

Appendix 7C

Fungi Survey Report

Ove Arup and Partners Ltd

**Proposed Global Centre for Rail Excellence
Nant Helen open cast mine and Onllwyn
washery**

Grassland fungi survey



Version 3 June 2020

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This report has been updated to exclude the recommendations detailed in the original report. Since the production of the initial report, the design has evolved, and specific up to date recommendations have been incorporated into the Ecology Chapter of the Environmental Statement, to be submitted for the proposed Global Centre for Rail Excellence scheme.

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Cover photographs: Left: acid grassland at Nant Helen; Right: *Hygrocybe phaeococcinea* growing out of coal spoil at Onllwyn Washery.

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1. Introduction

Ove Arup and Partners Ltd ('Arup') are currently undertaking surveys for the proposed Global Centre for Rail Excellence (GCRE) (hereafter referred to as the 'Project'), located on the Nant Helen opencast mine and Onllwyn washery, between Seven Sisters and Abercraf (approximate grid reference SN826110). The survey is required to support the design and assessment process for the Project. Several waxcap fungi were observed during ecology surveys carried out during June and July 2019, which indicated that the habitats within the Study Area had potential to support significant populations of grassland fungi. Arup subsequently commissioned Sturgess Ecology to investigate this further by carrying out a survey of some of the most likely areas during the autumn.



Waxcap and Pink-gill fungi seen in acid grassland at Onllwyn washery during botanical surveys in June 2019.

2. Survey method

The field work was carried out by Dr Peter Sturgess CEnv MCIEEM, an ecologist experienced in grassland fungi surveys, and familiar with the types of habitats and terrain that occur on the site.

There are currently no standard survey protocols for grassland fungi, and recording is mostly carried out using walk-over methods. In this case, because the area is so large, and fungi fruit over many months, the survey was limited to a sampling-based approach, focusing on a set of 12 areas considered to have high potential for grassland fungi, and sampling these on 2 occasions spread out through the main autumn fruiting period. Each survey was carried out over 2 days due to the large area to be walked over.

The survey dates were as follows:

- Visit 1: 26 & 27 September 2019.
- Visit 2: 10 & 14 October 2019.
- Visit 3: 5 & 6 November 2019.

The visits all coincided with good conditions for fungi fruiting (i.e. damp conditions with no heavy frosts).

The survey areas are shown in Figure 1. Each visit involved walking through the 12 survey areas, focussing on the patches of vegetation considered to have the highest potential value for grassland fungi; particularly short grassland with no evidence of agricultural improvement by ploughing or use of fertilisers. Patches of scrub, woodland, marshy grassland, recently disturbed ground and other longer grassland were mostly avoided as they have low potential value for grassland fungi. The coverage of each survey area typically took between 1 and 2 hours, depending on the size and complexity.



In a patchy habitat like this (in Area 12) the grassland fungi tended to be limited to the shorter grass. The rush patches and areas of marshy grassland were avoided.

The survey was restricted to three target groups that are generally recognised as being good indicators of nature conservation value for grassland fungi; namely waxcap fungi (*Hygrocybe* spp.), earth tongues (Geoglossaceae) and fairy clubs (Clavariaceae). Pinkgill fungi (*Entoloma* spp.) can also be good indicators of grassland quality, but in this case they were only identified to genus level due to their complex taxonomy and practical difficulties of identifying them (even with microscopy), except where the species has readily distinguishable features. It was possible to identify many of the species during the site survey, but some could not be determined in the field and had to be identified from specimens examined using a microscope. Other fungi were also noted incidentally during the survey, but as a lower priority and most were not identified to species level except where they were readily identifiable in the field.

Fungi taxonomy is currently undergoing major revision as a result of DNA studies, and several of the previously well known names for grassland fungi are changing (e.g. waxcaps are now split into several different genera in some emerging classifications). For the purposes of this study the nomenclature follows Boertmann (2010) for waxcaps, Laessle & Petersen (2019) for earthtongues, and Kibby (2019) for Fairy Clubs.

The fungi were recorded by compiling a simple species list for each survey area. No attempt was made to quantify or map the fungi fruiting bodies within each area.

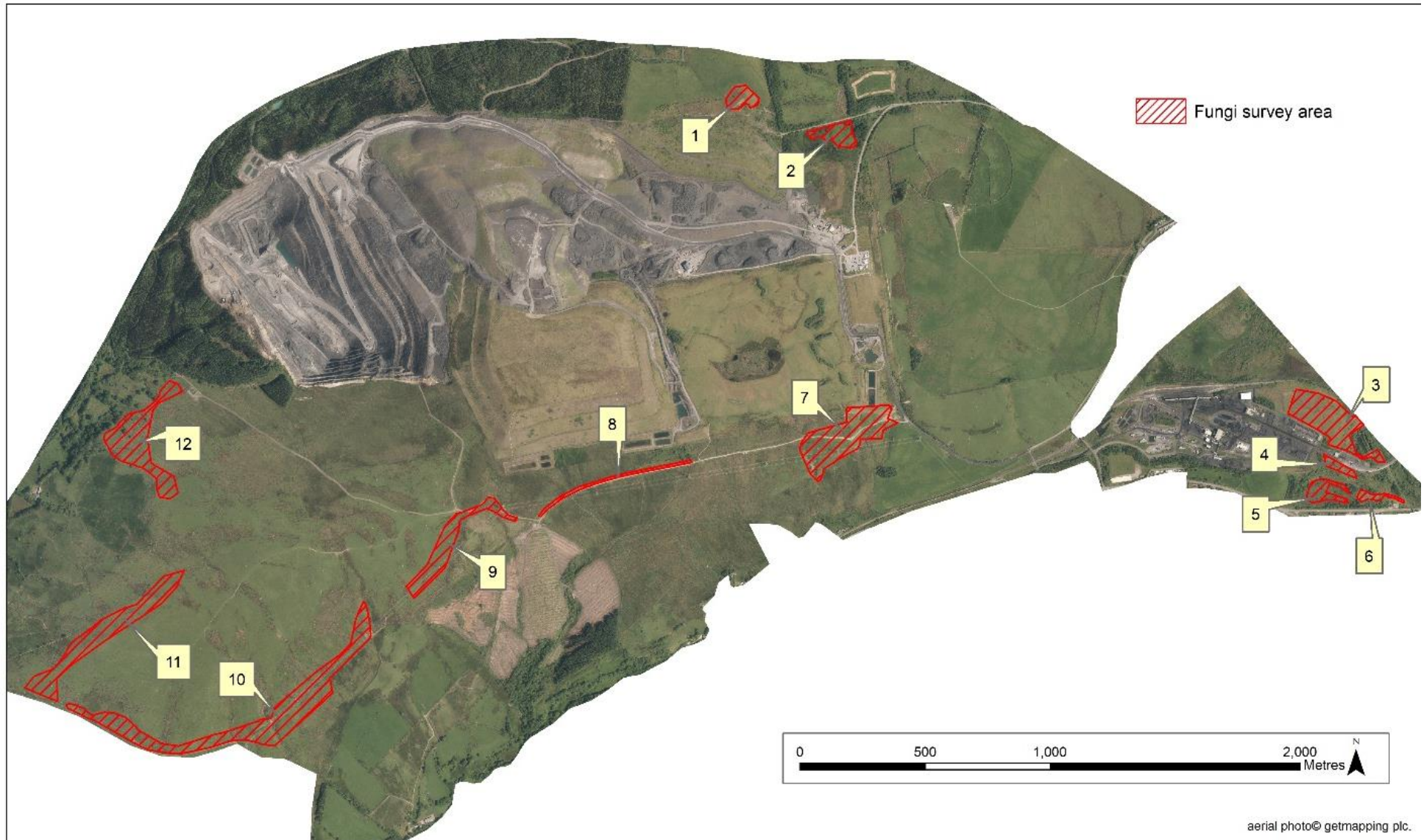


Figure 1. Location of fungi survey areas.

