

Environment and Rural Affairs Monitoring & Modelling Programme (ERAMMP)

ERAMMP Technical Report-91: Quick Start Toolboxes (Phase 1)

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Abbreviations Used in this Report

GHG Greenhouse gas

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1 SUMMARY

This report briefly describes three software tools which were produced to support the ERAMMP Quick Start Phase 1 modelling work

1. Land use/farm type spatial disaggregation tool
2. Habitat connectivity opportunity mapping tool
3. Peat greenhouse gas (GHG) emission mapping tool

The tools were produced as ArcGIS toolboxes. Code can be downloaded from <https://www.erammp.wales/91>¹ and will run from within an ArcMap project.

Detailed information on the inputs, processing steps and outputs are provided with each tool in the form of a help text document; also provided in this document as Annexes A, B & C.

There are also instructions and prompts built in to the toolbox itself, similar to any standard ArcGIS tool.

1.1 Scope

This report briefly describes the tools which were produced to support the ERAMMP Quick Start Phase 1 modelling work providing information to Welsh Government.

The report will explain the concepts behind the tools and provide some guidance on appropriate use. For description of how the tools were used in the Phase 1 modelling work, and the results of the implementation, please see ERAMMP Report-12TA1 (Cosby et al. (2019))².

¹ www.erammp.wales/91

² www.erammp.wales/12TA1

2 INTRODUCTION AND PURPOSE

2.1 Background

The ERAMMP Quick Start Phase 1 modelling work consisted of (i) national level modelling of three potential Brexit scenarios, and (ii) regional modelling of land management scenarios.

For the Brexit scenarios, it was necessary to create a tool to spatially map estimated farm type transitions, using estimated areas expected to transition and other spatial data on the likelihood of transition.

For the regional scenarios, we wanted to identify opportunities to increase connectivity between existing broadleaf woodland habitats, to construct an example priority layer for woodland planting.

For both sets of scenarios, we needed a means of estimating potential change in greenhouse gas emissions from peat, either due to potential land use change following Brexit (national level scenarios) or land management to restore or rewet peat (regional land management scenarios).

3 TOOLBOXES

There are three separate software tools.

3.1 Land use/farm type spatial disaggregation tool

The tool models conversion of land between different types (either of farm, land use, or land cover, depending on your scenario context). Conversion is modelled up to a user specified area, between two user specified classes. The tool will rank fields or farms by likelihood of change based on up to 5 user input criteria datasets. Whilst agricultural changes are strongly driven by land manager choices and other social factors, there is also strong influence from physical characteristics, such as slope, climate, soil type, for which spatial data are widely available.

The tool makes the following assumptions:

- Land use/land cover/farm type change occurs up to a set area, based on the relative rank of land parcels, based on user input criteria and weightings.

The tool does not:

- Predict likely magnitudes or types of land cover change - these must be identified from other means (socioeconomic modelling, survey, focus groups etc.)
- Consider the social factors or pragmatic issues - these should be considered prior to running the tool, and can be used to pre-filter your input data to a set of polygons likely to undergo the modelled change.

3.2 Habitat connectivity opportunity mapping tool

Understanding and planning for habitat connectivity in landscapes is a huge field of research, and a range of different conceptual approaches have been used elsewhere. This tool is designed to be simple to understand, and to produce very rapid results, to indicate where habitat restoration could potentially improve structural habitat connectivity in a landscape of interest. The final outputs from the tool identify opportunities for habitat creation to increase connectivity between neighbouring habitat patches.

The tool makes the following assumptions:

- Species can disperse out from existing habitat patches up to a maximum, user-defined, dispersal distance.
- Species can move the same distance between habitat patches, irrespective of intervening land covers, i.e. the permeability of the matrix between habitat patches is not accounted for.
- Species can move in any direction.
- The user's interest is in facilitating movement between neighbouring habitat patches in a landscape.

The tool does not:

- Account for the probability of dispersal to a particular distance.

- Calculate least-cost paths.
- Calculate cost-distances.
- Consider the connectivity of networks, or the entire landscape.

