Can we learn anything about bryophyte change from repeated site surveys?

Chris Preston discusses this question with particular reference to the BBS excursions in Cambridgeshire

△ Fleam Dyke, Cambridgeshire, January 2022. *Chris Preston*

The evidence we have for changes in the range of the more widespread British bryophytes can perhaps be grouped into three main categories. The first and most important is the national recording carried out under the auspices of the BBS. Vice-county totals have sometimes been used to document the spread of species (Watson, 1985; Smith, 2001), but most national analyses have been based on the more detailed recording work we have undertaken since 1960 (Hill & Preston, 2014, 2015; Pescott *et al.*, 2015). The immense amount of fieldwork carried out by recorders since 1960 has resulted in a database which has proved amenable to the statistical techniques which have been developed in recent years to analyse biological records. The strength of the BBS database is apparent from the comparative study of the distributional changes in epiphytic bryophytes and lichens by Pescott *et al.* (2015). We have been fortunate to have as fellow bryologists two such able exponents of these techniques as Mark Hill and Oli Pescott.

The second source of information lies in the historic records collected at the county level. Counties or vice-counties have usually been the units in which bryologists have operated. The intensity of historical and recent recording

varies greatly from county to county and can change dramatically across a county boundary, as the maps recently published by Amy & Pescott (2022) show. There are relatively few detailed analyses of distribution change at the county level. Jones (1991) published a masterly summary of bryophyte changes in Oxfordshire, based on a life-time's recording in the county, and other accounts of change have been published for counties such as Berkshire (Bates, 1995) and Cambridgeshire (Preston & Hill, 2019). Other counties possess a wealth of records which have not yet been analysed except on a species-by-species basis (e.g. Surrey), or have an excellent historical coverage but a dearth of recent records. Warwickshire is an outstanding example of the latter case, a county with detailed 19th and 20th century floras (Bagnall, 1891; Laflin, 1971), but perhaps the least well-recorded English county in recent decades. The opposite situation, counties with disappointingly meagre historical data but excellent recent coverage, is of course much more frequent. Even as attractive a county as Pembrokeshire, with its long history as a holiday destination, has virtually no 19th century bryophyte records and was recorded only sporadically in the 20th century (Bosanquet, 2010).

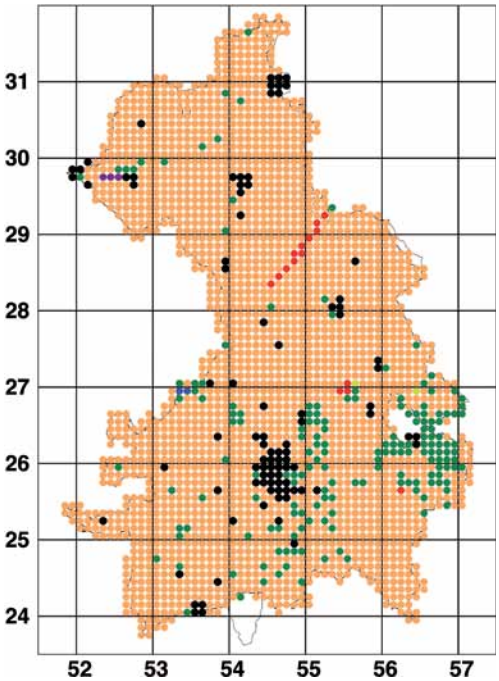
Eustace Jones' analysis of changes in the Oxfordshire flora drew heavily on my third source of information: our own experience of the changes we have seen in our bryological lifetime or those described to us by the tribal elders. It is perhaps more difficult to distinguish this information from the analytical information than one might expect, as the analyses we do are framed by this experience and as individuals we assess the analytical results against it.

For the rarest species detailed analyses of the number and size of populations are feasible, of the sort carried out in Red List assessments (e.g. Callaghan, 2023), but such rare species are not my concern in this paper.