3. Survey findings

A list of all the fungi species recorded during the survey is given in Appendix 1. Lists for the individual survey visits are presented in Appendix 2.

The findings included a total of 27 waxcap species, 5 species of earth tongues and 7 species of fairy clubs. Photographs of some of the key species are presented in Appendix 3.

A breakdown of the target species found in each area and a description of each area in relation to fungi habitat is given in the following section. (A few additional non-target species have also been included, where they are used in some fungi assessment methods.)

Figure 2 has been produced for the Ecology Chapter of the Environmental Statement to show the value of areas surveyed, as well as areas of potential value for fungi.

Area 1



Area 1, showing patchy mix of acid grassland, heath and scrub.

Target fungi species in Area 1

- *Hygrocybe conica*
- *Hygrocybe laeta*
- *Hygrocybe pratensis*
- *Hygrocybe psittacina*
- *Hygrocybe substrangulata*
- *Hygrocybe virginea*
- *Glutinoglossum glutinosum*

Area 1 is a soil mound that is developing a cover of acid grassland with patchy heath and scrub. It appears to be in the region of 25 to 30 years old (although this was not confirmed).

Grassland fungi were relatively sparse on all of the survey visits; the most frequent species were *H.pratensis* and *H.psittacina*.

Area 2



Area 2, looking north-east from nearby soil mound.

Target fungi species in Area 2

- *Hygrocybe calyptriformis*
- *Hygrocybe cantharellus*
- *Hygrocybe chlorophana*
- *Hygrocybe citrinovirens*
- *Hygrocybe conica*
- *Hygrocybe flavipes*
- *Hygrocybe glutinipes*
- *Hygrocybe lacmus*
- *Hygrocybe laeta*
- *Hygrocybe pratensis*
- *Hygrocybe psittacina*
- *Hygrocybe reidii*
- *Hygrocybe splendidissima*
- *Hygrocybe virginea*
- *Clavulinopsis fusiformis*
- *Clavulinopsis helvola*
- *Clavulinopsis luteoalba*
- *Dermoloma cuneifolium*
- *Entoloma* sp.

Area 2 is a field of grazed pasture on natural ground. It supports semi-improved neutral grassland, grading into semi-improved acid grassland, with occasional trees and scrub.

Grassland fungi were easily found on every survey visit, with *H.pratensis* and *Clavulinopsis fusiformis* being locally abundant. The greatest numbers of fungi were found in the mid-slope section. A patch of the locally uncommon species *H.lacmus* was present near the eastern end. This was the only part of the study area where *H.splendidissima* was recorded.

Area 3



Area 3, showing typical short turf over coal spoil, and patchy heath and scrub.

Target fungi species in Area 3

- *Hygrocybe acutoconica*
- *Hygrocybe calciphila*
- *Hygrocybe cantharellus*
- *Hygrocybe ceracea*
- *Hygrocybe chlorophana*
- *Hygrocybe conica*
- *Hygrocybe insipida*
- *Hygrocybe miniata*
- *Hygrocybe mucronella*
- *Hygrocybe phaeococcinea*
- *Hygrocybe pratensis*
- *Hygrocybe psittacina*
- *Hygrocybe quieta*
- *Hygrocybe reidii*
- *Hygrocybe russocoriacea*
- *Hygrocybe substrangulata*
- *Hygrocybe virginea*
- *Clavulinopsis corniculata*
- *Clavulinopsis helvola*
- *Geoglossum fallax*
- *Glutinoglossum glutinosum*
- *Trichoglossum hirsutum*
- *Dermoloma cuneifolium*
- *Entoloma sericellum*
- *Entoloma* sp.

Area 3 is an area of coal spoil at Onllwyn Washery. It supports a mix of sparse vegetation, with areas of developing heath and scrub. Much of the surface is damp with patchy rushes. The vegetation appears to be in the region of 20 to 30 years old, but this was not confirmed.

Grassland fungi were patchily distributed, with most being found in the better drained areas with the sparsest vegetation, particularly on the eastern slope. The fungi included several small red waxcap species in the very short turf, including *H.miniata* and the locally uncommon species *H.phaeococcinea* and *H.substrangulata*. The presence of *H.calciphila* and *H.mucronella* may indicate a high base mineral content to the substratum, as these are often found in lime-rich habitats. In the absence of management it is possible that several species could be lost to natural successional processes as the vegetation closes and becomes taller.

Area 4



Area 4, showing short turf over coal spoil, with patchy heath, scrub and tall herbs.

Target fungi species in Area 4

- *Hygrocybe conica*
- *Hygrocybe acutoconica*
- *Hygrocybe mucronella*

Area 4 is an area of coal spoil at Onllwyn Washery with a mix of short turf, tall herbs, heath and scrub. There are areas of flushing, supporting mosses and rushes. The vegetation appears to be in the region of 20 to 30 years old, but this was not confirmed.

Grassland fungi were only sparse in this area, and the few that were seen were mostly in ones or twos rather than larger groups. *H.acutoconica* was also recorded here during July.

Area 5



Area 5, showing short-grazed turf, with patchy rushes and scrub, and drier areas with ant-hills.

Target fungi species in Area 5

- *Hygrocybe chlorophana*
- *Hygrocybe conica*
- *Hygrocybe insipida*
- *Hygrocybe psittacina*
- *Clavulinopsis helvola*
- *Trichoglossum hirsutum*

Area 5 is an area of horse-grazed grassland that appears to have developed on very old coal workings. The field includes a mix of short turf, marshy grassland and scrub.

Grassland fungi were only found in small numbers and were limited to the drier grassland on what appear to be old spoil heaps, and a few in the grassy strip beside the north-eastern boundary. The heavy grazing pressure in this field may have meant that some fungi were damaged before they were large enough to be recorded.

Area 6



Area 6, during September survey, showing short-grazed turf with ant-hills.



Area 6, the same field in November survey, with heavy grazing pressure.