3.3 Peat greenhouse gas (GHG) emission mapping tool

The tool assigns estimated GHG emissions factors based on a user supplied table of emission factors, mapped land use/land cover data and user supplied peat extent; for example the unified peat map for Wales (Evans et al., 2020).

Ideally, the emission factor table should be updated in to align with the emission factors implemented in most recent national inventories. In the UK the latest (as of 10/10/2022) are available in Table A 3.4.24 of the NIR UK Greenhouse Gas Inventory 1990-2020 annexes (UK NIR 2022), along with explanations of the categories. An example table is provided with the toolbox, but this is not up to date.

The main potential sources of error and uncertainty in the output to be considered are:

- Coefficients used in national inventories are considered best available using current evidence but are subject to frequent updates with new evidence. They should also be considered more representative of national averages than site specific conditions.
- Land use/land cover classifications for spatial data may not be available in a form which exactly matches with the classifications used in national inventory tables. In these cases, it is necessary for the user to assign appropriate classifications, which may be subjective.
- If the tool is applied to a land use/land cover change scenario e.g. of peat rewetting or conversion between arable/grassland, the new coefficients may not apply immediately, due to rates of ecological change.

4 LICENSING AND MAINTENANCE

These three software tool packages are owned by the Welsh Government and are provided under Open Government Licence 3.0. The text of this licence is provided in Annex-D.

The software is provided 'as is' and is published as version 1.0.0. The ERAMMP project will make no further modifications or maintenance updates. As has been described above, the tools were developed and used for the production of ERAMMP Report-12³ and Technical Annex 12TA1⁴ and are not being maintained or developed by the programme further. No support is provided.

The licence allows use and further development and modification by any other party.

³ www.erammp.wales/12

⁴ www.erammp.wales/12TA1

5 ANNEX-A: USER GUIDE - LAND USE CHANGE MAPPING TOOL

Help text author: Amy Thomas

ArcGIS toolbox and Python code author: Amy Thomas

Code package is available at www.erammp.wales/91

The development of this tool was supported by the Environment and Rural Affairs Monitoring & Modelling Programme (ERAMMP)(Welsh Government Contract C210/2016/2017), by the UK Centre for Ecology & Hydrology (Projects: 06297&06810) and by national-capability funding provided by UKRI/NERC (UKCEH ref: 07067). We thank the Welsh Government and the ERAMMP team for their support and contributions. This product is ERAMMP-91TA1. Copyright the Welsh Government (2023). Open Government Licence 3.0.

Software requirements

The ArcGIS toolbox requires ArcGIS 10 with the Spatial Analyst extension.

Licensing, disclaimer, citation

This tool was created as part of the ERAMMP project to provide indicative maps of potential farm type change

Theoretical background

Whilst agricultural changes are strongly driven by land manager choices and other social factors, there is also strong influence from physical characteristics, such as slope, climate, soil type, for which spatial data are widely available.

The tool makes the following assumptions:

- Land use/land cover/farm type change occurs up to a set area, based on the relative rank of land parcels, based on user input criteria

The tool does not:

- Predict likely magnitudes or types of land cover change- these must be identified from other means (socioeconomic modelling, survey, focus groups etc)
- Consider the social factors or pragmatic issues - these should be considered prior to running the tool, and can be used to pre-filter your input data to a set of polygons likely to undergo the modelled change.

How the tool works

The tool goes through the following steps:

1. identifies polygons of the type projected to reduce
2. dissolves these on the supplied farm or field identifier
3. weights all criteria rasters as required, and uses these to assign a mean value to each field/farm unit (creating a zonal statistics table for each)
4. calculates a combined value of the weighted criteria for each field/farm unit

5. uses the combined weighted values to rank field/farm units by likelihood of change
6. simulates change in land use/land cover/farm type for field/farm units until the user supplied target has been reached (exceeded)
7. produces a polygon output file with all polygons selected in step 1, and a column (RFTall) indicating if they are assigned to baseline or new land use/land cover/field type

How to use the tool

Input data

The tool requires at least two input datasets:

- Polygon data of baseline land cover/land use/farm type
- Raster dataset for (at least one) criteria to be used to rank polygons by likelihood of change

Both of these datasets should be in the same projected coordinate system

Input parameters in the tool

The user defines the following input parameters:

Location of folder where output data will be stored

Define a folder where the tool should output model data. A file geodatabase (.gdb) will be created here by the tool.

