Haddo House: lawn management trials for waxcap fungi: Final report to National Trust for Scotland

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SUMMARY

With very little information available on the management of amenity grasslands for waxcap fungi (collectively known as CHEGD species), a project to evaluate the effect of scarification on the fruiting of these fungi on the bell lawn at Haddo House in Aberdeenshire, has been established. This lawn is known to support an outstanding assemblage of CHEGD fungi and is currently considered to be in need of scarification by the gardening team.

10 plots were marked out on the bell lawn during 2013. Five plots were scarified on April 16th 2014 and then, in 2015, three on April 15th and two on April 20th; the remaining 5 act as controls.

Visits to record the waxcaps were made in the autumn of 2014 (Holden 2014) and again in 2015. In both years the fruiting of CHEGD species occurred late in the season. Results from these visits were analysed (G. Griffith pers. comm.) and found to be significant, showing a positive impact on fruit body numbers in scarified plots. A further three years of plot scarification and recording is recommended to establish that this is not just an initial response to the change in management.

The terrace lawns were recorded and the archaeology plots assessed for CHEGD species during both 2014 and 2015 visits.

The 5 archaeology trenches excavated in 2011, were marked out in 2013 with the assistance of Stefan Sagrott and a high resolution global positioning system (GPS). The trenches are still difficult to locate but all corners were found and further information about their locations gathered in 2015. Limited fungal activity was noted within the trenches (one had fruiting club fungus in 2015). Limited fruiting may not be as a result of the disturbance to the turf caused by their excavation and the impact that the disturbance caused to the fungi remains inconclusive, although it is clear that CHEGD fungi have not been eliminated from the turf.

The terrace lawns have received more intensive management than the bell lawn during both 2013 and 2014 including scarification and the application of lawn improver and weed killer. This lawn is known to support an interesting suite of CHEGD species and a 1.5 metre strip around the edge was left without any management intervention to act as a refugia. CHEGD fungi continue to fruit on the terrace lawn although fruiting was poor in 2015. The impact of management on fungal fruiting remains inconclusive.

Objectives

- To establish scarification and control plots on the bell lawn, Haddo House prior to management work taking place in spring 2014
- To undertake a 2013 baseline survey of waxcap fungi fruiting within the plots to consolidate mapping work done in previous years on the lawn
- To mark the corners of the 5 archaeology trenches that were dug in the bell lawn in 2011 and monitor waxcap fruiting within them.
- To monitor fungal fruiting in the 10 scarification plots, the terrace lawn and the archaeology trenches.

INTRODUCTION

The bell lawn on the north west side of Haddo House in Aberdeenshire is known to support an outstanding assemblage of waxcap grassland fungi (Clavariaceae, *Hygrocybe*, *Entoloma*, Geoglossacea and *Dermoloma* known as CHEGD species) as well as the internationally rare species *Squamanita pearsonii* (Strathy Strangler), a parasite of the common grassland species, *Cystoderma amianthinum* (Earthy Powdercap) (Holden 2005, 2010).

The site is ungrazed by stock and relies on human intervention to maintain the short grassy sward. The gardening staff (U. Craven pers. comm.) recommend that the lawn is scarified to remove some of the current dense accumulation of thatch. It has been decided to take advantage of this need to investigate the effect of scarification on the CHEGD fungi.

In addition to the management research, five trenches were dug into the bell lawn in 2011 for the purposes of archaeological investigation. The methodology used required careful removal, storage and replacement of the turf and top soil so that the soil profiles were disturbed as little as possible. The monitoring of fungal fruiting once the ground had been re-instated is outlined in 'methodology' below.

METHODOLOGY
Haddo House was visited on April 15th, Oct. 19th and Nov. 15th 2015. The April visit was used to set out the scarification plots and assist with the mechanical scarification process. The later visits were to record all CHEGD species present in the plots, trenches and on the terrace lawn. In each case a mowing transect was employed to cover all of the ground within the target areas. Visit times were guided by reports of fungal fruiting by the garden staff.

Scarification plots: 10 plots of 20m x 10m were established in 2013. Five of these will act as control plots and five will be scarified. Two dice were used to randomly establish which plot would fulfil what function, thus plots 1, 2, 3, 5 and 10 are control plots and 4, 6, 7, 8 and 9 will be scarified (Appendix 1). To fit this size and number of plots onto the lawn, plot 7 was rotated through 90 degrees.

Only the corners of the plots were marked on the ground, initially using yellow plastic tent pegs. These proved so difficult to find that yellow plastic discs secured by a metal nail (disk-mark survey markers) and labelled with a waterproof pen were added during the second visit (Sept 24th 2013). Markers have to be low enough that they are not destroyed by the mowing process. A photographic record has been made of the plot locations (Appendix 2) and using this, a series of tapes and a metal detector, it proved possible to find and mark out the scarification plots at each visit.

Fig. 1: Yellow plastic disc marker used to mark plot corners. Held in place with a metal nail.

Scarification of the five plots was undertaken again on April 15th 2015, repeating the methodology used in 2014 (Holden 2014).

