Native Woodland Habitat Networks in the Scottish Borders

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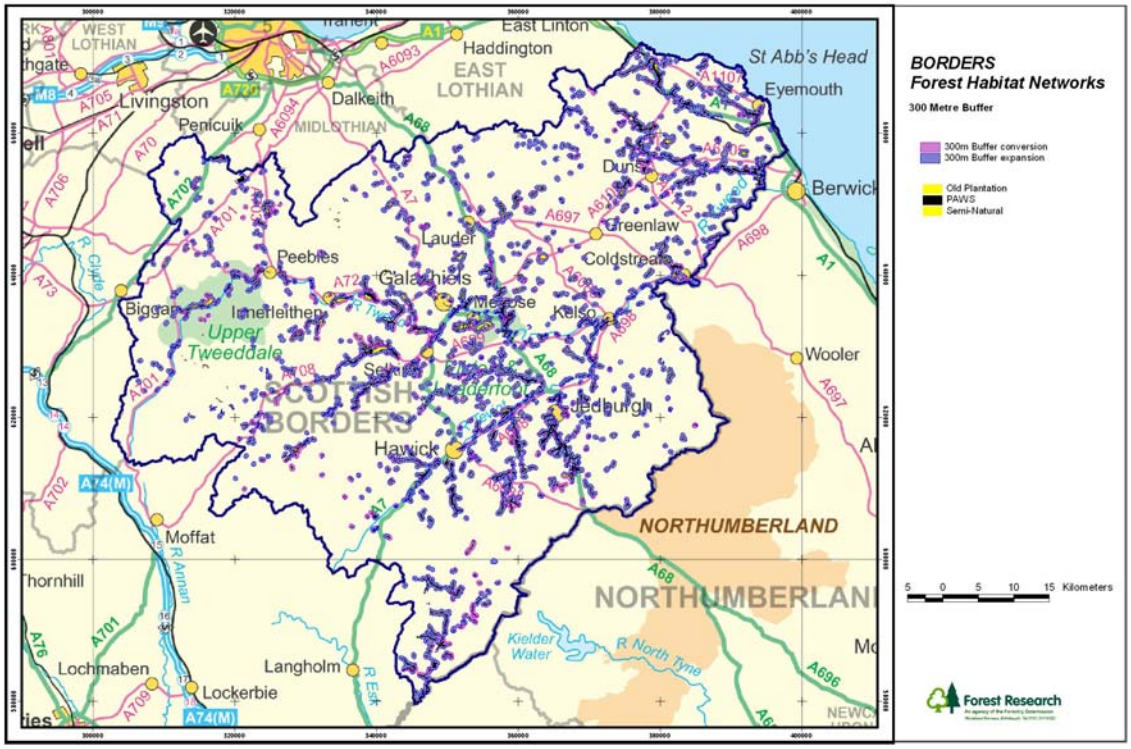


REPORT of a study funded by Forestry Commission Scotland, Scottish Natural Heritage, and Scottish Borders Council in 2003.

Executive Summary

1. This report describes a GIS based desk study to identify the semi-natural woodland framework for the development of a Native Woodland Habitat Network in the Scottish Borders. The work examines how the Scottish Forestry Grant Scheme (SFGS) policy will contribute to the development of Forest Habitat Networks in the Scottish Borders, and the likely impact this development will have on woodland HAP targets. It discusses a focal species approach to understanding and testing the landscape patch mosaics for species conservation. Finally, it examines the effect of native woodland expansion on a few important landscape character types in the Scottish Borders.

2. The SFGS includes a section designed to encourage the management and expansion of native woodland Forest Habitat Networks, through natural regeneration, planting, conversion and restoration. The SFGS Applicants Booklet suggests that 90 percent grants may be available where new native woodland is established or restored within 300 m of existing ancient semi-natural woodland. This work tests the effectiveness of 300 m and 500 m buffers in delivering a native woodland habitat network in the Scottish Borders.

3. Only small remnant ancient semi-natural woodlands remain in the Scottish Borders. The amount is uncertain because the Ancient Woodland Inventory was not completed for the region. The inventory identifies only 608 ha of ancient semi-natural woodland (0.13% of the land area)

4. Categories of ancient, long established and semi-natural woodland and the semi-natural and high native component classes of the SSNWI dataset were identified as 'framework woodland' for a native woodland habitat network. The additional LEPOs and SSNWI data increase the framework woodland to 5220 ha (1.4% of the land area).

5. Framework woodland was buffered to 300m and 500m and the existing land-use within the buffer examined. Non-native woodland within the buffer was measured for the potential conversion to native woodland. Open habitats were measured for the potential expansion of native woodland. Planted Ancient Woodland Sites (PAWS) account for 1355 ha (0.3% of the land area), and these were measured for potential restoration. The analysis provides a method which could be employed in other parts of Scotland to generate a GIS layer showing the extent of native woodland expansion within SFGS rules.

6. The ESC-GIS model was used to assess the potential native woodland HAP types, although these figures are indicative only. The ESC-GIS analysis made use of the Scottish National Digital Soil Sub-Group data at a scale of 1:250,000, however these data are not sufficiently detailed for site planning purposes. A site based survey should always be carried out to ensure the tree species for the planned woodland are suited to site conditions. The study indicated that the SFGS rules if taken up as schemes on the ground could deliver a significant amount of the wet woodland HAP target, the upland oak woodland HAP target and the Juniper SAP target in the Scottish Borders.

7. A Forest Research prototype landscape ecology model 'BEETLE' was used to assess the spatial position and extent of functional habitat networks, based on broad habitat types. Networks were defined, for woodland species and open species, as contiguous areas containing functionally connected habitat patches in a matrix. A network is defined as a landscape structure through which focal species can disperse freely between numerous habitat patches.

8. The effect of woodland expansion on habitat network size and position was assessed. In the Scottish Border catchments the woodland species model tested landscape suitability for squirrel. For example, this modelling approach allows planners to judge where broadleaved woodland habitat networks, well suited to grey squirrels, may fragment red squirrel reserves in coniferous woodland core areas. The model was also used to assess the effect of native woodland expansion on open habit networks, for example the large heath butterfly. The habitat suitability of other rare species important in the Borders such as black grouse could be tested by the model.

9. Native woodland habitat network development in the Scottish Borders should take care to maintain barriers to grey squirrel incursions around red squirrel reserves.

10. Forest Habitat Networks in the Scottish Borders will be concentrated mainly in the arterial valleys close to existing native woodland often riparian in character. To a lesser extent there could be expansion in steep sided upland valley, adjacent to cleuch woodland remnants.

11. The effect of the native woodland expansion policy has the potential to complement and soften rigid, hard-edged woodland blocks within several landscape character types, and improve the aesthetic appeal of many Scottish Border landscape types.

1. Objectives

1.1. Within the area of the Scottish Borders, develop a practical method to identify key areas for the restoration and expansion of native woodlands that link framework woodlands (both native and non-native on ancient woodland sites). The method should concur with the concept of developing forest habitat networks, and should be assessed for their contribution towards native woodland habitat action plan targets and/or objectives.

1.2. Develop a methodology to assess the contribution of habitat networks for conserving species within the landscape mosaic.

1.3. Examine the effect of native woodland expansion on the landscape character of selected catchments.

2. Background

2.1. The Scottish Forestry Strategy encourages the development of Forest Habitat Networks. The new Scottish Forestry Grant Scheme (SFGS) has been designed to target native woodland expansion and restoration where it will deliver environmental benefits to forest biodiversity. The SFGS will provide financial support for work that restores native woodland on ancient woodland sites, consistent with the recommendations in "Restoration of Native Woodlands on Ancient Woodland Sites" (Thompson *et al,* 2003) and to expand the area of native woodlands. In the case of the latter, the eligibility criteria within the SFGS Applicants Booklet include:

- To contribute to Forest Habitat Networks, there must normally be either existing native woodland within 300 metres of the proposed new woodland or areas of non-native forest within 300 metres of the proposed new woodland which meet the criteria for conversion to native woodland
- To contribute towards native woodland Habitat Action Plan expansion targets and/or objectives
- To be based on an assessment of the site potential

2.2. The concept of a Forest Habitat Network should

- Retain ancient woods and improve their condition
- Create large woods and well wooded districts
- Locate new woodland next to existing woodland to minimise isolation
- Improve 'matrix' quality (i.e. non woodland) by restoring scrub and other semi-natural habitat.

2.3. Peterken (2000) listed a number of approaches to network development that have been advocated including:

- Spatially uncontrolled: i.e. broadly how woodland has accumulated until now. In practice activities such as game management and fox hunting, natural features such as cliffs, soil quality and socio-economic factors have also influenced patterns of woodland distribution.
- Historical: involves the reversal of fragmentation by reforesting sites of known former woodland.

- Designed: pattern of new [and restored] woodland is designed to meet forestry biodiversity targets and the requirements of forest dependant species.

2.4. Forest Habitat Networks exist at a range of scales and are comprised of 'nodes' and 'links' (Peterken *et al*, 1995, Peterken, 2000). At the regional and national scales the nodes have been termed 'Core Forest Areas' (CFA) and should be linked by well-wooded belts of countryside. At the local level individual woods or clusters of woods represent nodes. The approach is similar to the concept of 'greenways' (Smith and Hellmund, 1993). Evidence suggests several key management principles which should guide the development of FHNs:

- Keep existing woods, particularly ancient woods, but also mature and structured secondary forests, as they are generally richer than young, even aged, single species secondary woods and contain a higher proportion of rare and slow colonising species. This is of particular importance in the Scottish Borders with a particularly low native and semi-natural woodland cover. Well managed and structured secondary forests of exotic species can have high woodland biodiversity value. Humphrey *et al* (2002) has reported the occurrence of over 600 species (12 red data book) in upland Sitka spruce forest compared with 500 species (4 red data book) in upland oak forest.

- Develop existing regional CFAs of woodland until the local land area is 30% wooded. Peterken (2000) proposed a case for recognising a 30% threshold, because theoretical woodland expansion placed in random blocks provides a minimal degree of isolation of new patches at this threshold (Forman, 1995). There is support for this critical threshold in ecological observations. Buckley and Fraser (1998) reported a reduction in the number of woodland patches in the landscape above 30% cover. In addition they showed the perimeter/area ratio of randomly located woodland is at a maximum at 30%. Also in practice well wooded districts, for example the Lower Wye Valley, Maentrog Valley, Speyside and Deeside; in which secondary woods contain many of the species found in the ancient woods of the district (Peterken, 2000).

- The shape of individual woods is debatable but 'the bigger the better' applies to size. Woods less than 4ha tend to have very few county registered vascular plant species (Kevin Watts pers. comm.). Increasing the area above the 4ha threshold produces a linear increase in the notable species. Woods over 20 ha are generally too large to ignore and are likely to contain rides and open space. The ecological significance of shape is uncertain, except that circular shapes offer a greater core area to total area ratio. However shape is likely to be determined by historic or landscape factors.

- Hawkins and Selman (2002) argued that site protection (conservation) strategies have failed to reverse fragmentation and the loss of species diversity from the wider countryside. In a landscape study within Nottinghamshire, experts compared the management recommendations from 3 planning approaches for maintaining and enhancing biodiversity. The greenways approach (Smith and Hellmund, 1993) provided a reasonable strategic model. However conflicts between nature conservation and other 'green usage' cannot be resolved by this approach. Hawkins and Selman

recommend the use of a focal species landscape assessment approach to plan woodland management within the landscape mosaic.

- Focal species models show how the distance between woodland is quite sensitive to the surrounding matrix, and varies from species to species. For woodland species with low dispersal ability the distance will be very small. In addition, plans must consider the effect on species that utilise open habitats. It is just as important to avoid fragmenting open habits of high ecological value.

- It has been suggested that FHNs should consist of well wooded riparian corridors and large-scale links between woodland areas. The best links are likely to be riparian, as the drainage network is the natural choice for the movement of many mobile species at the landscape scale.

- Locate new woodland beside existing semi-natural habitat wherever possible. This principle extends not only to existing semi-natural woodland, but to existing semi-natural open habitats too. Low management open-habitat communities exhibit higher biodiversity than intensively managed systems. Consequently, there is likely to be a greater biodiversity benefit to forest edge species in managing a woodland edge adjacent semi-natural open habitat edge.

- Management Plans – develop management plans for Core Woodland Areas and large blocks of individual woodland. Management Plans ensure a long-term view for the resource and can ensure a variety of woodland stages, such as: thinning, natural regeneration, felling and restocking programmes.

2.5. Hampson & Peterken (1998) recognised that the implementation of FHNs in Scotland would occur only through a national programme to develop and publicise the concept. This has happened e.g. Scottish Forestry Strategy (Anon, 2000), Scottish Forestry Grant Scheme (2003), and is being followed up by local studies to apply guiding principles tailored to local biophysical conditions and existing woodland cover (Peterken *et al*, 1995): Cairngorms (Towers *et al*, 1999) Loch Lomond (Anon, 2002), Clyde Valley (Peterken, 2002), Highland Perthshire (Worrell *et al*, 2003). The work reported here is an attempt to describe the native woodland habitat network potential in the Scottish Borders, and apply an objective planning model approach in more detail at a 'local' level, i.e. the catchment scale.

3. Method

3.1. Rules on the location of FHN boundaries have been discussed and agreed in consultation with the Borders woodland HAP Working Group. Current guidance in the SFGS encourages woodland expansion, conversion and restoration within 300m of native woodland, or within 300 m of plantations on ancient woodland sites (PAWS).

3.2. The high native component classes of woodlands identified in the Scottish Semi-Natural Woodland Inventory. Although there is a general nervousness about putting lines on maps and paying higher levels of grant to develop within designated areas, we feel that this is unavoidable in making the best use of scarce resources. There is a precedent for such an approach i.e. the Challenge Funds and particularly the JIGSAW challenge fund in England.

3.3. This report records the work of a pilot project to develop the criteria, methods and rules on which to base the targeting of FHN development based on a study of three hydrological catchments within the Scottish Borders Council (SBC) area. The project makes use of the GIS tools that have been developed in Scotland such as Ecological Site Classification (ESC) (Pyatt *et* al, 2001; Ray, 2001) and Native Woodland Model (NWM) (Towers *et* al, 2000) and a range of GIS data.

3.4. The SAWI data was used to define areas of ancient and semi-natural woodland and the recent plantations on ancient woodland sites (PAWS).

- three classes describe the antiquity of woodland sites: Ancient (of semi-natural origin), Long-established (of plantation origin), Other (on Roy map)
- two classes describe the semi-naturalness of the woodland: SN, Other
- polygon resolution is 2ha.

We amalgamated all of the ancient and semi-natural categories as woodlands with potentially high biodiversity value, by nature of their antiquity and/or existing semi-natural origin. The date of qualification of antiquity (i.e. on Roy maps C.1750 or the first edition OS maps C.1860) was not specified for this analysis.

3.5. PAWS sites were separated as a special case, and were found by intersecting woodlands with a semi-natural description of 'Other' and an Antiquity description of 'Ancient'. This was necessary to establish the potential area for PAWS restoration in the Scottish Borders.

3.6. Badenoch reported that the ancient semi-natural woodlands of Tweeddale covered 0.06% of the land area, "..a figure which compares closely to that of Caithness, surely the bleakest place in Scotland..." (Badenoch 1994). Consequently, in addition to SAWI, the two woodland categories representing ancient semi-natural and high native component semi-natural woodland classified in the Scottish Semi-Natural Woodland Inventory (SSNWI) were added to the native woodland resource for the Borders. The reasoning was that SSNWI includes semi-natural woodland with low canopy cover (not included in SAWI), and these woodlands could have a high biodiversity value, and should therefore be included in the analysis. This is

particularly important for the Scottish Borders, where ancient semi-natural and high native component woodlands are so under-represented.

3.7. Information from four other GIS data sets were used in the analysis. We wished to separate potential woodland conversion from woodland expansion. This required a spatially explicit knowledge of the existing secondary woodland from the Interpreted Forest Type (IFT) data in the National Inventory of Woodlands and Trees (NIWT) (Anon, 1999b). In addition, for the focal species analysis it was necessary to specify the spatial arrangement of broad open-habitats in the landscape matrix. The information was provided directly by the Land Cover Map 2000 (LCM) provided under licence ' Copyright NERC acknowledgements LCM2000 CEH Monks Wood'. Potential native woodland expansion and conversion was estimated from an ESC-GIS analysis which used soil quality estimated from the Scottish National Soil Sub-Groups supplied by MLURI under licence Number MSSG/2002/022 ©The Macaulay Institute 2002. All rights reserved. Finally, the Ordnance Survey 10m and 50m digital elevation models were used Ordnance Survey Licence Number is GD272388.

3.8. Ecological Site Classification (ESC) (Pyatt *et al*, 2001) was used to provide some of the woodland constraints. Land with a DAMS score (Quine and White, 1993 & 1994) greater than or equal to 20 or with a Accumulated Temperature (warmth index) of less than or equal to 575 day.degrees were both assessed as unsuitable for woodland expansion.

3.9. The constraints theme included: DAMS >= 20, AT <= 575 degree.days, inland water, urban areas, littoral habitat, SSSIs, NNRs, SACS, SAMS, wetland and blanket bog peatland.

3.10. Land qualifying for a 90% native woodland expansion grant under the SFGS, will be located within 300m of existing native woodland (ENW), or meet the criteria for restoration to native woodland as a quality PAWS site. In this study we have made an assumption that the main sites qualifying for expansion will be located up to 300 m from the ancient and semi-natural woodlands described in 3.4, 3.5 and 3.6 and for this study assumed to be the ENW of the Scottish Borders. There may be areas of new native woodland (NNW), and areas of woodland currently being established through natural regeneration, that might qualify. Recent areas of NNW are not included in SSNWI or SAWI and would have to be added to the NIWT to be included in the analysis. For the three catchment case studies, we have set the buffer distance to be 500 m from existing woodland.

4. Analysis

4.1. The first stage of the study involved a GIS analysis to give a broad prediction of the effect of the new SFGS policy on woodland expansion in the Scottish Borders (see Figure 4.1a). Since we have no knowledge of where land will become available for native woodland, except that it is likely that many scheme proposals will qualify for the 90% grant aid, we buffered the ENW to 300m across the Scottish Borders. Buffer that intersected existing NIWT woodland was assumed to qualify as woodland for conversion to native woodland. Buffer that intersected open habitat was assumed to qualify as land for native woodland expansion. PAWS areas were identified as qualifying for restoration to native woodland. Wherever the buffer intersected the constraints theme (see 3.8 and Figure 4.1b), that portion of the buffer was removed from the analysis. An ESC analysis of the buffer provided a strategic prediction of the NVC woodland type suitable for restoration, conversion and expansion.

4.1.1. Changes in habitat suitability resulting from woodland expansion on two key generic species associated with the Scottish Borders are assessed in section 5. One analysis representing medium dispersal, medium area requirement core woodland species, the other a medium dispersal unimproved grassland and heathland species requiring small to medium patch sizes. These analyses give an idea of the generic-species based approach of landscape ecological assessment that is possible on the GIS. The model assesses landscape scale ecological processes rather than the landscape metrics which have been used as a surrogate for ecological processes. Our new approach is discussed in relation to landscape metrics.

4.1.2. The effect of woodland expansion on landscape character in the context of published (positive and negative) attributes of the landscape, as well as the key landscape issues of the main character types are assessed in section 6. In addition, internal intervisibility in relation to the landscape character types was assessed using viewshed analysis from selected strategic viewpoints.

