Woodlands to Moorlands: Habitat Mapping for the South West - Technical User’s Guide

This Habitat Classification tool has been developed by SWEEP (<https://sweep.ac.uk/>), working in close collaboration with Dartmoor National Park Authority. Drawing on freely available satellite imagery (Sentinel-2) and LIDAR data, this remote sensing-based project created two tools – the Habitat Classification tool and the Habitat Change tool. The Habitat Classification tool enables habitat types across the entire extent of the National Park area to be classified and mapped to a fine resolution in a consistent and repeatable way, whilst the Habitat Change tool enables the detection of change in these habitat types over time.

This is the **Technical User’s Guide for both the Habitat Classification tool and the Habitat Change tool**. It steps through the workflow required to produce Habitat Classification, Habitat change and accuracy maps and associated outputs.

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# Time Requirement

Although quicker than a field survey this process does require time (Table 1), basic GIS skills, a willingness to use R (although no programming is necessary) and the ability to photo-interpret areal images.

Table Approximate time requirement for mapping

|  |  |
| --- | --- |
| Task | Approximate Time Taken (minutes)  dependent on the user, internet speeds and computer processors used. |
| Selecting Sentinel-2 images | 30 |
| Pre-Processing images | 30 |
| Obtaining LiDAR data | 45 |
| Defining Classification scheme | Will depend on the user |
| Creating training/testing data | ~60 pixels per hour |
| Running Habitat Classification Tool   * Load Images and derive VI’s * Load DTM and derive slope & aspect * Load peat shapefile & derive raster * Load and randomly split training/testing pixels * Run random forest classifier * Predict land cover for whole extent * Accuracy assessment by confusion Matrix * Reclassify areas over peat & uplands * Spatial accuracy assessment by logistical regression | Total 101 (30 in subsequent years)   * 0.5 * 67 (only required the first time) * 4 (only required the first time) * 1.1 * 16.6 * 8.3 * 0.01 * 2.0 * 1.1 |
| Running Habitat Change Tool | 11.5 |
| Running Pixel Assessment Tool | 2 |

# Selecting Sentinel-2 images

Sentinel data is only available via this method for ~18 months after the date of image collection so it is advised to schedule this work annually in October-November once all the summer images are available.

## Setting up a free Sentinel-hub account

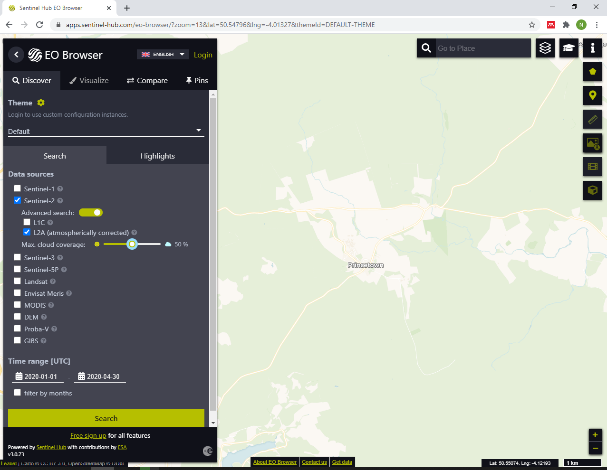
This has to be done once per user.

Go to <https://www.sentinel-hub.com/> click on “Apply for free account to explore all the features” and follow the onscreen instructions to create an account.

## Exploring the available Sentinel-2 data

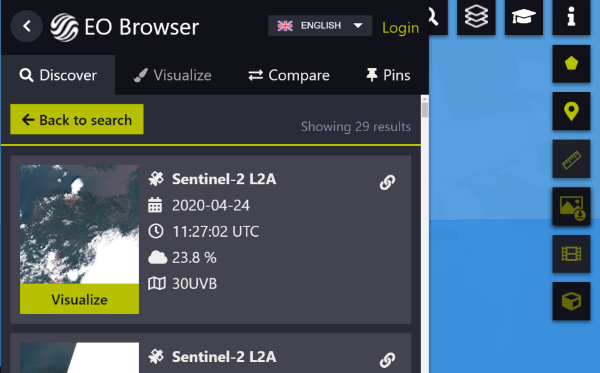
1. Go to <https://www.sentinel-hub.com/explore/eobrowser/> click on “START EXPLORING!”.
2. Navigate to Princetown as shown in Figure 1 (by zooming in you should only select the two tiles (30UAV\_A and 30UAV\_B) which cover DNP).
3. In the left-hand panel check “Sentinel-2” in Data Sources is ticked.
   1. Click on “Advanced search”.
   2. Check “L2A (atmospherically corrected) is ticked.
   3. Use the slider to change “Max. cloud coverage” to 50%.
4. In the left-hand panel adjust the time range [UTC]
   1. Spring YYYY-01-01 to YYYY-04-30 in this example 2020-01-01 to 2020-04-30.
   2. Summer YYYY-06-01 to YYYY-09-30.
5. Click “Search”

Figure Search page of Sentinel-hub



1. The map will turn blue.
2. In the left-hand panel check you have images from both 30UVA and 30UVB tiles (see Figure 2) – if you don’t, click on “Back to search”, zoom out and then click “Search” again.
3. If you have images from tiles other than 30UVA or 30UVB e.g. 29UQR click on “Back to search”, zoom in and then click “Search” again.

