Acknowledgements
The authors would like to thank the project steering group for advice; and the woodland owners and agents for allowing access to the sample woodlands.
Summary

The overall objectives of the project were to:
1. review the ecological and silvicultural aspects of both practice and guidance relating to creating new native woodlands;
2. assess experience in the field by sample survey of a range of new native woodlands.

The specific aims are to:
• assess how far new native woodlands meet FC guidance on design, location and composition etc.
• provide and account of the strengths and weaknesses of current practice in terms of the way that new native woodlands appear to be meeting biodiversity policy objectives.
• outline the factors that appear to drive outcomes in the field and recommend ways to enhance the quality of future new native woodland creation.
• assess guidance, policies and priorities and recommend any changes or improvements.

The following forms of guidance for the establishment and design of new native woodland were collated and reviewed: grant scheme documentation, specific guidance for native woods, and generic forestry guidance that is relevant to new native woodlands. The evolution of guidance, and the way that it reflects emerging ecological and silvicultural knowledge is described.

A total of 31 private sites were selected randomly for survey, representing a sampling intensity of about 0.6% by number of schemes. In addition, 2 FES schemes were assessed, representing new large native woodland schemes established in recent years. The information gathered was split between: subjective assessments made of aspects of whole sites, or parts of sites and plot-based data recorded from systematically located plots (based on a random starting point). For the subjective part of the analysis, nine main factors were assessed (using 16 more detailed attributes) based on a Multiple Attribute Utility (MAUA) scoring approach i.e.: site suitability, stocking /planting patterns, species choice, open space, connectivity, natural regeneration, browsing and dieback, invasive non-natives and cultivation techniques. The following variables were calculated from the plot based data: stocking (n/ha); tree and shrub species composition (%) for the individual woods and NVC types, grouped into major / minor recommended tree/shrub species as per Bulletin 112; leader damage, bark stripping and shoot or crown dieback.

The categorisation of private woods into 4 categories of overall woodland quality, was as follows:
• Category 1 Not meeting guidance: 6 woods (19 %)
• Category 2 Not wholly meeting guidance: 9 woods (29 %)
• Category 3 Meeting guidance – could be improved: 12 woods (39%)
• Category 4 Meeting guidance to a good standard: 4 woods (13 %).

This suggests a little under half of private woods have something fairly fundamental wrong with them, whereas a little over half were essentially satisfactory or better. The high proportion of unsatisfactory woods is clearly disappointing and suggests failings in ecological understanding, silvicultural expertise, delivery mechanisms or professional capacity. However on the other hand, the creation of new native woods by planting is a novel and complex undertaking, that the forestry profession launched itself into with little prior expertise and only an understanding of plantation silviculture to build on.

The main factors on which new native woodlands are performing poorly are species choice, browsing/dieback, cultivation and stocking /planting patterns. There are indications that, on average, sites established under SRDP are performing better than those under SFGF and WGS. The
two Forest Enterprise Scotland woods (though not a representative sample) performed relatively well, though one was partly compromised by high browsing levels.

**Recommendations**

**Quality rather than quantity**
The overall aim for native woodland creation should be a shift towards improved quality – to incentivise high quality schemes in smaller numbers, rather than larger numbers of more mediocre woods. It is widely recognised that some new native woodlands are created with the apparent main objective of simply gaining the grant. This can sometimes lead to acceptable outcomes if the work is done diligently; but too often such schemes are located on poorer land, are relatively large and aspects of the work are executed poorly.

**Recommendation 1:** A grants, guidance and delivery structure should be sought that incentivises high quality schemes in smaller numbers, rather than larger numbers of more mediocre woods. Mechanisms are needed to try to filter out, and/or work to improve, poorer schemes.

**Authenticity as an objective of conservation management**
Woods that successfully follow current guidance generally deliver good conservation outcomes. However, there are questions about the degree of authenticity of some of these woods i.e. are they adequate replicas of the semi-natural woodland appropriate for the site; and in the future will it be possible to perceive if the wood has been planted, rather than being of natural origin? From a conservation point of view, several aspects of current practice, especially species choice and cultivation, introduce too high levels of artificiality into new native woodlands.

**Recommendation 2:** Closer attention needs to be paid to the authenticity of the woods (i.e. their similarity to semi-natural woods). The aim of guidance and practice on most sites should be to create woods that are indistinguishable from semi-natural woods, by say year 15-20.

**Objectives other than conservation**
New native woodlands generally have conservation as their primary objective, plus landscape and recreation, including shooting, as important aims. A subset of woods, small at the moment, but probably larger in the future, have timber production as an objective. At present guidance pays insufficient attention to objectives other than conservation; and in particular there is little useful guidance on how to integrate timber production with other objectives.

**Recommendation 3:** Guidance should assessed, and where necessary revised, to ensure that owners interested in timber production have access to guidance covering the modifications to establishment silviculture that allow integration of timber production with the other aims of management (e.g. via site selection, stocking, species choice, choice of seed source etc.

**Unsuitable and marginal sites**
Woodland creation appears to be taking place on some sites where the soil conditions and climate are at best marginal, and in some case unsuitable, for woodland creation. These are unflushed peats, especially those over 30 cm, with vegetation strongly dominated by calcifuge mire indicator species such heather, deer grass, certain sphagnum species and bog asphodel; and on exposed sites and/or in very wet climates. Such sites are typically not suitable for native woodland. Some may be suitable for scattered trees or bog woodland and some may not be - our current ecological knowledge does not allow these distinctions. Sites such as these, where there is doubt about the ecological appropriateness of planting trees, should be left unplanted; and the longer term
gameplan should be to allow colonisation on these sites by natural regeneration during the next generation.

**Recommendation 4:** Native woodland creation on poor sites, where there is any doubt about the ecological appropriateness or the likelihood of successful establishment, should cease. These should be added to the list of habitats that are better left as open ground. Better definition of sites is required so as practitioners can differentiate between site conditions that are:
- a) unsuitable for new native woodlands;
- b) suitable only for sparse trees and/or bog woodland;
- c) suitable for new native woodlands.

Careful establishment of native trees and shrubs on peats, including bog woodland, should still be allowable; but see recommendation 14 below, that suggests a move toward a longer term strategy of facilitating establishment of trees on these sites by natural regeneration during the next generation.

**Marginal sites**
It is not clear that the guidance for marginal land is understood by practitioners and that they are following the advice.

**Recommendation 5:** There needs to be a convergence of guidance to give consistent coverage of: a) the unsuitable sites issue (recommendation 4 above), marginal land, and the emerging FCS peatland policy. Marginal land should in any case only be allowed where it is a small integral part of a new native woodland on otherwise suitable ground. In general there should be a retreat from planting on marginal sites.

**Cultivation**
Excavator mounding, especially on wet sites, often causes unacceptably high damage to the soil surface and undermines the authenticity of woods, has long lasting ecological effects on the ground cover and can make woods unpleasant for visitors. The best examples of shallow excavator mounding and trailed mounding can be acceptable, but these are in the minority. A surprisingly high proportion of woods (or parts of woods) were established, apparently successfully, without cultivation or by using hand cultivation; and also by the use of inverted excavator mounding.

**Recommendation 6:** Experience with alternative forms of cultivation (to conventional mounding), including no-cultivation and inverted excavator mounding needs to be assessed, so as to develop lower impact approaches to site preparation, with prescriptions matched to different soil and vegetation conditions.

**Selection of target NVC types and species composition:**
The study provides the first hard evidence of the match (or otherwise) between the ideal mix of tree / shrub species that best reflects the site type, and mixes actually chosen by practitioners. The quality of species choice at the NVC level was highly variable, with a few good schemes, a large number that were moderately good but where there was considerable room for improvement, and some poor schemes. The MAU analysis shows 5 woods (16%) where species choice is a serious problem; but equally only 2 woods get a good score for species choice and most woods returned intermediate scores, showing that there is widespread room for improvement. The principle species chosen broadly reflect the best fit NVC types; i.e. there is no sign of widespread, fundamental, serious misunderstandings. However there is huge room for improvement, in order to avoid the over representation of some species i.e. the ubiquitous pine, alder and rowan; and the under-representation of others i.e. goat willow, eared willow and bird cherry (all three of which were mysteriously almost absent), sessile oak, silver birch, grey willow, hazel, hawthorn and juniper. A
significant proportion of species planted (5-34%) were not recommended in the lists in Bulletin 112 for the individual NVC types. Practitioners appear to make the fewest/smallest errors on W9, W17 and W18 sites; and greater ones on W4, W7 and W11. W4 and W7 appear to be under-represented on average and W9, W17 and W18 appear to be somewhat over-represented. Bulletin 112 states that trees should be planted either in pure clumps, or clumps with two or three species; and this advice seems generally to have been followed.

**Recommendation 7:** Improved understanding of NVC woodland types, and the site factors that determine them, needs to be further promoted amongst agents and owners. A study to find out how agents are currently determining species choice would provide useful background for developing improved guidance; i.e. are they actually determining target woodland NVC types, using ESC, or using some other method to determine species choice?

**Recommendation 8:** Improved guidance on use of precursor vegetation and soils is needed to help agents to select correct target NVC type. There is a case for:

- scrutinising the lists of indicator species for the different NVC types, and maybe building on some of the recent work that FES and FR have undertaken;
- considering if some simplified elements of the Ecological Site Classification could be introduced into Bulletin 112 to improve the characterisation of sites - but avoiding the full blown computerised expert ESC system;
- simplifying the soils information, because the current adoption of the FC soils system, with all its complicated sub-categories and phases is off-putting for many users;
- running training courses aimed at the private sector agents.

There is currently no attempt in guidance to prescribe what is an acceptable composition of species (i.e. percentages) for particular NVC types in different parts of Scotland; yet this is a challenge that every manager faces at the point of attempting to place an order for plants with a nursery.

**Recommendation 9:** One of the most useful improvements that could be made to guidance would be to provide broad ranges for species composition for different NVC types in different part of Scotland – but with a list of caveats urging managers to consider each site individually and avoid formulaic outcomes. New guidance should also deal with both transitional NVC types (e.g. between W4, W17 and W18 or W8/9 and W10/11) and intimate mosaics of NVC types. Foresters need to better understand the ecological status of heather, so as they don’t feel the need to switch to W18 and pine at the first sign of a blade of heather. i.e. that it is a perfectly acceptable component of W17 oak-birch woods and W4 wet woods.

It would appear that some species are being largely missed out of schemes because they are not being demanded by agents and/or are not available from nurseries.

**Recommendation 10:** There should be encouragement to plant the under-represented species especially e.g. goat, grey and eared willow, birch cherry, and sessile oak; shrubs in general and some of the rarer species such as aspen. This needs to be taken up with the nurseries.

**Recommendation 11:** Managers should be made aware of the fact that poor species choice can:

- be an important and wholly avoidable element in tree mortality.
- contribute to lack of authenticity in planted new native woodlands, especially over-representation of particular tree species (especially pine, alder and rowan).
Stocking
Stocking was, generally below the levels prescribed in guidance and sometimes far below. At these woods failures were typically due to: inclusion of areas of unsuitable or marginal ground, poor species choice and browsing and dieback impacts. At the worst sites, the effects of two or all three of these factors were combined. Stocking levels were higher in most woods established under SRDP, showing that the higher targets (1600 stems/ha at year 5) had generally, but not always, led to increased stocking levels. Irregular planting and clumping was recorded on about 70% of schemes, which suggest that guidance is generally being followed.

Recommendation 12: There may be a case for guidance and grant mechanisms to allow greater flexibility in stocking, between the higher levels needed for timber production, conventional levels that deliver closed canopy woodland in a reasonable time frame, and wood pasture type configurations. It is important that the beating up is carried out with recommended species for the NVC type in question and that conservancy oversight of stocking levels/beating up is maintained or strengthened.

Browsing
The proportion of trees with leaders damaged by browsing typically varied between 5% and about 30% of trees. A few sites showed damage levels of 40-60% which is sufficient to prevent parts of site from ever becoming woodland.

Recommendation 13: Managers should be encouraged to adopt a regular monitoring schedule to assess the impacts of browsing and bark stripping lasting until trees are well above browse height, and this should be an integral part of the woodland creation application. If trees remain vulnerable once fences have ceased to function properly, and the browsing is unsustainable from a biodiversity viewpoint, other methods of control should be adopted. The ultimate aim is inclusion of deer in the woodland at sustainable levels.

Natural regeneration
Bulletin 112 raises the idea of facilitating natural regeneration in the next generation from the planted trees, and it would be useful to expand this idea and provide more detailed guidance.

Recommendation 14: More naturalistic outcomes would emerge if practitioners, in some circumstances, were encouraged to:
- establish planted trees and shrubs over more limited parts of sites, in locations and on site types that mimic the current distribution of semi-natural woodland;
- leave larger parts of sites unplanted with the intention of developing woodland by natural colonisation in the longer term.

Open ground and non-woodland habitat
Most woods had broadly the proportion of “open space” suggested in guidance.

Recommendation 15: More naturalistic outcomes would emerge if practitioners were allowed more flexibility, to adopt the proportions of woodland and non-wooded habitat that deliver the best ecological and landscape outcomes in different parts of Scotland, and on different site types and ownerships. This would deliver a wider range of woodland/open habitat configurations – from large areas of contiguous woodland needed to give interior woodland condition in some parts of Scotland; to mosaics of woodland and non-wooded habitat in other locations.
**Recommendation 16:** Simple, specific and reliable guidance is required on what are the important non-woodland habitats, including key indicator species.

**Recommendation 17:** Owners and agents should be encouraged to start thinking more in terms of integrated habitat networks i.e. conceiving of woodlands as a mosaic with open habitats and paying attention to the configuration and quality of other habitats in addition to woodland.
1. Introduction and Aims

1.1 Need for assessment

New native woodlands (NNW) have been created with support of grant schemes for about the last 25 years, beginning in about 1988. In recent years new native woodlands have comprised about 60-70 % of the area of new woodland created in Scotland annually.

There have been some partial assessments of these new native woodlands1, but there has not been a critical overview of their quality, and the extent to which they are meeting their objectives. Some of these woods are 20 years old and are now fully established, but we do not know how they are developing and whether they are fulfilling their expectations. Given the scale of planting and the level of investment involved, it is clear that a review of progress is a useful exercise.

This review aims to collate field experience across a period spanning 3 grant schemes (WGS, SFGS and SRDP), and provides a picture of the evolution of both practice and guidance. Currently, there is no information on the extent to which managers have followed FC Guidance when creating these woodlands, which is likely to have a bearing on their quality. If practice in the field deviates from guidance, we need to know about this; either to reinforce guidance or, if the guidance is inappropriate in certain ways, to revise and improve it. Conservancy staff dealing with individual schemes will have a collective view on these issues, but these aspects of practice in the field have never been formally assessed.

This work will therefore help evaluate the effectiveness of guidance and inform future priorities and policy in native woodland creation.

1.2 Scope of project

This report is concerned mainly with the ecological quality of new native woodlands, rather than their landscape, timber production or recreational potential. However reference is made to the other objectives of management in discussing the conclusions of this work.

The study took a broad view of what constitutes new native woodlands, spanning the range from large upland schemes, to smaller farm woodlands and areas of native woodland established as part of larger newly planted forests. However, broadleaves planted for landscaping purposes and/or that included a significant component of non-native tree species were excluded. Restock sites were excluded because the focus was on creation of new woodland.