Target fungi species in Area 6

- *Hygrocybe acutoconica*
- *Hygrocybe chlorophana*
- *Hygrocybe citrinovirens*
- *Hygrocybe conica*
- *Hygrocybe flavipes*
- *Hygrocybe glutinipes*
- *Hygrocybe helobia*
- *Hygrocybe psittacina*
- *Hygrocybe reidii*
- *Hygrocybe substrangulata*
- *Hygrocybe virginea*
- *Clavulinopsis helvola*
- *Trichoglossum hirsutum*
- *Camarophyllopsis schulzeri*
- *Entoloma sericellum*
- *Entoloma sp.*

Area 6 is an area of horse-grazed grassland that appears to have developed on very old coal workings. The field includes a mix of short turf with ant-hills, with patches of longer grass and scrub near the margins.

Grassland fungi were found in good numbers in the areas of short grass during the first survey, when the field was ungrazed, and these included the only record of *Camarophyllus schulzeri*. Horses were present in the field during the two later surveys and very few fungi were seen on these occasions (except a few damaged specimens).

Area 7



Area 7, showing old dry spoil heap with acid grassland; one of the more diverse parts of the area.



Area 7, showing old spoil heaps with acid grassland, with ant-hills and scattered scrub.

Target fungi species in Area 7

- *Hygrocybe chlorophana*
- *Hygrocybe conica*
- *Hygrocybe glutinipes*
- *Hygrocybe irrigata*
- *Hygrocybe lacmus*
- *Hygrocybe laeta*
- *Hygrocybe miniata*
- *Hygrocybe mucronella*
- *Hygrocybe phaeococcinea*
- *Hygrocybe pratensis*
- *Hygrocybe psittacina*
- *Hygrocybe quieta*
- *Hygrocybe virginea*
- *Clavaria acuta*
- *Clavulinopsis corniculata*
- *Clavulinopsis helvola*
- *Clavulinopsis laeticola*
- *Geoglossum fallax*
- *Geoglossum umbratile*
- *Glutinoglossum glutinosum*
- *Entoloma prunuloides*
- *Entoloma* sp.

Area 7 is an area of old coal workings now supporting semi-improved and acid grassland grazed by sheep and cattle, with intermittent patches of marshy grassland. A particularly diverse spoil heap at the eastern side is only grazed by sheep.

H.conica and *H.virginea* were common through most of the area; the other species tended to be more localised. The locally rare *H.lacmus* and *H.phaeococcinea* were associated with older, steeper coal-spoil heaps.

Area 8



Area 8, showing mix of short grass and rushes on old railway banking.

Target fungi species in Area 8

- *Hygrocybe chlorophana*
- *Hygrocybe citrinovirens*
- *Hygrocybe conica*
- *Hygrocybe intermedia*
- *Hygrocybe irrigata*
- *Hygrocybe laeta*
- *Hygrocybe phaeococcinea*
- *Hygrocybe pratensis*
- *Hygrocybe psittacina*
- *Hygrocybe russocoriacea*
- *Hygrocybe virginea*
- *Clavulinopsis corniculata*
- *Clavulinopsis helvola*
- *Geoglossum fallax*
- *Trichoglossum hirsutum*
- *Dermoloma cuneifolium*
- *Entoloma prunuloides*
- *Entoloma* sp.

Area 8 is a section of former railway banking that supports a patchy mix of semi-improved acid grassland and rushes on its sides. It is grazed by sheep and cattle.

The drier section of south-facing bank supported good numbers of grassland fungi, with *H.pratensis*, *H.chlorophana* and *H.virginea* being most common. The greatest species diversity was observed towards the eastern end of the surveyed section.

Area 9



Area 9, showing mix of short grass with ant-hills and patchy rushes.

Target fungi species in Area 9

- *Hygrocybe chlorophana*
- *Hygrocybe conica*
- *Hygrocybe lacmus*
- *Hygrocybe laeta*
- *Hygrocybe pratensis*
- *Hygrocybe psittacina*
- *Hygrocybe virginea*
- *Clavulinopsis helvola*
- *Geoglossum cookeanum*
- *Geoglossum fallax*
- *Trichoglossum hirsutum*
- *Dermoloma cuneifolium*
- *Entoloma prunuloides*
- *Entoloma sericellum*
- *Entoloma sp.*

Area 9 was chosen as a representative example of the open common to the south of the surface mine. It is grazed by sheep and cattle. The vegetation comprises patchy semi-improved and acid grassland, with areas of marshy grassland with rushes and Purple Moor-grass.

Grassland fungi were very patchily distributed, with locally abundant *H.conica*, *H.psittacina*, *H.virginea* and *Geoglossum fallax*, especially at the margins of areas that have been agriculturally improved (judging from the lack of ant-hills and lower plant diversity). The areas with greater species diversity tended to be the areas of older acid grassland with ant-hills, although the fungi were often sparse in these parts. The locally uncommon *H.lacmus* was only present as a few specimens in the south of the area.

Area 10



Area 10, showing a typical mix of semi-improved acid grassland with abundant ant-hills.

Target fungi species in Area 10

- *Hygrocybe calyptriformis*
- *Hygrocybe cantharellus*
- *Hygrocybe ceracea*
- *Hygrocybe chlorophana*
- *Hygrocybe citrinovirens*
- *Hygrocybe conica*
- *Hygrocybe flavipes*
- *Hygrocybe glutinipes*
- *Hygrocybe insipida*
- *Hygrocybe intermedia*
- *Hygrocybe irrigata*
- *Hygrocybe laeta*
- *Hygrocybe miniata*
- *Hygrocybe pratensis*
- *Hygrocybe psittacina*
- *Hygrocybe quieta*
- *Hygrocybe reidii*
- *Hygrocybe russocoriacea*
- *Hygrocybe virginea*
- *Clavaria fumosa*
- *Clavulinopsis corniculata*
- *Clavulinopsis helvola*
- *Geoglossum fallax*
- *Trichoglossum hirsutum*
- *Dermoloma cuneifolium*
- *Entoloma prunuloides*
- *Entoloma sericellum*
- *Entoloma serrulatum*
- *Entoloma sp.*

Area 10 is an area of common grazed by sheep and cattle, that supports semi-improved acid grassland as is characterised by abundant ant-hills. The remains of old coal workings are present at the western end of the section.

Grassland fungi were generally only found in low numbers through most of the area, mainly in the drier patches of the shortest grass. The most frequent species included *H.pratensis*, *H.laeta*, *H.psittacina* and *H.virginea*. However, the old mine workings supported the large numbers of fungi and a very high species diversity. This was the only area where *Clavaria fumosa* was recorded.

Area 11



Area 11, showing the wide slope with short, semi-improved acid grassland and patchy rushes.

