THE PLANT COMMUNITIES OF HARTLEBURY COMMON

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This paper is a summary of some of Dr Betts' PhD research in the 1980s that was published in the *Proceedings of the Birmingham Natural History Society*, volume 26 number 2 of 1990/1. The author has made minor edits for the purposes of our online website library publications. Note that it does not include the research on dune colonisation and stabilisation by psammophytic mosses and dispersal strategies relating to morphology and biology of some terrestrial lichens. Please email Dr Betts if you would like details of these (christopherbetts@bettsecology.com).

CONTENTS

SUMMARY

- The first systematic phytosociological survey of the 87 hectare heathland nature reserve in Worcestershire, England, known as Hartlebury Common is described.
- The survey was designed for ease of replication in order that changes in vegetation with time can be monitored and appropriate management action taken to reverse any undesirable trends.
- All vascular plants, mosses, liverworts and macro-lichens were recorded in quadrats of four square metres, placed using a systematic grid over the Common. Cover-abundance values were assigned using the Domin scale.
- The data were analysed by detrended correspondence analysis (DECORANA) to give ordinations of the species and samples, and two-way indicator species analysis (TWINSPAN) to give a classification.
- The DECORANA ordination revealed two principal ecological gradients amongst the sample quadrats: the first reflecting soil moisture and the second intensity of disturbance.
- An ecological interpretation is suggested for sixteen TWINSPAN groups which were sufficiently well defined to be mapped from observations on the ground.
- The vegetation of the site was shown to be diverse. Habitat types include wet and dry heath, floriferous grassland, pools, woodland and waste ground. Patterns in the vegetation are determined mainly by hydrology and former land use.
- The results provide knowledge of the communities with which rare plants are associated in the reserve. The data thus gained can be used in their conservation management.
- Recommendations are made concerning the appropriate conservation management of the site in order to maintain stability and species-richness.

INTRODUCTION

This paper defines and describes the plant communities of Hartlebury Common Local Nature Reserve (HCLNR), a lowland heath in Worcestershire near Stourport-on-Severn. HCLNR is a Grade 3 Site of Special Scientific Interest (SSSI) which received Local Nature Reserve status in 1979. Its importance derives from the presence of both wet and dry heathland communities and a varied flora (Smith 1934; Day, Holland & Fincher 1978).

HCLNR is managed by the Hereford and Worcester County Council (HWCC) with special attention to the conservation of the lowland heath communities. Tucker (1982) produced a management plan which reviews the history, geology, ecology, and land use of the site. Details of this and other recent work may be found in Tucker, Zaluckyj & Alma (1986).

HCLNR's position in the West Midlands makes it unusual in three ways:

1. It is towards the northern limit of lowland heath communities in Great Britain (Webb 1986);
2. It is isolated from other major tracts of lowland heath in the country (HCLNR and the nearby Rifle Range Reserve together represent about 90% of the heathland in Worcestershire (Tucker & Betts 1986);
3. It is one of the heathland areas in the British Isles most distant from the sea, a factor which appears to be significant in the distribution of heathland communities in Europe (Polunin & Walters 1985).

The site contains several regionally rare species, including *Carex canescens, Descurainia sophia, Comarum palustre, Teesdalia nudicaulis, Thalictrum minus,* and *Vaccinium oxycoccos.* The nationally rare *Arabis glabra* and *Silene conica* are also present. There has been a decline in species number, particularly amongst those of conservation importance, since 1910. Although exact figures are unknown, an overall species loss of about 30% is suggested by Tucker (1982). Criteria for rarity are also defined. The loss of species emphasizes the need for sound conservation management and monitoring today. Those species recorded for the first time at the site in recent years tend to be opportunists of ruderal habitats and are in marked ecological contrast to the species lost during the last seventy years.

Objectives

The objectives of the study were to define and delimit the plant communities of HCLNR; to establish a replicable classification and sampling procedure; to augment the autecological data on plant species endemic to the reserve, particularly the rare ones; and to form a basis for monitoring change in the vegetation to improve conservation management efficiency.

THE STUDY AREA

HCLNR (Fig. 1) covers an area of 87.5 hectares and is located approximately one kilometre east of the river Severn near Stourport-on-Severn, 17krn north of Worcester. It comprises an upper and lower terrace separated by an escarpment and lies on a substratum of Bunter and Keuper sandstone. The light, sandy, sharply-drained soils are typical of dry heath. The wet areas are the result of underlying layers of clay laid down by the river Severn (Careless 1986). A detailed description of the site and its history is given in Tucker, Zaluckyj & Alma (1986). The many and varied activities during the long history of the site have included extraction of clay and aggregate, peat digging, grazing, tipping, and the cutting up of salt blocks on route from Droitwich. A survey of the peat deposits of Rush Pool, which have been laid down during a period of about 10,000 years, shows that the early pine, birch, and hazel woodland were later replaced by oak and alder (Brown 1984). Cereal pollen dated from the Iron Age is then superseded by pollen of the **Ericaceae**, arable weeds, and *Plantago coronopus.*

