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Waxcap-grasslands - an assessment of English sites

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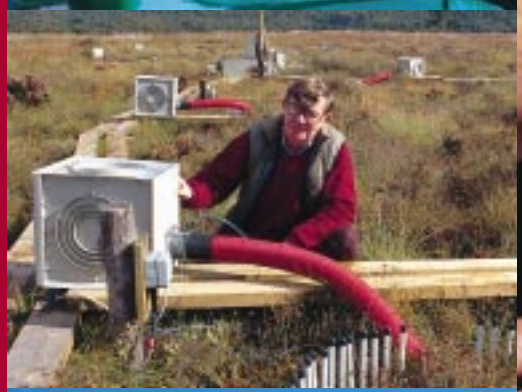

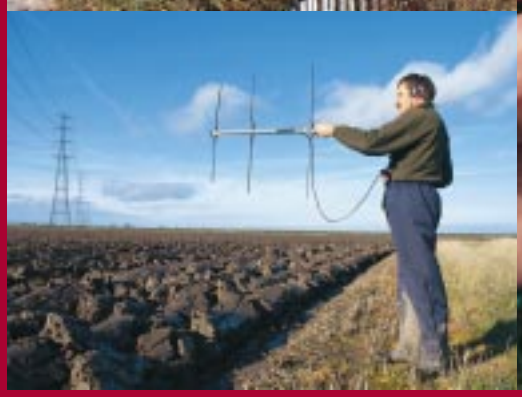

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Waxcap-grasslands – an assessment of English sites

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Summary

Waxcap-grassland fungi are of conservation interest as indicators of semi-natural, mycologically-rich unimproved grasslands, a habitat seriously threatened throughout the UK and Europe.

The species concerned are strongly associated with unfertilised, unimproved, nutrient-poor grasslands. They often thrive in short, moss-rich, often highly grazed swards, which may be of low interest for other organisms such as flowering plants. They have received little conservation concern until relatively recently with the inclusion of three grassland species on the UK Biodiversity Action Plan BAP (Anon 1999). Their ecology and distribution are still relatively poorly understood. Awareness of their importance amongst the wider nature conservation community and the public is still fragmentary.

The primary aims of this project have been a) to source and collate distribution data for all the indicator waxcap-grassland species in England, and b) to use this data to produce a preliminary list of the most important English grasslands known to date.

This, together with the dataset of nearly 20,000 records will for the first time enable well-informed decisions to be made on appropriate site protection.

Additional information is supplied to summarise the known threats to grassland indicator fungi, and on best management practice. To help inform the BAP process in England, three species dossiers have been produced for: 1) the pink waxcap *Hygrocybe calyptriformis*; 2) the date waxcap *Hygrocybe spadicea*, and 3) the olive earthtongue *Microglossum olivaceum*.

Initial UK interest in these fungi was sparked by the British Mycological Society's (BMS) waxcap-grassland survey (Rotheroe *et al* 1996). This is an ongoing, informal, non-systematic survey by volunteers to help stimulate better distribution data. Waxcap records generated in England since the BMS survey was initiated account for the majority (53%) of data collated in this study. As a result of BAP initiatives there have also been several specifically designed and commissioned surveys by the government agencies in Scotland, Northern Ireland and Wales. In England, the only systematic survey to date has been the relatively small scale Somerset survey (Thompson 2000).

Analysing this data has revealed various pitfalls when relying almost entirely (97%) on non-sytematic data sources. This makes meaningful comparison difficult and emphasises the need for more structured surveys. The most serious bias is that data has not been recorded in a standardised way. Some species and groups of grassland fungi are more difficult to identify than others, and many volunteer recorders ignore these. Data collected has not been subject to any quality control. Collections have not in most cases been retained, making verification impossible. Site names have not been applied with any consistency and site boundaries are not defined. There are huge data deserts where large areas of England have never been surveyed or where data is not easily available. The best-known sites still reflect the incompleteness of fungal recording in the UK (Evans *et al* 2001). They are more often a reflection of the distribution of mycologists than of fungi.

There remains in England a need for further systematic survey to complement the initial Somerset survey. This will enable a meaningful ranking of waxcap-grassland sites to be

undertaken in a local, regional, English and UK context, and will progress understanding of mycological interest and site monitoring.

The project results clearly show that England has some outstanding examples of waxcap-grassland sites both in a national and in a European context.

Twelve sites fulfil waxcap criteria set in Scandinavia by Rald (1985) and Vesterholt *et al* (1999) for sites of international importance. A further thirty-two sites fulfil these criteria for sites of national importance. England, together with the rest of the UK remains a stronghold for waxcap-grassland habitat. It does not appear to have yet experienced the devastating levels of suitable habitat decline which have taken place in much of Northern Europe. It holds 15% of known European sites for the pink waxcap, with the UK as a whole holding a staggering 50% of known sites (Evans 2003a)!

Contents

1. A portrait of waxcap-grassland fungi

1.1 What are waxcap-grassland fungi?

It is now well established that unimproved grassland is a key threatened habitat throughout the UK and northern Europe. Rapid decline has been documented by many researchers in the Netherlands (Arnolds 1980), Denmark (Nitare 1988, Boertmann 1995), Sweden (Rald 1985) and Germany (Winterhoff 1978). Many grassland species are considered threatened with extinction, with over 250 species included on the Red Data Lists of Europe (Arnolds & De Vries 1993).

The presence of certain species of 'waxcaps' and other larger fungi constitutes a quality ‘waxcap-grassland’ site. These indicator species include members of the Clavariaceae (club and coral fungi), Hygrophoraceae (waxcaps), Entolomataceae (pink-gilled agarics), and Geoglossaceae (earthtongues). Also included within this assemblage of quality indicators are a relatively few species of *Dermoloma*, *Porpoloma* and *Camarophyllopsis*, all of which are agarics.

The best known and easiest to identify amongst this suite of fungi are the waxcaps (*Hygrocybe* species) which typically have brightly coloured fruitbodies ranging from red, yellow, pink, and white to green and even blue. Some have classic pointed pixie caps and their textures range from felt-like to buttery or slippery. Excellent descriptions together with colour photographs are available in a well-presented and user-friendly monograph (Boertman 1995). In addition as part of the BMS waxcap survey the monograph’s author was tutor at two identification workshops held in Abergavenny, South Wales. This has enabled volunteer recorders in the mycological community to become particularly familiar with them. This is strongly reflected in the recording bias such that 58% of records in this collation are waxcaps (see Table 1).

The remaining genera from the ‘waxcap-grassland’ suite are by comparison less well known even amongst mycologists and some remain poorly understood taxonomically. In general they require much greater experience with microscope and keys to determine accurately. Their true distribution is therefore less well understood than the waxcaps.

The pink-gilled *Entoloma* spp. are a particularly frustrating group and yet they have potentially the highest number of species on the UK checklist (currently over 100). Many, formerly classed as *Nolanea* have fairly dull looking grey-brown fruitbodies though some have a silver sheen or contrasting stripe colours. Others (formerly *Leptonia*) are however quite attractive shades of blue and green, and may have dark fringes to the gills or distinctive smells of pear drops or even mouse droppings!

The club, coral and spindle-shaped Clavariaceae represent nearly 12% of the taxa from the English waxcap-grassland suite. They can be single, clumping or multiple branched like corals and are relatively easy to spot in grassland with their bright orange, yellow, pink and purple colours. The black, purple-black and olive earthtongues of the Geoglossaceae on the other hand are particularly difficult to detect. They have a tendency to swarm together with a mixture of species often growing in close proximity.

Table 1: Waxcap-grassland taxa in England

Name of group	% of collation	No of taxa
Clavariaceae	14	21
Hygrocybe	58	50
Entoloma	22	89
Geoglossaceae	3	14
Dermoloma	1	5
Porpoloma	1	2
Camarophyllopsis	1	5

1.2 How long do waxcap-grasslands take to develop?

Important waxcap-grasslands require a considerable period of time to develop their characteristic mycota. A minimum requirement (Keizer 1993) appears to be 20-30 years but often hundreds or thousands of years has been suggested for the finest sites (Feehan & McHugh 1992). Much is speculation, but some idea of timescales can be established from observation of the establishment of waxcaps in sites previously farmed intensively. Three or fewer species became established after 20-35 years at three sites in the Netherlands (Arnolds 1994). Whilst certain species establish or re-establish more rapidly than others, *Hygrocybe virginea* and *H. conica* appear particularly tolerant at fertilised sites and may reappear after about 10 years whilst more sensitive species like *Hygrocybe splendidissima* can require more than 30 years to appear (Ejrnaes & Bruun 1995).

1.3 What do waxcap-grassland fungi need?

Fruitbodies appear as a response to environmental triggers, and can according to data appear at almost any time of year, although February to May remain times of least fruiting whilst August to December are times of highest fruiting. Some species are known to occur particularly early eg *Hygrocybe helobia* whilst others occur quite late eg *Hygrocybe russocoriacea* (Boertmann 1995). The specific triggers are not well understood and can vary from one waxcap-grassland group to another as do their individual ecological needs.

Little is known for certain about the nutritional biology of waxcaps. They are thought to be saprotrophs, and occur in habitats with low sulphur and phosphate content, often associated with a well-developed moss layer (Arnolds 1980). In Wales, observations show this most commonly to be *Rhytidiadelphus squarrosus* (Griffith *et al* 2002). However, a better understanding of their needs is hampered because it has not yet been possible for researchers to culture them. Detail can only be gleaned from observation of the above ground fruitbodies and direct information about what is happening below ground is not yet available. Their mycelia are not visible to the eye in the litter layer and only *Hygrocybe virginea* germinates with reasonable ease under test conditions. Further research in Wales is planned over the next three years to investigate how and at what depth waxcaps feed in the soil horizon. One theory is that the mycelium may be growing in greater depths than usual for saprotrophs and be feeding on rather more heavily decomposed plant litter than in the top litter layers.

They occur in a range of grassland types, some of which are not easily described by some of the habitat classification systems commonly in use. Some of the most important sites in the UK are in upland areas of semi-natural grassland where habitat loss has been lower. Important lowland sites tend to be associated with estate parkland, ancient lawns, churchyards and cemeteries. The greatest diversity of waxcaps seems to occur on

mesotrophic grasslands (MG5) though upland (U4) and calcicolous grassland (CG1 and CG2) also appear productive (Griffith *et al* 2002). The most extensive observations on the ecology of grassland taxa comes from the Drenthe region of the Netherlands (Arnolds 1982). Here *Hygrocybe psittacina, H. glutinipes* and *H. miniata* are described as saprotrophic fungi associated with bryophytes. However data incorporating this level of detailed habitat description has been very limited in the UK and further study is needed to give a better picture of the ecology of all the fungi associated with waxcap-grasslands.

For the waxcaps, certain species appear to be restricted to more alkaline sites eg *Hygrocybe spadicea, H. calciphila*, and *H. persistens* var. *konradii*. Others show distinct preference for acidic grasslands eg *Hygrocybe laeta, H. miniata* and *H. turunda*. Some have a preference for dry sites (*Hygrocybe spadicea*) whilst others are nearly always associated with boggy, wet sites eg *Hygrocybe helobia, H. coccineocrenata* and *H. substrangulata*. Five taxa have yet to be reliably recorded from England of which four are restricted to arctic-alpine or subarctic heaths or fens eg *Hygrocybe citrinopallida, H. lilacina, H. salicis-herbaceae* and *H. xanthochroa*. The fifth, *Hygrocybe constrictospora*, is a coastal grassland dune species associated with *Salix repens*. One species, *Hygrocybe viola* has only so far been found in two sites in the UK, both in England (Ruislip Woods and The Mens) associated with moss in woodland environments.