The plots are marked out using tapes during each visit. Each plot is then walked using a mowing transect approx. 2m apart; all CHEGD species recorded.

The scarification plots are clipped by three of the archaeological trenches (Appendix 4) the lawn was not large enough to enable the trenches to be avoided. Calculations have demonstrated that 0.6% of the scarified plots are occupied by trench and 0.742% of the control plots (S. Holden pers. comm).

Archaeological trenches: Five trenches were dug in the August 2011 following a brief period of consultation about mitigation of the effects. Trench locations and alignments are shown in Appendix 4. It was agreed that turves should be dug to the deepest possible depth (aiming for about 30cm, D. Genney, G. Griffith pers. comm.), without losing soil integrity. Turves were stored on a plastic membrane and replaced as soon as the archaeological investigation was completed.

The site was visited in October 2011 (Murfitt 2011) when the trenches had been re-instated and were still clearly visible on the ground. No CHEGD species were fruiting on the trenches although a good diversity of species was recorded elsewhere on the lawn. 2012 was a very poor fruiting year for CHEGD species and no visit was made for monitoring purposes.

Following difficulty in accurately locating the trench corners in 2012 and 2013, a high resolution GPS system was used to definitively locate the corners (Stonex R6 Total Station 0 and Penmap software with an overall accuracy of c. 10cm). Each corner was marked with yellow plastic discs secured by a nail (disk-mark survey markers) and labelled with a waterproof pen. An extra nail was hammered into the soil at each corner to facilitate re-finding with a metal detector if necessary. Photographs were taken of each trench with a marker at each corner (Appendix 6). Further photographs and measurements were taken in April 2015 (Appendix 5) to assist with their location. The acquisition of a high specification metal detector would make the plots much easier to locate as the soil can cover the markers to a depth of up to two centimetres during the course of the winter and even between visits during the autumn.

Terrace Lawn: This lawn were scarified during the spring of 2013, 2014 and 2015. At the same time, the lawn was spread with Scot Cleanrun Pro10+2+4 - 35glm^2 a mini-granular fertiliser and herbicide for control of common broad leaved weeds, including daisy and white clover (Una Craven pers. comm.). A margin of 1.5 metres was left untreated around the outer edge of the terrace lawn to act as a refugia for the CHEGD species that are known to fruit there.

INTERIM RESULTS

Scarification plots: The species recorded during the pre-scarification visit in September 2013 are given in Appendix 3 (see also Holden 2013). 2014 and 2015 were both reasonable fruiting years but in both years, fruiting started much later than previous experience at the site would have suggested. September visits would have been a waste of time with waxcaps just appearing in October. This makes the fruit bodies very vulnerable to frost damage but fortunately serious frosts did not occur until after the recording visits.

Gareth Griffith (Aberystwyth University) has undertaken an initial analysis of the data.

Since the total number of fruitbodies recorded across all plots in both seasons (2014 / 2015) was fairly low (775), and comprised mostly of Hygrophoraceae (710), only limited analysis of the CHEGD subgroups was undertaken.

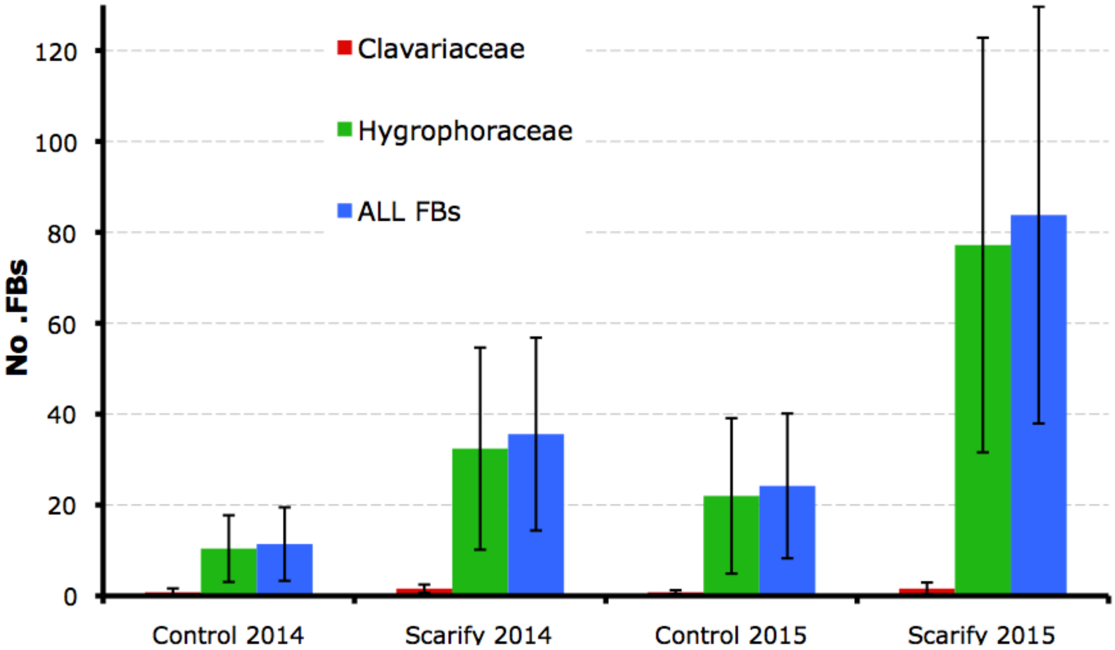

Fig. 1. *Mean number of fruit bodies recorded on Haddo bell lawn in 2014 and 2015 on plots which were scarified or not (5 replicates per treatment. Error bars indicate standard deviation)*