Target fungi species in Area 11

- *Hygrocybe conica*
- *Hygrocybe laeta*
- *Hygrocybe pratensis*
- *Hygrocybe psittacina*
- *Hygrocybe reidii*
- *Hygrocybe virginea*
- *Clavulinopsis helvola*
- *Geoglossum fallax*
- *Dermoloma cuneifolium*
- *Entoloma sericellum*
- *Entoloma sp.*

Area 11 is a west-facing slope of the common, grazed by sheep and cattle. It supports semi-improved acid grassland with patchy rushes and several areas of marshy grassland. Ant-hills are scattered through the slope, and there are remnants of several very small-scale coal workings in a few places.

The slope supports an assemblage of fungi typical of upland acid grassland. The fungi were generally limited to the drier parts and the shortest grassland, and were mostly only seen in small numbers. The most frequent waxcap species observed were *H.laeta*, *H.virginea*, *H.psittacina* and *H.pratensis*.

Area 12



Area 12, showing semi-improved acid grassland with abundant ant-hills in an area of old workings.



Area 12, showing old fields with anthills.

Target fungi species in Area 12

- *Hygrocybe cantharellus*
- *Hygrocybe ceracea*
- *Hygrocybe chlorophana*
- *Hygrocybe conica*
- *Hygrocybe flavipes*
- *Hygrocybe glutinipes*
- *Hygrocybe insipida*
- *Hygrocybe laeta*
- *Hygrocybe pratensis*
- *Hygrocybe psittacina*
- *Hygrocybe reidii*
- *Hygrocybe virginea*
- *Clavaria acuta*
- *Clavulinopsis fusiformis*
- *Clavulinopsis helvola*
- *Clavulinopsis luteoalba*
- *Geoglossum fallax*
- *Entoloma* sp.

Area 12 spans an area of the common where there are old mine-workings, and several sloping fields with scattered trees. The area is mainly grazed by sheep, although some of the fields are only lightly grazed.

The old workings with short-grazed grass supported good numbers and a moderate diversity of grassland fungi. The most frequent species were *H.virginea*, *H.laeta*, *H.chlorophana*, *H.conica* and *H.psittacina*. Very few fungi were found in the fields, presumably because the grass was too long. However, those present included some large specimens of *H.flavipes*, *H.irrigata* and *H.pratensis*, which might indicate that additional (smaller) species might be present in the soil and would produce fruiting bodies if closer grazing were to be reintroduced.

4. Evaluation

This section evaluates the nature conservation significance of the grassland fungi in a geographical context, based on the approach set out in 'Guidelines for Ecological Impact Assessment' (CIEEM, 2018). The criteria used to assist in the evaluation are summarised in Table 2.

Table 2: Evaluation criteria

Level of Value	Habitats
International	Areas designated as Special Areas of Conservation (SAC), Special Protection Areas (SPA) or Ramsar sites in response to European Directives and International Conventions.
National	Areas designated as Sites of Special Scientific Interest (SSSI), National Nature Reserve (NNR) or equivalent.
Regional	Areas of habitat of suitable size and quality to be considered for notification as SSSI (based on Guidelines for the Selection of Biological SSSIs, JNCC 1998). Extensive areas of Environment (Wales) Act (2016) Section 7 habitats, listed as 'habitats of principal importance for the purpose of maintaining and enhancing biodiversity in relation to Wales.
County	Areas meeting Wildlife Sites Guidelines selection criteria; areas of Section 7 habitats; areas of Ancient woodland.
District/Local value	Any non-designated habitat assemblage of moderate biodiversity value.

There are various ways of assessing the value of grassland fungi populations. Most focus on the total number of waxcap species, or the number seen in a single visit. The Wildlife Sites Guidelines includes the "Rald classification method" which is based on the total number of Waxcaps (*Hygrocybe* spp.) recorded from a site as follows:

- National importance = 17-32 species (or 11-20 during a single visit)
- Regional importance = 9-16 species (or 6-10 during a single visit)
- Local importance = 4-8 species (or 3-5 during a single visit)
- No importance = 1-3 species (or 1-2 during a single visit)

The guidelines expand on this to include rarity criteria, and consider the following would be considered as potential wildlife sites (i.e. significant in a county context):

- A site supporting 4-8 or more species of waxcaps, or 3-5 during a single visit. (This criterion was modified in the Selection of SINCs in the Mid-Valleys Area (Caerphilly County Borough Council *et al*, 2008) to require 9 species of waxcaps to qualify as county importance.)
- A site which supports a red data list species, or species included in the Environment Act (Wales) Section 7 'List of species of principal importance for the purpose of maintaining and enhancing biodiversity in relation to Wales'.
- A site which supports a species recorded from 10 or fewer 10km grid squares in Wales (where the distribution is well known).
- A site which supports a species which is recorded from 3 or fewer sites within a Watsonian Vice County (where the distribution is well known).
- A site which supports a significant population of a Local Priority Species as listed in the relevant Local Biodiversity Action Plan.

The threshold for national importance is generally based on the recently revised SSSI selection criteria (JNCC 2018). For grassland fungi, the main criterion based on waxcap diversity is that a site should be considered for notification if the total waxcap count reaches or exceeds 19. Sites that fail to reach this threshold but have records of 12-18 taxa should be prioritised for resurvey (multiple visits), or may be considered regionally important.

The SSSI thresholds for species other than waxcaps are as follows:

- Clavarioid fungi (clubs, spindles and corals) = 7 species
- *Entoloma sensu lato* (pinkgills) = 15 species
- Geoglossoid fungi (earth tongues) = 5 species
- *Dermoloma*, *Camarophylloopsis*, *Hodophilus* & *Porpoloma* (*Pseudotracheloma metapodium*) (crazed caps, fanvaults and meadowcaps) = 3 species.

The various survey areas used in the current study are evaluated below in Table 3 and shown in Drawing 1.

Table 3. Summary evaluation of survey areas based on grassland fungi diversity

	Waxcap species	Evaluation	Comments
Area 1	6	Local value.	Has potential for fungi value to increase as habitat develops.
Area 2	14	County value.	Greatest diversity seen in mid-slope.
Area 3	17	County value.	Potentially vulnerable to loss of some species to successional processes.
Area 4	3	Negligible value	Ground conditions may be too wet to support a higher diversity.
Area 5	4	Local value.	Much of the area is too damp for grassland fungi, but reduction in grazing pressure may allow additional fungi to appear.
Area 6	11	County value.	Reduction in grazing pressure may allow additional fungi to appear.
Area 7	13	County value.	Highest fungi diversity is associated with the old coal tips.
Area 8	11	County value.	Most fungi diversity was seen in the eastern part, on the south-facing slope.
Area 9	7	Local value.	Probably typical of the agriculturally improved part of the common. <i>H.lacmus</i> was only seen in one patch.
Area 10	19	County value.	Most of the species were limited to the old workings in the west, rather than being spread through the whole area.
Area 11	6	Local value.	Probably typical of the less improved acid grassland parts of the common
Area 12	12	County value.	Highest fungi diversity is associated with the old coal tips. Closer grazing in the western fields may enable more fungi to appear.

