Regional Strategic Woodland Creation Project Mapping Methodology

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Scottish Borders Council (SBC) was invited to participate in a Regional Strategic Woodland Creation project. SBC held a number of scoping meetings with Forestry Commission Scotland (now Scottish Forestry) to consider the detail of the proposal and to develop an initial approach to identifying potential areas of search for the project.

The initial mapping objective was to identify areas of search for pilot opportunity areas for new, large softwood plantations including potentially where a new woodland destination might be created. The new woodland and a woodland destination could provide a range of benefits including economic (e.g. new niche processing), social (e.g. Community business recreation, timber transport improvements) and environmental (e.g. landscape, biodiversity, flood protection benefits).

Methodology

GIS was used to identify areas of search for new woodland planting based on a number of criteria. The Project Team developed a set of criteria that we wanted the areas of search to meet, in this case:

- SBC Woodland Strategy, Upland-Upland Fringe, 'Preferred' and 'Potential' areas
- Not in National Scenic Area
- Not in Special Landscape Area
- Land Capability for Agriculture codes >4
- Not on existing woodland. Data from National Forest Inventory Scotland.
- In SBC boundary

Datasets included are shown in Table 1 below:

Layer	Date Source	Open or License
Existing Woodland	National Forest Inventory Woodland Scotland (FCS)	Open
Land Capability for Agriculture (1:250k)	James Hutton Institute	Open
National Scenic Areas	SNH	Open
Regional Landscape Areas (Landscape Character Areas)	SNH	Open
Baseline Confluence nested catchments	SEPA (SE web)	Open
Special Landscape Areas	SBC	OS derived data (End user licence)
Woodland Strategy layers	SBC	OS derived data (End user licence)
Timber Transport Network	Timber Transport Forum	Open

Visualisation

This involved an initial visualisation in GIS by simply displaying the constraints in red on top of a green background (Fig. 1). The visible green areas show locations that are not constrained by any of the above agreed criteria.

This is a purely visual method, no data is processed (beyond adding definition queries to some layers) and it does not create features for the areas of search. It is quick and easy to add new constraints or modify criteria in definition queries to experiment with different options. The details of the mapping approach, interactive .pdf and output layers are provided in Appendix A. Fig. 2 shows these areas meeting the criteria with river catchments overlain.

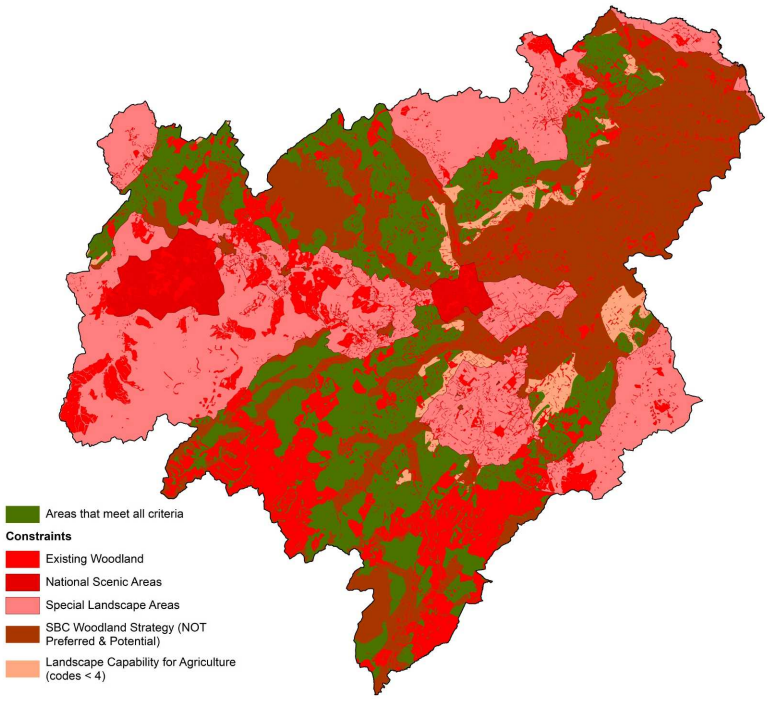

Fig. 1. The various shades of red are the constraints and the green shows unconstrained areas of search.

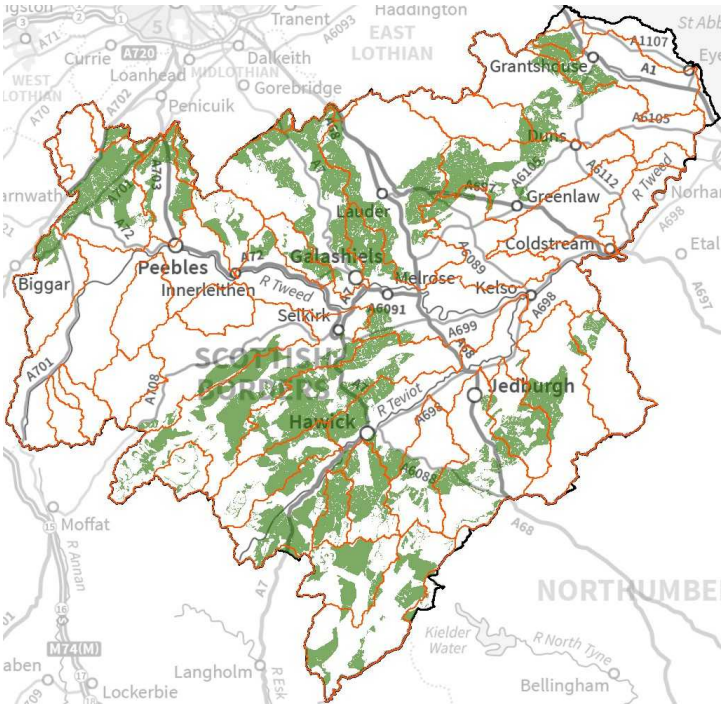

Fig. 2. The areas (in green) that meet all criteria, overlaid by river catchments.

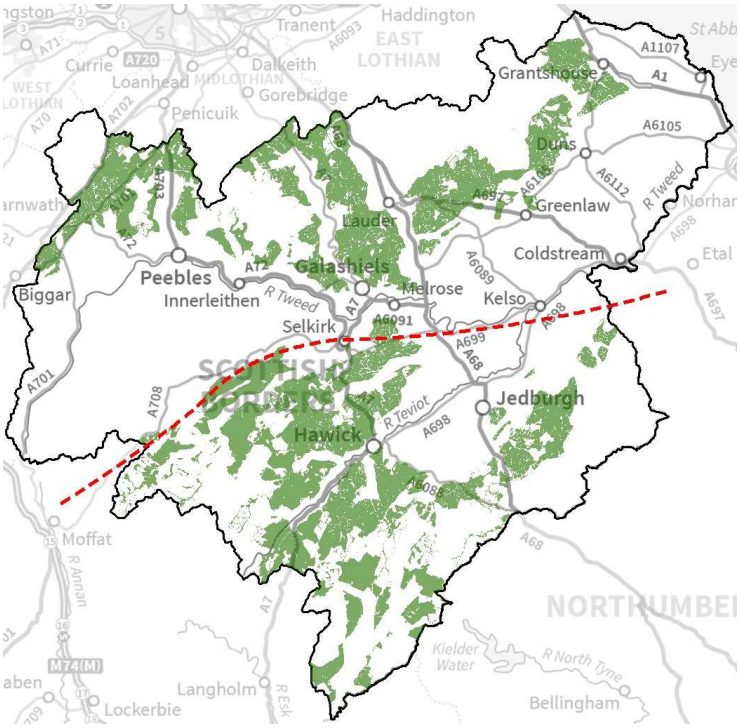

Fig. 3. The areas of search are grouped into two broad areas, one to the north of the Tweed valley and one to the south.