Figure Close up of results panel with information on the Data (Sentinel-2 L2A), image date (2020-04-24), image time (11:27:02 UTC), cloud cover (23.8% and tile (30UVB) and the link button.



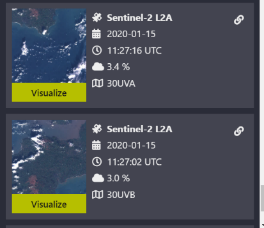
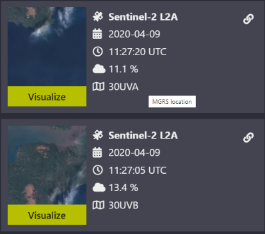
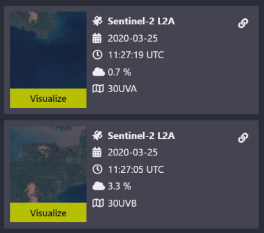
## Selecting the best available Sentinel-2 data

1. Use the scroll bar to look over the thumbnail images.

Shortlist the best cloud free images, see examples of good, moderate and too cloudy in

1. Figure 3.
   1. If only one tile (30UVA or 30UVB) appears in the results, then the other tile has >50% cloud cover and the date should not be shortlisted.
   2. Use the % cloud cover information to aid your selection.

Figure Examples of good (2020-03-25), moderate (2020-04-09) and too cloudy (2020-01-15, 2020-04-04) images.



1. If there are multiple good quality cloud free images
   1. For the spring image select the image from March > February > April >January.

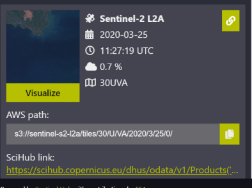
e.g. 2020-03-25 selected in preference to 2020-04-09

* 1. For the summer image select the image from June > July > August > September.

e.g. 2020-06-23 selected in preference to 220-09-21

1. Once the image dates have been selected click on the “link” button (Figure 4) which will display the “SciHub link:”.
2. Click on the SciHub Link to download the data, if necessary, log in with your Sentinel-hub login details. These are large (~1GB) zipped files so downloading may take some time.

Figure Link button to reveal SciHub link.



# Pre-processing the Sentinel-2 data

## Extracting and saving the image files

1. Create a folder for your raw image files e.g. Data\_raw
2. To reduce the chance of confusion later it is best to create a subfolder to each tile for each timestep e.g. 20200325\_UVA
3. Copy and paste from: Downloads\tile\_name.zip\tile\_name\GRANULE\tile\_name\IMG\_DATA\R10m

Where tile\_name is something like S2B\_MSIL2A\_20200325T112109\_N0214\_R037\_T30UVA\_20200325T150223

From the **R10** folder you want to copy the files that end

B02\_10m.jp2

B03\_10m.jp2

B04\_10m.jp2

B08\_10m.jp2

1. Copy and paste from: Downloads\tile\_name.zip\tile\_name\GRANULE\tile\_name\IMG\_DATA\R

Where tile\_name is something like S2B\_MSIL2A\_20200325T112109\_N0214\_R037\_T30UVA\_20200325T150223

From the **R20** folder you want to copy the files that end

B05\_20m.jp2

B06 \_20m.jp2

B07\_20m.jp2

B08A\_20m.jp2

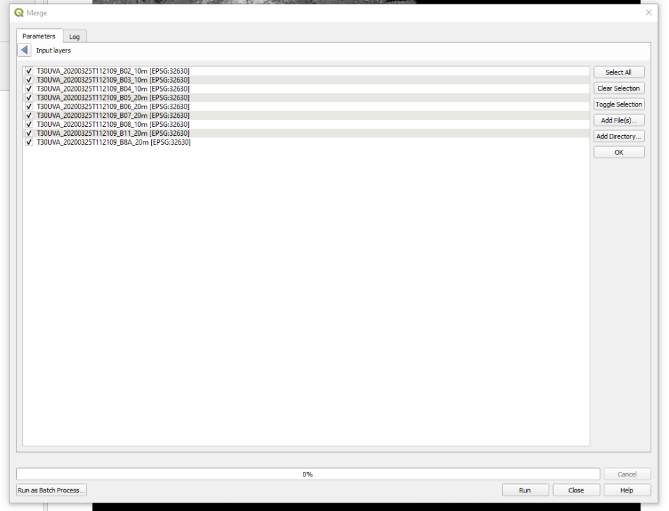
B11\_20m.jp2

1. Check that you have 9 files for each tile (UVA & UVB) for each timestep (spring & summer)
2. The large zipped files can now be deleted from the downloads folder.

