Change Detection Specification for Ground Data Collection

December 2022

NOTE: This document has been produced during survey planning and will be updated following a pilot phase.

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1 Introduction

The Living England (LE) and Change Detection (CD) projects, led by Natural England, are multi-year programmes delivering satellite-derived national habitat maps and assessment of habitat change in support of the Defra Environmental Land Management (ELM) System and the Defra Natural Capital and Ecosystem Assessment (NCEA). Living England uses a machine learning approach to image classification, developed under the Defra Living Maps project (Kilcoyne *et al.*, 2017). The method first clusters homogeneous areas of habitat into segments, then assigns each segment to a defined list of habitat classes using a Random Forest classification model (a machine learning algorithm). Through Phases I-IV (2018-2022) the LE project has undergone a number of iterations to develop the methodology and in Phase IV has released a habitat classification under an Open Government Licence (OGL). Phase V (2022-23) aims to standardise the methodology used in the classification to enable habitat change between iterations of the LE habitat maps to be assessed within the CD project, and Phase VI (2023-24) will implement the agreed standardised methods. The LE team intend to publish updated maps every two years with a CD assessment published in the intervening years to provide evidence as part of the Natural Capital Ecosystems Assessment (NCEA) classifying the distribution, extent and change in England's natural capital assets.

The NCEA is a transformative programme to understand the extent and condition of England's terrestrial and marine environmental assets over time, supporting the government's ambition to improve the environment within a generation.

To accommodate the phenological and habitat variation across England and to facilitate the acquisition of cloud-free image mosaics, LE divides England into 14 Biogeographic Zones (BGZs, Figure 1).

While the LE output is primarily derived from satellite data, the LE methodology does not in any way replace the need for field survey. It is a tool which requires input of recently captured field data to inform a classification model, allowing for the revision of habitat data at a national scale. The production and improvement of the map would not be possible without the regular provision of high-quality robust field survey data to train the model and carry out the model validation.

This document describes and supports the field data collection method that should be used for recording CD ground data points, using a mobile device and the ArcGIS Field Maps app (Esri, 2022).

For any enquires about this guidance or the LE or CD projects, please contact Natural England's Living England enquiries mailbox:

livingenglandenquiries@naturalengland.org.uk

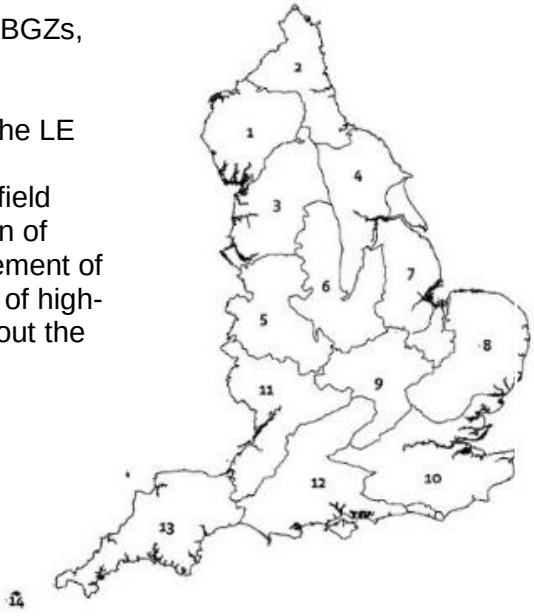


Figure 1: Biogeographic Zones

2 Habitat Types

2.1 LE and CD follow the UK Biodiversity Action Plan (UKBAP) classification framework with some adjustments, as shown in Table 1 (JNCC, 2011). The UKBAP habitat classification enables the habitat classification framework used by LE and CD to be published under an OGL.

2.2 The **LE UKBAP NCEA Classification Framework (2022) Vs2** sets out the relationship between ecosystems, broad and priority UKBAP habitats, and the "Broad" and "Detailed" LE Classification.

2.3 In most cases, Detailed LE habitats equate to the broad UKBAP level. Exceptions are introduced where classes can or cannot be confidently mapped in relation to the resolution of Sentinel-1 and Sentinel-2 satellite imagery. These include:

2.3.1 Acid, Calcareous, Neutral Grassland is a combined class equivalent to Semi-natural Grasslands at the ecosystem level.

2.3.2 Coastal Sand Dunes and Coastal Saltmarsh are mapped at the higher resolution priority habitat level.

2.3.3 Segments labelled as 'Unclassified' typically indicate locations where cloud-free satellite imagery was not available or where urban areas are misclassified as cloud.

2.3.4 Living England currently combines Inland Rock and Bare Soil/Peat into Bare Ground.

Table 1: Phase IV LE UKBAP habitat classification framework

Broad Habitat	UKBAP Level	Ecosystem Habitat
Acid, Calcareous, Neutral Grassland	Semi-natural Grasslands	Grassland
Arable and Horticultural	Broad	Cropland
Bare Ground	EO Resolution	Bare Ground
Bare Sand	EO Resolution	Bare Ground
Bog	Broad	Wetland
Bracken	EO Resolution	Grassland
Broadleaved, Mixed and Yew Woodland	Broad	Woodland
Built-up Areas and Gardens	Broad	Urban
Coastal Saltmarsh	Priority	Coastal
Coastal Sand Dunes	Priority	Coastal
Coniferous Woodland	Broad	Woodland
Dwarf Shrub Heath	Broad	Heath
Fen, Marsh and Swamp	Broad	Wetland
Improved Grassland	Broad	Grassland
Scrub	EO Resolution	Woodland
Water	EO Resolution	Freshwater
Unclassified	-	Unclassified

2.4 To improve the validation of the change maps using ground data collected for LE and CD, a higher level of habitat resolution than UKBAP priority habitat level is also collected using the European Union (EU) Habitats Directive Annex 1 habitat classification framework (EU, 2013) and species indicator lists for each of the LE broad habitats.

2.4.1 Descriptions of UKBAP Broad habitats, UKBAP Priority habitats (UK BAP Priority Habitats | JNCC - Adviser to Government on Nature Conservation) and EU Habitats Directive Annex 1 habitats are within the provided information pack. The Baseline Evaluation of Higher Tier Agreements (BEHTA) manual (Natural England, 2016) will aid defining the percentage cover of positive indicators for a range of habitat classes. An abridged BEHTA Grassland Key is suggested for gauging differentiation between improved and semi-natural grassland habitats (Improved Grassland and Acid, Calcareous and Neutral Grassland LE habitat classes).

2.4.2 Specific queries about where certain habitats fall under the adjusted LE UKBAP classification framework, with information about how to record them at UKBAP priority habitat and EU Habitats Directive Annex 1 level, are provided in Table 7 in Annex 3.

2.5 All habitats require ground data collection for CD validation focusing on those habitats which are likely to have changed in the past two years or may change in the next two years.

2.5.1 Habitat data is summarised in Table 2 by a “Ground Data Accepted” and “Ground Data Required” tick to indicate the priority habitats to be collected.

Table 2: LE Broad habitats required for ground data collection

	LE Broad Habitat	Ground Data Accepted	Ground Data Required	Justification
1	Arable and Horticultural	✓	✗	Only if the area has changed from or to
2	Bare Sand	✓	✓	
3	Bare Soil/Peat	✓	✓	
4	Bog	✓	✓	
5	Costal Sand Dunes	✓	✓	
6	Coastal Saltmarsh	✓	✓	
7	Dwarf Shrub Heath	✓	✓	
8	Fen, Marsh and Swamp	✓	✓	
9	Acid, Calcareous and Neutral Grassland	✓	✓	
10	Improved Grassland	✓	✓	
11	Inland Rock	✓	✓	
12	Bracken	✓	✓	
13	Scrub	✓	✓	
14	Built-up Areas and Gardens	✓	✓	
15	Water	✓	✗	Separate LE algorithm
16	Broadleaved, Mixed and Yew Woodland	✓	✓	If area has/likely to change
17	Coniferous Woodland	✓	✓	If area has/likely to change

Please note – before continuing you will need an ArcGIS Online account (for more information please see Section 4.1).