Initial Discussion and Next Steps

Fig. 3 shows that the northern area has some large areas meeting the criteria but they are separated by fairly broad areas of constrained land. 16.7% of the area north of the red line of the map above meets the criteria, giving a possible 48,100 ha of forest. However in policy terms, the Scottish Borders Woodland Strategy does not anticipate large scale new planting in the Lammermuir Moorfoot landscape area and Midland valley landscape area. Instead priorities are for lowland/upland fringe farm type woodland and native woodland, although there is potential for adding coniferous forest on the margins of the plateau moorland, subject to retaining a reasonable balance of open ground and forest, avoiding significant fragmentation of existing open habitats.

The southern area is more continuous with the main areas of search only separated by narrow bands in the valley bottoms. These valleys could be suitable for native riparian planting which would complement the softwood planting. 30.2% of the area south of the red line on the map above meets the criteria, giving a possible 56,300 ha of forest. SBWS identifies opportunities for Central Southern Uplands and Cheviot Hills landscape areas. Both areas have priorities for new woodland including new coniferous forest subject to retaining a reasonable balance of open ground habitats and avoiding significant fragmentation of existing open habitats. These woodlands should focus on improving the landscape fit of existing adjacent plantations, improving connectivity of woodland habitats and creating more effective linkages between existing productive woodlands to facilitate more effective timber transport routes.

The next steps considered in more detail the opportunities within sub-catchments within the Central Southern Uplands and Cheviot Hills landscape areas.

Stage 2

Investigating areas on the catchment scale complement much of the pilot work already undertaken by SBC in the Scottish Borders Land-Use Strategy pilot (2015) which uses an integrated approach to realise the multiple benefits of each catchment in providing ‘services’ from the land such as water quality, biomass and timber etc. and so facilitates the search for areas for woodland creation, and the preferred land types for the most suitable species, which can provide the greatest range of benefits from the land. In addition other important factors to consider such

as community council areas where decision-making and public engagement take place often coincide with these catchment boundaries as well as roads and timber transport routes and natural flood management opportunities. Consideration at the catchment scale therefore allows useful analysis of the potential contribution of woodland creation areas towards economic, social and environmental benefits.

We identified from the results of Stage 1 mapping that the areas that met criteria were broadly concentrated in catchments within the Central Southern Uplands and Cheviot Hills regional landscape areas (Fig. 4). We further narrowed-down sub-catchments for potential pilot areas based on fit with landscape area, local processing and timber transport routes, recreation tourism opportunities, natural flood management opportunities and community interests and impacts. This involved a quantitative assessment of the areas meeting all criteria by sub-catchment and a qualitative assessment of opportunities including natural flood management, local processing, recreation and sensitivities including communities and biodiversity. The results of this are shown in Appendix B.

Sub-catchments identified, which had greater than 2000 ha of 'areas meeting all criteria' were:

- Ale
- Allan
- Borthwick
- Ettrick(above Yarrow)
- Hermitage
- Jed Water
- Liddel
- Slitrig
- Teviot above Slitrig
- Yarrow

These catchments were considered further in the assessment. The relative sensitivity of the sub-catchment to large scale planting (cumulative effect if all the 'areas meeting criteria' was planted as a % increase in woodland cover) was also considered. Once we had identified key sub-catchments in Stage 2 mapping we moved on to Stage 3 mapping. These criteria were explored to identify those more spe-

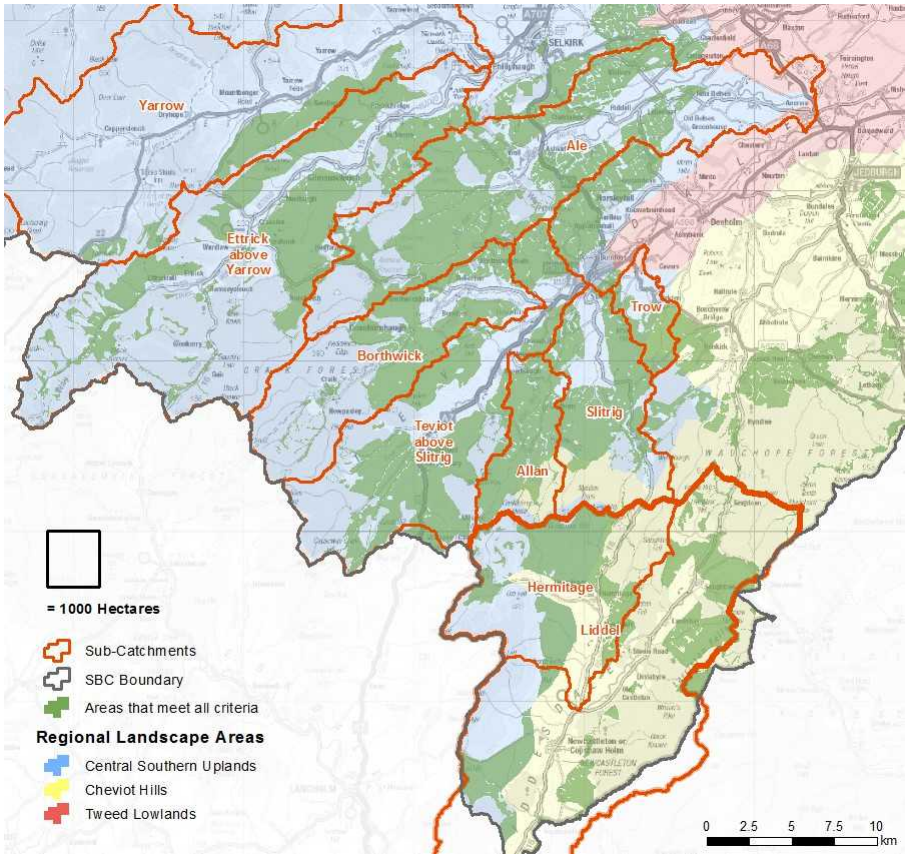

Fig. 4. The 'areas meeting all criteria' within regional landscape areas and sub-catchments

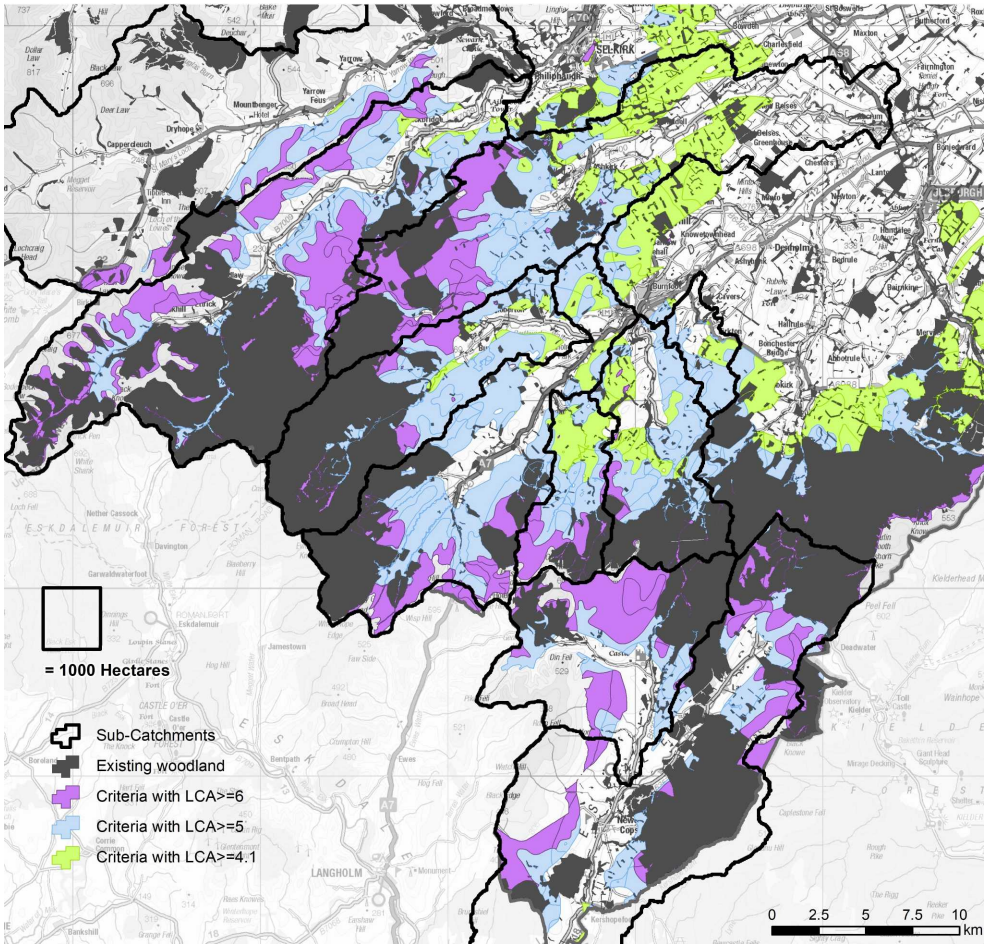

Fig. 5. 'Areas meeting criteria' with Land Capability for Agriculture LCA 4.1, 5 and 6 in river sub-catchments