Two-way ANOVA on CHEG total data was conducted in PAST 3.0 with treatment and year as factors (output shown below). There was a highly significant treatment effect (P=0.003; more FBs on scarified plots) and also a significant effect of survey year (P=0.02; more FBs in 2015). But there was no significant interaction (P=0.15) between these treatments (i.e. no evidence that the effects of scarification are cumulative).

	Sum of sqrs	df	Mean square	*F*	*p* (same)
Factor A:	8778.05	1	8778.05	12.22	0.002987
Factor B:	4651.25	1	4651.25	6.477	0.02162
Interaction:	1566.45	1	1566.45	2.181	0.1591
Within:	11490	16	718.125		
Total:	26485.8	19			

Thus there is a positive clear effect of scarification on fruiting of grassland fungi during these two years. However, this may be a transient effect and prolonged scarification may in the long term have a negative effect. The thatch etc removed in 2014 had probably been there for a long time and was not completely removed at that time (even after several passes). It is possible that removal of all thatch (which would presumably happen with regular annual scarification, may also have a long term negative effect on fungal fruiting.

A full species list (2015) per plot and breakdown of fruit bodies by species per plot can be found in Appendix 10 and 12 respectively. Data from 2014 is given in Appendices 9 and 11.

Cystoderma amianthinum (Earthy Powdercap) was fruiting throughout the plots in 2013/14/15 and wider lawn area. This is not a target species for waxcap grassland but is the host for the rare parasitic species, *Squamanita pearsonii* (Strathy Strangler), that was recorded on the lawn in October 2004 (Holden 2005). Its continued presence on the lawns is thus of potential benefit to fungal diversity.

Archaeology trenches:
The corners of each trench were located during the April 2015 visit and further location photographs and measurements were taken (Appendix 5). Corners were located in the October and November 2015 visits and any fruiting fungi recorded (Appendix 8). In 2014 *Hygrocybe pratensis* (meadow waxcap) was fruiting in trench 2 and in 2015, *Clavulinopsis luteoalba* (apricot club) was fruiting in trenches 3 and 4. A metal detector was still invaluable in the location of the markers and it should be noted that the low powered detector that has been used to date broke during the last 2015 visit. Access to a more powerful metal detector is strongly recommended.

Terrace lawns: The terrace lawns were visited during both the October and November visits in 2015. A noticeable reduction in the number of species and fruit bodies was recorded on the terrace lawns in 2015 (Appendix 7).

Fruit bodies were recorded across the lawn, both within the 1.5 m edge (untreated) and in the main lawn (treated), but with fewer species and fruit bodies found. *Clavaria fumosa* and *C. zollingeri*, which are usually fruiting on the interface of the lawn edge and the path, were not recorded at all in 2015. It was noted in November that these lawn edges have had an artificial edging dug in all the way around since the previous visit in October (U. Craven pers. comm.). No species were fruiting at all in this interface in November.

From this work there is no way to determine the extent of the below ground mycelia and whether or not these species are growing elsewhere in the lawn but just not fruiting. No attempt was made to quantify the effect on the fungi, of leaving a refugia.

DISCUSSION

Scarification plots:
To date we have two years worth of data (2014 and 2015) collected from 10 plots of 20m x 10m (5 control plots and 5 that have been scarified once in each of the years 2014 and 2015).

A useful outcome of this work would be to offer management advice to others looking after waxcap lawns (as opposed to grazed meadows), however, two years is not long enough to suggest that scarification is unequivocally good for waxcaps. It could be that the fruit bodies are just responding to a more open sward as a stress reaction and that this 'flush' of fruiting may not continue after further scarification episodes (normally undertaken annually on lawns).

Another factor to consider is that one of the possible effects of scarification might be to reduce the number of 'weed species' some of which are thought to be mycorrhizal partners for these fungi This might take some years to achieve. Given our current understanding that waxcaps are mycorrhizal, the removal of the host plants over time would be expected to have a negative effect on the fungi.

If a relevant PhD could be set up, the student could use the research system in place at Haddo as a sample site. The student would take soil samples (approx. 15 from each plot - the samples would not make any visible impact on the lawn) and monitor changes in fungal population based on analysis of DNA extracted from soil, a more costly process (G. Griffith pers. comm.). This would give us a much better idea of whether scarification was impacting on the organism as a whole, rather than just the fruit bodies. It also has the advantage of not being reliant on a good fruiting year as the mycelia should be functioning throughout.