3 Planning Your Survey

3.1 To optimise the usefulness of the ground data for CD, surveys should be targeted at the habitat classes in each BGZ which have changed in the past 2 years or likely to change in the next two years. Please note that BGZ14 (Isles of Scilly) is merged with BGZ13 for the LE classification and does not require points to be collected.

3.2 The total number of points to be collected is 6500 and should be distributed as equally as possible across all habitats and change classes. Where this is not possible or certain change classes have all been collected, this should be reported to the CD team during regular meetings and reporting.

3.3 Detailed priority areas and habitats for survey may be supplied by the CD team throughout the year as the change detection methodology and habitat change maps are investigated for errors or areas of low confidence. These specific areas and habitats should be a priority for surveyors as they have the potential to significantly improve the CD classification in future iterations.

3.4 Where possible, surveys should take place within the main growing season or productivity period for each habitat. For ease of identifying deciduous habitats such as broadleaved woodlands or semi-natural grasslands, plan the survey when vegetation is (as far as possible) in full leaf or before grasses are starting to fall over. However, where ecologists are confident (can identify the classes out of season and correctly measure the percentage cover of the segment), data may be collected at any time of year. This is particularly the case for upland habitats and will help manage surveys to coincide outside game management periods. The **Field Survey Calendar** has been developed to help identify when certain habitats should or should not be surveyed.

3.5 The spatial framework for the LE classification, and thus CD outputs, is based on a segmentation process using Sentinel-2 satellite imagery. This process groups together pixels of similar spectral appearance into polygons, which are referred to as “segments” and should approximately relate to homogenous stands of vegetation on the ground. These segments are classified by the LE modelling process, and each is assigned the most likely LE habitat class. Examples of LE segments are shown in Annex 1. These segments provide the basis for areas of change to be identified. Some whole segments may have changed, or sub-segments.

3.6 Use the **CD Quick Start Guide to Ground Data Collection** as a guide for how to identify which habitats are under-recorded in each BGZ, plan the CD surveys, and obtain access permissions for CD surveys.

3.7 The **CD Ground Data Dashboard** should be used to identify the current distribution of data points recorded using ArcGIS Field Maps, and plan new surveys accordingly to target regions or habitat change types which are under-represented. Further details on the dashboard are provided in Annex 2.

3.8 It is essential to ensure you have permission from landowners and tenants to visit the site and to record data for CD, that all necessary risk assessments have been completed, and that you are in compliance with all health and safety requirements, including for lone working if appropriate. If you are planning to survey a new area, you must use the **Living England Access Permission Letter** to ensure LE and CD can continue to be released as an OGL product and data used for other mapping products.

3.9 Prepare for your survey using the **Datasets listed below** (Table 3) to identify locations of where habitat change is likely to have occurred. These datasets should be used to help target habitats which have undergone recent (~2 years) change or are likely to change in the next 2 years e.g., if an area has planned management that will change the habitat class e.g., where farmers are being paid to plant on arable fields. Discuss regularly with the CD team who will update on habitats and locations to target for suspected change.

Table 3: Datasets to help identify areas of habitat change (all OGL)

	Dataset	Type of habitat change	Link
1	JNCC Landscape Monitoring App	Various	https://jncc.shinyapps.io/CUULandscapeMonitoring/
2	EA Priority Habitat Creation and Restoration	Various	Priority Habitat Creation and Restoration - data.gov.uk
3	National Moorland Change Map	Upland change	Defra Spatial Data Download
4	MoorLIFE 2000 Wildfires Log	Wildfires in the South Pennines and Peak District areas	https://www.wildfirelog.co.uk
5	Forestry Commission Planting and Felling Public Register	National Planting and Felling	experience.arcgis.com/experience/5dbc8a02c9234b0f91e73c3b89b54429/page/Page-1/
6	Ancient Woodland	Stable woodland	Ancient Woodland (England) | Natural England Open Data Geoportal (arcgis.com)
7	Conservation and Enhancement Scheme Agreements	Various	Conservation and Enhancement Scheme Agreements (England) | Natural England Open Data Geoportal (arcgis.com)
8	Midlands Heartlands Heathlands	Heathland creation in Midlands	Midlands Heartlands Heathland - Nature Recovery Opportunities Map | Natural England Open Data Geoportal (arcgis.com)

3.10 The CD survey method has been designed to collect additional plant indicator species to help identify true habitat change / control points at various stages.

3.11 CD ground data is captured in the field onto a mobile device (smartphone or tablet) using the ArcGIS Field Maps app (Esri, 2022). You must download and install “ArcGIS Field Maps” and configure it for use before going out on site (see Section 4 for details). Using the Field Maps app will make navigation to your survey points simple, as it uses your mobile device’s GPS and displays a map showing the LE segments and habitat classification, as well as high resolution satellite imagery. Data capture is then a simple form-based process (see Sections 4 and 5 for details).

4 Esri ArcGIS Field Maps User Guide

4.1 What you'll need – equipment and user account:

4.1.1 **Mobile device (phone or tablet) with GPS and camera.** Ideally your mobile device will have a SIM card although this is not essential, as maps can be downloaded for offline use over Wi-Fi. Your mobile device will need enough storage space available for installing ArcGIS Field Maps, storing offline map data, and storing your captured CD ground data points and photos.

4.1.2 **ArcGIS Online (AGOL) user account and group membership.** You will need a AGOL user account and to be a member of the "Change Detection External User Group". If you do not have an AGOL user account, please contact the Project Manager to set one up for you. Please CC your request to the LE enquiries mailbox (livingenglandenquiries@naturalengland.org.uk) so that we can ensure your new AGOL account is added to the Group.

4.1.3 Note that all screenshots in this section were taken using an Android (version 11) mobile phone with ArcGIS Field Maps (version 20.3.1). If you are using an Apple device, a different version of ArcGIS Field Maps, or ArcGIS Collector (predecessor of Field Maps), then the menus may appear slightly different, but this will not change the functionality of the app. The screenshots are numbered and labelled by their relevant points as: [*Fig. 2-01, 2-02*].

4.2 Getting and installing the ArcGIS Field Maps app:

4.2.1 On your mobile device, go to the appropriate app store (App Store on iPhone, Google Play store on Android) and search for "ArcGIS Field Maps". Click on the matching app name to go to its page. [*Fig. 2-01*]

4.2.2 Install ArcGIS Field Maps on your device, open the app, and click the "Sign in with ArcGIS Online" to log in with your AGOL account. [*Fig. 2-02, 2-03*]

4.2.3 When opened, Field Maps will present you with lists of the Maps and Groups which you have access to. [*Fig. 2-05, 2-08*]

4.3 Configuring app settings:

4.3.1 Make sure to allow the app to use any of your device's services the app requests access to (e.g., GPS, Camera, Photos etc.). [*Fig. 2-04*]

4.3.2 Only if using ArcGIS Collector (not Field Maps): Open the app settings by clicking the profile icon. Make sure the Accuracy is set to "9m", GPS Averaging is "Off", **Photo Upload Size is "Small"**, Snapping is "Off", and that Units are "Metric" for Measurement Units and "Automatic" for the others. [*Fig. 2-07*]