The study included only planted new native woodlands, rather than those where the primary method of establishment was natural regeneration. This is because planting is the dominant method of native woodland creation and the one where poor practice can potentially introduce elements of artificiality into woods that may undermine conservation objectives. The report covers the Scottish mainland and inner isles; the outer islands were excluded from the study on cost grounds.

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1 for example work by Forest Research on early tree growth.
1.3 Aims and objectives

The overall aims of the project were to:

1. review the ecological and silvicultural aspects of both practice and guidance relating to creating new native woodlands;
2. assess experience in the field by sample survey of a range of new native woodlands.

The specific objectives were to:

- To assess how far new native woodlands meet FC guidance on design, location and species composition etc.
- Provide an account of the strengths and weaknesses of current practice.
- Assess the extent to which new native woodlands appear to be meeting biodiversity policy objectives.
- To outline the factors which appear to drive outcomes in the field and recommend ways to enhance the quality of future new native woodland creation.
- To assess guidance, policies and priorities and recommend any changes or improvements.
2. **Guidance on the design and establishment of new native woodland**

Guidance for the establishment and design of new native woodland takes 3 main forms (see table 1):

1. **Grant scheme documentation**: These set out guidance associated with specific grant schemes covering:
   - eligibility criteria relating to aspects of the design and establishment practice i.e.:
     - size and configuration, proportion of open space, stocking densities, genetic origin of stock and types of land that are ineligible for grant.
   - in some cases criteria on the preferred location of schemes, especially in relation to forest habitat networks.
   - information that applicants are obliged to provide during the application process (e.g. site survey requirements).

2. **Specific guidance for native woods**: These are documents that give more detailed guidance on a range of aspects of new native woodland creation and typically apply across multiple grant schemes (e.g. Bulletin 112). Forest Enterprise Scotland has a suite of Operational Guidance Booklets that cover similar topics.

3. **Generic forestry guidance that is relevant to new native woodlands**: These cover overarching policy or research related issues that impinge on native woodlands e.g. UK Forest Standard and the Ecological Site Classification.

These have been published successively starting in 1988, with individual elements of guidance gradually building to form an increasingly comprehensive body of knowledge (see table 1).

The following sections give an overview of the guidance, divided into 4 time periods, within which the different elements of guidance are described in date order.

### 2.1 WGS1 &2 1989-1993: The first new native woodlands

**WGS 1**

WGS1, operated between June 1988 and June 1991, and offered grant aid for the establishment of broadleaved woodland, following on from similar provisions in the previous “Broadleaved Woodland Grant Scheme”.

The stated intention of WGS 1 was to “encourage the continued expansion of private forestry in a way which “achieves a reasonable balance with the needs of the environment”. The aims of the scheme were to:

- increase timber production
- promote the contribution which new woodlands can make to rural employment, to the provision of alternative uses for agricultural land no longer needed for food production
- enhancement of landscape, recreation and wildlife conservation

In order to comply with statutory requirements, the production of utilisable timber had to be one of the objectives; but the leaflet states that a secondary objective could be “woodland .....which is
designed to create a diversity of wildlife habitats”. So the scheme did not encourage native woodland for ecological benefits, which became the focus of later grant schemes.

The only guidance referred to in the 1988 WGS leaflet was the “Silviculture of Broadleaved Woodland “ and “Use of Broadleaved Species in Upland Forests”, which described standard silvicultural techniques for establishment and management of broadleaves. However some outline guidance on species choice, showing which species were native in different parts of Scotland, was provided.

### Native Pine wood Grant

The 1988 WGS grants extended the broadleaved rate of grant to the planting of native pinewoods in specified areas of Scotland described as: “the native pinewood localities identified by Steven and Carlisle in their book The Native Pinewoods of Scotland, together with additional areas which are agreed as suitable for encouraging the extension of the native pinewoods”.

In 1989 FCS produced a leaflet called (Native Pinewoods: Grants and Guidelines) setting out some eligibility rules and operational guidelines for the creation of new native pinewoods, in addition to those applying to WGS. The emphasis was firmly on extending existing pinewoods rather than new planting in areas remote from pinewoods. This stated that:

- Natural regeneration is the preferred method of woodland establishment and planting is a last resort;
- Stock must originate from the same locality
- Trees must be planted in a way that reflects natural habitat variation
- Full grant will be paid for a stocking of 1100 trees/ha (lower numbers paid pro rata)
- 15% of planted stock should be other native trees and woody shrubs
- Where possible planting should be undertaken without cultivation – and any cultivation should be as light, irregular and intermittent as practicable

### WGS2

WGS2 operated between June 1991 and September 1994. Whilst maintaining the specific focus on new native pinewoods, WGS 2 also encouraged the planting of a wider range of native species provided they are “silviculturally suited to the site”. WGS2 followed the main provisions for WGS1 but also introduced a several new features.

- Grant aid for all woody shrubs.
- Encouragement to leave suitable areas of open ground to enhance conservation value up to a maximum of 20%
- A general prohibition of draining
- Use of the map of zones of biochemical similarity to determine the seed sources of pine
- Grant banding by 4 woodland sizes

WGS 2 guidance also featured Environmental Assessments (EA) (initially introduced in 1988), and introduced the 100 ha limit that triggered an EA.

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Table 1 Main elements of guidance for the Establishment of New Native Woodlands (see also figure 1)

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<tr>
<th>Grant Scheme</th>
<th>Date</th>
<th>Main Elements of Guidance for New Native Woodlands</th>
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<tr>
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<td>Grant scheme guidance</td>
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<tr>
<td>WGS1</td>
<td>1988-1991</td>
<td>• Native Pinewood grant scheme leaflet (1989)</td>
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<td></td>
<td>• WGS Applicants Booklet</td>
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<td>WGS2</td>
<td>1991-1994</td>
<td>• Site Survey Requirements for New Native Woodland WGS Applications</td>
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| WGS3         | 1994-2003 | • Grant Aid for Native Pinewoods under the Woodland Grant Scheme (WGS) 1997 | • Creating New Native Woodlands Bulletin 112 1994 | • UK Forest Standard 1998
|              |         | • Using Local Stock for Planting Native Trees and Shrubs FC Practice Note 8 1999 | | |
|              |         | | • Forest habitat networks and SFGS expansion grants FCS Guidance Note 20 2003 | |
| SRDP         | 2006-2013 | • SRDP – Rural Priorities Woodland creation – Native Woodland pages | • Seed sources for planting native trees and shrubs in Scotland. FCS Guidance 2006 | • UK Forest Standard 2011 |
|              |         | • Assessing Marginal Sites for New Native Woodland RDC - Rural Priority Applications Guidance Note No 35 | • Developing native woodland habitat networks FCS Guidance 2009 | |
2.2 WGS3 1994-2002: Introducing ecological structures into woodland design

WGS3 was launched during September 1994 and was closed for new applications in February 2003. This formally introduced into guidance the idea of broadleaved native woodland (as opposed to new native pinewoods); though oddly the provision appeared within the section on “Numbers of trees per ha”. This stated that broadleaves could be planted at 1100 stems per ha “for new native woodlands on appropriate semi-natural habitats or areas adjacent to existing semi-natural woodland”. Meanwhile Native Pinewoods still had a separate section in the guidance.

For native pinewoods it was possible to obtain not just planting grant but “all other grants under WGS”, so: community supplement, locational supplement, better land supplement and farm woodland premium. It is not clear from reading the guidance if these were also available for broadleaved native woodland, but in reality they were.

This was the first grant scheme to have the benefit of detailed guidance on native woodlands set out in Bulletin 112 “Creating New Native Woodlands” and the Practice Guides 1-8 “The Management of Semi-natural Woodland” (see below).

2.2.1 WGS 3 Grant scheme documentation
This set out the following guidance:

2.2.2 “Creating New Native Woodland” (Bulletin 112) 1994
This provides principles behind the design of planted new native woodlands and sets out a framework for practitioners designing and establishing new native woodlands. The main recommendations are to:

- match locally native tree and shrub species to site type.
- allow new native species plantations to become semi-natural in the long term by using minimal soil disturbance (usually mounding rather than shallow ploughing), little or no artificial drainage, and by trying to mimic natural patterns of plant spacing and distribution.

The essential pre-requisite is a good knowledge of local site factors, gained partly through published maps and data, but largely through field survey. The main aspects of guidance are as follows:

Woodland Size: Woodlands should ideally be larger than 2-5 ha. If smaller they should have a compact shape rather than strip.

Site variation: The woodland canopy species should reflect site conditions (i.e. a mosaic in response to topography, wetness, altitude, geology) and lists of precursor vegetation species are provided to help guide species choice. Flushes should be picked out.

Open ground: This should be chosen as areas:
likely to naturally have lower tree cover – wetland, crag, scree, shallow soil, exposed ridges
areas which could carry woodland but would be better as open space including a range of soil/vegetation types
notable open ground habitats.

Open areas should be connected into irregular networks. The general amount of open space should reflect the characteristics of the site and the objectives of owner.

**Natural colonisation:** This should be favoured and provision should be made for this by leaving substantial areas (20-50% of scheme area) where (future) natural colonisation might take place – ideally across all soil types.

**Tree/shrub species choice:** No tree species should be planted outside their natural ranges. Species choice should reflect the lists of tree and shrub species provided in the bulletin for specific NVC types. The natural proportion of sessile and Pedunculate oak should be maintained – with predominantly sessile oak used where local woods are mainly sessile.

**Planting stock origin:** Avoid imported provenances and be aware of any unusual genotypes that may develop. Very rare tree and shrub species such as rare whitebeams should not be planted. Naturalised or exotic species and non-native invasive species should be removed.

**Planting patterns:** These should be varied following site conditions. Planted clumps and open areas should be utilised, with variable clump size (single trees to clumps 50m across). Spacing and species composition should be varied among clumps. Intimate mixtures with many species should be avoided (2-3 species at most in clumps). Glade sizes should be variable with mixes of clumps and glades.

**Stocking:** Stocking should be variable with spacings in the range 2-5 m. There should be variable tree spacing at transitions between woodland and open ground.

**Management:** Patch scarification is preferred on freely draining soils, and mounding on wetter. Ploughing and drainage is discouraged.
- Disturbance by vehicles/machinery, leading to invasive plant species gaining a foothold are discouraged.
- Fertilisers are confined to sites where their use is considered essential.
- Herbicides can be used, sometimes as a replacement for cultivation.
- Grazing; it is usually best to exclude all grazing for periods of 5-20 years.
- Management of early canopy structure/composition by careful respacing is often useful.

2.2.3 “Management of Semi-natural Woodlands” Forest Practice Guides 1 - 8 1994 (re-issued in 2003)

This series of guides is mainly focused on management of existing semi-natural woodlands, but does give some brief guidance about extending woodland by planting, especially for pine. The main elements are:
• **Local stock** should be used
• Planting patterns and choice of **species** should reflect natural site variation. At least 15% of species in new native pinewoods should be broadleaved species and slow colonisers like aspen and juniper can be planted into native pinewoods
• **Uneven spacing** should be used
• **Site preparation**: this should be minimal or none, and patch scarification preferred and drainage should be avoided
• **Weeding**: in general weeding is not needed, but hand weeding or spot herbicides can be used in years 1 and 2.
• **Open space**: areas of heath, mire, sedge; wet hollows, hard knoll, scree should be maintained.

2.2.4 “Seed sources for native trees and shrubs” 1999
This describes which seed origins are considered appropriate, using the FCS local seed zone system. The seed origin of planting stock was seen as one reason why plantings sometimes grew poorly and/or failed and this guidance sought to provide a structure for both advising on limits to seed transfer (between source and planting site) and regulating seed and plant supply.

2.2.5 “Grant Aid for Native Pinewoods under the Woodland Grant Scheme (WGS)” 1997
In 1997 FCS issued guidance specifically for native pinewoods in “Grant Aid for Native Pinewoods under the Woodland Grant Scheme (WGS)”. This stated that:

• Bulletin 112, ‘Creating New Native Woodlands’ should be used;
• New native pinewoods should be created within the native range of Scots pine, on areas consisting mainly of semi-natural heaths with suitable precursor vegetation and also suitable sites adjacent to existing pinewood.
• Planting was not normally acceptable in an existing native pinewood until after all reasonable steps to encourage regeneration have been tried and failed.
• Planting stock used should be as local as possible and from the appropriate “region of biochemical similarity”. In the north-west and south-west regions, only planting of stock from within that region was allowed. In the other 5 regions, planting stock must derive from within that region but we may accept modest transfer near the boundaries.
• The aim should be to create a natural distribution of plants on the site. Thus a clumped distribution is preferred, reflecting site features. Within the area to be planted there must be at least 1100 trees per hectare, but on certain sites more may be required.
• Normally, at least 15% of the area of new native pinewoods was to be native trees and shrubs other than pine. Tall woody shrubs such as juniper, hazel, holly and native shrub willows was allowable, up to a limit of 10% of the whole area getting grant. On suitable sites, we may agree to proposals to convert parts of broadleaved woodlands to pinewood.
• Open ground was grant-aided up to a limit of 20% of the area.
• Proposals to plant Native Pinewoods at higher elevations will need to be supported by an Ecological Site Classification (RIN 260 Sept 1995) and DAMS score report.

2.3 SFGS 2003-2006 - Introducing Riparian Woodland and Forest Habitat Networks

SFGS operated between June 2003 and August 2006 and marks the date at which Forestry Commission Scotland developed its own grant scheme (Scottish Forestry Grant Scheme). This provided two headings under which support could be sought for the creation of new native woodlands: P2 “to expand the area of native woodland” and P3 “to improve riparian habitat”. The stated objective was to “create woodlands with a diverse structure and a natural woodland character”.

2.3.1 Scottish Forestry Grant Scheme documentation (SFGS)

P2 Expand the area of native woodlands

Grants were available “to expand the area of native woodlands, to help deliver Habitat Action Plans, preferably through natural regeneration and the development of Forest Habitat Networks”. The list of eligibility criteria included reference to the following aspects:

• Contributions to Forest Habitat Networks (referring to FCS Guidance Note 20 ‘Forest Habitat Networks’- see below).
• in areas covered by Strategic Forest Habitat Network
• Contributions towards native woodland Habitat Action Plan expansion targets and/or objectives and woodland Species Action Plan objectives.
• Applications to be based on an assessment of the site potential.
• Minimum scheme area of 0.25 hectare and applications of more than 300 hectares of new planting were subject to negotiation.

Woodland type: Applications were required to specify the type of native woodland being created, using the Native Woodland Habitat Action Plan woodland types and National Vegetation Classification woodland types.

Stocking: The minimum required stocking density was to be agreed with FCS staff, but an average of at least 1,100 stems per hectare across the site was expected in order to define the area as being established. Higher average stocking densities were required on more demanding sites.

Woody shrubs: A proportion of native woody shrubs up to 20% of the grant-aidable area was acceptable but could be higher where this is justified in terms of site type and guidance on design of native woodlands.

Local provenance: Where planting was agreed, all planting stock was to be of a local provenance as defined in the FC Practice Note 8, ‘Using Local Stock for Planting Native Trees and Shrubs’. 

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Establishment operations: Applications needed to specify the establishment operations needed in order to prepare the site and establish the woodland.

P3 Improve riparian habitat

The list of eligibility criteria included reference to the following aspects

1. The minimum width of riparian zone allowed was 25 metres each side, from the edge of the watercourse. Narrower areas that would develop woodland character may be allowed where eligibility criteria are clearly being met. The riparian zone must adjoin watercourses greater than 1 metre in width, except where it is agreed that important habitat linkages can be made along a watercourse closer to its source.