## Merging the 9 layers from each tile (UAV or UVB) to form one continuous multi-band raster clipped to DNP extent

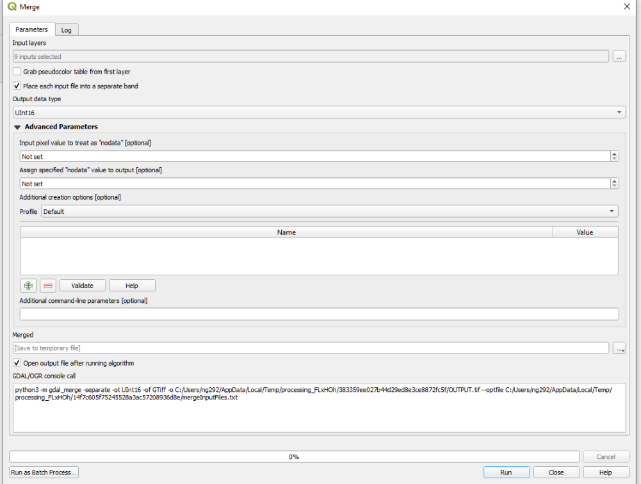
1. Open QGIS.
2. Select one tile (30UVA or30 UVB) at one timestep (spring or summer), load the 9 raster layers. Layer -> Add Layer -> Add Raster Layer.
3. Raster -> Miscellaneous -> Merge.
4. Click on the ellipsis (…) to the left of the Input Layers bar.
5. Select the 9 layers (Figure 5) then click on the back arrow to take you to the main menu. The Input layers bar should now read 9 inputs selected (Figure 6).

Figure Selecting all layers as Input Layers for the GDAL Merge tool



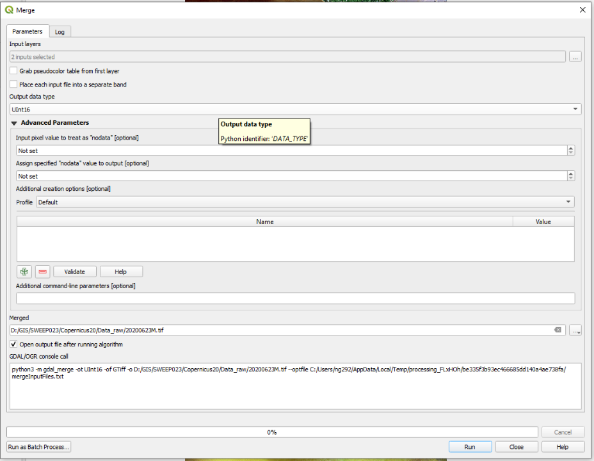
1. Tick “Place each input file into a separate band” (Figure 6).
2. Change Output data type to UInt16 (Figure 6).
3. Run (Figure 6).
4. Remove the 9 layers so you are left with the merged layer only.
5. Repeat steps 2-9 for other tile (UAV or UVB) within the timestep so you have 2 merged layers.

Figure Input parameters for the Merge tool when creating a multi-band image from the 9 layers



1. Again, using the Merge Tool (Raster -> Miscellaneous -> Merge)
2. Click on the ellipsis (…) to the left of the Input Layers bar.
3. Select the two merged layers then click on the back arrow to take you to the main menu. The Input layers bar should now read 2 inputs selected (Figure 7).
4. Make sure the “Place each input file into a separate band” box is NOT checked (Figure 7) this is different from step 6.
5. Change Output data type to UInt16 (Figure 7).
6. To the right of the Merged bar click on the ellipsis (…) and Save to file, browse to an appropriate folder and save this layer (Figure 7).
7. Run (Figure 7).
8. Repeat steps 3-17 for the other timestep (spring or summer).

Figure Input parameters for the Merge tool when mosaicking the two merged multi-band images



1. Once you are happy you have 2 input image files that work you may want to delete the intermediary files (36 individual layer files and 2 merged layer files) as collectively these can take up ~10GB and are no longer required.

# Obtaining LiDAR data and creating DTM

LiDAR data is optional, the tool will function without it, but accuracies would be expected to decrease.

Data for our study area was downloaded here: [www.tellusgb.ac.uk](http://www.tellusgb.ac.uk)

Data for other parts of England and Wales can be found via the Environment Agency’s National LiDAR Programme Survey here: <https://environment.data.gov.uk/DefraDataDownload/?Mode=survey>

Data for Scotland can be found via the Scottish Government Scottish Remote Sensing Portal here: <https://remotesensingdata.gov.scot/>

A list of freely available LiDAR data by country is available here: <https://arheologijaslovenija.blogspot.com/p/blog-page_81.html>

1. Open QGIS.
2. Select all the LiDAR tiles. Layer -> Add Layer -> Add Raster Layer.
3. Raster -> Miscellaneous -> Merge.
4. Click on the … to the left of the Input Layers bar.
5. Select the LiDAR layers then click on the back arrow to take you to the main menu.
6. To the right of the Merged bar click on … and Save to file, browse to an appropriate folder and save this layer as a Tiff.