Problems can arise if there are spaces in the file path. Note that the tool will fail to run if a .gdb with an identical name already exists in the folder

Ensure the filepath to this location has five or fewer levels (more levels may cause errors).

Landuse/farm type data

Choose a polygon data file which identifies land cover or farm type. The land cover/ farm type column must be labelled EFTx and be in a string/text format.

The polygon data should also have a column identifying polygons to be converted together e.g. a farm identifier if entire farms are to be converted. This can be a unique identifier for each field/polygon if you wish to convert at field level.

This data should be selected by browsing to the file location.

land use/farm type to change from

A string identifier for the current land use/land cover/farm type which you will be converting to a new type in this scenario (e.g. rough_grazing). The value must exactly match the string value in your dataset

area projected to change (in hectares)

Numeric value for the area projected to change. Land will be converted until the total land use change exceeds this value

land use/farm type to change to

A string identifier for the new land use/land cover/farm type which you will be creating in this scenario (e.g. Broadleaf_woodland).

Criteria raster (n)

A raster dataset representing a variable which may affect the likelihood of land use change, e.g. slope, elevation, soil type, climate etc. It may be necessary to pre-process this dataset if thresholds are relevant to the likelihood of change (e.g. exponentially decreasing likelihood above a certain elevation)

Weighting for Criteria raster (n)

The weighting to apply to the specified criteria raster. These can be negative if appropriate

Output data

The tool outputs the following files within the file geodatabase:

Name	Description
RFT_curr_tmp	all polygons selected for possible conversion
RFT_currD_tmp	all polygons selected for possible conversion dissolved on the supplied farm (or other grouping) identifier
RFT_JZS_tmp	RFT_currD_tmp linked to the ranking value derived from combined weighted criteria rasters
ordJZS_tmp	ordered version of RFT_JZS_tmp
UpdRFT_tmp	Polygons to be converted. Contains column NewRFT indicating the new land cover/farm type
NewLU	polygons which were selected for possible change contains columns NewRFT indicating the new land cover/farm type if changed, and RFTall new(if changed) or old (if not changed) land cover/farm type

Tables of zonal statistics for each criteria raster are also created in the output folder ZSR(n).dbf

6 ANNEX-B: USER GUIDE - HABITAT CONNECTIVITY MAPPING TOOL

Version 3 – April 2020

Help text author: Eleanor Warren-Thomas

ArcGIS toolbox and Python code author: Amy Thomas

Code edits/input from: Susan Jarvis, Eleanor Warren-Thomas

Code package is available at www.erammp.wales/91

The development of this tool was supported by the Environment and Rural Affairs Monitoring & Modelling Programme (ERAMMP)(Welsh Government Contract C210/2016/2017), by the UK Centre for Ecology & Hydrology (Projects: 06297&06810) and by national-capability funding provided by UKRI/NERC (UKCEH ref: 07067). We thank the Welsh Government and the ERAMMP team for their support and contributions. This product is ERAMMP-91TA2. Copyright the Welsh Government (2023). Open Government Licence 3.0.

Software requirements

The ArcGIS toolbox requires ArcGIS 10 with the Spatial Analyst extension.

Licensing, disclaimer, citation

This tool was created as part of the ERAMMP project to provide indicative maps of potential opportunities to improve structural habitat connectivity

Theoretical background

Understanding and planning for habitat connectivity in landscapes is a huge field of research. This tool is designed to be simple to understand, and to produce very rapid results based on simple input data, to indicate where habitat restoration could potentially improve structural habitat connectivity in a landscape of interest.