4.3.3 From the app settings (click on the profile icon), you can configure the map download and sync options using "Cellular data" (sync & download when off Wi-Fi) and "Auto-sync" (automatically sync offline edits) depending on your preferences (see Sections 4.4 and 4.8 for details about offline working and synchronisation). [*Fig. 2-07*]

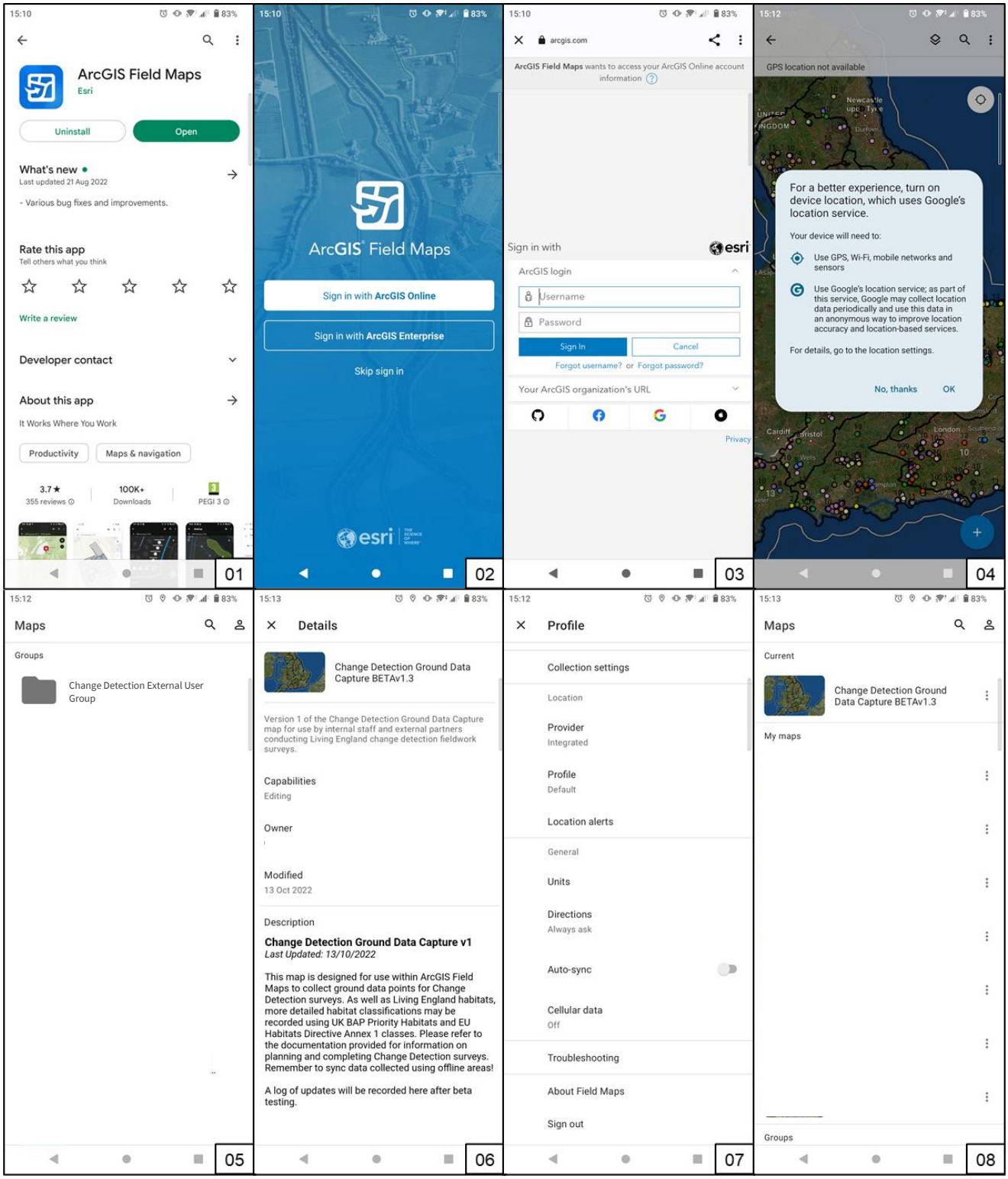


Figure 2: Screenshots 01-8 showing ArcGIS Field Maps (Esri, 2022) and the CD Ground Data Capture map. Background source: Esri et al. (2022) and OSM (2022).

4.4 Loading map and adding offline areas in Field Maps:

4.4.1 Within the “Groups” section of the app home screen, click on the Group called “Living England – Contracted field survey”. If the group is not listed, then you will need to request membership (see Section 4.1.2). [*Fig. 2-05*]

4.4.2 Within the group there is a list of the maps this group can access. Click on the map called **Change Detection Ground Data Capture v1.** [*Fig. 2-08*]

4.4.3 If you are connected to the internet (Wi-Fi or mobile signal), when you click on this map it will open in Field Maps in **online mode** (by default, it will automatically zoom to your location). This will use your internet connection to load the map and any data points collected are synced automatically as they are created/edited.

4.4.4 The menu icon next to the Change Detection Ground Data Capture map allows you to view the map details, download offline regions, and refresh the online map. [*Fig. 2-07, 2-08*]

4.4.5 You need to download **offline areas** to use the map in the field where your mobile signal will be unreliable or absent. Note that downloads can take a long time (30-45 minutes on a good Wi-Fi connection), and any disruptions can cause the download to fail. We recommend you download offline areas over Wi-Fi to avoid excessive use of your mobile data allowance. [*Fig. 2-09 to 2-11*]

4.4.6 When the download is complete, the progress indicator is replaced by a menu icon. This allows you to rename the offline area, synchronise your offline area to update it with new data points collected by other surveyors, or remove the area from your device. [*Fig. 2-12*]

4.4.7 Now that there is an offline area downloaded to your device, it will open by default when you click on the Change Detection Ground Data Capture map instead of opening in online mode. When disconnected from the internet, the downloaded region of the map is still visible. You can also synchronise the data from within the map using the circular arrows icon. [*Fig. 2-13, 2-14*]

4.5 Using the Change Detection Ground Data Capture map:

4.5.1 When you open the Change Detection Ground Data Capture map in either online or offline mode, the map will show CD ground data points, LE habitat classification and segmentation, BGZs, OpenStreetMap mapping (OSM, 2022), and a basemap showing Esri high resolution imagery (Esri et al., 2022). You can centre the map on your location (blue dot) using the location button. [*Fig. 2-14*]

4.5.2 You can change which layers are visible by selecting the layers icon and switching them on and off. The segmentation and classification layers are grouped so you can toggle all the whole layer easily without having to find the relevant BGZ. [*Fig. 2-15, 2-16*]

