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Update of the Open Mosaic Habitats GIS and Review of the Data Capture Rules

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Summary

Open Mosaic Habitat on Previously Developed Land (referred to as OMH) is found on a wide range of disturbed or modified sites including former industrial sites, railway sidings, quarries, brick pits. Its importance lies in the combination of open ground and a mosaic of other habitats such as grassland, heathland, scrub, wetlands and ponds and the variations in topography, hydrology and soil chemistry. Together these make it suitable for a range of rare and scarce invertebrates, lichens, plants, birds, reptiles and amphibians and it is a Habitat of Principle Importance listed under Section 41 of the Natural Environment and Rural Communities (NERC) Act (previously known as Priority Habitat).

An initial scoping study to understand and map the extent of OMH in England was conducted in 2013 but now requires reviewing and updating. This report sets out some GIS-based 'Review Rules' and summarises the results of applying these to each polygon within the 2013 OMH dataset.

Approximately a third of the original OMH polygons have been retained following the review (2,897 polygons, 34%). This figure increases to almost two thirds of assessed polygons when considering those retained with a clear boundary change (2,553 polygons, 30%). However, a quarter of the polygons assessed were identified for removal from the OMH layer (2,086, 25%).

Based on this exercise, we suggest an amended set of Data Capture Rules that should be used in future mapping of new OMH sites in order to fully understand the extent of this valuable habitat. We also scope out spatial datasets that could be used to identify new OMH, utilising one of the suggested approaches:

- **Historic land use approach** (using brownfield registers, vacant and derelict land and broadscale land cover maps to identify changes in land use); or
- **Habitat led approach** (using machine learning, for example with LIDAR data or multispectral imagery to recognise OMH).

Contents

1. Introduction

1.1 Open Mosaic Habitats on Previously Developed Land (OMH) is a very important habitat. Sites supporting this habitat are often characterised by a diverse mix of micro-habitats, including fringing scrub and tall/dense vegetation, but critically include early successional stages of bare ground and sparse vegetation. The bare ground elements originate from the sites' previous nature as anthropogenic environments ("on previously developed land"). Sites as a result often have undulating topography, which adds to the micro-habitat diversity. The varied topography and previous land uses, such as mineral extraction, may lead to the presence of small ponds while modifications to the substrate can lead to variations in soil chemistry. Overall, this level of micro-habitat diversity means OMH sites are hugely important for many rare species not present in other more homogenous habitats. The presence of OMH in the landscape is also noted to add value to the whole area (Macgregor et al., 2022).

1.2 OMH by its nature is often a transitional habitat where natural successional processes intervene to alter the habitat away from OMH. At some sites, such as on steep slopes or areas with hard standing, these processes can operate extremely slowly, maintaining open conditions for long periods of time. However, in other environments without management, OMH features can be very transient with swards closing over and scrub encroaching, providing a threat to this habitat. Additionally, due to their categorisation as "brownfield", OMH sites may be earmarked for redevelopment. Currently, there is increasing pressure for planning authorities to use brownfield sites for development over new greenfield sites, on the condition that the site in question is not of high environmental value[1].

1.3 Understanding the overall extent of the habitat and the location of sites that support this threatened, transitional habitat is extremely

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[1] https://www.gov.uk/government/news/derelict-sites-to-be-transformed-into-new-homes-as-new-brownfield-fund-opens

important and as such the resource should be regularly reviewed. Natural England (NE) has therefore commissioned this assessment of the current OMH GIS layer, which is now just over ten years old.

Definition of OMH

1.4   The definition of Open Mosaic Habitats on Previously Developed Land given in the Priority Habitat Descriptions[2] (last updated July 2020 for OMH) is given below. This aligns with the definition given in the UK Habitat Classification[3], and according to both the following five criteria must be met:

1. Open mosaic habitat **at least 0.25 ha** in size.
2. Known **history of disturbance** or evidence that soil has been removed or severely modified by previous use(s). Extraneous materials/substrates such as industrial spoil may have been added.
3. Site **contains some vegetation**. This will comprise early successional communities consisting mainly of stress-tolerant species (e.g. indicative of low nutrient status or drought). Early successional communities are composed of (a) annuals, or (b) mosses/liverworts, or (c) lichens, or (d) ruderals, or (e) inundation species, or (f) open grassland, or (g) flower-rich grassland, or (h) heathland.
4. Contains **unvegetated, loose bare substrate and pools** may be present.
5. The site shows **spatial variation**, forming a mosaic of one or more of **early successional communities** (a)-(h) above (criterion 3) **plus bare substrate**, within 0.25 ha.

1.5   As it contains early-successional habitat, OMH is often dynamic, changing as natural processes gradually increase the amount of scrub. This can make identifying the habitat according to these criteria difficult as it is not necessarily clear whether a site is no longer OMH or is OMH in poor condition. The explanatory notes for the above criteria 3 highlight that for many invertebrates, it is essential that the

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[2] https://data.jncc.gov.uk/data/2728792c-c8c6-4b8c-9ccd-a908cb0f1432/UKBAP-PriorityHabitatDescriptions-Rev-2011.pdf
[3] https://ukhab.org/

characteristic bare ground and early successional stages are juxtaposed with some areas of scrub and rough vegetation. The notes state that *"scattered scrub (up to 10–15% cover) may be present and adds to the conservation value of the site"*. Therefore, once the percentage cover of scrub on a site increases significantly beyond this level, it may no longer be considered as OMH even though, scrub clearance could promptly restore it. However, the information assessed as part of this review does not include planned management. We address the issue of scattered scrub in our assessment and highlight this may be a condition rather than classification issue.

2.   2013 Data Capture Rule Base

2.1   The previous work by Lush & Lush (2013) provided a set of Data Capture Rule Base that determined which polygons would constitute OMH. The work by Lush & Lush summarised 'Phase 2' which followed on from 'Phase 1', a pilot project on a small number of sites that determined how OMH could be identified both remotely and in the field (Riding et al., 2010). Lush & Lush built on Phase 1 methodology further and produced the initial OMH GIS inventory used today.

2.2   The initial data collection in 2013 used existing shapefiles (where available) from the National Land Use Database of Previously Developed Land, the BritPits dataset and Historic Landfill data as a starting point. This was then supported by other datasets, with additional sites provided by partnership organisations, such as Buglife (as part of the 'All of a Buzz' project) and often confirming polygons as OMH. Importantly, some of these sites from other partners were often classified as OMH following field surveying.

2.3   It is important to note that other methods of OMH data collection were considered, including overlap with Land Cover Map (2007), species data as an indicator of OMH, and infra-red aerial photography. Each of these were tested, for example a subset of species records (Hymenoptera and Coleoptera, a single Diptera and vascular plants) and the proportion that overlapped with OMH sites examined. However, the conclusions from this were that these datasets did not overlap significantly with the existing OMH dataset and therefore were not used further.

2.4   The 2013 Data Capture Rule Base stated criteria for the newly digitised polygons. These were:

- Snapping to OS MasterMap where possible;
- No maximum size limits;
- A minimum size of 0.25ha (smaller fragments accepted where part of a larger contiguous area);
- Polygons should not include large open water bodies, however, could include small wetland features such as bogs,

       fens and swamps where the fringes would likely be important for OMH communities;

- Polygons should include bare ground and short vegetation patches;
- Polygons should not include heavy metal contamination sites, which should be referred to the Calaminarian Grassland priority habitat layer;
- Polygons should not overlap with OS polygons such as roads or rivers, although overlap with smaller linear features is acceptable;
- OMH polygons should not overlap.

2.5   Using these criteria and merging the resulting data with the existing datasets mentioned above, the "Open Mosaic Habitats layer (Draft)" was produced and released by Natural England in 2013[4]. The distribution of the 8,410 polygons currently identified as OMH are shown in Map 1.