Grassland fungi exist within the soil as a mycelial network of microscopic hyphae, only producing their visible fruiting bodies at certain times, usually late summer/autumn. Fungi can be very erratic and unpredictable in their appearing, and some species may go for several years without producing fruiting bodies. It is therefore unlikely that this limited survey will have recorded all of the grassland fungi that are present, and further investigations would probably confirm the presence of additional fungi species. A small number of waxcap species found reasonably frequently on acid soils in the Welsh uplands were surprisingly not seen during the current survey and might be expected to be present. In particular, further survey might be likely to find *H.vitellina* and *H.punicea*.

The mycelium in the soil is very vulnerable to ground disturbance such as ploughing, or compaction by vehicles. It is also easily damaged by agricultural chemicals such as fertilisers or pesticides. The survey findings highlight that certain parts of the site have remained relatively undisturbed for many years. The areas with diverse assemblages of grassland fungi appear to correlate well with the presence of anthills and lack of agricultural inputs.

Two areas (3 & 10) could arguably be considered regionally important, although their diversity is rather patchy and some parts of them only support low diversity. Both of these diverse fungi assemblages have clearly developed on mine spoil. This historic disturbance appears to have increased the range of fungi that they can support, when compared with the otherwise undisturbed parts of the common. It is likely that the soil in the previously worked areas contains a higher proportion of base minerals such as calcium than the more acidic natural ground.

None of the fungi recorded are included within the Welsh Government's Environment (Wales) Act 2018 list of Section 7 species. It is possible that one or more of these species may be present, but was either not fruiting this year, or was only present at too low a density to be recorded during the survey.

Several species were found that are infrequently recorded in Wales. A data collation exercise was undertaken by David Mitchel in 2017/ 2018, on behalf of NRW (<http://www.nifgdata.org.uk/waleswaxcaps/species/atlas.htm>). This provides an indication of the distribution and abundance of most waxcap species within Wales, in relation to the number of 10km grid squares they occupy. The least common species found during the present survey were *H. substrangulata* (6 post-2000 squares), *H.phaeococcinea* (7 post-2000 squares) and *H.lacmus* (15 post-2000 squares). However, fungi are generally very under-recorded, and not all of the known records from some sources were able to be included in the 2018 data set. It is difficult to determine whether these fungi are genuinely rare or simply overlooked; especially in the case of species that appear in remote upland habitats that are not regularly visited by mycologists.

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Appendix 1. Fungi species list

The following species list presents the scientific and common names of the species identified during the survey. In many cases non-target fungi were only identified to genus level.

Species	Common name
<i>Agaricus campestris</i>	Field Mushroom
<i>Agaricus sp.</i>	Mushroom (indeterminate)
<i>Agaricus urinascens</i>	Macro Mushroom
<i>Bovista plumbea</i>	Grey Puffball
<i>Camarophyllopsis schulzeri</i>	Matt Fanvault
<i>Clavaria acuta</i>	Pointed Club
<i>Clavaria fumosa</i>	Smoky Spindles
<i>Clavulinopsis corniculata</i>	Meadow Coral
<i>Clavulinopsis fusiformis</i>	Golden Spindles
<i>Clavulinopsis helvola</i>	Yellow Club
<i>Clavulinopsis laeticola</i>	Handsome Club
<i>Clavulinopsis luteoalba</i>	Apricot Club
<i>Clitocybe fragrans</i>	Fragrant Funnel
<i>Clitocybe nebularis</i>	Clouded Agaric
<i>Conocybe sp.</i>	Conecap (indeterminate)
<i>Coprinopsis sp.</i>	Inkcap (indeterminate)
<i>Coprinus commatus</i>	Shaggy Inkcap
<i>Cordyceps militaris</i>	Scarlet Caterpillar-club
<i>Cystoderma amianthinum</i>	Earthy Powdercap
<i>Daldinia fissa</i>	Gorse Crampball
<i>Deconica coprophila</i>	Dung-loving Psilocybe
<i>Dermoloma cuneifolium</i>	Crazed Cap
<i>Entoloma prunuloides</i>	Mealy Pinkgill
<i>Entoloma sericellum</i>	Cream Pinkgill
<i>Entoloma serrulatum</i>	Blue-edge Pinkgill
<i>Entoloma sp.</i>	Pinkgill (indeterminate)
<i>Galerina sp.</i>	Bell (indeterminate)
<i>Geoglossum cookeanum</i>	Earthtongue
<i>Geoglossum fallax</i>	Deceptive Earthtongue
<i>Geoglossum umbratile</i>	Plain Earthtongue
<i>Glutinoglossum glutinosum</i>	Glutinous Earthtongue
<i>Handkea excipuliformis</i>	Pestle Puffball
<i>Hygrocybe acutoconica</i>	Persistent Waxcap
<i>Hygrocybe calciphila</i>	Limestone Waxcap
<i>Hygrocybe calyptriformis</i>	Pink Waxcap
<i>Hygrocybe cantharellus</i>	Goblet Waxcap
<i>Hygrocybe ceracea</i>	Butter Waxcap
<i>Hygrocybe chlorophana</i>	Golden Waxcap
<i>Hygrocybe citrinovirens</i>	Citrine Waxcap
<i>Hygrocybe conica</i>	Blackening Waxcap
<i>Hygrocybe flavipes</i>	Yellow-foot Waxcap
<i>Hygrocybe glutinipes</i>	Glutinous Waxcap
<i>Hygrocybe helobia</i>	Garlic Waxcap
<i>Hygrocybe insipida</i>	Spangle Waxcap
<i>Hygrocybe intermedia</i>	Fibrous Waxcap
<i>Hygrocybe irrigata</i>	Slimy Waxcap
<i>Hygrocybe lacmus</i>	Grey Waxcap

Species	Common name
<i>Hygrocybe laeta</i>	Heath Waxcap
<i>Hygrocybe miniata</i>	Vermillion Waxcap
<i>Hygrocybe mucronella</i>	Bitter Waxcap
<i>Hygrocybe phaeococcinea</i>	Shadowed Waxcap
<i>Hygrocybe pratensis</i>	Meadow Waxcap
<i>Hygrocybe psittacina</i>	Parrot Waxcap
<i>Hygrocybe quieta</i>	Oily Waxcap
<i>Hygrocybe reidii</i>	Honey Waxcap
<i>Hygrocybe russocoriacea</i>	Cedarwood Waxcap
<i>Hygrocybe splendidissima</i>	Splendid Waxcap
<i>Hygrocybe substrangulata</i>	A waxcap
<i>Hygrocybe virginea</i>	Snowy Waxcap
<i>Laccaria laccata</i>	Deceiver
<i>Lactarius deliciosus</i>	Saffron Milkcap
<i>Lactarius sp.</i>	Milkcap (indeterminate)
<i>Leccinum scabrum</i>	Brown Birch Bolete
<i>Lichenomphalina umbellifera</i>	Heath Navel
<i>Lycoperdon nigrescens</i>	Dusky Puffball
<i>Macrolepiota procera</i>	Parasol
<i>Mycena sp.</i>	Bonnet (indeterminate)
<i>Naucoria sp.</i>	Aldercap (indeterminate)
<i>Panaeolina foenisecii</i>	Brown Mottlegill
<i>Panaeolus papilionaceus</i>	Petticoat Mottlegill
<i>Panaeolus sp.</i>	Mottlegill (indeterminate)
<i>Pseudoclitocybe cyathiformis</i>	Goblet
<i>Psilocybe semilanceata</i>	Liberty Cap
<i>Rickenella fibula</i>	Orange Moss-cap
<i>Stropharia semiglobata</i>	Dung Roundhead
<i>Suillus cf bovinus</i>	Bovine Bolete
<i>Tremella mesenterica</i>	Yellow Brain
<i>Trichoglossum hirsutum</i>	Hairy Earthtongue
<i>Tricholoma fulvum</i>	Birch Knight
<i>Vascellum pratense</i>	Meadow Puffball

