Specialist site visit – The streams of Ashdown Forest, East Sussex

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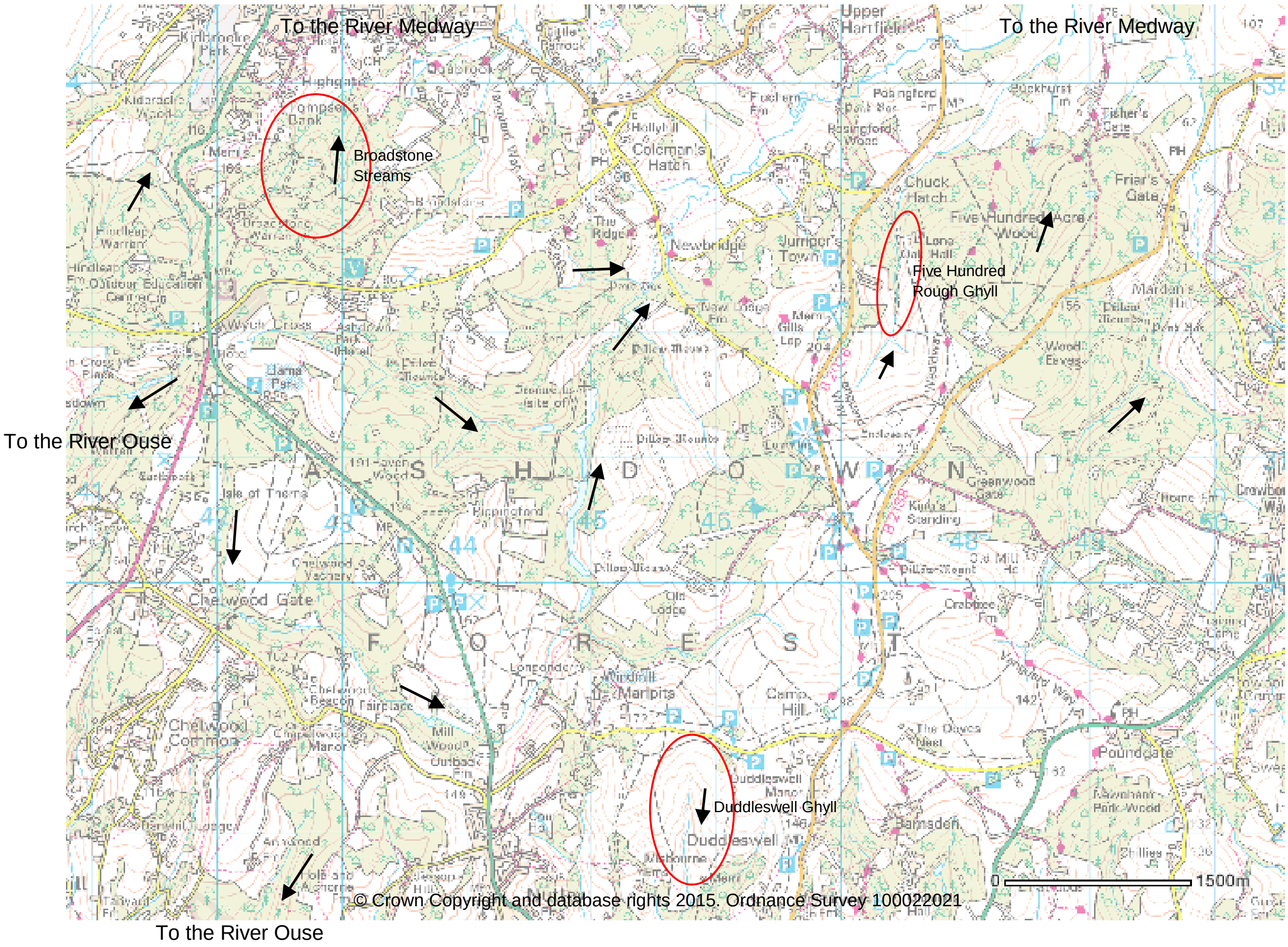
Ashdown Forest is an extensive area of wet and dry heath and woodland underlain mainly by Cretaceous sandstones, which is dissected by an abundance of streams and their associated valley bogs (see map below). It lies at the centre of the Wealden anticline within the High Weald, and is surrounded by concentric circles of younger geologies (greensand, gault clay and chalk). Being a high point within the Weald, the streams of the forest flow outwards in various directions, forming part of the headwater systems of the Medway and the Ouse. We visited a range of streams deemed to be amongst the most natural examples of the character of the Forest



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Map of Ashdown Forest streams.