Figure 4.1a - Schema of the GIS analysis procedure

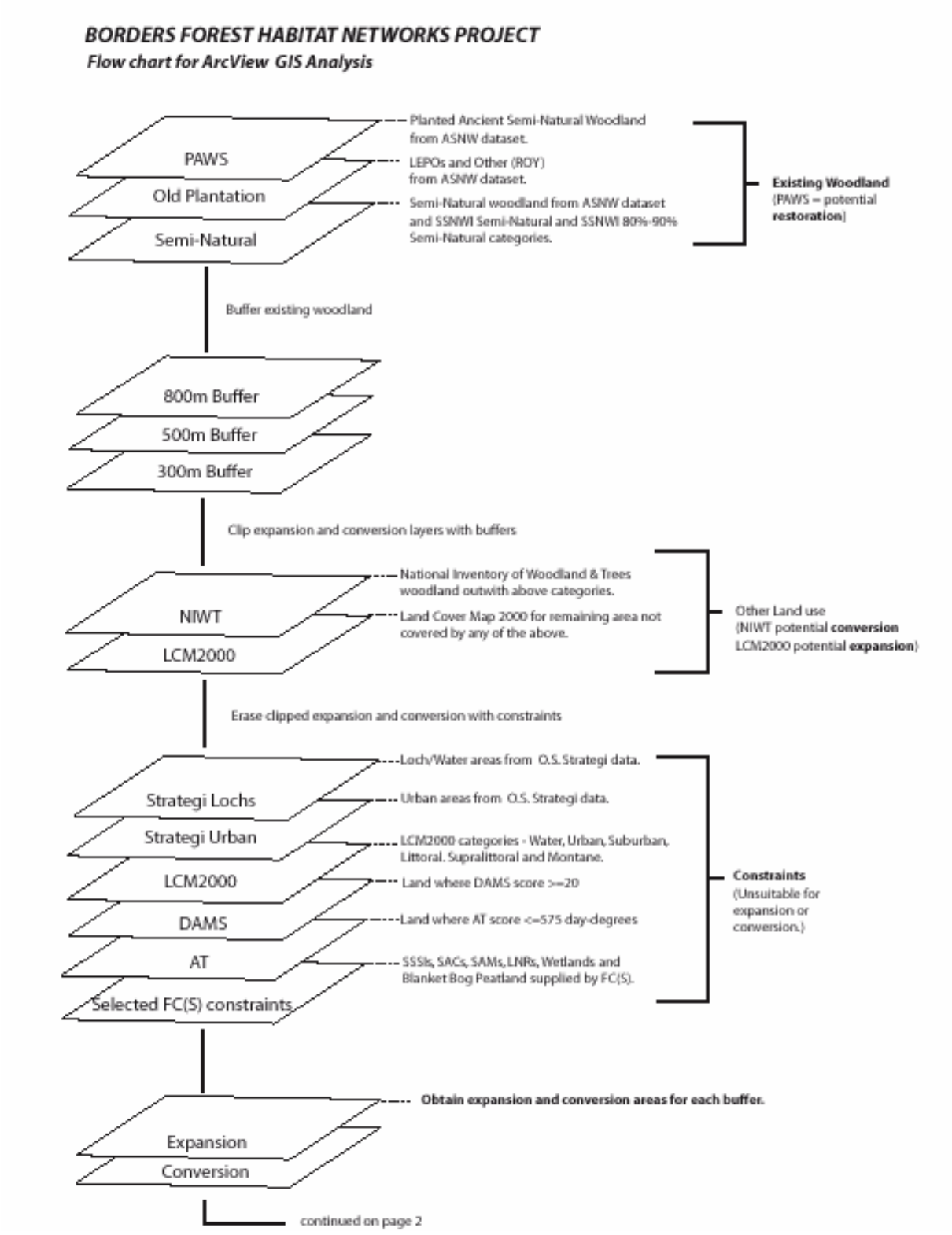
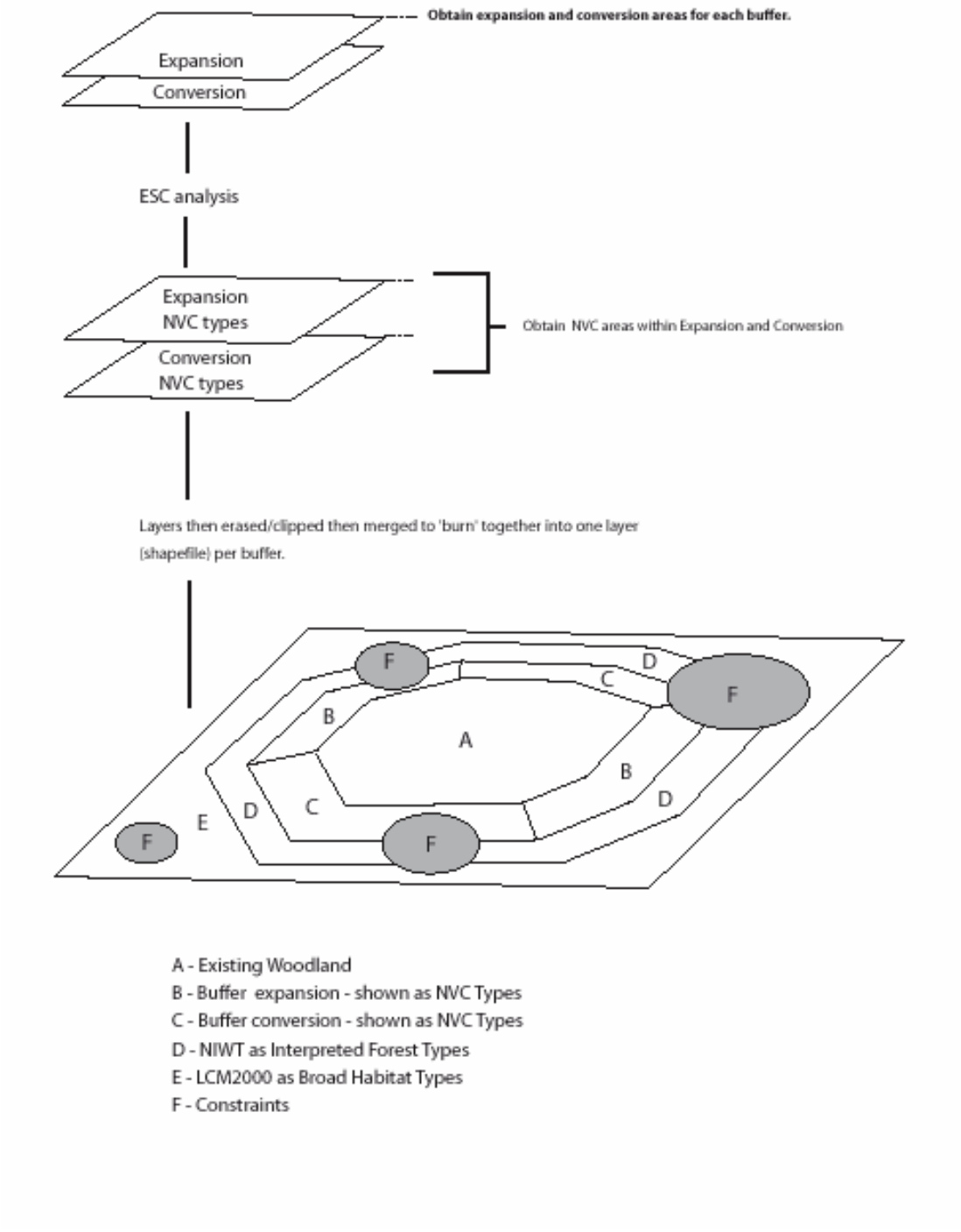


Figure 4.1b - Schema of the GIS analysis procedure



4.2. In the second stage of the study we investigated the effect of woodland expansion from both an ecological and a visual perspective at the catchment scale, performing analyses on three tributary catchments of the Tweed..

5. Strategic model for increasing native woodland in the Scottish Borders

5.1. The native woodland framework does not include recent new native woodland or native species in secondary plantations, and covers only 1.4% of the Scottish Borders land area (Table 5.1). Plantation woodland (conifer, broadleaved and mixed) covers 87500 ha (19.5% of the land area), but the largest land use is in the farming sector, accounting for almost 70% (open habitats - Table 5.1) of the land cover. Much of the constraints area is unsuitable for trees (high exposed mountains and moorlands) and will form open habitats. However the constraints areas include SSSIs and NNRs. In practice such areas may not exclude native woodland expansion, but for the purpose of this study the areas have been removed. The total area comprising open habitats in the Scottish Borders is therefore probably close to 80% of the land area.

Table 5.1 Current landcover in the Scottish Borders.

Scottish Borders Land Cover Type	Area (ha)	Approx area (%)
Total Land Area	474263	100
Open Habitats	315114	66
SSNWI plantation woodland (including PAWS)	87511	18.1
Native woodland framework (including PAWS)	6792	1.4
PAWS	1355	0.3
Constraints (see definition in 3.8)	71040	14.8

5.2. Figure 5.1 shows the application of a 300m buffer surrounding ENW and which is designated as expansion onto open land or conversion of existing NIWT woodland. The distribution of the buffered woodlands shows the potential for the development of a largely riparian Forest Habitat Network. In addition, there are a scattering of cleuch woodlands in high and steep sided valleys that would benefit from expansion and possible linkage where the existing woodlands have potentially high biodiversity value.

5.3. The potential for increasing native woodland is actually greater than the factor of 10 increase implied by the statistics of Table 5.2. A proposal may qualify for 90% SFGS grant if any part of the scheme came within 300 m of ENW. Since we cannot predict where, what shape, and how big proposed schemes might be, we have simply assessed the contribution that could be made by restoring, converting and expanding within the 300 m buffer.

5.4. Table 5.3 shows the area of native woodland by NVC type (and approximate woodland HAP type) predicted to be suitable within the 300m buffer. Figures are based on an ESC analysis, using ESC climate indices calculated at a resolution of 50m, and soil quality factors estimated from the Scottish National Soil Digital Map soil subgroups (copyright held by the Macaulay Institute). Note that the resolution of

soil mapping restricts the detailed prediction of woodland type at an operational scale. A site assessment method such as ESC (Pyatt et al, 2001; Ray, 2001) must be used to check all predictions.

5.5. Perhaps the most important contribution would be to restore native woodland on PAWS (planted ancient woodland sites). Guidance is available in Thompson *et al* (in press). The importance attached to restoration comes from the higher likelihood of plants, bryophytes and invertebrates associated with ancient woodland remaining on the site. With sensitive management and gradual restoration, woodland species can be maintained as the woodland is restored from a plantation back to a semi-natural community.

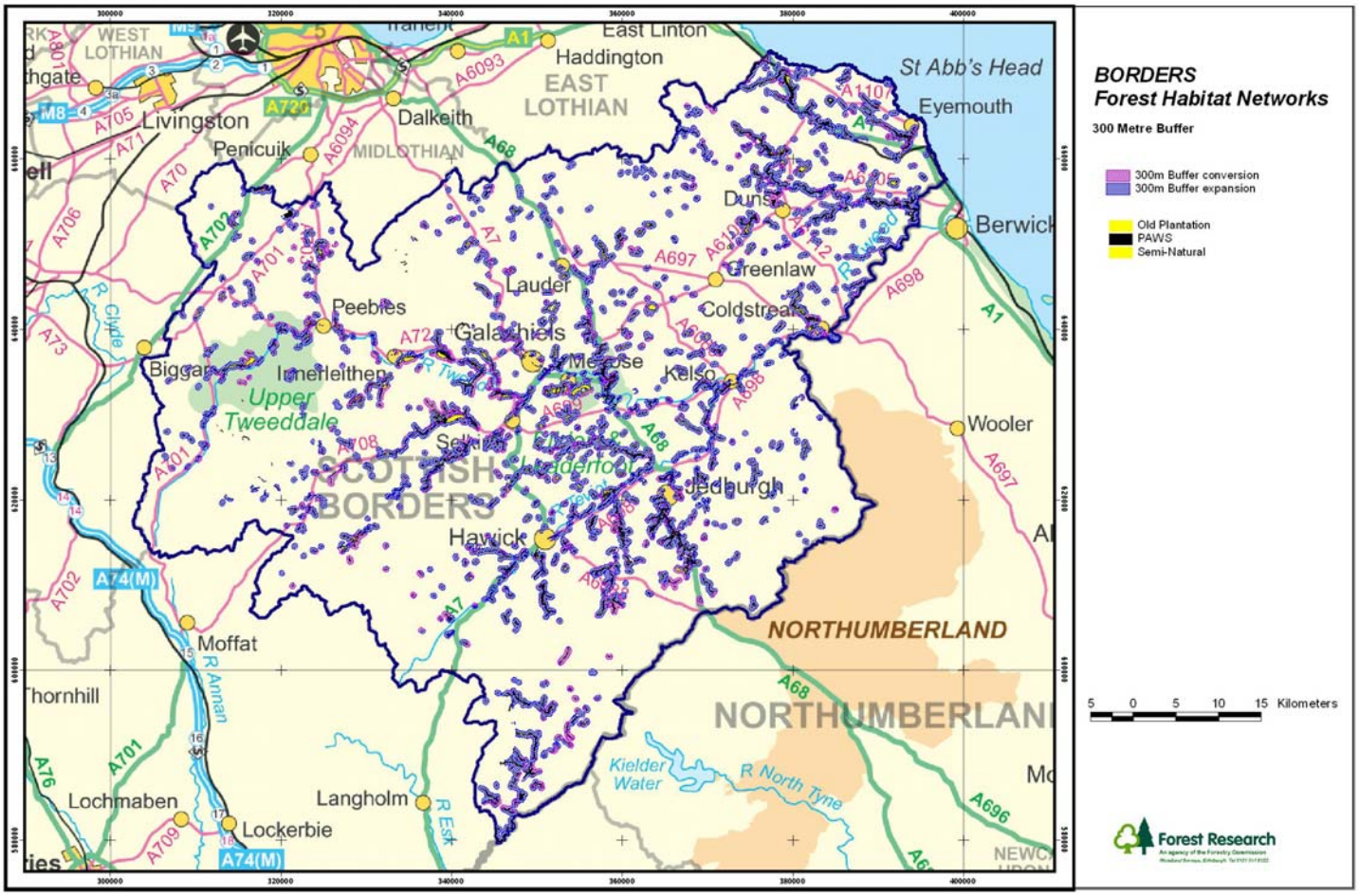


Figure 5.1 The effect of applying a 300m buffer around woodlands of semi-natural origin, old plantation origin, plantations on ancient woodland sites, and semi-natural woodland with a high native species component.

Table 5.2 The potential for restoration, conversion and expansion of native woodland within 300 m buffers of existing native woodland (ENW) with constraint area removed.

Scottish Borders Woodland Potential	Area (ha)	Area as a percentage of existing native woodland (ENW)
PAWS - **Restoration**	1302	20.6
Buffered NIWT - **Conversion**	7321	107.8
Buffered Open habitat - **Expansion**	59603	877.5
Total	68226	1004.5

Table 5.3 Native woodland type within 300 m buffers of existing native woodland (ENW) with constraint area removed, and with arable land removed from the analysis.

NVC type	Woodland HAP/SAP	Expansion (ha)	Conversion (ha)
W1	Wet woodland	10	0
W3		2947	424
W4		7869	1452
W7		2534	272
W11	Upland oak	20982	3494
W17	Upland birch	3785	782
W19	Juniper	546	167
		38673	6591

5.6. Predictions of the NVC woodland communities within a 500m buffer are shown in Figures 5.2-5.4 for three tributary catchments of the River Tweed in the Scottish Borders. The predicted NVC and woodland HAP types within 500 m from ENW are shown in Table 5.4a-b and c for the Ettrick, Yarrow and Jed catchments respectively.

5.7. The main question to be addressed is the extent to which the SFGS will facilitate the development of Forest Habitat Networks (FHN). Figure 5.1 shows that many of the Tweed tributaries could support clusters of buffered ENW remnants within the riparian corridors. However, the extent of the ENW in any locality of the Scottish Borders does not currently constitute native woodland FHN. Parts of the Upper Ettrick valley support a sizeable remnant wet woodland habitat that has been extended under sensitive management. Also, the lower Jed Water catchment and central Tweed support a sizeable amount of broadleaved woodland. The question of what constitutes a FHN and how the network can be defined and managed is considered in the next section.

Table 5.4a Ettrick catchment native woodland type within 300 m and 500 m buffers of existing native woodland (ENW) with constraint area removed, and with arable land removed from the analysis.

NVC type	Woodland HAP/SAP	300 m buffer		500 m buffer	
		Expansion (ha)	Conversion (ha)	Expansion (ha)	Conversion (ha)
W3	Wet woodland	3	0.5	8	0.5
W4		206	46	433	106
W7		228	85	280	108
W11	Upland oak	1365	167	2225	324
W17	Upland birch	202	146	566	331
W19	Juniper	57	20	132	41

Table 5.4b Yarrow catchment native woodland type within a 500 m buffer of existing native woodland (ENW) with constraint area removed, and with arable land removed from the analysis.

NVC type	Woodland HAP/SAP	500 m buffer	
		Expansion (ha)	Conversion (ha)
W3	Wet woodland	0	0.7
W4		281	24
W7		186	18
W11	Upland oak	2099	468
W17	Upland birch	1467	260
W19	Juniper	451	139

Table 5.4c Jed catchment native woodland type within a 500 m buffer of existing native woodland (ENW) with constraint area removed, and with arable land removed from the analysis.

NVC type	Woodland HAP/SAP	500 m buffer	
		Expansion (ha)	Conversion (ha)
W3	Wet woodland	0.2	0.6
W4		195	335
W7		45	1.6
W11	Upland oak	1661	470
W17	Upland birch	20	2
W19	Juniper	0	0

6. Identifying and managing the development of Forest Habitat Networks in the Scottish Borders

6.1. Peterken *et al* (1995) visualise a Forest Habitat Network as a landscape structure containing 'core forest areas' connected by woodland 'corridors'. The FHN structure was to allow woodland species of low dispersal ability, or requiring woodland habitat for dispersal, to expand into adjacent (woodland) habitat patches. It is assumed that the extension of habitat will help reverse native woodland habitat fragmentation, and it is hoped that the new patches will link sub-populations. This will help maintain and enhance genetic contact within the meta-population of the species and in turn will provide greater species resilience in times of external stress, such as climate change.

6.2. The FHN concept draws on landscape metrics to describe the shape, size and spatial arrangement of woodland habitat in a non-woodland matrix (e.g. Peterken *et al* 1995, Buckley and Fraser, 1998). The assumption being that the spatial pattern of habitats can be described and linked to the ecological processes operating spatially on the landscape. This leads to general principles interpreted as a simple rules for woodland patch design. The SFGS for example, suggests a distance of 300 m from ENW as suitable for maintaining dispersal of woodland species between patches. Generalisation means that some species will benefit from the policy while others will not.

6.3. The concept of the FHN is a good one in general terms for species conservation as described in the greenways model (Smith and Hellmund, 1993; Hawkins and Selman, 2002). However, it requires testing for species of conservation importance in a particular locality, and across specified types of patches of the landscape. The Biological and Environmental Evaluation Tool for Landscape Ecology (BEETLE) model has been prototyped by Forest Research within the Landscape Ecology Project (Watts, 2003). Instead of using metrics as surrogates for understanding the meaningful processes of species-landscape interactions, BEETLE tests the landscape pattern against specific 'focal' species profiles. This approach builds on the umbrella species concept, where the umbrella species encapsulates the requirements of the group of species requiring similar habitat, and interacting with landscape patches in a similar way (Lambeck, 1997). The approach has developed from island biogeography (MacArthur and Wilson, 1967) and meta-population theory and recent work by Vos *et al* (2001) on ecologically scaled landscape indices.

6.4. Three catchments: the Yarrow, Ettrick and Jed Water, have been analysed using the prototype BEETLE. The generic focal species chosen represent woodland species with medium dispersal ability and a high individual area requirement - e.g. red and grey squirrel, Table 6.2, and a generic open habitat (heathland & rough pasture) species of medium dispersal ability with a small individual area requirement - e.g. large heath (butterfly), Table 6.3. The focal species profiles describe the ease of movement across landscape patches and both focal species are moderately sensitive to habitat fragmentation - Table 6.1.

Table 6.1 Matrix of focal species sensitivity to habitat fragmentation

	Short Dispersal	Medium Dispersal	High Dispersal
Large Area Requirement	High fragmentation - high extinction - low colonisation		Low fragmentation - high extinction risk - good colonisation
Medium Area Requirement		Moderate extinction - fragmentation and colonisation	
Small Area Requirement	High fragmentation - Low extinction - low colonisation		Low fragmentation - low extinction - good colonisation

Table 6.2 Woodland (generic) focal species with medium dispersal - large area requirements - landscape patch suitability rules

Dispersal Cost	Broad habitat type patch requirements
0 = Habitat	broadleaved, mixed or coniferous woodland > 10 ha
1	broadleaved, mixed or coniferous woodland < 10 ha
20	bracken, dwarf heath
100 = Barrier	acid grassland, calcareous grassland, neutral grassland, improved grassland, arable, bare ground, bog, water

Table 6.3 Heathland - rough grassland (generic) focal species with medium dispersal - small area requirements - landscape patch suitability rules

Dispersal Cost	Broad habitat type patch requirements
0 = Habitat	bog, dwarf heath, acid grassland >3 ha
1	(bog, dwarf heath, acid grassland)<3 ha OR calcareous grassland, neutral grassland, improved grassland, arable, bare ground
20	broadleaved, mixed or coniferous woodland
100 = Barrier	urban, water

6.5. In this pilot study, the weighted cost distance buffer for the 2 focal species was calculated within the existing landscapes and used to amalgamate linked habitat patches using the dispersal cost distance range of both the woodland focal species, and the open habitat focal species. This was repeated for the buffered woodland expansion landscape for both 'woodland' and 'open' focal species. Figures 6.1 to 6.3 indicate the number and extent of linked or 'networked' habitat patches for each focal species. These landscape units (numbered in the key) can be defined as forest habitat networks as perceived by the woodland focal species (and open habitat networks by the open habitat focal species). It can be seen that the effect of the buffered expansion, conversion and restoration is to link and extend woodland habitat, but this reduces the number of woodland networks. Note that an individual network unit is not necessarily comprised of physically joined woodland blocks, but shows unified landscape patches that are either habitat (the woodland nodes) or are non-woodland patches that do not represent barriers to the dispersal of the focal species (dispersal corridors).

