GIS and Remote Sensing

Assessment 1 – Esk Catchment Landuse

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Introduction

History

Scotland’s landscape has changed drastically through-out the years.

Some of this has been natural changes but most changes to our landscape has been through anthropogenic forest and woodland clearances.

With increases in farming and agriculture, commercial woodland plantations and the development of large shooting estates, most of Scotland’s historic native woodlands have been lost.

By 1900’s, woodland cover was only 4% of Scotland's land mass. This is down massively from its peak around 6000 years ago where native woodland covered huge swathes of the country from the Western Isles to the Shetlands and everywhere in-between (NatureScot, 2023).

[Rewilding example - before and after]

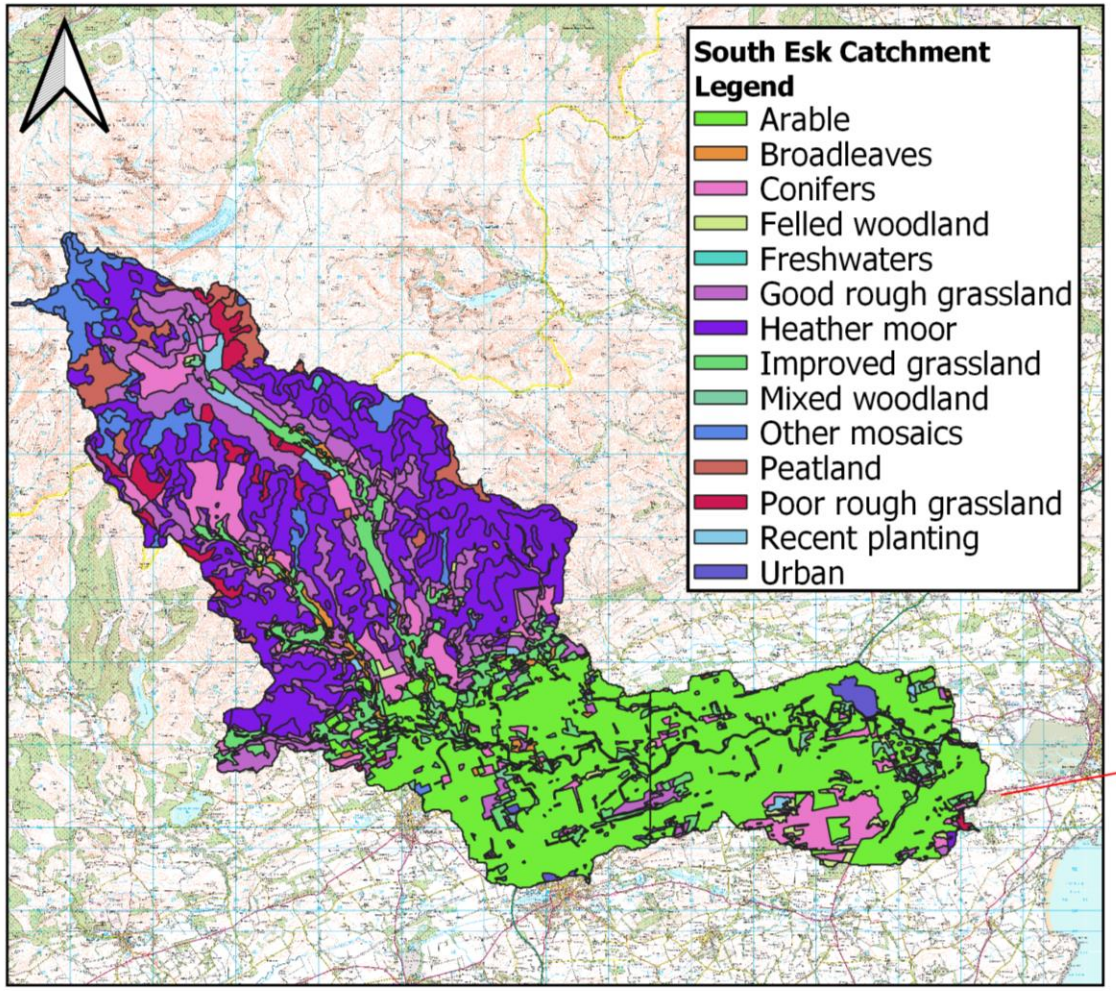
Present

Through conservation efforts from both UK and Scottish governments, local authorities, charities and the private sector, efforts have been made to protect, restore and/or expand Scotland’s native woodlands and forests.

Some of these efforts include re-forestation by planting new woodlands using native species of trees. Another method is “Re-Wilding”, which is simply letting nature take care of itself with little to no human influence (See example above).

The Project

The aim of the project is to establish woodland cover changes of the South Esk river catchment by comparing tree coverage in 1988 to June 2023. The South Esk catchment is a diverse area of 487 km2. It starts high in the mountainous eastern Cairngorms before going south/south-east through the diverse landscape of Strathmore which consists of agricultural and mixed-used recreational lands, touching upon the small urban areas of Brechin and Forfar before ending at the coastal region of the Montrose Basin.



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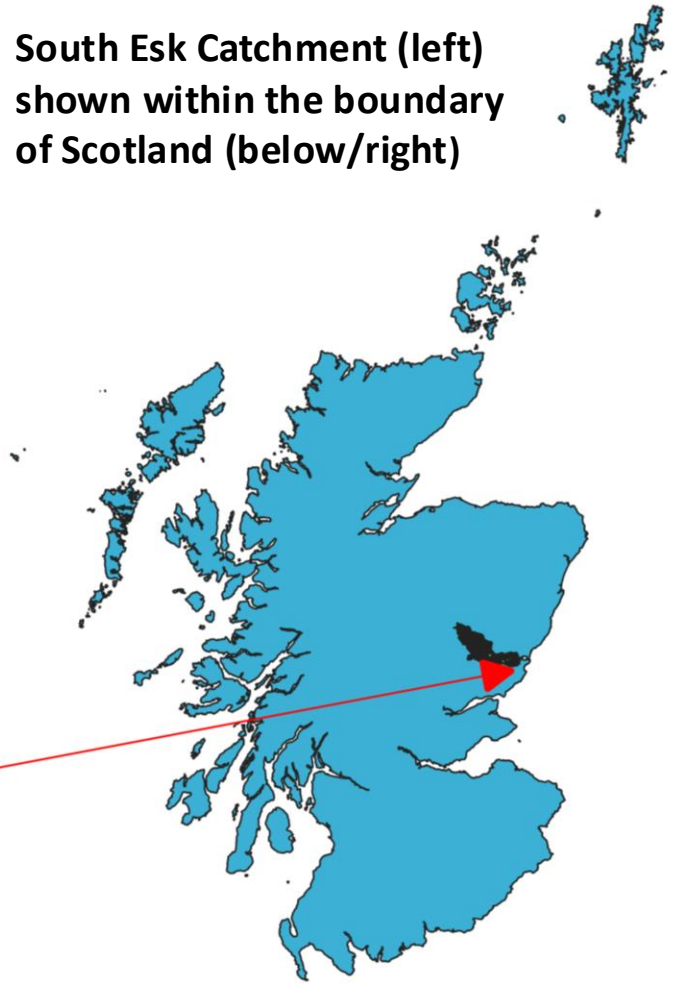
South Esk Catchment (left) shown within the boundary of Scotland (below/right)