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[4] https://www.data.gov.uk/dataset/8509c11a-de20-42e8-9ce4-b47e0ba47481/open-mosaic-habitat-draft According to the Natural England website, this layer was last updated on 18th December 2023.

Map 1: Current extent of identified Open Mosaic Habitat on Previously Developed Land

Legend
- Open Mosaic Habitats
- England outline

0   50   100 km

3. New Review Rules for screening

3.1   This project carries out an assessment of each OMH polygon within the original layer in order provide recommendations about their inclusion within an updated OMH dataset. We recognise that there is likely to have been vegetational succession as well as development on OMH polygons since the layer was last reviewed 10 years ago. To conduct this assessment effectively we produced a new set of 'Review Rules' to screen each site for selection/deselection.

3.2   The Data Capture Rule Base by Lush & Lush (2013) described above provides a useful starting point to understand the original inclusion criteria. The new 'Review Rules' described here are informed by the previous Data Capture Rule Base. It is important to acknowledge that the original Data Capture Rule Base was considered a working document likely to be subject to changes or additions. Mostly, the original Data Capture Rule Base criteria have been retained within the new Review Rules.

Data Sources used for screening

3.3   The Review Rules, outlined in detail below, were applied to each OMH polygon in GIS using aerial photography. Aerial Photography for Great Britain (APGB, supplied by Natural England) provided high quality aerial imagery appropriate for the task. Multiple years of APGB imagery were used, where available, and were supported with alternative imagery sources (Google/Bing aerials). The use of multiple aerial images assisted in the identification of features and conditions that may be seasonally dependent (i.e. imagery from periods of drought/rainfall may exaggerate/understate the presence of bare ground and short vegetation). In some instances, the use of older aerials allowed us to look at imagery from when the site was originally included in the OMH layer. Finally, Google Streetview imagery was sometimes able to assist in ground truthing aerials, informing final decision making where aerials were inconclusive.

3.4   To help ensure that the minimum size Review Rule was met, the aerial imagery was overlayed with a 50m x 50m (0.25 ha) grid. This allowed

us to assess whether the area of OMH on sites where the cover of woody vegetation had increased, or development has occurred was still sufficient for the site to still qualify. We made use of other tools, such as the "Go2NextFeature" to move quickly between polygons and speed up processing.

Summary of Review Rules

3.5   The 'Review Rules' are summarised here. Each step includes categories that are discrete, clear and remain as objective as possible. The first is the screening decision (outcome, field 1 in the GIS attribute table), and the second is the justification for the decision (justification, fields 2 - 10). These are supported by the addition of any relevant notes (field 11).

3.6   We assume that all sites within the current OHM layer were correct in their assessment as being on previously developed land (i.e. they are former anthropogenic environments, including residential and industrial developments, extraction sites etc.), and therefore we only reviewed habitat condition.

3.7   The criteria for the 'Review Rules' are summarised in Table 1 and given as a process in Appendix 1.

Outcomes

3.8   The four possible screening outcomes are listed below, and each polygon is assigned to just one outcome.

- **Retain OMH** (no issues recognised in the screening assessment from aerial photographs);
- **Retain OMH with uncertainty** (i.e. habitat unclear, meaning that the site may no longer be OMH, but this is not able to be determined with confidence from aerial images alone);
- **Retain OMH with clear boundary change required** (i.e. part of the site is potentially OMH, some may be "retained with uncertainty", but parts are clearly now not OMH and therefore a boundary change is required);
- **Remove from OMH** (clear land use change e.g., entire polygon is now a residential site).

Justification

3.9   The second step in our 'Review Rules' aims to provide an explanation for the given decision of each OMH polygon. These categories are included as further columns (fields 2 - 10) in the GIS layer to provide the reasoning, with multiple reasons possible. The reasoning may be assigned to the whole site, in the case of an outcome of "Remove from OMH" (e.g. site is completely lost to canopy cover), or part of the site, in the case of an outcome of "Retain OMH with uncertainty" / "Retain OMH with clear boundary change required" (e.g. site is partially lost to canopy cover).

- **Small size:** polygons less than 0.25 ha (including those which are multipart polygons).
- **Lost to vegetation succession:** sites support grassland/heather/bracken etc. which have become rank and form a closed sward. Bare ground or short vegetation is now entirely lacking.
- **Lost to canopy cover:** sites with a full/partial dense cover of trees/scrub where bare ground or short vegetation is now entirely lacking.
- **Scrub assessment required:** sites have some bare ground and short vegetation present but also have more than 15% scattered patches of scrub (although the exact amount of scrub can be hard to quantify), This issue is discussed more in the definitions section above. For these sites a field assessment would ideally be carried out to understand their condition and whether they still classify as OMH.
- **Lost to development**: sites fully/partially lost to development – area is now residential, industrial, commercial etc, and lacks any significant semi-natural habitat (i.e. no "green" environment, including areas of continuous cover of new concrete/tarmac). Roads are included within this category, although it is important to distinguish between these and dirt tracks and old broken up roads/tarmac that are starting to be colonised by vegetation.
- **Open water:** as areas of open water were excluded from mapping according to the original data capture rules, we have suggested boundary changes where areas are now entirely open water (retained with uncertainty) or where sites include significant (≥0.25 ha) of open water (a boundary

change required). However fluctuating water levels are common at OMH sites (e.g. extraction sites) and therefore we have not remove any sites based on the presence of open water from aerials.

- **Calaminarian Grassland:** identified using the Natural England Priority Habitat Inventory (PHI). This habitat is similar to OMH and may have been mistakenly categorised as OMH.
- **Amenity use:** OMH is an anthropogenic habitat, however, when associated with amenity uses, some sites become 'tidied', with a closed, short cut sward. Paths and human trampling provide bare ground, but this is likely to be insufficient to allow it to classify as OHM. Using the Ordnance Survey (OS) Greenspace layer allowed us to recognise where sites have been fully/partially lost to amenity uses.
- **Land use change:** OMH habitat is no longer present fully/partially in site due to a change in land use. This includes any built sports pitches, golf courses, agricultural/farmland, scrap yards and creation of parks or other general amenity areas. For some polygons this may require a boundary change or removal.

Table 1: Criteria applied in screening OMH sites.

Criteria	GIS Field 1 (single category only)	GIS Field 2-10 (multiple categories possible)
Size		
1) ≤ 0.25 ha in size[5]	Remove OMH	Small size
2) ≤ 0.25 ha in size, but part of a multi-part size (i.e. other polygons within 50m)	Retain OMH with clear boundary change	Small size
Succession		
3) Lacks any clear bare ground or short vegetation	Remove OMH	Lost to vegetational succession
4) Possibly has clear bare ground or short vegetation (this element can be harder to distinguish)	Retain OMH with uncertainty	Lost to vegetational succession
5) Includes extensive 'new' wood/ scrub (any OMH left is ≤ 0.25 ha)	Remove OMH	Lost to canopy cover
6) Includes 'new' wood/ scrub, but OMH left is ≥ 0.25 ha	Retain OMH with clear boundary change	Lost to canopy cover
7) Includes scattered scrub (makes up ≥15% of polygon), OMH left is ≥ 0.25 ha	Retain OMH with uncertainty	Scrub assessment required
Open water		
8) Entire site, or almost entire site (≤ 0.25 ha OMH remaining) is covered by water (in one or multiple reference aerials)	Retain OMH with uncertainty	Open water
9) Areas of open water (≥ 0.25 ha) and ≥ 0.25 ha OMH (in one or multiple reference aerials)	Retain OMH with clear boundary change	Open water
Development		
10) Polygon includes extensive 'new' development (inc. roads) (any OMH left is ≤ 0.25 ha)	Remove OMH	Lost to development