Figure 6.1a Woodland and open habitat networks identified in the current (2003) Ettrick valley landscape

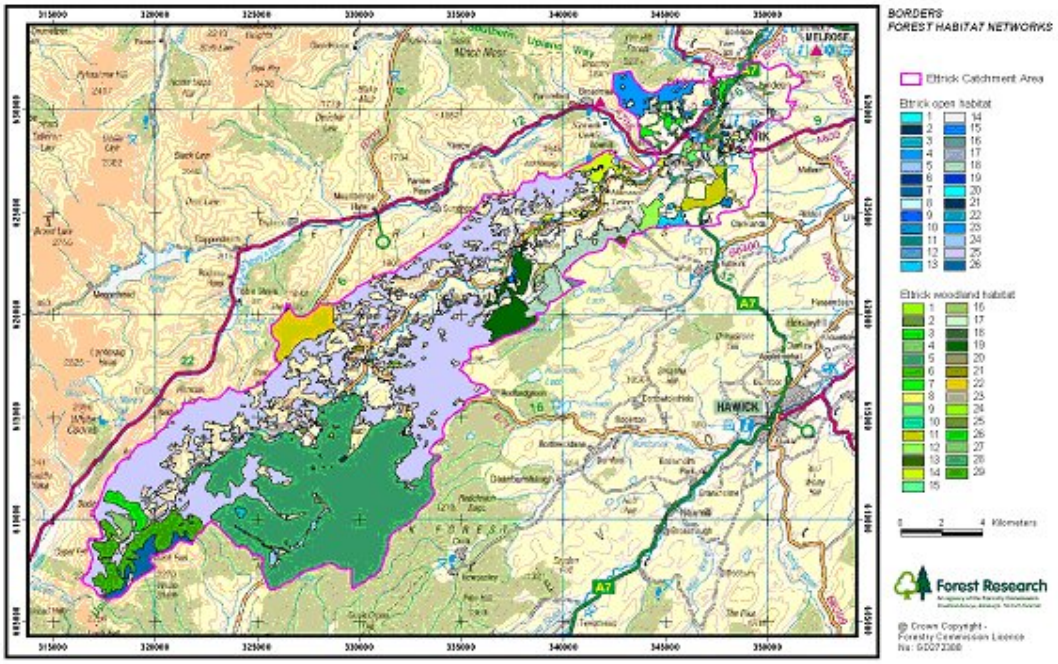


Figure 6.1b Woodland and open habitat networks after buffered expansion of existing native woodland by 500 m in the Ettrick Valley

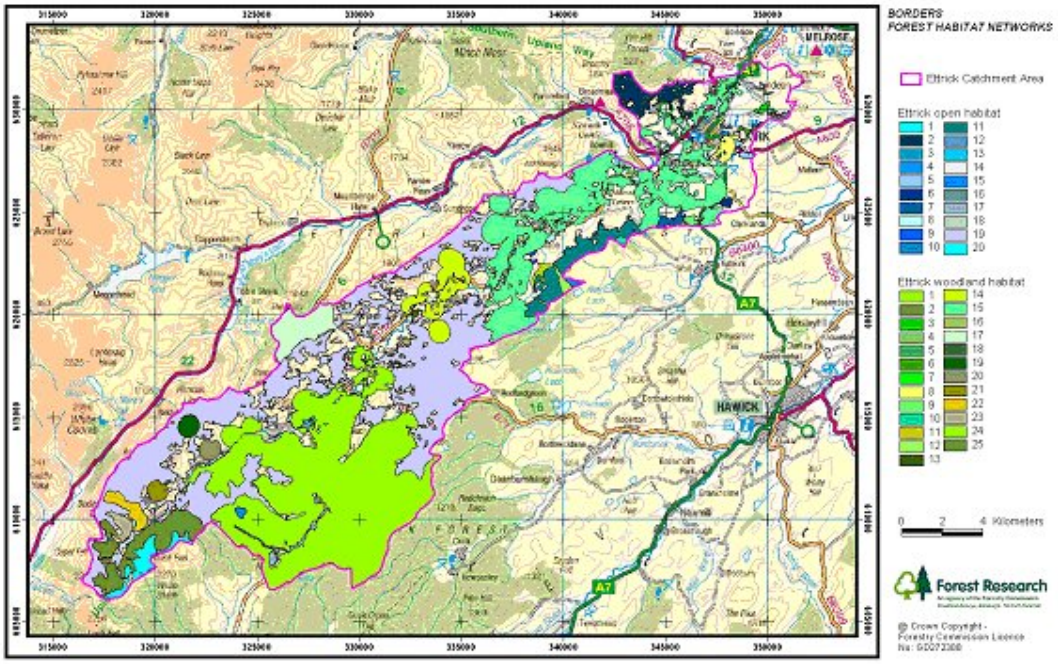


Figure 6.2a Yarrow habitat networks identified in the current (2003) landscape

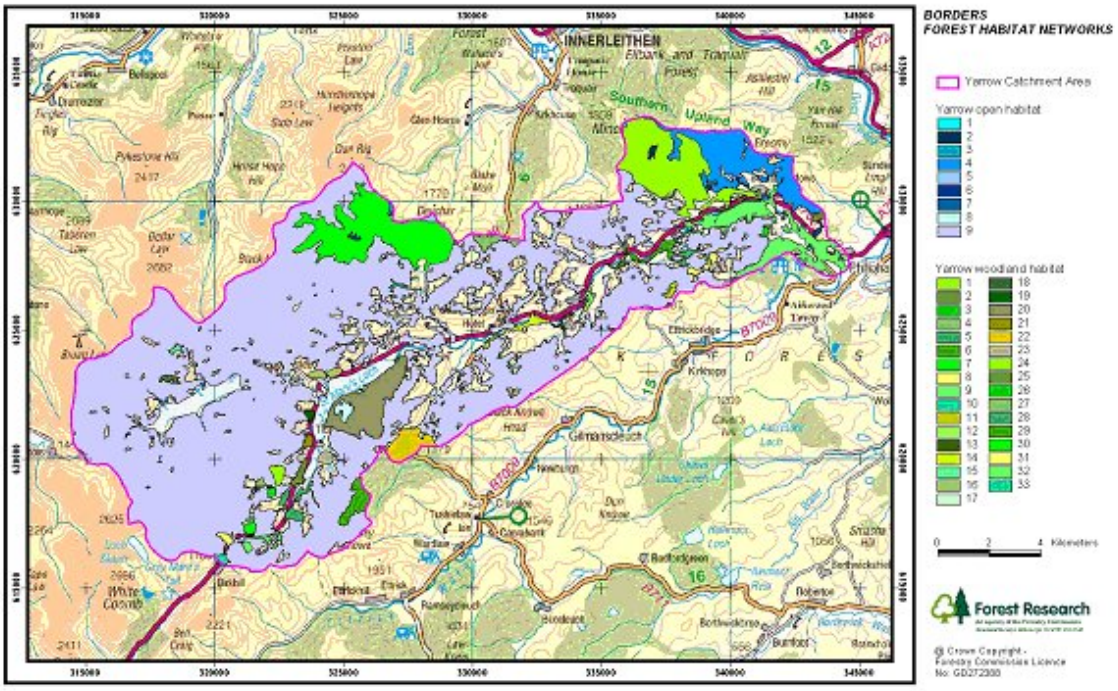


Figure 6.2b Yarrow habitat networks after buffered expansion of existing native woodland by 500 m

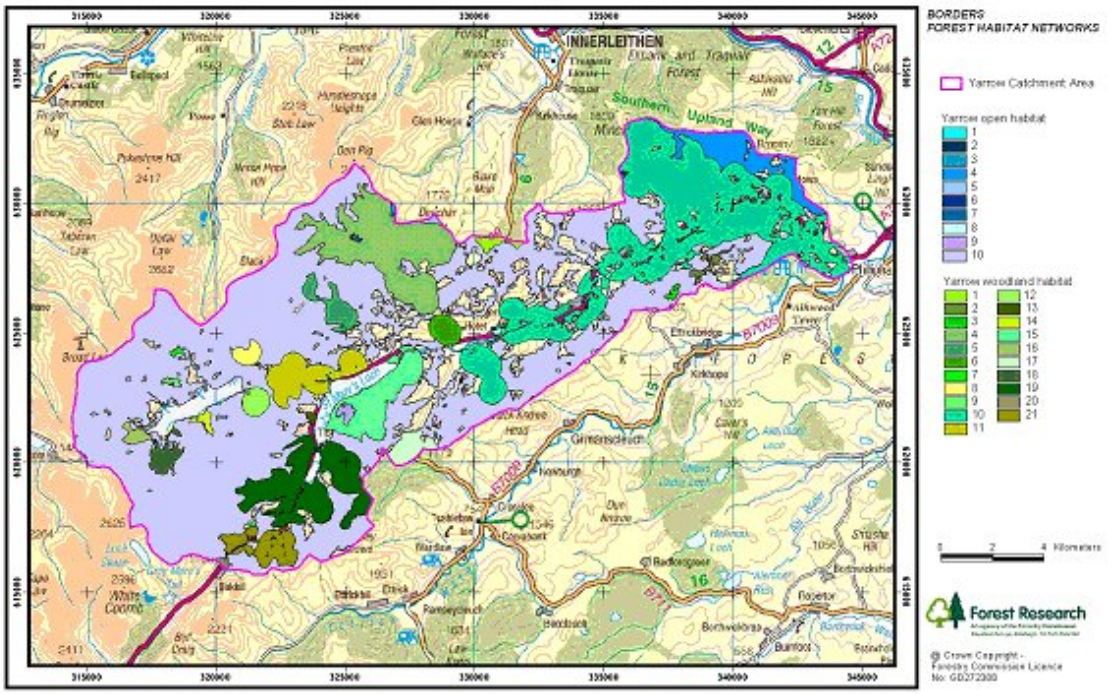


Figure 6.3a Jed habitat networks identified in the current (2003) landscape

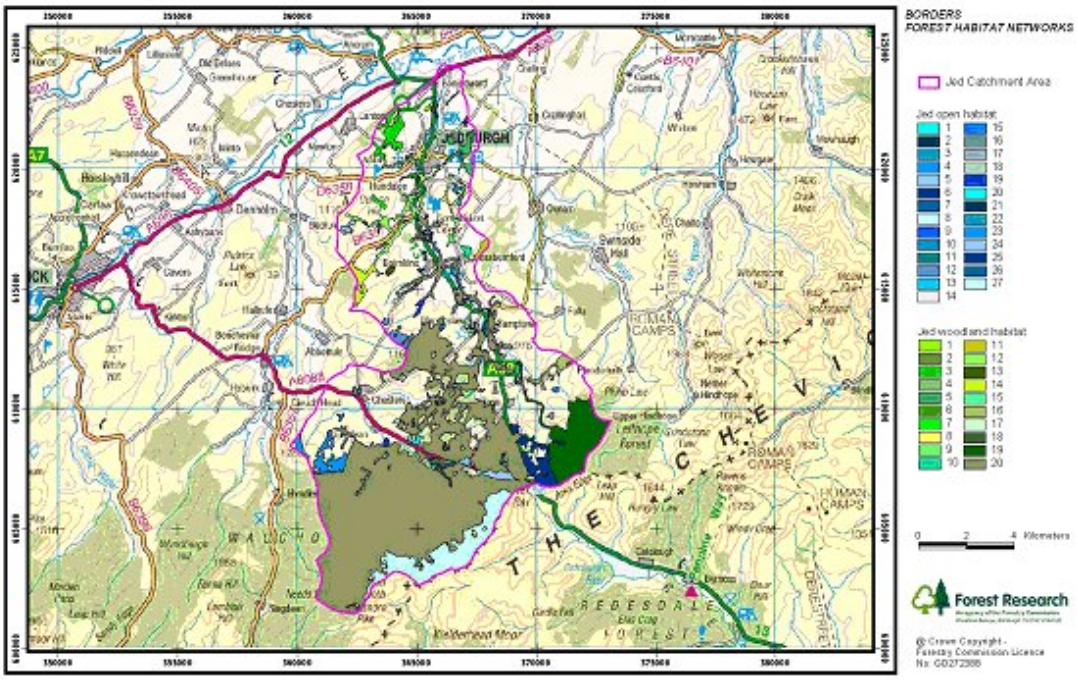
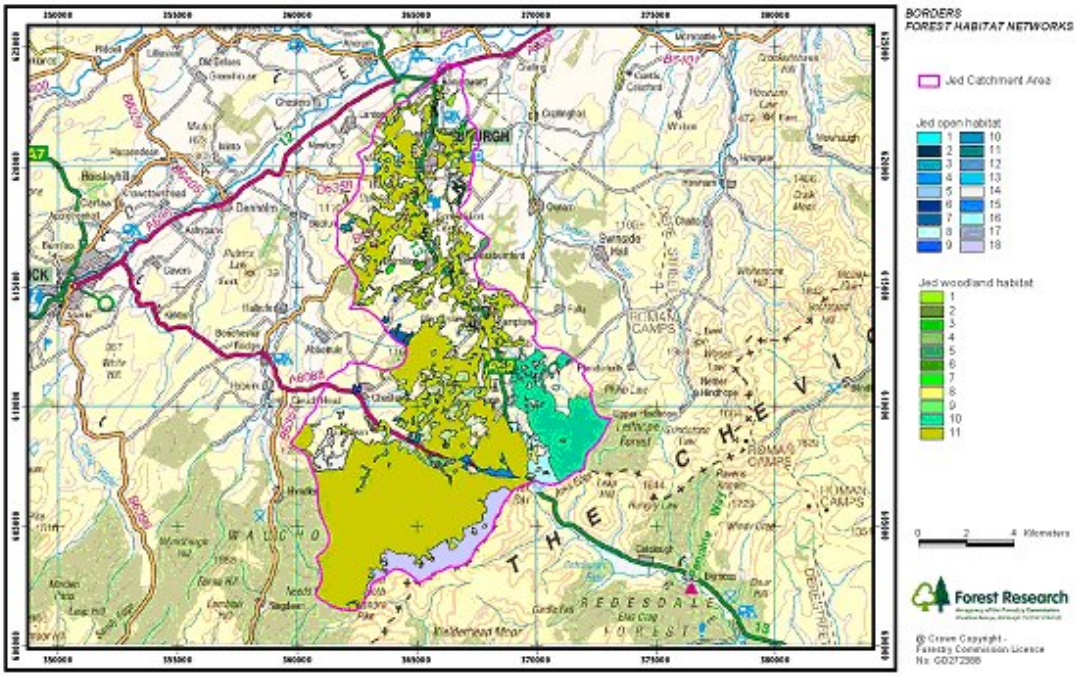


Figure 6.3b Jed habitat networks after buffered expansion of existing native woodland by 500 m



6.6. An example of the use of this modelling approach is the assessment of maintaining separation of Forest Habitat Networks suitable for red and grey squirrels. In the upper Ettrick catchment, Craik forest is a red squirrel core area separated from the broadleaved grey squirrel networks lower in the valley. The model can be used to check that broadleaved woodland expansion does not create a FHN that offers dispersal routes for grey squirrel into Craik forest.

6.7. The change in total habitat patch size for each focal species varies in each of the three catchments (Figures 6.1-6.3). The Ettrick and Yarrow currently have a relatively large number of smaller sized woodland patches, whereas the Jed contains a smaller number (20) of woodland patches, but of a larger average size (Table 6.4). The smaller core area, and larger perimeter to area ratio, of woodland patches (inferred from number and size in Table 6.4) in the Ettrick and Yarrow produces an increase in buffered area of about 50% (Figures 6.4 and 6.5), whereas in the larger compact (smaller perimeter to area ratio) woodland habitats of the Jed, buffering produces an increase of about 30% (Figure 6.6). Networks suitable for the open habitat focal species are significantly reduced in extent and number in the Ettrick and Yarrow. In the Jed catchment a number of small open habitat networks disappear with woodland expansion, but large networks on the southern border of the catchment are unaffected, and the overall loss in open habitat is less in the Jed than in the other two catchments.

Table 6.4 Network and habitat patch size statistics for the Ettrick, Jed and Yarrow catchments in the current landscape and after applying a 500m buffer.

		Ettrick		**Jed**		**Yarrow**	
		Existing	*Buffered*	*Existing*	*Buffered*	*Existing*	*Buffered*
Wood	*Network no*	31	25	20	11	33	21
	Patch no	31	29	28	17	39	23
	Mean patch size (ha)	290	506	301	706	109	380
Open	*Network no*	26	20	27	18	9	10
	Patch no	82	57	43	26	20	22
	Mean patch size (ha)	354	394	42	57	1643	1214

6.8. Figures 6.4-6.6 demonstrate big differences in habitat availability for the focal species tested. The Ettrick catchment, with Craik forest in the upper reaches, is evenly balanced in habitat for the two focal species, but 6 open habitat networks are lost by buffered expansion. The Yarrow contains considerably more habitat for the open focal species, and woodland expansion creates an additional open habitat network as a result of fragmentation. The Jed catchment contains more habitat for the woodland focal species than for the open habitat focal species, and buffered

expansion creates larger but fewer woodland habitat networks. One network links woodland habitat along the full length of the catchment.

Figure 6.4 The effect of native woodland expansion on the total habitat area for woodland and open-habitat focal species in the Ettrick catchment

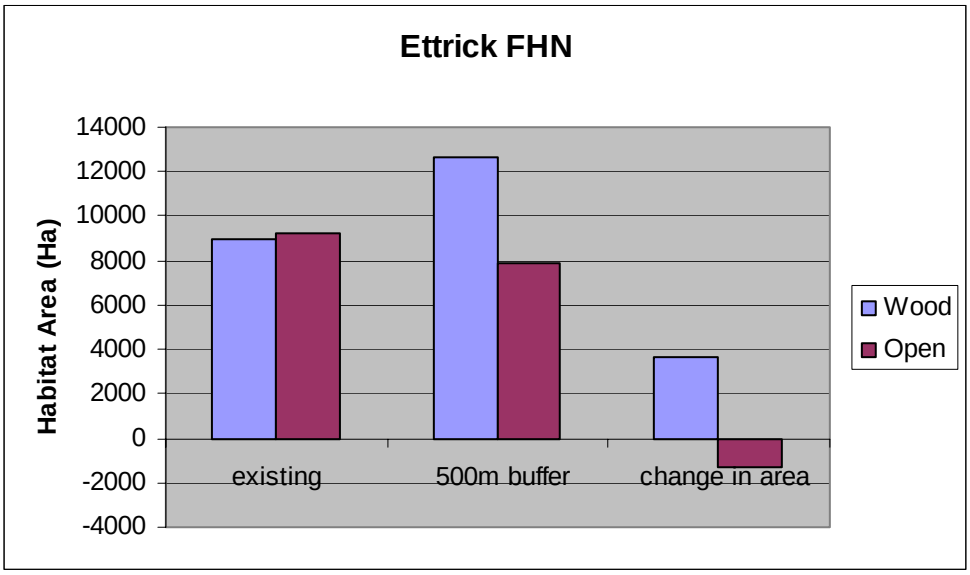


Figure 6.5 The effect of native woodland expansion on the total habitat area for woodland and open-habitat focal species in the Yarrow catchment

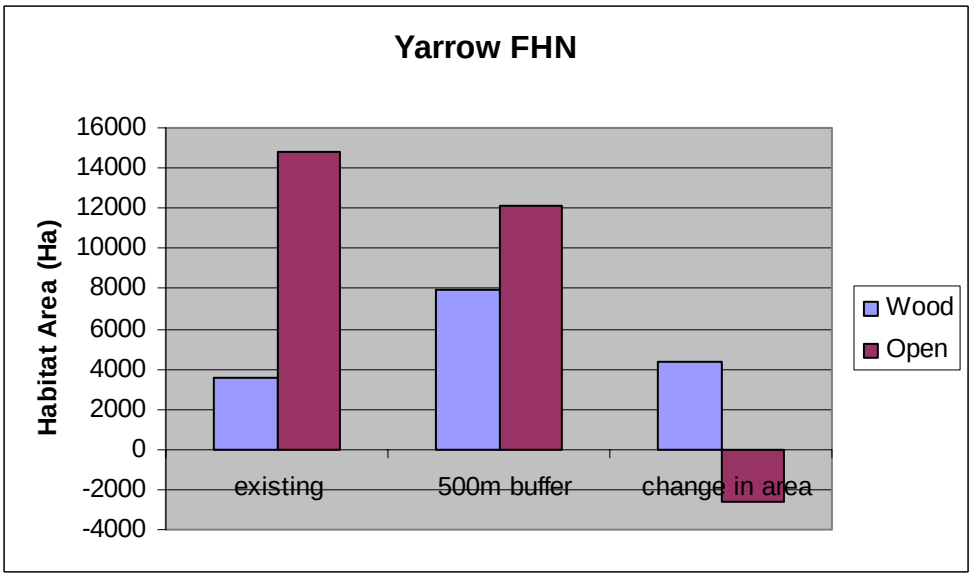
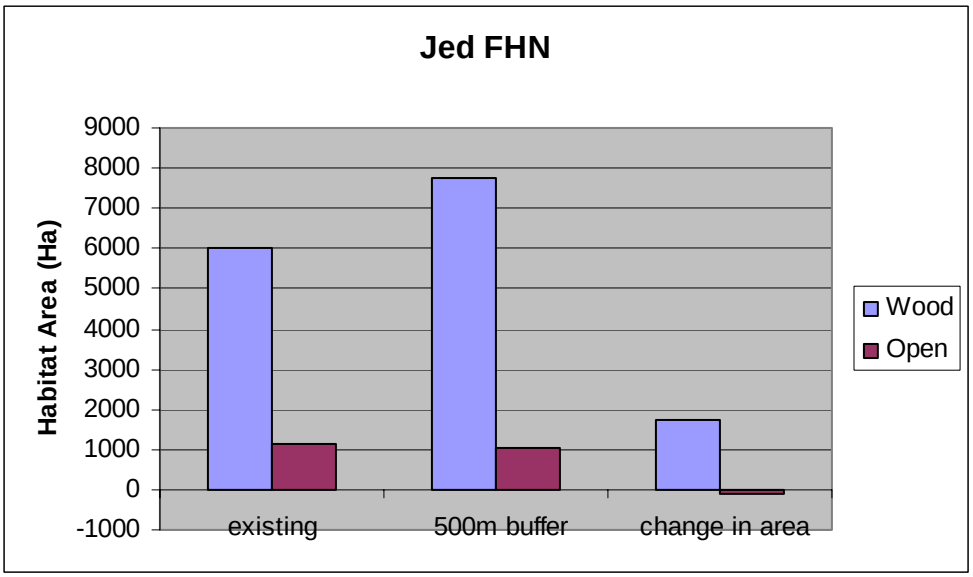


Figure 6.6 The effect of native woodland expansion on the total habitat area for woodland and open-habitat focal species in the Jed catchment



6.9. In each catchment, the increase in woodland habitat was not matched by a similar reduction in the open habitat. In all cases (but especially in the Jed catchment - Figure 6.6) a smaller reduction in the habitat of the open species occurred. This was due to woodland expansion over areas of open ground which do not form habitat for this generic open habitat focal species.