2. These vegetation zones should be managed in an integrated way so that the aquatic environment, water quality and value of the distinctive riparian habitat are maintained or enhanced.

3. Tree species should be locally native, accord with the principles of Ecological Site Classification and match the relevant National Vegetation Classification types. Scots pine was accepted in native pinewood areas.

A detailed map was required showing the design and layout of trees and open ground in order to ensure that wetland, species-rich flushes and other associated habitats were protected and that local topography and landform are taken into account. Where shading of new planting was likely to be a problem, or where physical damage to the developing riparian woodland could occur, a buffer zone of at least 10 metres was required. Open or partially wooded conditions were to be maintained, such that bankside vegetation thrives, thereby minimising bank erosion. Normally about half the length of watercourses was required to be left open to sunlight, with the remainder under dappled shade from trees and shrubs. Open ground to the south of a stream was regarded as most valuable.

2.3.2 “Forest habitat networks and SFGS expansion grants” FCS Guidance Note 20 2003

Guidance note 20 introduced the concept of forest habitat networks into guidance for planted woodlands. This recognized that some locations for new woodlands were better than others and that increasing the connectivity between new and existing native woodland offered considerable ecological benefits.

Guidance stated that to contribute to Forest Habitat Networks there must normally be either of two categories of ‘source woodland’ nearby:

- existing native woodland within 300 metres of the proposed new woodland; or
- areas of non-native forests within 300 metres of the proposed new woodland which meet the criteria for conversion to native woodlands as detailed in the practice guide ‘Restoration of Native Woodland on Ancient Woodland Sites’.

Distance to nearest ‘source wood’ should be lower where:
• natural colonisation prospects for associated woodland species are poor, e.g. intervening land is intensively managed agriculture (e.g. arable/improved pasture) or built development.
• there are no woodland, hedgerow or other suitable habitat features linking the proposed site to the existing native wood (PAWS site).
• the ‘source’ native wood is small (under 2 ha) and/or of low ecological quality.

Distance to nearest ‘source wood’ could be greater where:
• there are other well-linked woodland habitat features in the landscape (including non-native woodland, mixed woods, riparian woods and hedgerows) which provide good ecological connection between the proposed new planting and existing native woods.
• the intervening open land is mainly semi-natural vegetation, not intensively managed for agriculture.
• the ‘source’ native wood(s) are of good size (over 5 ha) and ecological quality.

2.4 Consolidating practice under SRDP (2006-present)

2.4.1 Scottish Rural Development Programme (SRDP)

The SRDP Native Woodland creation web page lists the eligibility criteria for new native woodlands as follows:

• You must comply with the UK Forestry Standard.
• The minimum width is 15 metres and the minimum eligible area is 0.25 hectare.
• The woodland must be comprised of native species and provenance appropriate to the site.
• The woodland must comprise a minimum of 75% and a maximum 90% native species (NBL / SPC) and a minimum 10% to maximum 25% open ground is allowed for management purposes.
• Minimum Stocking densities - 1600 trees per hectare at year 5, or when considered to be established, on the planted area (excluding mapable open ground).
• There is a presumption against planting on peat >50 cm deep. Any such areas must be mapped as 'other land' and will not be eligible for grant aid.

“Satisfactorily established” means that the trees must be present to the minimum stocking densities specified, healthy, and in a condition capable of continued growth given no further weeding but subject to normal ongoing maintenance operations such as protection from inappropriate grazing by wild or domestic animals.

http://www.scotland.gov.uk/Topics/farmingrural/SRDP/RuralPriorities/Options/WoodlandCreation/NativeWoodlands
Woodland Creation Technical Guidance web pages provide a list of sources guidance, including links to:

- UKFS
- Guidance about woodland creation on marginal sites
- Developing native woodland habitat networks
- Seed sources for planting native trees and shrubs
- Natural Regeneration
- Treeline woodlands
- Key species conservation

Bulletin 112 is not listed or cited under technical guidance links but is included in a list of relevant technical guidance on the native woodland creation page.

2.4.2 Woodland creation on marginal sites: Assessing marginal sites for new native woodland RDC - Rural Priority Applications Guidance Note No 35

These are sites classified as being poor/very poor - Soil Nutrient Regime and wet/very wet – Soil Moisture Regime as per ESC Ecological Site Classification (Bulletin 124). FCS seeks a robust demonstration of the sites capability to successfully establish and grow the proposed woodland type. Planting will be restricted to suitable parts of the site for planting, usually locally sheltered or of better soil moisture or nutrient regime and typically comprise of knolls, slopes and gullies. Applicants are required to map the main NVC communities (Grasslands, Heaths, Mires and Woodlands) and soils to the defined types in FC Record No 71. A detailed soil survey, giving accurate indicators of soil nutrient status and soil moisture regimes, can then be used with climate and topographic data in an ESC approach to planting design. In additions the following should be assessed: climate and exposure; topographic factors that influence tree growth, i.e.: elevation, aspect, slope, terrain, drainage/hydrology, and windiness (DAMS Score); and geology.

Plant communities which are of greater conservation value left unplanted should be identified. FCS currently operates a general presumption against new woodland creation on soils with peat exceeding 50cms in depth.

2.4.3 Treeline woodlands

Within Rural Priorities, up to 25% of the area of new native woodlands funded under the native woodland creation model may be allowed as treeline woodlands and receive expansion payments (See Forestry Commission Scotland Treeline Woodlands And Rural Development Contracts Rural Priorities Guidance Note No 13). Treeline woods will only be supported where they:

- encourage the expansion of existing semi-natural woodlands or
- enclaves of already established high-elevation trees and shrubs and
- where they will contribute to core FHN expansion zone

4 [http://www.forestry.gov.uk/website/forestry.nsf/byunique/infd-8rqlqs](http://www.forestry.gov.uk/website/forestry.nsf/byunique/infd-8rqlqs)
Where planting is necessary, applicants are required to match locally native tree and shrub species to site type. Particular attention should be paid to the need to select seed sources from seed zones and elevations suited to the proposed planting site.

Planting densities should be quite high to reduce the risk of unacceptable planting failure arising. Target stocking density of treeline woodlands, at establishment, is at least 1100/ha in planted areas with plants in groups of 2-3m spacing. Planting should be confined to suitable micro sites e.g. in sheltered gullies, corries and burnsides, or pockets of fertile base-rich soil. So the proportion of unplanted area may normally be quite high. A mosaic of woodland should be established which will allow natural expansion over time. Suitable species are: Scots pine, Downy and Dwarf Birches, Rowan, Juniper, Eared Willow and certain prostrate Willows.

Only minimal soil disturbance, little or no artificial drainage should be used and natural patterns of plant spacing and distribution should be adopted. In order to maximise biodiversity, woodland areas should be inter-connected in a matrix of woodland cover. It should be borne in mind that similar linkages must also be considered for moorland habitats in the montane zone.

It is critical with treeline woodlands that the relatively better drained and relatively more fertile sites are selected for initial establishment. Applicants should calculate DAMS scores and aim for a zone between 19 and 22.5 (with AT > 575 °C).

2.4.4 “Developing native woodland habitat networks SRDP version”: FCS Guidance 2009

This expands the guidance issued under SFGS and sets out three methods to help choose areas for native woodland expansion:

- habitat network plans or strategies agreed by local stakeholders;
- maps indicating potential native woodland network areas; and
- guidance for building native woodland networks in other areas.

Potential native woodland network maps for Scotland have been created by Forestry Commission Scotland, based on modelling analyses carried out by Forest Research. The maps include core woodland areas expected to have high conservation value, together with 2 potential expansion zones. These zones represent the distances over which woodland species of slow or moderate colonising ability might be expected to disperse and to establish themselves in new native woods created near to the core areas, within a period of 50-100 years.

Native woodland expansion should preferably be focussed around existing native or ancient woods, to help develop diverse and resilient native woodland habitat networks. However, in areas of very low native woodland cover some more isolated planting will be needed to develop new ‘nodes’, which can form the basis of future networks. As a general rule, try to locate areas of planting or natural colonisation of new native woodland so that they are adjoining or close to core woods in the networks. Biodiversity gains are likely to reduce in the following order, according to the proximity of core woodland:
a. Sites adjoining or partly adjoining core woodland.
b. Sites which are not directly adjoining any core woodland but are at least partly within the 250m network.
c. Sites outside the 250m network, but within the 1000m network.
d. New woodlands outside both expansion zones

Outside the mapped network areas, priority for locating new or converted native woodlands to help develop forest habitat networks should be in areas adjoining or close to mature native or riparian woodland habitat.

2.4.5 “Seed sources for planting native trees and shrubs in Scotland”. FCS Guidance 2006.

This built on the GB-wide guidance issued in 1999, and included lists of species considered native in each of the native seed zones. It also provided guidance for native woodlands grown for timber production.

2.5 Generic forestry guidance of relevance to new native woodlands

New native woodlands became progressively integrated into generic forestry guidance including UKFS, UKWAS, and Forestry Commission Ecological Site Classification, publications on the silviculture of broadleaved species and Scots pine, and Forestry and Woodland Frameworks. It is beyond the scope of this review to detail all these, but the important provisions of the UKFS are listed below.

UK Forest Standard (UKFS)

The UKFS (2011) includes the following overarching statements relevant to new native woodland creation under the biodiversity guidelines.

Native woodland

- Manage native woodlands to ensure their biodiversity is maintained or enhanced; base management proposals on protecting or extending semi-natural features and pay particular attention to ancient semi-natural woodlands.

Landscape ecology

- Improve the ecological connectivity of the landscape for woodland and other species by extending and linking habitat features; consider the juxtaposition of wooded and non-wooded habitats and aim for the best overall result for biodiversity

Tree and shrub species selection

- When managing or creating native woodland, encourage a representative range of the native species associated with the woodland type.
- Choose trees or shrubs which are well adapted to the site and are drawn from a sufficiently wide genetic base of parent trees to promote future adaptation.

Open scrub and edge habitats

- Plan open space in new and existing woodland to create and enhance networks of open-ground habitat.
• Develop graded edge habitats; thin woodland edges to create a diverse and convoluted structure and a transitional zone between habitats.
• Ensure wetland features such as springs, flushes and bogs are protected, and take opportunities to restore degraded features.

2.6 Evolution of ecological issues relating to native woodland establishment and design

An overview of the main provisions of new native woodland guidance and the dates at which they were introduced is shown in figure 1 below.

2.6.1 The early years – New Native Pinewoods

During these early years there was a period – which looks illogical with the benefit of hindsight – when provisions for native pinewoods were far more advanced than for all the various types of broadleaved woodland. For example, in the period up to 1994, new native pinewoods remained the only type of native woodland highlighted in grant scheme documentation and new native pinewoods benefited from advice on species composition and genetic origin of stock, whilst broadleaved woodland had none. This reflects foresters’ and ecologists fascination with the native pinewoods; and it took several years before broadleaved woodlands were, eventually, afforded similar status. This is despite the fact that Scotland’s Atlantic broadleaved woodlands are at least equally ecologically as valuable as Caledonian pine.

In early schemes, the main aspects of guidance on the design of new native pinewoods related to:

1. basic issues such as species choice, tree spacing, protection and the amount of open space; this limited suite of considerations being essentially inherited from the plantation silviculture of previous decades. Successful tree establishment was the main consideration
2. a limited number of special provisions for native woodland i.e. reduced and variable stock, use of local stock and limitation on the types of cultivation.

Perhaps the main change from standard silviculture was the adoption of 1100 trees / ha minimum stocking requirement. Intended as a minimum requirement, this stocking level was, predictably, adopted as the norm in order to minimise establishment costs. It became increasingly controversial, because it effectively precluded any chance of quality timber production on better lowland site, and some people argued that it did not emulate the close early spacings that can arise in native woodland via natural regeneration.

Cultivation advice briefly reflected the legacy of plantation silviculture by allowing the practice of ploughing to continue in new native woodland establishment for a number of years. Indeed there was a brief period when some practitioners sought simply to switch from afforestation of low fertility sites with spruce and replace these with native species at the lower stocking, using similar establishment techniques (e.g. Strath Cuillinard). Whilst ploughing could enhance early growth and survival, it soon became clear that this was not a satisfactory cultivation method for new native woodlands.
Introducing ecological design into new native woodlands – early 1990’s

The early 1990’s saw the development of design, genetic and silvicultural practices aimed at better emulating natural ecological features in new native woodland. During this period the differentiation between pinewoods and broadleaved native woodland disappeared, with all the different types of native woodland (i.e. HAP or NVC types) given similar status and treatment. Design and genetic aspects introduced in 1994 included:

- Matching species to vegetation and soil types
- Variable spacing and clumping of planting
- Careful choice of the location of open ground to reflect site conditions and achieve internal connectivity
- Guidance on seed sources to foster appropriate transfer distances between sources and planting sites

Silvicultural advice now precluded ploughing, and advocated “minimal site preparation”. In practice, accommodation was sought between minimising intervention whilst not exposing planted trees to undue risk of failure due to waterlogging, weed competition or lack of nutrients. Prescriptions varied between no/hand cultivation, scarification and mounding; and phosphate fertilisers at planting were advocated by some practitioners on the least fertile sites. There were multiple examples of schemes that partly failed, or where trees grew poorly; and a debate ensued about the reasons for failure and how to avoid it. The question as to whether some land was inherently unsuitable for trees was raised but largely left to the judgement of field practitioners and conservancy staff. The default cultivation practice became mounding either with mounding machines or excavators and only a minority of schemes were established without cultivation.

New native woodlands and landscape ecology

The next major advance was the introducing the principles of landscape ecology into native woodland guidance via the concept of forest habitat networks (FHN), and later as integrated habitat networks (IHN). This concept, first championed by SNH, was worked up by Forestry Commission starting in about 2000 and introduced as guidance in 2003. Choosing the location of new native woodlands so as to improve connectivity, using the BEETLE model as guidance, became an increasingly important aspect of evaluating the conservation value of new native woodland projects. Conservancies were able to discourage proposed new native woodlands isolated from existing native woodland. More recently the concept of IHNs has come to the fore where design seeks to consider the connectivity of both woodland and non-woodland habitats as habitat mosaics; but this is not codified in guidance at present. The management of woodland and other habitats as mosaics is emerging in larger “landscape-scale” native woodland restoration schemes.

The limits of new native woodland establishment - marginal land and treeline sites

A substantial proportion of new native woodlands have been established on poorer upland sites with low opportunity costs for owners. These have included whole sites or parts of sites that are marginal for woodland in terms of their soil conditions (low nutrient, high moisture) and climate (high exposure, low temperature). The different outcomes that are desirable on such sites – limited species choice, planting targeted towards the better microsites, low proportion of planted area - are recognised in the guidance for marginal sites and treeline sites introduced under SFGS in 2003 and revised for SRDP in 2008. New native
woodlands are only allowable on treeline sites when it involves expanding existing woodland towards the treeline.

Protection from deer
The vast majority of planted new native woodlands have been established behind deer fences, with a view to dismantling the fences once the trees are fully established and able to withstand the presence of substantial deer numbers. However, in recent years the practice has emerged of reducing deer numbers sufficiently by shooting to allow establishment of trees, particularly on landscape-scale restoration projects. This retains the presence of some deer, with the habitat benefits they bring, but at least temporarily, at low numbers. Smaller lowland new native woodlands are now often established using tubes behind stock fences.
Figure 1 The main provisions of guidance according to the main ecological and silvicultural features of new native woodland establishment. Green boxes = current.