cific to the Scottish Borders local authority area and within catchment areas.

The next stage focused on the sub-catchments in more detail in terms of Land Capability for Agriculture (LCA) scores; thus allowing for us to consider opportunities primarily based upon the extent of marginal hill farmland which could support productive woodland. This also included the use of other datasets such as the Phase 1 Habitat Survey to fine-tune the search for suitable areas.

The LCA scores were filtered so that initial Stage 1 mapping results ('areas meeting criteria') were compared against individual LCA categories; >=4.1 (greater than or equal to LCA 4.1 (Fig. 5 – Green)), >=5 (greater than or equal to LCA 5 (Fig. 5 – Blue)) and >=6 (greater than or equal to LCA 6 (Fig. 5 – Purple)). This allowed us to differentiate land capability further into less improved (LCA 5) and rough grassland (LCA 6) categories, highlighting these marginal farmland areas which are most suited for planting [productive conifer]. The results of this show some extensive areas across Ettrick valley, Upper Ale water, Borthwick water, Upper Teviot, Allan water, Slitrig water and Hermitage water.

Refinement with Phase 1 habitat data (Improved Grassland)

It was recognised that LCA 4.1 (Fig. 5 – green areas) could include suitable area but can also include improved, productive grassland which the study was attempting to avoid. To evaluate this we made use of Phase 1 Habitat data (derived from Aerial Imagery) (Fig. 6 – red and orange areas) overlaid this with LCA areas >=4.1 (Fig. 6 – red areas) identifying from the data areas of existing improved grassland which overlap LCA 4.1 (Fig. 6 – orange areas). This subsequently allowed us to differentiate

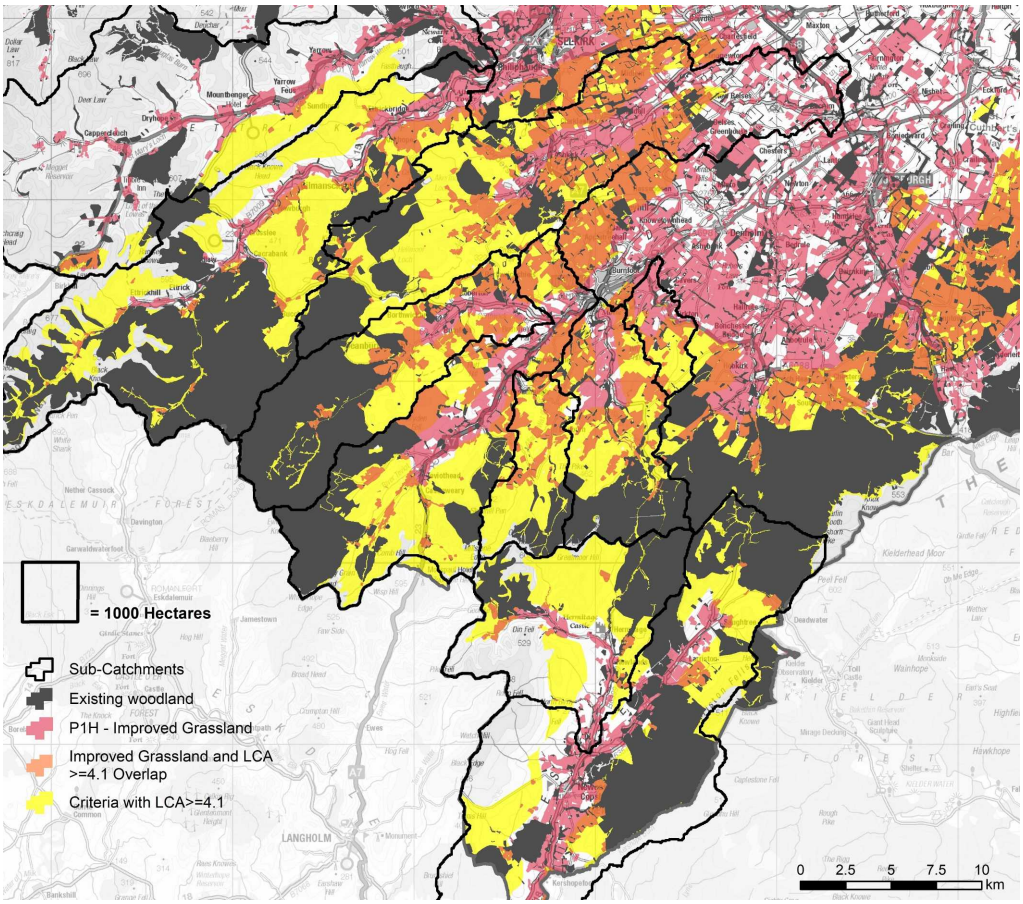

Fig. 6. Fig. 6 LCA >= 4.1 and Phase 1 Habitat - Improved Grassland Overlap

less preferred improved grassland areas in LCA 4.1 from the remaining preferred unimproved grassland and heathland habitat in the LCA criteria.

Note (Fig. 6) the red areas clearly indicate deeper lowland valley areas where the expected existing, more productive improved grassland is located.

From this analysis we calculated improved grassland (Phase 1 habitat categories B4 and B6) figures and percentages for each catchment to indicate how productive the hill farming is in each sub-catchment (Fig.7 and Appendix B. table 3). The proportion of the sub-catchments that are improved grassland is Ettrick (9.6%), Ale (30.2%- mostly in lower catchment), Hermitage(6.6%) and Upper Teviot (24.7% mainly in lower part of this catchment) respectively compared to the range of 10.4-47.5% for the other sub-catchments considered. Note (Fig. 6) the red areas clearly indicate deeper lowland valley areas where the expected existing, more productive improved grassland is located.