6.10. The size of functional habitat networks is also of major consideration. Referring to Figure 6.2a and Table 6.4, for the woodland focal species we see the Yarrow catchment contains 33 functionally connected habitat networks, decreasing to 21 networks with buffered woodland expansion. The change in the size distribution of networks resulting from buffered expansion can be seen in Figures 6.7 and 6.8. Expansion reduces the number of smaller networks under 100 ha from 28 -representing 21% of the total area, to 11 - representing only 5% of the area, but increases the large networks over 500 ha from 2 representing 49% of the area, to 4 networks greater than 500ha – representing 79 % of the area. Threshold areas of functional networks will need to be estimated for maintaining viable populations of taxa represented by the focal species.

Figure 6.7 Size contribution of functional woodland habitat networks in the Yarrow catchment

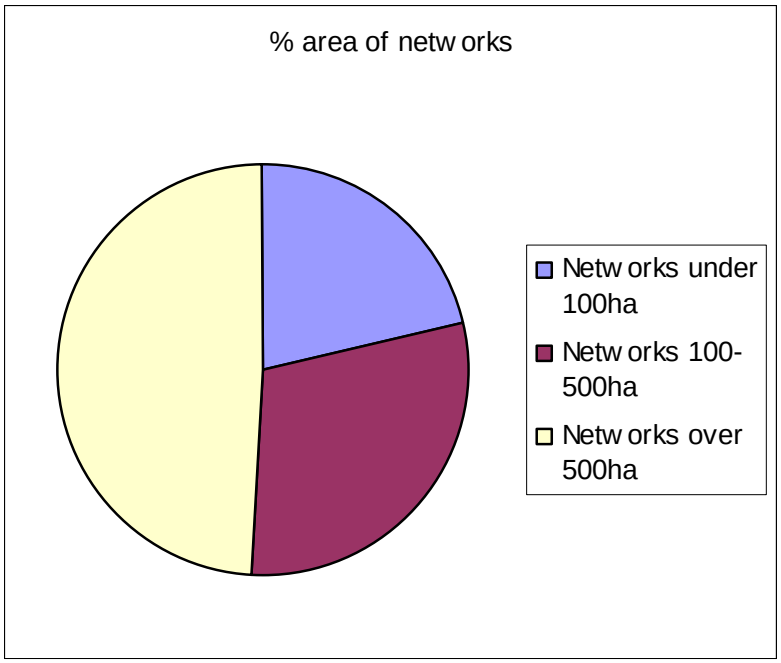
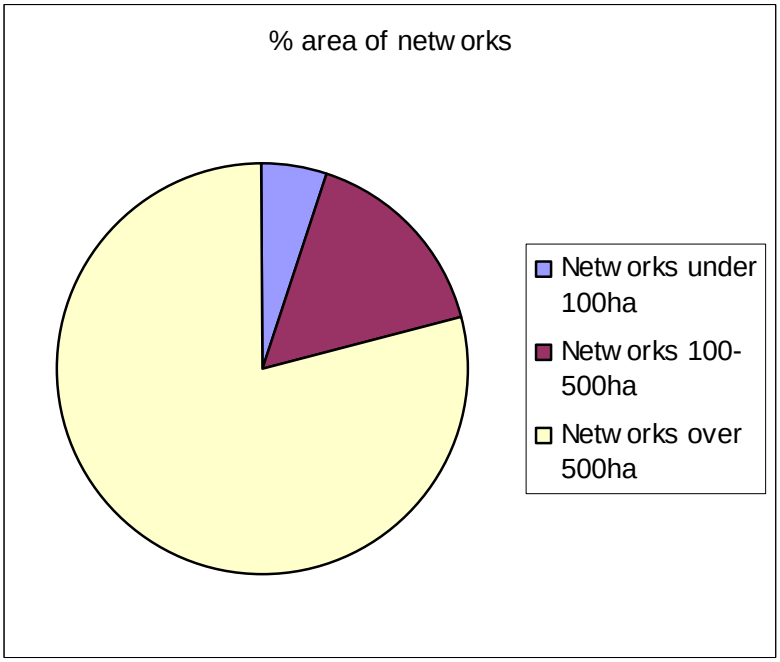


Figure 6.8 Size contribution of functional woodland habitat networks in the Yarrow catchment from 500m buffered expansion



7. The effect of Forest Habitat Network development on the Scottish Borders landscape.

7.1. The Scottish Borders includes a range of landscape types, including the montane environments of the Southern Uplands, foothill landscapes of the Moorfoot, Cheviot and Lammermuir Hills and the lowlands of the lower Tweed. It is within the context of the Southern Uplands, upland valleys with pastoral floor, upland valleys with woodland, the Cheviot foothills and the grasslands on rolling hill landscapes, described by ASH Consulting Group (Anon, 1998) that the study catchments of the Ettrick, Yarrow and upper Jed extend.

The upper Ettrick and Yarrow valleys cut deeply into the rolling, smooth montane landscape of the central Southern Uplands. The valley floor supports pasture, small coniferous woodland blocks, and in the Ettrick a substantial area of ENW (wet woodland). Steep glaciated valley sides support unimproved grazing, bracken, heather and conifer plantations. The valleys are enclosed by high rolling hills, typically with heather and acid grassland but also occasional extensive conifer forest.

At the margins of the foothills and the lowlands, the agriculture is mainly pastoral on improved and neutral grassland, giving way to arable farms in the Tweed lowlands. The ENW is still concentrated in river valleys, often as riparian woodland, and a 300 m buffer shows that many woodland blocks wood merge as riparian woodland corridors. The frequency of woodland patches on valley sides increases, but even when buffered many remain isolated. The lower part of the Ettrick and Jed catchments fall in to this foothills landscape.

Land use in the Tweed lowlands is largely agricultural with an arable core area surrounded by improved grassland, this is clearly seen in Figure 5.1. The lowlands are certainly depleted, but not entirely without ENW. The ENW patches occur close to the Eye Water, the Whitadder and the Tweed and its tributaries, and thus are predominantly riparian in character. The likelihood of native woodland expansion in the agricultural lowlands is probably lower on the more fertile arable farmland than on the rough hill farmland. However, if remnant ENW of the lowlands is good quality, with tree species native to the site, an internal woodland structure, or with a field and ground layer community indicative of the woodland type, then expansion would certainly help maintain some ecological diversity, locally.

7.2. Forest habitat network development will impact on the landscape character of the Borders Region. The Ettrick catchment is larger than the Yarrow and Jed catchments and extends across six landscape character types (Figure 7.1). The Yarrow is more self contained within the upland zone, and extends across three landscape character types (Figure 7.2). The Jed although rather small and compact, lies across the foothills/lowland divide with six landscape character types defined (Figure 7.3). The three catchments share 10 different landscape types (Table 7.1) which are ranked according to importance in each catchment. Four types, two from each catchment, have been assessed in this work. We have chosen the 2 landscape types which will be most affected by woodland expansion in each catchment (see Tables 7.2 - 7.5.)

Table 7.1 Range of Landscape Character Types in the Ettrick, Yarrow and Jed Water catchments, following the descriptions of the ASH Consulting Group (Anon, 1993) (** major landscape type * minor landscape type, + types discussed in this report)

Landscape type	Ettrick	Yarrow	Jed	Assessed
Cheviot foothills - type 7			**	+
Grassland with hills - type 11	*		**	+
Lowland valley with farmland - type 29			**	
Rolling farmland type 8			*	
Southern upland forest - type 5	**		*	
Wooded upland fringe - type 28			**	
Southern uplands with scattered forest - type 4	**	**		+
Upland valley with pastoral floor - type 22	**	**		+
Upland valley with woodland - type 25	*	*		
Upland fringe with settlement - type 27	*			

Figure 7.1 The landscape character types of the Ettrick catchment

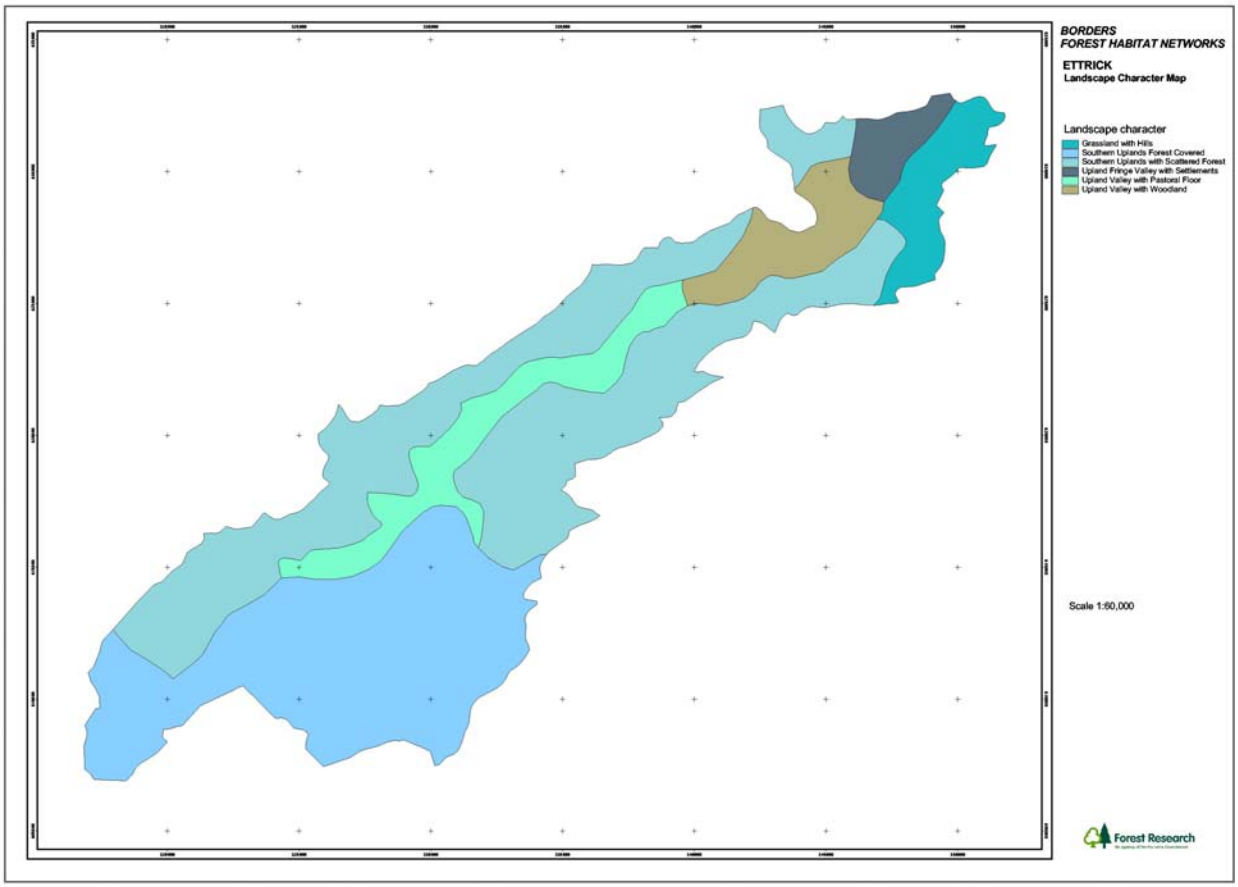


Figure 7.2 The landscape character types of the Yarrow catchment

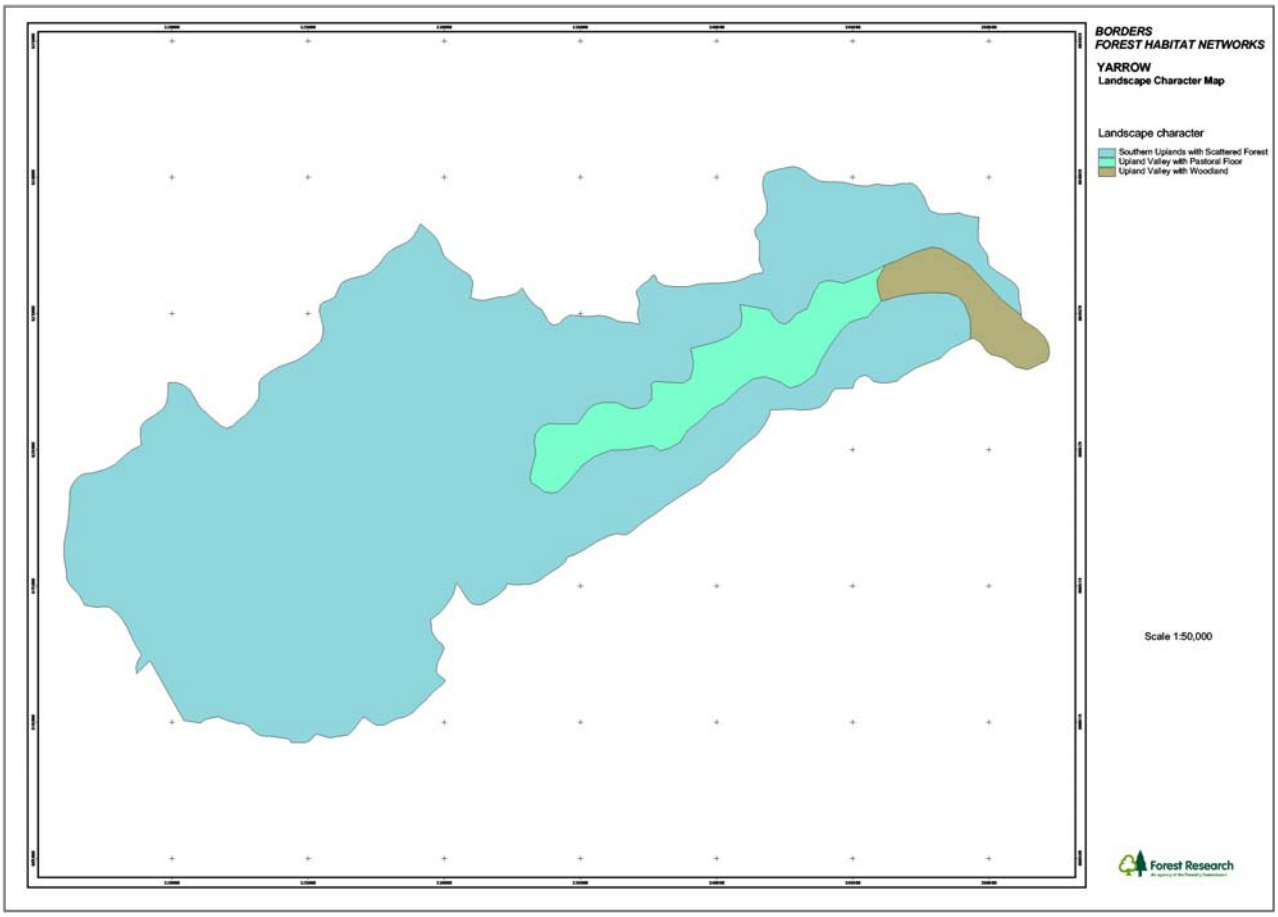

BORDERS
FOREST HABITAT NETWORKS
YARROW
Landscape Character Map
Landscape character
Southern Uplands with Scattered Forest
Upland Valley with Pastoral Floor
Upland Valley with Woodland
Scale 1:50,000
Forest Research

Figure 7.3 The landscape character types of the Jed catchment

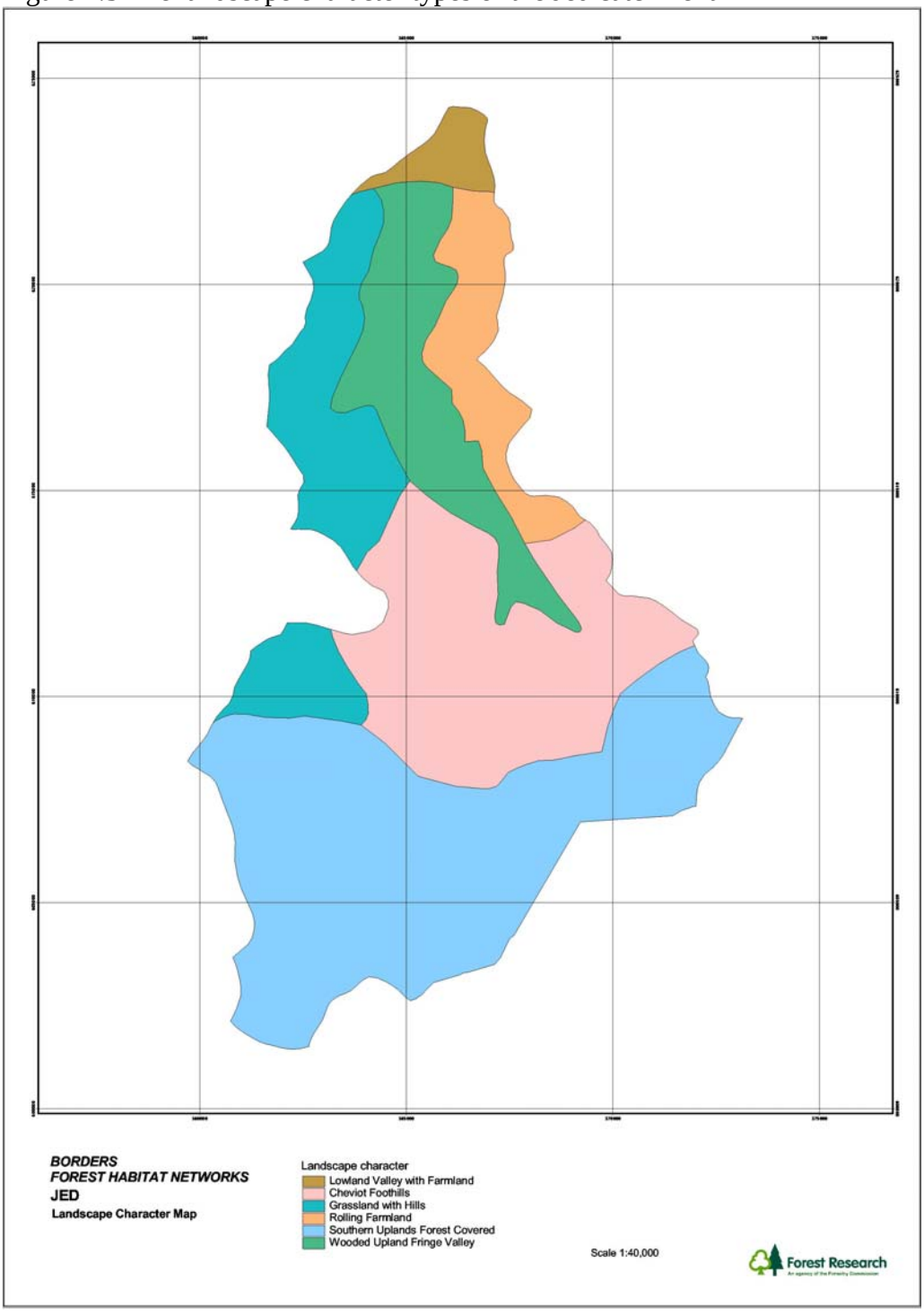


Figure 7.4a Woodland visibility within the Jed Water catchment as viewed from the A68 viewpoint at Carter Bar with existing woodland cover