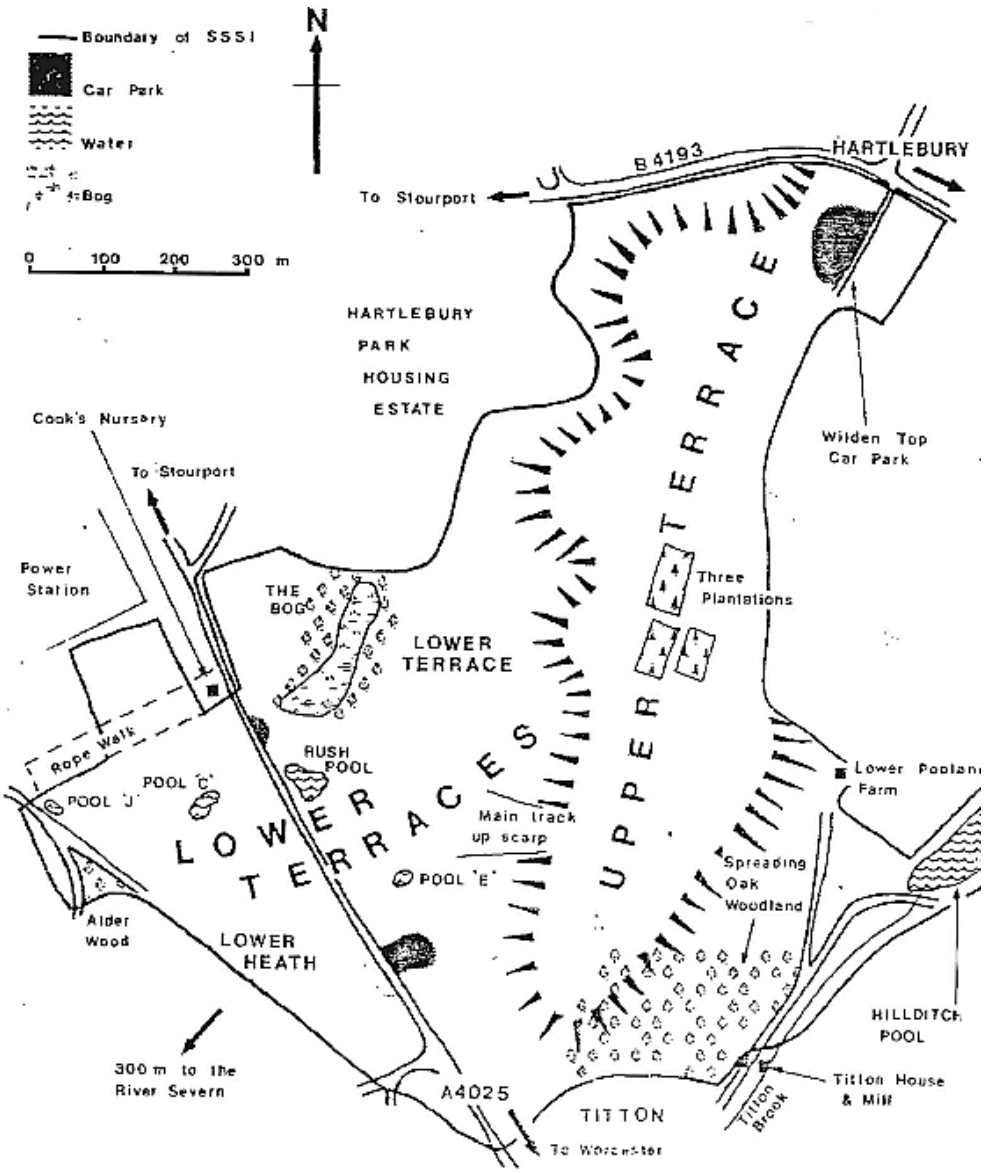

Figure 1: Map of Hartlebury Common (after Tucker, Zaluckyj and Alma 1986).

METHODS

HCLNR has been marked out with a square grid of ninety concrete posts at 100 metre intervals, *i.e*. one per hectare. Because it avoids subjectivity in selection of sample sites and allows the survey to be repeated easily, the grid posts were used for systematic sampling. A two metre by two metre quadrat was placed three metres north of each grid-post (to avoid any ground that was disturbed when the posts were erected). Twenty additional quadrats were placed within areas with distinct vegetation where it was known that sampling representation was poor or absent. Data were recorded on the Domin scale of cover-abundance as used by the National Vegetation Classification (RodweI11982-9). Cover values for each species were visually estimated, cover being defined as the proportion of the ground occupied by perpendicular projection onto it of the aerial parts of individuals of the species under consideration (Greig-Smith 1983). Only living plants were recorded and all vascular plants, mosses, liverworts and lichens were included.

Methods of analysis

The data collected were subjected to two analyses: ordination by detrended correspondence analysis (DECORANA) (Hill 1979a) and a classification by two-way indicator species analysis (TWINSPAN) (Hill 1979b). Classification of the species into clearly-defined groups was the most important objective and TWINSPAN was chosen for this because of its ability to aid classification of species-in-samples data into ecologically meaningful arrangements. Ordination using DECORANA was included to give, additionally, an overview of the broad ecological gradients of the site After examination of the TWINSPAN community classification, the whole of the reserve was inspected methodically on foot, in order to delimit the communities spatially (Fig.2) on the ground.

Nomenclature

Nomenclature of the vascular plants follows Clapham, Tutin & Warburg (1962). Bryophytes follow Watson (1981) and lichens follow Hawksworth, James & Coppins (1980)[1].

