Mapping Hill Tracks in the Cairngorms National Park

Introduction

Background

The CNPA commissioned a study to create a baseline map of existing hill tracks across the Cairngorms (area= 4500km^2) to inform track planning decision making. Through providing accurate spatial information on the nature and extent of hill tracks and generating a digital dataset using the best available data, the CNPA will be able to effectively and holistically reduce the impact of future vehicle tracks. This research comes at a pertinent time in policy, with developments of the Planning (Scotland) Bill and growing concern expressed by environmental campaign groups urging for better regulations and the removal of 'permitted development rights'.

Methodology

Data sources

Using ArcMap 10.3.1, various secondary datasets were inputted as layers into ArcGIS. The latest available getmapping digital aerial photography, available from 2007-2018, and ordnance survey maps set to (25,000, 10,000 and 6,000) formed the basemaps for primary analysis and creation of the polyline track features.

To build the dataset and add associated metadata to classify individual hill tracks, the following shape files were acquired; contour data, CNP boundary line, land-ownership data, Designations, planning consent data and authority data.

Aerial imagery has formed the basis for plotting tracks and analysis due to the high quality nature of the data when compared with freely available satellite data. Full coverage of the park is within the last 5 years with months as follows: 05/2018=north, 06/2018 = south, 07/2017, 06/2016 = south, 08/2016 = north, 10/2015. Therefore aerial photography quality may be variable depending on snow cover, tree cover and cloud cover which may affect mapping accuracy.

Historical map (OS One Inch 7th series, 1955-61) and aerial imagery data (1980's) acquired from the National Library of Scotland and National Collection of Aerial Photography sites have been used as a reference to determine approximately the relative ages of tracks and change. Alongside this 1981-82 survey data of vehicular hill tracks collected by Adam Watson and published by the North East Mountain Trust has been inputted in ArcGIS.

Produced by Rhiannon Holden (Hill Track Intern) on behalf of the Cairngorms National Park Authority

Summer 2019

Mapping procedure

Creation of features

Systematically polyline track features have been digitised at a scale between 1:1000 and 1:1500, which is accurate to 1-1.5m respectively and drawn directly onto a new layer using a Wacom Graphic Tablet and Pen precise drawing of lines. Splitting the park up by regional areas bounded by the National Park boundary and main A roads this produced four distinct areas for initial mapping (*Figure 1*).

1. Monadhliath Mountains & Strathspey- A9, A95 West
2. Hills of Cromdale, Ladder Hills & Donside – A939 East to A93 North
3. Deeside, Ballater south, Glen Clova- A93 South East
4. Central belt of Cairngorm Mountains- A9 East and North East, A939 South West, A93 West

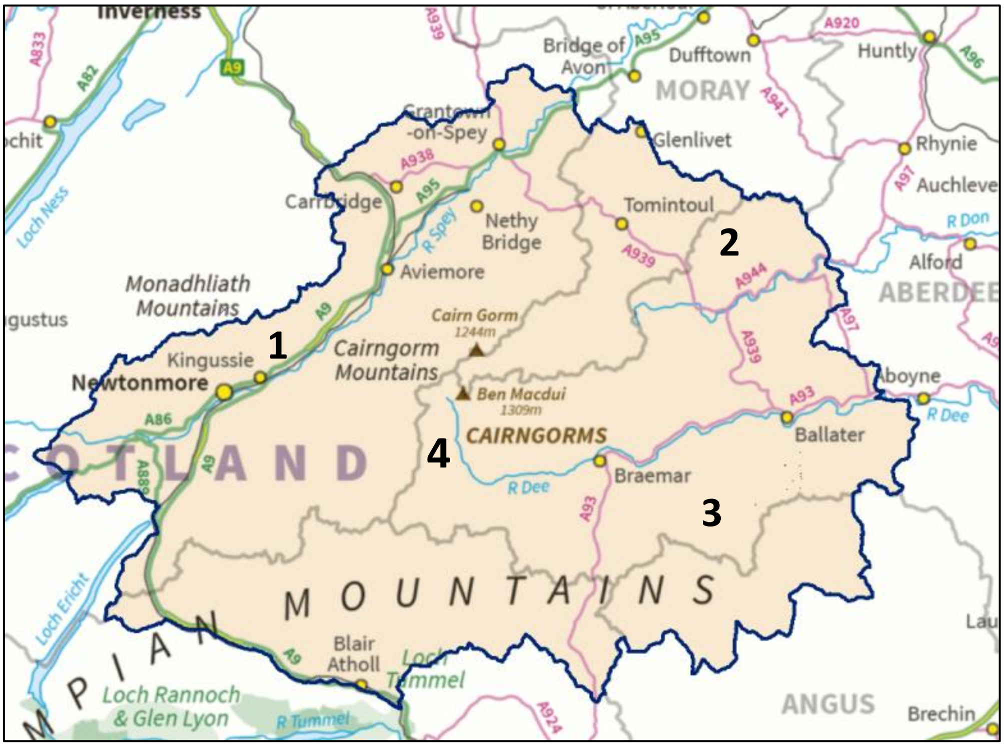


Figure 1: Regional Areas for Mapping

Reconnaissance and data exploration was conducted at a 1:5000 scale, panning across the park area clockwise to identify and draw constructed tracks. These can be defined as having a formalised surface whereby ex-situ material has been excavated and laid, often requiring machinery in the building process. From aerial photography constructed tracks can be seen to mostly have characteristics such as drainage ditches, widths starting from 1.5m, turfed sides, borrow pits along the length and are much lighter in appearance (*Figure 2*).

Master Map OS data was filtered for roads and paths and useful for cross comparison to highlight vehicle tracks for mapping and ensuring that rivers, land boundary lines & walls, firebreaks in forested areas, desire lines and hiking paths were excluded from the main dataset. This also acted as a detection aid to identify tracks in dense forest/woodland and infill gaps in the dataset.

Once the initial drawing was conducted for surfaced and formalised tracks, ATV tracks (less than 2m in diameter) and driven lines/tramlines have been plotted on the same layer and labelled in the attribute table as not constructed denoted as no. This is intended to hopefully feed into developments on the code of conduct for responsible ATV use and accentuate areas of particularly high densities of rutted tracks over sensitive peatland habitats.

Figure 2: Two images demonstrating the difference between constructed (a) and ATV tracks (b)

New shapefiles were added in the catalog left column selecting the desired file location, clicking new, then shapefile which will give you the choice of creating a polyline or polygon layer. Start editing in the editor toolbar and click on the Create Features tab to bring up the newly created layer and Construction Tools for drawing polyline vertices (*Figure 3*).

In the first stage of mapping, a large dataset of 7,000 individual polylines were formed consisting of tracks drawn in segments. To filter and downsize the dataset, residential tracks, potential fire breaks in woodlands and any tracks plotted below 300m in elevation (equivalent to an area of 587.96km^2) were removed using the Intersect Tool to automatically extract tracks above the 300m contour polygon (*Appendix 1*).

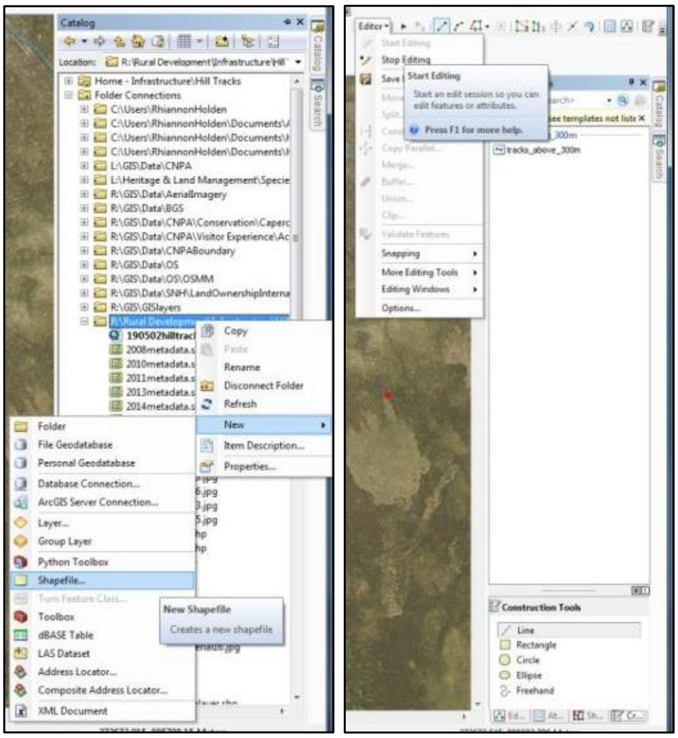


Figure 3: How to create a new shapefile and features

Further condensing of the dataset was conducted using the geoprocessing technique of Merging found in the merging toolbar, selecting segments of tracks that can be classed as one length with a common origin. The selection includes spurs of tracks but makes the distinction between ATV tracks and constructed, whereby these have been split and have a different ObjectID.

Classification of Tracks

In order to conduct detailed spatial analysis, manipulation and interpretation, each track within the dataset has been assigned values. The attribute table has been amended through adding new Fields and defining the field properties/type i.e. date, name, integer. After discussions with the Head of Planning and Enforcement Officer these include; the estate name, aerial photograph date , constructed status, authority, width, shape length, estimated age, altitude max and min, planning permission reference, track use and overlap with Natura designation sites (*Figure 4*).