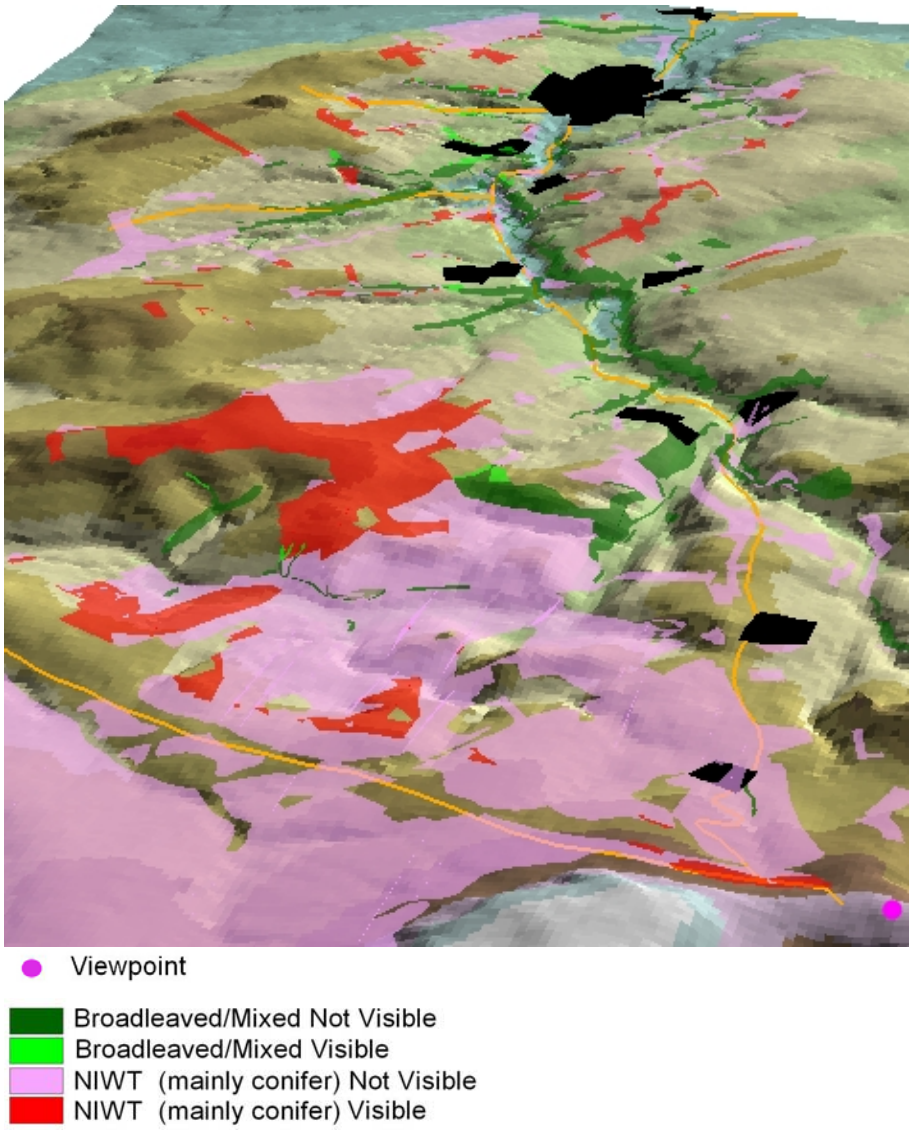
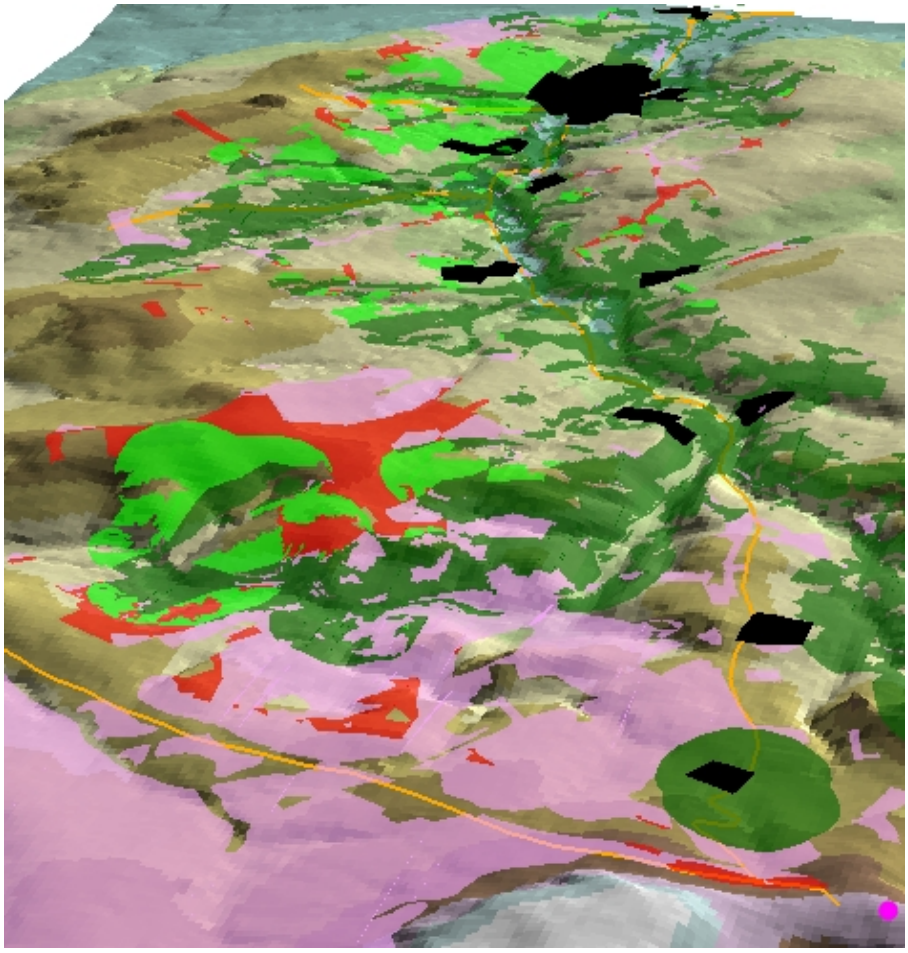


Figure 7.4b Woodland visibility within the Jed Water catchment as viewed from the A68 viewpoint at Carter Bar after woodland expansion within a 500m buffer of existing native woodland.



	Before (Area Ha)	After (Area Ha)
Broadleaved/Mixed visible	27.9	627.5
NIWT (mainly conifer) visible	524.2	366.2
Broadleaved/Mixed not visible	392.5	2524.1
NIWT (mainly conifer) not visible	5479.8	4828.5

7.3. **Cheviot foothills - landscape type 7**

Characterised by: dome and cone shaped hills and ridges, occasional rock outcrops on steepest slopes, grassland cover is dominant but with locally significant blocks of conifers, settlements in lower reaches of valleys. The positive and negative attributes of the landscape have been described by ASH consulting group and are summarised in Table 7.2 with some woodland expansion opportunities.

Table 7.2 Summary of positive and negative attributes of the Cheviot Foothills landscape with native woodland benefits.

Positive attributes	**Negative attributes**	**Native woodland expansion benefits**
distinctive hill landforms	absence of internal screening	will provide screening
simple and uniform landscape character	western fringe visually sensitive from A68 trunk road	visually attractive
open expansive unobstructed views		expansion away from road corridors to avoid obstructing views
wide visual influence, attractive views from vantage points (e.g. Carter Bar)		
no visually detracting features		
high heritage value		

Appendix 3A shows how an expansion of native woodland within a 500m of ENW would change the patch size distribution of broad habitat type classes within the Cheviot foothills landscape type 7. The graphs indicate a small reduction in the frequency of the smallest size class of under 10 ha in all types of grassland. The frequency of dwarf heath (heather moorland) and bracken patches would also be reduced. Several large patches of broadleaved woodland would be created, but the small woodland patch frequency would remain. There would be a reduction in the frequency of small conifer patches.

Native woodland expansion in the Cheviot foothills should avoid linear edges with adjacent open habitat. There are opportunities to visually link conifer plantations with native woodland in the upper south-western Jed catchment seen from the high elevation section of the A68 from Carter Bar northwards (Figure 7.4a & b). Expansion on the south-eastern side of the catchment would be within the valley below the A68, and not associated with conifer plantations. This would provide a strong semi-natural theme of mainly W11 oak woodland within the south-eastern part of the catchment, and could accentuate the dominance of the grass-covered hills of the Cheviot foothills.

7.4. **Grassland with hills - landscape type 11**

Characterised by: cone shaped volcanic hills, diverse types of landform, dominated by pasture and frequent woodlands, a low to medium density of settlement and rich visual contrasts. The positive and negative attributes of the landscape have been described by ASH consulting group and are summarised in Table 7.3 with some woodland expansion benefits.

Table 7.3 Summary of positive and negative attributes of the grassland with hills type landscape with native woodland benefits.

Positive attributes	**Negative attributes**	**Native woodland expansion benefits**
strong landform identity	high visual sensitivity from major trunk roads	will provide screening
unity of landuse on the lower ground	modern buildings out of character in the landscape	visually attractive
diversity of landform scale		will add to the nature conservation and scenic value of the landscape
both enclosed and expansive views		opportunity to expand woodland where views are currently enclosed (conversion)
frequent enclosure features of dykes and hedgerows		non LFA areas present landuse change opportunities
woodland is a significant component of the landscape		will complement and enhance the existing woodland
high scenic, nature conservation and heritage value		will extend and consolidate the nature conservation value

Appendix 3B shows how an expansion of native woodland within a 500m of ENW would change the patch size distribution of broad habitat type classes within the grassland with hills landscape type 11. The graphs indicate a small reduction in the frequency of the larger size patches of improved grassland. The frequency of dwarf heath (heather moorland) would be reduced. But the bracken habitat is relatively unaffected. Several large patches of broadleaved woodland would be created, and the frequency of small woodland patches would reduce. There would be a reduction in the frequency of small conifer patches.

Woodland is a significant component of the grassland with hills landscape type on the north-western side of the Jed to the east of Ruber's Law. Native woodland expansion wood link existing conifer woodland blocks, softening edges and adding to the high scenic, nature conservation and heritage value. Fiscal incentives for changing landuse may be more acceptable in areas without LFA status. The ENW in the Jed is largely confined to the valley floor and sides. Expansion out on to the surrounding plateau would provide a visual link between the grassland with hills landscape and the wooded upland

fringe valley. The outcome of expansion viewed from Carter Bar (Figure 7.4b), is of a well wooded valley, linking plantation forest in the south with extensive mature broadleaved oak woodland in the valley.

7.5. **Southern Uplands with scattered forest - landscape type 4**

Characterised by: a large scale rolling landform of peat, heather moorland on the upper slopes and plateaus and a grassland, rush, bracken mosaic on lower ground. Within this landscape are prominent scattered conifer plantations. The positive and negative attributes of the landscape have been described by ASH consulting group and are summarised in Table 7.4 with some woodland expansion opportunities.

Table 7.4 Summary of positive and negative attributes of the Southern Uplands with scattered forest type landscape with native woodland benefits.

Positive attributes	**Negative attributes**	**Native woodland expansion benefits**
smooth rolling landform creating a strong identity	absence of visual screening features	will provide screening
some high elevation glacial/geomorphic features ad to identity and distinctiveness	high visual sensitivity	will be visually attractive
remote and wild countryside with grandeur of scale	low diversity of landscape features	will add to the scenic value of the landscape
presence of reservoirs and lochs add visual appeal	semi-natural habitats under pressure (grazing and conifers)	will extend and enhance semi-natural habitats
high scenic and environmental quality designations	heather moorland dependent upon grouse management	will provide edge habitat for black grouse
drystone dykes and sheep stells divide the landscape	visual intrusion of forest edges and pylons	

Appendices 1A and 2B shows how an expansion of native woodland within a 500m of ENW would change the patch size distribution of broad habitat type classes within the Southern Uplands with scattered forest landscape type 4. The graphs indicate a small reduction in the frequency of the larger size patches of improved grassland. The frequency of patches is reduced across all size classes (except the largest) of neutral grassland in the Ettrick catchment. Some of the largest patches of acid grassland in the Yarrow catchment become fragmented by woodland expansion, producing larger frequencies in the next smallest class. The frequency of bracken patches would be reduced. Larger patches of dwarf heath are fragmented producing increased frequencies of smaller patches. Several large patches of broadleaved woodland would be created, and the frequency of small woodland patches would be reduced.

The landscape type extends across a large area of the upper Yarrow and Ettrick catchments. There are few native woodland remnants within the hills, with the exception of cleuch woodlands in a few steep sided valleys. The ENW and potential expansion is therefore largely on the valley floor, but with extensions up the valley sides. The few cleuchs provide valuable semi-natural habitat for a population of black grouse present in this part of the borders, and there is potential for expansion to connect to cleuch remnants in neighbouring catchments. Models of a 500m expansion suggest oak, birch and juniper woodland would make a significant contribution to linkage between several upland headwater catchments (Figure 7.5a & b). Expansion would also provide visual linkage with scattered conifer plantations in the landscape. The effect would be to ground plantation woodlands as part of a wider forest network, and remove the anomalous views of isolated plantations surrounded by grassland and heather moorland.

Figure 7.5a Visualisation of existing native woodland in the Yarrow catchment

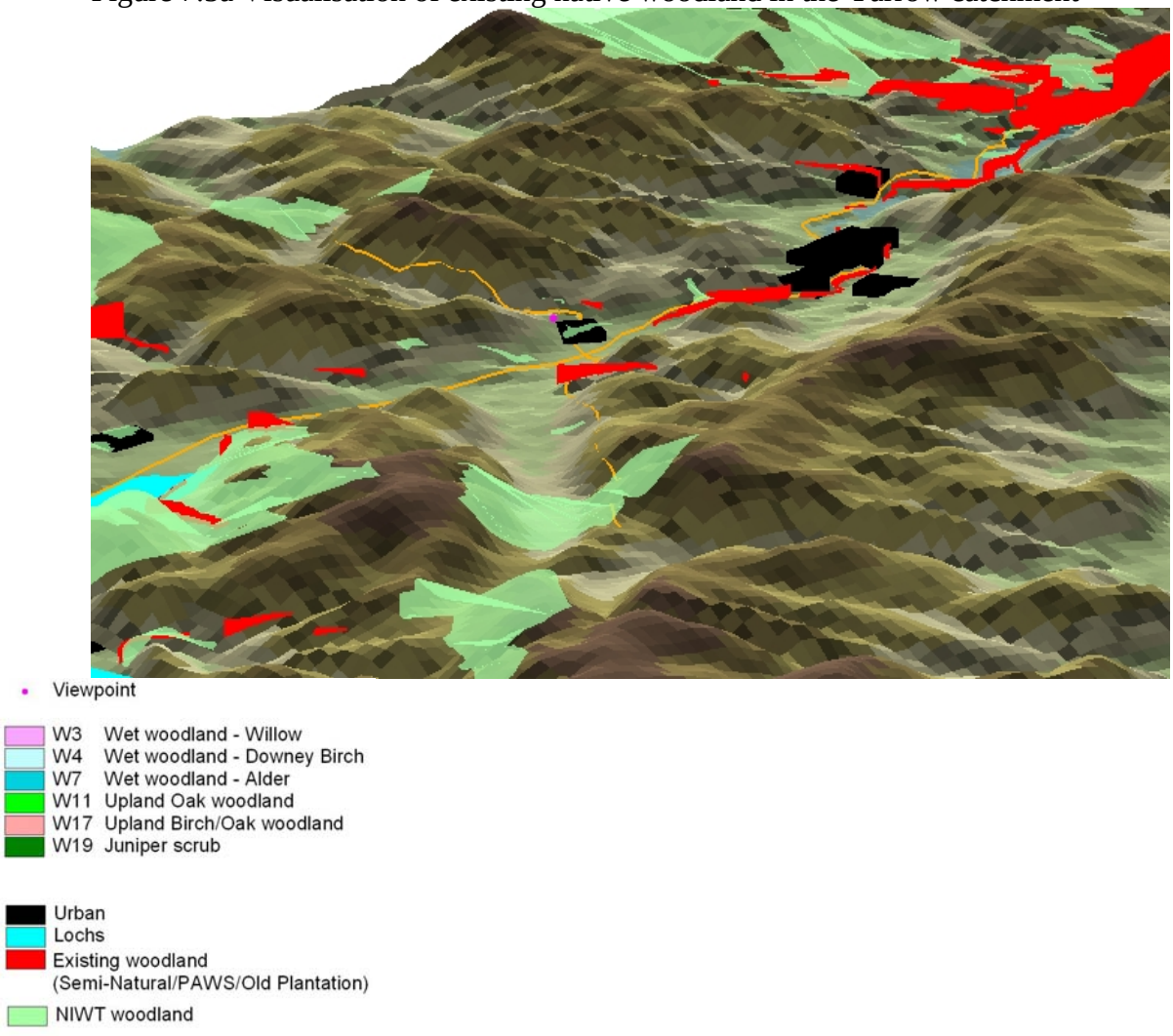
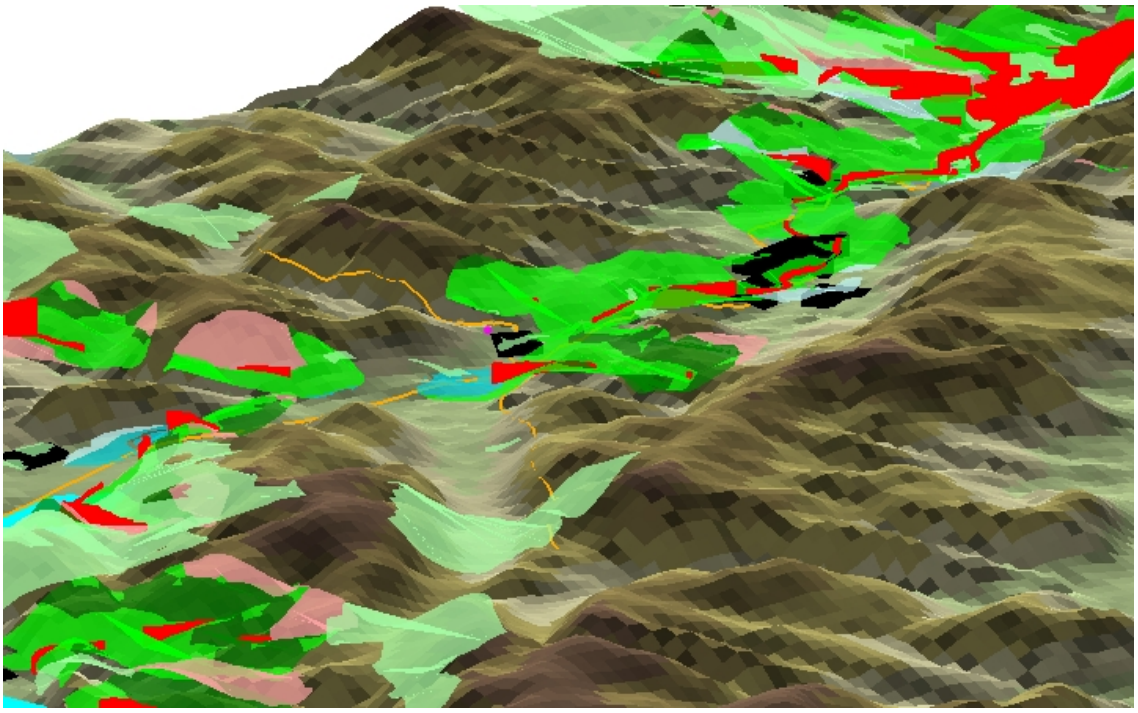


Figure 7.5b Visualisation of native woodland expansion within a 500 m buffer in the Yarrow catchment



Viewpoint

W3 Wet woodland - Willow
W4 Wet woodland - Downey Birch
W7 Wet woodland - Alder
W11 Upland Oak woodland
W17 Upland Birch/Oak woodland
W19 Juniper scrub

Urban
Lochs
Existing woodland
(Semi-Natural/PAWS/Old Plantation)
NIWT woodland

7.6. **Upland valley with pastoral floor - landscape type 22**

Characterised by: glaciated valleys with steep 'strong' slopes and river bluffs, improved pastures with occasional small woodlands and shelter belt tree lines on the valley floor, unimproved grass heather and bracken on the valley sides, distinctive landscape, enclosed by surrounding hills and intermittent long views along valley corridors. The positive and negative attributes of the landscape have been described by ASH consulting group and are summarised in Table 7.5 with some woodland expansion opportunities.

Table 7.5 Summary of positive and negative attributes of the upland valley with pastoral floor type landscape with native woodland benefits.

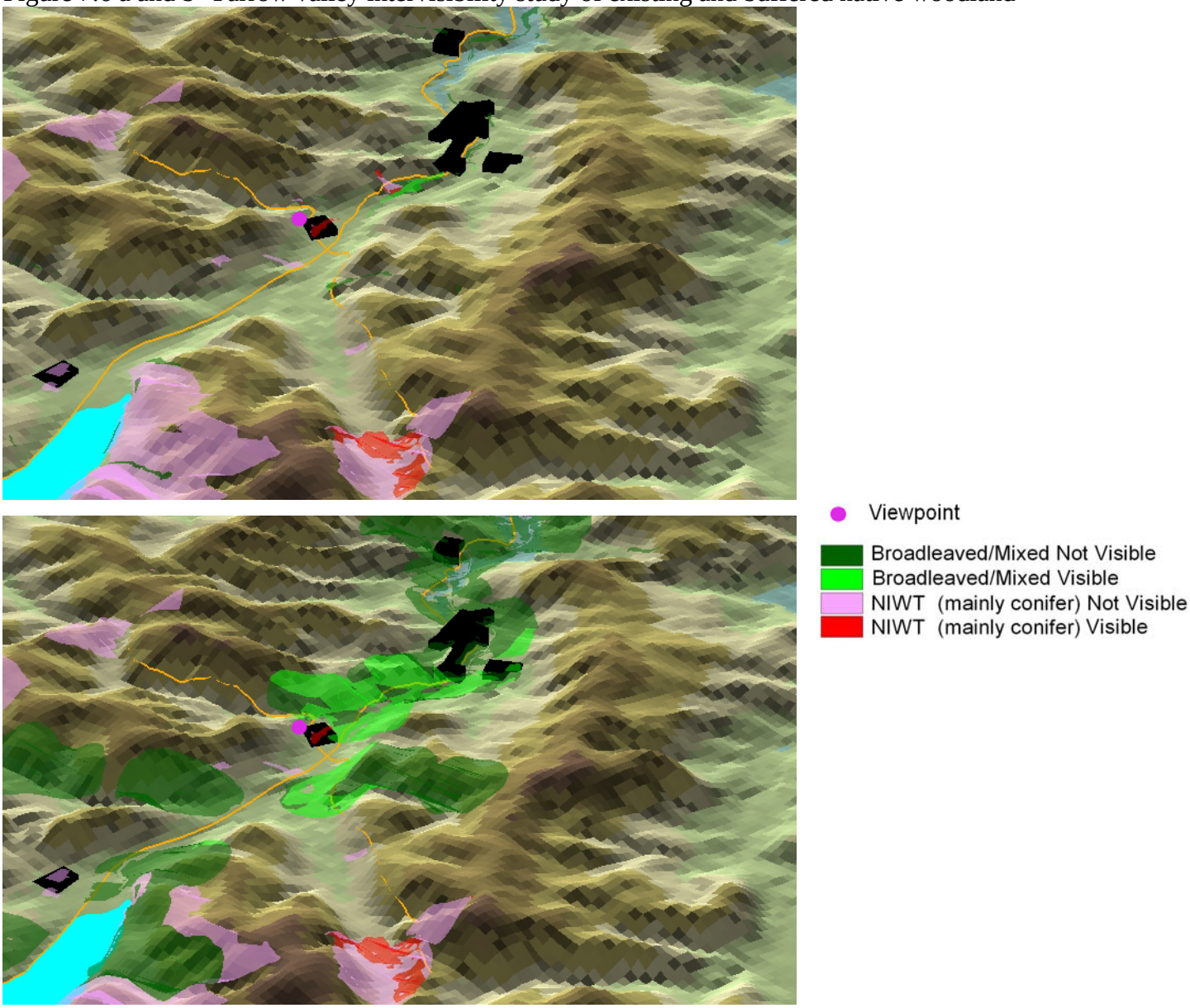
Positive attributes	**Negative attributes**	**Native woodland expansion benefits**
strong topographic definition, enclosed by valley sides within high hills	moderate to high visual sensitivity on roads along valley floors	will add to topographic definition - riparian zone and cleugh woodland in higher steeper valley
close visual relationship with adjoining uplands - surrounding uplands form the backdrop		visually attractive with upland backdrop
unity of land cover pattern		will soften the woodland block edges with the open pastoral matrix
common cultural heritage - valley routes through the uplands		will extend and consolidate the nature conservation value
close relationship between settlement and topography		non LFA areas present landuse change opportunities
diversity of colours and textures on a detailed scale		colours and textures will blend naturally with existing diverse landscape
conifers and broadleaved woods contribute to visual appeal, enclosure and diversity		

Appendices 1B and 2A shows how an expansion of native woodland within 500m of ENW would change the patch size distribution of broad habitat type classes within the upland valley with pastoral floor landscape type 4. The graphs indicate a general reduction in the frequency of the patches of all grassland types, but particularly the improved grassland in the Yarrow catchment and the acid grassland in the Ettrick catchment. An elimination of the largest patches of grassland indicates fragmentation. Dwarf heath communities are unaffected in this landscape type, but the bracken patches are reduced in number. Several large patches of broadleaved woodland would be created, and the frequency of small woodland patches would be reduced.