Some additional points to consider:

- Haddo offers a unique opportunity to undertake research in to the effects of management interventions on amenity grassland. There are very few areas known to be good for waxcaps that lend themselves to this kind of work e.g. they might be too small to enable replication or their managers do not wish to risk any detrimental visual impact from plot based interventions.
- A further three years of recording is recommended to establish whether or not the effect is persistent - with or without the input of the PhD.
- The continued support of the gardening staff would be essential to the success of this project. To enable the project to continue they would have to continue scarifying in the marked out plots 2016 - 2018 inclusive as they have done in the previous two years.
- The existing plots are still perfectly useable for any future work.
- A new metal detector would be required to speed up the location of the plot markers.
- It would be interesting to try and contact other managers of known waxcap lawns and find out whether they undertake regular scarification and if not, whether they stopped scarification following the precautionary principle. In the latter scenario, establish whether they have noticed any reduction in fruiting.
- Use this work to form the basis of a package of information about lawn management that could be presented to NT / NTS or other interested gardeners and land managers throughout Scotland and the rest of the UK, either as written articles or training sessions - or both.

Archaeology trenches:
With no baseline data of fruiting specific to the relatively small areas of the trenches, it is not known whether or not waxcaps were present and fruiting in the turf before it was lifted in August 2011. Thus it is impossible to know whether a lack of fruiting post lifting is because there were no target fungi there in the first place, or because of the intervention itself. This was discussed at the time of the intervention and it was accepted that the monitoring would only be useful if waxcaps were found fruiting in the turf post lifting. Unfortunately the lifting event was followed by three very poor fruiting years on the bell lawn (Murfitt 2011; Holden 2013). Further monitoring in 2014 (Holden 2014) and 2015 has demonstrated limited fruiting within the trench areas (see 'Results' above). It does seem likely that the careful manner in which the turves were cut and stored prior to replacement has enabled at least some waxcap mycelia to survive. Further data can be collected should the decision be taken to continue monitoring the scarification plots.

Terrace Lawns:
The number of species recorded and the number of fruit bodies were both low in 2015 compared with data from 2013 and 2014. Further monitoring will be needed to establish whether this will continue as a response to the addition of fertiliser and weed killer or whether other variables are responsible. The latter is possible as there was no obvious difference in fruiting between the 1.5m untreated buffer zone and the rest of the lawn.

The digging in of lawn edging strips may well interfere with the fruiting of species at the interface of the lawn and the path.

Further data can be collected should the decision be taken to continue monitoring the scarification plots.

RECOMMENDATIONS

- Three further years of monitoring should take place to establish whether or not the effect of the treatment is persistent, with or without the input from the suggested PhD (see 'Discussion' above).
- Recording should continue within the archaeology trenches and on the Terrace Lawns.
- A more sensitive metal detector should be acquired to enable the plots to be located more effectively.
- That a more efficient mechanism for collecting the grass clippings from the bell lawn be instated, to ensure that clippings are picked up immediately and also to reduce the amount of compaction resulting from two vehicles being involved for every cutting episode.

ACKNOWLEDGEMENTS
Thanks to Gareth Griffith for his help with the data and generous advice on how best to approach the project. Thanks also to both Pete and Simon Holden who assisted with the re-finding of the archaeology trenches in 2015 and to the latter for additional graphics and calculations. Special thanks to the gardening staff for their unfailing good humour, assistance and interest in the fungi and to Rob Dewar for supporting the project.

REFERENCES
Holden, E.M. (2005). *Collection of baseline data to enable future monitoring of the grassland fungi of Haddo House lawns 2004*. Unpublished report to the National Trust for Scotland.

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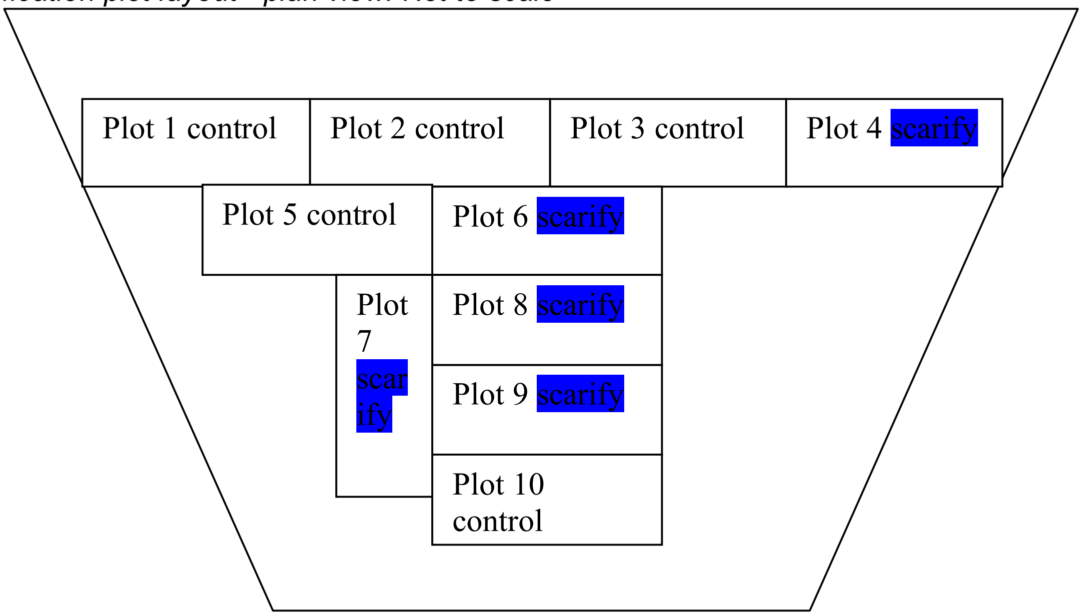
Murfitt A. (2011). Untitled and unpublished report to National Trust for Scotland.