# Defining your classification scheme

You will need to decide what land covers are of interest to you and choose your classes appropriately. The original tool was based on UKHab classes. Generally, more classes result in decreased accuracies. Land covers that are spectrally very similar may have to be grouped or the user may have to accept lower certainties about classification.

Create a csv table with two columns as in Table 2.

If you have classes that are spectrally similar but separated into different classes by elevation then use the pairs 1 (lowland) & 3 (upland), 4 (lowland) & 5 (upland), 6 (lowland) & 7 (upland) and 13 (lowland) & 14 (upland) as these classes are grouped during the classification and then separated by elevation post classification.

Classes 303, 314 and 328 should only be used for their assigned Class Name. An output will only be produced if a peat extent shapefile is input to the tool.

If you do not need any of the classes already in the csv file then delete the rows. It is suggested you start your class codes at 201 so as not to be confused with existing codes.

You can name your Class Names as you wish, these will be printed in the confusion matrix as written.

Table 2 Example of csv table defining class codes (first column) and class names (second column)

|  |  |
| --- | --- |
| Class | Class Names |
| 1 | Lowland acid grassland |
| 2 | Bracken |
| 3 | Upland acid grassland |
| 4 | Lowland calcareous grassland |
| 5 | Upland calcareous grassland |
| 6 | Lowland meadows |
| 7 | Upland hay meadows |
| 201 | Your habitat here |

# Creating a training/testing shapefile

1. In QGIS load your area of interest shapefile.
2. Load one of your sentinel images.
3. Raster -> Extraction -> Clip Raster by Mask Layer. Select the Sentinel image as the Input layer and AOI shapefile as the Mask Layer. Check “Match the extent of the clipped raster to the extent of the mask layer” is ticked. Tick “Keep resolution of input raster”. Click “Run”.
4. Raster Pixels to Points tool. Select your clipped raster layer and run.
5. Select by Location. Select features from your points layer that are within your area of interest shapefile.
6. Invert feature selection to select all the points outside of the area of interest.
7. Click on the Pencil to enable editing. Delete the selected points by clicking on the Bin icon. Click the pencil again to save edits.
8. **With no previous mapping**: Go to Vector-> Research Tools -> Random Selection. Use the percentage of selected features method to select between 5-10% of your pixels.
9. Make sure Random Points is the active layer by clicking on it in the Layers Panel then Invert Feature Selection.

Or

1. **With previous mapping:** Add previous mapping layer and Join attributes by location to the points layer.
2. Go to Vector-> Research Tools -> Random Selection within Subsets. Use the previous mapped classes as the subsets. Use the percentage of selected features method to select between 5-10% of your pixels for each mapped group.
3. Make sure the joined layer is the active layer by clicking on it in the Layers Panel then Invert Feature Selection.
4. **With or without previous mapping:** Click on the Pencil to enable editing. Delete Selected by clicking on the Bin icon. Click the pencil again to save edits.
5. Save Layer as your training/testing pixels.
6. To add google earth images to assist in photo-interpretation go to Layer -> Add Layer -> Add XY Layer -> New. Name it something appropriate e.g. Google Imagery. Paste in URL: [http://www.google.cn/maps/vt?lyrs=s@189&gl=cn&x={x}&y={y}&z={z}](http://www.google.cn/maps/vt?lyrs=s@189&gl=cn&x=%7bx%7d&y=%7by%7d&z=%7bz%7d) Click OK.
7. Right Click on the training/testing layer and Open Attribute Table. Click on the Field Calculator Icon to add a new column (field). Output field name “Class”. **It is important this field has this name and it is case sensitive**. Add a 0 to the expression to populate the column. Click OK.
8. Replace the 0’s in this column using the numerical code chosen when [Defining your classification scheme.](#_Creating_training/testing_shapefile)
9. Save changes as you go.

# Installing software and Unbundling the Zipped code (first time only)

## Installing R

1. You will need administrator rights to install R.
2. Either run R.4.0.5.win.exe saved on the hard-drive.

Or download R for Windows by navigating to <https://cran.r-project.org/>. Click on download R for Windows, then on install R for the first time then Download the version of R available. The link downloads an installer package which installs the most recent version of R.

1. Run the installer and step through the installation wizard. This will install R into your program files folders.

## Installing RStudio

1. You will need administrator rights to install RStudio.
2. Either run RStudio 1.4.1106.exe saved on the hard-drive.

Or download RStudio Desktop for free from <https://www.rstudio.com/products/rstudio/download/>

1. Run the installer and step through the installation wizard. This will install RStudio into your program files folders.