It starts high in the mountainous eastern Cairngorms before going south/south-east through the diverse landscape of Strathmore which consists of agricultural and mixed-used recreational lands, touching upon the small urban areas of Brechin and Forfar before ending at the coastal region of the Montrose Basin.

Processes

Data Sources

The three main information sources were:

- Landscape Character Assessment (LCA) – Downloaded from Moodle.
- LCS88 data – Downloaded from Moodle.
- 1:25k & 1:50k OS backdrop raster maps downloaded from Digimap.

These files were all unzipped and imported into a new QGIS project.

Main QGIS Processes

Using “Select expression” tool under AT, extracted just tree data from SouthEskLCS88.

→ Used the “Clip” tool under Geoprocessing to clip the dataset for the project.

→ Created new shapefile layers for each woodland type and digitised gains and losses of woodland, drawing Polygons.

→ Used the “Merge Vector” function to merge the three new digitised Woodland areas into one shapefile.

→ Checked AT for digitised shapefiles to ensure correct woodland type ID had been assigned to woodland type.

→ Used the Field Calculator to calculate area using *$area* for New Woodland shapefile. Repeated steps for Lost Woodland shapefile.

→ Had problems Union/Joining layers so used “Check Validity” tool for any errors in the Geometry of the Felled Woodland Shapefile.

→ Fixed some errors by tidying the badly drawn polygons. Then for a final tidy/fix-up used the “Dissolve” tool. Data now ready for Union/Join.

Processes continued

Main QGIS Processes Cont.

Using “Union” tool under Geoprocessing, joined clipped LCS88 Woodland data with New Woodland Data.

Using the same tool, the new “joint” file (LCS88 and New Woodland) was joined with Felled Woodland.

The latest “joint” file, now consisting of clipped LCS88 Woodland data, New Woodland area data and Felled Woodland area data, was joint with clipped LCA file for a complete dataset.

This complete dataset was exported as CSV for Excel analysis. Maps were then created using “New Print “Layout”.

Data Analysis (Excel) Processes

With the exported CSV containing all data via the “Union” function in QGIS, it now had all data including Woodland type and area of each type in metre-squared for: LCA Boundary, Woodland data (LCS88), New Woodland (OS June ‘23) and Felled Woodland (OS June ‘23).

The data within CSV was exported to a clean Excel document and using the “A-Z sort” and “Sum” functions, the following data was extracted:

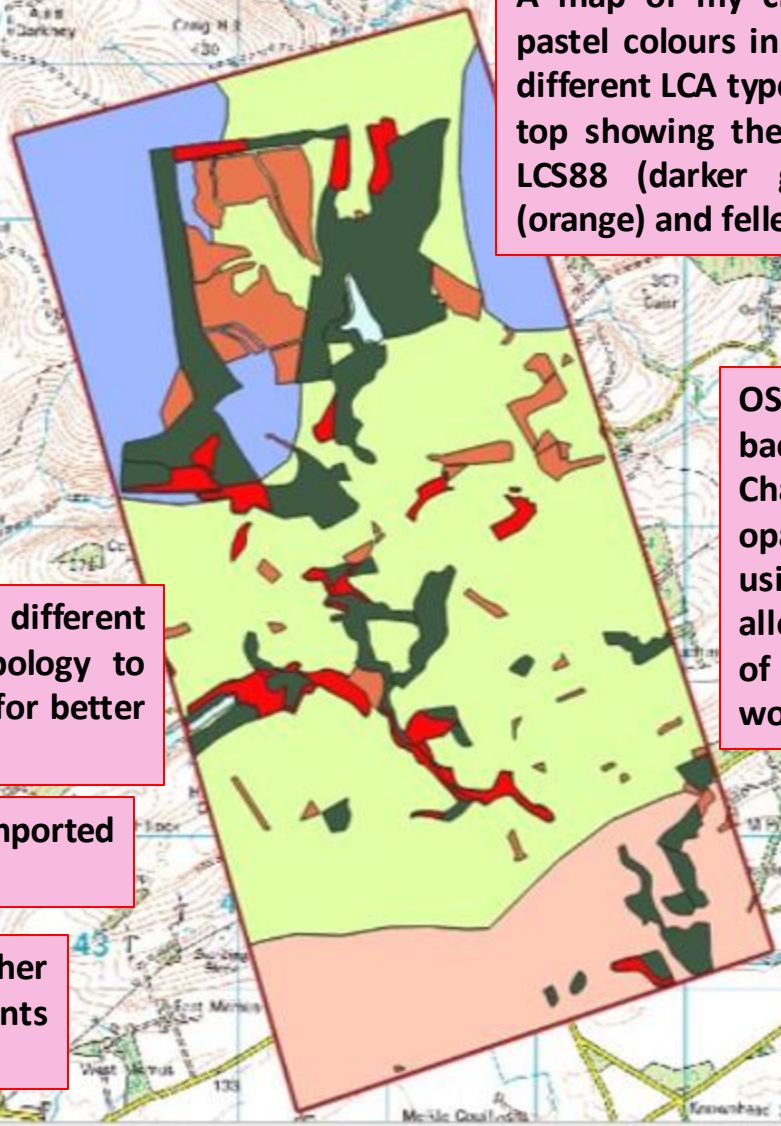
- LCA type, size in metre-squared and LCA % of clipped data.
- Type and amount of woodland for each LCA type for each polygon (LCS88, New Woodland, Felled Woodland)
- Graph’s created using “Chart” function showing loses and gains. Summary table created using “Sum” function.