Appendix 1: Layout of scarification plots on the bell lawn (graphic by Chris Knowles). Each plot 20m x 10m

Scarification plot layout - plan view. Not to scale



Appendix 2: Photographic record of scarification plot locations

Plot 1 from bottom left corner

Plot 1 from bottom right corner

Plot 2 from bottom right corner

Plot 3 from bottom right corner

Plot 4 from bottom right corner

Plots 1 - 4 from bottom left corner of 1

Plot 7 - coat marks bottom left corner

Plot 10 and bottom left corner of plot 7

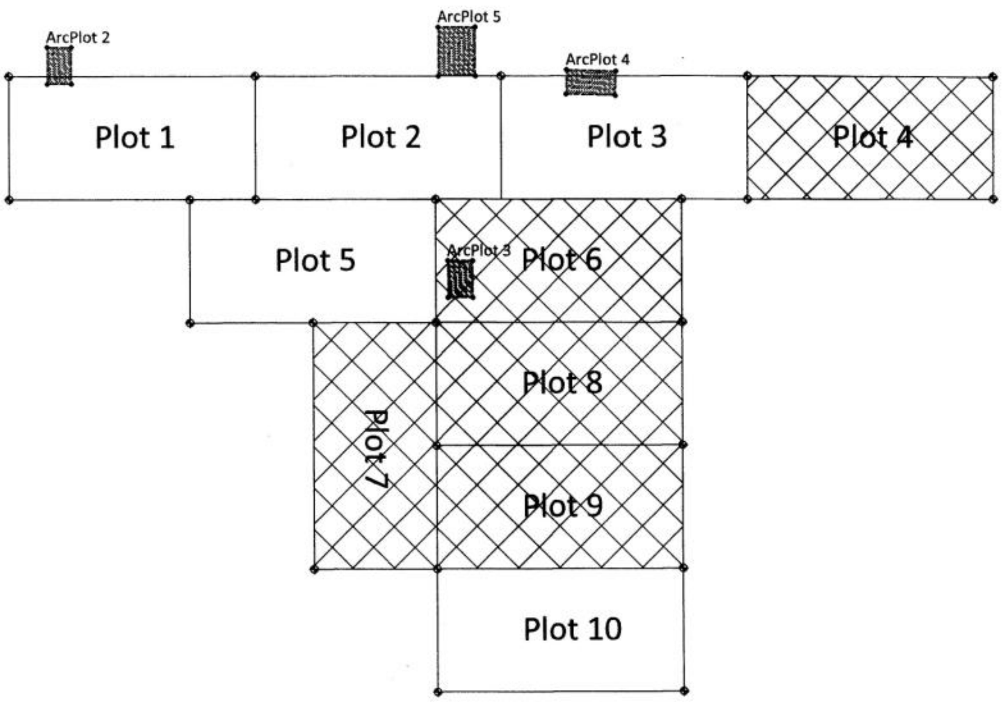
Plot 10 - 6 from bottom right corner of plot 10

Plot 10 - 6 from bottom left corner of plot 10

Appendix 3: List of CHEGD species from the plots on the bell lawn 2013 (before scarification). Orange = control

Species name	**Plot 1 Oct**	**Plot 2 Oct**	**Plot 3 Oct**	**Plot 4 Oct**	**Plot 5 Oct**	**Plot 6 Oct**	**Plot 7 Oct**	**Plot 8 Oct**	**Plot 9 Oct**	**Plot 10 Oct**
Clavulinopsis luteoalba	0	0	0	0	0	0	0	0	0	0
Hygrocybe ceracea	1	0	0	0	1	1	0	0	0	0
Hygrocybe chlorophana	0	1	0	0	0	0	0	0	0	0
Hygrocybe coccinea	1	1	0	0	0	0	0	0	0	0
Hygrocybe pratensis	1	0	0	0	0	0	0	0	0	0
Entoloma porphyrophaeum	0	0	0	0	1	1	0	0	1	0
Total no. of spp. per plot	**3**	**2**	**0**	**0**	**2**	**2**	**0**	**0**	**1**	**0**

