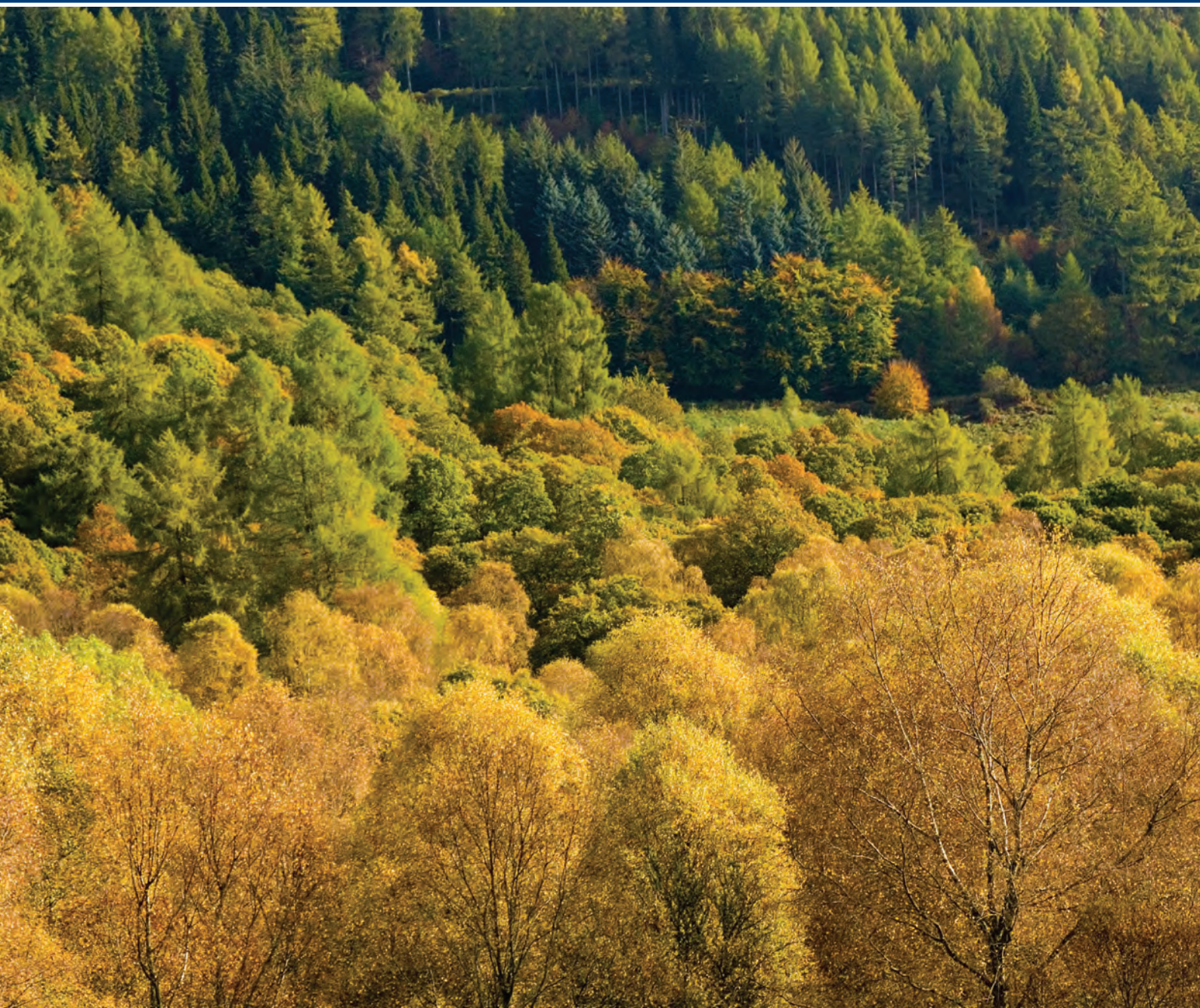




Forestry Commission Scotland
Coimisean na Coilltearachd Alba



Practice Guide

Achieving diversity in Scotland's forest landscapes



Practice Guide

Achieving diversity in Scotland's forest landscapes

Alison Grant and Rick Worrell
with Scott Wilson, Duncan Ray
and Bill Mason

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Foreword

Some 17% of Scotland is covered by forests and woodlands, most of which are conifer forests planted during the last century and managed primarily for commercial benefits. Many of these forests were established with little regard to the character of the local landscape and although they have contributed little towards local biodiversity, they have the potential to become more diverse habitats and landscapes yet still be valuable timber-producing forests.

These plantation forests – now reaching maturity – are being felled and replanted, offering an opportunity to restructure them to increase their environmental value. Replanting also gives us an opportunity to establish a replacement woodland which responds to new timber markets, such as local woodfuel supply, and is more likely to be resilient to climate change and other risks, such as pests and diseases.

Such forests also have considerable potential to contribute to current national environmental policies. With the UK adoption of the European Landscape Convention, the Scottish Government has attached considerable priority to increasing the value and enjoyment that we derive from our surroundings. The Convention stresses that it is all landscapes that matter, not only those recognised through landscape designation or accolade. Forests are an important and dynamic element of many Scottish landscapes, and with care can be designed to reflect the distinct differences in landscape character across Scotland.

The Scottish Government strategy ‘Scotland’s Biodiversity: It’s in Your Hands’ also aims to conserve biodiversity for the health, enjoyment and well-being of Scotland’s people. Our forests – both native and plantation - have the potential to make a vital contribution towards conserving threatened habitats and species as well as to increasing the variety of our wildlife.

Forestry Commission Scotland has prepared a comprehensive biodiversity programme for forest managers to help deliver these strategic objectives, aims that are further endorsed in the Forestry Commission’s new UK Forestry Standard (October 2011) and associated suite of Guidelines.

Through developing a thorough and well thought out forest plan, forest managers can identify the level of diversity that is appropriate for each forest. This publication offers guidance that aims to help with this process. It has been prepared by a team of landscape architects, forest ecologists and professional foresters and – pulling together those elements of the new Standard and Guidelines that relate to forest diversity – describes integrated management options for forest managers to consider.

This guidance will help forest managers to develop their plans in a way that will ensure that their forests continue to provide the nation with quality timber and other wood products, whilst also making an effective contribution to Scotland’s landscape and biodiversity.



Stewart Stevenson MSP
Minister for the Environment & Climate Change

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Introduction

This guidance is aimed at the owners and managers of conifer woodlands over 100 ha in size which have been planted primarily for timber production. It demonstrates ways in which the 'diversity' requirements of the revised UK Forest Standard¹ and the accompanying suite of Forest Guidelines² can be put into practice. It aims to:

- Demonstrate how forests can be diversified to increase their resilience to climate change and deliver biodiversity, landscape, operational and other benefits; and
- Provide practical advice on combining these benefits when planning for and implementing diversity.

It does not directly advise on how to implement other requirements of the Guidelines.

This guidance is laid out in a format that relates to the decisions which managers need to make when they are preparing a forest plan. There are normally several equally good management options which can be explored when preparing a forest plan. This guidance therefore does not offer a single 'best solution' for optimising diversity in a forest. Instead, it offers a range of advice and ideas from which you may select the options that meet your objectives and which you think are suitable for your forest.

Benefits of diversity

Increasing diversity is a useful planning tool. It can be used to meet a range of environmental, social and economic objectives, and is considered an important process to increase the ecological resilience of forests. Used wisely, it may provide the basis for adapting forests and their management to meet the future projected challenges of the changing climatic, environmental and market conditions.

Diversity in forests is important for conserving and expanding habitats and enhancing the landscape and recreation opportunities. In addition, introducing species and age diversity into commercial woodlands may also be a useful way to manage or reduce environmental and economic risk. An analysis of the UKCIP climate change projections has shown that changing site conditions and tree species suitability may place pressure on Scotland's forests and woodlands in the future³. The risk of serious impacts on forest ecosystems may be reduced by adapting forest management in several ways, including:

- **Establishing species that are well suited** to site conditions now, and **are likely to remain so in the future** as site climatic conditions change;
- **Building in resilience to pests, diseases and fire**, the occurrence of which is likely to be exacerbated by projected climate change; and
- **Diversifying timber production using a range of silvicultural systems to extend economic opportunities**, because the growing interest in timber as a sustainable resource is likely to increase demand for quality timber of all types.

Table 1 sets out the main risks and opportunities associated with climate change and the responses that managers should consider.

^{1&2} New UK Forestry Standard and associated suite of Guidelines are available to view and download at www.forestry.gov.uk/ukfs

³ Maps illustrating the projected changes to the warmth and droughtiness of Scotland's climate can be found at www.forestry.gov.uk/fr/climatechangescotland

Table 1 Diversity and the changing climate⁴.

Issue	Action by forest manager
There will be an increased risk from pests and pathogens. It is not possible to predict with any certainty the extent to which individual species will be affected.	Consider a wider range of species provided they are suited to site conditions in the current and predicted future climate. Diversify species and woodland structure using different silvicultural systems at all scales.
Seasonal changes in rainfall with drier and warmer summers will increase the occurrence of droughts the potential risk of forest fires. Dry conditions may limit species choice on shallow, and freely draining sandy textured soils. This will affect a number of species, including Sitka spruce.	Avoid planting species on sites which are either currently at the 'dry end' of the species tolerance range, or predicted to become so. Refer to Ecological Site Classification Decision Support System from Forest Research: www.forestry.gov.uk/esc Implement measures to increase the resilience of a forest against fire and for effective forest fire suppression.
The growth rates for many species will increase in a warmer Scottish climate on sites that are not limited by soil moisture and fertility.	Look for opportunities to extend the appropriate use of existing commonly planted species and identify opportunities to use other species which are well suited to the site.
Extreme weather events such as storms and high winds may increase in frequency and severity. In addition, wetter winters will reduce rooting depth on imperfectly and poorly draining soil types.	Manage forests to increase structural diversity, including increasing the use of CCF and using natural regeneration to diversify stands where possible. Establish a well-designed network of 'green' edges to help mitigate against widespread windblow.
In native woodlands, changes in the dynamics of competition between tree species and within the field layer may occur. This is not yet well understood.	When creating or managing native woodland habitats within forests, use the full range of native species associated with the intended type, to build in resilience. Adjust the proportions of species within the mixture to allow for future predicted climate.

⁴ References: Forest Research advice on the suitability of species to site conditions is available from: www.forestry.gov.uk/fr/treespecies
Forest Research – general portal to advice on Adapting Scotland's forests to a Future Climate: www.forestry.gov.uk/fr/climatechangescotland
Combating Climate Change – a role for UK forests, 2009 (also known as 'The Read report'): www.forestry.gov.uk/readreport
A Guide to increasing tree species diversity in Wales: www.forestry.gov.uk/wales

The challenges of creating a diverse forest

The benefits of a diverse forest need to be considered alongside the potential challenges. These include:

- Grazing by deer and other mammals often discourages managers from specifying palatable species;
- There are risks associated with establishing species which are potentially vulnerable to known pests or diseases;
- All commercially attractive species – even those that are for specialised markets – need to be planted in viable and marketable quantities. This may limit planning options or discourage managers from experimenting with less familiar species;
- While there are strategies which managers can use to respond to climate change, climate projections will always remain uncertain and so the evidence for how these adaption strategies can reduce risk and increase forest resilience will always remain limited;
- There can be tensions between different management objectives. For example, large coupes may fit well with the scale of an extensive landscape, but may compromise biodiversity objectives reliant on smaller coupes;
- Finally, there is increased interest in wood as a sustainable resource for both the woodfuel and construction industries. A wider range of timbers coming onto the market in the future will require changes in the processing sector which are not always straightforward to deliver.