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[5] No sites, which are not polygons of a multiple site

11) Polygon includes clear 'new' development (inc. roads), but OMH left is ≥ 0.25 ha	Retain OMH with clear boundary change	Lost to development
Other land uses		
12) Polygon is partially in PHI 'Calaminarian Grasslands' layer	Retain OMH with uncertainty	Calaminarian Grassland
13) Polygon is fully in PHI 'Calaminarian Grasslands' layer	Remove OMH	Calaminarian Grassland
14) Polygon is partially or fully in OS greenspace layer (or clearly amenity greenspace i.e. paths visible) AND bare ground or short vegetation is now no longer present (beyond paths)	Retain OMH with uncertainty	Amenity use
15) Polygon has some OMH elements remaining, but land use has largely changed. Includes sports pitches, farmland, parkland & scrap yards	Remove OMH	Land use change
16) Polygon is largely OMH, but may have temporary features that suggest a change in land use that is not permanent e.g. vehicle storage	Retain OMH with uncertainty	Land use change

3.10   In some cases, it may be that a boundary change is recommended, that, if implemented, would result in the new polygon of OMH being less than 0.25ha. Based on the above rules, these sites should be removed. However, there is ongoing research that suggests sites smaller than 0.25 ha are still important as stepping stones (Chris Hogarth *pers. comm.*).

3.11   There is an argument that all polygons currently in the OMH layer previously supported more than 0.25ha of OMH, and that despite their current small area they should be retained due to the importance of the habitat. However, this would mean that many polygons with only the tiniest area of OMH would be retained. As a result, we have still included some polygons with less than 0.25 ha in the "Remove OMH" category.

3.12   In addition, some polygons within the original OMH layer are less than 0.25ha, due to multiple smaller polygons being present at one site.

Therefore, whilst 0.25ha remains a criterion for any new polygons created, it serves as a guide only for the Review Rules, to avoid the loss of any OMH unnecessarily.

3.13 Table 2, along with Figure 1 and Figure 2, show some examples of polygons examined using the Review Rules to help inform the process.

Table 2: Description of each example polygon with their relevant outcome under the review rules.

Example polygons	ID	Description	Outcome Category (GIS Field 1)	Justification Category (GIS Fields 2-10)
A	0102:0010398	Appears to be an industrial site part of contiguous block. Less than 0.25 ha in size.	Remove OMH	Small size
B	0102:0008399	Some of site now developed. Remaining OMH is less than 0.25ha.	Retain OMH with clear boundary change	Small size
C	0102:0008405	Smaller site with encroaching vegetation around infrastructure. Small parcel of OMH in centre but less than 0.25 ha.	Remove OMH	Lost to vegetational succession
D	0102:0008402	Some areas of site lost to succession. Open water and bare ground remains in patches.	Retain OMH with uncertainty	Lost to vegetational succession
E	0102:0034255	Site is almost entirely trees, with small patches of bare ground and grassland likely to be attached to dwellings/amenity use.	Remove OMH	Lost to canopy cover
F	0102:0015900	Some areas of the site with clear successional changes. Mature scrub and trees now likely present.	Retain OMH with clear boundary change	Lost to canopy cover
G	0102:0015956	Site partially lost to development. Some evidence in remaining area of site of OMH, with scattered scrub encroaching.	Retain OMH with clear boundary change	Scrub assessment required

Example polygons	ID	Description	Outcome Category (GIS Field 1)	Justification Category (GIS Fields 2-10)
H	0102:0010262	Site has increasing levels of open water (from previous APGB to next) however it is not clear that this is present all the time.	Retain OMH with uncertainty	Open water
I	0102:0129345	All three previous APGB images show large expanse of open water in the centre of polygon. OMH around the edge of the water remains.	Retain OMH with clear boundary change	Open water
J	0102:0008755	New housing estate with some amenity greenspace alongside roads.	Remove OMH	Lost to development
K	0102:0008427	Railway lines. Portion to the north of the polygon has been developed.	Retain OMH with clear boundary change	Lost to development
L	0102:0008946	Polygon contains parts listed as Calaminarian Grassland listed as a secondary habitat. Remaining habitat appears to be OMH.	Retain OMH with uncertainty	Calaminarian Grassland
M	0102:0020554	Site is entirely listed within area identified as Calaminarian Grassland (main habitat listed).	Remove OMH	Calaminarian Grassland
N	0102:0044767	Site appears to be a park but is listed in Google as Ham Lands Nature Reserve.	Retain OMH with uncertainty	Amenity use
O	0102:0084572	Polygon appears to be a horse paddock. Improved grassland, therefore, not OMH.	Remove OMH	Land use change

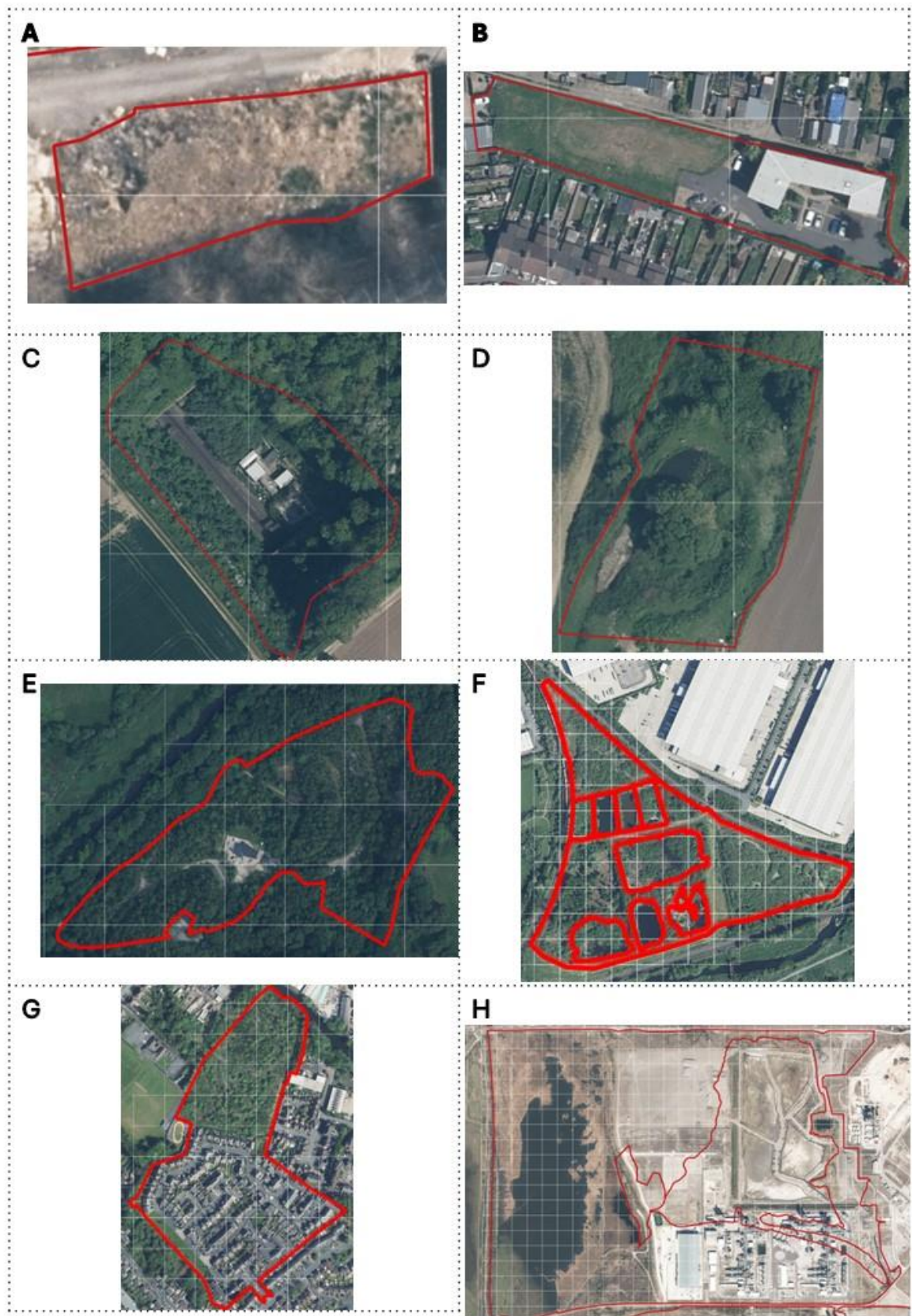| Example polygons	ID	Description	Outcome Category (GIS Field 1)	Justification Category (GIS Fields 2-10)
P	0102:0053798	Quarry site. Polygon has clear areas of OMH and meets initial criteria. Upon 2nd phase it is possible polygon could be extended to include surrounding areas that appear to be OMH.	Retain OMH	OMH present