	A	B	C	D	E	F
1	**LCA Type**	**LCA Size (m-squared)**	**LCA as % of Clipped Data**	**LCS88 (Mixed Woodland)**	**LCS88 (Conifer Woodland)**	**LCS88 (Broadleave Woodland)**
2	Broad Valley Lowland	3,563,548.84	16.82%	196676.34	116879.4	43803
3	Highland Foothills	14,122,053.28	66.66%	631153.3	1939903.57	474367
4	Highland Summits and Plateaux	4,136,520.35	16.52%	109723	1796650	0
5						
6	**Totals**	**21,822,122.47**	**100.00%**	**937552.64**	**3853432.97**	**518170**
7						
8						
9	**LCA Type**	**LCA Size (m-squared)**	**LCA as % of Clipped Data**	**NEW (Mixed Woodland)**	**NEW (Conifer Woodland)**	**NEW (Broadleave Woodland)**
10	Broad Valley Lowland	3,563,548.84	16.82%	0	23516	0
11	Highland Foothills	14,122,053.28	66.66%	587082	158853	361440
12	Highland Summits and Plateaux	4,136,520.35	16.52%	288490	162320	243874
13						
14	**Totals**	**21,822,122.47**	**100.00%**	**875572**	**344689**	**605314**
15						
16						
17	**LCA Type**	**LCA Size (m-squared)**	**LCA as % of Clipped Data**	**FELLED (Mixed Woodland)**	**FELLED (Conifer Woodland)**	**FELLED (Broadleave Woodland)**
18	Broad Valley Lowland	3,563,548.84	16.82%	23323	0	0
19	Highland Foothills	14,122,053.28	66.66%	190879	259173	148477
20	Highland Summits and Plateaux	4,136,520.35	16.52%	0	167415	0
21						
22	**Totals**	**21,822,122.47**	**100.00%**	**214202**	**426588**	**148477**

[Cleaned data, categorised, organised and calculated. Extracted from QGIS CSV file that contained the 4 “unions” of clipped LCS88, LCA, New and Felled data]

“Digitising” of the Woodland within QGIS

Three new shapefiles for the digitising of woodland. LCS88 data clipped, showing only woodland. A further shapefile for new woodland digitising and another showing removed woodland.



A map of my clipped area. The lighter pastel colours in the background are the different LCA types. The bolder colours on top showing the digitising of woodland. LCS88 (darker green), new woodland (orange) and felled woodland (red).

OS map in the background. Changing layer opacity and/or using swipe tool allowed digitising of new and felled woodland areas.

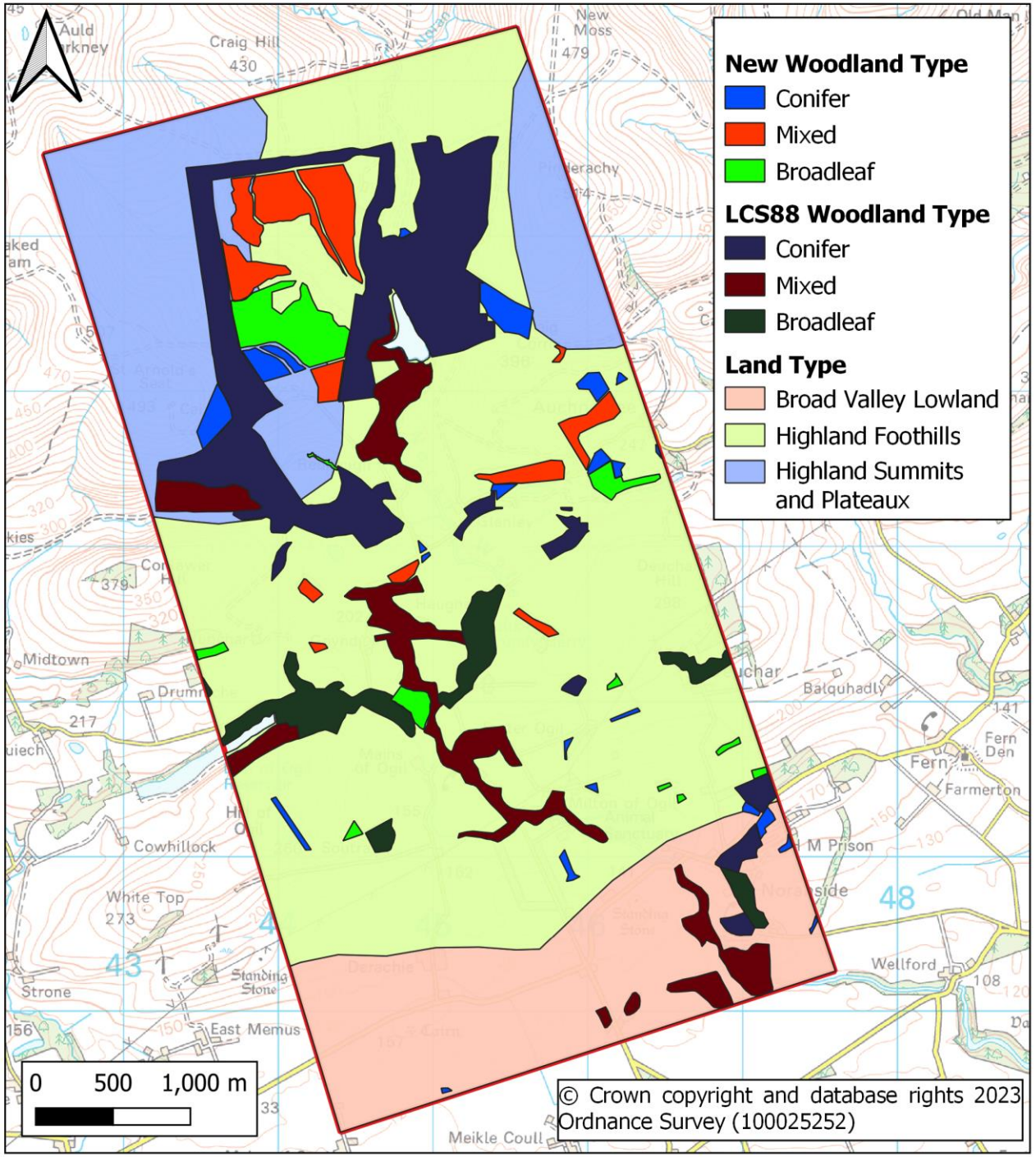
Clipped LCA showing 3 different areas. Changed Symbology to lighter pastel colours for better contrast.