Despite these challenges, planning and establishing a diverse forest is an exciting opportunity to be creative and ambitious. This guidance aims to inspire managers to think ahead and to be adventurous while still coming up with pragmatic solutions to complex issues.

How to use this guidance

The information in this guidance is presented in two parts.

Part 1: Planning for diversity describes options to make the most of diversity that can be built into a forest plan. This part offers advice on:

- Management options which have the potential to make a forest more diverse over the lifetime of a plan, including practical tips and suggestions made by those working in forest management; and
- Case studies which illustrate some of the advice.

If you are looking for practical advice or ideas on making the best use of diversity in forest management while preparing a forest plan, this is where to look.

Part 2: Diversity in the forest landscape illustrates four scenarios, each one demonstrating one option for introducing more diversity into four different forest landscape types.

If you are looking for examples of how the advice and tips might finally come together in a forest, this is where to look – simply find the type(s) of landscape which most closely resembles your site.

Part 1: Planning for diversity

When preparing a forest plan, consider how best to achieve an appropriate level of diversity both in different parts of the forest and for the forest as an integral part of the wider landscape.

Thinking about diversity when preparing a forest plan

Preparing a forest plan offers the opportunity to:

- Survey the forest to **identify features which already contribute to forest diversity**;
- Identify **new opportunities**, and **explore options to use diversity** to support forest management objectives; and
- Choose and implement **methods of forest management which make the most of the opportunities** identified.

The remainder of Part 1 is laid out in a way which reflects the key stages in the preparation of a forest plan, and can be used to 'dip into' when preparing a forest plan as shown in Figure 1 below.

Figure 1 The relationship between this guidance and the stages used for preparing a forest plan.

Key stages for preparing a forest plan	Relevant section in Part One	Page
Part B: Collect and commission survey and data	Diversity in existing forests	5
Part C: Analyse survey information and prepare plan concept	Analysing options	7
Part D: Prepare management proposals • Restructuring map • Plan of successor species	Thinning, felling and restocking	10
	Selecting successor species	14
Detail planning	Optimising opportunities for diversity	18
Implementation and monitoring	Monitoring	20

Key stages extracted from Strategic Forest Plans. Applicant's Guidance, September 2011 (FCS): www.forestry.gov.uk/wighelp

Diversity in existing forests

Many of the building blocks for woodland diversity are likely to be present in the existing forest and should be identified when undertaking the survey for a forest plan. Features are likely to include:

- Established trees which already provide species, age, colour or textural contrast;
- Stands which could be managed for CCF or specialist timber markets;
- Woodland and open ground habitats;
- Archaeological, geological or other features of interest;
- Viewpoints or established informal paths;
- Areas where establishment or harvesting is difficult and which could be replaced with open space or woodland which could provide additional forest diversity.

Aim to make the most of existing features. You may want to establish new types of habitat or other features, but it makes sense to start by identifying existing ones that can be improved or even resurrected. It is also likely to be more economical to try to retain at least some of the existing tree species diversity – especially if it is located where it provides public benefits – rather than start again completely from scratch. Table 2 gives more detailed examples of how to make the most of existing features.

Baseline information and forest survey

To make the most of existing diversity, use the survey stage of plan preparation to:

- **Start at a strategic scale and consider the regional context of the woodland.** Consider whether your forest can contribute to local or regional initiatives associated with particular species, habitats, long distant paths or cycleways, archaeological or other specialist trail. Linking to these will add value to your proposals.
- **Look beyond your own woodland and 'over the fence'.** Identify landscape features, paths, woodland and open ground habitats immediately adjacent to your own holding, as there may be opportunities to link these to specific features and habitats in your forest.
- **Carry out a good quality survey of the forest and site conditions.** A list of potential existing features and their usefulness is provided at Table 2. Good information on site conditions (geology, soil, flora) will help you select areas with the best potential for productive woodland, CCF stands and opportunities to create cost effective conservation gains.
- **Check whether the climate is likely to become unsuitable for some species over the next 30–50 years.** Using current guidance available on the Forest Research website⁵, including ESC analysis and Forest Gales, check where conditions may become unsuitable for current species or more suitable for other species during the period of the next forest management rotation.
- **Assess the value of your native woodland habitats to help prioritise management input.** Ancient semi-natural woodland is usually more valuable than areas of recently established woodland. Areas with a more complete range of trees, shrubs and other species characteristic of the habitat type are usually more valuable than less diverse ones. Veteran trees are usually very valuable. It can be cost effective to get in expert advice to sort out which areas of native woodland and PAWS are the highest priority for management input.
- **Identify appropriate areas where the forest could be expanded.** Extending your woodland may improve poorly designed forest boundaries, establish new habitat links, or extend the range of site conditions and opportunities to widen species choice within a forest.

⁵ General Forest Research advice on climate change and forestry in Scotland can be found at www.forestry.gov.uk/fr/climatechangescotland

Table 2 Features in the existing forest.

Feature	Potential usefulness	Management considerations
Potentially stable stands of non-native trees or mixed forest	CCF helps conserve soil moisture, stabilise soils on steep slopes and reduce storm water runoff as well as extending the age range of the forest. Spruce, hemlock, larches, Douglas fir, various silver firs, cedars, sycamore and beech have habitat value and will add visual interest if retained to grow on as large trees on stable soils. These might be particularly useful if located near to paths or forest edges. They may also have potential timber value when used to supply niche or specialist markets.	These can be managed to create stands of 'big trees' or more extensive areas of continuous cover forestry (CCF). If they are easily accessible, they can be selectively felled to maintain a long-term retention. Keeping a variety of existing trees may be easier and more cost-effective than new planting, especially if young trees are prone to deer damage or difficult to establish. Assess the invasiveness of non-native species to avoid their spread to neighbouring native woodland or other valuable semi-natural habitats.
Existing native or semi-natural woodland	Apart from already contributing to biodiversity, these trees will add recreation interest and often emphasise landscape features, such as watercourses or areas of thinner soils. Oak, ash, birch, Scots pine and other natives can be used to grow on as large trees. Existing native woodland can be used to provide a seed source for expansion, especially along watercourses or where grazing is light.	Most native woodland will usually benefit from some management, but sometimes can be left without intervention for periods. Management should aim to maintain or develop the natural composition and structure of the type. This can often be combined with small scale timber production.
Low maintenance open space (e.g. rocky outcrops, wetland)	Spaces which will remain open naturally because they are too wet, have poor, thin soils or are heavily grazed. Low maintenance open space is useful along paths and at viewpoints, but is also potentially well-established open ground habitat. These areas could also make useful deer glades.	These areas are unlikely to support regenerating trees, so require minimum maintenance to retain their openness.
Features (e.g. waterfalls, rock outcrops, archaeological sites)	These can be used to create a destination for paths and with appropriate management, their biodiversity value could be maintained and improved.	The areas surrounding these features may require some clearance of existing trees and regular intervention to maintain open space. If the open space at the edge of a forest can be managed by grazing, think about altering the fenceline to permit grazing. If open space requires regular management, plan to link it to convenient roads or paths.
Linear open space (e.g. wayleaves, roads, paths, rides and watercourses)	These will accommodate much of the forest infrastructure, but with careful management can become multi-purpose routes. These linear spaces are the backbone of the internal forest structure.	To improve visual impact and woodland edge habitat, aim to create varied edge profiles, using shrubs, and less dense spacing to create variety. Vary the width to avoid creating uniform corridors.
Deadwood⁶ and wind damaged areas	Wind throw, wind snapped stems and other deadwood can offer semi-permanent refuges for some species. Standing deadwood (snags) is not only good for biodiversity, but can be a visually interesting feature.	To get the most value out of this habitat, identify natural reserves and long-term retentions in areas of forest where accumulation of deadwood is likely to happen in the short to medium term. However, accumulations of deadwood can increase the risk of forest fires. Develop an appropriate fire management strategy that implements measures to reduce fuel loads. Minimise ignition sources and provide effective wild fire suppression. In some situations prescribed burning can contribute towards the achievement of management objectives. There may also be a potential hazard from standing deadwood.
Veteran trees⁷	A wide range of rare species of lichens, fungi and insects benefit from large old trees as well as some mammals, bats and birds such as woodpeckers. These feature trees also add visual interest, especially if located close to a path, and may be of cultural heritage interest or historic value.	Remove adjacent trees to prevent over-shading. Consider establishing successor trees.

⁶ Additional information on the importance of deadwood can be found in the publication *Life in the deadwood: a guide to managing deadwood in Forestry Commission forests* (2002), Humphrey, J.; Stevenson, A.; Whitfield, P.; Swales, J.

⁷ Further information on veteran tree can be found at www.forestry.gov.uk/fr/infnd-5w2g5b

Analysing options

Analysing options is the key part of the analysis and 'concept' stage in the forest plan process. It is likely to include:

- Setting clear objectives and priorities for the forest;
- Analysing the potential benefits of existing features identified in the baseline and forest survey;
- Assessing the implications of projected changes to the climate;
- Exploring different management options to make the most of existing opportunities, assessing their costs and benefits and considering future timber markets
- Adding value, for example by squeezing the most out of 'multi-purpose' features or creatively linking habitats, open spaces and other elements into a forest structure or network.

Diversity should help you achieve your forest management objectives. If you want to optimise both timber production and biodiversity, you might focus on developing high value timber crops, or expanding opportunities for energy crops, while also expanding a robust network of woodland habitats.

Alternatively, if recreation is a priority, the plan is likely to focus on adapting the forest structure so that people can experience different types of woodland and open space while minimising their interaction with large scale forest operations.

All parts of the forest have the potential to be multi-purpose. Sheltered open space can generally be managed for habitat value – for example for fritillary butterflies – and as part of a path network which may also coincide with a wayleave. A single clearfell may offer the opportunity to open up a view or a watercourse, create valuable hunting ground for raptors and allow a contractor access to thin an adjacent stand of pine or spruce for future long-term retention.

The value of individual elements is **further increased if they are physically linked together to form an internal forest structure** of roads, paths, open spaces and varied habitats, as shown in Box 1. There is likely to be more than one way to achieve such a structure, and the 'analysis' and 'concept' stages in the forest plan offer an opportunity to explore the options in more detail.

Exploring options and developing a design concept

When preparing a forest plan, it is usually helpful to begin with big scale decisions and then work down through the detail. Use the analysis and design concept stages of plan preparation to:

- **Decide the outer shape of the woodland.** Start by planning the shape of the woodland in relation to landform and key areas where planting is required to fit in with neighbouring woodlands. If you are extending the forest, integrate the species and timing of the new planting with the restocking of the existing forest. Identify key adjacent habitats to link with your woodland. If possible, increase the interlock between the forest and the adjacent landscape by establishing bold areas of open space extending into the forest, increasing the forest edge.
- **Explore silvicultural options.** Assess the benefits of CCF and different sizes of coupes to achieve landscape and biodiversity benefits while retaining operational efficiency. Explore different CCF management options, at both large and small scale, looking for multiple benefits, such as stabilising soil on steep slopes, limiting change to soil conditions and minimising landscape change.