Appendix 4: Overview of locations of archaeological trenches in relation to scarification plots (graphic by S.J. Holden)



Appendix 5: Archaeology trench location photos at April 2015

Trench 1 (2m x 4m)


Trench 1 (2m x 4m)


Trench 1 (2m x 4m)


Trench 1 (2m x 4m)


Trench 2 (2m x 3m)


Trench 2 (2m x 3m)

Trench 2 (2m x 3m)


Trench 3 (2m x 3m)


Trench 4 (line through top markers looking toward lower lawn) (2m x 4m)


Trench 4 (line through bottom markers looking over lower lawn) (2m x 4m)

Trench 4 (line through top markers looking away from lower lawn) (2m x 4m)


Trench 4 (line through bottom markers looking away from lower lawn) (2m x 4m)

Looking with back to house

Trench 4 line through right hand markers

Looking with back to house

Trench 4 line through left hand markers

Trench 4 whole plot looking away from house (2m x 4m)

Trench 4 looking down right hand markers toward house (2m x 4m)


Trench 4 looking down left hand markers toward house (2m x 4m)


Trench 5 looking along bottom markers away from lower lawn (3m x 4m)


Trench 5 looking along top markers away from lower lawn (3m x 4m)


Trench 5 looking down right hand markers toward house (3m x 4m)


Trench 5 looking down left hand markers toward house (3m x 4m)


Trench 5 looking down left hand markers with back to house (3m x 4m)


Trench 5 looking down right hand markers with back to house (3m x 4m)

Appendix 6: Archaeology trenches location photos - original images


Archaeology trench 1: location of corners

Archaeology trench 2: location of corners

Archaeology trench 2: showing location of corners in relation to the top edge of scarification plot 1


Archaeology trench 3: location of corners looking north east (Nov 2014)


Archaeology trench 3: location of corners looking north east (Nov 2014)


Archaeology trench 3: location of corners looking toward house (Nov 2014)


Archaeology trench 3: location of corners looking toward house (Nov 2014)

Archaeology trench 4: location of corners looking north east

Archaeology trench 4: location of corners looking north west


Archaeology trench 4: location of corners looking toward the house


Archaeology trench 5: location of corners looking north west

Archaeology trench 5: location of corners looking north east

Archaeology trench 5: location of corners looking toward house

Appendix 7: CHEGD species list from terrace lawns 2013/2014/2015

Species name	Oct. 2013	Sept. 2014	Nov. 2014	Oct. 2015	Nov. 2015
Clavaria fragilis	0	1	0	0	0
Clavaria fumosa	1	1	0	0	0
Clavaria straminea	1	0	1	0	0
Clavaria zollingeri	1	1	1	0	0
Clavulinopsis helvola	1	0	0	0	0
Clavulinopsis laeticolor	0	0	1	0	0
Dermoloma cuniefolium	1	1	0	0	0
Entoloma conferendum	0	0	1	0	0
Entoloma exile	0	1	0	0	0
Entoloma jubatum	0	1	0	0	0
Entoloma porphyrophaeum	1	0	0	0	0
Entoloma prunuloides	0	1	0	0	0
Hygrocybe calyptriformis	1	0	0	0	0
Hygrocybe cerecea	1	1	1	1	1
Hygrocybe chlorophana	1	1	1	0	0
Hygrocybe coccinea	1	0	1	1	1
Hygrocybe fornicata	1	0	0	0	0
Hygrocybe glutinipes	1	1	1	0	1
Hygrocybe insipida	1	0	1	0	0
Hygrocybe irrigata	1	1	1	0	0
Hygrocybe laeta	0	0	1	1	1
Hygrocybe pratensis	1	0	1	1	1
Hygrocybe psittacina	1	1	1	1	1
Hygrocybe punicea	0	0	1	0	0
Hygrocybe quieta	1	1	1	1	1
Hygrocybe reidii	0	1	0	0	1
Hygrocybe virginea	1	0	1	0	1
Total number of CHEGD species during visit	**18**	**14**	**16**	**6**	**9**

Appendix 8: CHEGD species list from archaeology trenches 2013/2014/2015

Species name	Trench 1 Oct 2013	Trench 1 Sept 2014	Trench 1 Nov 2014	Trench 1 Oct 2015	Trench 1 Nov 2015	Trench 2 Oct 2013	Trench 2 Sept 2014	Trench 2 Nov 2014	Trench 2 Oct 2015	Trench 2 Nov 2015	Trench 3 Oct 2013	Trench 3 Sept 2014	Trench 3 Nov 2014	Trench 3 Oct 2015	Trench 3 Nov 2015	Trench 4 Oct 2013	Trench 4 Sept 2014	Trench 4 Nov 2014	Trench 4 Oct 2015	Trench 4 Nov 2015	Trench 5 Oct 2013	Trench 5 Sept 2014	Trench 5 Nov 2014	Trench 5 Oct 2015	Trench 5 Nov 2015
Hygrocybe pratensis	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clavulinopsis luteoalba	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0

