Tufaceous Wet Flushes in the Wyre Forest

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Wet flushes occur where water emerges from springs and seepages, keeping the soil moist and bringing in elements derived by solution from soils and rocks. The soils of the flushes are therefore richer in plant nutrients than surrounding soils and carry a different suite of plants. They also provide breeding ground for insects that need wet ground for larval life.

In the Wyre Forest, wet flushes occur where sandstone layers in the Coal Measures sequence intersect with sloping ground. The sandstones are mostly well cemented, but the many faults which have cracked them and displaced them vertically promote their function as aquifers, whereas the intervening clays, silty clays and mudstones have closed the cracks, and, being soft, are readily eroded by water emerging from the sandstones. We therefore get slopes consisting of series of steps, the sandstone being the risers and the finer materials the sloping treads. Water seeps from each sandstone and washes down the clayey slopes in a network of rills. The rills shift laterally as flow varies, and spread sediment, over the flushed areas. A complex topography develops, with channels and tussocks, dryer and wetter topsoil, providing a range of habitats for plants and animals.

In the wet layer, trampling by deer (and no doubt, in former times, rooting by pigs) mixes sandier sediment, derived by soil creep from the slopes above, and the organic matter of decaying plant residues, into the upper part of clays. The saturated soils are dominated by anaerobic processes, resulting in reduction and movement of iron, giving grey and ochreous mottling, with sometimes the blue colours of vivianite, an iron phosphate. These soft, wet soils are usually up to some 50cm deep, with dryer, much stiffer, clay beneath.

Tufa is calcium carbonate precipitating from calcareous ground water where it emerges in springs, drips down rock faces, or trickles in shallow streams. Its precipitation is a result of the changed partial pressure of carbon dioxide when calcium-laden water emerges from the ground, and is often mediated by respiration of the moss *Palustriella commutata*. Tufa is usually found in limestone regions. Since the rocks of the Wyre Forest are predominantly non-calcareous, and the soils acid, the occurrence of tufa here may seem unlikely, but it had long been observed on the Great Bog and on a few drippy rock faces in stream sides. Two locations, the Great Bog and a flush in Shelfheld Coppice, were also known long ago as locations for the cranefly *Ellipteroides alboscutellatus* (Heaver, 2006). When Mick Blythe caught this insect, which is always associated with calcareous wet ground, in those locations and also in other wet flushes, what began as a survey of soils to inform plant survey, developed into a project to identify tufaceous deposits and to understand the source of the calcium in the groundwater.

Botanical survey is planned for the future. Meanwhile, we have noticed the frequency with which yew trees overhang the springs, and that hard fern, *Blechnum spicant*, is commonly found around the spring line, which is odd since various sources say it is a calcifuge.

Soil samples have been taken in a number of wet flushes and soil pH determined. Transects, using spade and/or auger, have been studied across the Great Bog (which is really a Great Wet Flush) and in three places through the series of flushes in Lords Yard and Shelfheld coppices on the east slope above Park Brook. Spot samples were taken from a very small flush on the west slope above Park Brook. Transects have also been studied down and across what has been called Holy Well Flush, in Longdon Wood (though the spring called Holy Well is elsewhere). A number of samples were also taken in the complex of flushes on the west flank of Longdon Orchard, and on the north slope of Postensplain. The results only from the Great Bog, the Shelfheld flushes and the spot west of Park Brook are given here.

Shelfheld

Table 1 gives the results from Shelfheld, each transect running from the acid soils under woodland above the flush to the floodplain of the Park Brook. Although the same sandstone layer provides the aquifer that feeds all the flushed areas along this slope, on only the middle one of these three did Mick Blythe take *E. alboscutellatus*, and it was this one which had a scatter of tufa fragments in the top soil, and near the seepage at the top of the flush the auger revealed a layer of tufa 20cm deep, its top at 19cm below the surface (figure 1). The pH values of transect 2 show the value of 8.5 at the point where the tufa lies, with lower values across the flush as the scatter of tufa washed down from the deposit dies away. The area of the deposit was very restricted, and tufa is not forming there now. Free calcium carbonate is stable at pH 8.5 and above, and in the soils with lower pH it will gradually dissolve. When it was forming, there would probably have been a clear spring, probably with cushions of *Palustriella* moss around which the tufa formed. The upper levels of the flush soils are disturbed by changing water flow and by deer footprints, so the granules of tufa are mixed and spread around its locus of formation.