[1] I have updated plant names in the main text. *Carex curta* is now *Carex canescens*; *Potentilla palustris* is now *Comarum palustre*. CJB

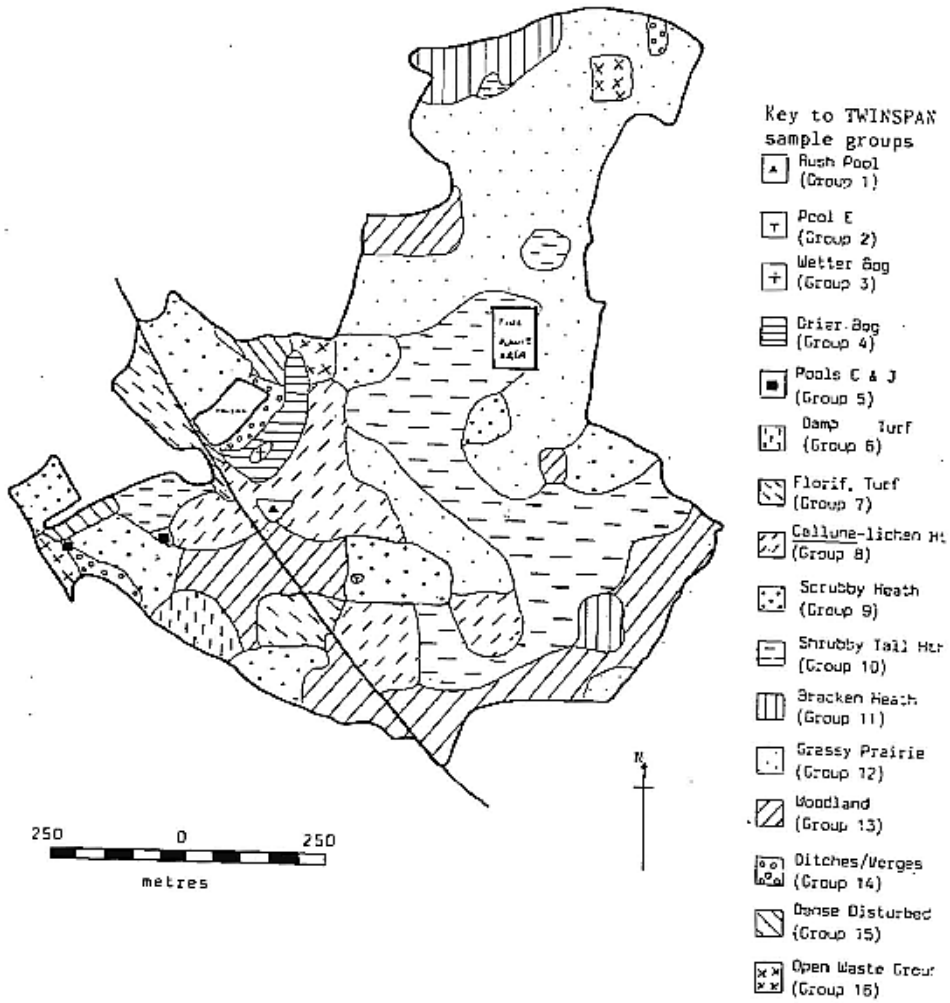

Figure 2: Map of the spatial extent of the sixteen plant communities on Hartlebury Common according to the TWINSPAN classifications of the 110 quadrat samples. Boundaries are approximate and have been drawn with reference to ground observations.

RESULTS

The TWINSPAN classification of the 110 quadrats and 162 species of the phytosociological survey identifies sixteen groups of samples which can be interpreted ecologically (Fig. 3). The primary dichotomy separates the entirely aquatic vegetation of Rush Pool from all other samples.

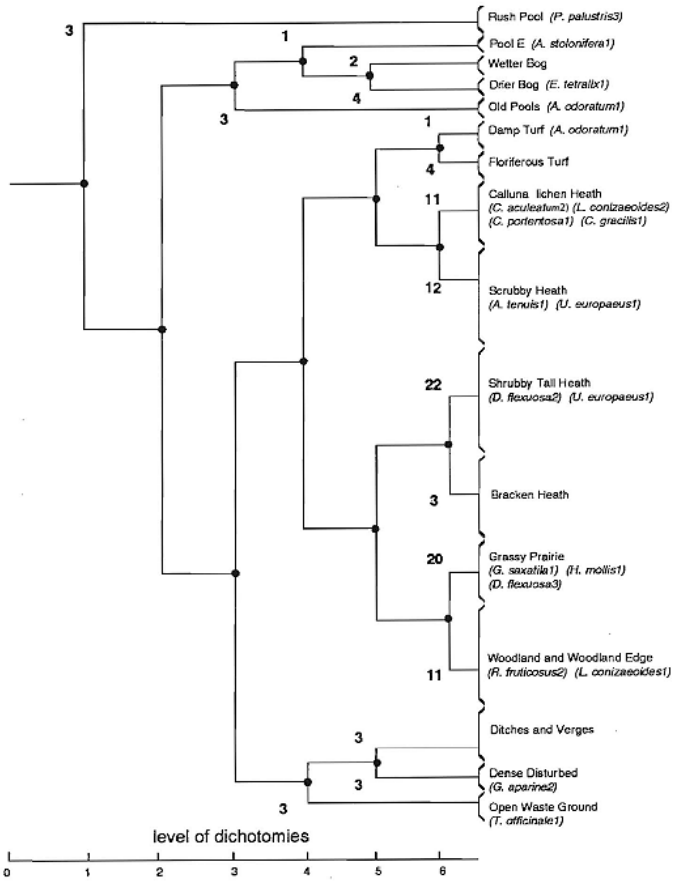

Figure 3: Dendrogram of sample quadrats TWINSPAN hierarchy showing the sixteen phytosociological groups. Species' names are the indicator species with their pseudospecies levels. Full names and explanation are given in the text. Note that the more floristically similar groups separate at lower hierarchical levels. The truly aquatic group (three samples from Rush pool) divides out at the primary dichotomy. Figures at the head of the dichotomies are the number of quadrat samples in that group. Note that four quadrats fell on parts of the reserve devoid of vegetation and have been omitted. [*NB.* Some botanical names are now different as the taxonomy has evolved. CJB]

The positive "indicator" species the of sixteen final groups of the TWINSPAN analysis are also given in Fig. 3 (in brackets in the final column – zoom text to read on screen). These are the species which are most positively preferential to the sample groups at the final dichotomy levels calculated. Indicator species are allocated at each dichotomy of the hierarchy on the basis of fidelity to the groups at that dichotomy. Not all groups possess species of sufficient fidelity to rank as indicators. Negative and positive indicator species for the other dichotomies and the full TWINSPAN solution were also derived but not shown in the Figure.