## Unbundling the zipped Code

### Installing packrat package

1. Run RStudio as an administrator
2. Install the packrat library

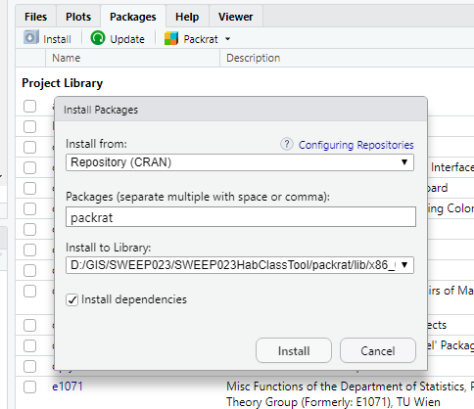
Option 1: copy and paste install.packages("packrat") into the console (after the >) then press return (

1. Figure 9).

This may result in an error message including the words “Error in install.packages: ERROR failed to lock directory” in which case choose

1. Option 2 which enables you to choose where to save the packrat package to: in the bottom right hand window, go to the Packages tab and click on Install (Figure 8).
2. In the pop-up window chose install from Repository (CRAN); Packages packrat; Install to Library and choose the library file within your R file e.g. C:\Program Files\R\R-4.0.5\library
3. Click to install (Figure 8).

Figure Installing packrat package



### Unbundling the zipped file

1. Create a folder where you wish to store the code and name appropriately (e.g. (LandCoverClassTool)
2. Find the filepath via the Windows Explorer window/folder to the saved bundled project LandCoverClassTool-2021-mm-dd.tar.gz and alter the first filepath text below
3. Find the filepath via the Windows Explorer window/folder to the recently created folder and alter the second filepath text below
4. Remember to use /.

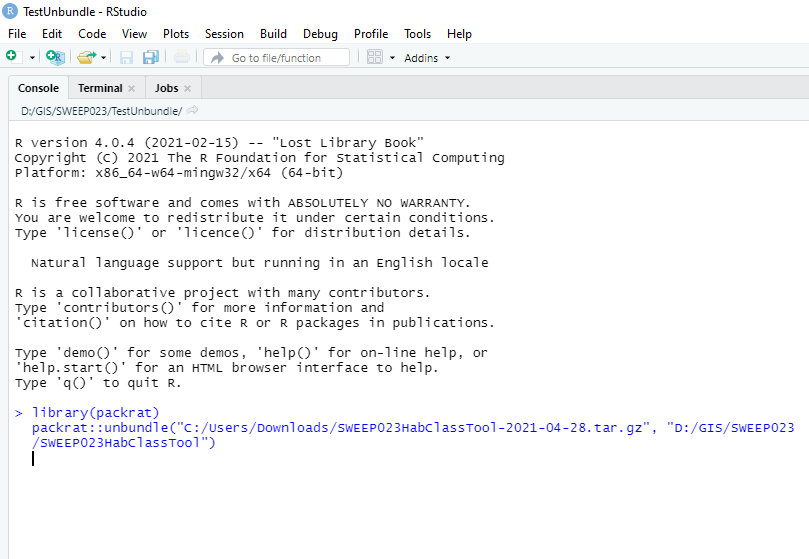
Copy and paste the following into the console (after the >) then press return (

1. Figure 9).

library(packrat)}

packrat::unbundle("C:/Users/Downloads/LandCoverClassTool-2021-04-28.tar.gz", "D:/GIS/SWEEP023/LandCoverClassTool")

Figure Code pasted into console



1. A folder (LandCoverClassTool) should appear in your folder

# Running the Habitat Classification and Habitat Change tools

The Habitat classification tool will take a while (>1hr) to run during which it will use all but one of your computer’s cores.

It is recommended to run the code in sections.

Left click with the mouse to highlight from dashed line to dashed line (------)

Click on Run.

A red Stop sign will appear in the top right-hand corner of the console. Once this disappears you can select and run the next section.

Navigate to LandCoverClassTool\LandCoverClassTool (Figure 10) double click and this should open in RStudio.

Figure LandCoverClassTool folder with project highlighted

Graphical user interface, table

Description automatically generated

If this folder does not exist yet see [Unbundle the zipped code](#_Unbundle_the_zipped)

If you get a warning about write access then Run RStudio as an administrator, then go to File->Open Project-> navigate to ~LandCoverClassTool\SWEEPHabClassTool RPROJ (Figure 10)

Go to the PixelAssessmentTool tab, HabClassTool tab or HabChangeTool tab as appropriate (Figure 11)

If the tab is not showing, go to file -> Open File -> navigate to LandCoverClassTool\R\ and select the appropriate tool.

Press the source button to run the code (not the run button) Figure 11.