- **Grant scheme**
  - FGS (1989)
  - WGS1,2 (1994)
  - WGS 3-FWPS (2003)
  - SFGS (2008)
  - SRDP (2008, present)

- **Size**
  - Minimum woodland size 0.25 ha / 15m wide
  - Large schemes subject to negotiation
  - FHNs introduced
  - Landscape-scale projects allowable
  - Riparian woodland introduced
  - Tree-line woods and marginal sites subject to special provisions

- **Location**
  - Species recommended only for pinewoods
  - Recommended species by NVC type for all woodland types; major trees, minor trees, shrubs.
  - Species choice determined by precursor vegetation / soil

- **Species composition**
  - Local origin preferred but only defined for Scots pine
  - Local seed zones introduced for all species

- **Genetics**
  - 1100/ha
  - Variable spacing introduced
  - Proportion of open space up to 20%
  - 1600/ha at year 5

- **Spacing**
  - Minimal cultivation preferred; mounding and scarification allowable
  - Drainage disallowed

- **Open space**
  - Clumping and internal connectivity introduced

- **Planting design**
  - Minimum woodland size 0.25 ha / 15m wide
  - Landscape-scale projects allowable

- **Cultivation**
  - Subject to negotiation
  - Introduced
  - Introduced
  - Introduced
3. Sample survey of Native Woodland Planting Schemes – Methods

In order to evaluate practice in the field, a random sample of new native woodland creation projects were selected and assessed in the field. The aims of this were to:

- collate quantitative and qualitative information on each wood;
- assess the attributes of each wood that contribute to biodiversity value and authenticity (i.e. the degree to which the woodland emulates a semi-natural woodland of the same age) using the data and expert judgement (for non-quantifiable aspects);
- aggregate the data from the woods to give an overall impression of how the new native woodlands collectively are performing in relation to guidance and their ecological expectations.

3.1 Creating the dataset – private woodlands

The Grants databases (WGS, SFGS and SRDP) were filtered to give a list of candidate planted new native woodlands on privately owned ground. Filtering was by:

- WGS 2 & 3 – New planting of NBL and SP/SPC (codes NP, NB, & NS)
- SFGS – Establishment grants for native woods (code P2, P3)
- SRDP – Woodland creation option; native woodlands; new planting

The resultant list comprised 4864 sites (and excluded new native woods established primarily by natural regeneration). A minimum woodland size of 5 ha was used, as this was regarded as the minimum size of wood worth investing resources to visit and assess. The youngest schemes included were those established in 2011 and therefore had three growing seasons when assessed.

The entries from the different grants databases were merged and useful information common to each database were extracted that gave an impression of the location, woodland type, date of establishment and ownership.

A number of difficulties were encountered during this process in terms of:

- the different information available in the different databases;
- the lack of consistent information to allow new native woods to be distinguished from other types of woodland;
- lack of availability of information in NWSS on the potential sample woods in Highland region.

Errors arising from these problems introduced some elements of uncertainty regarding the sampling process.

Random selection of the sample

The dataset was then stratified into 3 woodland sizes; 5-19 ha, 20-99 ha and 100+ ha. This was to equalise the chances of selecting from these different size classes and avoid biases due to either the large number of smaller schemes that are known to exist, or the effect of the sample happening to containing an anomalous number of large schemes, which would inevitably bias outcomes. For each of these strata 23 sample sites were initially selected using a random number generator.
The new native woodlands on this short list were then assessed for broad suitability, to exclude woods that were actually not *bona fide* native woods, but mixed broadleaved woods planted for amenity purposes. This assessment of suitability was done using NWSS and GoogleMaps aerial photos for southern and central Scotland; but in the Highlands where NWSS result were not yet available, sites were assessed using GoogleMaps, aerial photos and in some cases by confirming their suitability by talking to conservancy staff.

Sites were selected by ascending order of random number until a total of 69 apparently suitable sites were available. Of these, 31 sites were selected for surveying and the remainder were retained as “reserve” sites in case any of the 31 turned out to be unsuitable. In fact, nearly all the reserve sites were included in the final selection as a substantial number (37) of the initial sites were rejected, because they were either:

- primarily dominated by natural regeneration (38%);
- less than 5 ha comprised of native species (24%);
- too recent i.e. 2012 SRDP (16%);
- schemes with non-native conifers (11%);
- other reasons (11%).

**Sample size/sampling intensity**

The final tally of 31 private woods was chosen as a compromise between an initial aim to achieve a minimum sampling intensity of approximately 1% (which, by numbers of woods, would be 48) and the resources that were available to the project, which dictated a lower number of woods. One of the main sources of variation of interest in the research were the practices of individual agents and owners, and this meant that the sample size in terms of *numbers of woods* needed to be as high as possible (as opposed to maximising the area sample over a smaller number of ownerships).

**3.2 Sites on the National Forest Estate**

Forest Enterprise were keen to be included in the exercise, but they determined that their databases were not capable of reliably distinguishing new native woodlands from other woods (compartments) planted for landscape and amenity purposes. Hence it was not possible to identify a random selection of sites. As an alternative, two of their recent large scale woodland restoration projects were included in the project; though these are not statistically representative, and are treated separately in the analysis.

**3.3 Overview of the schemes selected for survey**

The 31 privately owned properties sampled have the following characteristics:

1. **GRANT SCHEME**: The breakdown by grant scheme is WGS 21 sites (68%), SFGS 3 sites (9%) and SRDP 7 sites (23%). Note that the split by grant scheme in the original (“long list”) database was WGS 76%, SFGS 8% and SRDP 16% suggesting that SRDP schemes are somewhat “oversampled” and WGS “undersampled”; but considering this is a random sample, the outcome appears to be reasonable.

2. **LOCATION**: Sites split Highland 64% and Non-Highland 36%.
The high proportion of new native woodland established under WGS reflected the longer time period that WGS operated for compared with the later grant schemes.

Table 2 Summary of sample woods by grant scheme, age, location, size and ownership.
3.4 Field survey method

The survey was conducted between October and early December 2013. The information gathered was split between:

1. Subjective assessments made of aspects of whole site, or parts of sites. This was collated as the site was traversed in the course of the day’s surveying, with observations being made both at plots and between plots
2. Plot-based data recorded at each plot.

These two types of information are outlined in table 3. The 16 “attributes” listed in column 1 of table 3 are derived from the main guidance booklets, i.e. Bulletin 112, marginal site guidance and FHN guidance. Notes were made in the field whilst traversing the site, and once the site had been fully surveyed, a score was assigned to each of the 16 attributes (see section 3.5.1).

Plot layout

Plots were set out systematically across each site, based on a random starting point. The sampling method and the way of determining the spacing between plots was based on (Kerr et al., 2002 FC Info Note 45).

Plots sizes of either 0.01 and 0.02 ha were used, with a view to maintaining the number of trees sampled per plot as a minimum of seven. Plots were included if any trees occurred in them when located on the ground i.e. if the plot included both planted and non-planted ground. If no trees occurred in the plot, the surveyor then assessed whether this was because all trees had failed, or if the plot had landed in open ground. If the latter, the plot was moved to a representative area of planted, or plantable, ground in the vicinity.

A trial survey showed that the maximum number of plots it was possible to assess in a day was 15, and this was adopted on most sites. However on a few sites smaller than 10 ha, this was reduced to 8-10 plots when the characteristics of the planting design and the site were both reasonably uniform (e.g. on lowland agricultural sites).

An example of plot layout is shown in figure 2.
Recording of NVC type

Two assessments of NVC type were made for each plot i.e.:

1. The apparent “intended” NVC of the woodland based on the trees within each plot (and sometimes using reference to trees in the immediate vicinity of plots)
2. The NVC indicated by the vegetation using mainly the precursor vegetation species listed in Bulletin 112.
A list of plant vascular species was made for every plot on a presence/absence basis, including all the “precursor” and “desired invaders” species listed in Bulletin 112. Some precursor species were present in all schemes, including the oldest ones.

Despite the late time of year when the survey was conducted, it proved possible to identify a reasonable suite of ground flora species and identify all the trees, despite having lost their leaves (young leafless trees in tubes were sometimes a challenge). It is clear that some vernal woodland indicator species will have been missed (though bluebell could still be identified from its seed heads).

**Additional site data**

Some additional data was collected either to strengthen the assessment of the site or the planted trees, i.e.

**Site:**
- Any features of particular conservation value.
- Soil type by FC major soil type

**Planted trees**
- Average height of trees by species (m).
- Canopy cover (%).
- Whether the *Q. robur* and *Q. petraea* and two species of birch had been correctly deployed.
- Protection (fencing, tubes).
Table 3 The main attributes assessed and the subjective observations and plot based data used to evaluate them.

<table>
<thead>
<tr>
<th>ATTRIBUTE</th>
<th>SUBJECTIVE ASSESSMENT</th>
<th>PLOT BASED DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>SITE SUITABILITY</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are there areas that are not physically suitable for planting, but were planted nevertheless?</td>
<td>Occurrences of peat &gt; 30 cm and &lt;50 cm with low nutritional status and/or exposed were noted also planted mires and flushes</td>
<td></td>
</tr>
<tr>
<td>Are there areas that are “marginal” for planting; if so was design appropriate?</td>
<td>Areas defined as marginal (deep peats, exposed) were noted</td>
<td></td>
</tr>
<tr>
<td>STOCKING AND PLANTING PATTERNS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is mean stocking density adequate?</td>
<td></td>
<td>Stocking (n/ha)</td>
</tr>
<tr>
<td>Is spacing and planting pattern irregular?</td>
<td>Regularity of planting was noted</td>
<td></td>
</tr>
<tr>
<td>Is planting clumped?</td>
<td>Presence/absence of clumping was noted</td>
<td></td>
</tr>
<tr>
<td>TREE AND SHRUB SPECIES – SPECIES CHOICE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>How well does the apparent intended woodland NVC match the NVC indicated by the vegetation species</td>
<td>Those woodland types that appear to match / not match the vegetation were noted</td>
<td>Apparent NVC from planted trees/shrubs and NVC indicated by vegetation were recorded</td>
</tr>
<tr>
<td>Are there over-represented tree/shrub species?</td>
<td>Over represented species were noted</td>
<td>Proportions of different species were recorded for each plot and NVC type (%)</td>
</tr>
<tr>
<td>Are there missing or under-represented tree/shrub species?</td>
<td>Under-represented species were noted</td>
<td></td>
</tr>
<tr>
<td>Are shrubs adequately represented ?</td>
<td>Representation of shrubs was noted</td>
<td></td>
</tr>
<tr>
<td>Any tree species outside their natural range; rare species?</td>
<td>Species outside their natural range and rare species were noted (Y/N)</td>
<td></td>
</tr>
<tr>
<td>OPEN SPACE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is the amount of open space appropriate to site?</td>
<td>Estimates were made of the amount of open space (% scheme area)</td>
<td></td>
</tr>
<tr>
<td>Is the choice of locations for open space appropriate for the site</td>
<td>Whether open space followed prescriptions in Bulletin 112 was noted</td>
<td></td>
</tr>
<tr>
<td>CONNECTIVITY</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is there connectivity of planted areas within scheme?</td>
<td>Degree of connectivity within blocks and between blocks was noted</td>
<td></td>
</tr>
<tr>
<td>Is there connectivity with native woodland / FHN beyond scheme?</td>
<td>Presence of adjacent native woodland, watercourses and other woodlands were noted</td>
<td></td>
</tr>
<tr>
<td>NATURAL REGENERATION</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Has account been taken of natural regeneration potential ?</td>
<td>Presence of seed sources and provision of unplanted areas adjacent to these were noted</td>
<td></td>
</tr>
<tr>
<td>BROWSING AND DIEBACK</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is browsing and dieback having negative impacts</td>
<td></td>
<td>Number of trees by species with leader damage, bark stripping or leader dieback (% of trees).</td>
</tr>
<tr>
<td>INVASIVE NON-NATIVE SPECIES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are invasive species present and do they have negative impacts?</td>
<td>Presence of INNS was noted</td>
<td></td>
</tr>
<tr>
<td>CULTIVATION</td>
<td></td>
<td></td>
</tr>
<tr>
<td>What form of cultivation was used; and does machine cultivation have negative impacts</td>
<td>Type of cultivation and how it affects the soil and site surface was assessed</td>
<td></td>
</tr>
</tbody>
</table>
3.5. Analysis

The analysis had two main strands:

1. **Numerical scoring**: Numerical scores were assigned to each of the 16 attributes of the wood (both for those assessed subjectively and those using plot based data), which could be summed to give an overall assessment of each wood; and which allowed the woodlands to be compared with each other.

2. **Plot based data**: Mean values, maxima and minima were calculated in Excel for all the plot based data for: each plot, the sum of plots on individual NVC types within woods, whole woods; and whole NVC types pooled across woods.

3.5.1 Numerical scoring:

Observations recorded on field forms were converted to scores for each of the 16 attributes using a Multi Attribute Utility Assessment (MAUA) approach (Mendoza & Martins, 2006). This involved:

1. Scoring each attribute on a scale 1-5.
2. Setting a weighting (1-5) for each attribute that reflects its importance in determining the biodiversity value or authenticity of the woodland.
3. Multiplying the score by the weighting to give an overall assessment of the contribution of each attribute to the value (biodiversity value and authenticity) of the wood (called “assessment scores”)

The setting of scores and weightings was done subjectively following discussions of each attribute by the team members. However this is quite complex, not just because the weightings are subjective, but because some criteria could be easily captured in one attribute (e.g. stocking) whereas other required multiple attributes (e.g. species choice) and therefore tended to be over-represented in the final score. The individual attributes were then gathered into 9 main “factors” (see tables D1-D33 in the Data Annex), that reflect the main elements of guidance i.e.:

- Site suitability
- Stocking /planting patterns
- Species choice
- Open space
- Connectivity
- Natural Regeneration
- Browsing and dieback
- Invasive non-natives
- Cultivation

Percentage scores were generated for each of these factors by adding the assessment scores (column 5 in tables D1-D33 in the Data Annex) for each attribute and expressing this as a percentage of the highest possible score (i.e. if each attribute was scored 5). This allows an overview of the performance of each wood in relation to each of the 9 main factors.

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Similarly a score was derived for the whole wood, by expressing the total of all the attribute scores as a percentage of the highest possible score (if all the attribute score were scored at 5). This gives an overall impression of how each wood is performing. Despite the uncertainties in determining the weightings and scores, the final scores for the woods appear to accord fairly well with the team members’ assessment of the woods, which gives us reassurance about the process and outcomes.

The total scores (table 4 and figure 3) were assigned into 4 categories, which best summarise the quality of the woodlands. The delineation of these categories was subjective, but woods close to the limits of each class were considered closely, so as the authors were content with their categorisation.

- **Category 1: Not meeting guidance** – total score 50% or below. These woods were unsatisfactory and had effectively failed over substantial areas.
- **Category 2: Not wholly meeting guidance** – total score 51%-69%. These woods scored satisfactorily on many factors, but one or two of the aspects of establishment were seriously flawed over all or part of the area.
- **Category 3: Meeting guidance – could be improved** – total score 70%-79%. These woods were satisfactory in all respects, but one or two aspects could have been improved.
- **Category 4 Meeting guidance to a good standard** - more than 80%. These were woods where all aspects were done to a good or very good standard.

The boundary between category 2 and category 3 woods was set at 69% because woods that only had one unsatisfactory aspect (i.e. not wholly meeting guidance) typically had scores in the range 65-69%.