Areas were then classified into 'Opportunities', 'Neutral' and 'Constraints' using the Phase 1 Habitat data and other data sets as set out below:

Constraints (including productive agricultural land and peatlands:

- Improved Grassland (Phase 1 habitat categories: B4 and B6)
- Carbon-rich soils (SNH class 1&2)
- Designated sites (SSSI, SPA, SAC)
- Existing woodland

Opportunities (Areas where large scale planting might be possible):

- Bracken (Phase 1 habitat categories: C1.1, C1.2)
- Rough Grass (Phase 1 habitat categories: B1.1, B1.2, B5)

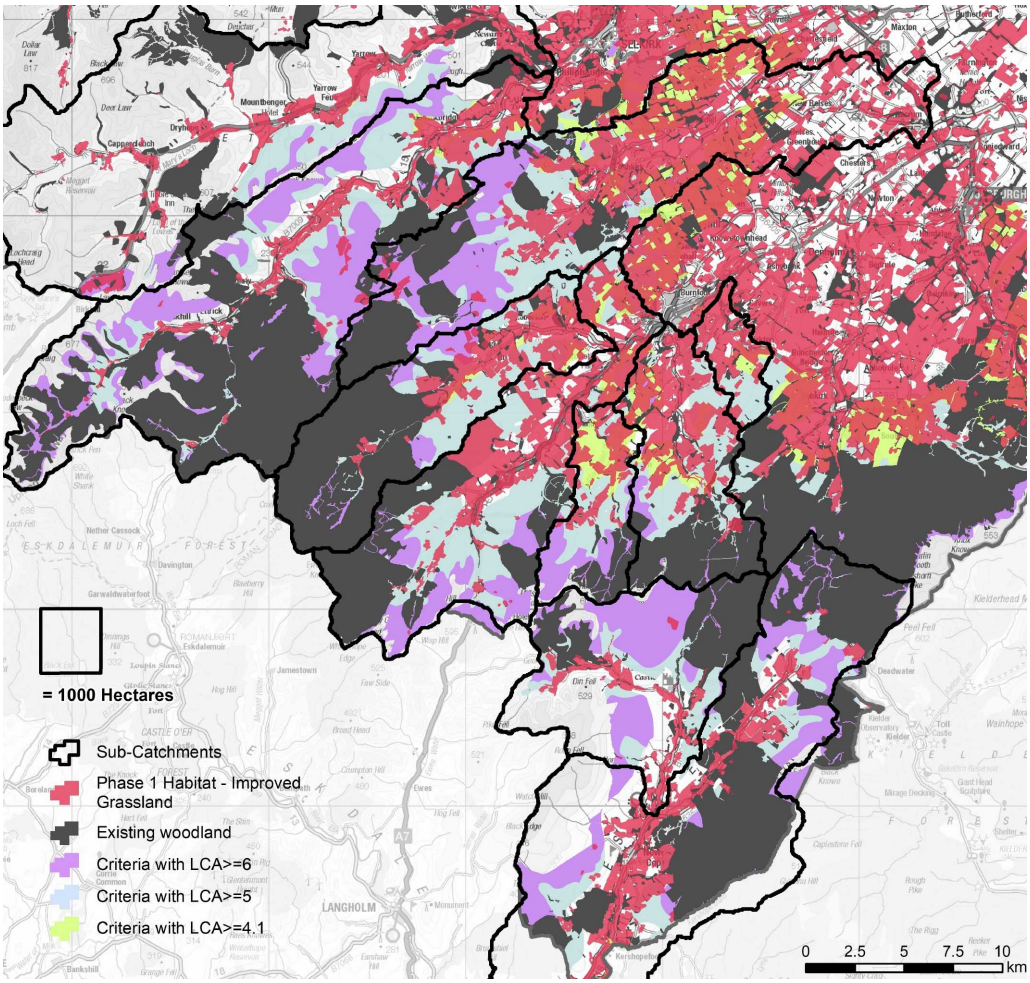

Fig. 7. Areas of marginal agricultural land mostly in LCA class 5 and 6

Neutrals (areas that might be considered as in due course as either opportunities or constraints):

- Heathland and Heathland/grassland mosaics (Phase 1 habitat categories: D1.1, D1.2, D2, D5, D6)

Opportunity areas (Fig.8 - blue) are based on rough grassland and bracken habitats. Heathland and heathland/grassland mosaic habitats are shown as neutral areas (Fig.8 - purple) on the basis that heathland dominated areas in good condition might be considered as constraints but very fragmented heathland within a mosaic of rough grassland may be considered as an opportunity. These areas require further consideration but might form part of the matrix for woodland expansion, taking into account the need to maintain moorland corridors (see below).

The more constrained areas are shown in red (Fig. 8), carbon-rich soils (Class 1 & 2), designated sites, productive grassland and existing woodland. The opportunity and neutral areas show extensive areas in mid-Ettrick, small part of the Yarrow catchment (outside of the Special Landscape Area) and parts of the Upper Ale catchment and a second extensive area that extends over the Upper Teviot/ Upper Allan Water and Hermitage catchment. This latter area may extend over into neighbouring Dumfries & Galloway.

Some issues to consider in the detailed design include maintaining heathland/moorland connectivity to areas to the north (Tweedsmuir hills SSSI and Moorfoot hills SAC/SSSI) and consideration of connectivity to Langholm-Newcastleton Hills SPA/SSSI and protecting important habitat areas for breeding waders and black grouse.

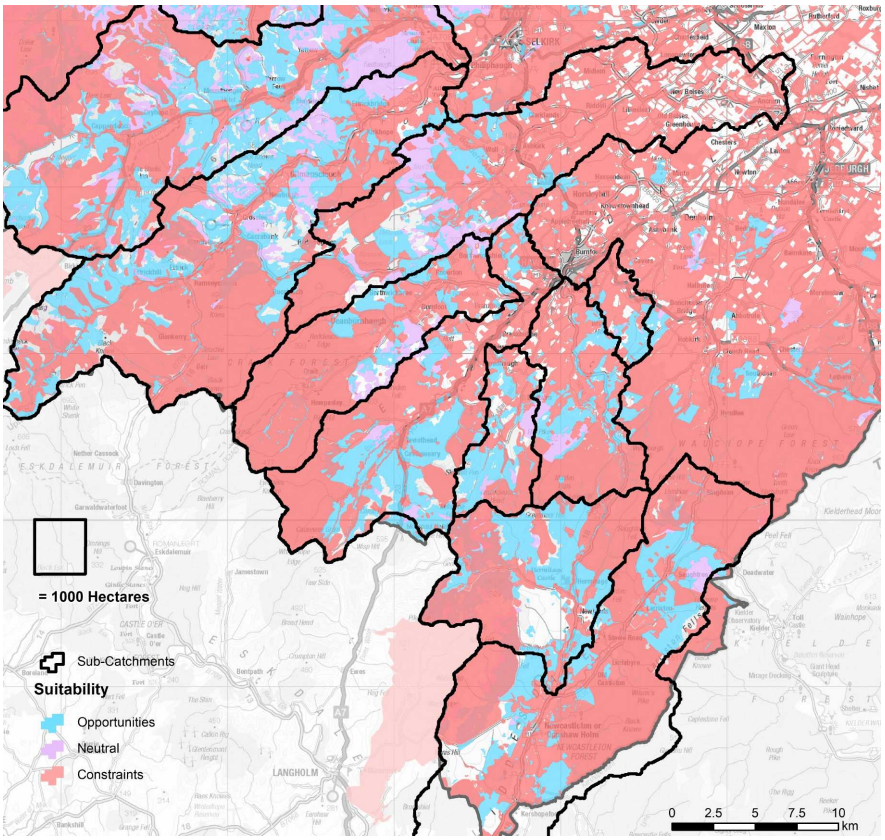

Fig. 8. Opportunity, neutral and constrained areas based on Phase 1 categories, designated sites and carbon-rich soils

The heathland layer and heathland habitat network layer can be used to identify where corridors of open moorland habitat could be safeguarded providing connectivity to these important areas of the moorland.

Other datasets were employed later, including data from SNH (Carbon and Peatland 2016 map) on areas of deep peat (with a threshold depth of >0.5m). These areas were compared with likely areas of deep peat identified in the latest Phase 1 Habitat survey using the relevant habitat codes (Fig. 10); blanket bog(E1.6.1), wet modified bog(E1.7), lowland raised bog(E1.6.2), valley mire(E3.1) and basin mire(E3.2).