TWINSPAN enables the user to divide each true species into a number of pseudospecies according to user-defined cut-off scores related to Domin cover-abundance. For this analysis, pseudospecies cut levels were entered so that species with Domin score of 1 fall into the first

pseudospecies category, Domin scores 2 to 4 are the second, Domin scores 5 to 9 are the third, and Domin score 10 is the fourth. The pseudospecies levels are denoted by the numbers 1, 2, 3 or 4 immediately following the indicator species name in Fig. 3 and elsewhere in the text. A full explanation of pseudospecies, indicator species and the TWINSP AN program may be found in Hill 1979b. The sixteen communities defined are identified as follows:

Aquatic and Marsh

1. Rush Pool
2. Pool E
3. Wetter Bog
4. Drier Bog
5. Old (former) Pools

Drier Heath

6. Damp Turf
7. Floriferous Turf
8. *Calluna*–Lichen Heath
9. Scrubby Heath
10. Shrubby Tall Heath
11. Bracken Heath
12. Grassy Prairie
13. Woodland & Woodland Edge

Ruderal

14. Ditches & Verges
15. Dense Disturbed
16. Open Waste Ground

Figure 4 shows the plots of the DECORANA ordination of the Hartlebury quadrat samples data set using axes 1 and 2. The first axis shows a general progression from dry to wet habitats. The second axis may be interpreted as a progression from disturbed habitats to more stable communities. There is great diversity of vegetation present in the samples and, inevitably, the DECORANA ordination can only be expected to give a general overview of variation in the presence of such heterogeneity. The ordination of species confirmed the hydrological and successional interpretations of the axes.

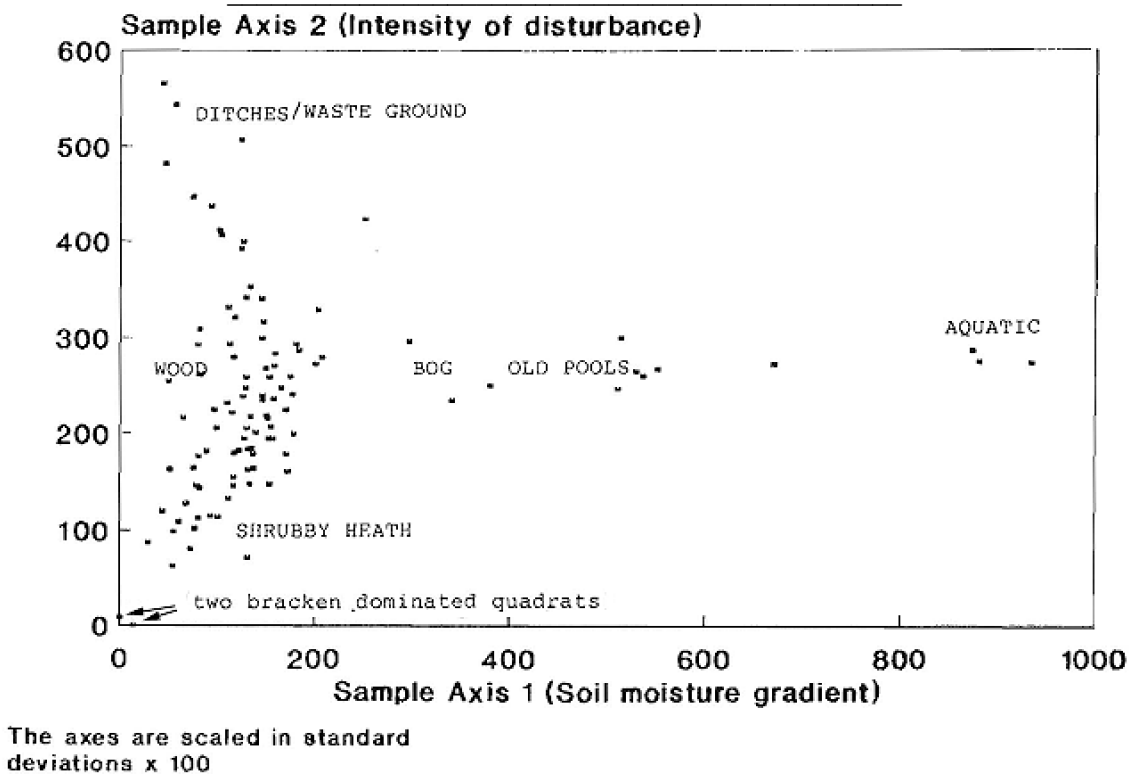

Figure 4: Plot of sample scores for the first and second DECORANA axes. The first axis extends from the drier axes to the damper ones and on to the three Rush Pool samples (highest SD scores). Axis 2 mar be interpreted as successional, samples from the disturbed, unstable communities generally appearing at the top of this axis (high SD scores) with undisturbed woodland and heath lower down. DECORANA tends to place anomalous samples, such as the two single species (bracken) stands, at the end of the ordination.