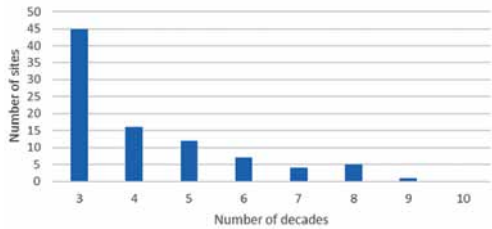
In the last decade the local BBS excursions in my own county of Cambridgeshire have been organised by Mark Hill, and I have written a report on each outing for the participants. In writing these reports, I have often looked at the previous records from the sites visited, and have come to wonder whether the repeat survey of individual sites can provide any additional information on changes in the commoner bryophytes to that which we have from the three sources outlined above. In this paper I discuss this question from a Cambridgeshire perspective. The surveys I'm discussing are those we do as ordinary BBS members, visiting sites and listing the species we see. I am not talking about the highly detailed, time-consuming studies of individual species, or the monitoring of quadrats, which might be undertaken by paid surveyors.

Repeat surveys in Cambridgeshire – the available records

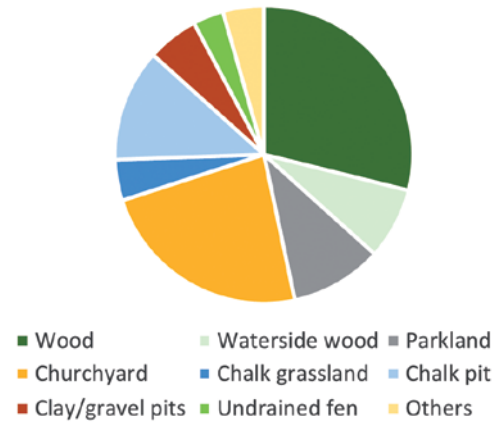
Cambridgeshire, unlike Warwickshire and many other English counties, was not well recorded in the 19th century. However, systematic recording was begun in 1927 by Paul Richards and since then it has had a continuity of bryological recording that is matched by few other counties (Preston & Hill, 2019). The county (Fig. 1) is of average size for a vice-county, lowland, rural, devoted to arable agriculture, and with almost entirely calcareous soils. Cambridge, a rapidly expanding city, lies in the south. Outside the towns and villages the county is almost entirely given over to arable agriculture. Bryologically rich sites generally form well-defined islands surrounded by a sea of arable land. This is particularly true of the county's woodlands, which have been isolated amongst open fields



△ Figure 1. Land-use of Cambridgeshire, derived from the Land Cover Map 2007. The predominant land-use categories are arable (orange), improved grassland (green), built-up areas and gardens (black) and improved grassland (red). © NERC/CEH.



△ Figure 2. The number of decades in which those Cambridgeshire sites recorded in at least three decades have been visited.



△ Figure 3. The habitats of the 90 Cambridgeshire sites visited in at least three decades.

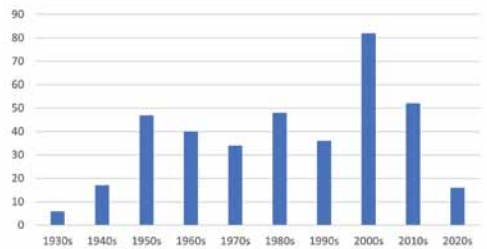
since medieval times, as shown by the entries for named woods in inventories such as the Ely Coucher Book of 1251 (Rackham, 2000).

What is the scope in the Cambridgeshire data for looking at site histories? I decided that a site must have been visited on at least three occasions in three different decades since 1930 before it has any potential as a source of information on change. The definition of a visit is also based on a low threshold: a list of ten or more species. We have 90 sites which fulfil these minimum criteria, of which half have only been visited in three separate decades, with 28 visited in four and five decades and a few in up to nine (Fig. 2). No site has been visited in all ten decades. Most of the 90 sites are woods, largely ancient woods, the others being parks, churches, chalk grassland sites and the relict fens (Fig. 3). Comparison with Fig. 1 shows that these are not the typical habitats of Cambridgeshire. In fact the reverse is true, as unsurprisingly it is the rarer habitats that have attracted the bryologists. The most visited studied sites, visited in 6–9 decades, are listed in Table 1.

If we look at the number of visits over the decades, there is a fairly even spread since the 1950s with a peak in the early 2000s when Mark and I did most of the fieldwork for our recent flora (Fig. 4). Almost all have been recorded since 2000, though two small plantations have been forgotten about and not visited since the 1960s and 1970s.