Table

tracks_above_300m

OBJECTID *	Shape *	FID	Id	Estate	Width	PP ref	Aerial photo	Track Use	SSSI/SPA/SACs	Age	Authority	Constructed	Centre_Strip	Altitude min	Altitude Max	Shape_Length
4048	Polyline	14	0	Mar Lodg	<Null>		00:00:00			0		yes	<Null>	0	0	1456.22
4049	Polyline	14	0	Mar Lodg	<Null>		00:00:00			0		yes	<Null>	0	0	876.83
4067	Polyline	14	0	Invercauld	<Null>		00:00:00			0		yes	<Null>	0	0	1867.22
4068	Polyline	14	0	Invercauld	<Null>		00:00:00			0		yes	<Null>	0	0	1436.07
4075	Polyline	14	0	Invercauld	<Null>		00:00:00			0		yes	<Null>	0	0	184.99
4249	Polyline	14	0	Invercauld	<Null>		00:00:00	Multi-use		0		yes	<Null>	0	0	2.04
4402	Polyline	<Nu	<N	<Null>	3.5	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	yes	no	300	750	10166.91
4422	Polyline	<Nu	<N	<Null>	3.5	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	yes	no	300	400	3423.58
4476	Polyline	<Nu	<N	<Null>	3.5	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	yes	no	300	350	3517.09
4484	Polyline	<Nu	<N	<Null>	4.5	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	yes	no	300	400	2356.86
4491	Polyline	<Nu	<N	<Null>	1.5	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	yes	no	300	350	1418.59
4498	Polyline	<Nu	<N	<Null>	2	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	yes	yes	300	550	4770.96
4903	Polyline	<Nu	<N	<Null>	3.5	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	yes	<Null>	350	800	9514.89
4977	Polyline	<Nu	<N	<Null>	2.5	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	yes	<Null>	400	600	2593.39
4985	Polyline	<Nu	<N	<Null>	5.5	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	yes	<Null>	450	500	486.62
5004	Polyline	<Nu	<N	<Null>	2.5	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	yes	<Null>	350	400	1680.53
5011	Polyline	14	2		2		<Null>			0		yes	<Null>	650	750	2978.45
5016	Polyline	14	0		3		00:00:00			0		yes	<Null>	0	0	25.27
5022	Polyline	14	0		2.5		00:00:00			0		yes	<Null>	350	850	11.04
5029	Polyline	14	0		4		00:00:00			0		yes	<Null>	350	500	2275.16
5053	Polyline	<Nu	<N	<Null>	2.5	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	yes	<Null>	300	450	6260
5058	Polyline	<Nu	<N	<Null>	3	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	yes	<Null>	350	550	2973.45
5078	Polyline	<Nu	<N	<Null>	2.5	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	yes	<Null>	350	600	3997.54
5148	Polyline	<Nu	<N	<Null>	3.5	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	yes	<Null>	300	400	4398.12
5188	Polyline	<Nu	<N	<Null>	3	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	yes	<Null>	300	550	10417.02
5198	Polyline	<Nu	<N	<Null>	4	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	yes	<Null>	300	350	1519.7
5203	Polyline	<Nu	<N	<Null>	3	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	yes	<Null>	300	350	5405.9
5232	Polyline	<Nu	<N	<Null>	2.5	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	yes	yes	350	500	1035.88
5241	Polyline	14	0	Delnadam	2		00:00:00			0		yes	yes	450	550	651.72
5245	Polyline	<Nu	<N	<Null>	3	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	yes	no	300	550	3876.88
5280	Polyline	14	0		4.5		<Null>			0		yes	<Null>	800	850	2111.01
5295	Polyline	14	0		3		<Null>			0		yes	yes	400	550	865.23
5297	Polyline	55	32		2		<Null>			0		yes	yes	300	400	1802.07
1012	Polyline	14	0		2		<Null>			0		yes	yes	300	450	8316.34
3401	Polyline	14	0		3		00:00:00			0		yes?	<Null>	400	850	13896.78
5013	Polyline	14	0		1.5		<Null>			0		yes?	<Null>	450	300	1161.47

0 (0 out of 1868 Selected)

tracks_above_300m

Figure 4: Attribute Table for Hill Tracks

Data extraction of these categorises can be divided into those which can be automatically generated using ArcGIS tools and those which are manually collected (*Table 1*).

Track Attribute Data Collection	
Manual/Visual Classification	**Automatic generation via Intersect Tool**
Width - Measurements to 0.5m accuracy	Estate- Landowner
Track Use - (where possible)	PP Ref – Planning Permission Reference
Constructed – ATV or surfaced	Aerial Photo – Date of imagery
Centre Strip – Greened reinstated middle	SSSI, SPAs, SACs –Designation
Altitude Min & Max - 300m+	Shape Length- Total merged track length
Age- Approximated	Authority- Local authority overlap with CNPA

Table 1: Manual vs Automated meta-data collection

Alongside merging the tracks the width has been measured using the Measuring Tool (*Figure 6*) on ArcMap and logged in the attribute table. This value is based on the average width of the vehicle track taken at four points of the track to alleviate tapering or narrowing and width changes on bends or passing spaces, these measurements are accurate to 0.5m and measured at 1:150 scale. This does not take into account the full disturbed width of constructed track features (i.e superficial material banked on sides, ditches, spurs etc.), therefore may underestimate the tracks total visual and environmental impact.

Measurements were ground-truthed on 04/07/19 on a site visit to the Balavil Estate, where the width of the constructed track was recorded in at four separate locations along the length whereby these measurements and average of 3.4m correlated with those attained through measuring aerial photographs on ArcMap.

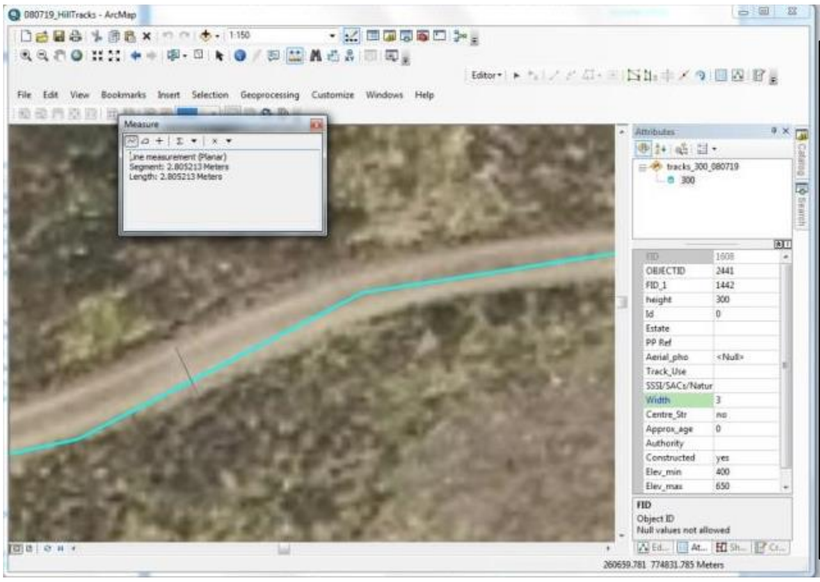


Figure 6: Measuring a constructed track at 1:150 scale

Figure 7: Presence of centre green strip

The elevation maximum and minimum has also been logged during this stage of merging observing where the track line intersects with the contours, this will be useful in prioritising enforcement consideration to tracks above a certain elevation. The construction status of tracks at the time of aerial photography has been noted in the metadata, simply as yes or no, this is based on the definition that a constructed track is one that has excavated, surfaced and maintained.

Indicators along the length such as borrow pits, high reflectivity due to surface material, a standard width of between 2m and 5m are useful in distinguishing between formalised and non-formalised vehicle tracks. Whether a centre green strip is present or absent has been logged (*Figure 7*). This can be established at the same map scale for measuring the width and observing if there is a darker, often green, line of vegetation on the middle of the surfaced track.

To ensure that all track features have been attributed for the above fields, the symbology via layer properties has been altered to highlight values not assigned through choosing certain categories (*Figure 8*).

Following manual classification and finalised mapping & merging of tracks, the total length (in metres) for each track has been calculated using the Calculate Geometry tool (*Figure 9*). To extract the estate, aerial photograph dates and this has been automatically generated using the Intersect Tool via geoprocessing. The tool merges the attribute tables and assigns values to the layers added, assessing which polylines interact with the polygons (*Figure 10*).

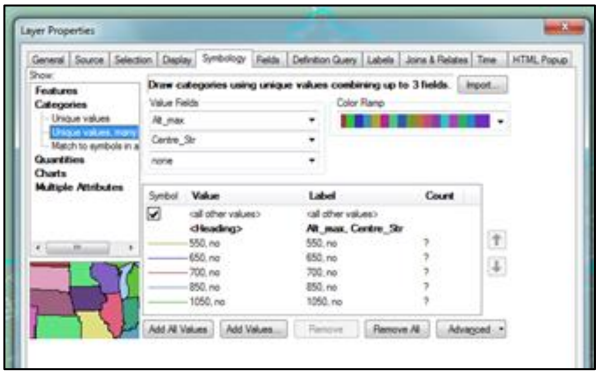


Figure 8: Category symbology changed to show tracks which haven't been attributed for maximum elevation