Box 1 The benefits of a semi-permanent forest structure.

A semi-permanent forest structure connects the open space, habitats and infrastructure within the forest. It links and supports the management coupes, and combines elements which will 'outlast' the rotations associated with individual coupes managed on a fell-restock basis.

A semi-permanent forest structure can be used to:

- Create well-shaped, wind firm 'green edges' for felling coupes;
- Accommodate the physical infrastructure of the forest, including roads, deer glades, necessary wayleaves and firebreaks;
- Creatively link path networks within a semi-permanent setting which will set them apart from on going forest management activities;
- Incorporate the habitat network within the woodland, linking areas of forest and open ground which have conservation value, and establishing links to external habitats at the woodland edge;
- Maintain the setting for archaeological sites, viewpoints, or retain key features of interest and visual foci, such as a group of pine on a knoll, or areas of autumn colour, which will enhance the landscape.

The structure is therefore likely to include:

- **Tree cover which is more or less continuous**, where trees are grown to a greater age and size than occurs in most felling coupes, together with areas of naturally regenerating woodland, native and riparian woodland and 'natural reserves'.
- **Open space** associated with wetland, rocky outcrops, archaeological sites, path networks, views, wind firm coupe boundaries, the forest road network, power lines and other infrastructure, rides and deer glades.

Planning the semi-permanent forest structure

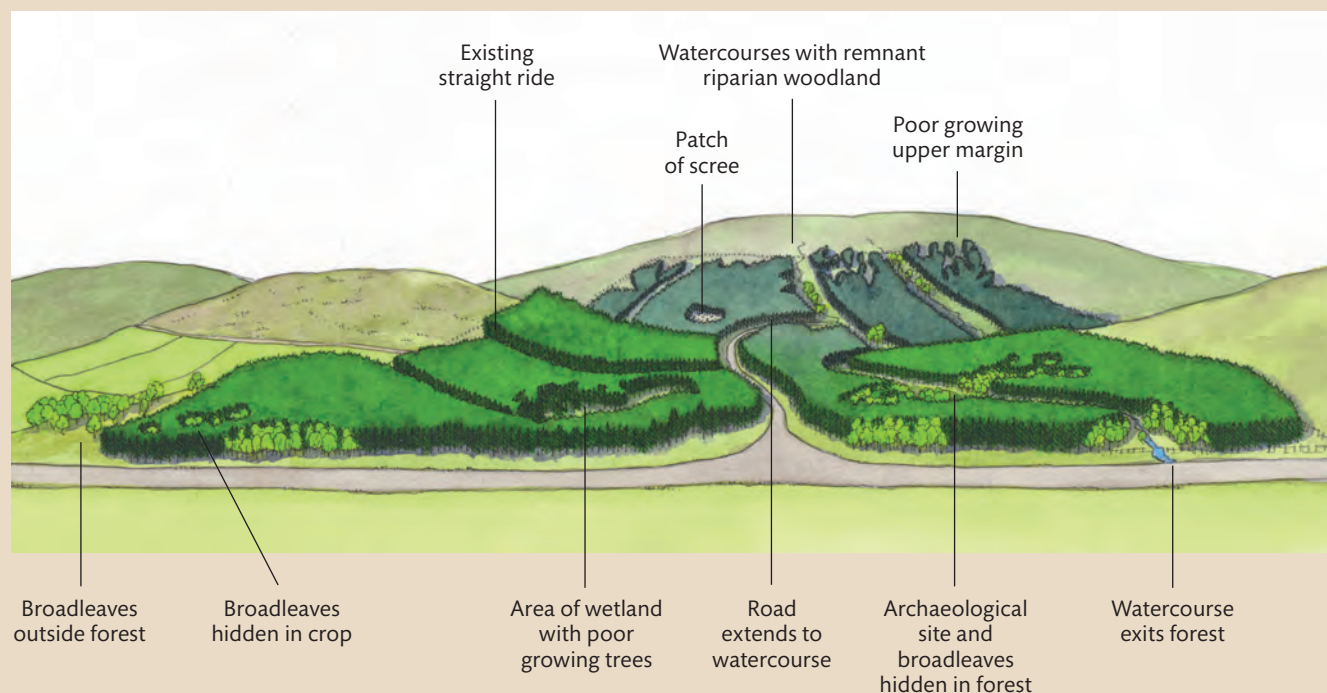
The best opportunity to establish this structure is when preparing a restocking plan. To make the most of an internal forest structure, it is useful to:

- **Bear in mind that there is no one single best design for this structure** – there are usually several options that work equally well, simply be clear why you have chosen the one you have. Make sure that the structure supports the management objectives;
- **Reflect the unique opportunities available in each forest** – the soils, micro-climate, ecology and landscape character alongside the owner's management objectives will all help to create a site specific structure
- **Keep options open** – objectives might change in the future, so use the structure to build in options for future managers. This may include leaving rides to be used for future roading options, establishing 'green' edges for coupe boundaries, so that future managers can vary the size and shape of coupes or manage some areas as CCF;
- **Incorporate the forest habitat network**⁸ – although individual networks will often comprise different types of habitat, try to form networks of one type, such as native woodland or grassland. Make sure that core areas of habitat are big enough to be ecologically robust. Small gaps in the network are quite acceptable, as many species are mobile. Try to establish networks at all scales, from individual sites to forest blocks and then the wider landscape scale.
- **'Look over the fence'** – link your woodland to other woodlands, your tree species to adjacent landscape features, such as riparian woodland, lines of field trees or nearby policies and extend open ground habitats to meet those on neighbouring properties.

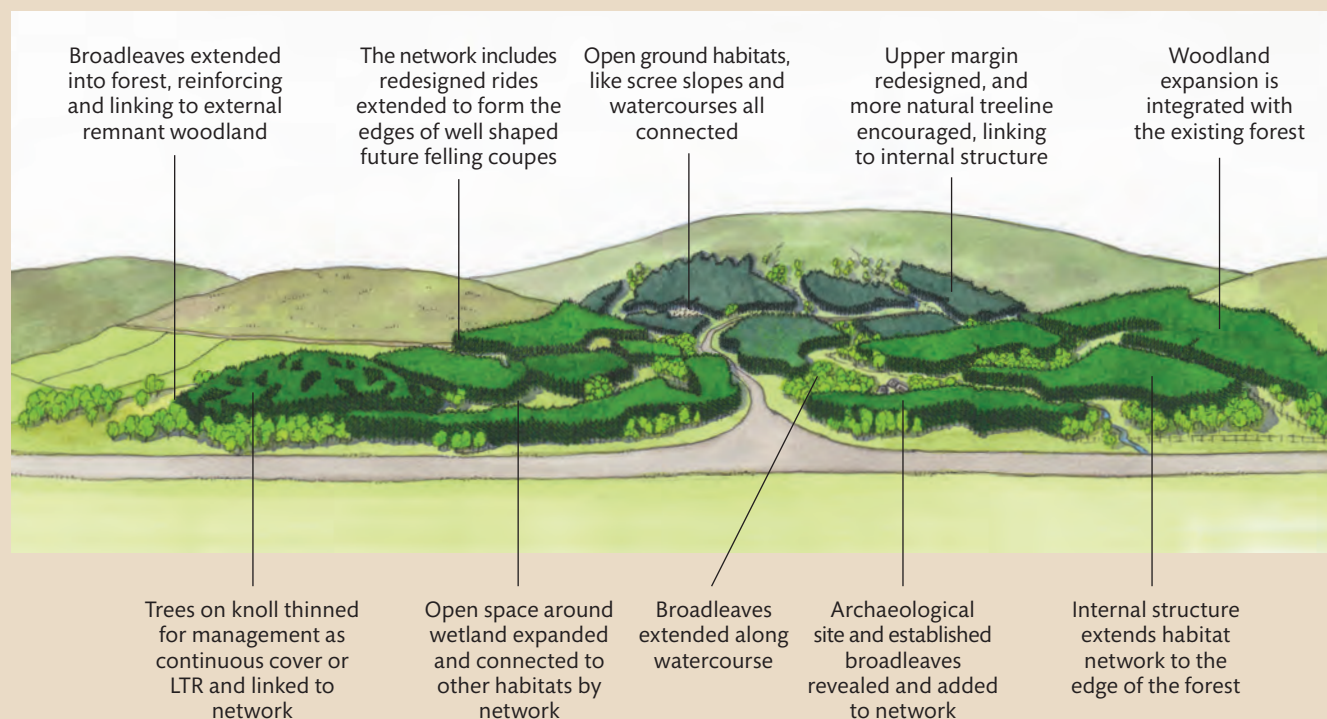
⁸ www.forestry.gov.uk/fr/habitatnetworks and www.forestry.gov.uk/habitatnetworkguidance

Figure 2 Planning an internal forest structure. Different ages of trees in coupes required for forest after restock.

Existing forest



Forest after restock



- **Identify areas within the forest where it is simply not practical or desirable to restock.** These will not just be areas of wetland or poor soil, but also areas which are difficult to harvest or fence cost effectively, such as small patches of land which require access across a watercourse. Evaluate how easy it has been to harvest areas after the first rotation. It may be more cost effective to simply leave difficult areas as open space to benefit habitat⁹, landscape or recreation interests.
- **Look for opportunities to restore or create new features.** Site survey will have identified areas where new features can be created such as habitats (e.g. mires created by blocking drains) or viewpoints; or where alterations to management can restore or expand important habitats such as patches of heathland or ancient woodland remnants. Try to ensure these new features deliver several benefits at once, and link them to the semi-permanent forest structure to further increase benefits.

Thinning, felling and restocking

Preparing the thinning and felling proposals for the forest plan offers the opportunity to:

- Review the success of the current crop and how well it achieves forest management objectives;
- Review the preferred silvicultural systems relative to site conditions and market, landscape and biodiversity benefits; and
- Consider whether there are opportunities to thin crops, establish continuous cover systems or manage stands for specialist markets.

Traditionally, most forests would be clear felled and replanted with a successor crop over time. This system offers opportunities to re-stock with species which may be more resilient to site conditions and climate change or which deliver landscape and biodiversity benefits. It is well suited to pioneer tree species which may colonise the bare ground after felling and has particular advantages for plants, birds and animals which thrive on disturbance. It also allows for fundamental re-design of the forest.

The introduction of continuous cover forestry or the creation of long-term retentions will enhance diversity within a forest predominantly managed on a clear fell system. Essentially these options provide areas of big, older trees where change is more gradual. These areas can also provide a source of large dimension timber.

In most forests, there will be opportunities for management using both clearfelling followed by restocking or silvicultural systems that aim to retain a continuity of canopy cover (CCF). Table 3 outlines some of the key ways that using these two approaches can help to diversify plantation forests.