The map in Fig. 2 shows how the sixteen sample groups identified by TWINSPAN and listed above are distributed over HCLNR as plant communities. It is stressed that the boundaries drawn are mostly not rigid divisions. *In situ* inspection suggests that most of the groups occur along continuous environmental gradients and should be considered as noda which merge one into the next (the five aquatic and marsh areas being notable exceptions). As Ramensky and Gleason both emphasized (in: Whittaker 1975), it is the interaction of each species with its environment which dictates its presence and abundance, and these interactions will alter with every species so that each will have a different distribution. A brief commentary on each of the defined community types follows.

Rush Pool (group 1) separates out as a community totally different from the rest of HCLNR at the first level of the TWINSPAN hierarchy. It was the only true pool in the reserve at the time of the survey (1984/5) and an area of open water is maintained in it by the ranger. Its vegetation is dominated by *Potentilla palustris* (now *Comarum palustre*) and that species is also the indicator (*P. palustris*3) for the community. Rush Pool also contains bog pondweed (*Potamogeton polygonifolius*) and the bogbean (*Menyanthes trifoliata*) both of which are very rare in central England.

The transient pool E is another clearly separated community but with some species in common with the Bog and the other wet areas denoted as pools C and J. Although pool E is largely dominated by *Molinia caerulea* and *Lotus pedunculatus*, it is the presence of *Agrostis stolonifera*, *Juncus effusus* and *J. articulatus*, and *Sphagnum cuspidatum* which distinguishes it from the other pools. *A. stolonifera*1 is the indicator.

The Bog may be classified into two areas, although a variety of microhabitats certainly exist within these. The smaller part (group 3) is wetter and surface water is usually visible in the hollows. *Erica tetralix* is absent and *Eriophorum angustifolium* predominates. *Viola palustris* grows in the damp, shady hollows between clumps of *Molinia caerulea.* The larger section (group 4) is the drier area and is more species-rich. The indicator is
E. tetralix. Many of the plants of the bog are typical of *Sphagnum* communities, rare for this part of the country.

Typical wet heath is found, predictably, in the area of pools C and J. These are now submerged only after unusually wet weather. This *Erica tetralix* community appears to be widespread over north and west Europe (Prentice & Prentice 1983, Polunin & Walters 1985, Rodwell 1982–9). As is the case with much of Lower Heath, these areas are still periodically grazed, preventing succession to scrub. The indicator for the group is
*Anthoxanthum odoratum*1.

The damp turf community identified in one area to the south-west of Lower Heath (group 6) is the first of the eight drier undisturbed community types. It is centred on a depression which was probably once a pool but no longer has water in it, even in wet spells. Although its indicator is *A. odoratum*1 like group 5, it is distinguished by its preferential species which are those of drier habitats than group 5. *E. tetralix* is absent.

Group 7 is the floriferous turf which is the most species-rich of the more stable communities of HCLNR, and the one in which *Silene conica* occurs. There are no clearly dominant species, nor indicators, and there are several smaller habitat types within the group. The barer areas support both lichen and moss communities, and the paths provide a niche for *Plantago coronopus,* noteworthy because its usual habitat is on rocky headlands or in the transition zone between dunes and slacks on the coast, often in association with *Sagina nodosa* as noted in Savidge's study of the phytosociology of the sand-dune flora near Aberystwyth (1976).

The *Calluna*–lichen heath, the scrubby heath and the tall shrubby heath are the three dry heath communities of Lower Heath. Lichen-rich *Calluna* heath (group 8) is mostly dominated by C. *vulgaris* with, as implied, many lichens. Indicators are *Coelocaulon aculeatum*2 [this lichen is now *Cetraria aculeata*], *Lecanora conizaeoides2, Cladonia portentosa*1 and C. *gracilis*l. The cladonias are the most conspicuous lichens, here forming large and complex colonies (Betts 1986).

The scrubby heath (group 9) is characterized by vegetation of a rather open scrubby nature, with *Ulex europaeus* and *Sarothamnus scoparius* [now *Cytisus scoparius*]. It is often dominated by *Agrostis tenuis* [now *A. capillaris*] with the mosses *Ceratodon purpureus* and *Polytrichum juniperinum* in abundance. Indicators are *A. tenuis*l and *U. europaeus*l. *Calluna vulgaris* is widely spread throughout groups 8, 9 and 10, and the presence of the psammophytes *Teesdalia nudicaulis* and *Rumex acetosella* highlights the existence of the open sandy patches and paths. A detailed study of the factors affecting distribution of *T. nudicaulis* at Hartlebury has been conducted by Marshall (1984) and the present phytosociological survey confirms the restricted nature of the habitat in which this species occurs.

The shrubby tall heath (group 10) is typified by *Ulex europaeus* with *Deschampsia flexuosa* and *Cytisus* in abundance. It is less open than the other two dry heath groups, and both bryophytes and *Cladonia* lichens are poorly represented with parts of the community showing

successional change towards woodland by the presence of young *Quercus robur*. Indicators are *D. flexuosa*2 and *U. europaeus*l.

Group 11 is the bracken heath of Wilden Top. It is often a single species stand of *Pteridium aquilinum* which has shaded out other plants. Current management includes controlling bracken with herbicide to prevent further invasion.

The grassy prairie (group 12) is the other main feature of Wilden Top. It was dominated by wavy hairgrass and *Deschampsia flexuosa*3 is one of the indicators with *Galium saxatile*1 and *Holcus mollis.* Since the survey, however, considerable change has occurred in this community and recent observations suggest colonisation by young heather and associated lichens and bryophytes.