Understanding of the ecological preferences of the other waxcap-grassland taxa is even more nebulous. According to Noordeloos (1992) the following *Entoloma* spp. are species of wet, marshy sites: *Entoloma albotomentosum, E. cuspidiferum, E, fuscomarginatum* and *E. rugosum. Entoloma phaeocyathus* is restricted to dune grasslands. For the earthtongues it is suggested (Silverside 1997) that *G. atropurpureum, G. cookeanum* and *G. umbratile* show preference for base rich sites, often dune grasslands, whilst *Geoglossum fallax* and *G .glutinosum* tend towards the acidic.

2. Species of conservation concern

The provisional Red Data List (RDL) of British Fungi (Ing 1992) is well outdated both in terms of our understanding of the distribution of UK fungi and our species concepts. Much tighter IUCN criteria now exist for species inclusion and a revision is nearing completion (Evans *et al*). Listing waxcap-grassland taxa from the provisional RDL would therefore be misleading. There are however thirty two such species on the 1992 list, and of these original RDL taxa only four species are likely to qualify for inclusion in the revision. This it should be stressed is largely an artefact of higher levels of recording rather than a removal of habitat threat.

Three waxcap-grassland species are included on the UK Biodiversity Action Plan and separate species dossiers have been included for these in Appendix 1. They are: 1) the pink waxcap *Hygrocybe calyptriformis*; 2) the date waxcap *Hygrocybe spadicea*, and 3) the olive earthtongue *Microglossum olivaceum*.

Three grassland taxa, all of which occur in England have now been proposed for inclusion in Appendix I of the Bern Convention on the Conservation of European Wildlife and Natural Habitats (Koune 2001). They are *Hygrocybe calyptriformis, Entoloma bloxamii* and *Geoglossum atropurpureum.* Ratified in 1982 the convention, through the Habitats Directive, aims to ensure the conservation and protection of species occurring in 'natural' areas defined by Natura 2000 descriptions. However for some habitats in which these fungi occur there are

no European habitats defined eg upland acidic grassland, neutral grassland or the more man-made sites such as churchyards, cemeteries or parks. Their known occurrence in England relative to Europe (Dahlberg & Croneborg 2003) is provided in Table 2.

Entoloma bloxamii, a distinctive blue fungus of medium stature, together with the earthtongue *Geoglossum atropurpureum* show preference for base rich grasslands whilst *Hygrocybe calyptriformis* appears mainly in neutral grasslands.

Table 2: Data on Bern proposed grassland species

Name of species	No of sites in England	No of sites in Europe	Occurrence in European countries	Occurrence on European RDLs
Hygrocybe calyptriformis	191	1012	22	9
Entoloma bloxamii	38	476	22	11
Geoglossum atropurpureum	2	170	12	8

The pink waxcap (*Hygrocybe calyptriformis)* has been the subject of much conservation attention as a flagship species, a status it readily deserves. Data assembled by members of the European Council for the Conservation of Fungi (ECCF) demonstrates that the UK holds nearly 50% of its known European sites. This serves to confirm the UK position as a European stronghold for waxcap-grasslands.

3. Distribution data on waxcap-grasslands

There has been a growing conservation interest in undisturbed, nutrient-poor grasslands in the UK, since the British Mycological Society (BMS) focussed interest with its waxcap-grassland survey in 1996 (Rotheroe *et al* 1996).

Up until then UK recording of all non-lichenised fungi was fairly haphazard and tended to target wooded rather than grassland habitats. Electronic databasing was the exception rather than the rule and the majority of fungal records were made on BMS residential forays. The BMS Recording Network, founded in 1995, enabled volunteer effort to be more co-ordinated. The survey is purely voluntary but the BMS organisers (Rotheroe, Evans and Newton) provided specialised recording sheets, cross-off cards, and organised keys to the main indicator genera as well as holding identification workshops for two of the main groups of grassland indicator fungi, *Hygrocybe* and *Entoloma*. Interest in the survey was high and generated the majority of records collated as part of this study (53%).

Knowledge about the conservation value of non-lichenised macrofungi, their distribution and needs was at this time restricted almost entirely to the mycological community. The publication of the UK BAP (Anon 1995) created a ‘need to know’ about fungi amongst non-mycologists. In particular it focussed interest and much needed funding for survey and research on grassland fungi via the BAP mechanism.

This led to a series of important studies on waxcap-grassland fungi in the UK. Collation and survey work was undertaken at a country level funded by English Nature (EN), Scottish Natural Heritage (SNH), Countryside Council for Wales (CCW) and Department of the Environment Northern Ireland (DoENI). To date there has been no UK-wide assessment of waxcap-grassland sites using comparable assessment criteria.

Collation studies have now been undertaken in Scotland (Newton *et al* 2000), Ireland (McHugh *et al* 2001), Wales (Evans & Holden 2003) and now England. Active systematic survey work has also been commissioned to gather additional distribution data, improve knowledge of waxcap assemblages and facilitate condition monitoring.

A three-year 'phase 1' systematic survey in Scotland funded by SNH has now been completed (Newton *et al* 2003). A similar three-year survey has completed its first year in Northern Ireland funded by DoENI. In Wales several small-scale surveys have been funded by CCW for Carmarthenshire (Rotheroe 1999), Cwm Clydach NNR (Evans 2000, 2002a and 2003b) and the Epynt Ranges (Rotheroe 2003). A further large-scale systematic survey is also planned. In England there has been a small-scale systematic survey in Somerset (Thompson 2000) part funded by EN.

4. Project aims

This primary aim of this project is to collate and database waxcap-grassland distribution data for England from a range of sources and to use this data to produce a preliminary list of top sites in England according to defined criteria. This will inform future site protection and help ensure more adequate representation of grassland fungi in the SSSI series as well as at local level through County Wildlife Sites (CoWS) and Local Nature Reserves (LNRs).

The project also aims to deliver a contribution in an English context to the UK BAP through the provision of species dossiers. In addition it aims to provide generic management advice for waxcap-grassland taxa and an overview of the major threats to these fungi. An account of the waxcap grassland species and summary of ecological requirements underpins this. The need for further research is also assessed.

This project provides an extensive database in electronic format of known English grassland taxa to supplement this report. An initial assessment of top sites in England is made although it is emphasised that more systematic survey of waxcap grasslands in England will be needed to enable a more meaningful comparative ranking of sites.

5. Methodology

5.1 Data sources

Data was collated from a range of sources and transferred into an Excel spreadsheet in a layout devised by the author. Approximately 4,500 additional records were keyboarded. The data sources include:

1. The BMS Fungal Records Database (BMSFRD). This is the UK repository for fungal records maintained by the Society's database manager. It includes data from BMS forays, local recording group and individual records, as well as some historical data from published records of BMS forays dating back to the early part of last century. It also includes some data already keyboarded as part of the BMS waxcap-grassland survey.

2. English herbarium collections of waxcap-grassland taxa held at the Royal Botanic Gardens, Kew (RBG Kew).

3. Individual datasets (over 25) in a variety of formats, largely 'paper' records, from participants in the BMS waxcap-grassland survey, members of the BMS Recording Network and subscribers to Field Mycology.

4. Data from the Somerset Grassland Fungi Project.

5. Literature references eg the 1950s work of P.D. Orton and T. Wallace on 'Goodmans', Devon.

5.2 Standardisation of recorded names

Once keyboarding was complete it was necessary to complete a current names field for each of the records. This standardised the species names being used by recorders to allow a more meaningful comparative assessment of each site to take place. The earliest records date from the 1700s and progressively increase in numbers through the 1800s, until the advent of the modern recording era in the 1960s. Many of these early records include synonyms, or names now deemed dubious or misapplied. For this collation 'current' names for Clavariaceae, *Hygrocybe*, and *Entoloma* have been based on information kindly made available to this project by Dr Brian Spooner at RBG Kew from the near complete British Basidiomycete Checklist Project. For Geoglossaceae the taxa adopted are those in the *Key to British Genera of Geoglossaceae* (Spooner 2000 unpublished).

This is not foolproof. Problems still remain where species concepts have altered over time and author citation becomes an issue. Such data is not usually available with records. A good example is *Hygrocybe lacmus* (Schumach.) P.D. Orton & Watling which has historically been recorded as *Hygrophorus subradiatus* var. *lacmus* and *Hygrocybe subviolacea*, and had also prior to the late 1980s been used to name collections of *Hygrocybe flavipes* (Britzelm.) Arnolds. So early records of *Hygrocybe lacmus* may well refer to *H. flavipes*, but without specimens this is impossible to determine. Similarly the apparent decline in current *H. lacmus* records could merely be an artefact of current understanding and recording of the two taxa.

5.3 Editing

Much effort was invested in the dataset to 'clean it up' sufficiently to provide a more user-friendly resource and to enable as accurate an assessment of sites as possible. Initially this involved eliminating species and sites inappropriately assigned to England together with a rough edit confirming correct entry of county, vice county, and sites.

The greatest challenge was in editing the site name upon which this project so heavily relies. Around 10% of the site names were found to be inconsistent, incorrectly spelt or duplicates and further research would undoubtedly continue to improve the present level of accuracy.

Grid references were added for a proportion of well-documented sites using an OS computerised gazetteer. Inevitably however there was a proportion of records which proved unusable, as the site information was too unspecific. Many early collectors were in the habit of stating their own location rather than the locality of the fungal collection and many were in the habit of swapping specimens with each other further confusing origins! Other historical

records were also too vague in respect of collection locality. BMS forays from the early 1900s were sourced from published lists in the BMS Transactions, which again tended to quote the place of the foray's residence as origin of the record rather than the collection site.

A considerable problem arose in a dataset of nearly 20,000 records through the use of non-standardised site names. Different recorders had the habit of assigning site names of their own devising to some localities, or of using variations on a theme. All of which renders database searching difficult without first standardising them. To facilitate this, grid reference searches were made to allocate a consistent site name (where appropriate) to sites with the same grid reference.

5.4 Quality control

Recorded species names have not been subject to any quality control as a part of this project. The names supplied by the recorder have been accepted in good faith except in rare instances where they conflict with information provided in the ongoing Basidiomycete Checklist Project or where habitat is unlikely eg arctic-alpine species in lowland grasslands. It is important to note that the majority of records collated as part of this study are unsupported by herbarium material making any future checking of taxonomic assignation impossible. This is a necessity for systematic surveys.

5.5 Site boundaries

Data provided in the majority of instances is unsupported by any specific information on site boundaries. Non-standardised recording tends to support the 'wandering sheep' methodology and it is inevitable that some site records may be inappropriately assigned. However volunteers involved in the BMS waxcap-grassland survey were encouraged to be as site specific as possible and recording forms were provided which encouraged this. Site maps may therefore be available from recorders for a small proportion of sites.

6. How to evaluate sites?

One of the principal aims of this project was to suggest simple selection criteria for important waxcap grasslands in England.

A range of methods has evolved since Rald (1985) devised an initial waxcap-grassland assessment based on numbers of *Hygrocybe* recorded at a site in a single visit. They include assessments for single or multiple site visits, simple or weighted rankings based on taxa or species present, and may be based on the presence of *Hygrocybe* alone or a combination of Clavariaceae, *Hygrocybe*, *Entoloma* and Geoglossaceae.

Choice of an artificial scoring system is largely arbitrary. There has been a tendency by successive experts to adapt existing scoring systems in an attempt to reflect differences in local or national distribution data. This can be fairly confusing when trying to compare rankings between countries.