Oak and birch woodland are suited to the lower slopes and juniper on more exposed sites, and alder birch and willow woodland in the riparian corridor. The wet woodland is a prominent feature of the Upper Ettrick catchment. Some of this ENW (wet woodland) falls

within 500m of the edge of Craik forest. Conversion of plantation forest to native woodland along this northern edge would link Craik with the wooded riparian valley of the Upper Ettrick catchment. The visibility of woodland expansion in an 'upland valley with pastoral floor' has been examined in the Yarrow. Figure 7.6a&b shows how the buffered expansion of small ENW remnants at Mountbenger would change the character of the views descending the hill from the B709. At this viewpoint, where 14 ha of broadleaved woodland are currently visible, the visible broadleaved woodland may increase to over 300 ha if the ENW was expanded within a 500m buffer.

Figure 7.6 a and b Yarrow valley intervisibility study of existing and buffered native woodland



8. Conclusions

This report documents a scientific study within the Scottish Borders on the use of GIS-based models to analyse the impact of targeted native woodland expansion on the ecology of the region at the landscape scale. This structured approach can be applied throughout Scotland using national inventories, and rules modified for locally defined (LBAP group?) focal species of concern. Regional modifications to the approach can be made, such as the inclusion or removal of SSNWI high native component woods. In the Borders this category was included because woodlands of ancient and semi-natural origin are under-represented compared to Scotland as a whole.

- Forest Habitat Networks are similar in concept and function to greenways. Thus the FHN provides a strategic model for the expansion of linear and linked corridors, but does not address potential conflicting use issues.
- Only small remnants of semi-natural woodland lie within the Scottish Borders.
- The incorporation of the SSNWI semi-natural and high native component woods provides a greater potential resource from which to improve biodiversity and develop Forest Habitat Networks within the Scottish Borders.
- Expansion, restoration and conversion of native woodland, within 300 m of existing native woodland, will in particular add to the upland oak woodland, upland birch woodland and wet woodland HAP expansion targets.
- Expansion of juniper, within 300m of existing native woodland, will significantly add to the juniper SAP target in the Scottish Borders.
- The 300m threshold for 90% grant aid in the SFGS may occasionally jeopardise the expansion of native woodland on suitable sites, where there wood be a significant habitat gain for locally important species. This is particularly true for mobile birds and mammals.
- A 500m threshold would provide a more continuous linkage between core riparian woodland forming the main framework. A 500m threshold would also allow a greater flexibility in locating native woodland schemes to link existing cleuch woodland in higher valleys, and to provide stepping stone linkage for moderately mobile species between catchments.
- Remnant woodlands are often small, overgrazed, without structure and with sparse canopy cover.
- Remnants typically occur near streams and rivers and in higher valley 'cleuch' woodlands.
- Existing Native Woodland quality will need to be considered to assess the degree of success likely in the stated objectives of woodland biodiversity improvement.
- Forest Habitat Networks and Open Habitat Networks for focal species should be assessed objectively, look at habitat networks from a species perspective - not just the woodland managers perspective.
- Woodland species have a tremendous range of dispersal distances and landscape patches vary in terms of suitability for dispersal between species.

- If species or habitat restoration is the key objective for native woodland expansion then the landscape scenario should be tested for suitable habitat and for that species.
- Red and grey squirrels have similar habitat preferences. Therefore in the Scottish Borders any Forest Habitat Network scenario should maintain a barrier between known red squirrel forest habitats and any native woodland expansion suitable for grey squirrel habitat expansion.
- Black grouse use forest edge habitat as shelter, native woodland expansion surrounding cleuchs adjacent to heathland would benefit this species.
- The character of four landscape types in three tributary catchments of the Tweed, identify woodland as a key component of the landscape.
- In the landscape types examined any expansion of broadleaved woodland would add to the visual appeal, provide screening, soften hard edges and improve the biodiversity of other semi-natural habitats.
- The 3D visualisation techniques and intervisibilty analysis with viewsheds from key vantage points, provides a tool with which forest planners can engage planning authorities and the public to discuss schemes.

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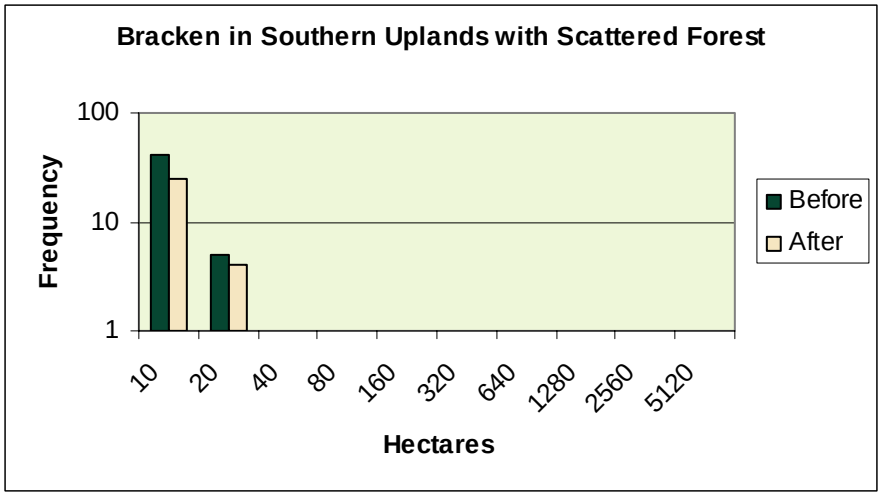
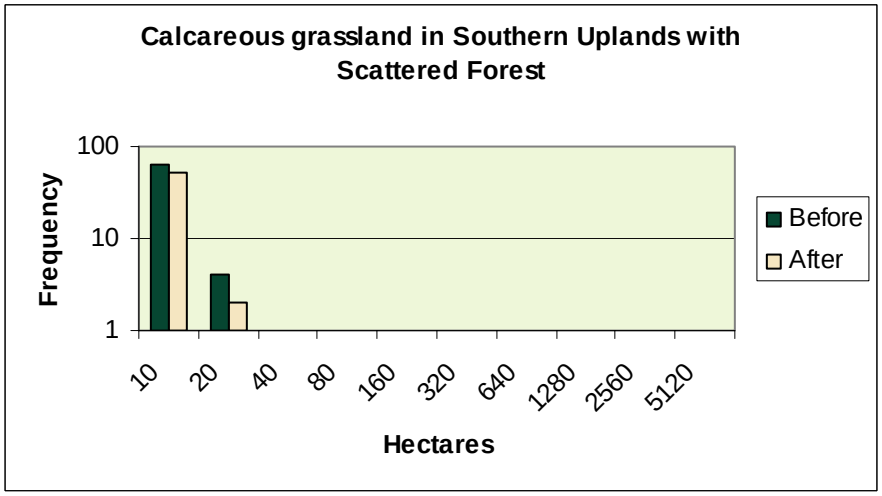
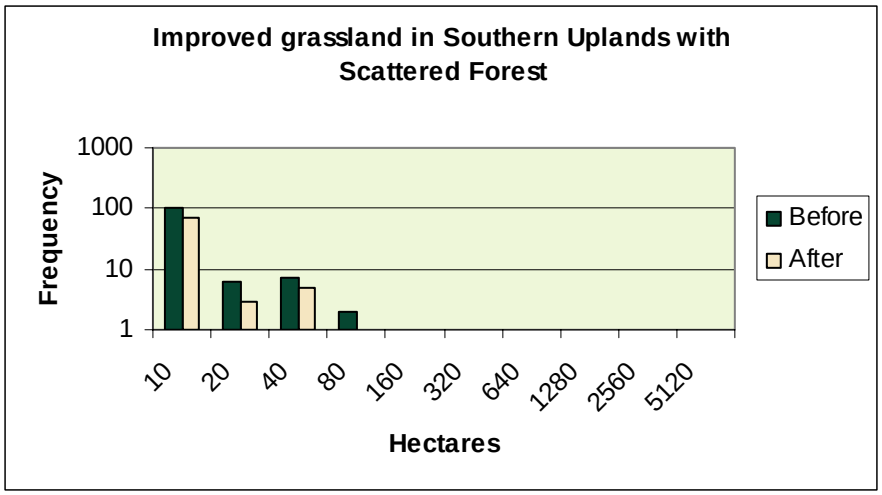
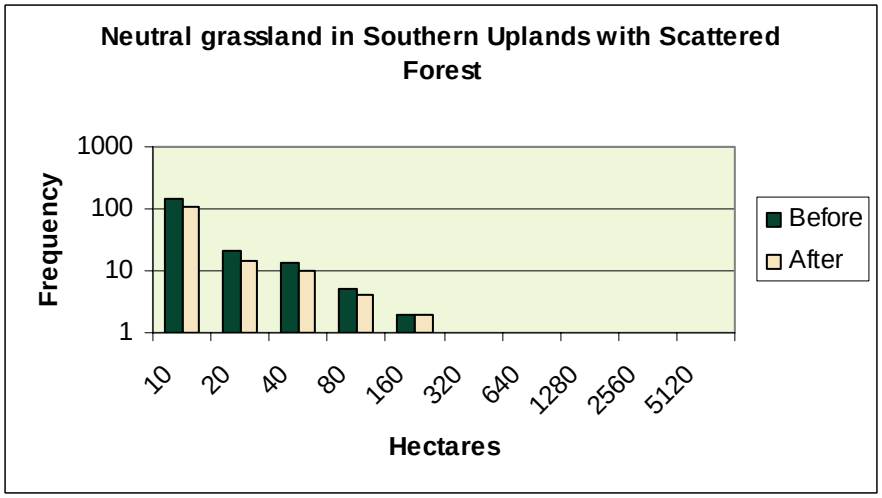
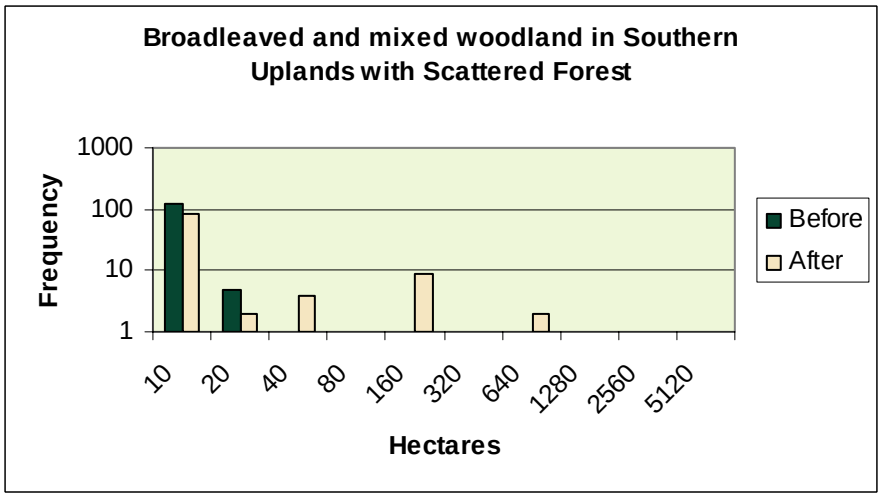
Appendix 1A - Ettrick catchment - Change within the Southern Uplands with scattered forest landscape type

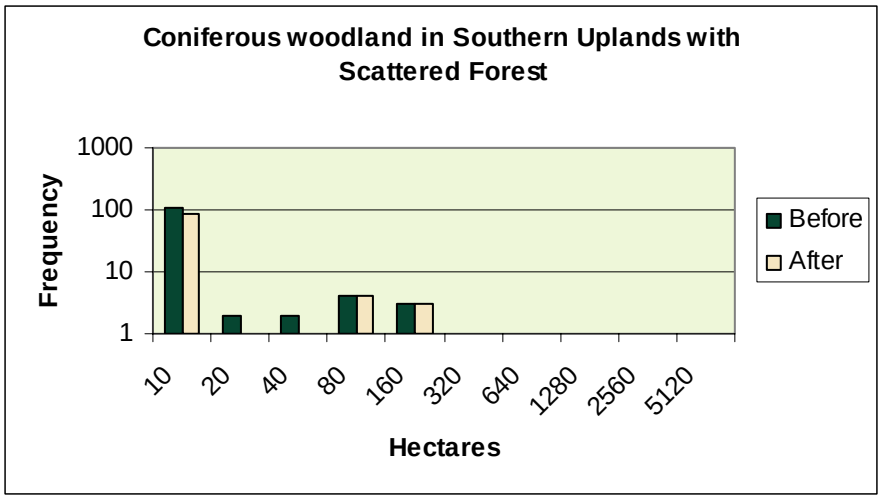


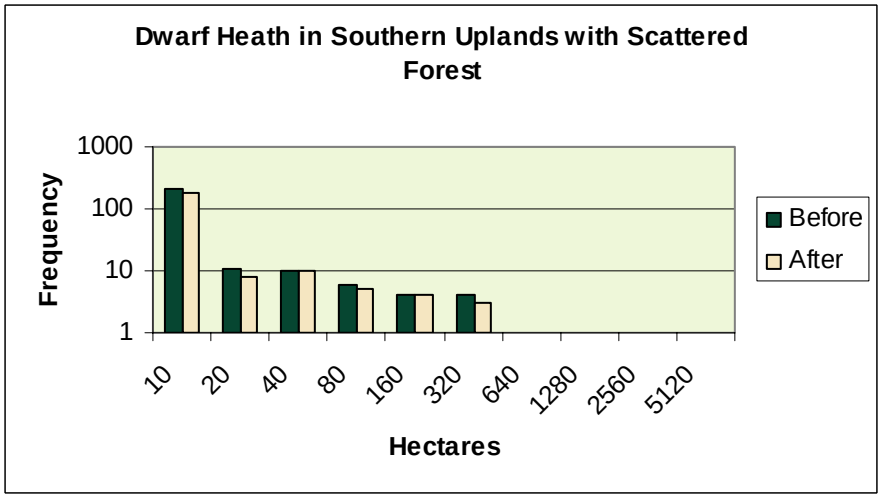



Improved grassland in Southern Uplands with Scattered Forest
Frequency
1000
100
10
1
10
20
40
80
160
320
640
1280
2560
5120
Hectares
Before
After

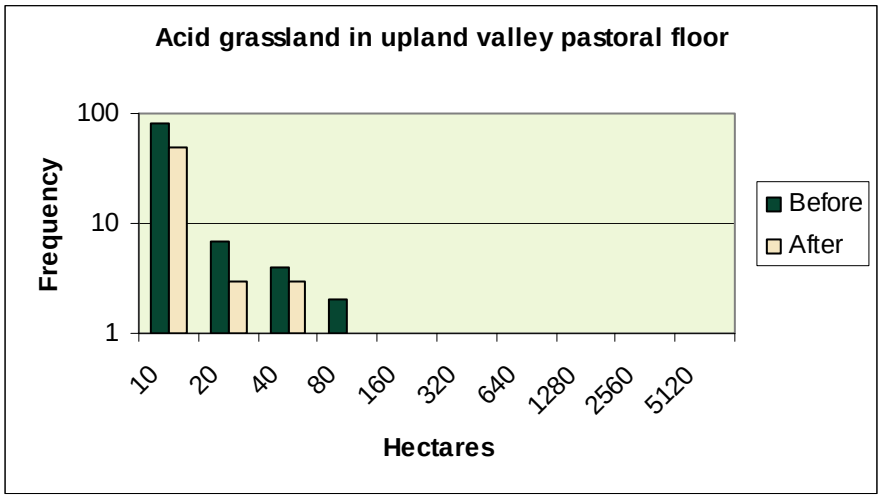

Neutral grassland in Southern Uplands with Scattered Forest
Frequency
1000
100
10
1
10
20
40
80
160
320
640
1280
2560
5120
Hectares
Before
After

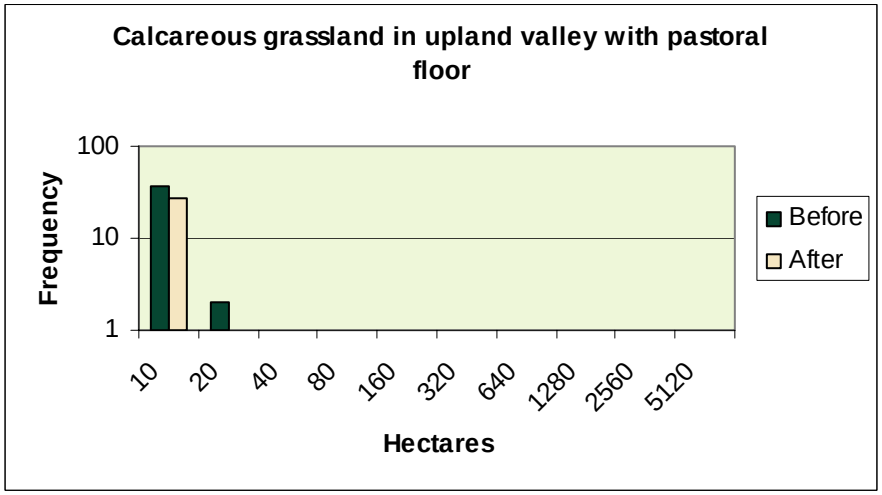

Broadleaved and mixed woodland in Southern Uplands with Scattered Forest
Frequency
1000
100
10
1
10
20
40
80
160
320
640
1280
2560
5120
Hectares
Before
After

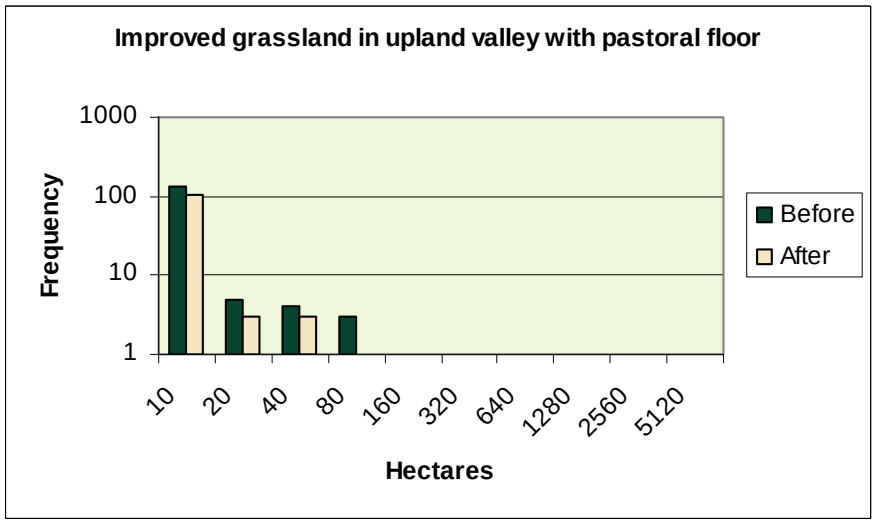

Coniferous woodland in Southern Uplands with Scattered Forest
Frequency
1000
100
10
1
10
20
40
80
160
320
640
1280
2560
5120
Hectares
Before
After

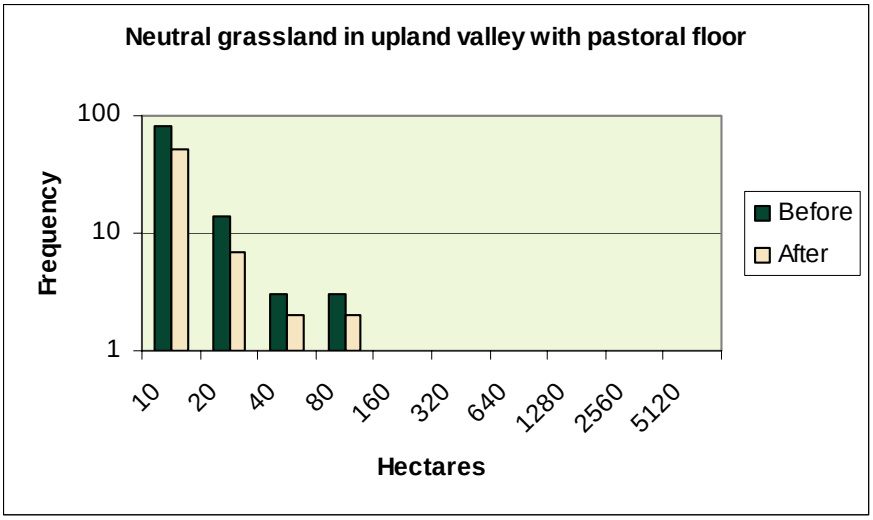

Dwarf Heath in Southern Uplands with Scattered Forest
Frequency
1000
100
10
1
10
20
40
80
160
320
640
1280
2560
5120
Hectares
Before
After