⁹ Additional information can be found in the Forestry Commission Scotland Technical Guidance Note *Creating and restoring open habitats from woodland* available to download from www.forestry.gov.uk/glsotland

Table 3 How different forest management systems can contribute to diversification of plantation forests.

	Clearfell-restock	Continuous cover forestry (CCF)
Adapting to climate change	Clearfell-restock provide periodic opportunities to revise species and provenance choice. Species and provenance should be selected to match site conditions now and into the future. Species and provenance should be selected to match site conditions now and into the future – refer to www.forestry.gov.uk/fr/treespecies and www.forestry.gov.uk/fr/climatechangescotland	CCF systems can be selected to transform stands with a more complex structure and species composition. The mixture of species and stand structure is likely to provide increased resilience from extreme climatic events (e.g. drought, waterlogging, pests and pathogens), as impacts often affect a single species or age class. CCF management causes less severe changes to the stand microclimate, soil moisture and nutrient conditions compared to clear-felling. Where appropriate thinning regimes are in place, irregular silviculture may result in woodland that is more wind-firm.
Operational considerations	Clearfell-restock requires a short period of intensive silvicultural operations at the time of clearfell-restocking. This is more efficient where the mode of working is highly mechanised. The timber produced is normally concentrated in a relatively small range of target diameter classes for key markets.	CCF favours a more 'constant input, constant offtake' mode of management that may be better suited to less mechanised systems. A higher level of field forestry skills is required to transform and maintain stands using CCF. Logs will have a greater range of dimensions, but may include a proportion of larger, higher value log sizes.
Forest economics	Clearfell-restock concentrates both income and costs in a relatively small phase of the total rotation length. This may result in higher costs for replanting, but these are offset by recent income from the sale of timber.	CCF results in a more even spread of income and costs over an equivalent rotation period. Harvesting costs per unit of timber production may be higher than under regular systems but the costs of restocking may be reduced if natural regeneration is used.
Habitat types	Felling and restocking coupes over, say, a twenty year timescale will result in open ground, young trees, polestage and then mature trees all within a single forest. This provides different habitats and niches that move around the forest over time. Each growth stage may be associated with a different suite of species. It also provides a large amount of forest edge habitat at any one time.	CCF provides extensive areas of mature 'forest' habitat which contain some larger, older trees and will experience less frequent disturbance. CCF is relatively less common in Scotland and therefore provides valuable woodland habitat. CCF may also provide more deadwood when a proportion of large trees are retained on site well beyond biological maturity.
Habitat disturbance	Clear fell mimics larger scale disturbances (e.g. wind, insect outbreaks or fire) and provides niches for species preferring large patch sizes.	CCF mimics smaller scale disturbance events (wind, disease, natural mortality) and favours species that thrive with lower disturbance levels and in smaller patch sizes.
Species	Clear fell-restock is suited to species that require forest edges and the periodic appearance of open ground e.g. deer, mice and voles and their predators such as owls and foxes, corvids, pigeon, finches and tits. Some woodland plants flower best after disturbance (e.g. coppicing), especially those requiring high levels of light.	CCF is suitable for species that like 'interior' woodland conditions such as tree creepers, woodpeckers and pine marten. More fungi species, especially ancient woodland specialists, tend to be present in mature woodlands. Some bryophytes also require undisturbed conditions with a constantly high humidity level.
Broad landscape context	Clear fell-restock provides the opportunity to fell coupes which will create open spaces that are in scale with and shaped to reflect extensive landforms and other large scale landscape features.	CCF can be used to pick out key landscape features in the wider landscape, such as prominent river valleys. In extensive forests, areas of mature woodland can provide a visual contrast to felled coupes.
Views and visibility	Clear felling provides an opportunity to reveal views which may have been enclosed for many decades.	CCF can be used to frame views or provide permanent screening for quarries, powerlines, or even built developments where screening will provide additional security or privacy.
Landscape change	Regular felling and restocking provides an opportunity to change species, for example to better reflect landscape character, to highlight a particular landform or to establish a species which will then go on to form a continuous canopy in the future. It also provides an opportunity to reshape visually intrusive internal or external forest margins.	CCF provides a relatively stable and 'unchanging' feature at the landscape scale, with desired species or structural changes taking place gradually. Visual appearance will change more slowly and at a smaller scale.

	Clearfell-restock	Continuous cover forestry (CCF)
Landscape or features	Provides an opportunity to open up woodland around natural or cultural features which can then be more visible or accessible.	CCF provides an opportunity to retain existing veteran or dramatic 'big trees' or to maintain an established setting for existing natural or cultural features.
Recreation context	Creates an opportunity to provide a dynamic forest environment, which changes over time, revealing new views and different spaces over the length of the rotation.	Provides continuous shelter and an established, familiar context, including large trees or more complex forest structures, such as shrub layers and regeneration.
Design of paths	Clearfell-restock provides an easy opportunity to establish spaces and species which enhance the recreation experience along path networks – although this can equally be established at a small scale in association with the path.	CCF creates a semi-permanent structure for a path network, where management intervention is less and at a smaller scale, and where the public can be more easily separated from large scale forest management activities.
Setting for historic sites	Clearfell-restock may provide an opportunity to clear damaging vegetation from archaeological sites. Clearfell-restock can offer the opportunity to establish appropriate species, which will provide a fitting, permanent setting for historic sites in the future. It can also be used to open up views from important sites, which may promote a better understanding of historic context.	CCF can create a semi-permanent setting for an archaeological site. It may also provide the opportunity to use more sensitive, site specific, small scale interventions which limit impact on archaeological features. Old or veteran trees, ancient woodland and established ground flora can contribute to the atmosphere of 'timelessness' which may enhance the experience of an archaeological site.

Preparing thinning and felling proposals

Use the preparation of the forest management plan to:

- **Restructure the age class in a forest, from a relatively narrow to a wider range of ages.** This is a tried and tested approach to increasing diversity. Over time try to add onto the age range of the forest, so that it continues to extend to eventually include trees of all age classes.
- **Think ahead and identify stands you want to thin to use as LTR or manage as continuous cover, even if you do not thin the rest of the crop.** It may well pay you to thin areas of minor species and retain them to enhance diversity where this meets your objectives. There is more detailed information on the benefits and challenges of the range of approaches to CCF in the Appendix (page 25) and examples of these in practice in Box 2.
- **Vary the size of the management coupes across the forest.** Small coupes are generally better for creating the woodland edge and glade conditions which many wildlife species require, but in landscape terms are more appropriate on lower hill slopes in the forest, or around key features like valleys and watercourses. Larger felled coupes are good for species which like disturbance, for example raptors which might hunt across restocked coupes. They are more easily absorbed into the sweeping scale of expansive landscapes and higher up the hills.
- **Plan ahead to establish wind firm boundaries.** You can add flexibility to future management options by establishing more coupe boundaries, so that a variety of stable 'green edges' provide different options for future felling or areas which might be converted to continuous cover. Additional 'green edge' coupe boundaries or rides can be cut into a young stable crop at the same time as thinning is taking place.

Box 2 Examples of continuous cover forestry within plantation forestry in Scottish public forest estate.

Craigvinean Forest – uniform shelterwood

This forest in Perthshire comprises a large extent of post-war plantations of Norway spruce, Douglas fir, European larch and Scots pine on visually prominent slopes above the A9 highway corridor. Red squirrel is an important aspect of local management. The uniform shelterwood system is being used to retain mature crops of Douglas fir and Norway spruce, promoting a future successor crop by natural regeneration and retaining a continuity of mature forest canopy and cone supply. This forest also produces some very high quality, large dimension Douglas fir.



Culbin Forest – group shelterwood

This forest on the coast of Nairnshire comprises large areas of even-aged Scots and Corsican pines on former sand dunes. Managers wish to avoid clearfelling to minimise the risk of visual intrusion, to diversify the age-structure of the forest and to reduce restock costs. After initial trials of group selection felling, the group shelterwood system is now being used to release pre-existing patches of light-demanding pine regeneration and transform the forest to uneven-age.



Glentress Forest – group selection

This diverse forest is on the north side of the Tweed Valley near Peebles. Crops include Norway and Sitka spruce, Douglas fir, larch and other conifers. In addition to timber production, the forest is popular for visitors to its extensive mountain biking trails. Since the 1950s University of Edinburgh and Forestry Commission have pursued a transformation trial on >100ha of the forest using group selection systems. Group size has increased over time and enrichment planting with beech and silver firs has been undertaken.



Faskally Wood – single tree selection

There are few examples of single tree selection forestry in Scotland, but Faskally Wood near Pitlochry comes close. A trial transformation by group selection began in the 1950s. The transformation is now well advanced, giving an attractive irregular structure of mixed conifers and hardwoods. A mixed approach involving single tree selection, group selection and group shelterwood systems is now being used to maintain this.



Selecting successor species

Selecting the successor species for the forest plan offers the opportunity to:

- Combine knowledge gained from the previous rotation, and a detailed analysis of ground conditions to fully inform options;
- Take into account projected changes to the Scottish climate, using the information and tools available on the Forest Research website. Assess how climate change will influence site conditions and species choice over the next 30–50 years;
- Identify and analyse areas where growth has been poor, or where ground conditions will become more adverse for existing species with predicted climate change. Use this information to identify different successor crops, review establishment techniques or leave areas as open space;
- Explore the likely costs and benefits associated with using different species at different scales;
- Identify opportunities to expand on existing features and open space, or add new species which will enhance biodiversity, reinforce landscape character or add to recreational interest;
- Identify and plug 'gaps' in the semi-permanent forest framework, establishing a network of interconnecting habitats and paths and developing variety which reflects topography and provides visual interest.

The main risks and opportunities associated with climate change are described in Table 1 (page 2). The evidence for how these strategies can reduce risks and increase forest resilience is still limited, but principles to bear in mind are:

- Choose species to suit both current and projected future site conditions;
- Spread your risk by diversifying species and woodland structure at suitable scales; and
- Consider using continuous cover silvicultural systems where conditions allow – if these are not available within the existing forest, establish suitable areas at restocking.

Preparing proposals for successor species

Use the selection of successor species to:

- **Respond to climate change.** If restocking or selective felling under CCF, favour species which are likely to respond well to the site conditions both now and in the future. Consider establishing a range of types of mixture: intimate mixtures are suitable for nutritionally poor sites and in CCF systems, while mosaics of pure stands will help spread risk. In mixtures, introduce species which have similar growth rates. Explore the practicability of using minor conifers and hardwoods to build in ecological and economic resilience – there is more information on species selection in Box 3. Box 4 describes an example of a forest where species choice is being altered to reflect changing site conditions;
- **Prepare a species inventory.** It is useful periodically to carry out an exercise that fundamentally re-assesses whether the species mix in the whole forest best suits the long-term objectives. This is particularly useful if important underlying aspects of forestry change, such as future climate or economic trends, or changes to policy or ownership. Carry out an exercise to think through what the ideal future composition of the forest might be in 50 years time, and institute changes in restocking that will deliver this.
- **Identify soils and sites that may provide greater scope for species choice.** Brown earth soils (and more fertile surface-water gleys) may provide more options for diversifying tree species composition. It is important to recognise soils and be aware of soil variation in coupes in order to consider species choice options carefully. Soil maps from the Soil Survey of Scotland¹⁰ are available but the resolution may not be appropriate for species selection in coupes.