6.1 Discussion

Does it matter which system is used? Several workers have analysed datasets using various combinations of methods (Boertmann 1995, McHugh *et al* 2001) and initial results suggest the same sites may feature whichever method is used. The final ranking of the top sites does however vary. Data collection especially in non-systematic surveys tends to be biased towards *Hygrocybe* (Evans & Holden 2003). The final choice of system is therefore largely a pragmatic one based on the type of data available.

Analysis restricted to one particular waxcap-grassland group such as *Hygrocybe* should however be treated with some caution. This risks ignoring sites important for other groups in the assemblage (Clavariaceae, *Entoloma* and Geoglossaceae). Initial evidence from Scotland (Newton *et al* 2003) indicates that sites important for one group are not necessarily important for another.

The 'best' sites ultimately need to hold as full an assemblage of the various waxcap-grassland indicator groups as possible. They should be representative of taxa with different ecological requirements. They should not for example be based solely on the top sites for *Hygrocybe*. This may neglect habitats like dune grasslands which have lower *Hygrocybe* numbers but may nevertheless be important for other taxa. The essential factor to achieve this is a flexible conservation mechanism.

Single or multiple site visits? Analysis of single site visits are useful in the absence of any other data, especially when rapid assessments are required if sites are under immediate threat. High species figures in a single visit invariably confirm the relative importance of the site. The converse is not necessarily true for low single site figures and such assessment should be approached with caution. Such sites, like Epynt Ranges A, in Wales (Woods pers. comm.), may prove initially mundane even after several visits, but of national importance on subsequent visits. Single visits require optimum timing for fungal fruiting and will vary in each year according to weather conditions. They further require optimum timing for each of the groups of fungi involved. Best timing for one group is not necessarily best timing for another. *Entoloma* fruits earlier and less reliably than *Hygrocybe* and Clavariaceae with Geoglossaceae fruiting much later (Rotheroe *et al* 1996).

Table 3 Waxcap-grassland data evaluation in the UK

Country	No of records* for all waxcap-grassland taxa	*Hygrocybe* %	No of sites	Visit type	Groups ranked	Level evaluated
England	19,340	58%	2,150	Multiple	All CHEG Not weighted	taxa
Northern Ireland	3,500	78%	<300	Multiple	All CHEG Weighted	species
Scotland	c.16,000	c.57%	1173 *Hygrocybe*	Single	All CHEG Not weighted	taxa
Wales	8,500	77%	911	Multiple	*Hygrocybe* Not weighted	taxa

* Data has been taken from published figures or from the BMSFRD.

More reliable assessments arise from analysing multiple visits. These are more likely to eradicate anomalies produced as a result of the vagaries of fungal fruiting. To produce comparable results, systematic surveys should ideally require regular similar numbers of repeat visits to sites at similar times. This helps eradicate bias in recorder effort and temporal fruiting patterns.

The BMS waxcap-survey generated over 50% of the data for this project. It encouraged repeat visits to sites at least three times a year over a period of years. Similarly the Somerset survey undertook several visits to each site. As the majority of data for this project is based on repeat visits, it is assessed accordingly.

Weighted or non-weighted ranking? Analysis of data based on weighted scoring systems for different species was developed in Europe based largely on local rarity and the presence of species on national Red Data Lists (Jordal 1997, Vesterholt *et al* 1999). This places strong reliance on recorder expertise in identifying rare taxa and requires regularly updated lists of local and national rarity.

In the UK, Rotheroe (1999) produced a simple two tier system of 'quality' indicators based on subjective observations. This has been modified further (McHugh *et al* 2001) to produce a weighted Irish quality score. The main object of the Irish system is to simplify waxcap-recording and enable its current systematic survey to provide rapid assessment of sites in a country with relatively little distribution data (see Table 3). Little statistical analysis has however been undertaken on these species to evaluate their appropriateness or determine their association with other waxcap-grassland taxa. The Irish system stresses that its design is specific to the Irish context and that it is important for comparison for experts to continue assessing sites using established methods.

The relatively extensive statistical analysis conducted on Scottish data is revealing. It strongly suggests our knowledge about the inter-relationships between the various waxcap-grassland groups remains inadequate. Furthermore, our assumptions about indicators of quality sites may be premature.

Assessment of English sites is based on information derived from an *ad hoc* range of largely non-systematic sources. No attempt to focus on collecting indicator species has been made in the recording process. The dataset has an acceptable proportion of *Hygrocybe* (Table 3) with a reasonable proportion of records from other groups. So all the indicator groups are assessed and no attempt to weight species is made in their analysis.

7. Criteria

Each group of waxcap-grassland fungi have been assessed separately to ensure that sites important for one group from the suite are not omitted.

The assessment for each group is made based on cumulative site visits and on grassland taxa derived from current names. The top sites for each group are tabled separately and expressed using a shorthand CHEG system adapted from Rotheroe (1999) such that numbers of taxa are expressed:

C = Clavariaceae
H = *Hygrocybe*
E = *Entoloma*
G = Geoglossaceae

Hygrocybe is the best-known and best-recorded group. The most commonly used criteria followed in the UK are those devised by Rald (1985) and adapted by Versterholt *et al* (1999). To facilitate comparison with other datasets in the UK, these criteria have been adopted for this dataset. Sites with 17 or more waxcaps are deemed of national importance and those with more than 22 taxa are of international importance. (Table 4)

Table 4. Waxcap assessment of Rald (1985) as adapted by Vesterholt *et al* (1999)

Conservation value	**Single visit *Hygrocybe* taxa**	**Total *Hygrocybe* taxa**
Internationally important	15(?)+	22+
Nationally important	11-14	17-21
Regionally important	6-10	9-16
Locally important	3-5	4-8
Of no importance	1-2	1-3

Clavariaceae, *Entoloma* and Geoglossaceae

In addition a dozen or so top sites are listed independently for each of these waxcap-grassland groups. They are sites with the greatest number of taxa for each group. Their evaluation allowed some provisional national threshold criteria to be set for this dataset (Table 5). It should be stressed however that further systematic survey work is needed to allow a more meaningful assessment of top sites. This may then enable these provisional levels for national importance in England to be confirmed or adjusted as appropriate. The criteria suggested by this study agree well with the range given in Nitare's graph for nationally important sites.

The dataset is too geographically incomplete to attempt to give generic selection criteria yet for regional or locally important sites. For the time being each site needs to be assessed relative to the local context based on known data.

Table 5. Criteria for sites of national importance in England

Waxcap-grassland fungi	**Total number of taxa**
Clavariaceae	7+
Hygrocybe	17-21 (after Rald /Vesterholt)
Entoloma	15+
Geoglossaceae	4+

8. The top sites in England

Table 6. The top sites for *Hygrocybe*

Site name	C	H	E	G	BAP species
International importance					
Longshaw Estate	8	**33**	24	4	*Hygrocybe calyptriformis*
Goodmans	0	**29**	24	0	*Hygrocybe calyptriformis*
Kerridge Hill	7	**29**	10	0	*Hygrocybe calyptriformis*
The Patches	1	**29**	14	1	*Hygrocybe calyptriformis*
Crimsworth Dean	5	**28**	29	3	*Hygrocybe calyptriformis, Microglossum olivaceum*
Smalley's farm	11	**25**	15	4	*Hygrocybe calyptriformis*
Roecliffe Manor	13	**24**	28	4	*Hygrocybe calyptriformis*
Brookwood cemetery	4	**23**	5	2	*Hygrocybe calyptriformis*
Windsor Great Park	5	**23**	6	3	
Blencathra	5	**22**	6	1	*Hygrocybe calyptriformis*
Danehill church	5	**22**	8	0	*Hygrocybe calyptriformis*
Slaugham church	2	**22**	1	0	*Hygrocybe calyptriformis*
National importance					
Bedgebury	11	**21**	21	3	
Luddenden	3	**21**	10	2	*Hygrocybe spadicea*
Chancellors Farm	2	**20**	3	0	*Hygrocybe calyptriformis*
Down House	8	**20**	9	3	*Hygrocybe calyptriformis*
Gait Barrows	7	***20**	0	1	
Ebernoe	4	**20**	4	1	*Hygrocybe calyptriformis*
Little Leighs church	1	**20**	0	0	*Hygrocybe calyptriformis*
Saltonstall	2	**20**	1	0	*Hygrocybe calyptriformis*
St Dunstan's farm	2	**20**	15	0	*Hygrocybe calyptriformis*
Back Fields	4	**19**	28	0	*Hygrocybe spadicea*
Bradgate Park	4	**19**	3	0	
Dolebury Warren	1	**19**	11	0	
Moccas Park	11	**17**	7	1	*Hygrocybe calyptriformis, Microglossum olivaceum*
Walstead cemetery	0	**19**	3	0	
Ashburnham Place	9	**18**	6	0	*Hygrocybe calyptriformis, H. spadicea*
Black Rock Reserve	5	**18**	6	1	
Bretton Park Lakes	4	**18**	4	0	*Hygrocybe calyptriformis*
Chatsworth Estate	5	**18**	7	0	*Hygrocybe calyptriformis*
Cleeve Common	1	**18**	1	3	*Hygrocybe calyptriformis*
Colemere Country Park	6	**18**	7	0	
Hackness Park	3	**18**	1	0	
Malham	3	**18**	13	0	
Minchinhampton Common	3	**18**	6	3	
Austwick	6	**18**	8	2	*Hygrocybe calyptriformis*
Pinkworthy	4	**18**	5	3	*Hygrocybe calyptriformis*
Baslow area	11	**17**	11	2	*Hygrocybe calyptriformis*
Button Oak	6	**17**	13	1	*Hygrocybe calyptriformis*
Digley reservoir	1	**17**	11	0	*Hygrocybe calyptriformis*
East Hoathly church	3	**17**	0	1	
Mulgrave Woods area	13	**17**	11	4	*Hygrocybe calyptriformis, Microglossum olivaceum*
Rodney Stoke	4	**17**	4	0	
Rotherfield Greys St Andrew's church	6	**17**	5	1	
Willow Bank	0	**17**	0	0	*Hygrocybe calyptriformis*

* *Hygrocybe* numbers from North West Fungus Group Newsletter – March 1996

Table 7. The top sites for Clavariaceae

Site name	C	H	E	G
Mulgrave Woods area	**13**	17	11	4
Roecliffe Manor	**13**	24	28	4
Smalley's Farm	**11**	25	15	4
Baslow area	**11**	17	11	2
Bedgebury	**11**	21	21	3
Moccas Park	**11**	17	7	1
Ashburnham Place	**9**	18	6	0
Down House	**8**	20	9	3
Fishpool Valley	**8**	14	6	1
Longshaw Estate	**8**	33	24	4
Savernake Forest	**8**	16	10	2
Gait Barrows	**7**	20	0	1
Dinmore Hill	**7**	6	3	1
Long Ashton	**7**	4	5	1

Sites in bold do not feature amongst the top sites for *Hygrocybe.*

Table 8. The top sites for *Entoloma*

Site name	C	H	E	G
Crimsworth Dean	5	28	**29**	3
Roecliffe Manor	13	24	**28**	4
Back Fields	4	19	**28**	0
Goodmans	0	29	**24**	0
Longshaw Estate	8	33	**24**	4
Kiberick Cove	3	15	**22**	3
Bedgebury	11	21	**21**	3
Walton Common	1	9	**16**	0
Broadhead Clough	2	13	**15**	1
Smalley's farm	11	25	**15**	4
St Dunstan's farm	2	20	**15**	0

Sites in bold do not feature amongst the top sites for *Hygrocybe.*

Table 9 The top sites for Geoglossaceae

Name of site	C	H	E	G
Gear Sands	3	10	1	**5**
Elmer Sands	0	3	0	**5**
Nices Hill	5	16	10	**5**
Upper Dunsop Valley	4	13	4	**5**
Ilkley Moor area	1	7	1	**4**
Longshaw Estate	8	33	24	**4**
Minions	3	12	1	**4**
Roecliffe Manor	13	24	28	**4**
Smalley's farm	11	25	15	**4**
Mulgrave Woods area	13	17	11	**4**

Sites in bold do not feature amongst the top sites for *Hygrocybe.*

9. Profiles of top 12 waxcap sites

Longshaw Estate

Location: Derbyshire Grid Reference: SK2579 CHEG: 8 33 24 4

BAP species present: *Hygrocybe calyptriformis*
Other species of interest: *Clavaria zollingeri, Entoloma bloxamii, Entoloma incanum, Hygrocybe nitrata, Hygrocybe punicea* and *Hygrocybe splendidissima.*

Recording: First record 1956. Recorders: Tony Lyons and Neil Barden

Habitat: 640 acres comprising a mosaic of unimproved grassland, mixed woodland and incorporating Padley Gorge SSSI. There are three main grassland fungal hotspots recorded over a number of years. Known as Longshaw pasture, 'upper meadow' and small *Hygrocybe* meadow'. Each has been separately recorded with 8 figure grid references.