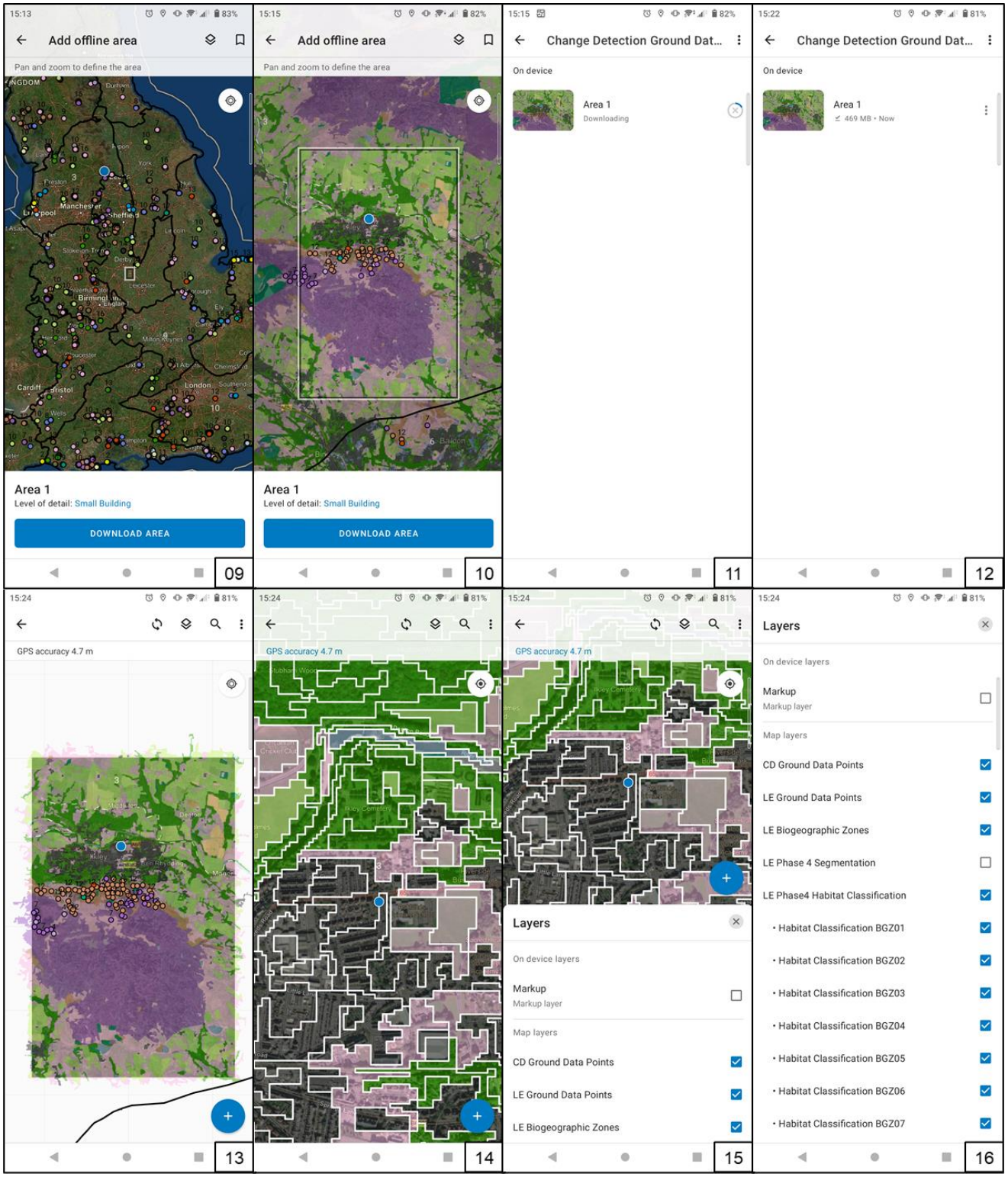


Figure 2 (cont.): Screenshots 09-16 showing ArcGIS Field Maps (Esri, 2022) and the CD Ground Data Capture map. Background source: Esri et al. (2022) and OSM (2022).

4.5.3 From the map menu icon, you can also view the legend for the map, change the basemap (only in online mode), view the bookmarks, and activate markup. Markup is a freehand drawing tool for you to annotate the map and highlight areas you may wish to survey. You can then toggle its visibility within the layers tab. Remember to clear your markups using the bin icon before syncing your offline map. [*Fig. 2-14, 2-15*]

4.5.4 As the default basemap does not have labels, you can use the search tool to find locations more easily. By dropping a pin, you can choose to save the pin location by clicking “Favourite” (“Add to my places” if using ArcGIS Collector). The pin will now stay on your device so you can easily find it again in the map and when downloading an offline area. Your saved locations can also be found from within the search tool (or within bookmarks if using ArcGIS Collector). [*Fig. 2-17, 2-18*]

4.5.5 You can view additional information about the habitat classification in the map based on the latest iteration of LE (currently Phase IV). When selected, the segment outline is highlighted in blue and its details show the predicted habitat class for the segment (A_pred), and the probability (as a percentage) that the segment is dominated by that class (A_prob). The second most likely habitat class for the segment and its probability (B_pred, B_prob) are also shown here. [*Fig. 2-19*]

4.5.6 Previously collected ground data points are shown on the map as coloured dots for both CD and LE surveys and are labelled with a number representing the main LE broad habitat class. The codes (1-18, 999) and colours for each class are shown in the legend. When selected, the details of a ground data point appear with the primary and secondary habitat classes and segment coverage. [*Fig. 2-20*]

4.5.7 When collecting or editing data points, it is essential to follow the survey method developed for Change Detection Ground Data Capture, as shown in Section 5.

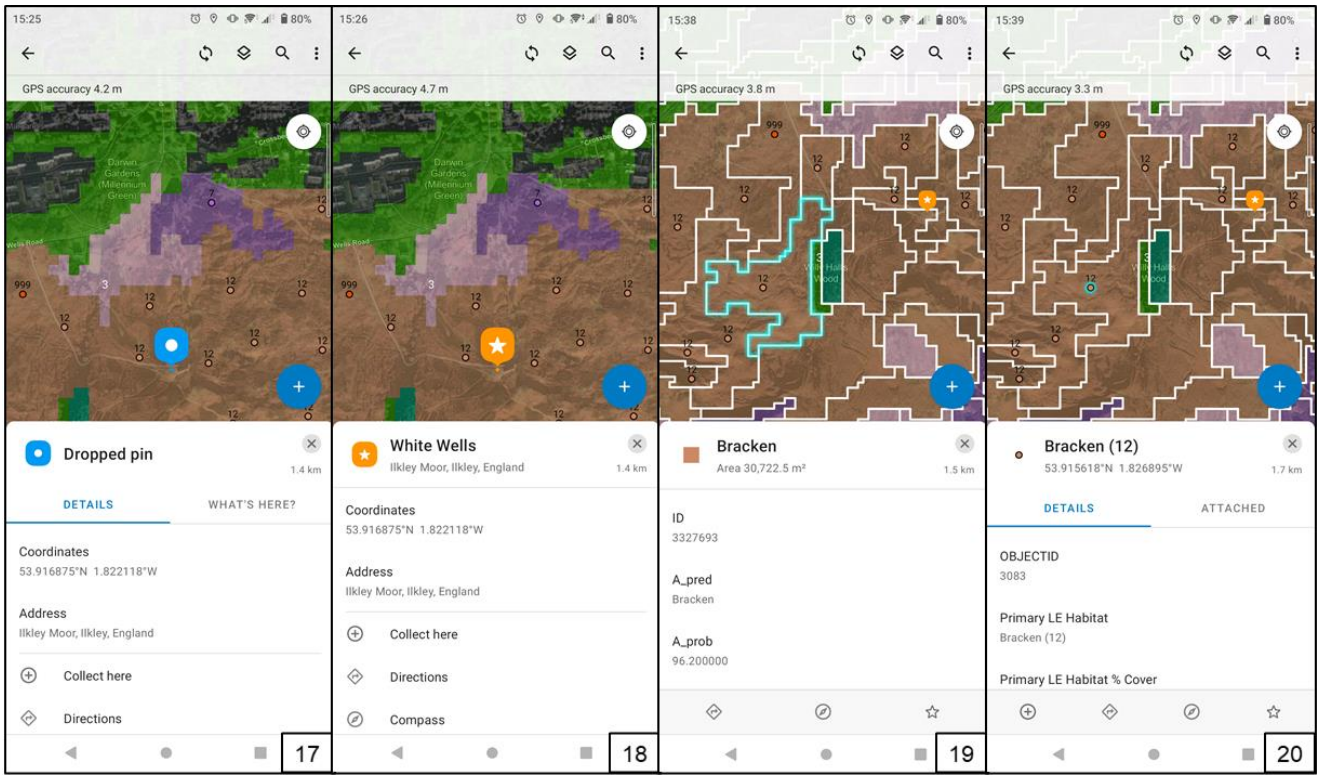


Figure 2 (cont.): Screenshots 17-20 showing ArcGIS Field Maps (Esri, 2022) and the CD Ground Data Capture map. Background source: Esri et al. (2022) and OSM (2022).