Woodland and woodland edge samples form group 13. The vegetation is mature and dominated by *Quercus robur* to the south-east of the reserve. On Lower Heath, it is mainly immature, in parts with very dense, tall stands of *Cytisus* and little else. The most preferential indicator is *Rubus fruticosus*2.

The third section of ecologically interpretable groups determined by TWINSPAN comprises the disturbed areas of HCLNR. Ditches and verges on the boundaries of the reserve typify group 14, especially where there has been tipping. It is species-rich, as would be expected, with many ruderals (*e.g*. *Senecio jacobaea* [now *Jacobaea vulgaris*], *Plantago lanceolata, Papaver rhoeas*). No species was generally dominant or sufficiently positively preferential to be positively indicative for this group at this level of the dichotomy.

Dense shady thickets typify group 15 which is similar to the last, but with generally taller vegetation. Again they are disturbed areas at the edge of the Common. *Galium aparine*2 is the positive indicator.

The open waste ground of group 16 represents grossly disturbed, open areas such as the car park of Wilden Top.

DISCUSSION

Hartlebury Common may generally be considered as belonging to H9 of the NVC (Rodwell 1982–9), the *Calluna vulgaris–Deschampsia flexuosa* heath type, although in a somewhat degenerate form. Degeneration is indicated by the frequency and abundance of ruderal species and opportunist acidophiles such as *Agrostis tenuis* [*capillaris*], *Festuca ovina, Senecio sylvaticus* and *Rumex acetosella.* The reserve also displays affinities to NYC community H8, the *Calluna vulgaris–Ulex gallii* association of western Britain, perhaps because of the influence of relatively warm Gulf Stream air funnelling up the River Severn valley.

Day, Holland & Fincher (1978) observed four broad vegetation zones on HCLNR. Zone 1 is the most floristically rich and the TWINSPAN classification distinguishes ten associations within it. Zone 2 includes all of the aquatic and semi-aquatic habitats which TWINSPAN separates into groups 1 to 5. Zone 3 is the Lower Terrace and scarp which may now be seen to comprise *Calluna*–lichen, grassy prairie, scrubby, tall shrubby, and bracken heath types as well as woodland. The woodland area is increasing and many seedling trees have been removed from adjacent heath as part of a management policy designed to prevent undesired successional change. Zone 4 is the botanically less diverse Upper Terrace and the current survey shows it to be grassy prairie to the north becoming shrubby tall heath to the south with patches of scrubby heath. Wilden Top car park is clearly defined as is the hedgerow leading to it. This hedge was destroyed by fire in 1985 after the present data were collected and will provide an interesting area for future monitoring. The plantation of *Pinus nigra* with some *P. sylvestris* which is also on Wilden Top was deliberately excluded from the current survey, but it may influence the surrounding vegetation by promoting podsolization, creating changes in local micro-habitats by increasing shelter and shade, and producing seedlings which could prove invasive.

By comparing the map in Fig. 2 with the geological map in Fig. 5, some relationship can be discerned between vegetation types and underlying soils. On Upper Terrace the grassy prairie corresponds mainly to the gravels, whereas the sands of Lower Terrace are favoured largely by the dry heath associations. Because of the heterogeneity of vegetation on Lower Heath, clear edaphic associations are not evident. The sharp boundaries of the aquatic groups are apparent, as expected, although some of the pools have shrunk in size and depth. Hydrology and land use factors are more important than the geology in the distribution of vegetation at Hartlebury.

Clear felling, burning, grazing, and other anthropogenic factors of a past age (Tucker, Zaluckyj & Alma 1986) creating the typical heathland paraclimax vegetation, have now largely ceased, and there is little doubt that, without positive management, HCLNR would in time revert wholly to oak forest. Couderc and Guédès (1974) have studied the changes which occur when the human intervention, which produces the heathland paraclimax on typically sandy soils, ends. Some ecologists (*e.g.* Corillon 1971) have stated that degradation of such soils is irreversible and that forest can never return to them. However, Couderc and Guédès found that, even on podzols, once human activity ceases, succession is re-established, the heathland paraclimax moves on, and forest is re-instated, at least in north-west Europe. There is certainly no lack of evidence on HCLNR of recolonisation by oak (*Quercus robur*) and birch (*Betula pendula*). This view generally agrees with the Gleasonian model that vegetation disjunctions are mainly accounted for by juxtaposition of different parts of temporal succession (Allen and Starr 1982) except where there are major hydrological or geological transitions.

This has important consequences for conservation management at Hartlebury which is discussed in more detail below, but decisions as to whether recolonisation should be prevented and how far the original character of the heath should be maintained are not always straightforward, (*cf*. the invasion of heathland in the New Forest area and policies for ecosystem conservation discussed in DiCastri, Baker and Hadley 1984.) More work needs to be done, for example to determine whether colonisation by oak and birch is most significant where *Calluna* is becoming senescent, and if so, whether a controlled burning regime, grazing or mowing should be carried out, or a combination of these. Gimingham (1987) has highlighted the dilemma of managing fragmented lowland heaths. The objective must be to maintain the mosaic pattern and uneven *Calluna* age structure, but the required financial and labour resources are seldom available to those who must manage the heaths.