### 3.5.2 Plot-base data

The following variables were calculated for each wood:

- Stocking (n/ha)
- Tree and shrub species composition (%) for the whole wood and for individual intended NVC types (assessed from tree species planted)
- Tree and shrub species composition (%) for NVC type indicated by vegetation, by grouped into:
  - Major tree species
  - Minor trees species
  - Recommended shrubs
  - Other (non-recommended) tree species
- Damage: number of trees (n/ha), for the whole wood and by species, with
  - Leader damage
  - Bark stripping
  - Shoot or crown dieback.

The appropriateness of the tree and shrubs species was assessed by:

- comparing the apparent intended NVC (assessed from tree species planted) with the NVC derived from vegetation indicator species
- evaluating the mix of trees species planted for an individual NVC type (derived from vegetation indicator species) using the categories in Bulletin 112.
4. Results – characteristics of sample woodlands and how they reflect guidance

4.1 How does woodland establishment reflect guidance?

The distribution of private woods among the 4 categories of overall woodland quality, based on the aggregate percentage score for each wood, was as follows (see figure 3 and table 4):

- **Category 1 Not meeting guidance**: 6 woods (19 %)
- **Category 2 Not wholly meeting guidance**: 9 woods (29 %)
- **Category 3 Meeting guidance – could be improved**: 12 woods (39%)
- **Category 4 Meeting guidance to a good standard**: 4 woods (13 %).

![Figure 3 Numbers of privately owned woods in four categories of total site score](image)

The scores for the 9 individual ecological and silvicultural factors are summarised in table 4; and detailed scores for the 16 individual attributes for each woodland are given in tables D1-D33 in the Data Annex (appended). In table 4, scores for the individual factors of less than 50% are highlighted in grey and provide an overview of aspects for which individual woods performed relatively poorly. It is not useful to place too much emphasis on the **absolute** scores and what these might mean; the important aspect is the relative performance of woods.
Table 4 Summary of percentage scores for the 9 ecological and silvicultural factors for the 33 individual woods.

<table>
<thead>
<tr>
<th>Score less than 50% for individual factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total site assessment score less than 50% = <strong>Category 1</strong> Not meeting guidance - Wood unsatisfactory and has effectively failed over substantial areas</td>
</tr>
<tr>
<td>Total site assessment score 50-70% = <strong>Category 2</strong>: Not wholly meeting guidance - Wood satisfactory on many factors, but one or two aspects of establishment were seriously flawed over all or part of the area</td>
</tr>
<tr>
<td>Total site assessment score of 70-80% = <strong>Category 3</strong>: Meeting guidance – could be improved - Wood satisfactory in all respects, but a few aspects could have been improved.</td>
</tr>
<tr>
<td>Total site assessment score of more than 80% = <strong>Category 4</strong>: Meeting guidance to a good standard - Woods where all aspects were done to a good or very good standard.</td>
</tr>
</tbody>
</table>

4.1.1 Average performance against different ecological and silvicultural factors

The average performance of the private woods against the 9 different site factors is shown in table 5. This shows that woods received the lowest mean scores for: stocking/planting patterns, browsing/dieback species choice and cultivation; whereas the least problems were encountered for invasive non-native species.

It should be noted that whilst woods on average perform well against “site suitability” (on most sites this is not an apparent problem), it is a problem on a subset of sites (see section 4.2 and 5.1).

Comparison of the mean score (column 1) with the number of wood scoring less than 50% (column 2) shows that low mean scores resulted from 2 patterns:
- a significant proportion of woods performing very badly e.g. browsing and cultivation;
- fewer woods performing very badly, and more woods generally receiving lower scores e.g. species choice, connectivity.

Table 5 Ranked mean score for private woods and numbers of woods with scores <50%

<table>
<thead>
<tr>
<th>Mean score private sites</th>
<th>Rank</th>
<th>No of woods with less than 50% score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stocking and planting patterns</td>
<td>61%</td>
<td>1 (poorest)</td>
</tr>
<tr>
<td>Browsing and dieback impacts</td>
<td>62%</td>
<td>2</td>
</tr>
<tr>
<td>Species choice</td>
<td>63%</td>
<td>2</td>
</tr>
<tr>
<td>Cultivation</td>
<td>63%</td>
<td>3</td>
</tr>
<tr>
<td>Open space</td>
<td>68%</td>
<td>5</td>
</tr>
<tr>
<td>Connectivity</td>
<td>69%</td>
<td>6</td>
</tr>
<tr>
<td>Natural regeneration</td>
<td>71%</td>
<td>7</td>
</tr>
<tr>
<td>Site suitability</td>
<td>78%</td>
<td>8</td>
</tr>
<tr>
<td>INNS</td>
<td>83%</td>
<td>9 (best)</td>
</tr>
</tbody>
</table>
4.1.2 Performance of different grant schemes

There are indications that, on average, sites established under SRDP are performing better than those under SFGF and WGS. However the estimates in table 5 have not been subject to a statistical test (and note the small number of SFGS and SRDP schemes).

Table 6  Mean assessment score by the 9 factors by grant scheme.

<table>
<thead>
<tr>
<th>Grant scheme</th>
<th>No. of schemes</th>
<th>Site Suitability</th>
<th>Stocking and planting patterns</th>
<th>Species choice</th>
<th>Open space</th>
<th>Connectivity</th>
<th>Natural Regeneration</th>
<th>Browsing and dieback</th>
<th>Invasive non-natives</th>
<th>Cultivation</th>
<th>TOTAL SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td>WGS</td>
<td>21</td>
<td>75</td>
<td>61</td>
<td>60</td>
<td>65</td>
<td>65</td>
<td>72</td>
<td>55</td>
<td>83</td>
<td>62</td>
<td>65</td>
</tr>
<tr>
<td>SFGS</td>
<td>3</td>
<td>93</td>
<td>60</td>
<td>66</td>
<td>67</td>
<td>84</td>
<td>53</td>
<td>67</td>
<td>73</td>
<td>67</td>
<td>70</td>
</tr>
<tr>
<td>SRDP</td>
<td>7</td>
<td>79</td>
<td>63</td>
<td>70</td>
<td>76</td>
<td>73</td>
<td>74</td>
<td>83</td>
<td>86</td>
<td>69</td>
<td>74</td>
</tr>
</tbody>
</table>

Some of the higher scores under SRDP may reflect the fact that these woodlands are still young and may not yet have encountered some of the problems manifested by older schemes, such as grazing impacts and dieback.

4.2 Site suitability – soil type and exposure

The 31 private woods can be categorised regarding site suitability, albeit somewhat roughly, as follows:

- 23 sites were suitable for native woodland creation, given current guidance; though at about 7 of these some planting had taken place on small areas of mire, flushes and areas of stagnant *Juncus* mire, and so the MAUA score had been reduced to take account of this.
- 8 sites were judged to have significant areas that were either marginal or unsuitable. Planting had taken place on quite substantial areas of peat > 30 cm, including deep peats (> 45 cm) and/or skeletal soils. Many of these areas of peat were quite low nutrient status (e.g. with heather, deer grass and bog asphodel) and were very wet. At 5 of these sites trees show significant signs of poor survival and growth and in 3 of these sites there were extensive failures. Some were quite recent, including SRDP schemes, and at those survival was still good.
It is beyond the scope of this study to do a detailed analysis of all the poorer sites to determine which of these are “officially marginal” according to the criteria in the SRDP documentation; but parts of the 8 sites probably would fall into that category; of which only 1 was an SRDP scheme. Sometimes the planting correctly avoided the poorer ground, but sometimes it did not. At the single SRDP scheme that included marginal land, the guidance did not appear to have been followed adequately with several areas of poor ground having been planted.
4.3 Stocking and planting patterns

4.3.1 Stocking

The mean stocking levels for the woods are shown in table 7 (details for each wood are shown in the data report tables 34-155). As a rule, the woods are still in the establishment phase and self-thinning has not started, and so the stocking levels reported here reflect: a) the original stocking, and b) the effects of losses due to unsuitable sites, inappropriate species choice, browsing and other (known or unknown) effects. It should be noted that the survey method employed here:

- was based on randomly located plots, some of which ended up being located at the edge of planted areas, and were therefore partly stocked,
- will have included open ground within planted areas, which appeared to the surveyors could/should have been planted, yet for reasons not apparent in the field was unplanted. This was a difficult factor to deal with in some woods in the Highlands on poor sites which were established as intimate mosaics of planted and unplanted ground.

Both these factors reduce the estimates of stocking density in table 7 and explain the very low estimates of stocking at some woods. It should be emphasised that the results recorded here often will not tally with the estimates made by conservancy staff auditing schemes.

Stocking was, generally below the levels prescribed in guidance and sometimes far below. 12 out of the 31 woods (39%) had stocking levels where the upper level of the confidence interval fell below 75% of the prescribed stocking level (woods marked in red in table 7). At these woods failures were typically due to: inclusion of areas of unsuitable or marginal ground, poor species choice and browsing and dieback impacts. It is also possible that poor provenance choice may have contributed in some cases, but it was not possible to determine this.

At the worst sites, the effects of two or all three of these factors were combined. On a few sites on otherwise good ground for tree growth, failed areas occurred due to competition from bracken alone. At a minority of WGS sites, trees had been planted at quite high stocking (say about 2000 -2500 stems / ha) but nevertheless had failed over substantial areas. In these cases it appears that the mean stocking is satisfactory, when in fact large parts of the woods had failed.

Stocking levels appear to be higher on average in most woods established under SRDP than those established under WGS.

At some recently planted sites on poor peaty soils, survival was still good, due to continued beating up and probably aided by the transplants still having access to nutrients added as slow release fertilisers by the nurseries.
Table 7 Mean stocking density. (Schemes where the upper level of the confidence interval fell below 75% of the prescribed stocking level are highlighted in red).

<table>
<thead>
<tr>
<th>Woodland</th>
<th>Grant scheme / year</th>
<th>Mean stems/ha</th>
<th>Range</th>
<th>Confidence limits (95%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>SRDP 11</td>
<td>1400</td>
<td>900 – 1800</td>
<td>± 157</td>
</tr>
<tr>
<td>2</td>
<td>SRDP 11</td>
<td>1143</td>
<td>700 – 1600</td>
<td>± 266</td>
</tr>
<tr>
<td>3</td>
<td>SRDP 11</td>
<td>956</td>
<td>0 – 1450</td>
<td>± 196</td>
</tr>
<tr>
<td>4</td>
<td>SRDP 10</td>
<td>1200</td>
<td>500 – 2000</td>
<td>± 237</td>
</tr>
<tr>
<td>5</td>
<td>SRDP 10</td>
<td>437</td>
<td>0 – 1250</td>
<td>± 238</td>
</tr>
<tr>
<td>6</td>
<td>SRDP 10</td>
<td>1180</td>
<td>600 – 1700</td>
<td>± 182</td>
</tr>
<tr>
<td>7</td>
<td>SRDP 09</td>
<td>1260</td>
<td>500 – 1900</td>
<td>± 304</td>
</tr>
<tr>
<td></td>
<td><strong>MEAN SRDP</strong></td>
<td><strong>1082</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>SFGS 07</td>
<td>1310</td>
<td>600 – 1800</td>
<td>± 279</td>
</tr>
<tr>
<td>9</td>
<td>SFGS 05</td>
<td>907</td>
<td>150 – 2200</td>
<td>± 302</td>
</tr>
<tr>
<td>10</td>
<td>SFGS 05</td>
<td>925</td>
<td>200 – 1450</td>
<td>± 228</td>
</tr>
<tr>
<td></td>
<td><strong>MEAN SFGS</strong></td>
<td><strong>1047</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>WGS 03</td>
<td>1153</td>
<td>0 – 2550</td>
<td>± 348</td>
</tr>
<tr>
<td>12</td>
<td>WGS 03</td>
<td>540</td>
<td>0 – 1400</td>
<td>± 229</td>
</tr>
<tr>
<td>13</td>
<td>WGS 02</td>
<td>820</td>
<td>50 – 1700</td>
<td>± 259</td>
</tr>
<tr>
<td>14</td>
<td>WGS 02</td>
<td>470</td>
<td>0 – 1550</td>
<td>± 221</td>
</tr>
<tr>
<td>15</td>
<td>WGS 01</td>
<td>737</td>
<td>50 – 1500*</td>
<td>± 265</td>
</tr>
<tr>
<td>16</td>
<td>WGS 01</td>
<td>633</td>
<td>0 – 1550</td>
<td>± 269</td>
</tr>
<tr>
<td>17</td>
<td>WGS 00</td>
<td>387</td>
<td>0 – 1000</td>
<td>± 180</td>
</tr>
<tr>
<td>18</td>
<td>WGS 00</td>
<td>647</td>
<td>0 – 1500</td>
<td>± 320</td>
</tr>
<tr>
<td>19</td>
<td>WGS 00</td>
<td>1096</td>
<td>300 – 3400</td>
<td>± 500</td>
</tr>
<tr>
<td>20</td>
<td>WGS 00</td>
<td>140</td>
<td>0 – 700</td>
<td>± 139</td>
</tr>
<tr>
<td>21</td>
<td>WGS 00</td>
<td>947</td>
<td>0 – 2200</td>
<td>± 330</td>
</tr>
<tr>
<td>22</td>
<td>WGS 99</td>
<td>530</td>
<td>0 – 1150</td>
<td>± 229</td>
</tr>
<tr>
<td>23</td>
<td>WGS 97</td>
<td>118</td>
<td>0 – 700</td>
<td>± 132</td>
</tr>
<tr>
<td>24</td>
<td>WGS 97</td>
<td>120</td>
<td>0 – 750</td>
<td>± 108</td>
</tr>
<tr>
<td>25</td>
<td>WGS 97</td>
<td>1240</td>
<td>200 – 2500</td>
<td>± 365</td>
</tr>
<tr>
<td>26</td>
<td>WGS 97</td>
<td>277</td>
<td>0 – 800</td>
<td>± 151</td>
</tr>
<tr>
<td>27</td>
<td>WGS 96</td>
<td>896</td>
<td>200 – 1800</td>
<td>± 307</td>
</tr>
<tr>
<td>28</td>
<td>WGS 95</td>
<td>745</td>
<td>80 – 1650</td>
<td>± 237</td>
</tr>
<tr>
<td>29</td>
<td>WGS 95</td>
<td>430</td>
<td>0 – 1550</td>
<td>± 229</td>
</tr>
<tr>
<td>30</td>
<td>WGS 94</td>
<td>347</td>
<td>50 – 750</td>
<td>± 237</td>
</tr>
<tr>
<td>31</td>
<td>WGS 94</td>
<td>2210</td>
<td>1500 – 1800</td>
<td>± 310</td>
</tr>
<tr>
<td></td>
<td><strong>MEAN WGS</strong></td>
<td><strong>690</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FE</td>
<td></td>
<td>783</td>
<td>50 – 1550</td>
<td>± 267</td>
</tr>
<tr>
<td>FE</td>
<td></td>
<td>2167</td>
<td>300 – 5300</td>
<td>± 1004</td>
</tr>
</tbody>
</table>
4.3.2 Irregular planting and clumping

Irregular planting was recorded on about 70% of schemes, which suggest that guidance is generally being followed. It occurred most commonly in upland woods where the owners/agents were making clear attempts to mimic the structures of semi-natural woodland; and tended to be least common in smaller woods on agricultural land.