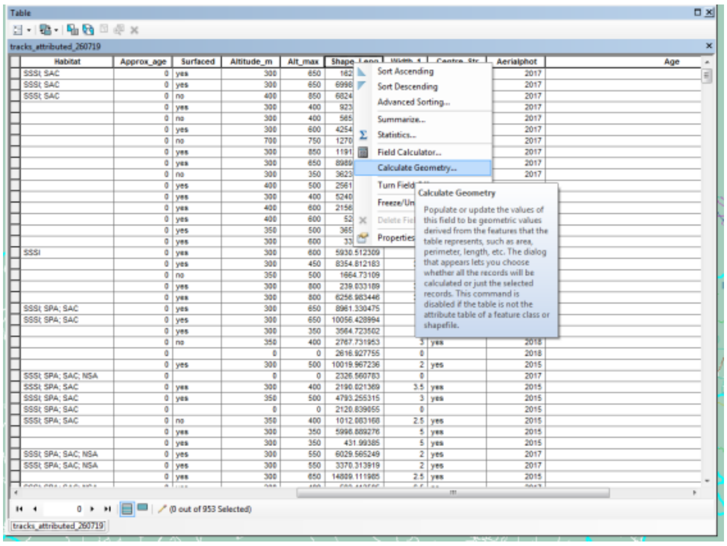


Figure 9: Calculate Geometry tool for generating total track length

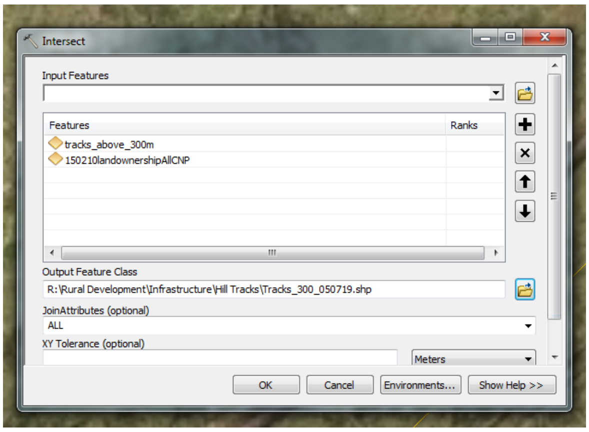


Figure 10: Intersect tool showing the estate layer and track layer

To determine whether the tracks overlap with any Designations, tracks have been selected by location for each layer of Site of Special Scientific Interest (SSSI), Special Protected Area (SPA), National Scenic Area (NSA) and Special Area of Conservation (SAC) and name inputted into the attribute table (*Figure 11*). There 19 SACs, 12 SPAs and 46 SSSIs within the Park.

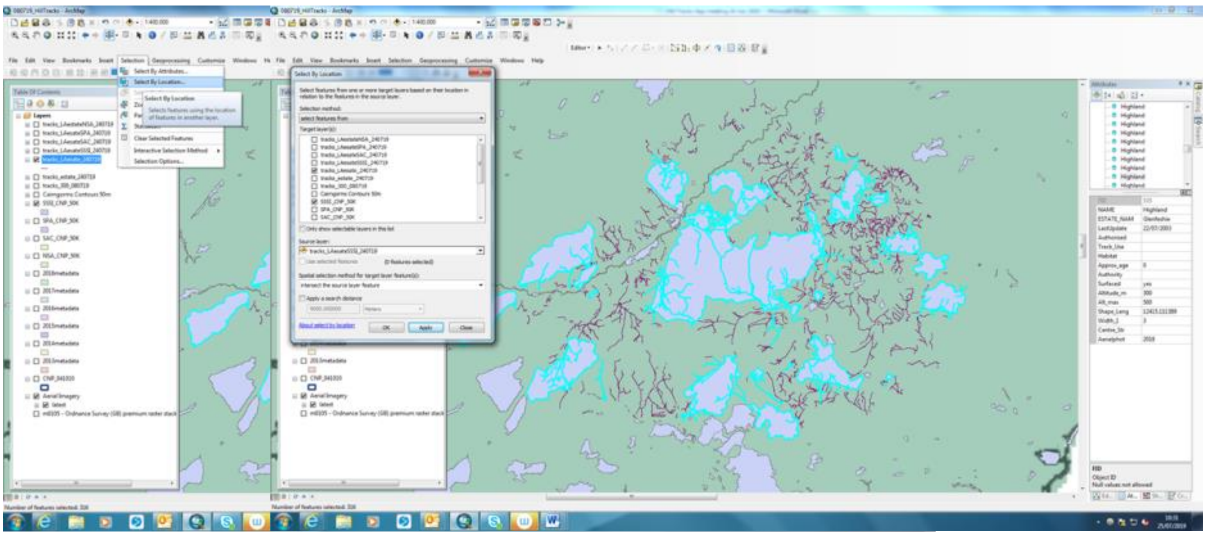


Figure 11: Select by location tool with tracks intersecting the SSSI area selected

Planning permission consent data in the form of a shapefile has been extracted from the Uniform database on 01/08/2019 for ‘private ways’ and ‘track’ as the proposed field. Clipping this dataset and removing all tracks below 300m, the total number of polygon features with planning consent since the park was established in 2003 is 98. To aid hill track selection, the colour and width of permitted private ways has been changed to highlight the overlap and assign planning reference values (*Figure 12*).

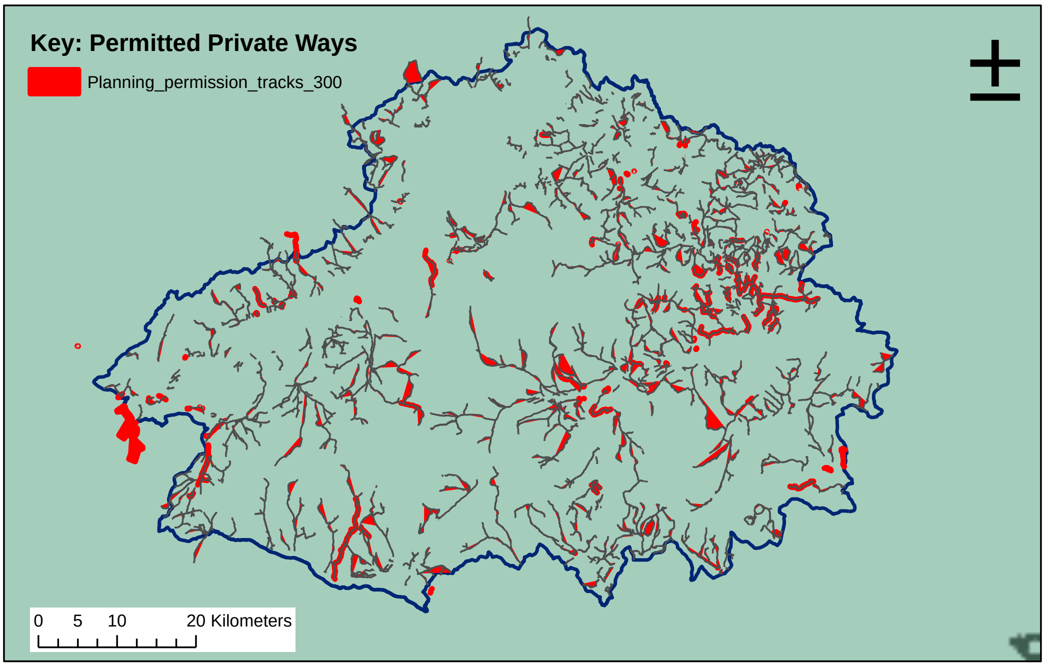


Figure 12: Extent of private ways with planning permission since 2003

Within the brief of the project it was also discussed that approximate age would be determined for tracks and entered into the digital dataset. This consisted of logging tracks that were present on archival OS map data (1955-1961), whereby tracks and footpaths share the same dotted line symbol (*Figure 13*) and cross comparing the latest OS maps at 1:30,000 overlaid with plotted hill tracks (*Figure 14*). If the track was absent on the old OS map the value has been left blank and if present this has been denoted as e.g. OS 1956. To support this comparison more recent data has been used such as aerial images acquired from the National Collection of Aerial Photography, this involves individually selecting images and matching them with current tracks, logging them as e.g. NCAP 1988. In addition to these survey map data collected by Adam Watson in 1980-81 and later digitised as a shape file has been layered in ArcMap. The latter two data sources have mid-range coverage, whereby AW’s data only covers the NE of the Cairngorms (*Appendix 2*). This has been attributed as e.g. AW 1980.

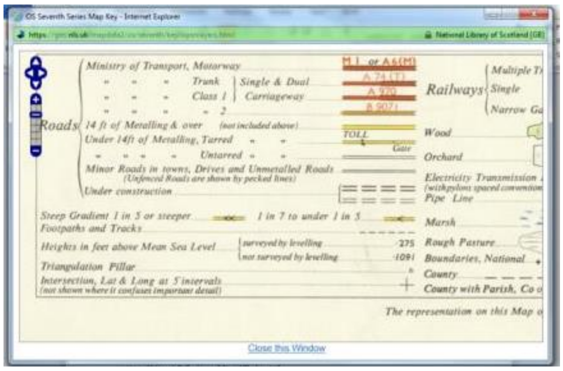


Figure 13: Key for OS map 1955-1961 demonstrating no distinction between Footpaths and Tracks