Duddleswell Ghyll

This is a highly natural example of a south-flowing ghyll, draining into the Ouse system. We walked from the top of the catchment at Holly car park (TQ 461 287) and walked downstream through the headwater mires and flushes and along the stream side for about 500 hundred metres to TQ 458 280. Figure 1.1 shows the heathland character of the catchment.

Figure 1.1 The catchment of Duddleswell Ghyll.

The headwater mires are intact without any signs of drainage (Figure 1.2), transitioning into flushes and seepages with abundant Sphagnum and patchy willow cover (Figure 1.3), as well as *Molinia*, *Eriophorum* and sedges such as yellow sedge These give way to pools amongst tussock-forming species (Figure 1.4), and finally into a defined channel (Figures 1.5 and 1.6).

Figure 1.2 The start of mire vegetation in the headwater catchment near Holly car park.

Figure 1.3 Flush habitat at the upstream end of the ghyll.

Figure 1.4 Pool formation at the upstream end of the ghyll.

Figure 1.5 Initiation of the stream channel.

Figure 1.6 The recogniseable stream in the ghyll.

The stream channel is highly natural in structure, with high levels of riparian trees providing root systems and woody debris that generate debris dams and associated habitat mosaics (Figure 1.6). A plentiful supply of leaf litter provides characteristic habitat for leaf-shredding invertebrates that are so characteristic of wooded headwater streams. As the stream continues downstream, intact flushes continue to feed into the channel (Figure 1.7).

Figure 1.7 A flush feeding into the channel.

The streambed in the upper stream is dominated by bedrock overlain with peat deposits, although in some places mixed mineral substrates are evident (Figure 1.8). Bryophytes form on the channel sides (Figure 1.8), including rare species such as *Nardia compressa* (typically an upland species) and *Hyocomium armoricum* (a western oceanic species but also very characteristic of High Weald ghyll streams – pers comm Tom Ottley).

Figure 1.8 Occasional mixed mineral substrates forming in the channel, alongside the rare bryophyte *Nardia compressa.*

Bedrock on the streambed is impressively displayed at Breakneck Fall (Figure 1.9), which supports a range of ferns, mosses, liverworts and algae (Figure 1.10). Downstream of the waterfall the bedrock domination of the streambed begins to give way to boulders, cobbles and gravels (Figure 1.11) largely generated by erosion of the bedrock of the waterfall. These substrates are still extensively overlain with debris dams with considerable amounts of leaf litter from the extensive riparian tree canopy, and abundant peaty organic deposits originating from upstream and lateral mires and leaf breakdown (Figure 1.12). This generates a complex mosaic of meso-scale habitats that caters for a range of characteristic invertebrates.

Figure 1.9 Breakneck Fall.

Figure 1.10 Liverworts and algae at Breakneck Fall – mainly *Pellia epiphylla* (pers comm Tom Ottley).

Figure 1.11 The stream immediately downstream of Breakneck Fall.

Figure 1.12 Organic deposits, leaf litter, woody debris and debris dams in the stream channel downstream of Breakneck Fall.

Lateral flushes continue to feed into the channel, including from further impressive bedrock falls that support an extensive lower plant flora (Figures 1.13 and 1.14).

Figure 1.13 A lateral flush feeding into the main ghyllstream.

Figure 1.14 A lateral flush feeding into the main channel via bedrock.

As we walked downstream, the same stream habitat mosaic of debris dams, organic sediments and occasional outcropping bedrock and mixed mineral substrates was evident (Figure 1.15). Tom Ottley explained that the stream continues with this character for some distance downstream (at least a kilometre), transitioning in and out of mire (Figure 1.16). These transitions relate to stream gradient and are probably largely bedrock-controlled, as has been evident in ghyll streams visited elsewhere in the vicinity where bedrock is less obscured by overlying deposits (most notably in St Leonards Forest).

Figure 1.15 Characteristic habitat mosaic continuing downstream.

Figure 1.16 Stream reverting to mire in shallower gradient sections.