¹⁰ Soil Survey of Scotland (Macaulay Land Use Research Institute) is available at www.macaulaysoils.com.

Box 3 Productive conifers and hardwoods.

In many Scottish plantation forests, use of a wider range of conifer and hardwood species will help to:

- Diversify the forest both structurally and visually;
- Reduce the overall climate and pest/disease risk profile and
- Create new opportunities for marketing naturally durable timber.

The main commercial species in Scotland are Sitka spruce, larches and Scots pine. Other conifer and hardwood species have either been grown in Scotland for decades and have a proven track record, or have been grown elsewhere and appear to have potential. Detailed information about the less frequently used species is available from Forestry Commission Scotland¹¹. Selection of species should always be informed by a thorough field-survey of the planting or restocking site and application of the Ecological Site Classification (ESC) or equivalent.

Species	Advantages	Challenges
Norway spruce	Good record of growth in Scotland. Timber easily sold to same markets as Sitka spruce. Cones favoured by red squirrel.	Only suitable for the more sheltered sites. Late natural regeneration (50–70 years). Longer rotations than Sitka.
Douglas fir	Valuable, strong timber for construction when well-grown. Can be used under a range of silvicultural systems. Attractive.	Establishment more difficult than for Sitka spruce. Usually best grown on longer rotations. Needs thinning to regenerate. Susceptible to deer browsing.
Western red cedar/Coast redwood	Highly productive species, with durable timbers suitable for cladding and outdoor use. Good for use under selection systems.	Can only be used on the more sheltered, fertile sites. Markets for timber still under-developed in Scotland. Longer rotations.
Western hemlock	Grows well in many parts of Scotland and produces a good timber if well-grown. Shade tolerant, strong natural regeneration.	Timber not highly valued by the trade in Scotland. Concerns over spread of regeneration into nearby native woodland habitat.
Grand, noble and silver fir	Grows very quickly, producing large volumes of lighter timbers. Noble fir is tolerant of wind exposure. Very strong natural regeneration.	Very palatable by deer when young. Timber is light and not favoured by the sawmillers in Scotland. Risk of drought crack.
Lawson/Leyland cypress Japanese red cedar	Potentially valuable timbers, good natural durability. Shade tolerant. Can be used under selection silvicultural systems.	Little experience of growing in Scotland with only niche markets to date. Can only be used on the better site types. Threat to Lawson cypress from <i>Phytophthora</i> disease.
Macedonian pine	A hardy species that tolerates poorer sites. Good all-round milling timber.	Little experience in Scotland. Difficulty in obtaining planting stock from nurseries due to slow establishment and early growth.
Oak	Highly marketable and valuable timber. Whilst aspects of its silviculture are challenging, it can be grown well in Scotland. Forms part of key native woodland communities and supports much biodiversity.	Establishment and growth are slow and rotations are long. Requires high investment to produce good form. Prone to shake on dry lowland sites. Timber production is mainly from better lowland sites. Improved seed not likely to be available for many years, although seed is available from registered seed stands.
Ash	Good timber stems can attract moderate to high prices. The hurley stick market can be profitable for thinnings. Easy and quick to establish with quite short rotations. Resistant to squirrel damage. Improved material from breeding programmes may become available.	Requires good quality, fertile and wind-sheltered sites to produce valuable timber. Regular thinning is essential. Timber prices fluctuate more than for oak or sycamore.
Sycamore	Grows well in many parts of Scotland and produces a valuable timber. Easy and quick to establish on quite short rotations. Grows best on heavier more fertile soils. Rather more tolerant of exposure than ash. Improved material from breeding programmes may become available.	Highly prone to damage from grey squirrel. Should not be grown adjacent to high quality native woodland sites due to the likelihood of invasion by seedlings.

¹¹ Wilson, S.McG. (2011). *Using alternative conifer species for productive forestry in Scotland*. Forestry Commission Scotland, Edinburgh. Advice on characteristics of trees grown in the UK, including site and climatic preferences, is available at www.forestry.gov.uk/fr/treespecies

Species	Advantages	Challenges
Beech	Grows well in many parts of Scotland and produces a potentially usable timber. Shade-tolerance makes it suitable for mixed forestry with conifers. Highly tolerant of exposure.	Establishment and growth are slow and rotations are long. Timber is currently undervalued and prices fluctuate. Some Scottish beech timber is inferior due to growing conditions. Improved seed sources not likely to be available for many years though seed is available from registered seed stands. Should not be grown adjacent to high quality native woodland sites due to the likelihood of invasion by seedlings.
Birch	Can grow well on a wide range of site types, establishing quickly with rapid growth and short rotations. Improved material from breeding programmes for silver birch may become available.	Much birch growing stock in Scotland has poor form and standing volumes tend to be quite low. Markets for birch timber (as opposed to woodfuel) in Scotland are poorly developed. Future interest for timber focuses on silver birch (<i>Betula pendula</i>) grown on better soils at elevations below 200 m. Downy birch usually of little interest for commercial timber but useful for wood fuel.
Wild cherry	Can produce valuable timber when grown on the better sites. Quick and easy to establish, short rotations. Improved material currently available (Wildstar).	Can be difficult or expensive to get good planting stock. Some planting material prone to canker and aphid damage. Usually only grown in small quantities.

It is better to develop field craft skills of soil and plant identification, and to use site classification systems – such as the NVC¹² or ESC analysis¹³ – to inform species choice.

- **Identify potential low input / low output areas.** Assess whether it is better to opt for low input / low output options, such as pine, larch or spruce mixtures, rather than using expensive establishment measures to produce high yielding crops.
- **Plan ahead and identify where trees which can be established for future CCF or LTR.** It is likely to be more cost effective if these areas are identified up front, and that the stand is allowed to develop a 'green edge'. These areas should be located where they are accessible for thinning even if the rest of the crop is not.
- **Extend small, but potentially high value, timber options.** On suitable sites, less commonly grown conifer and broadleaved species¹⁴ could be commercial options. Box 3 describes the benefits and challenges of some of these species. Such species require a greater investment in establishment costs, but have the potential to supply high value markets. In addition, most trees can be planted with energy/biomass/firewood markets in mind, especially fast growing broadleaves such as alder, birch, aspen, poplar and willow.
- **Extend the use of natural regeneration.** This may be most successful in association with CCF, but regeneration can also be used to promote a more natural transition between the forest and open land. Fencelines sited away from the immediate forest edge for example, perhaps enclosing wetland or higher hill tops, may encourage scattered regeneration – there is more on this topic in Box 5 (page 18).
- **Don't re-establish a network of rides just because it is there already.** Planning offers an opportunity to remove inconvenient or visually intrusive rides and establish wind firm boundaries which will create better shaped coupes in the future.
- **Select a level of species diversity which is appropriate to landscape character.** In areas with complex topography and diverse vegetation, a variety of colour and texture will be appropriate. But where there is a visually simple land form and vegetation pattern, plant more simple species patterns and establish more variety associated with watercourses, small topographical features or in shallow valleys.
- **Increase the ecological and visual value of woodland by adding shrubs.** In addition to establishing trees, include shrubs in native woodland, broadleaved planting, or even under larch. Shrubs are especially useful in providing small-scale or narrow links between habitats through areas of more extensive fell-restock coupes and are a valuable addition to the semi-permanent forest structure.

¹² Further information on the National Vegetation Classification is available at www.jncc.defra.gov.uk/page-4259

¹³ Ecological Site Classification Decision Support System (ESC-DSS) tool: www.forestry.gov.uk/esc

¹⁴ Further information on quality broadleaves is available at www.forestry.gov.uk/fr/infnd-7ydb5q

Box 4 Selecting alternative conifer species for productive forestry, Clashindarroch Forest, Aberdeenshire.

History of Clashindarroch Forest

Clashindarroch Forest is the largest plantation in Grampian, established by the Forestry Commission during the 1930s. A wide range of conifer species was tried out in early plantings in the Kirkney Water area of the forest. There was also a detailed study of the soils and vegetation of the forest, conducted by Muir & Fraser of Aberdeen University in the 1930s.



Current challenges

The forest is valued for timber, landscape, recreation and biodiversity. Standing crops of Sitka spruce and lodgepole pine are coming up to final felling age, and extensive restocking is required. However Sitka spruce has shown signs of drought-cracking since 2003 and red-band needle blight has badly affected lodgepole pine. Choice of species for the future is a key issue.



Species diversification

Mature Norway spruce is being retained for red squirrel. Alternatives to Sitka spruce, including Scots pine, Douglas fir and larch are likely to expand their role within the forest in the next rotation. As time goes on there may be an increased role for shade-tolerant conifers such as western red cedar, western hemlock and grand fir if suitable markets can be encouraged.



Use of even-aged mixtures and CCF systems

Some older stands of Norway spruce, Douglas fir and Scots pine will now be managed under shelterwood systems to enhance structural diversity. In the younger crops "insurance mixtures" such as pine-spruce, larch-spruce and larch-Douglas fir are being used as one way of "hedging the forestry bets" against climate change and disease. These can arise by natural regeneration.



Expansion of native woodland habitats

Where conifers are being removed from the riparian buffer strip within the forest, native hardwoods such as alder, birch and willow are allowed to regenerate. The forest is also being extended by planting of new native woodland on surrounding open land under the Scottish Forest Alliance programme. Oak, ash and birch will be managed for carbon storage, timber and biodiversity.



Box 5 The benefits of a more natural forest edge.

A more natural forest edge of dispersed, regenerating trees or scrub is a relatively uncommon habitat which can be used to create a gentle transition in the landscape between dense forest and more open moor or hill land. Naturally regenerating native species will have the most useful biodiversity benefits, especially montane species which are found above the natural treeline. But even regenerating non-native species has habitat value and may complement the landscape character to create a more naturalistic forest edge.

This type of woodland is of particular benefit to some bird species, such as black grouse and provides sheltered habitat for butterflies and moths. In expansive moorland or upland landscapes, the subtle change from a dense woodland to open moor or hill is not only an additional valuable habitat, but also reinforces the semi-natural landscape character by avoiding the harsh boundary created by dense woodland adjacent to heather or grass moor.

This type of effect can be difficult to establish, but may be useful where the upper reaches of a hillside are rocky or characterised by thin soils, a naturally regenerating upper margin can be a more suitable way of shaping the upper edge than trying to set out a well-shaped fenceline in rocky ground.

Opportunities

Opportunities to create a more natural forest edge are likely to be:

- **Fencing a hill top into the forest** – this presents an ideal opportunity to create a natural upper margin. Sometimes it is cheaper and more effective to fence in a whole hill top than to try to construct a practical upper fence line on difficult ground;
- **Wetland, thin soils or rocky outcrops at the edge of the forest** – where poor ground exists on or very close to the edge of the forest, fencing to include these areas within the forest can ensure regeneration;
- **Establish key species at the edge of the planted forest** – some species, such as juniper, may be appropriate for the site. Consider planting local provenance shrub species as part of your broadleaved and shrub allocation along the edge of the forest. These may then regenerate away from the forest edge;
- **Fence as high up gulleys and watercourses as is possible** – small pockets of remnant riparian woodland may regenerate quickly if grazing has been reduced, forming a source of seed for future colonisation.