4.6 Adding a new point:

4.6.1 When you have arrived at the location of the point you wish to record, click the blue plus button in the bottom-right corner to add a data point.

4.6.2 A pop-up menu then appears to select the dominant LE habitat within the segment you are surveying. Once you have selected this, a second menu appears to fill out the remaining details for the data point and attach photos of your surrounds (see Section 5 for details). Sections of this form are grouped to distinguish between the main LE ground data collection, recording the indicator species present, and the additional information. [*Fig. 2-21 to 2-25*]

4.6.3 When you have completed data entry, check that the "GPS accuracy" has stabilised on a value lower than 9 m. The ring around your location will show as blue if it is less than 9 m, and red if it is more than 9 m. [*Fig. 2-21, 2-22*]

4.6.4 To submit the point, click "Submit" (iOS) or the tick icon (Android) in the top right of the screen. If you are working offline, this will store the point data locally on the device until you synchronise your map. If you are working online, the point data will be uploaded immediately. [*Fig. 2-22 to 2-25*]

4.6.5 You can cancel the point collection at any time by clicking "Discard" (iOS) or the cross icon (Android) in the top left of the screen. [*Fig. 2-21 to 2-25*]

4.6.6 You can change the location of the point you are recording by dragging the crosshair on the map to the desired location and clicking "Update Point". This can be very useful if the location you want to record is inaccessible, but you can clearly identify the habitats within the segment. [*Fig. 2-22*]

4.6.7 Note that by moving the point location away from your position, the GPS information will be lost (the GPS accuracy ring no longer shows as blue or red).

4.6.8 You can also record points away from your location by dropping a pin on the map (see [*Fig. 2-17*]) and clicking "Collect here". This will open a data collection form for a new point at the location of the pin (see [*Fig. 2-21 to 2-25*]). This option should only be used when the vegetation is difficult to pass through and can be done with accuracy i.e. dense scrub. Take a photo of the habitat showing the habitat clearly you have dropped a pin in.

4.7 Editing points:

4.7.1 When a ground data point is selected, you can use the icons near the bottom of the pop-up to edit or copy the point. You can only edit points you have created. From the edit (pen) icon you can change the form details, move the point, and attach photos as shown in Section 4.6. [*Fig. 2-26*]

4.7.2 You should only use the edit functionality to correct mistakes you may have made when collecting data. **If the segment habitat has changed you should not change the point's form details; instead collect a new point in the same segment.** You may move points so that they are not directly on a segment boundary.

4.8 Syncing your offline data points:

4.8.1 You should sync the data when you have a stable network connection (preferably Wi-Fi), by clicking the circular arrows icon within the map. This indicates if you have data ready to be synced by showing a small dot under the icon. [*Fig. 2-26, 2-27*]

4.8.2 Click the icon to access the synchronise screen, which shows you any offline edits that have been made so you can review your points before you sync by clicking the “Sync now” button. [*Fig. 2-27*]

4.8.3 Optionally you can choose to “Auto-sync” at defined time intervals defined under the app settings. If you use this option, Field Maps will synchronise when the device next connects to a network. [*Fig. 2-07, 2-27*]

4.8.4 You can sync an offline area from the menu options in the offline areas screen. This will show how many offline edits there are to sync. [*Fig. 2-12, 2-28*]

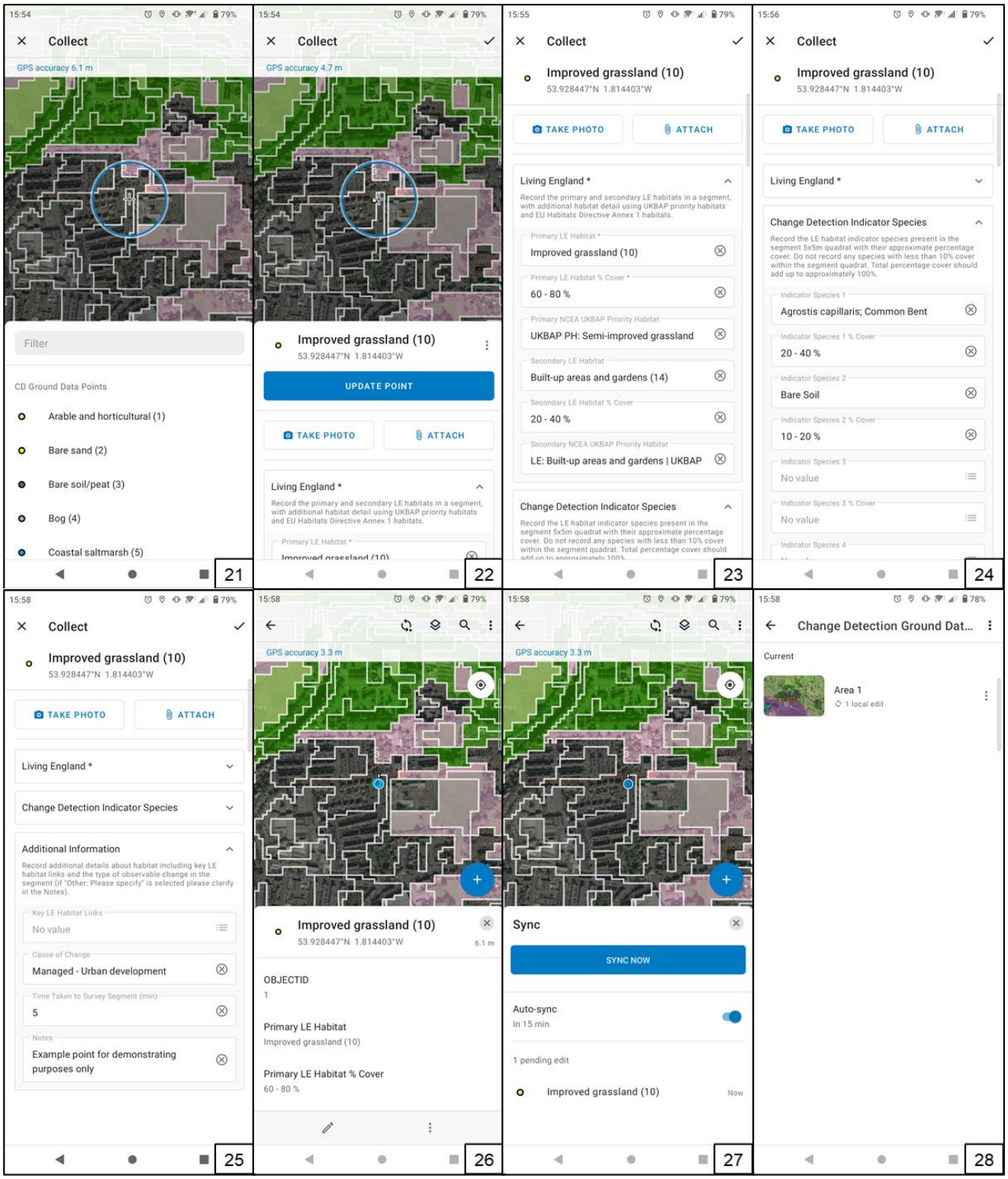


Figure 2 (cont.): Screenshots 21-28 showing ArcGIS Field Maps (Esri, 2022) and the CD Ground Data Capture map. Background source: Esri et al. (2022) and OSM (2022).