Woodland Expansion Advisory Group (WEAG outputs)

The Opportunities, Neutral and Constraints data were then compared to the FCS dataset Areas with greatest Woodland Creation potential which is derived from the data for WEAG "Phase 3" land (land most likely to have potential for woodland expansion) for farm business units > 200 ha (also included in Fig. 9)

The Opportunity areas based on Phase 1 habitat data (rough grassland and bracken) were compared with the FCS data for Areas with greatest potential for woodland expansion (Fig. 9). There is a reasonable overlap between the two (green areas). Where they vary includes areas identified for potential in the FCS data but not the Phase 1 habitat data which may reflect the broader criteria in the FCS data. There are also areas identified as opportunities in the Phase 1 habitat data but not the FCS data which is more difficult to explain and worth investigating further

We then compared both SBC and FCS output with JHI SNH/JHI carbon rich soil data and Phase 1 mire habitat categories thus allowing for peat cover data validation. Some of these areas didn't coincide as seen in the Hermitage and Liddel water catchments (Fig. 10). These data were overlaid with SBC and FCS output so it could be seen where areas of potentially peat/deep peat didn't coincide with areas of opportunity.

An area within the Hermitage catchment was identi-

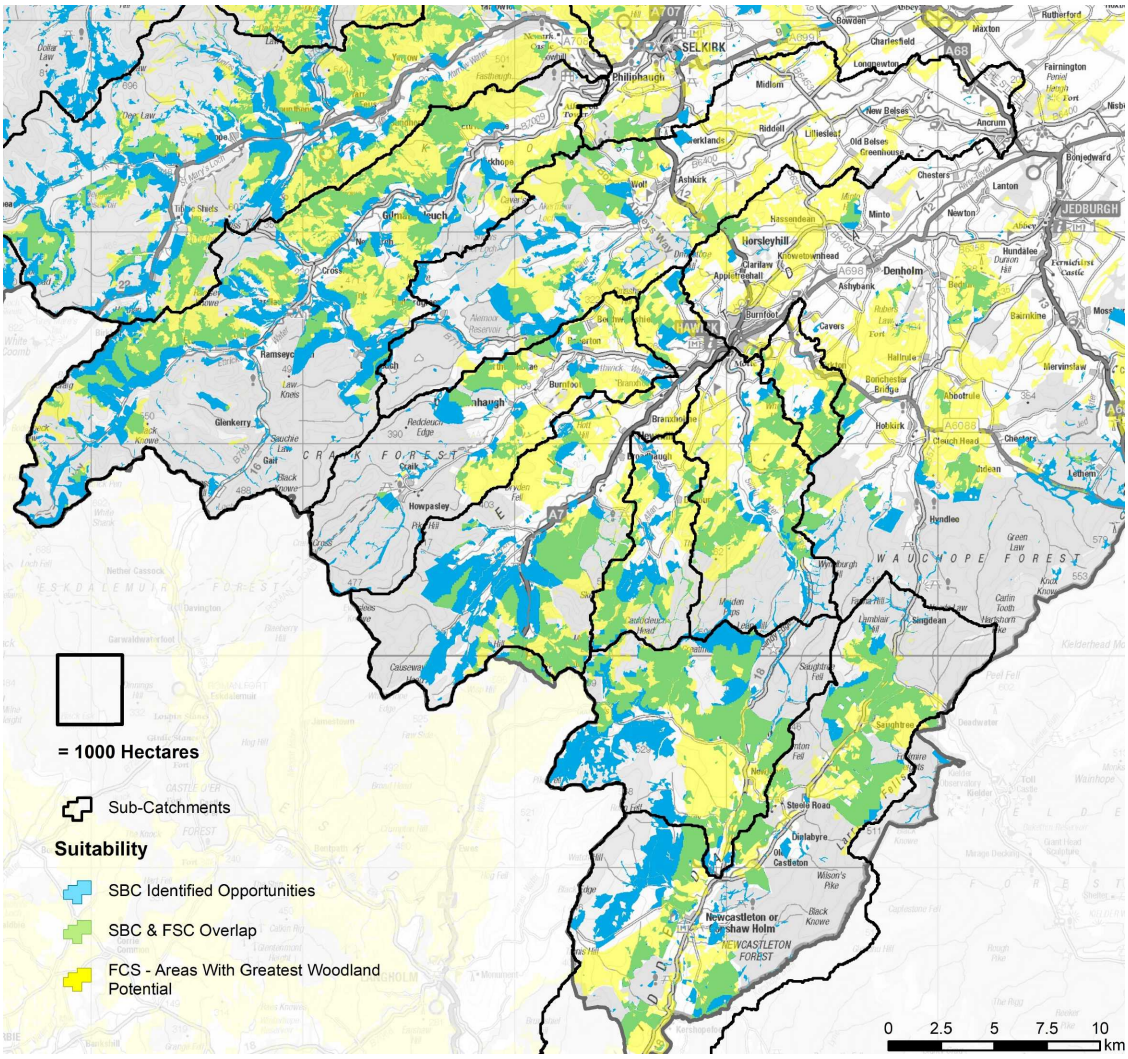

Fig. 9. Areas of suitability- Opportunities-SBC vs Woodland Potential- FCS).

fied as wet modified bog (E1.7) in Phase 1 habitat data and was not present in the SBC output but was included in FCS opportunity output (Fig. 9 - yellow).

Fig. 10 shows these areas of carbon-rich soils classes 1 & 2 and areas of Phase 1 mire habitat. The carbon-rich soils data was included in the constraints layer as this national dataset includes nationally important carbon-rich soils, deep peat and priority peatland habitat and areas of potentially high conservation value and restoration potential. The Phase 1 habitat data was not included as a constraint but was used to visualise where further areas of peatland and open mire habitats may need to be safeguarded.

Identification of potential pilot areas

Taking into account the above factors the following areas were identified as potential pilot areas containing sufficient opportunity areas were large scale woodland creation might be realistically achievable (Fig. 11):

Area 1: An area including part of mid-Ettrick water, part Yarrow water and Upper Ale water catchments.
Area 2: An area including Hermitage water and Upper Teviot sub-catchments and extending into adjacent areas in Dumfries Galloway.

The potential opportunity areas in each are (Appendix B. table 4)