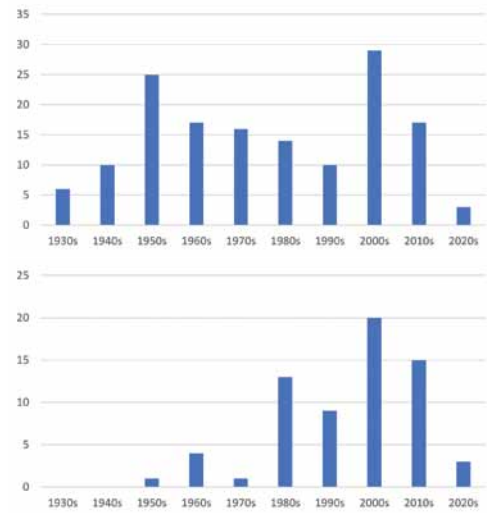
Name of site	No. of decades with visits	Nature of site
Buff Wood	6	Ancient woodland
Byron's Pool	6	Riverside woodland
Gogs Beechwood	6	Nineteenth-century plantation
Madingley Park	6	University-owned parkland
Madingley Wood	6	Ancient woodland
Pampisford Hall	6	Private parkland
Trumpington church	6	Churchyard
Cambridge Botanic Garden	7	University-owned botanic garden
Hardwick Wood	7	Ancient woodland
Wandlebury	7	Public parkland
Wicken Fen	7	Fen
Cherry Hinton Chalk Pits	8	Disused and (until 1984) active chalkpits
Chippenham Fen	8	Fen
Devil's Dyke	8	Ancient earthwork; chalk grassland
Gamlingay Wood	8	Ancient woodland
Hayley Wood	8	Ancient woodland
Fleam Dyke	9	Ancient earthwork; chalk grassland

Table 1. The most frequently visited bryophyte sites in Cambridgeshire, 1930–2022.



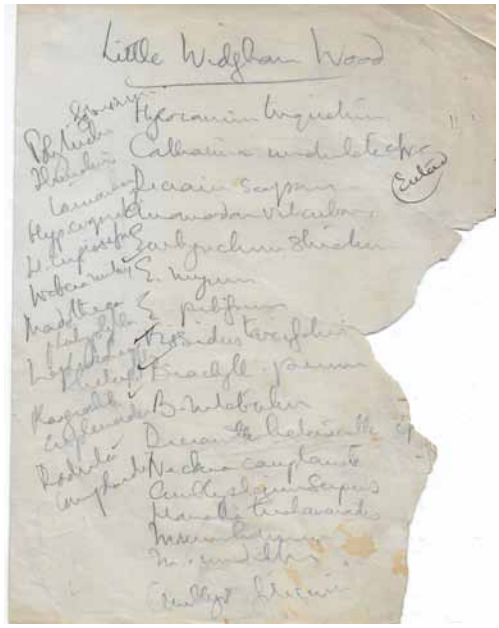
△ Figure 4. The number of the 90 sites visited in each decade.

There are differences between habitats in the history of visiting (Fig. 5). The churchyards have only been regularly visited since the 1980s, when Phil Stanley encouraged us to start recording them. So the 21 churchyards on the list have largely been visited in three recent decades and anyway have a fairly limited flora. As such, they are of little interest when identifying long-term change and I will not say anything further about them. By contrast there is a much longer history of visiting woodland, with peaks in the 1950s and the 2000s.

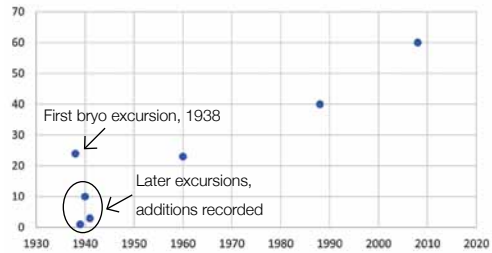


△ Figure 5. The number of the 90 Cambridgeshire woodland (top) and churchyard (above) sites visited per decade.