Appendix 2. Species lists by survey visit

The following lists presents the fungi observed at each site during the different survey visits.

26 & 27 September 2019

TARGET FUNGI SPECIES	1	2	3	4	5	6	7	8	9	10	11	12
<i>Hygrocybe acutoconica</i>			X	X								
<i>Hygrocybe calyptriformis</i>		X										
<i>Hygrocybe cantharellus</i>										X		
<i>Hygrocybe ceracea</i>										X		
<i>Hygrocybe chlorophana</i>		X				X		X	X	X		X
<i>Hygrocybe citrinovirens</i>		X				X						
<i>Hygrocybe conica</i>	X		X	X	X	X	X	X	X	X	X	X
<i>Hygrocybe flavipes</i>		X				X				X		X
<i>Hygrocybe glutinipes</i>		X				X	X			X		X
<i>Hygrocybe substrangulata</i>	X		X			X						
<i>Hygrocybe insipida</i>			X							X		
<i>Hygrocybe intermedia</i>								X		X		
<i>Hygrocybe laeta</i>							X					X
<i>Hygrocybe pratensis</i>		X					X			X	X	
<i>Hygrocybe psittacina</i>		X	X		X	X	X		X	X	X	X
<i>Hygrocybe quieta</i>										X		
<i>Hygrocybe reidii</i>		X	X			X					X	
<i>Clavaria acuta</i>							X					
<i>Clavaria fumosa</i>										X		
<i>Clavulinopsis helvola</i>					X	X		X				X
<i>Clavulinopsis corniculata</i>			X									
<i>Clavulinopsis fusiformis</i>		X										
<i>Clavulinopsis luteoalba</i>												X
<i>Geoglossum fallax</i>								X				
OTHER FUNGI SPECIES												
<i>Agaricus cf campestris</i>								X				
<i>Agaricus urinascens</i>										X		
<i>Bovista plumbea</i>							X			X		
<i>Clitocybe nebularis</i>	X											
<i>Clitocybe fragrans</i>							X					
<i>Conocybe sp.</i>								X				
<i>Coprinopsis sp.</i>								X				
<i>Cystoderma amianthinum</i>	X	X								X	X	X
<i>Daldinia fissa</i>			X									
<i>Deconica coprophila</i>							X	X	X	X		
<i>Dermoloma cuneifolium</i>		X							X		X	
<i>Entoloma prunuloides</i>							X	X	X	X		
<i>Entoloma sericellum</i>			X						X		X	
<i>Entoloma sp.</i>		X	X				X	X	X	X	X	X
<i>Galerina sp.</i>	X		X				X				X	
<i>Handkea excipuliformis</i>			X									
<i>Laccaria laccata</i>	X		X			X						
<i>Lactarius deliciosus</i>			X									
<i>Lycoperdon nigrescens</i>	X	X									X	
<i>Macrolepiota procera</i>										X		
<i>Panaeolina foenicicii</i>							X			X		
<i>Panaeolus papilionaceus</i>								X		X		
<i>Psilocybe semilanceata</i>		X			X	X	X	X	X	X		X
<i>Stropharia semiglobata</i>		X			X		X		X	X	X	X
<i>Vascellum pratense</i>							X					

10 & 14 October 2019

	1	2	3	4	5	6	7	8	9	10	11	12
TARGET FUNGI SPECIES												
<i>Hygrocybe acutoconica</i>			X									
<i>Hygrocybe calciphila</i>			X									
<i>Hygrocybe calyptriformis</i>										X		
<i>Hygrocybe cantharellus</i>		X	X									X
<i>Hygrocybe ceracea</i>										X		
<i>Hygrocybe chlorophana</i>		X	X		X		X	X		X		X
<i>Hygrocybe citrinovirens</i>		X				X		X		X		
<i>Hygrocybe conica</i>		X	X	X	X	X	X	X	X	X	X	X
<i>Hygrocybe glutinipes</i>						X	X					
<i>Hygrocybe helobia</i>						X						
<i>Hygrocybe insipida</i>			X		X							X
<i>Hygrocybe intermedia</i>										X		
<i>Hygrocybe irrigata</i>								X		X		
<i>Hygrocybe laeta</i>		X							X	X	X	X
<i>Hygrocybe miniata</i>										X		
<i>Hygrocybe mucronella</i>			X	X								
<i>Hygrocybe phaeococcinea</i>			X									
<i>Hygrocybe pratensis</i>	X	X	X				X			X	X	X
<i>Hygrocybe psittacina</i>	X	X	X		X	X	X	X	X	X	X	X
<i>Hygrocybe quieta</i>			X							X		
<i>Hygrocybe reidii</i>		X	X							X	X	X
<i>Hygrocybe russocoriacea</i>			X									
<i>Hygrocybe splendidissima</i>		X										
<i>Hygrocybe virginea</i>		X	X			X	X	X	X	X	X	X
<i>Clavaria fumosa</i>										X		
<i>Clavulinopsis helvola</i>		X	X		X	X	X		X	X	X	X
<i>Clavulinopsis corniculata</i>			X							X		
<i>Clavulinopsis fusiformis</i>		X										X
<i>Clavulinopsis laeticola</i>							X					
<i>Clavulinopsis luteoalba</i>		X										
<i>Trichoglossum hirsutum</i>						X						
OTHER FUNGI SPECIES												
<i>Agaricus sp.</i>							X					
<i>Agaricus urinascens</i>												X
<i>Bovista plumbea</i>							X					
<i>Camarophylloopsis schulzeri</i>						X						
<i>Clitocybe fragrans</i>							X					
<i>Conocybe sp.</i>											X	
<i>Cordyceps militaris</i>	X						X	X	X	X	X	
<i>Cystoderma amianthinum</i>	X	X					X		X	X	X	X
<i>Daldinia fissa</i>			X									
<i>Deconica coprophila</i>							X	X				
<i>Dermoloma cuneifolium</i>			X					X	X	X		
<i>Entoloma prunuloides</i>							X			X		
<i>Entoloma sericellum</i>			X			X			X	X		
<i>Entoloma serrulatum</i>										X		
<i>Entoloma sp.</i>		X	X			X	X	X	X	X	X	X
<i>Galerina sp.</i>	X					X		X	X	X	X	X
<i>Handkea excipuliformis</i>			X									
<i>Laccaria laccata</i>	X		X									
<i>Lactarius sp.</i>	X											
<i>Leccinum scabrum</i>			X		X							
<i>Lichenomphalina umbellifera</i>			X									
<i>Lycoperdon nigrescens</i>	X	X					X		X	X	X	X