Figure Habitat Classification Tool open in RStudio, source button is highlighted

Graphical user interface, text, application

Description automatically generated

## Inputs for the Habitat Classification tool

### A series of windows will pop up to ask for these inputs:

1. Year of interest – type the year and select ok e.g. 2019
2. Shapefile of area of interest - a single part polygon covering the area of interest e.g. DNP\_extentWGS.shp
3. Spring Image File e.g. 2019/20190420
4. Summer Image File e.g. 2019/20190704
5. Photo-interpreted training/testing points e.g. Training\_Data/2019PIPoints.shp
6. Table of class names e.g., ClassNames.csv

#### LiDAR data

If these do not exist, see the section [Obtaining LiDAR data](#_Obtaining_LiDAR_data)

The first time you run the tool a dialogue box will ask for the DTM e.g. DNPA\_TellusDTM and the definition of upland e.g. 300 m. The tool will create slope, aspect and uplands extent files and save these to the folder for use in future. These will need to be moved/deleted to run the tool for a different area.

#### Sentinel-2 images

1. A spring and summer image should be saved appropriately, e.g. LandCoverClassTool\Inputs\2019\20190420.tif and LandCoverClassTool\Inputs\2019\20190704.tif.
2. If these do not exist, see the [Selecting Sentinel-2 mages](#_Selecting_Sentinel-2_Images).

#### Peat extent

If you do not have this data click cancel, the tool will run without.

The first time you run the tool a dialogue box will ask for the peat extent e.g. DNPPeat50.shp. The tool will create a raster layer defining the peat extent for future use. The shapefile requires peat areas to be bounded by polygons and the non-peat areas to be NA.

#### Photo-interpreted training/testing points

1. If this is the first time running the tool see [Creating training/testing shapefile](#_Creating_training/testing_shapefile)
2. If this is not the first time running the tool then run the [photo-interpretation pixel assessment tool](#_Inputs_for_the) first.

#### Table of class names

If this does not exist, see the section [Defining your classification scheme](#_Defining_your_classification).

## Inputs for the Pixel Assessment tool

### A series of windows should pop up to ask for the inputs:

1. The existing photo-interpreted pixels. E.g. Training\_Data/2019PIPoints.shp
2. The existing random forest model. E.g. Models/2019RF\_models.rds
3. This year’s spring and summer images. E.g. Inputs/2020/20200325 and 20200623

#### Photo-interpreted training/testing points from year YYYY

1. A shapefile of photo interpreted points evaluated prior to the most recent use of the Habitat Classification tool in year YYYY should be saved in e.g. LandCoverClassTool\Inputs\Photo\_Interpreted\_Points\2019PIPoints.shp.

#### Sentinel-2 images of current year of interest

1. A current spring and summer image should be saved appropriately, e.g. LandCoverClassTool\Inputs\2020\20200325.tif and LandCoverClassTool\Inputs\2020\20200623.tif.
2. If these do not exist, see the [Selecting Sentinel-2 mages](#_Selecting_Sentinel-2_Images).

#### Existing Random Forest Model

1. A random forest model should have been created when the Habitat Classification Tool was run for year YYYY. It should be saved in e.g. LandCoverClassTool\Models\2019RF\_model.rds
2. If this does not exist then the Habitat Classification tool will have to be run for year YYYY.

## Inputs for the 3-year Habitat Change tool

### A series of 14 windows will pop up to ask for these inputs:

1. Earlier timeframe of interest – type the timeframe and select ok e.g. 2018to2020
2. Later timeframe of interest – type the timeframe and select ok e.g. 2019to2021
3. For the first 3-year timeframe select the **first** Habitat Classification Map (YYYYHabitatClass) – e.g. 2018HabitatClass
4. For the first 3-year timeframe select the **second** Habitat Classification Map (YYYYHabitatClass) – e.g. 2019HabitatClass
5. For the first 3-year timeframe select the **third** Habitat Classification Map (YYYYHabitatClass) – e.g. 2020HabitatClass
6. It will then ask for the 3 Habitat Classification maps for the second timeframe
7. It will then ask for the 3 Habitat Classification Accuracy maps for the first timeframe
8. Lastly it will ask for the 3 Habitat Classification Accuracy maps for the second timeframe

Although Habitat Change 2017-2019 compared to 2018-2020 is provided it is recommended to use 2018-2020 as the baseline year. Atmospherically corrected data is preferable and only top of atmosphere images were available for 2017.

It is intended that the two timeframes do not overlap but this will not be possible until 2023 (3-year mode).

#### Habitat Classification and Habitat Classification Accuracy maps

1. There should be Habitat Classification maps and Habitat Classification Accuracy maps for two 3-year timeframes of interest in the folder LandCoverClassTool\Habitat\_Classification\_Maps
2. If these do not exist, use the [Habitat Classification](#_Inputs_for_the_1) tool to create them.

## Outputs

When the tool is finished the word “Finished” will appear in the Console in the bottom left hand window.

### Habitat Classification

The Habitat Classification tool will output two TIF files (YYYYHabitatAccuracy and YYYYHabitatClass) and two csv files (YYYYConfusionMatrix and YYYYErrorAdjustedArealExtent), these will be saved in the Habitat\_Classification\_Maps folder.