5 Field Method

5.1 General approach: On site, your aim is to record a data point in each LE segment or sub-segment you survey using ArcGIS Field Maps, recording your point in a homogenous patch (minimum of 15 m radius around you) of the most abundant broad habitat class present within the segment, away from segment edges. Where points are collected in areas of change, these should be in the centre of the area that has changed, where possible.

5.1.1 **Open habitats:** Place a camping peg at the location where the point was taken for measuring out a 25 m² (5 m x 5 m) quadrat that is to have one edge along a N-S axis. The sampling point will be at the centre of the quadrat. Using the remaining 3 camping pegs and a 30 m tape, measure out the quadrat for recording the vegetation cover of the dominant indicator species present. This will provide a sample of species cover estimates from within the identified homogenous habitat patch and the Primary Habitat that can be used to set a baseline to identify habitat change in future years.

5.1.2 **Woodland Habitats**: A 900 m² (30 m x 30 m) quadrat is to be used to observe an area for looking up into the canopy to record the % cover of the dominant tree species present, at the canopy level. A 30m tape can be set along a N-S axis to guide the observation a homogenous area of the woodland canopy from within the target segment.

5.2 Remember that LE segments were created automatically from satellite imagery, so they often have odd or unexpected shapes which will cross some of the vegetation types you will see on the ground. Give some thought to a rough route around the site, taking in the segments you plan to survey. **You do not have to survey every segment, concentrate on segments with wholly or predominantly homogeneous habitat cover, which has likely changed or is likely to change within 2 years**.

5.3 Where only part of a segment has clearly changed habitat class recently, please record one point for the area that has changed, and one point for the area which has not. Try to take each point in the centre of the area of change/not changed. You should then record the habitats present and indicator species with percentage cover at each point location. You can record additional information within the free text notes if the area has not changed and take a photo where each point has been collected. You can record the likely reason for any habitat change within the app if evident.

5.4 Use the map interface in the Field Maps app to orient yourself on the site, and to navigate to each segment or area to survey (drop a pin and use the compass function to help guide you to the centre of your next segment).

5.5 At the segment/sub-segment:

5.5.1 Observe the extent and shape of the segment using the Field Maps map. Identify the LE habitat classes within the segment from the vegetation around you. You should walk briefly across the segment to “get your eye in”, making a mental note of the different types present and their percentage cover across the whole segment. You must have been able to see the whole of the segment/sub-segment area to record a point.

5.5.2 At each point location, you should record the most abundant LE broad habitat class that has equal to or > 60% cover, as the Primary Habitat i.e., wholly or predominantly covers the segment and if present record the second most abundant class if it covers > 10% of the segment (this takes into account any minimal transition towards another habitat).

5.5.3 If after assessing the cover of a segment you have identified there are three or more broad habitat classes present, each covering > 10 % of the segment, record a point in a central part of the segment as having “MULTIPLE” LE habitat classes and move on to the next segment. **Add in the notes** briefly which LE habitats have > 10 % cover in the segment and their approximate percentage cover.

5.5.4 Note that points collected as “MULTIPLE”, marked as not required in Table 2, or points where the primary habitat has a coverage of < 60 % within the segment, will not be suitable for use as ground truth data as they do not represent a homogenous segment. These points can be used for validating the LE classification and CD, but **it is better to collect fewer high-quality homogenous points than to survey every segment.**

5.5.5 Navigate to the area of the segment containing the largest homogenous patch of the most abundant habitat class. You will record a single point at this location. If you cannot locate the largest patch, navigate to a patch ideally at least 30 x 30 m in size (or 15 m radius), and in all cases within the boundary of the segment.

5.6 At the point, record the following in Field Maps – **Living England** (see Section 4.6 for details):

5.6.1 **Primary (most abundant) LE habitat class (equal to or > 60 % cover of the segment).** There are 17 Habitat Classes, each name is followed by its code number in brackets, e.g., Bog (4). The additional class “MULTIPLE (999)” is available for recording a point in those segments where 3 or more habitat classes are significantly represented, and a dominant class is not apparent.

5.6.2 **Primary (most abundant) LE habitat class % cover across the segment.** Choose from: 40% - 60%, 60% - 80%, 80% - 99%, 100%.

5.6.3 **Primary (most abundant) NCEA UKBAP priority habitat class.** Priority habitat and Annex 1 classes have been combined into a single list, which will be constrained to those UKBAP priority habitat classes which are appropriate for the Primary LE habitat class you have chosen for this point. Spend no more than 5 minutes determining this. If you cannot decide within this timeframe, don’t record an entry.

5.6.4 **Secondary (second most abundant, > 10 % cover) LE habitat class % cover across the segment.** Not always required. This should not be the same as the primary class recorded. Choose from: 10% - 20%, 20% - 40%, 40% - 60% (if it is > 60 % then it should be the Primary habitat).

5.6.5 **Secondary (second most abundant) UKBAP priority habitat class.** LE classes, Priority habitat and Annex 1 classes have all been combined into a single long list. You can filter the options using the search functionality within the list. Spend no more than 5 minutes determining this. If you cannot decide within this timeframe, don’t record an entry.

Continue to record the following in Field Maps – **Change Detection Indicator Species**

5.6.6 Identify up to 10 of the most dominant species with the highest % cover across the 5 m x 5 m quadrat that have equal to or > 10% cover. It is the same approach for Woodlands except using a 30 m x 30 m quadrat observed within the canopy. Then record as follows.

5.6.7 **Indicator Species 1.** Record the most dominant indicator species present with the highest percentage cover first. This will be informed already by the indicator species used to identify the broad LE habitat class selected previously.

5.6.8 **Indicator Species 1 % cover.** Estimate and record the percentage cover of the individual key species within the quadrat located within the segment/sub-segment. Note that due to the different layers or levels of vegetation, total cover for all species may exceed 100%.

5.6.9 **Indicator Species 2-10.** Repeat the step above (5.6.7) identifying the indicator species with the next highest percentage cover. Continue to repeat until you have either recorded the top 10 indicator species (by percentage cover) present, or until only indicator species with percentage cover < 10% remain.

5.6.10 **Indicator Species 2-10 % cover.** Estimate and record the percentage cover of each of the indicator species identified.

Continue to record the following in Field Maps – **Additional Information**

5.6.11 **Cause of change.** Where it is evident that the segment or part of a segment has changed habitat class, record the cause of the change where possible. Choose from Natural or Managed.

5.6.11.1 Where Natural please select from: Wildfires, Natural transitional Change/Succession, Pests and/or Disease, or Other: please specify (using the free text box).

5.6.11.2 Where Managed please select from: Controlled Burning, Felling, Coppicing, Planting, Mown, Grazed, Lime, Manured, Fertilised, Sown, Urban Development, Quarrying, or Other: Please specify (using the free text box).

5.6.12 **Time taken to survey segment (min).** The time taken in minutes to locate and survey the segment and record the point.

5.6.13 **Notes.** Any short supporting text to help explain your responses above or provide useful context and additional information.

5.6.14 **Take 2 photos using the app button to access the camera.** One focussing in on the vegetation at your feet or immediately around you, and the other with a wider view of the habitat patch you are in, which should be the primary (most abundant) LE class present in the segment.

5.7 The Field Maps app will automatically capture your AGOL account ID (not visible in the app or Dashboard), the date and time of capture of the record, and the location of the point.