Area 1: 4,862 ha and **Area 2: 8,540 ha**

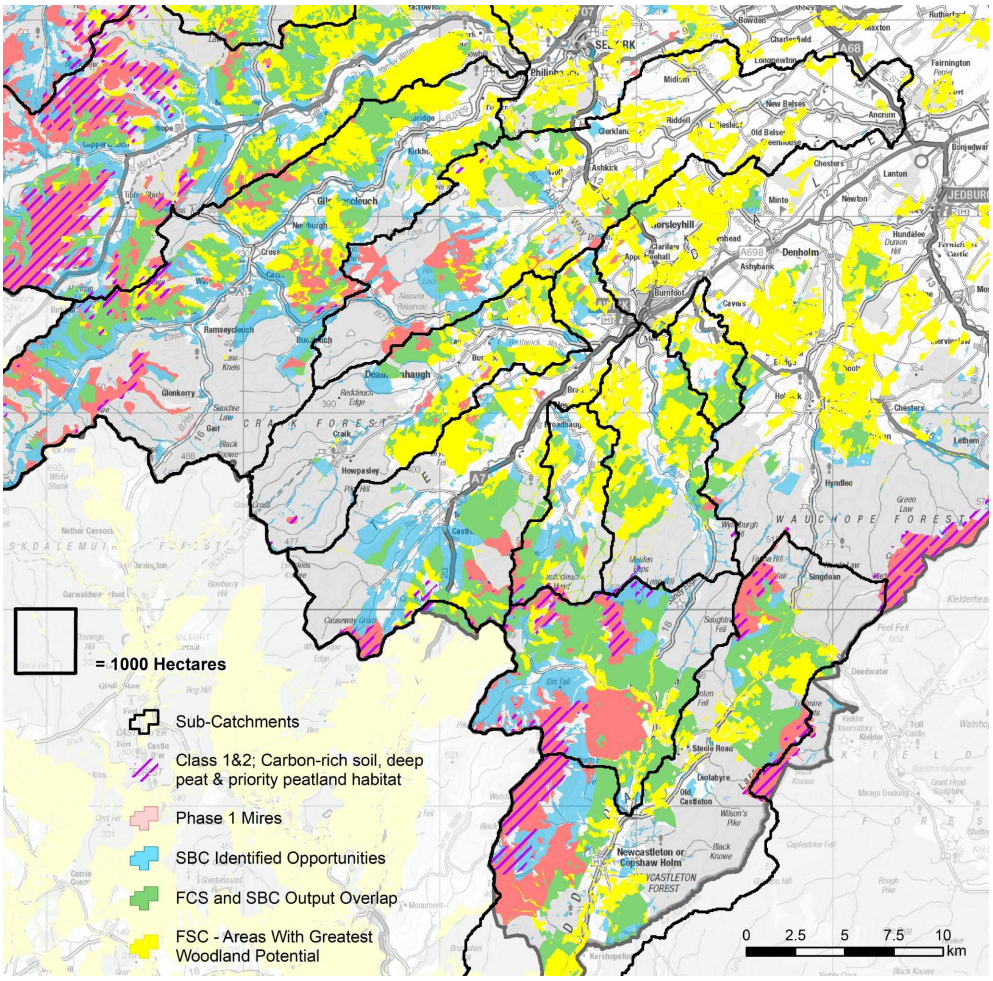

Fig. 10. Carbon rich soils (SNH 2016) and Phase 1 habitat mire habitat categories overlaying opportunity areas (SBC and FCS WEAG)

This suggests that there are sufficient areas of suitable land within the two identified potential pilot areas based on the Phase 1 habitat data. This may be an underestimate of the real opportunity areas

We can consider further whether neutral areas (3,146 ha and 831 ha in areas 1 and 2 respectively) can be included as either opportunities or constraints.

There may be additional opportunity areas in Dumfries & Galloway adjacent to Area 2.

These areas could form the basis of potential pilot areas to consider but this does not preclude additional areas being worthy of consideration for new large scale forestry plantations.

Existing woodland and potential cumulative impacts

The new woodland area may reach across sub-catchments and also cross regional boundaries which might lessen cumulative impacts. An indication of cumulative impacts can be given by the area of existing woodland plus additional woodland opportunity areas within a sub-catchment, but taking into account that potential pilot areas may transcend catchment boundaries. Existing woodland cover in Ettrick water sub-catchment is 41.4%, Ale water 22.1 %, Upper water 7.1% and Hermitage water 23.9%. Consideration should be given to how any new woodland area can be planned and distributed to avoid significant cumulative impacts.

Broad, indicative potential pilot areas were identified as shown below (Fig. 11).

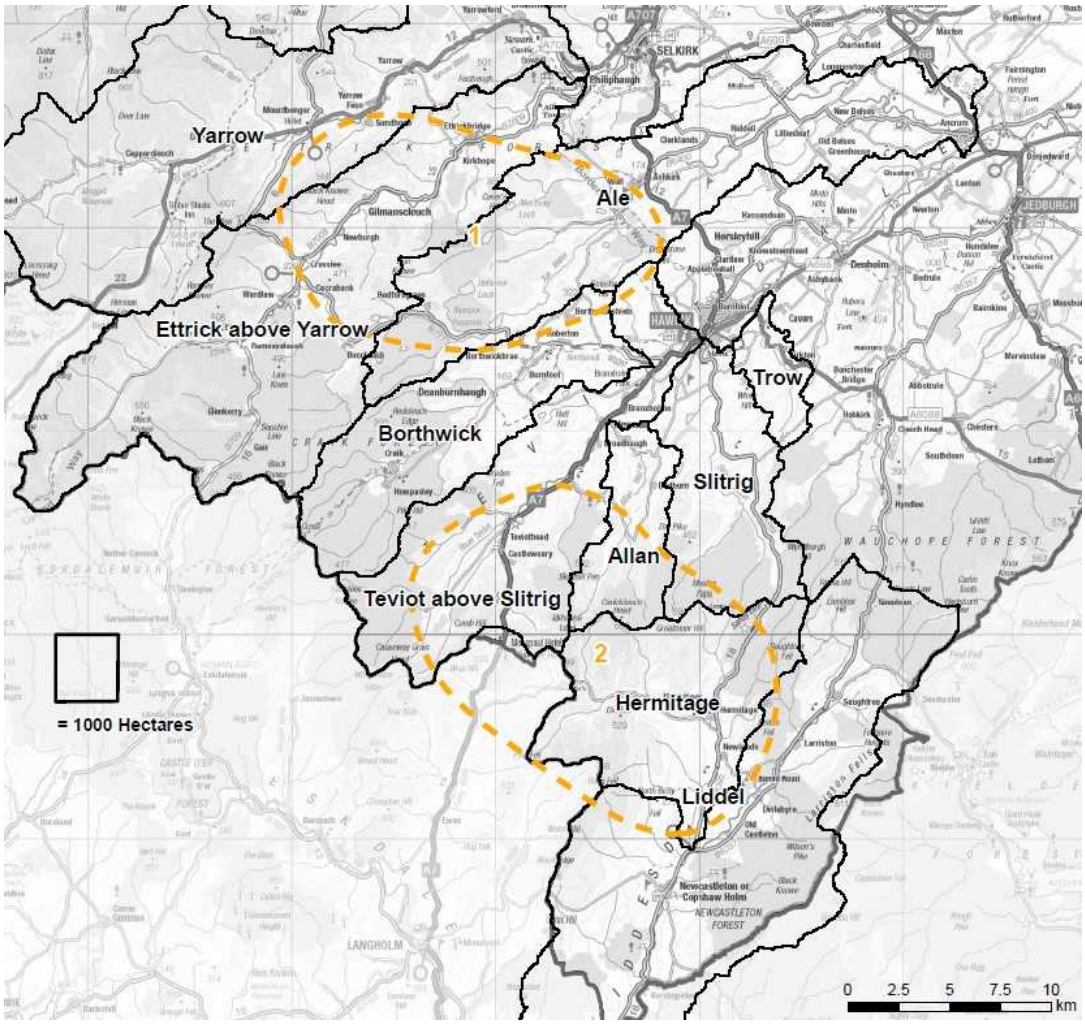

Fig. 11. Indicative potential pilot areas

Final pilot area boundaries

Boundaries were identified by clipping largely to catchment boundaries and road networks to generate discrete boundaries.

For Area 1, the boundary was clipped to the road network including timber transport routes.

For Area 2, the Langholm-Newcastleton moor SPA was excluded, as was an area directly behind Hermitage Castle which in part sits in the setting of the castle and part lies within the boundary of the Windy Edge wind farm and the south-west boundary of the area is the regional boundary with Dumfries and Galloway.

The boundaries should be considered as "fuzzy"; they are likely to contain sufficient areas of suitable land for large scale planting. Further consideration of opportunities and constraints is to be explored during a stakeholder engagement phase to explore issues such as landscape capacity, biodiversity, cultural heritage, access and tourism, economic development, timber transport and other key issues. It is hoped that as a result of this next stage, real preferred areas can be identified.