An *ad hoc* composite sample of aquatic macroinvertebrates was taken as we walked down the stream. The species found reflect the predominant substrate of organic silts along this section, and included the nymphs of Leuctrid and Nemourid stoneflies and the Golden-ringed dragonfly (*Cordulegaster boltonii*), as well as pea mussels and adult and larval water beetles. The Leuctrid stoneflies were *Leuctra nigra*, whilst the Nemourid stoneflies were *Nemoura cinerea*. These are both common acid-tolerant species that have benefited from the historical acidification impacts on Ashdown Forest streams (Hildrew 2009), increasing in dominance as less tolerant species declined. The nymphs of both species prefer silty stretches of stony streams and exhibit a variety of feeding traits, including shredding leaf litter and vegetation, grazing algae and biofilms, and gathering fine particulate organic matter. *Cordulegaster* nymphs also inhabit muddy/silty pools in moorland streams, where they lay partially buried waiting for prey. The freshwater shrimp *Gammarus pulex* is absent from the fauna due to its high acid-sensitivity, its niche taken in acidic streams by shredding stoneflies.

The red gelatinous alga *Batrachospermum* is also present, which favours cool, low-nutrient streams particularly near their spring sources.

We intended to inspect the ghyll further downstream at the end of the day but ran out of time. The assumption is that it moves off the predominantly peat and bedrock bed onto a predominantly cobble/gravel bed. The stream then runs out of the forest into a series of artificial on-line impoundments, at which point the natural character ends.

1. Five Hundred Rough Ghyll

This is a north-flowing stream draining into the Medway system. We walked from a car park on the B2026 at TQ 471 326, meeting the ghyll at TQ 474 327. We walked upstream to the headwater flushes around TQ 473 317. Figure 2.1 shows the heathland character of the catchment. Tom Ottley reports that this stream is characteristic of many of the ghyll streams within the forest.

Figure 2.1 The catchment of Five Hundred Rough Ghyll.

Taken as a whole, the stream exhibits a characteristic zonation from peat flushes at the upstream end through bed rock control then increasingly smaller sized substrates down to gravel. We saw this zonation in reverse as we walked up the stream.

The downstream end of the stream exhibited an excellent natural habitat mosaic, consisting of boulders, cobbles, gravels and finer substrates with woody debris, leaf-litter and debris dams (Figure 2.2). Again, tree root systems and debris dams are instrumental in shaping the habitat mosaic, along with the larger mineral substrate elements.

Figure 2.2. The habitat mosaic at the downstream end of the walk.

The importance of larger debris dams and fallen trees in shaping channel morphology was very evident (e.g. Figure 2.3). Bed levels are raised above the obstruction, whilst a scour-pool forms below the obstruction which throws up a shallow riffle of coarse substrate below the pool. This process is often accompanied by a lateral deflection of the flow that generates planform movement, which creates a sinuous channel that increases stream length (habitat extent) and adds greater meso-scale habitat variation. The resultant habitat mosaic is vital for characteristic biological assemblages, creating a range of conditions exploited by different species and (within a species) life stages. Different species and life stages have evolved to exploit this variation in habitat conditions, acquiring a range of behavioural and morphological traits that are suited to different parts of the mosaic.

Figure 2.3 Stream dynamics in action – the effect of a debris dam on the provision of instream habitat.

Lateral flushes feed into the stream channel at various points (e.g. Figure 2.4). The ghyll is broader than at Duddleswell, which facilitates more lateral movement of the stream in response to flow deflections cause by fallen trees and debris dams. This has sometimes resulted in secondary channels forming (Figure 2.5).

Figure 2.4 A lateral flush feeding into the stream.

Figure 2.5. Secondary channel (the main channel can just be seen running parallel in the upper part of the image).

In some places the action of fallen trees and large woody debris has also generated significant amounts of seasonal exposed lateral sediments in the channel (Figure 2.6), which constitute a further habitat niche which can be exploited by a range of invertebrate species (particularly specialist beetles).

Figure 2.6. Areas of seasonally exposed sediment associated with the sinuous channel created by the action of trees and their debris.

Some of the lateral flushes are very clearly sustained by large woody debris, acting to retain wetness and allow accumulation of peat. Figure 2.7 shows the point of mire-stream transition in one of these lateral flushes, directly associated with woody debris.