LCA and LCS88 data imported from Moodle.

OS “tiffs“ grouped together allowing easy CSR adjustments & on/off toggling.

Processing Toolbox allowing easy access to a lot of tools. Allows some jobs to be “done on the fly” saving time.

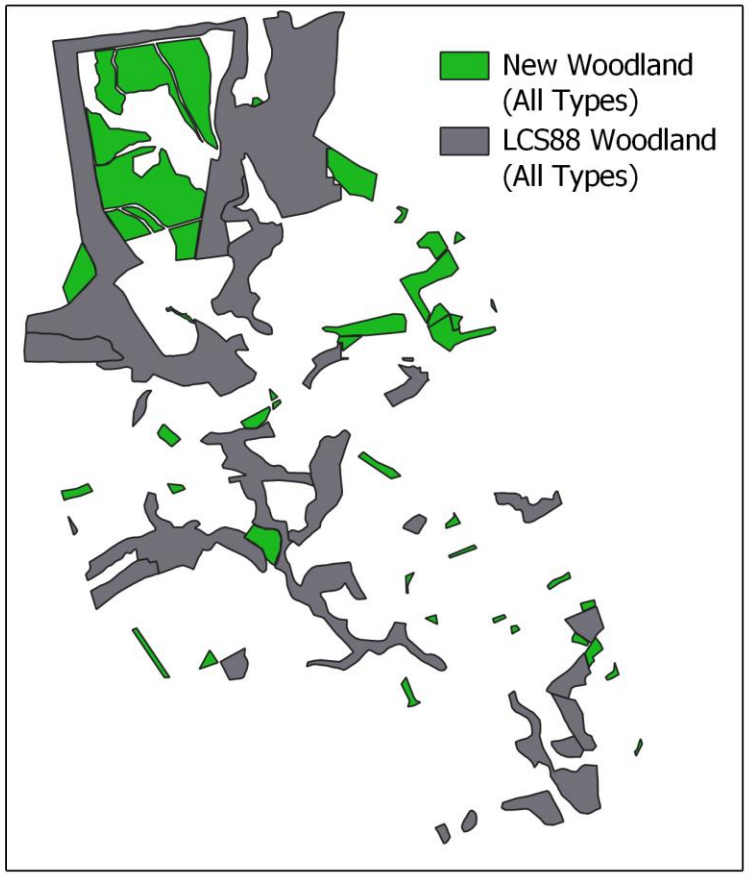
1a



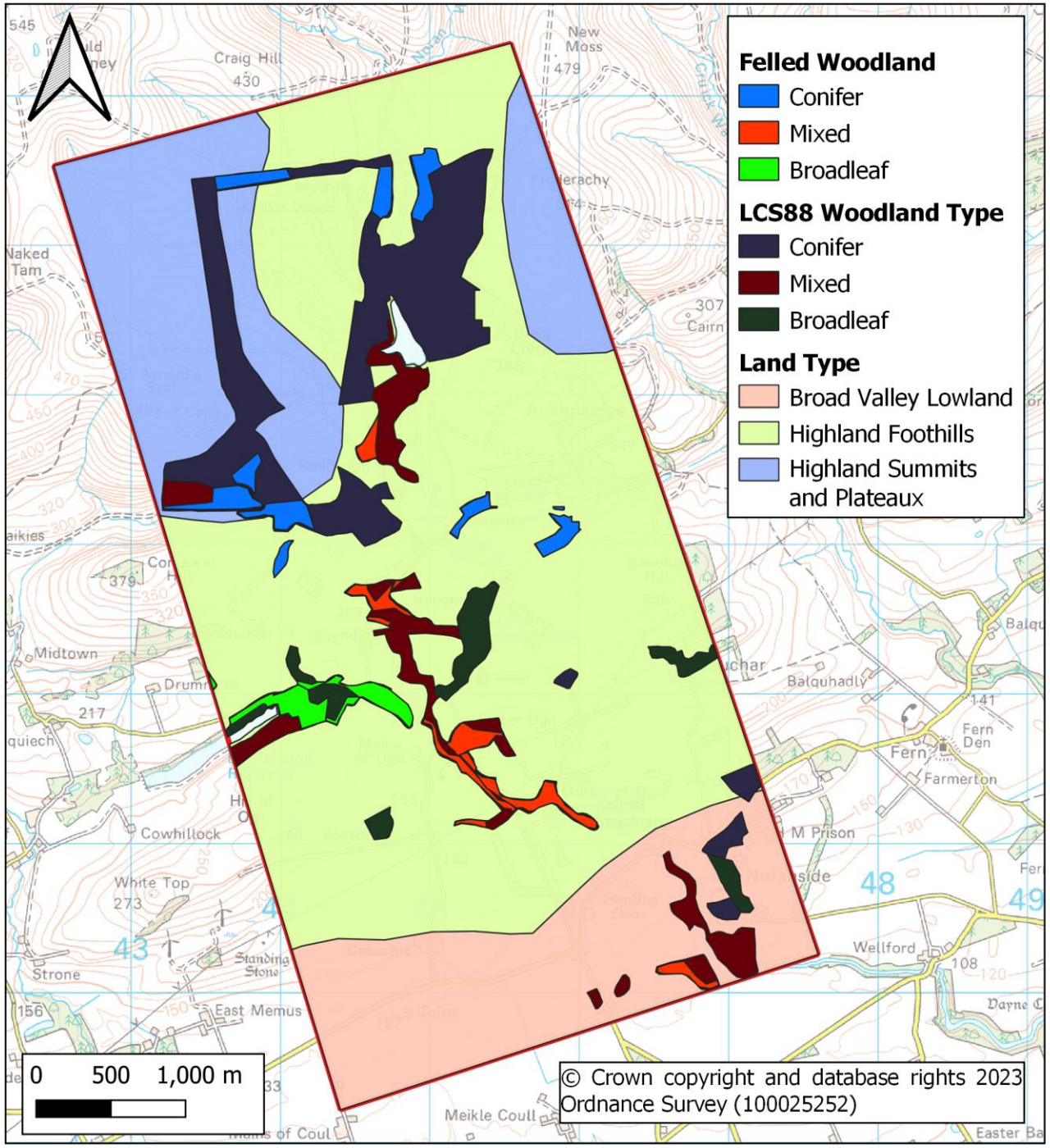
Maps

- Map 1a (left) shows 3 different land types from Land Character Assessment Scotland. Overlayed on top of that is the LCS88 woodland data with new gained woodland data, symbology changed to categorised showing different woodland and tree types.
- Map 1b (below) shows the same woodland data but stripped back for an easier visual comparison between LCS88 woodland and new gained woodland, with symbology (single) simplified.