5.8 Remember to synchronise your app when you are next connected to a network. If you do not do this, your data will not be used. Details of how to do this are shown in Section 4.8.

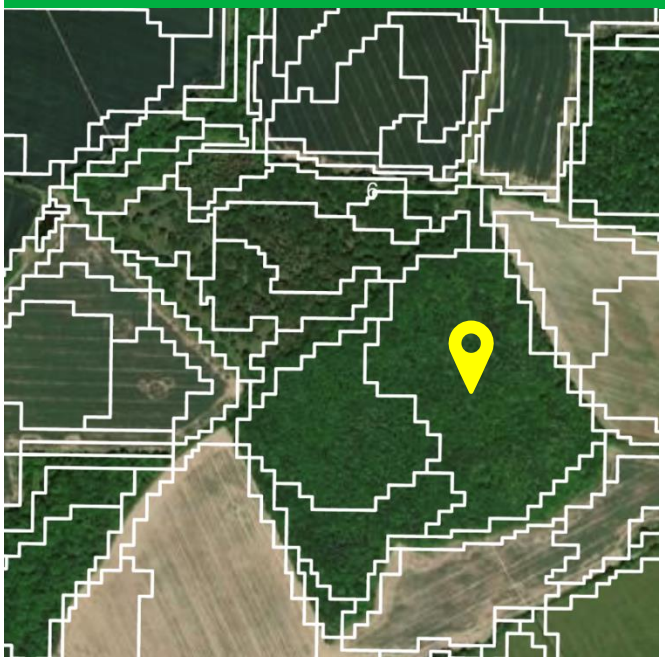
5.9 Hypothetical examples of segments, habitats, and how to record points are provided in Annex 1.

Annex 1

The following 3 examples (Table 4, Table 5,

Table **6**) illustrate scenarios you may encounter when in the field. They are illustrative only, and the habitats on the ground may differ from those shown below. Yellow location icons represent suitable locations for recording a point within the segment.

Table 4: Example 1 – LE segment containing only woodland.

Habitat imagery and segment outline	LE ground data fields	Data entry
	Primary LE Habitat	Broadleaved mixed and yew woodland (16)
	Primary LE Habitat % Cover	100%
	Primary UKBAP Priority Habitat	UKBAP PH: Lowland mixed deciduous woodland | Annex 1: Dry oak-dominated woodland
	Secondary LE Habitat	[Empty]
	Secondary LE Habitat % Cover	[Empty]
	Secondary UKBAP Priority Habitat	[Empty]
	Key habitat links	[Empty]
	Cause of change	Managed Coppicing
	Time Taken (min)	4
	Notes	[Empty]

Background source: Esri et al., 2022.

Table 5: Example 2 – LE segment containing mixture of woodland and grassland.

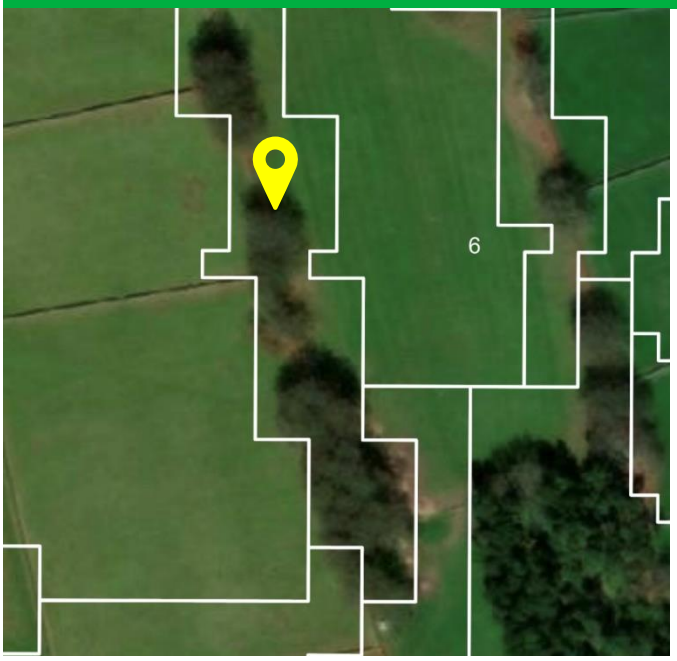
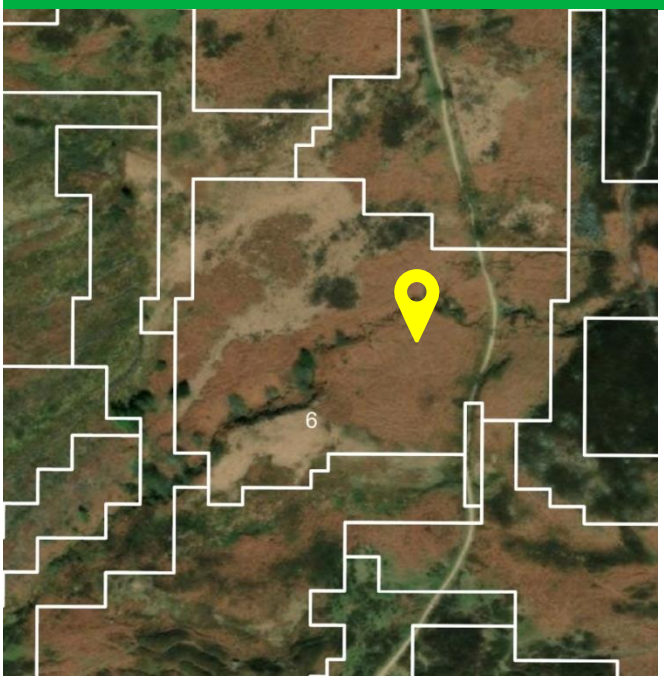
Habitat imagery and segment outline	LE ground data fields	Data entry
 *Background source: Esri et al., 2022.*	Primary LE Habitat	Broadleaved, mixed and yew woodland (16)
	Primary LE Habitat % Cover	40% - 60%
	Primary UKBAP Priority Habitat	UKBAP PH: Lowland mixed deciduous woodland | Annex 1: Dry oak-dominated woodland
	Secondary LE Habitat	Acid, calcareous and neutral grassland (9)
	Secondary LE Habitat % Cover	20% - 40%
	Secondary UKBAP Priority Habitat	LE: Acid, calcareous and neutral grassland | UKBAP PH: Lowland acid grassland
	Key habitat links	Acid, calcareous and neutral grassland (9)
	Cause of change	Managed Planting
	Time Taken (min)	8
	Notes	[Empty]

Table 6: Example 3 – LE segment containing multiple habitats. This is a large upland segment containing Dwarf Shrub Heath, Bracken, and Acid, Calcareous and Neutral grassland, each covering > 10 % of the segment.

Habitat imagery and segment outline	LE ground data fields	Data entry
 *Background source: **Esri et al., 2022.***	Primary LE Habitat	MULTIPLE (999)
	Primary LE Habitat % Cover	[Empty]
	Primary UKBAP Priority Habitat	[Empty]
	Secondary LE Habitat	[Empty]
	Secondary LE Habitat % Cover	[Empty]
	Secondary UKBAP Priority Habitat	[Empty]
	Key habitat links	[Empty]
	Cause of change	Natural Wildfires
	Time Taken (min)	10
	Notes	Contains: Dwarf Shrub Heath (40%), Bracken (40%), Acid Calcareous Neutral Grassland (20%).

Annex 2

All points collected plus the map from the ArcGIS Field Maps app is visible on the **Change Detection Ground Data Dashboard.**

- On the dashboard (**Error! Reference source not found.**), data can be filtered by BGZ to keep track of which habitat types in each BGZ are under-represented and require attention.