Management: This is a National Trust property previously owned by the Duke of Rutland and run as a shooting estate. It has been traditionally managed and not had any forms of 'improvement' in the last century.

Goodmans

Location: East Devon Grid Reference: ST2605 CHEG: 0 29 24 0

BAP species present: *Hygrocybe calyptriformis*
Other species of interest: *Camarophyllopsis atropuncta, Camarophyllopsis foetens, Camarophyllopsis schulzeri, Entoloma bloxamii, Hygrocybe nitrata, Hygrocybe ovina, Hygrocybe punicea* and *Hygrocybe splendidissima*.

Recording: Annually from c1955- 1985 Recorders: Tom Wallace and Peter Orton

Habitat: approx 2 square miles of countryside surrounding the Goodmans property. An outlier of the Blackdown Hills, the grassland known locally as 'sidelings' are composed of steep valley sides too steep for ploughing. Not at the time of recording in any way 'improved'. Short basic sward. Site boundaries are not known.

Management: The current management and condition of this site is unknown.

The Patches

Location: West Gloucestershire Grid Reference: SD6308 CHEG: 1 29 14 1

BAP species present: *Hygrocybe calyptriformis*
Other species of interest: *Entoloma incanum, Hygrocybe lacmus, Hygrocybe nitrata, Hygrocybe punicea* and *Hygrocybe splendidissima*

Recording: Frequently from 1984-2000 Recorders: Jack Marriott, Alan Hedgley, Dean Group

Habitat: unimproved lowland acid grassland. Relatively short sward without application of fertilisers. Ancient grassland (over 500yrs) within the Forest of Dean Royal Forest - probably remnant wood pasture.

Management: Sheep grazed, some reduction in numbers in recent years. Forest operations nearby and possible bracken invasion. Forest Enterprise are aware and sympathetic to the needs of the site (1999).

Kerridge Hill

Location: Cheshire Grid Reference: SJ942767 CHEG: 7 29 10 0

BAP species present: *Hygrocybe calyptriformis*
Other species of interest: *Hygrocybe ingrata, Hygrocybe nitrata* and *Hygrocybe punicea*

Recording: recorded annually since 1996 BMS waxcap survey Recorder: Rachel Hunter

Habitat: Unimproved upland pasture

Management: This site is in an area designated to become the Royal Macclesfield Forest. It is owned by a complex of landowners, and various bodies appear involved in its management including North West Water and The Groundwork Trust. The current situation and management are not known.

Crimsworth Dean

Location: South-west Yorkshire Grid Reference: SD9829-SD9929 CHEG: 5 28 29 3

BAP species present: *Hygrocybe calyptriformis, Microglossum olivaceum*
Other species of interest: *Entoloma incanum, Hygrocybe nitrata,* and *Hygrocybe ovina*

Recording: Intermittently since 1892 until present . Recorders: various- region is seat of BMS foundation. Historic recorders incl. J.Needham 1910. Recently Roy Watling 1960s + and Mike Sykes 1990s. BMS centenary foray 1996.

Habitat: Large upland acid grassland. Centred on Crimsworth Dean but incorporating various broad areas as well as recent more specific sites eg Hardcastle Crags. Some detail on individual field compartments giving current known hotspots.

Management: Sheep grazed. Area also popular for hill walking.

Smalley's farm

Location: Mid-west Yorkshire Grid Reference: SD718346 CHEG: 11 25 15 4

BAP species present: *Hygrocybe calyptriformis*
Other species of interest: *Hygrocybe nitrata, Hygrocybe splendidissima, Porpoloma metapodium* and *Trichoglossum walteri*

Recording: From 1990s onward Recorder: Irene Ridge (site owner)

Habitat: Acid grassland including semi-improved pasture and unimproved lawn. Waxcap hotspot centred on lawn.

Management: Sympathetic to fungi and the needs of waxcap-grasslands. No fertiliser or moss killer applications and regime of mowing / grazing.

Roecliffe Manor

Location: Leicestershire Grid Reference: SK532126 CHEG: 13 24 28 4

BAP species present: *Hygrocybe calyptriformis*
Other species of interest*: Camarophyllopsis atropuncta, Camarophyllopsis foetens, Entoloma bloxamii,* and *Hygrocybe punicea*

Recording: Regularly since 1997 Recorder: Peter Long

Habitat: Lawn. Nutrient poor with mixed pH. Acid heath-type component with *Calluna vulgaris* and *Potentilla erecta.* Also basic component near the house from mortar leaching. Probable age dating from that of house in 1820s.

Management: Mowed and intensively rabbit grazed, very short sward. Certainly without any applications of fertiliser or moss killer since charitable ownership in 1920s. Designated a SSSI in 2001 for its waxcap-grassland mycota. Ownership from Cheshire Home Foundation under change.

Brookwood cemetery

Location: Surrey Grid Reference: SU955565 CHEG: 4 23 5 2

BAP species present: *Hygrocybe calyptriformis*
Other species of interest: *Hygrocybe nitrata* and *Hygrocybe punicea*

Recording: From1998 throughout the year.
Recorders: Ted Brown, Dennis Cook, Dick Alder, Shelley Evans and Peter Roberts. BMS day foray 2002.

Habitat: Cemetery. Dates from 1854 (the London Necropolis) then the world's largest. Still the UK's largest at 143ha. Mosaic of unimproved grassland in places reverting to heath with scrub invasion of *Betula* and *Calluna*. Mosaic of pH – generally acid but with pockets of base rich turf near roads and tombstones. Several known hotspots with short sward and high % moss cover. High water table.

Management: Some signs of mowing in restricted areas but otherwise unkempt. Rabbit grazing keeps sward short in parts. Some deer grazing. Vegetation rank in many parts with scrub invasion. Whole site subject to periodic maintenance including: ground clearance, building and tomb maintenance, landscaping and drainage work. Use of heavy machinery. All trees subject to TPOs. Woking Borough Council unsympathetic to conservation needs, with a ban on seedling removal. Site subject to fly tipping and vandalism. Privately owned and run by Brookwood Cemetery Ltd. Listed as SSSI by English Heritage under Parks & Gardens. Also an SNCI.

Windsor Great Park

Location: Berkshire Grid Reference: SU96 CHEG: 5 23 6 4

BAP species present: none
Other species of interest: none

Recording: First in 1923 then 1960s and regularly in last 20 years
Recorders: Numerous BMS day forays – P.Kirk, J.Cooper, D.Reid, N.Legon, E,Green, A.Henrici.

Habitat: Areas of unimproved neutral to acid grassland. Ancient Royal Forest with mosaic of grassland habitats including wood pasture. Sward length very variable depending on the locality. Many waxcap taxa recorded with relatively short mossy sward. Huge site of 5,600ha and precise locality of most taxa not recorded. Few 'quality' species. Numbers may reflect the site's size. Many areas have not been explored.

Management: Mowing in some areas. The extent reduced in recent years. Also grazing by deer, sheep and rabbits. No fertiliser application. Sympathetic to the general conservation needs of fungi. Aware of the particular needs of waxcap-grasslands. This is an SSSI owned by Crown Estates with management input from English Nature.

Blencathra

Location: Cumbria Grid Reference: NY3025 CHEG: 5 22 6 1

BAP species present: *Hygrocybe calyptriformis*
Other species of interest: *Clavaria purpurea* and *Clavaria zollingeri*

Recording: 1997 BMS foray onwards Recorders: Sheila & John Weir, Irene Ridge

Habitat: Upland unimproved grassland. Short lightly mossy sward. Nutrient poor. The site comprises the Blencathra Field Studies Centre and fields in the immediately vicinity at NY303256 and NY301256.

Management: Sheep and rabbit grazed.

Danehill church

Location: East Sussex Grid Reference: TQ402276 CHEG: 5 22 8 0

BAP species present: *Hygrocybe calyptriformis*
Other species of interest: *Hygrocybe ingrata* and *Hygrocybe punicea*

Recording: only 1998 Recorder: Peter Russell

Habitat: Churchyard. Unimproved lowland grassland. Short sward. All Saints is late Victorian and the grassland is likely to date from this time.

Management: Mown regularly.

Slaugham church
Location: West Sussex Grid Reference: TQ257281 CHEG: 2 22 1 0
BAP species present: *Hygrocybe calyptriformis* Other species of interest: *Hyrocybe punicea*
Recording: 1997-8 Recorder: Peter Russell
Habitat: Churchyard. Unimproved lowland grassland. Short sward. St Mary's dates from the 11th century but the date of the grassland is unknown.
Management: Mown regularly.

10. Profiles of top sites for Clavariaceae, *Entoloma* and Geoglossaceae

Table 10 Top additional site profiles for Clavariaceae, *Entoloma* and Geoglossaceae

Site name - group	County	Grid ref	BAP sp	Other notable sp	Recorder
Clavariaceae					
Fishpool Valley	Herefordshire	SO4566	*H.cal*	*Clavaria zollingeri, Camarophyllopsis atropuncta, Hygrocybe punicea*	E.Blackwell J. Weightman J.Bingham
Savernake Forest	North Wiltshire	SU2266	*H.cal*	*Entoloma incanum, Hygrocybe punicea, Porpoloma metapodium*	R.Davies D.Shorten
Dinmore Hill	Herefordshire	SO5051		*Camarophyllopsis atropuncta, Hygrocybe nitrata Hygrocybe punicea*	E.Blackwell S.Thompson
Long Ashton	North Somerset	ST5470		*Camarophyllopsis foetens, Entoloma incanum*	Anon
Entoloma					
Kiberick Cove	East Cornwall	SW9239	*Mic. ol*	*Hygrocybe nitrata Hygrocybe punicea*	BMS foray
Walton Common	North Somerset	ST425735		*Entoloma incanum*	R.Betts
Broadhead Clough	SW Yorkshire	SE0024			R.Watling
St Dunstan's farm	East Sussex	TQ3031	*H. cal*		P.Russell
Geoglossaceae					
Gear Sands	West Cornwall	SW7755	*Mic.ol*		BMS foray
Elmer Sands	West Sussex	SZ9899			D.Reid
Nices Hill	South Hants	SU1911	*Mic.ol*		P.Orton G.Dickson A.Leonard S.Evans
Upper Dunsop	Westmorland	SD655510		*Clavaria greletii*	I.Ridge
Ilkley Moor	Mid-West Yorkshire	SE14			P.Walker
Minions	East Cornwall	SX264714		*Geoglossum atropurpureum Hygrocybe punicea*	BMS foray

11. Results

There is now a collated dataset of 19,340 records for waxcap-grassland fungi in England as a result of this project. This is believed to be the largest dataset so far analysed for the UK. This represents 186 grassland taxa from a possible 198 currently represented on the UK checklist project. The remaining 6% of UK taxa representing subarctic or arctic alpine species. The first record is for the year 1775 and analysis of the record dates shows the following contribution to the whole dataset: 1700s - 0.5%; 1800s – 4%; 1900-1960 – 2.5%; 1960-1995 – 40%; 1995 onward – 53%.