	1	2	3	4	5	6	7	8	9	10	11	12
<i>Macrolepiota procera</i>											X	
<i>Mycena sp.</i>	X		X		X	X	X	X	X	X		
<i>Panaeolina foenisecii</i>											X	
<i>Panaeolus papilionaceus</i>										X		
<i>Panaeolus sp.</i>						X						
<i>Psilocybe semilanceata</i>	X						X	X	X	X	X	X
<i>Rickenella fibula</i>						X			X	X		X
<i>Stropharia semiglobata</i>							X	X	X	X	X	X
<i>Suillus cf bovinus</i>			X									
<i>Tremella mesenterica</i>		X										
<i>Tricholoma fulvum</i>		X										
<i>Vascellum pratense</i>							X	X		X		

5 & 6 November 2019

TARGET FUNGI SPECIES	1	2	3	4	5	6	7	8	9	10	11	12
<i>Hygrocybe acutoconica</i>						X						
<i>Hygrocybe calyptriformis</i>		X										
<i>Hygrocybe ceracea</i>			X							X		X
<i>Hygrocybe chlorophana</i>			X				X	X	X	X		X
<i>Hygrocybe conica</i>			X			X	X		X	X	X	X
<i>Hygrocybe insipida</i>			X									
<i>Hygrocybe irrigata</i>							X					
<i>Hygrocybe lacmus</i>		X					X		X			
<i>Hygrocybe laeta</i>	X	X					X	X	X	X	X	X
<i>Hygrocybe miniata</i>			X				X					
<i>Hygrocybe mucronella</i>							X					
<i>Hygrocybe phaeococcinea</i>			X				X	X				
<i>Hygrocybe pratensis</i>	X	X	X				X	X	X	X	X	X
<i>Hygrocybe psittacina</i>		X			X	X	X	X		X	X	
<i>Hygrocybe quieta</i>							X			X		
<i>Hygrocybe reidii</i>		X	X									X
<i>Hygrocybe russocoriacea</i>			X					X		X		
<i>Hygrocybe splendidissima</i>		X										
<i>Hygrocybe virginea</i>	X	X	X			X	X	X	X	X	X	X
<i>Clavaria acuta</i>												X
<i>Clavaria fumosa</i>										X		
<i>Clavulinopsis helvola</i>									X	X	X	
<i>Clavulinopsis corniculata</i>			X				X	X		X		
<i>Clavulinopsis fusiformis</i>		X										
<i>Geoglossum cookeanum</i>									X			
<i>Geoglossum fallax</i>			X				X	X	X	X	X	X
<i>Geoglossum umbratile</i>							X					
<i>Glutinoglossum glutinosum</i>	X		X				X					
<i>Trichoglossum hirsutum</i>			X		X			X	X	X		
OTHER FUNGI SPECIES												
<i>Agaricus sp.</i>									X			
<i>Bovista plumbea</i>									X			
<i>Conocybe sp.</i>		X					X		X	X		
<i>Coprinus commatus</i>									X			
<i>Cordyceps militaris</i>		X	X				X		X			X
<i>Cystoderma amianthinum</i>	X	X					X	X	X	X	X	X
<i>Deconica coprophila</i>								X	X	X		
<i>Entoloma sericellum</i>										X		
<i>Entoloma sp.</i>							X			X	X	
<i>Galerina sp.</i>	X		X		X	X	X	X	X	X	X	X
<i>Laccaria laccata</i>					X							
<i>Lichenomphalina umbellifera</i>										X		
<i>Lycoperdon nigrescens</i>		X					X		X	X	X	
<i>Mycena sp.</i>			X			X	X		X	X		X
<i>Naucoria sp.</i>					X							
<i>Panaeolus papilionaceus</i>										X		
<i>Panaeolus sp.</i>					X		X	X		X		X
<i>Psilocybe semilanceata</i>							X	X	X	X		X
<i>Pseudoclitocybe cyathiformis</i>					X							
<i>Rickenella fibula</i>										X		
<i>Stropharia semiglobata</i>					X			X	X	X	X	
<i>Tremella mesenterica</i>										X		

Appendix 2. Photographs of selected species



Photograph 1. *Hygrocybe acutoconica*: Blackening Waxcap (27 Sept 2019).



Photograph 2. *Hygrocybe calciphila*: Limestone Waxcap (14 October 2019).



Photograph 3. *Hygrocybe calyptriformis*: Pink Waxcap (27 September 2019).



Photograph 4. *Hygrocybe cantharellus*: Goblet Waxcap (11 October 2019). A damaged specimen, but confirmed by microscopy.



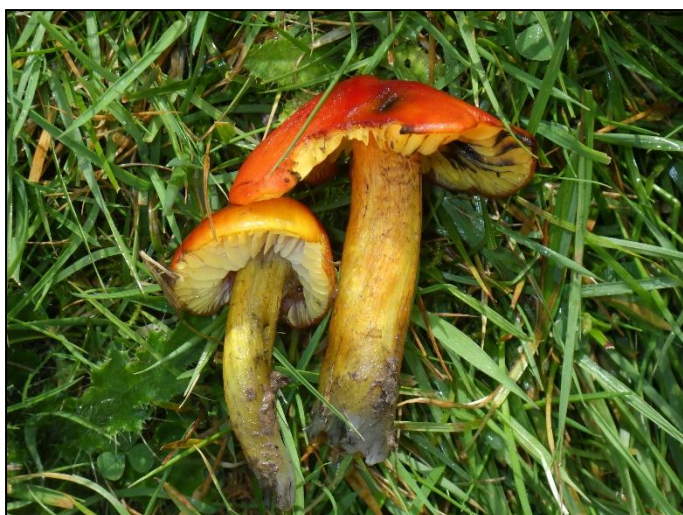
Photograph 5. *Hygrocybe ceracea*: Butter Waxcap (5 November 2019).



Photograph 6. *Hygrocybe chlorophana*: Golden Waxcap (26 September 2019).



Photograph 7. *Hygrocybe citrinovirens*: Citrine Waxcap (10 October 2019).



Photograph 8. *Hygrocybe conica*: Blackening Waxcap (26 September 2019).



Photograph 9. *Hygrocybe flavipes*: Yellow-foot Waxcap. (26 September 2019). Damaged specimen.



Photograph 10. *Hygrocybe glutinipes*: Glutinous Waxcap (10 October 2019).