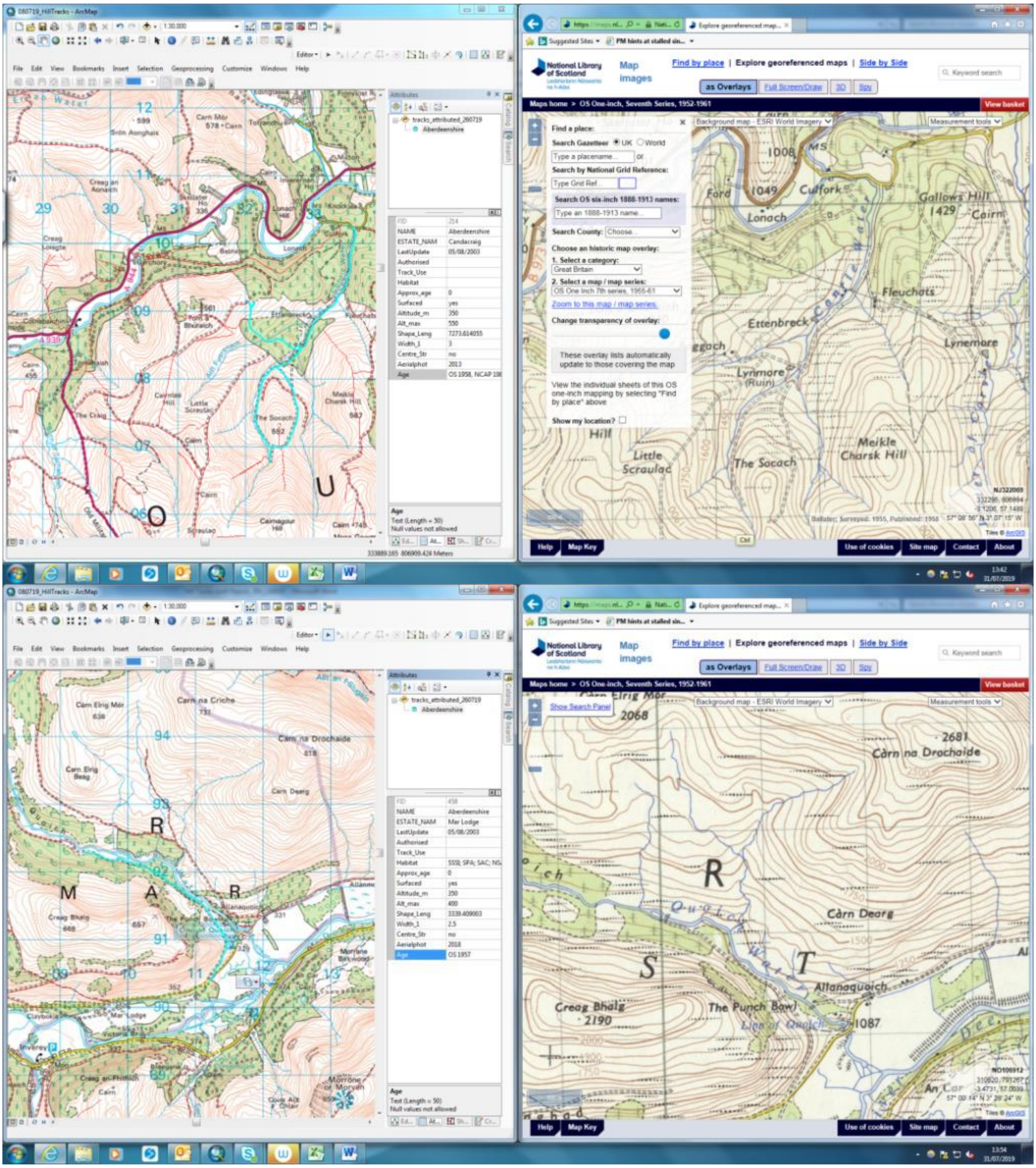


Figure 14: Demonstrating the methodology for adding age metadata and comparing the presence of tracks between the latest OS map and OS map 1955-61 acquired from National Library of Scotland

After attributing the dataset for approximate ages present on NCAP, OS 1955-61, AW 1980-81 data sources, the OS MM-line layer was filtered for roads, tracks and paths and clipped to 300m elevation was used as a further dating source. The digitised infrastructure OS data from MM 1970- 2014 (data input) was overlaid with the tracks derived from aerial photography and 'New' Values in the 'Change' attribute field extracted manually. To aid this process they were grouped by year in the symbology and other values hidden such as 'Modified, reclassified, position etc.'

Following analysis and interpretation of polyline track data, borrow pits for four randomly selected estates encompassed in the 4 regional areas in the national park; Cawdor, Glen Muick, Mar and Pitmain. The borrow pits and depressions have subsequently been plotted as polygon shape files on a new layer using the create polygon tool and drawn at 1:500 scale (*Figure 15*).

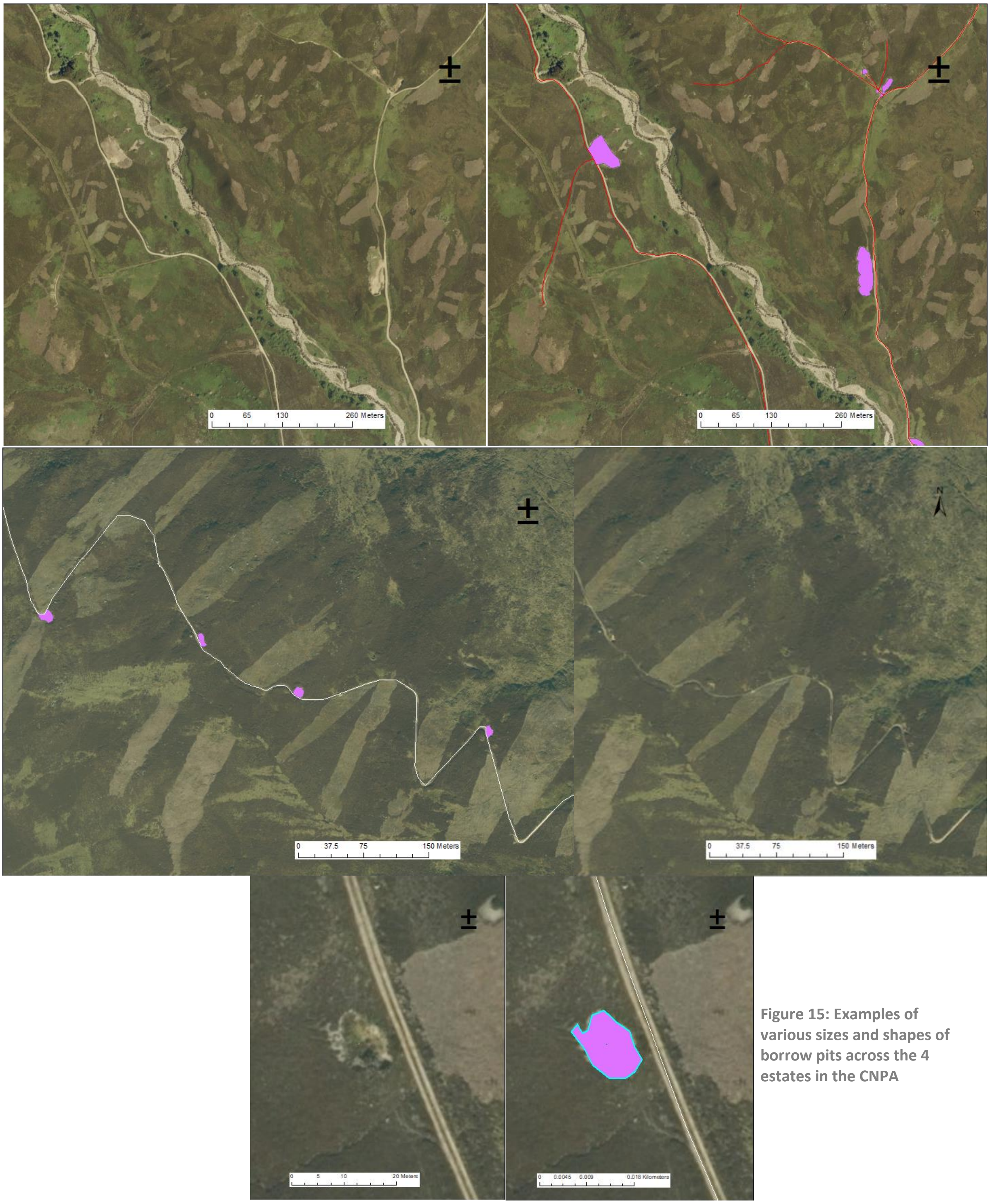


Figure 15: Examples of various sizes and shapes of borrow pits across the 4 estates in the CNPA

Further investigation, refinement of the dataset and comparisons were drawn from the following acquired shapefiles consisting of hiking paths and trails across the Cairngorms available on the internal R: drive at the URLs:

- **Core Paths:** R:\GIS\Data\CNPA\Visitor Experience\Access\CPP\CPP_adopted2015_modifed.mdb
- **Mar Lodge estate (NTS):** R:\GIS\Data\CNPA\VisitorExperience\Access\MAR_UplandPaths_2018.shp
- **Invercauld Estate:** R:\GIS\Data\CNPA\Visitor Experience\Access\Invercauld_estate_paths.shp
- **Scottish Rights of Way:** R:\GIS\Data\ScotWays\Jan2016update\Cairngorms_National_Park_January_2016.shp

In this study the capabilities of satellite data and imagery were explored, this has the potential to allow for 'real-time' monitoring of tracks to a higher frequency acquisition than aerial photography and could bridge gaps in data coverage. Four opensource and free datasets proved to be of value and are numbered in order of quality below (*Figure 16*):

1. **Sentinel Data Access Service** (https://sedas.satapps.org/): Provided by the UK Space Agency they offer free satellite high resolution data across the UK with focus on the national parks. The data can be either accessed in the browser or through creating an account, this is available freely to public sector bodies. The resolution is to 10m accuracy and the date range of imagery can be altered.
2. **Google Earth Pro.** (https://www.google.com/earth/versions/): A high quality resource generating images every 16 days with the latest imagery available on 22/4/2019 from CNES/Airbus satellites. The resolution is generally good enough to extract constructed tracks around 15m accuracy. There is a feature where you can time slide between historical images, which would be of use for dating ages of tracks and for the Cairngorms this extends back to 2005. The drawbacks to Google Earth is there is limited application for analysis as there no free option for downloading the data into ArcGIS, therefore comparisons need to be made between windows.
3. **Sentinel Hub Playground** (https://www.sentinel-hub.com/explore/sentinel-playground): In addition to the browser version, a time-limited trial WMS feed can be downloaded into ArcGIS for 6 weeks per account allowing for enhanced spatial analysis. The resolution is grainy but larger tracks can be ascertained. There is a feature for changing the cloud control and there are 12 layers to flip between from Natural Colour (bands:4,3,2), Infrared (bands 8, 4,3) and False Colour (bands 12,11,4), etc. which gives the ability to pick out different features depending on their spectral signature.
4. **USGS Land Look (**https://landlook.usgs.gov/viewer.html): Similar coverage to Sentinel Hub Playground with a poor resolution of 30m but provides access to Landsat 'natural colour' imagery. There is the option of viewing historical multispectral images collected since 1972, allowing for ages of larger tracks to be extracted.

