be yes, but it is an aspect of natural function that is well beyond living memory, and socioeconomic systems have grown up in the species' absence that people expect to be protected. It is important to untangle conservation aims from socioeconomic aims in this debate, even though the two have to be brought back together again to generate a workable management strategy. For instance, what may constitute an impact of beaver on (for instance) an exploited salmon fishery should not be construed as an impact on the conservation of salmon as a species. The aim of fishery management is typically to maximise the productivity of the fishery, whilst the aim of conserving the species is to sustain populations as a balanced part of a healthy characteristic community within naturally functioning habitat.

The overall effect of beavers on any riverine species (including salmonids) is typically not negative in any case, if considered at a landscape scale and if management approximating to natural population control mechanisms is put in place. The limited circumstances under which beavers create dams, the permeability of many beaver dams, and the dynamics of dams being created and washed away in different parts of the catchment at different times and flow conditions, provides a dynamic and varied picture of habitat conditions that caters for all species that are characteristic of a river system. In relation to salmonids, it allows all parts of the catchment to be utilised for spawning and juvenile development over a period of years, and the reasonable number of year-classes in salmonid populations allows genetic character to be maintained in different parts of the catchment on these timeframes,

The key issue is getting the beaver management strategy right, and in particular setting a suitable range of acceptable population densities, and defining the circumstances under which dams and individual beavers can be justifiably removed at a given location. Maximising salmon production in each year in each part of a catchment is not a justifiable reason, but the creation of long-term inaccessibility to a sub-catchment would be. Flood risk to people and property would of course be a justifiable reason. Discouraging beavers from inconvenient locations is one thing, but ultimately in the longer-term (when all 'convenient' habitat is occupied) it will come down to controlling populations at environmentally sustainable levels in each catchment, mimicking natural controls.