Limitations

The creation of a more natural forest edge can be limited by landownership constraints, the high conservation value of adjacent open ground or grazing of potential regeneration. Furthermore, to be successful in landscape terms, this type of woodland is more effective if it is relatively extensive and not limited to a thin margin of sparse woodland fringe which looks out of scale when adjacent crops are felled. Problems may also arise where regeneration of non-native species is not appropriate.

Optimising opportunities for diversity

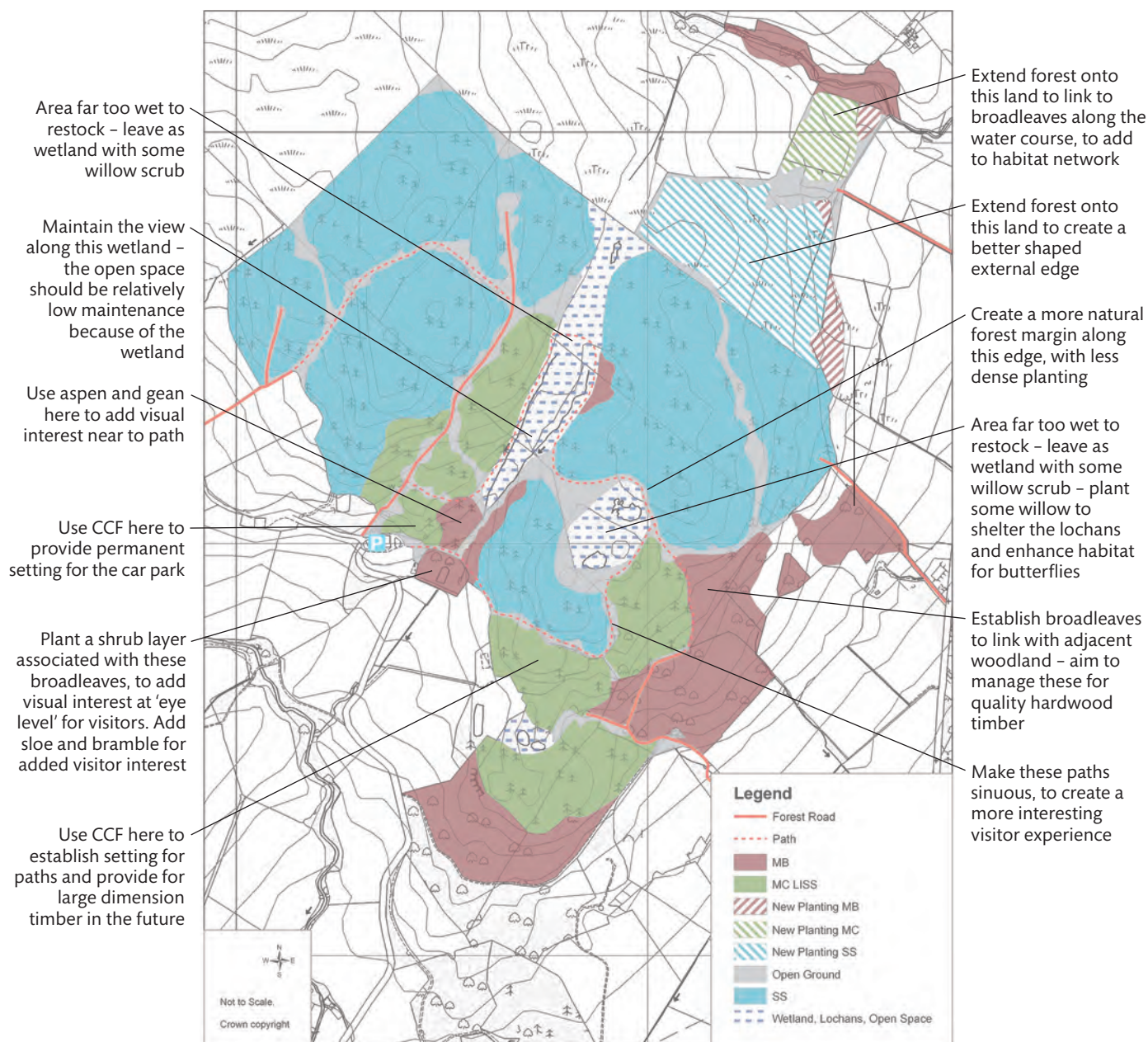
Expanding the detail within the 'management operations' section of the forest plan offers the opportunity to:

- Maximise added value, for example by planning an additional thinning which may allow trees to grow on to produce large dimension timber, tweaking a species mix to include spring flowering broadleaves along a path, or choosing hardwoods which could be grown on to produce quality timber;
- Use small interventions to create a big impact – even a single feature tree can create a big visual impact if well selected and carefully sited;

- Ensure that forest managers have as many options as practically possible to both maximise revenue and to reinforce diversity in the future. This may include establishing opportunities which may or may not be realised, but which cost no more to establish.

Taking a bit of extra time to consider small interventions can make a big difference and can add value to your strategic decisions. Figure 3 illustrates examples of this scale of detail.

Figure 3 Optimising opportunities for diversity.



Objectives

- To establish an economically and ecologically resilient woodland through choosing species which are most likely to do well in the changing climate.
- To expand the amount of CCF in the forest, including opportunities for large dimension timber and quality hardwoods on appropriate sites.
- To enhance wetland habitat and develop habitat network links within woodland and to adjacent key habitats.
- To improve the recreation experience.

Monitoring

Regular inspection and monitoring is essential for checking that the forest is responding positively to interventions and meeting the forest management objectives. Monitoring allows you to:

- **Assess the success of forest management against both your objectives and against more fundamental changes affecting the forestry industry.** This might include changes to forestry policy, future climate predictions and market trends;
- **Check that management choices remain robust in the face of changing site conditions.** It also allows you to review species resilience in relation to pests and diseases. This may include bringing some operations forward because of the need to replace species or change silvicultural options;
- **Take advantage of unforeseen opportunities.** When a coupe is being felled, for example, opportunities may be revealed that were not apparent when a plan was being prepared. Don't ignore these, keep an open mind and work with your best opportunities

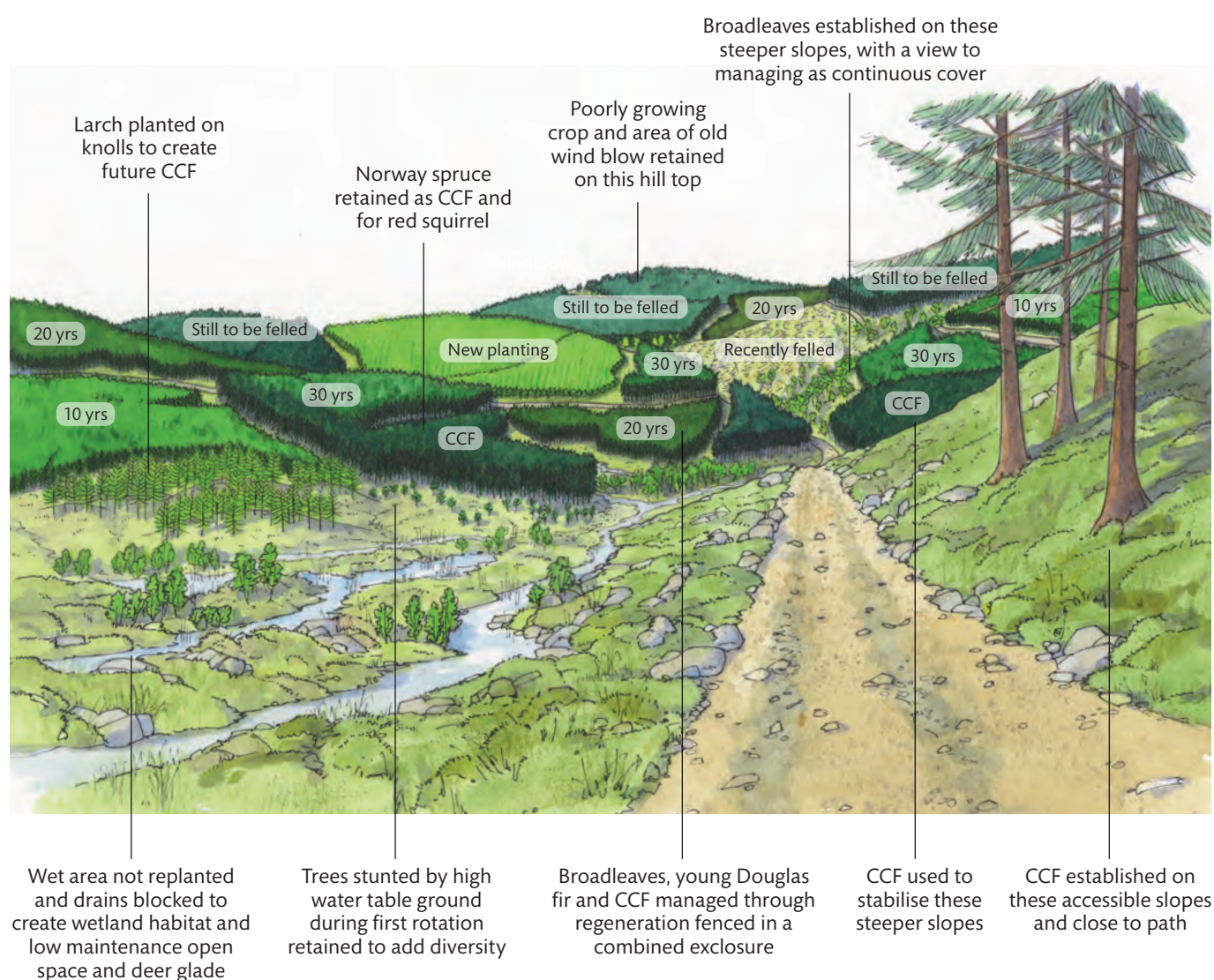
Don't get carried away with monitoring to try to prove increasing conservation value. Unless monitoring is required for specific, well defined reasons, it is rarely worth while – accept that adopting best practice will be producing conservation benefits.