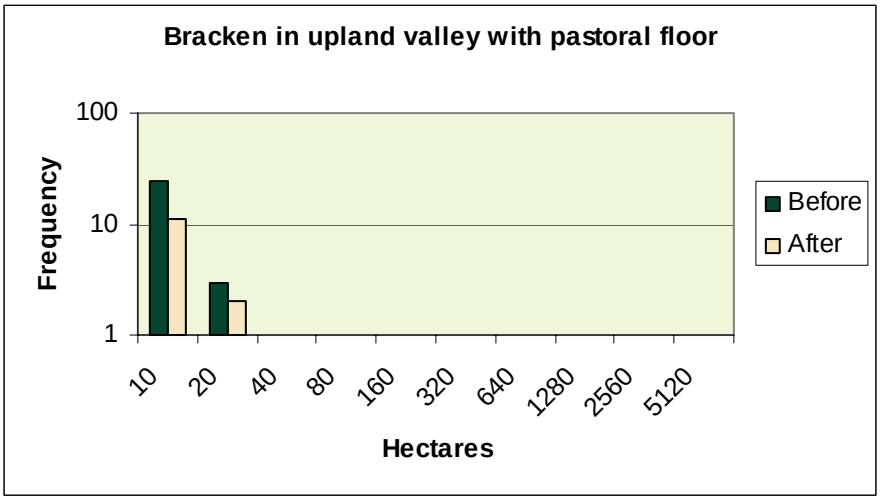
Appendix 1B - Ettrick catchment - Change within the Upland valley with pastoral floor forest landscape type

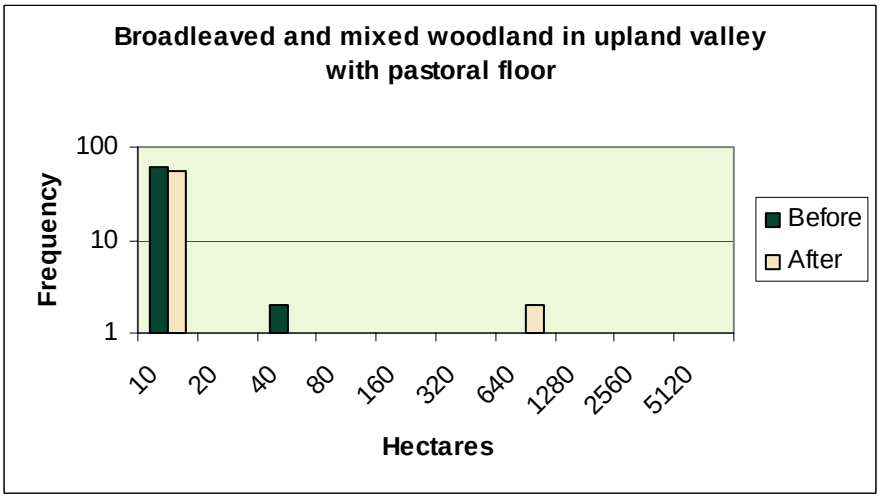


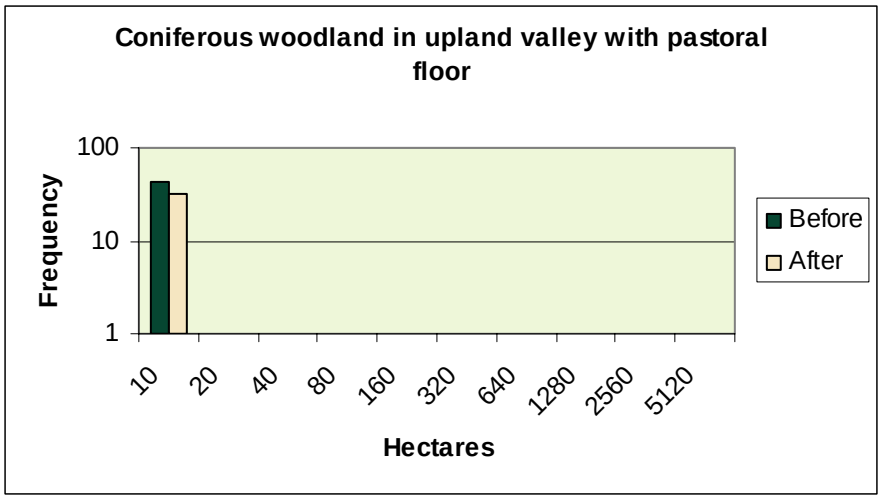




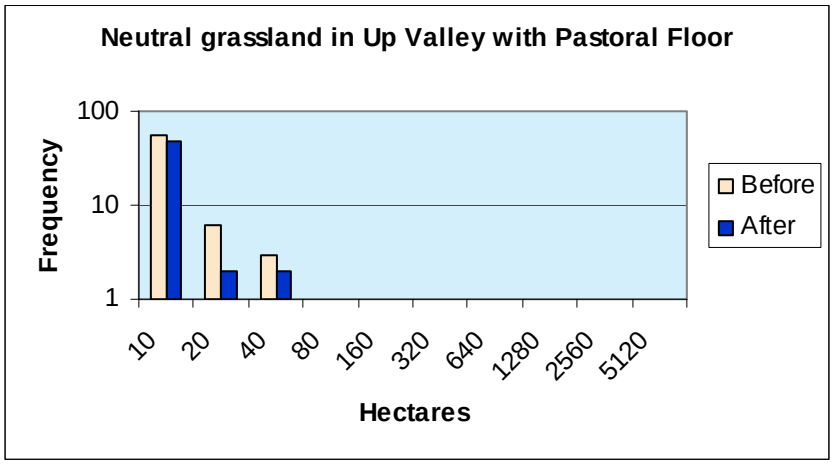

Neutral grassland in upland valley with pastoral floor
100
10
1
Frequency
10
20
40
80
160
320
640
1280
2560
5120
Hectares
Before
After

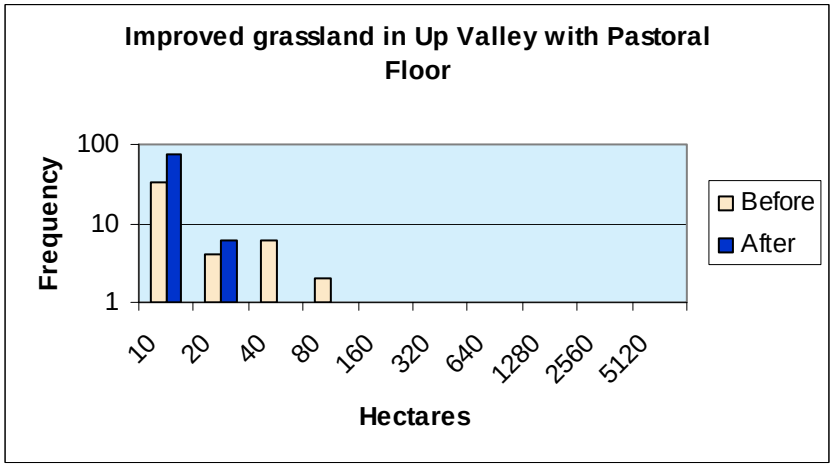

Bracken in upland valley with pastoral floor
100
10
1
Frequency
10
20
40
80
160
320
640
1280
2560
5120
Hectares
Before
After

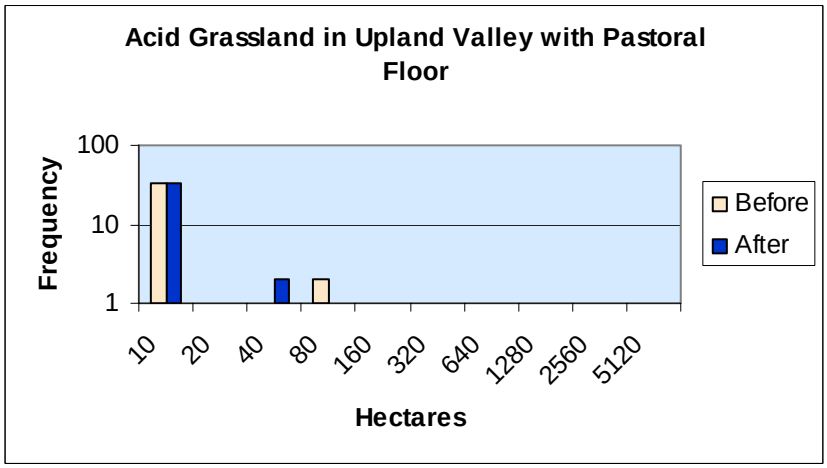

Broadleaved and mixed woodland in upland valley with pastoral floor
100
10
1
Frequency
10
20
40
80
160
320
640
1280
2560
5120
Hectares
Before
After

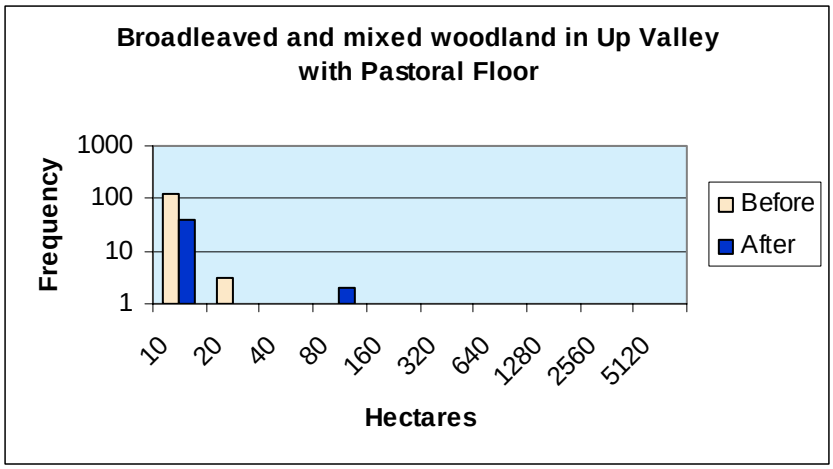

Coniferous woodland in upland valley with pastoral floor
Frequency
100
10
1
10
20
40
80
160
320
640
1280
2560
5120
Hectares
Before
After

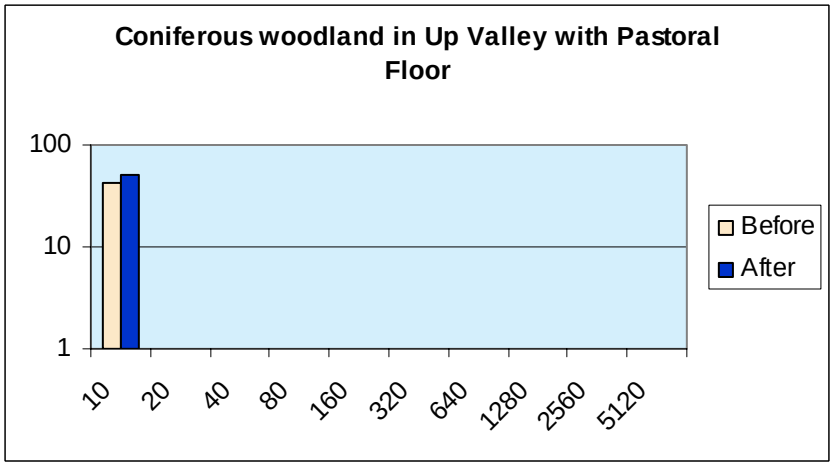
Appendix 2A - Yarrow Catchment -Change within the Upland valley with pastoral floor forest landscape type








Broadleaved and mixed woodland in Up Valley with Pastoral Floor
Frequency
1000
100
10
1
10
20
40
80
160
320
640
1280
2560
5120
Hectares
Before
After


Coniferous woodland in Up Valley with Pastoral Floor
100
10
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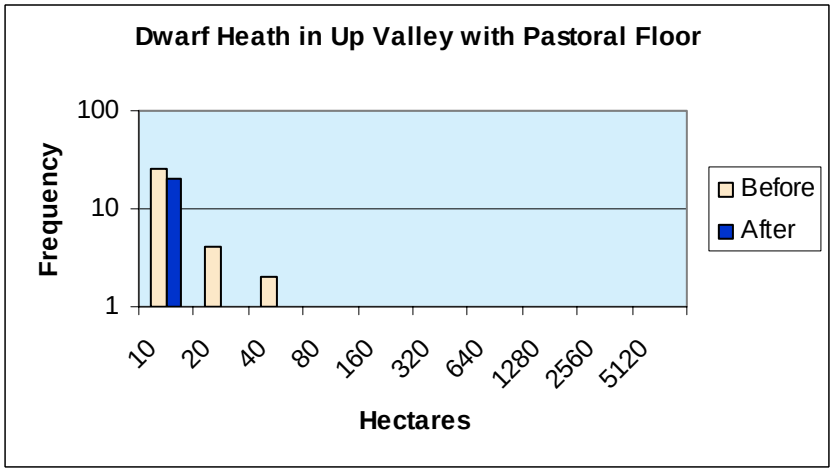
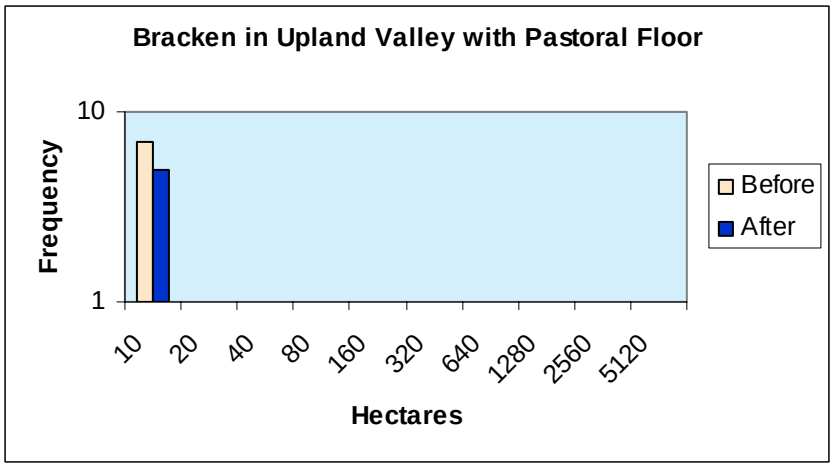
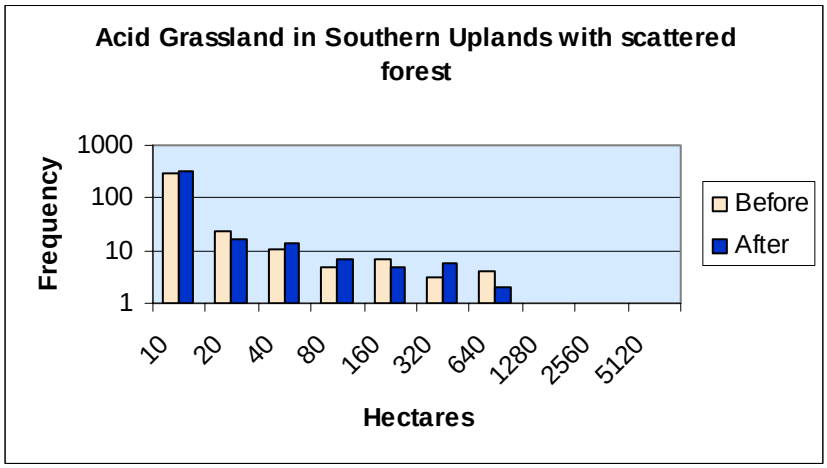
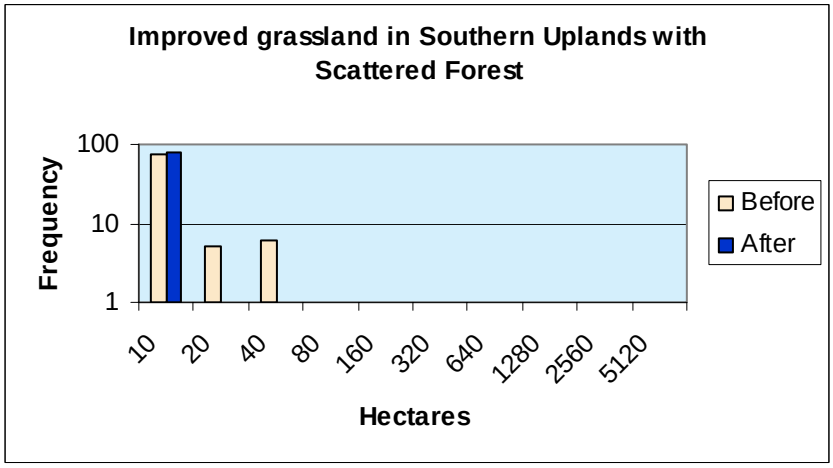
10
20
40
80
160
320
640
1280
2560
5120
Before
After

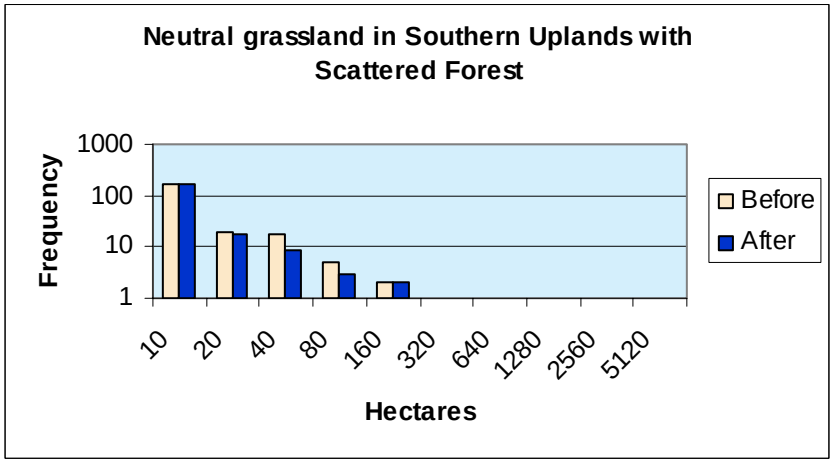

Dwarf Heath in Up Valley with Pastoral Floor
Frequency
100
10
1
10
20
40
80
160
320
640
1280
2560
5120
Hectares
Before
After

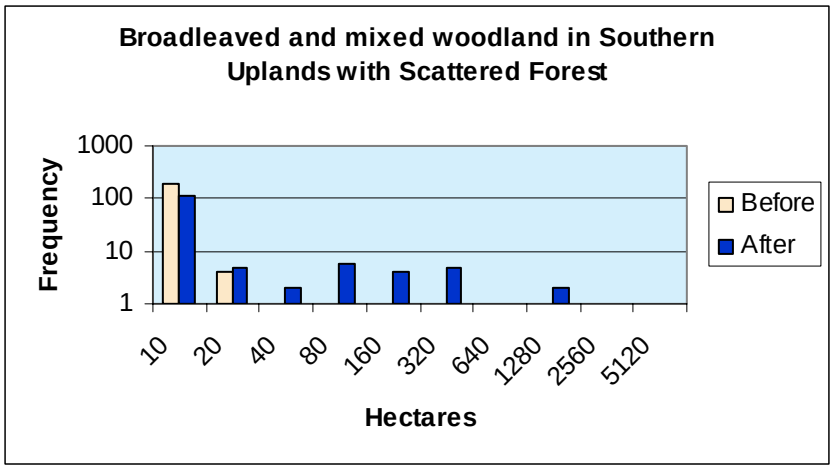

Bracken in Upland Valley with Pastoral Floor
Frequency
10
1
10
20
40
80
160
320
640
1280
2560
5120
Hectares
Before
After

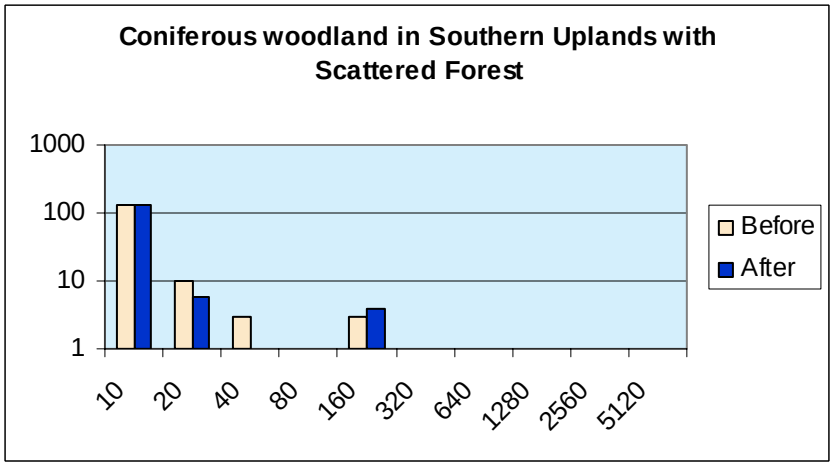
Appendix 2B - Yarrow Catchment -Change within the Southern Uplands with scattered forest landscape type