Figure 2.7 Lateral flush sustained by large woody debris.

Further upstream, bedrock becomes a more predominant controlling factor on stream morphology (Figures 2.8 and 2.9). The uniform vertical fracturing of the bedding plains has the appearance of artificial modification. It is this fracturing that is generating the boulders, cobbles and gravels further downstream.

Figure 2.8 Increasing bedrock control of stream morphology.

Figure 2.9. Bedrock control further upstream.

Riparian landslips were evident in some places (Figure 2.10), revealing the mechanism responsible for broadening the ghyll. Whilst this can be exacerbated by over-grazing to a level at which the disturbance levels are damaging to stream ecology, there is no evidence that this is happening in this instance. These landslips are in fact important in allowing the stream to move laterally and generate greater sinuosity, which supports a more diverse habitat mosaic and greater overall stream habitat.

Figure 2.10 Riparian landslip.

Further upstream, a major crossing has been built in stone (Figure 2.11). This is unsympathetic to the stream habitat, restricting the stream to two concrete pipes. It is particularly incongruous in such a naturally functioning stream. Widespan bridges that do not affect stream habitat, or just fords if the traffic frequency is low, are preferred options.

Figure 2.11 Stone-built crossing.

Further upstream we arrived at the first mire-stream transition (Figure 2.12). The role of bedrock versus wood debris in creating the obstruction necessary for the mire to develop upstream was not clear, due to over-growing vegetation. It seems probably that in this instance the obstruction is a combination of the two. Closer investigation was not possible since it appeared that the transition was on the verge of disintegrating, which would result in at least a minor blow-out of mire (back to bed-rock control).

Figure 2.12. The most downstream mire/stream transition.

Within the upstream mire, the vegetation was dominated by tussock grasses and sedges underneath a willow canopy (Figure 2.13). Moving further upstream the habitat reverted to a distinct stream channel with drier banks (Figure 2.14).

Figure 2.13. Mire vegetation upstream of the mire-stream transition.

Figure 2.14. Transition back to stream channel again (upstream of the mire in Figure 2.13).

Further upstream, the stream-mire system comes out of the ghyll and into open heathland. The system forms a significantly sized pool (Figure 2.15), presumably controlled by bedrock and providing a valuable additional habitat. Upstream again and the stream channel is evident, before another mire-stream transition (Figure 2.16), seemingly bed-rock controlled.

Figure 2.15. Pool formed in the mire-stream system.

Figure 2.16. Second mire-stream transition.

This was the upstream limit of our walk. Tom Ottley explained that the flushes and seepages continue upstream for some distance.

An *ad hoc* composite sample of aquatic macroinvertebrates was taken as we walked up the stream. Stoneflies were the most abundant group found. The most numerous stonefly was *Nemurella picteti*, and *Leuctra nigra* and *Nemoura cinerea* were also present. All three species reflect the presence of finer organic sediments and leaf litter. Larvae of the caseless-caddis-fly genus *Plectrocnemia* were also present – probably *P. conspersa* which is strongly associated with acidic headwater streams, spinning nets in stream pools to catch prey and detritus. These nets are fragile, collapsing if current velocities are too low and swept away if too high. Again *Gammarus pulex* is a notable absentee from the invertebrate fauna due to its acid sensitivity. Bullhead were also found, indicating faster-water habitat and coarse substrates.

2. Broadstone Warren

We visited the two main streams draining Broadstone, which flow northwards into the Medway system. We walked from the scout camp offices on the TQ 419 329, walking eastwards to meet the east ghyll around TQ 430 333. We walked down the east ghyll until the boundary of the warren, then walked back up the west ghyll for a few hundred metres to TQ 426 336.

The two ghylls are highly contrasting in nature. The east ghyll has well-developed flushes and seepages and is heavily coated in ochre precipitate from chalybeate streams, smothering the coarse substrates of the streambed and greatly reducing light penetration. The west ghyll is largely fee of ochre, generating an open bed of coarse substrates. In both streams there is a high degree of leaf litter being actively shredded and decomposed.

The source of the east ghyll is surrounded by Sphagnum beds under alder (Figure 3.1). Runnels drain out of this flush zone to create the distinct channel.

Figure 3.1. Sphagnum beds around the source of the east ghyll.