The Habitat Classification and Habitat Classification Accuracy maps have the spatial reference: EPSG:32630 - WGS 84 / UTM zone 30N – Projected.

### Pixel Assessment

The pixel assessment tool will output a csv file called YYYY-MM-DDPixels\_to\_check.csv will appear in the Training\_Data folder.

The csv will list 10 % of pixels that have been incorrectly classified using the current years images and the previous random classifier.

#### Adding the Pixels to Check delineated text file

Add the existing photo interpreted pixels layer to your map: Layer -> Add Layer -> Add Vector Layer

Save a copy: Right click on Layer name -> Export -> Save Features As

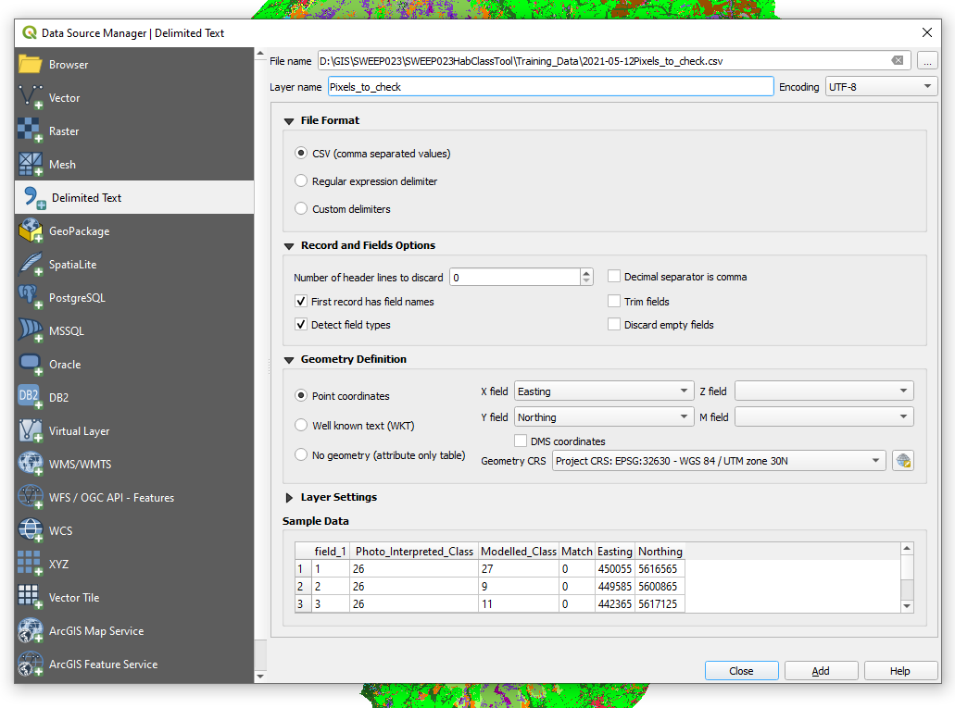
Name e.g. 2020PIP and save appropriately e.g.LandCoverClassTool\Inputs\Photo\_Interpreted\_Points\2020PIPoints.shp.

Add the pixels to check: Layer -> Add Layer -> Add Delimited Text Layer

Browse to the file

Change the Geometry CRS to: EPSG:32630 - WGS 84 / UTM zone 30N (Figure 15)

Figure Adding the Pixels to Check delineated text file



#### Selecting pixels in the photo-interpreted pixels layer to check

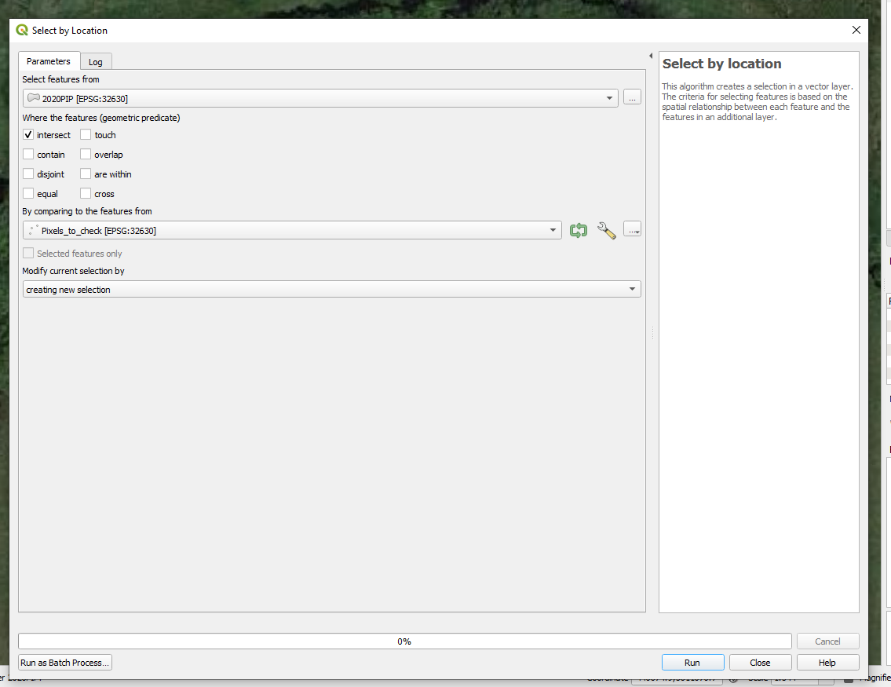
In the Processing Toolbox Vector selection: Select by location

Select features from: Select the new PIP file

Where features: intersect

By comparing to the features from: Pixels\_to\_check (**Figure 13**).