Part 2: Diversity in the forest landscape

Part 2 demonstrates how some of the ideas outlined in Part 1 can be used in developing forest diversity in these four different landscape types, which are illustrated on the following pages:

- Forests on rounded hills
- Forests on rugged hills
- Forests in the lowlands
- Forests on blanket bog

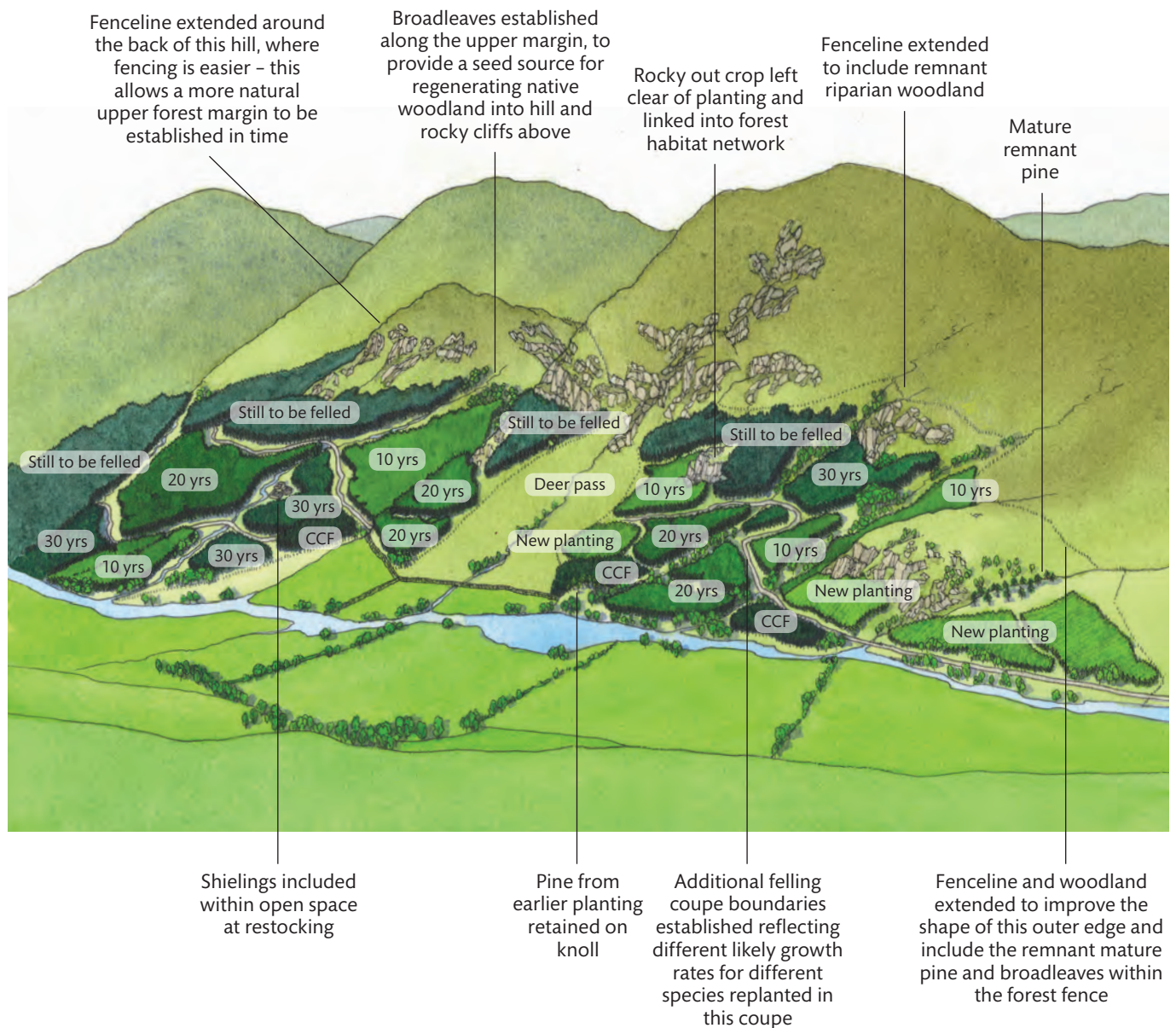
Figure 4 Introducing diversity into forests on rounded hills.



Objectives

- To build in a wider range of felling options for future managers, by establishing an extensive range of rides which could be future management coupe boundaries
- To use CCF to extend age range, stabilise the steeper slopes and to create potential for large dimension timber in the future
- To establish an economically and ecologically resilient woodland through choosing species which are most likely to do well in the changing climate
- To improve habitat especially for red squirrel and to consolidate habitat network.

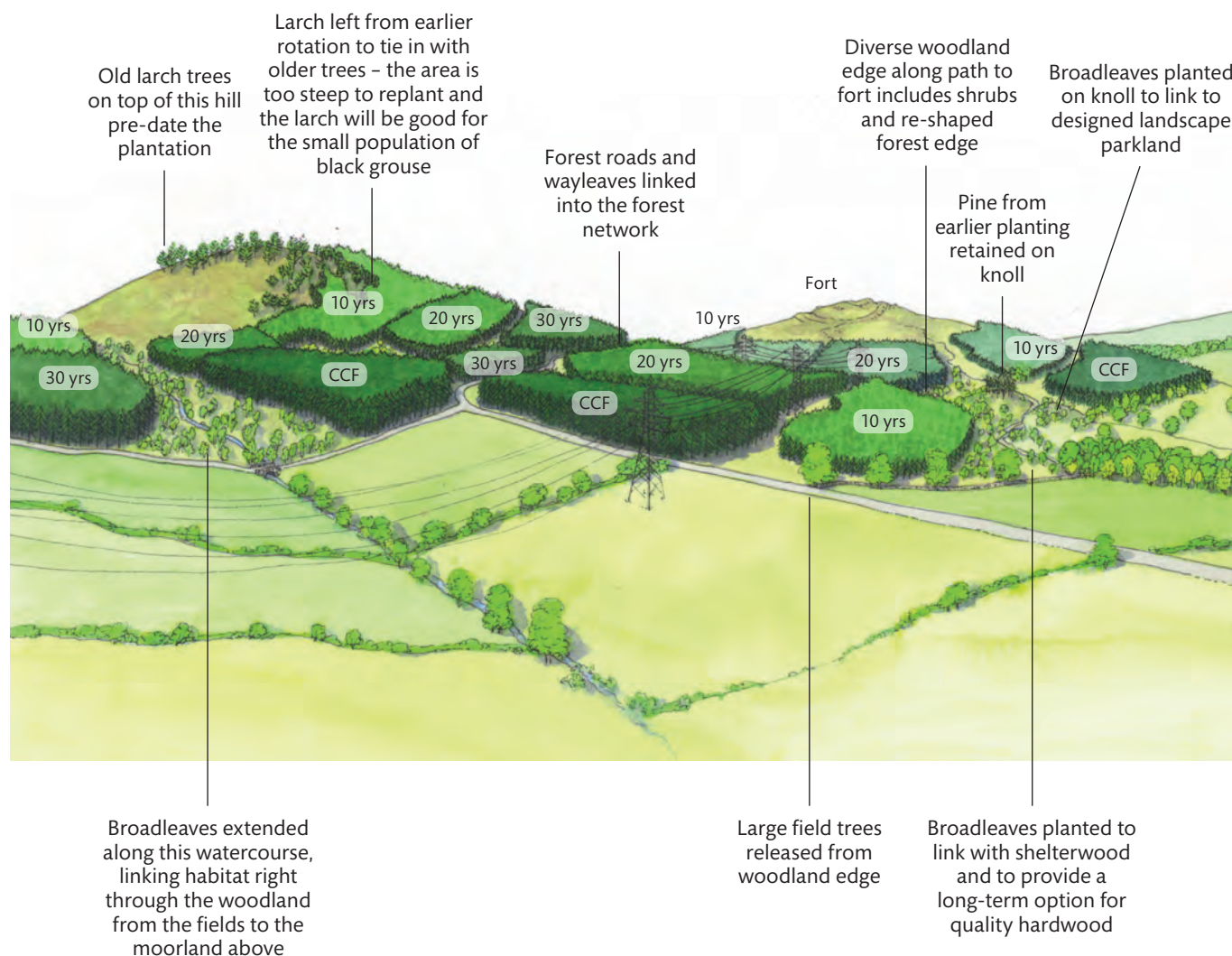
Figure 5 Introducing diversity into forests on rugged hills.



Objectives

- To build in a wider range of felling options for future managers, by establishing an extensive range of rides which could be future management coupe boundaries
- To establish an economically and ecologically resilient woodland through choosing species which are most likely to do well in the changing climate
- To improve habitat network links through the woodland
- To improve the landscape design by extending the woodland to re-shape the outer margin along lower slopes
- To re-align the fenceline to allow for a more natural upper tree line to form in time

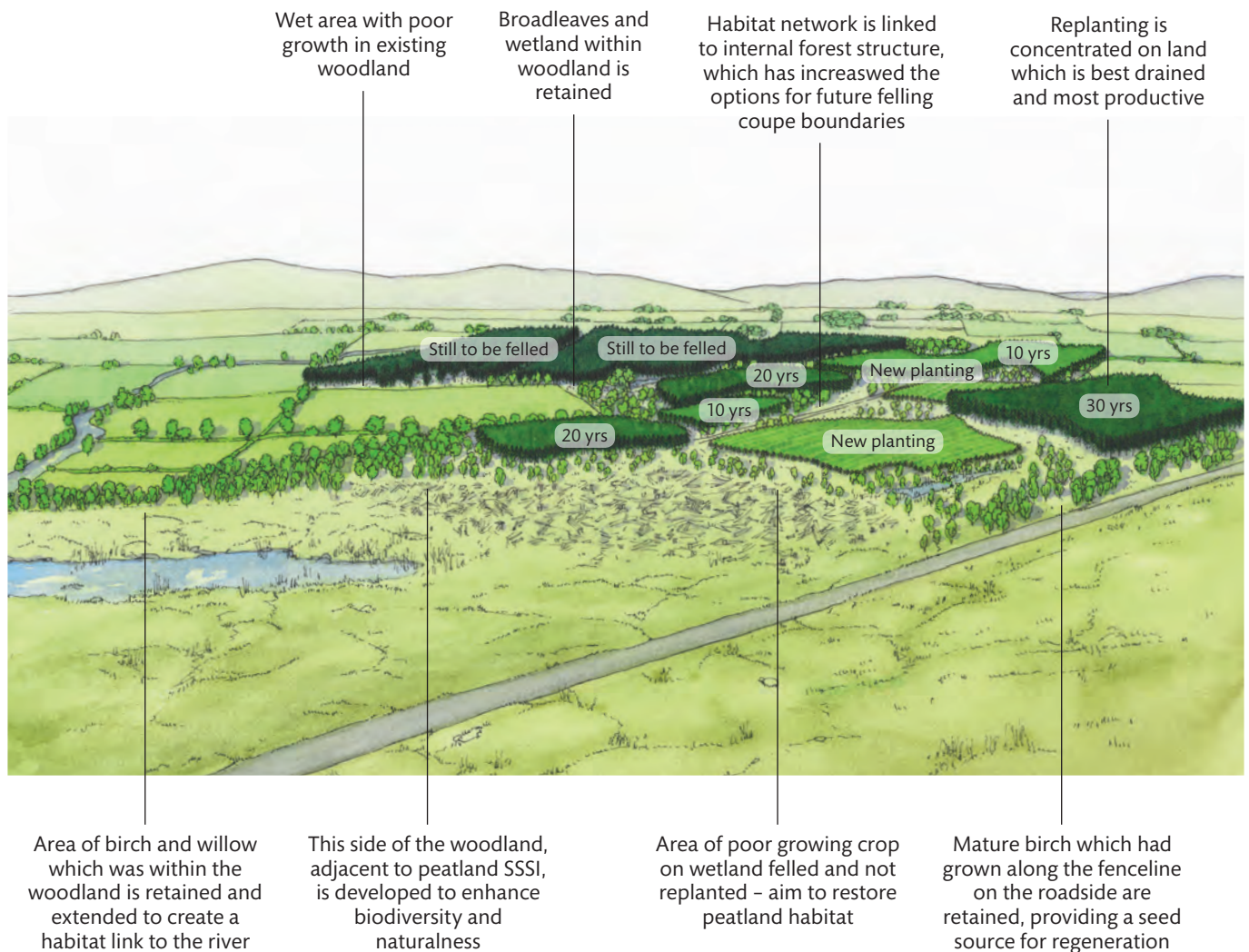
Figure 6 Introducing diversity into a lowland forested landscape.