Appendix 9: CHEGD species list from the scarification plots 2014 (post scarification). Orange = control
NB Geoglossum spp. and C. zollingeri = no. of clubs/clusters. Other clavariacea just given 1 if present i.e. not counted

Species name	**Plot 1 Sept 2014**	**Plot 1 Nov 2014**	**Plot 2 Sept 2014**	**Plot 2 Nov 2014**	**Plot 3 Sept 2014**	**Plot 3 Nov 2014**	**Plot 4 Sept 2014**	**Plot 4 Nov 2014**	**Plot 5 Sept 2014**	**Plot 5 Nov 2014**	**Plot 6 Sept 2014**	**Plot 6 Nov 2014**	**Plot 7 Sept 2014**	**Plot 7 Nov 2014**	**Plot 8 Sept 2014**	**Plot 8 Nov 2014**	**Plot 9 Sept 2014**	**Plot 9 Nov 2014**	**Plot 10 Sept 2014**	**Plot 10 Nov 2014**
Clavaria acuta	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Clavaria fragilis	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Clavaria zollingeri	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Clavulinopsis helvola	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Clavulinopsis luteoalba	0	1	0	1	0	0	0	1	0	1	0	1	0	1	0	0	0	1	0	0
Dermoloma cuneifolium	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Entoloma conferendum	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Entoloma jubatum	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Entoloma porphyrophaeum	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Geoglossum fallax	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0
Hygrocybe aurantiosplendens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Hygrocybe calyptriformis	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0
Hygrocybe ceracea	0	1	1	1	0	0	0	1	0	1	1	1	0	0	0	1	0	1	0	0
Hygrocybe chlorophana	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Hygrocybe coccinea	0	1	0	1	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0
Hygrocybe flavipes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Hygrocybe glutinipes	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Hygrocybe insipida	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
Hygrocybe irrigata	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Hygrocybe pratensis	0	0	0	0	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
Hygrocybe quieta	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
Hygrocybe reidii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Total no of species per plot	**0**	**4**	**1**	**4**	**0**	**2**	**0**	**6**	**0**	**4**	**2**	**8**	**3**	**5**	**0**	**8**	**0**	**5**	**0**	**2**

Appendix 10: CHEGD numbers of species from the scarification plots 2015 visits (post scarification). Orange = control Geoglossum spp. and C. zollingeri = no. of clubs/clusters. Other clavariacea just given 1 if present i.e. not counted

Species name	**Plot 1 Oct 2015**	**Plot 1 Nov 2015**	**Plot 2 Oct 2015**	**Plot 2 Nov 2015**	**Plot 3 Oct 2015**	**Plot 3 Nov 2015**	**Plot 4 Oct 2015**	**Plot 4 Nov 2015**	**Plot 5 Oct 2015**	**Plot 5 Nov 2015**	**Plot 6 Oct 2015**	**Plot 6 Nov 2015**	**Plot 7 Oct 2015**	**Plot 7 Nov 2015**	**Plot 8 Oct 2015**	**Plot 8 Nov 2015**	**Plot 9 Oct 2015**	**Plot 9 Nov 2015**	**Plot 10 Oct 2015**	**Plot 10 Nov 2015**
Clavaria acuta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clavaria fragilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clavaria straminea	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Clavaria zollingeri	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clavulinopsis helvola	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0
Clavulinopsis luteoalba	0	1	0	1	0	1	0	0	0	0	1	1	0	0	0	1	0	1	0	1
Dermoloma cuneifolium	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0
Entoloma conferendum	0	1	0	1	0	1	0	1	0	0	0	1	0	1	0	1	0	1	0	1
Entoloma jubatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Entoloma porphyrophaeum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Geoglossum fallax	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Geoglossum glutinosum	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Hygrocybe aurantiosplendens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Hygrocybe calyptriformis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hygrocybe ceracea	1	1	1	1	0	0	0	1	0	0	1	0	0	0	1	1	1	1	0	1
Hygrocybe chlorophana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hygrocybe coccinea	0	1	0	1	0	0	0	1	1	1	1	1	1	1	1	1	0	1	0	0
Hygrocybe flavipes	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Hygrocybe glutinipes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hygrocybe insipida	1	0	0	0	0	0	0	1	0	0	1	1	1	0	1	1	0	1	0	1
Hygrocybe irrigata	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0
Hygrocybe pratensis	0	1	0	0	0	0	1	1	0	0	0	0	1	1	0	1	0	1	0	1
Hygrocybe psittacina	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
Hygrocybe punicea	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Hygrocybe quieta	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	1	0	0	0	0
Hygrocybe reidii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total no of species per plot	**2**	**5**	**1**	**4**	**0**	**2**	**1**	**9**	**1**	**2**	**5**	**6**	**5**	**5**	**4**	**9**	**2**	**8**	**0**	**5**

Appendix 11: CHEGD numbers of fruit bodies from the scarification plots 2014 visits (post scarification). Orange = control Geoglossum spp. and C. zollingeri = no. of clubs/clusters. Other clavariacea just given 1 if present i.e. not counted