Figure 1: Examples of polygons reviewed under the review rules (A-H) as described in Table 2.
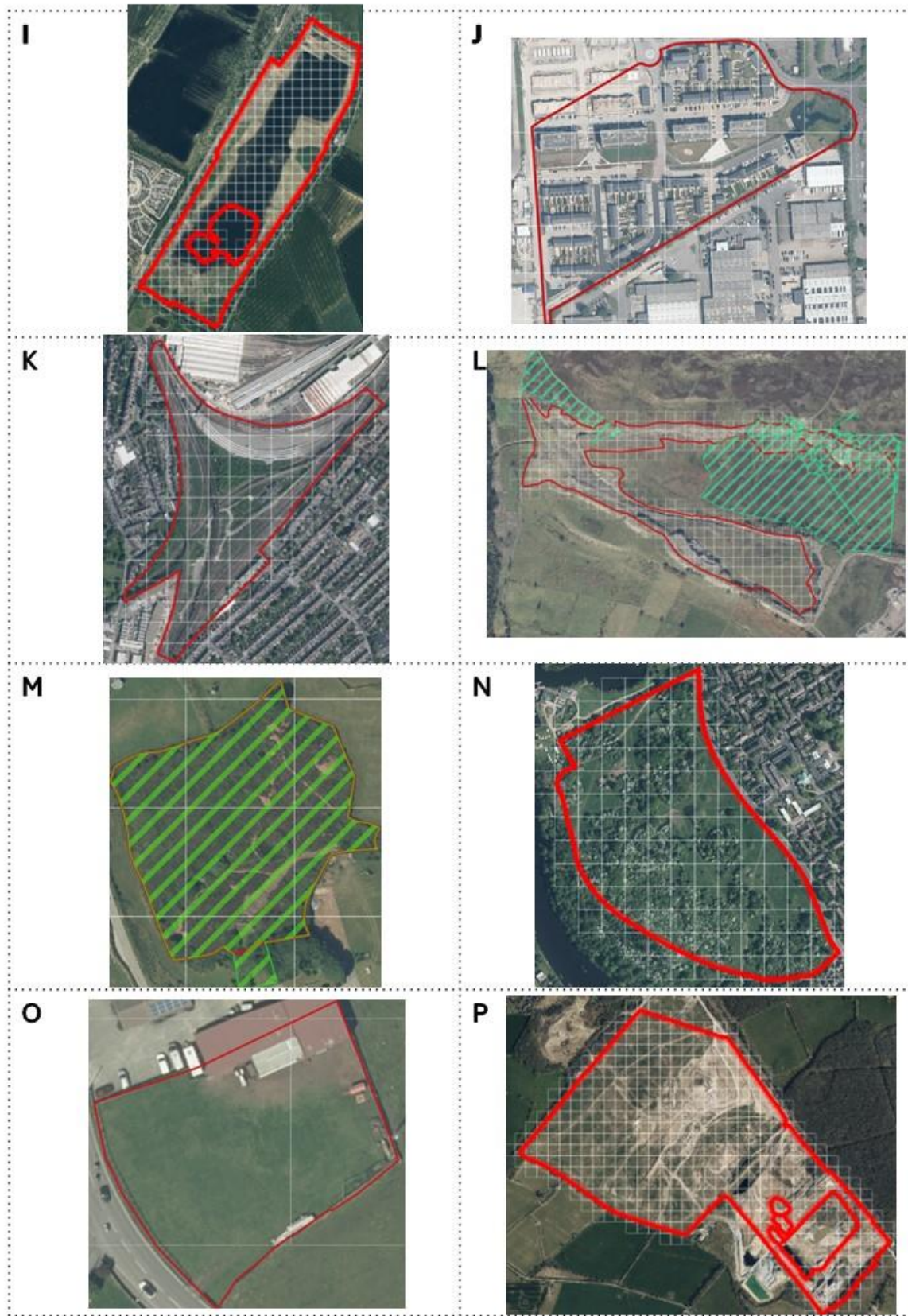
Figure 2: Examples of polygons reviewed under the review rules (I-P) as described in Table 2.

Notes

3.14   Additional notes were recorded in Field 11. These consist of a free text field of any important notes about the polygon assessment or justification for the outcome.

Retained information

3.15   All fields from the original OMH GIS were retained for completeness.

3.16   One of these fields contains the primary and, where relevant, secondary sources used originally to classify the site as OMH. As discussed in the original 2013 methodologies earlier, some sites were identified by partner organisations (see sources in Table 3). Some of these organisations own and manage these sites as OMH for nature conservation, and furthermore originally identified these with a high level of confidence via field surveying. The sources which we believe involved field surveys are also highlighted in Table 3.

3.17   However, some sites previously identified by partner organisations as OMH in 2013 may no longer meet the OMH criteria but could still support OMH if managed appropriately. We retain the information about primary and secondary sources so that this can be considered in the context of the results of the 2024 screening.

Table 3: Summary of the original 2013 sources of data, including partner organisations that provided original OMH data. Note that these are a best guess at which sites were field surveyed.

Sources used in original OMH assessment	Field surveyed sites?
British Geological Survey BritPits database	✗
Butterfly Conservation Dingy Skipper data	✓
National Land Use Database - Previously Developed Land	✗
Environment Agency Historic Landfill Sites	✗
Buglife All Of A Buzz Data	✓
UK Perspectives Aerial Photography	✗
Staffordshire Wildlife Trust OMH data	?
Walsall Council Brownfield Sites	✗
www.conopsentomology.co.uk/conopsentomology.co.uk/West_Midlands_aculeate_sites_list.html[6]	?
Dudley MBC - Inventory Review	?
Stoke on Trent City Council - Inventory Review	?
OMH Survey 2012	?
INCA - Inventory Review	?
www.friendsofradstockrailwayland.org	?
Lee,P. - A report on a survey of the invertebrates of the HMS Ganges site, Shotley, Suffolk	✓

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[6] Updated link at http://www.conopsentomology.co.uk/west-midlands-aculeate-database/

4. Results of the OMH screening

4.1   All 8,410 polygons within the 2013 OMH layer were manually assessed using aerial photography. A total of 86 polygons had no APGB data from any year, and therefore a combination of Google / Bing Satellite imagery were used for these polygons. The polygons were identified within the 'Notes' column of the output GIS layer.

4.2   The headline results following our Review Rules screening (outcome) are presented below in Table 4 and given spatially in Map 2. Approximately a third of all polygons have been retained (with no uncertainty) and remain entirely as OMH habitat (2,897, 34%). This increases to almost two-thirds of all polygons assessed when considering those retained with a clear boundary change (2,553, 30%). However, a quarter of all polygons assessed were identified as suitable for deselection from the OMH layer (2,086, 25%).