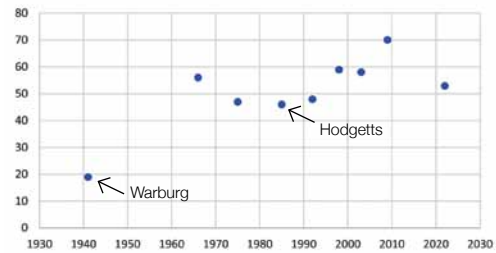
One thing we do know is that the number of species recorded per visit has tended to increase over the years. An extreme example is Little Widgham Wood, the site of the first organised



△ Figure 6. The list from the first organised Cambridge bryophyte excursion, to Little Widgham Wood on 5 February 1938, compiled by Paul Richards.



△ Figure 7. The number of species recorded on visits to Little Widgham Wood.



△ Figure 8. The number of species recorded on visits to Hayley Wood.

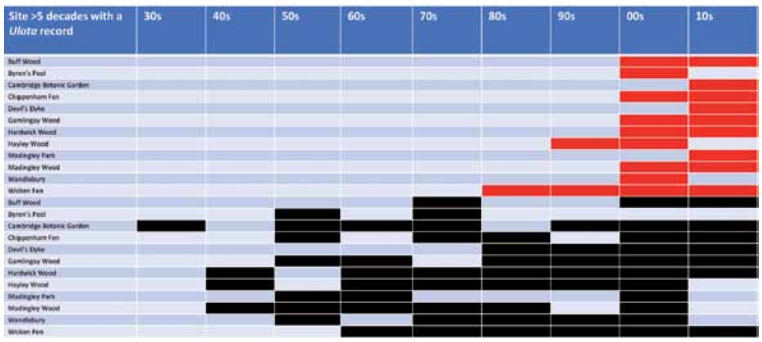
bryophyte excursion in 1938 (Figs 6, 7). There are 24 records from this excursion, and 23 in a later visit, in 1960. By contrast, 40 and 60 species were recorded on anniversary excursions in 1988 and 2008 respectively. The 2008 team was a particularly strong one, including Tom Charman, Jo Denyer, Richard Fisk, Jonathan Graham, Mark Hill and Robin Stevenson. This is a very different party to the mixed group of undergraduates and flowering plant specialists led by Paul Richards in 1938. The variation in list length at Hayley Wood is less extreme, with a short early list and reasonable later lists (Fig. 8). All were made on excursions except for the two individual visits I've marked. Both E.F. Warburg and Nick Hodgetts were at the start of their distinguished bryological careers. Hodgetts' full list is known whereas Warburg entered records on species files kept by Paul Richards and the list has been reconstituted from that. We don't know if there were species present that he didn't bother to record, though he did note some very common species such as *Brachythecium rutabulum*.

Potential use of repeat survey data

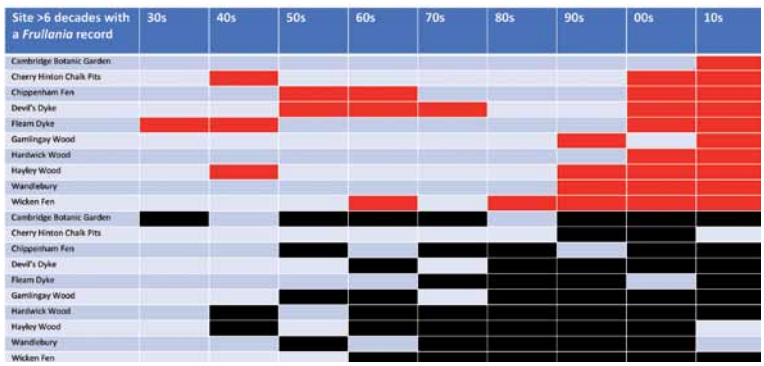
What use might we make of the evidence from the repeat surveys outlined above? There are various questions we might ask, including the following: Is there evidence for the trends already suggested by broad-scale national analyses? Is there evidence for trends in very common species which might not be revealed by studies at the national scale? Is there evidence for site-specific changes (e.g. disturbance, succession)?