At present, tufa is forming on the lower part of a drippy rock face on the east bank of Park Brook below the

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Table 1: NNE-SSW transects down three parts of the complex of flushes in Shelfheld coppice, from well drained acid soils on sandstone, under oak canopy, across wet ground with flush vegetation to the carr and stream-bank woodland beside Park Brook. Samples at 5m intervals.

sample	pH	soil characteristics	situation
Transect 1			
1	6.4	thin brown-earth	strongly sloping under oak woodland
2	5.2	micropodzol	strongly sloping under oak woodland
3	5.0	micropodzol	strongly sloping under oak woodland
4	6.4	thin brown earth	strongly sloping under oak woodland
5	6.9	thin brown earth	moderately steep slope under oak woodland
6	5.9	thin brown earth	moderately steep, near top of steep slope, still under oak
7	6.5	gley	foot of very steep slope, top of flush
8	6.4	gley	moderately sloping with tussocks, flush
9	6.5	gley	moderately sloping with tussocks, flush
10	6.2	humic gley	moderately sloping with tussocks, flush
11	6.5	humic gley	moderately sloping, flush, just out from birch and oak canopy
12	6.5	humic gley	gently sloping, flush, fallen logs, oak and birch canopy
Transect 2			
1	5.3	micropodzol	strongly sloping under oak woodland
2	5.3	micropodzol	strongly sloping under oak woodland
3	5.1	micropodzol	strongly sloping under oak woodland
4	5.2	micropodzol	top of steeper slope under oak woodland
5	5.0	micropodzol	half way down very steep slope under oak woodland
6	6.4	Humic gley	foot of precipitous slope, still under tree canopy, with hard fern
7	8.5	gley, with tufa granules	moderately steep slope with tussocks, flush
8	8.3	gley, fewer tufa granules	moderately steep slope with tussocks, flush
9	7.6	humic gley, traces of tufa	moderately steep slope with tussocks, flush
10	7.3	humic gley, traces of tufa	strongly sloping with tussocks, flush
11	7.3	humic gley	strongly sloping, under alder canopy
12	7.4	alluvial sand	floodplain, alder carr
Transect 3			
1	5.2	micropodzol	gently sloping under oak woodland
2	4.9	micropodzol	gently sloping under oak woodland
3	4.8	micropodzol	moderately steep slope under oak woodland
4	5.1	micropodzol	moderately steep, close to top of steep slope, oak, birch, holly
5	7.0	humic gley	below steep slope, spring line, flush, with hard fern, oak, birch
6	6.6	humic gley	moderate slope with tussocks, flush, oak
7	6.4	gley	strongly sloping, flush, oak, alder,
8	6.8	humic gley	strongly sloping, flush, birch and alder
9	7.0	humic gley	strongly sloping, bottom of flush, oak, birch
10	6.7	alluvial sandy clay	floodplain, oak, alder, birch carr

northern margin of the area crossed by transect 1. The sandstone here is a layer further down in the sequence than the one feeding the flushes, and it seems probable that the flow of calcium-rich water has gone down a fault and emerged at a lower level. Traces of tufa were also found further north along the area of flushes.

A very small flush high on the steep slope on the west side of Park Brook, where Mick Blythe took *E. albascutellatus* gave pH values no higher than 7.4. No tufa was found in its soil, or on the rock face from which water fed the flush, but the rock was found to have a few grains of a calcareous clay among its constituents. A very small tufa encrustation was found on a wood fragment on the flush surface, so it would seem that this was sufficient to attract the insect.