- The dashboard updates automatically as new points are collected (or synced from offline areas), and can be accessed here: https://defra.maps.arcgis.com/apps/dashboards/e39edf47258945879f8b939639208704

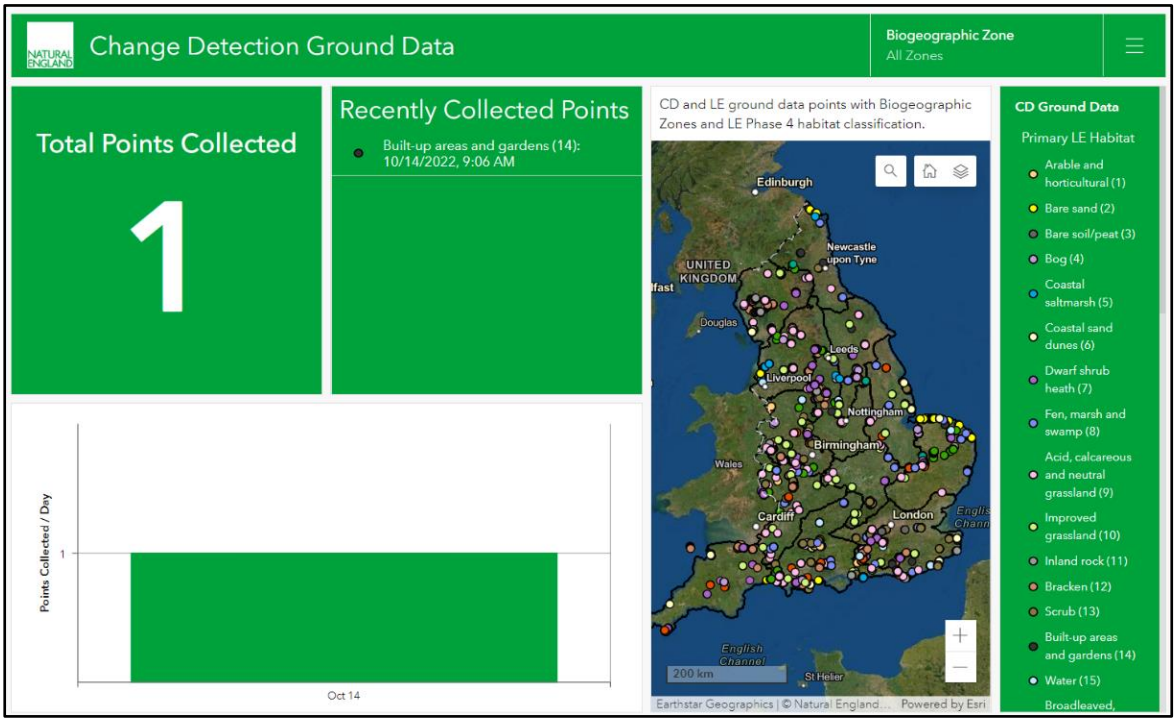


Figure 3: CD dashboard showing a national summary of CD ground data points recorded. Background source: Esri et al. (2022) and OSM (2022).

Annex 3

Details about specific habitat types and how they fit into the LE UKBAP classification framework (UKBAP priority habitat (PH) (JNCC, 2011) and EU Habitats Directive Annex 1 (EU, 2013) habitat level) are shown in Table 7. Where several habitats could be applied the options are indicated as: [*First habitat /Second habitat*].

Table 7 (continued next page): Details of how to record specific habitats within the LE UKBAP classification framework

Habitat type	What to record for LE	Description
Bogs which are dominated by dwarf shrub heath	LE: Dwarf shrub heath | UKBAP PH: [*Upland/Lowland*] heath (dominating on bog)	Although the habitat is bog, record the LE class as dwarf shrub heath (as that is what is visible with satellite imagery) and use the additional UKBAP PH level class to record that it is dwarf shrub heath dominating on bog.
Bogs which are dominated by purple moor grass	LE: Bog | UKBAP PH: [*Lowland raised/Blanket*] bog (dominated by purple moor grass)	Where bogs are dominated by purple moor grass, there is an additional UKBAP PH level class to record this.
Fens, Marshes & Swamps which meet the priority habitat criteria for purple moor grass and rush pasture	LE: Fen, marsh and swamp | UKBAP PH: Purple moor grass and rush pasture	Updated in Nov 2022, use UKBAP PH level class for purple moor grass and rush pasture.
Fens, Marshes & Swamps which meet the priority habitat criteria for purple moor grass and rush pasture	LE: Fen, marsh and swamp | UKBAP PH: Purple moor grass and rush pasture	Updated in Nov 2022, use UKBAP PH level class for purple moor grass and rush pasture.
Acid Grasslands which are dominated by purple moor grass	LE: Acid, calcareous and neutral grassland | UKBAP PH: [*Upland/Lowland*] acid grassland | Annex 1: Purple moor-grass meadows	Use the Annex 1 code for purple moor grass meadows (H6410) to record upland or lowland acid grassland segments dominated by purple moor grass.
Coastal Vegetated Shingle when heavily vegetated	LE: Inland rock | UKBAP PH: Coastal vegetated shingle (heavily vegetated)	Record under inland rock, but with the option to select when it is heavily vegetated at UKBAP PH level as may appear very different to bare shingle.
Maritime Cliffs & Slopes when heavily vegetated	LE: Inland rock | UKBAP PH: Maritime cliffs and slopes (heavily vegetated)	Record under inland rock, but with the option to select when it is heavily vegetated at UKBAP PH level as may appear very different to bare cliffs/slopes.
Coastal Sand Dunes covered with sea-buckthorn scrub	LE: Scrub | UKBAP PH: Single species scrub | Annex 1: Dunes with sea-buckthorn	Record scrub covered sand dunes using scrub as the LE class as that is what is visible with satellite imagery.

Areas of scrub with more than 1 species	LE Scrub | UKBAP PH: Mixed Scrub	Add in the notes what species are present if it is more than 1 scrub species.
Orchards	LE: Broadleaved, mixed and yew woodland | UKBAP PH: Traditional orchards	Previously orchards were recorded under Arable & Horticultural, but under UKBAP record them using Broadleaved, Mixed and Yew woodland.
Semi-improved grassland	LE: Improved grassland | UKBAP PH: [*Good/Poor quality*] Semi-improved grassland	Record using the Improved Grassland LE class with good & poor quality semi-improved grasslands defined at UKBAP PH level.
Montane Heath	LE: Dwarf shrub heath | UKBAP PH: Montane heath	Record areas of Montane Heath at UKBAP PH level within the Dwarf Shrub Heath LE class.
Coastal and floodplain grazing marsh	LE: Improved grassland | UKBAP PH: Coastal and floodplain grazing marsh	Updated in Nov 2022, now record under the Improved Grassland LE class at UKBAP PH level rather than under Coastal Saltmarsh.
Various habitats dominated by rush pasture	LE: [*Bog/Fen, marsh and swamp/Acid, calcareous and neutral grassland/Improved grassland*] | UKBAP PH: [*Various*] (rush dominated)	Added in Nov 2022, areas dominated by rush pasture should be recorded using the dedicated UKBAP PH level category.
Calcareous grassland dominated by Brachypodium Pinnatum	LE: Acid, calcareous and neutral grassland | UKBAP PH: [*Upland/Lowland*] calcareous grassland (brachypodium pinnatum dominated)	Added in Nov 2022, areas of calcareous grassland dominated by heath false brome or tor-grass should be recorded using the dedicated UKBAP PH level category.

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