4.4 Choice of species and target NVC type

The MAUA analysis (table 4) shows 5 woods (16%) where species choice is a serious problem (score <50%). Equally there are only 2 woods which returned a good score for species choice (with a score of > 80%); and most woods returned intermediate scores showing that there is widespread room for improvement. The strengths and weaknesses of the choice of species and target NVC type, which are interlinked issues, are set out below.

4.4.1 “Apparent intended” and “Best fit” NVC woodland types

Practitioners should have assessed the sites and established a target NVC type, either by using Bulletin 112 or by applying the FC Ecological Site Classification. The breakdown of NVC woodland type by area is shown in table 8 and figure 4 below; split between “Apparent intended NVC type” assessed by the trees planted and “Best fit NVC type” assessed by the vegetation indicators species. Details for each wood are shown in the data report tables 34-155. If there is a good match between the trees planted and the vegetation indicators, then the mismatch values in table 8 and figure 4 would be low. Negative values of mismatch indicate that the representation of that NVC type in the planted trees is too low (i.e. other NVC type tree mixes have been planted on that site type); and positive values suggest that representation of that NVC type in the planted trees is too high (i.e. that NVC type tree mix has been planted on sites not suited to it).

The histograms in figure 4 show the mismatches in categories of ±10%, ±11-30%, ±31-50% and 50%+. Mismatches of less than 10% suggest a good fit between intended and best fit NVC, ±30% suggests substantial error and ±50% suggest a very poor match. However even where the mismatch is low, this does not guarantee a good outcome. A zero mismatch simply states, for example, that the best fit NVC for 30% of the site is say W17, and the practitioner has planted NVC 17 on 30% of the site; but we do not know if those 2 areas coincide. It should be noted that the sample size of woodland is so small that the differences between NVC types cannot be taken at face value.

The results suggest:
- there is very wide divergence from scheme to scheme in the fit between intended and best fit NVC; with both positive errors (over-representation) and negative ones (under-representation) occurring.
- practitioners make the fewest/smallest errors on W9, W17 and W18 sites; and greater ones on W4, W7 and W11 (i.e. note the spread in the histograms)
- W 4 and W7 appear to be under-represented on average and W9, W17 and W18 appear to be somewhat over –represented (i.e. note displacement of the histograms).

Note that no mean values of mismatch are calculated, because this would merely express the degree to which positive mismatches on one site are cancelled by negative mismatches at other sites, which is not a meaningful metric.
Table 8  Comparison between “Apparent intended NVC” assessed by the trees planted and “Best fit NVC” assessed by the vegetation indicators species. Negative values of mismatch indicate that the representation of that NVC type in the planted trees is too low (i.e. other NVC type tree mixes have been planted on that site type); and positive values suggest that representation of that NVC type in the planted trees is too high (i.e. that NVC type tree mix has been planted on sites not suited to it). Note that entries for individual woods generally do not add up to 100%, because for some areas the intended NVC is unidentifiable, and other areas were recorded as unplanted or unsuitable for planting.

<table>
<thead>
<tr>
<th>NVC TYPES</th>
<th>W4 % Intended</th>
<th>% Best fit</th>
<th>Mismatch</th>
<th>W7 % Intended</th>
<th>% Best fit</th>
<th>Mismatch</th>
<th>W9 % Intended</th>
<th>% Best fit</th>
<th>Mismatch</th>
<th>W11 % Intended</th>
<th>% Best fit</th>
<th>Mismatch</th>
<th>W17 % Intended</th>
<th>% Best fit</th>
<th>Mismatch</th>
<th>W18 % Intended</th>
<th>% Best fit</th>
<th>Mismatch</th>
</tr>
</thead>
<tbody>
<tr>
<td>W4</td>
<td>0</td>
<td>4</td>
<td>-4</td>
<td>87</td>
<td>82</td>
<td>5</td>
<td>13</td>
<td>14</td>
<td>-1</td>
<td>31</td>
<td>6</td>
<td>25</td>
<td>33</td>
<td>59</td>
<td>-26</td>
<td>40</td>
<td>0</td>
<td>40</td>
</tr>
<tr>
<td>W7</td>
<td>69</td>
<td>94</td>
<td>-25</td>
<td>13</td>
<td>27</td>
<td>-14</td>
<td>53</td>
<td>53</td>
<td>0</td>
<td>13</td>
<td>13</td>
<td>0</td>
<td>10</td>
<td>20</td>
<td>-20</td>
<td>13</td>
<td>13</td>
<td>0</td>
</tr>
<tr>
<td>W9</td>
<td>27</td>
<td>32</td>
<td>-5</td>
<td>13</td>
<td>41</td>
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Figure 4 The apparent mismatch in percentage area of woods between “Intended NVC types” (from planted trees) and “Best fit NVC types” (from vegetation indicators). Negative values of mismatch indicate that the representation of that NVC type in the planted trees is too low (i.e. other NVC type tree mixes have been planted on that site type); and positive values suggest that representation of that NVC type in the planted trees is too high (i.e. that NVC type tree mix has been planted on sites not suited to it).
Figure 4 The apparent mismatch in percentage area of woods between “Intended NVC types” (from planted trees) and “Best fit NVC types” (from vegetation indicators). Negative values of mismatch indicate that the representation of that NVC type in the planted trees is too low (i.e. other NVC type tree mixes have been planted on that site type); and positive values suggest that representation of that NVC type in the planted trees is too high (i.e. that NVC type tree mix has been planted on sites not suited to it).
4.4.2 Species composition by NVC type

Figures 5-14 show the species composition by NVC type pooled across all sites. The tables D34 – D155 in the data report also show the composition by NVC type for the individual woodlands, with the species categorised into major/minor recommended trees species, recommended shrubs species and other (non-recommended) tree species (as in Bulletin 112).

The figures give a useful overview of the aggregate effect of planting. However, it should be noted that an adequate representation of a species in a particular NVC type almost certainly does not mean that it was well represented at all the woods; and may often result from over-representation at some woods and little or no representation at others.

W4 Birch wet woodland

![Diagram of species composition](image)

Fig 5 Proportion of tree and shrub species recorded in W4 community (data from 20 private schemes)

Strengths - private sites
- Major recommended species: Downy birch (42%) is the most frequently planted species, which follows guidance.
- Minor recommended species: Alder is frequently planted (12%).
- Shrubs – grey willow represents 12% of planting.

Weaknesses - private sites
- Minor recommended species: Goat willow is practically absent.
- Shrubs: Eared willow is practically never planted.
There is a high incidence of non-recommended species (see Data Annex for details).

**Fig 6.** Proportion of tree and shrub species recorded in W4 community (data from 2 woods on NFE).

**FES sites**

W4 woodlands on FES sites are dominated by eared willow (which is very common as natural regeneration) and downy birch. There is also high incidence of non-recommended species (see Data Annex for details).
W7 Alder wet woodland

Figure 7 Proportion of tree and shrub species recorded in W7 community (data from 14 private schemes)
Note that species listed appear clockwise in the pie-chart

Strengths - private sites
- Major recommended trees: Alder (42%) is the most frequently planted species, which follows guidance; ash is present but at rather low proportions (6%).
- Minor recommended trees: downy birch is represented at 13% which is at a quite low proportion; pedunculate oak is well represented, but at a rather high proportion (10%);
- Major recommended shrubs – grey willow, hazel, hawthorn all present.
- Minor recommended shrubs – elder, guelder rose, blackthorn all present.

Weaknesses - private sites
- Minor recommended species: Goat willow and bird cherry are practically absent
- There is a high incidence of non-recommended species – 13% (see Data Annex for details)
W9 Ash woodland

Figure 8 Proportion of tree and shrub species recorded in W9 community (data from 13 private schemes. Note that species listed appear clockwise in the pie-chart.

Strengths - private sites

- Major recommended trees: Ash 32% is the most frequently planted species, which follows guidance; downy birch is present but at rather low proportions (10%). Rowan is adequately represented.
- Minor recommended trees: oak (pedunculate) is well represented, but at a rather high proportion (12%); wych elm is present (but only very few sites); alder is strongly represented (12%); holly and aspen are occasionally planted.
- Major recommended shrubs – hazel is present (5%).
- Minor recommended shrubs – hawthorn and grey willow are present.

Weaknesses - private sites

- Minor recommended species: Goat willow and bird cherry are practically absent.
• Minor recommended shrubs: elder is absent.
• There is a high incidence of non-recommended species – 17% (see Data Annex for details).

W11 Oak-birch woodland

Figure 9 Proportion of tree and shrub species recorded in W11 community (data from 14 private schemes)
Note that species listed appear clockwise in the pie-chart.

**Strengths - private sites**
- Major recommended trees: Downy birch is frequently planted (32%), which follows guidance. Oak (pedunculate) is well represented (22%), but see weaknesses below.
- Minor recommended trees: Rowan (10%) is well represented, probably a little too strongly. The proportion of silver birch (5%) seems reasonable, but maybe a little low. Holly (1%) is adequately represented. Aspen was included.
- Recommended shrubs – hazel (4%) and hawthorn (3%) show reasonable representation.

**Weaknesses - private sites**
- Major recommended trees: The proportion of sessile oak (< 1%) is low and the main oak planted is pedunculate oak and hybrids of pedunculate. This reflects the fact that pedunculate oak is planted more frequently, but may be exacerbated by the fact that for a proportion of sites the oak had lost their leaves at survey time, or were inaccessible seedlings at the bottom of tubes, and surveyors may have somewhat over-recorded pedunculate oak by default.
- Recommended shrubs: Hazel and hawthorn are probably adequately represented. There is very little juniper.

The proportion of non-recommended native species (20%) is high, including alder and Scots pine.
The proportions of species on the two NFE sites were broadly similar to those on the private sites, though with rather more oak, more of which is sessile, and more silver birch, and far less non-recommended native tree species.
Figure 11 Proportion of tree and shrub species recorded in W17 community (data from 15 private schemes)
Note that species listed appear clockwise in the pie-chart.

**Strengths - private sites**
- Major recommended trees: downy birch is frequently planted (48%), which follows guidance.
- Minor recommended trees: pedunculate oak is represented but at quite a low proportion (5%); rowan is represented, but far too strongly (23%). The proportion of silver birch (3%) seems reasonable, but maybe a little low. Holly (1%) is adequately represented.
- Recommended shrubs – hazel (1%), juniper (3%) and hawthorn are all present.

**Weaknesses - private sites**
- Major recommended trees: Sessile oak appears to be absent and the proportion of oak in general is low. The low proportion of sessile oaks reflects reality, but may be exacerbated by the fact that for a proportion of sites the oak had lost their leaves at survey time, or were inaccessible seedlings at the bottom of tubes, and surveyors may have somewhat over-recorded pedunculate oak by default.
- Minor recommended trees: The proportion of silver birch (3%) seems low. Holly appears to be under represented.
- The proportion of non-recommended native species (18%) is high, including alder and Scots pine.
FES sites

Strengths - FES sites

- Major recommended trees: Downy birch is frequently planted (46%), which follows guidance.
- Minor recommended trees: Sessile oak (10%), rowan (10%) and silver birch (13%) are all quite well represented.
- Recommended shrubs – hazel (1%), juniper (3%) and hawthorn are all present.

Weaknesses - FES sites

- Major recommended trees: The proportion of oak in general is low.
- Minor recommended trees: Holly is not adequately represented.
- The proportion of non-recommended native species (18%) is high, including alder and Scots pine.
Figure 13  Proportion of tree and shrub species recorded in W18 community (data from 10 private schemes).

**Strengths - private sites**
- Major recommended trees: Scots pine is frequently planted (74%), which follows guidance.
- Minor recommended trees: Downy birch (15%), and rowan (6%) are both well represented.
- The incidence of non-recommended species is relatively low.

**Weaknesses - private sites**
- Minor recommended trees: Silver birch is practically absent.
- Recommended shrubs: Juniper is practically absent.
- Use of non-recommended species (probably often alder) is 5%.
Figure 14 Proportion of tree and shrub species recorded in W18 community (data from 1 site on NFE).

**FES sites**
The sample is too small to generalise and the data are derived to a few plots. The high incidence of juniper is a sampling artefact but show that the species is represented. The lack of downy birch reflects the fact it was not planted but that natural colonisation is anticipated in the long term. Note the lack of non-recommended species, the only example (NVC/ownership combination) for which this was recorded. Use of non-recommended species was lower on FES sites than private.

**4.4.3 Over-represented species**
Species that are generally over-represented are:
- **Scots pine**: this was recorded on W11, W9, W7 sites where it is inappropriate. It is also recorded on W4 and W17 sites where it can be appropriate where these sites intergrade towards W18.
- **Alder**: this is often over represented and is planted on a wide variety of NVC types where it is often not appropriate, including W10, W17 and W18.
- **Rowan**: this is often over represented and on almost every NVC type.

**Hazel**, planted into mires and flushes, was encountered on several sites, where it was usually inappropriate and growing poorly.

**4.4.4 Under-represented and missing species**
Species that are generally under-represented are:
- **Goat willow, eared willow, bird cherry, aspen, crab apple and wych elm**: these are rarely planted and represent a major omission.
- **Sessile oak**: this is under-represented and probably mainly reflects problems in seed and plant supply.
- **Oak**: several sites with good soils and bracken cover had quite low proportions of oak.
- **Silver birch** – whilst the predominance of planting of downy birch over silver birch is ecologically sound, the overall percentage of silver birch on sites where it is appropriate (W7, W11, W17 and W18) seem rather too low.

- The following shrubs appear to be under-represented: grey willow and many of the rarer sallows and osiers, hazel, hawthorn, guelder rose and juniper.

**Species mixtures**

Bulletin 112 states that trees should be planted either in pure clumps, or clumps with two or three species; and this advice seems generally to have been followed.

### 4.5 Browsing impacts

The proportion of trees with leaders damaged by browsing typically varied between 5 and about 30% of trees (see table 9). Sites with more than 25% of the trees damaged by leader browsing are highlighted in table 9. A few sites showed damage levels of 40-60 % and at these sites browsing was a principal factor preventing proper development of the wood. Woods with 0% browsing were typically young, with the seedlings trees still in tubes, or old established woods that may or may not have suffered browsing when young. Browsing levels showed no clear trend with the different grant schemes. Browsing impacts are broadly similar to those recorded in the Native Woodland Survey of Scotland (NWSS) (Patterson et al., 2014).

Deer (red and roe) were the main factor involved in damage to young trees and this also concurs with the results of the NWSS. In most of the cases the degree of herbivore impacts will permit adequate development in many of the tree species but some palatable ones may fail to grow. This may impact on the future regeneration potential of the new native woods since biodiversity will be reduced if certain key tree species and vulnerable elements of the field layer fail to develop.

Estimates of bark stripping and dieback were far lower. These are shown for the individual woods in the Data Annex. Dieback was most common in alder.
Table 9 Numbers and proportions of trees with leader browsing. Woods where damage was > 25% of the trees planted are highlighted in red.

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4.6 Amount and configuration of open habitats

Most woods had broadly the proportion of open space suggested in guidance. The following problems were encountered:

- Some woods have greater than the prescribed amount of open space, especially on poorer sites. This has frequently been extended by trees failing, especially in older schemes, where the passage of time had allowed this to develop.
- On some sites the configuration of planted and unplanted ground appears to have been largely determined by where cultivation machinery was able to operate. This means that some steeper slopes and sheltered gulleys which can be ideal for tree growth are left unplanted; and equally, low lying flatter areas, which are frequently wetter and less suitable for trees are then planted up.
- Smaller woods in the lowlands sometimes have quite low proportions of open space.