Figure 3.2 Chalybeate springs draining out of the Sphagnum beds to form the stream channel.

All the way down the east ghyll, chalybeate springs continue to drain into the stream from lateral flush zones covered in Sphagnum (Figure 3.3). As a result, the stream bed is thickly coated in ochre precipitate, which through its smothering and light-reducing effects on the stream bed limits the invertebrate assemblage. An *ad hoc* composite sample of aquatic macroinvertebrates was taken as we walked down the east ghyll. The fauna is largely reflective of acidic conditions, slow flow, fine silts and leaf litter, comprising small numbers of nymphs of *Cordulegaster boltonii*, alder-fly (Sialidae), and Leuctrid and Nemourid stoneflies. Larvae of the caseless-caddis-fly genus *Plectrocnemia* were also present (again probably *P. conspersa)*.

Figure 3.3. Lateral flush and ochre precipitate coating the streambed.

Walking back up the west ghyll, the contrast in habitat conditions is stark. The exposed cobble and gravel substrate provides more diverse habitat opportunities for the invertebrate fauna (Figure 3.4), and allows a fuller expression of the habitat mosaic generated by the action of tree roots and large woody debris (Figure 3.5).

An *ad hoc* composite sample of aquatic macroinvertebrates was taken as we walked up the west ghyll. The difference in the habitat mosaic between the east and west ghylls was reflected in the species found. The west ghyll supports abundant nymphs of the stoneflies *Isoperla grammatica* and *Chloroperla torrentium*, both predatory species of swift-flowing water and coarse bed substrates. There is an absence of Nemourid stoneflies, resulting from the lack of silty organic substrates, Leuctrid stonefly nymphs were found but do not appear to *L. nigra* as found previously - possibly *L. inermis*, which inhabits swift, stony-bottomed streams. Caseless caddis-fly larvae from the genus *Hydropsyche* were abundant, again specialists of swift-flowing water, whilst *Plectrocnemia* spp (again probably *conspersa*) were also present. Mayfly nymphs (Baetidae) were abundant, again reflecting the presence of swift-flowing water.

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Figure 3.3. Clean cobble and gravel substrates in the west ghyll.

Figure 3.4. Debris dams forming on the west ghyll generating added diversity in the habitat mosaic.

Overall, the east ghyll is more impressive in its provision of retentive stream habitats and associated mire habitat, but naturally less able to support a diverse stream invertebrate fauna because of the heavy ochre deposition. The west ghyll provides little associated mire habitat, but supports better stream habitat for rheophilic (current-loving) invertebrates. Together, these stream provide a wide range of mesohabitats characteristic of the Forest, highlighting the importance of viewing the streams of the Forest as an ecological network rather than as individual streams that all provide the same habitat opportunities.

Key messages

1. *Notified features*

Ashdown Forest contains highly natural headwater streams that are worthy of notification for river habitat. They are particularly important given the rarity of lowland heathland streams in England. It is recommended that river habitat is made a general feature of Ashdown Forest SSSI, rather than identifying those streams that are most natural and notifying them for river habitat specifically. A general notification provides greater flexibility and direction for restoring those parts of the stream network in the forest that have been degraded, for instance by artificial on-line impoundments or other physical structures. Alternatively, it is possible to include river habitat within a habitat mosaic feature, as long as river habitat is specifically recognised and within that feature and managed/restored for its natural function.

2. *Priority habitat mapping*

The streams of the forest have been included in refinements to the England priority river habitat map (Mainstone *et al*. 2015). The priority habitat map captures the most natural rivers and streams in England, in relation to physical, hydrological, chemical and biological naturalness. All streams in the forest have been included, although some of the modifications immediately downstream of the forest make downstream sections unsuitable.

3. *Objectives*

Common Standards guidance provides a clear picture of the level of naturalness and natural habitat function we should be aiming for in notified river habitat, which includes riparian and other hydrologically connected habitat. The broad aims for priority river habitat are essentially the same. A narrative has been produced (Mainstone *et al.* in press) to explain our approach to river habitat conservation and its links to river-related species conservation, which underpins our objectives for river habitat including its characteristic communities.