11.1 Top sites in England

58 sites feature in this report as important in England for their waxcap-grassland fungi. 44 are best *Hygrocybe* sites, twelve of which feature as of international importance on the Rald/Vesterholt scale, whilst 32 are of national importance. Only thirteen of these sites (30%) also feature as important for one of the other waxcap indicator groups based on suggested criteria. A further 14 such sites have been identified. (Table 10.)

The dataset is biased towards the recording of *Hygrocybe*. As stated above this is mainly because they are a better-understood group taxonomically and therefore easier to identify. Of the 198 UK grassland taxa only 27% are *Hygrocybe* yet they represent 58% of dataset records. By contrast *Entoloma* accounts for 53% of the UK waxcap-grassland taxa but only 22% of records. This bias makes interpretation of the composition of top sites difficult, but the indication is that sites important for *Hygrocybe* will not necessarily pick up those important for other waxcap-grassland groups. (Table 11). This needs to be addressed in future survey and conservation targets.

Site boundaries and the relative size of the top sites are also an issue. The definition of site boundaries is particularly difficult to quantify. This is especially so for historically recorded sites or sites where data has been collated from more than one recorder using different site names for what may or may not be the same location. In relation to the top listed sites, this is particularly true of Austwick, Baslow, Blencathra, Crimsworth Dean, Ebernoe (which includes Ebernoe Common and Ebernoe church), Goodmans, Ilkley Moor, Luddenden, Malham, and Mulgrave Woods.

Some account should also be taken of the relative size of sites when attempting to assess their conservation importance. Large sites like Windsor Great Park and areas like Malham, Ilkley Moor and Austwick may be important throughout the site, holding a full range of widely dispersed waxcap-grassland taxa, or they may be largely mundane for most of their area but with waxcap-grassland hotspots. Small well-defined sites such as Danehill and Slaugham churches represent concentrated waxcap-grassland hotspots. Each type needs to be identified and a mixture of both small concentrated hotspots and large well dispersed waxcap-grasslands conserved.

Top sites also reflect recorder input. This is particularly obvious for the top Geoglossaceae sites which are largely a product of the attention they have received from experts and enthusiasts like Derek Reid, Brian Spooner, Peter Orton, and Irene Ridge.

Table 11 Top sites not featured for their *Hygrocybe* interest

Waxcap-grassland group	% top sites not featured for *Hygrocybe*
Clavariaceae	30%
Entoloma	27%
Geoglossaceae	50%

Criteria for selecting sites of importance for Clavariaceae, *Entoloma* and Geoglossaceae can only be provisional as based on data in this compilation. Further systematic survey work and more specialists in these groups will be needed before such criteria can be proposed with certainty for England or the UK as a whole. These provisional criteria do however fulfil the project target and provide a starting point for further systematic survey, discussion and assessments.

11.2 Species of conservation concern

All three UK BAP species are represented as summarised in the species dossiers in Appendix 1. The pink waxcap *Hygrocybe calyptriformis* is present at 191 sites in England, the date waxcap *Hygrocybe spadicea* at 7 sites and the olive earthtongue *Microglossum olivaceum* present at 32 sites. Both the latter appear to be genuinely rare.

With the potential site implications for the Habitats Directive, the proposed Bern grassland taxa are also assessed. *Entoloma bloxamii* occurs at 38 sites although only four of these sites (Goodmans, Malham, Minchinhampton Common and Roecliffe Manor) actually feature amongst any analysis of the top sites. Without further survey at the other 34 sites it is not possible with certainty to state that these sites are of little waxcap-grassland conservation value. However it does seem to raise some doubt over the appropriateness of using *Entoloma bloxamii* as an indicator of quality waxcap-grasslands.

The other Bern proposed species *Geoglossum atropurpureum* only occurs at two sites in England one featuring as a top waxcap site (Pinkworthy), the other for its Geoglossaceae (Minions).

11.3 Data deserts

There remain however notable data deserts for certain vice counties. For some of these good data on waxcap-grassland does exist but has not reached this dataset. The response to requests in various publications and by letter for data for this project was generally very good. However many recorders still only have paper records or are in the process of transferring them into database formats. Only one week before the completion of this project one such large dataset of 3,000 records was received from Yorkshire. However the main reason for geographical gaps in recording is simply lack of survey. Much can however be achieved through relatively short but intensive survey over several years. It is interesting to note that from the top 12 *Hygrocybe* sites, seven of them were recorded since 1996 as a result of the BMS waxcap-survey.

Vice counties currently with less than 100 records in this dataset are: Bedfordshire, Cambridgeshire, Cheviotland, Dorset, Durham, Huntingdonshire, Isle of Man, Isle of Wight, Middlesex, Northamptonshire, Northumberland and Nottinghamshire. It is hoped this project will focus survey and recording attention.

It is clear that England has some outstanding mycologically rich sites for grassland fungi and that sites in England are likely to prove of considerable importance in a European context. There remains a need for further systematic survey to complement the initial Somerset survey. This will enable a more meaningful ranking of sites and progess understanding of mycological interest and site monitoring.

12. Management for waxcap-grasslands

- Maintain short grassland sward – grazing or mowing.
- Maintain low nutrient levels.
- Maintain current drainage patterns.
- Avoid application of chemicals and fertiliser.
- Avoid physical disturbance.

Waxcap-grassland fungi thrive in short, nutrient-poor, moss-rich sward and the basis for successful habitat management at existing sites is simply to maintain these conditions.

Only limited references are available on relationships between management practices and fungi (Kiezer 1993) and there is equally little data on the specific ecology of individual waxcap-grassland species. At this stage in our understanding, therefore, the best one can do is to suggest management practices that are generally positive for waxcap-grasslands.

12.1 Maintaining short grassland sward

Long-established practice at the site is the best example to follow in all instances.

Grazing (livestock and rabbits). If the site has traditionally been grazed by livestock (horses, cattle, deer or sheep), this practice should be continued, keeping approximately the same numbers and type of animals as before. This may be particularly important in the aftermath of the 2000-2001 Foot and Mouth outbreak, which saw grazing levels decrease in affected areas allowing grass to become rank and overgrown. It is equally important when land ownership changes, when land usage changes (eg by facilitating public access to the site), or when agricultural practices change (often as result of changes in subsidies, particularly in hill country). Note that traditional grazing practices may have included some routine maintenance, such as the removal of ragwort, thistles, etc. Encroachment by bracken and scrub should also be carefully monitored.

Sites that are rabbit-grazed should be monitored to ensure that long-established levels of grazing remain more or less constant. Particular attention should be given so that ungrazed weeds (ragwort, thistles etc) do not become dominant. In the even of a sudden decline in a rabbit population resulting in rank grass, mowing may be a safer option than introducing livestock.

Mowing. Sites such as churchyards, cemeteries, lawns, and amenity grasslands should continue to be traditionally managed, keeping similar schedules, machinery, and usage as before. Thus if the norm is to remove grass cuttings from the site when it is mown, this practice should be maintained. It mimics animal grazing by removal of nutrients from the cycle but without the input from their dung, so theoretically if these taxa do thrive best in the

poorest nutrient conditions then mown sites should prove to be the best waxcap-grasslands of all. There is no data available on the pros and cons of mowing using strimmers or heavier traditional mowers with rollers, but the latter has been the norm throughout most of the twentieth century and appears to have done no harm.

12.2 Maintaining low nutrient levels

Pasture sites. The loss of ancient waxcap-grasslands throughout Europe is mainly the result of agricultural 'improvement'. At its extreme, this has meant the complete destruction of semi-natural pastures by ploughing and reseeding with fast-growing high-yield grass mixes. Lesser, but still destructive improvements include the application of chemical fertilisers, manure, lime, weed-killers, and (of course) fungicides.

Management of existing pasture sites should therefore avoid any grassland 'improvements', particularly those which may change pH levels or increase nutrient levels. Note that this may include monitoring of neighbouring sites, watercourses, etc., since run-off and spindrift from intensive agriculture can cause problems.

Lawns, cemeteries, and amenity grasslands. In England, the desire for immaculate moss and weed-free lawns and amenity turf continues to pose a severe threat to waxcap-grassland sites, in stately homes and country houses, private lawns and public parks, golf courses, cemeteries, and old churchyards. As with pasture sites, re-sowing means complete destruction, whilst the application of chemicals and fertilisers means probable destruction. Once again, good management means maintaining the status quo, continuing long-established routines, and avoiding 'improvements'.

Drainage. Needs for waxcap-grasslands seem to vary, but for many of the fungi some seasonal waterlogging of a site seems acceptable. Indeed some of the best sites occur in high rainfall areas and in places where drainage may cause periodic inundation.

Physical disturbance. The below-ground mycelia (as opposed to the fruitbodies) of these fungi seem relatively resilient to the effects of moderate trampling, either by livestock or in the case of lawns/churchyards by human activity. Some of the top sites featured in this report are habitats subject to moderate trampling and use. However, physical disturbances such as surfacing, dumping of boulders or spoil heaps, rutting by vehicles (including bikes) and horse-riding, building or construction work (even of nearby walls or fences) should all be avoided.

12.3 Encouraging and creating waxcap-grasslands

From the foregoing, it should be clear than any change in the management of existing waxcap-grasslands should be approached with extreme caution, if at all. However, it may be possible to encourage waxcap-grasslands in sites with some existing potential (maybe a handful of species present) and even create new sites (eg from set-aside agricultural land, inherited lawns and amenity grasslands) as a very long-term goal.

The basic procedures would be to encourage or extend short sward, low nutrient regimes. This should be relatively easy in lawns and mown grasslands, though the results may take many years to become apparent (at least 10 – 20, depending on the starting point). Other sites (perhaps derelict or overgrown) would obviously require a review of their existing wildlife,

flora, and mycota before contemplating any change. If grazing is adopted, light-footed, close-cropping sheep are probably preferable to cattle.

13. Threats to waxcap-grasslands

13.1 Habitat loss

One of the major threats to waxcap-grasslands fungi is the loss of suitable pasture habitat by development, dereliction, and afforestation as a result of changing agricultural policies.

Grassland accounts for about 65% of the UK's land cover with nutrient poor semi-natural grasslands representing a much neglected biodiversity reservoir. Since the Second World War agricultural practices have altered significantly with the destruction of over 95% of species rich hay meadows (Lovegrove *et al* 1995) and some 80% of chalk pasture (Rotheroe *et al* 1996).

Equally important has been the loss of old lawns through re-sowing, over-fertilisation, and the application of weed killers and fungicides. Until recently, the loss of these sites has been almost completely overlooked by the conservation community, since they have not been considered of any value in terms of their fauna and flora. Indeed, some ancient-grassland sites (in, for example, parks and churchyards) have been destroyed in the name of conservation, by turning them into rank wild-flower and butterfly meadows without consideration of their mycota.