We detect only very limited instances of valuable open ground habitats or other conservation features having been planted inappropriately with trees; usually scattered planting of mires and flushes. However it was difficult to include comprehensive coverage of this in the survey because of the need to traverse the sites from plot to plot, rather than seek out instances where this might have occurred.

4.7 Connectivity - location in relation to FHNs and internal connectivity

Connectivity is a factor that most woods score fairly well on average (see table 5) and woods established after the guidance was issued (SFGS = 84%, SRDP = 73%) score better than earlier schemes (WGS = 65%).

Woods were categorised in relation to their location in respect of FCS Potential Native Woodland Networks (see table 10) as follows:

- Adjacent to core habitat: 17 woods (55%)
- Only within the 250m expansion zone: 1 woods (3%)
- Only within the 1000m expansion zone: 2 woods (6%)
- Isolated woods (outside expansion zones): 11 woods (35%)

This shows that 65% of woods are within the FCS potential forest habitat networks, which suggests that guidance in this respect is being followed; i.e. that sites within Potential Native Woodland Networks are being chosen preferentially.
Table 10 Location of sites in relation to Forest Habitat Networks

<table>
<thead>
<tr>
<th>Woodland name</th>
<th>Adjacent to core woodland</th>
<th>Within 250m expansion zone</th>
<th>Within 1000m expansion zone</th>
<th>Isolated woods (outside expansion zones)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private</td>
<td></td>
<td></td>
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<td>Forestry Commission</td>
<td></td>
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</tr>
</tbody>
</table>


**Internal connectivity** of planted areas was generally good i.e. configurations with isolated blocks of planted trees generally do not occur. The main exceptions to this are:

- where a single scheme is split into multiple isolated blocks in a valley system. This was recorded mainly in Southern Scotland where the small units appear to be planted for pheasant cover and shelter.
- in upland woods on poor sites with planting patterns and/or high failure rate that result in small isolated blocks and thus poor connectivity.

Connectivity of open space within woods seems good.

**4.8 Inclusion of natural regeneration**

About half the sites have potential for natural regeneration in the future, from either:

- existing native woodland adjacent to, or included within, the wood;
- the woods themselves because suitable areas of open habitat had been left that could be colonised by trees and shrubs.

However where apparently suitable open ground had been left, it was unclear whether there actually was any intention to facilitate natural regeneration in the future.

**4.9 Cultivation**

The incidence of no/hand cultivation, machine mounding and ploughing over the whole or parts of the sample woods are as follows (see table 11):

- No-cultivation, or hand cultivation: 15 woods
- Machine mounding: 20
- Ploughing: 2 woods

Machine mounding was the dominant form of cultivation (20/31 woods), with ploughing in 2 out of the 31 samples. No cultivation or hand cultivation was recorded on a surprisingly high number of woods (15); and was the only form of cultivation in 8 of these. This was recorded more frequently in more recent woods, particularly on better agricultural sites. However it had also been used successfully at some typical upland sites e.g. site 19.

Many of the sites where mounding was used still had deep pits, showing that this form of cultivation will persist, probably for decades and will quite possibly never really disappear. This clearly adversely impacts on the soil and field layer and, for the foreseeable future, it will be quite obvious that these woods are of planted rather than semi-natural origin. In contrast, in those woods established with no-cultivation or hand mounding, it will be far harder to determine if they were originally planted.

The best use of machine mounding was one FE site, were the material dug out of the pits had simply been turned back into the pits (inverted mounding). This appears to be highly effective, and will probably be undetectable in the medium term future.

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6 It was not possible to determine the if trees land not machine cultivated has been notch planted or hand screefed/mounded.
## Table 11  Cultivation type and protection

<table>
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<th>Site name</th>
<th>Grant scheme / date</th>
<th>Cultivation type</th>
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<th>Fence stock</th>
<th>Unfenced</th>
<th>Tubes &amp; Quills</th>
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<td>✓</td>
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</table>

| Forestry Commission |
|---------------------|------------------|
| FE                  | ✓                | ✓               | ✓ t         |        |
| FE                  | ✓                | ✓ inverted      | ✓ t         |        |

1. Deer fenced removed
2. Possibly FE landscape scale perimeter fence present elsewhere.

### 4.10 Protection

The incidence of different types of protection (fencing was) as follows:

- Deer fence: 21 woods
- Stock fence: 8 (with tubes at 6 of these)
• Unfenced: 2 woods (where the fence had been removed or where there was a strategic deer fence in the wider environs)

The fact that browsing was an issue at some sites shows that protection remains a challenge for some practitioners on some sites. Problems typically arose because:

• the design of fencing was inadequate i.e. use of stock fencing when deer fencing was necessary
• of entry of deer into large fenced enclosures, followed by inadequate control.
5. Discussion and Conclusions

This report seeks to determine the extent to which native woods planted in the last 20 years:

- follow FCS guidance;
- are delivering high conservation (biodiversity) value;
- appear to be reasonably authentic i.e. are they adequate replicas of the semi-natural woodland appropriate for the site; and in the future it will be impossible to perceive if woods have been planted, rather than being of natural origin

The categorisation of private woods by their overall value in the MAUA analysis provides a good initial answer to these questions:

- Not meeting guidance: 19 %
- Not wholly meeting guidance: 29 %
- Meeting guidance – could be improved: 39 %
- Meeting guidance to a good standard: 13 %.

This suggests a little under half of private woods have something fairly fundamental wrong with them, whereas a little over half were essentially satisfactory or better. It is not easy to interpret this headline result. At one level, the high proportion of more or less unsatisfactory woods is clearly disappointing and suggests failings in ecological understanding, silvicultural expertise, delivery mechanisms or other aspects of professional capacity. However on the other hand, the creation of new native woods by planting is a novel and complex undertaking, that the forestry profession launched itself into with little prior expertise and only an understanding of plantation silviculture to build on. Seen from this perspective, it is hardly surprising that some of the outcomes are less than ideal. Indeed in the early years, some of the guidance was quite rudimentary, and with the best will in the world, it takes several years for new guidance to bed into the collective consciousness and working practices of woodland managers.

The fact that the average scores for woods appear to be increasing with time, from WGS to SRDP (see table 6), suggests that practice is improving. Having said that, there is still considerable room for improvement (see sections 5.1- 5.8 below); for example, this survey reveals evidence that some aspects of guidance, issued as long ago as 1994, are yet to be properly implemented e.g. identification of target NVC types and species choice.

We are fairly confident that the MAUA scores give a reasonable reflection of the degree to which the woods have successfully followed guidance; because that is how the project was designed. The MAUA scores can also be interpreted to tell us about conservation value and authenticity of the woods. The starting assumption is that woods that successfully follow guidance will also deliver good conservation value and be reasonably authentic. This seems broadly to be true, but there are some areas where following guidance, as mediated by current delivery mechanisms, does not lead to the best ecological outcomes i.e.:

1. Native trees are being established on areas of ground that are not suitable for woodland (see section 5.1 below), so either the guidance, or its interpretation or delivery are inadequate.
2. The use of conventional excavator machine mounding, allowable by current guidance, seriously undermines authenticity and impacts on some aspects of conservation value (see 5.2 below).
3. Failure to meet prescribed stocking targets gets recorded as a negative in terms of meeting guidance, but might have some benign and even beneficial outcomes for conservation value and authenticity (see section 5.3).
In the text below we discuss the strengths and weaknesses of the woods we sampled; and in most cases meeting guidance, conservation value and authenticity will coincide, but we highlight those instances where this is not the case.

A further complicating issue is the fact that we are moving out of the era when conservation and recreation were the only objectives for new native woods; in the future a proportion of native woods will increasingly embrace timber production, at least over part of their sites. Whilst this is outside the scope of this project, it only makes sense to comment on those areas of guidance where there is either conflict, or congruence, between provisions for conservation and timber production.

5.1 Unsuitable and marginal sites

Woodland creation appears to be taking place on some sites where the soil conditions and climate are at best marginal, and in some case unsuitable, for woodland creation. By these we mean unflushed peats, especially those over 30 cm, but less in some cases\(^7\), with vegetation strongly dominated by calcifuge mire indicator species such heather, deer grass, certain sphagnum species and bog asphodel; and on exposed sites, and/or in very wet climates. Such sites are typically not suitable for native woodland. Some may be suitable for scattered trees or bog woodland; and some may not be - our current ecological knowledge does not allow these distinctions. Sites such as these, where there is doubt about the ecological appropriateness of planting trees, should be left unplanted; and the longer-term gameplan should be to learn about the status of woodland on these sites by observing the progress of natural regeneration during the next generation. Furthermore, the cultivation required on these sites in order to establish trees according to current standards is typically so intrusive that authenticity of the resultant woodland is often entirely sacrificed. Even on sites where a case could be made that some woodland cover is appropriate, growth can be so slow that getting trees to a stage where they are resistant to deer damage can exceed the life expectancy of the deer fencing. A key criterion should be whether a fully functioning woodland ecosystem will develop on these sites in the long term, or whether the outcome risks being only a single generation of trees. In any event, woodland creation on sites where there is any doubt about the ecological appropriateness, or the likelihood of successful establishment, cannot be considered a priority use for forestry funds.

It was not clear that guidance on “marginal sites” was being adopted by practitioners. With only a few of the sample woodlands containing marginal sites, and without being able to access to the files for the individual grant applications, it is hard to comment on how this has been implemented. Suffice to say that this guidance is apparently only being implemented on some site and not others. This might be because managers are unaware of the guidance, or because managers and/or conservancy staff find it hard to interpret and implement; or because coverage in this study was not robust enough to detect its influence.

Our reservations about site suitability should not be interpreted as a blanket ban on establishing native trees and shrubs on peats. In some drier, less exposed parts of Scotland, all manner of pine woodland can be found on peats, from bog woodland to closed canopy woodland; and including, at Abernethy, 20 m tall pine trees growing on several metres of peat and detectable by the fact that the trees lean at odd angles\(^8\). Eared

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\(^7\) Such as shallow peat on bedrock

willow and downy birch seem to be quite adept at operating on many types of deep peat; and bog woodland is one of our most under-represented habitat types. At the same time Scotland has some extensive naturally treeless bogs, for example in the Flow Country, and delineation of these different peatlands in terms of their potential for supporting trees remains unclear.

Reflecting these issues in improved guidance will require careful analysis and needs to accept the fact that we don’t know all the answers at present.

5.2 Machine mounding

Machine mounding is allowable under, and to some extent promoted by, guidance. The best examples of shallow excavator mounding and trailed mounding might be acceptable, but the majority of mounding we encountered, especially in large upland schemes, has the effect of undermining authenticity and impacting on conservation values. In fifty or a hundred years time, someone walking into most of the woods that we sampled with excavator mounding will still clearly be able to see the unpleasant, regular pits and probably also some of the mounds. Whilst many components of the flora and fauna associated with native woods will be wholly unaffected by the presence of mounding; the conservation value of soil and field layer is compromised. Furthermore the forest floor it is critical for people enjoying the woods. There is only so many times that you can stick a foot into 15 inches of icy water in one of these hidden pits before any sense of delight of being in native woodland is completely dispelled. This is particularly true of wet areas where mounding tends to get deeper; and whether this is intentional on the part of operators or just what tends to happen, is unclear. A further problem is that in some cases we could see that managers had let the configuration of the woodland be partly determined by where the excavator operator was comfortable operating; sometime with the perverse outcome of trees ending up on the poorer soils.

We are aware that cultivation involves a difficult trade-off, on the one hand between the understandable desire on the part of practitioners and regulators to reduce the risk of failures in establishment, and on the other hand, the authenticity and conservation value of the resultant woodland. We also understand that some soils have been degraded and compacted under intensive grazing and that cultivation can rectify this. Our view is that guidance has been too liberal in allowing the wide use of conventional mounding and that we need to move on from the era when mounding was needed to make up for inadequacies in other aspects of establishment silviculture (site selection, species and provenance choice, weeding, protection). Current practice on a considerable proportion of sites does not follow the principle of employing the “minimum intervention” deemed likely to result in the establishment and development of a woodland ecosystem. We now need to work out how to establish native trees successfully without the “crutch” provided by conventional excavator mounding. A retreat from planting on marginal sites will reduce the need for mounding to some extent. We were heartened to see how many woods (or parts of woods) were being established, apparently successfully, without cultivation or by using hand mounding; and also the impressive use of inverted excavator mounding at Loch Katrine. These examples now need to be used to develop a better approach to cultivation.

In woods where timber production is an important objective there will be a case for more thorough cultivation, and so any new guidance will need to allow for this.
5.3 Stocking

Stocking was higher on average in woods established under SRDP, suggesting that the higher targets (1600 stems/ha at year 5) had generally, but not always, led to increased stocking levels. In some recently established woods on poorer sites, stocking was probably still higher than in equivalent older woods because mortality factors had not yet had a chance to manifest themselves. In a considerable number of woods, stocking was lower than the prescribed target levels. It is difficult to be definitive about this because the stocking estimates in this study were low partly as a result of our chosen sampling method (see section 4.3); but even allowing for this, the stocking levels recorded appear to be below target quite frequently. Large scale failures, especially in older schemes, occur due to the combined effects of poor sites, poor species choice, browsing, and inadequate weeding. Our interpretation of the low levels of stocking we encountered suggest:

- Poor species choice is a factor. This is a particularly regrettable and wholly avoidable source of failure.
- Problems get severe when several of the factors listed above combine, and practitioners need to be aware of this possibility. Trees can often (not always) struggle through a situation where one element is inadequate; but a combination of two or three of these factors usually leads to high mortality.

Sites with low stocking were marked down in the MAUA analysis because such sites were failing to meet guidance. However on some of these sites, our view was that modest reductions in stocking were not necessarily leading to poorer outcomes for conservation (or recreation or landscape); and could be quite benign and even positive for conservation in some cases. This is because patchy woodland and wood pasture type structures, in the long term, are probably an equally desirable end point in parts of many, or all, of the woods. Whilst the provision for variable spacing in current guidance get us away from excessive uniformity, it does not deliver the types of widely spaced trees that are typically encountered in semi-natural woods and wood pasture. Guidance and grant mechanisms could be improved by allowing greater flexibility in stocking, between the higher levels needed for timber production, conventional levels that deliver closed canopy woodland in a reasonable time frame, and wood pasture type configurations.

5.4 Target NVC types and species choice

The study provides the first hard evidence of the various ways in which mismatches occur between the ideal mix of tree / shrub species that best reflects the site type, and mixes actually chosen by practitioners. This can be considered at 2 levels:

- Representation of woodland NVC types – the degree to which practitioners choose the right NVC types to plant (if indeed that is done at all), and whether certain NVC types are over or under-represented;
- Species representation – the degree to which, having determined a NVC type, acceptable mixes of tree and shrub species are then used.

In practice these two issues get conflated. Because we did not have access to the files for the sample woods, it was not possible to know if applicants had actually gone through the process of determining the best fit NVC types, or whether a different route had been taken to determining species choice. It would be useful to find out how practitioners are currently setting about this task. An additional element here is whether the guidance in Bulletin 112 is complete, accurate and adequately user-friendly.
Section 4.4.1 sets out the degree of mismatch between “best fit” NVC and the apparent “intended” NVC judged from the trees planted. This attempts to evaluate how good practitioners are at assessing sites in terms of the target NVC woodland type to plant. The histograms in figure 4 give an impression of the species mixes that practitioners collectively have planted on individual NVC site types. These strands of evidence suggest a complicated pattern i.e.:

- quite high incidence of mismatches being within ±10% and therefore presumably fairly satisfactory;
- equally, incidences of mismatch up to ±50% or more; which signal very poor outcomes;
- practitioners appear to make the fewest/smallest errors on W9, W17 and W18 sites; and greater ones on W4, W7 and W11
- W4 and W7 appear to be under-represented on average and W9, W17 and W18 appear to be somewhat over-represented

Our overall impression was that the quality of species choice at the NVC level was highly variable, with a few good schemes, a large number that were moderately good but could be improved and some poor schemes; and that there was considerable room for improvement. This pattern is reflected in the MAUA scores where only 9 woods (29%) received a score of 70% or over.