Trends suggested by national analysis – the expansion of epiphytes

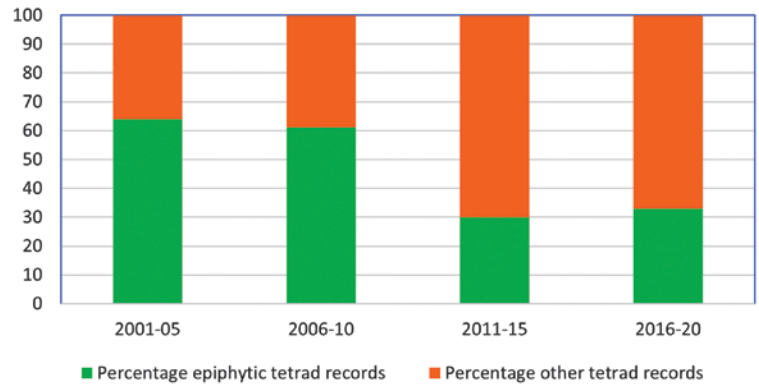
The best documented national change in the British bryophyte flora in recent decades has



◁ Figure 9. Records of *Ulota crispa sens. latiss*. (red) and *Dicranoweisia cirrata* (black) from sites recorded in six or more decades.



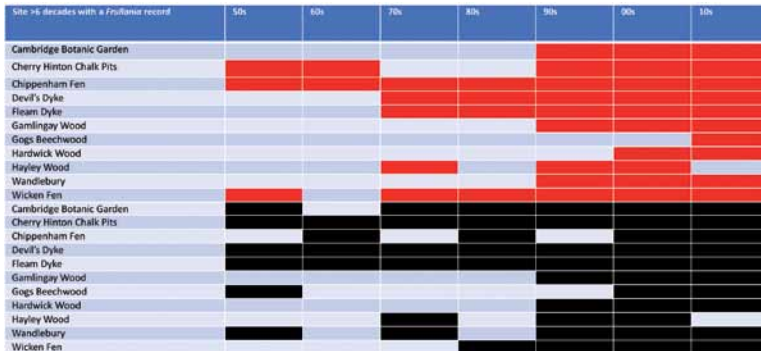
◁ Figure 10. Records of *Frullania dilatata* (red) and *Dicranoweisia cirrata* (black) from sites recorded in seven or more decades.



◁ Figure 11. Proportion of Cambridgeshire tetrad records of *Dicranoweisia cirrata* from living trees and from other substrates since 2000.

been the increase in epiphytes. Is this apparent from the site data? Fig. 9 shows the presence in decades of *Ulota crispa* and related species in sites visited in six decades or more. A control species is included for comparison, *Dicranoweisia cirrata*, which was always a frequent epiphyte. The expansion of *Ulota* is obvious and indeed the species wasn't seen anywhere in the county in the early 20th century. It was refound at Wicken Fen in 1989 and the subsequent colonisation is clearly shown.

Frullania dilatata (Fig. 10) is a more complicated case. It was recorded in the county in the mid 20th century, but very infrequently.



◁ Figure 12. Records of *Lewinskya affinis* (red) and *Orthotrichum diaphanum* (black) from sites recorded in six or more decades.

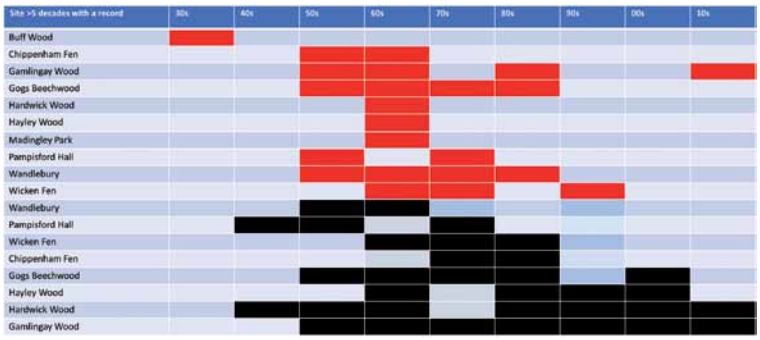
◁ Figure 13. Abundant *Lewinskya affinis* at Overhall Grove, 2018. *Chris Preston*

Again, the recent expansion started (as far as we know) in the sheltered and humid fen carr at Wicken, and one would expect to see it now on most days in the field. The control species, *Dicranoweisia*, is in decline, driven by the loss of epiphytic populations. We have made a point of recording the substrate of *Dicranoweisia* since 2000 and the species has become increasingly confined to rotten wood, though since 2011 the proportion of records from living trees seems to have stabilised at about one third of the total (Fig. 11).