1b



2a

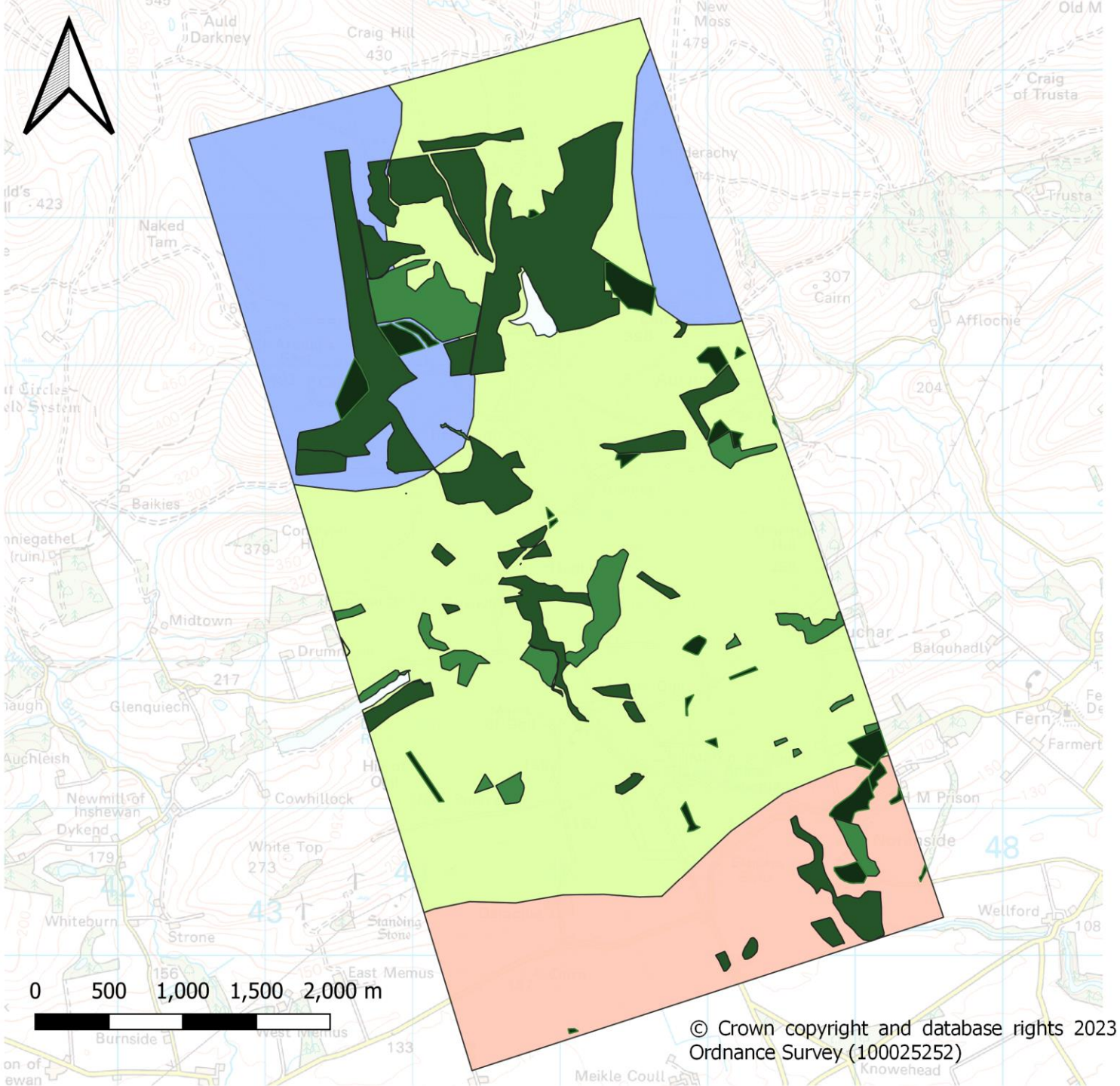


Maps

- Map 2a (left) shows 3 different land types from Land Character Assessment Scotland. Overlayed onto that is the LCS88 woodland data with lost felled woodland data, both showing woodland types via changes to symbology (categorised).
- Map 2b (below) shows the same woodland data but stripped back for an easier visual comparison between LCS88 woodland and lost felled woodland by changing to single symbology.

2b

3



Maps

- Map 3 (left) is the final most up-to-date map. Map 3 shows the woodland cover as of June 2023 (OS map date).
- Using the “Difference” tool, Felled/Lost Woodland polygons were removed from the LCS88 data.
- The new “Difference” shapefile was then merged with the New Gained Woodland shapefile.
- Symbology changed to Categorised to show different woodland types
- This data has been overlayed on the LCA boundary data, which has been overlayed on the OS map data with layer opacity reduced for easier reading