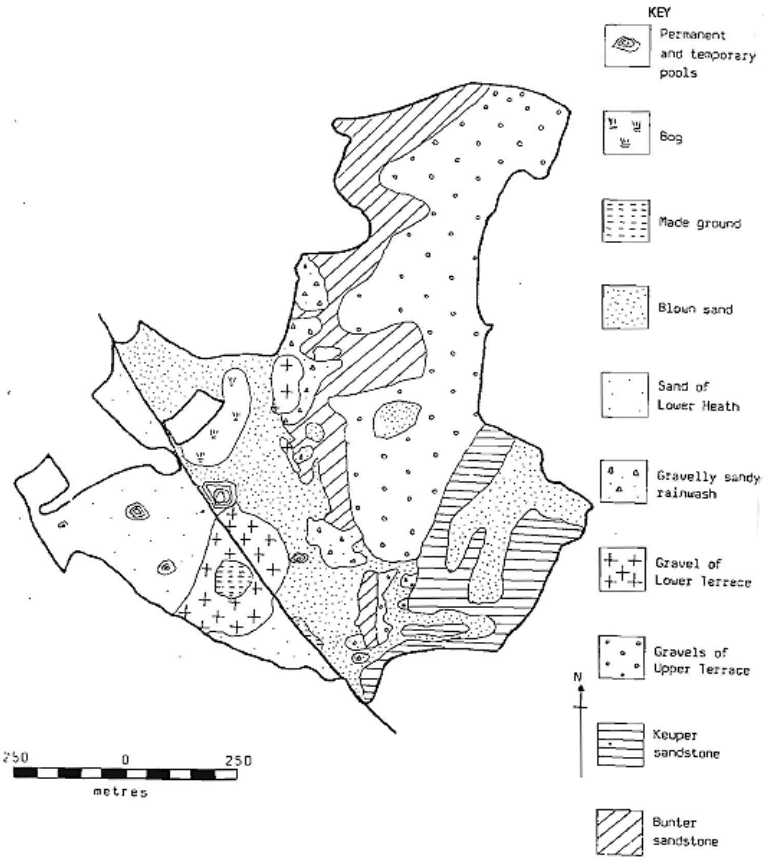

Figure 5: The geological features of Hartlebury Common (after Wills 1926). Some correlation may be observed, for example between the gravels of Upper Terrace and the grassy prairie community (group 12) and, predictably, the pools and Bog with the aquatic and damp grassland communities (groups 1 to 6).

The role of plant ecology in conservation at HCLNR

Since this study has been conducted primarily with the conservation management of HCLNR in mind, it is appropriate to discuss this aspect more thoroughly. Conservation Objectives for HCLNR (see Tucker 1982) include the preservation of tracts of dry and wet heath and floriferous turf communities; maintenance of existing species-richness with consideration for the re-introduction of some of the species which have been lost; and discouragement of invasion by undesirable pioneer and ruderal species and erosion of the more stable heathland ecosystems. For a wildlife heathland reserve, Gimingham (1971) has advocated prevention of tree and shrub invasion and encouragement of small-scale pattern by promoting an uneven age-structure of *Calluna* to create a broad range of ecological niches and thus wide diversity of the fauna and

flora in a small area. Webb (1986) reiterates the role of ecology in the management and maintenance of populations and communities, as well as stressing the problems of fragmentation and isolation of lowland heaths in Britain.

Work by Hobbs and Gimingham (1984), in Scotland, indicates that abundances of grass, forb and lichen species reappearing after burning declines with increasing age of the pre-burn stand. Also, where regrowth of *Calluna* is slow, *D. flexuosa* spreads rapidly both vegetatively and by seed, which may be an important causal factor of the Wilden Top grassy prairie. Hobbs and Gimingham conclude that the floristic composition set up immediately after the fire is the main determinant of post fire development. Certainly, the whole question of recolonisation is a complex one. Grubb (1977) has pointed out that gaps produced by plants dying may be colonised by a very large variety of species, many of which may be able to survive there, not just one. This is because these gaps may be regarded as regeneration niches which are themselves differentiated. A policy for maximum species richness may not always be appropriate for maintaining the presence of a particular species (Harper 1981), which may need specific conservation treatment. This is best carried out after a thorough and detailed study of its population biology. The tiny population of *Drosera rotundifolia* in the Bog is a case in point. It has fluctuated in recent years for reasons which still remain obscure and in spite of careful general management to maintain species richness in that habitat. Work is also needed to define the minimum area and population size required for all the key species in HCLNR to maintain viability.

Because many of the habitats within the reserve are derived from discontinued land use practices, positive management of the Common is required to maintain the vegetation types and their component species. In view of the complexity of interactions of populations and individuals within ecosystems, this is not a simple exercise, and the greater the understanding of the plant communities, the greater the likelihood that correct management can be successfully carried out.

A detailed phytosociologica1 map of the reserve provides greater understanding of the habitats of, and other species associated with, the populations of the rarer plants occurring there, and so suggests some of their ecological preferences. By repeating the survey at regular intervals, any major trends and changes can be identified and their likely effect evaluated. If the change appears detrimental to any population which it is important to conserve, once recognized, measures can be taken to halt or reverse it.

Community	Dominant Species	Management Comments
Rush Pool	*Potentilla palustris* [= *Comarum palustre*]	Monitor for eutrophication/pH; maintain water table; maintain open water.
Pool E	*Juncus effusus, Agrostis stolonifera*	Check invasion by *J. effusus;* maintain water table; possible site for reintroductions.
Wetter Bog	*Eriophorum angustifolium*	Monitor for eutrophication & pollution; maintain water table, remove tree seedlings.
Drier Bog	*Erica tetralix, Sphagnum cuspidatum*	As for Wetter Bog
Pools C & J		Maintain water table, graze moderately.
Damp Turf		As for Pools C & J. Remove tree seedlings.