Moccas Park in Herefordshire is a prime example. The site, an ancient deer park, features in this project as a nationally important site for waxcap-grassland fungi with 17 taxa of *Hygrocybe*, but the sad case is that most of these records pre-date recent habitat loss through agricultural 'improvement'. First forayed in 1873 by the Woolhope Club, forerunners of the today's BMS, the site has continued to be recorded periodically until the present day (Blackwell 1999). Between 1964 and 1972 extensive changes to the grassland habitat took place including ploughing, discing, drainage, levelling of anthills and applications of slag and lime. The practices of fertilising, liming, topping and rolling continued well into the 1980s when they were phased out by agreement and finally ceased in 1996. Just in time for the BMS waxcap-grassland survey! Early records and those from 1926 and 1951 continue to show a range of waxcap-grassland taxa including two BAP species (pink waxcap and olive earthtongue). However more recent visits in the 1990s have only revealed four common species (*Hygrocybe coccinea, conica, chlorophana,* and *pratensis*). The site is now an NNR, the first for parkland, thanks to the foresight of its owner. English Nature is currently conducting a three year fungal survey at the site. However, it is likely to be many decades before any reversals in waxcap fortune may be glimpsed, if at all.

13.2 Increased nutrient levels

One of the main characteristics of high quality waxcap-grassland is its very low levels of dissolved nitrates and phosphates in the soil (Ejrnaes & Bruun 1995). According to Boertmann (1995) this not only applies to waxcaps themselves (*Hygrocybe* species) but to the other characteristic fungi (Geoglossaceae, Clavariaceae, *Dermoloma* and grassland *Entoloma* (*Leptonia*) species.

The spreading of dung and addition of artificial fertilisers have often been encouraged by European agricultural policies as a means of boosting grassland productivity. These fertilisers completely change the waxcap-mycota in favour of a more nitrophilous mycota, which includes dung-loving toadstools such as *Conocybe*, *Panaeolus* and *Coprinus* ('ink-cap') species (Arnolds 1989). Similar changes occur in the vascular plant cover (Eriksson et al 1995).

A few commoner species such as *Hygrocybe virginea* and *H. conica* appear more tolerant to fertilisers, and will be amongst the first waxcaps to recolonise grasslands if and when 'improvement' ends (Bruun & Ejrnaes 1993), typically appearing after as little as ten years. However, in the Netherlands, Arnolds (1994) observed that three such intensively treated sites subsequently managed for nature conservation still had no more than three species of *Hygrocybe* present after as long as 20-25 years. The timescale required for the re-establishment of a high quality waxcap-grassland mycota is therefore likely to be far in excess of 25 years. Similar statistics from lowland grasslands in Ireland (Tunney 1997) indicate that 30 years of no nutrient input combined with active nutrient removal through silage cropping would be needed to reduce soil profiles to pre-1950 levels. Research is ongoing in Wales (Griffith *et al* 2002) to monitor waxcap response to a combination of treatments (nitrogen, lime, nitrogen and lime, and a biocide) and the subsequent fruiting recovery in plots after treatments cease.

13.3 Air pollution

Air pollutants are known to have played a role in the Europe-wide decline of tree-associated ectomycorrhizal fungi, both through a reduction in the trees' ability to photosynthesise and through changes in soil acidification and nitrogen accumulation (Arnolds 1991). Similar, but less studied effects are probable for grasslands.

13.4 Grazing levels

Waxcap-grasslands are not only dependent on a long continuity of poor nutrient levels, but also on grazing from cattle, horses, sheep, deer and rabbits to maintain a short sward and prevent invasion of scrub. In early phases low grazing promotes rank grasses, which may change the microclimate at and beneath the soil surface, leading to a gradual change in the soil microfungi, invertebrate fauna, and in the composition of mosses, grasses and other flora. As scrub invasion occurs some waxcap grassland taxa may still persist, as can be seen at sites like Orley Common and Spitchwick Common in Devon, but species numbers are far lower than would be expected in a short unimproved sward.

13.5 Lack of awareness

Conservation concern at grassland habitat losses and grazing levels has largely been directed at addressing this situation for assemblages of plants and animals, with flagship species like orchids and butterflies of chalk downlands being well-publicised and understood amongst the British public. However despite growing awareness amongst the few concerned with conservation at national and local levels through the implementation of BAPs, awareness about these attractive waxcap-grassland fungi still has not spread sufficiently to the policy makers or the public. Their needs still require much energetic publicity if they are to be protected from destruction through ignorance.

High profile was given in the press and wildlife magazines (Baines 2002) to bringing back the UK's missing wildlife within a generation through habitat restoration schemes. This hugely laudable aim is central to the 'Living landscapes' initiative launched in 2002. Yet one of its assumptions (Evans 2002b) that much of the UK's grazed uplands are biodiversity deserts, best turned into woodlands to soak up rainfall and prevent Britain's lowland flooding problems ignores their importance as a UK and European stronghold for waxcap-grassland fungi.

Another example of lack of awareness is the UK government's new Sheep Quota Purchase Scheme introduced in 2002 to reduce sheep numbers in 'overgrazed' uplands. This subsidy comes into full force in 2003 and will operate for five years. In the wake of the Foot and Mouth outbreak, many upland waxcap-grassland areas are more likely to be in need of higher levels of grazing rather than less, so this is a potentially detrimental policy which needs careful monitoring to ensure individual quality waxcap-grassland sites are not damaged (Evans 2003c).

At an individual level, many of the best waxcap-grasslands especially in lowland England are likely when fully investigated to prove to be tightly cut, mossy old lawns and churchyards. Yet still it is the fashionable trend amongst gardeners to treat lawns with moss killer to remove what is deemed as unsightly moss in favour of grass monoculture. This attitude is largely a result of ignorance of the conservation and aesthetic value of waxcap-grasslands and it is one that is most in need of change.

13.6 Decline in fungal taxonomists

Last year also saw the publication of the House of Lords report 'What on earth? The threat to the science underpinning conservation'. It is no surprise to learn that taxonomists themselves are a seriously threatened RDL species and fungal taxonomists in particular have the equivalent of Schedule 8 status. Since the previous report ten years ago their populations have declined drastically – Roy Watling not replaced at RBG Edinburgh, David Pegler not replaced at RBG, Kew and a drop of over 50% in fungal taxonomists at CABI BioScience. Kew's Director, Peter Crane, acknowledges that the only area "to fall below critical mass at Kew is systematic mycology" and that it is endangered in the UK as a whole.

14. Recommendations

- Undertake systematic surveys of grasslands in England.
- Assess condition of top waxcap-grassland sites.
- Afford site protection to vulnerable sites.
- Research appropriate indicators and site monitoring.
- Research ecology of all waxcap-grassland taxa.
- Encourage specialist training.
- Promote wider understanding of waxcap-grasslands.

14.1 Survey

This project represents no more than an initial collation exercise based almost entirely on non-systematic survey data from volunteers. An immediate research priority is therefore to undertake properly designed and funded systematic countrywide surveys similar to those

which have taken place in Scotland, and which are underway and projected for Northern Ireland and Wales.

Survey should target both upland and lowland habitats and include more ‘man-made’ habitats like lawns, churchyards, reservoirs and parks. It should particularly focus on the data deserts outlined at county level and counties with few quality grasslands identified (such as Devon).

Individual site surveys to assess the current status of sites identified in this report should also be undertaken. This is particularly important for sites identified as vulnerable.

14.2 Site protection

With the exception of chalk downland and a few other areas conserved for their specialist flora, English grassland is poorly protected.

Fungal interest in England needs to be promoted and better represented within the SSSI system. At present, few sites specifically mention fungi, and most do so only in the most general way by reference to important fungal assemblages. The general premise amongst mycologists that the fungi at protected sites are safeguarded by association is unfortunately ill-founded. There is no requirement on the site manager to take fungi into account when formulating management policies, unless they are mentioned specifically within the site designation. In cases where there are conflicting needs, organism groups for which the site is listed (almost always specified flora and fauna) will have priority and fungal interest at the site may be jeopardised or even destroyed.

A priority as a result of this report is to investigate the current status and management of the top waxcap-grassland sites listed and to consider notification as SSSIs any which are confirmed as vulnerable. In particular it is recommended that the status and management of the following sites be confirmed; Goodmans, The Patches, Kerridge Hill, Brookwood Cemetery, Blencathra, and Danehill and Slaugham churches. In the first instance approaches should be made in co-operation with the BMS Conservation Officer with recorders and follow up consultation take place with site owners.

For generic guidance the criteria suggested in this report can be followed. In addition protected sites need to hold as full an assemblage or representation of the various waxcap-grassland indicator groups as possible. They should be representative of taxa with different ecological requirements. A flexible and pragmatic site protection approach is desirable.

14.3 Monitoring and indicator species

Thought in future needs to be given to site condition monitoring. An approach needs to be developed which is both appropriate to the lifestyle and ecology of fungi and a workable solution to more rapid monitoring needs. More research needs to be undertaken to statistically evaluate the inter-relationships of the different waxcap-grassland assemblages. This will enable the most appropriate indicator species to be identified.

14.4 Research

Comparatively little scientific research has been undertaken on waxcap-grasslands fungi, beyond systematic and taxonomic accounts of species and general ecological assessments. An exception is the initial research on fruiting responses to chemical applications recently undertaken in Wales (Griffith *et al* 2002). Additional research of this kind needs to be funded to understand their ecology. It still requires confirmation whether waxcaps are saprotrophs and, if so, where and on what they are living. Projected research in Aberystwyth may go some way to answering this. But the same question needs answering for the Clavariaceae, *Entoloma* and Geoglossaceae.

There are many additional answers needed which would help waxcap-grassland conservation:

1. What triggers the different waxcap-grasslands to fruit? Is it a response to stress – is that why increases in nutrient levels cause lower fruiting levels? How long, if at all, before fruiting recovers for different taxa after physical disruption or nutrient or chemical changes?

2. Do nutrient increases or chemicals actually damage the fungal organism or is the mycelium unaffected?

3. Is the presence of fruitbodies actually a good indication of the scarcity or commonness of subsurface fungal mycelia (it may be, for example, that 'rare' species are in fact 'rarely fruiting')?

4. Why do *Hygrocybe* occur in woodlands in more southerly temperate zones? Were they originally woodland ectomycorrhizal species which through post glacial deforestation switched mycorrhizal partners to grasslands or mosses in NW Europe?

5. Are there alternatives to fertiliser applications in agricultural practice? Could agricultural practices make better use of saprotrophic fungal recycling processes?

14.5 Training

In particular funding is needed for taxonomic experts based in the UK to specialise in these taxa.

In addition support and encouragment should be given to the BMS waxcap-grassland survey and the BMS local recording network. Further recorder training is needed in all the waxcap-grassland taxa not just *Hygrocybe.*

14.6 Promotion

Heavily grazed or mown short sward needs greater conservation awareness as a potential habitat for important waxcap-grassland assemblages. This would help prevent their destruction and stop them from reverting to long-grass meadowland to the detriment of waxcap-grassland fungi.

Outside the SSSIs, the importance, value, interest, and attractiveness of waxcaps (which are quite photogenic) need substantial promotion within:

a) conservation organisations;

b) landowners including large landowning bodies like: the National Trust, English Heritage, the church, local government, as well as stately homes and country estates;

c) natural history groups and wildlife associations;

d) gardeners and garden-owners;

e) the general public.