Map Legend

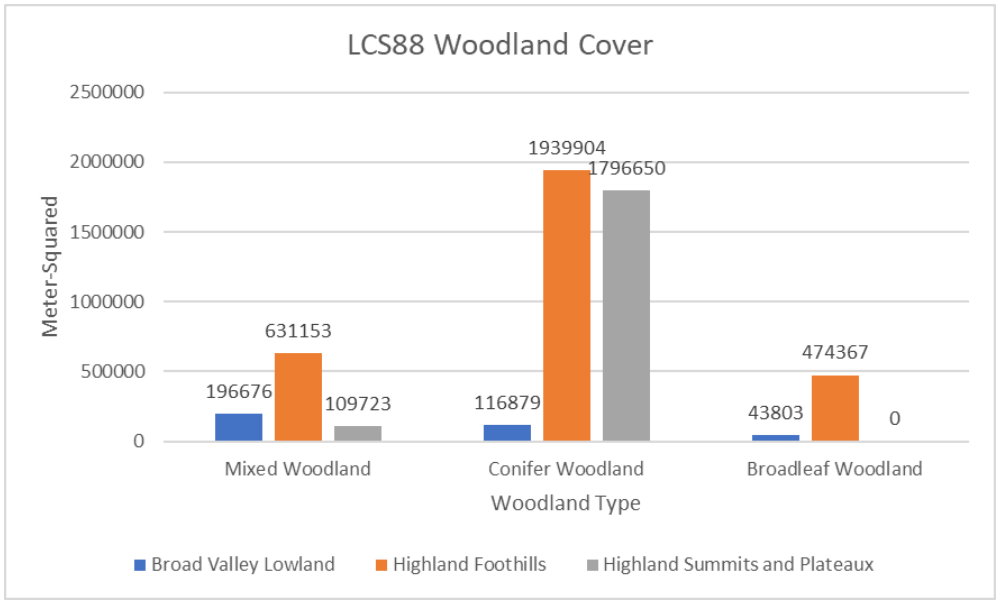
Total Woodland as of June 2023

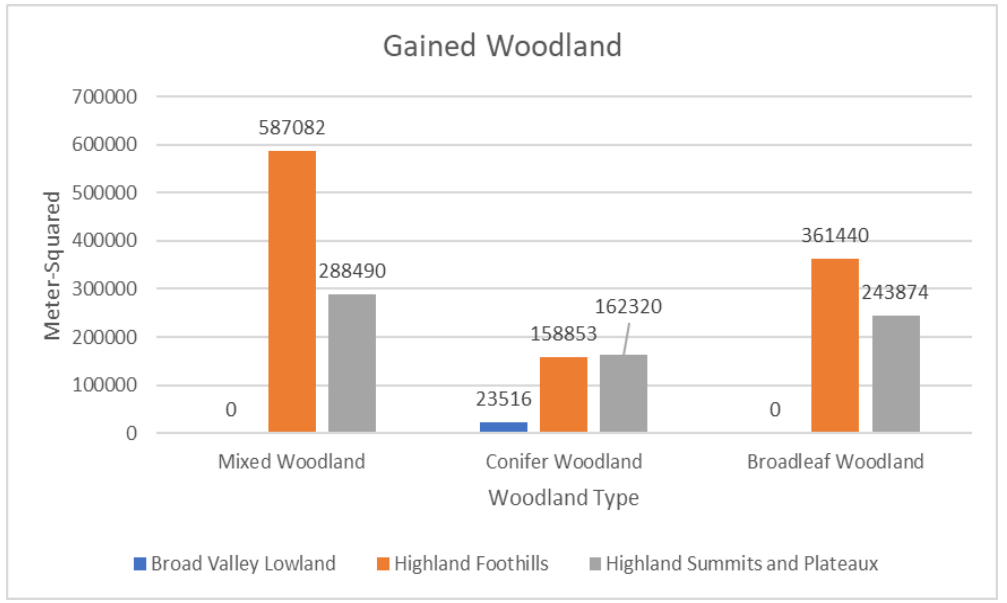
- Conifer
- Mixed
- Broadleaf

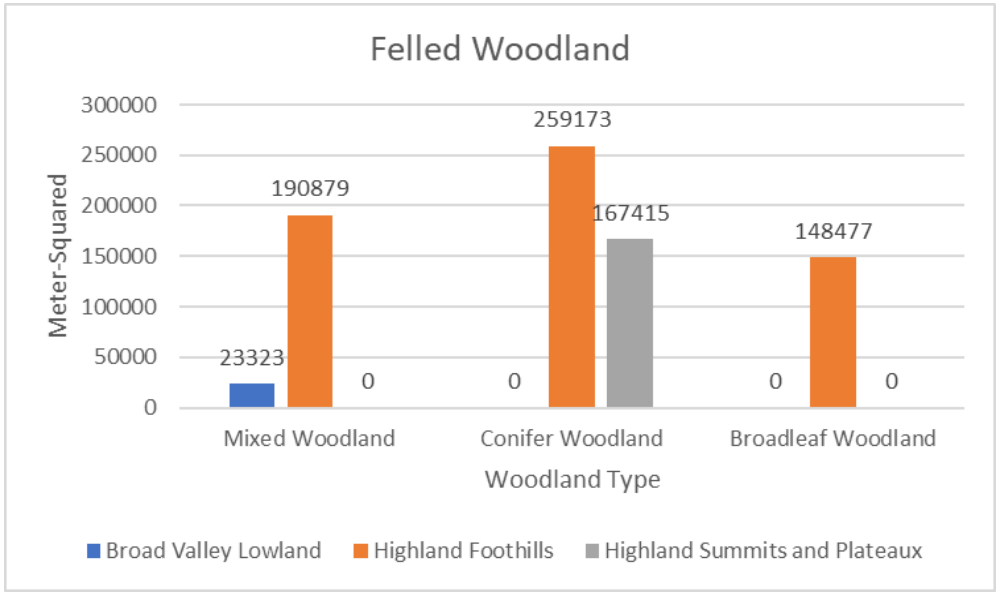
Land Character Assessment Types

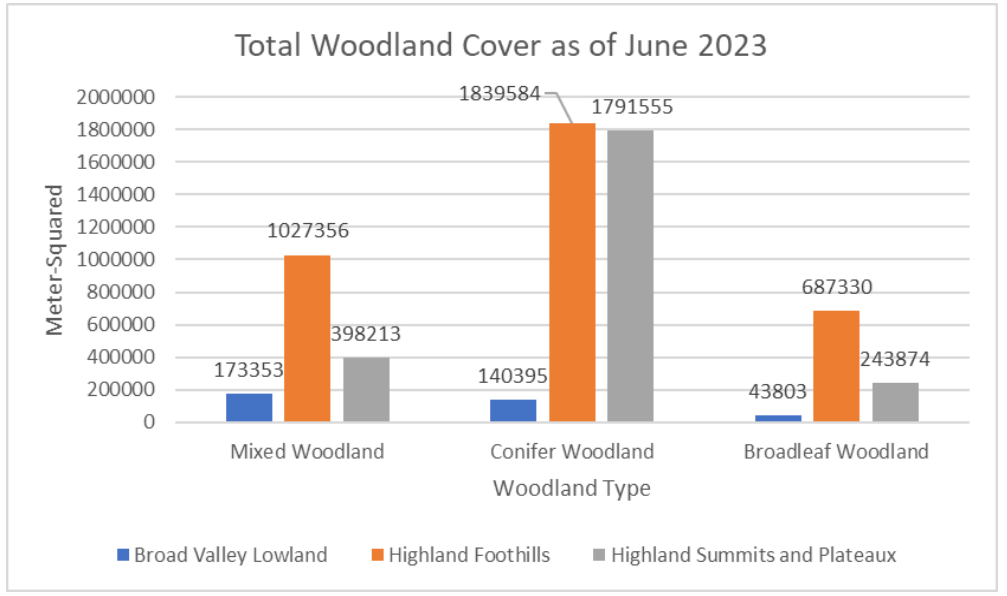
- Broad Valley Lowland
- Highland Foothills
- Highland Summits and Plateaux