Floriferous Turf		Remove invading pioneers; graze moderately; study *Silene conica* & other rarities & protect.
Calluna–lichen Heath	C*alluna vulgaris*	Remove oak/birch seedlings; maintain mosaic; needs research to define conservation needs.
Scrubby Heath	*Agrostis tenuis* [=*A. capillaris], Ulex europaeus, Sarothamnus* [= *Cytisus*] *scoparius*	Check succession to woodland.
Shrubby Tall Heath	*U. europaeus, C. scoparius, Pteridium aquilinum, Deschampsia flexuosa*	Maintain open paths and blown sand areas; control spread of bracken.
Bracken Heath	*P. aquilinum*	Consider reduction of this community.
Grassy Prairie	*D. flexuosa*	Monitor and research grazing/burning needs.
Woodland & Woodland Edge	*Quercus robur*	Control spread into adjacent communities.
Ruderal Areas		Monitor and control spread; look out for reappearance of any rarities in disturbed ground.

Figure 6: A summary of suggested conservation management comments arising from the plant community survey work. The heathland communities of HCLNR are all anthropogenic and, as such, will require active and continuous management if they and their component species are to survive. In particular, there is evidence of rapid and widespread colonization by oak, birch and bracken on the reserve.

Figure 6 presents a summary of suggested recommendations for conservation management and the conditions needed for maintenance of the plant communities in the light of the phytosociological survey. Community boundaries to be carefully monitored are those between the relatively stable ecosystems of heath, bog and floriferous turf and the disturbed areas where the *limes divergens* of van Leeuwen & Westhoff (Westhoff 1970), indicating unstable ecological gradient types, occur. The survey shows that such boundaries are found on Hartlebury Common bordering the car park and its access road at Wilden Top, to the north and west of the Bog, and to the southwest of the reserve near the power station. Disturbances around the edge of the Common tending to create eutrophic conditions need to be controlled and emphasize the management aim stated above to protect the ecoclines between such areas of eutrophic conditions and the stable oligotrophic ones prevailing within the reserve. However, it is not suggested that disturbed waste areas should be eliminated because there has certainly been a high degree of disturbance on the Common throughout its recorded history. Rather, a close watch should be kept in these sectors for the reappearance of any rarities which may germinate following disturbance of the seed bank. In general, management must strive to replicate former land use practices as much as possible.

External changes may also be affecting HCLNR. Although an urban area adjoins the northern boundary, much of the rest of the reserve is close to an intensively-farmed area[2] which has seen a revolution in agricultural methods since the war, as have many other parts of lowland Europe. Recent observations in the Netherlands indicate that the change of large areas of heath into *Deschampsia* and/or *Molinia* grassland may have been favoured by an increased aerial nitrogen input from surrounding farmland. This accelerates the nutrient build-up, already high from cessation of heath management and the effects of the heather beetle *Lochmaea suturalis* attacking the ageing (unmanaged) *Calluna*, allowing the competitive advantage to shift decisively in favour of the grasses. Willis (1963) has shown that addition of mineral nutrients

[2] But note the Rifle Range and recent acquisition of land by the Worcestershire Wildlife Trust. CJB

to semi-natural communities on poor soils promotes the growth of grass species but generally reduces species diversity. It is also important that drainage run-off from surrounding regions into oligotrophic wetland areas like the Bog should remain acid (see Harrison 1974). Of course, many of the rarer taxa which occur at Hartlebury were not found in the quadrat samples of the survey. A large number of species are very locally distributed and are therefore inevitably missed in a study of this kind. The lists of vascular plants, lichens and bryophytes of HCLNR number almost 500 species. Thus the 162 species recorded in this survey's samples represent just over 32% of the total thought to occur now. Indeed, ten new species were found by the survey, mostly mosses, indicating that the bryophyte list, at least, is incomplete. Further details of species, associations and their habitat types may be found in Betts (1985).

The phytosociological map defining and delimiting the vegetation types allows the community associated with any given area or species to be identified: for example, striated catchfly (*Silene conica*) in the floriferous turf of Lower Heath; marsh cinquefoil (*Potentilla palustris* [*Comarum palustre*]) in Rush Pool and the wet Bog; and cranberry (*Vaccinium oxycoccos*) in the drier Bog. Such data are of considerable relevance in the event of attempted reintroductions of extinct species which were once indigenous, or the taking into storage or cultivation of propagules from threatened populations. Should it be deemed desirable at a later date to take some of the autochthonous rarities into cultivation, then knowledge of their natural habitat and associations will be vital, especially as many species do not have wide ecological flexibility. Providing accommodation in a botanical garden for rarities in their appropriate associations can be essential for their survival (Kemp 1978).

Hartlebury Common is a relatively tiny reserve in a densely populated and industrial area of Britain. It is subject to intense visitor pressure, and it is to be hoped that this might ensure that sufficient funding is provided for its conservation and management. It is also very fragile, and the possibility of changes in its hydrology or of serious pollution cannot be ignored.

CONCLUSION

This survey and analysis have given a structured and informative description of the vegetation. The plant communities have been defined and may be observed on the ground. The methods used form the basis for a standard monitoring of the phytosociology of the reserve, which can be repeated without difficulty as and when necessary. Greater knowledge of the distribution of vegetation and habitats has been gained. Some contribution has been made to autecologica1 data on species indigenous to the LNR, and it is hoped that the whole study will prove to be of value in effecting the appropriate conservation of the reserve.

The spatial variation in the vegetation of the Common has been shown to be considerably greater than was at first thought. Some of the communities and habitats require further sampling and definition. The TWINSPAN classification program, in particular, has been shown to be an excellent tool for this type of plant community analysis, and can be recommended for use on other regional sites of conservation interest. The adjoining Hillditch Pool SSSI, the near-by Rifle Range, and the Devil's Spittleful reserve are cases in point.

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