Photograph 11. *Hygrocybe helobia*: Garlic Waxcap. (This photo was taken during the botanical survey on 2 July 2019).



Photograph 12. *Hygrocybe insipida*: Spangle Waxcap (10 October 2019).



Photograph 13. *Hygrocybe intermedia*: Fibrous Waxcap (26 September 2019).



Photograph 14. *Hygrocybe irrigata*: Slimy Waxcap (10 October 2019).



Photograph 15. *Hygrocybe lacmus*: Grey Waxcap (5 November 2019).



Photograph 16. *Hygrocybe laeta*: Heath Waxcap (10 October 2019).



Photograph 17. *Hygrocybe miniata*: Vermillion Waxcap (10 October 2019).



Photograph 18. *Hygrocybe mucronella*: Bitter Waxcap (5 November 2019).



Photograph 19. *Hygrocybe phaeococcinea*: Shadowed Waxcap (5 November 2019).



Photograph 20. *Hygrocybe pratensis*: Meadow Waxcap (14 October 2019).



Photograph 21. *Hygrocybe psittacina*: Parrot Waxcap (10 October 2019).



Photograph 22. *Hygrocybe quieta*: Oily Waxcap (26 September 2019).



Photograph 23. *Hygrocybe reidii*: Honey Waxcap (27 September 2019).



Photograph 24. *Hygrocybe russocoriacea*: Cedarwood Waxcap (5 November 2019).



Photograph 25. *Hygrocybe splendidissima*: Splendid Waxcap (14 October 2019).



Photograph 26. *Hygrocybe substrangulata* (10 October 2019).



Photograph 27. *Hygrocybe virginea*: Snowy Waxcap (14 October 2019).



Photograph 28. *Clavaria acuta*: Pointed Club (5 November 2019).



Photograph 29. *Clavaria fumosa*: Smoky Spindles (26 September 2019).



Photograph 30. *Clavulinopsis corniculata*: Meadow Coral (14 October 2019).



Photograph 31. *Clavulinopsis fusiformis*: Golden Spindles (10 October 2019).



Photograph 32. *Clavulinopsis helvola*: Yellow Club (10 October 2019).



Photograph 33. *Clavulinopsis luteoalba*: Apricot Club (26 September 2019).



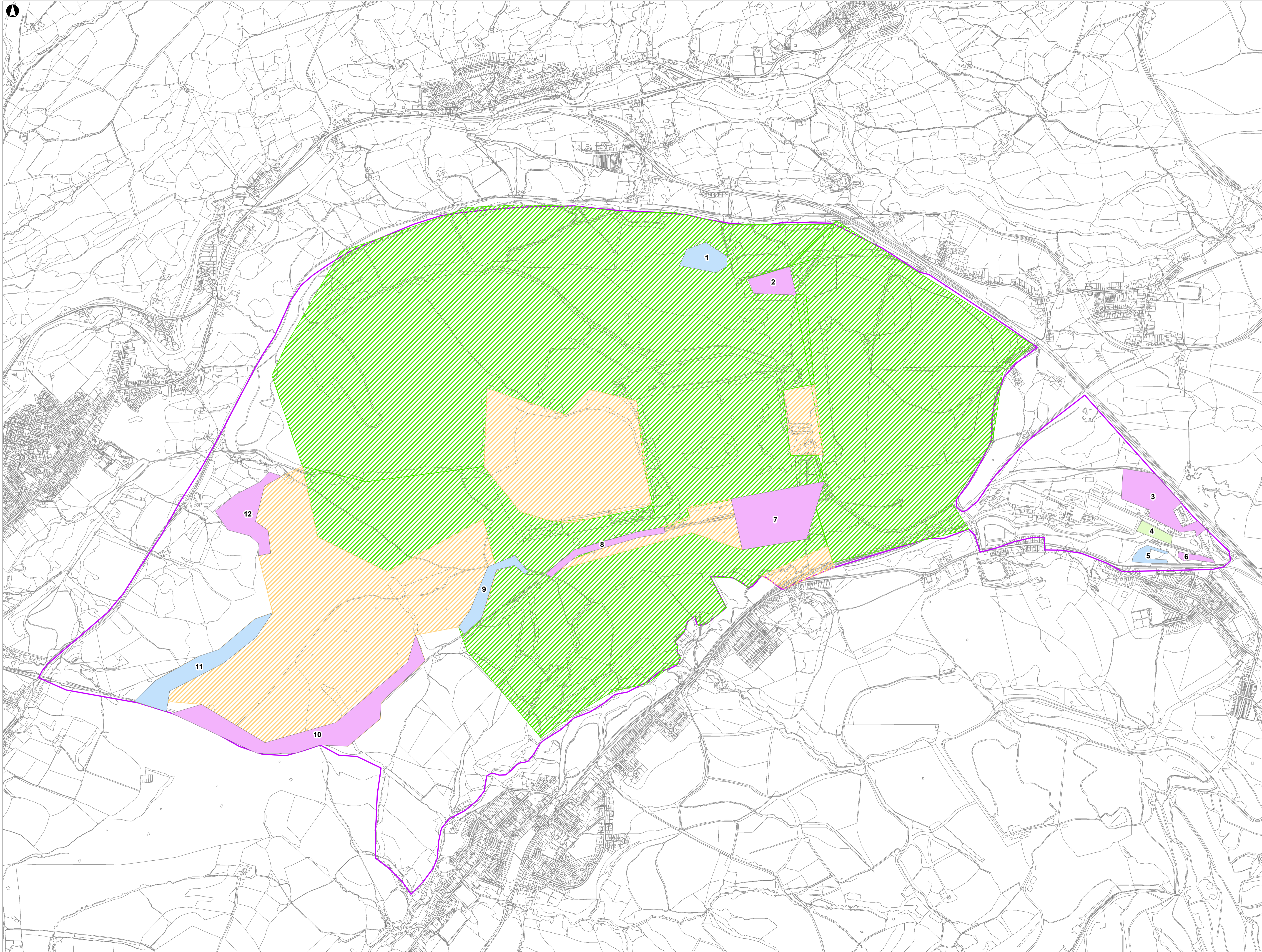
Photograph 34. *Geoglossum fallax*: Deceptive Earthtongue (5 November 2019).



Photograph 32. *Geoglossum cookeanum* (5 November 2019).



Photograph 33. *Trichoglossum hirsutum*: Hairy Earthtongue (14 October 2019).



Legend

- Study Area
- Surveyed Areas**
- Confirmed County Level
- Confirmed Local Level
- Confirmed Negligible Level
- Habitat Suitability**
- Likely Low Level
- Likely Medium Level

F1	2018-11-20	MSJ	GP	MM
Issue	Date	By	Checkd	Appr'd



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Client
Welsh Government

Job Title
Global Centre for Rail Excellence

Habitat Suitability for Fungi

Scale at A1

Job No	Drawing Status
264904	For Issue
Drawing No	Issue
2	F1