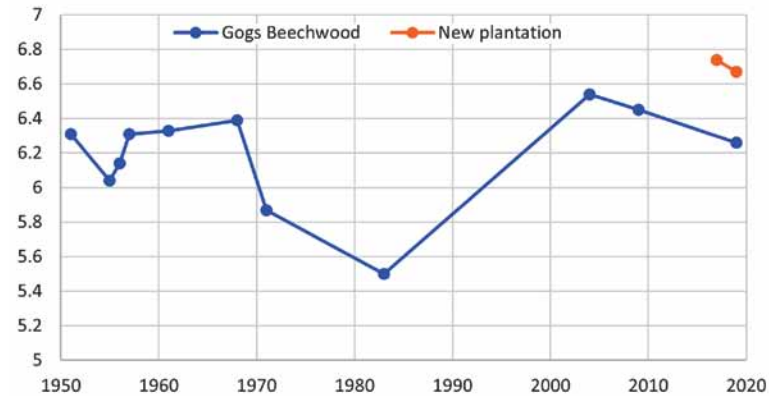
Lewinskya affinis and *Orthotrichum diaphanum* are very common epiphytes, though *O. diaphanum* is also frequent on other stable substrates. The site records show clear evidence for an increase, especially for *L. affinis* which was found for the first time since 2000 at several previously well-recorded sites (Fig. 12). In recent years we have seen it in striking abundance in some sites such as Overhall Grove (Fig. 13), a well-visited site where it was first found in 2000 (whereas *Dicranoweisia* was recorded there on four occasions before 2000). Mark Hill's analysis of all the Cambridgeshire records also indicates that these species are increasing in woodland (Preston & Hill 2019, p. 80).

The decline of calcifuge species

The reverse side of the epiphyte expansion, at least in south-east England, is the decline of calcifuge species. Two identified by the analysis of all Cambridgeshire records are *Pohlia nutans* and *Dicranella heteromalla*. The individual site records clearly confirm the decline of *Pohlia*, with the loss of the species from almost all its



◁ Figure 14. Records of *Pohlia nutans* (red) and *Dicranella heteromalla* (black) from sites recorded in six or more decades.



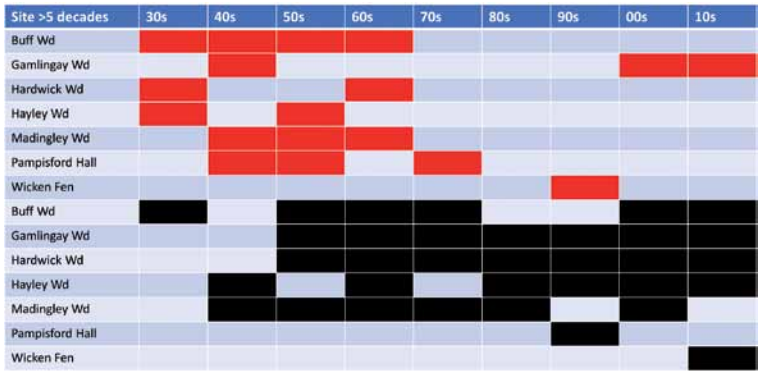
◁ Figure 15. Mean Ellenberg R values for the species recorded on visits to the Gogs Beechwood between 1951 and 2019. The higher the R value, the more base-demanding the species.

sites (Fig. 14). The site records for another calcifuge, *Dicranella heteromalla*, show that there are persistent populations in ancient woods where some areas of acid soil remain. However, it has gone from parkland sites and the fens where the amount of suitable habitat was probably much more limited. *Campylopus flexuosus* (data not shown here) shows a similar pattern, with some persistent sites and some from which it has been lost.