Summary & Analysis









Quick Summary

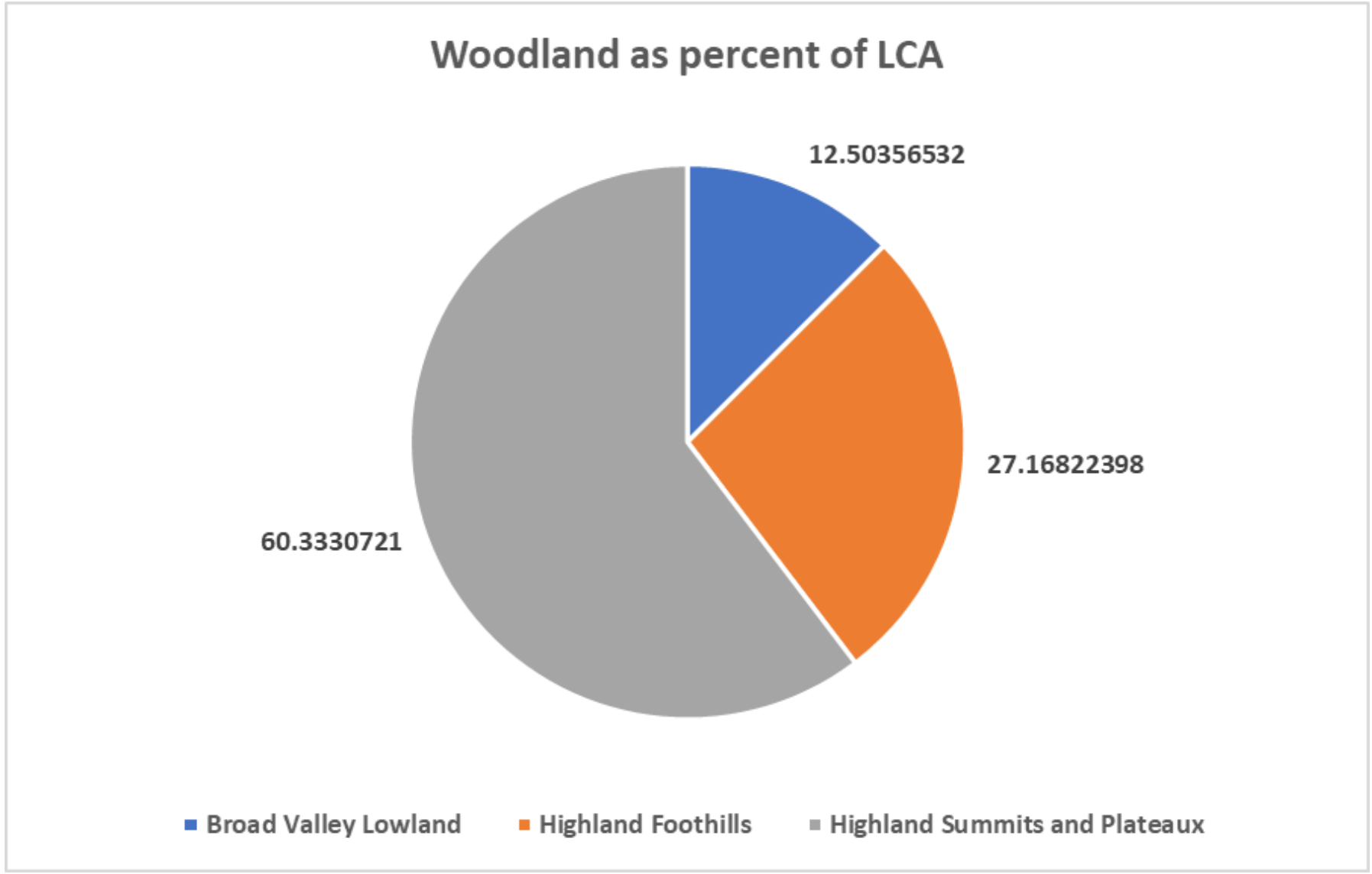
Highland foothills and Highland Summits & Plateaux both have reductions in conifer with modest conifer gains in Broad Valley Lowland.

Slight reduction in mixed woodland in Broad Valley Lowland, with significant Mixed woodland gains for Highland Foothills and High Summits & Plateaux.

Broadleaf woodland unchanged in Broad Valley Lowland with significant gains of this woodland in both Highland Foothills and Highland Summits & Plateaux. (Data used: LCS88 + Gained Woodland – Felled Woodland)

Summary & Analysis

- Chart two shows how much land of each of the three different LCA types is classified as Woodland as June 2023.
- This data was created by first establishing each LCA type size which was gathered from the exported CSV on the latest “union” file from QGIS
- Amount of woodland was calculated from same data source by adding LCS88 woodland with new woodland and subtracting felled woodland.
- Percentages worked out using “Sum” function on Excel



Summary

LCA Type	Mixed Gains	Conifer Gains	Broadleaf Gains	Total Gains
Broad Valley Lowland	0	23516	0	23516
Highland Foothills	587082	158853	361440	1107375
Highland Summits and Plateaux	288490	162320	243874	694684

LCA Type	Mixed Loses	Conifer Loses	Broadleaf Loses	Total Loses
Broad Valley Lowland	23323	0	0	23323
Highland Foothills	190879	259173	148477	598529
Highland Summits and Plateaux	0	167415	0	167415

LCA Type	Net Mixed Gains	Net Conifer Gains	Net Broadleaf Gains	Total Net Gains
Broad Valley Lowland	0	23516	0	23516
Highland Foothills	396203	0	212963	609166
Highland Summits and Plateaux	288490	0	243874	532364
			Total Gains all LCA Types	**1165046**

***all numbers in meters-squared**

- Modest net gains of woodland for clipped area in the Esk Catchment
- Woodland gains in-line with Scotland, with forest woodland cover now 18% compared to 5% in 1900's
- Despite good progress Scotland still lags behind
- EU average woodland forest cover of 38%
- Work still needs to be done for more woodland forest area to meet biodiversity and CC targets (Scottish Government, 2019)

Table one (left), shows a complete summary of the findings.