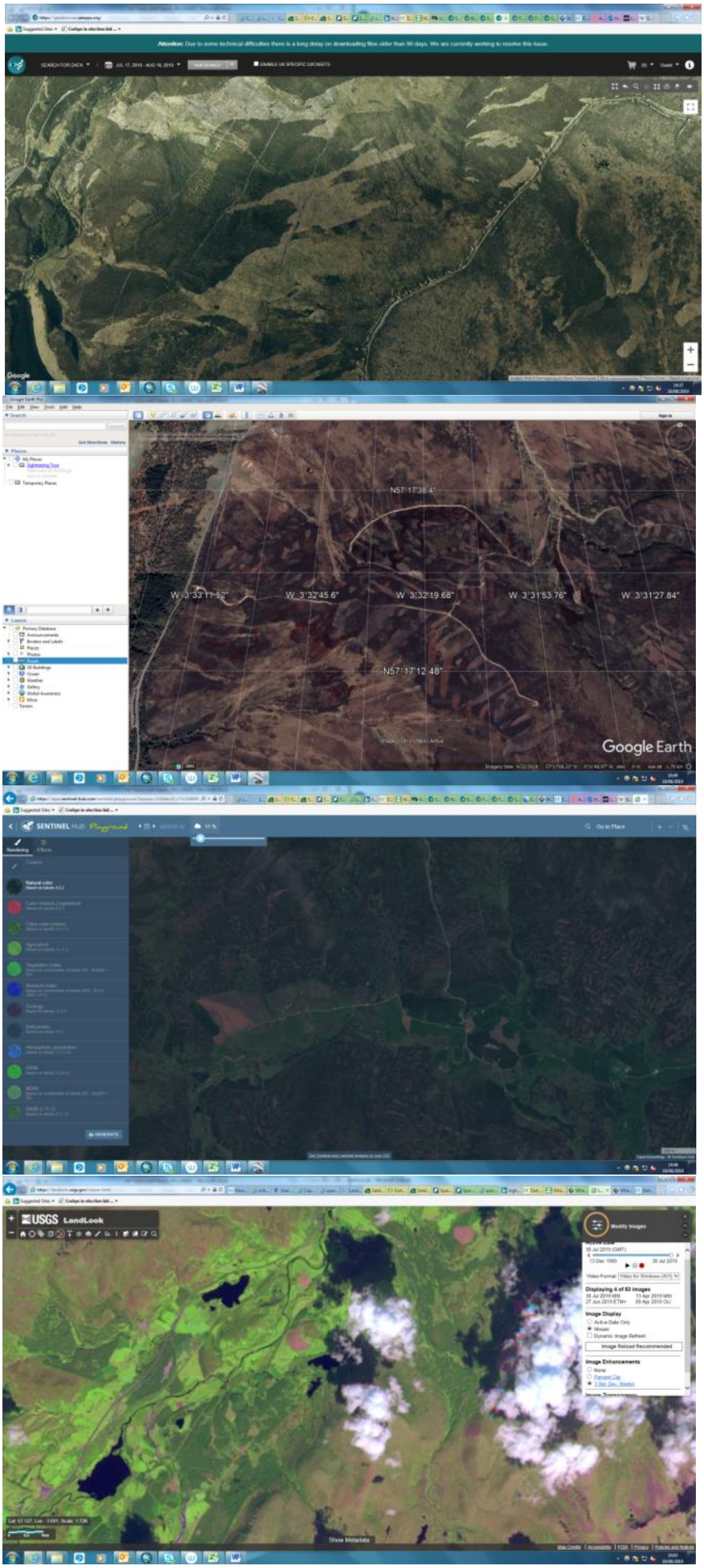


Figure 16: **Example pages from varying satellite data sources a) SeDAS b) Google Earth Pro c) Sentinel Hub Playground d) USGS Land Look**

Before the data could go public, it was decided by internal management and the planning committee that there should be a ground-truthing exercise conducted by the estates across the national park ; a) To verify the extent of tracks b) Identify any errors in the dataset c) Include landowners in the process. This consisted of creating bespoke maps (at 20k- 100k scales) for each estate demonstrating the constructed hill track picture for land over 300m in elevation. This generated 59 main estates with with more than 3000m of track within their jurisdiction (*Figure 17*). It is anticipated that estates will return these maps with additions/amendments/errors through drawing on lines.

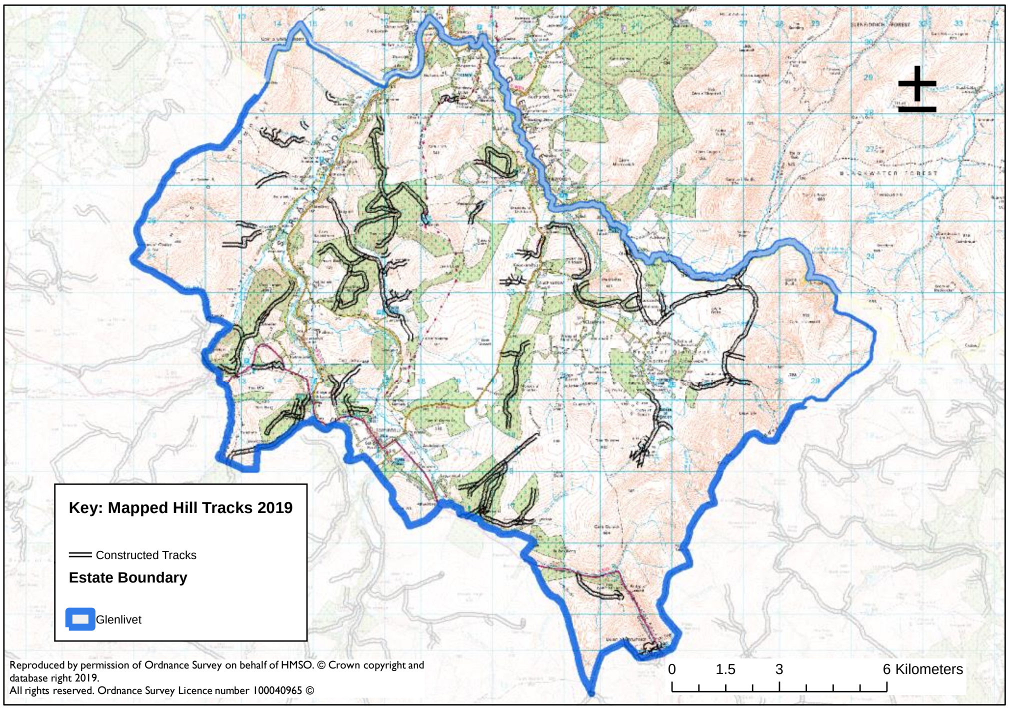


Figure 17: Map output for one of the CNPA estates demonstrating the mapped constructed tracks

To create these maps ready for postal sendout, the layout view was used in ArcGIS for fomatting and export. A legend, north arrow, scale bar (km) were inserted and the estate zoomed to. The scale, position and layout (portrait or landscape) was amended each time to allow for the most appropriate coverage of each estate. The following layers were used starting with the bottom layers first:

- OS50K:- R:\GIS\Data\OS\50k\OS50K.mdb , Raster image OS Map
- Latest mapped hill track dataset: filtered for just 'surfaced'/'constructed' tracks under categories, with the symbology changed to double plain and the thickness increased to 1.00
- Estate Boundaries: R:\Rural Development\Infrastructure\Hill Tracks\Landownership_CNPA_clip_19.shp , filtered for 'ESTATE_NAM' and symbol amended to no fill colour, outline 5.00 and navy blue colour, display then transparency changed to 20% and 'all other values' set to white. This is changed for each estate i.e. Gaskbeg, and allows focus to the

The map layout has been saved to R:\Rural Development\Infrastructure\Hill Track\Estate_output_hilltracks_210819 Individual maps can be found under 'Estate Tracks Maps'

Spatial Analysis and Results

Following mapping the full extent and footprint of vehicle tracks and ensuring all were attributed, informal consultations were held internally with the Planning Committee- 16th August and CNPA staff- 20th August. These were to illustrate the nature of the data using map outputs, what further spatial analysis could be conducted and to determine next steps.

Firstly the dataset was filtered for the constructed field denoted either yes or no. Copying the layer 4 times and altering the properties and symbology (transparency, colour and width) in categories, the tracks have been exaggerated and enhanced to show them against a greyscale Digital Terrain Mode (*Figure 17 and Table 2*). This is called a 'light saber' effect (https://www.esri.com/arcgis-blog/products/arcgis-pro/data-management/lightsaber-lines-i-mean-firefly-lines/). Another map has been produced with a colour DTM (*Figure 18*).