Table 4: A summary of the results of the Review Rules, stating the number of polygons within each outcome category.

Outcome	Number of polygons
Retain OMH	2,897 (34%)
Retain OMH with clear boundary change	2,553 (30%)
Retain OMH with uncertainty	874 (10%)
Remove OMH	2,086 (25%)

4.3   Map 2 shows that many clusters of polygons that no longer support OMH are around cities (London, Birmingham, Manchester and Liverpool). Similarly, polygons where a clear boundary change is required also appear to be more clustered around the edges of cities. In contrast, the Peak District appears to be an area where OMH habitat has changed little and where many polygons have been retained.

4.4   The frequency of the different reasons for the outcomes of the screening are summarised in Table 5. It is important to note that for each individual polygon there may be multiple reasons for boundary

changes or deselection, thus resulting in higher total polygons counts. Overall, just over 1 in 10 OMH polygons had more than 1 reason (13%) for a boundary change. For most polygons, reasons for boundary changes related to full or partial loss of OMH to development (1,986 polygons, 36% of all polygons removed or to be retained with a boundary change or uncertainty), the full/partial loss of OMH to canopy cover (1,723 polygons, 31%) and the full/partial loss of OMH to vegetational succession (1,242 polygons, 23%).

4.5   Similarly, of the 2,086 OMH polygons that were identified as suitable for removal, 15% had more than one reason for removal. The most frequent reason was the loss of OMH to development (1,322 polygons, 63%), the next most common reason was loss to canopy cover (277 polygons, 13%).

4.6   Of the 874 OMH polygons that were identified as suitable for retention but with uncertainty, most were placed in this category due to ambiguity around the amount of bare ground and/or short vegetation present (as deduced from the aerial imagery). For around half of all OMH polygons, the reason was loss to vegetational succession (420 polygons, 48%). The next most common reason was changes in land use (255 polygons, 29%), often to amenity greenspaces or, more infrequently, derelict land (i.e. old scrap yards) or low intensity pasture.

4.7   From the 2,553 polygons that were to be retained as OMH, but with a boundary change required, over half require a boundary change due to increase in canopy cover (52%, 1,332). This usually relates to expanding woodland fringes or an encroaching hedgerow. However, it should also be noted a quarter of the polygons requiring a boundary change were due to redevelopment (25%, 637).

Map 2: Outcome of the Review of Open Mosaic Habitat on Previously Developed Land
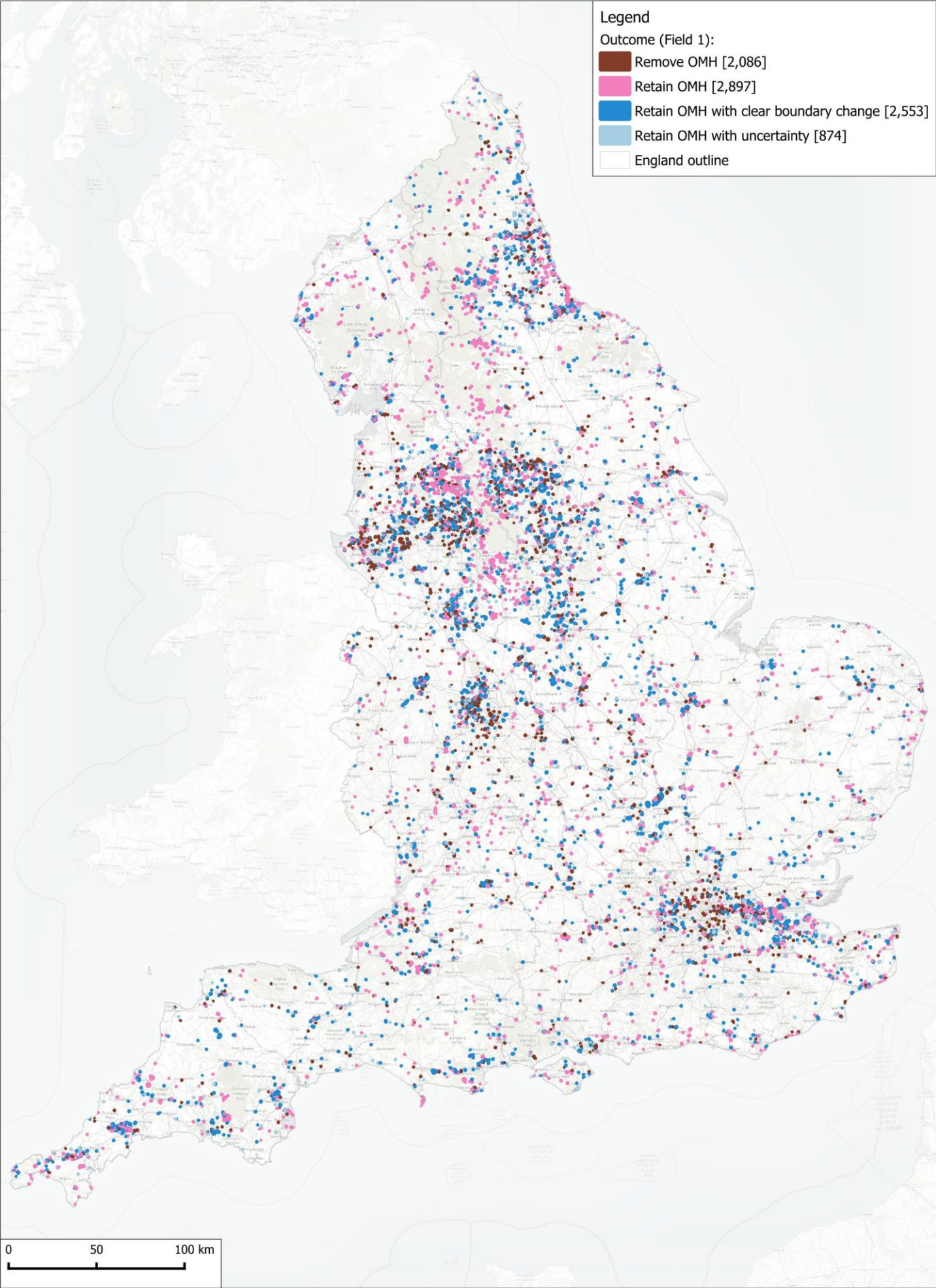
Legend

Outcome (Field 1):

- Remove OMH [2,086]
- Retain OMH [2,897]
- Retain OMH with clear boundary change [2,553]
- Retain OMH with uncertainty [874]
- England outline

0   50   100 km

Table 5: A summary of the frequency of the different reasons for the outcome of the screening. Note more than one reason can be given for each polygon. Percentages give the number of polygons assigned to a justification as a percent of all sites within that screening outcome category. Red text highlights the most cited reason for each screening outcome.

	Retain OMH with uncertainty	Retain OMH with clear boundary change	Remove OMH
Small size	4 (0%)	2 (0%)	171 (8%)
Lost to vegetational succession	**420 (48%)**	545 (21%)	277 (13%)
Lost to canopy cover	32 (4%)	**1,332 (52%)**	359 (17%)
Scrub assessment required	106 (12%)	46 (2%)	8 (0%)
Open water	7 (1%)	209 (8%)	31 (1%)
Lost to development	27 (3%)	637 (25%)	**1,322 (63%)**
Calaminarian Grassland	12 (1%)	7 (0%)	4 (0%)
Amenity use	66 (8%)	24 (1%)	71 (3%)
Land use	255 (29%)	136 (5%)	183 (9%)
Number of polygons	**874 (100%)**	**2,553 (100%)**	**2,086 (100%)**
Total number of reasons	**929**	**2,938**	**2,426**

Discussion of Review Rules as a process

4.8   During the review some polygons were clearly more difficult to assess than others. The greatest uncertainty related to the degree of vegetational succession and whether bare ground and/or short vegetation still persisted. One of the main issues from examination of the aerial imagery was the seasonality between years, i.e. images were taken at different times of year, so apparent changes may be due to seasonal variation rather than a change in habitat. Where the habitat appeared to have changed radically, with clear bare ground and short vegetation present only a year or two earlier, these polygons were 'Retained with uncertainty', due to this degree of doubt.