- The biggest gains in woodland area was the Highland Foothills with 1107375m2
- Biggest gains in any woodland type was also the Highland Foothill areas with Mixed Woodland gains of 587082m2
- The biggest losses in Woodland was again Highland Foothill areas with 598529m2 in total lost, of which 259173m2 was conifers.
- The Highland foothills is the biggest LCA area, around 66% of my clipped study area. It's also diverse, hills in the upper regions with little value so good for new forest planting. Lower parts is agricultural land and small urban areas. Large amounts of woodland felled for new roads and buildings in the lower parts of the area type.

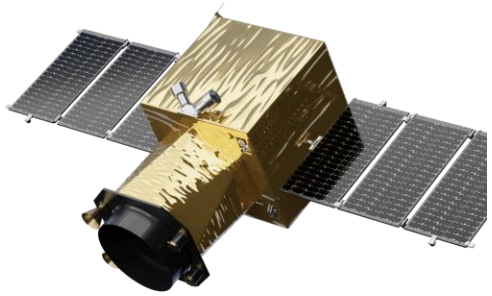
Alternative Approaches

While GIS is a great method of establishing land use changes such as losses and gains to woodlands, there are other approaches that could also be used to achieve this depending on the budget available and project requirements. There are pros and cons for each method as outlined below.

Satellite Imaging

From satellites equipped with cameras and other remote sensing technology, huge areas of land the size of a country can be photographed. This can provide constant up-to-date surveillance of large-scale land-use changes over a country or greater to witness how things are changing on a regular basis.

Limitations: Very high cost. Potential low-resolution images can't detect small changes. Images can become obscured by cloud cover.



Drone Imaging

Drones equipped with cameras can be an affordable and transportable alternative to satellite images for smaller sites. Flight paths can be pre-determined, the drone taking to site and hundreds if not thousands of close-up photographs can be taking then analysed for real-time changes.

Limitations: Training required. Will require travelling. Some areas (near military bases & airports) out of bounds. Weather (wind) can restrict flights.

Airplane Imaging

Planes equipped with remote sensing kit to the underside of the aircraft can be flown over areas to determine real-time land use changes. This is a great alternative method for land sizes smaller than an entire country (captured via satellite) but bigger than part of a wood or farm (captured via drone).

Limitations: Flights can be expensive. Images obscured by cloud. Higher altitude images might miss small changes. Not environmentally friendly.

Computer Languages and A.I – Instead of manual analysis of data, using computer languages and software development as well as artificial intelligence models in conjunction with the above methods and GIS apps, can improve automation and accuracy of the analysis and results.

GIS Applications

GIS applications and processing, such as QGIS and ArcGIS is a great way of measuring land use change amongst other uses, especially compared to some of the alternatives.

GIS applications are affordable. QGIS is completely free and open-source with great support communities online, while there is subscription and support plans available for ArcGIS for professional users.

There is no specialised equipment required. This project was completed using QGIS (free) with a 4-year-old mid spec laptop meaning GIS is available to almost everyone (Note: advanced projects be require advanced computers).

GIS applications and secondary data sources don't require travelling and can be done remotely. This can reduce travel time, be more environmentally friendly and reduce costs. Projects aren't affected or delayed by adverse weather, difficult terrain or areas out of bounds.

Despite the benefits of Geographical Information System applications there are some drawbacks that should be discussed:

A GIS project is only going to be as good and accurate as the information sources. For this project, the information sources consisted of data from NatureScot, James Hutton Institute and Ordnance Survey.

These information sources are trusted, credible and reliable however the data used for this project to establish woodland gains was 5-6 months. In that time new woodlands could've been planted, or newer woodlands could've been damaged (for example flooded or trampled and eaten by deer).

The quality of data being used can't always be guaranteed. Some secondary information sources (maps, datasets, images etc) could be incorrect or out-of-date. For this project, the map blurred when zooming in, so was difficult to see woodland gains/losses in busy areas due to contours and other symbology in the OS maps.

Training will be required for GIS applications. The basics can be picked up easy but more advanced features need taught. It can also be labour intensive with a lot of manual work which could affect the accuracy of the project, such as drawing polygons, or merging and analysing large datasets.

References

- History of Scotland's forests (Slide 2) - https://www.nature.scot/professional-advice/land-and-sea-management/managing-land/forests-and-woodlands/history-scotlands-woodlands
- Before and after rewilding image (Slide 2) - https://www.independent.co.uk/climate-change/news/rewilding-scotland-carrifren-biodiversity-woodland-b2133144.html
- South Esk Catchment Info (Slide 3) - https://nrfa.ceh.ac.uk/data/station/info/13003
- OS Maps (Slides 3, 3-9) - https://digimap.edina.ac.uk/
- LCS88 – SRUC Moodle via https://www.hutton.ac.uk/learning/exploringscotland/landcover-scotland-1988/landcover-dataset
- LCA data – SRUC Moodle via https://www.nature.scot/professional-advice/landscape/landscape-character-assessment/what-landscape-character-assessment
- Scotland Outline (Slide 2) - https://digimap.edina.ac.uk/
- QGIS logo (Slide 14) - https://www.qgis.org/en/site/
- ArcGIS logo (Slide 14) - https://www.arcgis.com/index.html
- All decorative images inserted and used under CC BY 2.0 - https://creativecommons.org/licenses/by/2.0/
- Scotland and EU woodland stats – Scottish Forestry Strategy 2019 – 2029 (slide 12) - https://www.gov.scot/publications/scotlands-forestry-strategy-20192029/documents/