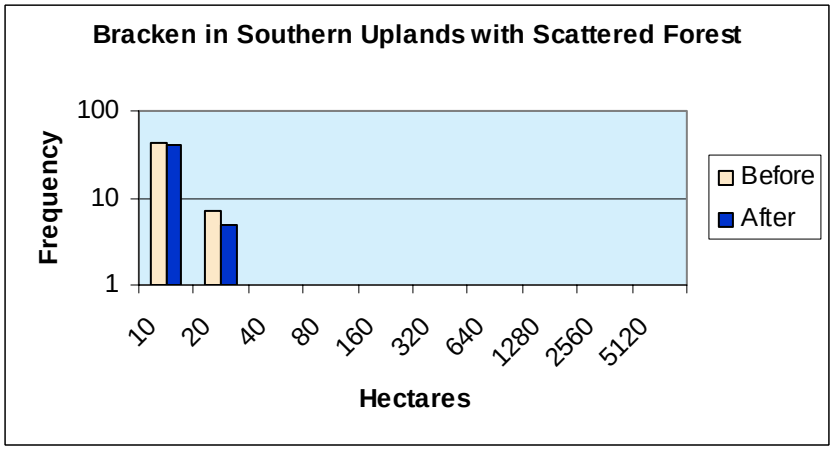


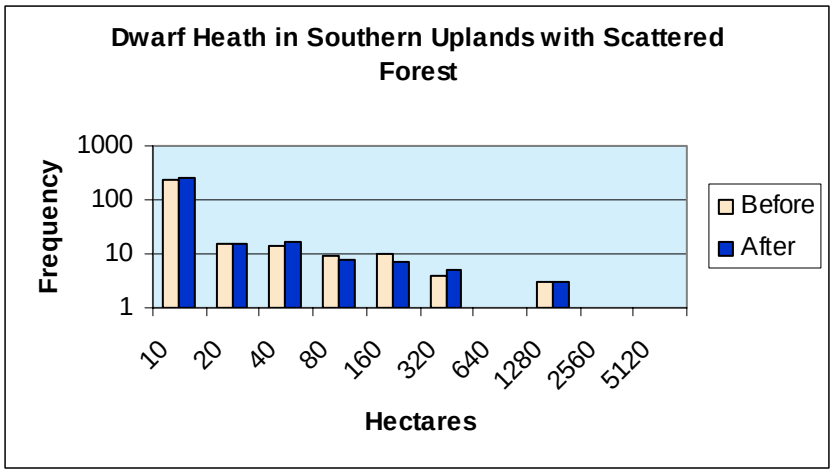




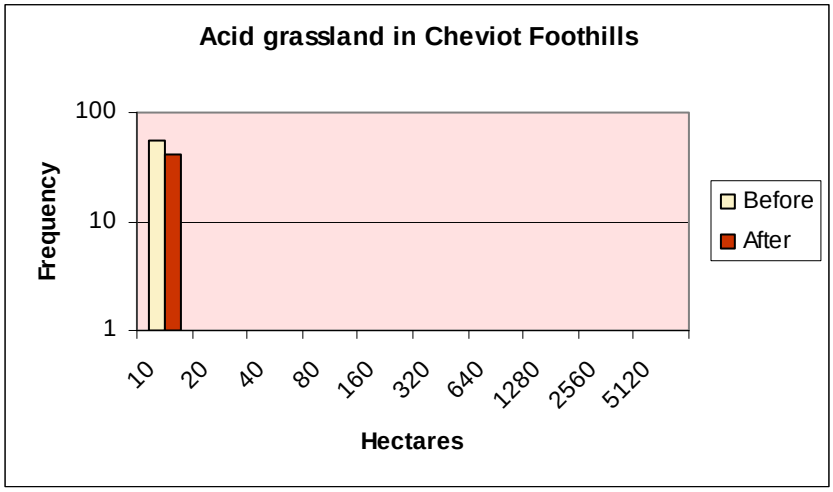

Broadleaved and mixed woodland in Southern Uplands with Scattered Forest
Frequency
1000
100
10
1
10
20
40
80
160
320
640
1280
2560
5120
Hectares
Before
After

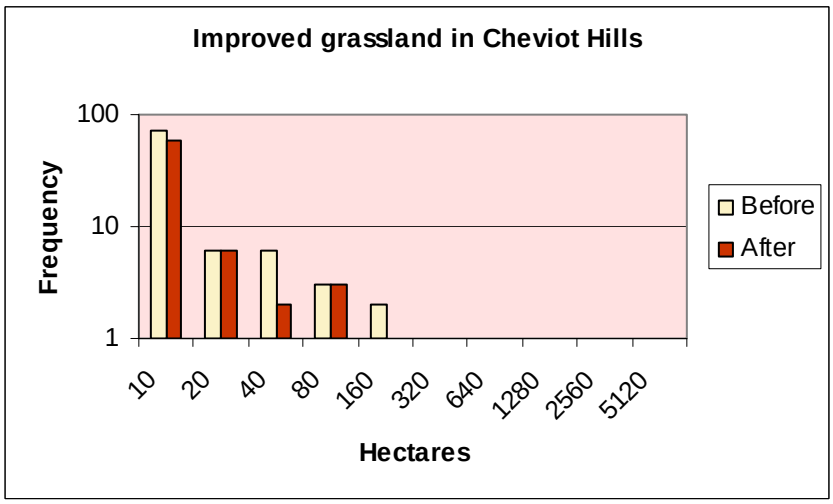

Coniferous woodland in Southern Uplands with Scattered Forest
1000
100
10
1
10
20
40
80
160
320
640
1280
2560
5120
Before
After

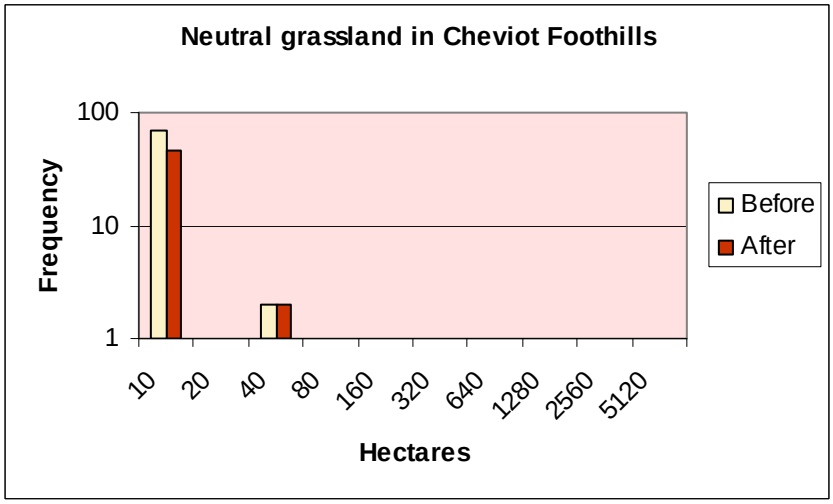

Bracken in Southern Uplands with Scattered Forest
Frequency
100
10
1
10
20
40
80
160
320
640
1280
2560
5120
Hectares
Before
After

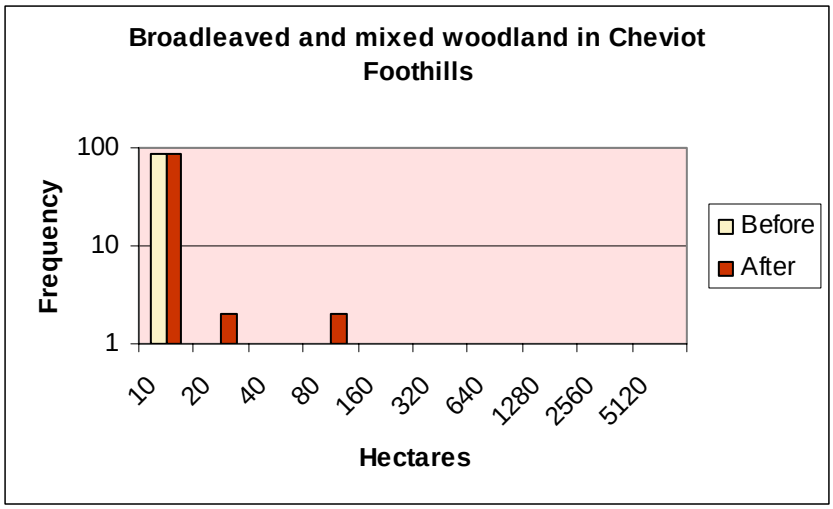

Dwarf Heath in Southern Uplands with Scattered Forest
Frequency
1000
100
10
1
10
20
40
80
160
320
640
1280
2560
5120
Hectares
Before
After

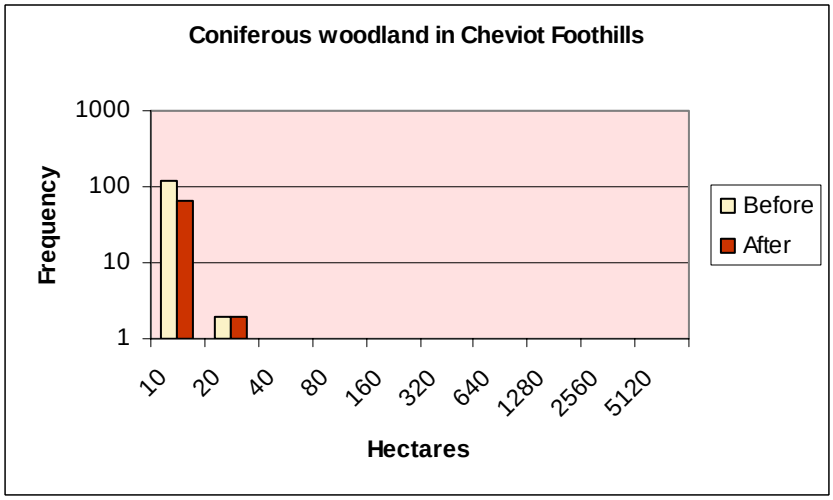
Appendix 3A - Jed Catchment -Change within the Cheviot foothills landscape type

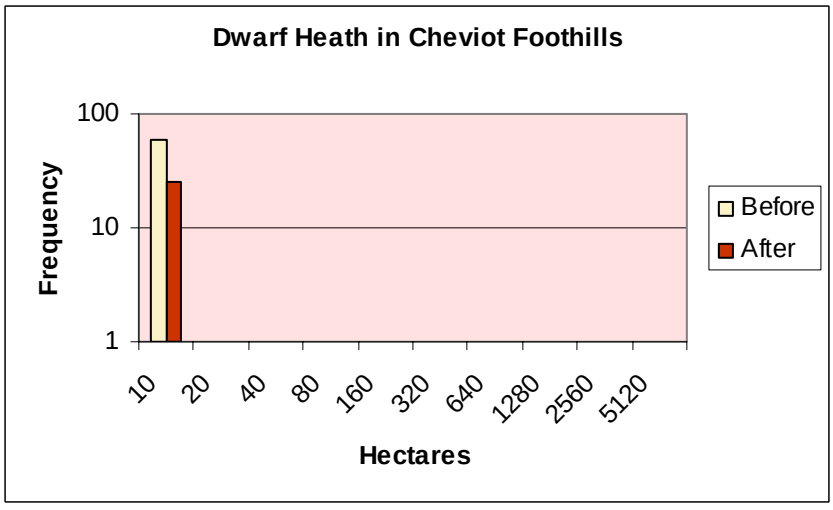


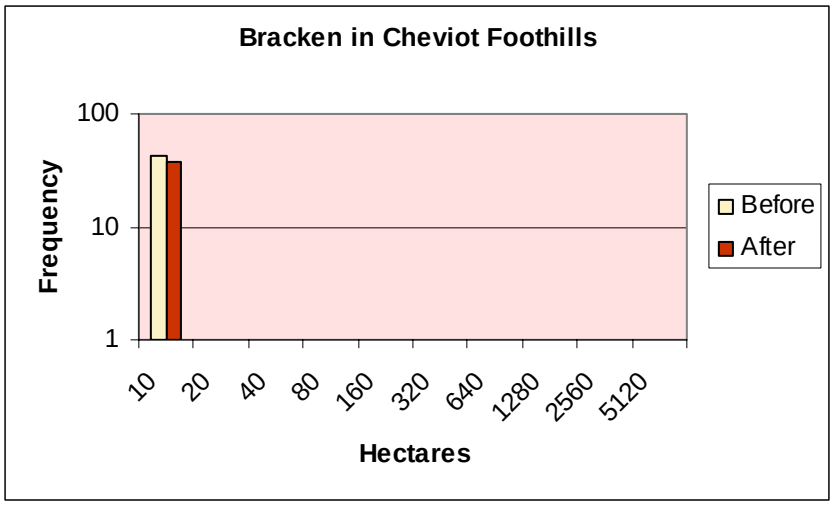




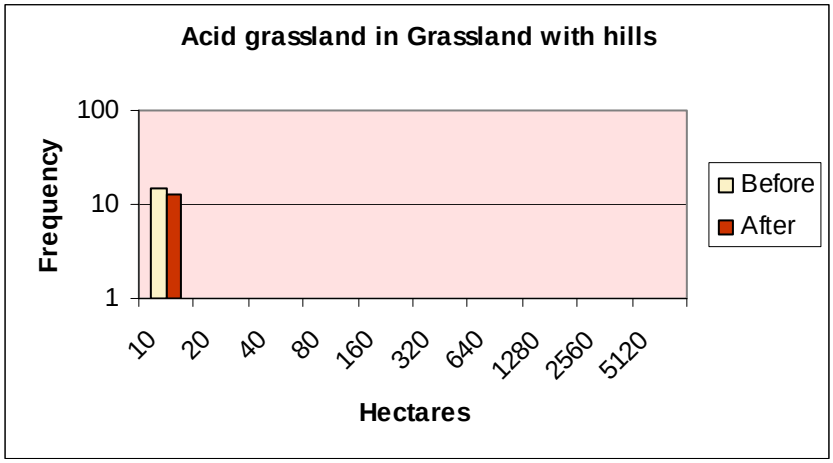

Broadleaved and mixed woodland in Cheviot Foothills
Frequency
100
10
1
10
20
40
80
160
320
640
1280
2560
5120
Hectares
Before
After

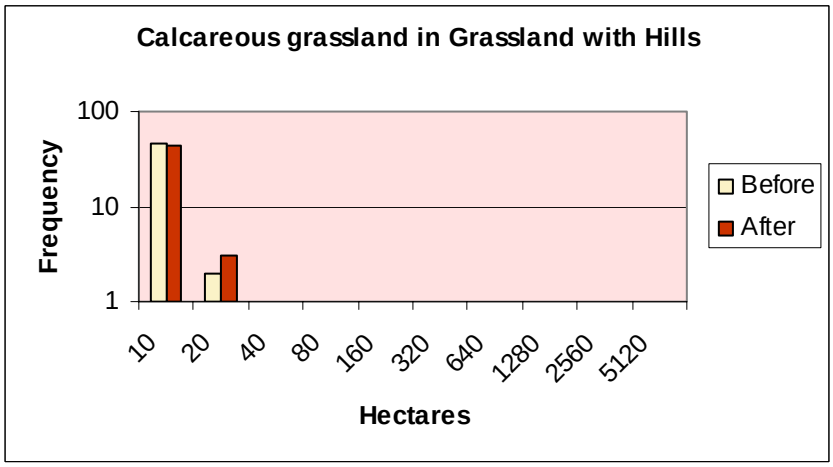

Coniferous woodland in Cheviot Foothills
Frequency
1000
100
10
1
10
20
40
80
160
320
640
1280
2560
5120
Hectares
Before
After

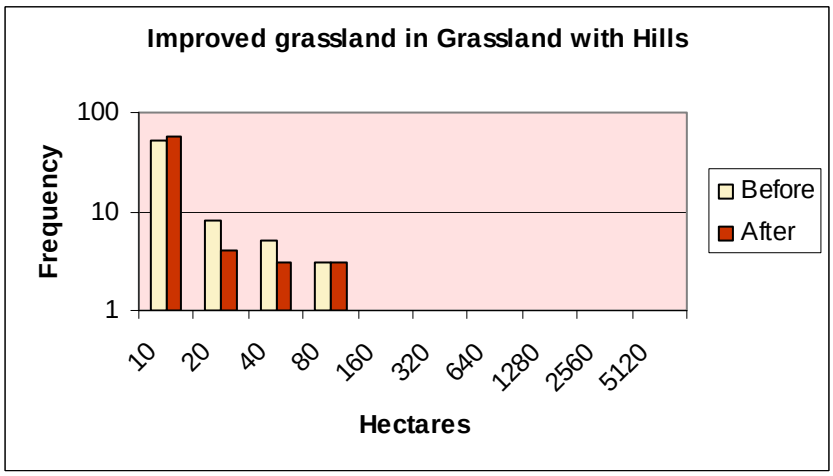

Dwarf Heath in Cheviot Foothills
Frequency
100
10
1
10
20
40
80
160
320
640
1280
2560
5120
Hectares
Before
After

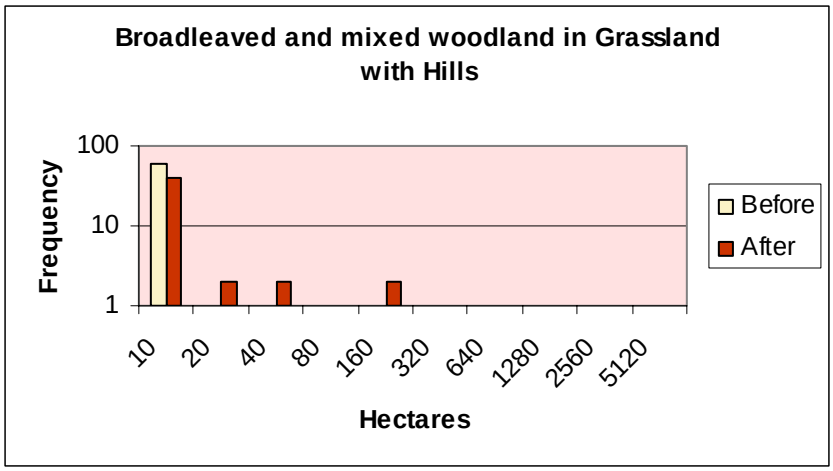

Bracken in Cheviot Foothills
100
10
1
Frequency
10
20
40
80
160
320
640
1280
2560
5120
Hectares
Before
After

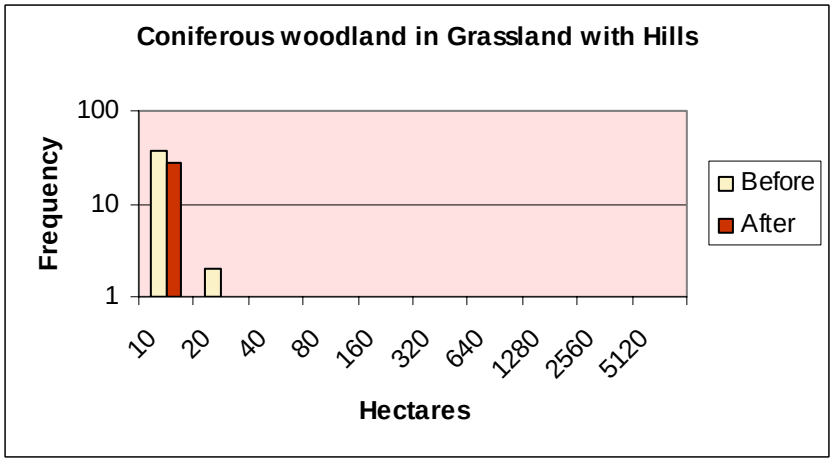
Appendix 3B - Jed Catchment -Change within the grassland with hills landscape type

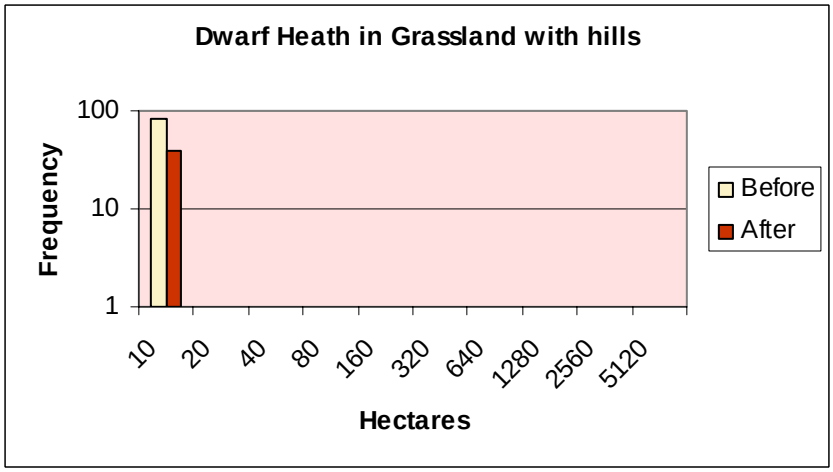


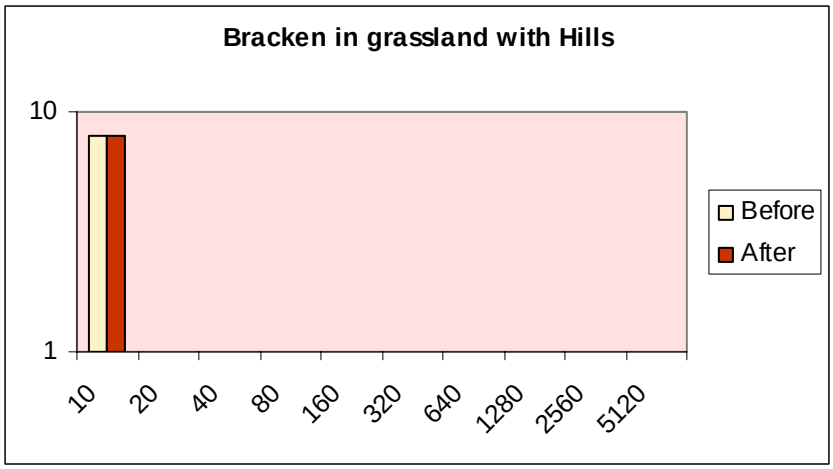





Broadleaved and mixed woodland in Grassland with Hills
Frequency
100
10
1
10
20
40
80
160
320
640
1280
2560
5120
Hectares
Before
After


Coniferous woodland in Grassland with Hills
Frequency
100
10
1
10
20
40
80
160
320
640
1280
2560
5120
Hectares
Before
After


Dwarf Heath in Grassland with hills
Frequency
100
10
1
10
20
40
80
160
320
640
1280
2560
5120
Hectares
Before
After


Bracken in grassland with Hills
10
1
10
20
40
80
160
320
640
1280
2560
5120
Before
After