Species name	Plot 1 Sept 2014	Plot 1 Nov 2014	Plot 2 Sept 2014	Plot 2 Nov 2014	Plot 3 Sept 2014	Plot 3 Nov 2014	Plot 4 Sept 2014	Plot 4 Nov 2014	Plot 5 Sept 2014	Plot 5 Nov 2014	Plot 6 Sept 2014	Plot 6 Nov 2014	Plot 7 Sept 2014	Plot 7 Nov 2014	Plot 8 Sept 2014	Plot 8 Nov 2014	Plot 9 Sept 2014	Plot 9 Nov 2014	Plot 10 Sept 2014	Plot 10 Nov 2014
Clavaria acuta	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Clavaria fragilis	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Clavaria zollingeri	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Clavulinopsis helvola	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Clavulinopsis luteoalba	0	1	0	1	0	0	0	1	0	1	0	1	0	1	0	0	0	1	0	0

Dermoloma cuneifolium	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
Entoloma conferendum	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
Entoloma jubatum	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Entoloma porphyrophaeum	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Geoglossum fallax	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0
Hygrocybe aurantiosplendens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0
Hygrocybe calyptriformis	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0	4	0	0	0	0
Hygrocybe ceracea	0	7	1	13	0	0	0	32	0	3	2	1	0	0	0	19	0	6	0	0
Hygrocybe chlorophana	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Hygrocybe coccinea	0	12	0	2	0	0	0	4	0	0	0	0	0	5	0	5	0	0	0	0
Hygrocybe flavipes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
Hygrocybe glutinipes	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Hygrocybe insipida	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	1	0	0	0	0
Hygrocybe irrigata	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Hygrocybe pratensis	0	0	0	0	0	2	0	30	0	6	0	1	0	18	0	3	0	9	0	1
Hygrocybe quieta	0	0	0	0	0	0	0	0	0	0	0	1	0	5	0	0	0	0	0	0
Hygrocybe reidii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Total no. of fruit bodies	**0**	**21**	**1**	**17**	**0**	**4**	**0**	**69**	**0**	**11**	**3**	**11**	**7**	**31**	**0**	**36**	**0**	**21**	**0**	**3**

Appendix 12: CHEGD numbers of fruit bodies from the scarification plots 2015 visits (post scarification). Orange = control Geoglossum spp. and C. zollingeri = no. of clubs/clusters. Other clavariacea just given 1 if present i.e. not counted

Species name	**Plot 1 Oct 2015**	**Plot 1 Nov 2015**	**Plot 2 Oct 2015**	**Plot 2 Nov 2015**	**Plot 3 Oct 2015**	**Plot 3 Nov 2015**	**Plot 4 Oct 2015**	**Plot 4 Nov 2015**	**Plot 5 Oct 2015**	**Plot 5 Nov 2015**	**Plot 6 Oct 2015**	**Plot 6 Nov 2015**	**Plot 7 Oct 2015**	**Plot 7 Nov 2015**	**Plot 8 Oct 2015**	**Plot 8 Nov 2015**	**Plot 9 Oct 2015**	**Plot 9 Nov 2015**	**Plot 10 Oct 2015**	**Plot 10 Nov 2015**
Clavaria acuta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clavaria fragilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clavaria straminea	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Clavaria zollingeri	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clavulinopsis helvola	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0
Clavulinopsis luteoalba	0	1	0	1	0	1	0	0	0	0	1	1	0	0	0	1	0	1	0	1
Dermoloma cuneifolium	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0	3	0	0	0
Entoloma conferendum	0	1	0	1	0	4	0	6	0	0	0	1	0	1	0	9	0	1	0	1
Entoloma jubatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Entoloma porphyrophaeum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Geoglossum fallax	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Geoglossum glutinosum	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Hygrocybe aurantiosplendens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hygrocybe calyptriformis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hygrocybe ceracea	14	2	7	7	0	0	0	34	0	0	1	0	0	0	36	2	15	5	0	2
Hygrocybe chlorophana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hygrocybe coccinea	0	23	0	14	0	0	0	11	6	23	2	19	32	83	17	22	0	2	0	0

Hygrocybe flavipes	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Hygrocybe glutinipes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hygrocybe insipida	2	0	0	0	0	0	0	2	0	0	1	4	7	0	8	6	0	3	0	6
Hygrocybe irrigata	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	3	0	0
Hygrocybe pratensis	0	1	0	0	0	0	9	21	0	0	0	0	1	4	0	1	0	4	0	1
Hygrocybe psittacina	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	7	0	0
Hygrocybe punicea	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0
Hygrocybe quieta	0	0	0	0	0	0	0	0	0	2	0	0	4	9	0	3	0	0	0	0
Hygrocybe reidii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total no. of fruit bodies	**16**	**28**	**7**	**23**	**0**	**5**	**9**	**81**	**6**	**25**	**6**	**27**	**46**	**98**	**62**	**46**	**18**	**26**	**0**	**11**