The tool makes the following assumptions:

- Species can disperse out from existing habitat patches up to a maximum, user-defined, dispersal distance.
- Species can move the same distance between habitat patches, irrespective of intervening land covers, i.e. the permeability of the matrix between habitat patches is not accounted for.
- Species can move in any direction
- The user's interest is in facilitating movement between neighbouring habitat patches in a landscape

The tool does not:

- Account for the probability of dispersal to a particular distance
- Calculate least-cost paths
- Calculate cost-distances
- Consider the connectivity of networks, or the entire landscape

How the tool works

The tool goes through the following steps:

- 1) Selects patches of the relevant habitat type above the user input threshold minimum area
- 2) Creates buffers around these habitat patches using the dispersal distance defined by the user and identifies overlapping areas of buffers
- 3) Counts how many habitat patches are contained within each buffer (a measure of existing connectivity for a particular habitat patch)
- 4) Joins and overlays the buffers to create segments, within which further calculations are done
- 5) Counts how many buffers overlap each segment (i.e. the potential total connectivity of each segment)
- 6) Counts the number of existing habitat patches that each segment intersects with (i.e. the current connectivity of each segment)
- 7) Identifies segments with multiple overlapping buffers, which do not currently contain the habitat of interest; habitat creation in these regions would connect the existing habitat patches

How to use the tool

Troubleshooting: important notes about input data location

- The depth of the filepath to your chosen location for outputs, and the location of the raster grid (explained below) must be five levels or lower. Errors may occur when the tool tries to run the Union tool if these locations are saved in a deeper file structure.
 - This does work: L:\EWT\HabConFeb20\AllWales\results (**4 levels**)
 - This doesn't work: L:\EWT\HabConFeb20\All Wales\results\habcon\Cat_01 (**6 levels**)
- The polygon data must be added into the tool from within the ArcMap document (from the drop-down menu in the tool, or by dragging in a layer that has already been added in to the ArcMap document).
 - The polygon data should not be added by browsing to a file location from within the tool – this creates errors.

Input data

The tool only requires two input datasets:

- Polygon data of habitat classes for the landscape of interest, with a field identifying the land cover of each polygon (this can either be a land cover map of many habitat classes or a map containing only the habitat of interest, as only polygons labelled with the habitat of interest will be used in analysis). Must be dissolved on habitat type before use (uncheck multipart) to ensure adjoining woodland is combined, for correct implementation of patch size thresholds.
- Raster grid (containing any data) that covers the landscape of interest, in the same coordinate system as the polygon dataset, and with a grid cell size appropriate for interpreting outputs (smaller is better, to retain detail).

Both of these datasets should be in the same projected coordinate system so that distance units are meaningful.

Input parameters in the tool

The user defines the following input parameters:

Location of folder where output data will be stored

Define a folder where the tool should output model data. A file geodatabase (.gdb) will be created here by the tool, with a name that includes the minimum habitat patch size and dispersal distance (defined below).

Problems can arise if there are spaces in the file path. Note that the tool will fail to run if a .gdb with an identical name already exists in the folder (i.e. has the same minimum habitat patch size and dispersal distance as a previous run).

Ensure the filepath to this location has five or fewer levels (more levels may cause errors).

Habitat map

Choose a polygon data file that contains the habitat of interest. This should be a feature class in the same coordinate system as the output grid (defined below), and should be projected so that dispersal distance (i.e. buffer distance) units are meaningful.

The polygon data should have a field detailing the habitat class of each polygon.

This data should be added to the ArcMap document first, then selected using the drop-down menu or by dragging it into the field on the menu. It should not be selected by browsing to a file location (this may cause errors).

Habitat label

Choose the habitat class of interest for the connectivity model (e.g. Broadleaf_woodland).

Habitat field

Choose which field (column) of the habitat polygon data table contains the habitat class (e.g. Land_Cover).

Minimum area of relevant habitat patch

Define the minimum size for a habitat patch to be of interest, in the units relevant for the coordinate system of the habitat polygon data. Any habitat patches of this size, or larger, will be included in the connectivity analysis. Any habitat patches smaller than this size will be disregarded, and will not contribute to connectivity measures.