Vehicle Tracks	Constructed	Informal
Length (km)	1862	660
Number of features	520	385
Centre strip (no., km, %)	326, approx.= 1106.4, 62.7	N/A
Mean width (m)	2.92	2.03
Median width (m)	2.5	2
Maximum elevation over 600m	47	N/A

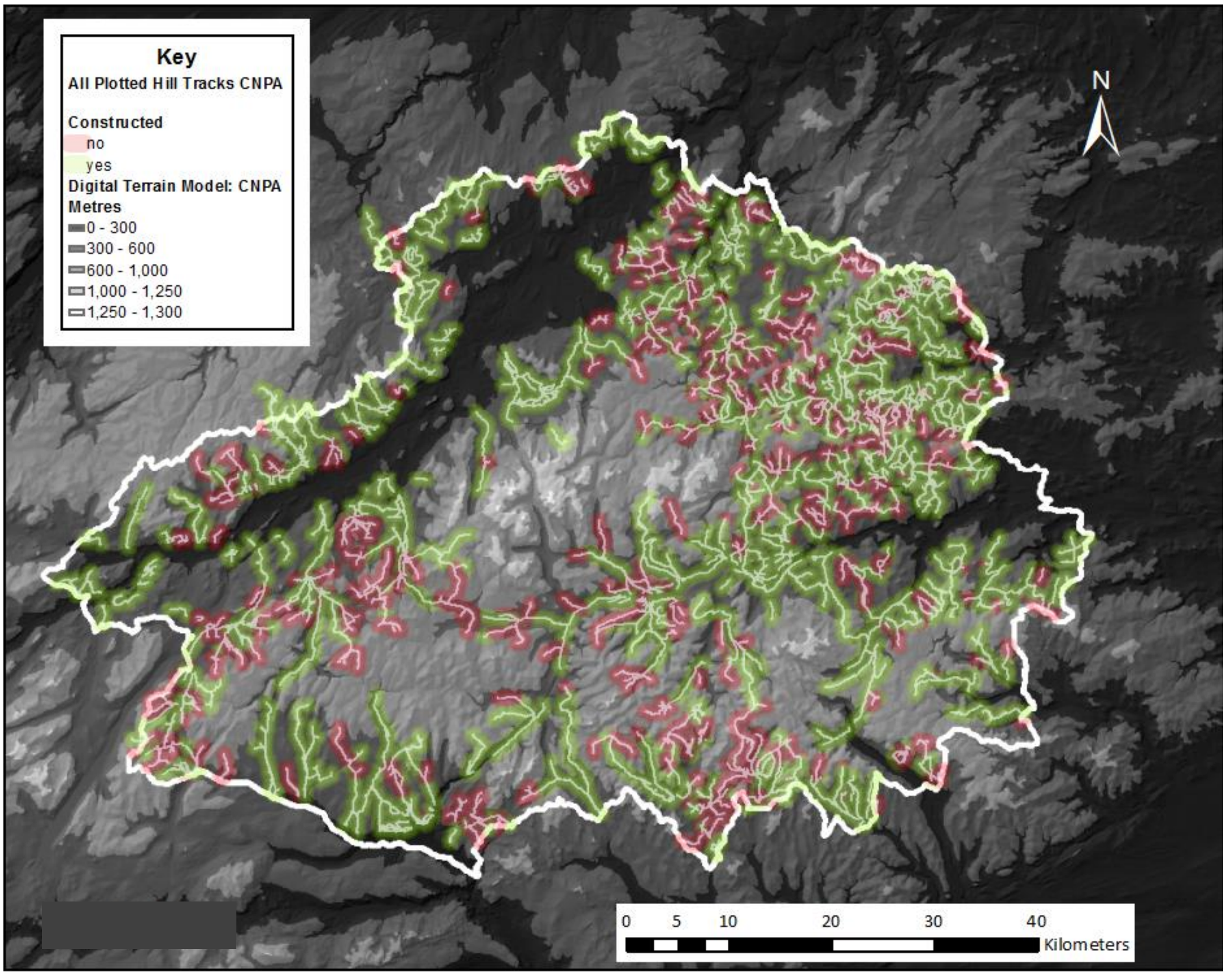


Figure 17: Map showing extent of constructed and informal tracks across the Cairngorms National Park area

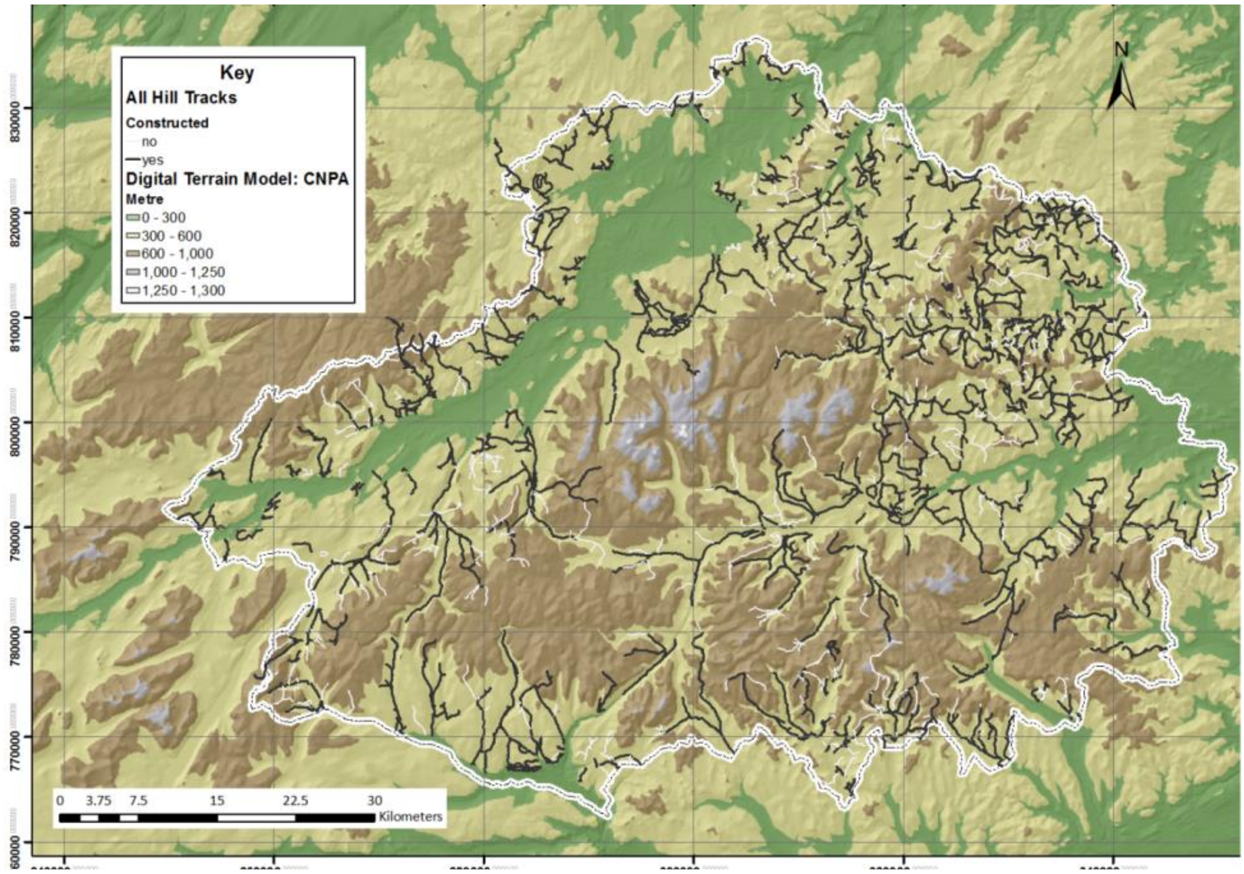


Figure 18: Map showing extent of constructed and informal tracks across the Cairngorms National Park area

To understand the accuracy of the mapped hill track in terms of date captured by aerial photography, the dataset was overlayed with this metadata ranging from 2013-2018 (*Figure 19, Table 3*). This demonstrated that the last 4 years (since 2015) had a aerial imagery percentage coverage of 83.6% for constructed and 81% for informal vehicle tracks, with the best coverage in 2018. Once the 2019 data is released this will be reflected in the hill tracks dataset.

Vehicle Tracks	2013	2014	2015	2016	2017	2018
Constructed (no.)	74	11	146	21	68	199
Informal (no.)	64	9	88	25	29	170

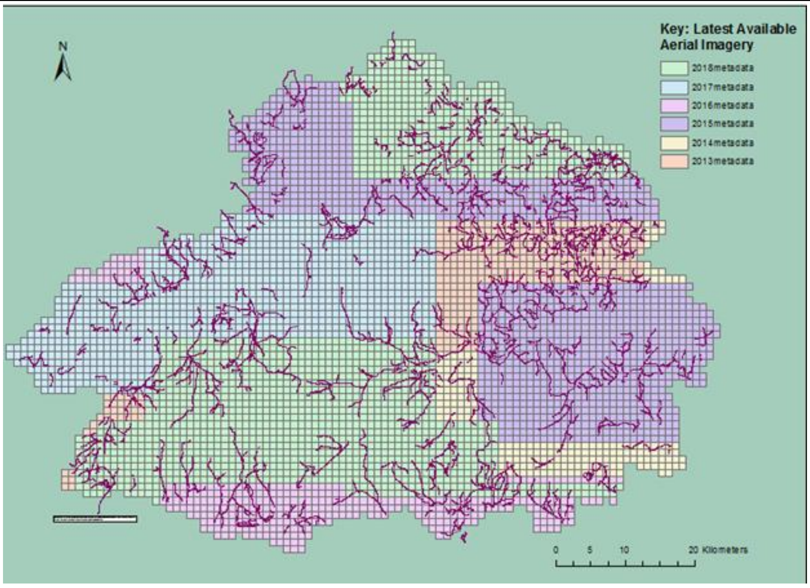


Figure 19: Aerial photography coverage across the park

Establishing the approximate age of tracks by recording presence in the attribute table has been achieved best and most accurately through using archival OS maps from 1957-61 and Adam Watson's data from 1981-82. However there are limitations to this data, AW's data only covers the NE of the Cairngorms and tracks & footpaths on the OS 1957-61 map have the same symbol. It was found that approximately a minimum of 284 constructed tracks were present before 1982 across the Cairngorms, corresponding to a maximum estimation of 1381.68km of track (*Figure 20, Table 4*).