Another way of analysing the site data is to look at the overall species lists. Fig. 15 shows the mean Ellenberg R values for species recorded in the Gogs Beechwood. This is a rather unusual site for Cambridgeshire, a beechwood planted in the 19th century on shallow chalk soils and now a nature reserve. It has a curious mix of calcicole and calcifuge species, and the graph suggests that the calcifuges were more prominent in the 1970s and 1980s than in earlier or later years – though it is unfortunate that this is a period when there were few visits to the site. The wood has recently been extended by planting on the adjacent arable land and, as you might expect, the Ellenberg values for the species in the extension indicate a more calcicole flora.

Less well understood changes

In addition to the well-documented changes outlined above, there are some that we understand less well. One of these is the behaviour of *Hylocomiadelphus triquetrus*. Analysis of the Cambridgeshire data as a whole suggests a pattern of decline then recovery (Preston & Hill 2019, p. 80). I have coupled it with *Thamnobryum* as a control species, a large



◁ Figure 16. Records of *Hylocomiadelphus triquetrus* (red) and *Thamnobryum alopecurum* (black) from sites recorded in six or more decades.

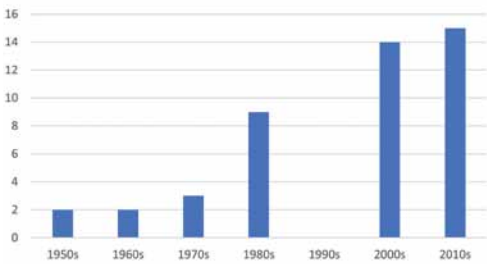
◁ Figure 17. Records of *Brachytheciastrum velutinum* (red) and *Rhynchostegium confertum* (black) from sites recorded in six or more decades.

and equally easily spotted species (Fig. 16). The site records show the loss of *Hylocomiadelphus* from all but one of the woodland and parkland sites visited in six decades or more. The pattern suggests a decline as severe as that of *Pohlia nutans*, but in this case we have some records from additional open sites. Maybe the decline in woodland populations has been a response to increasing shade in non-managed woodland.

Another puzzling species is *Brachytheciastrum velutinum*. Comparison of our experience in Cambridgeshire with the descriptions of the species in the county in the 1950s and 1960s suggests that we now see it much less frequently, whereas the control species, *Rhynchostegium confertum*, remains one of our most familiar mosses. The analysis of Cambridgeshire data shows an overall decline of *B. velutinum* interrupted by a not very believable spike in the 1990s. The site records show a rather erratic pattern, with less obvious evidence of continuity than *R. confertum*, especially in the later period (Fig. 17). Perhaps this is a pattern you would expect to see if the species is just becoming rarer and more difficult to find? If so, what is the cause? It remains a puzzle. Callaghan & Gadsdon (2023) have recently suggested that *R. confertum* has responded positively to increasing nitrogen levels, which might provide part of the solution.

Site-specific changes

Changes at one Cambridgeshire site, Wicken Fen, have been highlighted by previous studies (Lock, 1990). The colonisation and subsequent spread of calcifuges at this site in the second half of the 20th century and their subsequent decline was striking (Preston & Hill 2019, p. 105). This increase of the calcifuges was initially interpreted

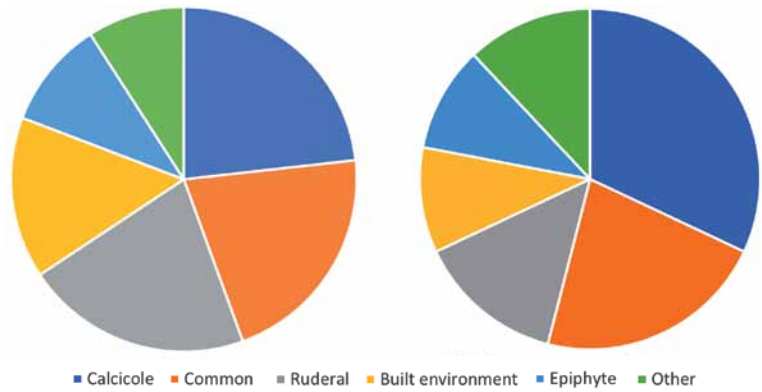


△ Figure 18. Number of species in the Arable and Ruderal habitat groups, as defined by Preston & Hill (2019), recorded per decade at Chippenham Fen.