A ‘Blue Peter’ approach to late-autumn waxcap-spotting would do wonders for awareness of these threatened fungi. A good start has been made with the Plantlife/BMS initiative to promote waxcap fungi to the public in 2002 through its Pink Waxcap Survey.

15. Acknowlegements

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Appendix 1 Grassland BAP species dossiers

Hygrocybe calyptriformis

Name and synonyms

Hygrocybe calyptriformis (Berk. & Broome) Fayod, *Annls Sci. Nat*. **9**: 309 (1889).
Agaricus calyptriformis Berk. & Broome, *Notices of British Fungi,* **63** (1838).
Hygrophorus calyptriformis (Berk. & Broome) Berk., *Outl. Brit. Fungi*,: **202** (1860).
Hygrocybe calyptriformis var. domingensis Lodge & S.A. Cantrell, *Mycol. Res*. **104**(7): 876 (2000).

English name

Agaric or toadstool; 'pink waxcap'

Description and distinguishing features

Cap: conical at first and remaining so, but expanding up to 70 mm wide, often splitting and becoming irregularly lobed; surface slightly greasy at first, becoming dry and somewhat polished, splitting as it expands to appear finely silky-fibrous; rose to pale pink, fading with age, showing whitish flesh where split. **Gills**: pale pink to pinkish white, rather widely spaced, not or barely attached to the stem. **Stem**: cylindrical, up to 120 mm x 15 mm wide, dry, rather fibrous, of similar colour to the gills.

Basidia: 4-spored. **Cystidia**: absent. **Basidiospores**: ellipsoid, 6.5 - 9 x 4.5 – 6 µm, smooth, hyaline, thin-walled, inamyloid.

Hygrocybe calyptriformis is one of the easiest waxcaps to distinguish, thanks to its pink colour. No other British *Hygrocybe* species is similarly coloured. A variety having a more deeply coloured stem (*H. calyptriformis* var. *domingensis*) has been described from the Caribbean and southern England, but hardly appears distinct.

Illustrations and further details

The standard text on European *Hygrocybe* species by Boertmann (Fungi of Northern Europe, Vol 1, 1995) has a good colour photo and description. Arnolds (Flora Agaricina Neerlandica, Vol 2, 1990) has a good description and line drawings of microscopic details. Phillips (Mushrooms and Other Fungi of Great Britain and Europe, 1981) has a colour photo and brief description.

Status and distribution

Hygrocybe calyptriformis is listed as "vulnerable" in the Provisional Red Data List of British Fungi (Ing 1992).

The species is common in England, having been reported from more than 30 vice-counties, from West Cornwall to Cumberland. It is also known from Scotland, Wales, and Northern Ireland. It is, however, much less common in continental Europe, where it is widespread but

rarely recorded. The UK holds 50% of the known European localities. It has been reported from North America, the Caribbean, and Asia.

Ecology

The ecology of *Hygrocybe calyptriformis* has not been studied in any detail. Field observations suggest, however, that it is saprotrophic (growing on dead grass or moss), and prefers old, undisturbed and unimproved largely neutral grassland. As with other *Hygrocybe* species, fruitbodies only appear in short grass, kept continually low by year-round grazing (typically by rabbits) or frequent mowing. It appears tolerant of sites with high water table or periodic inundation. Typical sites include churchyards and cemeteries, old and unimproved lawns, and unimproved pastures.

Hygrocybe calyptriformis site details

County	Site name	Grid ref	Latest record
Bedfordshire	Deadmansea WoodWhipsnade		1957
Buckinghamshire	Penn Wood (vicarage lawn)	SU9296	2000
Cornwall	Helston Cemetery		2000
Cheshire	Kerridge Hill (KU), Bollington	SJ942768	1998
Cheshire	Macclesfield Forest Pasture	SJ971719	1997
Cornwall	Perranaworthal, St. Piran's Church	SW779389	2000
Cornwall	St. Neot's Church	SX186679	2000
Cornwall	Truro Cemetery	SW834447	2000
Cornwall	Trelowarren Gardens	SW721238	1994
Cumberland	Blencathra Field Study Centre (fields)	NY303256	2000
Cumberland	St John's Church Yard, Keswick	NY267232	1999
Cumbria	Bassenthwaite Woods	NY2333	1922
Cumbria	Crummack Dale	SD776720	1999
Derbyshire	Baslow area	SK2572	1909
Derbyshire	Chatsworth House	SK2670	1956
Derbyshire	Ladybower	SK1888	1970
Derbyshire	Longshaw Estate	SK2679	199X
Derbyshire	Porter Clough	SK2884	1956
Devon	Exeter area	SX9292	1901
Devon	Goodmans	ST2605	
Essex	Chelmsford Cemetery	TL60	2001
Essex	Fryerning Church, Chelmsford	TL6200	2001
Essex	Holmwood House school	TL958254	2001
Essex	Little Leighs Church	TL7017	2001
Gloucestershire	Brockweir	SO5401	1994
Gloucestershire	Cleeve Common	SO990260	1997
Gloucestershire	Hope Wood	SO6818	1994
Gloucestershire	Silkwood, Westonbirt	ST8489	1997
Gloucestershire	The Patches	SO6308	1999
Hampshire	Bramble Hill Hotel	SU261157	2000
Hampshire	Busketts Lawn	SU312112	1998
Hampshire	Denny Woods, churchyard	SU3306	1966
Herefordshire	Brockhampton	SO6855	18XX
Herefordshire	Colwall	SO7442	18XX

County	Site name	Grid ref	Latest record
Herefordshire	Downton Gorge	SO4273	1951
Herefordshire	Fishpool Valley	SO4566	1993
Herefordshire	Garnons, Bridge Sollers	SO4441	1967
Herefordshire	Garnstone Park	SO4050	18XX
Herefordshire	Hergest Croft garden	SO2856	2001
Herefordshire	Holm Lacy Park	SO5535	1902
Herefordshire	Kinsham Court	SO3665	2001
Herefordshire	Moccas Park NNR	SO3442	18XX
Herefordshire	News Wd Malv'ns	SO7538	1982
Herefordshire	Putley church	SO6437	1999
Herefordshire	Stoke Edith Park	SO6040	18XX
Herefordshire	Walm's Well Woods	SO7539	1985
Herefordshire	Wellington Heath church	SO712407	2000
Herefordshire	Whitfield	SO4233	18XX
Herefordshire	Wormesley	SO4247	1926
Hertfordshire	Chorleywood Common	TQ0396	1998
Isle of Wight	Osborne Estate	SZ513948	1997
Kent	Benenden Hospital	TQ834352	2001
Kent	Brenchley Church	TQ679416	1997
Kent	Chelsfield Church	TQ479640	1984
Kent	Chislehurst Common	TQ442702	1992
Kent	Down House, Downe	TQ431611	1982
Kent	Knole Park, Sevenoaks	TQ5354	1967
Kent	Stonewall ParkChiddingstone Hoath	TQ505424	1998
Kent	Tunbridge	TQ8074	1966
Lancashire	Merlewood Research Station	SD409796	1997
Lancashire	Watergrove	SD391418	1998
Lancashire	White Coppice	SD6118	1988
Leicestershire	(private address)	SK551159	2001
Leicestershire	Roecliffe Manor SSSI	SK532126	2001
Leicestershire	Ulverscroft Reserve	SK490124	1997
Lincolnshire	Ashby, Partney	TF4266	1950
Lincolnshire	Barton on Humber	TA02	1924
Lincolnshire	Holton le Moor	TF0897	1916
Lincolnshire	Mausoleum Wood	TA1209	1982
Lincolnshire	Tumby	TF25	1909
Mid-west Yorkshire	Austwick area	SD76	1949
Mid-west Yorkshire	Appletreewick area		1943
Mid-west Yorkshire	Barden area	SE05	1900
Mid-west Yorkshire	Bastow Wood	SD993655	2000
Mid-west Yorkshire	Buckden area	SD97	1936
Mid-west Yorkshire	Burnsall area	SE06	1931
Mid-west Yorkshire	Flasby Moor N.	SD9657	1996
Mid-west Yorkshire	Grass Wood/Bastow Wood area	SD96	1943
Mid-west Yorkshire	Hackfall Woods areaMickley	SE27	1948
Mid-west Yorkshire	Harewood area	SE34	1888
Mid-west Yorkshire	Harewood Park E	SE322445	2000
Mid-west Yorkshire	Ingleton Glens	SD6973	1934
Mid-west Yorkshire	Leathley Mill, nr FarnleyOtley	SE24	1978
Mid-west Yorkshire	Lenny Wood, Ingleton	SD6973	1975

County	Site name	Grid ref	Latest record
Mid-west Yorkshire	Over Kinsey	SD808664	2000
Mid-west Yorkshire	Oxenber/Feizor/Wharfe Wood area, Austwick	SD7868	1996
Mid-west Yorkshire	Saw Wood area, nr Thorner	SE3739	1981
Mid-West Yorkshire	Smalley's Farm	SD717346	1997
Mid-west Yorkshire	Trow Gill area, Ingleborough	SD7571	1996
Mid-west Yorkshire	Wood End	SD7868	1996
Mid-west Yorkshire	Wood Nook, nr Grassington	SD9764	1997
Northamptonshire	King's Cliffe	TL0097	1837
North-east Yorkshire	Arnecliff Wood, nr Glaisdale	NZ70	1946
North-east Yorkshire	Castle Howard area	SE77	1909
North-east Yorkshire	Duncombe Park, nr Helmsley	SE68B	1920
North-east Yorkshire	Egton Lodge area, Esk Dale	NZ80	1902
North-east Yorkshire	Forge Valley, nr Scarborough	SE9887	1994
North-east Yorkshire	Helmsley area		1903
North-east Yorkshire	Mulgrave Woods area, Sandsend	NZ81	1946
North-east Yorkshire	Rievaulx area	SE58	1903
North-east Yorkshire	Saltonstall. (Near Lower) "Grave Field"	SE0328	2001
North-east Yorkshire	Scarborough area		1905
North-east Yorkshire	Sleightholme DaleKirkbymoorside	SE68	1965
Northumberland	Housesteads	NY7868	1971
Northumberland	Newcastle upon Tyne area	NZ2464	1907
North-west Yorkshire	Brignall Banks, nr Barnard Castle	NZ01	1904
North-west Yorkshire	Deepdale area, nr Barnard Castle	NZ01	1963
North-west Yorkshire	Hartforth pasturesRichmond	NZ10	1939
North-west Yorkshire	Richmond area		1956
North-west Yorkshire	Rokeby area, nr Barnard Castle	NZ01	1904
North-west Yorkshire	Swinton Park, nr Masham		1948
Nottinghamshire	Bingham cemetery	SK739505	2000
Shropshire	Attingham Park	SJ5509	1998
Shropshire	Baveney Wood	SO6978	1996
Shropshire	Bomere	SJ4719	1917
Shropshire	Clee Hill, Titterstone	SO623779	2000
Shropshire	Cockshutt Churchyard	SJ4329	1998
Shropshire	Ditton Priors Churchyard	SO608892	1998
Shropshire	Dudmaston Estate	SO7489	1982
Shropshire	Myddle Churchyard	SJ4623	1998
Shropshire	Plowden	SO3888	1917
Shropshire	Pontsford Hill	SJ4005	1997
Shropshire	Shrewsbury Cemetery	SJ4812	1998
Shropshire	Whitcliffe	SO4974	1880
Somerset	Chancellors Farm	ST527525	2000
Somerset	Cockercombe (Round Hill) Quantock Hills	ST1853	1999
Somerset	Dillington House	ST368156	2000
Somerset	Dunster	SS94	1997
Somerset	Nettlecombe	ST056378	1997
Somerset	Quantock HillsCockercombe (Round Hill)		1999
Somerset	Pinkworthy	SS7241	1997
South-east Yorkshire	Westwood area, Beverley	TA000393	1997
South-west Yorkshire	Bretton Park Lakes NR	SE285125	1999
South-west Yorkshire	Broadhead, Crag Vale.	SD9925	1993