The pie charts in section 4.4.2 provide good data on what practitioners are planting on sites assigned by the authors to the different NVC types (based on the indicator vegetation species). The broad picture is:

- The species chosen broadly reflect the best fit NVC types; there is no sign of widespread, fundamental, serious misunderstandings. So for example, there was usually representation of at least one of the major recommended tree species and several of the minor recommended species.
- There is huge room for improvement, in order to avoid the over-representation of some species i.e. the ubiquitous pine, alder and rowan; and the under-representation of others i.e. goat willow, eared willow and bird cherry (all three of which are mysteriously almost absent), sessile oak, silver birch, grey willow, hazel, hawthorn and juniper and wych elm.
- A significant proportion of species planted were not included in the lists of recommended tree species in Bulletin 112 for the individual NVC types (we called these “non-recommended” species) - and these comprised between 5%-34% across the different NVC types. The usual culprits were pine (on almost every conceivable non-pine NVC type) and alder, often used as a beat-up species on sites ranging from dry bracken slopes to deep peats. The biggest errors appeared to be on W4 and W11 sites.

There is currently no easy and reliable way for practitioners judging what is the “right” composition of species for a particular NVC type in a particular part of the country. Yet this is a challenge that every manager faces at the point of attempting to place an order for plants with a nursery - all too often with limited time to consider the problem properly and with the planting season uncomfortably close at hand. Bulletin 112 only sets out species as “Major recommended” and “Minor Recommended” and leaves it up to practitioners to fill in the numbers. Perhaps one of the most useful improvements that could be made to guidance would be to provide broad ranges for species composition for different NVC types in different part of Scotland – but with a list of caveats urging managers to consider each site individually and avoid formulaic outcomes.

We were left with a few doubts about the species lists in Bulletin 112. The distinction between major and minor is not ideal. Species can be minor in terms of numbers, but nevertheless of major ecological importance (e.g. goat willow or bird cherry in W9 and W7) and the major/minor distinction has a plantation
forestry smack about it. We are unconvinced about the emphasis on sessile oak: e.g. being “major” and pedunculate oak being “minor” in W11 and 17. Some species such as goat willow and eared willow that occur on a wide variety of sites seem to get limited mention. Finally there is no coverage of how to deal with transitional NVC types (e.g. between W17 and W18) which are very common and we suspect that this contributes to perpetuating some harsh transitions between woodland types that do not reflect ecological realities.

There is also evidence of some practitioners ignoring advice in Bulletin 112, for example the persistent over-representation of pine seems to result from a tendency for foresters to switch to W18 at the first sign of a blade of heather; whereas in reality heather is a perfectly acceptable component of W17 oak-birch woods and W4 wet woods.

Poor species choice is a factor that contributes to lack of authenticity in planted new native woodlands. Whilst there is quite high variability in species mixes that are acceptable on any site, some elements of species choice easily give away the planted origin of woods. This is typically: a) over-representation of species (e.g. 30% rowan immediately gives away a wood as planted), b) use of non-recommended species, or c) clumps of rare species. Species choice guidance could highlight these potential pitfalls.

We also felt that there was a case for:
- scrutinising the lists of indicator species for the different NVC types, and maybe building on some of the recent work that FES and FR have undertaken;
- considering if some simplified elements of the Ecological Site Classification could be introduced into Bulletin 112 to improve the characterisation of sites, - but avoiding a full blown treatment or attempting to capture the process in the form of a computerised expert system;
- simplifying the soils information, because the current adoption of the FC soils system, with all its complicated sub-categories and phases is off-putting for many users;
- running training courses aimed at the private sector agents.

A careful revision of those parts of Bulletin 112 dealing with how to determine target NVC types and species choice would be a useful exercise. This might also present a useful opportunity to consider how to introduce any changes that might be necessary to take account of possible impacts of climate change (e.g. changes in species range and composition).

5.5 Forest habitat networks

This aspect of guidance seems to have been properly implemented and has had good outcomes for conservation on the majority of sites. In an ideal world all native woodland expansion would take place adjacent to or in the close vicinity of, existing native woodland; in the real world at present 55% of planted new native woodlands fulfil this and a further 9% are within the FCS’s Potential Native Woodland Networks. However there is still a case for attempting, via guidance or incentives, to continue to encourage owners in those areas with existing semi-natural woodland to prioritise woodland expansion on sites adjacent or close to existing woodland.

Perhaps more importantly owners might be encouraged to start thinking more in terms of integrated habitat networks i.e. conceiving of woodlands as a mosaic with open habitats and paying attention to the configuration of other habitats in addition to woodland.
Internal connectivity of planted areas was generally good i.e. configurations with isolated blocks of planted trees are fairly rare (though there are some exceptions - see section 4.6).

5.6 Open space and non-woodland habitat

Most woods had broadly the proportion of “open space” suggested in guidance. Some woods have greater than that prescribed by guidance, especially on poorer sites, and often exacerbated by trees failing. Smaller woods in the lowlands sometimes have quite low proportions of open space.

Having a prescribed proportion of open space applicable across the board is clearly administratively simple, but does not reflect ecological reality. Ideally practitioners would be allowed more flexibility, to reflect the proportions of woodland and non-wooded habitat that:

- deliver the best ecological and landscape outcomes in different parts of Scotland and on different site types and ownerships.
- allow for greater amounts of non-wooded habitat, some of which could be allowed to develop to woodland by natural regeneration in the future (see section 5.7 below).

It is also probably a good time to excise the term “open space” from forestry guidance and replace it with a better term that places more value on non-woodland habitats; for example “open habitat” or “non-woodland habitat”.

5.7 Inclusion of natural regeneration

About half the sites have potential for natural regeneration in the future. However where apparently suitable open ground had been left, it was unclear whether there actually was any intention to facilitate natural regeneration. This is one area where the guidance Bulletin 112 lacks useful detail and options are typically constrained by grant schemes specifications on the proportion of open ground. More naturalistic outcomes would emerge if practitioners were encouraged to:

- establish planted trees and shrubs over more limited parts of sites, in locations and on site types that mimic the current distribution of semi-natural woodland;
- leave larger parts of sites unplanted with the intention of developing woodland by natural colonisation in the longer term.

This would raise challenges in terms of protection and vegetation management needed to encourage future regeneration. It would lead to smaller areas of woodland being established by planting, whilst fencing or deer control costs remained the similar.

5.8 Habitat mosaics

Virtually all of the woodland visited were exactly that, woodlands - albeit with a limited component of heathland, grassland and mire. This is a perfectly acceptable outcome, especially for smaller woods and on lowland sites. However it would be useful if provision could also be made for some schemes to be conceived of, and managed as, habitat mosaics i.e. mixes of woodland, grassland, heath and mire. On such sites the planting of trees could launch the site on an altered trajectory, but without wholly pre-determining the long term outcomes. This has been trialled as some of the landscape-scale woodland restoration
projects such as parts of Abernethy and Loch Katrine; and it would be useful to develop this type of approach more widely.
6. Recommendations

**Quality rather than quantity**
The overall aim for native woodland creation should be a shift towards improved *quality* – to incentivise high quality schemes in smaller numbers, rather than larger numbers of more mediocre woods. It is widely recognised that some new native woodlands are created with the apparent main objective of simply gaining the grant. This can sometimes lead to acceptable outcomes if the work is done diligently; but too often such schemes are located on poorer land, are relatively large, and aspects of the work are executed to a mediocre standard.

**Recommendation 1:** A grants, guidance and delivery structure should be sought that incentivises high quality schemes in smaller numbers, rather than larger numbers of more mediocre woods. Mechanisms are needed try to filter out, and/or work to improve, poorer schemes.

**Authenticity as an objective of conservation management**
From a conservation point of view, too many aspects of current practice, especially species choice and cultivation, introduce too high levels of artificiality into new native woodlands.

**Recommendation 2:** Closer attention needs to be paid to the authenticity of the woods (i.e. their similarity to semi-natural woods). The aim of guidance and practice on most sites should be to create woods that are indistinguishable from semi-natural woods, by say year 15-20.

**Objectives other than conservation**
New native woodlands generally have conservation as their primary objective, plus landscape and recreation, including shooting, as important aims. A subset of woods, small at the moment, but probably larger in the future, have timber production as an objective. At present guidance pays insufficient attention to objectives other than conservation; and in particular, there is little useful guidance on how to integrate timber production with other objectives.

**Recommendation 3:** Guidance should be revised where necessary to ensure that owners interested in timber production have access to guidance covering the modifications to new native woodland establishment silviculture that allow integration of timber production with the other aims of management e.g. via site selection, stocking, species choice, choice of seed source etc.

**Unsuitable and marginal sites**
Native woodland creation continues on unsuitable sites i.e.: poorest unflushed peats in exposed locations, and/or in very wet climates.

**Recommendation 4:** Native woodland creation on poor sites, where there is any doubt about the ecological appropriateness or the likelihood of successful establishment of a fully functioning woodland ecosystem,
should cease. These should be added to the list of habitats that are better left as open ground. Better definition of sites is required so as practitioners can differentiate between site conditions that are:

- unsuitable for new native woodlands;
- suitable only for sparse trees and/or bog woodland;
- suitable for new native woodlands.

Careful establishment of native trees and shrubs on peats, including bog woodland, should still be allowable; but see recommendation 14 below, that suggests a move toward a longer term strategy of facilitating establishment of trees on these sites by natural regeneration during the next generation.

It is not clear that the guidance for marginal land is understood by practitioners and that they are following the advice.

**Recommendation 5:** There needs to be a convergence of guidance to give consistent coverage of: a) the “unsuitable sites” issue (recommendation 4 above), marginal land, and the emerging FCS peatland policy. Marginal land should in any case only be allowed where it is a small integral part of a new native woodland on otherwise suitable ground. In general there should be a retreat from planting on marginal sites.

**Cultivation**

Excavator mounding, especially on wet sites, often causes unacceptably high damage to the soil surface and undermines the authenticity of woods, has long lasting ecological effects on the ground cover and can make woods unpleasant for visitors. The best examples of shallow excavator mounding and trailed mounding can be acceptable, but these are in the minority. A surprisingly high proportion of woods (or parts of woods) were established, apparently successfully, without cultivation or by using hand cultivation; and also by the use of inverted excavator mounding.

**Recommendation 6:** Experience with alternative forms of cultivation (to conventional mounding), including no-cultivation and inverted excavator mounding needs to be assessed, so as to develop a lower impact approaches to site preparation, with prescriptions matched to different soil and vegetation conditions.

**Selection of target NVC types and species composition**

**Recommendation 7:** Improved understanding of NVC woodland types, and the site factors that determine them, needs to be further promoted amongst agents and owners. A study to find out how agents are currently determining species choice would provide useful background for developing improved guidance; i.e. are managers actually determining target woodland NVC types, using ESC, or using some other method to determine species choice?

**Recommendation 8:** Improved guidance on use of precursor vegetation and soils is needed to help agents to select correct target NVC type. There is a case for:

- scrutinising the lists of indicator species for the different NVC types, and introducing some of the recent work that FES and FR have undertaken;
- considering if some simplified elements of the Ecological Site Classification could be introduced into Bulletin 112 to improve the characterisation of sites - but avoiding the full blown computerised expert ESC system.
• simplifying the soils information, because the current adoption of the FC soils system, with all its complicated sub-categories and phases is off-putting for many users;

• FCS running training courses aimed at private sector agents.

There is currently no attempt in guidance to prescribe what is an acceptable composition of species (i.e. percentages) for particular NVC type; yet this is a challenge that every manager faces at the point of attempting to place an order for plants with a nursery.

**Recommendation 9:** One of the most useful improvements that could be made to guidance would be to provide broad ranges for species composition for different NVC types in different part of Scotland – but with a list of caveats urging managers to consider each site individually and avoid formulaic outcomes. New guidance should also deal with both transitional NVC types (e.g. between W4, W17 and W18 or W8/9 and W10/11) and intimate mosaics of NVC types. Foresters need to better understand the ecological status of heather, so as they resist the urge to switch to W18 and pine at the first sight of a blade of heather i.e. it is a perfectly acceptable component of W17 oak-birch woods and W4 wet woodland.

It would appear that some species are being largely missed out of schemes because they are not being demanded by agents and/or are not available from nurseries.

**Recommendation 10:** There should be encouragement to plant the under-represented species especially goat, grey and eared willow, bird cherry, and sessile oak; shrubs in general, and some of the rarer species such as aspen. This issue needs to be taken up with the nurseries.

**Recommendation 11:** Managers should be made aware of the fact that poor species choice can:

- be an important and wholly avoidable element in tree mortality.
- contribute to lack of authenticity in planted new native woodlands, especially over-representation of particular tree species (especially pine, alder and rowan and also rare species).

**Stocking**

**Recommendation 12:** There may be a case for guidance and grant mechanisms to allow greater flexibility in stocking, between the higher levels needed for timber production, conventional levels that deliver closed canopy woodland in a reasonable time frame, and wood pasture type configurations. It is important that the beating up is carried out with recommended species for the NVC type in question and that conservancy oversight of stocking levels / beating up is maintained or strengthened.

**Browsing**

**Recommendation 13:** Managers should be encouraged to adopt a regular monitoring schedule to assess the impacts of browsing and bark stripping lasting until trees are well above browse height, and this should be an integral part of the woodland creation application. If trees remain vulnerable to planting once fences have ceased to function properly, and the browsing is unsustainable from a biodiversity viewpoint, other methods of control should be adopted. The ultimate aim is inclusion of deer in the woodland at sustainable levels.
Natural regeneration

Bulletin 112 raises the idea of facilitating natural regeneration in the next generation from the planted trees, and it would be useful to expand this idea and provide more detailed guidance.

**Recommendation 14:** More naturalistic outcomes would emerge if practitioners, in some circumstances, were encouraged to:
- establish planted trees and shrubs over more limited parts of sites, in locations and on site types that mimic the current distribution of semi-natural woodland;
- leave larger parts of sites unplanted with the intention of developing woodland by natural colonisation in the longer term.

Open ground and non-woodland habitat

Having a prescribed proportion of open space applicable across the board is clearly administratively simple, but does not reflect ecological reality.

**Recommendation 15:** More naturalistic outcomes would emerge if practitioners were allowed more flexibility, to adopt the proportions of woodland and non-wooded habitat that deliver the best ecological and landscape outcomes in different parts of Scotland, and on different site types and ownerships. This would deliver a wider range of woodland / open habitat configurations – from large areas of contiguous woodland needed to give interior woodland condition in some parts of Scotland; to mosaics of woodland and non-wooded habitat in other locations.

**Recommendation 16:** Simple, specific and reliable guidance is required on what are the important non-woodland habitats, including key indicator species.

**Recommendation 17:** Owners and agents should be encouraged to start thinking more in terms of integrated habitat networks i.e. conceiving of woodlands as a mosaic with open habitats and paying attention to the configuration and quality of other habitats in addition to woodland.