*The total track length is a gross over-estimation, if a track section/segment was present on the maps it was logged even if the whole extent of the track was not present (including spurs and merged lines).

Vehicle Tracks	OS 1957-61	AW 1981-82	Appox. total presence before 1982	Rough percentage of current tracks present before 1982
Constructed (no.)	151	133	284	54.6 %
Constructed Length (km)*	858.30	523.38	1381.68	74.2 %
Informal (no.)	26	82	108	28.05 %
Informal Length (km)*	86.58	157.13	243.71	63.3 %

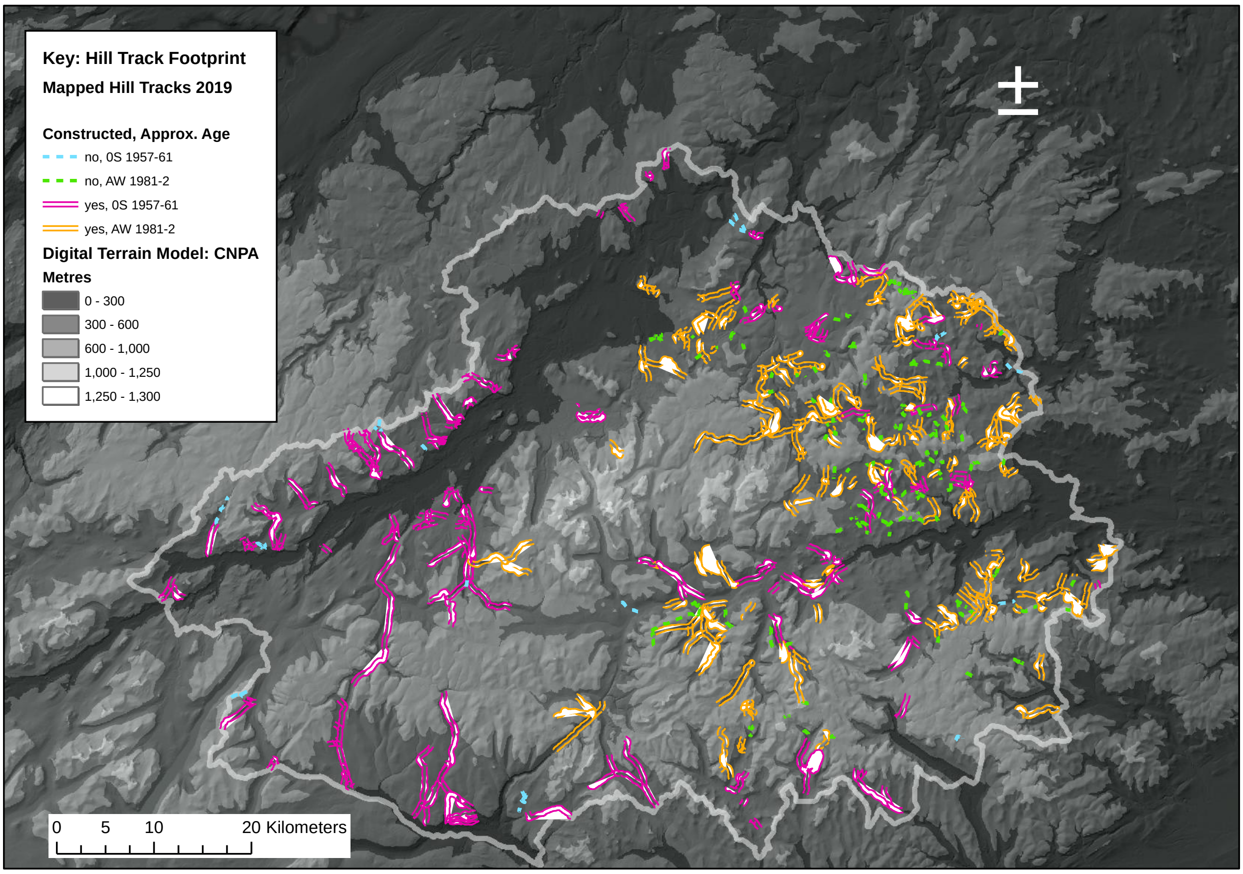


Figure 20: **Mapped constructed and informal tracks attributed with approximate age data as reflected in the map (Adam Watson data in orange and OS map data pink)**

Unfortunately there was a data gap between 1990s and 2000s for map and track data, whereby I was unable to establish an age during this period. OS Master Map digital data has been utilised for years between 2004 and 2013 to provide a rough picture of the appearance of tracks following the development of the Cairngorms National Park in 2003. This MM data is also prior to the latest aerial photography used to plot the hill tracks ranging from 2013-2018. It was found that 13.5% of or 70 constructed tracks were 'new' or updated 'new' on the MM dataset between 2004 and 2013 (*Table* 5).

Vehicle Tracks	**MM 2004-2013**	**Percentage of current tracks**
Constructed (no.)	70	13.5 %
Constructed Length (km)*	221.82	11.9%
Informal (no.)	12	3.12%
Informal Length (km)*	30.39	4.61%

There is potential for further analysis to be conducted on the rate of track development in the park, this has not been explored in this study.

It was also requested that Land Cover use could be extracted from the data; this was acquired from Land Cover Scotland shapefiles and clipped to 300m elevation (R:\GIS\Data\SNH\LSCMAP_SCOTLAND). Merging the two attribute tables, it was possible to keep only the LCS label added to each polyline and as the intersection tool splits features at boundary lines this produced 4017 separate features with 25 different LCS categories and the length recalculated. This has been examined and condensed for constructed tracks only.

Filtering the data in Excel for; Blanket bog & Peatlands, Heather Moor, Coarse Grassland, Smooth Grassland, Improved Grassland and Woodland Recently Felled this produced 2117 constructed features of the 4015 records (informal and constructed). This translates to 1405.65km crossing/intersecting these 7 categories (*Table 6*). Moorland covers approximately 40% of the Park with a further 30% classified as the higher montane zone (CNPA 2017, Partnership Plan 2017-2022). R:\Rural Development\Infrastructure\Hill Tracks\Excel Data\Tracks_Dataset_Land_cover_280819

Constructed track	**Heather Moor**	**Blanket bog & Peatlands**	**Coarse Grassland**	**Smooth Grassland**	**Improved Grassland**	**Woodland Recently Felled**	**Total**
Length (km)	1003.43	143.84	32.58	145.63	68.29	10.25	1405.65
No. of features	1226	265	68	350	179	27	2117

There are limitations to this LCS shapefile data as it is from a survey from the late 1980s. The track dataset could be overlaid with Habitat Map data for Scotland or HabMoS, and a comparison drawn in future analysis.

Appendix

Analysis on how many tracks overlap with designations: SSSIs, SACs, SPAs and NSA was conducted for the 520 constructed tracks and 385 informal tracks (*Figure 21 and Table 7*). Further analysis could extend to overlaying wild land shapefile data.

Vehicle Tracks	SSSI	SACs	SPAs	NSA
Constructed (no.)	131	121	167	103
Informal (no.)	93	85	145	48

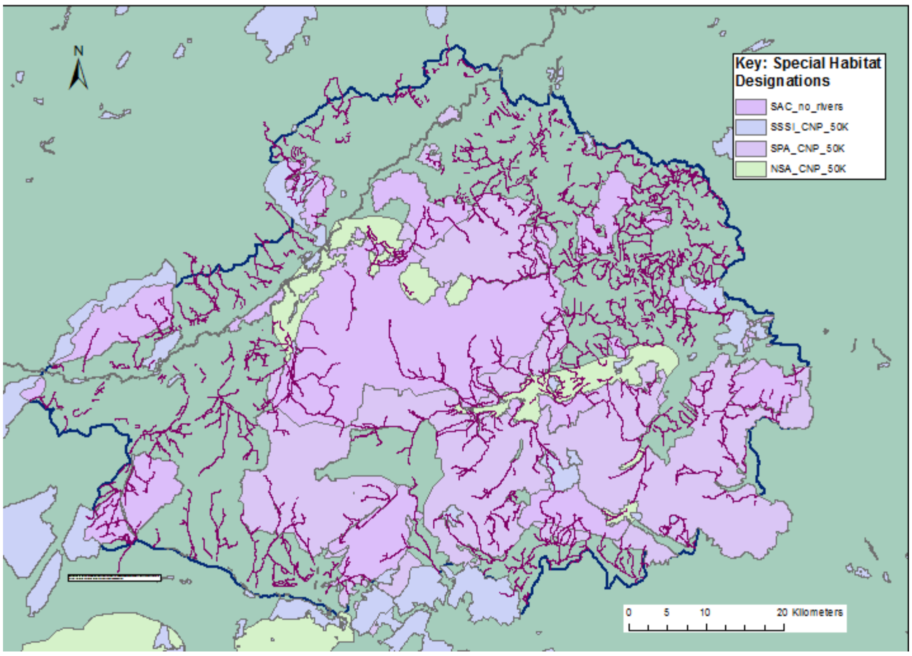
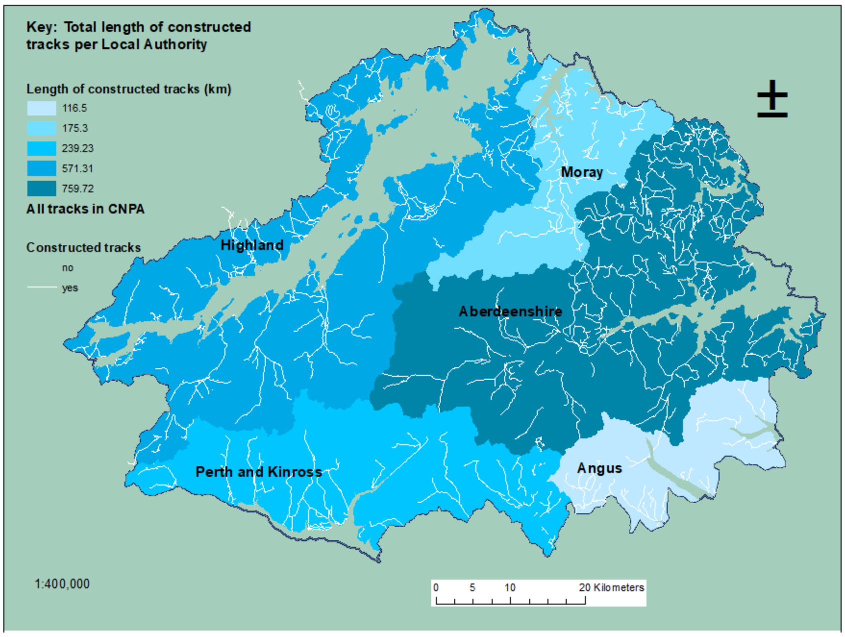