County	Site name	Grid ref	Latest record
South-west Yorkshire	Cawthorne area, nr Barnsley	SE2808	1987
South-west Yorkshire	Craggale, nr Mytholmroyd	SD9925	1993
South-west Yorkshire	Crimsworth Dean, Hebden Bridge (CD 1)	SD989291	2001
South-west Yorkshire	Digley Dam. near Holmfirth	SE1106	1998
South-west Yorkshire	Slaithwaite areaHuddersfield	SE01	1906
South-west Yorkshire	Wadsworth area, Hebden Bridge	SE02	1904
Staffordshire	Barleyford	SJ944639	1997
Staffordshire	Dunwood Hall	SJ947544	1997
Staffordshire	Hollinhall	SJ956637	1997
Staffordshire	Wincle Minn Pasture	SJ948657	1998
Surrey	Holmwood Common	TQ1745	1977
Surrey	Kew : Royal Botanic Gardens		2000
Surrey	Limpsfield Chart St Andrews church	TQ426518	2001
Surrey	West Molesey, Elmbridge Cemetery		2000
Surrey	Brookwood CemeteryWoking	SU955565	2000
Sussex	Ashburnham Place	TQ693143	1997
Sussex	Brightling Church	TQ684210	1997
Sussex	Danehill Church	TQ402276	1998
Surrey	Dorking Cemetery		1999
Sussex	Ebernoe Church	SU976278	1998
Sussex	Ebernoe Common Northchapel	SU92	1998
Sussex	Fittleworth Church	TQ009192	1998
Sussex	Framfield Church	TQ494203	1999
Sussex	Haywards Heath Church	TQ331219	1999
Sussex	Horsebridge Cemetery	TQ577119	2000
Sussex	Isle of Thorns	TQ402276	1998
Sussex	Old Heathfield Church	TQ598202	1998
Sussex	Petworth Old Cemetery	SU92	1999
Sussex	Rye : Rye Hill		2000
Sussex	Rye Cemetery	TQ92	1998
Sussex	Slaugham Church	TQ257281	1998
Sussex	St Dunstan's Farm	TQ3031	1997
Sussex	Staplefield Church	TQ278282	2000
Sussex	Stedham Church	SU86422713	1999
Sussex	Warbleton Church	TQ609182	1997
Sussex	Willingford Farm	TQ657226	1998
Warwickshire	(private address) Stratford on Avon	SP2481	1997
Warwickshire	Draycote Meadows	SP450707	1999
Warwickshire	Meriden Hall	SP2481	1998
Warwickshire	Packington Park	SP2284	1969
Warwickshire	Tamworth-in-Arden	SP1170	1998
Warwickshire	Warwickshire		19XX
Westmorland	Bowberhead Farm, Ravenstonedale	NY741032	1996
Westmorland	Ravenstonedale Churchyard	NY357304	1997
Wiltshire	Cadley Church Churchyard	SU2066	2000
Wiltshire	Savernake Forest	SU2266	1999
Wiltshire	St.Katherine's Churchyard	SU2564	1997
Worcestershire	Lichey Hills, Birmingham		1952
Worcestershire	Madresfield	SO8047	1987
Worcestershire	Stennels Field	SO978836	2000

County	Site name	Grid ref	Latest record
Worcestershire	Willow Bank	SO745733	2001
Worcestershire	Wyre Forest, Lodge Hill Farm meadows	SO758765	1999
Yorkshire	Cray Village Area	SD935795	2000
Yorkshire	Wadsworth, Halifax	SK5697	1900
Yorkshire	Whitby area	NZ8911	1904

Hygrocybe spadicea

Name and synonyms

Hygrocybe spadicea (Scop.) P. Karst., Rys., Finl. Skand.Halföns. *Hattsv.*: **237** (1879)
Agaricus spadiceus Scop., *Flora Carniolica,* **2**(2): 443 (1772)
Hygrophorus spadiceus (Scop.) Fr., *Epicrisis systematis mycologici*: **332** (1838)

English name

Agaric or toadstool; ‘date waxcap’

Description and distinguishing features

Cap: conical at first, then expanding to becoming flattened, up to 80 mm wide, with a raised point at centre; surface slightly greasy at first, becoming dry and somewhat polished, splitting as it expands to appear finely silky-fibrous; variously reddish brown to olive-brown, showing yellowish flesh where split. **Gills**: typically lemon yellow, rather widely spaced, not or barely attached to the stem. **Stem**: cylindrical, up to 90 mm x 12 mm wide, dry, brittle, rather fibrous, of similar colour to the gills.

Basidia: 4-spored. **Cystidia**: absent. **Basidiospores**: ellipsoid to oblong, some constricted, 9 – 12 x 5 – 7 µm, smooth, hyaline, thin-walled, inamyloid.

Hygrocybe spadicea is one of the easiest waxcaps to distinguish, thanks to its distinctly brown cap with yellow gills and stem. No other British *Hygrocybe* species has this colour combination, though some of the yellow waxcaps may discolour weakly brownish in the cap when old.

Illustration and other details The standard text on European *Hygrocybe* species by Boertmann (*Fungi of Northern Europe,* Vol.1, 1995) has a good colour photo and description. Arnolds (*Flora Agaricina Neerlandica,* Vol 2, 1990) has a good description and line drawings of microscopic details.

Status and distribution

Hygrocybe spadicea is listed as “vulnerable” in the Provisional Red Data List of British Fungi (Ing 1992). It has rarely been recorded in England, and is known from less than half-a-dozen very scattered sites, from Devon to Cumberland. It is also known from Scotland and Wales and from various locations in continental Europe, where it is equally rarely recorded. It has been reported from North America, Asia, and New Zealand.

Ecology

The ecology of *Hygrocybe spadicea* has not been studied. Limited field observations suggest, however, that it is saprotrophic (growing on dead grass or moss), and prefers comparatively dry, old, undisturbed and unimproved grassland on non-acidic soils. Devon specimens were found on calcareous dune turf and on an inland limestone common. As with other *Hygrocybe* species, fruitbodies only appear in short grass, kept continually low by year-round grazing (typically by rabbits) or frequent mowing. The absence of *Hygrocybe spadicea* from the best-known English waxcap sites suggests, however, that it may have some ecological requirements distinct from other waxcap species.

Hygrocybe spadicea sites

county/province	Site name	Grid ref	Latest
Cumberland	Braithwaite		1992
Devon (South)	Bantham Ham	SX6643	1995
Devon (South)	Orley Common, Ipplepen	SX8266	1995
Sussex (East)	Ashburnham Place	TQ693143	1998
Worcestershire	Stennels Field	SO978836	1998
Yorkshire (Mid-west)	Kilnsey/Netherside area Wharfedale	SD96	1940
Yorkshire (South-west)	Firbeck area	SK58	1905
Yorkshire (South-west)	Luddenden, Wade Wood	SE0327	1995
Somerset (North)	Back Fields, Walton-in-Gordano	ST420738	1996

Microglossum olivaceum

Name

Microglossum olivaceum (Pers.) Gillet (1879)

English name

Earthtongue; ‘olive earthtongue’.

Description and distinguishing features

Fruitbody: cylindrical to club-shaped, up to 50 mm high, smooth, sometimes somewhat furrowed or flattened; typically dark to blackish olive, but often wholly or partly brownish, purplish, or pinkish.

Asci: 8-spored. **Paraphyses**: branched. **Ascospores**: fusiform, 14 - 21 x 4 – 5 µm, smooth, hyaline, thin-walled, aseptate or inconspicuously septate.

Microglossum olivaceum is distinguished from most other earthtongues (which are typically black) by its rather variable, but frequently olive to brownish colours. A related species, *M. viride*, is also greenish, but prefers woodland habitats and has a finely scaly stem. In case of doubt, the comparatively small, hyaline ascospores should be diagnostic.

Illustration and further detail

The standard text on British Ascomycetes (Dennis 1980) has a description and colour painting.

Status and distribution

Microglossum olivaceum is listed as ‘vulnerable’ in the Provisional Red Data List of British Fungi (Ing 1992).

The species is not uncommon in England, having been reported from some 20 vice-counties, from West Cornwall to North Yorkshire. It is also known from Scotland, Wales, and Northern Ireland.

Ecology

The ecology of *Microglossum olivaceum* has not been studied in any detail. Field observations suggest, however, that it is saprotrophic (growing on dead grass or moss), and prefers old, undisturbed and unimproved grassland. As with most other members of the *Geoglossaceae*, fruitbodies normally appear in short grass, kept continually low by year-round grazing (typically by rabbits) or frequent mowing. It typically appears in some numbers although does not appear to fruit every year. Sites include churchyards and cemeteries, old and unimproved lawns, and unimproved pastures.

Microglossum olivaceum sites

County	Site name	Grid ref	Latest
Cheshire	Bidston	SJ29	1954
Cornwall	Kiberick Cove	SW922382	2000
Cornwall	Gear Sands	SW7755	2000
Derbyshire	Hargatewell		1963
Devon	Membury	ST20	1956
Devon	Torquay, Hope's Nose	SX9463	1997
Hampshire	Appleslade Bottom, New Forest	SU1809	1999
Hampshire	New Forest, Brockenhurst		1984
Hampshire	Nices Hill	SU190110	2001
Hampshire	Whitefield Moor	SU2702	1984
Herefordshire	Holm Lacey		1873
Hertfordshire	Baldock, Weston Hills	TL2434	1992
Kent	Temple Ewell LNR	TR24	1968
Lancashire	Lancaster, Trowbridge		1978
Lancashire	Lancaster, Williamson Park		1978
Lancashire	Leck Beck	SD67	1987
Lancashire	Silverdale, Eaves wood		1978
Lancashire	Silverdale, Gait Barrows		1987
Norfolk	Lound Run Waterworks	TG50	1966
Oxfordshire	Chilterns		1958
Shropshire	Ludlow	SO5074	19XX
Shropshire	Whitecliffe Wood, nr Ludlow	SO47	1883
Somerset	Leigh Down		1853
Somerset	Dolebury Warren	ST457589	1999
Somerset	Leigh woods	ST57	19XX
Surrey	Haslemere	SU93	1957
Surrey	Limpsfield Chart St Andrews church		2001
Sussex	Staplefield Church	TQ278282	1999
Wiltshire	Swallowcliffe, Grovely wood		1970
Yorkshire	Helmsley, Duncombe Park	SE6082	1903
Yorkshire	Mulgrave Woods area	NZ81	1912
Yorkshire	Crimsworth Dean, Hebden Bridge	SD92	1964

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Front cover photographs:
Top left: Using a home-made moth trap.
Peter Wakely/English Nature 17,396
Middle left: Co_2 experiment at Roudsea Wood and Mosses NNR, Lancashire.
Peter Wakely/English Nature 21,792
Bottom left: Radio tracking a hare on Pawlett Hams, Somerset.
Paul Glendell/English Nature 23,020
Main: Identifying moths caught in a moth trap at Ham Wall NNR, Somerset.
Paul Glendell/English Nature 24,888