4.9   In some polygons with bare ground and short vegetation clearly present there were still some issues related to land uses. On farmland (mostly low intensity pasture/rough grassland and very occasionally fallow arable areas) confirmation of the presence of OMH became difficult as an apparent short sward and frequent bare ground are potentially as result of management and the degree of cultivation of the soil in arable areas. Examination of the historic aerial imagery showed in these instances that the polygons usually appeared to be under the same land uses at the time of the previous categorisation. In most cases these polygons were 'Retained with uncertainty' but marked as farmland in the 'Notes' column. The exception to this general rule was any obvious current arable, with sown crops. These polygons were removed, either completely or with a clear boundary change.

4.10   Other land use types found within polygons that were also dependent on the exact management of the area included scrap yards and quarries. Polygons with bare ground/hard standing that appeared well used with little vegetation present, or used for storage purposes, were removed. However, polygons with yards or quarries that had sparse short vegetation around the edges, or intermittently throughout were retained as OMH. A boundary change is suggested for any such polygons where only part is now OMH.

4.11   There were a number of other less common land uses where although some elements of OMH may persist, overall it was considered incorrect to record the whole area as OMH. These included solar farms, golf courses, cemeteries, allotments and covered reservoirs.

4.12   Finally, during our review we discovered some new potential OMH sites that were immediately adjacent to the current OMH polygons. These were often in an urban context where redevelopment sites become larger over time, or extraction sites which also became larger over time. These sites could be readily included in the future OMH data by looking at existing sites.

4.13   Overall, the polygons were assessed consistently with few known discrepancies between outcomes. Difficult polygons were assessed by other members of the team to provide a second opinion in addition to the use of other aerial photography sources (as outlined in our methods). For the most part, the outcome of the polygon review was clear, particularly where one habitat or factor (e.g. development) dominated the entire polygon. For this reason, we are confident with our recommendations for the retention or otherwise of polygons within the original OMH layer to create an updated layer.

5. Review of Data Capture Rules

5.1 The need to update the Data Capture Rules was acknowledged by Lush and Lush within the original Rule Base. To inform any subsequent, in-depth revisiting of the whole OHM GIS layer which would capture new sites and revise the site boundaries, we review the 2013 Data Capture Rules here and discuss potential new datasets or approaches.
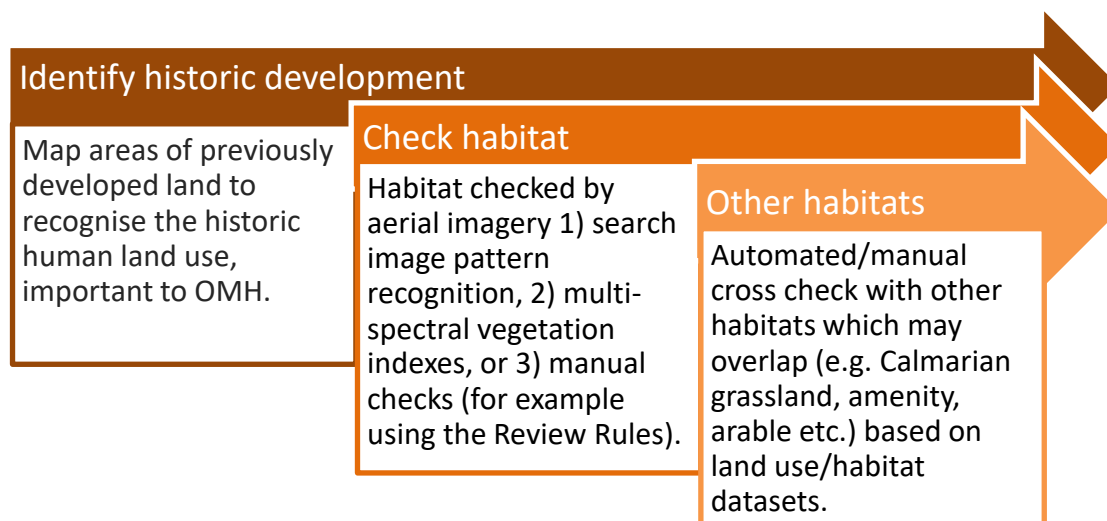
Data Capture Rules Recommendations

5.2 The current Data Capture Rules are mentioned earlier in para 2.4. We believe that the previous data capture rules were largely fit for purpose, and we consider that few changes to the rules are required. However, our review has raised some issues that should be addressed when the OMH dataset is updated.

5.3 We suggest that multipart polygons would be useful to indicate individual sites that contain more than one OMH polygon. Previously some sites, often smaller ones, included several individual polygons. These were often smaller than the 0.25 ha requirement but were presumably included as they were clearly fragmented parts of a larger site (e.g. sites divided by tracks, small areas of parking, or open water). We suggest that these should be mapped as a single multipart polygon to recognise they are all part of one "site" and would therefore be included in the GIS layer as a single row.

5.4 In addition, our review raises the question of the inclusion of some sites that have clear amenity use. These sites may still support OMH, but this is dependent on the exact management (i.e. mowing, the use of fertilisers/pesticides etc.) and potentially also the degree of visitor pressures on these amenity areas. It is hard to assess the appropriateness of including these sites without visiting them and understanding their management. It is suggested that this issue should be investigated further to develop a rule for how to treat these types of sites.

5.5   Similarly, based on examination of the aerial imagery, some polygons appear to be pasture or arable land that nonetheless meet some of the criteria for OMH. For example, polygons with clear topographical variation with patches of bare ground and early scrub cover e.g. bunkers. As with the amenity land uses discussed above, their appropriateness is dependent on the site management such as the intensity of grazing regimes and other associated land uses. We suggest that further investigation of such sites is undertaken to better understand the interventions that allow these conditions to persist and whether these sites are really OMH.

5.6   Finally, we recommend that archived versions of the datasets are always kept, including the original 2013 dataset and any subsequent versions. This will allow tracking of the state of OMH over time and retain the potential for restoring former OMH sites should opportunity arise.
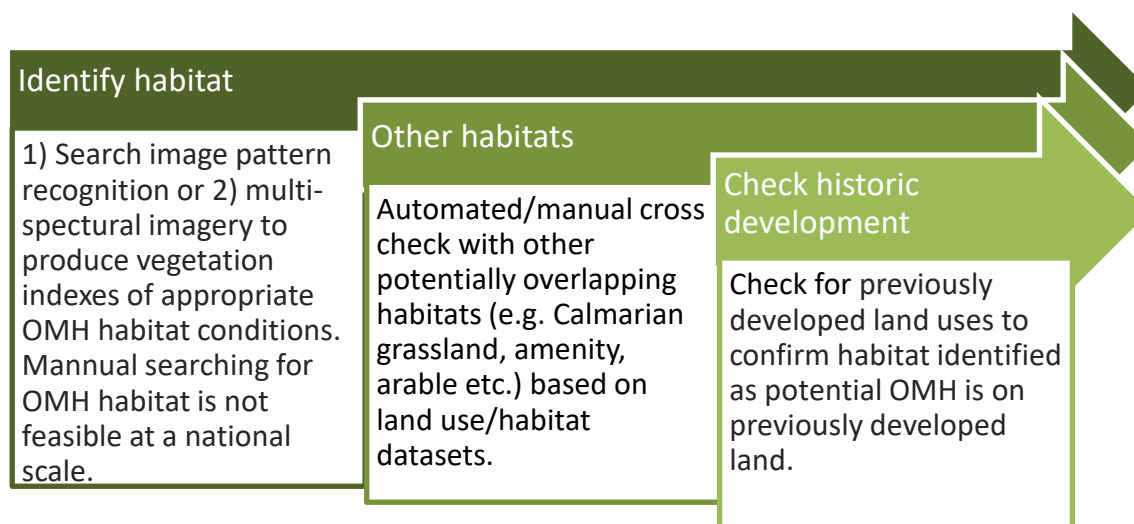
Alternative data sources