solely in the light of management changes at Wicken, including the spread of scrub and the subsequent acidification of the peat surface; this was then reversed by the restoration of a higher, calcareous water table and eventually widespread scrub clearance. However, Preston & Hill (2019) argue that the acidification phase must be seen in the light of the high prevailing levels of SO_2 pollution at the time. Changes which are more obviously site-specific have been demonstrated for the bryophytes of Chawley Brick Pit, Berkshire, which was colonised by some remarkable calcifuges after spontaneous combustion of iron pyrites deposits in the Pit in 1943 created intensely acidic conditions (Jones, 1986; Porley, 1996; Wright & Wright *c*. 2004).

At Chippenham Fen, another important fenland site, the number of species of disturbed habitats has increased in recent decades (Fig. 18). I think that this can be tied into the increasing use of large machines to manage the Fen, and the introduction of water buffalo in 2001 (Fig.19). Most of the species are found along the rides which are disturbed by vehicles, or in the areas where the buffalo wallow. However, large changes are not always reflected in the bryophyte data. The main chalk pit at Cherry Hinton was completely cleared of scrub and the pit floor reprofiled in 2010–11 by the Wildlife Trust. We have good bryophyte surveys before and after these works but the bryophyte list is

▽ Figure 19. Water buffalo wallowing at Chippenham Fen, July 2006. *Natural England*.



◁ Figure 20. Proportion of bryophytes in different habitat groups at Cherry Hinton East Pit before (left) and after (right) scrub clearance. The habitat groups are defined on the basis of all records from Cambridgeshire.

remarkably similar despite a very striking visual landscape change (Fig. 20). There is an increase in the proportion of calcicoles, the species for which the site is valued, rather surprisingly at the expense of ruderal species, but otherwise little change.

Conclusions

What is the value of site studies? In the case of Cambridgeshire they don't tell us much that we didn't know already about the large-scale changes we have documented from national recording. However, they do offer supporting evidence. National studies are based on an amalgamation of many different datasets, at different scales, collected for different purposes and all with their individual biases (Pescott *et al.*, 2019). The best statistical analysts seek to understand the datasets and devise techniques which take these biases into account, but it is clearly reasonable to ask whether the changes they reveal are real or artefactual. Lawley (2005, 2013) expressed an extreme degree of scepticism, warning bryologists in the later version of his paper against being 'duped by a farrago of pap, for most of these changes are not of the natural world, but products of fevered imaginations'. Site lists will certainly share some of the biases inherent in the national datasets – if we have become more adept at recognising a species, for example, that will be reflected in both site surveys and the cumulative national dataset. However, the site surveys are a much simpler dataset, with biases that are easier to assess, and the confirmation of national trends at the site level provides supporting evidence for their reality.

The site studies also throw light on the processes behind the broad changes. They show the loss of *Hylocomiadelphus* from woodland, for example, and suggest that the decline of *Campylopus flexuosus* and *Dicranella heteromalla* in response to the reduction in SO_2 pollution is a result of the loss of populations in those sites where the amount of suitable habitat was always very restricted. They also provide some scope for monitoring the effect of management changes, although I suspect that more detailed within-site recording will be needed to exploit this potential to the full.

In a more sophisticated site study, published as I was preparing this article for publication, Callaghan & Gadsdon (2023) analysed the bryophyte records from Epping Forest. They reached similar conclusions to mine, identifying the recent increase in epiphytic bryophytes and the decline of acidophiles, and also highlighting an increase in nitrophilous species. However, they were unable to detect in the record any effect

of increased shading of the Forest as a result of the cessation of pollarding in 1889, just as I am unable to detect the effect of the clearance of the scrub at Cherry Hinton.

Acknowledgements

This article is based on a paper I gave to the BBS Autumn meeting at Teesside University in 2022. I thank Ambroise Baker for the opportunity to talk at this meeting, and Andrew Branson for suggesting that I write up the talk for publication and for his editorial scrutiny of the paper. It is based largely on work carried out jointly with Mark Hill since 2000, decades in which we have repeatedly discussed the issues raised in the paper.

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