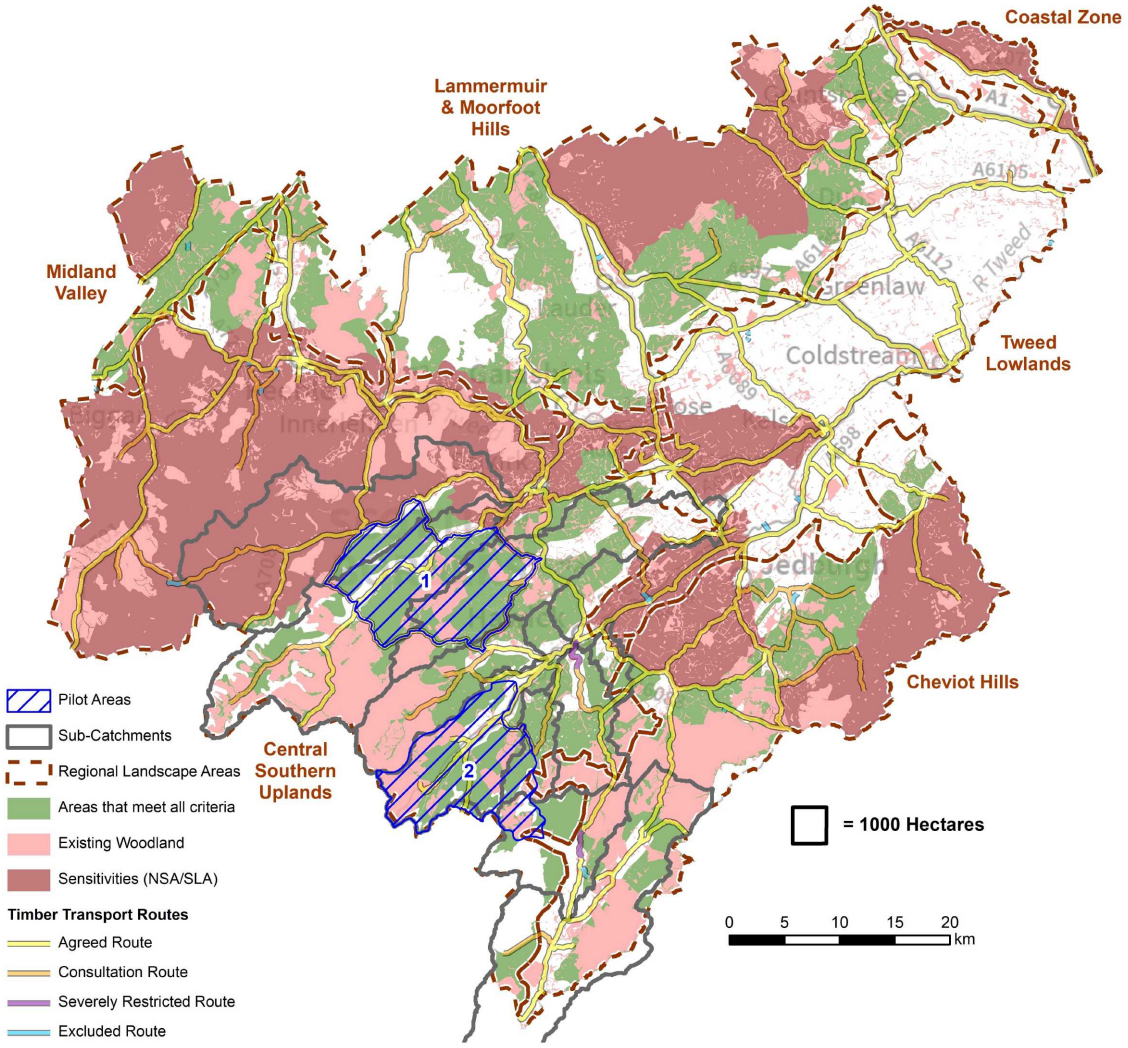

Fig. 12. Final pilot area boundaries

Appendices

Appendix A - Generating 'Meet Criteria'

1. Interactive PDF

If set up correctly the initial visualisation can be exported to PDF from Esri's ArcMap so that it saves the vector data as separate layers (Fig. 13) that can be turned on and off. This allows you to look at the effects of different constrains in a similar way to GIS but without specialist software

1.1. Layers must not have a transparency set. All layers below a layer with transparency are merged with the background map and cannot be turned on or off.

1.2. Visibility is controlled in the Layers tab in Adobe Reader.

1.3. Groups are retained and appear as folders. They are minimised by default so must be expanded by clicking the '+'

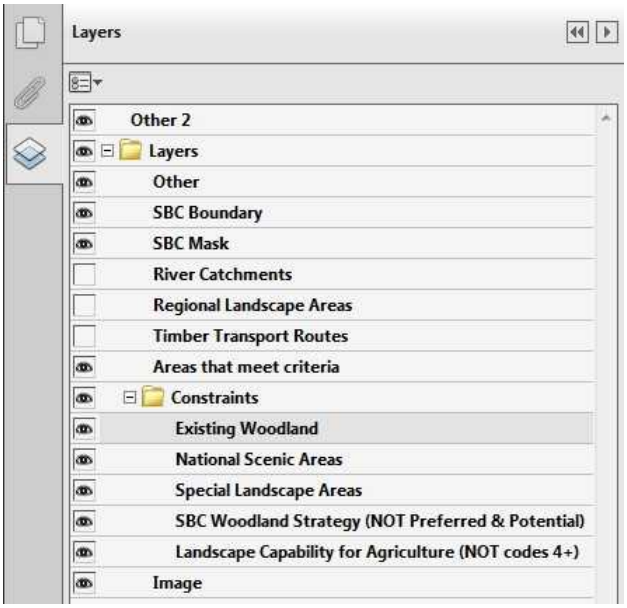

Fig. 13. PDF Layers

2. Union

To create a GIS layer containing the areas of search you must overlay the criteria layers using the Union tool (Fig. 14). This splits the polygons where they overlap and each new polygon contains the attributes of both polygons that went into it.

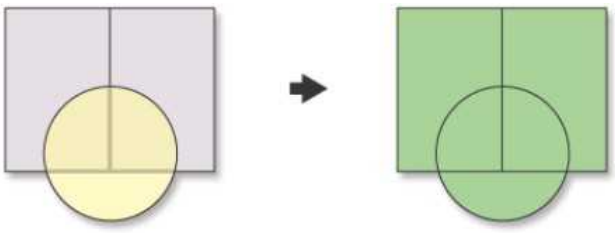

Fig. 14. Example of Union
Image from Esri

2.1. Start by removing any definition queries you used in the initial visualisation. You will apply criteria to the output using a definition query so having all values allows you to change the criteria thresholds if you want.

2.2. Turn off any attributes you don't need. Ideally you'll just have one attribute from each layer.

2.3. Use the Union tool to overlay the criteria layers. Depending on your licence you may need to do this one layer at a time, overlaying the next layer with the output of the previous union.

2.4. Once all layers have been unioned you will have an output layer covering the whole region in which every polygon contains attributes for every criteria, so you can see which criteria each polygon passes or fails on (Fig. 15 - 'Unioned').

3. Apply definition criteria using query

Construct a definition query to display the polygons that meet the criteria (Fig. 15 - 'Meet criteria') you decided on. This could also be done to show areas that don't meet the criteria. Because all attributes are included you can experiment with varying the criteria by changing the definition query.

4. Dissolve output layer

Once you are happy with your final set of criteria you can use the Dissolve tool to create a simplified output showing the area of search (Fig. 15 - 'Dissolved').

Note: Some layers may benefit from pre-processing. For example if you are using a national dataset you could clip it to the Council boundary to reduce the number of features and make later processing run faster.

Fig. 15. GIS Steps
Image from Esri

FME

The above procedure can be done in ArcMap or other GIS software, but if you have access to FME you can build a workbench to automate it. Having a workbench means you can quickly and easily change criteria and rerun to get a fresh output.