5.7   The main concern for any future attempts to capture all OMH habitat will be finding appropriate data sources to use. The datasets required will depend on the approach taken to recognise the OMH habitat and we see that there are two ways to go about this. Either (1) checking for relevant previous land uses and then checking for appropriate habitat conditions – see Figure 3, or (2) looking for appropriate habitat conditions and then checking for previous land uses – see Figure 4.

5.8   The approach used for the 2013 dataset was primarily led by the previous land use, relying on exisiting datasets that recognise relevant historic land uses (i.e. brownfield, gravel pits, land fills), supported with other novel datasets. However, we suggest that there is the potential to start with a habitat led approach, looking for suitable OMH habitat nationally using pattern recognition and vegetation indices. This approach will require complex GIS abilities and advanced machine learning - the extent to which this is the most suitable or cost-effective approach is open to discussion.

Identify historic development

Map areas of previously developed land to recognise the historic human land use, important to OMH.

Check habitat

Habitat checked by aerial imagery 1) search image pattern recognition, 2) multi-spectral vegetation indexes, or 3) manual checks (for example using the Review Rules).

Other habitats

Automated/manual cross check with other habitats which may overlap (e.g. Calmarian grassland, amenity, arable etc.) based on land use/habitat datasets.

Figure 3: Historic land use led approach.

Identify habitat

1) Search image pattern recognition or 2) multi-spectural imagery to produce vegetation indexes of appropriate OMH habitat conditions. Mannual searching for OMH habitat is not feasible at a national scale.

Other habitats

Automated/manual cross check with other potentially overlapping habitats (e.g. Calmarian grassland, amenity, arable etc.) based on land use/habitat datasets.

Check historic development

Check for previously developed land uses to confirm habitat identified as potential OMH is on previously developed land.

Figure 4: Habitat led approach.

5.9   For each of the given approaches outlined in Figures 3 & 4 we would recommend that a pilot study, potentially in a built-up area where previously developed land is easily identifiable, is used to test the appropriateness of each method for finding new OMH. Additionally, the study could test various data sources (including any subsequently identified outside of this report) that will assist identification of new OMH.

5.10   We have given consideration to some of the potential data sources that may be appropriate below. These are summarised in Table 6, which also includes potential constraints in using the data.

Table 6: Summary of potential data sources that could be useful for identifying new OMH.

Dataset	Description	Contraints
Brownfield land registers	Individual local authorities provide up to date GIS boundaries for brownfield sites listed on data.gov [7] and as a collated dataset on the data.gov Planning Data Platform[8]. This dataset currently consists of 27,111 polygons, of which only 487 overlap with polygons in the existing OMH layer, and so this clearly recognises new sites.	Current understanding is that local authorities only have to keep these registers up to date for sites that are earmarked for development, and for some only residential development. Therefore, this is not an exhaustive list of sites and may only represent the last five years, not a complete list since the last iteration of the OMH.
Vacant and Derelict land	A Vacant and Derelict Land Register[9] exists for Scotland, a similar dataset could exist or be created for England. It is believed Forest Research is currently compiling a register of this title for the purposes of replanting (*Chris Hogarth pers. comm.*). If this registry becomes available, then these sites may also be suitable for direct use in the OMH layer.	Layer potentially not yet complete. Also, given that the list is being collated for the purposes of forest planting, it is possible that the derelict land may not remain as potential OMH for very long.
National land use dataset	Potentially has mapped Vacant and Derelict land that might be of use. The National Land Use Database of Previously Developed Land[10] was a main resource in the original data capture exercise.	Historic data, and no longer believed to kept up to date. Unclear if this dataset will ever be revisited and updated.

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[7] https://www.data.gov.uk/search?q=brownfield&filters%5Bpublisher%5D=&filters%5Btopic%5D=&filters%5Bformat%5D=&sort=best
[8] https://www.planning.data.gov.uk/dataset/brownfield-land
[9] https://www.gov.scot/publications/scottish-vacant-and-derelict-land-survey---site-register/
[10] https://www.gov.uk/government/collections/national-land-use-database-of-previously-developed-land-nlud-pdl

Dataset	Description	Contraints
Landcover map	Broadscale land cover in the UK is updated regularly (latest edition 2021[11]) and so any changes at a fine scale to the mapped urban and suburban classifications may be detectable.	The data is broadscale and therefore lacks the detail down to individual buildings. It is unknown whether the land cover map will detect demolition of buildings (that become brownfield sites) or whether these would still display as part of the urban/suburban environment.
OS Vector datasets	Ordnance Survey vector data recognises the outline of buildings, and a comparison between years in these outlines will highlight the demolition of buildings and potential new OMH. This can also be used to find new redevelopment which may have removed OMH.	Not necessarily clear in built-up areas, where building footprints often change very slightly between years. Also, derelict land with important OMH habitat where buildings have been retained may not be recognised as a change.

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[11] https://catalogue.ceh.ac.uk/documents/017313c6-954b-4343-8784-3d61aa6e44da

Dataset	Description	Contraints
Landfills and gravel pits etc.	The Environment Agency maintains a dataset of historic landfill sites[12] (used in 2013) and current authorised landfills[13], the latter of which is noted to recognised new OHM sites. The Britpits dataset of mineral sites[14] was used in the original data capture exercise. The latest version contains 230,000 entries including historic sites, active mines/quarries, but also major mineral handling sites (i.e. wharfs and rail depots).	Britpits dataset contains subterrain mines and oil/gas wells which may be less applicable.
Other historic land use datasets	Other historical features may also be suitable for OMH. Features which have a cultural importance, such as wartime airfields[15] and disused railways[16] are often mapped and we noted new potential OMH sites. Some local authority archaeological departments can have comprehensive records which could be filtered and collated.	These datasets may not be mapped as polygons or mapped in GIS at all. They can also be locally specific rather than a UK wide dataset. In addition, most "historic" sites are often too long for OMH conditions to still be present (i.e. many of the oldest airfields and railways are closed canopy woodland).

[12] https://www.data.gov.uk/dataset/aa35a23f-f837-4d94-a91d-35b7cc14de38/historic-landfill-sites-quarterly-summary
[13] https://www.data.gov.uk/dataset/ad695596-d71d-4cbb-8e32-99108371c0ee/permitted-waste-sites-authorised-landfill-site-boundaries
[14] https://www.bgs.ac.uk/datasets/britpits/
[15] https://www.abct.org.uk/
[16] https://www.railmaponline.com/UKIEMap.php

Dataset	Description	Contraints
Aerial photography (RGB)	There are two ways in which standard RGB photography could be used to examine for OMH features (i.e. bare ground and short vegetation): **A manual approach**, as conducted for this report, can be used to look for sites. However, **an automated approach,** has the potential to screen many more sites in the same time. There is the potential to base this on various exact approaches. Deep learning models are used to produce land cover classification (although more commonly on multispectral imagery) to classify areas of OMH. Alternatively, a pattern recognition approach would allow for simply determining the presence of features (i.e. probable bare ground and short vegetation) and can be done from this basic RGB imagery.	**A manual approach** can only be conducted as the second step (i.e. Figure 3). It is time consuming when considering a large pool of potential sites. **An automated approach** could be conducted as the first step of a new OMH assessment (i.e. Figure 4), however the computational effort required would be substantial. This approach would likely be best suited to the second step (i.e. Figure 3), where it would replace manual approaches of aerial photography. However, the cost-effectiveness of this automation, particularly of a pattern recognition, compared to a manual assessment is unclear.