**Figure 13 Selecting pixels in the photo-interpreted pixels layer based on the location of pixels in the pixels to check layer**

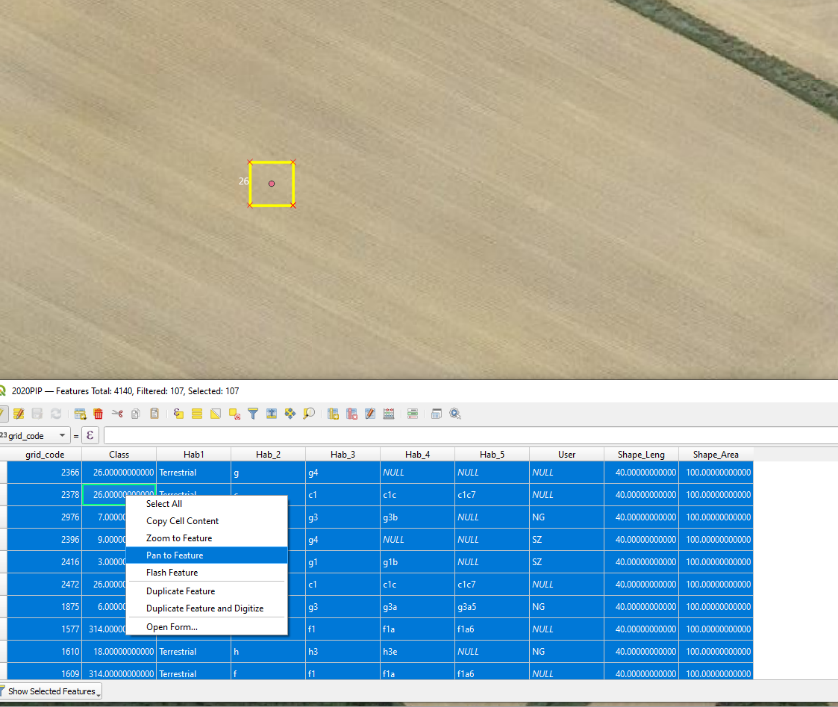


Open the attribute table of the new PIP shapefile, Change to Show Selected Features.

Right click and Zoom or Pan to Feature

Assess the Habitat Class for that pixel and amend the Class, Hab\_2, Hab\_3, Hab\_4 and Hab\_5 columns if necessary (Figure 14).

Figure Pixel to check, was classed as 26 Cropland, still Cropland so no amendment required, moving to next pixel



### Habitat Change

The Habitat Change tool will output three TIF files (YYYYtoYYYY\_cf\_YYYYtoYYYYAccuracyHabitatChange, YYYYtoYYYY\_cf\_YYYYtoYYYYHabitatIncrease and YYYYtoYYYY\_cf\_YYYYtoYYYYHabitatDecrease) and a csv file (HabitatClassChangeYYYYtoYYYY\_cf\_YYYYtoYYYY) will be saved in the Habitat\_Change\_Maps folder.

The Habitat Increase, Habitat Decrease and Habitat Change Accuracy maps have the spatial reference: EPSG:32630 - WGS 84 / UTM zone 30N – Projected.

### Habitat Change Metric for Small Extents 3- and 5-year Modes

These output a csv file (HabitatClassChange\_area\_YYYYtoYYYY\_cf\_YYYYtoYYYY) to the Habitat\_Change\_Maps folder.

# QGIS QML style files

Suggested map styles are saved in Habitat\_Classification\_Maps folder

Raster: SWEEP\_Hab\_Class\_Style\_Raster

Vector: SWEEP\_Hab\_Class\_Style\_Vector

# Potential Error Messages and Suggested Fixes

Error in makePSOCKcluster(cores[1] - 1) : Cluster setup failed. 1 worker of 3 failed to connect

This is an error when the code is trying to use your computers cores separately and one of the cores (workers) has failed to connect. It maybe that the core was busy, or connection was dropped.

First try running the code again using the Source button.

Second run the code in sections.

Left click with the mouse to highlight from dashed line to dashed line (------)

Click on Run.

A red Stop sign will appear in the top right-hand corner of the console. Once this disappears you can select and run the next section.

Error message that says Error: package xxx is required

Install the package xxxx using one of the methods described for [packrat.](#_Installing_packrat_package)