The Great Bog

Table 2 gives pH values for the E-W transect across the topography of this complex flush, which is fed by the same sandstone layer which provides the aquifer for the Shelfheld flushes. Tufa is found in the principal runnel through the middle of the site, in granular form in the water and on stones and plant debris, and this is picked out by the high pH values, but these are in the soils, not in the runnel itself. Tufa has probably been spread by deer trampling and by water when it overflows the runnel; these pH values are below 8.5, so the tufa is not stable in the soil.

Discussion

pH determination of stream and spring water has yielded surprisingly high values, in agreement with the

Table 2. East-west transect across the Great Bog, samples at 10m intervals. The transect runs from dry ground, across a runnel forming the eastern boundary of the bog, a higher area between this and the main runnel (samples 2, 3), runnel, (4), a second relatively raised area (5), a broad lower area with minor runnels (6), up a slope to a dryer ridge (7,8), a slight dip (9) and then up towards the west side of the bog (10).

sample	pH	soil characteristics	situation
1	4.9	micropodzol	moderately steep, dry ground, sparse oak, bracken, bramble
2	6.2	humic gley	moderately steeply sloping, flush
3	8.4	humic gley, tufa granules	moderately steeply sloping, flush
4	8.3	humic gley, traces of tufa	just above spring, beside main runnel below borehole
5	8.2	humic gley	steeply sloping, flush
6	7.9	humic gley	moderately steeply sloping, alder coppice
7	7.2	humic gley	moderately steeply sloping, alder coppice
8	6.9	gleyed brown earth	dryer area, gently sloping, oak canopy
9	6.7	humic gley	moderately steeply sloping, flush, beyond oak canopy
10	6.5	gleyed brown earth	moderately steeply sloping, dryer margin of flush

assessment of the aquifers of the Wyre Forest by the Environment Agency (Pearson 2008), which recorded high calcium, with high sodium at greater depth. An older study which gave analyses for a number of wells and springs in the Worcester part of the forest also indicated figures, expressed as hardness of the water, which are in accord with these data (Richardson, 1930).

Where, then, does the calcium come from? There is only one small outcrop of a thin limestone in the rocks within the forest and within the Dowles catchment, running from Hawkbatch through the Pound Green area. Limestone is recorded in a mineshaft at Kingswood, but at too great a depth to contribute to our calcium-rich groundwater. Both these Spirorbis limestone bands are found where downfaulted Halesowen Formation (formerly known as Highly Beds) occurs, whereas the rest of the forest lies on the Etruria Formation mudstones and sandstones and Pennine lower/middle Coalmeasures, which have no limestone layers. Guided by Mark Lawley's identification of obligate calcicole moss species, I have recognised calcareous sandstone among the outcrops in Chamberlain Wood, north of Dowles, but so far I have found only very small granules of calcareous material in a coarse sandstone in the southern part of the forest.

Beneath the Carboniferous rocks, an eroded surface of Devonian rocks slopes steeply down from its outcrop, between 100 and 190m above sealevel, to the south of the Callow Hill ridge, so that the contact lies 146m below Dowles Brook at Knowles Mill (that is, it is well below sea level). My hypothesis is that thin limestones and cornstones (breccia containing limestone fragments) in the Devonian sequence, provide most of the calcium. Because of the folding following the Devonian period, these rocks lie at very steep angles in this area, and they are intersected by numerous faults. Water percolating through the Devonian rocks can therefore carry calcium into the fault network providing the Wyre forest aquifer. The complexity of the aquifer and the location of the limestone layers beneath it means that only in some localities would calcium concentration be high enough to yield tufa.

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Maps: Sheet 182, Droitwich; Sheet 167, Dudley.
Updated geological maps: British Geological Survey, www.bgs.ac.uk

Fig. 1: Core from Shelfheld flush 2 showing tufa deposit — Mick Blythe

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