Figure 21: Map showing tracks overlapped with SSSIs, SACs, SPAs and NSAs

The lengths and density of constructed tracks was analysed per local authority; Highland, Moray, Aberdeenshire, Angus and Perth & Kinross. Results from this analysis found that the highest length of constructed track was in Aberdeenshire at 759.72km, however this LA had the lowest density of 1.759m/km^2 (*Figure 22*).



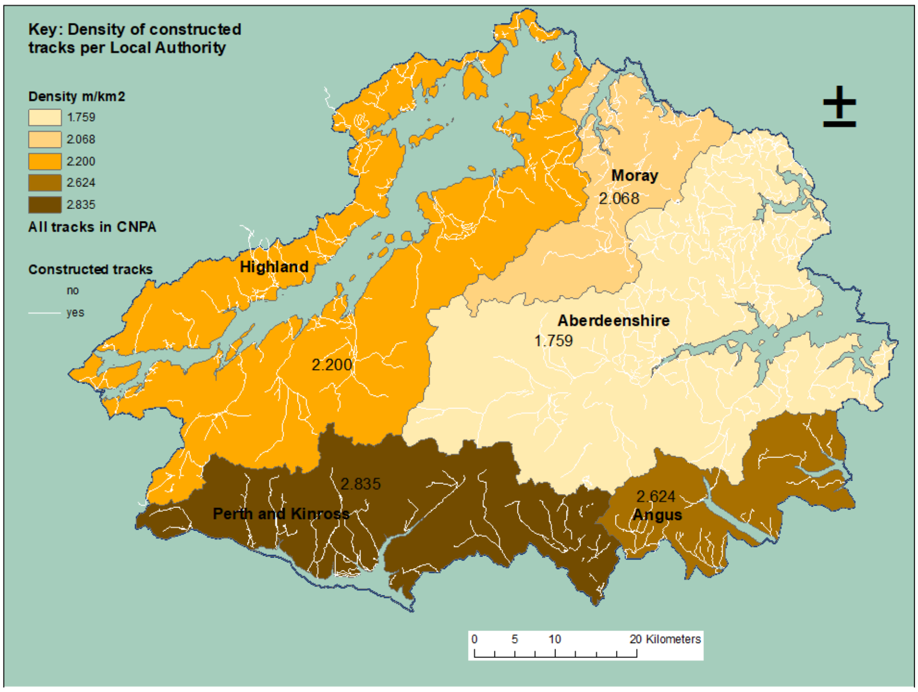


Figure 22: Two maps showing the total length and density of constructed tracks per Local Authority

Analysis looking at mapped borrow pits from four randomly selected estates found that on average 0.02% of the estate area consists of borrow pits (BP) with an average area of 283.38m^2. R:\Rural Development\Infrastructure\Hill Tracks\120819_borrowpit_database and a zipped file of all borrow pit data in R:\Rural Development\Infrastructure\Hill Tracks\General Map Outputs

Estate	Total area of BP (m^2)	BP % Estate Area	Average area of BP (m^2)	Largest area of BP (m^2)	count of BP (no.)
Glen Muick	11952.30899	0.022637916	249.0064373	1984.684533	48
Pitmain	15334.93178	0.044629792	312.9577914	2132.830767	49
Mar Estate	7841.970221	0.012767433	392.0985111	1559.716969	20
Cawdor	3230.02921	0.014065618	179.4460672	853.659354	18

Mainly only occurring on constructed tracks, some borrow pits have undergone natural regeneration or have been converted to turning areas. From the aerial photography it is difficult to establish the depth and hence the volume of the borrow pits. A code of practice could be developed for borrow pit construction to mitigate large excavations in areas of designation or geological sensitive areas.

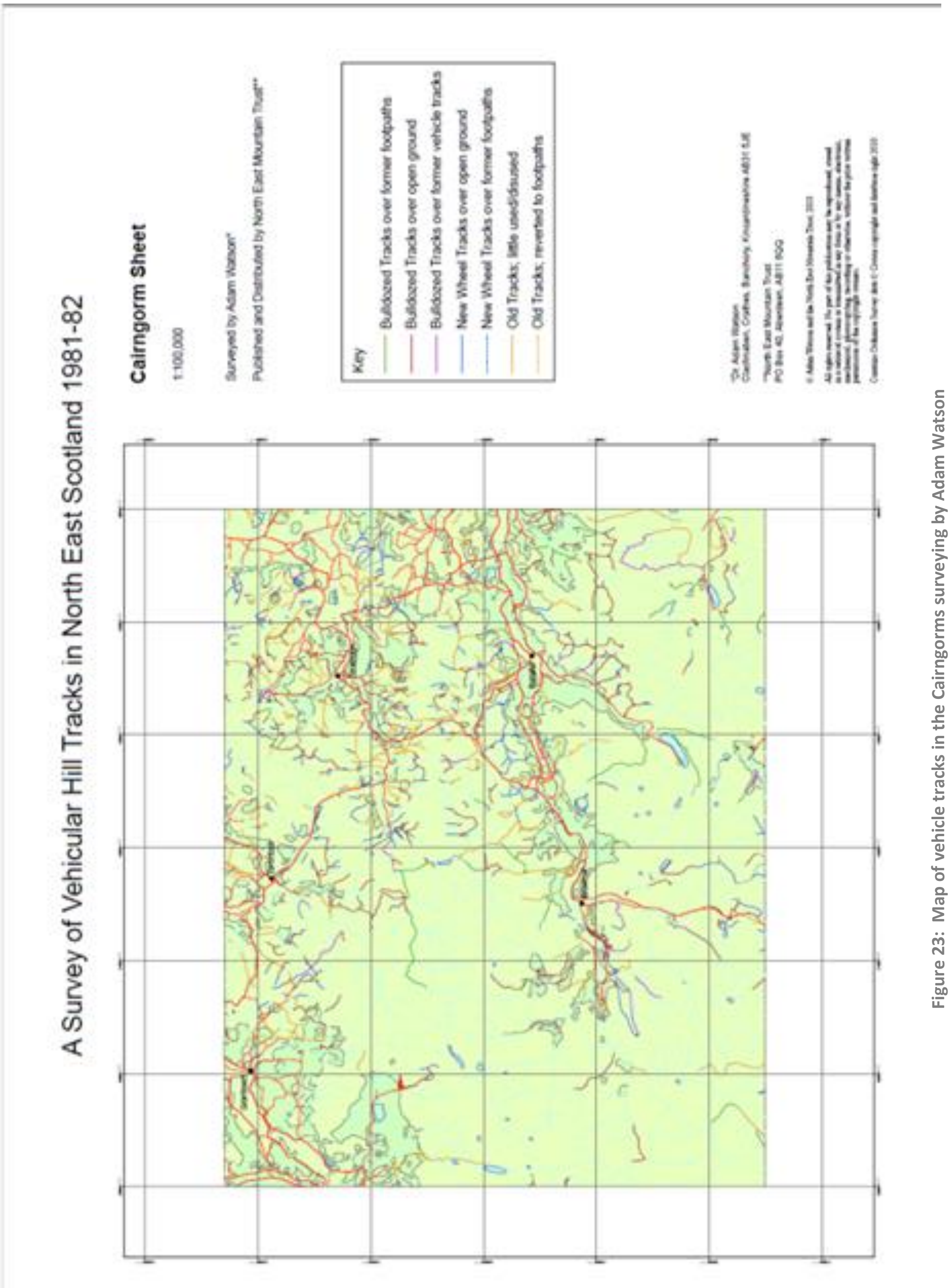


Figure 23: Map of vehicle tracks in the Cairngorms surveying by Adam Watson

Limitations to Mapping Hill Tracks

- Infrequent aerial photography and imaged at different times of year and conditions producing variable quality of images. Snapshot in time
- MM OS data to an accuracy of 2.5m
- Tree cover in places, difficult to observe tracks through thick canopy and shadows.
- Different soil types: some vehicles travelling over thinner soil on higher elevations and don't leave an imprint, whereas boggy environments may pick
- Different land surfaces express tracks as more or less defined, i.e. over saturated ground and bog environments, or in habitats which are quick to re-naturalise.