Dataset	Description	Contraints
Aerial multispectral imagery	Automated approaches using deep learning models would be able to examine multi-spectral imagery and classify OMH habitats or the components within these, such as areas of bare ground and short vegetation. Discrete signals would be produced from different micro-habitats based on their different light reflective properties of multi-band imagery. There are companies which have pretrained models which can conduct land cover classifications from aerial imagery (however it is likely that a generic classification would not work for this requirement).	The multi-spectral imagery required to conduct this analysis would need to be of very fine scale to be able to the subtle habitat differences in an OMH (i.e. recognising small patches of scattered bare ground). This data is not widely present across the whole country to use this as the first step (i.e. Figure 4). However, it is also unlikely that it would not be possible to obtain this kind of data as a check to a selection of screened sites if used as the second step (i.e. Figure 3). Furthermore, a complex modelled approach may require a seasonal composite image and also require other context dataset (i.e. a DEM) to assist in a more accurate result.

| Dataset	Description	Contraints
LiDAR	LiDAR has the potential to be used in two ways; 1) to detect the historic land uses, or 2) recognise the OMH conditions. 1) LiDAR can be used to detect earthworks and historic features (see Cannock example[17]). This acts as another means of recognising poorly understood sites and helping to indicating previous anthropogenic land uses. 2) In addition, the difference between surface models and terrain models can be used to quantify the vegetation height to examine if the bare ground and sparse vegetation required for OMH is present.	LiDAR is overall unlikely have much added value in terms of recognising historic features, as the most obvious features will already be recognised. It would however help identify where sites with the potential for restoration to OMH are (i.e. WWII structures). For both these approaches a high level of resolution is required, particularly for understanding small differences in vegetation. The availability of this data would be a concern, as national coverage at this resolution is not necessarily available. Furthermore, a significant element of GIS processing would be required.

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[17] https://historicengland.org.uk/research/current/discover-and-understand/landscapes/cannock-chase/

5.11   For some of the above data sources there are some availability issues, particularly at finer scales. However, datasets are continually being updated and refined, and therefore by the time the OMH layer is revisited, the availability of the data will have changed.

5.12   Furthermore, not all of these datasets may be publicly, or freely available. Consideration should therefore be given to the cost of the analysis using these datasets to produce the required outputs.

5.13   This report has scoped out future work, providing a series of recommendations for updating the current OMH GIS layer, using repeatable, transferable and concise rules to review the individual polygons. Building on the previous report by Lush & Lush (2013) it is clear that the definitions and general guidance given for identifying OMH has changed little over time. However, the datasets previously used are largely no longer updated or available, requiring new and potentially innovative new methods to conduct the next phases of this work.

Appendix 1: Flow chart of Review Rules
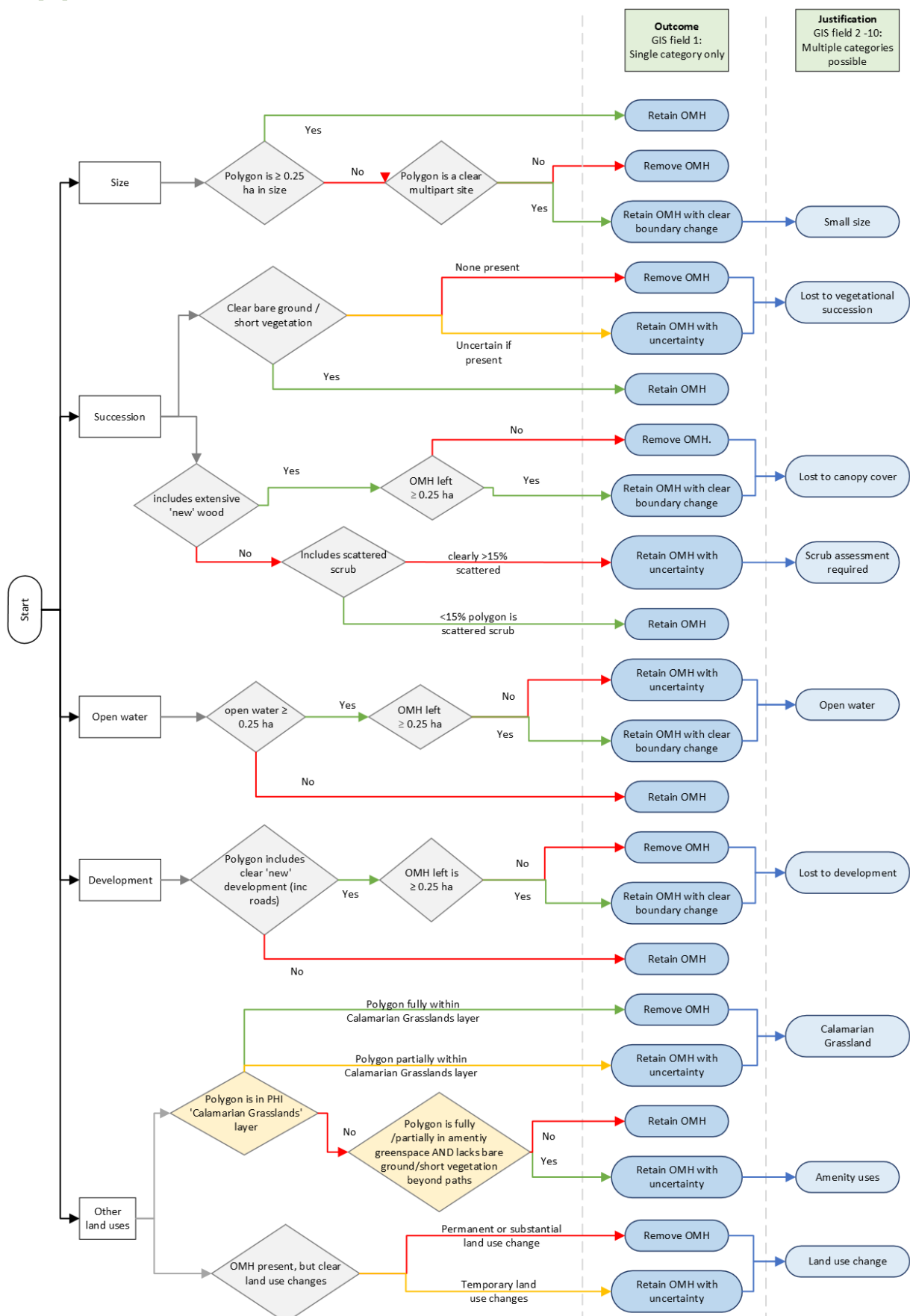
Appendix 2: GIS field names

	Abbreviation	Full name
1	Field 1	Outcome (Overall decision)
2	SmallSize	Justification (Small size)
3	VegSuc	Justification (Lost to vegetational succession)
4	Canopy	Justification (Lost to canopy cover)
5	ScrubAsses	Justification (Scrub assessment required)
6	OpenWat	Justification (Open water)
7	Develop	Justification (Lost to development)
8	CalMinGr	Justification (Calaminarian Grassland)
9	Amenity	Justification (Amenity use)
10	LandUse	Justification (Land use change)