Objectives

- To expand CCF and establish quality hardwoods to extend future timber market options
- To establish an economically and ecologically resilient woodland through choosing species which are most likely to do well in the changing climate
- To establish a well designed path to the iron age hill top fort
- To improve habitat network links through the woodland
- To reflect the designed landscape features which exist outwith the woodland

Figure 7 Introducing diversity into forests on blanket bog.



Objectives

- To build in a wider range of felling options for future managers, by establishing an extensive range of rides which could be future management coupe boundaries
- To replant on drier ground only to ensure even growth and improve practicability of management and harvesting
- To establish an economically and ecologically resilient woodland through choosing species which are most likely to do well in the changing climate
- To enhance wetland/peatland habitat adjacent to SSSI, and develop habitat network links within woodland and to adjacent key habitats

Appendix: Continuous Cover Forestry (CCF) silvicultural systems

Selecting CCF silvicultural systems for plantation forests

While most first-rotation plantation forests in Scotland have been managed under the 'clearfell and replant' silvicultural system, there are alternatives. CCF will help adapt the forest to changes to the climate, especially by providing structural diversity and retaining soil moisture. It may also have landscape and biodiversity benefits.

CCF is most applicable to sheltered sites. Some of the systems are best operated with species with shade-tolerant regeneration, such as western red cedar, western hemlock and the silver firs. Some of these silvicultural systems will require more intensive and expert management, such as regular marking and thinning, but will avoid the costs associated with replanting provided deer browsing is kept under control. All systems require regular monitoring to assess the success of the regeneration. Some key silvicultural systems are:

Table 6 Key CCF silvicultural systems.

System	Characteristics	Benefits and limitations
Uniform shelterwood	An even-aged system, but where the successor stand is secured by natural regeneration. Most of the old canopy is harvested, often in stages leaving a cover of seed trees, which are felled after the new crop establishes. Often applied to pine, larch, spruce, oak, birch and ash.	Avoids cost of replanting and may produce a better stocked stand. Best suited to poor soils where vegetation competition is not a problem. Uniform timber size classes. Tends to retain the regular appearance of clearfell-replant and still results in significant disturbance at the time of stand replacement.
Group / irregular shelterwood	A system which focuses on releasing patches of natural regeneration that arise during the rotation, enabling these to develop by opening up the canopy. Gradually diversifies the age structure. Often applied to spruce, larch and hardwoods.	Avoids replanting costs. Restocking disturbance tends to be dispersed. May result in some stems being harvested below optimal size, others above.
Group selection	A system based on harvesting groups of trees (small coupes) when these reach optimum size for marketing. The gaps created allow natural regeneration to develop, sometimes with enrichment planting. Suited to Douglas fir, spruce, western red cedar, ash and sycamore.	Achieves a gradual diversification of even-aged stands without harvesting timber too early. Group size must be related to shade-tolerance of regeneration sought. Some planting may still be required. Requires good forest access, regular inventory and monitoring.
Single tree selection	A system based on harvesting individual valuable stems as these reach a target diameter for marketing. The whole forest is worked through at low intensity on a regular cycle. Natural regeneration is used. Best for very shade-tolerant species, such as western hemlock, grand and silver firs and beech.	Can produce individual stems of very high quality/ value. Little or no disturbance of the forest. Requires expert forest marking and selection but avoids restock costs. A mature 'steady-state' forestry system.

References and further information

Foreword

Policy and planning

- *Forest Design Planning: A Guide to Good Practice* (1998). Forestry Commission, Edinburgh.
- Scottish Forestry Strategy www.forestry.gov.uk/sfs
- The European Landscape Convention: promotes the protection, management and planning of European landscapes. www.coe.int/t/dg4/cultureheritage/heritage/landscape

Introduction

Policy context

- Revised UK Forestry Standard (UKFS)
- Revised series of UKFS Guidelines

Climate change and forestry

- Maps illustrating the projected changes to the warmth and droughtiness of Scotland's climate can be found at: www.forestry.gov.uk/fr/climatechangescotland
- A summary of current climate change research projects being undertaken by Forest Research can be found by following the links on each topic at: www.forestry.gov.uk/fr/climatechange
- Forest Research advice on the suitability of species to site conditions can be found at www.forestry.gov.uk/fr/treespecies. This site provides information on over 60 tree species that are either widely grown in British forests at the present time or which could play an increasing role in the future, focusing on those species which could be expected to produce usable timber in British conditions.
- General Forest Research advice on climate change and forestry in the UK can be found at: www.forestry.gov.uk/fr/climatechange
- General Forest Research advice on climate change and forestry in Scotland, including a list of relevant publications can be found at: www.forestry.gov.uk/fr/climatechangescotland
- *Combating Climate Change – a role for UK forests* (2009) (also known as 'The Read report') www.forestry.gov.uk/readreport
- Table 1 draws on information provided in *A Guide to increasing tree species diversity in Wales*: www.forestry.gov.uk/wales

Part 1: Planning for diversity

Forest planning

- This section is on the stages of the forest plan set out in the Forestry Commission Guidance Note *Strategic Forest Plans*, September 2011 (FCS).

Diversity in existing forests

Site conditions

- The Ecological Site Classification Decision Support System (ESC-DSS) tool can be found at www.forestry.gov.uk/esc

Survey of features

- Forestry Commission Scotland is leading a field-based survey of all of Scotland's native woodlands to identify their location, extent, type and condition. The results of the surveys undertaken to date can be found at the Native Woodland Survey of Scotland site: www.forestry.gov.uk/nwss

- Additional information on the importance of deadwood can be found in the publication *Life in the deadwood: a guide to managing deadwood in Forestry Commission forests* (2002), Humphrey, J.; Stevenson, A.; Whitfield, P.; Swailes, J.
- Additional information on veteran trees can be found at:
www.forestry.gov.uk/fr/infid-5e2g5b
- The Forestry Commission has produced a Technical Notes on *Forest and Moorland Fire Suppression and Planning Controlled Burning Operations in Forestry* which can both be downloaded from www.forestry.gov.uk/publications

Analysing options

Forest Habitat Network

- The **Forest Habitat Network** aims to link woodlands of all ages to form a more continuous woodland cover than at present. This will benefit wildlife by providing wider and more sustainable habitats, and it will enhance opportunities for people who live near, work in, or simply enjoy our woodlands. More information can be found at:
www.forestry.gov.uk/foresthabitatnetworks
- Additional advice on **native woodland habitat networks** can be found in the Forestry Commission Scotland publication *Developing Native Woodland Habitat Networks*:
www.forestry.gov.uk/habitatnetworkguidance
- **Habitat networks** allow species to move and disperse through a landscape. More information on current research on habitat networks can be found at: www.forestry.gov.uk/glscotland

Habitat restoration

- There is information on **restoring different open ground habitat types** on the Forest Research website at: www.forestry.gov.uk/fr/openhabitats
- Additional information can be found in the Forestry Commission Scotland Technical Guidance Note *Creating and restoring open habitats from woodland* available at:
www.forestry.gov.uk/glscotland

Thinning, felling and restocking

Continuous cover forestry

- Further information on **continuous cover forestry and climate change** can be found at:
www.forestry.gov.uk/fr/climatechangescotland
- *The evidence supporting the use of continuous cover forestry in adapting Scotland's forests to the risks of climate change* (2009). Stokes, V and Kerr, G. available at:
www.forestry.gov.uk/fr/climatechangescotland

Selecting successor species

Site conditions and species choice

- Forest Research **advice on the suitability of species to site conditions** can be found at www.forestry.gov.uk/fr/treespecies. This site provides information on over 60 tree species that are either widely grown in British forests at the present time or which could play an increasing role in the future, focusing on those species which could be expected to produce usable timber in British conditions.
- Further information on the **National Vegetation Classification** available from:
www.jncc.defra.gov.uk/page-4259
- The **Ecological Site Classification Decision Support System** (ESC-DSS) tool can be found at www.forestry.gov.uk/esc
- **Soil survey maps** are available from The Macaulay Land Use Research Institute at:
www.macaulaysoils.com/MacaulayMaps.html

- Advice on the **alternatives to current commercial conifer species** can be found in *Using alternative conifer species for productive forestry in Scotland* (2011). Wilson, S.McG. Forestry Commission Scotland, Edinburgh.

Tree Line Woodlands

- '**Action for Mountain Woodlands**' is a project which assesses the current state of Scotland's mountain woodlands and is undertaking habitat restoration across several locations in Scotland. For further information see: www.mountainwoodlands.org
- **Juniper** is a UK biodiversity action plan priority species. It grows on well-drained nutrient-poor sites and is frequently found on open ground adjacent to woodland as its growth is limited by shade. For more information see Forestry Commission Delivery Note *Action for Juniper*: www.forestry.gov.uk/speciesactionnotes
- SNH provides a description of the types and benefits of **montane scrub** to be found in Scotland in its publication *Montane Scrub*: www.snh.org.uk/publications/on-line/heritagemanagement/montanescrub
- '**Treeline woodlands**' is the term used by the Forestry Commission Scotland to describe woodland above the timberline. This can be either new native woodlands, extensions to semi-natural woodlands or upper additions to commercial forests. Further information on treeline woodlands and the related discretionary grant scheme, see the Forestry Commission Scotland Guidance Note 13: www.forestry.gov.uk/fcsguidancenotes

Acronyms and glossary

Acronyms

ATC – Alternative to clearfell

CCF – Continuous cover forestry

ESC – Ecological Site Classification

ESC-DSS – Ecological Site Classification Decision Support System

FCS – Forestry Commission Scotland

FR – Forest Research

LISS – Low impact silvicultural system

LTR – Long-term retention

NVC – National Vegetation Survey

SNH – Scottish Natural Heritage

Glossary

Montane species

Low growing trees and dwarf woody shrubs which form a natural permanent climax vegetation at higher elevations. Some plants associated with these 'montane scrub' and 'subalpine' communities, such as prostate juniper and mountain willows, are UK Biodiversity Action Plan priority species.

Many of Scotland's productive forests were established during the 20th century as relatively simple plantations in terms of species and structural diversity. The new UK Forestry Standard and associated suite of Guidelines (2011) requires forest managers to consider ways to diversify these forests when developing their management plans.

Diversity in forests is essential to conserve biodiversity and expand habitats, and to contribute towards enhancing landscape quality and recreation opportunities. In addition, introducing species and age diversity throughout a forest can increase their resilience to pests, diseases and fire, and extend economic opportunities.

This Practice Guide offers advice and ideas from which a forest manager may select options that meet their management objectives and are appropriate for their forest. The format of the guidance relates to the decisions which forest managers need to make when they are preparing fully integrated management proposals which will contribute to a Forest Plan.



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