For broadleaf woodland in the UK, a minimum size of 0.5ha (500 square metres) is commonly used.

Expected dispersal distance of species from existing habitat patches

Define the dispersal distance of interest in the units relevant for the coordinate system of the habitat polygon data. This distance will be used to create buffers around existing habitat patches and identify areas of overlap and connectivity.

In the absence of a specific focal species, a 200 m distance may be a pragmatic option for poorly-dispersing broadleaf woodland specialist in the UK.

Raster grid for output

Choose a raster grid to use as the basis for the final raster outputs. Any raster grid that covers the area of interest and is in the same coordinate system can be used.

Try to use the finest available resolution to avoid loss of information.

Ensure the filepath to this data has five or fewer levels (more levels may cause errors).

Output data

The tool outputs the following files within the file geodatabase:

Name	Description
hab_polys	Subset of original input habitat patch data, with patches above minimum size
habbuff	Buffers around each habitat patch using the user-defined distance
habbuffi	Union of habbuff, so that overlaps become discrete areas
hbuffmask	Same as habbuffi, but with duplicated areas in overlaps (intersections) between buffers deleted
rawhbuff	Join of habitat polygons with their buffers, showing buffers that already connect habitats (Join_Count gives value for how many hab_polys intersect with each buffer)
habbuffj	Join of hab_polys with intersections of buffers, showing how sub-sections of the total buffers connect with existing habitat (Join_Count gives value for how many hab_polys intersect with each sub-section). Areas with a Join_Count of 0 or 1 are only connected to their own habitat patch, and connect with no additional polygons. Areas with a Join_Count of 2 or more are in each of 2 or more polygons (and are therefore potentially useful places to restore habitat to improve connectivity).
habbuffj2	Join of individual intersections (hbuffmask) with original, duplicated intersections. Join_Count gives a value for how many buffers overlap at each intersection.
networks	Dissolves boundaries between habitat buffers, generating networks of habitat patches that are already connected, that each have a unique ID. NOTE these networks are effectively connected at double the specified dispersal distance i.e. a distance of 200m will mean an organism would need to travel 400m to definitely reach all patches within the network
habR	Raster version of habbuffj
buffR	Raster version of habbuff2
HabCon	Raster version of rawhbuff
OppCon	Number of buffer overlaps (habbuffj2) minus number of patches already connected (habbuffj), giving the number of patches that would be connected if habitat were created in that area. Values of 0 or 1 mean new habitat would connect to either 0 or 1 patches, so only values of 2 or more represent opportunities for additional connectivity.
OppCon_F	Values of OppCon of 2 or more

Versions of these files with the suffix “_b” have original habitat erased out.

OppCon_F_b has been set to 0 if there is habitat anywhere in the segment, since there is already some provision of connectivity within these segments.

How to use the outputs

The OppCon rasters show places where habitat creation could provide connectivity between patches not currently connected (based on the minimum patch size and dispersal distance defined by the user). Further work will then be needed to decide which of these areas might be priorities for habitat creation. For example, areas where habitat restoration is impossible could be masked out (e.g. urban areas, freshwater, other habitats of conservation priority). Habitat patches of particular interest for conservation could be highlighted. This could include

highlighting areas that may be vulnerable to species invasions if connected to other habitat patches, or areas that could benefit from habitat creation to increase patch size.

There is considerable debate around the relative emphasis on the different aspects of “bigger, better, joined-up” habitat networks for nature. The results of this habitat connectivity mapping tool should be interpreted in the context of this debate, the specific conservation objectives for the landscape of interest (e.g. habitats and species of interest), and in light of evidence around habitat size and connectivity (for example, the recent evidence review on nature recovery networks published by Natural England (<http://publications.naturalengland.org.uk/publication/6105140258144256>)).