4. *Condition assessment*

Common Standards guidance for SSSI river habitat is complex, using quantitative data from a number of different sources to assess the condition of the major components of habitat integrity: physical, hydrological, chemical and biological. It is primarily designed to assess whole-river SSSIs, where a range of data is available from Environment Agency monitoring. Common Standards guidance allows for the assessment of certain attributes, and whole aspects of habitat integrity, to be omitted based on a lack of pressures.

Highly natural headwater streams such as those in Ashdown Forest can therefore be assessed using a reduced range of attributes, focused on those indicative of significant pressures operating on the site. Based on the highly natural (unmodified) physical nature of the stream channel and its mires and flushes, and the apparent lack of most pressures (including grazing, land-derived pollution and abstraction), streams such as Duddleswell and Five Hundred Rough ghylls would pass nearly all condition indicators for river habitat.

Atmospheric deposition is the main concern. Sulphur deposition has caused considerable damage in Ashdown Forest streams in the past (Hildrew 2009).This is declining and being replaced with nitrogen deposition, which has a milder acidifying effect but an additional eutrophication effect. Tom Ottley thinks this explains the increasing abundance of Molina in the forest, which is crowding out characteristic mire vegetation. The stream invertebrate community has been simplified by the historical acidification, with assemblages being dominated by acid-tolerant and often generalist feeders (such as the stonefly *Leuctra nigra*). There are some signs of improving diversity but it seems to be a slow process. The Forest has a long-term monitoring site at Old Lodge that forms part of the Upland Waters Monitoring Network, which has been monitoring acidifications effects for many years. The Conservators are also undertaking monitoring of nitrogen deposition effects.

Physical modifications to stream channels is a relatively minor issue in the forest but where significant needs to be flagged up in condition assessment. This could be done either by bespoke River Habitat Survey (RHS, see CSM guidance and NE implementation guidance) of affected streams, or using a subset of CSM physical condition indicators that do not rely on RHS.

Occasional foaming of the water – foaming can be a natural phenomenon associated with high levels of dissolved organic carbon (DOC) derived from upstream peat bodies. Whilst DOC levels can be elevated by peatland drainage, there is no evidence of significant drainage in the catchment and so the phenomenon is likely to be natural.

5. Management issues

Mire stream transitions – Trees within mires and alongside streams, and associated woody debris, seem critical in sustaining natural mire-stream transitions, alongside more permanent bedrock controls. We need to view these transitions as being in dynamic equilibrium, with the position and nature of the transition varying over time according to the evolution of tree root systems and woody debris dams that stabilise the upstream mire. As individual trees die or debris dams decay, the upstream mire may be destabilised and erode back to another stabilising control (which may be bedrock or tree-related). Other tree root systems or debris dams may then develop downstream and allow the mire to rebuild along the section upstream of them. Such dynamics can be seen as a healthy part of a dynamic landscape-scale habitat complex such as Ashdown Forest.

Stream bed levels - It is also very evident, from observations in Ashdown Forest and of other lowland headwater streams on a range of geologies running through woodland, that riparian trees and associated woody debris dams have a fundamental influence on stream bed levels. Where a significant woody dam develops, substrates from upstream tend to rapidly infill the bed up to the level of the dam. The converse is likely to be true – take the trees away and the streambed may be destabilised and incise downwards and upstream, potentially destabilising upstream mires. This emphasises the critical importance of riparian woodland, woody debris supply, and retention of woody debris in the channel.

The contrast with the New Forest is instructive. The New Forest has similar natural mire and stream character, even though the underlying solid and drift geologies have different origins. In the New Forest the natural mire-stream transition has been extensively damaged by historical drainage and forestry operations. This damage is being repaired through the efforts of the Forestry Commission, but it is worth reflecting on the functioning of natural mire-stream transitions in Ashdown Forest to see what lessons can be learnt about how the restored transitions can be sustained. Observations in Ashdown suggest that patchy tree planting through the main hydrological pathway of the restored mire, and a relaxed and large-scale perspective to the subsequent dynamics of the transition, may provide a natural and sustainable solution in the New Forest.

Raising the public profile of the streams - A local initiative to find or develop names for all of the ghylls, and map them, would be a positive step for stream conservation in the forest. The lack of names (or at least well-known names) seems symptomatic of a lack of societal value assigned to the streams. It would help focus greater attention on them and their conservation importance, and encourage greater care over activities affecting them.

References and further reading

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