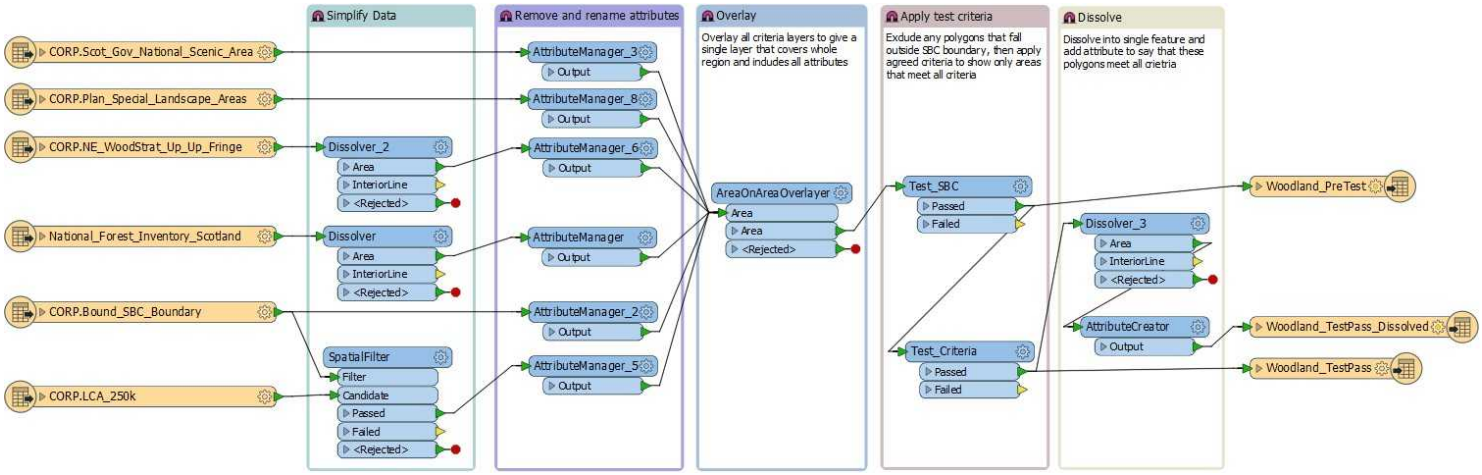

Fig. 16. FME Workbench used for creating Meet Criteria

Appendix B - Metadata

Table 2. Metadata

Dataset	Phase 3 Mapping	Constraint Rating	Codes (Phase 1)	Licence/Owner	Date of data published
Land Capability for Agriculture	>4.1, 5 & 6 best	N/A	N/A	James Hutton Institute James Hutton Institute Open Data Licence	2016-08-01
River Catchments (SEPA)	N/A	N/A	N/A	SEPA	2018-08-08
Phase 1 habitat (TWIC)	Improved Grassland	Constraint	(B4, B6)	SBC	2018-05-31 (SBC Updated) (actual published date unknown)
Phase 1 habitat (TWIC)	Mire (to compare with deep peat (SNH carbon-rich soils class 1 & 2 which are derived from JHI 250k national soil map).	Constraint (might be deep peat, peat)	(E.1.6.1, E1.6.2, E1.7, E1.8, E3.2 (basin mire) E3.3 (floodplain mire) however no E3.2.1 or E3.3.1 (which are modified habitats – unfortunately these are ones likely to not be on deep peat which the Borders area has none of).	SBC	2018-05-31 (SBC Updated) (actual published date unknown)
Existing Forestry	Existing forestry	Constraint	N/A	NFI (FCS*) – 'woodland scotland'	2017 NFI base map
Carbon Rich Soils	Presence of peat	Constraint	Classes 1&2	SNH (JHI 250K & 25K soil data/Land Cover Scotland 1988)	2016-06-29
Designated sites	N/A	Constraint	SSSI, SAC, SPA	SNH	SSSI=2018-09-29 SAC=2018-12-20 SPA=2018-12-20
Phase 1 habitat (TWIC)	Heathland (purple)	Neutral (likely to be protected / have peat / low yield)	(D1.1, D1.2, D2, D5, D6)	SBC	2018-05-31 (SBC Updated) (actual published date unknown)
Phase 1 habitat (TWIC)	Rough Grassland (B1.1, B1.2, B5) Bracken (C1.1, C1.2)	Opportunities	N/A	SBC	2018-05-31 (SBC Updated) (actual published date unknown)
Areas with greatest woodland potential (FCS*)	FCS* study	N/A	N/A	FCS* (WEAG Phase 3 – yellow)	2011

*now 'Scottish Forestry'

Appendix B - Data

Table 3

Catchment	Area of Catchment (ha)	Area in SBC (ha)	Area (Improved Grassland) (ha)	% (Improved grassland)	Area (Other) (ha)	% (Other)
Ale	17461.75	17461.75	5265.30	30.2	12196.45	69.8
Allan	3535.75	3535.75	664.45	18.8	2871.30	81.2
Borthwick	9047.50	9044.42	1693.98	18.7	7350.44	81.3
Ettrick	22746.75	22696.68	2178.19	9.6	20518.49	90.4
Hermitage	9223.25	9214.78	605.15	6.6	8609.63	93.4
Liddell	32598.25	26484.36	2755.51	10.4	23728.85	89.6
Slitrig	6637.50	6637.50	1927.54	29	4709.96	71
Teviot	12490.75	12481.64	3080.37	24.7	9401.28	75.3
Yarrow	1557.50	1557.50	739.04	47.5	818.46	52.5

Table 4

Pilot Area total within SBC (ha)	
Pilot Area 1	Pilot Area 2
16110.30	17990.25

Catchment	Pilot Area	Opportunity Areas SUM (ha)	Neutral Areas SUM (ha)	Total River Catchment Area (ha)	% of Catchment Opportunity Areas	% of Catchment Neutral Areas
Ale	1	1729.74	1402.38	17461.75	9.91	8.03
Allan	2	873.14	86.19	3535.75	24.69	2.44
Borthwick	1	149.34	129.13	9047.50	1.65	1.43
Ettrick	1	2505.92	1239.92	22746.75	11.02	5.45
Hermitage	2	4028.61	454.25	9223.25	43.68	4.93
Liddell	2	4619.45	488.96	32598.25	14.17	1.50
Slitrig	2	77.00	2.96	6637.50	1.16	0.04
Teviot	2	2858.21	258.15	12490.75	22.88	2.07
Yarrow	1	429.36	353.69	23323.50	1.84	1.52
Totals (ha)		17270.79	4415.65			

Catchment	Pilot Area	SUM Opportunities + Neutral Areas (ha)	% of Catchment Opportunities + Neutral Areas	% of Pilot Area within SBC - Opportunity Areas	% of Pilot Area within SBC - Neutral Areas	SUM Opportunity + Neutral as % of Pilot Area within SBC
Ale	1	3132.12	17.94	10.74	8.70	19.44
Allan	2	959.33	27.13	4.85	0.48	5.33
Borthwick	1	278.47	3.08	0.93	0.80	1.73
Ettrick	1	3745.85	16.47	15.55	7.70	23.25
Hermitage	2	4482.86	48.60	22.39	2.52	24.92
Liddell	2	5108.41	15.67	25.68	2.72	28.40
Slitrig	2	79.97	1.20	0.43	0.02	0.44
Teviot	2	3116.36	24.95	15.89	1.43	17.32
Yarrow	1	783.05	3.36	2.67	2.20	4.86
Totals (ha)		20903.38				

Table 4 - Final Totals

Pilot Area 1 - Total % Opportunities	Pilot Area 1 - Total % Neutrals	Opportunity + Neutral Areas as % of Pilot Area 1
30.18	19.53	49.71
Pilot Area 2 - Total % Opportunities	Pilot Area 2 - Total % Neutrals	Opportunity + Neutral Areas as % of Pilot Area 2
47.47	4.62	52.09
Pilot Area 1 - Total Opportunity Area (ha)	Pilot Area 1 - Total Neutrals Area (ha)	Opportunity + Neutral Areas of Pilot Area 1 (ha)
4862.16	3146.17	8008.33
Pilot Area 2 - Total Opportunity Area (ha)	Pilot Area 2 - Total Neutrals Area (ha)	Opportunity + Neutral Areas of Pilot Area 2 (ha)
8539.78	831.66	9371.44

References

1. WEAG recommendation No 10: Increasing the integration of farming and forestry in Scotland: a summary of recent research The James Hutton Institute (2014)
2. Report of the Woodland Expansion Advisory Group (2012)
3. Towers, W et al. (2011) Woodland Expansion GIS Project. James Hutton Institute and Forest Research
4. Scottish Borders Woodland Strategy (2005)
5. Scottish Borders Pilot Regional Land Use Framework (2015):