7 ANNEX-C: USER GUIDE - PEAT GHG EMISSION MAPPING TOOL

Help text author: Amy Thomas

ArcGIS toolbox and Python code author: Amy Thomas

Code package is available at www.erammp.wales/91

The development of this tool was supported by the Environment and Rural Affairs Monitoring & Modelling Programme (ERAMMP)(Welsh Government Contract C210/2016/2017), by the UK Centre for Ecology & Hydrology (Projects: 06297&06810) and by national-capability funding provided by UKRI/NERC (UKCEH ref: 07067). We thank the Welsh Government and the ERAMMP team for their support and contributions. This product is ERAMMP-91TA3. Copyright the Welsh Government (2023). Open Government Licence 3.0.

Software requirements

The ArcGIS toolbox requires ArcGIS 10 with the Spatial Analyst extension.

Licensing, disclaimer, citation

This tool was created as part of the ERAMMP project to provide indicative maps of potential change in GHG emissions from peat

Theoretical background

The tool assigns estimated GHG emissions factors based on mapped land use/land cover and a user supplied table.

Ideally, the table should be updated in to align with the emission factors implemented in national inventories. In the UK the latest (as of 10/10/2022) are available here:

The main potential sources of error and uncertainty in the output to be considered are:

- Coefficients used in national inventories are considered best available using current evidence but are subject to frequent updates with new evidence. They should also be considered more representative of national averages than site specific conditions.
- Land use/land cover classifications for spatial data may not be available in a form which exactly matches with the classifications used in national inventory tables. In these cases, it is necessary for the user to assign appropriate classifications, which may be subjective.
- If the tool is applied to a land use/land cover change scenario e.g. of peat rewetting or conversion between arable/grassland, the new coefficients may not apply immediately, due to rates of ecological change.

How the tool works

The tool goes through the following steps:

1. intersects polygons representing land use/land cover data with peat extent polygons, to create a new polygon dataset

2. links the polygons created in step 1 to a user supplied table of peat GHG emission factors based on land use/land cover. This step assigns a per hectare value for peat GHG emissions
3. A column is added to the polygon data with area of peat for each field (area_ha)
4. A further column is added to the polygon data in which total peat GHG emissions are calculated for each field, using values from 2 and 3

Note: The tool will fail if columns named either "tco2eq_yr" or "area_ha" are already in your input data.

How to use the tool

Input data

The tool requires at least three input datasets:

- Polygon data of baseline land cover/land use/farm type
- Polygon dataset of peat extent

Both of the spatial datasets should be in the same projected coordinate system

- tabular data (in .dbf format) of peat GHG emission coefficients for each land use/land cover type in your polygon data (which intersects with the peat extent).

The land use classes must match exactly between the table and the polygon data (including case, spelling, spaces etc)

Input parameters in the tool

The user defines the following input parameters:

Location of folder where output data will be stored

Define a folder where the tool should output model data. A file geodatabase (.gdb) will be created here by the tool

Problems can arise if there are spaces in the file path. Note that the tool will fail to run if a .gdb with an identical name already exists in the folder

Ensure the filepath to this location has five or fewer levels (more levels may cause errors).

Land use/land cover data

Choose a polygon data file which identifies land cover or land use

This data should be selected by browsing to the file location.

land use/farm type

A string identifier for the current land use/land cover

land use field

Name of the column containing the identifier for land use/land cover. These identifiers must be represented in your attribute table (below)

table with GHG attributes

User supplied table of peat GHG emission factors for each land use/land cover present in your study area

Output data

The tool outputs 2 polygon files within the file geodatabase:

1. LUP_int_tmp: an intermediate file which is simply the land use polygon data intersected with peat
2. LUP_intj_t : a feature class polygon file with data for each field portion under peat.

Each area of peat is assigned

- An emissions intensity in t CO2 equivalents per ha per year, based on the assigned land use/land cover, and the user supplied table of export coefficients.
- area in ha (area_ha)
- total emissions for field portion in t CO2 equivalents per year (tco2eq_yr)

8 ANNEX-D: OPEN GOVERNMENT LICENCE v3.0 (OGL 3.0)

www.nationalarchives.gov.uk/doc/open-government-licence/version/3/



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⁵ <https://www.nationalarchives.gov.uk/information-management/re-using-public-sector-information/uk-government-licensing-framework/>

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